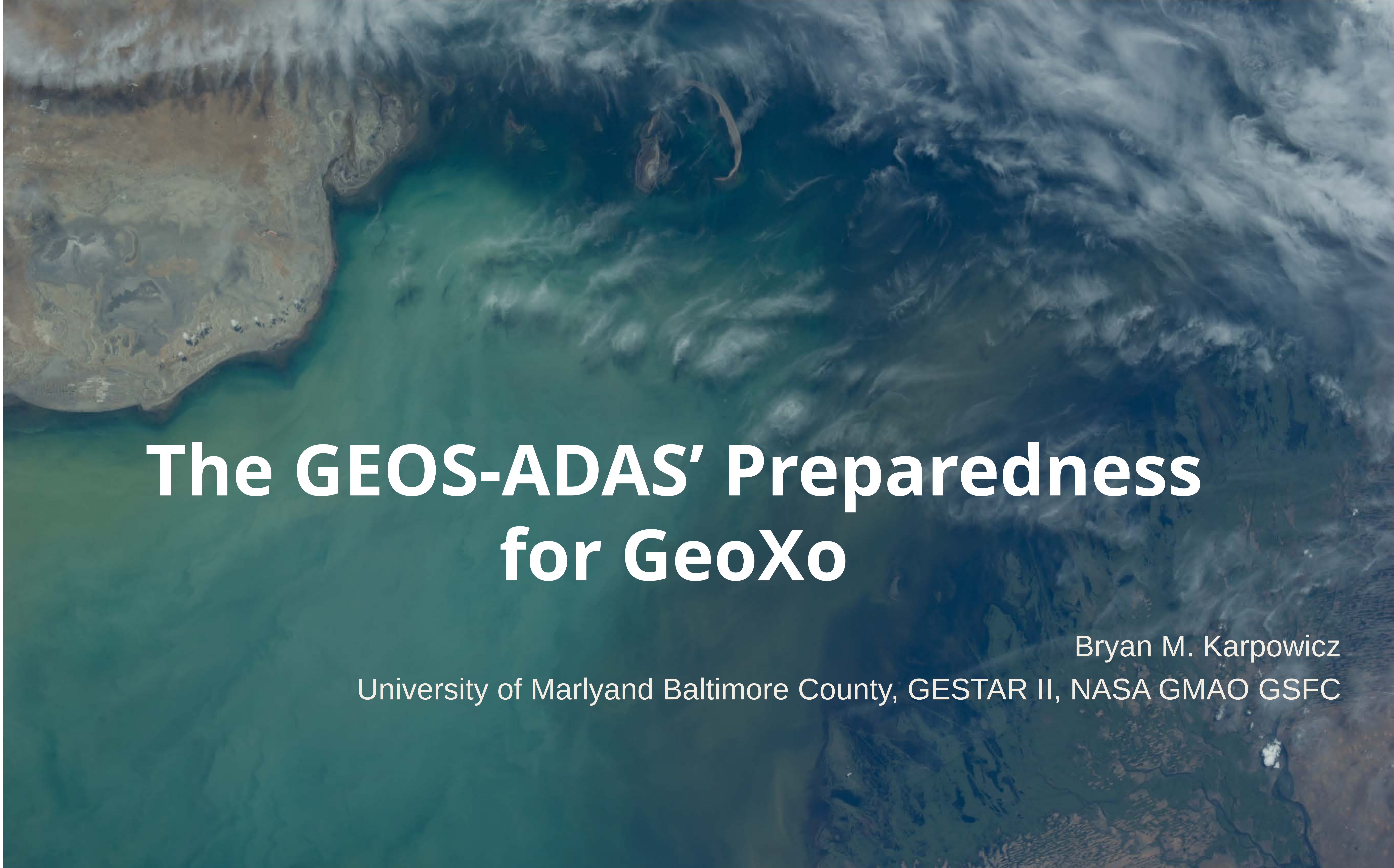

# The GEOS-ADAS' Preparedness for GeoXo

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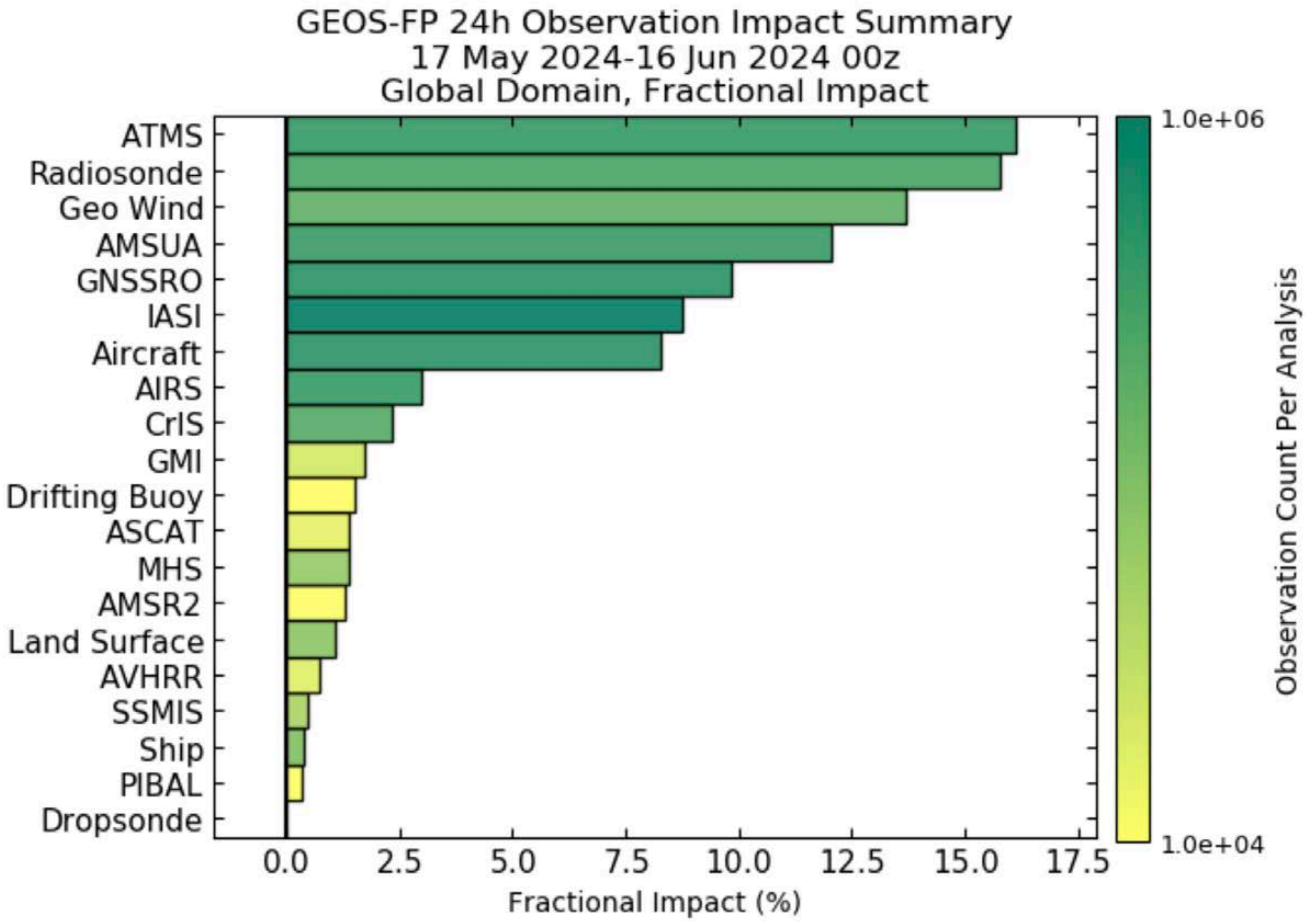
- Quick overview of observations used in GEOS-ADAS
- Deep-ish dive into Cloud detection and why we can’t have nice things…
- Initial results from IASI using reconstructed radiances from PC scores
- Future Ideas

- Suite of Global Microwave, Infrared, GPS-RO, Conventional, Aircraft, Ship, etc
- Relevant for GeoXo
  - GEO imagers → Only assimilate AMVs
  - GEO imager Clear Sky Radiances → Don't Assimilate Directly Marginal impact
  - IASI – METOP B and METOP C
  - CrIS – NOAA20
    - Don't assimilate NPP or N21
    - NPP may be possible to turn back on with SW/MW cloud det work in-progress (Jones et al. 2024)
    - Several Issues with implementation (a few with unimplemented fixes)
    - Suboptimal CrIS implementation blocking in part turning on N21



