GODDARD EARTH SCIENCES

Assimilation of Reconstructed Radiances from IASI and CrIS Principal Component Scores

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Motivation

- Work by Cristina Lupu at ECMWF showed they saw no ill effects when the switched to using PC scores
- Wanted to try in GEOS-ADAS to prepare for instruments like MTG-IRS and GeoXo where PC scores will be used
- *spoiler*: also not sure cloud detection/bias correction would be as forgiving as CADS vs minimum residual method in GEOS

Principal Component Scores

1. Lots of Spectra Derive Eigenvectors → Principal Component Eigenvectors (E) Noise Normalization Matrix (N) → Compression Decompression Operator

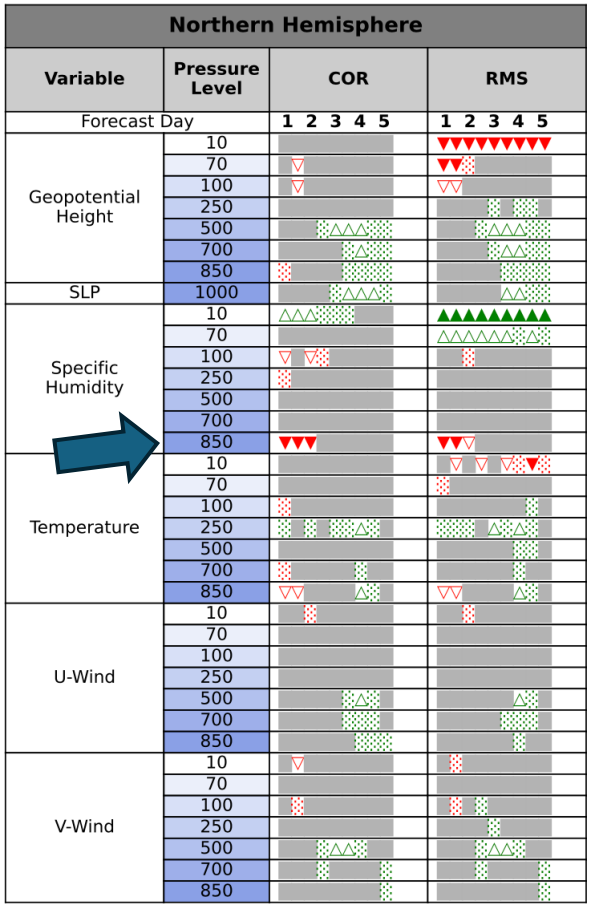
2. Measured Radiance Spectra → Compression $p = E^T N^{-1} (y - \bar{y})$ → PC Scores (p)

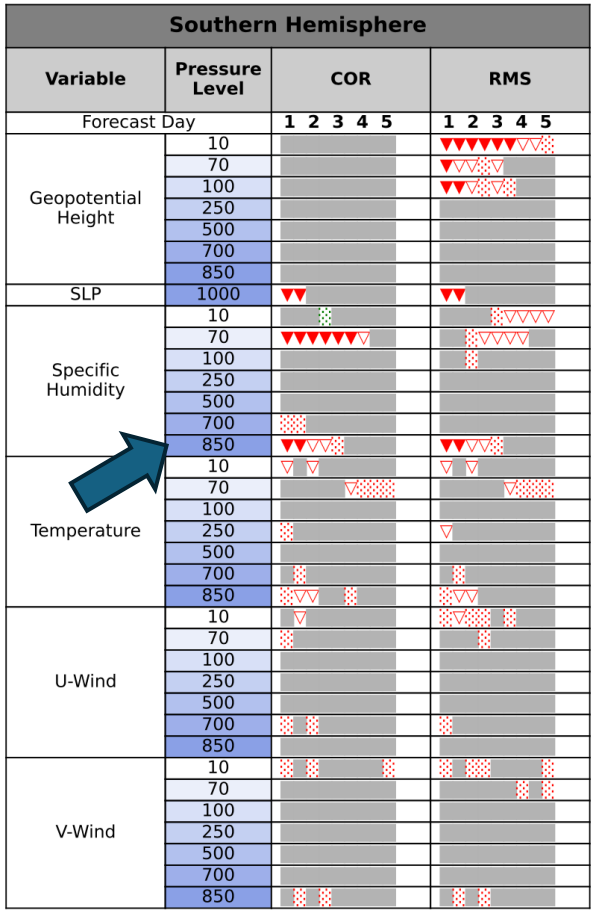
3. PC Scores (p) → Reconstruct Radiances $\tilde{y} = NEp + \bar{y}$ → Reconstructed Radiances $\tilde{y}$

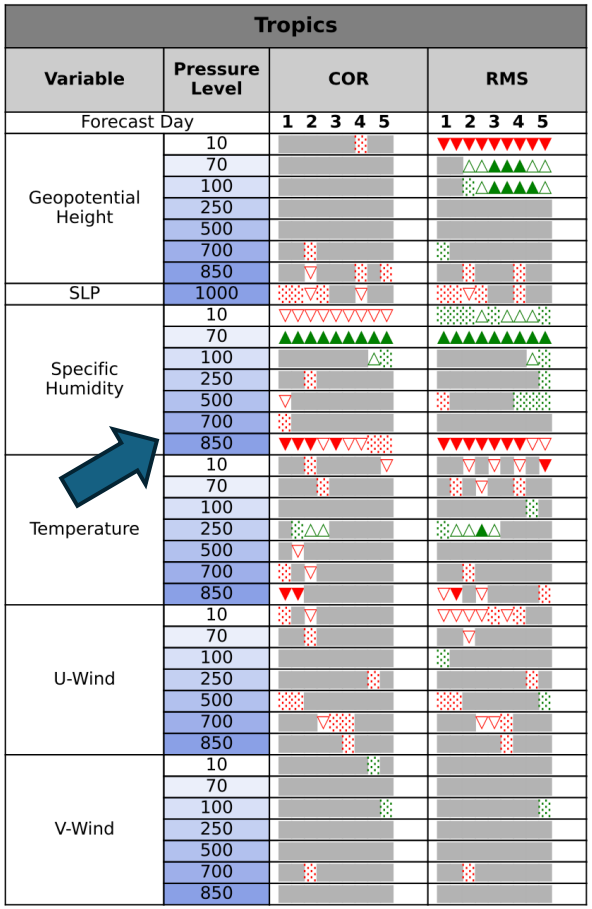
- Steps 1 & 2 are performed by the distribution center, Step 3 is the data user's pr
- Omitting a few extra steps depending on product like BUFR formatting, apodizat product is unapodized, etc. (time spent implementing not proportional to talk c

