Estimation of outgoing longwave radiation from Cross-track Infrared Sounder (CrIS) radiance measurements

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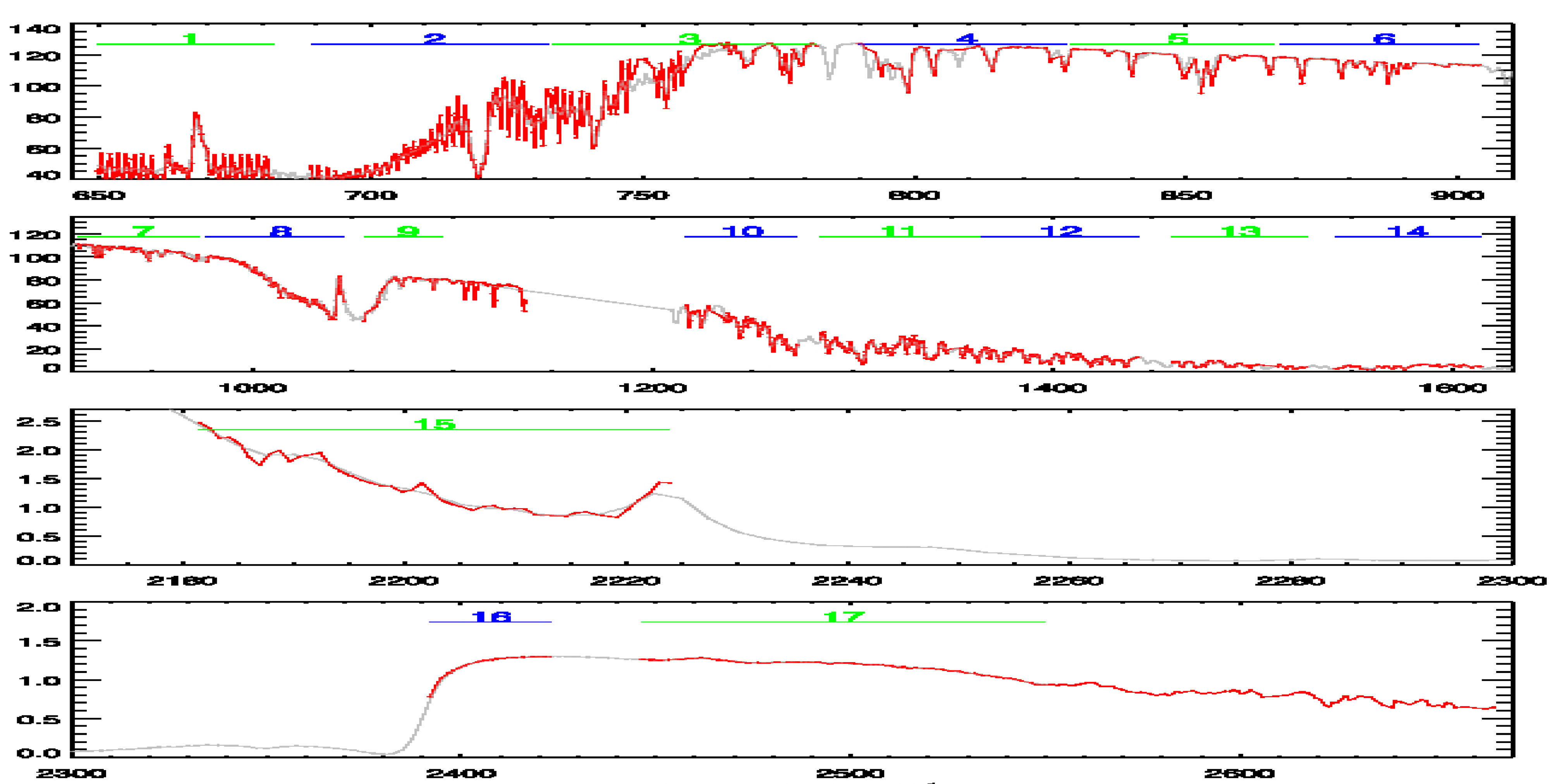
Abstract:

The purpose of this study is to provide real time *CrIS-track Infrared Sounder* (CrIS) *Outgoing Longwave Radiation* (OLR) using the hyperspectral infrared sounder radiance measurements. *Atmospheric Infrared Sounder* (AIRS) is used as the third transfer instrument, and the least-squares regression algorithm is applied to generate two sets of regression coefficient. One is between collocated Clouds and the *Earth's Radiant Energy System* (CERES) OLR on *Aqua* and pseudo channel radiance calculated from *AIRS* radiance. The other regression equation is obtained by relating the pseudo channel radiance difference between AIRS and CrIS to the individual measured CrIS radiance in each pseudo channel, which is called adjustment coefficient. CrIS OLR is estimated as weighted linear combination of CrIS adjusted 17 pseudo channel radiances. We validate CrIS OLR by using very limited available CERES NPP OLR observations over 1°X1° global grids, and we also validate it against CERES (Aqua) OLR cases over the S-NPP and Aqua *Simultaneous Nadir Overpass* (SNO) observations. The results show that the precision of CrIS OLR estimation is within 3 W/m^2, and the accuracy is within 5 W/m^2.