Observed Channel Radiances

Simulated Clear Channel Radiances

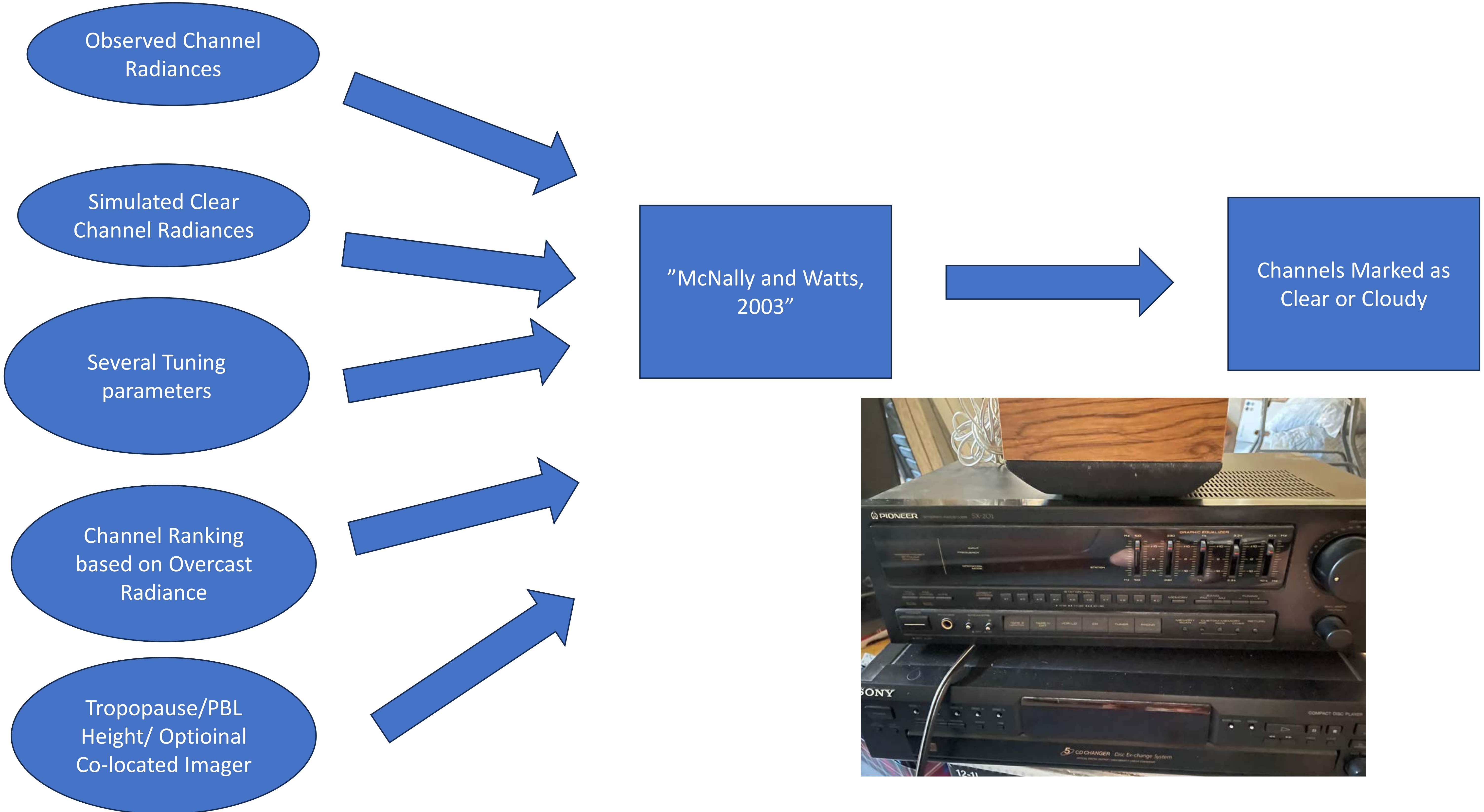
Only Real Knob → Channel Noise Level/Error Variance

Overcast Channel Radiance at Pressure level (From Jacobians)

Tropopause Height

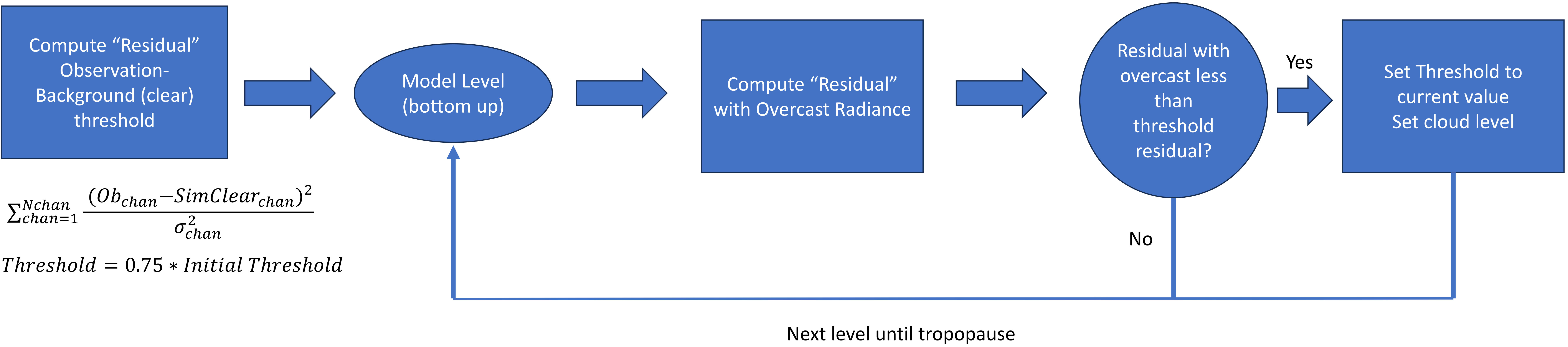
→ ”Eyre and Menzel, 1989” → Channels Marked as Clear or Cloudy

Imager Data Used for Thinning Not in Detection itself (Pick Clearest FOV)


Observed Channel Radiances
Simulated Clear Channel Radiances
Several Tuning parameters
Channel Ranking based on Overcast Radiance
Tropopause/PBL Height/ Optioinal Co-located Imager
”McNally and Watts, 2003”
Channels Marked as Clear or Cloudy
PIONEER
SONY

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

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

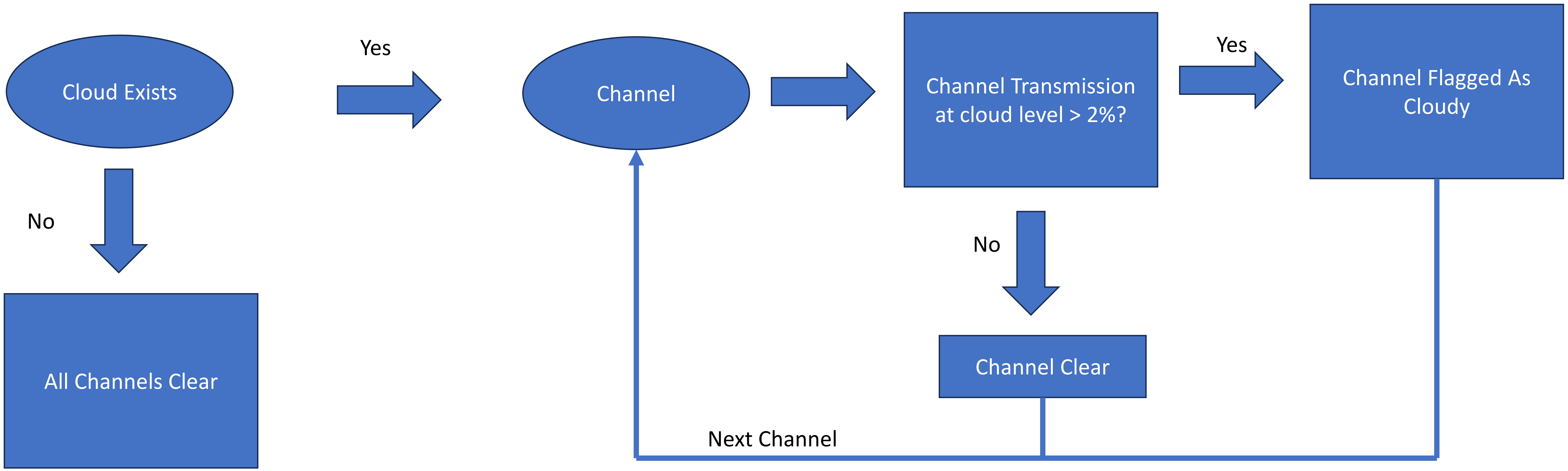



$$\sum_{chan=1}^{Nchan} \frac{(Ob_{chan} - SimClear_{chan})^2}{\sigma_{chan}^2}$$

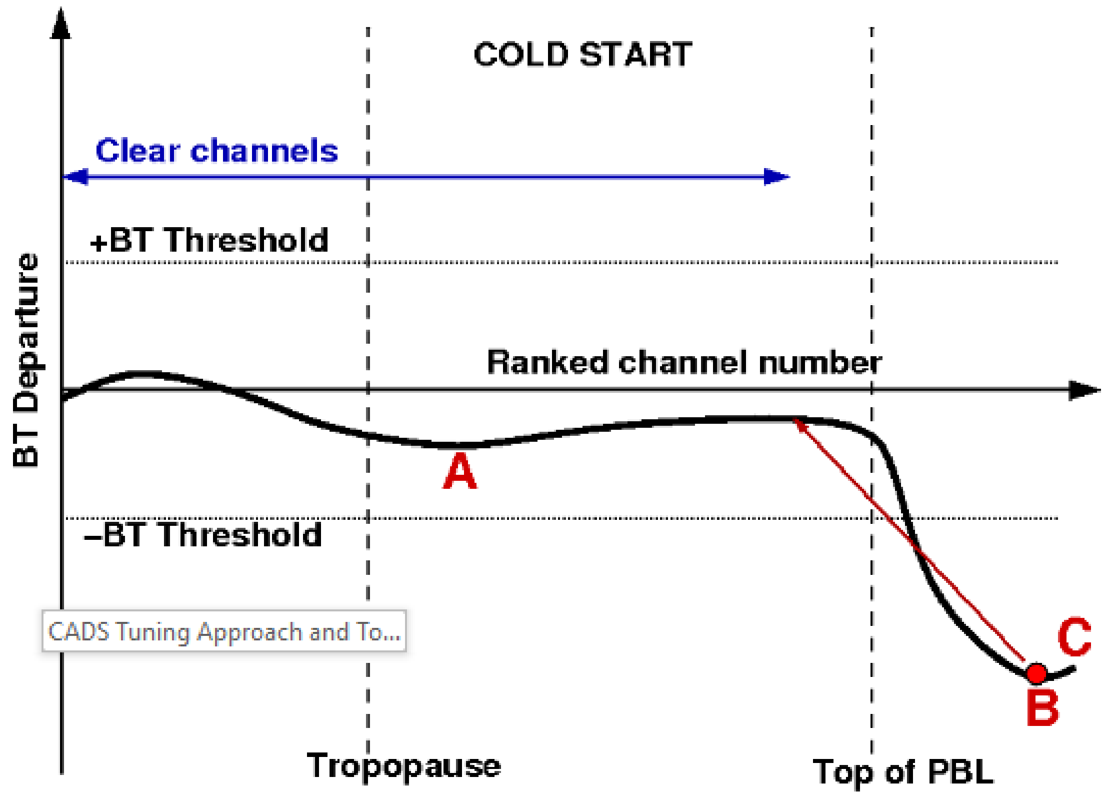
$$Threshold = 0.75 * Initial\ Threshold$$

