Strait of Canso Port Model Hindcast Evaluation

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Abstract

Drozdowski, A., Horne, E., 2022. Strait of Canso Port Model Hindcast Evaluation. Can. Tech. Rep. Hydrogr. Ocean Sci. 341: viii + 88 p.

The oceanography sub-initiative of Canada's Ocean Protection Plan (OPP) aims to develop high-resolution operational port-scale hydrodynamic models, to enhance safe navigation and response to events such as oil spills. The Strait of Canso was one of six ports selected for this initiative.

Model evaluation is an integral part of development, and essential to building confidence in the operational systems. Here, the Strait of Canso port models are evaluated against available observational data and the parent model, using a hindcast covering the years 2016 to 2019. The models were downscaled from the Coastal Ice-Ocean Prediction System East (CIOPSE). Atmospheric forcing was provided by the High-Resolution Deterministic Prediction System (HRDPS). In terms of the water level properties analyzed (tidal constituents and residual time series), all models performed exceptionally well, but the port models showed no improvement over CIOPSE. The port models demonstrated significant improvement over CIOPSE in validation of currents, particularly closer to shore and where topography plays a role. In addition, inshore temperature and salinity improved, because of the port models' ability to resolve topographic driven processes such as upwelling/downwelling, internal tides and deep water intrusions over a sill. The port model with the finer grid spacing (100 m) demonstrated some improvement over the coarser (500 m) model but only inside the strait and predominantly with flow direction, internal tides and deep water intrusions.

Résumé

Drozdowski, A., Horne, E., 2022. Strait of Canso Port Model Hindcast Evaluation. Can. Tech. Rep. Hydrogr. Ocean Sci. 341: viii + 88 p.

L'initiative du Plan de Protection des Océans (PPO) du Canada a pour but de développer des modèles hydrodynamiques à l'échelle des ports afin d'augmenter la sécurité de la navigation et répondre aux événements tels que les déversements de pétrole. Le Détroit de Canso est un des six ports sélectionnés sous cette initiative. L'évaluation des modèles fait partie intégrante des développements et est essentielle pour créer de la confiance dans les systémes opérationnels. Ici, les modèles du Détroit de Canso sont évalués avec des données observées et ils sont comparés au modèle à plus grande échelle en utilisant une modélisation rétrospective de 2016 à 2019. Les modèles ont été régionalisés à partir du Système Canadien de Prévision Glace-Océan pour l'est du Canada (SCPGO-E). Le forçage atmosphérique a été fourni par le Système à Haute Résolution de Prévision Déterministe(SHRPD). Tous les modèles performent exceptionnellement bien pour reproduire les niveaux d'eau (composantes de la marée et séries temporelles résiduelles) mais les modèles des ports n'ont pas montré d'amélioration par rapport au SCPGO-E. Les modèles des ports ont démontré une amélioration significative, dans la validation des courants par rapport au SCPGO-E, particulièrement près des côtes là où la topographie joue un rôle. De plus, les températures et salinités modélisées pour les modèles des ports ont été améliorées dû à la capacité des modèles à haute résolution de résoudre les processus influencés par la topographie tels que les ondes internes et les intrusions d'eau profondes par-dessus un seuil. Le modèle à 100 m de résolution horizontale a démontré une amélioration par rapport au modèle à résolution plus grossière (500 m) mais seulement à l'intérieur du détroit et principalement dans la direction des courants, les ondes internes et les intrusions d'eau profondes.

1 Introduction

Canada's Ocean Protection Plan (OPP) was launched in 2016 to support initiatives aimed at protecting our marine environment from anthropogenic pressures (DFO, 2016). The oceanography sub-initiative of OPP specifically aims to develop high-resolution operational port-scale hydrodynamic models, to improve safe navigation, and provide operational emergency response to events such as oil spills. The Strait of Canso, located between mainland Nova Scotia and Cape Breton Island, and one of the busiest Canadian ports in terms of tonnage shipped, was one of six ports selected for this project. The evaluation of the models developed for this region under OPP, are the subject of this report.

The Strait of Canso, is actually a 20 km long, 2-3 km wide fjord with steep sides and a 35–55 m deep main channel behind a 30m sill near the entrance. The name is retained from the original strait that separated Cape Breton Island from the mainland, and was blocked by a causeway in the 1950s. The causeway is fitted with a small lock to accommodate small-to-medium-sized vessel traffic during ice-free months, and separates the head of the strait from the Gulf of St. Lawrence. The causeway was treated as a closed land boundary by the present model, as the through-flow is negligible (Bugden et al., 2020). The strait is connect to the open shelf through Chedabucto Bay, a large bay roughly 20 by 30 km and as deep as 150 m. The region has two rivers Guysborough and Inhabitants, with climatological average monthly discharge peaking in April at 17 and 33 $m^3\ s^{-1}$. The entire Canso-Chedabucto Embayment has a water shed area of 2148.4 km^2 with maximum discharge of 155 $m^3\ s^{-1}$ (Gregory, 1993). The water properties of the region are typical of the inner eastern Scotian Shelf (Petrie et al., 1996), largely influenced by runoff from the Gulf of Saint Lawrence. For additional history and physical oceanography of the region refer to Drozdowski and Jiang (2020).

Modelling efforts for the area began with Barber and Taylor (1977), who investigated the resonant response of the embayment using a two-dimensional circulation model. The model of Drozdowski and Jiang (2020) is the best recent 3-dimensional model for the area, and was a prototype to the present modelling system. This unstructured model resolved the coastal regions to within 30 m and resolution gradually lessened to 2 km cells towards the open boundary. The present structured grid modelling system, despite a somewhat coarser nearshore resolution and higher demand for computational resources, supplanted the prototype in 2018 to facilitate operationalization and standardize modelling efforts across the department (Nudds et al., 2020; Paquin et al., 2019).

Operationalization of the port models is currently under development, with the aim of providing regular 48 hour forecasts to clients. To this end, the development is aligned with the multi-level nested operational ocean-forecasting systems being developed under the Canadian Operational Network of Coupled Environmental Prediction Systems (CONCEPTS; Government of Canada, 2016). These include Global Ice-Ocean Prediction System (GIOPS; Smith et al., 2016), a North Atlantic-Arctic Regional Ice-Ocean Prediction System (RIOPS; Dupont et al., 2015), as well as two regional models, Coastal Ice-Ocean Prediction Systems East (CIOPSE) and West (CIOPSW). At time of writing, the Strait of Canso Port models are state-of-the-art for the region, offering well resolved nearshore features coupled to the best available operational model, CIOPSE.

Model evaluation is critical in order to provide a reliable product people trust. In this report, the 100 and 500 m grid resolution Strait of Canso models are evaluated against observational data with the aim of demonstrating improvements over the coarser CIOPSE.

2 Methods

2.1 Port Model Domains and Nesting

Two levels of downscaling (one-way nesting) from the parent model were utilized for the port modelling study. Both downscaled grids (Fig. 1), follow the tri-polar ORCA configuration produced by Drakkar Group (2007), and are cut out directly from the CIOPSE grid, which has a nominal resolution of 2.5 km (1/36°) and covers a large part of the Northwest Atlantic (Fig. 2). The first port model level (STC500), 500 m grid spacing, was forced by CIOPSE and covered the embayment complex of interest, Strait of Canso, Chedabucto Bay and coastal margins, as well as a part of the inner eastern Scotian Shelf. The second level (STC100), 100 m grid spacing, was forced with STC500 and only covered the embayment complex. The most recent bathymetry available from the Canadian Hydrographic Service (CHS) was interpolated to the port model grids. No vertical adjustments were made to the bathymetry which was provided in Chart Datum. The CanCoast coastline product (Atkinson et al., 2016) was used to delineate land from ocean. The bathymetry was first decimated to 200 m for STC500 and 50 m for STC100, using a median filter. This was done to put patches of very fine multi-beam data on same footing as other data, and create a more uniform product before interpolation. The 200 m decimated bathymetry is shown in Figure 3. The figure shows that aside from some bare patches in the northeast, the domain has plenty of bathymetric data. The interpolation from the irregular scatter of points to the regular model grids was performed with triangulation using the *griddata* function in MATLAB®. Additionally, manual edits were performed to ensure the bathymetry conforms to the coastline. Smoothing was applied within the first 10 grid cells of the open boundaries to ensure a smooth transition from the parent model. For STC500, the eastern boundary required additional smoothing to improve the penetration of the coastal fresh water signal associated with the runoff from the Gulf of Saint Lawrence into the port domain.

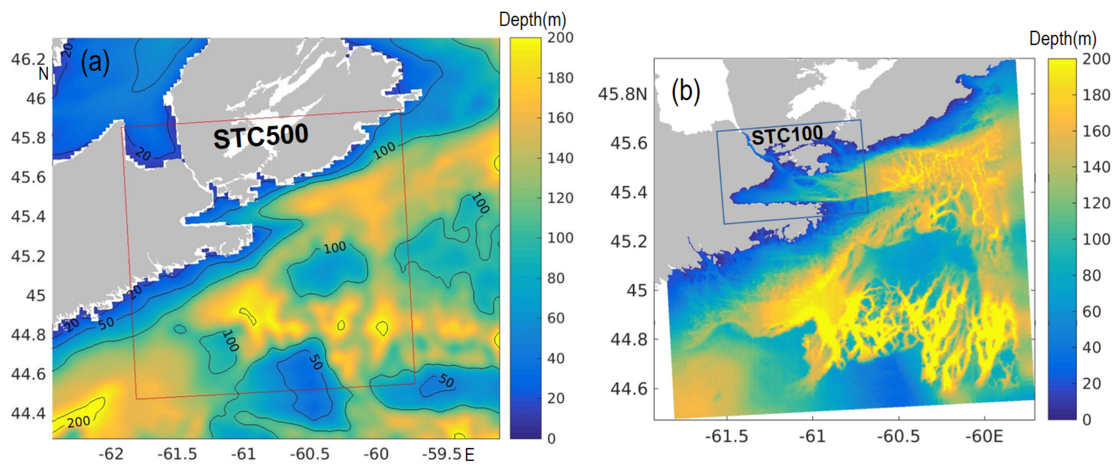

Figure 1: Port model domains: (a) STC500 inset shows nesting in CIOPSE with CIOPSE bathymetry, (b) STC100 inset shows nesting in STC500 domain with STC500 bathymetry.

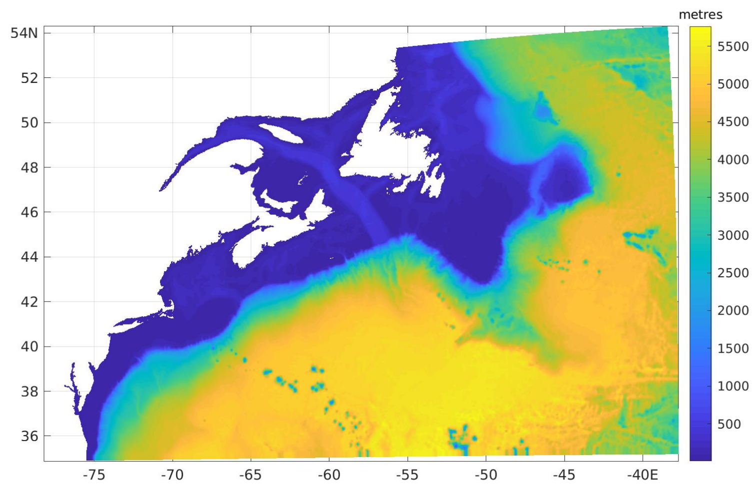

Figure 2: Parent model CIOPSE grid bathymetry.

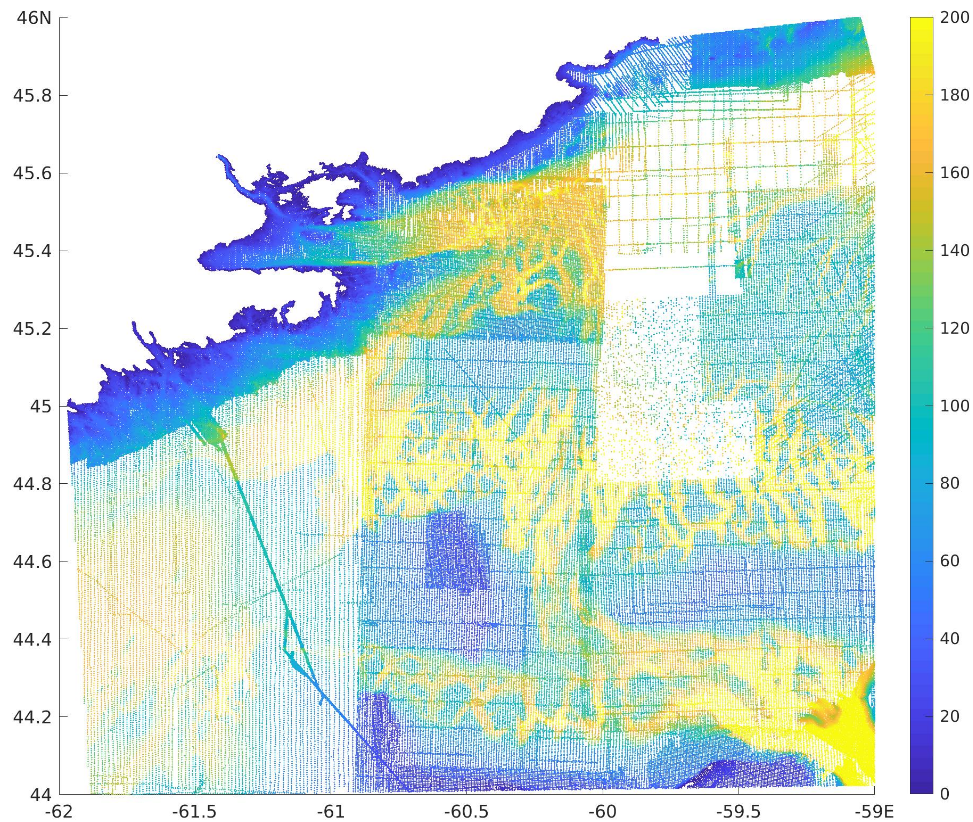

Figure 3: Original bathymetry from CHS decimated to 200 m. Color scale in metres.

2.2 Model Code Details

The modelling work for this study was based on the Nucleus of European Modelling of the Ocean (NEMO; http://www.nemo-ocean.eu), version 3.6 (Madec et al., 2017). Furthermore, CONCEPTS has been developing its own branch of NEMO 3.6 with customizations specific to its operational needs (eg. Dupont et al., 2015). This was the code (download from the repository on Aug. 28, 2020) used to perform the runs for the analysis here. Compilation of the code requires a choice of keys, which activate specific modules and features (Madec et al., 2017). The code was compiled with the following keys: `key_bdy key_dynspg_ts key_ldfslp key_zdfgls key_vvl key_mpp_mpi key_iomput key_dynldf_c3d key_traldf_c3d key_dynldf_smag key_traldf_smag key_xios2 key_nosignedzero key_netcdf4 key_rpne`. These keys were based on previous nearshore NEMO v3.6 applications (e.g. Paquin et al., 2019), some of which will be discussed below.

2.3 Physical and Numerical Consideration

NEMO solves the primitive 3-d hydrostatic equations of motion for an incompressible geospatial fluid, utilizing the hydrostatic and Boussinesq approximations. In the present port model configuration, the explicit time-splitting free surface formulation was used (*key_dynspg*) which follows Shchepetkin and McWilliams (2005). For both port model resolutions, a 50 layer Z-level vertical grid with bottom partial cells was used to represent the topography, with thinner layers near the surface gradually thickening at depth. Maximum depth was 400 m with 1 m thickness in the first layer and 18 m in the deepest. This vertical resolution was comparable to CIOPSE, which had 75 vertical levels but theirs extended to several thousands of metres in the Atlantic, and hence were more stretch out at depth. The variable volume level (*key_vvl*) scheme (Levier et al., 2007) was utilized to more accurately enforce conservation of volume by allowing for variation in the thickness of vertical layers in response to changes in the free surface. The Generic Length Scale (*key_zdfgls*) scheme was used for vertical turbulence closure with the option of $k - \epsilon$ for closure (Rodi, 1987), and the first method proposed by Canuto et al. (2001) for the stability function.

The vector invariant form was used for the advection terms of the momentum equation which, along with the Coriolis terms, are evaluated with the leapfrog time stepping scheme. A partial slip boundary condition was applied along the lateral land boundaries. The advection of tracers was handled with the TVD scheme. The lateral diffusion of momentum (*key_dynldf_smag*, *key_dynldf_c3d*) and tracers (*key_traldf_smag*, *key_dyntra_c3d*) was handled with the 3-d time-varying scheme based on Smagorinsky (1993), where diffusion is proportional to a local deformation rate based on horizontal shear and tension. Lateral open boundaries used the 'specified' condition for 3-d and Flather (1976) for 2-d variables. The 2-d variables where specified hourly and 3-d daily. Tidal forcing for the models was supplied directly from parent model in the 2-d elevation and barotropic currents.

Momentum and heat exchange with the atmosphere, as well as the evaporation rate were computed using the CORE bulk formulation (Large and Yeager, 2004) available in NEMO. The required atmospheric variables: 10 m winds, 2 m air temperature, specific humidity, precipitation and surface incoming longwave and shortwave radiation were supplied by the High-Resolution Deterministic Prediction System (HRDPS; Milbrandt et al., 2016)

The surface salinity was diluted by climatological river inputs taken from CIOPSE. The river input was spread over a large coastal area and assumed to be in the surface layer of the model and to match the ocean temperature.

Ice was not considered a significant factor for the present study and hence ignored. A temperature limiter was used to prevent non-physical water temperatures in the winter.

Further details of the control parameters and model setup (namelist_cfg and namelist_ref) are included in Appendix A and B for the STC500 model. For STC100, namelist_ref was identical to STC500, and the differences in namelist_cfg are included in C.

2.4 Oceanographic Data

This section provides locations and other metadata details for the observational data used in this report. Sources are provided where available. The discussion is subdivided by data type.

2.4.1 Water Level

Modelled water level was validated by means of a 4-year time series of water level, available from Marine Environmental Data Section (MEDS). The station (ID=575) is located in Port Hawkesbury (Fig. 4; 45.6167° N, 61.3667° W). The hourly version of the data was downloaded from `https://www.isdm-gdsi.gc.ca/isdm-gdsi/twl-mne/inventory-inventaire/sd-ds-eng.asp?no=575&user=isdm-gdsi&region=ATL`. These data were used to validate the tidal and residual water level properties of the models. Historic CHS tidal constituents were also available from five stations in the area. These were based on relatively short (month long) observations in close geographic proximity, and because they offered little additional information, were omitted from discussion, however the level agreement with those data was comparable to the FVCOM modelling results reported in Drozdowski and Jiang (2020). As the water level time series had sampling period of less than one hour, they were hourly averaged to match the model output.

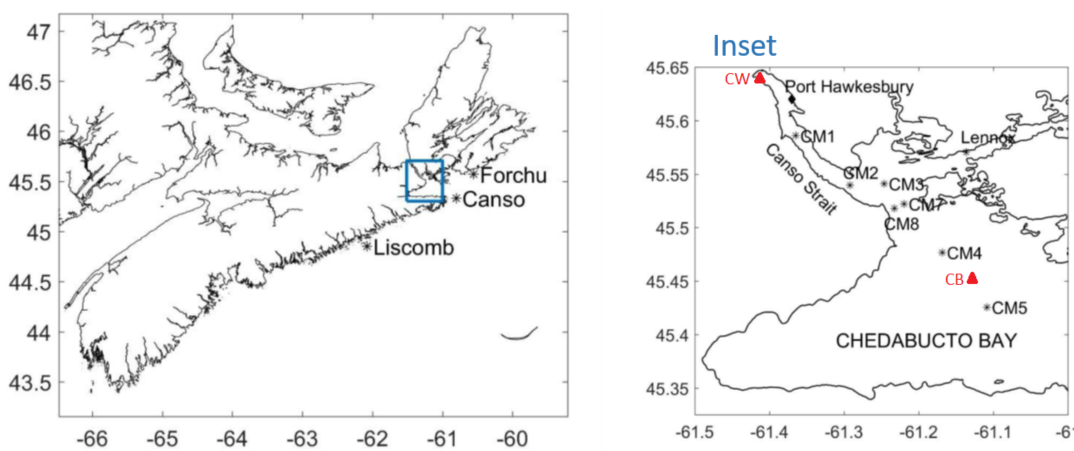

Figure 4: Locations of current meters (*) and moored CTDs (red trianges).

2.4.2 Current Meter

A collection of data from 17 ADCP deployments was available for validation. These were collected specifically for the OPP project between 2015-2017. For details refer to Drozdowski et al. (2018). Figure 4, reproduced from that report, shows the locations of the stations. All deployments were between one and six months long with the exception of Forchu, which was only three weeks long due to instrument malfunction. Many time series had sampling periods of less than one hour, these were hourly averaged.

2.4.3 Temperature and Salinity

A collection of 22 CTD casts performed during the deployment and recovery (spring and fall cruises) of the OPP ADCPs was used for T-S profile validation. The original data sets contained numerous casts in close proximity to each other. As these offered little additional information they were viewed as duplicates and removed, keeping deepest profiles available. The casts are presented in Section 5.1 with maps showing location of each cast. Additionally the title above the map panel identifies the cast number and name tag containing a unique cruise and casts identifier which can be used to track the original file from MEDS.

Moored CTD (microcat or MCAT) time series offer a continuous record of T-S at fixed location. Several of these instruments were available in the port area. The deployment locations are shown in Figure 4, with additional metadata included in Table 1. The 2016 deployments were conducted as part of the OPP program while the one in 2019 was deployed by the Habit Ecology Section (Bugden et al., 2020). The time series were daily averaged for analysis and plots.

Station	LON(E)	LAT(N)	Cruise ID	Deploy Date	Model_Serial#
CB-11m	-61.106	45.435	BCD2016914	04-MAY-2016	SBE37SM-RS232_03714440
CB-49m	-61.106	45.435	BCD2016914	04-MAY-2016	SBE37SM-RS232_03714390
CW-2016-5m	-61.415	45.644	PER2016007	04-MAY-2016	SBE37SM-RS232_14387
CW-2016-57m	-61.415	45.644	PER2016007	04-MAY-2016	SBE37SM-RS232_14389
CW-2019-5m	-61.406	45.645	BCD2019899	08-JUL-2019	SBE37SM-RS232_03714389

Table 1: Microcat observational metadata.

The vertical profiles were collected using the Sea-Bird SBE25, while the moored time series used the SBE37. Processing for both was done using the CTD Data Acquisition and Processing System (CTDDAP), a collection of processing tools from the manufacturer, as well as custom modules developed by the ODIS section at the Bedford Institute of Oceanography (BIO). The CTDDAP processing packaged performs a number of quality control checks, including a median filter to remove anomalous spikes. As part of the CTD operational standards at BIO's instrument shop, instruments are sent to manufacturer for re-calibration every three to four years. During this period, the conductivity sensors are periodically checked against a standard salinity solution. The temperature sensors on the SBE's are known to be highly accurate and drift between re-calibrations is not a concern.

2.5 Error and Skill Metrics

Below we describe the choice of error metrics used to assess model performance. All sums here are over a total of N point values from a particular station, group of stations or time period. Vertical bars denote point-wise absolute values, while over-bars, the sample mean of the distribution. The point-wise model error is defined as

$$E = X_m - X_o, \tag{1}$$

where X_m and X_o represent discrete modelled and observed values. The distribution of E can be summarized with the following five statistics: the bias

$$\overline{E} = \frac{\sum E}{N}, \tag{2}$$

the root-mean-square (RMS) of the model error

$$RMSE = \sqrt{\frac{\sum E^2}{N}}, \tag{3}$$

the maximum error for each period

$$EMAX = sign(E(t_{EMAX}))max(|E|), \tag{4}$$

the Pearson correlation coefficient

$$PCOR = \frac{\sum(X_m - \overline{X_m})(X_o - \overline{X_o})}{\sqrt{\sum(X_m - \overline{X_m})^2 \sum(X_o - \overline{X_o})^2}}, \tag{5}$$

and finally the Willmott (1981) skill

$$WSK = 1 - \frac{\sum E^2}{\sum(|X_m - \overline{X_o}| + |X_o - \overline{X_o}|)^2}. \tag{6}$$

The bias measures systematic model error, $RMSE$ the overall absolute model error (at times here abbreviated to just "error"), while $EMAX$ is the worst case scenario (t_{EMAX} gives the date and time of this occurrence). These three error metrics are easy to interpret and useful in real world application because they are in the same units as the quantity being modelled. However as absolute metrics, they might not reflect real model skill and make it difficult to compare performance at different stations. Of the two dimensionless skill metrics used here, $PCOR$ ranges between -1 and 1, with 1 indicating perfect agreement, 0 (or close to it) no agreement, while negative values imply something is really wrong and the model is doing the opposite of what it should. $PCOR$ captures the covariance between model and data but ignores systematic (in the linear sense) errors. Lastly, WSK captures both systematic and unsystematic errors, 1 indicating perfect agreement and 0 no skill. This metric shows up frequently in the model validation literature (recent e.g. Nudds et al., 2020; Katavouta et al., 2016).

To investigate systematic errors in more detail, linear regressions of model vs data were included where it was deemed relevant.

For purely tidal processes, $RMSE$ was calculated directly from each constituent

$$RMSE = \sqrt{1/2(A_o^2 + A_m^2) - A_o A_m \cos(\phi_m - \phi_o)}, \tag{7}$$

with A_o,A_m,ϕ_o and ϕ_m the observed and model amplitudes and phases. For all velocities, the total vector $RMSE$ is reported and calculated as

$$RMSE = \sqrt{RMSE_x^2 + RMSE_y^2}, \tag{8}$$

using the Cartesian east ($RMSE_x$) and north ($RMSE_y$) as defined by Eq.3 or 7. Additionally, to give a sense of systematic directional errors, principal axis ellipses are plotted for velocities, which represent standard deviations along direction of maximum and minimum variance (Thomson and Emery, 2014).

As many of the T-S time series had a strong seasonal cycle, the normalized skill metrics were computed from the original time series as well as from a version of the time series (anomalies) which had the seasonal cycle removed. This was accomplished by least-square-fitting a harmonic with a period of a year to the observations. For shorter series this had the effect of removing the trend. The purpose of this exercise, was to ascertain how much of the skill can be attributed to the long term trend versus short term covariance.

To make the language in this report more objective, the following arbitrary ranges were chosen for skill scores (both WSK and $PCOR$): very high (> 0.9),high ($0.75 - 0.90$), moderate ($0.6 - .75$), low ($.4 - .6$) and poor ($< .4$).

2.6 Tidal Analysis

Tidal analysis of water level and currents was performed in MATLAB® using T_TIDE (Pawlowicz et al., 2006), a tool which draws extensively from the original FORTRAN tidal package of Foreman (1977). The results are used both for reporting constituents and calculating residual series by removing the tidal forecast.

2.7 Standard Colour Scheme

Due to the large number of figures here, a consistent linetype-color (marker) scheme is used with solid-red (+) used for data, solid-blue (x) for STC100, dashed-blue (+) for STC500 and solid-green (+) for CIOPSE. Tables list model results in the same order.

3 Results: Water Level

3.1 Tides

Tidal analysis was performed for the period 2016-18 (inclusive) for both model results and data. All 68 standard constituents where used in the analysis but the criteria for resolve-ability (and synthesis of tidal forecast used for computing residual) was chosen based on the signal-to-nose ratio (SNR) ≥ 2 . Following T_TIDE

$$SNR = \frac{A^2}{A_{95CI}^2}, \tag{9}$$

where A is the amplitude and A_{95CI} is T_TIDE's 95% bootstrap confidence limit based on the uncorrelated bi-variate colour noise model. T_TIDE's other two error models (white noise and linear) produced similar intervals but tended to be smaller. Summary statistics from the analyses are included in Table 2. Tides account for the majority of the signal. Data and all models are in close agreement.

	VAR(%)	RMS (m)	MIN (m)	MAX (m)
DATA ALL	94	0.46	-0.99	1.09
DATA 6	93	0.45	-0.90	0.99
STC100	95	0.45	-0.93	1.00
STC500	95	0.47	-0.97	1.05
CIOPSE	95	0.46	-0.94	1.04

Table 2: Tidal analysis summary for Port Hawkesbury wharf station. VAR is the total tidal variance predicted as a percentage of the total variance. Other statistics pertain to tidal synthesis for the analysis period. DATA 6 row includes results using only the six dominant constituents in the analysis.

The validation of the modelled tidal signal is presented constituent-wise. To avoid an excessively long presentation, constituents with data amplitudes smaller than 0.01 m are omitted (the full set was used to compute the residual and in the above table). This truncation resulted in 18 constituents which were further grouped into six dominant ($A_o > 0.04$ m), and 12 lesser constituents. One exception was the secular constituent (SA) which had $A_o > 0.04$ m but SNR of only 12 (all dominants had SNR over 100) and was grouped with the lesser. Dominant modelled and observed constituents are presented in Table 3. M2 had the largest amplitude at just under 0.6 m. Other semi-diurnal amplitudes were a fifth of M2 while diurnals a tenth. The over-tide M4 was present at roughly the magnitude of diurnals. All models performed exceptionally well with only small differences. All amplitudes were within a centimeter of observation, semi-diurnal phases within 4° and diurnals and M4 within 8°. The largest $RMSE$ was 0.012 m and generally under 0.01 m.

The lesser constituents are reported in Table 4. The ability to resolve many of these constituents requires long time series. In particular SA requires several years. More subtle are lesser constituents with periods close to the dominants. An example of this is K2 and S2 for which the Rayleigh criteria of resolution is 180 days (Foreman, 1977). The K2 amplitude was 40% of S2's and with analysis shorter than six months the K2 energy will modulate the S2 amplitude and phase with a semiannual period (by 4 cm and 10°

based on monthly analysis; not shown). This modulation will also occur for P1, S1 and K1 which are all very close in frequency and will require six months to resolve K1 from S1, and a full year for all 3. All models did a reasonable job reproducing many of the lesser constituents. SA, K2, MN4 and P1 were particularly well modelled, while NU2, MU2, L2, 2N2 and T1 were missed completely. The investigation of these lesser constituents demonstrates the need for long time series analysis in validating the finer points of water level forecasting. Many of these constituents were small and perhaps negligible but collectively their inclusion in forecasts is required to achieve higher accuracy. Table 2 demonstrates this point with an analysis done using only the dominant constituents. The lesser constituents account for only 1% percent of the variance but increase/decrease the min/max by ≈10 cm. Using a tidal forecast based on a short time series analysis would clearly increase errors further as the estimated constituents could be modulated by unresolved lesser constituents by as much as 40%.

