MODULE 4.2B

SHORT RANGE FORECASTING OF CLOUD, PRECIPITATION AND RESTRICTIONS TO VISIBILITY

Synoptic Cloud and Precipitation

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SYNOPTIC CLOUD AND PRECIPITATION

1. FORECAST APPROACHES

The problem of forecasting synoptic cloud, or mid cloud, can be handled in several ways - depending on whether or not the cloud exists at the time that the forecast is prepared. If the cloud exists, the forecast problem is one of anticipating both where the cloud system will be at the future time and to what extent the system will change. When forecasting the evolution of existing synoptic cloud, the short range forecasting techniques of extrapolation and synoptic correlation work reasonably well when combined with adjustments for any relevant physical processes at play (such as for expansion or dissipation of cloud boundaries). When the mid and high cloud does not yet exist but is expected to develop, the solution to the forecast problem must rely on indirect inference. The forecaster must anticipate large-scale or synoptic vertical motions and must assess future developments of atmospheric moisture.

Since the production mechanisms for mid cloud are associated with synoptic systems, these cloud areas tend to move and maintain consistency with their supporting synoptic features. The reason that synoptic correlation and, for that matter, extrapolation techniques work so well for the short term forecast is because supporting synoptic features often have a highly regular motion. These approaches work as well when synoptic systems undergo change and areas of mid cloud depart from earlier correlations with synoptic features. Significant changes in the supporting systems require that adjustments be made to synoptic correlation techniques that account for changes in the intensity of the system.

Other occasions occur where the pure application of extrapolation and synoptic correlation techniques may not prove adequate. These occasions happen with relative frequency in areas where topographical influences are important (cloud moving over or to the lee of mountains), or when diurnal changes may be significant (early morning ACC, spreading of CBs into AC). In such instances, a subjective adjustment is required that allows for the additional physical processes at play.

Synoptic correlation techniques can sometimes become unreliable, even when the situation appears ideal for their application. This failure can result because of limitations inherent in the technique. When a statistical relationship appears to exist between two parameters, the success of the forecast depends upon two main factors - the persistence of the correlation as a function of time and the success achieved in predicting the parameters which are used as predictors. In operational meteorology, both of these conditions may be violated with a resulting poor forecast. For example, on a certain day an altostratus deck may correlate well with an area of PVA. The next day, the cloud may still be there, but its correlation with PVA may be poor because, in the meantime, significant PTA had developed. The really relevant predictor would have been the vertical motion but it only happened to be coincidental that, at a particular time, one of the factors contributing to the vertical motion happened to predominate. However great the correlation with vertical velocity, reality dictates that forecastable predictors be used.

The first step in producing a short range prediction of synoptic clouds using correlation techniques is a diagnosis of the current pattern. Reasonable synoptic correlators or predictors must be found that define the current cloud areas. These predictors must correlate well with the cloud and must also be forecastable with reasonable accuracy in the short term. Once reasonable correlators are found and their positions and intensifies predicted, the synoptic cloud can be forecast with respect to the synoptic feature using the relationships that held at the initial time.

The use of satellite imagery can prove to be of considerable assistance when forecasting synoptic cloud. Satellite imagery is quite suited to the short range problem because of its ability to provide a history on the motion of the cloud as well as an inferred history on the supporting features. The imagery can prove helpful even to those forecasters graced with a relatively dense network of upper and surface data. Because satellite data is continuously updated, the forecaster can be made aware of sudden developments in cloud areas well before conventional data would have alerted otherwise.