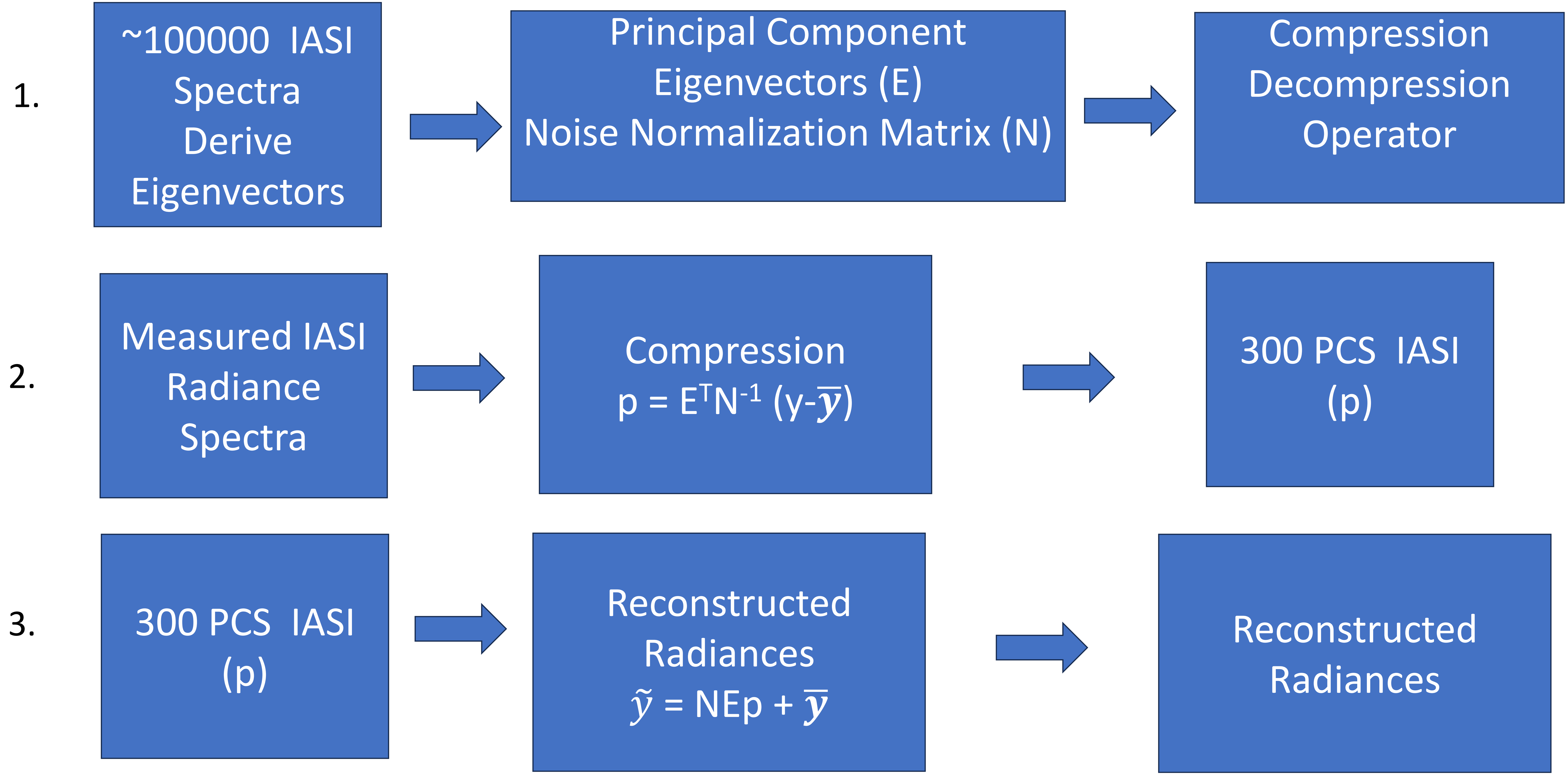
$$\sum_{chan=1}^{Nchan} \frac{((Ob_{chan} - SimClear_{chan}) \quad - N^2\,(Overcast_{chan}(plevel) - SimClear_{chan}))^2}{\sigma_{chan}^2}$$

? Typo somewhere

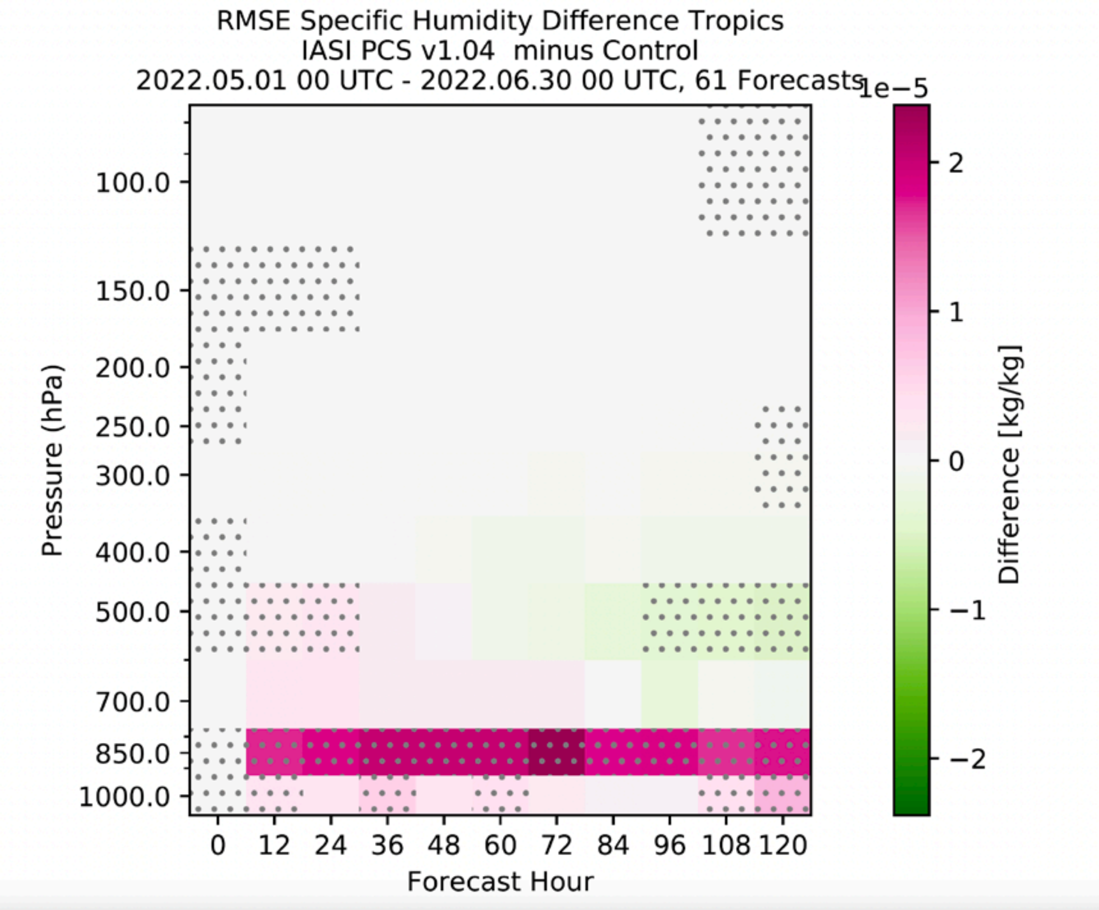

Cloud Exists
Yes
No
All Channels Clear
Channel
Channel Transmission at cloud level > 2%?
Yes
Channel Flagged As Cloudy
No
Channel Clear
Next Channel

