FORWARD MODEL IMPROVEMENTS: PRESENT AND FUTURE

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Joint Center for Earth Systems Technology and
UMBC Department of Physics

Outline

- CrIS FSR forward model
- CrIS minor gas trend retrievals
- Single footprint retrievals

FSR Forward Model

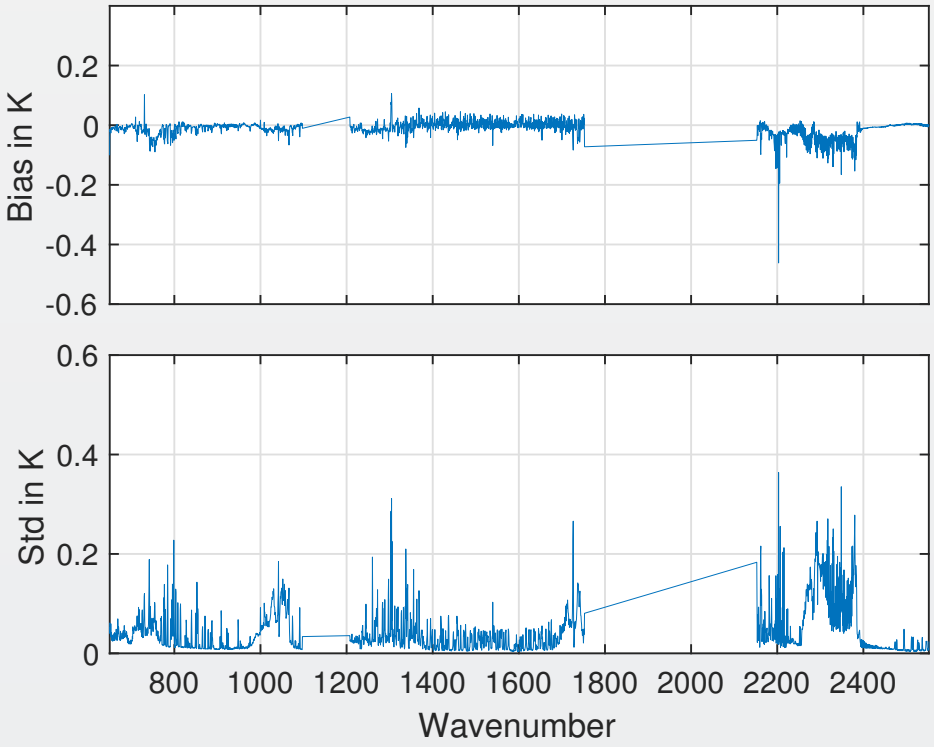
Summary of FSR SARTA

- CrIS high-resolution ILS
- HITRAN 2012 (vs 2008 in original CrIS RTA)
- LBLRTM Line Mixing for CO2 and CH4, H2O continuum
- UMBC line-by-line for water
- Code Change: improved reflected thermal for high secant angles
- Tested on 750+ profiles (from ECMWF selected subset), regressed on 49 profiles
- Error covariance estimates available from 750+ profile testing

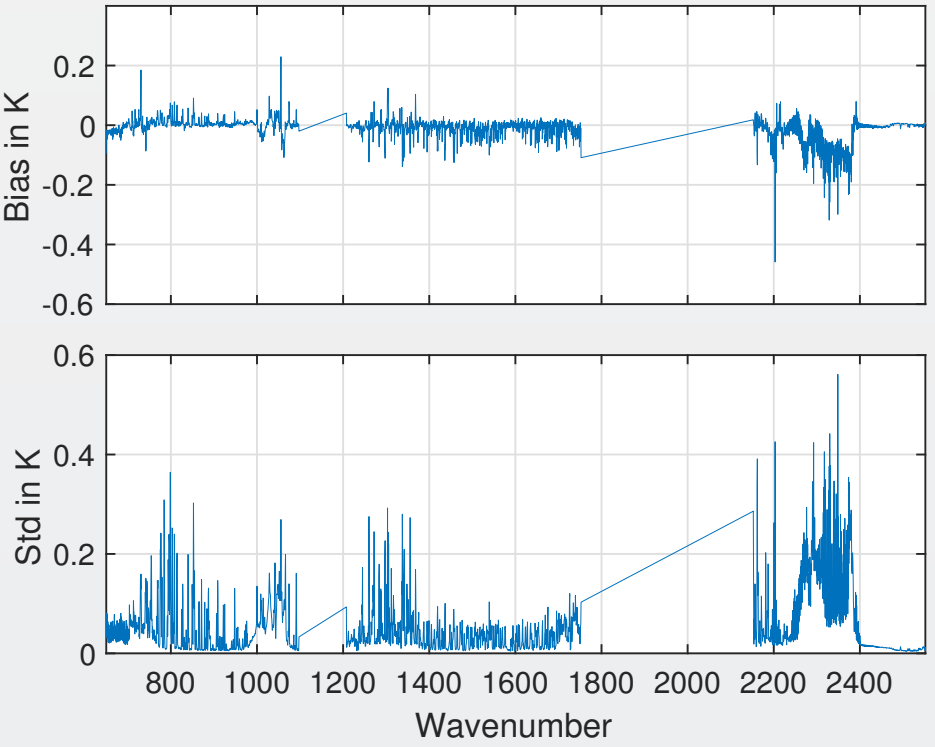
kCARTA (LBL) partially trained on LBLRTM allows us to compute 25,000 plus monochromatic test profiles!

