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Potential for Development Analysis using Satellite Data

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INTRODUCTION

Techniques have been developed to assess the potential for development of weather systems based on an energetics approach (Gardner et al). Although very useful over areas with high data density, and in particular areas with numerous upper air stations, these techniques have not, until very recently, been fully integrated into operational forecast procedures on a routine basis at the Pacific Weather Centre.

This is largely due to the fact that many of the parameters required in the assessment procedure have not been available with sufficient accuracy from available upstream data.

Information now routinely available from satellite imagery can be incorporated into a potential for development analysis. This information can be used to complement upper air analyses from CMC. Accurate upper air analyses are essential in the process of determining any weather system's potential for development.

This Technical Note discusses several areas in which information from satellite imagery can be applied in an evaluation of development potential. It also presents an assessment sheet which can be utilized in an operational setting to assist in assessing development potential. Once this assessment has been made, the forecaster is in a position to critically evaluate the numerical guidance.

THE APPROACH

A Satellite Analysis Chart (see example in Figure 1) is currently produced on a routine basis at the Pacific Weather Centre. This analysis chart contains a great deal of the information required to carry out a potential for development analysis. This analysis can be applied to the question of development potential in two discrete but very interdependent areas. The first area concerns future changes in large scale features such as general flow patterns, positions and intensities of upper highs and lows. From this analysis, certain key areas where development is most likely to occur can be determined. The second area concerns the identification and examination of key areas where development is indicated.

PROCEDURE

A knowledge of the present state of the atmosphere must be obtained from analysis of satellite data and other information. Basic dynamic concepts are then applied in order to determine future changes in large scale features. The assessment sheet given in the appendix outlines the major points to look for in the dynamic assessment.

Satellite information, complemented by high level aircraft wind reports, can assist the meteorologist in a quite precise analysis of jet streams. Tilts of troughs and ridges and confluence or diffluence of those features, as well as broadscale changes in thermal fields and available cold air supplies, can also be effectively ascertained from satellite imagery. As outlined by Gardner in the Winter Severe Weather correspondence course, all these features must be taken into account in attempting to predict large-scale changes in flow patterns.

After the large-scale changes in the upper air pattern have been evaluated, certain key potential development areas should become evident. Examples are digging troughs, cold air cumulus injection, PVAL's approaching a frontal zone, the area upstream from a building ridge, increased circulation within a cloud field, etc. Each of these areas must then be evaluated. Cloud edges, areal extents, and shapes should be examined for any of the signs of development cited in Weldon's notes. Delta cloud areas as well as any signs of 'uncoupling' (Funk) should be looked for as these are generally associated with non-developing systems. Waves and lows in regions suitable for development should be closely examined. The assessment sheet sets out in more detail the pertinent points in this part of the evaluation. From the analysis and assessment of a situation, development potential and expected motions should be used to construct a short range prognosis.

CONCLUSIONS

The analysis, development potential assessment, and resultant prognosis procedure should help the meteorologist to critically evaluate the numerical guidance. The best numerical prognosis available can then be used, and perhaps modified, to provide medium and longer range guidance with a greater confidence value.

A more complete knowledge of development theory can be obtained by reference to Gardner's Winter Severe Weather correspondence course or other papers dealing with the energetics approach to weather system development.

REFERENCES

Anderson, R.K., et al, The Use of Satellite Pictures in Weather Analysis and Forecasting, World Meteorological Organization, Technical Note #124, 1973.

Weldon, R., Satellite Training Course Notes, Part IV, Patterns and Upper Air Wind Fields, National Environmental Satellite Service, Applications Division, January 1979.

Gardner, D., et al, Correspondence Course in Winter Severe Weather, Environment Canada, Atmospheric Environment Service, Training Branch, Professional Development Division.

Funk, L., Uncoupling of Cloud Systems - A Forecast Problem, Pacific Region Technical Note 83-002.

APPENDIX

DYNAMIC ASSESSMENT OVER THE NORTH PACIFIC

The assessment is done from satellite analysis charts that include (See Weldon and Ralph Anderson re: Imagery Interpretation Techniques).

- main streams
- closed centres
- mean troughs and ridges
- shortwave troughs and ridges
- vorticity maxima and minima
- areas of diffluence and confluence
- jet streams and maxima
- significant cloud pattern
- areas of convection
- areas of increasing low clouds

As well, TOVS (Tiros Operational Vertical Sounder) thickness fields and AIREP winds should be used when available.

PART A - LARGE SCALE FEATURES

-to be filled in-

FACTOR	CONTRIBUTION TO DEVELOPMENT	WHAT TO LOOK FOR
Flow pattern Type - zonal - meridional - cold vortex - split flow Changes in tilt and amplification		- Weldon's development models - orientation of jet streams - digging or building streams - motion of series of shortwaves
Diffluence of broadscale troughs/ridges		- split flow - diverging streams - deformation zones/fanning out of cirrus
Broadscale changes in thermal fields		- TOVS data - general cloud tops
Available cold/warm air supply		- TOVS data - large area of convective clouds upstream - consider flow source area
Check with prog analyst for longwave situation e.g. Hovmöller		- cloud animation loop - history of previous weather systems

ISOLATE POSSIBLE KEY DEVELOPMENT AREAS THEN PROCEED TO PART B

PART B - DEVELOPMENT ASSESSMENT FOR EACH KEY AREA

-to be filled in-

FACTOR	CONTRIBUTION TO DEVELOPMENT	WHAT TO LOOK FOR
Changes in cloud edges, patterns, areal extent, uncoupling		- sharpening edges indicate development - rarely get development in delta cloud areas - systems generally weaken after uncoupling
Where is the key area with respect to the overall flow pattern?		- is this the leading shortwave or last out of a mean trough position?
Amplitude of thermal/ thickness pattern		- TOVS data - Legal's technique
Position of area with respect to jet maximum		- right/left entrance/exit - (jet maximum located upstream from cloud surge areas, between vorticity max/min pairs)
Vorticity advection over the area		- positive vorticity advection lines (PVALS) - enhanced cumulus - rapidly developing clouds
Stability considerations		- differential thickness advection - developing/embedded convective cloud
Latent heat release		- rain in warm sector on surface chart
Diabatic considerations		- system moving southeast over warmer water
Terrain roughness		- system moving from land to water or vice versa

Subjective assessment of situation:

-fill in-

Subjective assessment verses numerical guidance:

-fill in-

Compose FXCN4:

NOTE: THE ASSESSMENT STEPS SHOULD BE EVALUATED FOR RELEVANCE AND DOCUMENTED. ALSO ANY USEFUL OPERATIONAL TECHNIQUES AND OR OBSERVATIONS SHOULD BE ADDED TO THIS LIST FOR EVALUATION.

Figure 1

Satellite Analysis Chart
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