Western Region Technical Attachment
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THE EFFECT OF SURFACE SPECIFICATION ON RAFS FORECASTS

[Editor's Note: This Technical Attachment is condensed from a paper presented by Dr. Ralph Petersen, NMC Development Division, at the 12th Conference on Weather and Forecasting, sponsored by AMS, during the first week in October.]

Introduction

The response of low-level model forecast fields to boundary layer processes can, on occasion, produce substantial errors in the forecasts of low-level temperature and wind, as well as precipitation. Without an understanding of their causes, the persistence of these errors through successive forecast cycles can greatly reduce forecaster confidence in the reliability of the numerical guidance. This paper will examine the problems related to the specification of snow cover and subsoil temperatures in the Regional Analysis and Forecast System (RAFS).

Snow Cover

The influences of snow cover vary spatially and temporally, are difficult to anticipate, and have a wide variety of forecast implications. To get a better understanding on how snow cover effects the RAFS, a short discussion on how this field is derived is appropriate.

Once a week, the Synoptic Analysis Branch of NESDIS analyzes the extent of snow cover (but not snow depth) over the northern hemisphere. Areas covered by snow are determined subjectively using polar and GOES imagery and are digitized onto a 190 km resolution grid. All grid squares whose areas are at least 50% covered by snow are considered to be fully covered and vice versa. This analysis is normally done on Mondays and first affects the RAFS forecasts at 00Z Tuesday or Wednesday. Forecast implications include:

- o Once the snow cover is set at the beginning of the week, the NGM snow cover field is kept fixed until the next analysis, a week later. The snow field is not allowed to change through additional accumulation or melting.

- o Where there is snow cover, the earth's surface (skin) temperature in the NGM is not allowed to exceed 32°F. Forecast errors of 10-20°F in the lowest sigma layer are possible when the actual snow field and the NGM snow field differ. This can lead to other errors such as the forecast of frozen vs. liquid precipitation.

For example, a light widespread snowfall that occurs over a weekend, will likely be mapped onto the grid during Monday's analyses. Subsequent warming early in the week may melt most of the snow cover. This is most likely during the late fall and early spring periods. However, the NGM will carry this snow field through the week, adversely affecting temperatures in the lowest sigma layer. This is the type of situation to be alert for.

Subsoil Temperatures

Subsurface soil temperatures play a significant role in the atmospheric surface energy budget, especially during clear nights early in the cold season. At such times, the relatively warm subsurface acts as a non-trivial heat source to the surface energy budget and reduces the nighttime drop-off in the low-level air temperature. However, the RAFS specification of subsoil temperature is computed using a procedure which causes the subsoil temperature to respond too quickly to changing air masses. As a result, the subsoil acts as a heat sink rather than a source, when cold air moves over warm ground. The effects of this procedure seem to be more pronounced at higher elevations.

Since the daily mean subsurface soil temperature varies slowly, a RAFS experiment was run in which the subsoil temperature was assigned a value equal to the 15-day running average of the RAFS analyzed air temperature of the lowest model sigma level. The RAFS forecast, using the experimental method, was run in parallel with the operational RAFS this spring. Results for Great Falls, Montana, are shown in Figure 1. The experimental approach eliminated both the large cycle-to-cycle variations of subsoil temperature, as well as the cold bias.

Why is This Information Important to the Forecaster?

The cold bias, resulting from the current RAFS snow cover and subsoil specification, mainly affects the lowest sigma layer (boundary layer) of the NGM model. As a result, forecasters who use the NGM FOUS (FRHTxx) output may note discrepancies between the boundary layer temperature and NGM MOS guidance, which may be critical in determining a rain vs. snow forecast. The effect of this cold bias may or may not influence the NGM MOS; it depends on the predictors used by the MOS equations. For most sites, NGM MOS temperature guidance is closely tied to current observations and the 850 mb height/temperature fields, so it's unlikely that MOS temperatures will be affected.

The LFM also uses the same snow cover field in its analysis, however, since the lowest LFM model layer is somewhat thicker than the NGM's, the effect on the LFM FOUS (FRHxx) data is not as noticeable.

Again, the NGM FOUS data is most affected by these surface specification of snow cover and subsoil temperature.

Proposed Changes

Efforts are now underway to reduce the deficiencies in the snow cover specification procedures. NMC is investigating the feasibility of using an analysis of snow depth (not just snow cover) that has a higher resolution and is updated daily rather than weekly. Using such a procedure could allow more flexibility in the model. For example, the air temperature in areas of shallow snow cover could be allowed to rise above 32°F.

As noted above, the RAFS experiment of using the 15-day summary average of analyzed low-level air temperature to eliminate the cold bias and cycle variations in subsoil temperature has proved successful. Therefore, this procedure is projected for implementation in January 1990.

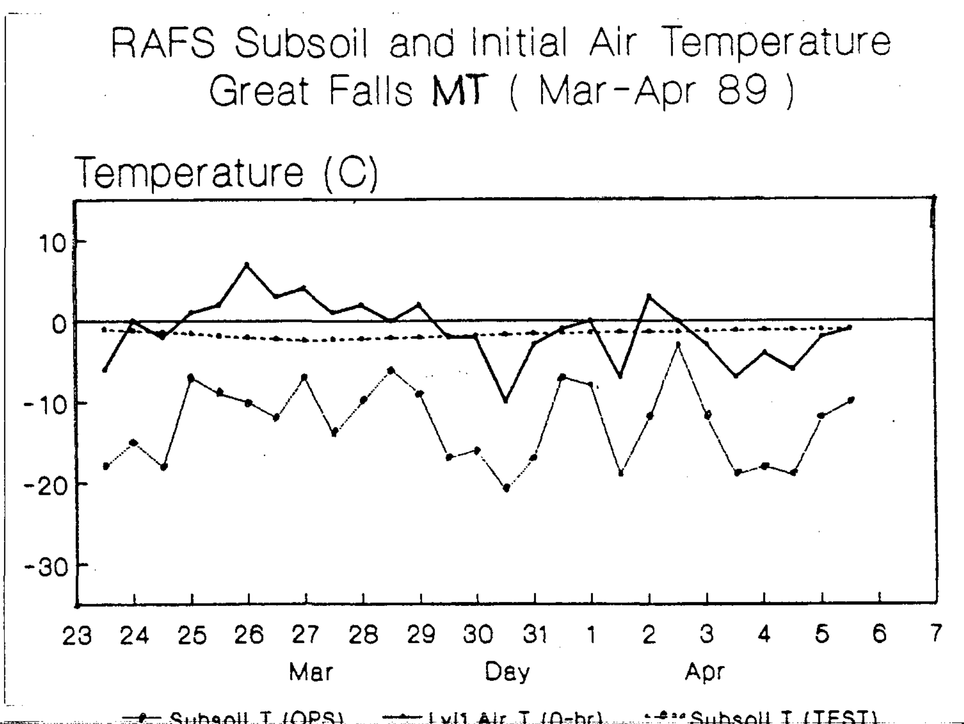

Fig. 1 RAFS operational (dotted) and test (dashed) subsoil temperature and 0-h lowest-level air temperature (bold) at Great Falls, MT for each 12-h analysis cycle from 1200 UTC 23 March 1989 to 1200 UTC 6 April 1989.