Parameterization Errors

Regression Profiles: 49*7



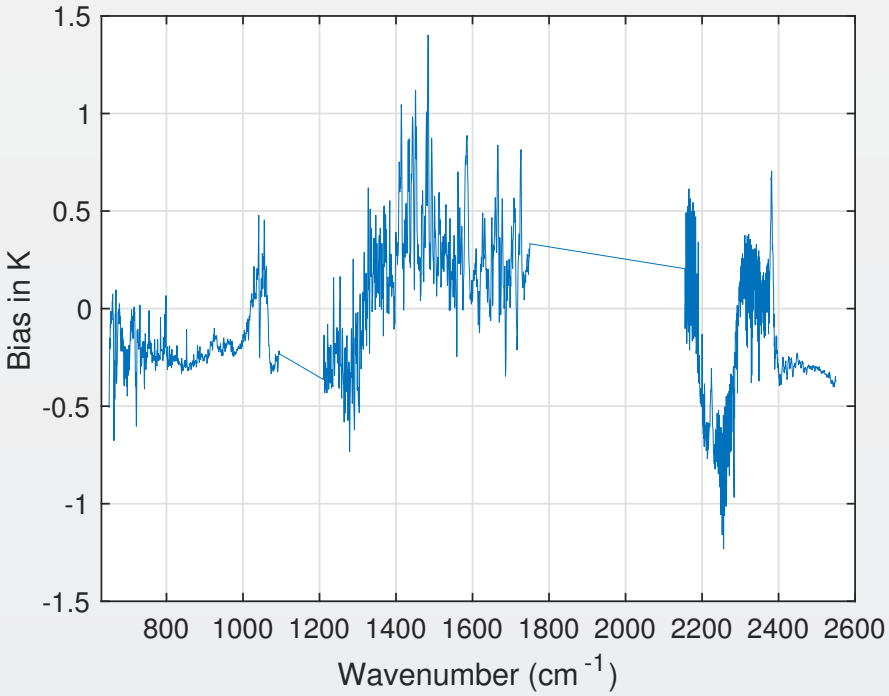
SAF Profiles: 705*7



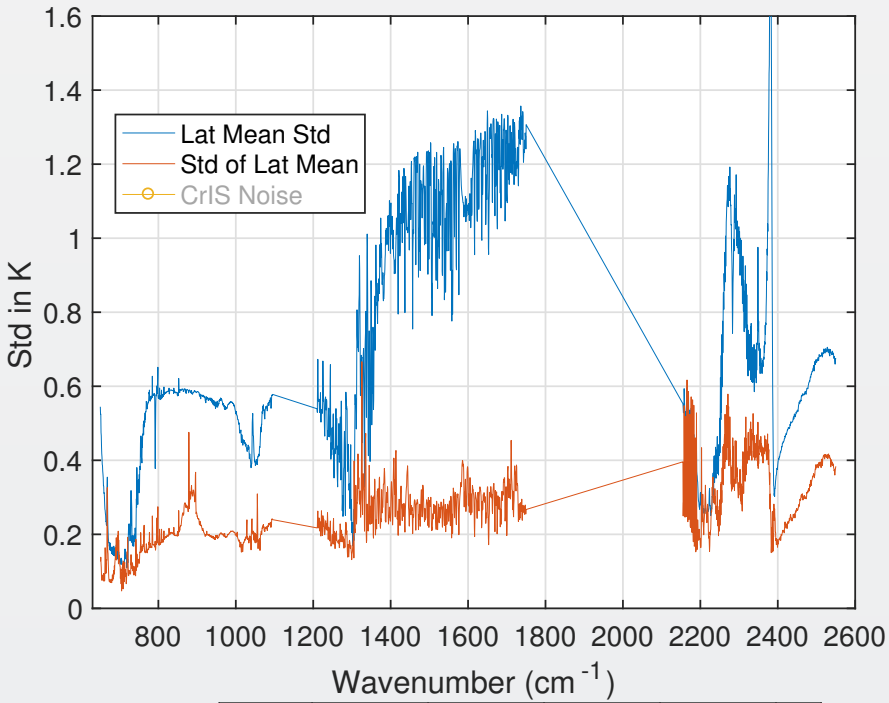
Some increase in Mean/Std errors with SAF. Can diagonose with so many test cases.

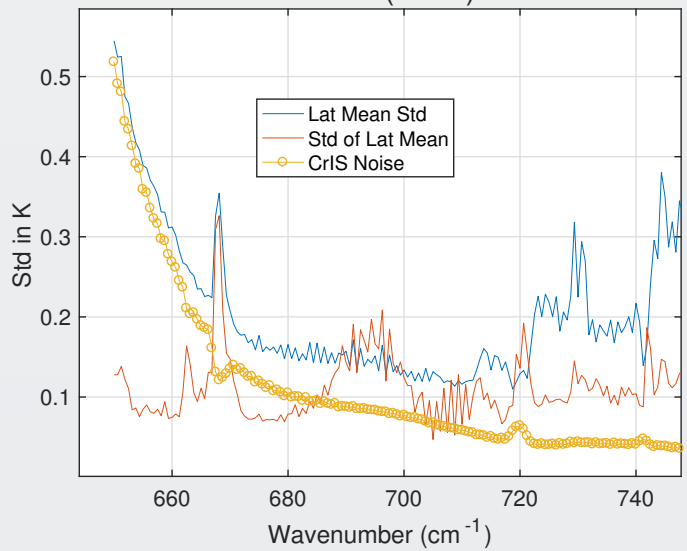
Bias/Std versus ECMWF: 3 days ocean clear