Compression $p = E^T N^{-1} (y - \bar{y})$

First IASI PCS Experiment







- Make no modifications to the DAS, only difference is replacing the data source to use reconstructed radiances (replace Metop B & C IASI radiances)
- 1 May 2022 – 30 June 2022 (61 days)
- Generally Neutral Impact except for 850 hPa

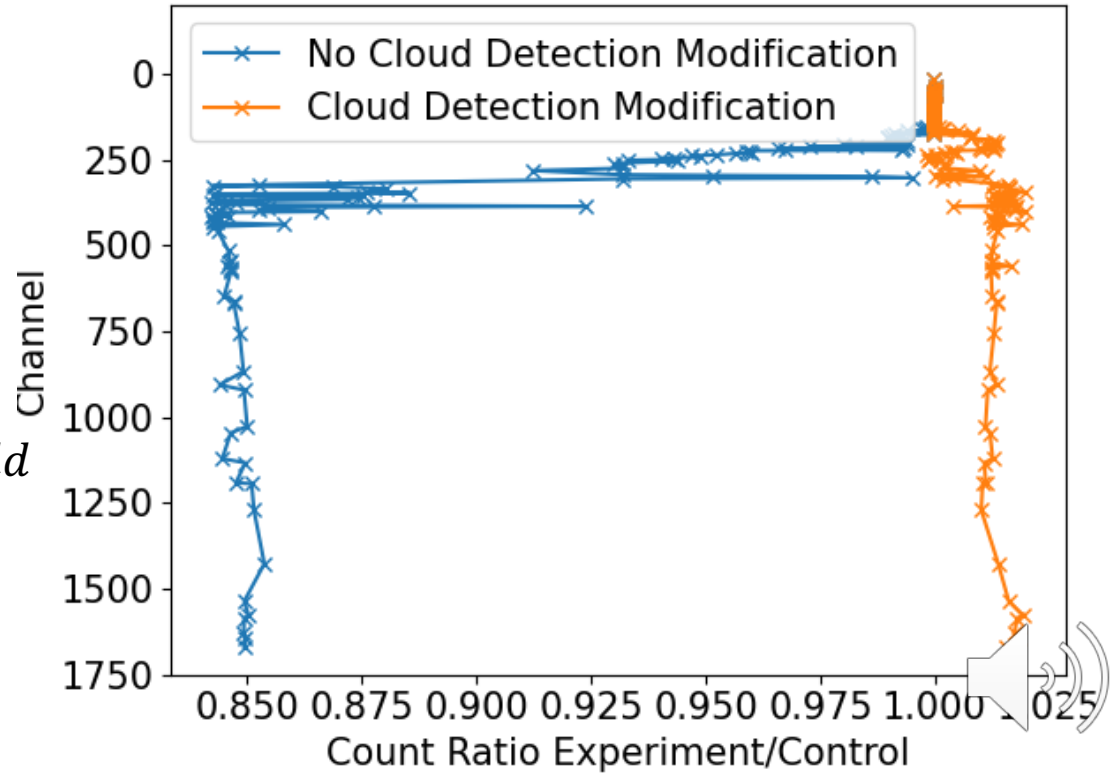
▲ far better, significant (99.99% confidence)
△ better, significant (99% confidence)
⁘ slightly better, significant (95% confidence)
▒ no significant difference
⁘ slightly worse, significant (95% confidence)
▽ worse, significant (99% confidence)
▼ far worse, significant (99.99% confidence)

Cloud Detection Problem

- GSI minimum residual method relies on normalization of by the expected “noise” ~Eyre and Menzel, 1998
- PC compression effectively “drops” noise making it less noisy
- Using the original noise estimate results in cutting off cold end of distribution on surface channels, causing the bias to shift positive, results in a feedback
- “Denoising” of higher peaking channels needs to be accounted for

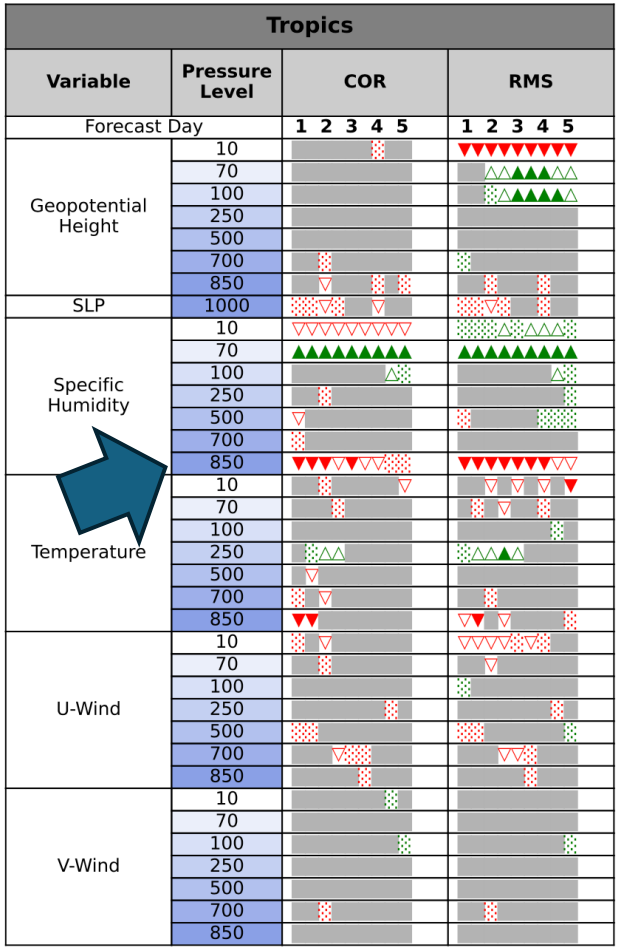
$$\sum_{chan=1}^{Nchan} \frac{(Ob_{chan} - SimClear_{chan})^2}{\sigma_{chan}^2}$$

