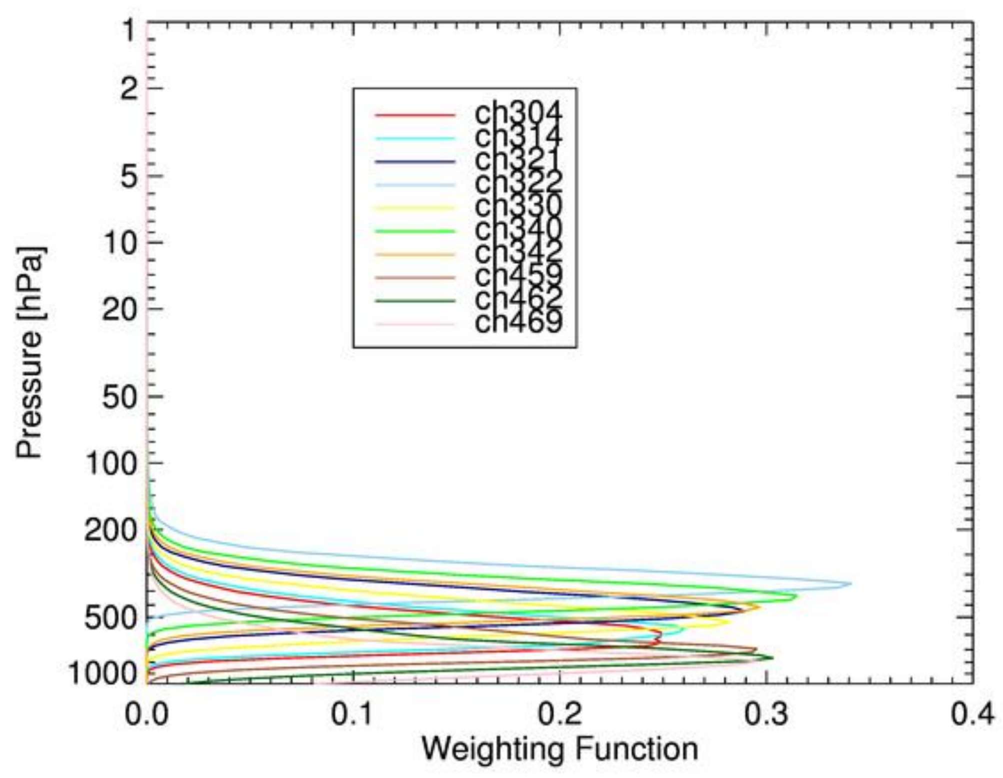
Towards the assimilation of all-sky infrared radiances for selected humidity sensitive IASI channels at NCEP/EMC

Li Bi [1] , Andrew Collard [2] , Emily Liu [3] , James Jung [4] , John Derber [5]

[1,2] NWS/NCEP/EMC/IMSG, [3] NWS/NCEP/EMC/SGI, [4] CIMSS/UW-Madison, [5] NWS/NCEP/EMC

Introduction

This work focuses on the step towards the assimilation of all-sky infrared radiances of selected Infrared Atmospheric Sounding Interferometer (IASI) channels using NCEP GFS model. Radiances simulation are implemented using Community Radiative Transfer Model (CRTM) that includes profiles for liquid-water content and ice-water content. The new released CRTM tag which includes cloud over computation is used in this study. Four overlap schemes are available for selection: weighted average overlap assumption (Geer et al,.2009), maximum, random. and maximum/random overlap assumptions (Morcrette and Jakob,2000). Statistical analysis that over the ocean of observation minus background departure (O-B) as well as total cloud cover computed from these four overlap assumptions are evaluated for selected humidity sensitive channels. The observation screening procedure was developed to improve the cloudy scenes selection. Cloud-dependent quality controls and observation error are evaluated in this study. The cloud effect on O-B is evaluated in this study. The goal for this preliminary work is to extend the microwave (MW) all sky radiances assimilation at NCEP/EMC to infrared (IR) all sky assimilation for the channel that are suited in all sky conditions.