Bias

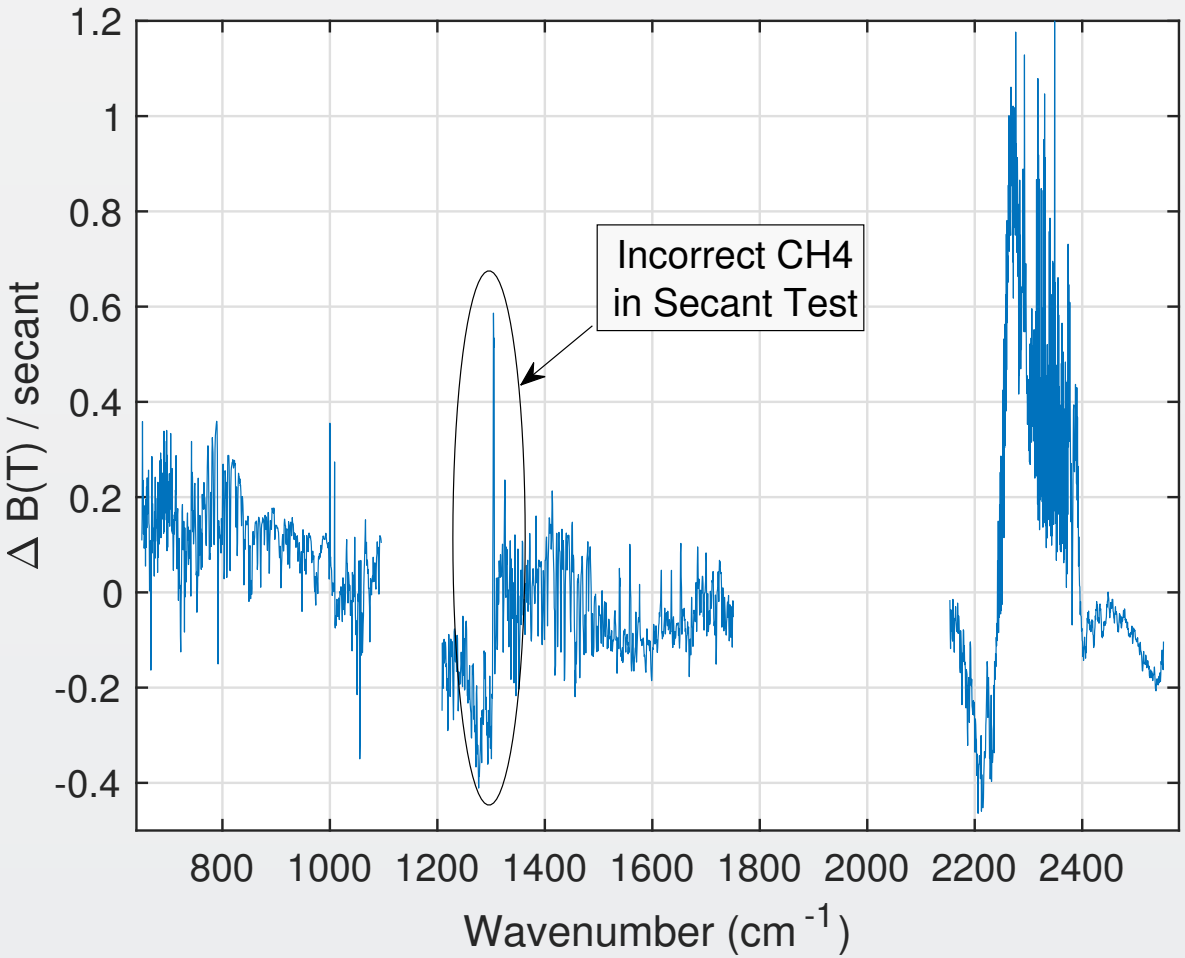


Std





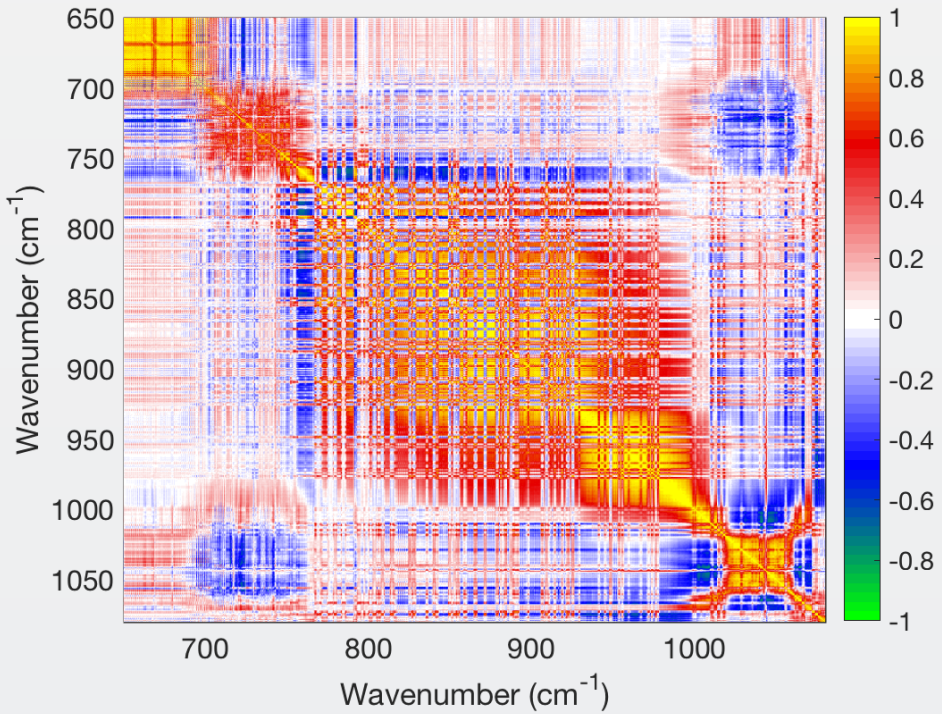
Secant Angle Dependence



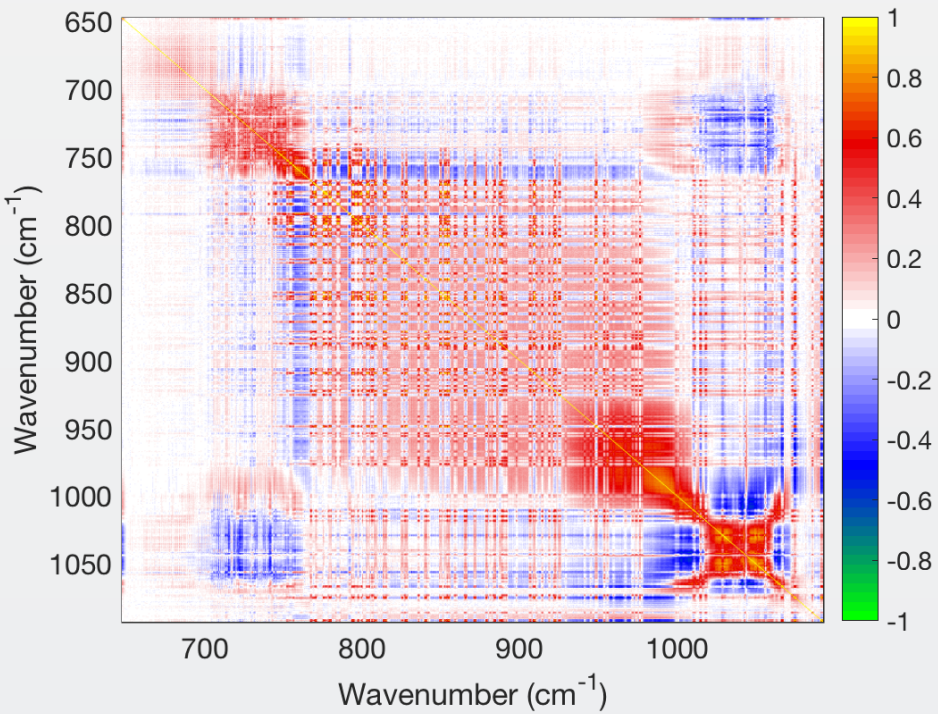
- Fit for slope of each channel versus secant of viewing angle
- Used 10 angles from nadir to max scan angle
- Errors are about ± 0.1K except less near 700-720 cm^{-1}

