NPP and N20 CrIS Full Spectral Resolution FOV Differences Derived from the NCEP GDAS.

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Introduction

The Cross-track Infrared Sounder (CrIS) is a high spectral resolution Fourier Transform Spectrometer developed as a temperature and water vapor profiling instrument for weather forecasting. Its high accuracy also makes it suitable for climate applications. To use CrIS data in numerical weather prediction, it is important that its radiometric accuracy be understood. While several studies have looked at satellite inter-calibration (Goldberg et al., 2011; Chadderdon et al., 2013), few have calimed instrument field of view (FOV) to FOV differences (Gaubert et al., 2012; Strow et al., 2013). Tetha et al. (2013) points negative, FOV-to-FOV differences become of greater concern to both Numerical Weather Prediction (NWP) and Climate studies.

Methodology and Design

A methodology for on-orbit adjustment of nonuniformity correction parameters to reduce the overall contribution of on-orbit nonuniformity and reduce the FOV-to-FOV variability of CrIS on Suomi National Polar-Orbiting Partnership (SNPP) and NOAA-20 is described in Tetha et al. (2013). To quantify the remaining FOV-to-FOV differences, a low resolution cycled version of the National Center for Environmental Prediction (NCEP) Global Data Assimilation System (GDAS) is used. This system has a specified resolution of 2.5° x 2.5° and a temporally consistent technique. 80 ensemble members are used to derive the model background error statistics for the data assimilation step. The NCEP GDAS version used here is similar to the 2017 operational version and assimilated all non-stationary operational data. This baseline cycled assimilation also included the 431 subset CrIS from both SNPP and NOAA-20.

The FOV tests split off from the baseline cycled assimilation by using the 3.9-hour forecast and the ensemble. All data were used by the baseline assimilation except CrIS. Quality control modifications specific to these experiments include: accepting clear pixels only every other cycle, and accepting shortwave channels only at night. These quality control criteria reduce the errors associated with the radiative transfer model. The Gsycled Statistical Interpolations (GSI) code was modified to accept data from only one CrIS FOV. The 22111 channel CrIS data were passed through all of the filtering and quality control procedures but were monitored instead of assimilated. The bias correction statistics in CrIS were removed at the start of the FOV experiments to allow statistics from each FOV to spin up independently of any previous FOVs. Results were adjusted based only on the specific FOV through the next 28 cycles (7 days).

The FOV experiments were conducted for 44 cycles (10 days) from 20180730 through 20180808. Bulk bias and standard deviation statistics were collected for each FOV. Assimilation statistics were monitored for any potential anomalies during this period. The results were consistent between channels and among the 9 FOVs.

References


Experiment Results

Standard deviation (σ) and bias statistics were derived from the GDAS analysis, averaged over all 44 cycles, then averaged over the 9 FOVs to determine the overall mean standard deviation and mean bias for SNPP and N20. The standard deviation statistics are shown in Figures 1, 2, and 3 for SNPP, Figure 4, 5, and 6 for N20. The standard deviations for SNPP are shown in panels a) and b) while the standard deviations for N20 are shown in panels c) and d). Similarly, the bias statistics are shown in Figures 7, 8, and 9 for band 1 and 2, respectively. The average of each FOV then subtracted from the mean to determine FOV differences shown in panels e) and f).

Any bias differences between FOVs should be accounted for in the assimilation through the observation error. This is done by incorporating the FOV bias and standard deviations into the observation error. Since the mean bias is removed by the assimilation system, only the residuals from each FOV must be accounted for. The baseline standard deviation difference for each FOV is defined as:

\[\Delta \sigma_{\text{baseline},\text{fov}} = \sigma_{\text{baseline},\text{fov}} - \sigma_{\text{baseline},\text{avg}}\]

The variances for each FOV becomes:

\[\sigma^2_{\text{FOV},\text{fov}} = \sigma^2_{\text{fovs},\text{fov}} + \sigma^2_{\text{bias},\text{fov}} + \sigma^2_{\text{airmass},\text{fov}}\]

The observation error typically accounts for several errors including the representative error, forward model error, and instrument error. The other errors are assumed to be independent of the instrument error. The change in the instrument error for each FOV is:

\[\Delta \sigma_{\text{bias},\text{fov}} = \sigma_{\text{FOV},\text{fov}} - \sigma_{\text{FOV},\text{avg}}\]

Conclusions

The FOV statistics shown here are consistent with the results from the CrIS Gsycled Statistical Interpolations (GSI) code modified to accept data from only one CrIS FOV. The 22111 channel CrIS data were passed through all of the filtering and quality control procedures but were monitored instead of assimilated. The bias correction statistics in CrIS were removed at the start of the FOV experiments to allow statistics from each FOV to spin up independently of any previous FOVs. Results were adjusted based only on the specific FOV through the next 28 cycles (7 days).

The differences in instrument errors computed from (4) are shown in Figure 10 panels b) and c) for SNPP and N20 respectively. The errors for band 1, 2, and 3 are in panels a), b), and c) respectively. Note: The standard deviation difference of a specific FOV may be smaller than the mean. An adjustment needs to be made to the radiative transfer model if the assimilation system uses statistics of the instrument instead of the FOV.

Acknowledgements

Funding for this research was provided by the Joint Polar Satellite System through Cooperative Agreement grant NAW1314312001. Computing resources were provided by the NASA Center for Climate Simulation.