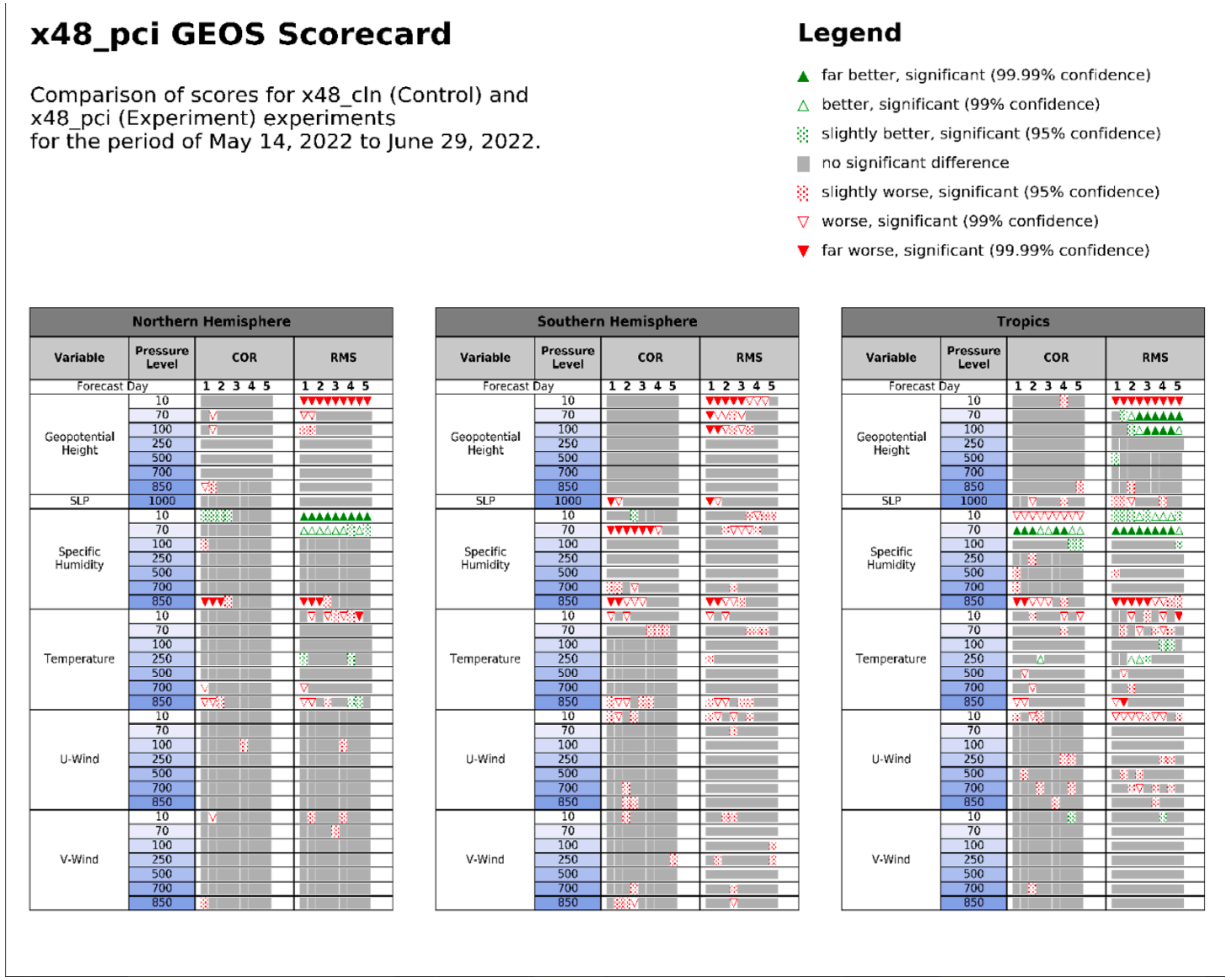
- Essentially based on McNally and Watts, 2003
- Cloud signal is assumed to be a smooth signal between vertically ranked channels
- The algorithm smooths the O-B of vertically ranked channels, and detects a cloud based off departures/gradients in sounding channels and gradients in window channels
- If a cloud is detected in one channel, all channels ranked below it vertically are flagged as cloudy
- Three scenarios warm start, cold start, quick exit
- Several knobs, smoothing window, gradient threshold, absolute threshold
- Where available co-located imager data incorporated into the process
- Minimal use of Overcast Radiance, only used to determine channel rank/height



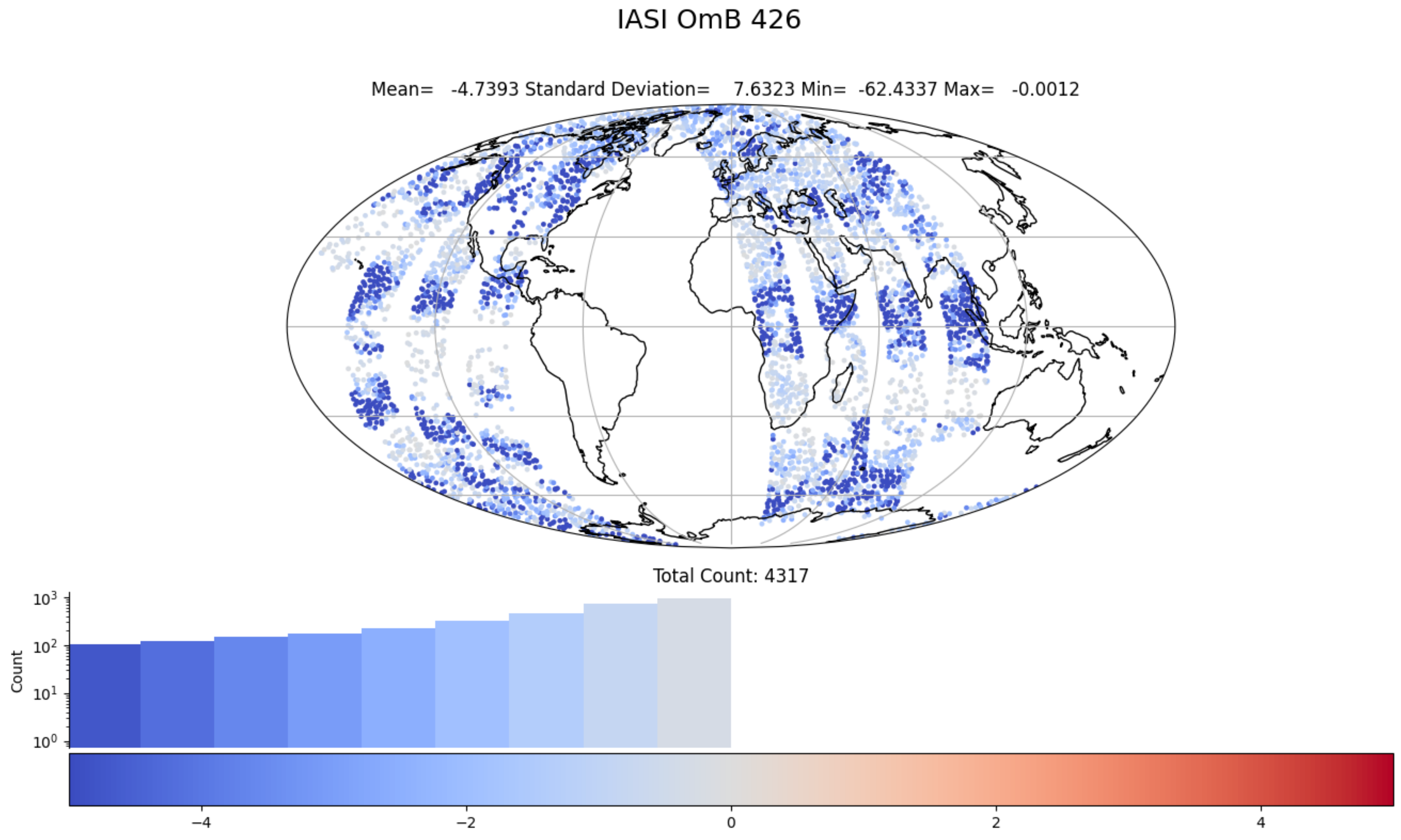

1.
~100000 IASI Spectra Derive Eigenvectors
Principal Component Eigenvectors (E)
Noise Normalization Matrix (N)
Compression Decompression Operator
2.
Measured IASI Radiance Spectra
Compression
$p = E^T N^{-1} (y - \bar{y})$
300 PCS IASI (p)
3.
300 PCS IASI (p)
Reconstructed Radiances
$\tilde{y} = NEp + \bar{y}$
Reconstructed Radiances

- Make no modifications to the DAS, only difference is replacing the data source to use reconstructed radiances
- Generally Neutral Impact except for 850 hPa
- Why?
  - Bias correction?
  - Cloud Detection?
  - Combination of both.