Channel number	Wave number (cm^{-1})	Channel index
2889	1367	304
2958	1384.25	314
2993	1393	321
3002	1395.25	322
3049	1407	330
3105	1421	340
3110	1422.25	342
5381	1990	459
5399	1994.5	462
5480	2014.75	469

$$Rad_{allsky} = (1\text{-}TCC)*Rad_{clear} + TCC*Rad_{cloudy}$$

-- Calculate the total cloud cover (TCC) using the four overlap schemes from the cloud fraction profile

-- Select all points from cloudy and clear simulation for humidity sensitive channels from the table.

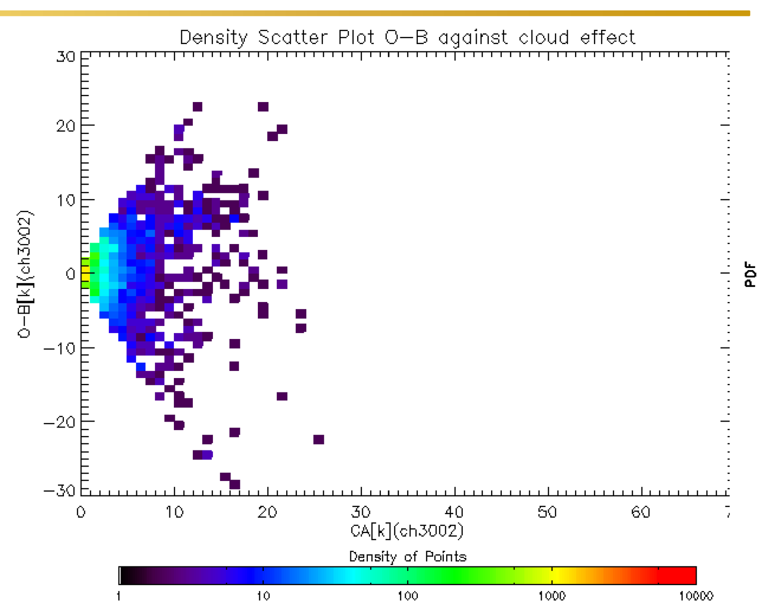
-- Default overlap scheme is average overlap assumption.

--Apply computed TCC to calculate the all sky radiances:

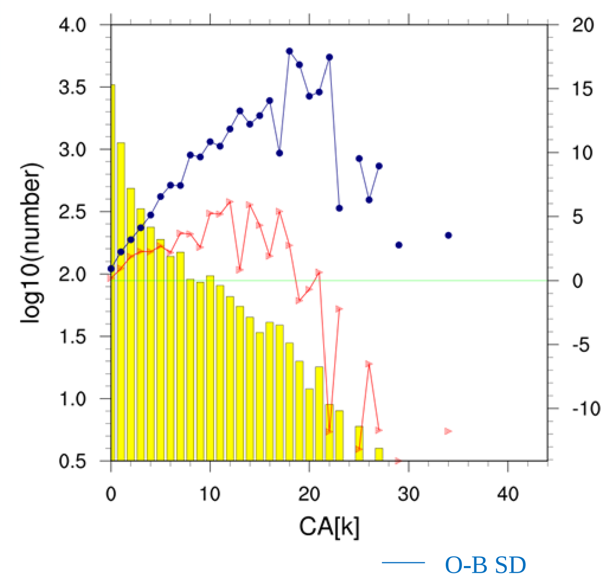
--Include all the points (no QC)

