

Operational Assimilation of GOES Imager Water Vapor Channel at MSC

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Abstract

The assimilation of GOES imager radiance data at 6.7 micron (channel 3) was made operational in the Canadian Meteorological Center (CMC) global 3Dvar analysis system June 19th 2003. GOES imager channel 3 is sensible to moisture in the atmosphere at 500 to 250 mb. The MSCFAST physical radiative transfer model is used as forward operator (Garand et al. 1999). This implementation of GOES water vapor radiances was made in the same time as ATOVS AMSU B radiance data were added in the assimilation system. Impact on water vapor fields of these two data sets assimilated separately is quite similar for overlapping areas in the 500 to 250 mb layer. The improvement of adding independently GOES imager channel 3 on moisture analysis and forecasts is shown. Positive impact on the quality of forecasted moisture fields is present up to 48 hours. Quantitative precipitation forecasts improvement over North America is also noted. The monitoring suite of data treatment shows stable innovations statistics. Furthermore geographical maps of monthly averages of innovations show no viewing angle bias problems yet significant local monthly mean corrections. These data are to be implemented in the regional system as the new main frame computer becomes operational. GOES radiance data are readily available for the CMC's regional system despite a short cutoff time. This is not necessarily the case for AMSU B data where large data voids are noted.

Similarity of impacts of GOES imager water vapor and AMSU B radiances

In order to evaluate the effect of a new data type on the quality of the assimilation system an experimental cycle is launched with the addition of this data. Here two experiments were run with each the addition of GOES channel or ATOVS AMSU B data only. Maps of 6 weeks averaged differences to the control of dew point depression (T-Td) analysis are shown for both experiments (see Fig. 1). These averaged "corrections" to the control are remarkably similar. This is a strong validation of both data sets as they show almost the same behavior when tested independently.

Impact on analysis and forecast quality

An objective evaluation of both cycles was done. The improvements noted were mainly on moisture fields, but mass fields were also somewhat better. Figure 2 shows objective scores of the forecast issued from the cycle with added GOES data using radiosonde measurements from South America as reference observations. Even if the analysis does not agree as well with radiosondes, the 6 hour forecasted moisture is greatly improved over the control run and is still somewhat present up to 48 hours. The scores are more neutral over North America. However a significant gain over that area is noted in precipitation scores when goes radiances are added (see Fig. 3).

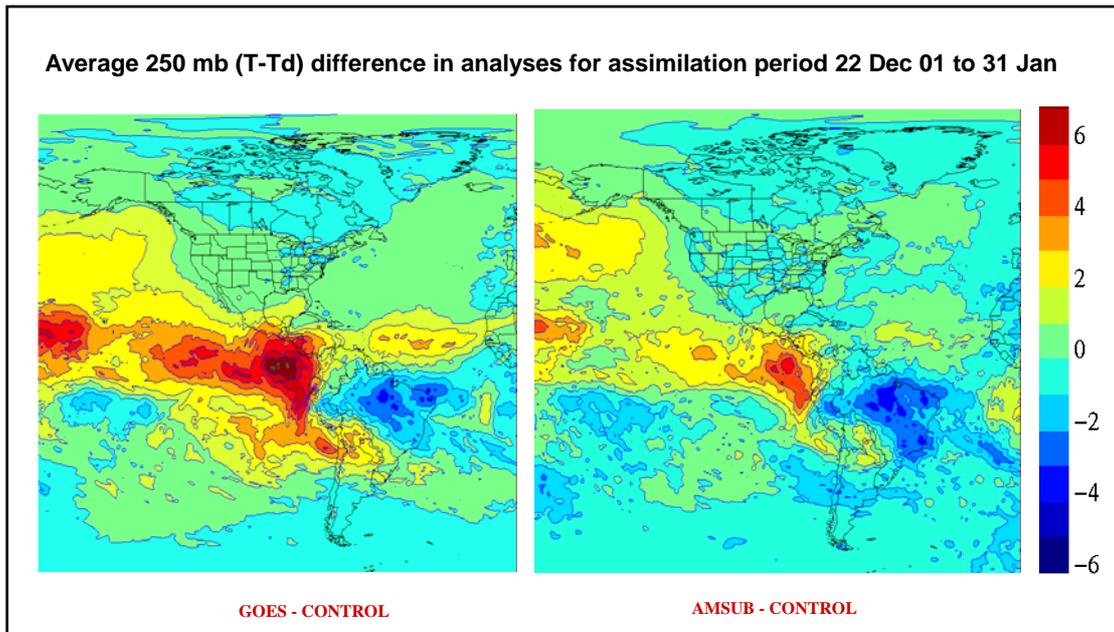


Fig. 1: Comparison of mean dew point depression changes induced by adding of GOES Imager channel 3 and AMSUB radiances derived from a 41 day analysis cycle.

