Gridded Anomaly Retrievals for Climate Trending

AIRS Virtual Science Team Meeting

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October 5, 2020

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Introduction: Long Term Approach

- Generate gridded radiance anomalies and use for geophysical anomaly retrievals, using CHIRP Level 1 radiances (nominal 3° x 5° grid averaging 16 days of data).
- This approach, already demonstrated for clear scenes, shows that little a-priori information is needed
- Anomaly retrievals by-pass always troublesome bias adjustments!
  - Both RTA and instrument biases
- Relatively low compute power needed
  - Allows for frequent reprocessing for algorithm developement (needed for climate-level products)
  - Quick re-generation of products in instrument stability is improved
  - Allows detailed assessment of uncertainties via frequent reprocessing
  - Hopefully attractive to users far in the future

Gridding Schemes

Grids will likely contain several types of averages:

- Mean over all radiances
- Mean of hottest (1-5)% radiances for surface T and lower tropospheric anomalies
- Several additional grids containing means over remaining radiances that contain increasing cloud-contamination
- Allows a "reverse onion-peeling" approach
- Simulations show high-quality surface temperature anomalies trends can be retrieved with a very small percentage of the original data

Generation of Datasets

- We finally were able to install the full L1c radiance data at UMBC
- And, we have enough space to make a copy that is a "transpose" of the normal L1c granules
  - Re-format with full time-series of radiances per grid cell in 16-day files
  - Allows easy experimentation since easy to read in full mission data for single grid cells.
  - Can easily do further higher spatial resolution gridding.
- Note that in theory you want the full time series for a grid cell in order to remove to form the radiance anomalies.
- AIRS L1c "transpose" will be in GSFC DIS netcdf compliant format using back end of operational CHIRP algorithm

We hope to complete this transpose in the next 2 months.

First Test: All-Scene Averaged Gridded Dataset

- Simple test used to produce 64x72 latitude/longitude grid
- All date averaged into 16-day bins
- Each 16-day grid cell has ~10,000 observations averaged
- Nominally similar to a CLARREO dataset, but with much higher sampling density
- We did NOT separate ascending from descending for this test, wanted to keep it really simple
- This approach allowed us to match to ERA-I for Jacobians quite easily (no subsetting, we just needed average profiles).
- Data record is (407 days, 2645 (400) channels, 64 latitudes, 72 longitudes)

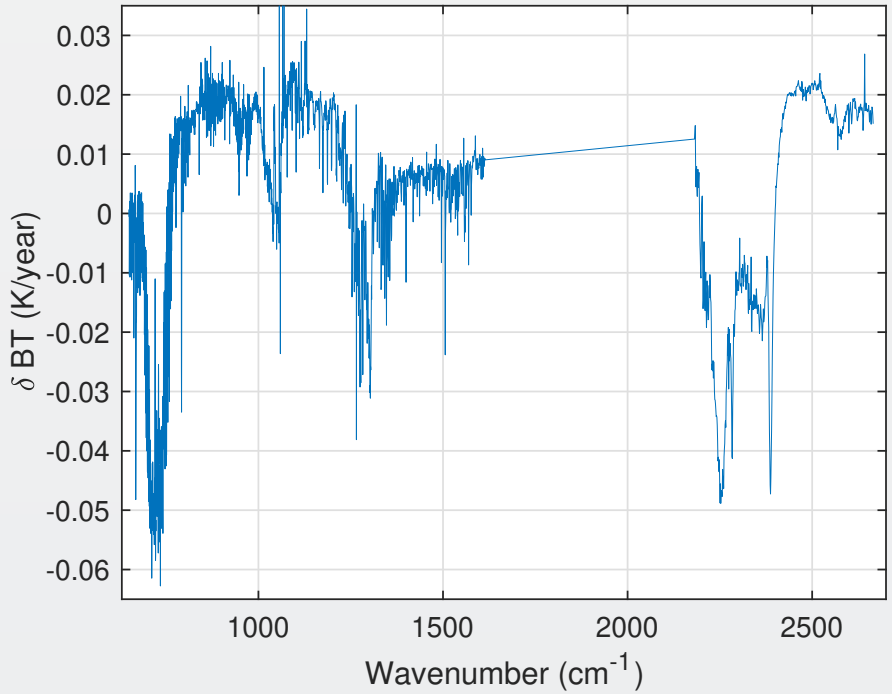
Goals

- Examine channel BT trends to ensure data looks good
- Possibly do anomaly retrievals (not yet done)
- Determine if all-sky averages precludes high quality trend retrievals of T and H_2O profiles and surface T.