RTA (SARTA) Parameterization Error Correlations

Raw: No Noise



With CrIS Noise

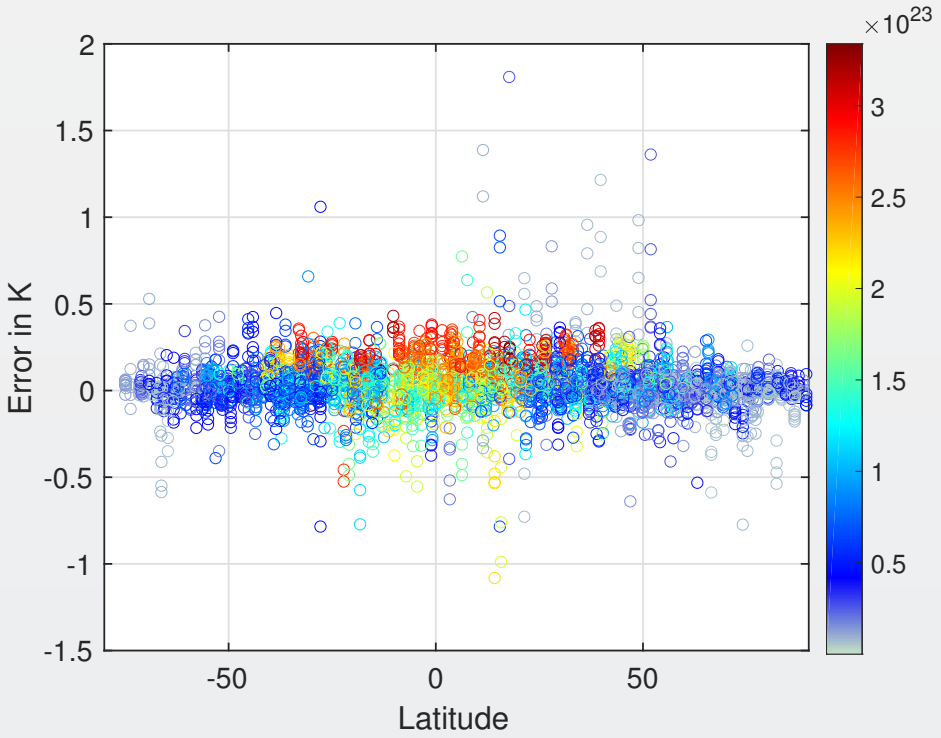


- 705 global profiles
- Computed correlations for LBL (kCARTA) minus fast RTA (SARTA)
- Same kCARTA used to create SARTA parameterizations

Water region errors (no shown) highly correlated.

Future Improvements?

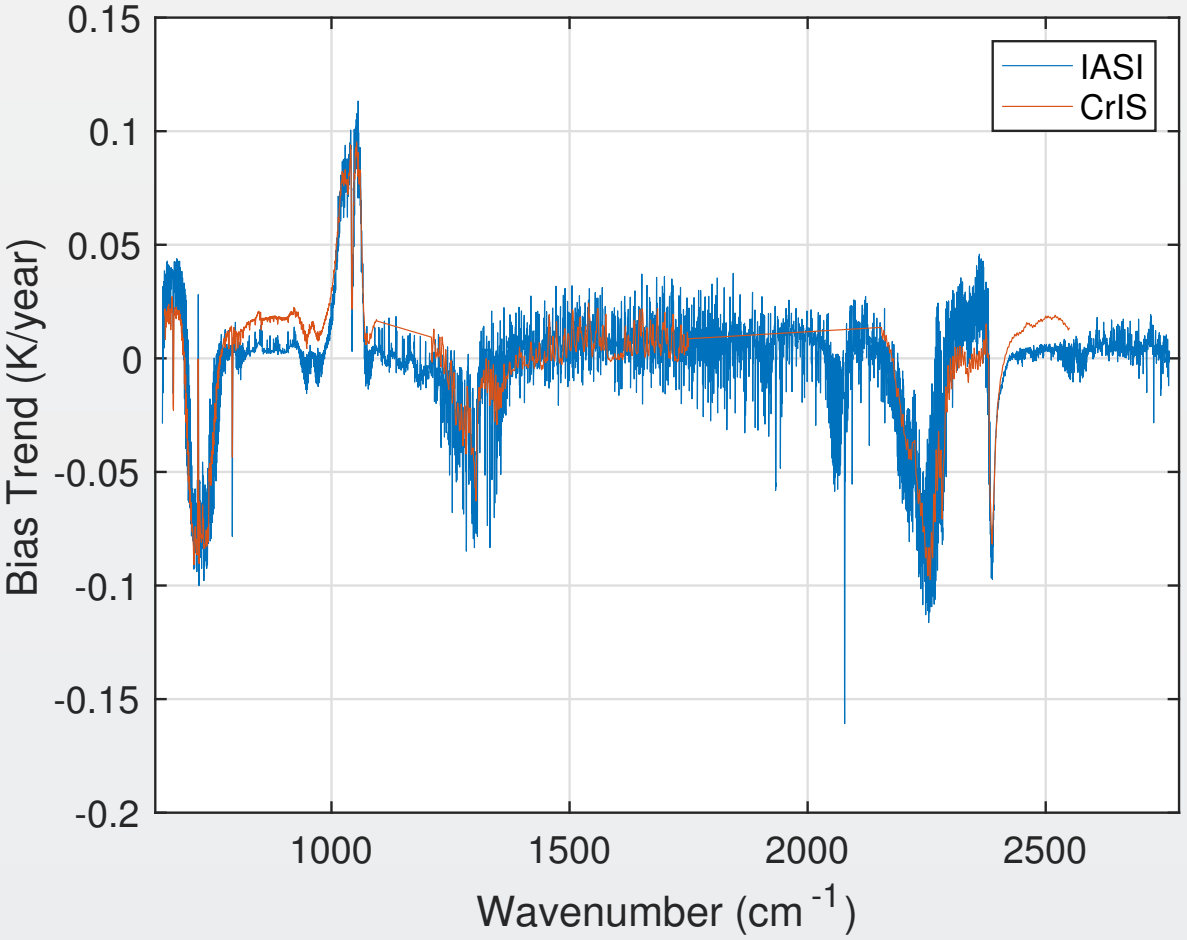
- Testing neural-net (2-3 layer, feed-forward) for parameterization of absorption coefficients
- Done for each optran layer, but hoping can use one net for all layers
- Using SAF 705*7 profile set, can expand to 25,000 profiles
- Really helps finding problem profiles, regression set is pretty good!