--In radiance space

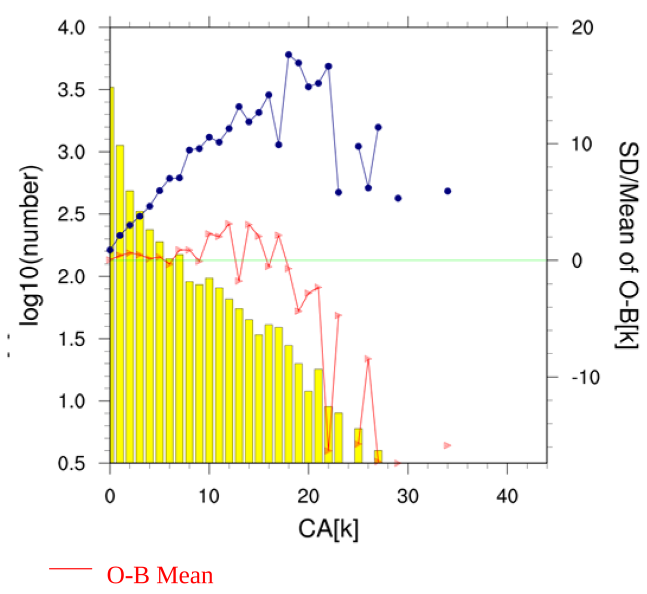
--Over the ocean



Prediction of O-B variability using the cloud effect parameter (IASI Ch3002)

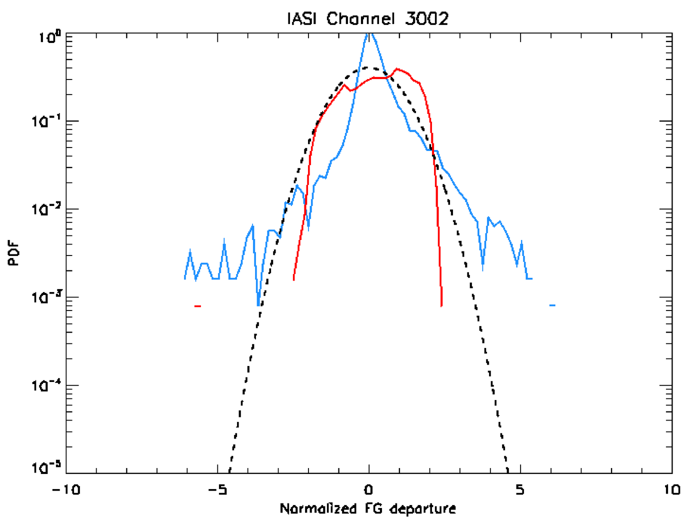


O-B assuming overcast

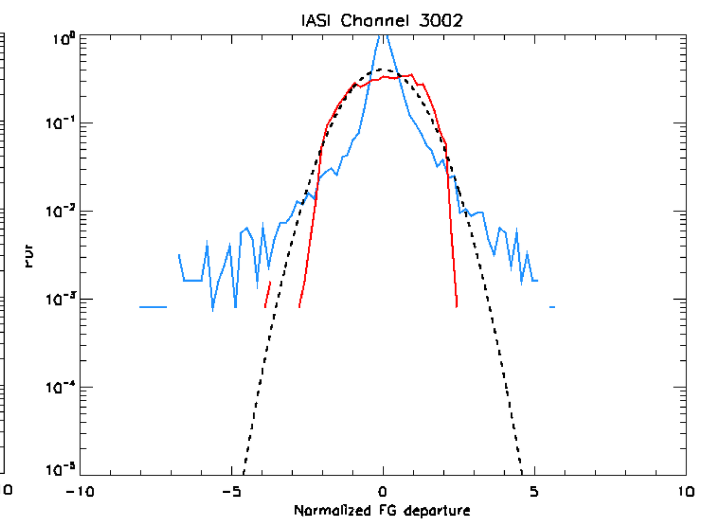


O-B using model's cloud fraction

PDFs of O-B normalized by O-B SD (function of CA)