Modelling the Weather

A considerable amount of subjective adjustment, i.e. modelling, is required when forecasting synoptic cloud or precipitation for regions downstream from a data sparse area. In Canada, these regions can cover a sizeable area. Of these areas, the Pacific coast, the Yukon, and the Northwest Territories are particularly hard hit in many flow situations by a sparseness of upstream data. The west coast, for example, looks upstream to the Pacific Ocean for much of its incoming weather - an upstream area that is covered by only the odd report (or none) over a distance that covers some one-third of the Northern Hemisphere. Without upstream data, synoptic correlation techniques become difficult to apply and considerable inference or modelling becomes necessary. As expected, satellite imagery provides much of the information needed to model synoptic cloud and precipitation in these areas. Other areas where the forecaster often has to model synoptic clouds and precipitation occur in regions lying over and to the lee of mountain ranges. When orographic influences significantly affect the moisture and the synoptic support for the cloud shield, the forecaster must subjectively modify the cloud area to account for processes associated with the mountains. Orographic influences on synoptic cloud are particularly significant to British Columbia, Alberta, Yukon and the Mackenzie Valley of the Northwest Territories. When forecasting synoptic cloud for a site, the forecaster also must keep diurnal trends in mind.

Thus, subjective adjustments or modelling plays an important part in predicting synoptic cloud and precipitation for a number of forecast districts in Canada. In order to successively model this weather, the forecaster requires a sound knowledge of cloud and precipitation processes.

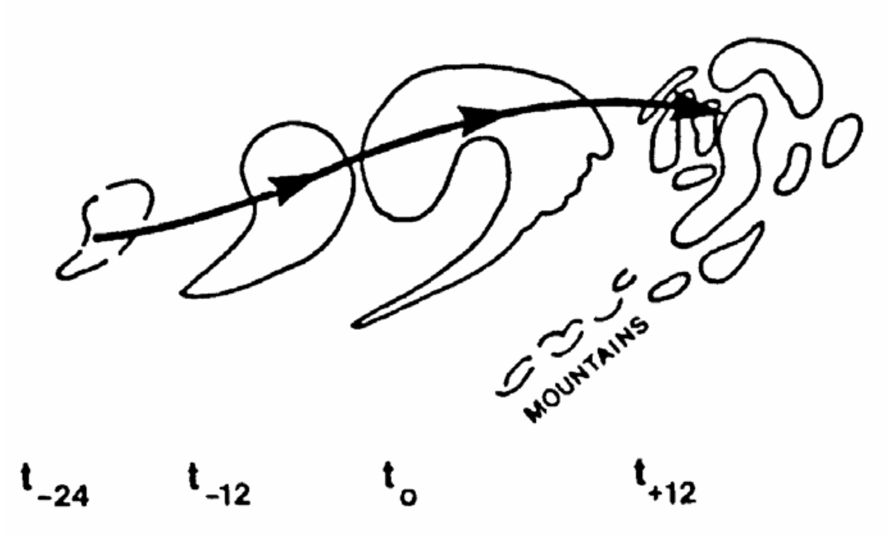

Figure 1. Modelling the effect of mountains on incoming synoptic cloud.

Frequently Used Synoptic Predictors

Table 1 on the following page lists some commonly used synoptic correlators for clouds and precipitation. The table also includes suggestions on how these correlators may be forecast.

Diurnal Trends

Although diurnal trends are of greatest significance when forecasting boundary layer and convective clouds, they are still worthy of consideration for the synoptic cloud problem. Indeed, recent verification studies of precipitation given in the public forecasts tend to suggest that forecasters sometimes forget the importance of nocturnal radiational cooling at mid levels in producing early morning ACC and TCU and associated showers. Nocturnal cooling acts by destabilising and cooling mid cloud tops, resulting in either a thickening of existing cloud or a formation of cloud in an area where moisture existed earlier. This cooling effect can be particularly significant in Western Canada.

Locally, daytime heating can also contribute to the formation of mid cloud, given that the thermal structure of the atmosphere is favourable. In such cases, a combination of cumuliform cloud build-ups from daytime heating plus the presence of an inversion aloft can result in broken mid cloud (or high SC) over an area. Mid cloud ceilings can also result from the diurnal dissipation of convective cloud near or after sunset. The length of time during which these evening and night time ceilings can persist is often a function of the preceding amount of convective cloud. Finally, diurnal heating can also appear to 'burn off' or dissipate a thin disorganized area of AC during the odd occasion in summer.