The bias are marginally affected (top panels of Fig. 3) but the threat scores are better for every precipitation class (bottom panels), and this is true for the first and second day of the forecast (left and right panels). This may be attributed to the added information in upstream moisture captured by GOES west over the Pacific Ocean.

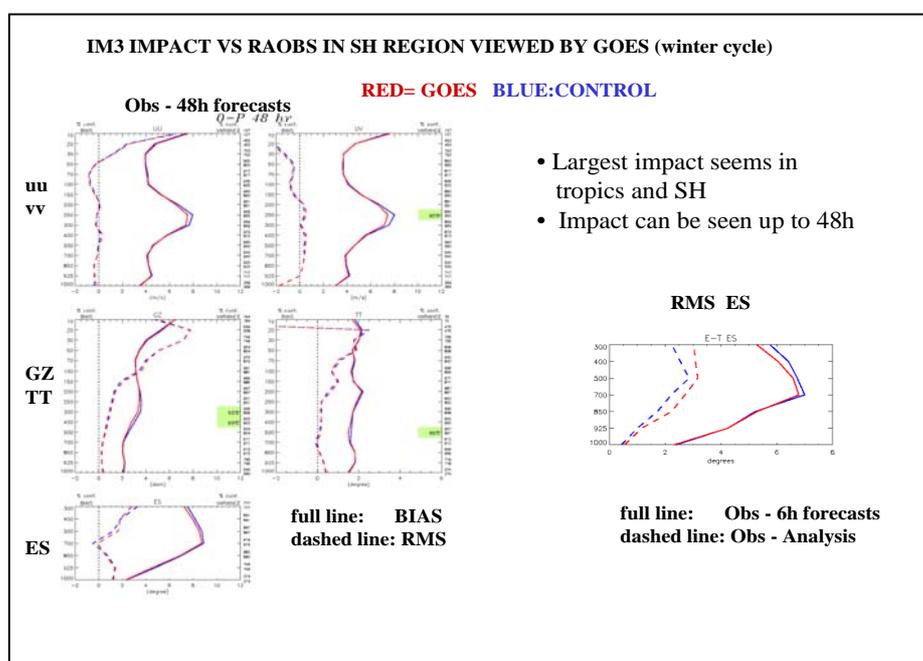


Fig. 2: Comparison over a 2 month period of the quality of analysis and forecasts against South American radiosonde data between a control cycle (blue) and a test cycle that included GOES imager 3 data (red).

The cycle with AMSU B data only has greater positive impact on scores (not shown). Results from a similar cycle with both AMSU B and GOES radiance included shows substantial improvement over the southern hemisphere and good improvement over the northern hemisphere, with gains lasting up to 96 hours (see Chouinard and Hallé, this volume).