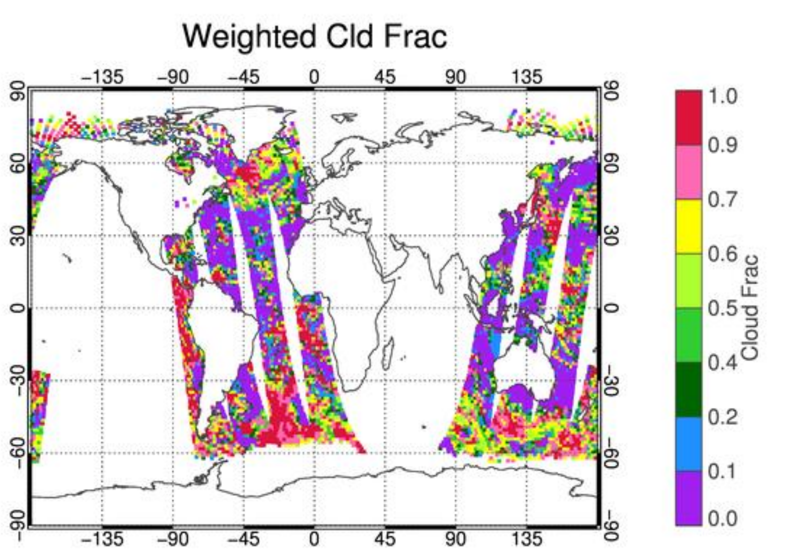


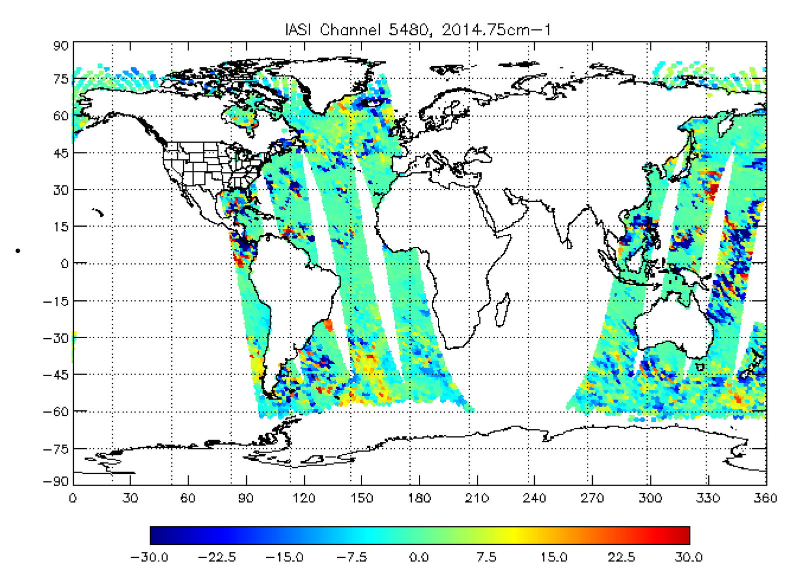
O-B assuming overcast



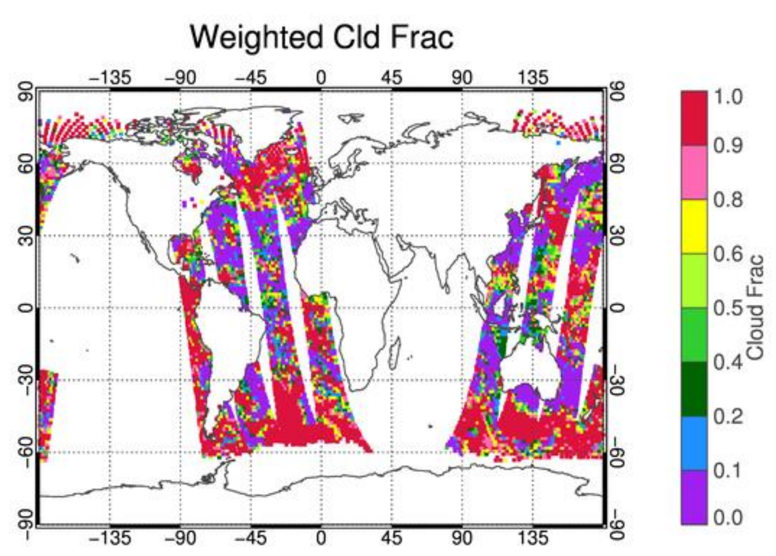
O-B using model's cloud fraction

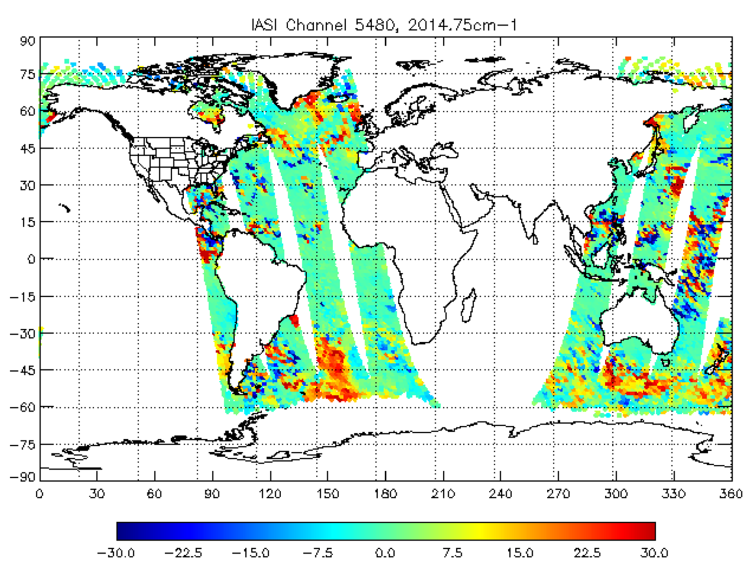
Overlap Assumption I: Average Overlap



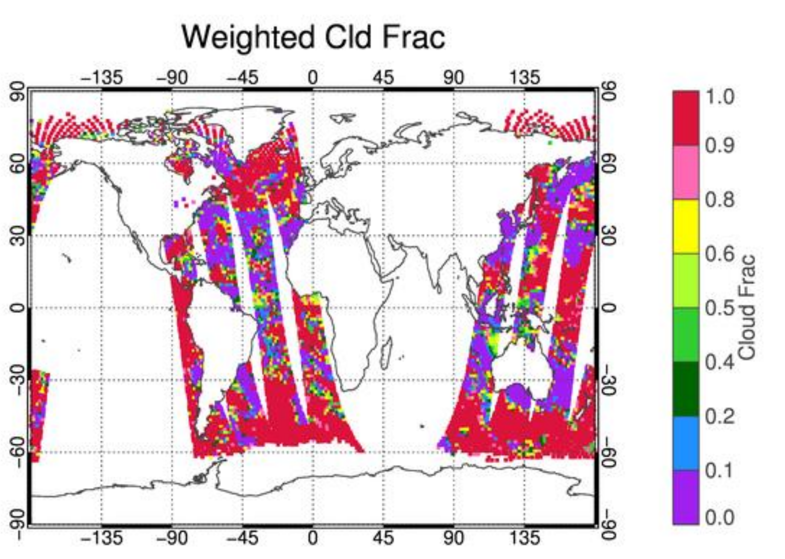


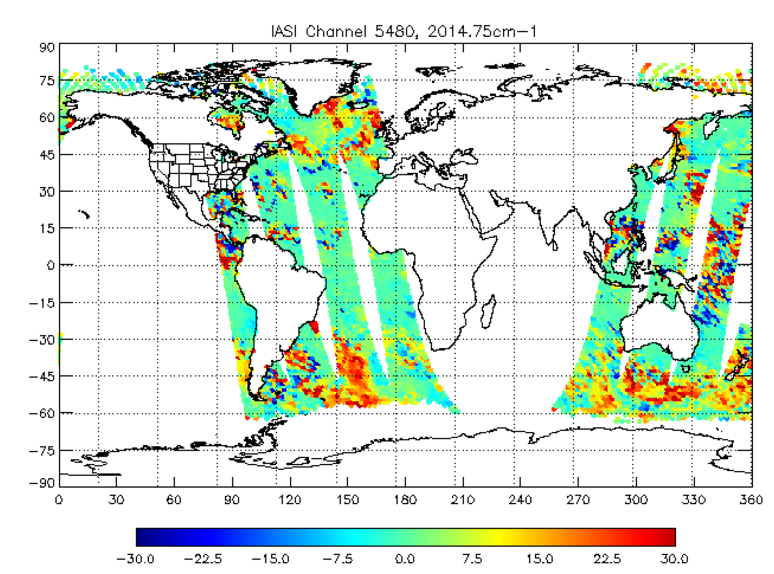
Overlap Assumption II: Maximum Overlap



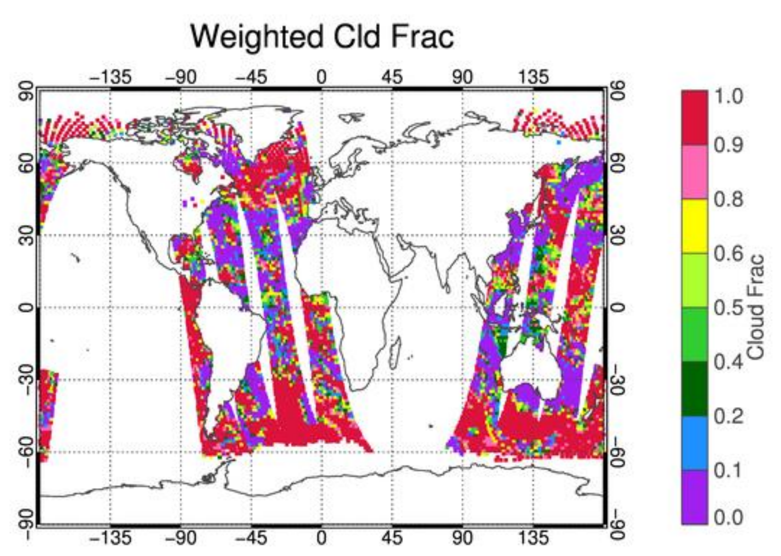


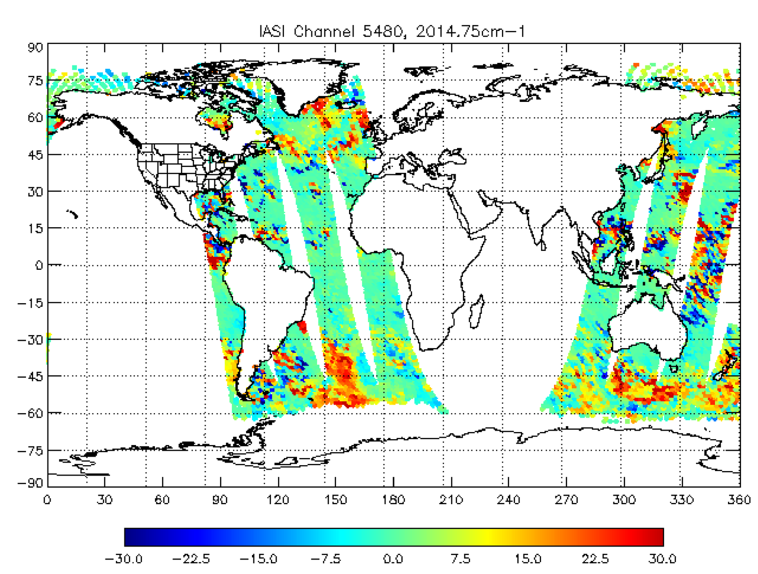
Overlap Assumption III: Random Overlap



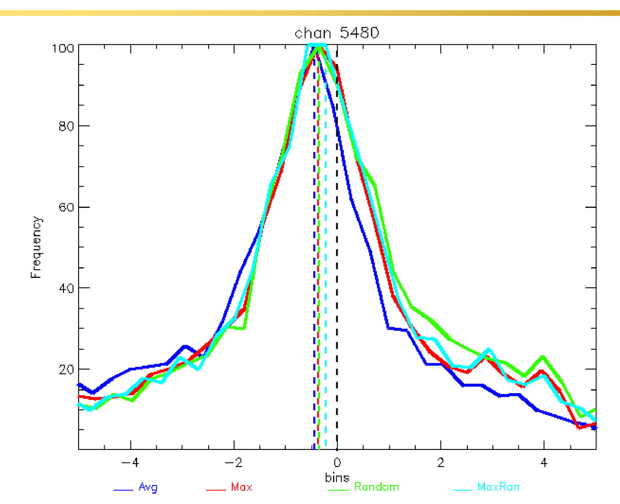


Overlap Assumption IV: MaxRan Overlap



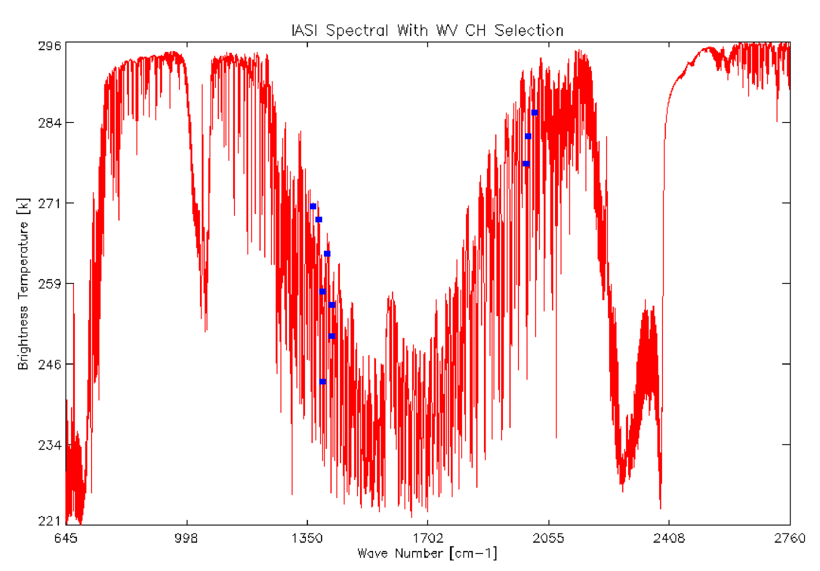


Weighted cloud fraction | O-B for ch 5480 | Weighted cloud fraction | O-B for ch 5480



➢ O-B GSI stats (no bias correction) for different overlap assumptions:

Avg: -0.6026438 Max: -0.1840927 Ran: 0.0111103 MaxRan: -0.1490755