$$Threshold = 0.75 * Initial\ Threshold$$

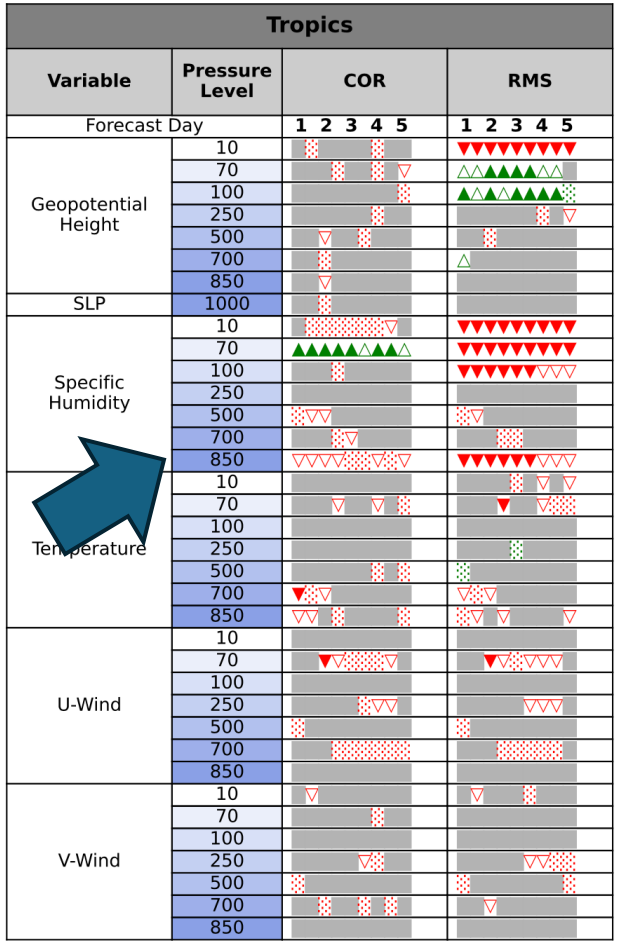


Adjustment Helps, but still…

- The modification to cloud detection helps, but still some degradation
- Seems a bit weird for surface sensitive channels to that much of an impact on near surface Q



w/o cloud detection Modification



w/ cloud detection Modification

▲ far better, significant (99.99% confidence)
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slightly better, significant (95% confidence)
no significant difference
slightly worse, significant (95% confidence)
▽ worse, significant (99% confidence)
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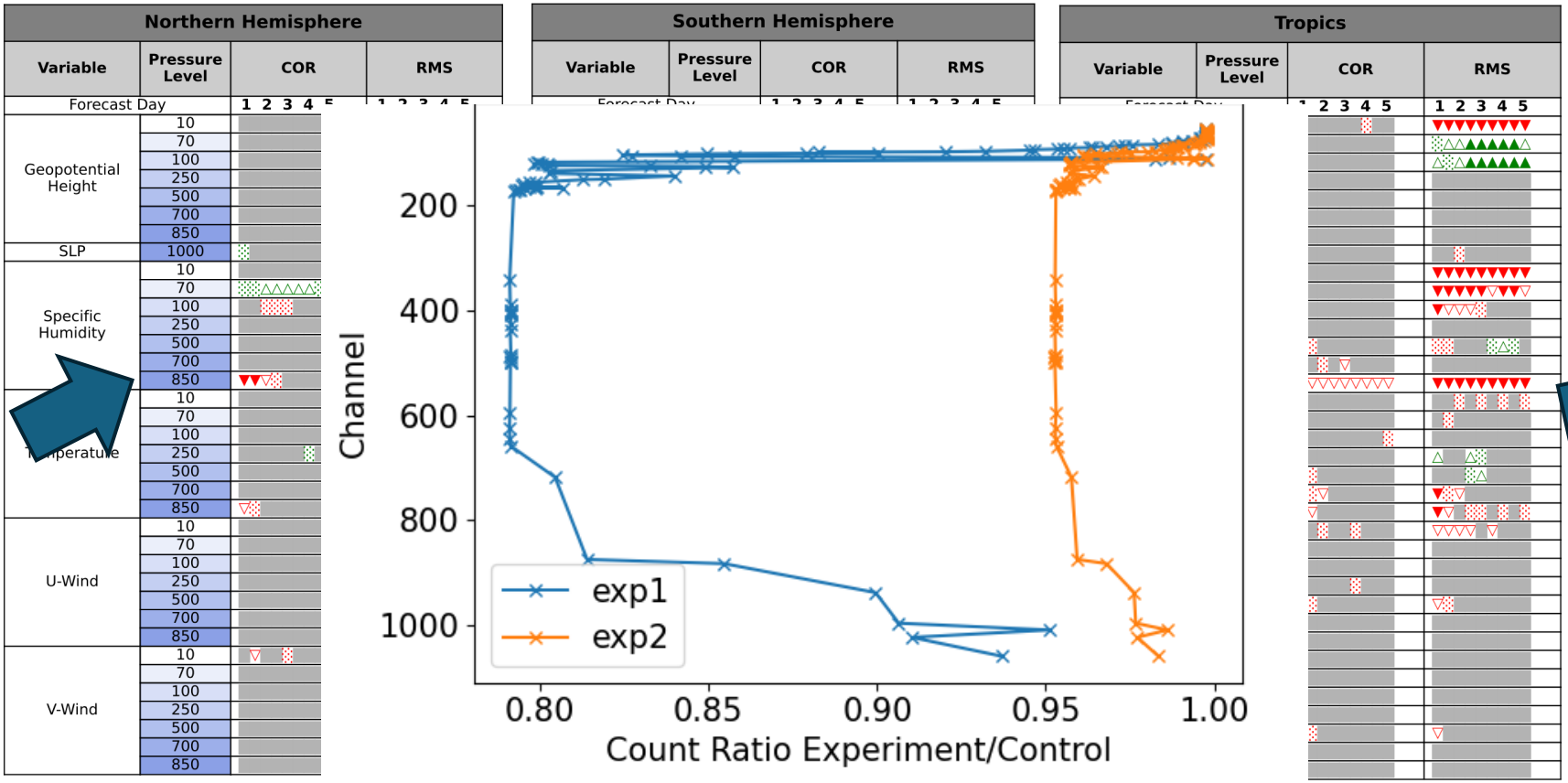
Trying CrIS PC scores NOAA 20

