# P3.18 IMPACT STUDIES OF THE ASSIMILATION OF GOES IMAGING CHANNELS

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## 1. INTRODUCTION

At the MSC, satellite radiances are directly assimilated in the 3D-var analysis system. Currently, microwave AMSU-A temperature channels are assimilated while AMSU-B humidity channels will soon be introduced (see Hallé and Chouinard, P3.7). At the same time, work is well under way to assimilate infrared (IR) imaging (IM) channels from GOES-East and West. There are four IR channels. IM2 (3.9 μm), IM4 (10.7 μm), and IM5 (12μm) are sensitive to the surface and low level (750 hPa to surface) temperature and humidity. IM3 (6.7 μm) is mostly sensitive to humidity between 200-450 hPa. This paper reports on first results of the impact of these data in assimilation cycles. More definitive results will be available by the time of the conference. While similar work is being done with Meteosat 6.7 μm radiances at ECMWF (see Kopken et al, P3.11), we are not aware of a comprehensive description of the impact of surface sensitive IR channels in numerical weather prediction (NWP), notably over land. This is an important issue for the full utilization of the upcoming AIRS data (AQUA satellite, 281 IR channels made available to NWP centers).

## 2. GOES PROCESSING

The assimilation of IR data is certainly more difficult than that of microwave data because IR radiances are much more sensitive to clouds. GOES processing steps are described in detail in a recent paper (Garand, 2003). Briefly, a cloud analysis is done from GOES images at 1 X 1 deg resolution. Only one pixel in each box is selected for assimilation. The location of that pixel is based on IM4 radiances. That same location is used for the other three channels. For surface channels, the pixel is required to be clear with a low local variance. IM2 data, sensitive to the sun, are only used at night. For the water vapor channel, low clouds can be present, with top at least 1 km lower than a chosen threshold of the humidity Jacobian. Maps of surface emissivity are available for each channel. Emissivity is fixed over land, but varies with viewing angle and surface wind speed over ocean. The forward radiative transfer model used in the assimilation is MSCFAST (Garand et al, 1999). This model appears accurate to better than 0.1 K for surface channels and 0.25 K for IM3 based on a validation against line-by-line models (Garand et al, 2001). A simple bias correction is applied to observed brightness temperatues (BT, in the form: bias = a BT + b) based on the assumption that over oceans the difference between observed and calculated BTs is zero for large data volumes.

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## 3. IMPACT IN CYCLES

### 3.1 Upper level impacts

So far three cycles were made covering the 5-week period 22 Dec 2001 to Jan 31 2002.
CONTROL is the operational MSC model. SAT1 differs only by the assimilation of IM3 radiance. SAT2 is defined by the assimilation of all four GOES channels. Data from both GOES-08 and GOES-10 are used without overlap (separated at 105 W).

Fig. 1 shows the mean dew point depression (DPD = T - Td, where Td is dew point temperature. Fig. 2 shows the mean 250 hPa DPD difference (SAT2 - CONTROL).

