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CORRELATION ANALYSIS OF WIND AND ICE DRIFT DATA TAKEN AT LINCOLN BAY 1972

by

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PROJECT NO.
97-67-05

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ABSTRACT

A set of programs were written to analyse wind and ice drift speed correlations in the data taken at Lincoln Bay in 1972. The maximum correlation for each station indicates that about 20% of the drift can be attributed to wind. The effects of time lag and Coriolis forc were examined but due to the complexity of the problem no generalization on ice floe measurement could be made.

RÉSUMÉ

Un jeu de programmes fut rédigé pour analyser la corrélation entre la vitesse du vent et celle de la dérive des glaces en utilisant les données obtenues à la Baie Lincoln en 1972. La corrélation maximum à chaque poste indique que 20% de la dérive peut être attribué au vent. Les effets du décalage de temps et de la force de Coriolis ont été examinés mais aucune généralisation concernant la dérive des glaces n'a été faite en raison de la complexité du problème.

INTRODUCTION

The Defence Research Establishment Ottawa has been conducting a study of ice drift in Robeson Channel and has gathered a considerable amount of drift and environmental data to date. The object of the study is to develop a mathematical description of the drift that can be used as a predictive tool in other situations where only the synoptic environmental data are available. One part of the model development involved a study of wind and ice drift correlations and this report describes that study. The data used were obtained in 1972 at Lincoln Bay and have been partially reported by Keys et al (1).

The study further discusses the effect of time lag and Coriolis force on the correlations obtained, other difficulties inherent in the analysis of the data and establishes computer programs for synchronizing and correlating the experimental data.

METHOD AND PROGRAMMING

GENERAL

A set of FORTRAN programs has been written to calculate correlation coefficients, and these are summarized in Flow Chart: Appendix A, and Program Information: Appendix B. In beginning the correlation analysis the wind and drift data sequences had to be synchronized. Program "TSYNC" performs this function to the nearest minute and the output disk file of "TSYNC" consists of the X and Y components of the wind and drift vectors.

In the coordinate system used, the positive X axis is pointing down channel. The positive Y axis points NW from geographical north. At the origin of the system the angle between true north and magnetic north subtends 80° and as all the original data were based on magnetic north they were converted to projections on this cartesian system.

The saved file from "TSYNC" is then used as the input file to SPD 2. This program calculates the speeds and then determines the magnitudes as they would be if projected onto a set of vectors at 0°, 22.5°, 45°,

67.5^{o} and 90^{o} clockwise from the wind vector. The output file from 'SPD 2' is then used as the input to program 'CORREL'. This is the program which produces correlation table with coefficients for each angle of projection at each time lag.

ELIMINATION OF TIDAL EFFECTS

An attempt was made to eliminate the tidal effect on the drift data using Fourier analysis. The program for this required that all higher frequencies be integer multiples of the basic frequency, with a period of 25 hours. Program 'COMPAN 2' produces an input file for 'CORREL' in which the drift speed is the remainder of the original drift speed minus a periodic function evaluated for each time interval. The subroutine for Fourier analysis was provided by John Moffat.

OUTPUT AND LISTINGS

The computer output and listings of these programs are contained in three binders. Binder #1 contains the printout of 'TSYNC" and the correlation table for each station. Binder #2 contains the output 'SPD 2', for each station. Binder #3 contains the output of 'COMPAN 2' and the correlation tables for each station, after a calculated tidal effect has been subtracted from the original data.

Each program and its compiled version is stored on disk file and on a tape. Also on this tape are the outputs of program 'SPD 2' for each station's data.

RESULTS

The singular movement of each ice floe necessitates a close examination of the correlation coefficients for each station. In Table I the maximum positive and negative coefficients are outlined. The average time lag for the maximum positive correlation is 4.88 hours.

DISCUSSION

Direct observation of the effect of a change of wind on the ice drift raises doubts about the high average time lag. Several factors may be contributing to the discrepancy between time lag shown in the table and the 1 - 2 hours usually observed. An increasing time lag truncates the data sequence eliminating 3 pairs of data for each hour lag. Drift data are lost from the beginning of the sequence and wind data are severed from the end. The shorter data sequence may result in less variance in the data and therefore a higher correlation. However, this is not an accurate reflection. The correlation data for station 6.11 are a good example of increasing magnitude of the coefficient as the data sequence is shortened.

A peculiar characteristic of correlation analysis when dealing with periodic data, such as tide-influenced drift, is that a high correlation may be calculated at a lag time which is some multiple of the basic frequency. Such a problem is difficult to detect. The presence of a tidal influence on the ice drift adds other complexities to the predicting of ice drift as the data sequence may include periods of relatively calm winds with predominantly tidal drift.