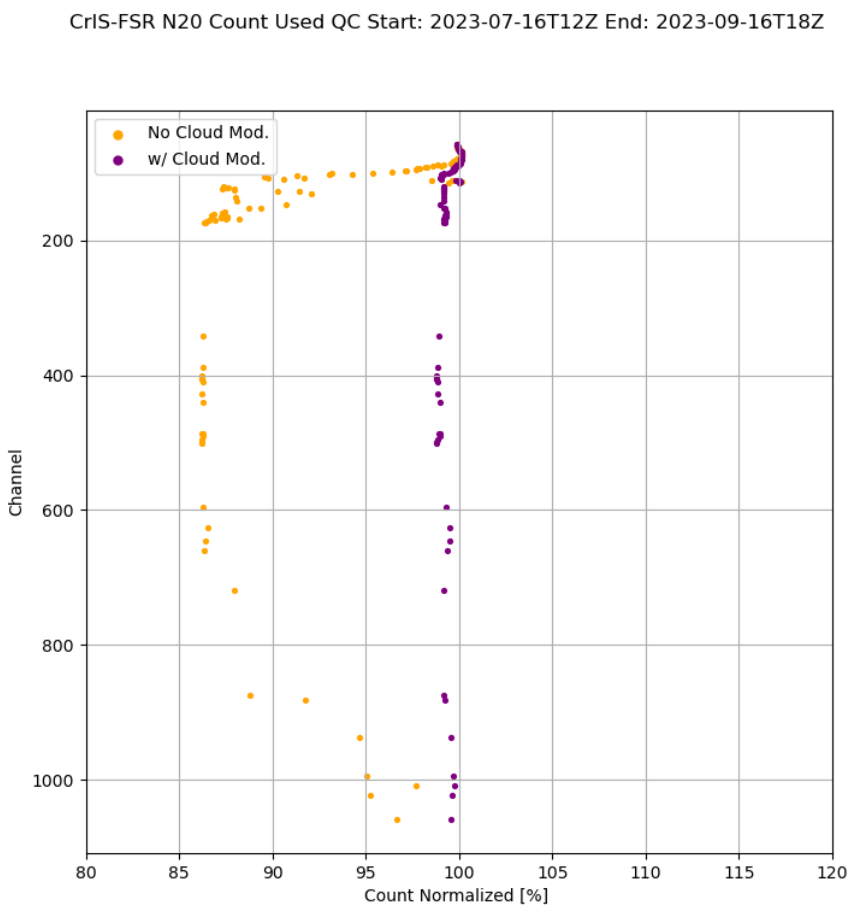


- Same Story as IASI, but just about as bad for replacing 1 CrIS on N20 as for 2 IASI's on Metop B & C
- Go through exercise of modifying cloud detection, but can't improve it
- Weird! Something else going on here/broken with the system?

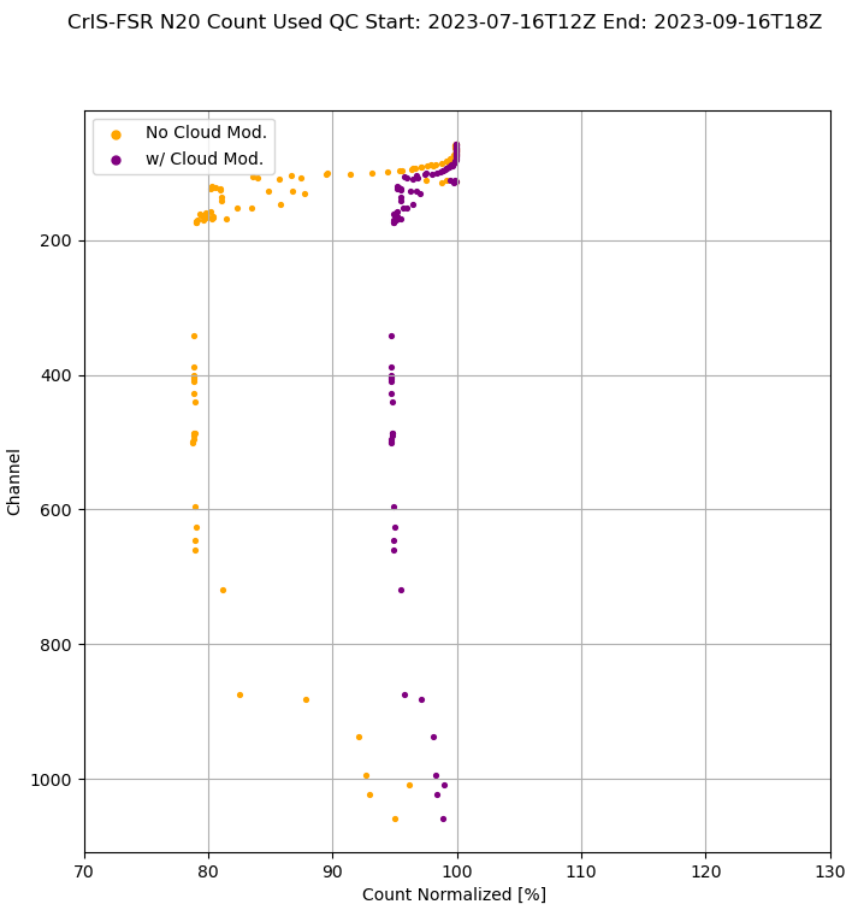
What's going on here?

- Results up to this point with a system that had known issues with all-sky microwave bias correction
- Updated system also includes a model update which improved near surface water vapor forecasts
- Current untested hypothesis slight variations in IR channel counts/bias correction modulating Microwave bias correction, causing degradation
- Now for a "Re-Do" for CrIS N20 PC scores (haven't done IASI, yet) ….
- Mid-July through Mid September 2023 (~60 days)