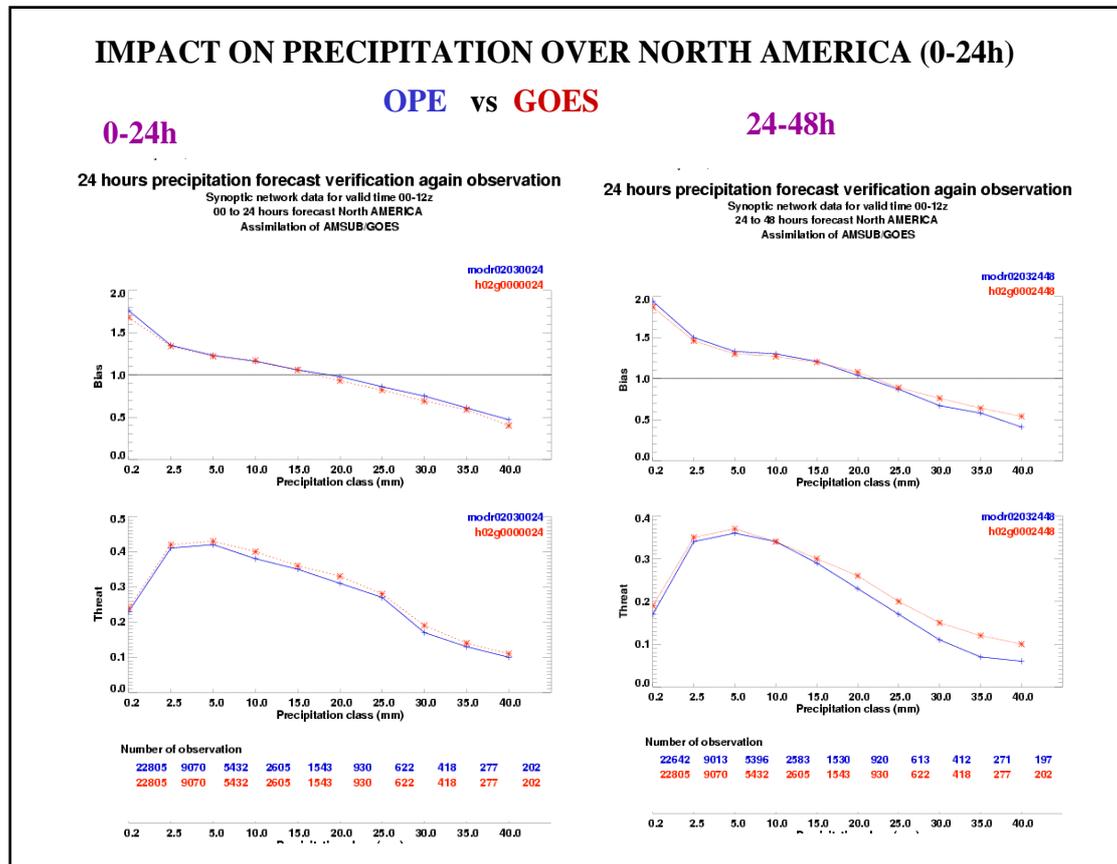


Fig. 3: Evaluation over a 2 month period of the quality of 24 hour accumulated forecast precipitation against North American synoptic rain gages for the control cycle (blue) and a test cycle that included GOES imager 3 data (red). Bias and threat scores are shown with the number of observations per rainfall category.

Monitoring diagnosis

When assimilating large amounts of satellite data it is essential to routinely check the quality of the data. A time series trough every analysis time of the average and standard deviation of the innovations (observation – 6 hour forecast) allows for identification of any sudden drop in data quality. For GOES data, the stability of the bias correction and standard deviation can be verified on Figure 4: no derivation in time of the statistics is noted. The bias correction used here is a simple linear fit with brightness temperature (Garand, 2003). The coefficients found are kept constant until the need of readjustment is revealed from the monitoring. Figure 4 also shows the residuals (observation – analysis) time series. Note the standard deviation reduction from red to blue confirming a good fit of the analysis to these observations.

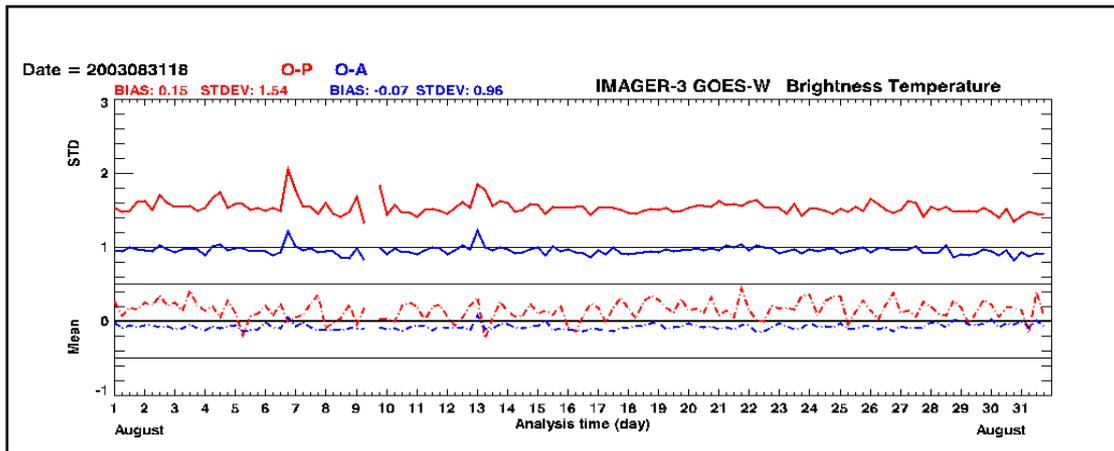


Fig. 4: A monthly time series of imager 3 brightness temperatures innovations (Observation minus 6 hours Forecast, in red) in CMC's current operational analysis system. A significant variance reduction is obtained after assimilation represented by brightness temperature residuals (Observation – Analysis, in blue). The solid lines show the standard deviation and the dotted lines the bias.