On the other hand the data sequence may also consist of those times when a strong wind continued to be recorded on a station which had been halted due to other constraining floes or contact with the shoreline. Considering these two possibilities, it is easy to see that a large variance could exist in the drift speed at any given wind speed.

In light and moderate winds, the tidal currents have been observed to have the dominant influence. In Robeson Channel the tidal currents are not simple. However, an experienced observer can give a good estimate of the relative speed of the ice drift at a given time by knowing the times of the high and low tides.

The short data sequences available yield poor resolution in the Fourier components of the tide. Thus it is difficult to remove the tidal components of the ice drift. The drift speed drops by a factor of 10 when this is done indicating that the tidal current is certainly important. The extreme differences between magnitudes of wind speed and ice drift coupled with the large variance of the drift reduced the correlation coefficients to insignificance.

Station 6.4 provides the best example of the effect of Coriolis force on ice drift. Here a correlation of .702 was obtained for 0 hours lag and 45° off-vector projection. Until all of the contributing forces to the ice drift can be isolated, it will be impossible to assign any real significance to this finding.

The presence of large negative correlations indicates the complexity of the situation and the need to continue investigating how the mathematics reflects the real situation. Periodicity and truncation of short sequences of data compound the correlation analysis.

TABLE I

Station	Max ρ	Pos Lag	ρ_o	Max ρ	Neg Lag	ρ_o
6.3	.222	9	22.5	-.400	3	22.5
6.4	.702	0	45	-.516	12	0
6.6	.644	1	45	-.524	12	0
6.7	.565	9	0	-.666	4	22.5
6.8	.577	0	22.5	-.239	4	90
6.9	.508	1	22.5	-.661	12	22.5
6.10	.584	8	0	-.559	12	90
6.11	.870	8	0	-.076	12	90
6.12	.350	7	0	-.293	12	90
7.2	.303	0	67.5	-.122	9	0
7.3	.228	4	0	-.578	9	67.5
7.4	.443	11	22.5	-.314	5	0
7.5	.369	9	0	-.597	12	90
7.6	.657	0	90	-.519	12	90
7.7	.809	0	0	-.719	12	0
7.8	.631	5	0	-.562	11	22.5
7.9	.263	8	22.5	-.388	12	22.5
8.3	.474	8	90.0	-	-	-

LAG = 4.88 hrs

ANGLE = 24.975^{o}

LAG = 9.6 hrs

ANGLE = 40.5^{o}

CONCLUSIONS

Computer programs were written synchronizing and correlating wind and drift data on eighteen stations. The effects of time lag and Coriolis force were examined but due to the complexity of the problem no generalization on ice floe movements can be made. The maximum correlation for each station indicates that about 20% of the drift can be attributed to the effect of wind.

An improvement on the predictive power could be obtained by carefully examining the drift data and using only those data for periods of minimal restriction of movement due to other floes. Clearly, a much more detailed knowledge of the oceanographic environment of each floe is required. Tidal current must be considered to be an important contributor to the ice drift and it is necessary to find the relative speed of the ice with respect to the current, in order to assess the wind effect.

