Quantifying the Sensitivity of NCEP's GDAS/GFS to CrIS Detector Differences

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Introduction

- Use of array detectors to make simultaneous observations for advanced IR sounders. Eg.: CrIS (3 by 3), GOES-Sounder (2 by 2 offset), IASI (2 by 2), IRS (160 by 160) and GIRS (32 by 4).
- Detectors have different radiometric characteristics.
- NWP centers: not desirable to treat each detector as an independent instrument => reduced usage of the observation if choose to select data from one detector to avoid complication.

Observation simulation

- NASA GEOS-5 Forward Processing analyses.
- 15 June -31 August 2018.
- Assumptions:
  - Clear sky throughout.
  - AQUA planet – avoid emissivity complication because CrIS channel 501 (surface channel) is assimilated.
- CRTM 2.3.0.
- Bilinear interpolation in space.
- Linear interpolation in time.

Generation of CrIS observations with detector differences

- CrIS radiances = Perfect CrIS observation + N *Δ radiance, where N is a multiplier.
- Derivation of Δ radiance: Control (exp1) has constant Δ = inherent difference added to all FOVs. Experiments have a range of N applied to delta radiance for addition to FOV 7 (Fig.1).
  - 1. Detector Differences
    - NeDN estimated from calibration of Internal Calibration Target (ICT) views using ICT and Deep Space views from that granule.
    - Result of inherent detector (FOV) sensitivity differences and the calibration processing.
    - Simulated by a constant offset in radiance.
    - Δ radiance for chan 501 = 0.04077 mW/m^2 sr cm^{-1}.
    - exp 2 to exp 6.
  - 2. Systematic Bias
    - Derive from O-B from GFS.
    - Bias for chan 501 in K = 0.3343.
    - Derive bias in radiance based on ref. T @ 300K
    - Δ radiance = 0.5503639 mW/m^2 sr cm^{-1}.
    - crisg, crisi and crisj.

Global Forecasting System

- 2017 GFS with GSI version from Dec 2018.
- Low resolution (T670) 4DEnVar with 80 ensemble members.
- Conventional data, GPSRO data and microwave radiances assimilated.
- Bias correction coefficients spin-up for 25 days starting from 0 for resolution and observation adjustments.
- Selection
  - First guess warmer than the surface channel (chan501) BT.
  - Warmest cloudy profile nearest to the center of the thinning box.
- Assimilates only surface channel (chan 501) at 962.5cm^{-1}.
- Data system modifications
  - Aqua planet assumption for CrIS.
  - Bypassed cloud detection and emissivity check for CrIS.
- Statistics - 29 days

Acknowledgements
This project is funded by Joint Polar Satellite System Proving Ground and Risk Reduction Program. The experiments were run on the NOAA/NESDIS Supercomputer for Satellite Simulations and data assimilation Studies (S4) located at the University of Wisconsin–Madison.

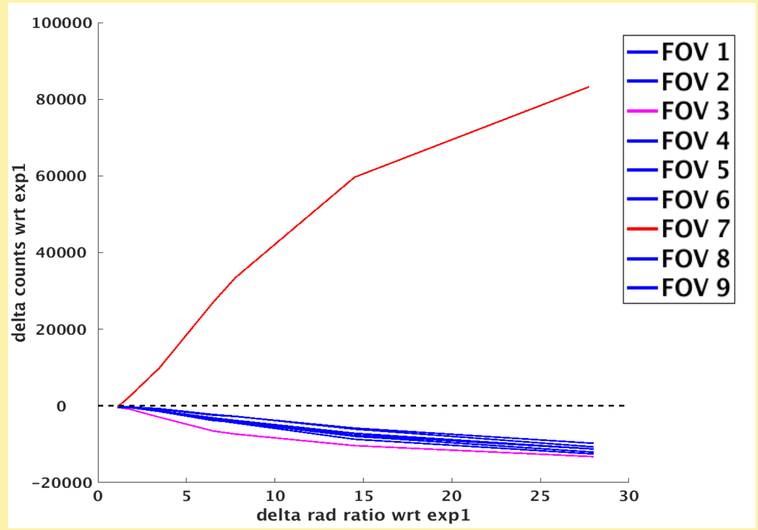
Objective: Understanding what level these inter-detector differences begins to affect NWP analysis and forecast systems

Summary

- Increase positive delta radiance added to FOV 7 leads to selection preference which can introduce biases into analysis.

Upcoming tasks

- Generation of CrIS observations with realistic surface and clear sky extent.
- Assimilate all operational active CrIS FSR channels.
- Quantify impact on GFS forecast skill.