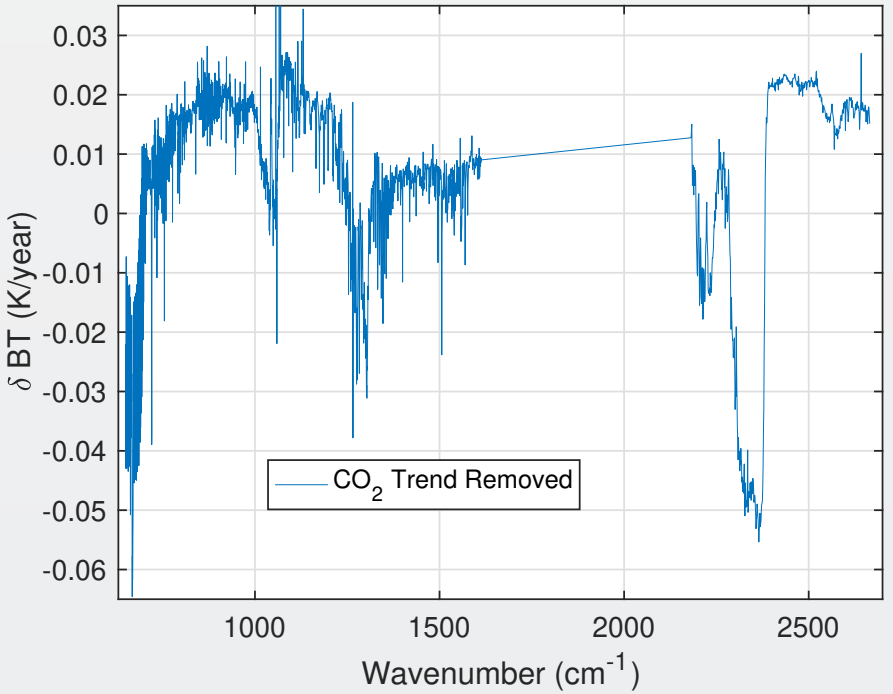
Retrieval results shown here were done by Sergio in the last two weeks!

