Assimilation of cloud- and land-affected satellite sounding data at the Data Assimilation Office

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Satellite data from passive microwave and infrared sounders consistently improve forecasts and analyses in data assimilation systems. However, most numerical weather prediction (NWP) centers use only a small fraction of the data available from these instruments. In particular, NWP centers often exclude data from infrared instruments, which are affected by clouds more than are microwave sensors. Similarly, most NWP centers omit data from land-affected channels.

Sensitive areas for medium-range forecasts are frequently cloudy. Clouds affect ~80% of infrared pixels from the Advanced TIROS Operational Vertical Sounder (ATOVS) flying on NOAA weather satellites. Conservative cloud detection schemes may declare 90% or more pixels as cloud-contaminated.

The next generation of infrared kilo-channel sounders offers more information than the current ATOVS infrared sounding instrument. This next generation includes the Atmospheric Infrared Sounder (AIRS), which will fly on the NASA EOS Aqua satellite. Our ability to use land- and cloud-affected data from these instruments may increase their impact on forecasting capabilities.

Several methods exist for utilizing cloud-affected data in a data assimilation system. These include (1) directly assimilating the cloudy radiances and (2) assimilating cloud-cleared radiances. Direct assimilation of cloudy radiances is very challenging, as it requires reasonably accurate model-generated clouds and a fast and accurate radiative transfer model. At the NASA Data Assimilation Office (DAO), we examined the latter approach.

Assimilating cloud-cleared radiances involves estimating the clear-column radiance that would have been observed in the absence of cloud. We examined the effectiveness of this approach using the DAO¹s next-generation finite-volume Data Assimilation (fvDAS) with a 1D variational radiance assimilation scheme. This system simultaneously performs cloud-clearing and retrieves information about temperature, humidity, ozone, and surface parameters including the surface skin temperature.

The fvDAS experimental setup was at a resolution of 2° latitude × 2.5° longitude for the month of August 1999 with a 2 week spin-up. We conducted a series of experiments using different ATOVS data: 1) DAO CC (includes cloud-cleared data) 2) DAO CLR (clear data only) 3) NESDIS (operational retrievals). One major caveat is that the DAO experiments used the NOAA 15 satellite with the Advanced Microwave Sounding Unit (AMSU) whereas the NESDIS experiment did not.

Figure 1 shows the spatial RMS of the bias and the standard deviation of the radiosonde observed minus 6 hour forecast residuals for heights. Both the DAO CC and DAO CLR have substantially less height bias. The DAO CC has a smaller bias in height in all regions except Asia (NE), where the type of radiosonde used has known temperature bias. Improvements in 5 day forecasts with DAO CC were also achieved. Similar experiments were conducted with and without land-affected channels. A positive but smaller impact was shown on the 6-hour forecast heights.

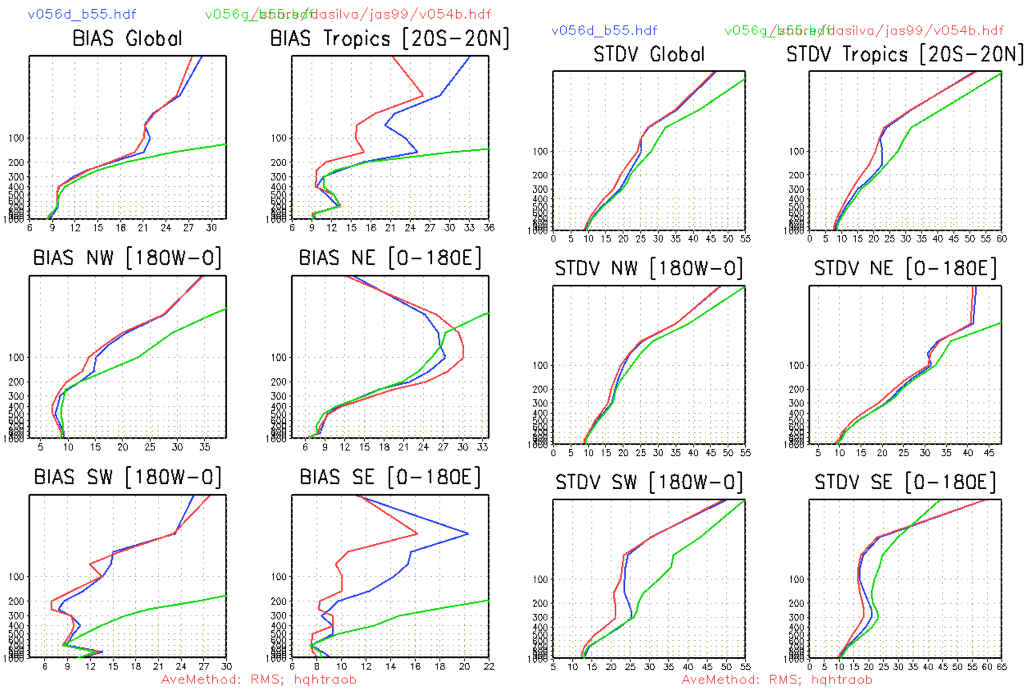

Figure 1: Spatial *RMS of the bias (left) and standard deviation (right) of radiosonde observed heights minus 6 hour forecast residuals averaged over August 1999. Red: DAO CC; Blue: DAO CLR; Green: NESDIS*