Constituent	Amplitude (A; m)			Phase(ϕ; °GMT)			RMSD(m)
	Observed	Modelled	Difference	Observed	Modelled	Difference	
M2	0.586	0.577	-0.009	345.7	346.2	0.5	0.007
		0.602	0.016		346.1	0.5	0.012
		0.593	0.007		345.1	-0.6	0.007
N2	0.126	0.126	-0.001	322.8	324.4	1.5	0.002
		0.131	0.005		324.2	1.4	0.004
		0.129	0.003		323.2	0.3	0.002
S2	0.138	0.126	-0.012	24.7	21.7	-3.0	0.010
		0.132	-0.007		21.9	-2.9	0.007
		0.128	-0.010		20.7	-4.1	0.010
K1	0.069	0.074	0.005	48.6	50.4	1.8	0.004
		0.072	0.003		47.8	-0.9	0.002
		0.073	0.004		47.2	-1.5	0.003
O1	0.049	0.047	-0.002	344.6	351.6	7.1	0.004
		0.046	-0.003		348.3	3.7	0.003
		0.047	-0.003		347.6	3.0	0.003
M4	0.047	0.045	-0.002	253.2	259.4	6.1	0.004
		0.054	0.007		261.5	8.3	0.007
		0.053	0.006		258.3	5.1	0.005

Table 3: Dominant constituent comparison for Port Hawkesbury wharf station. For each constituent, modelled values listed top to bottom for STC100, STC500 and CIOPSE.

CON	PERIOD(h)	A_o	A_m	ϕ_o	ϕ_m	SNR_o	SNR_m
SA	8766.2	0.054	0.049	323.8	316.1	1.2e+01	1.2e+01
			0.049		315.8		8.5e+00
			0.049		313.3		9.8e+00
K2	11.967	0.040	0.037	21.2	19.1	4.3e+02	9.1e+02
			0.039		19.0		9.6e+02
			0.038		17.7		8.2e+02
SSA	4382.9	0.028	0.016	148.6	174.3	3.5e+00	8.3e-01
			0.015		174.1		1.0e+00
			0.017		176.9		1.2e+00
NU2	12.872	0.024	0.001	323.4	159.3	3.1e+02	7.6e-01
			0.001		162.4		8.9e-01
			0.001		159.9		9.1e-01
MN4	6.269	0.023	0.025	200.0	188.1	1.9e+02	8.8e+02
			0.029		189.9		8.9e+02
			0.028		186.9		7.8e+02
P1	24.066	0.022	0.023	38.3	41.6	2.9e+01	5.0e+01
			0.022		39.1		4.7e+01
			0.023		39.6		5.9e+01
MS4	6.103	0.021	0.027	15.7	348.8	1.4e+02	8.3e+02
			0.032		351.1		1.1e+03
			0.032		347.5		9.5e+02
MU2	12.872	0.020	0.002	328.6	359.2	2.4e+02	5.4e+00
			0.002		359.7		8.0e+00
			0.002		358.7		4.5e+00
L2	12.192	0.017	0.002	8.7	264.9	1.8e+02	6.1e+00
			0.002		265.3		5.6e+00
			0.002		269.6		4.9e+00
2N2	12.905	0.016	0.000	303.6	4.9	1.5e+02	2.1e-01
			0.000		4.8		2.3e-01
			0.000		5.8		3.9e-01
S1	24.0000	0.011	0.006	287.5	237.1	5.5e+00	2.1e+00
			0.005		232.9		1.9e+00
			0.006		250.1		3.4e+00
T2	12.0164	0.011	0.001	6.1	148.2	6.6e+01	1.3e+00
			0.001		153.1		1.5e+00
			0.001		152.0		1.0e+00

Table 4: Comparison of lesser constituent at Port Hawkesbury wharf station.

3.2 Residual

The residual water level was calculated by subtracting the tidal forecast reported above. In addition, long term means (2016-2018 inclusive) were removed from the time series in order to bring everything to a common vertical datum. The winter of 2019 had a problem with tidal ramp (pers. comm. S. MacDermit) in CIOPSE, which manifested with anomalous spikes in the elevation. As a result, the port models had stability issues during this period. This was resolved by first smoothing the de-tided elevation specified on the open boundaries, and then adding the tides back to the signal. This stabilized the model runs but performance was still relatively poor during this period, perhaps suggesting that smoothing of the barotropic currents was also required. For the time being, results from this period are excluded from further discussion.

The models were evaluated using metrics described in 2.5 computed over the whole period and seasonally. Additionally, the RMS elevations of observed (RMS_o) and modelled (RMS_m) were reported to show the scale of variability and highlight any systematic errors. The results are presented in Table 5. $RMSE$ was in the range 0.04-0.08 m, with larger values generally in the stormier winter seasons and around 50% of the total RMS values. RMS_m was consistently smaller than RMS_o by around 10-20% with the port models showing only a minor improvement. These errors were investigated further with scatter plots and regressions of model versus observation for each model over the entire modelled period (Fig. 5), and show very similar performance by all three models and in particular, a ≈25% underestimation in the slope and no bias (as expected by removing means). Overall $PCOR$ and WSK score were consistently above 0.85 and 0.92, indicating very high level of agreement. Seasonally, both correlation and skill are highest in the winter seasons (opposite to $RMSE$) highlighting the value of normalized error metrics which here tell us the $RMSE$ was higher in the winter due to overall higher variability and models actually do better in the winter. Maximum errors are generally in the 0.2-0.4 m range but reach 0.75 on 15-Mar-2018 and -0.95 on 28-June-2018 fairly consistently for all models. A quick look at these events indicates that they are 2-4 h long anomalies in the data, which the models miss entirely. These rare events are also graphically visible clustered around the x-axis in Figure 5.

The ability to model port response to extreme weather events demonstrates the robustness of the systems. Here we focus on two large storms. Residual water level time series for the Christmas storm of 2017 and post tropical storm Dorian, is shown in Figures 6 and 7. All three models reproduced the observation reasonably well. The Christmas storm caused a 0.5 m storm surge that lasted about 12 hours. A second more powerful storm follows 10 days later with 0.5-0.8 m surge lasting for a few days. The models reproduced the main Christmas storm surge correctly, but underestimated some of the lows that followed in its wake, as well as underestimating the surge of the followup storm by about 0.2 m. Dorian caused the water level to surge by up to one metre but only for a few hours. Secondary peaks followed the first surge, indicating a possible shelf wave. All models reproduced the timing of these features, but the peaks were underestimated by ≈0.1 m. Overall the models missed the high frequency (3-4 h period) oscillation associated with the seicheing of the embayment (Barber and Taylor, 1977). The fault was attributed a lack of excitation energy in the seiche frequency band of the model forcing. Further investigation is beyond the present scope, but for the port models this energy would be lacking in the remote (CIOPSE) forcing, or in inadequate temporal (and perhaps spatial) resolution of the wind forcing (Ma et al., 2017).

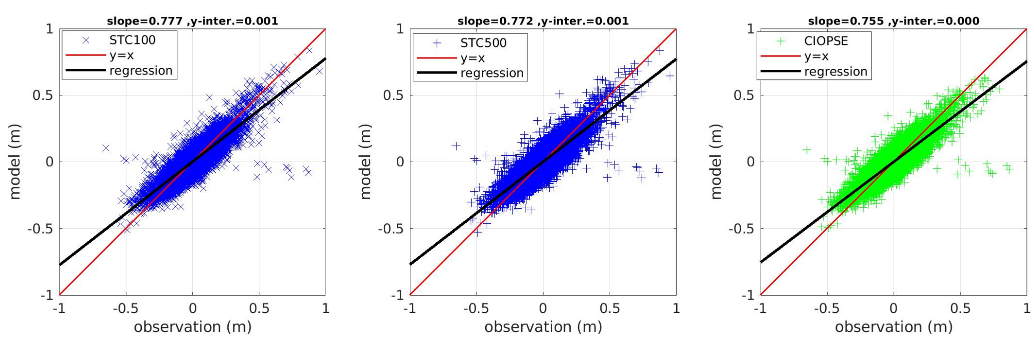

Figure 5: Scatter plots of modelled versus observed residual water levels for the three models.

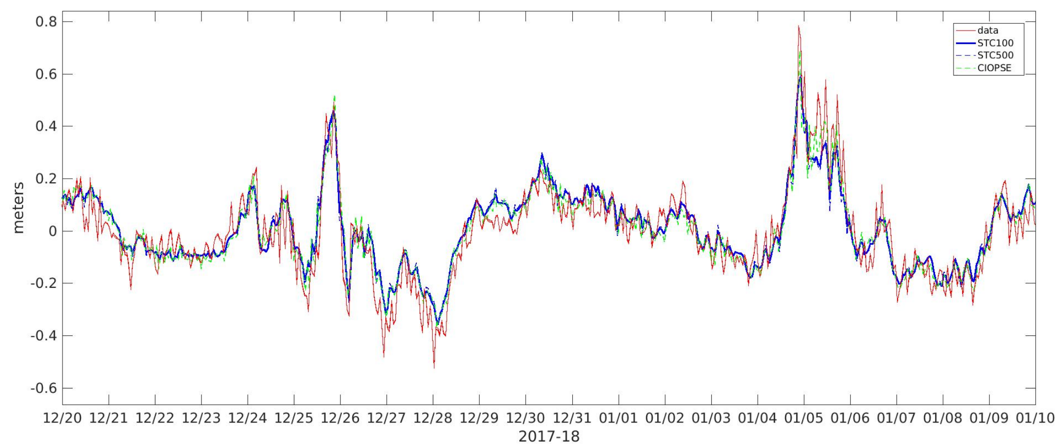

Figure 6: Residual water level from the Port Hawkesbury station during the Christmas storm of 2017.

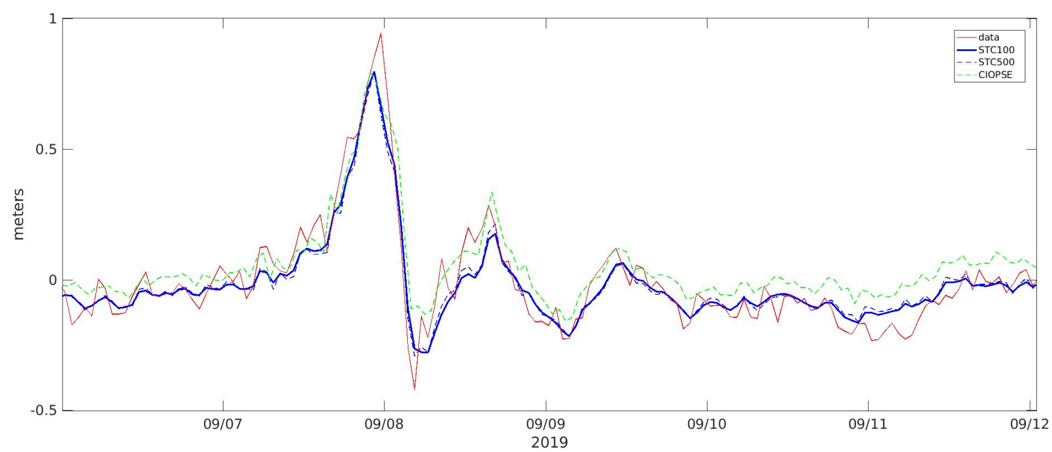

Figure 7: Residual water level from the Port Hawkesbury station during tropical storm Dorian

Period	RMS_o (m)	$RMS_m(m)$	$RMSE$(m)	$EMAX$(m)	t_{EMAX}	$PCOR$	WSK
01-Jan-2016	0.118	0.106	0.059	-0.949	2018062806	0.864	0.926
to	0.118	0.106	0.061	-0.948	2018062806	0.855	0.921
08-Jan-201 9	0.118	0.104	0.059	-0.924	2018062806	0.870	0.927
01-Jan-2016	0.142	0.130	0.068	0.360	2016013001	0.884	0.934
to	0.142	0.131	0.071	0.386	2016013001	0.872	0.928
31-Mar-2016	0.142	0.123	0.066	0.304	2016013003	0.890	0.935
01-Apr-2016	0.106	0.093	0.053	0.258	2016041015	0.858	0.920
to	0.106	0.094	0.055	0.287	2016041015	0.847	0.915
30-Jun-2016	0.106	0.090	0.051	0.235	2016041015	0.871	0.925
01-Jul-2016	0.072	0.061	0.045	0.364	2016092114	0.787	0.874
to	0.072	0.062	0.047	0.365	2016092114	0.771	0.867
30-Sep-2016	0.072	0.058	0.046	0.374	2016092114	0.783	0.867
01-Oct-2016	0.118	0.101	0.060	0.326	2016102301	0.870	0.921
to	0.118	0.102	0.062	0.316	2016102301	0.860	0.916
31-Dec-2016	0.118	0.100	0.060	0.356	2016102301	0.867	0.920
01-Jan-2017	0.158	0.146	0.072	0.756	2017021011	0.896	0.941
to	0.158	0.147	0.074	0.773	2017021011	0.888	0.936
31-Mar-2017	0.158	0.142	0.069	0.743	2017021011	0.903	0.944
01-Apr-2017	0.091	0.084	0.047	0.236	2017043009	0.865	0.924
to	0.091	0.086	0.049	0.232	2017043009	0.853	0.918
30-Jun-2017	0.091	0.081	0.046	0.231	2017043009	0.872	0.926
01-Jul-2017	0.078	0.068	0.044	-0.184	2017083113	0.813	0.895
to	0.078	0.070	0.045	-0.192	2017083123	0.802	0.890
30-Sep-2017	0.078	0.066	0.043	-0.227	2017083113	0.817	0.896
01-Oct-2017	0.125	0.108	0.057	-0.353	2017112307	0.885	0.934
to	0.125	0.108	0.059	-0.378	2017112307	0.876	0.929
31-Dec-2017	0.125	0.105	0.057	-0.285	2017112307	0.888	0.934
01-Jan-2018	0.156	0.149	0.073	0.343	2018031505	0.885	0.939
to	0.156	0.150	0.076	0.352	2018031414	0.876	0.934
31-Mar-2018	0.156	0.145	0.071	0.388	2018031414	0.891	0.941
01-Apr-2018	0.116	0.090	0.081	-0.949	2018062806	0.725	0.828
to	0.116	0.091	0.082	-0.948	2018062806	0.718	0.826
30-Jun-2018	0.116	0.087	0.080	-0.924	2018062806	0.731	0.829
01-Jul-2018	0.083	0.073	0.046	0.179	2018092418	0.824	0.899
to	0.083	0.073	0.047	0.177	2018092418	0.811	0.892
30-Sep-2018	0.083	0.070	0.046	0.172	2018092418	0.824	0.895
01-Oct-2018	0.151	0.139	0.064	-0.278	2018110408	0.907	0.947
to	0.151	0.139	0.067	-0.265	2018110408	0.898	0.942
31-Dec-2018	0.151	0.134	0.063	-0.238	2018110408	0.910	0.946
01-Apr-2019	0.112	0.102	0.056	-0.323	2019041607	0.866	0.926
to	0.112	0.103	0.058	-0.325	2019041607	0.859	0.922
30-Jun-2019	0.112	0.098	0.055	0.302	2019040403	0.871	0.927
01-Jul-2019	0.094	0.086	0.050	-0.266	2019090723	0.855	0.913
to	0.094	0.086	0.051	-0.306	2019090723	0.849	0.910
30-Sep-2019	0.094	0.084	0.049	0.282	2019090804	0.864	0.913

Table 5: Residual water level performance metrics (See 2.5) for Port Hawkesbury wharf station. For each period, modelled values listed top to for STC100, STC500 and CIOPSE. t_{EMAX} reported in format: YYYYMMDDHH

4 Results: Currents

4.1 Depth Averaged Currents

A depth averaged current comparison offers insight into model performance in terms of overall circulation. In this section, depth averaged model results are compared to available ADCP data. NB: as the ADCP data sets do not sample the water column nearest the surface due to surface side lobe contamination (RD Instruments, 1996), and nearest the bottom due to instrument mounting constraints, model results were averaged over the same vertical range. Henceforth these are referred to as depth averaged (or barotropic) even though they are proxies. In addition, unless otherwise indicated, all derived constituents and statistics are computed from the time period where model and data overlapped.

4.1.1 Tides

Depth averaged M2 current constituents are presented in Tables 6 to 7. For stations with multiple deployments, only the longest deployment was used for the analysis. These were close to six months with the exception of Forchu, which was only three weeks. M2 current ellipses are plotted at selected stations in Figure 8. The region has M2 currents generally under 0.06 $\mathrm{m\,s^{-1}}$, except in the entrance of the strait (CM7 & 8) where it reaches 0.15 $\mathrm{m\,s^{-1}}$. Ellipses tend to be thin, particularly in the strait where flow is constrained by the topography. Port model amplitude errors are generally under 0.01 $\mathrm{m\,s^{-1}}$and phase errors under 7°. The largest $RMSE$ error was 0.014 $\mathrm{m\,s^{-1}}$ but mostly under 0.01 $\mathrm{m\,s^{-1}}$. CIOPSE performs considerably worse inside the strait where it underestimates the amplitudes and gets the wrong orientation. Worst performance was in the entrance, where the amplitudes were underestimated by 60%, inclination errors were 14-17°, and $RMSE$ was 0.06-0.07 $\mathrm{m\,s^{-1}}$. In the outer embayment area, CIOPSE performed as well as the port models in all stations other than CM4. This station is close to the strait entrance which CIOPSE does not resolve.

As S2 and N2 amplitudes were small (≈20% of M2), and as their levels of agreement comparable to M2, they were omitted from presentation.

Diurnals K1 and O1 comparison is shown in Tables 8 - 11 only for stations where the major amplitude was over a centimeter. All models performed well with $RMSE$ under 0.03 $m\,s^{-1}$. Port models outperform CIOPSE at Canso by reducing the K1 $RMSE$ by a half. The larger CIOPSE error at this station is coming from an overestimation of the minor amplitude and slight phase lag, both likely due to inadequate resolution of bathymetry. However, no significant improvement was seen at the other external stations, Liscomb and Forchu.

4.1.2 Residual Flow

Depth averaged residual currents are shown as principal axis ellipse and mean flow for all 17 ADCP deployment in Figures 9 and 10. Further discussion is grouped into four regions. For the inner strait (CM1 and CM2), the residual currents were small, generally under 0.03 $m\,s^{-1}$, and strongly distributed along the axis of the strait with no mean flow. In the outer strait (CM3,CM7 and CM8), currents were stronger with major amplitude around 0.05 $m\,s^{-1}$. Mean current was also small but non-zero here, particularly at CM3 where it reached 0.03 $m\,s^{-1}$ into the strait, suggesting tidal rectification caused by the sharp bend in the main channel around the promontory to the left of the entrance to the strait. The feature was reproduced by port models. In Chedabucto Bay (CM4 and CM5), major amplitudes were also around 0.05 $m\,s^{-1}$, but the ellipses were more oval. On the open Scotian Shelf (Canso, Forchu and Liscomb), major amplitudes were largest of the regions at around 0.12 $m\,s^{-1}$, with ellipse orientation strongly following the local along-shelf topography. The mean flows were in the 0.06-0.08 $m\,s^{-1}$ range directed south to southwest, consistent with the Nova Scotia Current (NSC; Drinkwater et al., 1979). CIOPSE results were excluded from the inner strait while STC100 from Scotian Shelf comparison as the stations were outside the respective model domain. Overall, the models did a reasonable job reproducing the ellipse shape but generally underestimated the variability. For the outer strait and Chedabucto Bay, CIOPSE performed poorly compared to the port models. The finer STC100 outperformed STC500 for the inner and outer strait but only in terms of ellipse orientations. On the shelf, all models performed equally well.

Station Date	Major Amp. ($m\,s^{-1}$)			Minor Amp. ($m\,s^{-1}$)			RMSE
	Modelled	Observed	Difference	Modelled	Observed	Difference	($m\,s^{-1}$)
CM1 Nov2015-May2016	0.027	0.026	0.001	0.001	0.001	-0.000	0.002
	0.028	0.026	0.002	-0.000	0.001	-0.001	0.003
	—	—	—	—	—	—	—
CM2 Sep2016-Mar2017	0.033	0.043	-0.010	0.000	-0.001	0.001	0.010
	0.038	0.043	-0.004	-0.001	-0.001	-0.001	0.010
	—	—	—	—	—	—	—
CM3 Nov2015-May2016	0.051	0.058	-0.007	0.004	0.003	0.001	0.006
	0.060	0.058	0.002	0.004	0.003	0.001	0.006
	0.022	0.058	-0.036	0.001	0.003	-0.002	0.028
CM4 Nov2015-Mar2016	0.064	0.065	-0.001	-0.012	-0.013	0.001	0.007
	0.065	0.065	0.000	-0.012	-0.013	0.001	0.006
	0.039	0.065	-0.026	-0.002	-0.013	0.011	0.021
CM5 Nov2015-May2016	0.046	0.046	0.000	0.002	0.003	-0.001	0.004
	0.049	0.046	0.003	0.005	0.003	0.001	0.005
	0.043	0.046	-0.003	0.001	0.003	-0.002	0.005
CM7 Nov2016-May2017	0.125	0.141	-0.016	0.001	0.002	-0.000	0.014
	0.126	0.141	-0.015	0.002	0.002	0.000	0.018
	0.042	0.141	-0.099	0.001	0.002	-0.001	0.072
CM8 Nov2016-May2017	0.126	0.126	-0.000	0.001	-0.002	0.003	0.003
	0.127	0.126	0.001	-0.001	-0.002	0.001	0.015
	0.043	0.126	-0.084	0.001	-0.002	0.003	0.061
Canso May2017-Nov2017	0.032	0.038	-0.006	-0.008	-0.004	-0.004	0.008
	0.034	0.038	-0.003	-0.008	-0.004	-0.004	0.009
	0.042	0.038	0.004	-0.010	-0.004	-0.006	0.006
Liscomb May2017-Nov2017	—	—	—	—	—	—	—
	0.020	0.020	-0.000	0.001	0.003	-0.002	0.002
	0.018	0.020	-0.002	0.003	0.003	0.000	0.004
Forchu May2017	—	—	—	—	—	—	—
	0.027	0.032	-0.005	0.001	0.002	-0.000	0.006
	0.029	0.032	-0.003	0.000	0.002	-0.002	0.006

Table 6: Depth averaged M2 current constituent comparison. For each current meter deployment period, modelled values listed top to bottom for STC100, STC500 and CIOPSE. Dashes indicate station is outside of the model domain.

Station Date	Inclination °T			Phase °GMT		
	Modelled	Observed	Difference	Modelled	Observed	Difference
CM1 Nov2015-May2016	-34	-39	5	260	262	-3
	-32	-39	7	258	262	-4
	—	—	—	—	—	—
CM2 Sep2016-Mar2017	-63	-71	8	271	285	-15
	-65	-71	6	267	285	-18
	—	—	—	—	—	—
CM3 Nov2015-May2016	-40	-45	5	273	275	-2
	-41	-45	4	282	275	7
	-24	-45	21	260	275	-15
CM4 Nov2015-Mar2016	-44	-47	3	260	253	7
	-45	-47	2	258	253	6
	-58	-47	-11	252	253	-1
CM5 Nov2015-May2016	-61	-67	6	255	251	3
	-60	-67	7	252	251	1
	-72	-67	-5	258	251	6
CM7 Nov2016-May2017	-25	-27	3	264	260	4
	-20	-27	8	265	260	5
	-11	-27	17	252	260	-8
CM8 Nov2016-May2017	-23	-24	1	261	261	0
	-19	-24	6	268	261	7
	-11	-24	14	252	261	-9
Canso May2017-Nov2017	-83	83	15	240	70	-10
	-78	83	18	245	70	-5
	83	83	0	75	70	5
Liscomb May2017-Nov2017	—	—	—	—	—	—
	-60	-54	-6	261	258	3
	-63	-54	-9	265	258	7
Forchu May201 7	—	—	—	—	—	—
	89	86	3	71	57	13
	87	86	0	70	57	13

Table 7: Depth averaged M2 current constituent comparison (continued).

Station Date	Major Amp. ($m\,s^{-1}$)			Minor Amp. ($m\,s^{-1}$)			RMSE
	Modelled	Observed	Difference	Modelled	Observed	Difference	($m\,s^{-1}$)
CM7 Nov2016-May2017	0.009	0.012	-0.003	-0.000	0.001	-0.001	0.003
	0.008	0.012	-0.003	-0.000	0.001	-0.001	0.003
	0.002	0.012	-0.010	0.000	0.001	-0.001	0.007
Canso May2017-Nov2017	0.115	0.101	0.014	-0.018	-0.024	0.006	0.013
	0.122	0.101	0.021	-0.022	-0.024	0.002	0.016
	0.117	0.101	0.016	-0.046	-0.024	-0.021	0.029
Liscomb May2017-Nov2017	—	—	—	—	—	—	—
	0.080	0.073	0.007	-0.012	-0.002	-0.011	0.017
	0.077	0.073	0.004	-0.005	-0.002	-0.003	0.007
Forchu May2017	—	—	—	—	—	—	—
	0.053	0.053	0.000	-0.006	-0.011	0.005	0.004
	0.051	0.053	-0.001	-0.004	-0.011	0.007	0.009

Table 8: Depth averaged K1 current constituent comparison. Dashes indicate station is outside of the model domain.

Station Date	Inclination °T			Phase °GMT		
	Modelled	Observed	Difference	Modelled	Observed	Difference
CM7 Nov2016-May2017	-29	-34	5	346	337	9
	-16	-34	18	338	337	1
	-11	-34	23	314	337	-22
Canso May2017-Nov2017	28	28	0	181	187	-6
	24	28	-4	185	187	-2
	42	28	14	189	187	2
Liscomb May2017-Nov2017	—	—	—	—	—	—
	67	71	-4	246	260	-14
	68	71	-3	267	260	6
Forchu May2017	—	—	—	—	—	—
	68	65	2	224	221	3
	66	65	1	209	221	-11

Table 9: Depth averaged K1 current constituent comparison (continued).

Station Date	Major Amp. ($m\,s^{-1}$)			Minor Amp. ($m\,s^{-1}$)			RMSE
	Modelled	Observed	Difference	Modelled	Observed	Difference	($m\,s^{-1}$)
Canso May2017-Nov2017	0.072	0.073	-0.000	-0.010	-0.014	0.004	0.005
	0.078	0.073	0.005	-0.013	-0.014	0.001	0.006
	0.078	0.073	0.005	-0.026	-0.014	-0.012	0.017
Liscomb May2017-Nov2017	—	—	—	—	—	—	—
	0.061	0.055	0.007	-0.012	0.001	-0.013	0.014
	0.061	0.055	0.007	-0.004	0.001	-0.004	0.008
Forchu May2017	—	—	—	—	—	—	—
	0.036	0.028	0.008	0.002	-0.004	0.007	0.010
	0.036	0.028	0.008	0.001	-0.004	0.005	0.010

Table 10: Depth averaged O1 current constituent comparison. For each current meter deployment period, modelled values listed top to bottom for STC100, STC500 and CIOPSE. Dashes indicate station is outside of the model domain.

Station Date	Inclination °T			Phase °GMT		
	Modelled	Observed	Difference	Modelled	Observed	Difference
Canso May2017-Nov2017	26	29	-2	150	154	-4
	24	29	-4	153	154	-1
	43	29	15	155	154	2
Liscomb May2017-Nov2017	—	—	—	—	—	—
	67	69	-2	218	230	-12
	68	69	-1	238	230	8
Forchu May2017	—	—	—	—	—	—
	74	57	17	192	197	-5
	67	57	10	181	197	-16

Table 11: Depth averaged O1 current constituent comparison (continued).

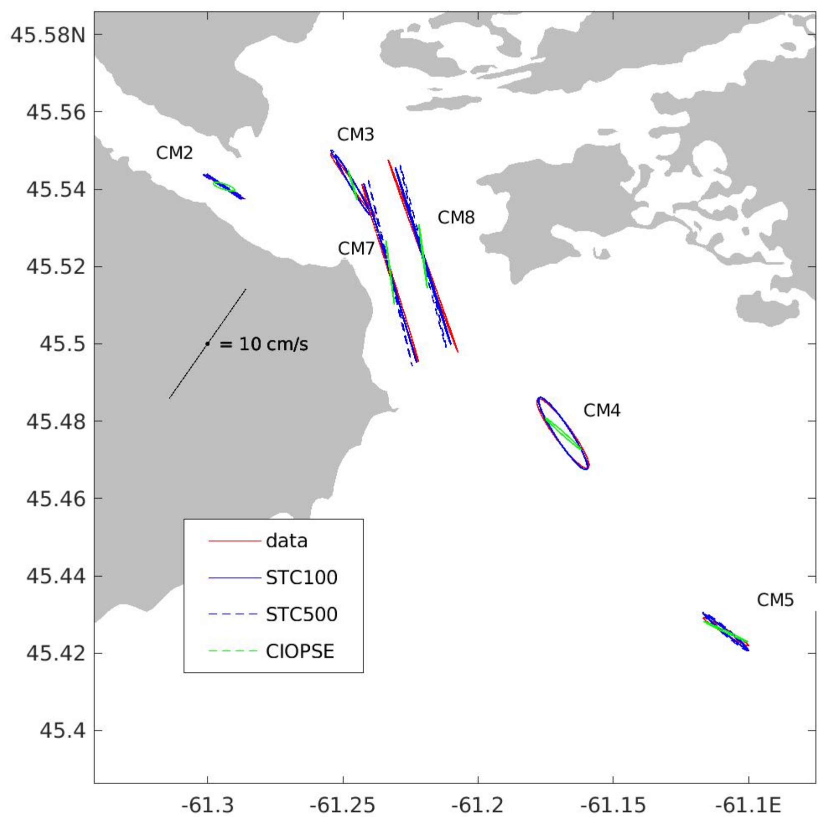

Figure 8: Tidal ellipses at select stations. Scale refers to major/minor amplitudes.

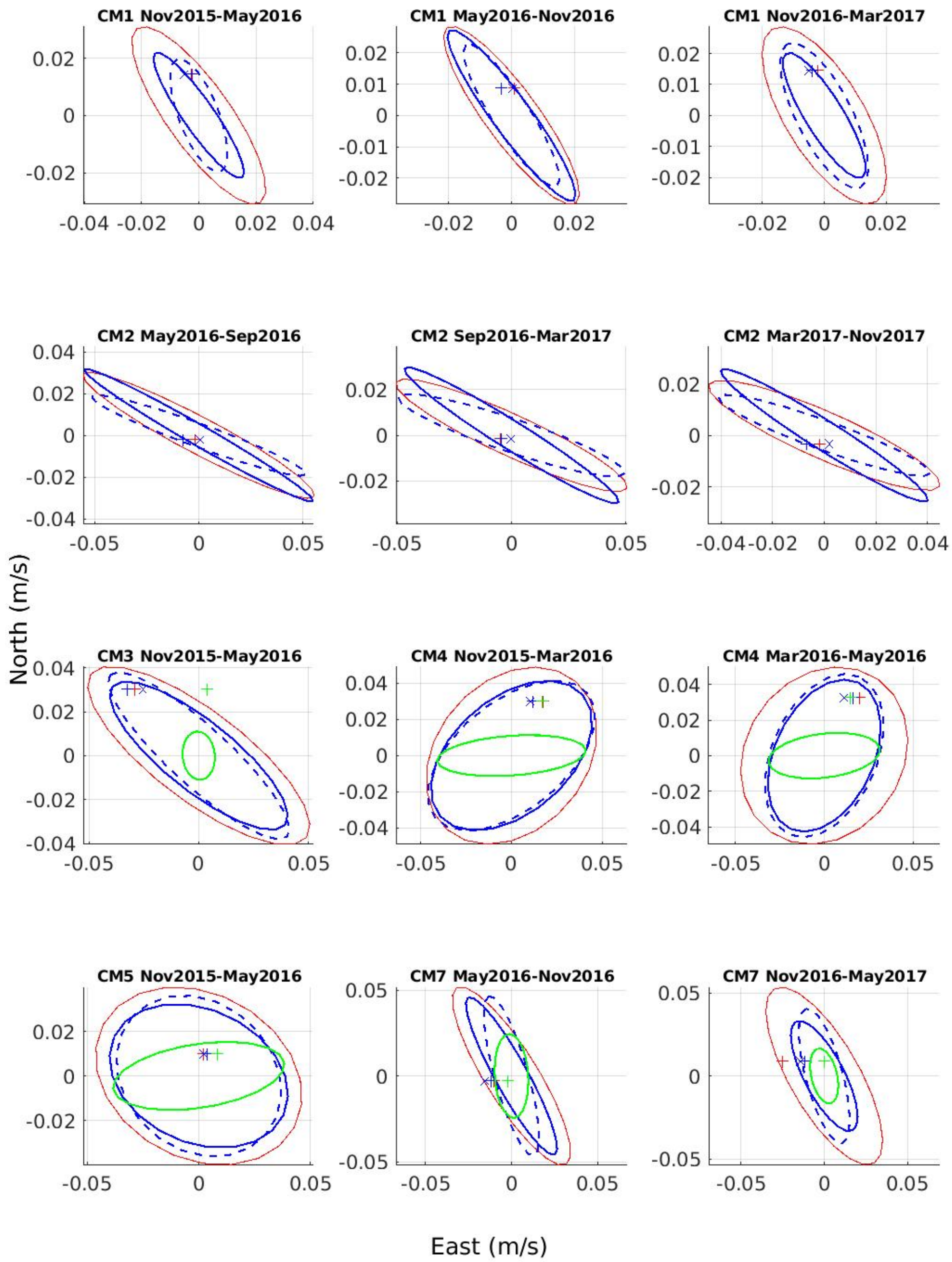

Figure 9: Principal axis ellipses and mean (markers) for residual barotropic currents. Standard colour scheme applies. Part 1.