Global Trends

Global 17-Year All-Sky Trends

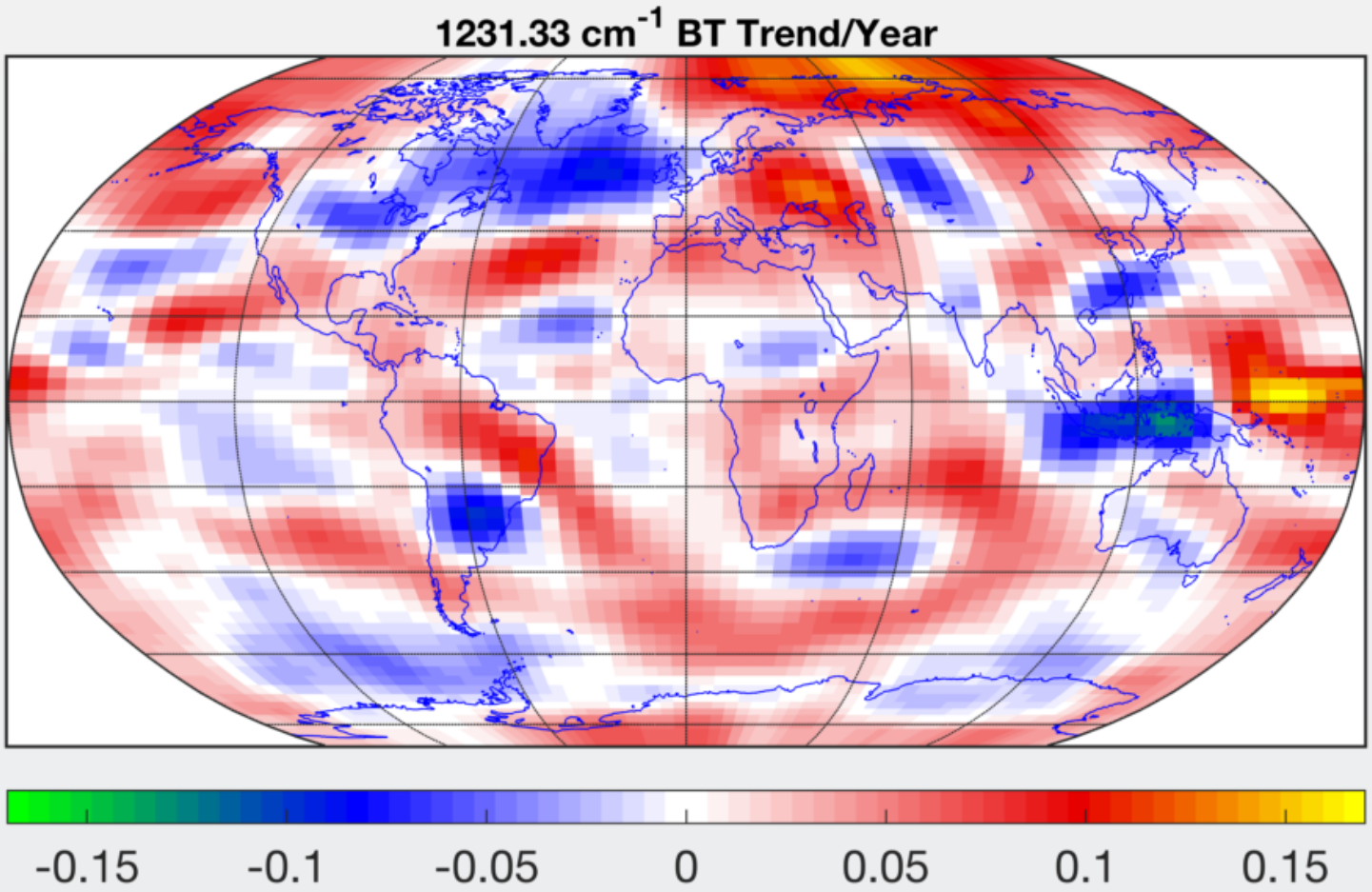


CO_2 Trend Removed



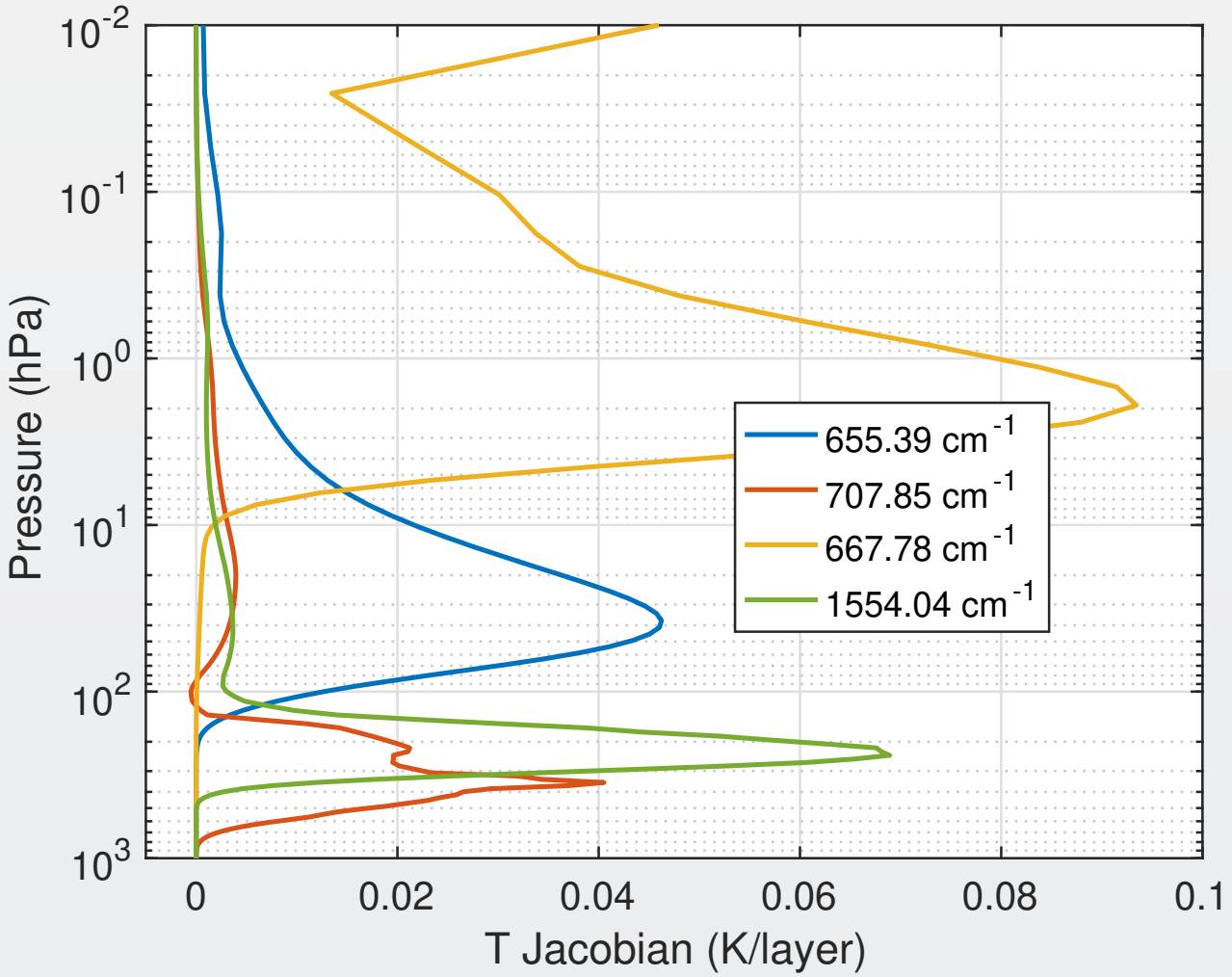
- CO_2 trend removed using Jacobians that include water and ice cloud effects
- N_2O and CH_4 greenhouse effect remain in spectrum