Still need to modify cloud detection to bring counts up…



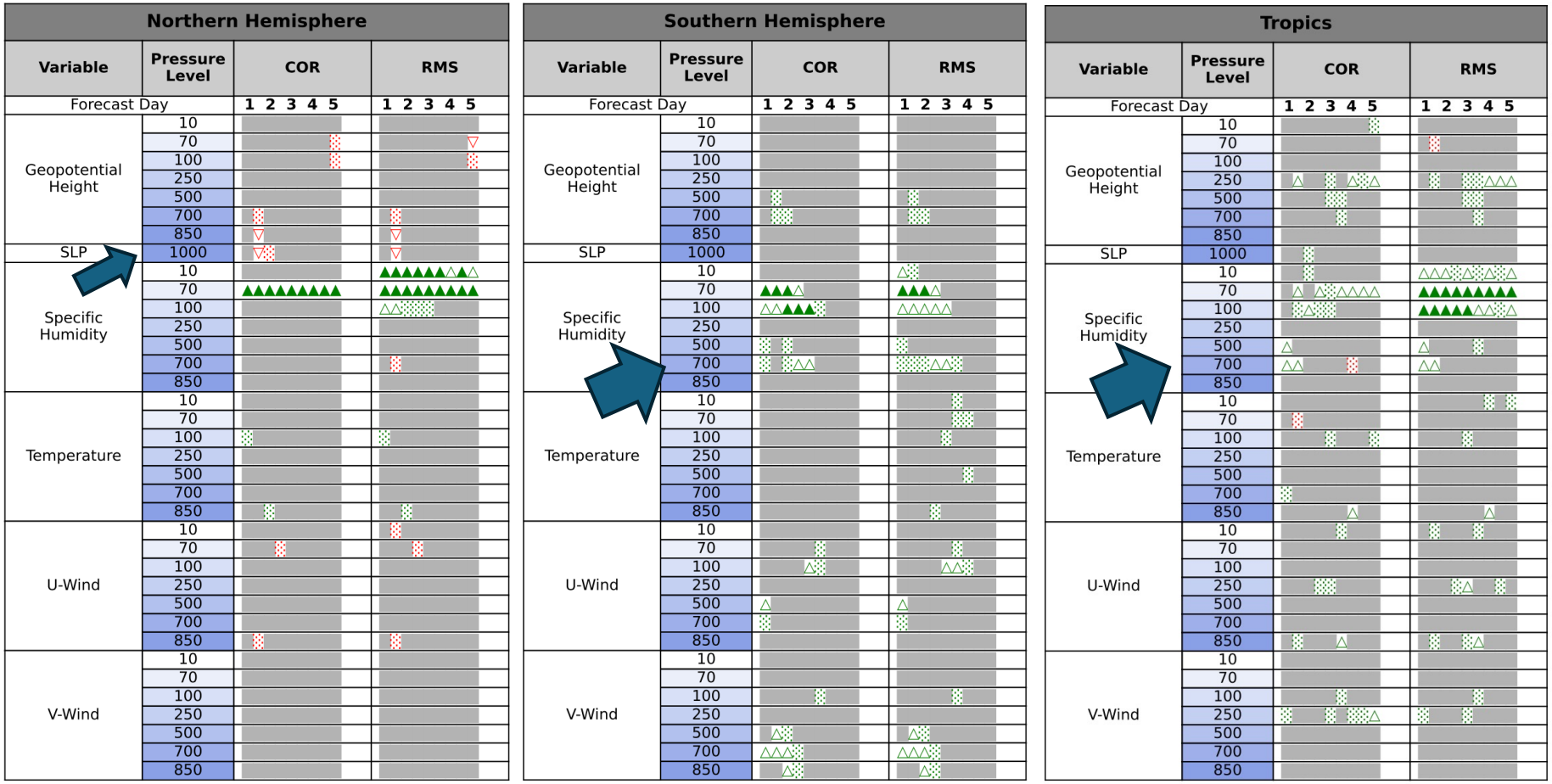
Observations that pass QC



Points that are used by Analysis

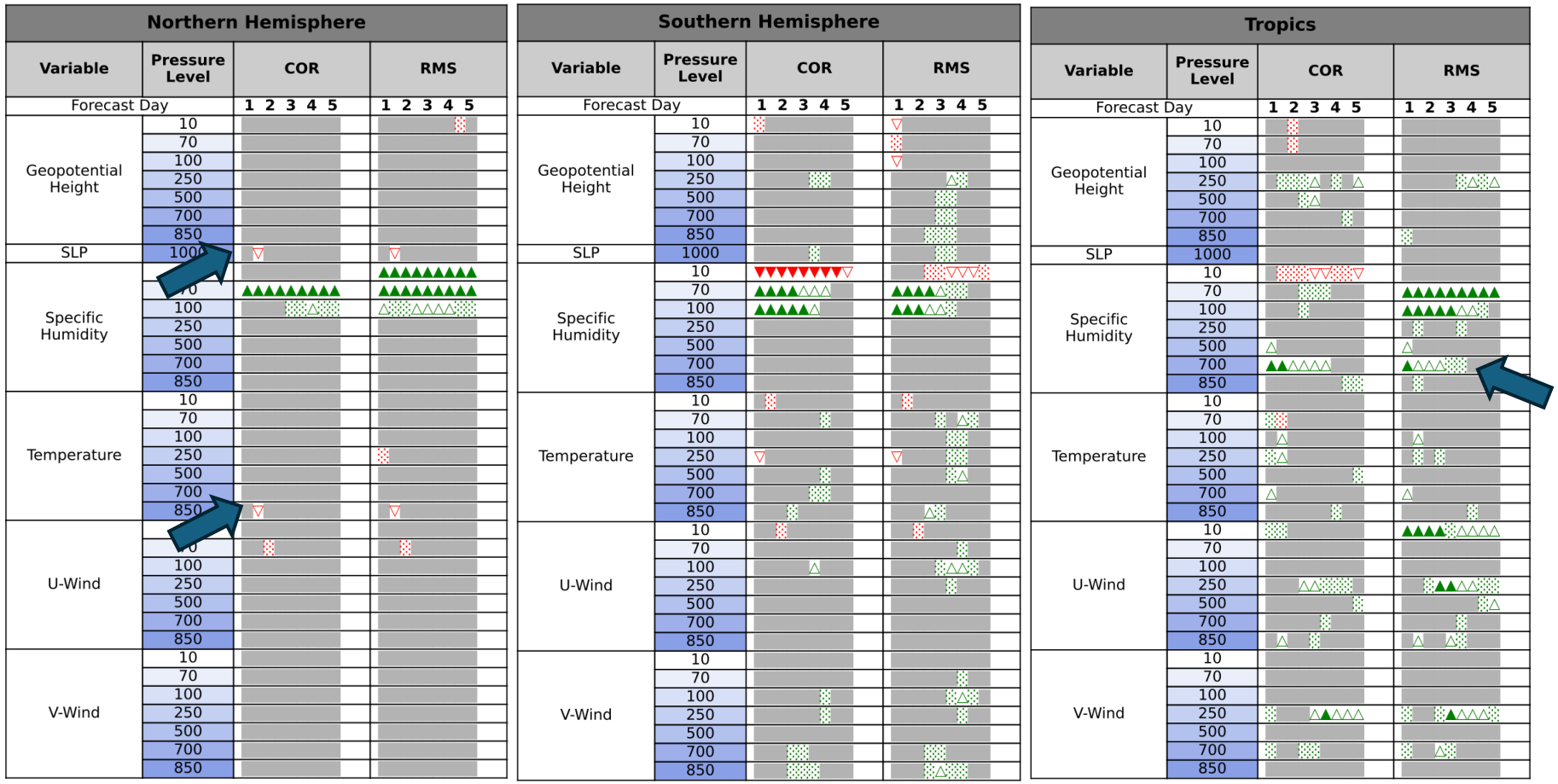
- Repeat two experiments one with no modification to cloud detection, other the same cloud detection modification previously
- Possibly could "loosen" cloud detection a little bit more