Algorithm Description

In this work, we use broadband radiometer CERES OLR as truth, and AIRS as the third transfer instrument. Radiance adjustment regression database between AIRS and CrIS is derived with theoretical radiative transfer model simulations given 'noaa88' and 'noaa89' sounding collections for all sky conditions. Cloud conditions were simulated by ATOV derived cloud properties. Cloud is black except for cirrus which has spectral-dependent emissivity. We degrade AIRS, CrIS radiance spectra into 17 pseudo channels, and in each pseudo channel, the CrIS pseudo channel radiance is adjusted to AIRS pseudo channel radiances. Least squares regression algorithm is applied to relate CERES (Aqua) OLR to adjusted pseudo channel radiances calculated from CrIS radiances. Eight sets of regression coefficients are trained to account for view angle dependence of CrIS radiances. CrIS OLR is estimated directly as the weighted sum of pseudo channel radiance calculated from CrIS radiances.



$$R(i)=\sum_{k=1}^{K}\frac{1}{\nu_{2i}-\nu_{1i}}\cdot r(k)\cdot\Delta\nu(k)$$

Convolved pseudo channel radiance for both AIRS and CrIS

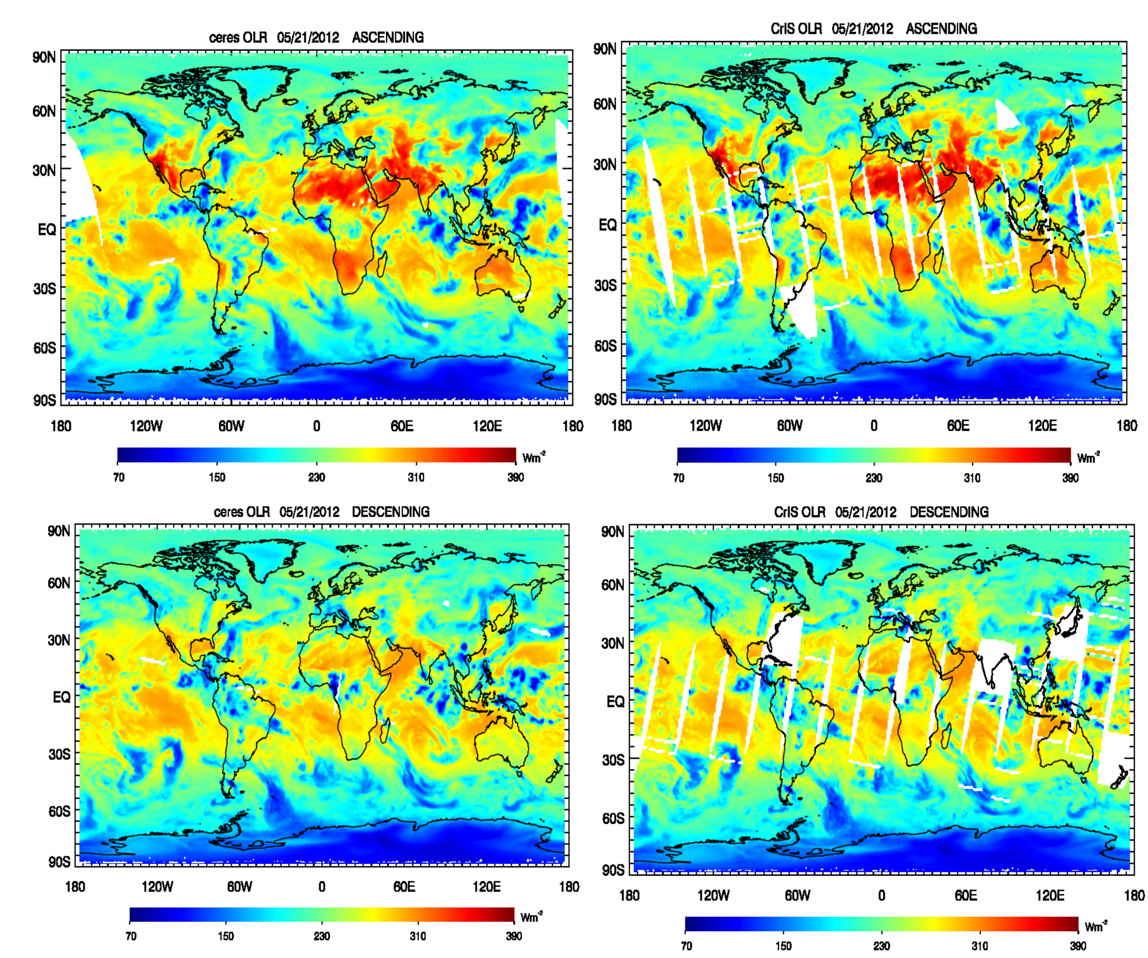
$$\Delta R(i)=a_0+\sum_{k=1}^{K}a(k)\cdot r_{CrIS}(k)$$