Another way of evaluating the behavior of this type of data in an assimilation system is to map mean brightness temperatures. Figure 5 shows such a map where pixels are averaged over a month of innovations located within a 2 degree box. This plot indicates no presence of obvious bias with viewing angle. Furthermore the plot shows areas of substantial correction to the model's climatology. Here positives innovations imply drying of the atmosphere.

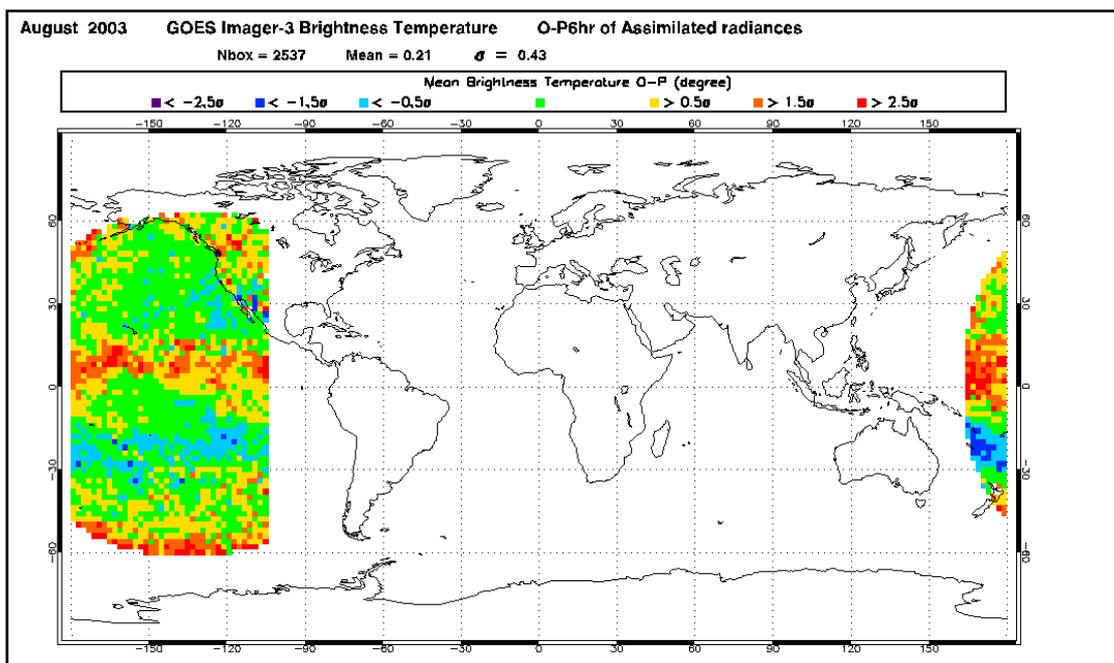


Fig. 4: A monthly average of brightness temperatures innovations (observation minus 6 hours forecast) over 2 degree boxes in CMC's current operational analysis system. The color scale is in units of the overall standard deviation ($\sigma = 0.43$ K).

Data availability

An important consideration for the operational use of satellite measurements is the timeliness of the availability of the data. This is especially true when a model has to be launched with a relatively short cutoff time. At the Canadian Meteorological Center, the regional model (with higher resolution over North America) has a 1 hour and 40 minutes cutoff time. As one can see on figure 6, the late arrival of the NOAA17 data makes for large gaps in the coverage at the regional cutoff time. Depending on time of day, the available swaths can miss regions of interest for the regional model. However the GOES coverage is precisely over the area of interest and is available within 15 minutes of the analysis time (see Figure 7). This is an important additional justification for including also GOES channel 3 data in the operational assimilation system even if moisture information seems redundant when AMSU B data from the NOAA satellites are present.