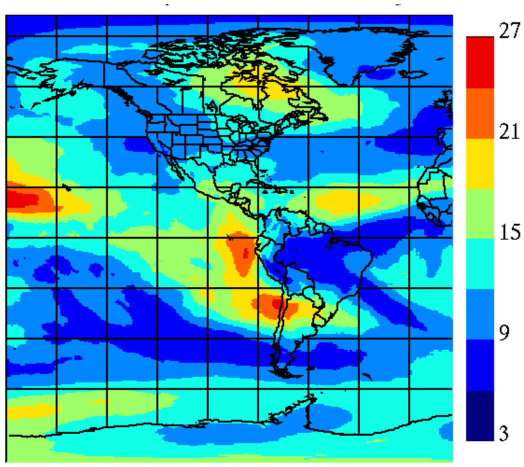


Fig. 1. Mean SAT2 DPD at 250 hPa for the assimilation period

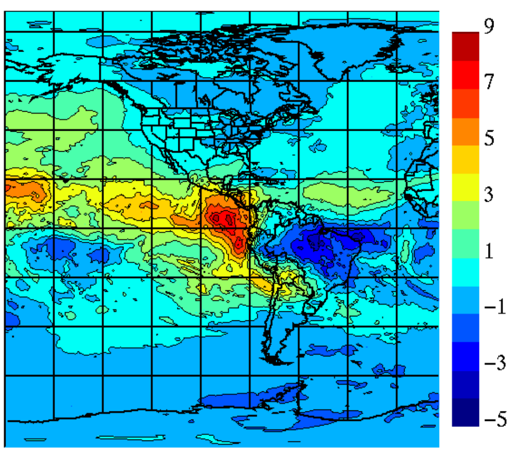


Fig. 2. Mean DPD difference (SAT2 - CONTROL) at 250 hPa.

A significant drying is noted in the Tropics, but in regions which were already dry. Similarly, moistening occurs over Brazil where DPDs were already low. Some dry areas like Hudson's Bay are slightly humidified. SAT1 and SAT2 results are very similar, as expected, at high levels. A validation is made against radiosondes for the 6-h forecasts (P) referred to as (O-P) statistics. Similarly (O-A) expresses the statistical difference between radiosonde and the analysis. This is shown in Fig. 3 for the radiosonde stations in Mexico, Carabeans and Central America. A clear improvement is noted for levels 300-500 hPa (radiosondes do not report at lower pressures). A reduction of the bias at these levels is also noted. A similar gain was noted from South American sites. Results were more neutral over North America. There was no significant impact on other variables such as temperature, geopotential and winds. The gain noted in Fig. 3 gradually diminishes to become negligible after 48 h.

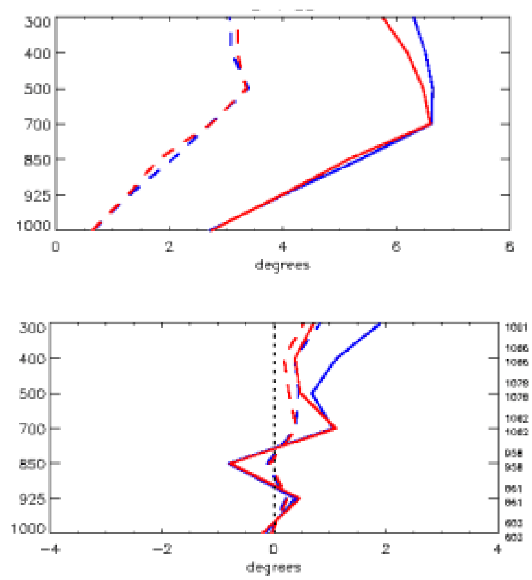


Fig. 3 (O-P), full line, and (O-A), dashed line, DPD statistics. Red is for SAT1 and blue for CONTROL. Top panel is standard deviation (K) and lower panel is bias. This is for the 5-week assimilation period and in the tropical region. Number of collocations indicated on the left of the bias panel.

### 3.2 Lower level impacts

In the SAT2 assimilation, the impact of the surface channels is relatively large on the skin temperature $T_s$, notably over land. This is shown in Fig.4. Unfortunately, these changes to $T_s$ are currently not retained in subsequent analyses and forecasts. The analysis of $T_s$ which drives forecasts and serves as background for the analysis, is still done daily independently and maintained fixed in forecasts. No attempt is made to depict the diurnal cycle. It is a goal of this research to include in the future the analysis of Ts in the 3D-var system. Fig. 4 shows maxima over mountains because the daytime $T_s$ maximum is significantly underestimated. Significant cooling is noted over Quebec and Ontario. Over oceans there rare sectors where corrections larger than 0.5 K occur.