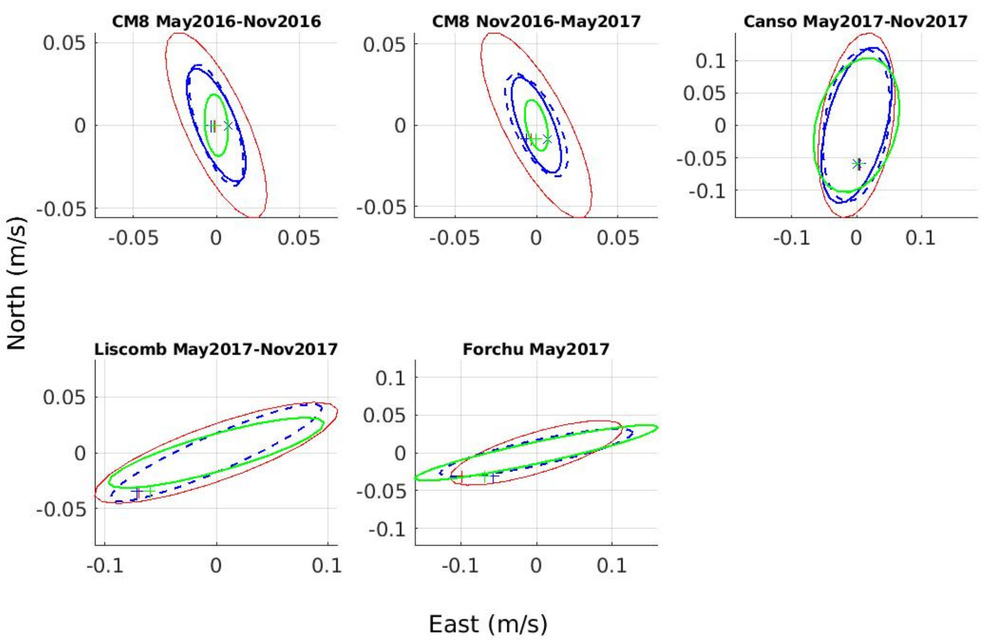

Figure 10: Principal axis ellipses and mean (markers) for residual barotropic currents. Standard colour scheme applies. Part 2.

4.1.3 Error and Skill Metrics

Errors and skill metrics for both total and residual barotropic currents, were combined for the stations inside the four regions discussed above in Table 12. Model performance was consistent with the residual flow discussion above with port models outperforming CIOPSE in all regions other than Scotian Shelf. The $RMSE$ increased from 0.03 $\mathrm{m\,s^{-1}}$ for the inner strait to 0.1 $\mathrm{m\,s^{-1}}$ on the shelf reflecting overall strong currents further from shore. The $RMSE$ of the total flow was very close to that of the residual flow indicating a strong predominance for residual errors. One exception was CIOPSE in the Outer Strait which had high tidal and non-tidal errors. In term of model skill in each region, the total and residual port models skills for the inner strait were high. For the outer strait, the total skills were very high but the residuals drop to low to moderate range. The gain in the total skill here reflects the added skill from the well modelled stronger tidal flow in the entrance of the strait despite loss of skill in the residual. CIOPSE had poor residual skills in the outer strait, but fared better in total with high $PCOR$ and moderate WSK, which was attributed to tidal phases being modelled correctly in CIOPSE, leading to high levels of covariance in the tidal currents. In Chedabucto Bay, skills were moderate to high for the port models while CIOPSE performance was in the moderate range. Skills on the Scotian Shelf were moderate to high.

4.2 Near-surface and Near-bottom Error and Skill

Near-surface and near-bottom current performance is summarized with error and skill stats in Tables 13 and 14. These comparisons were done with top and bottom most ADCP bin and nearest model vertical level.

Near-surface performance was generally worse than for depth averaged currents, reflecting larger variability and unresolved processes in the surface layer. The only exception was the outer strait where the skills were comparable, likely due to the strong topographic steering of this region. The $RMSE$ in all regions was roughly double the barotropic, and as before, increased further away from shore. The total and residual errors were almost identical. Interestingly, while port models clearly outperformed CIOPSE in the outer strait, in Chedebacto Bay there was no improvement like there was for barotropic currents, suggesting topography is not as important here. There was a modest improvement for the 100 m over 500 m resolution model in the inner strait, not seen for the barotropic currents.

Near-bottom performance followed the overall trends of the near-surface and barotropic comparison with error and skill levels falling generally between the two. In contrast to the near-surface currents, CIOPSE skills in Chedabucto Bay are poor to low and the 100 m model shows a notable improvement over the 500 m in the inner and outer strait. As one would expect bottom layer circulation modelling benefits from improved resolution of the coastal regions.

Region	$RMSE$ ($\mathrm{m\,s^{-1}}$)	$PCOR$ Maj.	WSK
Inner Strait	0.033 (0.032)	0.82 (0.76)	0.89 (0.86)
	0.033 (0.031)	0.82 (0.76)	0.89 (0.85)
	—	—	—
Outer Strait	0.053 (0.052)	0.90 (0.61)	0.94 (0.75)
	0.059 (0.057)	0.89 (0.56)	0.92 (0.71)
	0.092 (0.063)	0.77 (0.18)	0.61 (0.39)
Chedabucto Bay	0.060 (0.060)	0.71 (0.59)	0.83 (0.74)
	0.057 (0.057)	0.75 (0.66)	0.84 (0.78)
	0.064 (0.061)	0.60 (0.62)	0.75 (0.67)
Scotian Shelf	—	—	—
	0.104 (0.102)	0.78 (0.72)	0.87 (0.83)
	0.102 (0.100)	0.80 (0.74)	0.88 (0.83)

Table 12: Depth averaged total (residual) current error and skill metrics grouped into four regions. $PCOR$ is given for the major axis only while the other skills are for total vector error. Modelled values listed top to bottom for STC100, STC500 and CIOPSE. Dashes indicate the region falls outside model domain.

Region	$RMSE$ ($\mathrm{m\,s^{-1}}$)	$PCOR$ Maj.	WSK
Inner Strait	0.084 (0.084)	0.59 (0.53)	0.71 (0.68)
	0.086 (0.085)	0.54 (0.48)	0.69 (0.64)
	—	—	—
Outer Strait	0.096 (0.096)	0.80 (0.59)	0.86 (0.71)
	0.095 (0.097)	0.82 (0.60)	0.87 (0.72)
	0.124 (0.110)	0.65 (0.12)	0.53 (0.32)
Chedabucto Bay	0.100 (0.100)	0.57 (0.50)	0.72 (0.67)
	0.099 (0.099)	0.60 (0.54)	0.74 (0.70)
	0.098 (0.097)	0.60 (0.56)	0.69 (0.64)
Scotian Shelf	—	—	—
	0.174 (0.173)	0.63 (0.58)	0.77 (0.74)
	0.168 (0.168)	0.67 (0.63)	0.79 (0.77)

Table 13: Near-surface total (residual) current error and skill metrics grouped into four regions. $PCOR$ is given for the major axis only while the other skills are for total vector error.

Region	$RMSE$ ($\mathrm{m\,s^{-1}}$)	$PCOR$ Maj.	WSK
Inner Strait	0.074 (0.073)	0.59 (0.55)	0.73 (0.71)
	0.078 (0.078)	0.55 (0.47)	0.60 (0.58)
	—	—	—
Outer Strait	0.089 (0.088)	0.82 (0.64)	0.87 (0.75)
	0.101 (0.097)	0.80 (0.59)	0.82 (0.69)
	0.131 (0.108)	0.63 (0.31)	0.47 (0.37)
Chedabucto Bay	0.078 (0.078)	0.72 (0.69)	0.82 (0.79)
	0.082 (0.082)	0.69 (0.66)	0.81 (0.78)
	0.108 (0.105)	0.19 (0.15)	0.47 (0.41)
Scotian Shelf	—	—	—
	0.124 (0.124)	0.74 (0.63)	0.82 (0.76)
	0.118 (0.113)	0.76 (0.68)	0.82 (0.78)

Table 14: Near-bottom total (residual) current error and skill metrics grouped into four regions. $PCOR$ is given for the major axis only while the other skills are for total vector error.

4.3 M2 Tidal Profile

Drozdowski et al. (2018) found a seasonally varying vertical profile of tidal constituents at some current meter stations. This was further investigated with the prototype model for this port based on the unstructured FVCOM (Chen and Beardsley, 2003), and found to be linked to local internal tide generation and propagation (Drozdowski and Jiang, 2020). Only M2 was investigated, as the contribution from other constituents was much smaller. As this internal tide processes was found to significantly contribute to the current structure in the Strait of Canso, it's important to demonstrate the ability to model this feature with the new NEMO based system. Figure 11 shows a comparable M2 profile validation of the NEMO port models to their figure 3 results. For the comparison here, tidal analysis was performed at each vertical level of the model and data. The time period for the analysis was the entire 2015 May-Sep (CM1,3,5) and 2016 May-Oct (CM7) instrument deployment period. As model results were not available for 2015, the same period from 2016 was used. As elsewhere in this document, results from the 100 m, 500 m and CIOPSE grid are shown. Modelled profiles generally stayed within the observed 95% confidence envelope, with higher resolution grids showing progressive improvement. Also note that the 95% envelopes shown here were the output from T_TIDE bootstrap error model (see Sec. 3.1), whereas the (Drozdowski and Jiang, 2020) envelopes where estimated by looking at the range in values from overlapping 28 day segments, which tended to produce wider envelopes. The present STC100 results are as good or better than from Drozdowski and Jiang (2020). The phase profiles were better modelled here as is the bottom amplitude amplification at CM1 and CM3. The improvements are attributed to realistic stratification used here compared to climatology used in the FVCOM results. The port models outperformed CIOPSE, even at CM5 which in the middle of Chedabucto Bay and well within the CIOPSE domain.

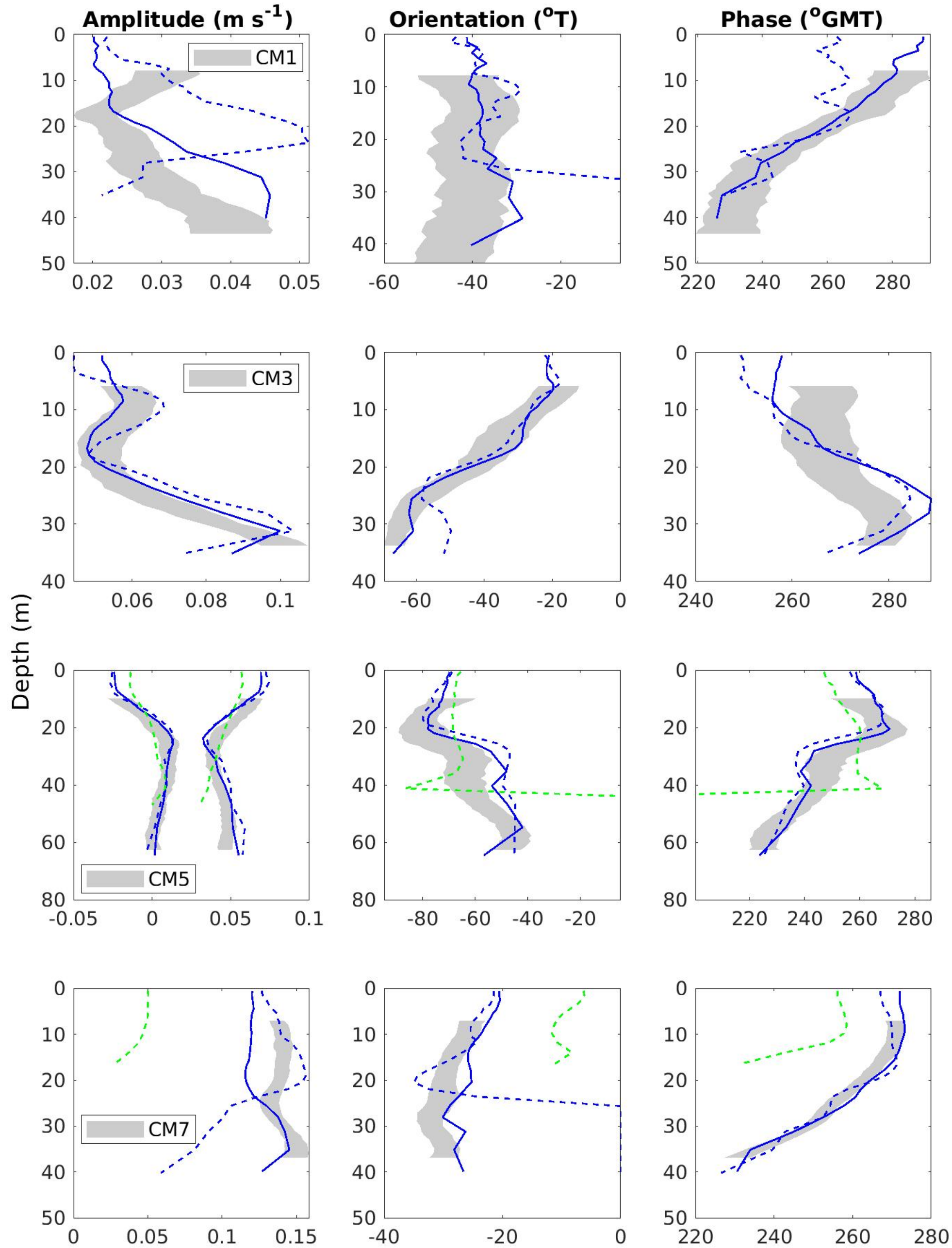

Figure 11: Tidal M2 velocity profile validation. Minor amplitude only shown at CM5. ADCP data shown as gray 95% confidence interval envelope from tidal analysis. Standard colour scheme applies.

5 Results: Temperature and Salinity

5.1 CTD Casts

This section presents the comparison of the profiling CTD data versus the three models being considered. The results are plotted in Figures 12 to 17. Each cast corresponds to a row of panels with a plot of the location followed by the temperature and salinity casts. The title above the temperature panel provides the date of the profile. Sampling was limited to May and November 2016-18. Model results were daily averaged for that day at the nearest model grid point. There was general agreement between the casts and model results. Typically point errors were less than 1°C and 0.5 $\mathrm{g\,kg^{-1}}$. Major improvement over CIOPSE was seen in the nearshore (casts: 1-2,5-7,9-18). In all of the stations inside the Strait of Canso, and some in Chedabucto Bay, a warm bias of around 1° was seen throughout the water column, more pronounced at depth and during the fall. A salty bias of around 0.5 $\mathrm{g\,kg^{-1}}$ was present in many profiles (e.g. casts 9-12), but most pronounced in the fall in the surface layer, gradually decreasing at depth and vanishing around 20-30 m. These two biases noted here were present in all three models. The three offshore casts (20-22), were reproduced exceptionally well.

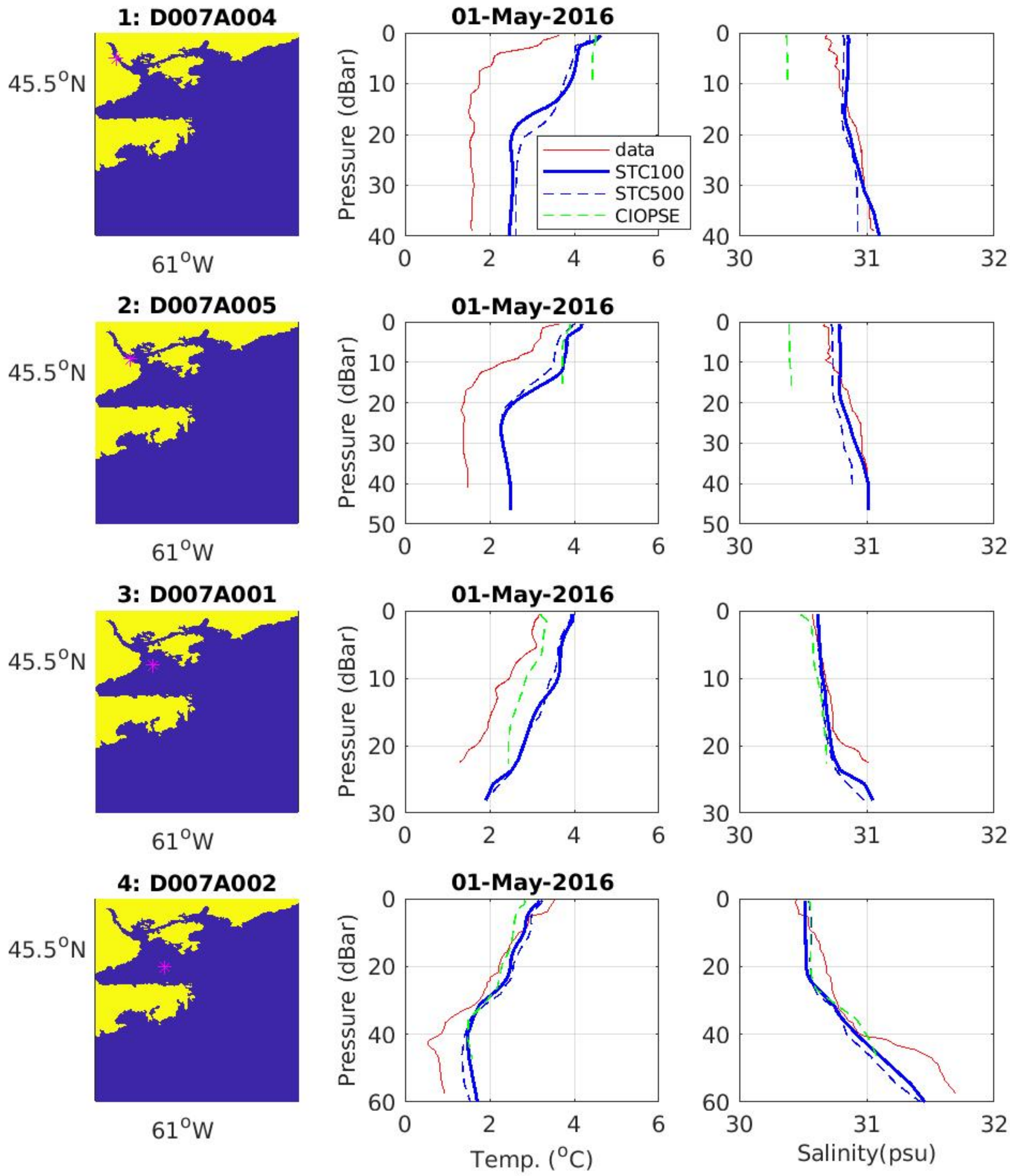

Figure 12: Profiles of T-S. Each row corresponds to a single cast (Part 1).

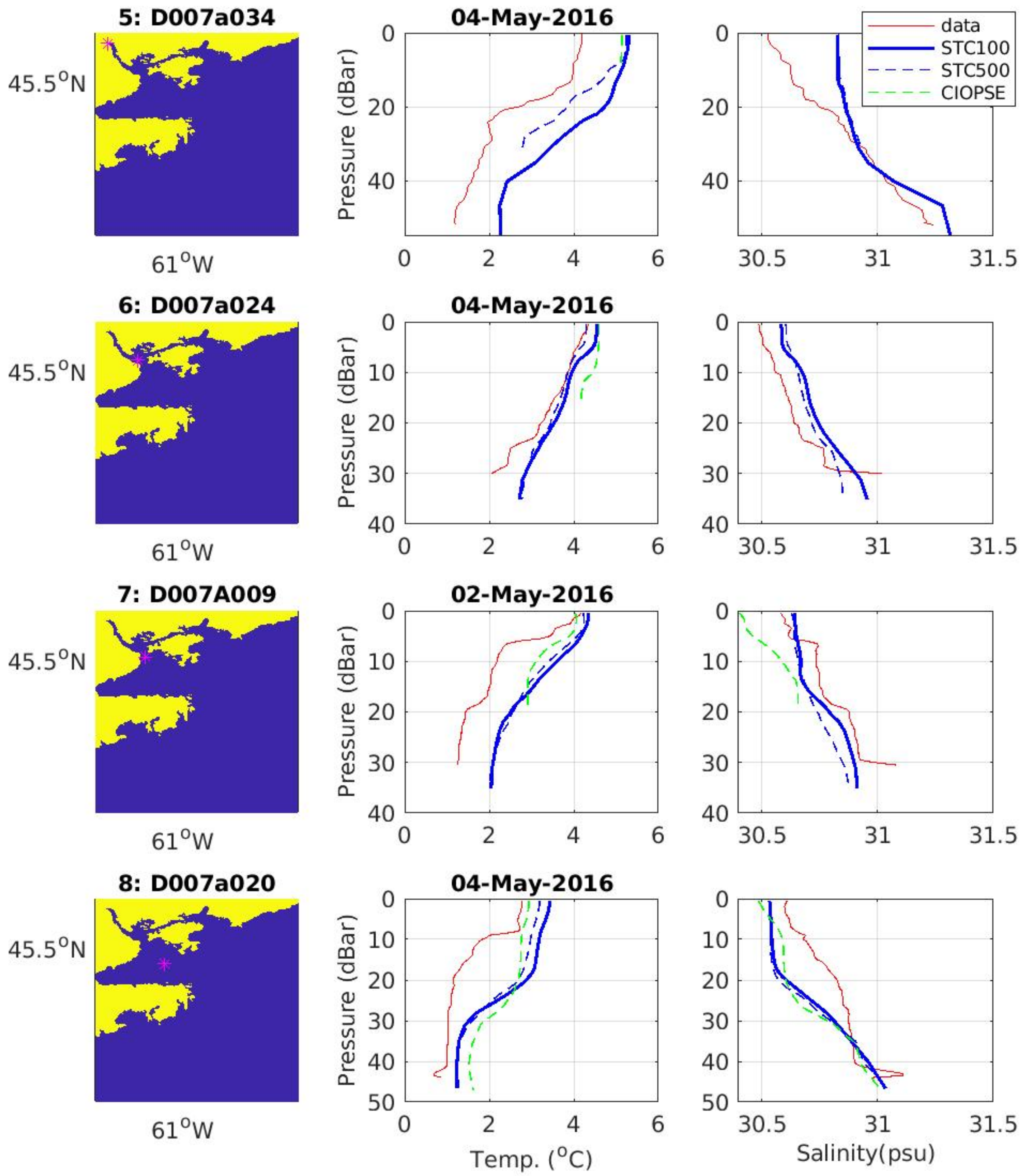

Figure 13: Profiles of T-S. Each row corresponds to a single cast (Part 2).

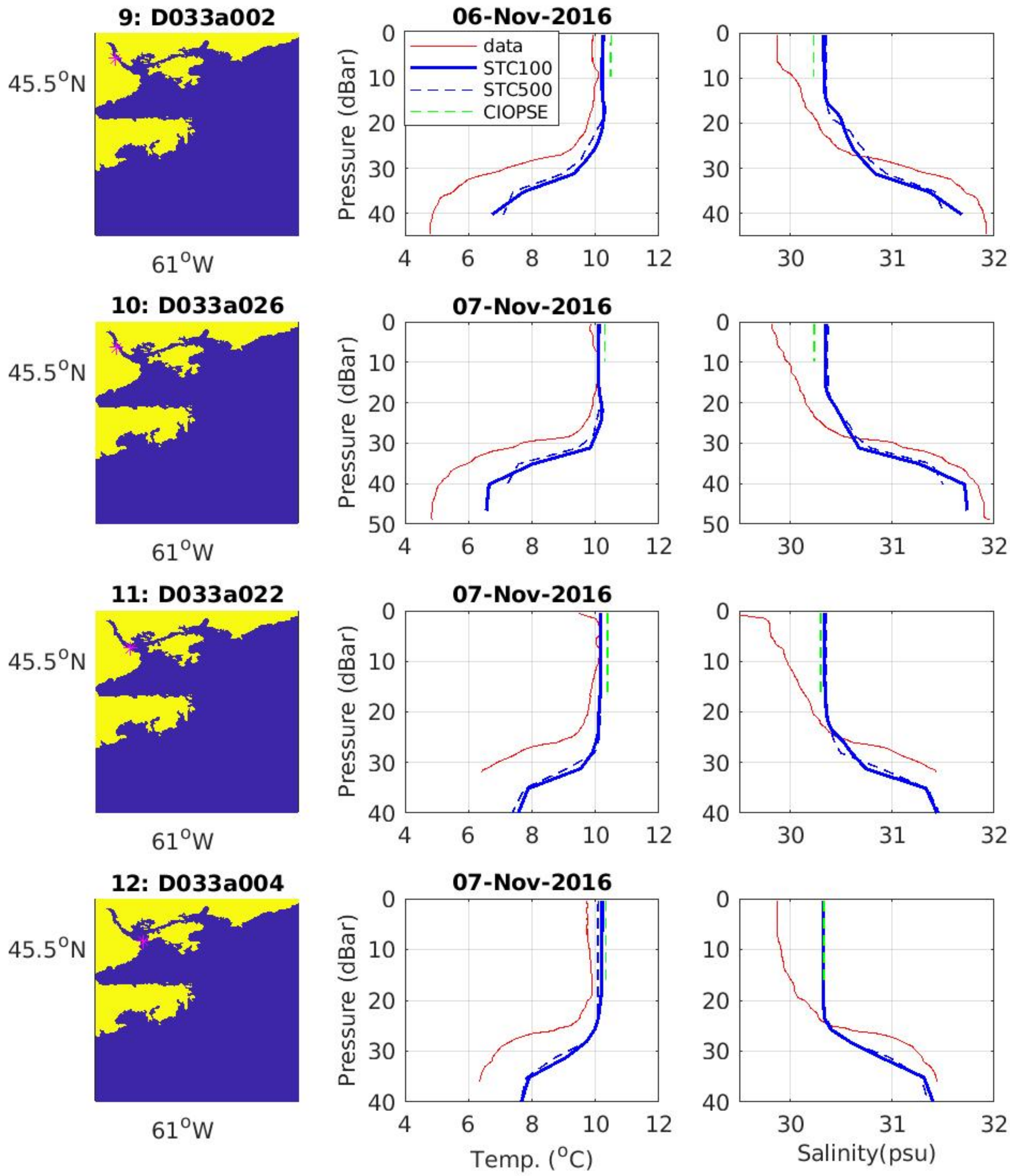

Figure 14: Profiles of T-S. Each row corresponds to a single cast (Part 3).

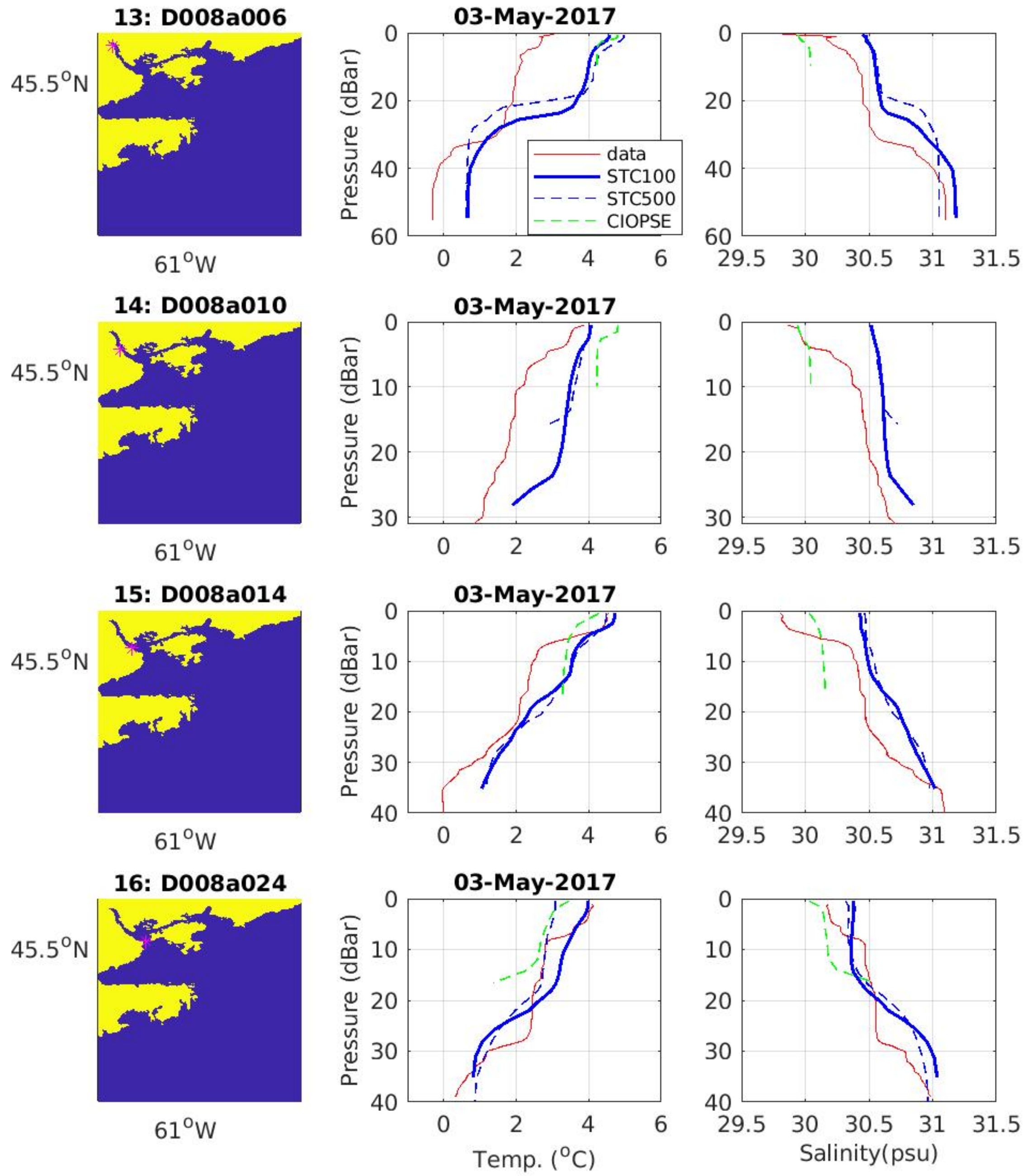

Figure 15: Profiles of T-S. Each row corresponds to a single cast (Part 4).