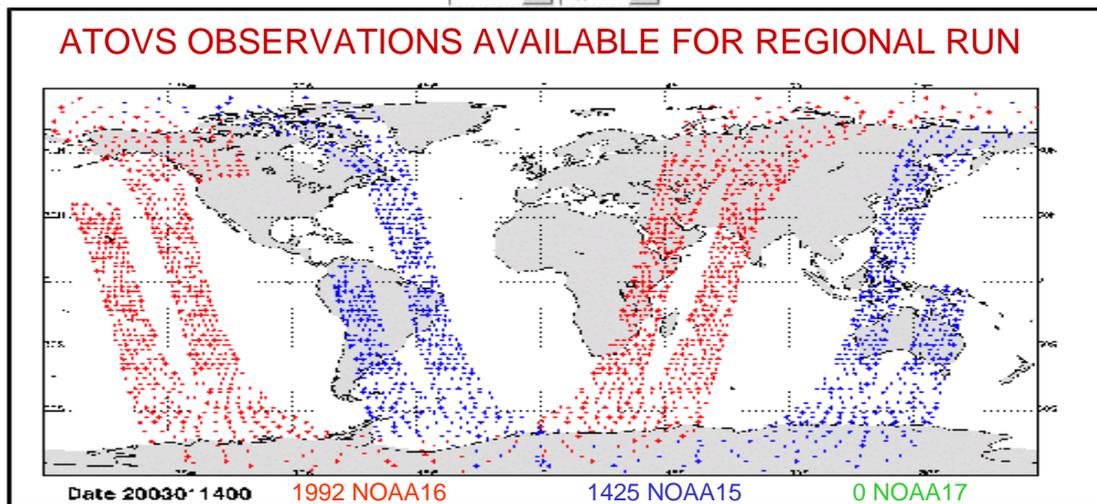


Fig. 6: An example of NOAA ATOVS coverage available at CMC for regional model (after thinning).

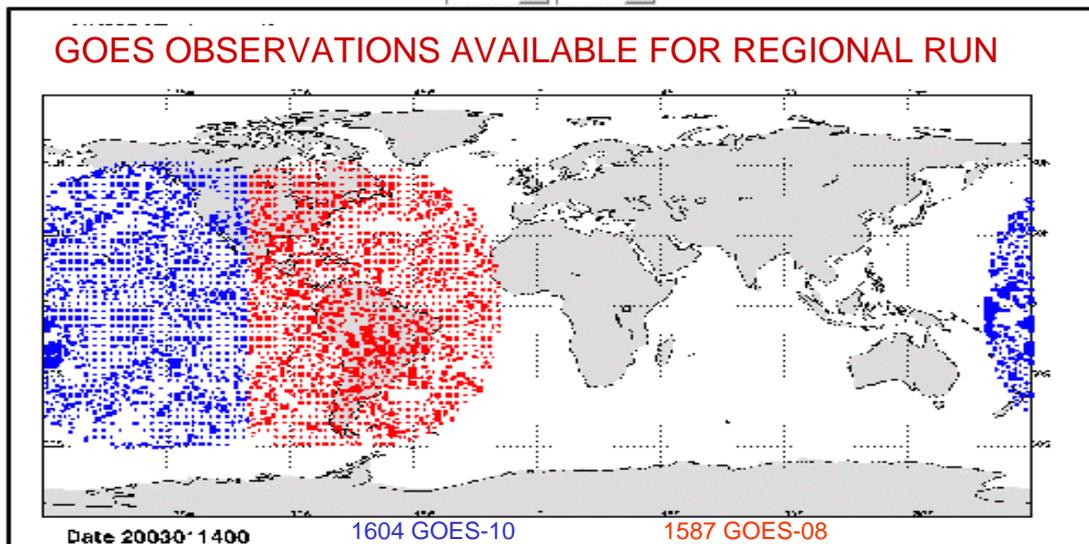


Fig. 7: An example of GOES imager data coverage available at CMC for regional model (after thinning).

Conclusions

GOES water vapor channel has a positive impact on analyses and forecasts, especially over South America. A good synergy with AMSU B data is noted. The availability within 15 minutes of GOES data makes possible its use in CMC's regional model (centered over North America) despite its short cutoff time. Work is under way to include radiances from the recently activated GOES-12 satellite. Assimilation at higher temporal frequency is foreseen with implementation of 4Dvar (2004). Surface channels imager 4 and 5 are also monitored and available for eventual assimilation (see Garand et al., this volume). Applying a similar procedure to geostationary satellites MSG and MTSAT water vapor channels is planned in order to cover the whole globe in the tropics and mid-latitudes.

References

- Garand, L., D.S. Turner, C. Chouinard and J. Hallé 1999. A physical formulation of atmospheric transmittance for the massive assimilation of satellite infrared radiances. *J. Appl. Meteor.*, **38**, 541-554.
- Garand, L., 2003. Toward an Integrated Land-Ocean Surface Skin Temperature Analysis from the Variational Assimilation of Infrared Radiances *J. Appl. Meteor.*, **42**, 570-583.