1. Introduction

- The majority of satellite channel data affected by clouds are discarded in the NCEP operational data assimilation systems. These systems have been geared towards utilization of observations in clear sky conditions, since this is the most straightforward use of the data.
- However, as clouds and precipitation often occur in regions with high forecast sensitivity, improvements in the temperature, moisture, wind and cloud analysis of these regions are likely to contribute to significant gains in NWP accuracy.
- Efforts to assimilate cloud affected radiance data in the NCEP NWP models has been progressing continuously under NOAA/NCEP, NASA, HFIP and JCSDA support. The work initially is directed towards the inclusion of microwave satellite data with a cloud signal, since the microwave data has the ability to penetrate most clouds.

2. NCEP Global Data Assimilation System (GDAS)

- NCEP GDAS is composed of (1) Gridpoint Statistical Interpolation (GSI) system, (2) Global Forecast System (GFS) system, and (3) Community Radiative Transfer Model (CRTM).
- GSI is an unified variational data assimilation system for both global and regional applications. It was initially developed by the NOAA NCEP. The GSI analysis system became operational as the core of the North American Data Assimilation System (NDAS) in June 2006 and the Global Data Assimilation System (GDAS) in May 2007 at NOAA.
- Since then, the GSI system has been adopted in various operational systems, including the NASA global atmospheric analysis system, the NCEP Real-Time Mesoscale Analysis (RTMA) system, the Hurricane WRF (HWRF), the Rapid Refresh (RR) system, and the Air Force Weather Agency (AFWA) operational system.
- Getting analyses by assimilating observations can be described as minimizing a cost function J, which is defined as:

\[ J = (x-x_0)^T H^T R^{-1} H (x-x_0) + (x-x_0)^T \sigma_z^T \sigma_z (x-x_0) \]

where \( x \), \( x_0 \) = background, \( B \) = Background error covariance, \( H \) = Observation operator, \( R \) = Observations, \( \sigma_z \) = Observation error covariance

3. Quick View of Progress to Date

<table>
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<th>Operational GSI (Clear Sky radiance DA)</th>
<th>New GSI (All-sky radiance DA)</th>
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<tr>
<td>(1) Forward operator &amp; First guess fields</td>
<td>Do not include cloud</td>
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<td>(2) AMSU-A data</td>
<td>Clear sky over land and ocean</td>
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<td>(6) Observation error</td>
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- Assimilating AMSU-A Cloud affected radiance data in NCEP Global Data Assimilation System (GDAS) resulted in cloud analysis fields much closer to the satellite observed clouds.
- Including NCEP Global Forecast System (GFS) model’s cloud and precipitation microphysics schemes in optimizations improved cloud analysis fields.

4. AMSU-A Observation vs. NCEP Global NWP Model

5. AMSU-A Observation Error for All-Sky (Clear+Cloudy Sky) Condition

6. Preliminary Results

- Comparisons of static background error covariance with ensemble background error covariance for hybrid GSI system are under way.
- Testing impacts on GFS model forecasts and HWRF model forecasts skill scores.

7. Future Work

- Comparisons of static background error covariance with ensemble background error covariance for hybrid GSI system are under way.
- Testing impacts on GFS model forecasts and HWRF model forecasts skill scores.