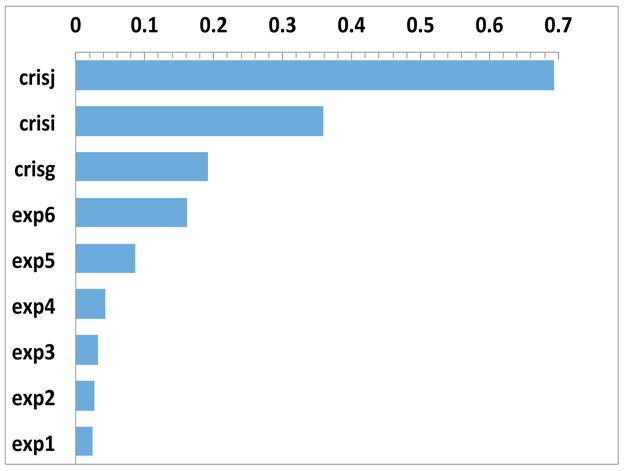


Fig. 1 Amount of Δ radiance added to chan 501 for each FOV 7. exp 1 is the control where all FOVs have the same amount of detector variance.

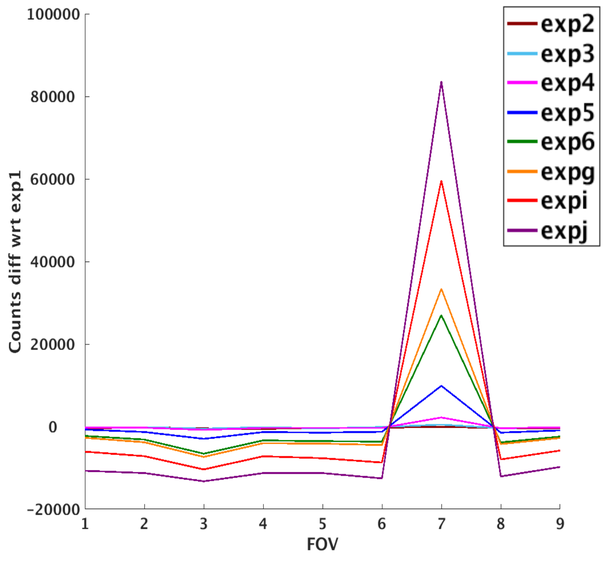


Fig. 2 Difference in the number of observations picked w.r.t. exp1 for each FOV. Warm pixel selection criterion in GSI has lead to FOV 7 being favored.

