Assimilating Megha-Tropiques SAPHIR Data in the NOAA GDAS

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1. Introduction

The National Oceanic and Atmospheric Administration (NOAA) Center for Satellite Applications and Research (STAR), in support of the Joint Center for Satellite Data Assimilation (JSDA), has extended the Gridpoint Statistical Interpolation (GSI) data assimilation system used in the National Centers for Environmental Prediction (NCEP) Global Data Assimilation System (GDAS) to assimilate SAPHIR L1A2 brightness temperature (TB) data into the Global Forecast System (GFS) in a clear-sky, ocean-only capacity. Extending the GDAS to assimilate SAPHIR TBs has been a multi-step process: the SAPHIR data were obtained in BUFR format from a EUMETSAT data stream and assessed for errors and biases, quality control (QC) procedures tailored to SAPHIR had to be developed and implemented, and the impacts of assimilating SAPHIR TBs on global analyses and forecasts have been examined and assessed.

2. SAPHIR Data Assessment and Quality Control

Prior to assimilation, the SAPHIR L1A2 data were assessed in the COAT for quality. The COAT is a widely independent of any data assimilation system, and has the ability to co-location observations. In this case, SAPHIR L1A2 TBs with fields from European Center for Medium-range Weather Forecasting (ECMWF) analyses or GDAS/GFS analyses. It uses the Community Radiative Transfer Model (CRTM) to simulate TBs from co-located numerical weather prediction (NWP) analysis fields, and provides a channel-by-channel assessment of satellite-observed TBs with respect to the co-located simulated TBs in all sky conditions and over all surface types. As a result of these capabilities, the COAT may be used as a testbed to implement and evaluate QC and filtering procedures for SAPHIR L1A2 TB data before these procedures are implemented within an assimilation system.

The focus of this work was the assimilation of clear-sky SAPHIR L1A2 TBs. Though it is not expected that SAPHIR will be sensitive to the surface/rays/conservation approach adopted, and only data over ocean have been considered. As SAPHIR is also not expected to be sensitive to cloud, it was only necessary to filter out precipitation-contaminated brightness temperatures from the assessment. A gridded water path (GPW) retrieval was developed in order to screen for coverage TBs may have been affected by the precipitation. The retrieval, which is a match in location trained on simulated brightness temperatures from ECMWF analyses fields, was implemented in the COAT, and any points where retrieved GPW exceeded (0.1) g/m² were assumed to be in precipitating conditions, and removed from further consideration in the quality data assessment.

3. Analysis and Forecast Impacts

A reader to ingest SAPHIR L1A2 BUFR data into the GSI was developed. This reader filters out points with non-ocean surface classifications, and any data flagged within the BUFR file as being bad, thinning the data to a user-prescribed thinning grid. A GPW retrieval, tested in COAT, was implemented in the GSI, and a QC subroutine was developed to filter out any points where retrieved GPW is over 0.5 kg/m² as was done in the COAT). The system uses user-prescribed errors/weights for each channel, as well as user-prescribed values for a gross check.

To assess the impact that the assimilation of SAPHIR TBs on the GDAS analysis and GFS forecasts, experiment results were compared to analyses from the control (GDAS) to assimilate SAPHIR data and a control (without SAPHIR). Comparisons are made against ECMWF analyses from the same time period. The percentage difference between experiment and ECMWF is shown in the right column; results in green indicate a positive change, and red indicate analysis degradation.

4. Conclusions

SAPHIR L1A2 TBs have been assimilated in the GSI, COAT procedures for clear-sky filtering of SAPHIR TBs have been developed, and the GDAS has been extended to assimilate these TBs in clear-sky conditions over ocean. Initial assessments of the impact, relative to ECMWF, that the assimilation of SAPHIR TBs has on analyses and forecasts from the GDAS/GFS system have been made.

- GDAS/GFS analyses and forecasts:
  - The implementation of a filter for SAPHIR TBs based upon thresholding retrieved GPW from SAPHIR L1A2 data has shown efficacy in improving the quality statistics (e.g. bias, standard deviation) of SAPHIR data in the COAT.
  - The impact of precipitation on analysis TBs is expected to be minimal, and filtered cases, with TBs simulated from ECMWF analysis fields as a reference.

5. Future Work

- Continue assessing the impacts that assimilating SAPHIR data has on GDAS/GFS analyses and forecasts.
- Perform additional tests for forecasts skill.
- Analyze hurricane track errors.
- Optimize SAPHIR representation in the GSI and use of SAPHIR TBs by continuing to fine-tune error estimates and by further tailoring QC routines to SAPHIR; it needs to be based on results from forecast assessments, and from the COAT and MIDSAS.

Table 2. Root mean square error (RMSE) and standard deviation (Stdv) equal to two decimal places, averaged over the 42-day time period of 7 June 2015 to 18 July 2015 of analysis RH at multiple levels for a GDAS cycle assimilating SAPHIR data and a control (without SAPHIR). Comparisons are made against ECMWF analyses from the same time period. The RMSE result shows the forecast RMSE for global RH given by ECMWF at 100hPa, 500hPa, and 1000hPa for the 07 June 2015 to 18 July 2015 time period.

Table 3. Bias, standard deviation (Stdv, rounded to two decimal places), and observation count (Count) observed versus simulated TBs for, left to right, channels 1 (183.31 ± 2.80 GHz), 2 (183.31 ± 1.10 GHz), and 6 (183.31 ± 0.20 GHz) for SAPHIR assimilated, and no assimilation. Impacts are shown for (for 00Z cycles only) were compared against results from a control run where no SAPHIR data were used, and ECMWF analyses. There are indications of a positive impact in analysis and forecast RH at upper levels when SAPHIR data are assimilated.

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