Neural net error for 1691.25 cm^{-1} channel versus total column water

CrIS Minor Gas Trends

OE Minor Gas Retrievals from BT Trends: CO_2

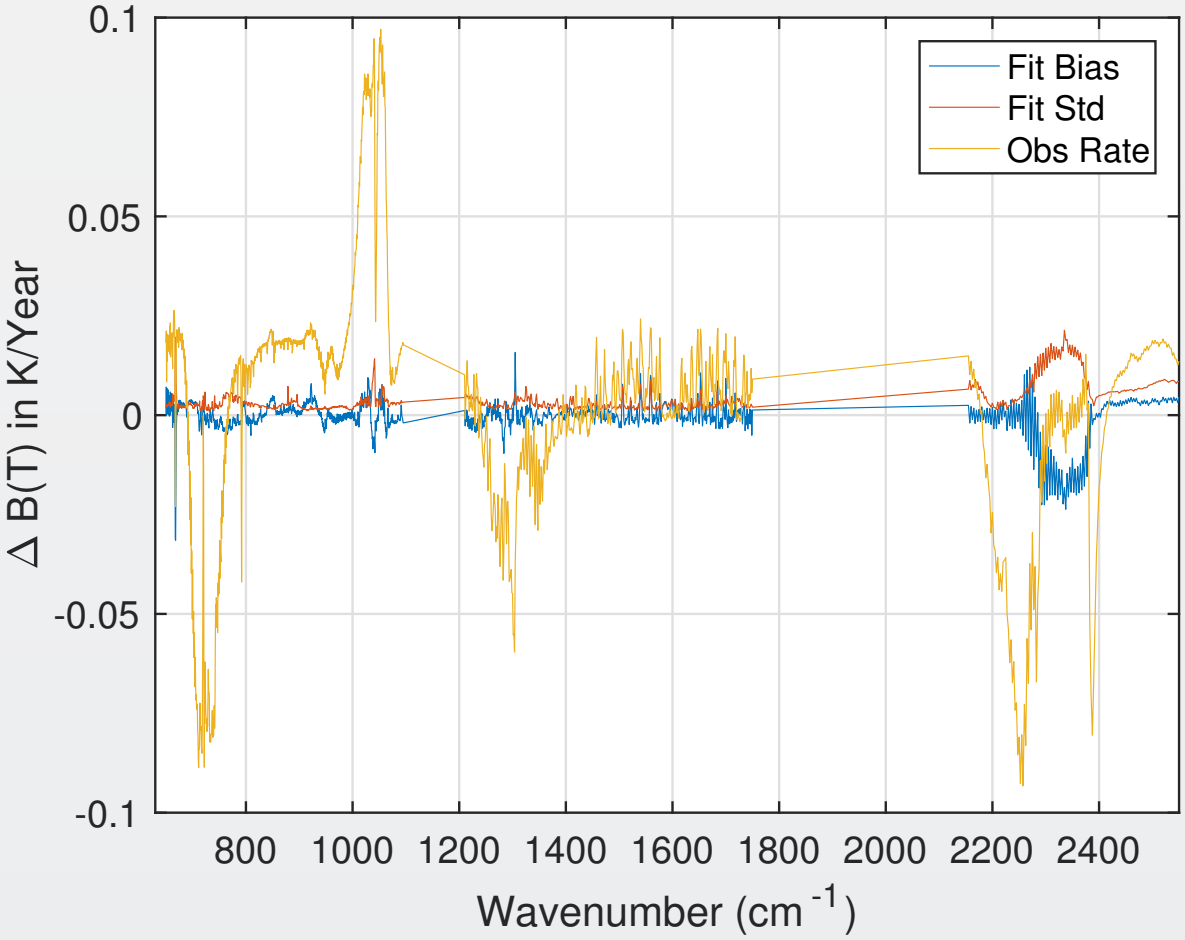


MLO: 2.49 ppm/year (last 5 years)

CriS Tropics: 2.56 ppm/year (last 5 years)

Difference = 0.0035K/year in possible drift!

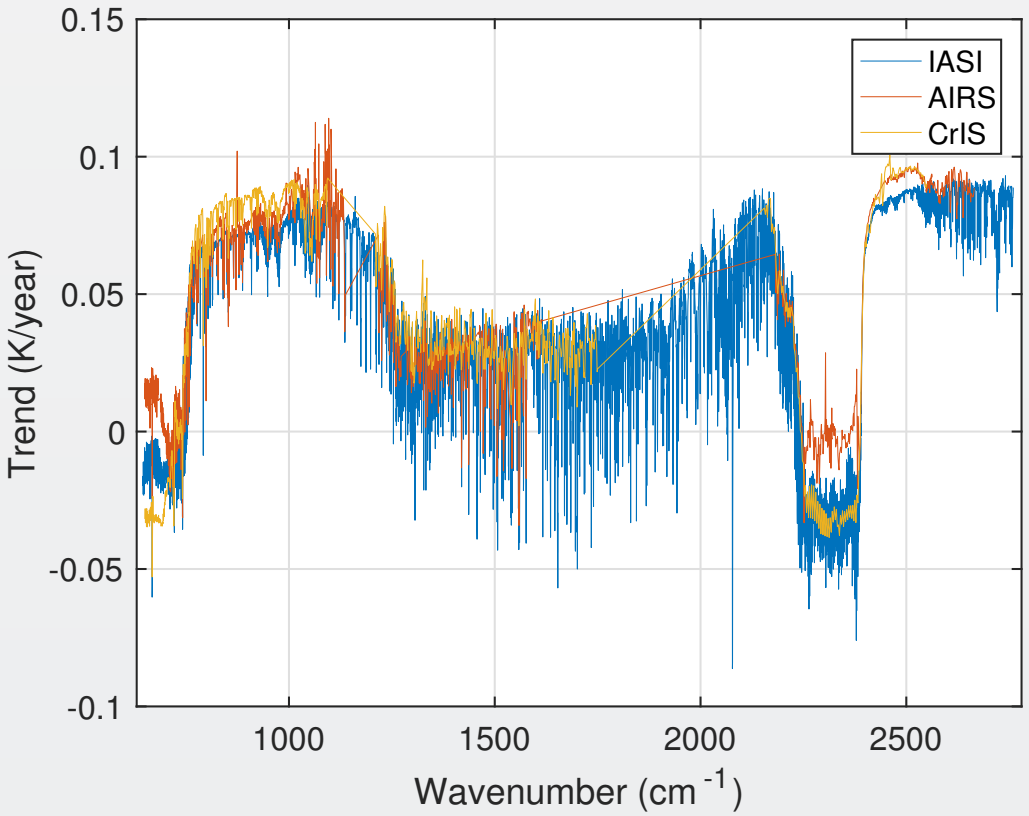
OE Minor Gas Retrievals from BT Trends: CH_4:



SST vs ERA (ghrsst): 0.0035K/year in BT units

CH_4 vs MLO: ~0.01K/year (MLO: 8.6 ppb/year, CrIS: 8.1 ppb/year)

CrIS All-Sky Trends



For 900 cm^{-1} channels:

CrIS: 0.085 K/year

AIRS: 0.076 K/year

IASI: 0.072 K/year

±0.05K uncertainty including lag-1 corrections

Latitude variability high: ±0.2-0.3K/year BUT within 2σ estimated uncertainties.

This is a short time period. 14-year AIRS trend is ~0.015K ±0.01K.