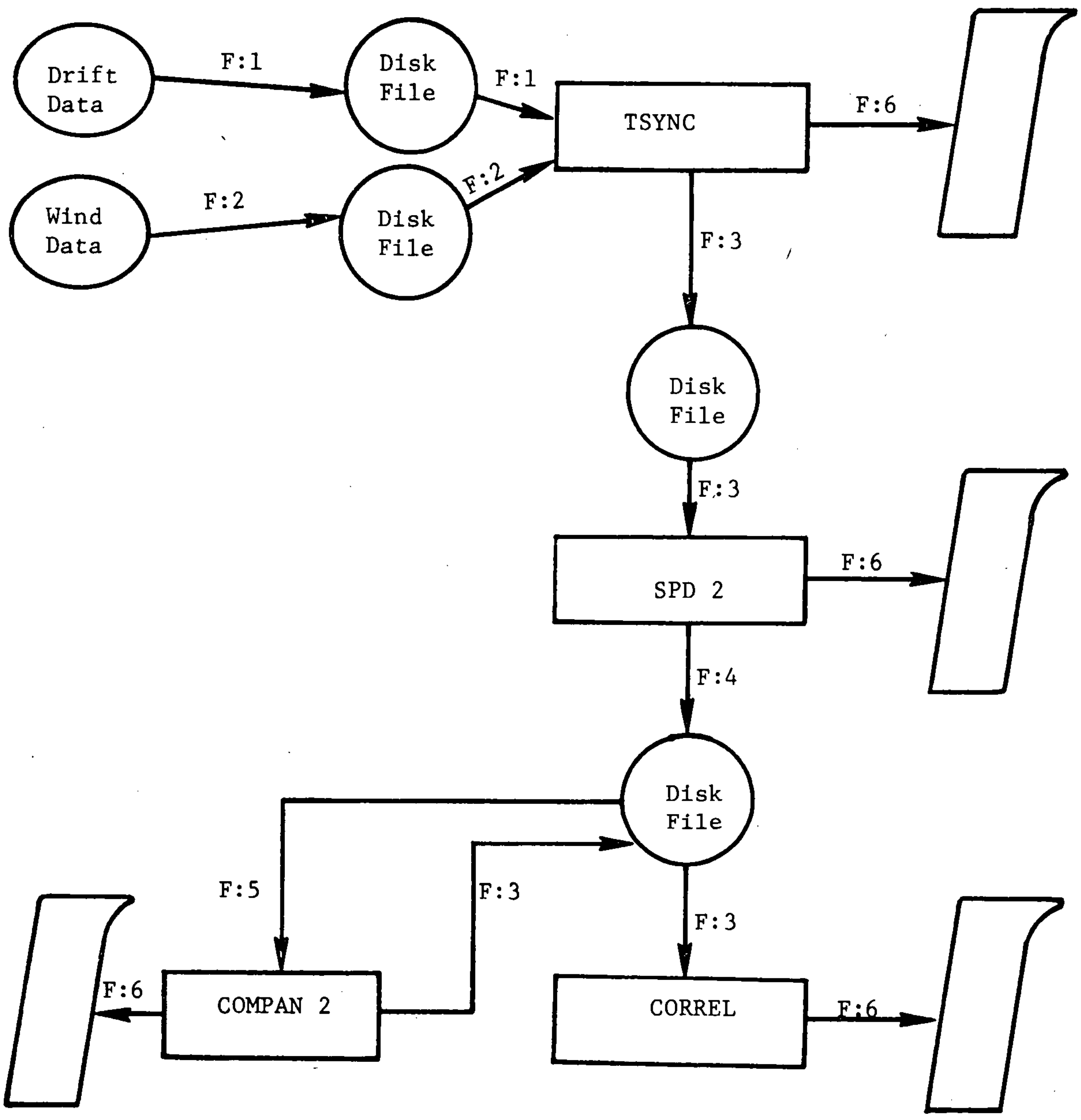
Further data gathering should coincide with the time of maximum open water, late in the Arctic summer, when individual floes may be tracked with no interaction with other floes. With simultaneous current measurements, the various factors affecting drift might be more easily isolated.

REFERENCES

1. Keys, J.E., Dunbar, M., Finlayson, D.J., and Moffat, J.W., Radar Measurements of Ice in Robeson Channel 1972 (U) DREO Technical Note 74-21 August 1974, Unclassified.

APPENDIX A

FLOW CHART



APPENDIX B

PROGRAMS

1.	TSYNC (TSCOMP)	Synchronize wind and drift data
	input files: Fig: 1	Drift (John Moffat's Tape)
	Fig: 2	Wind (Jim Rozee's Tape)
	output files: Fig: 3	Save-file of synchronized data
		Each file has data preceded by three header cards (80 AA). The data is in the form: no., drift x comp, drift y comp, wind x comp, wind x component, with a format (I8, 4F 12.2)
	Fig: 6	Program messages
2.	SPD 2 (SPCOMP)	Calculates wind and drift speeds and projects drift speed onto vectors at 0^{o}, 22.5^{o}, 45^{o}, 67.5^{o}, 90^{o} clockwise to the wind vector.
	input file: Fig: 3	The output of TSYNC
	output files: Fig: 4	Save-file of data for correlation
		Each file has data preceded by three header cards. The data is in the form: wind speed, drift speed projected at angles: 0^{o}, 22.5^{o}, 45^{o}, 67.5^{o}, 90^{o}, with a format (8x, 6F 12.2)
	Fig: 6	Program messages
3.	CORREL (CORCOMP)	Correlates wind and drift speeds for each of the five projected vectors at each hour of lag to 12 hours
	input file: Fig: 3	The output of SPD 2
	output files: Fig: 6	Program messages and correlation tasks
4.	COMPAN 2 (COCOMP, FORCOMP)	Fourier analysis of data on output file pan SPD 2 for the removal of tidal effect.
	input file: Fig: 5	The output of SPD 2
	output files: Fig: 3	can be read by 'CORREL'

* Bracketed word after program is the name of the disk file containing the compiled version of this program.

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