TABLE I

Common Synoptic Cloud and Precipitation Predictors

POTENTIAL PREDICTOR	CORRELATES WITH	SOURCE OF PREDICTION
1. 500 mb trough (or PVA)	trailing edge of synoptic cloud or precipitation	chart history, satellite history, 1/2 of 500 mb flow speed, subjective assessment of development
2. 700 mb trough	trailing edges - usually for weaker systems	chart history, perhaps satellite history
3. 500 mb ridge	leading edge of cloud or precipitation	chart history, satellite history
4. 700 mb ridge	leading edge	chart history, perhaps satellite history
5. surface features (fronts, troughs)	orientation and pattern of cloud and precipitation	isobaric prog, satellite history
6. 500 mb S/W troughs vorticity centres	trailing edges; wrap around; history assessment	satellite history
7. stability analysis & diurnal trends	AC forming from spreading out of convective cloud	tephigrams, subjective convective potential
8. deformation zones	leading edges of cloud and precipitation	satellite history, chart history
9. jet streams	edges of cloud and precipitation, dry surges	chart history, satellite history
10. PVA, PTA	edges and shapes of cloud and precipitation	chart history, satellite history

2. FORECASTING THE FINE SCALE

When forecasting synoptic clouds and precipitation, quantitative information such as bases and tops of cloud, precipitation visibilities and time of onset or termination of weather must be given. Since synoptic cloud systems often can include more than just middle and high clouds, boundary layer forecasting techniques may also be required when specifying detail such as cloud bases or the timing for lowering ceilings.

Most of the quantitative information required when predicting synoptic clouds and precipitation can be obtained by using either synoptic correlation techniques or representative tephigrams. While mid cloud bases are less critical to aviation than are lower cloud bases, a need still exists for their specification. When only middle and high cloud are expected, cloud bases and tops usually can be forecast using representative soundings. When the synoptic support is strong enough to give cloud layers throughout the atmosphere, including the boundary layer, the resulting cloud bases normally are forecast using a number of techniques intended for boundary layer clouds. Most of these techniques are described in the following section; in particular, the techniques described in 4.3C for forecasting the lowering of boundary layer clouds in continuous precipitation are quite useful.

Normally, restricted visibilities in synoptic precipitation are the result of additional boundary layer processes and can be handled using either synoptic correlation techniques or other boundary layer forecast techniques. For liquid or freezing precipitation, restricted visibilities are normally the result of added haze or fog or blowing snow, since precipitation intensity alone has to be moderate or greater to affect visibility. On the other hand, snow alone can result in lowered visibilities, with the actual value determined by the moisture content of the snow, its intensity, and whether or not fog and wind (blowing) are contributors.

3. SYNOPTIC PRECIPITATION

The procedure for forecasting synoptic precipitation is practically the same as that for synoptic cloud. The main difference between the two is the requirement that the lifting mechanisms needed to give organized synoptic precipitation normally be stronger and the moisture greater than that required for cloud only. Disorganized or tattered synoptic precipitation, however, can result from the same intensity of lifting processes as those needed to give mid cloud alone.

Precipitation from organized synoptic cloud can, in the short term, often be forecast by extrapolation or by use of isochrones. In the very short term, the trends given by radar and satellite imagery can prove invaluable. However, in somewhat longer time frames, any extrapolation from the imagery or charts must be confirmed by identifying the physical processes that account for the precipitation. Synoptic correlation techniques, on the other hand, can prove valuable when forecasting precipitation both in the very short term and on longer time frames. In practice, most forecasting procedures for dealing with synoptic precipitation involve a mix of synoptic correlation, extrapolation, and modelling techniques.

When upstream data is sparse or when orographic influences are likely to be significant, the forecaster must rely to a fair extent on satellite extrapolation, synoptic modelling, and on a knowledge of climatology to obtain the predicted precipitation areas.

The techniques available for forecasting the type of synoptic precipitation are outlined at a later point in the documentation, Document 4.3E. These techniques are applicable to precipitation of all varieties, whether forced by synoptic, boundary layer, or convective processes. Methods for forecasting the amounts of precipitation expected are also covered in 4.3E.