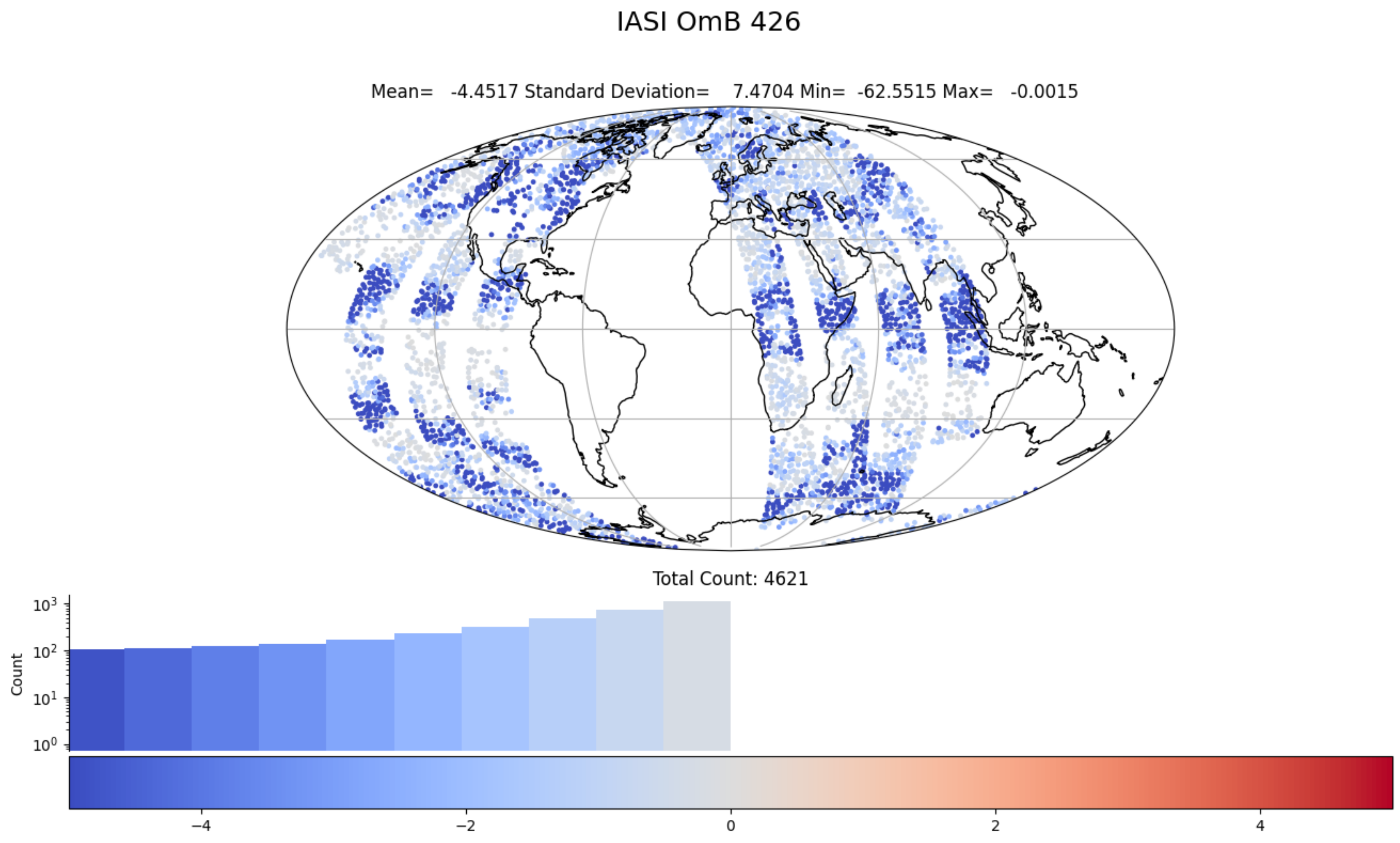


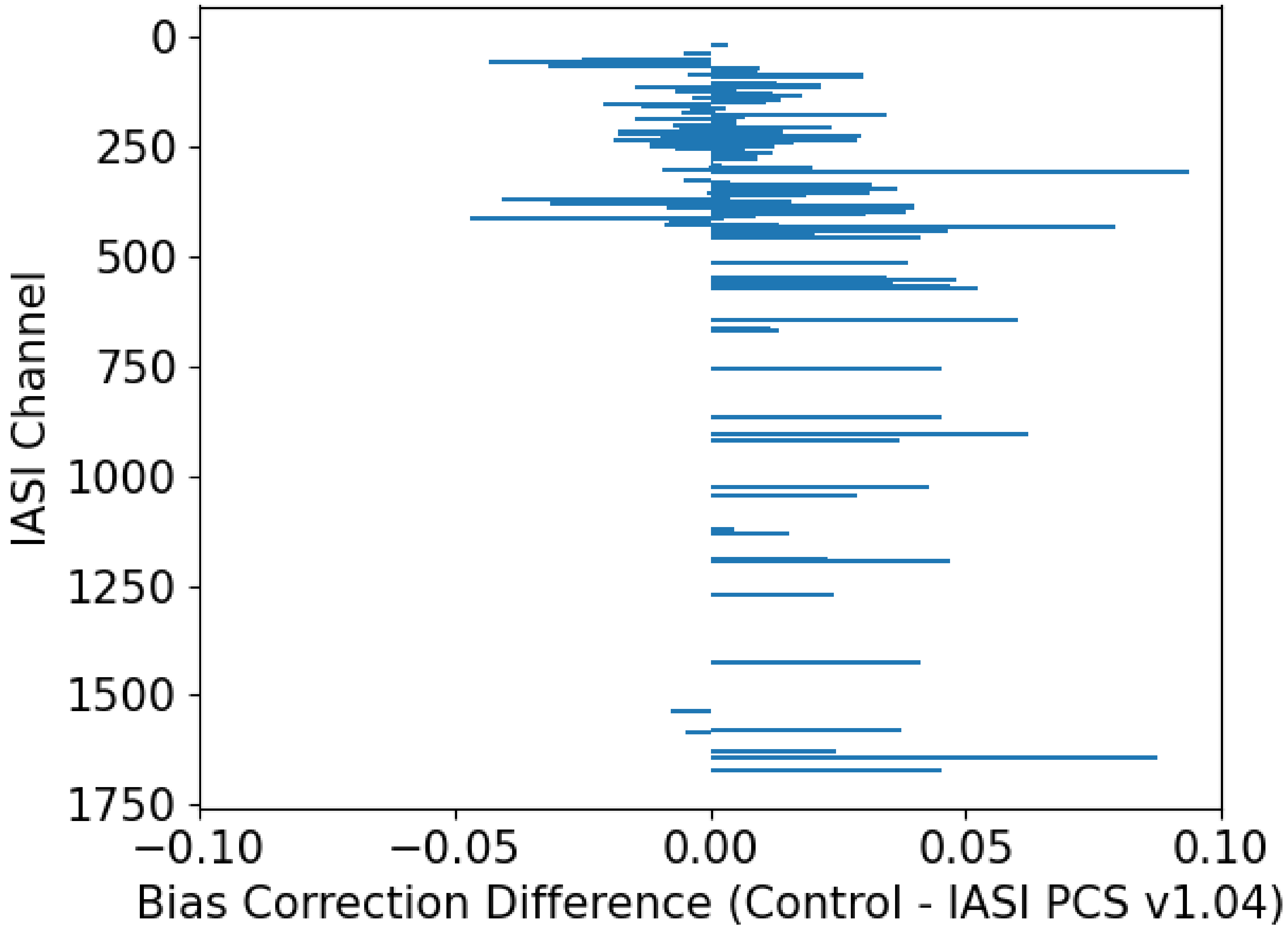
- GSI minimum residual method relies on normalization of by the expected “noise”
- PC compression effectively “drops” noise making it less noisy
- Using the original noise estimate results in cutting off cold end of distribution on surface channels, causing the bias to shift positive, results in a feedback
- Similar phenomenon exists for CrIS after inclusion of Correlated observation error → surface channel drift (also arbitrary 0.75 scaling of threshold questionable)