Forecast Scores w/o Cloud Detection Modification



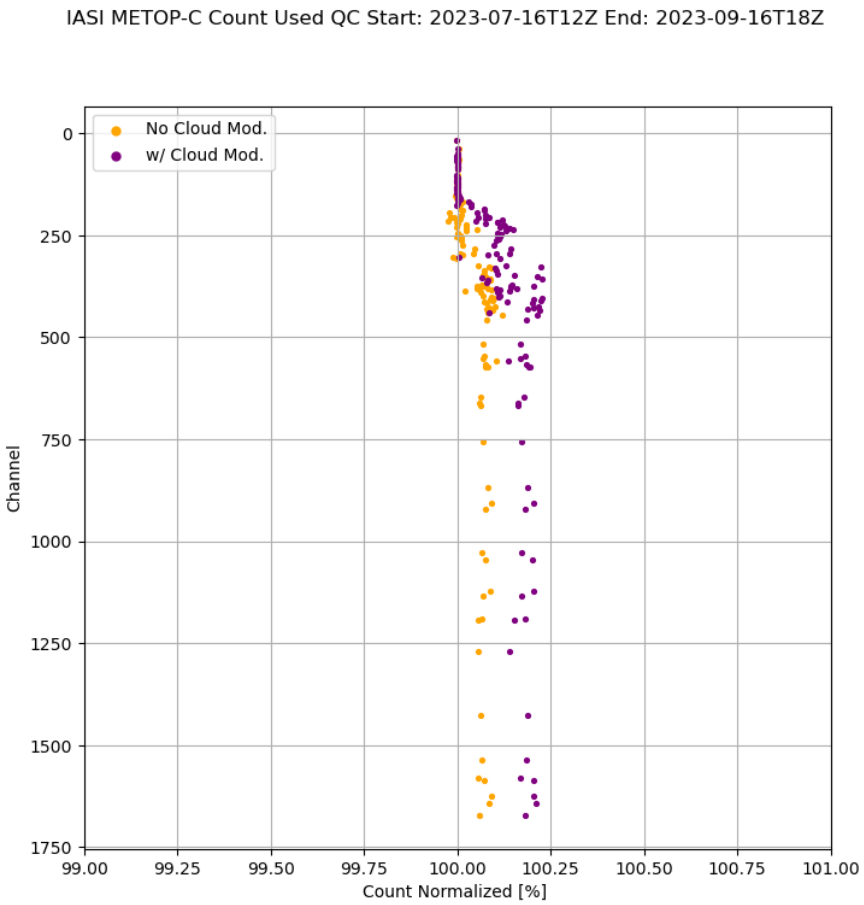
- Much better result, even modest improvement of Q and 700 hPa in SH and Tropics
- Some degradation NH Geopotential Height and SLP

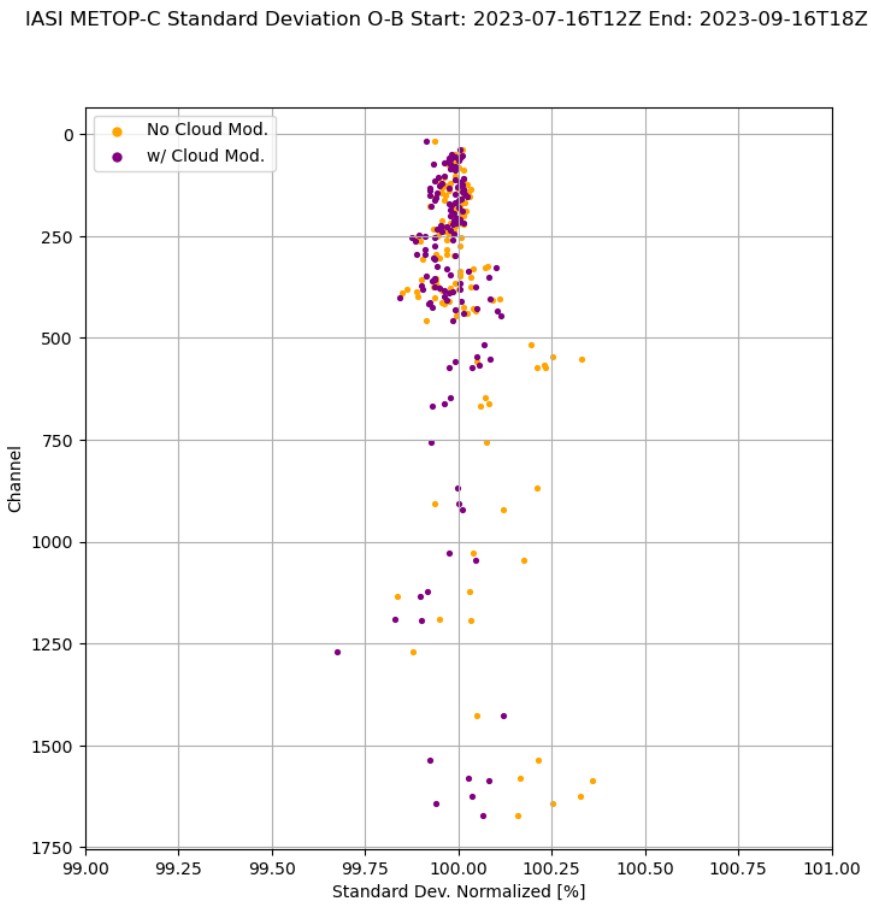
Forecast Scores w/ Cloud Detection Modification



- Improved Q at 700 hPa in the tropics
- Geopotential Height degradation removed in NH
- Some degradation in SLP in NH remains
- Expecting neutral, but neutral to positive → won't complain!

