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THE AVN/MRF MODEL ENHANCEMENTS

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NCEP has implemented a bundle of changes for the Operational AVN/MRF Analysis and Forecast System. The list of changes include; 1) increase in horizontal and vertical resolution, 2) physics updates, 3) new analysis and assimilation updates. This new AVN/MRF package was run in parallel with the operational model for two months. During this two-month period, the following improvements were noted:

1) reduction in the wet bias of precipitation over land
2) reduction of the cold bias over much of the atmosphere, including the stratosphere and near-surface layers
3) reduction in jet level vector errors
4) increase accuracy in tropical winds
5) slightly better 5-day 500mb anomaly correlations
6) maintaining transient eddy kinetic energy

Resolution Changes

The horizontal and vertical resolution have been changed from T126L28 to T170L42. This resolution is run out to 78 hours for the 4-per-day AVN and for the first 84 hours of the MRF. Beyond 84 hours, the MRF is run at the T126L28 resolution until 168 hours. At 168 hours, the resolution is set to T62L28. The change in resolution at these times is done with minimal impact to the forecast through the use of a filter. The T170 represents a grid resolution of 80km, while the L42 represents a change to 42 sigma levels.

The increase in vertical resolution is distributed evenly throughout the atmosphere. There are three new levels in the stratosphere, eight in the middle to upper troposphere, and three in the boundary layer. The top sigma level is now 200mb up from 270mb in the current operational model. This now allows for a prognostic ozone variable in the stratosphere. The vertical resolution minimizes the truncation error in the vertical differentiation, integration, and in the resolving of fronts.

New Land-Surface Parameterizations

1) Vegetation: monthly mean vegetation cover with eight soil categories and 11 vegetation categories versus a vegetation cover constant.
2) Canopy Water: Maximum canopy water content has been reduced in order to increase temperature forecasts.
3) Transpiration: The new formulation allows for transpiration to cease after dark. It also decreases the amount of transpiration when the air is too hot or too dry.
4) Snow Cover: Snow cover is not allowed in a grid box if it is less than one inch.
5) Frozen Soil: None in order to better represent runoff.
6) Snow Depth: Water equivalent has been reduced in order to better represent snow melt.
7) Runoff: This has been increased to allow for a more representative runoff. This is achieved as the 15% of the grid box becomes saturated, whereas before the whole grid box had to become saturated in order for runoff to occur.
8) Roughness Length: The thermal roughness length has been changed to represent observations made from recent field experiments in order to improve the model skin-to-air temperature gradient.

Convection Changes

The model uses a Simplified Arakawa-Schubert scheme. This formula has been modified to allow for earlier initiation of convection. The upper limit of a tunable cloud work parameter has been modified to correct precipitation bulls-eye problems encountered over ocean surfaces.

A modification has also been made to the evaporation formula for convective rain in order to retain better precipitable water values. The evaporation efficiency factor has been allowed to vary with the strength of the wind shear. This change was made only over ocean grid points.

Enhanced Gravity Wave Drag

Gravity Wave Drag (GWD) arises from the interaction of sub-grid scale gravity waves generated by the wind and orography and the subsequent vertical propagation of these waves and their interaction with the atmosphere. The model response to GWD is to improve systematic NWP model errors. Improvements to the parameterization on the lower atmosphere have resulted in better cyclone track speed and development intensity. Thereby reducing mid-latitude westerlies and warming the polar atmosphere. This improvement should help increase the accuracy of predicting leeside mountain cold air outbreaks.

Radiation and Clouds

The new shortwave radiation parameterization scheme consists of a multi-spectral band technique, an improved calculation in cloudy atmospheres, the addition of climatological aerosol effects, and a new surface albedo. Significant improvements were noted in the model-computed radiation budget at both the top of the atmosphere and the earth's surface. Surface albedo was also shown to improve. Southwest radiative heating is enhanced in the new model, resulting in a warmer troposphere, especially in the Tropics. The long-wave radiation scheme is also slightly modified in regions of model multi-layer cloud. This procedure allows for long-wave cooling at the cloud top, which was not part of the model previously.

The model diagnoses clouds from model relative humidity throughout the model troposphere. A set of cloud/humidity relationships has been developed from synoptic US Air Force RTNEPH cloud analyses and includes cloud/humidity relationships for lower atmospheric clouds. Previously, the model only allowed for lower atmospheric clouds in suspected marine stratus regions. This led to low stratus not being modeled well, affecting sensible weather parameters.

Ozone

A prognostic ozone variable has been added. Previously, ozone was represented by a zonal and seasonal mean climatology. This new scheme helps to provide a first guess field. This first guess of ozone is an integral part of incorporating GOES and TOVS measured radiances. The spatial variability of ozone can also help in the calculation of the UV Index.

Assimilation Improvements

The time interpolation has been improved in order for the model to incorporate more observations into its initial analysis. Improvements to the nonlinear analysis allow for the minimization of the nonlinearities found in SSM/I wind speeds and atmospheric moisture. The SSM/I wind speeds are now more heavily weighted to observations. The minimization of moisture has led to a better precipitable water calculation and the unlikelihood of persistent negative areas. Also, in this change, an external iteration is done on the entire analysis procedure. This procedure is done to incorporate weak nonlinearities in the observation and balance constraints.

A reformulated background error covariance determines the spatial and multi-variate distribution of information in the analysis. Currently, it only varies by latitude, and will, in the future, vary per synoptic situation. This will allow for the model to better handle tropical analyses and forecasts and to model the latitudinal variation in the moisture field.

Among the changes involving satellite data, three polar orbiting satellites providing HIRS (High Resolution Infrared Sounding) and MSU (Microwave Sounding Unit) data along with GOES-8 and GOES-9 radiances are currently being used in the analysis system. OPTRAN (Atmospheric transmittance calculations) and radiative transfer code has been modified to include the data from the three polar orbiting satellites and cut computational costs. Surface emissivity calculations have been modified for both the microwave and infrared channels. GOES-8 and GOES-9 radiances are used directly over the oceanic surfaces. With the inclusion of new surface emissivity calculations, elimination of land or cloud contaminated fields of view is made easier. Only data which is observed within +/- 1.5 hours of the analysis time are used. A 3-D ozone analysis has been implemented in order to use radiances in the ozone analysis and to include predicted ozone in the forecast model.

The increased resolution has allowed for the analysis resolution to be increased. The increased resolution should reduce the differences between the observed and modeled elevations in order to assimilate observations better. The vertical resolution increase helps with better representation of the satellite radiances.

The full document of changes is detailed in a Technical Procedures Bulletin at http://sgi62.wwb.noaa.gov:8080/tpb97/TPB98/test.419.html or via the NWS TPB Home Page at http://www.nws.noaa.gov/om/tpbpr.htm