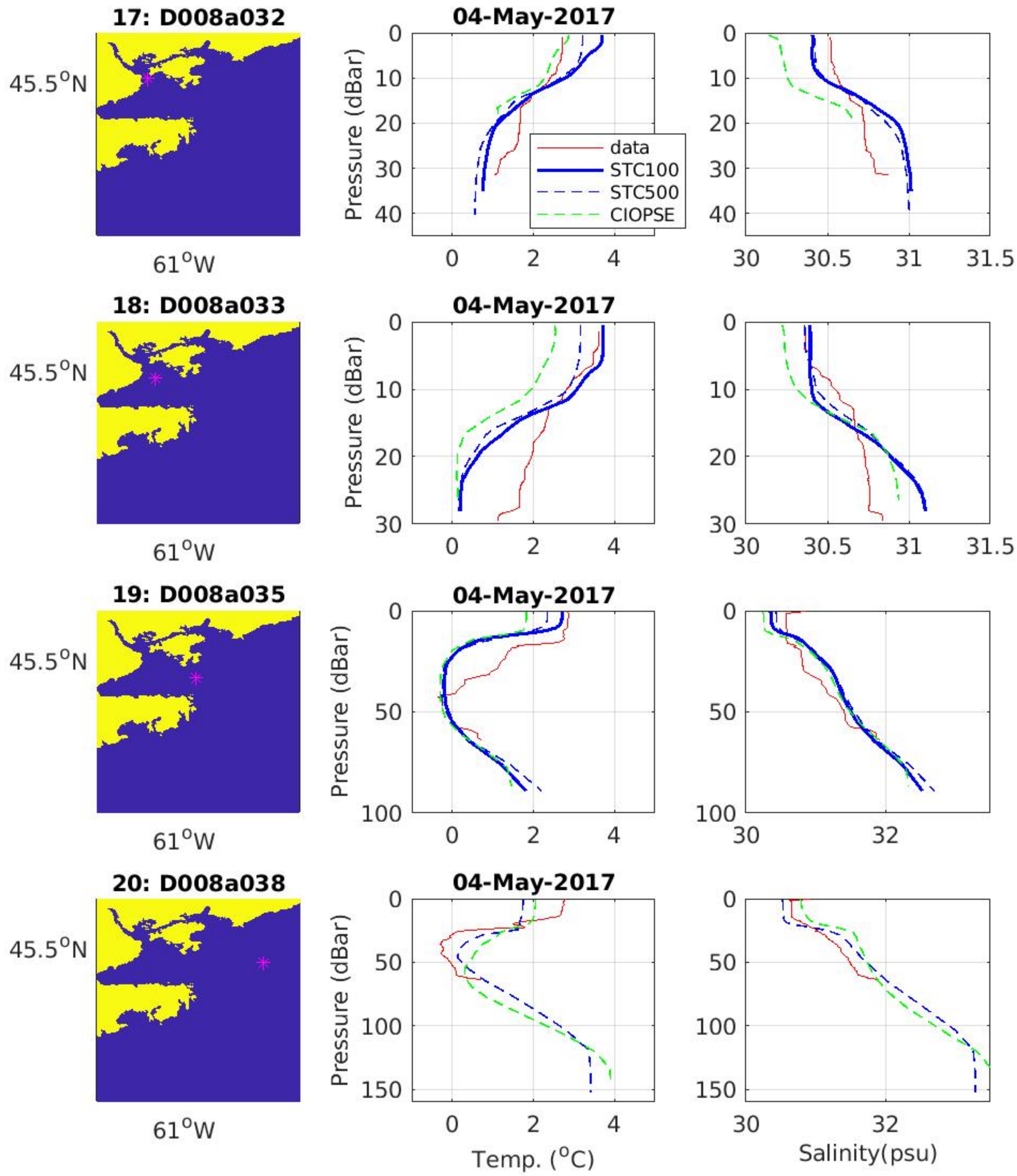

Figure 16: Profiles of T-S. Each row corresponds to a single cast (Part 5).

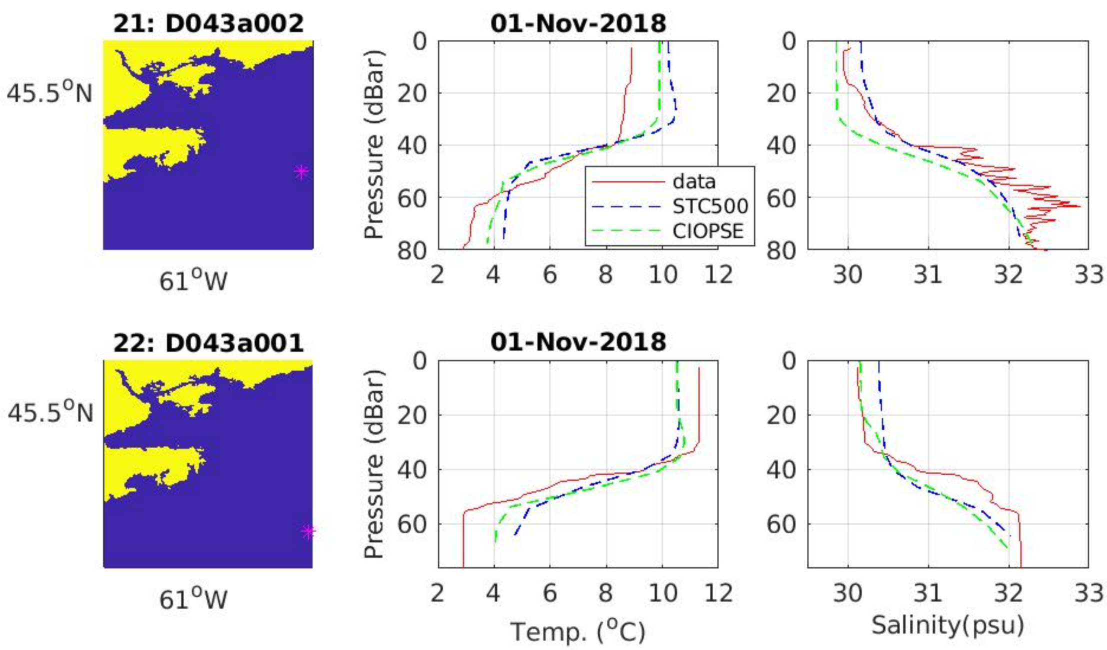

Figure 17: Profiles of T-S. Each row corresponds to a single cast (Part 6).

5.2 Moored CTD Time Series

This section describes T-S features and model performance based on the time series at the location of available moored CTDs (See Section 2.4). All series were daily averaged for plots and analysis. Model performance is summarized with error metrics (see Section 2.5) in Tables 15 and 16. A discussion follows station-wise.

5.2.1 Chedabucto Bay Station

The Chedabucto Bay (CB) station offered almost a full year of near-surface (CB-11m) and near-bottom (CB-49m) T-S coverage. Time series are shown in Figure 18 and 19.

Near-surface

The near-surface salinity exhibited a seasonal cycle, starting around 31 $\mathrm{g\,kg^{-1}}$ in spring and gradually freshening in summer and fall when values below 29.5 were recorded. In late fall and winter the salinity gradually returned to higher values. This seasonal cycle was captured by the models and is consistent with patterns previously seen on the Scotian Shelf where a salinity low occurs in the fall associated with the outflow of fresh water from the Gulf of St. Lawrence (Drinkwater et al., 1979; Petrie et al., 1996). Fluctuations at synoptic time scales (taken here as a few days to a few weeks) were of the same order as the seasonal cycle, strongest during late summer and fall. The models did not capture the full intensity of the salinity lows but did follow the general trend. There was a salty bias of $\approx$0.5 $\mathrm{g\,kg^{-1}}$ between August and December, but for the whole time series it is only 0.2. No clear performance difference was evident between the three models with regards to near-surface salinity. The $RMSE$ was 0.3 $\mathrm{g\,kg^{-1}}$ for all three. Skill metrics were high on the original time series but decrease substantially for the anomalies. The $PCOR$ drops to a poor score of 0.38, while WSK goes down to the low range. As is also evident from the time series, most of the model skill comes from seasonal cycle being correctly reproduced.

The near-surface temperature exhibited a strong seasonal cycle. Low temperatures in the 3-6$^{\circ}C$ range persisted until late spring. During spring and summer temperature gradually increased and peaked in August at just below 20$^{\circ}C$, then gradually decreased to near-zero in February and March. Like salinity, temperature fluctuated in the summer months by as much as 8°C. Temperature lows were coherent with salinity highs, suggesting upwelling which brings cooler saltier water from deeper layers (Petrie et al., 1987). The models reproduced the overall trend and annual cycle, evident from the very high skill scores. Skill scores on the anomalies were in the low to moderate range indicating that the models struggled to get the correct fluctuations. There was an annual 0.6°C cold bias which was only present during the summer period when errors occasionally reached -5°C. All models perform equally well.

Near-bottom

Near-bottom salinity did not exhibit a clear seasonal cycle but was dominated by synoptic variability, which modulated the salinity between 30 and 32.5 $\mathrm{g\,kg^{-1}}$ respectively. The freshening was likely caused by the deepening of the surface layer caused by downwelling, while the saltier water arrives due to the shore-ward Ekman transport of deeper layers associated with coastal upwelling. Overall the skills were in the high to very high range. The port models outperformed CIOPSE by 5-8%.

Near-bottom temperature followed an annual cycle similar to the near-surface but lagged by about two months (peaking in October), and not as warm, staying just below 15°C. Synoptic variability was present and overall coherent (180° out of phase) with the near-bottom salinity. Downwelling events are evident from temperature spikes which approach near-surface values (e.g. Sep. 29). Overall skill was very high and high for the anomalies. However it is evident from the time series that the models underestimated the intensity of the fluctuations. The port models did not outperform CIOPSE as they did for salinity. As seen in the CTD there was a warm bias of ≈0.4°C overall and up to 1°C the late spring consistent with the CTD validations.

5.2.2 Causeway Station

Time series from the 2016 Causeway station (CW2016) are shown in Figure 20. Data from the near-surface instrument (CW2016-5m) was only available until July 1st, while near-bottom (CW2016-57m) provided data until November. The 2019 causeway station (CW2019-5m) only recorded near-surface data (Fig. 21) but covers July to November hence supplementing the cutoff observations in 2016.

Near-surface

The models followed the salinity trend at CW2016-5m loosely but missed the lows. Also the salty bias noted previously, was more prominent here (0.6 $\mathrm{g\,kg^{-1}}$). Skills were low to moderate for the most part. CIOPSE had the lowest skill, but the smallest bias (nearest model point here was from the entrance of the strait hence closest to the fresh water plume). STC100 had the highest $PCOR$ but no clear improvement over STC500 was seen in the time series and can likely be attributed to small gains in the covariance masked by large systematic errors. Modelled temperature at CW2016-5m has high to very high skills for the ports and while CIOPSE has a high overall score it rates poorly in the anomaly skills as it fails to reproduce the fluctuations. The port models have a $1.1°C$ warm bias (opposite of CB-11m), hinting perhaps at atmospheric forcing biased by land or inadequate water exchange with the outside. The findings for CW2019-5m are generally the same as for CW2016-5m. Port models have a clear advantage over CIOPSE in terms of the temperature anomaly skill. The salty bias was evident in that year as well but no warm bias during this period.

Near-bottom

As the station is a deep nearshore station, isolated behind a sill, near-bottom T-S (CW2016-57m) characteristics are very different from the CB-49m station outside. The salinity remains between 30.5 and 31.5 $\mathrm{g\,kg^{-1}}$ during the observation period. The water stays cool all summer, peaking at 8° in October. Synoptic fluctuations were not present and the overall trends were linear increase (decrease) for temperature (salinity), interrupted by episodic step-like features indicative of external water intrusions over a sill. This process is known to contribute to stagnant water renewal in fjords (Farmer and Freeland, 1983).

For salinity at CW2016-57m, the port model skills were moderate to high and mostly poor for CIOPSE, which does not resolve the sill. Difference between overall and anomaly skills were small. STC100 had higher WSK but lower $PCOR$ than STC500, hence no clear improvement. However, these statistics should be interpreted with caution due to the sharp event-like features of the generally monotonic time series; STC100 qualitatively outperformed the other models in terms of reproducing these events even though the details are not perfectly modelled.

Modelled temperature performance was comparable to salinity, but skills were higher overall than for anomalies. The port models skills ranged from low to very high and outperformed CIOPSE, which had high overall skills but poor for anomalies. The warm bias for this station was 1.5-2°C, higher than at other stations.

Station	$\overline{E}$(g kg^{-1})	$RMSE$ (g kg^{-1})	$PCOR$	WSK
CB-11m	0.2	0.3	0.85 (0.38)	0.77 (0.55)
	0.2	0.3	0.83 (0.38)	0.79 (0.56)
	0.2	0.3	0.84 (0.38)	0.80 (0.58)
CB-49m	0.1	0.2	0.88 (0.84)	0.93 (0.91)
	0.1	0.2	0.89 (0.86)	0.94 (0.92)
	0.1	0.3	0.80 (0.75)	0.88 (0.85)
CW2016-5m	0.6	0.7	0.72 (0.70)	0.52 (0.52)
	0.6	0.7	0.56 (0.54)	0.49 (0.49)
	0.3	0.5	0.42 (0.39)	0.47 (0.47)
CW2016-57m	0.0	0.2	0.69 (0.69)	0.83 (0.83)
	0.1	0.2	0.77 (0.73)	0.67 (0.70)
	-0.4	0.6	0.27 (0.26)	0.44 (0.43)
CW2019-5m	0.6	0.6	0.88 (0.70)	0.48 (0.41)
	0.8	0.8	0.69 (0.42)	0.44 (0.39)
	0.5	0.6	0.55 (0.39)	0.50 (0.47)

Table 15: Salinity performance metrics from MCAT stations. For each station, modelled performance listed top to bottom for STC100, STC500, CIOPSE. Skill values in parentheses have been computed with harmonic seasonal trend removed (Sec. 2.5).

Station	$\overline{E}(^\circ C)$	$RMSE$ $(^\circ C)$	$PCOR$	WSK
CB-11m	-0.6	1.6	0.97 (0.51)	0.98 (0.69)
	-0.6	1.6	0.97 (0.51)	0.98 (0.69)
	-0.8	1.8	0.97 (0.49)	0.97 (0.67)
CB-49m	0.5	1.1	0.95 (0.83)	0.97 (0.86)
	0.4	1.0	0.96 (0.84)	0.97 (0.89)
	0.3	1.0	0.95 (0.81)	0.97 (0.88)
CW2016-5m	1.1	1.6	0.95 (0.89)	0.94 (0.89)
	1.1	1.7	0.94 (0.84)	0.93 (0.87)
	-1.2	2.7	0.76 (0.17)	0.74 (0.46)
CW2016-57m	2.0	2.2	0.91 (0.57)	0.72 (0.44)
	1.5	1.6	0.90 (0.66)	0.77 (0.46)
	4.1	4.8	0.70 (0.18)	0.43 (0.20)
CW2019-5m	-0.7	2.1	0.83 (0.63)	0.90 (0.78)
	-0.1	1.8	0.87 (0.73)	0.93 (0.85)
	0.7	2.3	0.81 (0.53)	0.87 (0.68)

Table 16: Temperature performance metrics from MCAT stations. Skill values in parentheses have been computed with harmonic seasonal trend removed (Sec. 2.5).

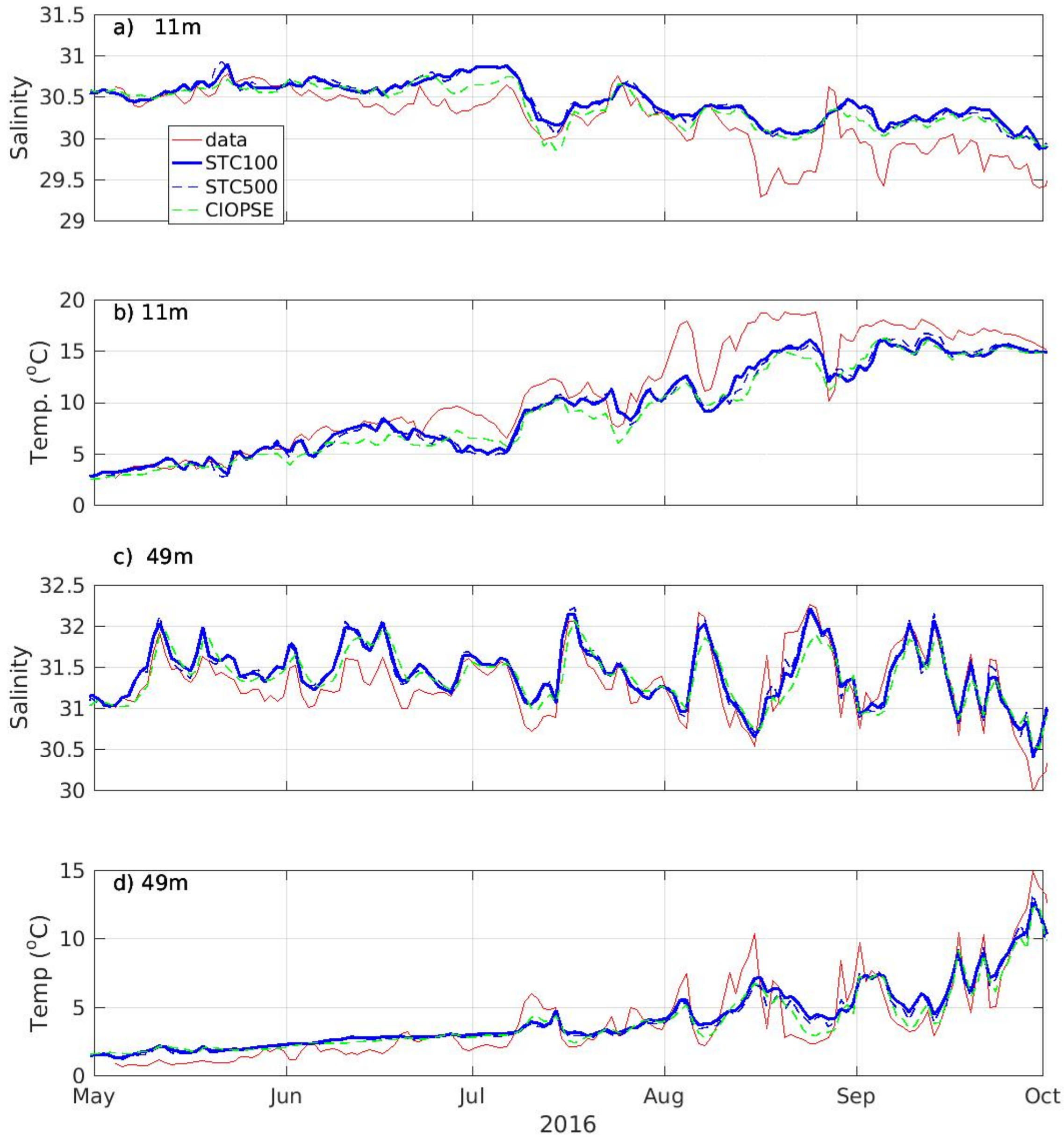

Figure 18: Time series comparison of T-S at station CB. Instrument moored near-surface a) and b), and near-bottom c) and d).

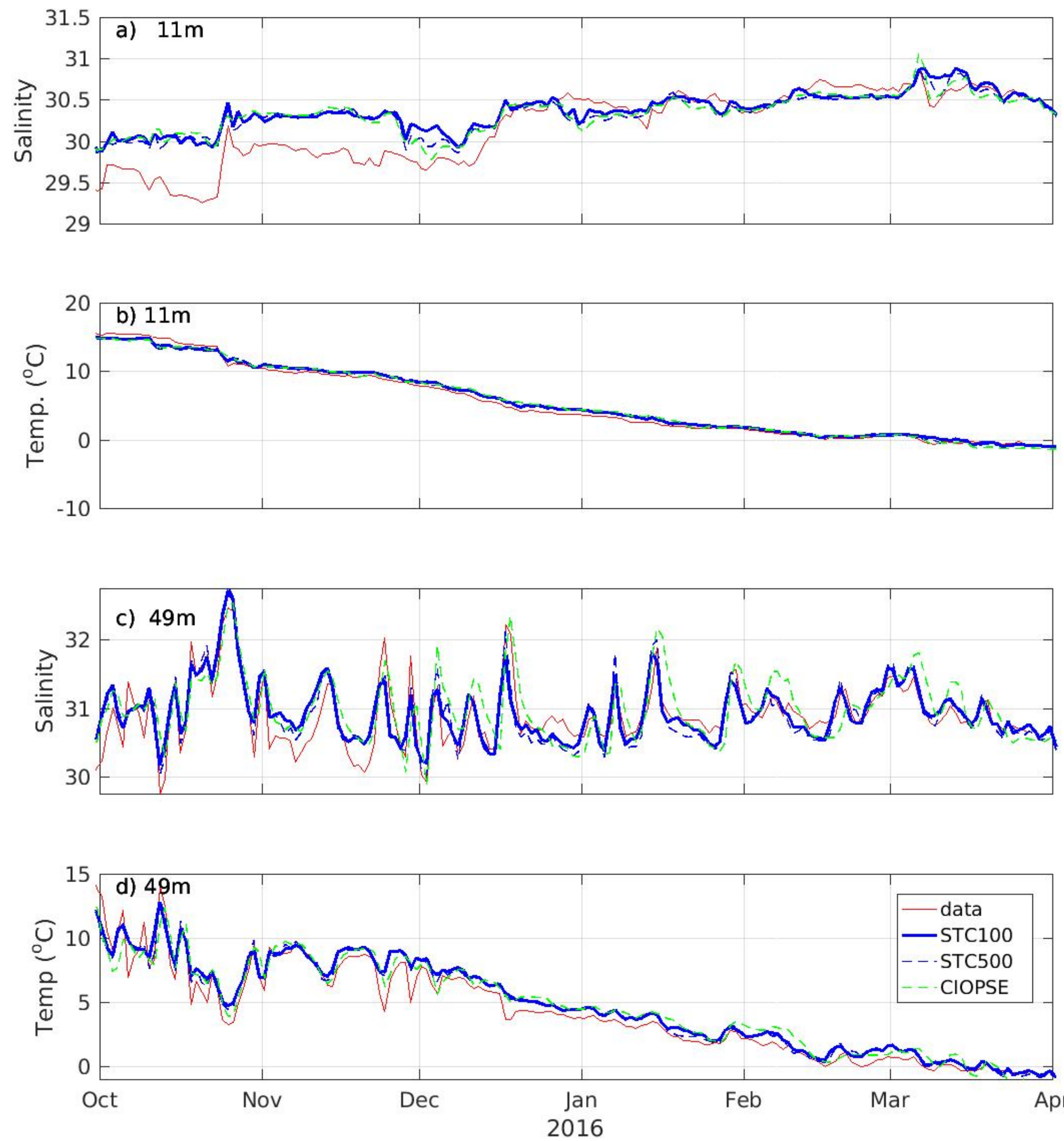

Figure 19: Time series comparison of T-S at station CB. Instrument moored near-surface a) and b), and near-bottom c) and d).

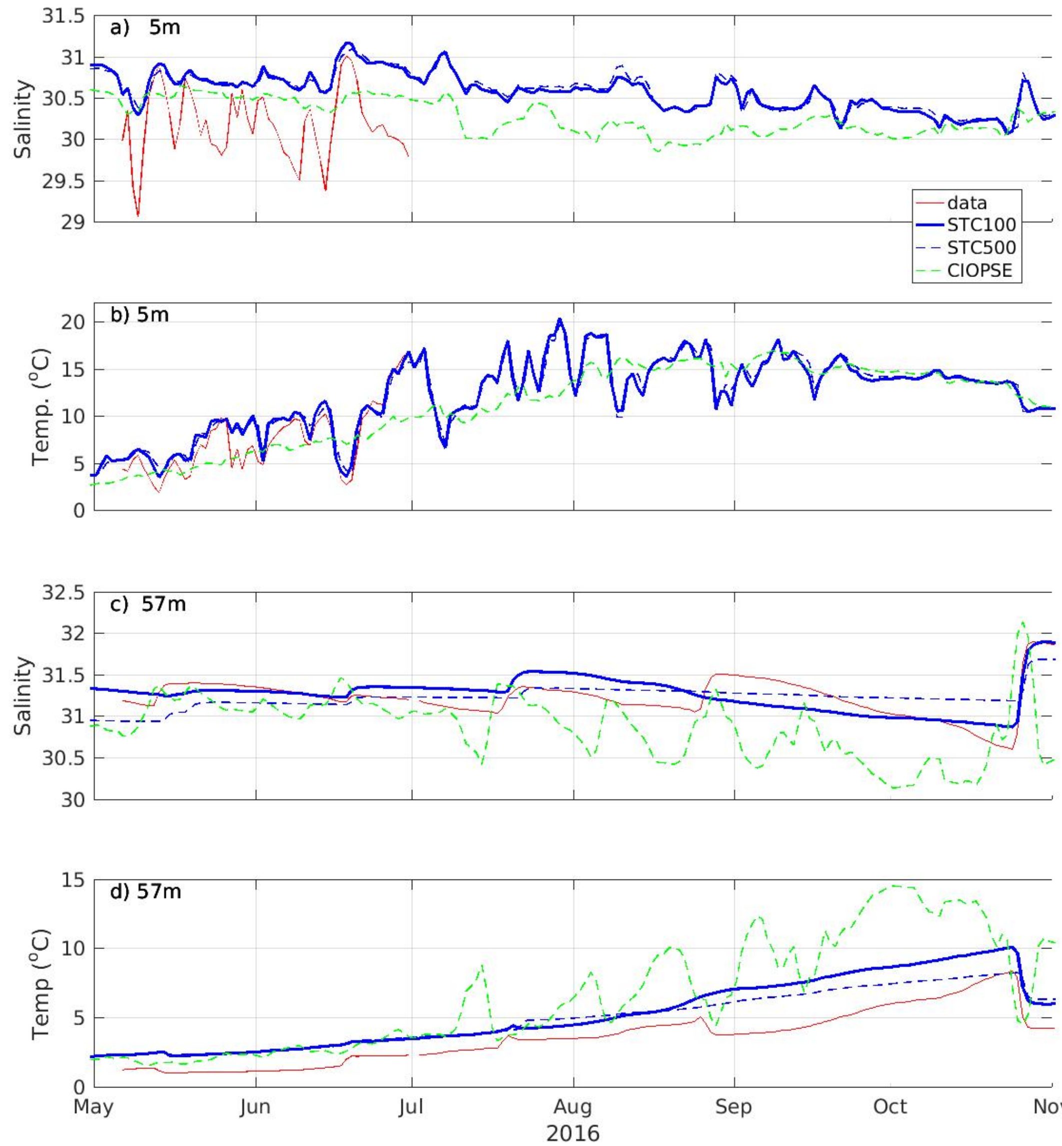

Figure 20: Time series comparison of T-S at station CW-2016. Instrument moored near-surface a) and b), and near-bottom c) and d).

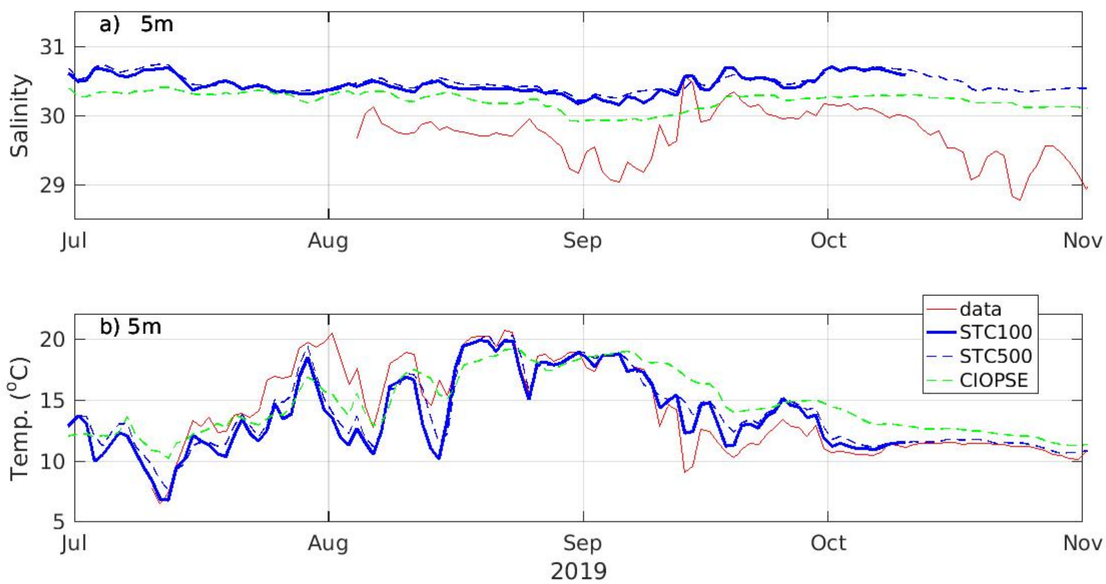

Figure 21: Time series comparison of T-S at station CW-2019. Instrument moored near-surface.

6 Discussion and Conclusion

Available observational data which included a water level gauge, profiling current meters, CTD casts and moored CTD records, were used to evaluate high resolution hydrodynamic models for the Strait of Canso. The focus was placed on identifying improvements (or lack of) derived from increased resolution and offering rationalizations and suggestions for how the systems could be improved. Here we summarize the results.

Water Level

Water level properties were analyzed using tidal analysis to derive tidal constituents and residual time series. All three models performed exceptionally well with no major difference between them. For example, the $RMSE$ for the tidal constituents was generally under a centimetre and residual skill above 0.85. The models were able to correctly predict some lesser constituents such as SA,K2 and P1, but completely missed others such as NU2 and L2. These lesser constituents are generally small in amplitude, but can modulate dominant constituents with similar frequencies. In the case of K2, the modulation was 40% of the S2 amplitude. The analysis of the four year water level time series demonstrated that even though these lesser constituents only represent 1% of the variance they can add 10 cm to the maximum errors and hence are significant in accurate water level forecasting.

A few large residual water level errors occurred during the evaluation period which was much higher than the overall $RMSE$ of 0.1 m. The largest of these peaked at 0.95 m, and lasted a few hours. Further investigation of these anomalies is beyond the present scope, but they are either measurement errors or meteotsunami type events (Dusek et al., 2019)), which here would likely be caused by the harbour seiche known to occur in the area (Barber and Taylor, 1977). The inability of the models to reproduce the correct seiche was also noted in time series plots following large storms, and attributed to inadequately resolved high frequency band of the local wind or of the remote open boundary forcing.