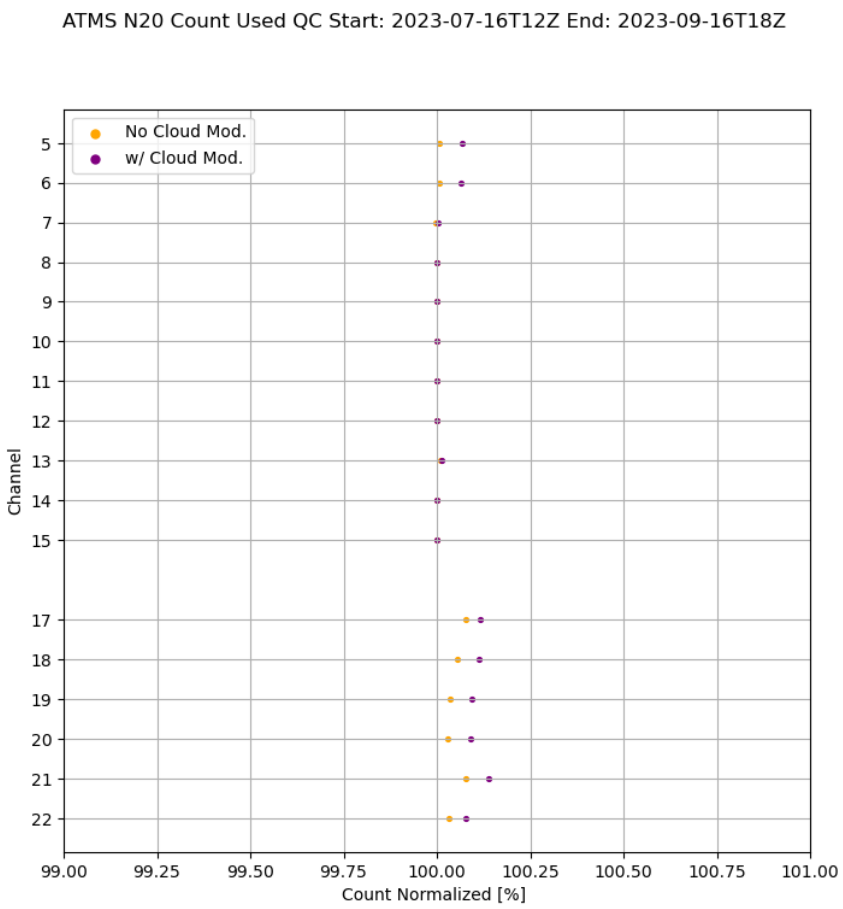
Observations Fit IASI-Metop-C

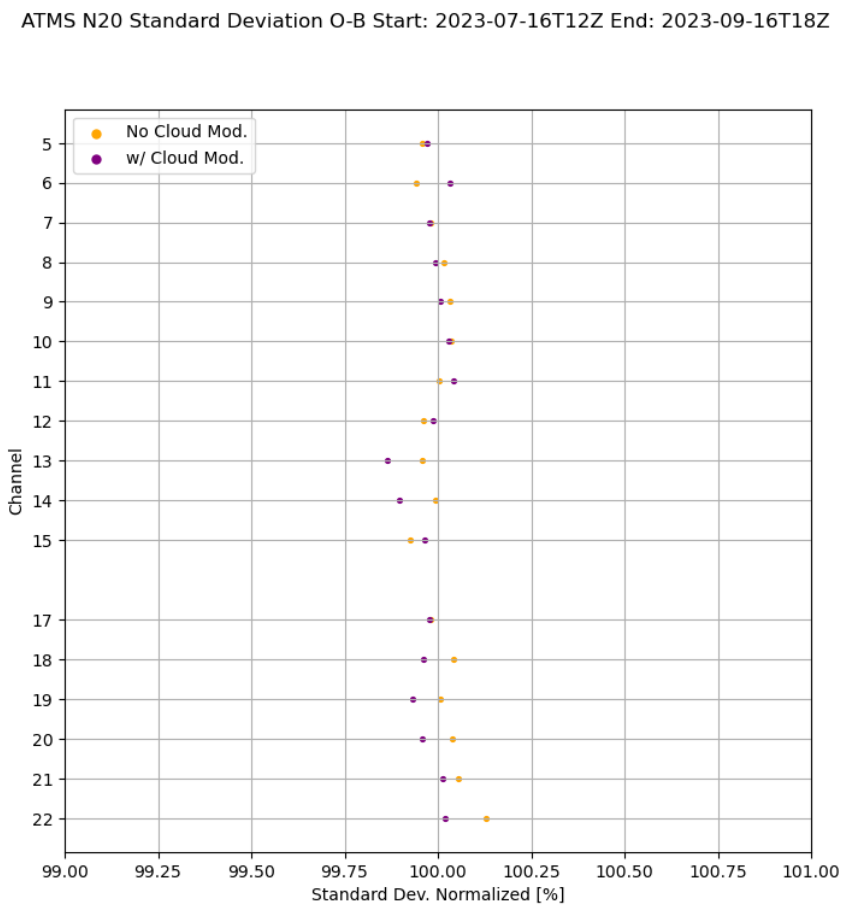




- More Observations pass QC for both cases, but w/ cloud detection has more
- Hit/Miss with standard deviations, but w/ cloud detection modification generally speaking improved, relative to w/o cloud detection modification
- Changes here possibly not statistically significant

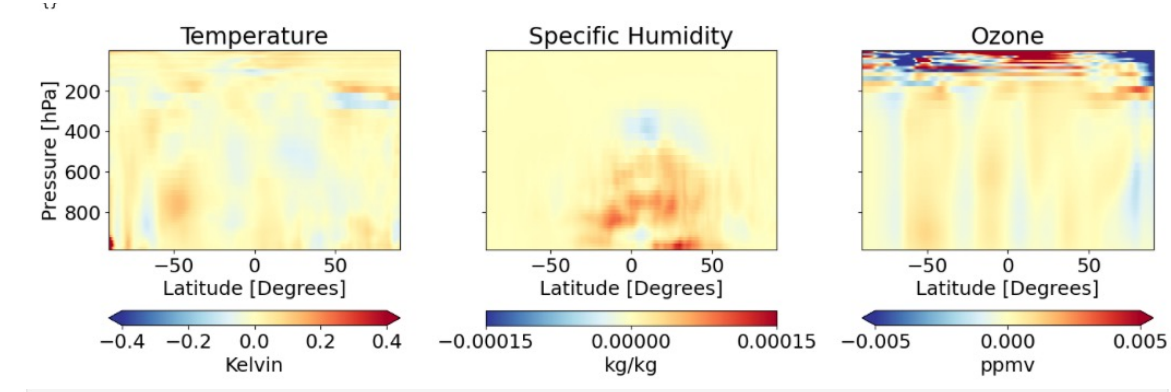
Observations Fit ATMS NOAA 20



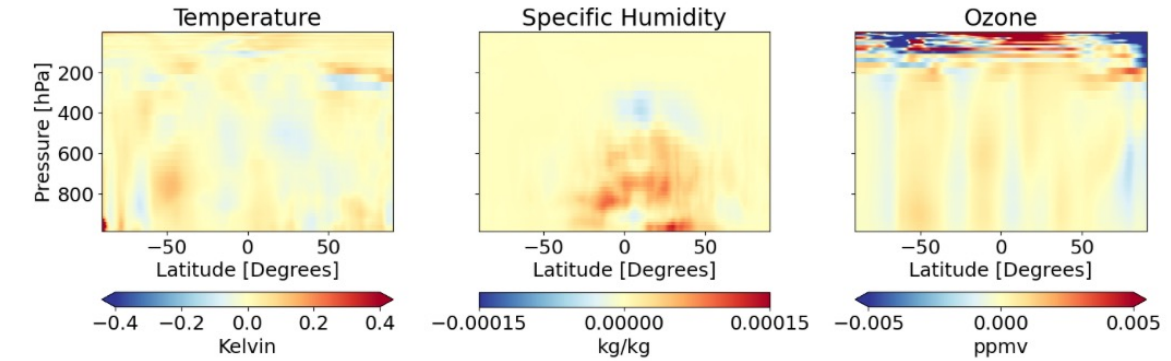


- More Observations pass QC for both cases looking at water vapor channels
- Also more pass QC for 5&6 w/ cloud detection mod
- Generally speaking w/ Cloud modification has improved standard deviation, and definitely relative to w/o cloud modification (changes here possibly not statistically significant)