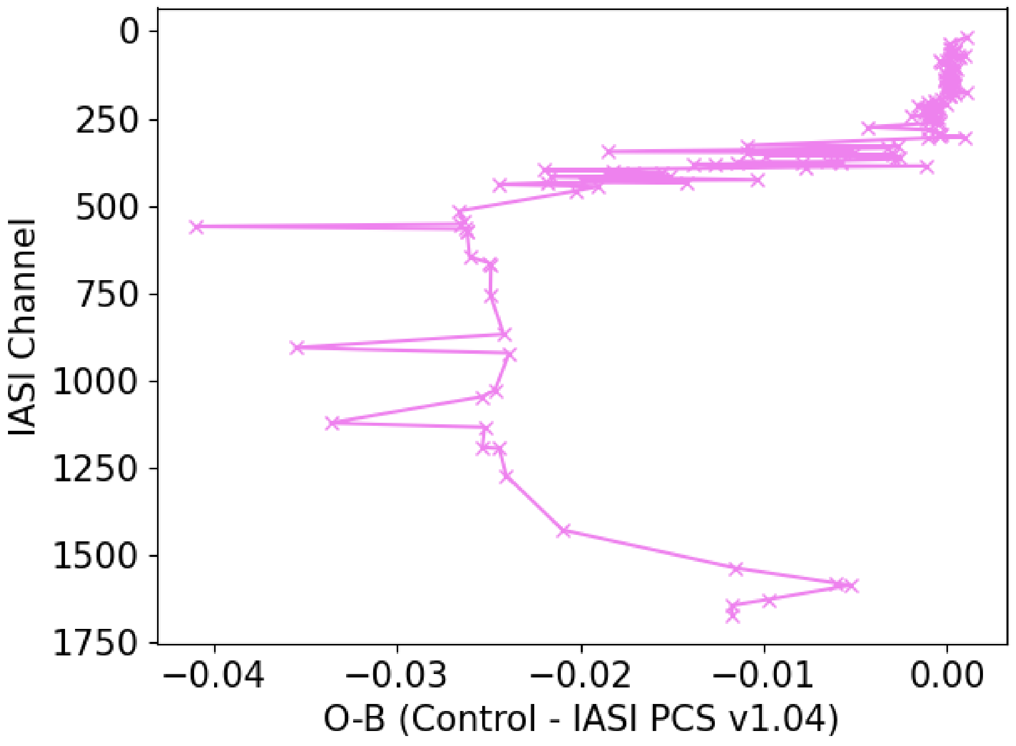
Cold Cloud Flagged Pixels Control

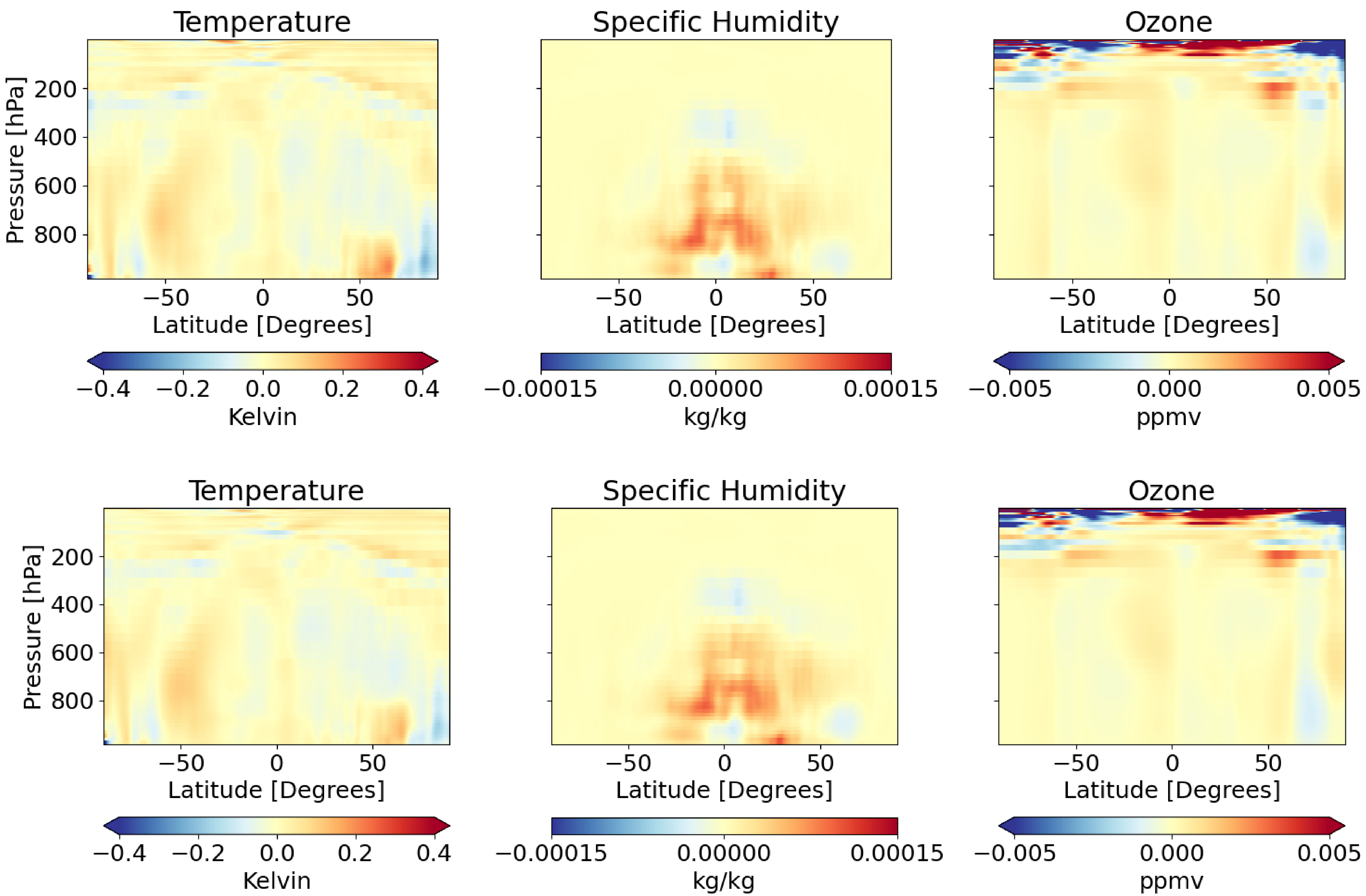


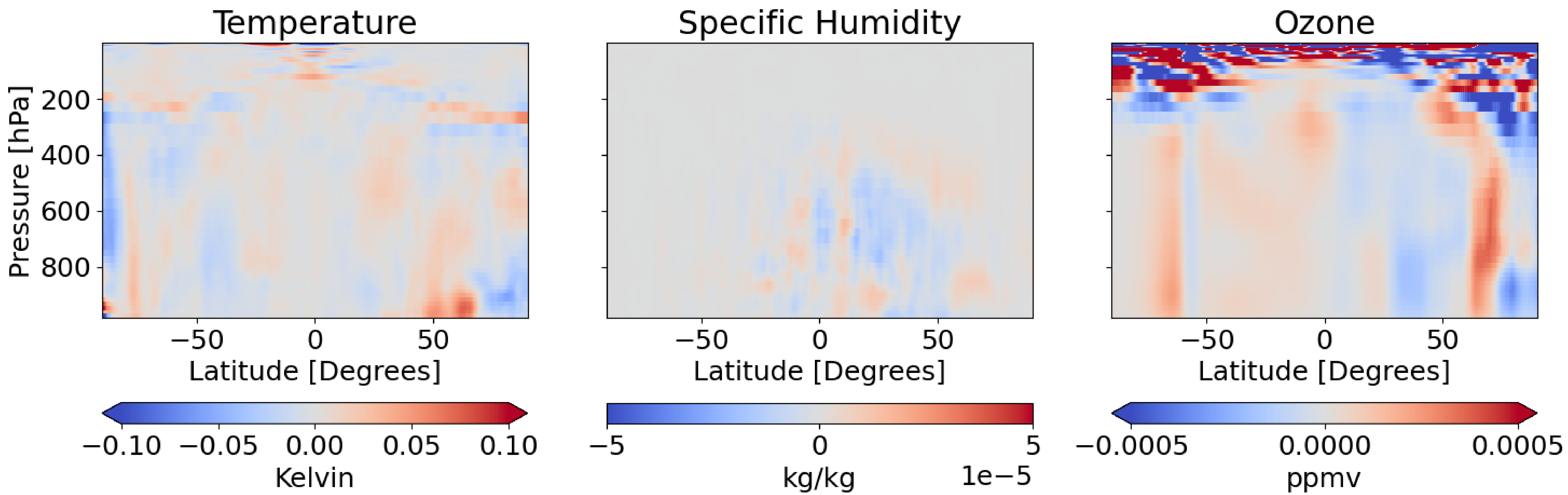
Cold Cloud Flagged Pixels Experiment

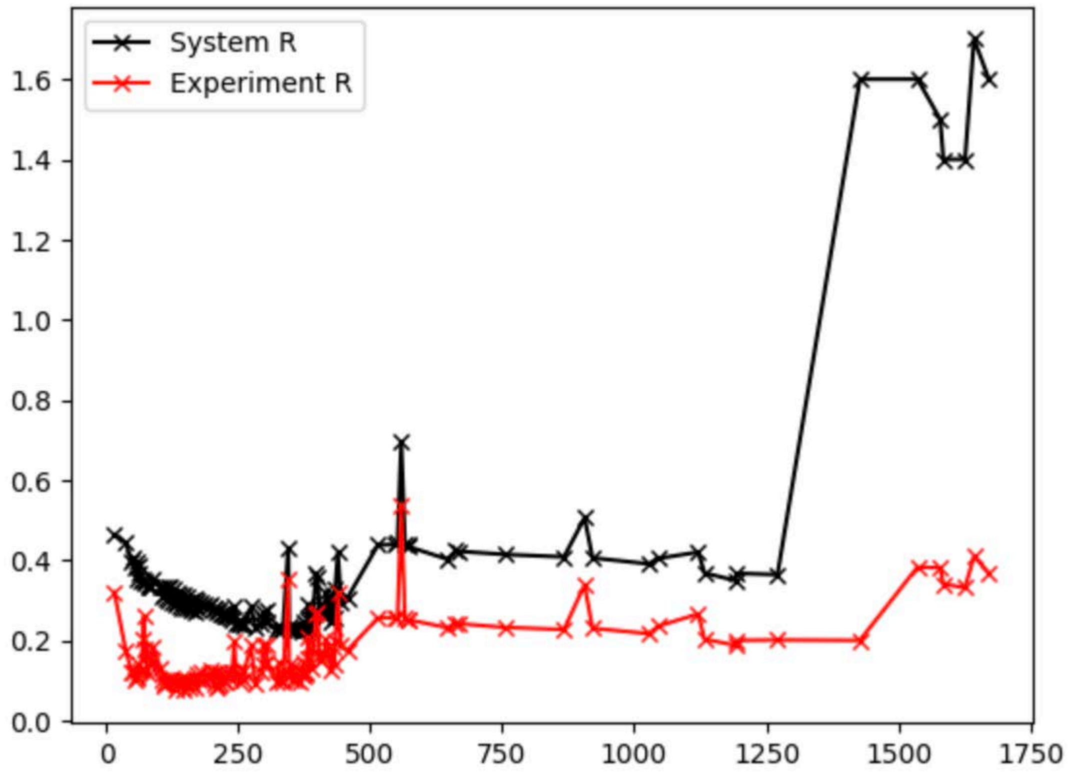


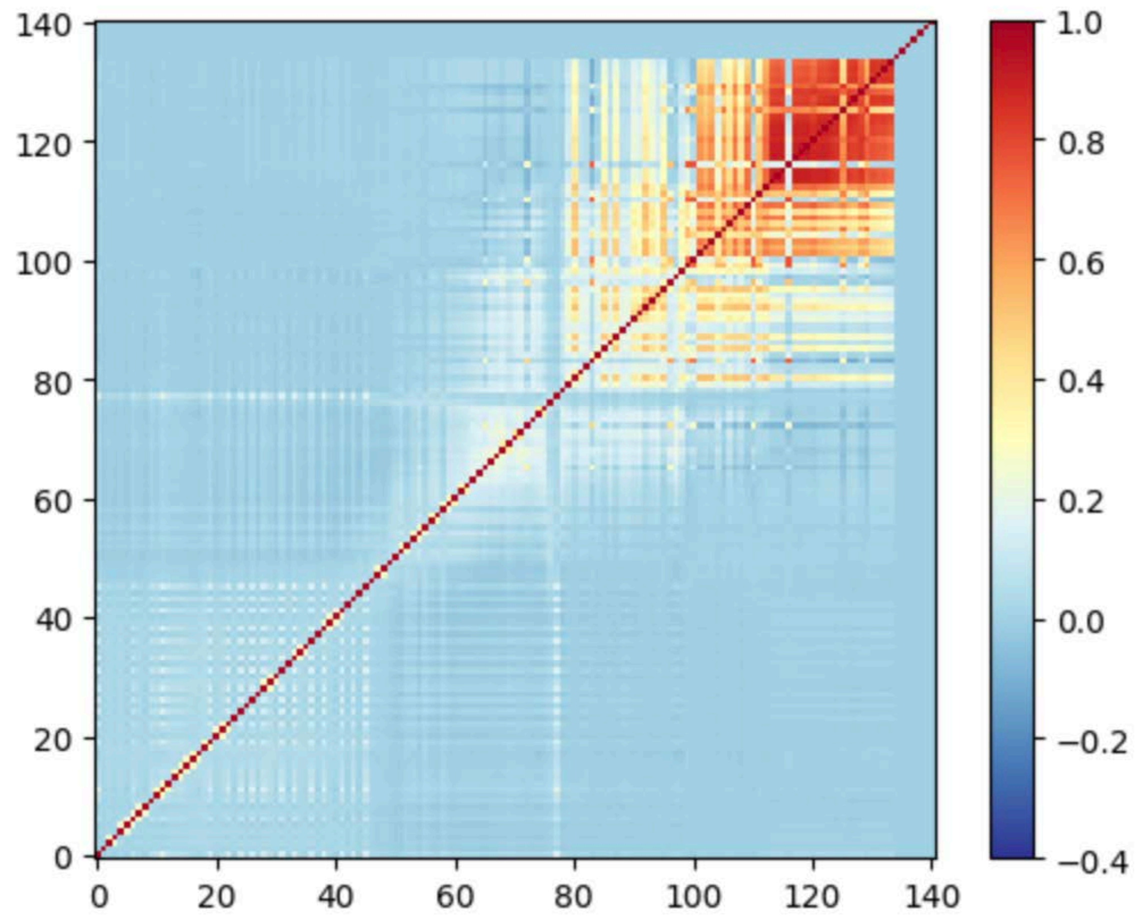
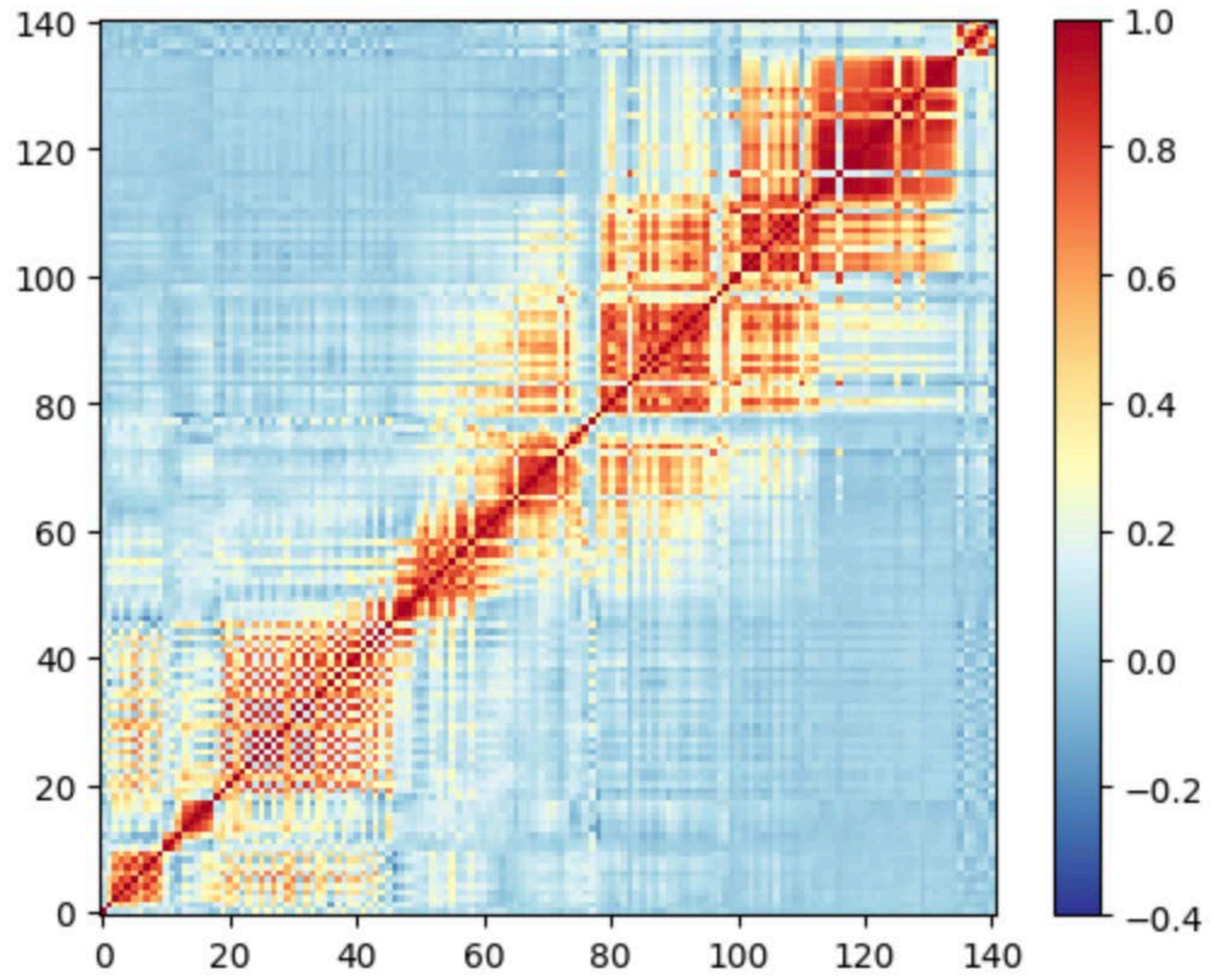

- The over enthusiastic cloud detection causes the bias correction to shift the distributions positive for more surface sensitive channels
- Most likely what is causing the undesirable features at 850 hPa forecast error