- Clear trend depression in H_2O regions (H_2O greenhouse effect)
- Strong strospheric cooling
- Hash is A/B artifacts

Window Channel B(T) Trends



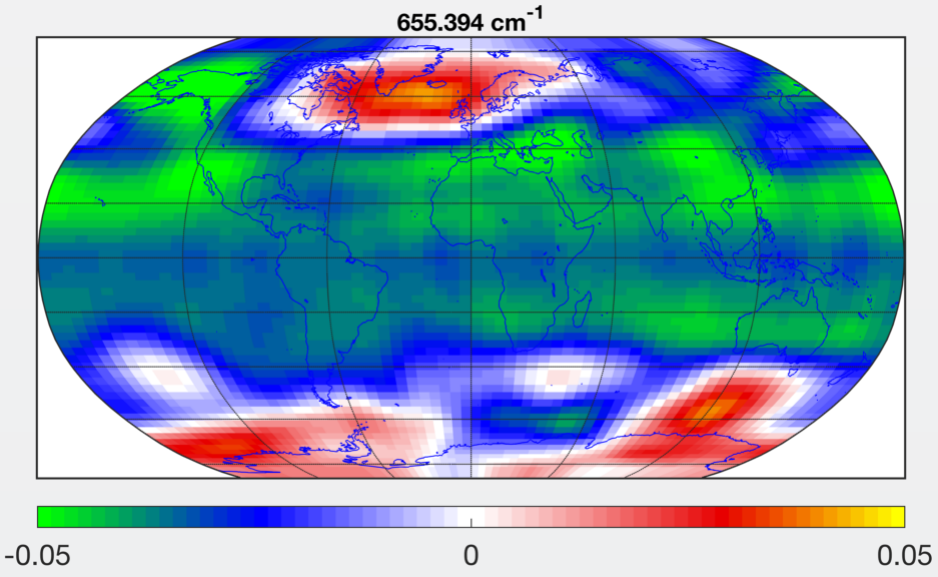
- Clearly some cloud variability remains after 17 years
- Rough correspondance to surface temperature trends
- Global average: 0.017 K/year