Currents

The port models demonstrated significant improvement over the parent model in terms of current meter comparisons (both tidal and residual flow). The largest improvement was inside the Strait of Canso which CIOPSE resolves poorly or not at all. For instance, CIOPSE tidal $RMSE$ error in the entrance was reduced from 0.07 to 0.014 $\mathrm{m\,s^{-1}}$. In

Chedabucto Bay, all analyzed current metrics showed improvement other than surface currents. The biggest improvement for this region was in the bottom currents, where skill metrics for CIOPSE were poor to low while moderate to high for port models. The only improvement on the open shelf was in reducing the K1 error by 50% at the Canso station.

In terms of the 100 versus the 500 metre resolution model, there was no significant improvement in barotropic tide, but not much room for improvement as $RMSE$ errors are generally under 0.01 $\mathrm{m\,s^{-1}}$. There was a small improvement in the outer strait region residual (e.g. WSK =0.75 from 0.71). This additional skill was attributed to a better principal axis orientation resulting from resolved topographic features. Comparable improvements were also seen for near-surface and near-bottom currents inside the strait but not in Chedabucto Bay. The most notable 100 m improvement was in the M2 tidal constituent profiles inside the strait which were attributed to internal tide. For instance, at the entrance stations (CM7), STC500 amplitude was 0.1 $\mathrm{m\,s^{-1}}$ too small near the bottom while STC100 was correct. This is consistent with the requirement for high resolution in modelling internal tide effectively in the coastal zone (Carter et al., 2012). Nominally the requirement is for resolution to be well below the internal wavelength, which in this region can be on the order of a few kilometers (Drozdowski and Jiang, 2020), but in reality likely smaller due to non-linear effects caused by coastal upwelling and advection terms near steep topography. Improvement in currents of the 100 m model over the 500 m was not as large as for the port models versus CIOPSE. However, given their primary importance (particularly surface currents) for drift and navigation, these findings are encouraging.

Temperature and Salinity

Based on CTD casts, port model improvements were seen in some inner stations unresolved (or poorly resolved) by CIOPSE. This was more apparent in the inner moored CTD time series error and skill scores. For example, the port models at CW2016-5m have high to very high skills for temperature, and while CIOPSE has a high overall score it rates poorly in the anomaly skills as it fails to reproduce the upwelling events. Near the bottom (CW2016-57m) CIOPSE misses the effect of water being trapped behind a sill and the episodic step-like features, which appear to be intrusions of colder saltier water from further offshore. However, at the more outer Chedabucto Bay Station, improvement was not as evident, with no gain near the surface and a modest 5-8% increase in salinity skill metrics near bottom. T-S improvements of STC100 over STC500 where not visible in the CTD casts or time series error and skill metrics. However STC100 was qualitatively better able to reproduce the episodic step-like features at CW2016-57m mentioned above.

	Temperature		Salinity	
	Inner	Outer	Inner	Outer
Top	+	-	++	+
Bottom	++	+		

Table 17: Systematic model T-S bias summary schematic. Inner region applies to port models only while the outer also includes CIOPSE.

Three systematic biases in T-S were observed for all three models. In the CB-11m model salinity comparison, a salty bias of $\approx$0.5 $\mathrm{g\,kg^{-1}}$ persisted between August and December. This feature was even more pronounced in the near-surface Causeway stations both in 2016 and 2019. Additionally, this bias was also noted in many of the CTD casts. There was a 1.2$°C$ cold near surface bias at CB-11m during the summer period, only seen at this station. In many of the CTD stations, a warm bias of around 1° was seen throughout the water column both in the spring and fall but more pronounced near bottom and in the inshore regions. This finding was corroborated by moored CTD data. At CB-49m there was a warm bias of $\approx$1$°C$ May to June, while at CW2016-5m, the port models have a 1.1$°C$ warm bias. At CW2016-57m, the warm bias was even higher at 1.5-2$°C$. The biases are summarized schematically in Table 17. The CIOPSE inner region is not relevant due the extrapolation used to get the results there, hence those entries in the table apply to the port models only. Given the consistency of the biases in outer region for all three models, it is clear that bias there originated from the parent model. It appears that CIOPSE does not export enough Gulf of Saint Lawrence water onto the inner eastern Scotian Shelf which during the summer brings fresher and warmer water in the top layer and during the spring colder on the bottom (Drinkwater et al., 1979; Petrie et al., 1996), consistent with the timing of the biases. The fact that biases were intensified for the inner port region, suggests that other processes may be significant, perhaps the atmospheric forcing was biased by land (the inner station was surrounded by land), or local runoff plays a role, or there is inadequate water exchange with the outside. A more detail investigation would need to be carried out to test these hypotheses.

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A STC500 namelist_cfg

```
!!>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
!! NEMO/OPA  Configuration namelist : used to overwrite defaults values defined in SHARED/namelist_ref
!!>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
!
!-----------------------------------------------------------------------
&namrun       !   parameters of the run
!-----------------------------------------------------------------------
nn_no       =  NUMERO_DE_RUN   !  job number (no more used...)
cn_exp      =  EXPER  !  experience name
nn_it000    =  NIT000   !  first time step
nn_itend    =  NITEND   !  last  time step (std 5475)
nn_date0    =  NDATE0   !  date at nit_0000 (format yyyymmdd) used if ln_rstart=F or (ln_rstart=T and nn_rstctl=0 or 1)
ln_rstart   =  BREST    !  start from rest (F) or from a restart file (T)
nn_rstctl   =  DATERST  !  restart control ==> activated only if ln_rstart=T
!  = 0 nn_date0 read in namelist ; nn_it000 : read in namelist
!  = 1 nn_date0 read in namelist ; nn_it000 : check consistancy between namelist and restart
!  = 2 nn_date0 read in restart  ; nn_it000 : check consistancy between namelist and restart
nn_stock    =  NNSTOCK  !  frequency of creation of a restart file (modulo referenced to 1)
/
!-----------------------------------------------------------------------
&namcfg       !   parameters of the configuration
!-----------------------------------------------------------------------
cp_cfg      = "Canso500m"         !  name of the configuration
jp_cfg      =  36                  !  resolution of the configuration
jpidta      =  379                 !  1st lateral dimension ( >= jpi )
jpjdta      =  374                !  2nd    "         "    ( >= jpj )
jpkdta      =  50                  !  number of levels      ( >= jpk )
jpiglo      =  379                 !  1st dimension of global domain --> i =jpidta
jpjglo      =  374                !  2nd    -                  -    --> j  =jpjdta
jpizoom     =  1                   !  left bottom (i,j) indices of the zoom
jpjzoom     =  1                   !  in data domain indices
jperio      =     0               !  lateral cond. type (between 0 and 6)
!  = 0 closed                 ;   = 1 cyclic East-West
!  = 2 equatorial symmetric   ;   = 3 North fold T-point pivot
!  = 4 cyclic East-West AND North fold T-point pivot
!  = 5 North fold F-point pivot
!  = 6 cyclic East-West AND North fold F-point pivot
ln_use_jattr = .false.             !  use (T) the file attribute: open_ocean_jstart, if present
!  in netcdf input files, as the start j-row for reading
/
!-----------------------------------------------------------------------
&namzgr       !   vertical coordinate
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namdom       !   space and time domain (bathymetry, mesh, timestep)
!-----------------------------------------------------------------------
nn_bathy    =    1      !  compute (=0) or read (=1) the bathymetry file
rn_bathy    =    0.0    !  value of the bathymetry [when nn_bathy=0]. if (=0) bottom flat at jpkm1
nn_msh      =    1      !  create (=1) a mesh file or not (=0)
rn_hmin     =   -3.0    !  min depth of the ocean (>0) or min number of ocean level (<0)
rn_e3zps_min=   20.0    !  partial step thickness is set larger than the minimum of [GoMSS]
rn_e3zps_rat=    0.3    !  rn_e3zps_min and rn_e3zps_rat*e3t, with 0<rn_e3zps_rat<1        ! XHU--BoF36 OPP - test smaller values
!
rn_atfp     =    0.1    !  asselin time filter parameter
nn_acc      =    0      !  acceleration of convergence : =1      used, rdt < rdttra(k)
!                             =0, not used, rdt = rdttra
ln_crs      = .false.   !  Logical switch for coarsening module
jphgr_msh   =      0    !  type of horizontal mesh
!  = 0 curvilinear coordinate on the sphere read in coordinate.nc
!  = 1 geographical mesh on the sphere with regular grid-spacing
!  = 2 f-plane with regular grid-spacing
!  = 3 beta-plane with regular grid-spacing
!  = 4 Mercator grid with T/U point at the equator
ppsur       =   999999   !XHU BoF180-P1bP3
ppa0        =     999999   !XHU BoF180-P1bP3
```

```
ppa1        =    999999    !XHU BoF180-P1bP3
ppkth       =   30.0     !
ppacr       =   5.0     !
ppdzmin     =   1.0      !
pphmax      =   400      ! AD_Feb4  !5750.0
ldbletanh   =  .FALSE.   !  Use/do not use double tanf function for vert coordinates
ppa2        =  999999.0  !  Double tanh function parameters
ppkth2      =  999999.0  !
ppacr2      =  999999.0  !


rn_rdt      = 90 !  time step for the dynamics (and tracer if nn_acc=0)
rn_rdtmin   = 90 !  minimum time step on tracers (used if nn_acc=1)
rn_rdtmax   = 90 !  maximum time step on tracers (used if nn_acc=1)
rn_rdth     = 90 !  depth variation of tracer time step  (used if nn_acc=1)
/
!-----------------------------------------------------------------------
&namsplit      !   time splitting parameters                            ("key_dynspg_ts")
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namcrs        !   Grid coarsening for dynamics output and/or
!   passive tracer coarsened online simulations
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namtsd    !   data : Temperature  & Salinity
!-----------------------------------------------------------------------
!-----------------------------------------------------------------------
! !  file name              ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
! !                         !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_tem  = 'votemper.nc' ,   -12   ,'votemper' ,   .false.   , .true. , 'yearly'   , ''       ,   ''    ,    ''
sn_sal  = 'vosaline.nc' ,   -12   ,'vosaline' ,    .false.    , .true. , 'yearly'   , ''       ,   ''    ,    ''
!
cn_dir        = './'     !  root directory for the location of the runoff files
ln_tsd_init   = .true.   !  Initialisation of ocean T & S with T &S input data (T) or not (F)
ln_tsd_tradmp = .false.  !81->true.   !  damping of ocean T & S toward T &S input data (T) or not (F)
/
!-----------------------------------------------------------------------
&namuvd    !   data: U & V currents
!-----------------------------------------------------------------------
!             !  file name                ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!             !                           !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_ucur     = 'vozocrtx.nc',        -12        ,'vozocrtx',   .false.    , .true. , 'yearly' ,  ''      ,  ''   , ''
sn_vcur     = 'vomecrty.nc',        -12        ,'vomecrty',   .false.    , .true. , 'yearly' ,  ''      ,  ''   , ''
sn_ssh      = 'sossheig.nc',        -12        ,'sossheig',   .false.    , .true. , 'yearly' ,  ''      ,  ''   , ''
!
cn_dir        = './' !  root directory for the location of the files
ln_uvd_init   = .true.    !  Initialisation of ocean U & V with U & V input data (T) or not (F)
ln_uvd_dyndmp = .false.    !  damping of ocean U & V toward U & V input data (T) or not (F)
/

!-----------------------------------------------------------------------
&namuvd_rpn    !   data: U & V currents                                 ("key_rpne")
!-----------------------------------------------------------------------
!         !  file name  ! freq. (h) ! variable ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!         !             ! (if <0mth)!   name   !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
!sn_ucur = 'U_20150915',    -12    ,'vozocrtx',   .false.    , .false., 'yearly'  ,  ''      ,  ''      , ''
!sn_vcur = 'V_20150915',    -12    ,'vomecrty',   .false.    , .false., 'yearly'  ,  ''      ,  ''      , ''
!sn_ssh  = 'H_20150915',    -12    ,'sossheig',   .false.    , .false., 'yearly'  ,  ''      ,  ''      , ''
sn_ucur     = 'vozocrtx.nc',         -12        ,'vozocrtx',   .false.    , .true. , 'yearly' ,  ''      ,  ''   , ''
sn_vcur     = 'vomecrty.nc',         -12        ,'vomecrty',   .false.    , .true. , 'yearly' ,  ''      ,  ''   , ''
sn_ssh      = 'sossheig.nc',         -12        ,'sossheig',   .false.    , .true. , 'yearly' ,  ''      ,  ''   , ''
!
cn_dir        = './'        !  root directory for the location of the files
ln_uvd_init_rpn   = .true.  !  Initialisation of ocean U & V with U & V input data (T) or not (F)
ln_uvd_dyndmp_rpn = .false. !  damping of ocean U & V toward U & V input data (T) or not (F)
/
!-----------------------------------------------------------------------
```

```
&namsbc        !   Surface Boundary Condition (surface module)
!-----------------------------------------------------------------------
ln_blk_core = .true.    !  CORE bulk formulation                     (T => fill namsbc_core)
!   ln_blk_rpn  = .false.    !  RPNE bulk interface                        (T => fill namsbc_rpn)
!   ln_ist_imp  = .false.    !  Implicit surface ice stress               (Thu Nov  3 14:40:02 GMT 2016)
!   ln_rpncpl   = .false.   !  Activate coupling with atmospheric model or not
nn_ice      = 1         !  =0 no ice boundary condition   ,
ln_rnf      = .true.    ! .false.   !  runoffs                                       (T => fill namsbc_rnf) # luo
ln_ssr      = .false.   !  Sea Surface Restoring on T and/or S       (T => fill namsbc_ssr)
nn_fwb      = 0         !  FreshWater Budget: =0 unchecked
ln_apr_dyn  = .true.    !  Patm gradient added in ocean & ice Eqs.   (T => fill namsbc_apr )
/
!-----------------------------------------------------------------------
&namsbc_core   !   namsbc_core  CORE bulk formulae
!-----------------------------------------------------------------------
!       !   file name        ! frequency (hours) ! variable   ! time interpol. !  clim   ! 'yearly' or ! ! weights  ! rotation !
sn_wndi  = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'u_wind'    ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m', 'U', ''
sn_wndj  = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'v_wind'    ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m', 'V', ''
sn_qsr   = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'solar'     ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m' , '', ''
sn_qlw   = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'therm_rad' ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m' , '', ''
sn_tair  = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'tair'     ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m' , '', ''
sn_humi  = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'qair'      ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m' , '', ''
sn_prec  = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'precip'    ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m' , '', ''
sn_snow  = 'HRDPS_OPPeast_ps2.5km'    ,        1.0          , 'snow'      ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso500m' , '', ''
cn_dir      = './ATMDATA/'  !  root directory for the location of the bulk files
ln_taudif   = .false.   !  HF tau contribution: use "mean of stress module - module of the mean stress" data
rn_zqt      = 2.        !  Air temperature and humidity reference height (m)
rn_zu       = 10.        !  Wind vector reference height (m)
rn_pfac     = 1000.  !luo change unit from kg m-2 to kg/m2/s  !  multiplicative factor for precipitation (total & snow)
rn_efac     = 1.        !  multiplicative factor for evaporation (0. or 1.)
rn_vfac     = 0.        !  multiplicative factor for ocean/ice velocity
!  in the calculation of the wind stress (0.=absolute winds or 1.=relative winds)
/
!-----------------------------------------------------------------------
&namsbc_rpn   !   namsbc_rpn  RPNE bulk interface
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namsbc_readrpn   !   namsbc_readrpn fldread_rpn config
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namtra_qsr    !   penetrative solar radiation
!-----------------------------------------------------------------------
!             !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!             !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_chl      ='chlorophyll',        -1         , 'CHLA'    ,   .true.     , .true. , 'yearly'  , ''       , ''       , ''

cn_dir      = './'      !  root directory for the location of the runoff files
ln_traqsr   = .true.    !  Light penetration (T) or not (F)
ln_qsr_rgb  = .true.   !  RGB (Red-Green-Blue) light penetration ---NEP036
ln_qsr_2bd  = .false.    !  2 bands              light penetration ---NEP036
ln_qsr_bio  = .false.   !  bio-model light penetration
nn_chldta   =      0    !  RGB : Chl data (=1) or cst value (=0)
rn_abs      =   0.58    !  RGB & 2 bands: fraction of light (rn_si1)
rn_si0      =   0.35    !  RGB & 2 bands: shortess depth of extinction
rn_si1      =   10.0    !  2 bands: longest depth of extinction

/
!-----------------------------------------------------------------------
&namsbc_rnf    !   runoffs namelist surface boundary condition
!-----------------------------------------------------------------------
!              !  file name        ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !                   !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_rnf      = 'runoff_clim',  -1         , 'sorunoff',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_cnf      = 'runoff_clim',   0         , 'socoefr' ,   .false.    , .true. , 'yearly'  , ''       , ''       , ''
sn_t_rnf    = 'rivers_TS_nwa36',   -1         , 'riv_tem' ,   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_s_rnf    = 'rivers_TS_nwa36',   -1         , 'riv_sal' ,   .true.     , .true. , 'yearly'  , ''       , ''       , ''
cn_dir       = './'      !  root directory for the location of the runoff files
```

```
ln_rnf_mouth = .false.     !  specific treatment at rivers mouths, increase diffusivity at rivers mouths (true)
rn_hrnf      =  8.e0        !  depth over which enhanced vertical mixing is used
rn_avt_rnf   =  2.e-3   !  value of the additional vertical mixing coef. [m2/s]
rn_rfact     = 1.e0        !  multiplicative factor for runoff
ln_rnf_depth = .false.   !  read in depth information for runoff
ln_rnf_tem   = .false.   !  read in temperature information for runoff
ln_rnf_sal   = .false.   !  read in salinity information for runoff
ln_rnf_depth_ini = .true.  ! compute depth at initialisation from runoff file
rn_rnf_max   = 5.735e-4  !  max value of the runoff climatologie over global domain ( ln_rnf_depth_ini = .true )
rn_dep_max   = 7.      !  depth over which runoffs is spread ( ln_rnf_depth_ini = .true )
nn_rnf_depth_file = 0    !  create (=1) a runoff depth file or not (=0)
/
!-----------------------------------------------------------------------
&namsbc_apr    !   Atmospheric pressure used as ocean forcing or in bulk
!-----------------------------------------------------------------------
!             !  file name     ! frequency (hours) ! variable  ! time interp. !  clim   ! 'yearly'/  ! weights         ! rotation ! land/sea mask !
!             !                !  (if <0  months)  !   name    !   (logical)  !  (T/F)  ! 'monthly'  ! filename        ! pairing  ! filename      !
sn_apr      = 'HRDPS_OPPeast_ps2.5km'      ,        1.0        ,'seapres',    .true.     , .false. , 'daily'  ,  'weights_bilinear_Canso500m'      ,   ''     , ''
cn_dir      = './ATMDATA/'   !  root directory for the location of the bulk files    XHU -- BoF36
rn_pref     = 101000.        !  reference atmospheric pressure   [N/m2]/
ln_ref_apr  = .false.        !  ref. pressure: global mean Patm (T) or a constant (F)
ln_apr_obc  = .false.        !  inverse barometer added to OBC ssh data
/
!-----------------------------------------------------------------------
&namsbc_iif   !   namsbc_iif  ice-if formulation
!-----------------------------------------------------------------------
!       !   file name        ! frequency (hours) ! variable   ! time interp    ol. !  clim   ! 'yearly' or ! ! weights  ! rotation !
!       !                    !  (if <0  months)  !   name     !   (logical    )   !  (T/F)  !  'monthly'  ! ! filename ! pairing  !
cn_dir   = './ICE/'         ! Directory where ice file(s) are found
sn_ice   = 'iceif_zero', -12, 'ice', .false., .true., 'yearly', 'weights', '', ''
! Info about the ice files.  Same structure as runoff etc.
/
!-----------------------------------------------------------------------
&namsbc_ssr    !   surface boundary condition : sea surface restoring
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namsbc_alb    !   albedo parameters
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namhbar       !   Hbar parameters
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namberg       !   iceberg parameters
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namlbc        !   lateral momentum boundary condition
!-----------------------------------------------------------------------
rn_shlat    =    0.1    !  shlat = 0  !  0 < shlat < 2  !  shlat = 2  !  2 < shlat
/
!-----------------------------------------------------------------------
&namcla        !   cross land advection
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nam_tide      !   tide parameters (#ifdef key_tide)
!-----------------------------------------------------------------------
ln_tide_pot   = .true.   !  use tidal potential forcing SBD
ln_tide_load  = .false.  !  use self attraction and loading (SAL) SBD
filetide_load = 'tidal_harmonics_load_FES.nc' ! filename for load potential
ln_tide_load_conj = .true. ! conjugate the imaginary part
ln_tide_ramp  = TIDERAMP !Peng   !
rdttideramp   =    0.25    !  days
clname(1)     = 'M2'     !  name of constituent
clname(2)     = 'N2'     !  name of constituent
clname(3)     = 'S2'     !  name of constituent
```

```
clname(4)     = 'K1'     !  name of constituent
clname(5)     = 'O1'     !  name of constituent
!clname(6)     = 'K2'     !  name of constituent
!clname(7)     = 'P1'     !  name of constituent
!clname(8)     = 'Q1'     !  name of constituent
/
!-----------------------------------------------------------------------
&nambdy        !  unstructured open boundaries                          ("key_bdy")
!-----------------------------------------------------------------------
nb_bdy         = 3                      !  number of open boundary sets
ln_coords_file = .false.,.false.,.false.         !  =T : read bdy coordinates from file
cn_coords_file = 'coordinates.bdy.nc'    !  bdy coordinates files
ln_mask_file   = .false.                !  =T : read mask from file
cn_mask_file   = ''                     !  name of mask file (if ln_mask_file=.TRUE.)
cn_dyn2d       = 'flather','flather','flather'     !
nn_dyn2d_dta   = 1,1,1                    !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
!  = 2, use tidal harmonic forcing data from files
!  = 3, use external data AND tidal harmonic forcing
cn_dyn3d      =  'specified','specified','specified' ! SBD
nn_dyn3d_dta  =  1,1,1                    !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
cn_tra        =  'specified','specified','specified' ! SBD
nn_tra_dta    =  1,1,1                    !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
cn_ice_lim      =  'none','none','none'         !
nn_ice_lim_dta  =  0,0,0                  !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
rn_ice_tem      = 270.                  !  lim3 only: arbitrary temperature of incoming sea ice
rn_ice_sal      = 10.                   !  lim3 only:      --   salinity           --
rn_ice_age      = 30.                   !  lim3 only:      --   age                --

ln_tra_dmp    =.true.,.true.,.true.            !  open boudaries conditions for tracers SBD true
ln_dyn3d_dmp  =.true.,.true.,.true.            !  open boundary condition for baroclinic velocities SBD true
rn_time_dmp   =  0.2,0.2,0.2                  ! Damping time scale in days
rn_time_dmp_out = 0.2,0.2,0.2                ! Outflow damping time scale SBD 1.
nn_rimwidth   = 10,10,10                   !  width of the relaxation zone
ln_vol        = .false.                 !  total volume correction (see nn_volctl parameter)
nn_volctl     = 1                       !  1 ==> the total volume is constant
/
!-----------------------------------------------------------------------
&nambdy_index  !  structured open boundaries definition     ("key_bdy")
!-----------------------------------------------------------------------
ctypebdy ='S'                  ! Open boundary type (W,E,S or N)
nbdyind  = -1                  ! indice of velocity row or column
! if ==-1, set obc at the domain boundary
!        , discard start and end indices
nbdybeg  = 2                   ! indice of segment start
nbdyend  = 713                 ! indice of segment end
/

!-----------------------------------------------------------------------
&nambdy_dta      !  open boundaries - external data           ("key_bdy")
!-----------------------------------------------------------------------
!      !  file name                                ! frequency (hours) ! variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!      !                                           !  (if <0  months)  !   name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !

bn_ssh =     'obc_south_sossheig'  ,     1.0        , '-sossheig' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u2d =     'obc_south_vozotrtx'  ,     1.0      , '-vozotrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v2d =     'obc_south_vometrty'  ,     1.0      , '-vometrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u3d  =    'obc_south_vozocrtx' ,      24.0        , 'vozocrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v3d  =    'obc_south_vomecrty' ,      24.0        , 'vomecrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_tem  =    'obc_south_votemper' ,      24.0        , 'votemper' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_sal  =    'obc_south_vosaline' ,      24.0        , 'vosaline' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
cn_dir  =    'OBCDATA/'
ln_full_vel = .false.
/
```

```
!-----------------------------------------------------------------------
&nambdy_index  !  structured open boundaries definition     ("key_bdy")
!-----------------------------------------------------------------------
ctypebdy ='W'                  ! Open boundary type (W,E,S or N)
nbdyind  = -1                  ! indice of velocity row or column
! if ==-1, set obc at the domain boundary
!        , discard start and end indices
nbdybeg  = 2                   ! indice of segment start
nbdyend  = 373                 ! indice of segment end
/

!-----------------------------------------------------------------------
&nambdy_dta      !  open boundaries - external data           ("key_bdy")
!-----------------------------------------------------------------------
!      !  file name                                ! frequency (hours) ! variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!      !                                           !  (if <0  months)  !   name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !
bn_ssh =     'obc_west_sossheig'  ,     1.0        , '-sossheig' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u2d =     'obc_west_vozotrtx'  ,     1.0      , '-vozotrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v2d =     'obc_west_vometrty'  ,     1.0      , '-vometrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u3d  =    'obc_west_vozocrtx' ,      24.0        , 'vozocrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v3d  =    'obc_west_vomecrty' ,      24.0        , 'vomecrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_tem  =    'obc_west_votemper' ,      24.0        , 'votemper' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_sal  =    'obc_west_vosaline' ,      24.0        , 'vosaline' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
cn_dir  =    'OBCDATA/'
ln_full_vel = .false.
/

&nambdy_index  !  structured open boundaries definition     ("key_bdy")
!-----------------------------------------------------------------------
ctypebdy ='E'                  ! Open boundary type (W,E,S or N)
nbdyind  = -1                  ! indice of velocity row or column
! if ==-1, set obc at the domain boundary
!        , discard start and end indices
nbdybeg  = 2                   ! indice of segment start
nbdyend  = 1019                ! indice of segment end
/

!-----------------------------------------------------------------------
&nambdy_dta      !  open boundaries - external data           ("key_bdy")
!-----------------------------------------------------------------------
!      !  file name                                ! frequency (hours) ! variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!      !                                           !  (if <0  months)  !   name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !
bn_ssh =     'obc_east_sossheig'  ,     1.0     , '-sossheig' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u2d =     'obc_east_vozotrtx'  ,     1.0     , '-vozotrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v2d =     'obc_east_vometrty'  ,     1.0     , '-vometrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u3d  =    'obc_east_vozocrtx' ,      24.0    , 'vozocrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v3d  =    'obc_east_vomecrty' ,      24.0    , 'vomecrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_tem  =    'obc_east_votemper' ,      24.0    , 'votemper' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_sal  =    'obc_east_vosaline' ,      24.0    , 'vosaline' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
cn_dir  =    'OBCDATA/'
ln_full_vel = .false.
/

!-----------------------------------------------------------------------
&nambdy_tide     ! tidal forcing at open boundaries
!-----------------------------------------------------------------------
filtide          = 'OBCDATA/tide'  !  file name root of tidal forcing files
ln_bdytide_2ddta = .true.
ln_bdytide_conj  = .true.
/

!-----------------------------------------------------------------------
&nambdy_tide     ! tidal forcing at open boundaries
!-----------------------------------------------------------------------
filtide          = 'OBCDATA/tide'  !  file name root of tidal forcing files
ln_bdytide_2ddta = .true.
ln_bdytide_conj  = .true.
/
```

```
!-----------------------------------------------------------------------
&nambdy_tide     ! tidal forcing at open boundaries
!-----------------------------------------------------------------------
filtide          = 'OBCDATA/tide'  !  file name root of tidal forcing files
ln_bdytide_2ddta = .true.
ln_bdytide_conj  = .true.
/
!-----------------------------------------------------------------------
&nambfr        !   bottom friction
!-----------------------------------------------------------------------
rn_bfri2    =  2.5e-3 !  bottom drag coefficient (non linear case).
!  Minimum coeft if ln_loglayer=TXHU -- BoF36
rn_bfeb2    =  1.0e-3 !  bottom turbulent kinetic energy background  (m2/s2)
!  XHU -- BoF36, OPP - set to 0 if tides explicitely simulated
rn_bfrz0    =  0.003  !  bottom roughness [m] if ln_loglayer=T
!  OPP - sensitivity
/
!-----------------------------------------------------------------------
&nambbc        !   bottom temperature boundary condition
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nambbl        !   bottom boundary layer scheme
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nameos        !   ocean physical parameters
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namtra_adv    !   advection scheme for tracer set to tvdzts in orig SBD
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namtra_adv_mle !  mixed layer eddy parametrisation (Fox-Kemper param)
!-----------------------------------------------------------------------
/
!----------------------------------------------------------------------------------
&namtra_ldf    !   lateral diffusion scheme for tracers
!----------------------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namtra_dmp    !   tracer: T & S newtonian damping                          JPP 2018/05/31 copied from Fred's orca1
!----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namsdp       !   Tracer spectral damping ('key_trasdmp')
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nam_filters  !   Tracer spectral damping ('key_trasdmp')
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namdyn_adv    !   formulation of the momentum advection ubs in orig SBD
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nam_vvl    !   vertical coordinate options
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namdyn_vor    !   option of physics/algorithm (not control by CPP keys)
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namdyn_hpg    !   Hydrostatic pressure gradient option
!-----------------------------------------------------------------------
```

```
/
!-----------------------------------------------------------------------
&namdyn_ldf    !   lateral diffusion on momentum
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namzdf        !   vertical physics
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namzdf_tke    !   turbulent eddy kinetic dependent vertical diffusion  ("key_zdftke")
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namzdf_gls                !   GLS vertical diffusion                  ("key_zdfgls")
!-----------------------------------------------------------------------
rn_emin       = 1.e-7   !  minimum value of e   [m2/s2]
rn_clim_galp  = 0.267   !  galperin limit
/
!-----------------------------------------------------------------------
&namzdf_ddm    !   double diffusive mixing parameterization            ("key_zdfddm")
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namzdf_tmx    !   tidal mixing parameterization                       ("key_zdftmx")
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namsol        !   elliptic solver / island / free surface
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nammpp        !   Massively Parallel Processing                       ("key_mpp_mpi)
!-----------------------------------------------------------------------
cn_mpi_send =  'I'      !  mpi send/recieve type   ='S', 'B', or 'I' for standard send,
!  buffer blocking send or immediate non-blocking sends, resp.
nn_buffer   =   0       !  size in bytes of exported buffer ('B' case), 0 no exportation
ln_nnogather=  .false.  !  activate code to avoid mpi_allgather use at the northfold
jpni        =  18      !  jpni   number of processors following i (set automatically if < 1)
jpnj        =  18      !  jpnj   number of processors following j (set automatically if < 1)
jpnij       =  260      !  jpnij  number of local domains (set automatically if < 1)
/
!-----------------------------------------------------------------------
&namctl        !   Control prints & Benchmark
!-----------------------------------------------------------------------
nn_timing   =    0      !  timing by routine activated (=1) creates timing.output file, or not (=0)
/
!-----------------------------------------------------------------------
&namptr       !   Poleward Transport Diagnostic
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namhsb       !  Heat and salt budgets
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nam_diaharm   !   Harmonic analysis of tidal constituents ('key_diaharm')
!-----------------------------------------------------------------------
nit000_han = 4321         ! First time step used for harmonic analysis
nitend_han = NITEND    ! Last time step used for harmonic analysis
nstep_han  = 60         ! Time step frequency for harmonic analysis
tname(1)   = 'M2'      ! Name of tidal constituents                                          JPP--BoF180
tname(2)   = 'K2'      ! Name of tidal constituents
tname(3)   = 'S2'      ! Name of tidal constituents
tname(4)   = 'N2'      ! Name of tidal constituents
tname(5)   = 'O1'      ! Name of tidal constituents
tname(6)   = 'P1'      ! Name of tidal constituents
tname(7)   = 'Q1'      ! Name of tidal constituents
tname(8)   = 'K1'      ! Name of tidal constituents
```

```
/
!-----------------------------------------------------------------------
&namharm_cmc    !   cmc on-line tide harnomic analyses
!-----------------------------------------------------------------------
ln_str_tdhm     = @{STRING_ln_rstart}        ! start harmo-analyses in this cycle
/
!-----------------------------------------------------------------------
&namdyn_nept  !   Neptune effect (simplified: lateral and vertical diffusions removed)
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namobs       !  observation usage                                   ('key_diaobs')
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&nam_asminc   !   assimilation increments                            ('key_asminc')
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namsto       ! Stochastic parametrization of EOS
!-----------------------------------------------------------------------
/
!-----------------------------------------------------------------------
&namtrd       !   diagnostics on dynamics and/or tracer trends
!-----------------------------------------------------------------------
/
```