Single Footprint Retrievals with SARTA

Scattering SARTA

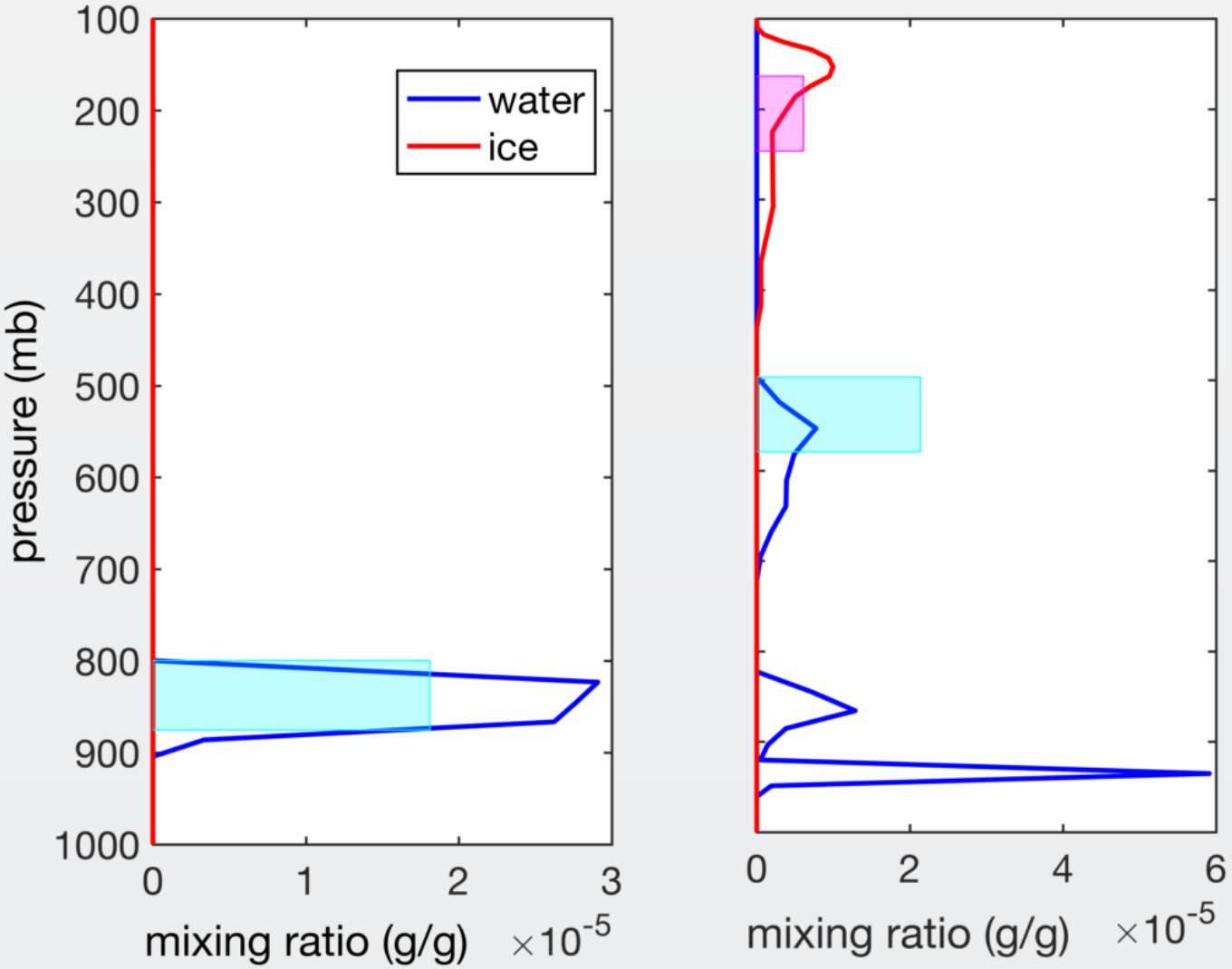
- Designed to mimic what *can be retrieved*.
- Very simple scattering, 2X slower than clear SARTA
- Two scattering layers, some mix of ice cloud, water cloud, aerosol (dust, volcanic ash)
- Two major liens vs PCRTM tests with ECMWF (Xu Liu)
  - 2 layers, no statistical cloud overlap computations
  - Less accurate scattering, likely only an issue with solar in SW

Single Footprint Retrievals

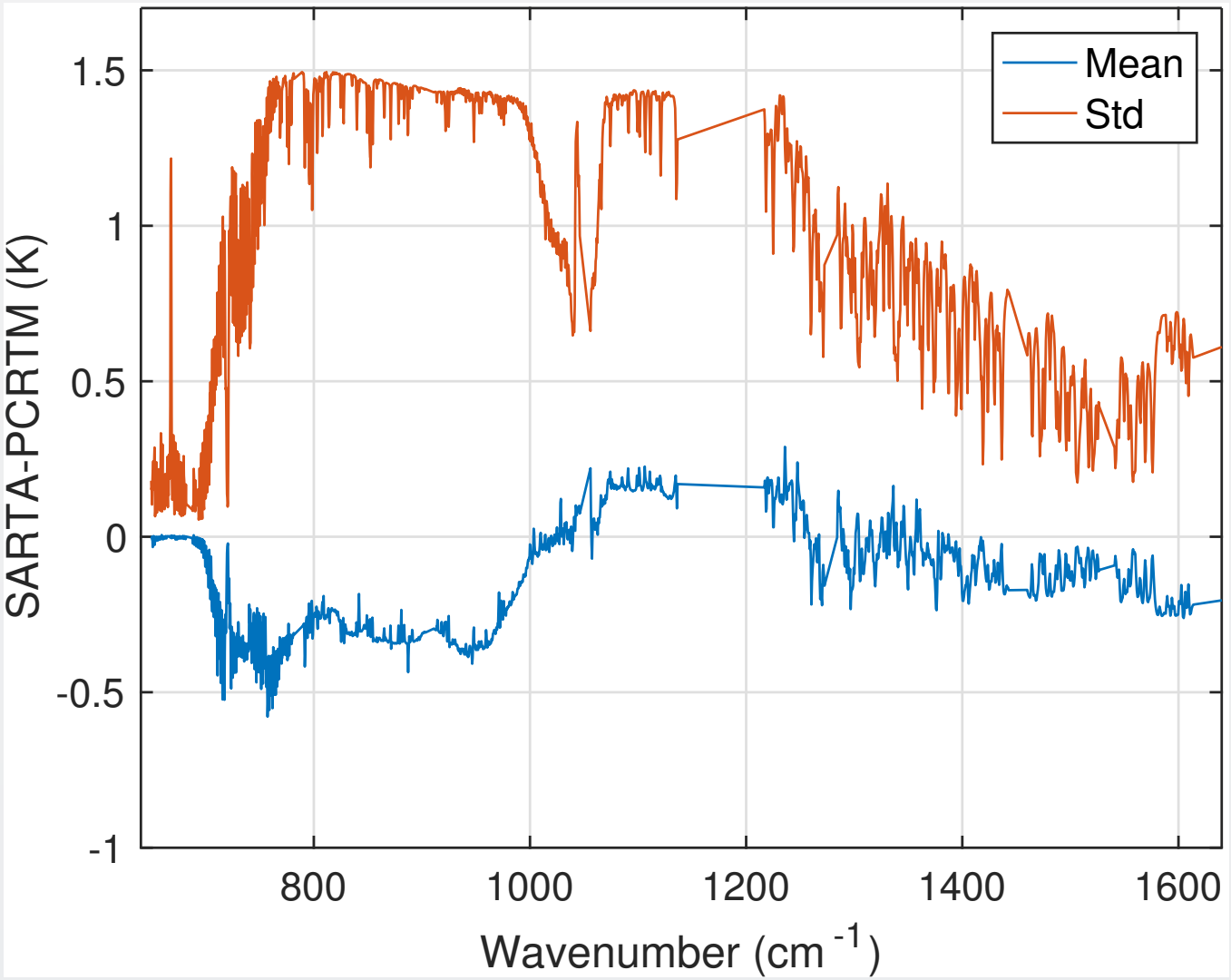
- Cloud initialization by using NWP model (ERA) clouds (find close-by grid point similar to observations)
- Could be initialized with climatology
- Fixed cloud heights, fit for cloud amount and particle size
- Tested first with smooth a-priroi climatology
- Then, move to ERA a-apriori
- Mostly used for trend retrievals. Hope to use for radiosonde intercomparisons
- Lots of testing, mostly analyzing special cases.

