Very short range atmospheric forecasts using a nudging procedure to combine analyses of cloud related variables with a numerical forecast model.

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High forecast accuracy of cloud cover and precipitation is needed in order to make quality predictions of various weather parameters close to the ground. A specific example is the problem of providing accurate local predictions of frost and/or snow on road surfaces. At DMI (Danish Meteorological Institute) a forecast module predicting road conditions (Sass, 1997) has recently been integrated to a version of the atmospheric model DMI-HIRLAM (Sass et al., 2002) used operationally at DMI. In this way an efficient exchange of data between the two models, e.g. cloud and precipitation variables, is possible during model execution. In order to utilize cloud- and precipitation data for assimilation, a nudging procedure is currently being developed which combines a 3-D cloud analysis and a precipitation analysis with a DMI-HIRLAM forecast to improve the quality of short range predictions of cloud cover and precipitation. The production of a 3-D cloud analysis and a precipitation analysis is a non-trivial issue and is currently at an early stage where only conventional data are used in combination with a model first guess. During an assimilation period (1 to 6 hours) prior to a forecast, the cloud and precipitation analyses are assimilated by a tendency modification for both specific humidity and cloud condensate which are both prognostic variables. The tendency modification depends on differences between analysed and forecasted cloud cover and on the difference between analysed and forecasted precipitation. Non-local vertical structures are imposed to incorporate precipitation effects. 1-dimensional tests indicate a considerable skill to adjust model cloud cover and precipitation towards analysed amounts. The assimilated information is retained into the forecast phase. Cloud cover modifications during 1-D asimilation tests extend in many cases with a weak dynamical forcing into a forecast range of more than +12 hours and sometimes beyond +18 hours.

An example of a 3-D assimilated and forecasted total cloud cover for Denmark and surrounding areas is shown in figure 1. The case applies to a situation on 13 December 2001 dominated by low level clouds. The left panel shows the forecast results after nudging was run, and the right panel shows the corresponding results without nudging. When comparing with cloud observations the results using nudging appears to be the most realistic.

Experience indicates that nudging of cloud cover plus precipitation information shows a considerable sensitivity to the methodology applied for the nudging. Furthermore the assimilation appears to be sensitive to the the model physics used in connection with cloud- and precipitation processes.

References

Sass, B. (1997). A numerical forecasting system for the prediction of slippery roads. *J. Appl. Meteor.*, 36:801–817.

Sass, B. H., Nielsen, N. W., Jørgensen, J. U., Amstrup, B., and Kmit, M. (2002). The operational DMI-HIRLAM system. Dmi tech. rep. no. 02-5, Danish Meteorological Institute.

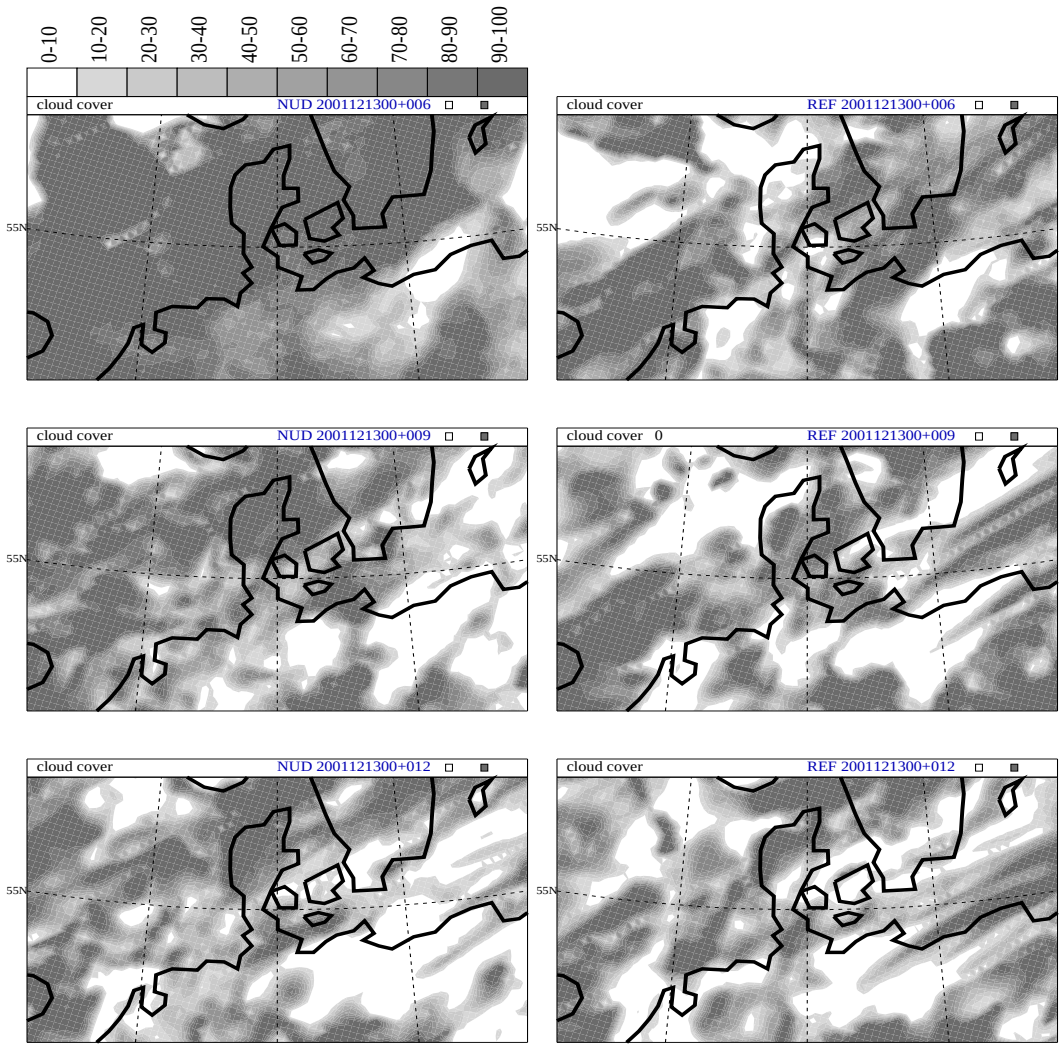

Figure 1: Total cloud cover for 3-D case on 13 December 2001 with nudging applied (NUD) and without nudging (REF). The +006 applies to the end of the nudging period while +009 and +012 correspond to 3 and 6 hours real forecasts.