B STC500 namelist_ref

```
!!>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>
!! NEMO/OPA  :  1 - run manager      (namrun)
!! namelists    2 - Domain           (namcfg, namzgr, namzgr_sco, namdom, namtsd)
!!              3 - Surface boundary (namsbc, namsbc_ana, namsbc_flx, namsbc_clio, namsbc_core, namsbc_sas
!!                                    namsbc_cpl, namtra_qsr, namsbc_rnf,
!!                                    namsbc_apr, namsbc_ssr, namsbc_alb)
!!              4 - lateral boundary (namlbc, namcla, namagrif, nambdy, nambdy_tide)
!!              5 - bottom  boundary (nambfr, nambbc, nambbl)
!!              6 - Tracer           (nameos, namtra_adv, namtra_ldf, namtra_dmp)
!!              7 - dynamics         (namdyn_adv, namdyn_vor, namdyn_hpg, namdyn_spg, namdyn_ldf)
!!              8 - Verical physics  (namzdf, namzdf_ric, namzdf_tke, namzdf_kpp, namzdf_ddm, namzdf_tmx, namzdf_tmx_new)
!!              9 - diagnostics      (namnc4, namtrd, namspr, namflo, namhsb, namsto)
!!             10 - miscellaneous    (namsol, nammpp, namctl)
!!             11 - Obs & Assim      (namobs, nam_asminc)
!!>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>

!!======================================================================
!!                   ***  Run management namelists  ***
!!======================================================================
!!   namrun       parameters of the run
!!======================================================================
!
!-----------------------------------------------------------------------
&namrun        !   parameters of the run
!-----------------------------------------------------------------------
nn_no       =       0   !  job number (no more used...)
cn_exp      =  "ORCA2"  !  experience name
nn_it000    =       1   !  first time step
nn_itend    =    5475   !  last  time step (std 5475)
nn_date0    =  010101   !  date at nit_0000 (format yyyymmdd) used if ln_rstart=F or (ln_rstart=T and nn_rstctl=0 or 1)
nn_leapy    =       1   !  Leap year calendar (1) or not (0)
ln_rstart   = .false.   !  start from rest (F) or from a restart file (T)
nn_euler    =       1   !  = 0 : start with forward time step if ln_rstart=T
nn_rstctl   =       0   !  restart control ==> activated only if ln_rstart=T
```

```
!    = 0 nn_date0 read in namelist ; nn_it000 : read in namelist
!    = 1 nn_date0 read in namelist ; nn_it000 : check consistancy between namelist and restart
!    = 2 nn_date0 read in restart  ; nn_it000 : check consistancy between namelist and restart
cn_ocerst_in  = "restart"   !  suffix of ocean restart name (input)
cn_ocerst_indir = "."       !  directory from which to read input ocean restarts
cn_ocerst_out = "restart"   !  suffix of ocean restart name (output)
cn_ocerst_outdir = "."      !  directory in which to write output ocean restarts
nn_istate   =       0   !  output the initial state (1) or not (0)
ln_rst_list = .false.   !  output restarts at list of times using nn_stocklist (T) or at set frequency with nn_stock (F)
nn_stock    =    5475   !  frequency of creation of a restart file (modulo referenced to 1)
nn_stocklist = 0,0,0,0,0,0,0,0,0,0 ! List of timesteps when a restart file is to be written
nn_write    =    5475   !  frequency of write in the output file   (modulo referenced to nn_it000)
ln_dimgnnn  = .false.   !  DIMG file format: 1 file for all processors (F) or by processor (T)
ln_mskland  = .false.   !  mask land points in NetCDF outputs (costly: + ~15%)
ln_cfmeta   = .false.   !  output additional data to netCDF files required for compliance with the CF metadata standard
ln_clobber  = .false.   !  clobber (overwrite) an existing file
nn_chunksz  =       0   !  chunksize (bytes) for NetCDF file (works only with iom_nf90 routines)
/
!
!!======================================================================
!!                      ***  Domain namelists  ***
!!======================================================================
!!   namcfg       parameters of the configuration
!!   namzgr       vertical coordinate
!!   namzgr_sco   s-coordinate or hybrid z-s-coordinate
!!   namdom       space and time domain (bathymetry, mesh, timestep)
!!   namtsd       data: temperature & salinity
!!======================================================================
!
!-----------------------------------------------------------------------
&namcfg     !   parameters of the configuration
!-----------------------------------------------------------------------
cp_cfg      =  "default"            !  name of the configuration
cp_cfz      =  "no zoom"            !  name of the zoom of configuration
jp_cfg      =       0               !  resolution of the configuration
jpidta      =      10               !  1st lateral dimension ( >= jpi )
jpjdta      =      12               !  2nd    "         "    ( >= jpj )
jpkdta      =      31               !  number of levels      ( >= jpk )
jpiglo      =      10               !  1st dimension of global domain --> i =jpidta
jpjglo      =      12               !  2nd    -                  -    --> j =jpjdta
jpizoom     =       1               !  left bottom (i,j) indices of the zoom
jpjzoom     =       1               !  in data domain indices
jperio      =       0               !  lateral cond. type (between 0 and 6)
!  = 0 closed                 ;   = 1 cyclic East-West
!  = 2 equatorial symmetric   ;   = 3 North fold T-point pivot
!  = 4 cyclic East-West AND North fold T-point pivot
!  = 5 North fold F-point pivot
!  = 6 cyclic East-West AND North fold F-point pivot
ln_use_jattr = .false.              !  use (T) the file attribute: open_ocean_jstart, if present
!  in netcdf input files, as the start j-row for reading
/
!-----------------------------------------------------------------------
&namzgr        !   vertical coordinate
!-----------------------------------------------------------------------
ln_zco      = .false.   !  z-coordinate - full    steps   (T/F)      ("key_zco" may also be defined)
ln_zps      = .true.    !  z-coordinate - partial steps   (T/F)
ln_sco      = .false.   !  s- or hybrid z-s-coordinate    (T/F)
ln_isfcav   = .false.   !  ice shelf cavity               (T/F)
/
!-----------------------------------------------------------------------
&namzgr_sco    !   s-coordinate or hybrid z-s-coordinate
!-----------------------------------------------------------------------
ln_s_sh94   = .true.    !  Song & Haidvogel 1994 hybrid S-sigma   (T)|
ln_s_sf12   = .false.   !  Siddorn & Furner 2012 hybrid S-z-sigma (T)| if both are false the NEMO tanh stretching is applied
ln_sigcrit  = .false.   !  use sigma coordinates below critical depth (T) or Z coordinates (F) for Siddorn & Furner stretch
!  stretching coefficients for all functions
rn_sbot_min =   10.0    !  minimum depth of s-bottom surface (>0) (m)
rn_sbot_max = 7000.0    !  maximum depth of s-bottom surface (= ocean depth) (>0) (m)
rn_hc       =  150.0    !  critical depth for transition to stretched coordinates
```

```
!!!!!!!  Envelop bathymetry
rn_rmax     =    0.3    !  maximum cut-off r-value allowed (0<r_max<1)
!!!!!!!  SH94 stretching coefficients  (ln_s_sh94 = .true.)
rn_theta    =    6.0    !  surface control parameter (0<=theta<=20)
rn_bb       =    0.8    !  stretching with SH94 s-sigma
!!!!!!!  SF12 stretching coefficient  (ln_s_sf12 = .true.)
rn_alpha    =    4.4    !  stretching with SF12 s-sigma
rn_efold    =    0.0    !  efold length scale for transition to stretched coord
rn_zs       =    1.0    !  depth of surface grid box
!  bottom cell depth (Zb) is a linear function of water depth Zb = H*a + b
rn_zb_a     =    0.024  !  bathymetry scaling factor for calculating Zb
rn_zb_b     =   -0.2    !  offset for calculating Zb
!!!!!!!! Other stretching (not SH94 or SF12) [also uses rn_theta above]
rn_thetb    =    1.0    !  bottom control parameter  (0<=thetb<= 1)
/
!-----------------------------------------------------------------------
&namdom        !   space and time domain (bathymetry, mesh, timestep)
!-----------------------------------------------------------------------
nn_bathy    =    1      !  compute (=0) or read (=1) the bathymetry file
rn_bathy    =    0.     !  value of the bathymetry. if (=0) bottom flat at jpkm1
nn_closea   =    0      !  remove (=0) or keep (=1) closed seas and lakes (ORCA)
nn_msh      =    1      !  create (=1) a mesh file or not (=0)
rn_hmin     =   -3.     !  min depth of the ocean (>0) or min number of ocean level (<0)
rn_e3zps_min=   20.     !  partial step thickness is set larger than the minimum of
rn_e3zps_rat=    0.1    !  rn_e3zps_min and rn_e3zps_rat*e3t, with 0<rn_e3zps_rat<1
!
rn_rdt      = 5760.     !  time step for the dynamics (and tracer if nn_acc=0)
rn_atfp     =    0.1    !  asselin time filter parameter
nn_acc      =    0      !  acceleration of convergence : =1      used, rdt < rdttra(k)
!                             =0, not used, rdt = rdttra
rn_rdtmin   = 28800.          !  minimum time step on tracers (used if nn_acc=1)
rn_rdtmax   = 28800.          !  maximum time step on tracers (used if nn_acc=1)
rn_rdth     =  800.           !  depth variation of tracer time step  (used if nn_acc=1)
ln_crs      = .false.      !  Logical switch for coarsening module
jphgr_msh   =       0               !  type of horizontal mesh
!  = 0 curvilinear coordinate on the sphere read in coordinate.nc
!  = 1 geographical mesh on the sphere with regular grid-spacing
!  = 2 f-plane with regular grid-spacing
!  = 3 beta-plane with regular grid-spacing
!  = 4 Mercator grid with T/U point at the equator
ppglam0     =       0.0             !  longitude of first raw and column T-point (jphgr_msh = 1)
ppgphi0     =     -35.0             ! latitude  of first raw and column T-point (jphgr_msh = 1)
ppe1_deg    =       1.0             !  zonal      grid-spacing (degrees)
ppe2_deg    =       0.5             !  meridional grid-spacing (degrees)
ppe1_m      =    5000.0             !  zonal      grid-spacing (degrees)
ppe2_m      =    5000.0             !  meridional grid-spacing (degrees)
ppsur       =    -4762.96143546300  !  ORCA r4, r2 and r05 coefficients
ppa0        =      255.58049070440  ! (default coefficients)
ppa1        =      245.58132232490  !
ppkth       =       21.43336197938  !
ppacr       =        3.0            !
ppdzmin     =       10.             !  Minimum vertical spacing
pphmax      =     5000.             !  Maximum depth
ldbletanh   =    .TRUE.             !  Use/do not use double tanf function for vertical coordinates
ppa2        =      100.760928500000 !  Double tanh function parameters
ppkth2      =       48.029893720000 !
ppacr2      =       13.000000000000 !
/
!-----------------------------------------------------------------------
&namsplit      !   time splitting parameters                            ("key_dynspg_ts")
!-----------------------------------------------------------------------
ln_bt_fw      =    .FALSE.           !  Forward integration of barotropic equations
ln_bt_av      =    .TRUE.           !  Time filtering of barotropic variables
ln_bt_nn_auto =    .FALSE.           !  Set nn_baro automatically to be just below
!  a user defined maximum courant number (rn_bt_cmax)
nn_baro       =    30               !  Number of iterations of barotropic mode
!  during rn_rdt seconds. Only used if ln_bt_nn_auto=F
rn_bt_cmax    =    0.8              !  Maximum courant number allowed if ln_bt_nn_auto=T
nn_bt_flt     =    1                !  Time filter choice
```

```
!  = 0 None
!  = 1 Boxcar over   nn_baro barotropic steps
!  = 2 Boxcar over 2*nn_baro     "        "
/
!-----------------------------------------------------------------------
&namcrs        !   Grid coarsening for dynamics output and/or
!   passive tracer coarsened online simulations
!-----------------------------------------------------------------------
nn_factx    = 3         !  Reduction factor of x-direction
nn_facty    = 3         !  Reduction factor of y-direction
nn_binref   = 0         !  Bin centering preference: NORTH or EQUAT
!  0, coarse grid is binned with preferential treatment of the north fold
!  1, coarse grid is binned with centering at the equator
!    Symmetry with nn_facty being odd-numbered. Asymmetry with even-numbered nn_facty.
nn_msh_crs  = 1         !  create (=1) a mesh file or not (=0)
nn_crs_kz   = 0         ! 0, MEAN of volume boxes
! 1, MAX of boxes
! 2, MIN of boxes
ln_crs_wn   = .true.    ! wn coarsened (T) or computed using horizontal divergence ( F )
/
!-----------------------------------------------------------------------
&namc1d        !   1D configuration options                            ("key_c1d")
!-----------------------------------------------------------------------
rn_lat1d    =      50   !  Column latitude (default at PAPA station)
rn_lon1d    =    -145   !  Column longitude (default at PAPA station)
ln_c1d_locpt=  .true.   ! Localization of 1D config in a grid (T) or independant point (F)
/
!-----------------------------------------------------------------------
&namtsd    !   data : Temperature  & Salinity
!-----------------------------------------------------------------------
!-----------------------------------------------------------------------
!          !  file name                            ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!          !                                       !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_tem  = 'data_1m_potential_temperature_nomask',         -1        ,'votemper' ,    .true.    , .true. , 'yearly'   , ''       ,   ''    ,    ''
sn_sal  = 'data_1m_salinity_nomask'             ,         -1        ,'vosaline' ,    .true.    , .true. , 'yearly'   , ''       ,   ''    ,    ''
!
cn_dir        = './'     !  root directory for the location of the runoff files
ln_tsd_init   = .true.   !  Initialisation of ocean T & S with T &S input data (T) or not (F)
ln_tsd_tradmp = .false.   !  damping of ocean T & S toward T &S input data (T) or not (F)
/
!!======================================================================
!!           ***  Surface Boundary Condition namelists  ***
!!======================================================================
!!   namsbc          surface boundary condition
!!   namsbc_ana      analytical         formulation
!!   namsbc_flx      flux               formulation
!!   namsbc_clio     CLIO bulk formulae formulation
!!   namsbc_core     CORE bulk formulae formulation
!!   namsbc_mfs      MFS  bulk formulae formulation
!!   namsbc_cpl      CouPLed            formulation                     ("key_oasis3")
!!   namsbc_sas      StAndalone Surface module
!!   namtra_qsr      penetrative solar radiation
!!   namsbc_rnf      river runoffs
!!   namsbc_isf      ice shelf melting/freezing
!!   namsbc_apr      Atmospheric Pressure
!!   namsbc_ssr      sea surface restoring term (for T and/or S)
!!   namsbc_alb      albedo parameters
!!======================================================================
!
!-----------------------------------------------------------------------
&namsbc        !   Surface Boundary Condition (surface module)
!-----------------------------------------------------------------------
nn_fsbc     = 1         !  frequency of surface boundary condition computation
!     (also = the frequency of sea-ice model call)
ln_ana      = .false.   !  analytical formulation                    (T => fill namsbc_ana )
ln_flx      = .false.   !  flux formulation                          (T => fill namsbc_flx )
ln_blk_clio = .false.   !  CLIO bulk formulation                     (T => fill namsbc_clio)
ln_blk_core = .true.    !  CORE bulk formulation                     (T => fill namsbc_core)
ln_blk_mfs  = .false.   !  MFS bulk formulation                      (T => fill namsbc_mfs )
```

```
ln_cpl      = .false.   !  atmosphere coupled   formulation          ( requires key_oasis3 )
ln_mixcpl   = .false.   !  forced-coupled mixed formulation          ( requires key_oasis3 )
nn_components = 0       !  configuration of the opa-sas OASIS coupling
!  =0 no opa-sas OASIS coupling: default single executable configuration
!  =1 opa-sas OASIS coupling: multi executable configuration, OPA component
!  =2 opa-sas OASIS coupling: multi executable configuration, SAS component
ln_apr_dyn  = .false.   !  Patm gradient added in ocean & ice Eqs.   (T => fill namsbc_apr )
nn_ice      = 2         !  =0 no ice boundary condition   ,
!  =1 use observed ice-cover      ,
!  =2 ice-model used                         ("key_lim3" or "key_lim2")
nn_ice_embd = 1         !  =0 levitating ice (no mass exchange, concentration/dilution effect)
!  =1 levitating ice with mass and salt exchange but no presure effect
!  =2 embedded sea-ice (full salt and mass exchanges and pressure)
ln_dm2dc    = .false.   !  daily mean to diurnal cycle on short wave
ln_rnf      = .true.    !  runoffs                                   (T   => fill namsbc_rnf)
nn_isf      = 0         !  ice shelf melting/freezing                (/=0 => fill namsbc_isf)
!  0 =no isf                  1 = presence of ISF
!  2 = bg03 parametrisation   3 = rnf file for isf
!  4 = ISF fwf specified
!  option 1 and 4 need ln_isfcav = .true. (domzgr)
ln_ssr      = .false.    !  Sea Surface Restoring on T and/or S       (T => fill namsbc_ssr)
nn_fwb      = 0         !  FreshWater Budget: =0 unchecked
!     =1 global mean of e-p-r set to zero at each time step
!     =2 annual global mean of e-p-r set to zero
ln_wave = .false.       !  Activate coupling with wave (either Stokes Drift or Drag coefficient, or both)  (T => fill namsbc_wave)
ln_cdgw = .false.       !  Neutral drag coefficient read from wave model (T => fill namsbc_wave)
ln_sdw  = .false.       !  Computation of 3D stokes drift               (T => fill namsbc_wave)
nn_lsm  = 0             !  =0 land/sea mask for input fields is not applied (keep empty land/sea mask filename field) ,
!  =1:n number of iterations of land/sea mask application for input fields (fill land/sea mask filename field)
nn_limflx = -1          !  LIM3 Multi-category heat flux formulation (use -1 if LIM3 is not used)
!  =-1  Use per-category fluxes, bypass redistributor, forced mode only, not yet implemented coupled
!  = 0  Average per-category fluxes (forced and coupled mode)
!  = 1  Average and redistribute per-category fluxes, forced mode only, not yet implemented coupled
!  = 2  Redistribute a single flux over categories (coupled mode only)
/
!-----------------------------------------------------------------------
&namsbc_ana    !   analytical surface boundary condition
!-----------------------------------------------------------------------
nn_tau000   =   0       !  gently increase the stress over the first ntau_rst time-steps
rn_utau0    =   0.5     !  uniform value for the i-stress
rn_vtau0    =   0.e0    !  uniform value for the j-stress
rn_qns0     =   0.e0    !  uniform value for the total heat flux
rn_qsr0     =   0.e0    !  uniform value for the solar radiation
rn_emp0     =   0.e0    !  uniform value for the freswater budget (E-P)
/
!-----------------------------------------------------------------------
&namsbc_flx    !   surface boundary condition : flux formulation
!-----------------------------------------------------------------------
!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_utau     = 'utau'      ,        24         , 'utau'    , .false.      , .false., 'yearly'  , ''       , ''       , ''
sn_vtau     = 'vtau'      ,        24         , 'vtau'    , .false.      , .false., 'yearly'  , ''       , ''       , ''
sn_qtot     = 'qtot'      ,        24         , 'qtot'    , .false.      , .false., 'yearly'  , ''       , ''       , ''
sn_qsr      = 'qsr'       ,        24         , 'qsr'     , .false.      , .false., 'yearly'  , ''       , ''       , ''
sn_emp      = 'emp'       ,        24         , 'emp'     , .false.      , .false., 'yearly'  , ''       , ''       , ''

cn_dir      = './'      !  root directory for the location of the flux files
/
!-----------------------------------------------------------------------
&namsbc_clio   !   namsbc_clio  CLIO bulk formulae
!-----------------------------------------------------------------------
!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_utau     = 'taux_1m'   ,       -1          , 'sozotaux',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_vtau     = 'tauy_1m'   ,       -1          , 'sometauy',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_wndm     = 'flx'       ,       -1          , 'socliowi',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_tair     = 'flx'       ,       -1          , 'socliot2',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_humi     = 'flx'       ,       -1          , 'socliohu',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_ccov     = 'flx'       ,       -1          , 'socliocl',   .false.    , .true. , 'yearly'  , ''       , ''       , ''
```

```
sn_prec     = 'flx'       ,       -1         , 'socliopl',   .false.    , .true. , 'yearly'  , ''       , ''       , ''

cn_dir      = './'      !  root directory for the location of the bulk files are
/
!-----------------------------------------------------------------------
&namsbc_core   !   namsbc_core  CORE bulk formulae
!-----------------------------------------------------------------------
!            !  file name                   ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights                               ! rotation !
!            !                              !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename                              ! pairing  !
sn_wndi     = 'u_10.15JUNE2009_fill'       ,         6         , 'U_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bicubic_noc.nc'   , 'Uwnd'   , ''
sn_wndj     = 'v_10.15JUNE2009_fill'       ,         6         , 'V_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bicubic_noc.nc'   , 'Vwnd'   , ''
sn_qsr      = 'ncar_rad.15JUNE2009_fill'   ,        24         , 'SWDN_MOD',   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bilinear_noc.nc'  , ''       , ''
sn_qlw      = 'ncar_rad.15JUNE2009_fill'   ,        24         , 'LWDN_MOD',   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bilinear_noc.nc'  , ''       , ''
sn_tair     = 't_10.15JUNE2009_fill'       ,         6         , 'T_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bilinear_noc.nc'  , ''       , ''
sn_humi     = 'q_10.15JUNE2009_fill'       ,         6         , 'Q_10_MOD',   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bilinear_noc.nc'  , ''       , ''
sn_prec     = 'ncar_precip.15JUNE2009_fill' ,        -1         , 'PRC_MOD1',   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bilinear_noc.nc'  , ''       , ''
sn_snow     = 'ncar_precip.15JUNE2009_fill' ,        -1         , 'SNOW'    ,   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bilinear_noc.nc'  , ''       , ''
sn_tdif     = 'taudif_core'                ,        24         , 'taudif'  ,   .false.    , .true. , 'yearly'  , 'weights_core_orca2_bilinear_noc.nc'  , ''       , ''

cn_dir      = './'      !  root directory for the location of the bulk files
ln_taudif   = .false.   !  HF tau contribution: use "mean of stress module - module of the mean stress" data
rn_zqt      = 10.        !  Air temperature and humidity reference height (m)
rn_zu       = 10.        !  Wind vector reference height (m)
rn_pfac     = 1.        !  multiplicative factor for precipitation (total & snow)
rn_efac     = 1.        !  multiplicative factor for evaporation (0. or 1.)
rn_vfac     = 0.        !  multiplicative factor for ocean/ice velocity
!  in the calculation of the wind stress (0.=absolute winds or 1.=relative winds)
/
!-----------------------------------------------------------------------
&namsbc_mfs   !   namsbc_mfs  MFS bulk formulae
!-----------------------------------------------------------------------
!            !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights     ! rotation ! land/sea mask !
!            !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename    ! pairing  ! filename      !
sn_wndi     =   'ecmwf'   ,        6          , 'u10'     ,    .true.    , .false. , 'daily'  ,'bicubic.nc' , ''       , ''
sn_wndj     =   'ecmwf'   ,        6          , 'v10'     ,    .true.    , .false. , 'daily'  ,'bicubic.nc' , ''       , ''
sn_clc      =   'ecmwf'   ,        6          , 'clc'     ,    .true.    , .false. , 'daily'  ,'bilinear.nc', ''       , ''
sn_msl      =   'ecmwf'   ,        6          , 'msl'     ,    .true.    , .false. , 'daily'  ,'bicubic.nc' , ''       , ''
sn_tair     =   'ecmwf'   ,        6          , 't2'      ,    .true.    , .false. , 'daily'  ,'bicubic.nc' , ''       , ''
sn_rhm      =   'ecmwf'   ,        6          , 'rh'      ,    .true.    , .false. , 'daily'  ,'bilinear.nc', ''       , ''
sn_prec     =   'ecmwf'   ,        6          , 'precip'  ,    .true.    , .true.  , 'daily'  ,'bicubic.nc' , ''       , ''

cn_dir      = './ECMWF/'      !  root directory for the location of the bulk files
/
!-----------------------------------------------------------------------
&namsbc_cpl    !   coupled ocean/atmosphere model                       ("key_oasis3")
!-----------------------------------------------------------------------
!                  !     description       !  multiple  !    vector   !      vector          ! vector !
!                  !                       ! categories !  reference  !    orientation       ! grids  !
! send
sn_snd_temp   =       'weighted oce and ice' ,    'no'    ,     ''      ,         ''           ,   ''
sn_snd_alb    =       'weighted ice'         ,    'no'    ,     ''      ,         ''           ,   ''
sn_snd_thick  =       'none'                 ,    'no'   ,    ''      ,         ''           ,   ''
sn_snd_crt    =       'none'                 ,    'no'    , 'spherical' , 'eastward-northward' ,  'T'
sn_snd_co2    =       'coupled'              ,    'no'    ,     ''      ,         ''           ,   ''
! receive
sn_rcv_w10m   =       'none'                 ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_taumod =       'coupled'              ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_tau    =       'oce only'             ,    'no'    , 'cartesian' , 'eastward-northward',  'U,V'
sn_rcv_dqnsdt =       'coupled'              ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_qsr    =       'oce and ice'          ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_qns    =       'oce and ice'          ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_emp    =       'conservative'         ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_rnf    =       'coupled'              ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_cal    =       'coupled'              ,    'no'    ,     ''      ,         ''          ,  ''
sn_rcv_co2    =       'coupled'              ,    'no'    ,     ''      ,         ''          ,  ''
!
nn_cplmodel   =     1     !  Maximum number of models to/from which NEMO is potentialy sending/receiving data
ln_usecplmask = .false.   !  use a coupling mask file to merge data received from several models
!   -> file cplmask.nc with the float variable called cplmask (jpi,jpj,nn_cplmodel)
```

```
/
!-----------------------------------------------------------------------
&namsbc_sas    !   analytical surface boundary condition
!-----------------------------------------------------------------------
!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_usp      = 'sas_grid_U' ,    120          , 'vozocrtx' ,  .true.    , .true. ,   'yearly'  , ''       , ''             , ''
sn_vsp      = 'sas_grid_V' ,    120          , 'vomecrty' ,  .true.    , .true. ,   'yearly'  , ''       , ''             , ''
sn_tem      = 'sas_grid_T' ,    120          , 'sosstsst' ,  .true.    , .true. ,   'yearly'  , ''       , ''             , ''
sn_sal      = 'sas_grid_T' ,    120          , 'sosaline' ,  .true.    , .true. ,   'yearly'  , ''       , ''             , ''
sn_ssh      = 'sas_grid_T' ,    120          , 'sossheig' ,  .true.    , .true. ,   'yearly'  , ''       , ''             , ''
sn_e3t      = 'sas_grid_T' ,    120          , 'e3t_m'    ,  .true.    , .true. ,   'yearly'  , ''       , ''             , ''
sn_frq      = 'sas_grid_T' ,    120          , 'frq_m'    ,  .true.    , .true. ,   'yearly'  , ''       , ''             , ''

ln_3d_uve   = .true.    !  specify whether we are supplying a 3D u,v and e3 field
ln_read_frq = .false.    !  specify whether we must read frq or not
cn_dir      = './'      !  root directory for the location of the bulk files are
/
!-----------------------------------------------------------------------
&namtra_qsr    !   penetrative solar radiation
!-----------------------------------------------------------------------
!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_chl      ='chlorophyll',        -1         , 'CHLA'    ,   .true.     , .true. , 'yearly'  , ''       , ''       , ''

cn_dir      = './'      !  root directory for the location of the runoff files
ln_traqsr   = .true.    !  Light penetration (T) or not (F)
ln_qsr_rgb  = .false.    !  RGB (Red-Green-Blue) light penetration
ln_qsr_2bd  = .true.   !  2 bands              light penetration
ln_qsr_bio  = .false.   !  bio-model light penetration
nn_chldta   =      1    !  RGB : 2D Chl data (=1), 3D Chl data (=2) or cst value (=0)
rn_abs      =   0.58    !  RGB & 2 bands: fraction of light (rn_si1)
rn_si0      =   0.35    !  RGB & 2 bands: shortess depth of extinction
rn_si1      =   23.0    !  2 bands: longest depth of extinction
ln_qsr_ice  = .true.    !  light penetration for ice-model LIM3
/
!-----------------------------------------------------------------------
&namsbc_rnf    !   runoffs namelist surface boundary condition
!-----------------------------------------------------------------------
!              !  file name           ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !                      !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_rnf      = 'runoff_core_monthly',        -1         , 'sorunoff',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_cnf      = 'runoff_core_monthly',         0         , 'socoefr0',   .false.    , .true. , 'yearly'  , ''       , ''       , ''
sn_s_rnf    = 'runoffs'            ,        24         , 'rosaline',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_t_rnf    = 'runoffs'            ,        24         , 'rotemper',   .true.     , .true. , 'yearly'  , ''       , ''       , ''
sn_dep_rnf  = 'runoffs'            ,         0         , 'rodepth' ,   .false.    , .true. , 'yearly'  , ''       , ''       , ''

cn_dir       = './'      !  root directory for the location of the runoff files
ln_rnf_mouth = .true.    !  specific treatment at rivers mouths
rn_hrnf      =  15.e0    !  depth over which enhanced vertical mixing is used
rn_avt_rnf   =   1.e-3   !  value of the additional vertical mixing coef. [m2/s]
rn_rfact     =   1.e0    !  multiplicative factor for runoff
ln_rnf_depth = .false.   !  read in depth information for runoff
ln_rnf_tem   = .false.   !  read in temperature information for runoff
ln_rnf_sal   = .false.   !  read in salinity information for runoff
ln_rnf_depth_ini = .false.  ! compute depth at initialisation from runoff file
rn_rnf_max   = 5.735e-4  !  max value of the runoff climatologie over global domain ( ln_rnf_depth_ini = .true )
rn_dep_max   = 150.      !  depth over which runoffs is spread ( ln_rnf_depth_ini = .true )
nn_rnf_depth_file = 0    !  create (=1) a runoff depth file or not (=0)
/
!-----------------------------------------------------------------------
&namsbc_isf    !  Top boundary layer (ISF)
!-----------------------------------------------------------------------
!              ! file name ! frequency (hours) ! variable ! time interpol. !  clim   ! 'yearly'/ ! weights  ! rotation !
!              !           !  (if <0  months)  !   name   !    (logical)   !  (T/F)  ! 'monthly' ! filename ! pairing  !
! nn_isf == 4
sn_qisf      = 'rnfisf' ,         -12      ,'sohflisf',    .false.      , .true.  , 'yearly'  ,  ''      ,  ''
sn_fwfisf    = 'rnfisf' ,         -12      ,'sowflisf',    .false.      , .true.  , 'yearly'  ,  ''      ,  ''
! nn_isf == 3
```

```
sn_rnfisf    = 'runoffs' ,         -12      ,'sofwfisf',    .false.      , .true.  , 'yearly'  ,  ''      ,   ''
! nn_isf == 2 and 3
sn_depmax_isf = 'runoffs' ,       -12        ,'sozisfmax' ,   .false.  , .true.  , 'yearly'  ,  ''      ,   ''
sn_depmin_isf = 'runoffs' ,       -12        ,'sozisfmin' ,   .false.  , .true.  , 'yearly'  ,  ''      ,   ''
! nn_isf == 2
sn_Leff_isf = 'rnfisf' ,       0          ,'Leff'         ,   .false.  , .true.  , 'yearly'  ,  ''      ,   ''
! for all case
ln_divisf   = .true.  ! apply isf melting as a mass flux or in the salinity trend. (maybe I should remove this option as for runoff?)
! only for nn_isf = 1 or 2
rn_gammat0  = 1.0e-4   ! gammat coefficient used in blk formula
rn_gammas0  = 1.0e-4   ! gammas coefficient used in blk formula
! only for nn_isf = 1
nn_isfblk   =  1       ! 1 ISOMIP ; 2 conservative (3 equation formulation, Jenkins et al. 1991 ??)
rn_hisf_tbl =  30.      ! thickness of the top boundary layer           (Losh et al. 2008)
! 0 => thickness of the tbl = thickness of the first wet cell
ln_conserve = .true.   ! conservative case (take into account meltwater advection)
nn_gammablk = 1        ! 0 = cst Gammat (= gammat/s)
! 1 = velocity dependend Gamma (u* * gammat/s)  (Jenkins et al. 2010)
!     if you want to keep the cd as in global config, adjust rn_gammat0 to compensate
! 2 = velocity and stability dependent Gamma    Holland et al. 1999
/
!-----------------------------------------------------------------------
&namsbc_apr    !   Atmospheric pressure used as ocean forcing or in bulk
!-----------------------------------------------------------------------
!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_apr      = 'patm'      ,         -1        ,'somslpre',    .true.     , .true. , 'yearly'  ,  ''      ,   ''     , ''

cn_dir      = './'      !  root directory for the location of the bulk files
rn_pref     = 101000.    !  reference atmospheric pressure   [N/m2]/
ln_ref_apr  = .false.    !  ref. pressure: global mean Patm (T) or a constant (F)
ln_apr_obc  = .false.    !  inverse barometer added to OBC ssh data
/
!-----------------------------------------------------------------------
&namsbc_ssr    !   surface boundary condition : sea surface restoring
!-----------------------------------------------------------------------
!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_sst      = 'sst_data'  ,        -1         ,  'sst'    ,    .true.    , .true., 'yearly'  , ''       , ''       , ''
sn_sss      = 'sss_data'  ,        -1         ,  'sss'    ,    .true.    , .true. , 'yearly'  , ''       , ''       , ''

cn_dir      = './'      !  root directory for the location of the runoff files
nn_sstr     =     0     !  add a retroaction term in the surface heat       flux (=1) or not (=0)
nn_sssr     =     0     !  add a damping     term in the surface freshwater flux (=2)
!  or to SSS only (=1) or no damping term (=0)
rn_dqdt     =   -40.    !  magnitude of the retroaction on temperature   [W/m2/K]
rn_deds     =  -166.67  !  magnitude of the damping on salinity   [mm/day]
ln_sssr_bnd =   .false.  !  flag to bound erp term (associated with nn_sssr=2)
rn_sssr_bnd =   4.e0    !  ABS(Max/Min) value of the damping erp term [mm/day]
/
!-----------------------------------------------------------------------
&namsbc_alb    !   albedo parameters
!-----------------------------------------------------------------------
nn_ice_alb   =    1   !  parameterization of ice/snow albedo
!     0: Shine & Henderson-Sellers (JGR 1985), giving clear-sky albedo
!     1: "home made" based on Brandt et al. (JClim 2005) and Grenfell & Perovich (JGR 2004),
!        giving cloud-sky albedo
rn_alb_sdry  =  0.85  !  dry snow albedo         : 0.80 (nn_ice_alb = 0); 0.85 (nn_ice_alb = 1); obs 0.85-0.87 (cloud-sky)
rn_alb_smlt  =  0.75  !  melting snow albedo     : 0.65 ( '' )          ; 0.75 ( '' )          ; obs 0.72-0.82 ( '' )
rn_alb_idry  =  0.60  !  dry ice albedo          : 0.72 ( '' )          ; 0.60 ( '' )          ; obs 0.54-0.65 ( '' )
rn_alb_imlt  =  0.50  !  bare puddled ice albedo : 0.53 ( '' )          ; 0.50 ( '' )          ; obs 0.49-0.58 ( '' )
/
!-----------------------------------------------------------------------
&namberg       !   iceberg parameters
!-----------------------------------------------------------------------
ln_icebergs              = .false.
ln_bergdia               = .true.              ! Calculate budgets
nn_verbose_level         = 1                   ! Turn on more verbose output if level > 0
nn_verbose_write         = 15                  ! Timesteps between verbose messages
```

```
nn_sample_rate           = 1                   ! Timesteps between sampling for trajectory storage
! Initial mass required for an iceberg of each class
rn_initial_mass          = 8.8e7, 4.1e8, 3.3e9, 1.8e10, 3.8e10, 7.5e10, 1.2e11, 2.2e11, 3.9e11, 7.4e11
! Proportion of calving mass to apportion to each class
rn_distribution          = 0.24, 0.12, 0.15, 0.18, 0.12, 0.07, 0.03, 0.03, 0.03, 0.02
! Ratio between effective and real iceberg mass (non-dim)
! i.e. number of icebergs represented at a point
rn_mass_scaling          = 2000, 200, 50, 20, 10, 5, 2, 1, 1, 1
! thickness of newly calved bergs (m)
rn_initial_thickness     = 40., 67., 133., 175., 250., 250., 250., 250., 250., 250.
rn_rho_bergs             = 850.                ! Density of icebergs
rn_LoW_ratio             = 1.5                 ! Initial ratio L/W for newly calved icebergs
ln_operator_splitting    = .true.              ! Use first order operator splitting for thermodynamics
rn_bits_erosion_fraction = 0.                  ! Fraction of erosion melt flux to divert to bergy bits
rn_sicn_shift            = 0.                  ! Shift of sea-ice concn in erosion flux (0<sicn_shift<1)
ln_passive_mode          = .false.             ! iceberg - ocean decoupling
nn_test_icebergs         =  10                 ! Create test icebergs of this class (-1 = no)
! Put a test iceberg at each gridpoint in box (lon1,lon2,lat1,lat2)
rn_test_box              = 108.0,  116.0, -66.0, -58.0
rn_speed_limit           = 0.                  ! CFL speed limit for a berg

!             ! file name ! frequency (hours) !   variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!             !           !  (if <0  months)  !     name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !
sn_icb =  'calving' ,       -1          , 'calvingmask',  .true.        , .true.  , 'yearly'  , ''       , ''       , ''

cn_dir = './'
/

!!======================================================================
!!              ***  Lateral boundary condition  ***
!!======================================================================
!!   namlbc        lateral momentum boundary condition
!!   namcla        cross land advection
!!   namagrif      agrif nested grid ( read by child model only )       ("key_agrif")
!!   nambdy        Unstructured open boundaries                         ("key_bdy")
!!   namtide       Tidal forcing at open boundaries                     ("key_bdy_tides")
!!======================================================================
!
!-----------------------------------------------------------------------
&namlbc        !   lateral momentum boundary condition
!-----------------------------------------------------------------------
rn_shlat    =    1.     !  shlat = 0  !  0 < shlat < 2  !  shlat = 2  !  2 < shlat
!  free slip  !   partial slip  !   no slip   ! strong slip
ln_vorlat   = .false.   !  consistency of vorticity boundary condition with analytical eqs.
/
!-----------------------------------------------------------------------
&namcla        !   cross land advection
!-----------------------------------------------------------------------
nn_cla      =    0      !  advection between 2 ocean pts separates by land
/
!-----------------------------------------------------------------------
&namagrif      !  AGRIF zoom                                            ("key_agrif")
!-----------------------------------------------------------------------
nn_cln_update =    3    !  baroclinic update frequency
ln_spc_dyn    = .true.  !  use 0 as special value for dynamics
rn_sponge_tra = 2880.   !  coefficient for tracer   sponge layer [m2/s]
rn_sponge_dyn = 2880.   !  coefficient for dynamics sponge layer [m2/s]
/
!-----------------------------------------------------------------------
&nam_tide      !   tide parameters (#ifdef key_tide)
!-----------------------------------------------------------------------
ln_tide_pot   = .true.   !  use tidal potential forcing
ln_tide_ramp  = .false.  !
rdttideramp   =    0.    !
clname(1)     = 'DUMMY'  !  name of constituent - all tidal components must be set in namelist_cfg
/
!-----------------------------------------------------------------------
&nambdy        !  unstructured open boundaries                          ("key_bdy")
!-----------------------------------------------------------------------
```

```
nb_bdy         = 0                    !  number of open boundary sets
ln_coords_file = .true.               !  =T : read bdy coordinates from file
cn_coords_file = 'coordinates.bdy.nc' !  bdy coordinates files
ln_mask_file   = .false.              !  =T : read mask from file
cn_mask_file   = ''                   !  name of mask file (if ln_mask_file=.TRUE.)
cn_dyn2d       = 'none'               !
nn_dyn2d_dta   =  0                   !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
!  = 2, use tidal harmonic forcing data from files
!  = 3, use external data AND tidal harmonic forcing
cn_dyn3d      =  'none'               !
nn_dyn3d_dta  =  0                    !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
cn_tra        =  'none'               !
nn_tra_dta    =  0                    !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
cn_ice_lim      =  'none'             !
nn_ice_lim_dta  =  0                  !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
rn_ice_tem      = 270.                !  lim3 only: arbitrary temperature of incoming sea ice
rn_ice_sal      = 10.                 !  lim3 only:      --   salinity           --
rn_ice_age      = 30.                 !  lim3 only:      --   age                --

ln_tra_dmp    =.false.                !  open boudaries conditions for tracers
ln_dyn3d_dmp  =.false.                !  open boundary condition for baroclinic velocities
rn_time_dmp   =  1.                   ! Damping time scale in days
rn_time_dmp_out =  1.                 ! Outflow damping time scale
nn_rimwidth   = 10                    !  width of the relaxation zone
ln_vol        = .false.               !  total volume correction (see nn_volctl parameter)
nn_volctl     = 1                     !  = 0, the total water flux across open boundaries is zero
/
!-----------------------------------------------------------------------
&nambdy_dta      !  open boundaries - external data           ("key_bdy")
!-----------------------------------------------------------------------
!              !  file name      ! frequency (hours) ! variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !                 !  (if <0  months)  !   name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !
bn_ssh =     'amm12_bdyT_u2d' ,         24        , 'sossheig' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
bn_u2d =     'amm12_bdyU_u2d' ,         24        , 'vobtcrtx' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
bn_v2d =     'amm12_bdyV_u2d' ,         24        , 'vobtcrty' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
bn_u3d  =    'amm12_bdyU_u3d' ,         24        , 'vozocrtx' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
bn_v3d  =    'amm12_bdyV_u3d' ,         24        , 'vomecrty' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
bn_tem  =    'amm12_bdyT_tra' ,         24        , 'votemper' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
bn_sal  =    'amm12_bdyT_tra' ,         24        , 'vosaline' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
! for lim2
!   bn_frld  =    'amm12_bdyT_ice' ,         24        , 'ileadfra' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
!   bn_hicif =    'amm12_bdyT_ice' ,         24        , 'iicethic' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
!   bn_hsnif =    'amm12_bdyT_ice' ,         24        , 'isnowthi' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
! for lim3
!   bn_a_i  =    'amm12_bdyT_ice' ,         24        , 'ileadfra' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
!   bn_ht_i =    'amm12_bdyT_ice' ,         24        , 'iicethic' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
!   bn_ht_s =    'amm12_bdyT_ice' ,         24        , 'isnowthi' ,     .true.     , .false. ,  'daily'  ,    ''    ,   ''     , ''
cn_dir  =    'bdydta/'
ln_full_vel = .false.
/
!-----------------------------------------------------------------------
&nambdy_tide     ! tidal forcing at open boundaries
!-----------------------------------------------------------------------
filtide          = 'bdydta/amm12_bdytide_'         !  file name root of tidal forcing files
ln_bdytide_2ddta = .false.
ln_bdytide_conj  = .false.
/
!!======================================================================
!!                 ***  Bottom boundary condition  ***
!!======================================================================
!!   nambfr        bottom friction
!!   nambbc        bottom temperature boundary condition
!!   nambbl        bottom boundary layer scheme                         ("key_trabbl")
!!======================================================================
!
```

```
!-----------------------------------------------------------------------
&nambfr        !   bottom friction
!-----------------------------------------------------------------------
nn_bfr      =    2      !  type of bottom friction :   = 0 : free slip,  = 1 : linear friction
!                             = 2 : nonlinear friction
rn_bfri1    =    4.e-4  !  bottom drag coefficient (linear case)
rn_bfri2    =    1.e-3  !  bottom drag coefficient (non linear case). Minimum coeft if ln_loglayer=T
rn_bfri2_max =   1.e-2  !  max. bottom drag coefficient (non linear case and ln_loglayer=T)
rn_bfeb2    =    2.5e-3 !  bottom turbulent kinetic energy background  (m2/s2)
rn_bfrz0    =    3.e-3  !  bottom roughness [m] if ln_loglayer=T
ln_bfr2d    = .false.   !  horizontal variation of the bottom friction coef (read a 2D mask file )
rn_bfrien   =    5.    !  local multiplying factor of bfr (ln_bfr2d=T)
rn_tfri1    =    4.e-4  !  top drag coefficient (linear case)
rn_tfri2    =    2.5e-3 !  top drag coefficient (non linear case). Minimum coeft if ln_loglayer=T
rn_tfri2_max =   1.e-1  !  max. top drag coefficient (non linear case and ln_loglayer=T)
rn_tfeb2    =    0.0    !  top turbulent kinetic energy background  (m2/s2)
rn_tfrz0    =    3.e-3  !  top roughness [m] if ln_loglayer=T
ln_tfr2d    = .false.   !  horizontal variation of the top friction coef (read a 2D mask file )
rn_tfrien   =    50.    !  local multiplying factor of tfr (ln_tfr2d=T)

ln_bfrimp   = .true.    !  implicit bottom friction (requires ln_zdfexp = .false. if true)
ln_loglayer = .true.   !  logarithmic formulation (non linear case)
/
!-----------------------------------------------------------------------
&nambbc        !   bottom temperature boundary condition
!-----------------------------------------------------------------------
!              !                              !  (if <0  months)  !
!              !  file name      ! frequency (hours) ! variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !                 !  (if <0  months)  !   name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !
sn_qgh      ='geothermal_heating.nc',  -12.  , 'heatflow'      ,   .false.      , .true.  , 'yearly'  , ''       , ''       , ''
!
cn_dir      = './'      !  root directory for the location of the runoff files
ln_trabbc   = .false.    !  Apply a geothermal heating at the ocean bottom
nn_geoflx   =    2      !  geothermal heat flux: = 0 no flux
!     = 1 constant flux
!     = 2 variable flux (read in geothermal_heating.nc in mW/m2)
rn_geoflx_cst = 86.4e-3 !  Constant value of geothermal heat flux [W/m2]

/
!-----------------------------------------------------------------------
&nambbl        !   bottom boundary layer scheme
!-----------------------------------------------------------------------
nn_bbl_ldf  =  0      !  diffusive bbl (=1)   or not (=0)
nn_bbl_adv  =  0      !  advective bbl (=1/2) or not (=0)
rn_ahtbbl   =  1000.  !  lateral mixing coefficient in the bbl  [m2/s]
rn_gambbl   =  10.    !  advective bbl coefficient                 [s]
/

!!======================================================================
!!                       Tracer (T & S ) namelists
!!======================================================================
!!   nameos        equation of state
!!   namtra_adv    advection scheme
!!   namtra_adv_mle   mixed layer eddy param. (Fox-Kemper param.)
!!   namtra_ldf    lateral diffusion scheme
!!   namtra_dmp    T & S newtonian damping
!!======================================================================
!
!-----------------------------------------------------------------------
&nameos        !   ocean physical parameters
!-----------------------------------------------------------------------
nn_eos      = 0     !  type of equation of state and Brunt-Vaisala frequency
!  =-1, TEOS-10
!  = 0, EOS-80
!  = 1, S-EOS   (simplified eos)
ln_useCT    = .false.  ! use of Conservative Temp. ==> surface CT converted in Pot. Temp. in sbcssm
!                             !
!                    ! S-EOS coefficients :
!                             !  rd(T,S,Z)*rau0 = -a0*(1+.5*lambda*dT+mu*Z+nu*dS)*dT+b0*dS
```

```
rn_a0       =  1.6550e-1      !  thermal expension coefficient (nn_eos= 1)
rn_b0       =  7.6554e-1      !  saline  expension coefficient (nn_eos= 1)
rn_lambda1  =  5.9520e-2      !  cabbeling coeff in T^2  (=0 for linear eos)
rn_lambda2  =  7.4914e-4      !  cabbeling coeff in S^2  (=0 for linear eos)
rn_mu1      =  1.4970e-4      !  thermobaric coeff. in T (=0 for linear eos)
rn_mu2      =  1.1090e-5      !  thermobaric coeff. in S (=0 for linear eos)
rn_nu       =  2.4341e-3      !  cabbeling coeff in T*S  (=0 for linear eos)
/
!-----------------------------------------------------------------------
&namtra_adv    !   advection scheme for tracer
!-----------------------------------------------------------------------
ln_traadv_cen2   =  .false.   !  2nd order centered scheme
ln_traadv_tvd    =  .false.    !  TVD scheme
ln_traadv_muscl  =  .false.   !  MUSCL scheme
ln_traadv_muscl2 =  .false.   !  MUSCL2 scheme + cen2 at boundaries
ln_traadv_ubs    =  .false.   !  UBS scheme
ln_traadv_qck    =  .false.   !  QUICKEST scheme
ln_traadv_msc_ups=  .false.   !  use upstream scheme within muscl
ln_traadv_tvd_zts=  .true.   !  TVD scheme with sub-timestepping of vertical tracer advection
nn_traadv_tvd_zts=     5      !     number of sub-time steps for ln_traadv_tvd_zts=T
/
!-----------------------------------------------------------------------
&namtra_adv_mle !   mixed layer eddy parametrisation (Fox-Kemper param)
!-----------------------------------------------------------------------
ln_mle    = .true.      ! (T) use the Mixed Layer Eddy (MLE) parameterisation
rn_ce     = 0.06        ! magnitude of the MLE (typical value: 0.06 to 0.08)
nn_mle    = 1           ! MLE type: =0 standard Fox-Kemper ; =1 new formulation
rn_lf     = 5.e+3       ! typical scale of mixed layer front (meters)                      (case rn_mle=0)
rn_time   = 172800.     ! time scale for mixing momentum across the mixed layer (seconds)  (case rn_mle=0)
rn_lat    = 20.         ! reference latitude (degrees) of MLE coef.                        (case rn_mle=1)
nn_mld_uv = 0           ! space interpolation of MLD at u- & v-pts (0=min,1=averaged,2=max)
nn_conv   = 0           ! =1 no MLE in case of convection ; =0 always MLE
rn_rho_c_mle  = 0.01    ! delta rho criterion used to calculate MLD for FK
/
!----------------------------------------------------------------------------------
&namtra_ldf    !   lateral diffusion scheme for tracers
!----------------------------------------------------------------------------------
!                       !  Operator type:
ln_traldf_lap    =  .true.   !  laplacian operator
ln_traldf_bilap  =  .false.  !  bilaplacian operator
!                       !  Direction of action:
ln_traldf_level  =  .false.  !  iso-level
ln_traldf_hor    =  .false.  !  horizontal (geopotential)   (needs "key_ldfslp" when ln_sco=T)
ln_traldf_iso    =  .true.   !  iso-neutral                 (needs "key_ldfslp")
!           !  Griffies parameters             (all need "key_ldfslp")
ln_traldf_grif   =  .false.  !  use griffies triads
ln_traldf_gdia   =  .false.  !  output griffies eddy velocities
ln_triad_iso     =  .false.  !  pure lateral mixing in ML
ln_botmix_grif   =  .false.  !  lateral mixing on bottom
!                       !  Coefficients
! Eddy-induced (GM) advection always used with Griffies; otherwise needs "key_traldf_eiv"
! Value rn_aeiv_0 is ignored unless = 0 with Held-Larichev spatially varying aeiv
!                                  (key_traldf_c2d & key_traldf_eiv & key_orca_r2, _r1 or _r05)
rn_aeiv_0        = 0.    !  eddy induced velocity coefficient [m2/s]
rn_aht_0         =  0.1   !  horizontal eddy diffusivity for tracers [m2/s]
rn_ahtb_0        =     0.    !  background eddy diffusivity for ldf_iso [m2/s]
!                                           (normally=0; not used with Griffies)
rn_slpmax        =     0.01  !  slope limit
rn_chsmag        =     1.    !  multiplicative factor in Smagorinsky diffusivity
rn_smsh          =     0.    !  Smagorinsky diffusivity: = 0 - use only sheer
rn_aht_m         =  2000.    !  upper limit or stability criteria for lateral eddy diffusivity (m2/s)
/
!-----------------------------------------------------------------------
&namtra_dmp    !   tracer: T & S newtonian damping
!-----------------------------------------------------------------------
ln_tradmp   =  .false.   !  add a damping termn (T) or not (F)
nn_zdmp     =    0      !  vertical   shape =0    damping throughout the water column
!                  =1 no damping in the mixing layer (kz  criteria)
!                  =2 no damping in the mixed  layer (rho crieria)
```

```
cn_resto    = 'resto.nc' ! Name of file containing restoration coefficient field (use dmp_tools to create this)
/

!!======================================================================
!!                     ***  Dynamics namelists  ***
!!======================================================================
!!   namdyn_adv    formulation of the momentum advection
!!   namdyn_vor    advection scheme
!!   namdyn_hpg    hydrostatic pressure gradient
!!   namdyn_spg    surface pressure gradient                            (CPP key only)
!!   namdyn_ldf    lateral diffusion scheme
!!======================================================================
!
!-----------------------------------------------------------------------
&namdyn_adv    !   formulation of the momentum advection
!-----------------------------------------------------------------------
ln_dynadv_vec = .true.  !  vector form (T) or flux form (F)
nn_dynkeg     = 1       ! scheme for grad(KE): =0   C2  ;  =1   Hollingsworth correction
ln_dynadv_cen2= .false. !  flux form - 2nd order centered scheme
ln_dynadv_ubs = .false. !  flux form - 3rd order UBS      scheme
ln_dynzad_zts = .true. !  Use (T) sub timestepping for vertical momentum advection
nn_dynzad_zts =    5    !     number of sub-time steps for ln_dynzad_zts=T
/
!-----------------------------------------------------------------------
&nam_vvl    !   vertical coordinate options
!-----------------------------------------------------------------------
ln_vvl_zstar  = .true.           !  zstar vertical coordinate
ln_vvl_ztilde = .false.          !  ztilde vertical coordinate: only high frequency variations
ln_vvl_layer  = .false.          !  full layer vertical coordinate
ln_vvl_ztilde_as_zstar = .false. !  ztilde vertical coordinate emulating zstar
ln_vvl_zstar_at_eqtor = .false.  !  ztilde near the equator
rn_ahe3       = 0.0e0            !  thickness diffusion coefficient
rn_rst_e3t    = 30.e0            !  ztilde to zstar restoration timescale [days]
rn_lf_cutoff  = 5.0e0            !  cutoff frequency for low-pass filter  [days]
rn_zdef_max   = 0.9e0            !  maximum fractional e3t deformation
ln_vvl_dbg    = .false.           !  debug prints    (T/F)
/
!-----------------------------------------------------------------------
&namdyn_vor    !   option of physics/algorithm (not control by CPP keys)
!-----------------------------------------------------------------------
ln_dynvor_ene = .false. !  enstrophy conserving scheme
ln_dynvor_ens = .false. !  energy conserving scheme
ln_dynvor_mix = .false. !  mixed scheme
ln_dynvor_een = .false.  !  energy & enstrophy scheme
ln_dynvor_een_old = .true.  !  energy & enstrophy scheme - original formulation
/
!-----------------------------------------------------------------------
&namdyn_hpg    !   Hydrostatic pressure gradient option
!-----------------------------------------------------------------------
ln_hpg_zco  = .false.   !  z-coordinate - full steps
ln_hpg_zps  = .false.    !  z-coordinate - partial steps (interpolation)
ln_hpg_sco  = .true.   !  s-coordinate (standard jacobian formulation)
ln_hpg_isf  = .false.   !  s-coordinate (sco ) adapted to isf
ln_hpg_djc  = .false.   !  s-coordinate (Density Jacobian with Cubic polynomial)
ln_hpg_prj  = .false.   !  s-coordinate (Pressure Jacobian scheme)
ln_dynhpg_imp = .false. !  time stepping: semi-implicit time scheme  (T)
!          centered      time scheme  (F)
/
!-----------------------------------------------------------------------
!namdyn_spg    !   surface pressure gradient   (CPP key only)
!-----------------------------------------------------------------------
!                         !  explicit free surface                    ("key_dynspg_exp")
!                         !  filtered free surface                    ("key_dynspg_flt")
!                         !  split-explicit free surface              ("key_dynspg_ts")

!-----------------------------------------------------------------------
&namdyn_ldf    !   lateral diffusion on momentum
!-----------------------------------------------------------------------
!                      !  Type of the operator :
```

```
ln_dynldf_lap    =  .true.   !  laplacian operator
ln_dynldf_bilap  =  .false.  !  bilaplacian operator
!                        !  Direction of action  :
ln_dynldf_level  =  .false.  !  iso-level
ln_dynldf_hor    =  .true.   !  horizontal (geopotential)            (require "key_ldfslp" in s-coord.)
ln_dynldf_iso    =  .false.  !  iso-neutral                          (require "key_ldfslp")
!                        !  Coefficient
rn_ahm_0_lap     = 0.1   !  horizontal laplacian eddy viscosity   [m2/s]
rn_ahmb_0        =     0.    !  background eddy viscosity for ldf_iso [m2/s]
rn_ahm_0_blp     =     -1.e8    !  horizontal bilaplacian eddy viscosity [m4/s]
rn_cmsmag_1      =     1.    !  constant in laplacian Smagorinsky viscosity
rn_cmsmag_2      =     3.     !  constant in bilaplacian Smagorinsky viscosity
rn_cmsh          =     0.    !  1 or 0 , if 0 -use only shear for Smagorinsky viscosity
rn_ahm_m_blp     =    -1.e12 !  upper limit for bilap  abs(ahm) < min( dx^4/128rdt, rn_ahm_m_blp)
rn_ahm_m_lap     = 10000.    !  upper limit for lap  ahm < min(dx^2/16rdt, rn_ahm_m_lap)
/

!!======================================================================
!!            Tracers & Dynamics vertical physics namelists
!!======================================================================
!!    namzdf           vertical physics
!!    namzdf_ric       richardson number dependent vertical mixing     ("key_zdfric")
!!    namzdf_tke       TKE dependent vertical mixing                   ("key_zdftke")
!!    namzdf_kpp       KPP dependent vertical mixing                   ("key_zdfkpp")
!!    namzdf_ddm       double diffusive mixing parameterization        ("key_zdfddm")
!!    namzdf_tmx       tidal mixing parameterization                   ("key_zdftmx")
!!    namzdf_tmx_new   new tidal mixing parameterization               ("key_zdftmx_new")
!!======================================================================
!
!-----------------------------------------------------------------------
&namzdf        !   vertical physics
!-----------------------------------------------------------------------
rn_avm0     =   1.0e-5  !  vertical eddy viscosity   [m2/s]          (background Kz if not "key_zdfcst")
rn_avt0     =   1.0e-6  !  vertical eddy diffusivity [m2/s]          (background Kz if not "key_zdfcst")
nn_avb      =    0      !  profile for background avt & avm (=1) or not (=0)
nn_havtb    =    0      !  horizontal shape for avtb (=1) or not (=0)
ln_zdfevd   = .true.    !  enhanced vertical diffusion (evd) (T) or not (F)
nn_evdm     =    0      !  evd apply on tracer (=0) or on tracer and momentum (=1)
rn_avevd    =  10.     !  evd mixing coefficient [m2/s]
ln_zdfnpc   = .false.   !  Non-Penetrative Convective algorithm (T) or not (F)
nn_npc      =    0            !  frequency of application of npc
nn_npcp     =  365            !  npc control print frequency
ln_zdfexp   = .false.   !  time-stepping: split-explicit (T) or implicit (F) time stepping
nn_zdfexp   =    3            !  number of sub-timestep for ln_zdfexp=T
/
!-----------------------------------------------------------------------
&namzdf_ric    !   richardson number dependent vertical diffusion       ("key_zdfric" )
!-----------------------------------------------------------------------
rn_avmri    = 100.e-4   !  maximum value of the vertical viscosity
rn_alp      =   5.      !  coefficient of the parameterization
nn_ric      =   2       !  coefficient of the parameterization
rn_ekmfc    =   0.7     !  Factor in the Ekman depth Equation
rn_mldmin   =   1.0     !  minimum allowable mixed-layer depth estimate (m)
rn_mldmax   =1000.0     !  maximum allowable mixed-layer depth estimate (m)
rn_wtmix    =  10.0     !  vertical eddy viscosity coeff [m2/s] in the mixed-layer
rn_wvmix    =  10.0     !  vertical eddy diffusion coeff [m2/s] in the mixed-layer
ln_mldw     = .true.    !  Flag to use or not the mized layer depth param.
/
!-----------------------------------------------------------------------
&namzdf_tke    !   turbulent eddy kinetic dependent vertical diffusion  ("key_zdftke")
!-----------------------------------------------------------------------
rn_ediff    =   0.1     !  coef. for vertical eddy coef. (avt=rn_ediff*mxl*sqrt(e) )
rn_ediss    =   0.7     !  coef. of the Kolmogoroff dissipation
rn_ebb      =  60.    !  coef. of the surface input of tke (=67.83 suggested when ln_mxl0=T)
rn_emin     =   1.e-6   !  minimum value of tke [m2/s2]
rn_emin0    =   1.e-4   !  surface minimum value of tke [m2/s2]
rn_bshear   =   1.e-20  ! background shear (>0) currently a numerical threshold (do not change it)
nn_mxl      =   3       !  mixing length: = 0 bounded by the distance to surface and bottom
!                 = 1 bounded by the local vertical scale factor
```

```
!                 = 2 first vertical derivative of mixing length bounded by 1
!                 = 3 as =2 with distinct disspipative an mixing length scale
nn_pdl      =   1       !  Prandtl number function of richarson number (=1, avt=pdl(Ri)*avm) or not (=0, avt=avm)
ln_mxl0     = .true.    !  surface mixing length scale = F(wind stress) (T) or not (F)
rn_mxl0     =   0.04    !  surface  buoyancy lenght scale minimum value
ln_lc       = .true.    !  Langmuir cell parameterisation (Axell 2002)
rn_lc       =   0.15    !  coef. associated to Langmuir cells
nn_etau     =   1       !  penetration of tke below the mixed layer (ML) due to internal & intertial waves
!        = 0 no penetration
!        = 1 add a tke source below the ML
!        = 2 add a tke source just at the base of the ML
!        = 3 as = 1 applied on HF part of the stress    ("key_oasis3")
rn_efr      =   0.05    !  fraction of surface tke value which penetrates below the ML (nn_etau=1 or 2)
nn_htau     =   1       !  type of exponential decrease of tke penetration below the ML
!        = 0  constant 10 m length scale
!        = 1  0.5m at the equator to 30m poleward of 40 degrees
/
!-----------------------------------------------------------------------
&namzdf_kpp    !   K-Profile Parameterization dependent vertical mixing  ("key_zdfkpp", and optionally:
!------------------------------------------------------------------------ "key_kppcustom" or "key_kpplktb")
ln_kpprimix = .true.    !  shear instability mixing
rn_difmiw   =  1.0e-04  !  constant internal wave viscosity [m2/s]
rn_difsiw   =  0.1e-04  !  constant internal wave diffusivity [m2/s]
rn_riinfty  =  0.8      !  local Richardson Number limit for shear instability
rn_difri    =  0.0050   !  maximum shear mixing at Rig = 0    [m2/s]
rn_bvsqcon  = -0.01e-07 !  Brunt-Vaisala squared for maximum convection [1/s2]
rn_difcon   =  1.       !  maximum mixing in interior convection [m2/s]
nn_avb      =  0        !  horizontal averaged (=1) or not (=0) on avt and amv
nn_ave      =  1        !  constant (=0) or profile (=1) background on avt
/
!-----------------------------------------------------------------------
&namzdf_gls                !   GLS vertical diffusion                  ("key_zdfgls")
!-----------------------------------------------------------------------
rn_emin       = 1.e-6   !  minimum value of e   [m2/s2]
rn_epsmin     = 1.e-12  !  minimum value of eps [m2/s3]
ln_length_lim = .true.  !  limit on the dissipation rate under stable stratification (Galperin et al., 1988)
rn_clim_galp  = 0.53   !  galperin limit
ln_sigpsi     = .true.  !  Activate or not Burchard 2001 mods on psi schmidt number in the wb case
rn_crban      = 100.    !  Craig and Banner 1994 constant for wb tke flux
rn_charn      = 70000.  !  Charnock constant for wb induced roughness length
rn_hsro       =  0.02   !  Minimum surface roughness
rn_frac_hs    =   1.3   !  Fraction of wave height as roughness (if nn_z0_met=2)
nn_z0_met     =     2   !  Method for surface roughness computation (0/1/2)
nn_bc_surf    =     1   !  surface condition (0/1=Dir/Neum)
nn_bc_bot     =     1   !  bottom condition (0/1=Dir/Neum)
nn_stab_func  =     2   !  stability function (0=Galp, 1= KC94, 2=CanutoA, 3=CanutoB)
nn_clos       =     1   !  predefined closure type (0=MY82, 1=k-eps, 2=k-w, 3=Gen)
/
!-----------------------------------------------------------------------
&namzdf_ddm    !   double diffusive mixing parameterization            ("key_zdfddm")
!-----------------------------------------------------------------------
rn_avts     = 1.e-4     !  maximum avs (vertical mixing on salinity)
rn_hsbfr    = 1.6       !  heat/salt buoyancy flux ratio
/
!-----------------------------------------------------------------------
&namzdf_tmx    !   tidal mixing parameterization                       ("key_zdftmx")
!-----------------------------------------------------------------------
rn_htmx     = 500.      !  vertical decay scale for turbulence (meters)
rn_n2min    = 1.e-8     !  threshold of the Brunt-Vaisala frequency (s-1)
rn_tfe      = 0.333     !  tidal dissipation efficiency
rn_me       = 0.2       !  mixing efficiency
ln_tmx_itf  = .false.    !  ITF specific parameterisation
rn_tfe_itf  = 1.        !  ITF tidal dissipation efficiency
/
!-----------------------------------------------------------------------
&namzdf_tmx_new    !   new tidal mixing parameterization               ("key_zdftmx_new")
!-----------------------------------------------------------------------
nn_zpyc     = 1         !  pycnocline-intensified dissipation scales as N (=1) or N^2 (=2)
ln_mevar    = .true.    !  variable (T) or constant (F) mixing efficiency
```

```
ln_tsdiff   = .true.    !  account for differential T/S mixing (T) or not (F)
/
!!======================================================================
!!                 ***  Miscellaneous namelists  ***
!!======================================================================
!!   namsol           elliptic solver / island / free surface
!!   nammpp           Massively Parallel Processing                   ("key_mpp_mpi)
!!   namctl           Control prints & Benchmark
!!   namc1d           1D configuration options                        ("key_c1d")
!!   namc1d_uvd       data: U & V currents                            ("key_c1d")
!!   namc1d_dyndmp    U & V newtonian damping                         ("key_c1d")
!!   namsto           Stochastic parametrization of EOS
!!======================================================================
!
!-----------------------------------------------------------------------
&namsol        !   elliptic solver / island / free surface
!-----------------------------------------------------------------------
nn_solv     =      1    !  elliptic solver: =1 preconditioned conjugate gradient (pcg)
!                    =2 successive-over-relaxation (sor)
nn_sol_arp  =      0    !  absolute/relative (0/1) precision convergence test
rn_eps      =  1.e-6    !  absolute precision of the solver
nn_nmin     =    300    !  minimum of iterations for the SOR solver
nn_nmax     =    800    !  maximum of iterations for the SOR solver
nn_nmod     =     10    !  frequency of test for the SOR solver
rn_resmax   =  1.e-10   !  absolute precision for the SOR solver
rn_sor      =  1.92     !  optimal coefficient for SOR solver (to be adjusted with the domain)
/
!-----------------------------------------------------------------------
&nammpp        !   Massively Parallel Processing                      ("key_mpp_mpi)
!-----------------------------------------------------------------------
cn_mpi_send =  'I'      !  mpi send/recieve type   ='S', 'B', or 'I' for standard send,
!  buffer blocking send or immediate non-blocking sends, resp.
nn_buffer   =   0       !  size in bytes of exported buffer ('B' case), 0 no exportation
ln_nnogather=  .false.  !  activate code to avoid mpi_allgather use at the northfold
jpni        =   0       !  jpni   number of processors following i (set automatically if < 1)
jpnj        =   0       !  jpnj   number of processors following j (set automatically if < 1)
jpnij       =   0       !  jpnij  number of local domains (set automatically if < 1)
/
!-----------------------------------------------------------------------
&namctl        !   Control prints & Benchmark
!-----------------------------------------------------------------------
ln_ctl      = .false.   !  trends control print (expensive!)
nn_print    =    0      !  level of print (0 no extra print)
nn_ictls    =    0      !  start i indice of control sum (use to compare mono versus
nn_ictle    =    0      !  end   i indice of control sum        multi processor runs
nn_jctls    =    0      !  start j indice of control               over a subdomain)
nn_jctle    =    0      !  end   j indice of control
nn_isplt    =    1      !  number of processors in i-direction
nn_jsplt    =    1      !  number of processors in j-direction
nn_bench    =    0      !  Bench mode (1/0): CAUTION use zero except for bench
!     (no physical validity of the results)
nn_timing   =    0      !  timing by routine activated (=1) creates timing.output file, or not (=0)
/
!-----------------------------------------------------------------------
&namc1d_uvd    !   data: U & V currents                               ("key_c1d")
!-----------------------------------------------------------------------
!              !  file name  ! frequency (hours) ! variable  ! time interp. !  clim  ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!              !             !  (if <0  months)  !   name    !   (logical)  !  (T/F) ! 'monthly' ! filename ! pairing  ! filename      !
sn_ucur     = 'ucurrent'  ,         -1        ,'u_current',   .false.    , .true. , 'monthly' ,  ''      ,  'Ume'   , ''
sn_vcur     = 'vcurrent'  ,         -1        ,'v_current',   .false.    , .true. , 'monthly' ,  ''      ,  'Vme'   , ''
!
cn_dir        = './'    !  root directory for the location of the files
ln_uvd_init   = .false. !  Initialisation of ocean U & V with U & V input data (T) or not (F)
ln_uvd_dyndmp = .false. !  damping of ocean U & V toward U & V input data (T) or not (F)
/
!-----------------------------------------------------------------------
&namc1d_dyndmp !   U & V newtonian damping                            ("key_c1d")
!-----------------------------------------------------------------------
ln_dyndmp   =  .false.  !  add a damping term (T) or not (F)
```

```
/
!-----------------------------------------------------------------------
&namsto       ! Stochastic parametrization of EOS
!-----------------------------------------------------------------------
ln_rststo = .false.           ! start from mean parameter (F) or from restart file (T)
ln_rstseed = .true.           ! read seed of RNG from restart file
cn_storst_in  = "restart_sto" !  suffix of stochastic parameter restart file (input)
cn_storst_out = "restart_sto" !  suffix of stochastic parameter restart file (output)

ln_sto_eos = .false.          ! stochastic equation of state
nn_sto_eos = 1                ! number of independent random walks
rn_eos_stdxy = 1.4            ! random walk horz. standard deviation (in grid points)
rn_eos_stdz  = 0.7            ! random walk vert. standard deviation (in grid points)
rn_eos_tcor  = 1440.0         ! random walk time correlation (in timesteps)
nn_eos_ord  = 1               ! order of autoregressive processes
nn_eos_flt  = 0               ! passes of Laplacian filter
rn_eos_lim  = 2.0             ! limitation factor (default = 3.0)
/

!!======================================================================
!!                  ***  Diagnostics namelists  ***
!!======================================================================
!!   namnc4       netcdf4 chunking and compression settings            ("key_netcdf4")
!!   namtrd       dynamics and/or tracer trends
!!   namptr       Poleward Transport Diagnostics
!!   namflo       float parameters                                     ("key_float")
!!   namhsb       Heat and salt budgets
!!======================================================================
!
!-----------------------------------------------------------------------
&namnc4        !   netcdf4 chunking and compression settings           ("key_netcdf4")
!-----------------------------------------------------------------------
nn_nchunks_i=   4       !  number of chunks in i-dimension
nn_nchunks_j=   4       !  number of chunks in j-dimension
nn_nchunks_k=   31      !  number of chunks in k-dimension
!  setting nn_nchunks_k = jpk will give a chunk size of 1 in the vertical which
!  is optimal for postprocessing which works exclusively with horizontal slabs
ln_nc4zip   = .true.    !  (T) use netcdf4 chunking and compression
!  (F) ignore chunking information and produce netcdf3-compatible files
/
!-----------------------------------------------------------------------
&namtrd        !   diagnostics on dynamics and/or tracer trends
!              !       and/or mixed-layer trends and/or barotropic vorticity
!-----------------------------------------------------------------------
ln_glo_trd  = .false.   ! (T) global domain averaged diag for T, T^2, KE, and PE
ln_dyn_trd  = .false.   ! (T) 3D momentum trend output
ln_dyn_mxl  = .FALSE.   ! (T) 2D momentum trends averaged over the mixed layer (not coded yet)
ln_vor_trd  = .FALSE.   ! (T) 2D barotropic vorticity trends (not coded yet)
ln_KE_trd   = .false.   ! (T) 3D Kinetic   Energy     trends
ln_PE_trd   = .false.   ! (T) 3D Potential Energy     trends
ln_tra_trd  = .FALSE.   ! (T) 3D tracer trend output
ln_tra_mxl  = .false.   ! (T) 2D tracer trends averaged over the mixed layer (not coded yet)
nn_trd      = 365       !  print frequency (ln_glo_trd=T) (unit=time step)
/
!!gm   nn_ctls     =   0       !  control surface type in mixed-layer trends (0,1 or n<jpk)
!!gm   rn_ucf      =   1.      !  unit conversion factor (=1 -> /seconds ; =86400. -> /day)
!!gm   cn_trdrst_in      = "restart_mld"   ! suffix of ocean restart name (input)
!!gm   cn_trdrst_out     = "restart_mld"   ! suffix of ocean restart name (output)
!!gm   ln_trdmld_restart = .false.         !  restart for ML diagnostics
!!gm   ln_trdmld_instant = .false.         !  flag to diagnose trends of instantantaneous or mean ML T/S
!!gm
!-----------------------------------------------------------------------
&namflo       !   float parameters                                      ("key_float")
!-----------------------------------------------------------------------
jpnfl         = 1          !  total number of floats during the run
jpnnewflo     = 0          !  number of floats for the restart
ln_rstflo     = .false.    !  float restart (T) or not (F)
nn_writefl    =      75    !  frequency of writing in float output file
nn_stockfl    =    5475    !  frequency of creation of the float restart file
```

```
ln_argo       = .false.    !  Argo type floats (stay at the surface each 10 days)
ln_flork4     = .false.    !  trajectories computed with a 4th order Runge-Kutta (T)
!  or computed with Blanke' scheme (F)
ln_ariane     = .true.     !  Input with Ariane tool convention(T)
ln_flo_ascii  = .true.     !  Output with Ariane tool netcdf convention(F) or ascii file (T)
/
!-----------------------------------------------------------------------
&namptr       !   Poleward Transport Diagnostic
!-----------------------------------------------------------------------
ln_diaptr  = .false.    !  Poleward heat and salt transport (T) or not (F)
ln_subbas  = .false.     !  Atlantic/Pacific/Indian basins computation (T) or not
/
!-----------------------------------------------------------------------
&namhsb       !  Heat and salt budgets
!-----------------------------------------------------------------------
ln_diahsb  = .false.    !  check the heat and salt budgets (T) or not (F)
/
!-----------------------------------------------------------------------
&nam_diaharm   !   Harmonic analysis of tidal constituents ('key_diaharm')
!-----------------------------------------------------------------------
nit000_han = 1         ! First time step used for harmonic analysis
nitend_han = 75        ! Last time step used for harmonic analysis
nstep_han  = 15        ! Time step frequency for harmonic analysis
tname(1)   = 'M2'      ! Name of tidal constituents
tname(2)   = 'K1'
/
!-----------------------------------------------------------------------
&namdct        ! transports through sections
!-----------------------------------------------------------------------
nn_dct      = 15       !  time step frequency for transports computing
nn_dctwri   = 15       !  time step frequency for transports writing
nn_secdebug = 112      !      0 : no section to debug
!     -1 : debug all section
!  0 < n : debug section number n
/

!!======================================================================
!!           ***  Observation & Assimilation namelists ***
!!======================================================================
!!   namobs       observation and model comparison                     ('key_diaobs')
!!   nam_asminc   assimilation increments                              ('key_asminc')
!!======================================================================
!
!-----------------------------------------------------------------------
&namobs       !  observation usage switch                              ('key_diaobs')
!-----------------------------------------------------------------------
ln_t3d     = .false.    ! Logical switch for T profile observations
ln_s3d     = .false.    ! Logical switch for S profile observations
ln_ena     = .false.    ! Logical switch for ENACT insitu data set
ln_cor     = .false.    ! Logical switch for Coriolis insitu data set
ln_profb   = .false.    ! Logical switch for feedback insitu data set
ln_sla     = .false.    ! Logical switch for SLA observations
ln_sladt   = .false.    ! Logical switch for AVISO SLA data
ln_slafb   = .false.    ! Logical switch for feedback SLA data
ln_ssh     = .false.    ! Logical switch for SSH observations
ln_sst     = .false.    ! Logical switch for SST observations
ln_reysst  = .false.    ! Logical switch for Reynolds observations
ln_ghrsst  = .false.    ! Logical switch for GHRSST observations
ln_sstfb   = .false.    ! Logical switch for feedback SST data
ln_sss     = .false.    ! Logical switch for SSS observations
ln_seaice  = .false.    ! Logical switch for Sea Ice observations
ln_vel3d   = .false.    ! Logical switch for velocity observations
ln_velavcur= .false     ! Logical switch for velocity daily av. cur.
ln_velhrcur= .false     ! Logical switch for velocity high freq. cur.
ln_velavadcp = .false.  ! Logical switch for velocity daily av. ADCP
ln_velhradcp = .false.  ! Logical switch for velocity high freq. ADCP
ln_velfb   = .false.    ! Logical switch for feedback velocity data
ln_grid_global = .false. ! Global distribtion of observations
ln_grid_search_lookup = .false. !  Logical switch for obs grid search w/lookup table
```

```
grid_search_file = 'grid_search'  !  Grid search lookup file header
! All of the *files* variables below are arrays. Use namelist_cfg to add more files
enactfiles = 'enact.nc' !  ENACT input observation file names (specify full array in namelist_cfg)
coriofiles = 'corio.nc' !  Coriolis input observation file name
profbfiles = 'profiles_01.nc' ! Profile feedback input observation file name
ln_profb_enatim = .false !        Enact feedback input time setting switch
slafilesact = 'sla_act.nc' !  Active SLA input observation file names
slafilespas = 'sla_pass.nc' ! Passive SLA input observation file names
slafbfiles = 'sla_01.nc' ! slafbfiles: Feedback SLA input observation file names
sstfiles = 'ghrsst.nc'   ! GHRSST input observation file names
sstfbfiles = 'sst_01.nc' ! Feedback SST input observation file names
seaicefiles = 'seaice_01.nc' ! Sea Ice input observation file names
velavcurfiles = 'velavcurfile.nc'  ! Vel. cur. daily av. input file name
velhrcurfiles = 'velhrcurfile.nc'  ! Vel. cur. high freq. input file name
velavadcpfiles = 'velavadcpfile.nc' ! Vel. ADCP daily av. input file name
velhradcpfiles = 'velhradcpfile.nc' ! Vel. ADCP high freq. input file name
velfbfiles = 'velfbfile.nc' ! Vel. feedback input observation file name
dobsini = 20000101.000000  !  Initial date in window YYYYMMDD.HHMMSS
dobsend = 20010101.000000  !  Final date in window YYYYMMDD.HHMMSS
n1dint = 0  !              Type of vertical interpolation method
n2dint = 0  !              Type of horizontal interpolation method
ln_nea = .false.   !       Rejection of observations near land switch
nmsshc     = 0     !       MSSH correction scheme
mdtcorr = 1.61     !       MDT  correction
mdtcutoff = 65.0   !       MDT cutoff for computed correction
ln_altbias = .false.    ! Logical switch for alt bias
ln_ignmis  = .true.     ! Logical switch for ignoring missing files
endailyavtypes = 820    ! ENACT daily average types - array (use namelist_cfg to set more values)
/
!-----------------------------------------------------------------------
&nam_asminc   !   assimilation increments                              ('key_asminc')
!-----------------------------------------------------------------------
ln_bkgwri = .false.    !  Logical switch for writing out background state
ln_trainc = .false.    !  Logical switch for applying tracer increments
ln_dyninc = .false.    !  Logical switch for applying velocity increments
ln_sshinc = .false.    !  Logical switch for applying SSH increments
ln_asmdin = .false.    !  Logical switch for Direct Initialization (DI)
ln_asmiau = .false.    !  Logical switch for Incremental Analysis Updating (IAU)
nitbkg    = 0          !  Timestep of background in [0,nitend-nit000-1]
nitdin    = 0          !  Timestep of background for DI in [0,nitend-nit000-1]
nitiaustr = 1          !  Timestep of start of IAU interval in [0,nitend-nit000-1]
nitiaufin = 15         !  Timestep of end of IAU interval in [0,nitend-nit000-1]
niaufn    = 0          !  Type of IAU weighting function
ln_salfix = .false.    !  Logical switch for ensuring that the sa > salfixmin
salfixmin = -9999      !  Minimum salinity after applying the increments
nn_divdmp = 0          !  Number of iterations of divergence damping operator
/
!-----------------------------------------------------------------------
&namsbc_wave   ! External fields from wave model
!-----------------------------------------------------------------------
!             !  file name  ! frequency (hours) ! variable     ! time interp. !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!             !             !  (if <0  months)  !   name       !   (logical)  !  (T/F)  ! 'monthly' ! filename ! pairing  ! filename      !
sn_cdg      =  'cdg_wave' ,        1          , 'drag_coeff' ,     .true.   , .false. , 'daily'   ,  ''      , ''       , ''
sn_usd      =  'sdw_wave' ,        1          , 'u_sd2d'     ,     .true.   , .false. , 'daily'   ,  ''      , ''       , ''
sn_vsd      =  'sdw_wave' ,        1          , 'v_sd2d'     ,     .true.   , .false. , 'daily'   ,  ''      , ''       , ''
sn_wn       =  'sdw_wave' ,        1          , 'wave_num'   ,     .true.   , .false. , 'daily'   ,  ''      , ''       , ''
!
cn_dir_cdg  = './'  !  root directory for the location of drag coefficient files
/
!-----------------------------------------------------------------------
&namdyn_nept  !   Neptune effect (simplified: lateral and vertical diffusions removed)
!-----------------------------------------------------------------------
! Suggested lengthscale values are those of Eby & Holloway (1994) for a coarse model
ln_neptsimp       = .false.  ! yes/no use simplified neptune

ln_smooth_neptvel = .false.  ! yes/no smooth zunep, zvnep
rn_tslse          =  1.2e4   ! value of lengthscale L at the equator
rn_tslsp          =  3.0e3   ! value of lengthscale L at the pole
! Specify whether to ramp down the Neptune velocity in shallow
```

```
! water, and if so the depth range controlling such ramping down
ln_neptramp       = .true.   ! ramp down Neptune velocity in shallow water
rn_htrmin         =  100.0   ! min. depth of transition range
rn_htrmax         =  200.0   ! max. depth of transition range
/
```