--- Blue dots represent the selected channels

Cloud parameter for IR radiances

❖ Symmetric cloud parameter for IR radiances

- $CA_i = (|OB_i - FG_{clr,i}| + |FG_i - FG_{clr,i}|)/2$

  FG_{clr}: clear-sky FG, i: channel

- $CA_i = (|C_O| + |C_M|)/2$

The concept of a symmetric cloud effect parameter is introduced by Geer and Bauer (2011) for the microwave, and Okamato *et al*. (2014) for the infrared. We applied the development of the symmetric cloud parameter for IR radiances to this study to express the cloud effect on variability in O-B.

The density scatter plot of O-B against the cloud effect average is shown for channel 3002. The standard deviation of O-B for the same channel as a function of CA is shown to explain the prediction of O-B variability using the cloud effect parameter.

We show results from calculations assuming both overcast situations and using the cloud fraction from the model. The ordinary threshold QC check was switched off.

Statistical analysis that over the ocean of observation minus background departure (O-B) as well as total cloud cover computed from the aforementioned four overlap assumptions are shown for low peaking humidity sensitive channel 5480. The O-B histogram comparison for the same channel with different overlap assumptions is shown. Although the average overlap scheme is the default set up, the other overlap assumptions show advantage with smaller bias from GSI statistics with ordinary threshold QC check. Although not shown, for high peaking channels, the O-B difference for these four overlap schemes are minimal.

All the results shown here are from a single cycle simulation and the data over sea-ice and land were excluded. The GFS model is run at T1534.

Path forward

- Apply the predicted O-B cloud dependent standard deviation for a QC procedure and observation error estimation. Although not shown, the initial check for O-A statistics using new observation error based on cloud effect has positive impact.
- Continue to work on the selection of optimal cloud cover scheme for all sky IR humidity sensitive channel radiances assimilation.
- Perform two season impact study and get ready for operation parallel tests.

Reference

- Geer AJ, Bauer P. 2011: Observation errors in all-sky data assimilation. *Q. J. R. Meteorol. Soc.* **137**: 2024–2037, doi: 10.1002/qj.830.
- J.-J. Morcrette and C.Jakob. 2000: The response of the ECMWF model to changes in the cloud overlap assumption. *Mon. Wea.Rev.*, 128(6):1707-1732.
- Okamoto K, McNally A.P., and Bell W. 2014: Pregress towards the assimilation of all-sky infrared radiances: an evaluation of cloud effects. *Q. J. R.Meteorol. Soc.* **140**: 1603–1614, doi: 10.1002/qj.2242.