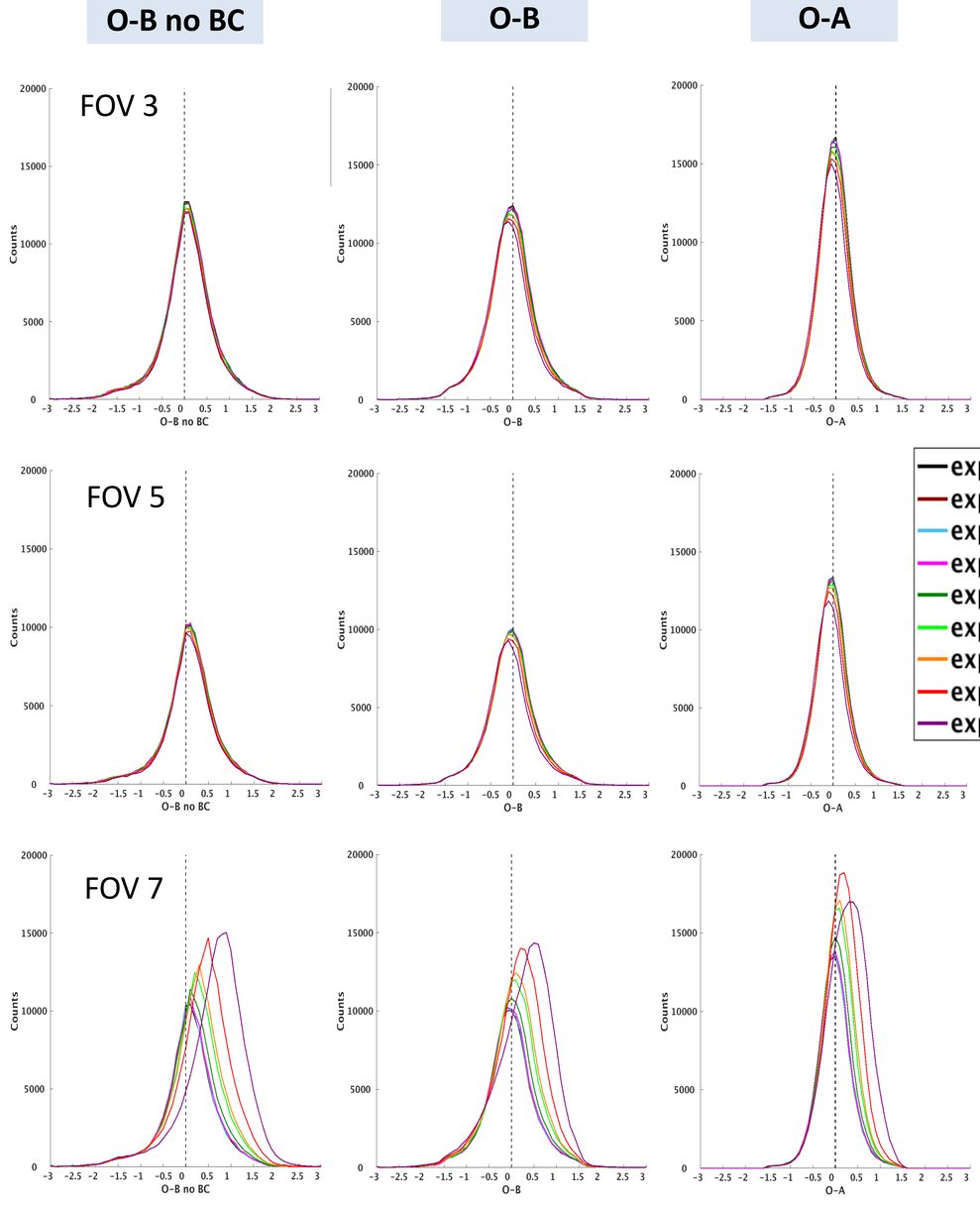


Fig. 4 Histograms of O-B/O-A for FOV 3, 5 and 7. Shift in O-B/O-A histograms becomes more prominent for FOV 7 as Δ radiance increases. Shift in histograms for FOV 3 and 5 are much less. The slight shift possible due to analysis getting more bias from continuous cycling.

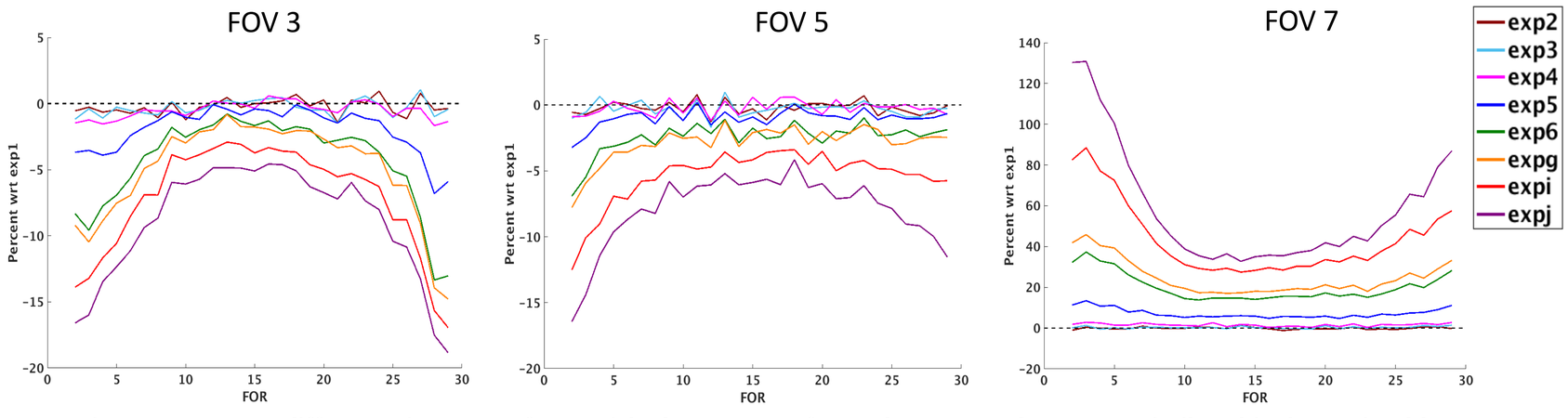


Fig. 3 Percentage difference in count of FOV picked w.r.t. exp1 for each FOR. Total counts assimilated is determined by the thinning grid, Increase number of FOV 7 being preferred results in drop in counts in other FOVs being selected with FOV 3 being most sensitive. In addition, FOVs at the edge of the swath are also more sensitive though not symmetrical.