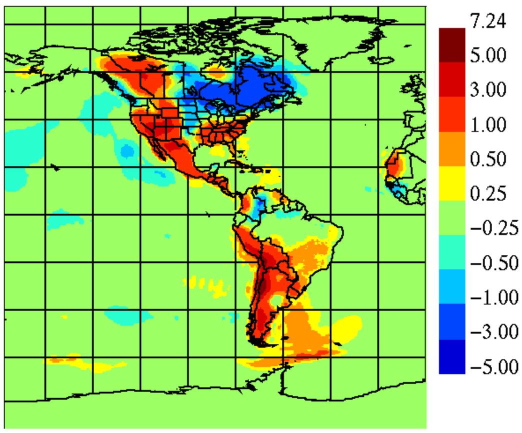


Fig. 4. (SAT2 - CONTROL) Ts (K) difference.

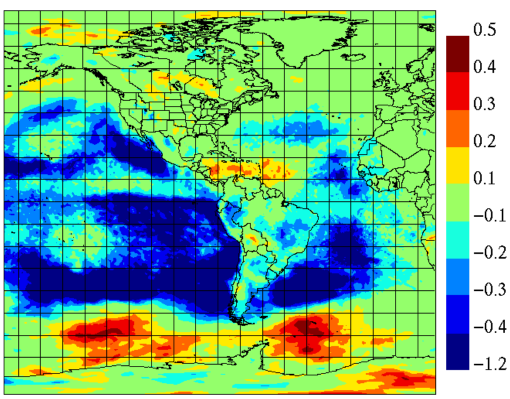


Fig. 5 (SAT2 - CONTROL) T(K) difference at eta level 0.922 (~922 hPa).

Fig.5 shows the (SAT2 - CONTROL) temperature difference at the eta level 0.922 (near 922 hPa over low terrain). Contrarily to Fig. 4, larger increments are found over oceans. The large blue areas indicate differences up t0 -0.8 K. This result requires further investigation since we expect Ts increments to exceed in magnitude T(0.922) increments. The DPD (η=.922) difference are shown in Fig.6. As expected, maximum areas near minus 2-3 K match maximum negative T increments, both the result of

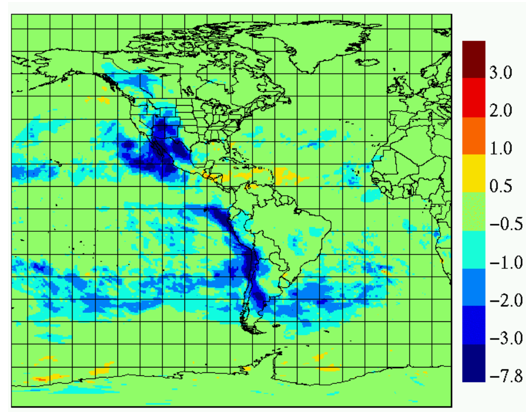


Fig. 6 Same as Fig. 5 for DPD (.922).

assimilating BTs lower than the equivalent background BT. No significant impact was noted in verifications against 6-h forecasts except a slight deterioration of DPD at 700 hPa. This was traced back to mountainous sectors where surface emissivity is often low. New experiments are now conducted with restrictions on surface emissivity to values > 0.95, which also occurs over see at viewing angles > 55 deg.

## 4. CONCLUSION

Preliminary results appear promising for the direct assimilation of GOES imager data. More conclusive results will be available at the time of the conference, notably on the impact of surface channels

## 5. REFERENCES

Garand, L., D. S. Turner, C. Chouinard, and J. Hallé, 1999: A physical formulation of atmospheric transmittances for the massive assimilation of satellite infrared radiances. *J. Appl. Meteor.*, **38**, 541-554.

_______, and Coauthors, 2001: Radiance and Jacobian intercomparison of radiative transfer models applied to HIRS and AMSU channels. *J. Geophys. Res.*, **106**, 24,017-24,031.

_______, 2003: Toward and integrated land-ocean surface skin temperature analysis from the variational assimilation of infrared radiances. To appear in *J. Appl. Meteor*, **42.**