- Also average OMB difference for surface sensitive channels



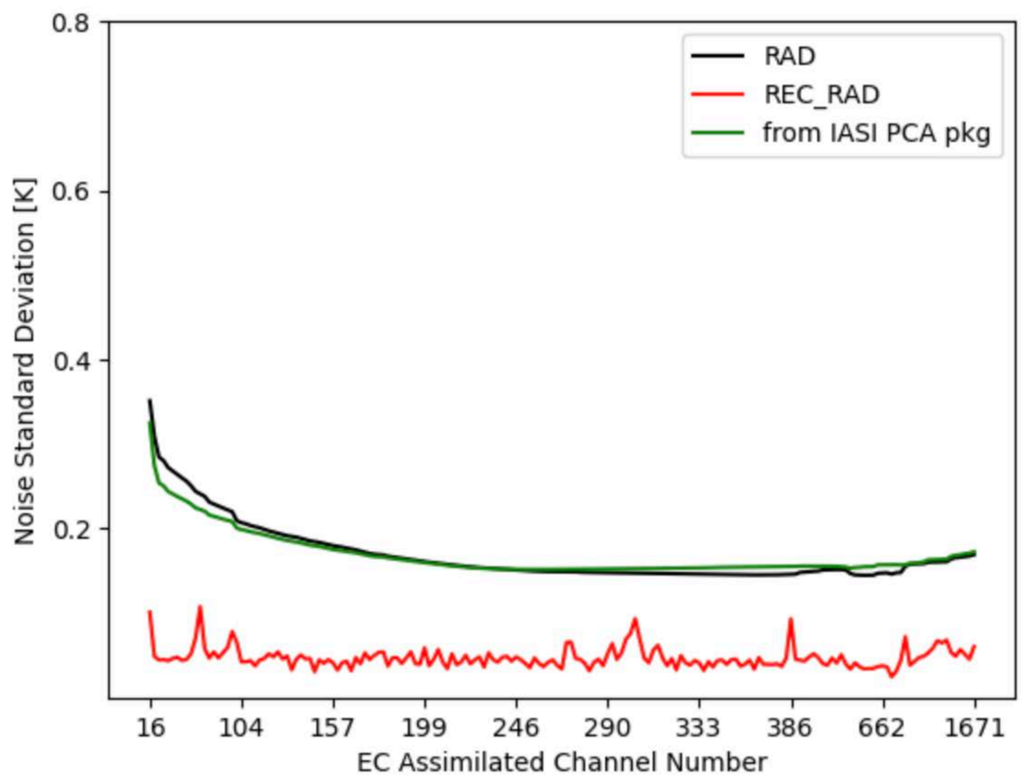

Temperature
Specific Humidity
Ozone
Pressure [hPa]
200
400
600
800
−50
0
50
Latitude [Degrees]
−0.4
−0.2
0.0
0.2
0.4
Kelvin
−0.00015
0.00000
0.00015
kg/kg
−0.005
0.000
0.005
ppmv
Temperature
Specific Humidity
Ozone
Pressure [hPa]
200
400
600
800
−50
0
50
Latitude [Degrees]
−0.4
−0.2
0.0
0.2
0.4
Kelvin
−0.00015
0.00000
0.00015
kg/kg
−0.005
0.000
0.005
ppmv