Pseudo channel radiance difference (between CrIS and AIRS) adjustment

$$\hat{F}_{CrIS}=b_0+\sum_{i=1}^{17}b(i)\cdot[R(i)+\Delta R(i)]$$

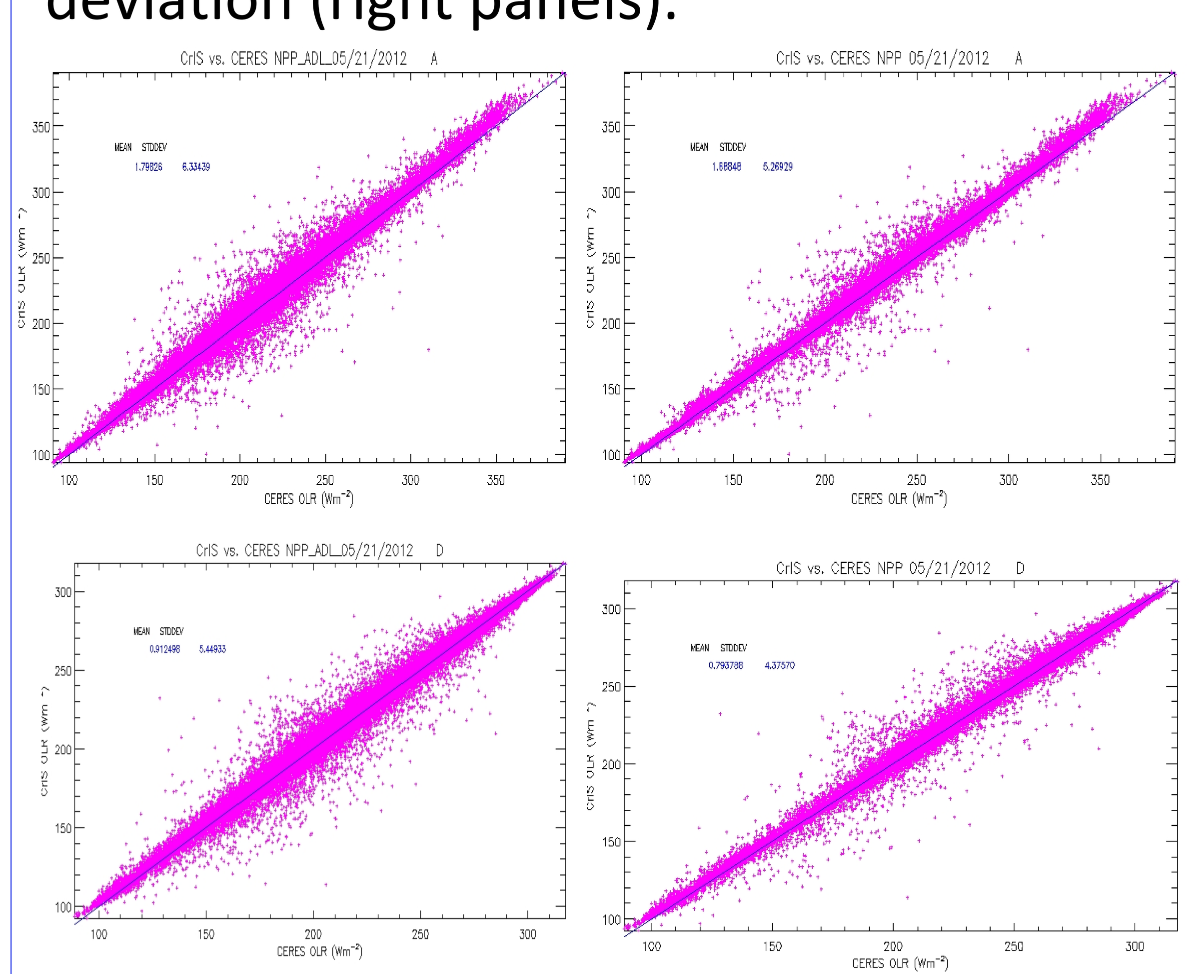
Estimated CrIS OLR

Algorithm Validation



Homogeneous Scenes

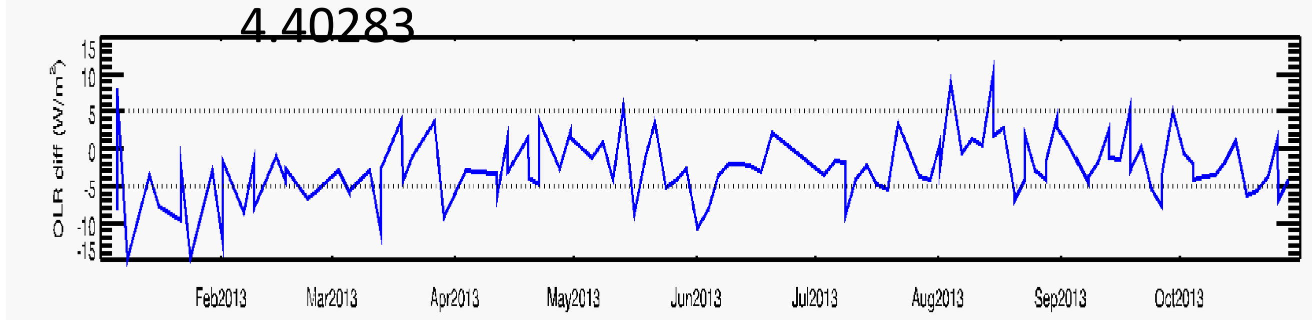
We take the ratio of coefficient of variation less than 15%, and we get more homogeneous scenes and better standard deviation (right panels).



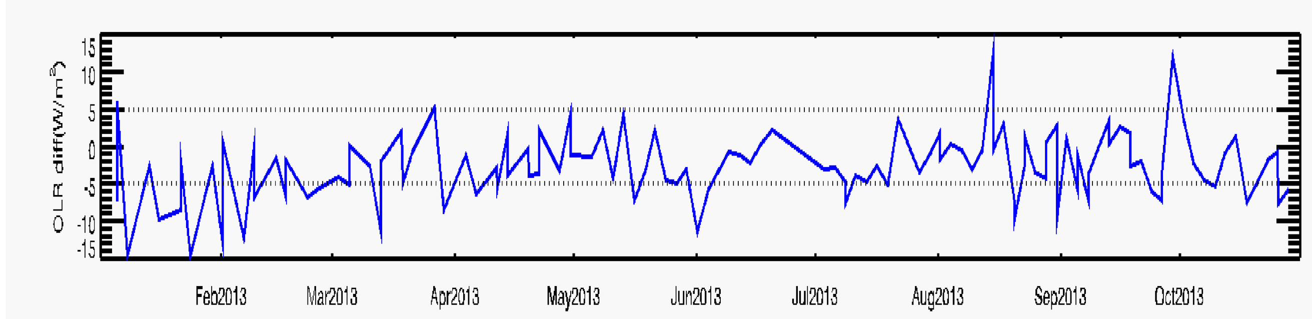
Simultaneous Nadir Overpass (SNO) observations comparison

Compare the estimated CrIS OLR with Aqua CERES OLR over the SNO observations. Take S-NPP and Aqua SNO observations from Jan. 2013 to Oct. 2013. *Average samples* for both CrIS and Aqua OLR within time difference less than 90 seconds, and distance difference less than 45 km; *Single sample pairs* with the smallest time and distance differences.

Average sample: Mean= -2.57486, std= 4.40283



Single sample: Mean= -2.65107, std= 4.58340



Summary

CrIS OLR was compared with simultaneous CERES NPP OLR directly over 1°X1° global grids. For CrIS homogeneous scenes , the results show that the standard deviation is within 5 w/m^2, and the bias is within 2 w/m^2.

SNO OLR comparison shows that the standard deviation between CrIS OLR and Aqua OLR are within 5 W/m2, and bias are less than 3 w/m^2.

References

[1] Sun, F., M. D. Goldberg, X. Liu, and J. J. Bates (2010a), Estimation of outgoing longwave radiation from Atmospheric Infrared Sounder radiance measurements, J. Geophys. Res., 115, D09103, doi:10.1029/2009JD012799.

Poster # 2, STAR JPSS 2015 Annual Science Team Meeting, 24-28 August, NCWCP, College Park, MD.

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