OE framework very good at accuracy estimates, let's you naturally Q/A cloud problems (thick clouds)

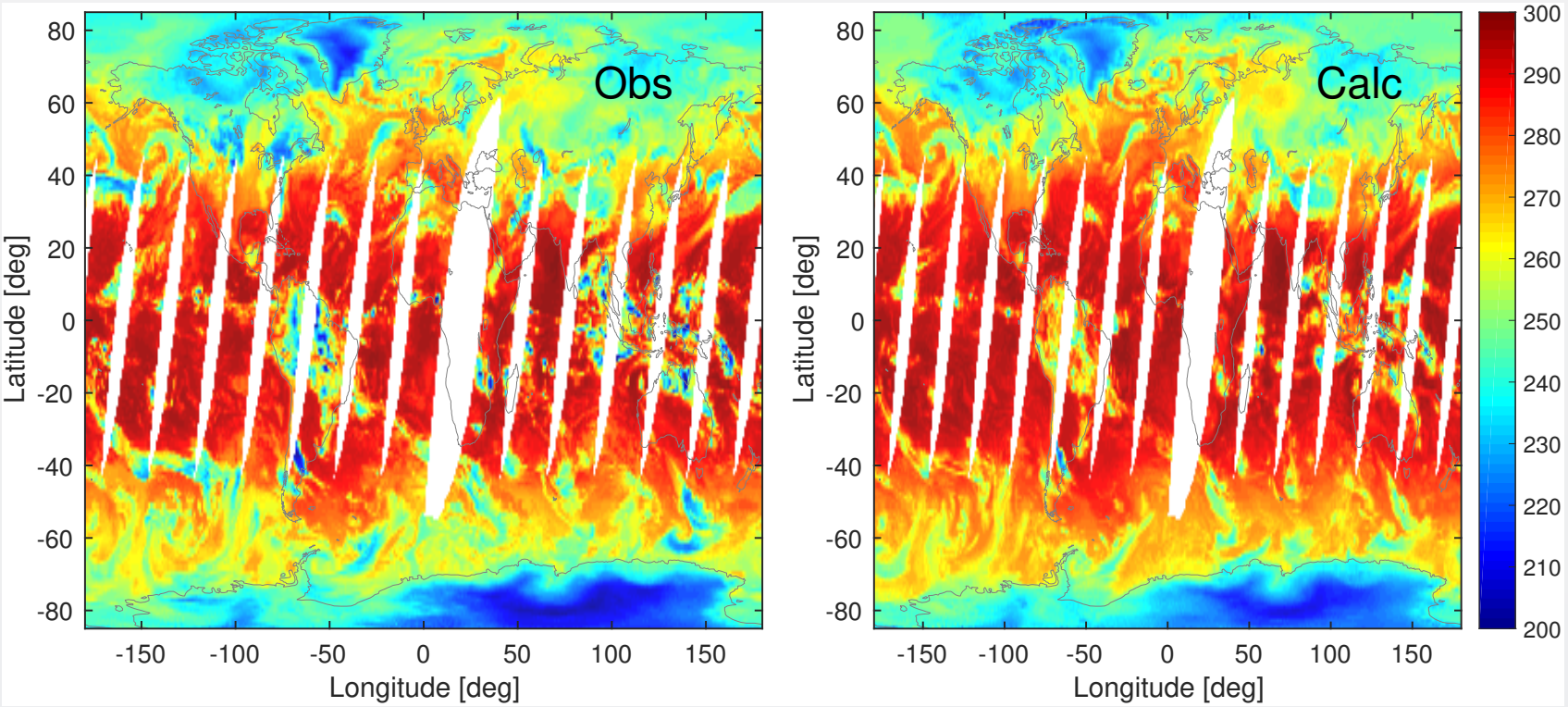
ECMWF 91 to SARTA 2 layer cloud conversion