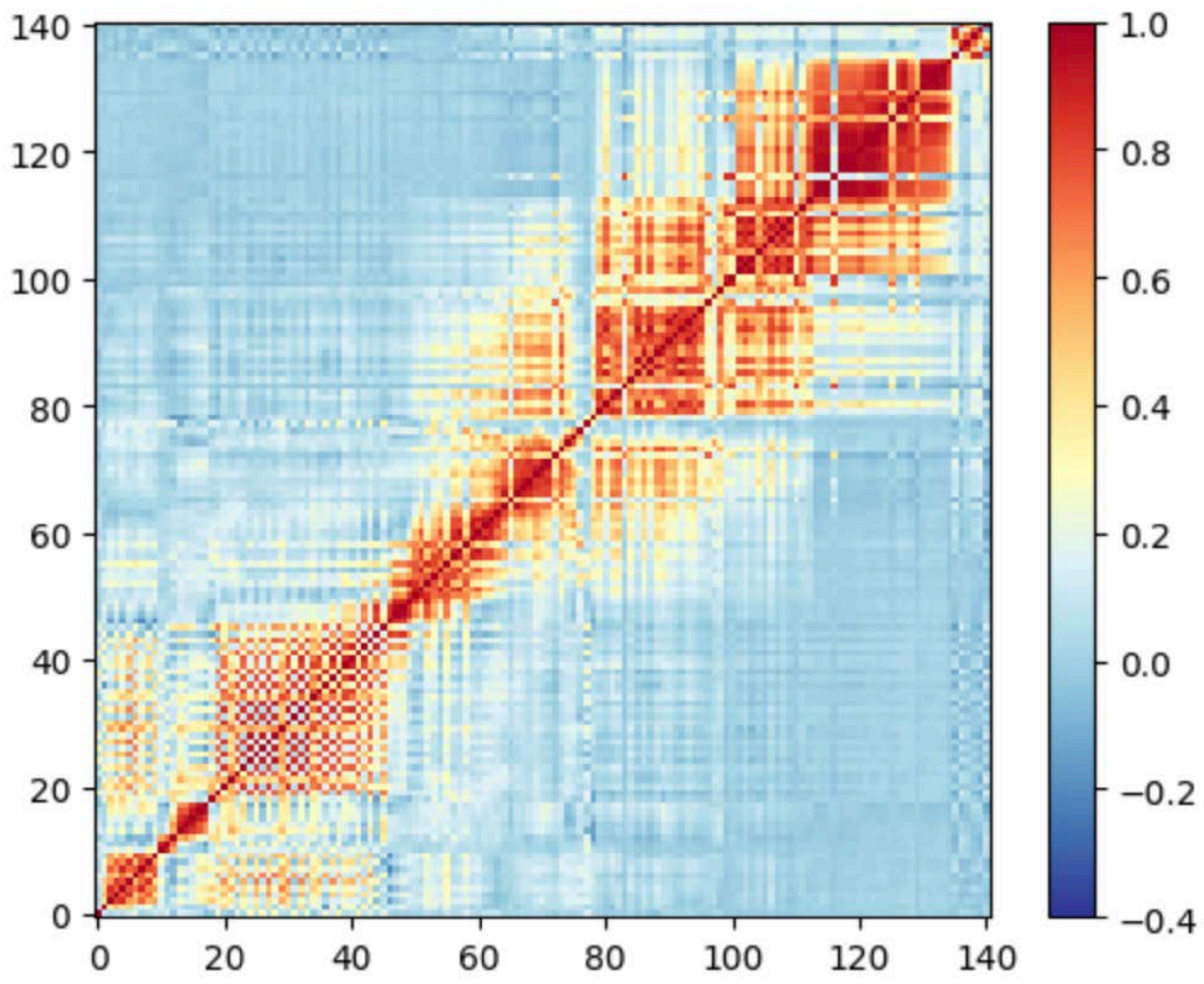

Temperature
Specific Humidity
Ozone
Pressure [hPa]
200
400
600
800
−50
0
50
Latitude [Degrees]
−0.10
−0.05
0.00
0.05
0.10
Kelvin
−5
0
5
kg/kg
1e−5
−0.0005
0.0000
0.0005
ppmv

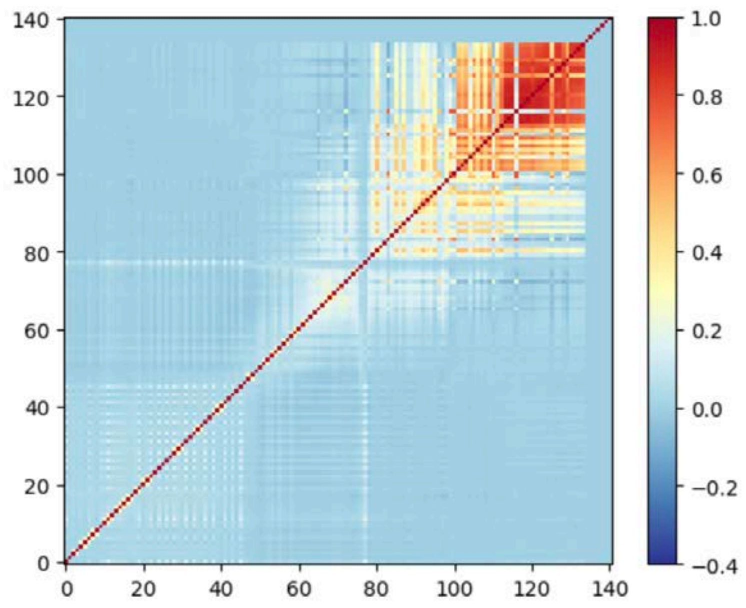


- Noise filtering performed by PC compression also generates very complex correlation structures
- Open question: How best to estimate the error (that will work in a DAS) when you don't have an existing instrument without PC compression (e.g., MTG-IRS, GeoXo, etc)?

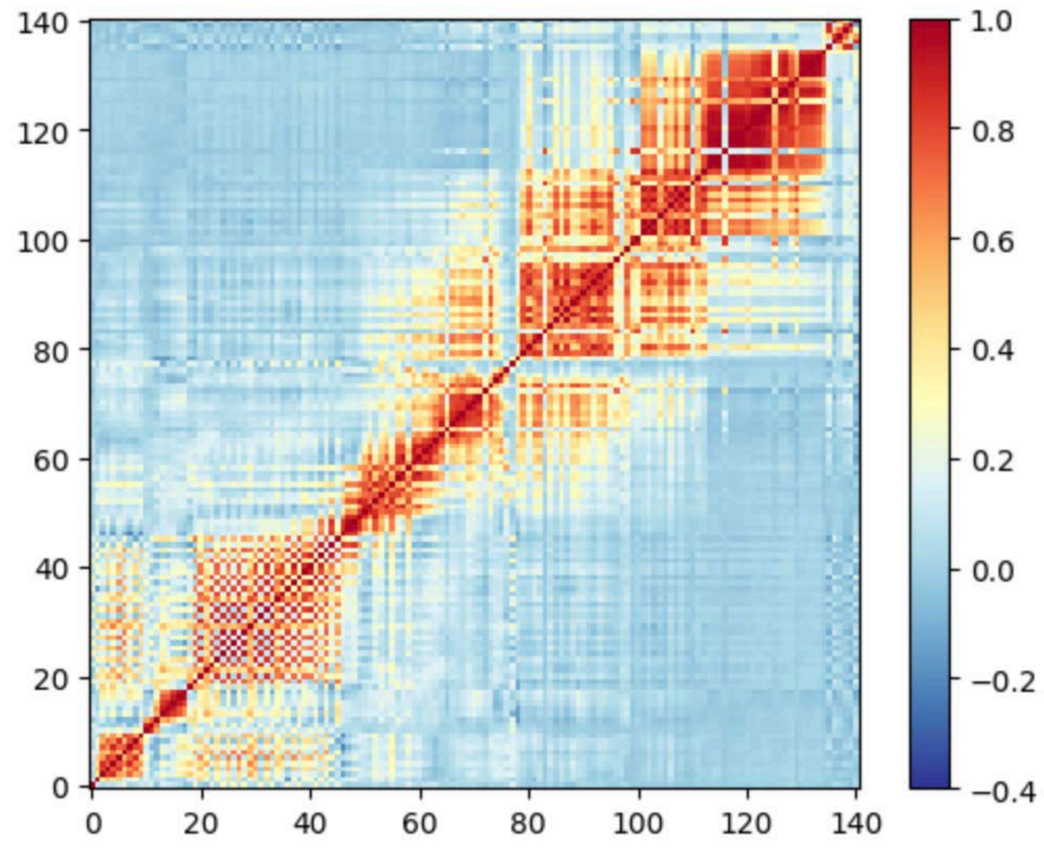



**Desrozier Estimate + Difference in instrument Noize matrix and Noise that remains in reconstructed radiances**

**Gives observation error covariance matrix similar to what is used operationally for conventional radiance assimilation**




- Rerun Reconstructed Radiance case with cloud detection consistent with background error estimate for reconstructed radiances
- Run experiment with using inflated Desroziers estimate based upon reconstructed radiances → pretend we're assimilating a "new instrument"
- Look at similar principal component products such as CrIS
- Prepare for assimilation of MTG-IRS
- PCA reconstructed radiances should be readily assimilated with some modifications to cloud detection
- Direct assimilation of PC scores with PCRTM a possibility
- Use of more observations over land being explored
- All-Sky cloud sensitive radiances → possibility, but a ways off (at least at GMAO)
- Improved cloud detection in GEOS-ADAS will be key