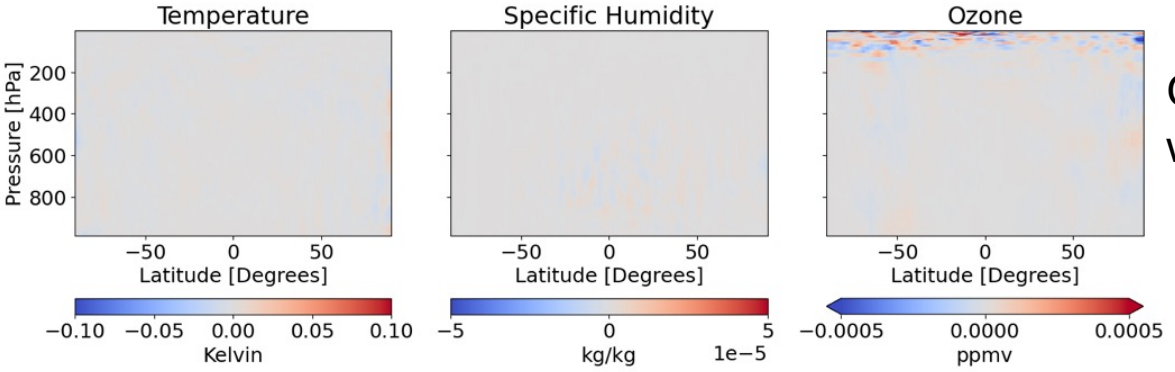
Experiments with CrIS PC scores using updated system Increments (no cloud detection modification)



Control

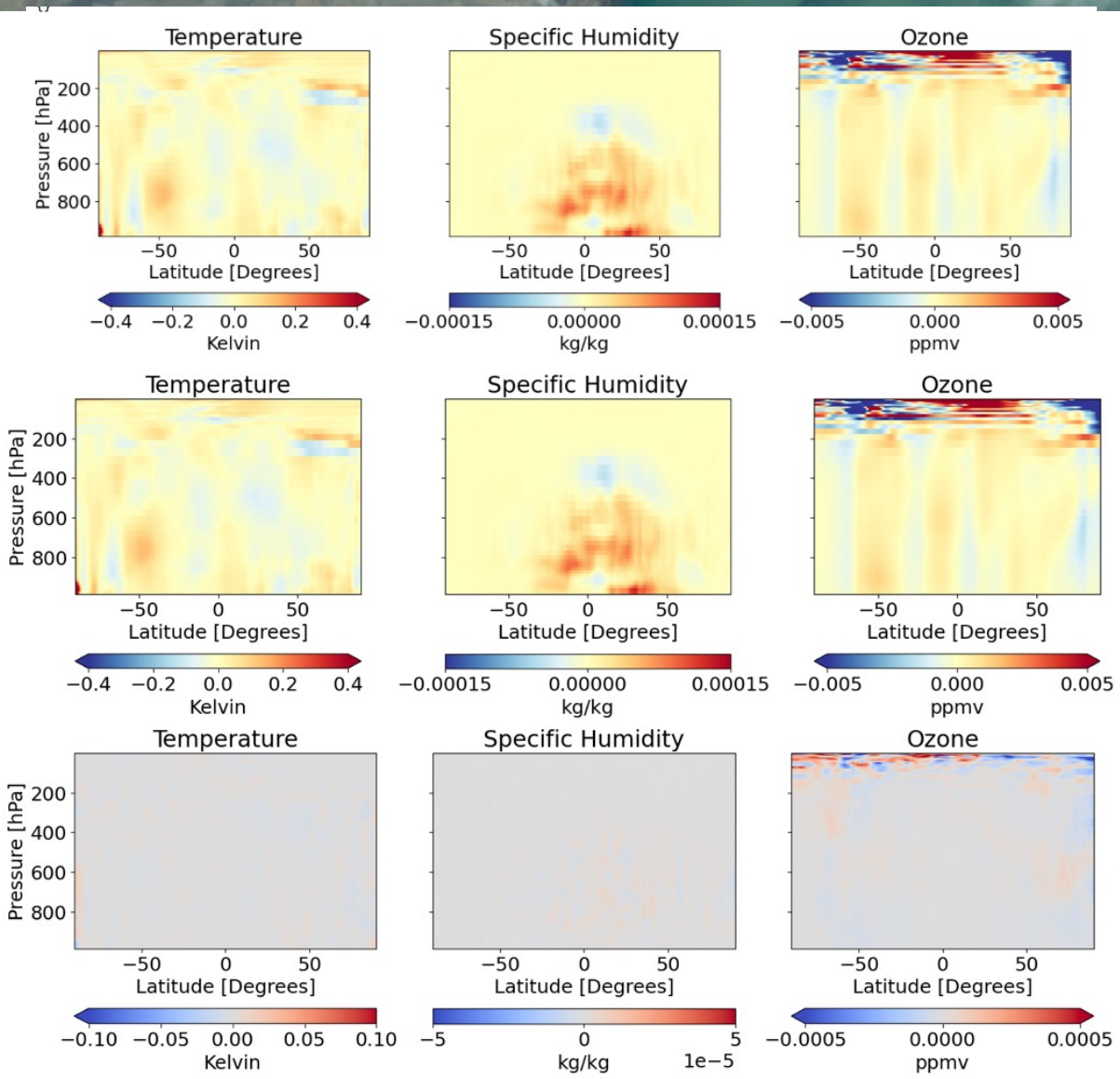


PC Scores w/o Cloud Modification



Control Minus w/o Cloud Modification

Experiments with CrIS PC scores using updated system Increments (with cloud detection modification)



Control

PC Scores w/o Cloud Modification

Control Minus w/ Cloud Modification

Next Steps/Conclusions/Future Areas

- Run experiment with using Desroziers or Desroziers-like estimate based upon reconstructed radiances → pretend we're assimilating a "new instrument"
- Prepare for assimilation of MTG-IRS → use sample data set to establish plumbing
- PCA reconstructed radiances should be readily assimilated with some modifications to cloud detection
- Using CADS (Eumetsat/NWPSAF cloud detection) which ECMWF uses has been added to EMC GSI, and coming to JEDI → potential benefits to reducing bias correction/cloud detection feedback