C STC100 partial namelist_cfg

```
&namcfg        !   parameters of the configuration
!-----------------------------------------------------------------------
cp_cfg      = "Canso100m"         !  name of the configuration
jp_cfg      =  36                  !  resolution of the configuration
jpidta      =  714                 !  1st lateral dimension ( >= jpi )
jpjdta      =  479                !  2nd    "         "    ( >= jpj )
jpkdta      =  50                  !  number of levels      ( >= jpk )
jpiglo      =  714                 !  1st dimension of global domain --> i =jpidta
jpjglo      =  479                !  2nd    -                  -    --> j  =jpjdta
jpizoom     =  1                   !  left bottom (i,j) indices of the zoom
jpjzoom     =  1                   !  in data domain indices
jperio      =      0              !  lateral cond. type (between 0 and 6)
!  = 0 closed                 ;   = 1 cyclic East-West
!  = 2 equatorial symmetric   ;   = 3 North fold T-point pivot
!  = 4 cyclic East-West AND North fold T-point pivot
!  = 5 North fold F-point pivot
!  = 6 cyclic East-West AND North fold F-point pivot
ln_use_jattr = .false.             !  use (T) the file attribute: open_ocean_jstart, if present
!  in netcdf input files, as the start j-row for reading
/

&namsbc_core   !   namsbc_core  CORE bulk formulae
!-----------------------------------------------------------------------
!       !   file name       ! frequency (hours) ! variable   ! time interpol. !  clim   ! 'yearly' or ! ! weights  ! rotation !
sn_wndi  = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'u_wind'    ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m', 'U', ''
sn_wndj  = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'v_wind'    ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m', 'V', ''
sn_qsr   = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'solar'     ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m' , '', ''
sn_qlw   = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'therm_rad' ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m' , '', ''
sn_tair  = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'tair'     ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m' , '', ''
sn_humi  = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'qair'      ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m' , '', ''
sn_prec  = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'precip'    ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m' , '', ''
sn_snow  = 'HRDPS_OPPeast_ps2.5km'   ,        1.0          , 'snow'      ,     .true.    , .false. ,   'daily'  , 'weights_bilinear_Canso100m' , '', ''
cn_dir      = './ATMDATA/'  !  root directory for the location of the bulk files
ln_taudif   = .false.   !  HF tau contribution: use "mean of stress module - module of the mean stress" data
rn_zqt      = 2.        !  Air temperature and humidity reference height (m)
rn_zu       = 10.       !  Wind vector reference height (m)
rn_pfac     = 1000.  !luo change unit from kg m-2 to kg/m2/s  !  multiplicative factor for precipitation (total & snow)
rn_efac     = 1.        !  multiplicative factor for evaporation (0. or 1.)
rn_vfac     = 0.        !  multiplicative factor for ocean/ice velocity
!  in the calculation of the wind stress (0.=absolute winds or 1.=relative winds)
/

&namsbc_apr    !   Atmospheric pressure used as ocean forcing or in bulk
!-----------------------------------------------------------------------
!             !  file name     ! frequency (hours) ! variable  ! time interp. !  clim   ! 'yearly'/  ! weights         ! rotation ! land/sea mask !
!             !                !  (if <0  months)  !   name    !   (logical)  !  (T/F)  ! 'monthly'  ! filename        ! pairing  ! filename      !
sn_apr      = 'HRDPS_OPPeast_ps2.5km'      ,        1.0        ,'seapres',    .true.     , .false. , 'daily'  ,  'weights_bilinear_Canso100m'      ,   ''     , ''
cn_dir      = './ATMDATA/'   !  root directory for the location of the bulk files    XHU -- BoF36
rn_pref     = 101000.       !  reference atmospheric pressure   [N/m2]/
ln_ref_apr  = .false.       !  ref. pressure: global mean Patm (T) or a constant (F)
ln_apr_obc  = .false.       !  inverse barometer added to OBC ssh data
/

&nambdy        !  unstructured open boundaries                         ("key_bdy")
!-----------------------------------------------------------------------
nb_bdy         = 2                      !  number of open boundary sets
```

```
ln_coords_file = .false.,.false.        !  =T : read bdy coordinates from file
cn_coords_file = 'coordinates.bdy.nc'    !  bdy coordinates files
ln_mask_file   = .false.                 !  =T : read mask from file
cn_mask_file   = ''                      !  name of mask file (if ln_mask_file=.TRUE.)
cn_dyn2d       = 'flather','flather'     !
nn_dyn2d_dta   = 1,1                     !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
!  = 2, use tidal harmonic forcing data from files
!  = 3, use external data AND tidal harmonic forcing
cn_dyn3d      =  'specified','specified' ! SBD
nn_dyn3d_dta  =  1,1                     !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
cn_tra        =  'specified','specified' ! SBD
nn_tra_dta    =  1,1                     !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
cn_ice_lim      = 'none','none'         !
nn_ice_lim_dta  = 0,0                   !  = 0, bdy data are equal to the initial state
!  = 1, bdy data are read in 'bdydata   .nc' files
rn_ice_tem      = 270.                   !  lim3 only: arbitrary temperature of incoming sea ice
rn_ice_sal      = 10.                    !  lim3 only:      --   salinity           --
rn_ice_age      = 30.                    !  lim3 only:      --   age                --

ln_tra_dmp    =.true.,.true.             !  open boudaries conditions for tracers SBD true
ln_dyn3d_dmp  =.true.,.true.             !  open boundary condition for baroclinic velocities SBD true
rn_time_dmp   =  0.2,0.2                   ! Damping time scale in days
rn_time_dmp_out = 0.2,0.2                 ! Outflow damping time scale SBD 1.
nn_rimwidth   = 10,10                    !  width of the relaxation zone
ln_vol        = .false.                  !  total volume correction (see nn_volctl parameter)
nn_volctl     = 1                        !  1 ==> the total volume is constant
/
!-----------------------------------------------------------------------
&nambdy_index  !  structured open boundaries definition     ("key_bdy")
!-----------------------------------------------------------------------
ctypebdy ='S'                  ! Open boundary type (W,E,S or N)
nbdyind  = -1                  ! indice of velocity row or column
! if ==-1, set obc at the domain boundary
!        , discard start and end indices
nbdybeg  = 2                   ! indice of segment start
nbdyend  = 1713                 ! indice of segment end
/

!-----------------------------------------------------------------------
&nambdy_dta      !  open boundaries - external data           ("key_bdy")
!-----------------------------------------------------------------------
!      !  file name                               ! frequency (hours) ! variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!      !                                          !  (if <0  months)  !   name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !

bn_ssh =     'obc_south_sossheig'  ,     1.0        , 'sossheig' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u2d =     'obc_south_vozotrtx'  ,     1.0      , 'vozotrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v2d =     'obc_south_vometrty'  ,     1.0      , 'vometrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u3d  =    'obc_south_vozocrtx' ,      24.0        , 'vozocrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v3d  =    'obc_south_vomecrty' ,      24.0        , 'vomecrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_tem  =    'obc_south_votemper' ,      24.0        , 'votemper' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_sal  =    'obc_south_vosaline' ,      24.0        , 'vosaline' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
cn_dir  =    'OBCDATA/'
ln_full_vel = .false.
/

&nambdy_index  !  structured open boundaries definition     ("key_bdy")
!-----------------------------------------------------------------------
ctypebdy ='E'                  ! Open boundary type (W,E,S or N)
nbdyind  = -1                  ! indice of velocity row or column
! if ==-1, set obc at the domain boundary
!        , discard start and end indices
nbdybeg  = 2                   ! indice of segment start
nbdyend  = 1019                ! indice of segment end
/

!-----------------------------------------------------------------------
```

```
&nambdy_dta      !  open boundaries - external data           ("key_bdy")
!-----------------------------------------------------------------------
!      !  file name                                 ! frequency (hours) ! variable   ! time interp.   !  clim   ! 'yearly'/ ! weights  ! rotation ! land/sea mask !
!      !                                            !  (if <0  months)  !   name     !   (logical)    !  (T/F ) ! 'monthly' ! filename ! pairing  ! filename      !
bn_ssh =     'obc_east_sossheig'  ,     1.0     , 'sossheig' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u2d =     'obc_east_vozotrtx'  ,     1.0     , 'vozotrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v2d =     'obc_east_vometrty'  ,     1.0     , 'vometrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_u3d  =    'obc_east_vozocrtx' ,      24.0    , 'vozocrtx' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_v3d  =    'obc_east_vomecrty' ,      24.0    , 'vomecrty' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_tem  =    'obc_east_votemper' ,      24.0    , 'votemper' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
bn_sal  =    'obc_east_vosaline' ,      24.0    , 'vosaline' ,     .true.     , .false. ,  'monthly'  ,    ''    ,   ''     , ''
cn_dir  =    'OBCDATA/'
ln_full_vel = .false.
/

&nammpp        !   Massively Parallel Processing                        ("key_mpp_mpi)
!-----------------------------------------------------------------------
cn_mpi_send =  'I'      !  mpi send/recieve type   ='S', 'B', or 'I' for standard send,
!  buffer blocking send or immediate non-blocking sends, resp.
nn_buffer   =   0       !  size in bytes of exported buffer ('B' case), 0 no exportation
ln_nnogather=  .false.  !  activate code to avoid mpi_allgather use at the northfold
jpni        =  34      !  jpni   number of processors following i (set automatically if < 1)
jpnj        =  23      !  jpnj   number of processors following j (set automatically if < 1)
jpnij       =  519      !  jpnij  number of local domains (set automatically if < 1)
/
```