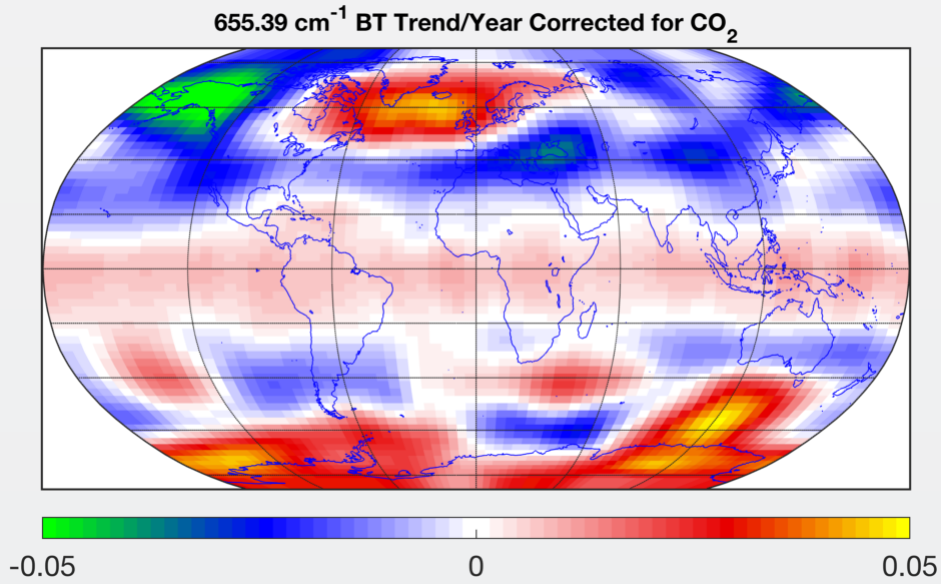
Temperature Jacobians for Several Channels

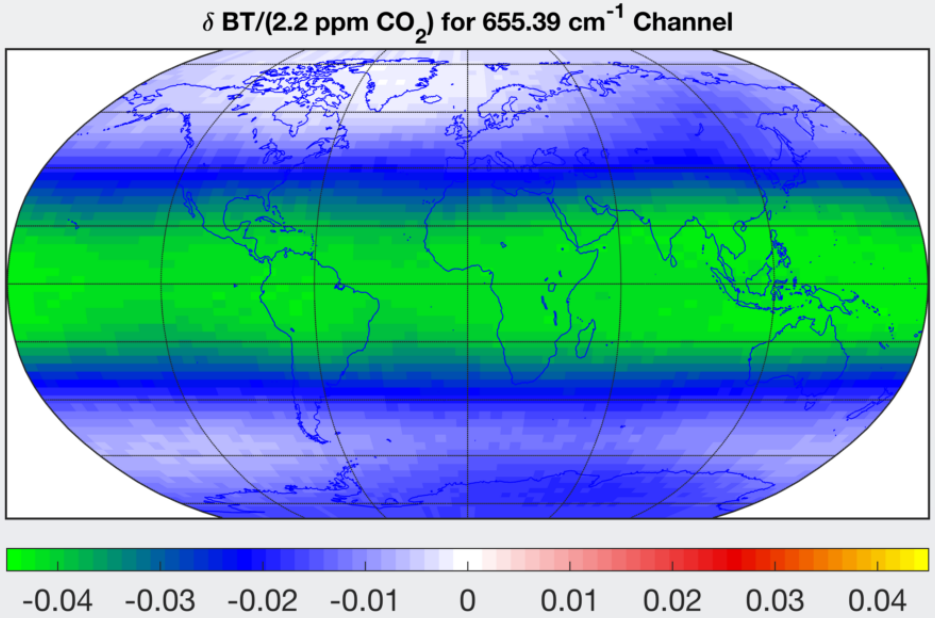


Will examine global trend maps of these channels

655.39 cm^{-1} Trends (40 hPa)

