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DIFFERENCES IN RELATIVE HUMIDITIES IN THE NMC MODEL SUITE

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INTRODUCTION

For many years, forecasters were only able to forecast model cloud development and movement by looking at the relative humidity forecasts available from numerical guidance. By using simple rules of thumb based on percentages of relative humidity, forecasters estimated the amount of areal coverage of these clouds. Recently, an explicit cloud prediction scheme was developed and implemented into the Eta model (Zhao et al., 1996). This scheme replaced the diagnostic cloud scheme already in place and produces explicit, three-dimensional forecasts of both cloud fraction and water content. This paper will address the differences between this scheme and the previous scheme and discuss the impact to operational forecasters.

LARGE-SCALE SATURATION ADJUSTMENT SCHEME

Until recently, all NMC models used a large-scale saturation adjustment scheme (Hoke et al., 1989) in the parameterization of large-scale condensation and precipitation. This scheme treated the complicated processes associated with condensation and precipitation in a very simplistic manner without taking into effect any microphysical processes occurring in the model clouds.

In this scheme, large scale effects such as vertical motions and advections are allowed to modify the model relative humidity forecasts. In addition, some modification of the humidity field occurs through the convective parameterization in the model. Grid-scale precipitation occurs when the relative humidity at a grid point exceeds about 95% (Phillips, 1981). Supersaturation in excess of 100% is reduced to 100%, with values between 95% and 100% reduced gradually toward 95%. This method allows for inhomogeneities of moisture within a grid box and permits a more gradual onset of precipitation than a scheme in which 100% saturation is required. This precipitation is then allowed to fall and evaporate in lower layers in which the relative humidity is less than 95%. The precipitation is evaporated into a subsaturated layer until the relative humidity is increased to 95%, upon which the remaining precipitation falls to the next model layer, and so forth. While this simplistic approach has produced reasonable cloud and precipitation forecasts, the lack of realistic three-dimensional clouds has limited the success of this method.

EXPLICIT CLOUD PREDICTION SCHEME

Recently, an explicit cloud prediction scheme was added to the Eta and Meso Eta models. This scheme explicitly represents cloud liquid water and cloud ice in the model's prognostic equations. Results have shown significant improvement in moisture and precipitation forecasts and some small positive impacts on variables such as wind and temperature (Zhao and Black, 1994). Additionally, this scheme produces explicit, three-dimensional forecasts of both cloud fraction and water content, which are used to link the hydrologic cycle to the radiation parameterization package in the model.

Clouds are produced in this scheme from large-scale condensation processes, just like in the previous scheme. Two three-dimensional cloud fields are calculated: cloud fraction is computed from relative humidity, and cloud water/ice content is calculated by the cloud water/ice mixing ratio, which is an explicit variable in the model. Clouds in this scheme consist of either liquid droplets or ice particles, depending on the temperature of the cloud.

Condensation occurs in the model at two different percentages. Over land, condensation is allowed to begin when the relative humidity exceeds 75%. Over water, condensation begins to occur at 85%, to avoid excessive condensation. This higher value over water is due to the fact that condensation can occur much easier over the ocean than on land, especially in the lower atmosphere, because of the availability of moisture. These percentages allow for sub-grid variations in the relative humidity field.

Precipitation in this scheme is calculated from the cloud water/ice mixing ratio. Once precipitation is produced from cloud water/ice, it is assumed to fall to the ground in one time step. Six major microphysical processes are used in the parameterization of precipitation production from clouds. These processes are: autoconversion of cloud water to rain, collection of cloud droplets by the falling rain drops, autoconversion of ice particles to snow, collection of ice particles by the falling snow, melting of snow below the freezing line, and evaporation of precipitation below cloud bases. The evaporation process is similar to that of the previous scheme, whereby precipitation is evaporated until the layer moistens to the critical value of 75% over land or 85% over water before falling to the next layer.

IMPLICATIONS

Because of the differences in the two types of schemes, forecasters will need to interpret the output of relative humidities produced in each model differently. Models which use a large-scale saturation adjustment scheme, like the NGM and Aviation (AVN) models, will tend to have higher relative humidity fields than models which have an explicit cloud prediction scheme, like the Eta and Meso Eta. This difference in relative humidity values is mainly due to two processes.

First, since condensation is allowed to occur earlier in the explicit scheme, and precipitation allowed to begin sooner, less moisture will be available to allow the relative humidity to rise above 90%, except in strongly forced situations. In the saturation adjustment scheme, since condensation does not occur until 95%, it is much easier to reach these high values of relative humidity.

Second, because some water is tied up in cloud water/ice in the explicit model, the relative humidity will be even lower because this cloud water/ice is not added to the large-scale relative humidity field. However, since the model produces explicit three-dimensional clouds, the forecaster can see the actual model produced clouds, as opposed to guessing where they are by using relative humidity rules of thumb. Unfortunately, due to limited computer resources, the cloud fraction fields are not available to the field. This will hopefully change in the near future. In the meantime, forecasters should be aware of the differences in the interpretation of the relative humidity fields produced by the various models, and not wonder any longer why the Eta model always looks "so dry".

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