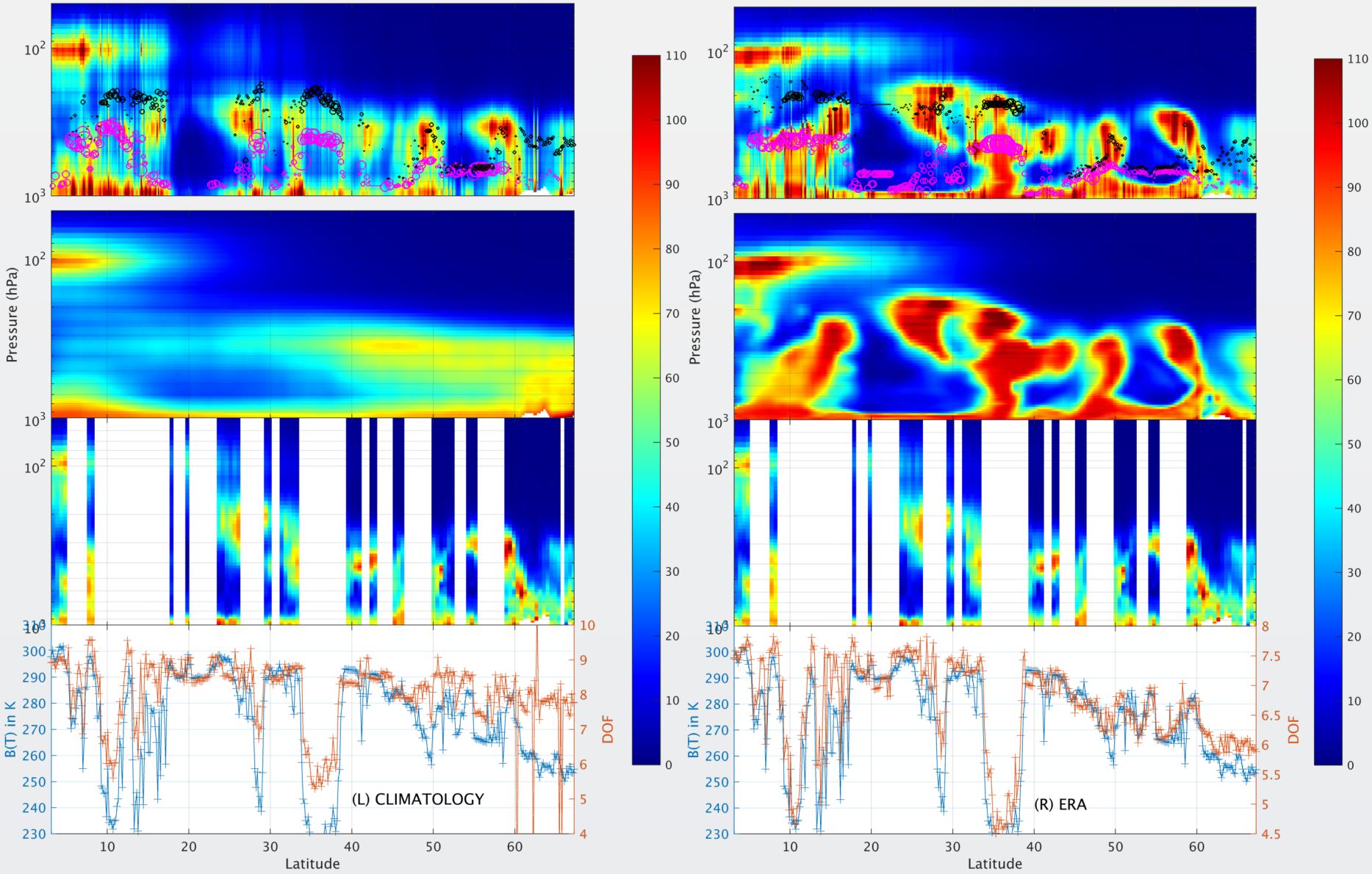
Comparison to PCRTM (with Statistical Cloud Overlap)



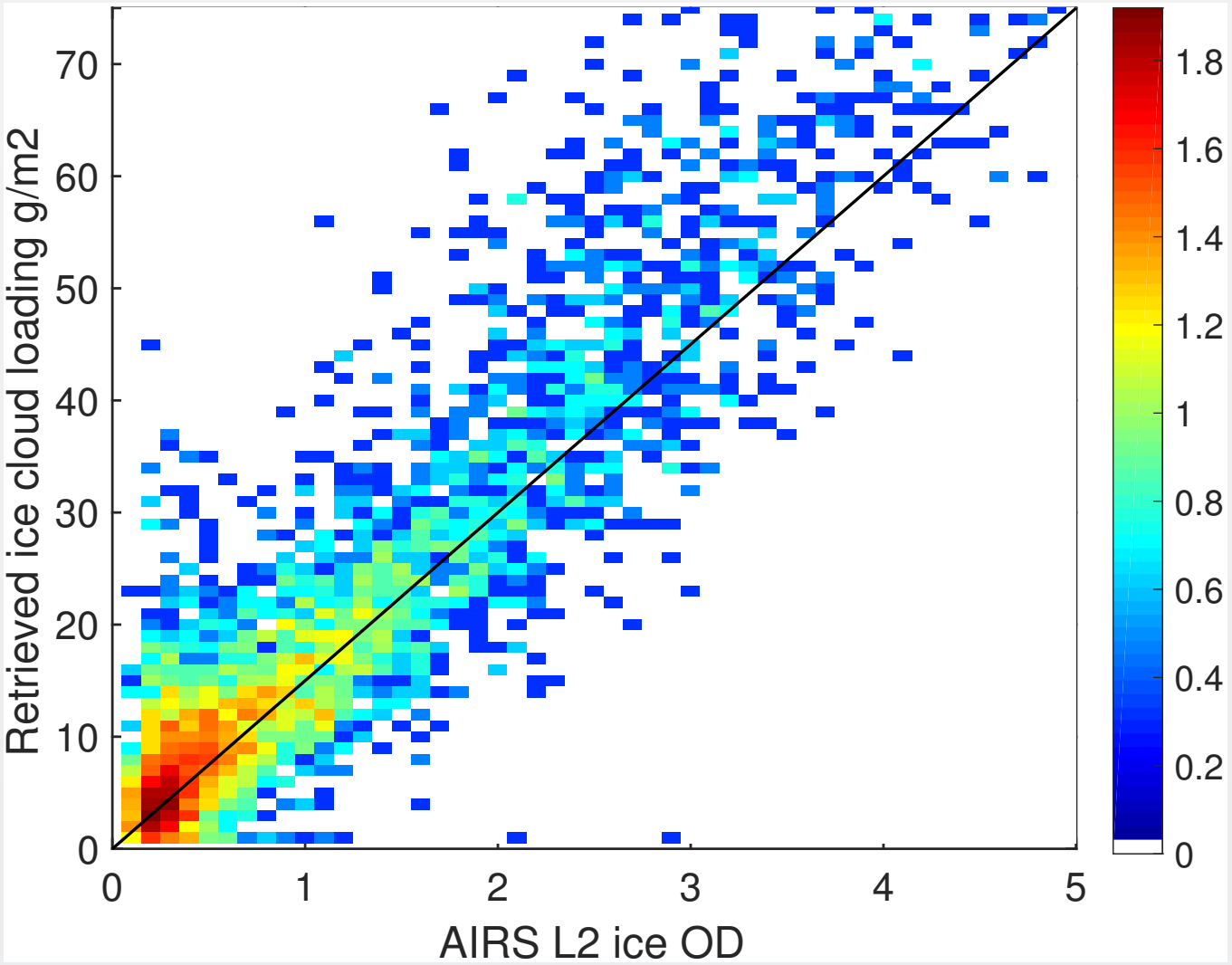
Global Simulation from ERA



Retrieval Sample: RH for Atmospheric River



Cirrus Cloud Optical Depth Comparisons with AIRS



Cloud Top Height Comparisons with MODIS