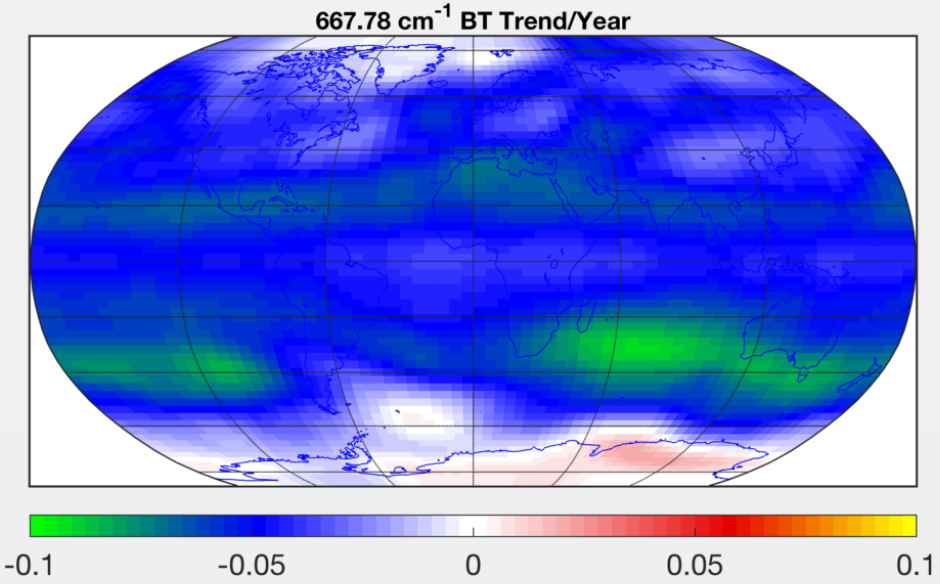


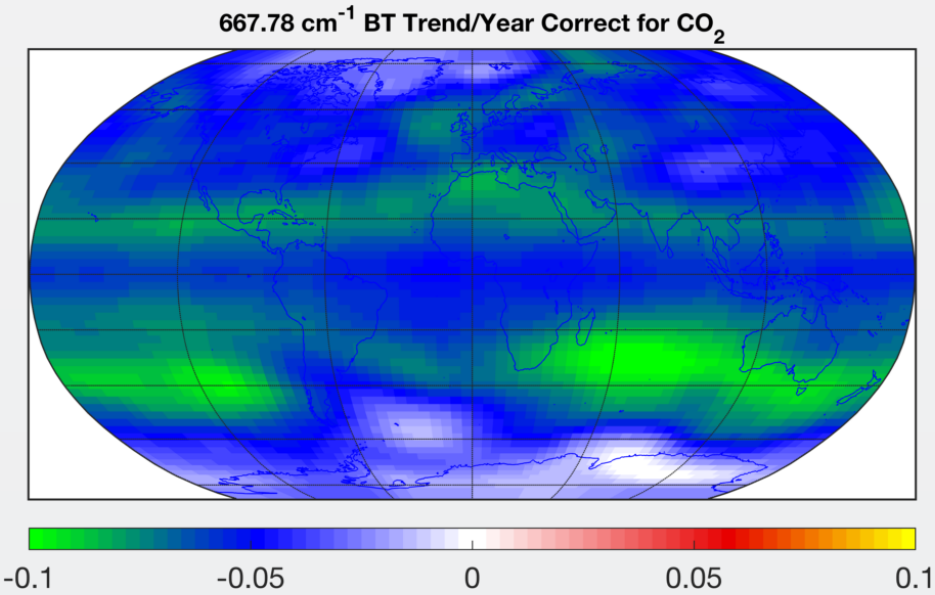


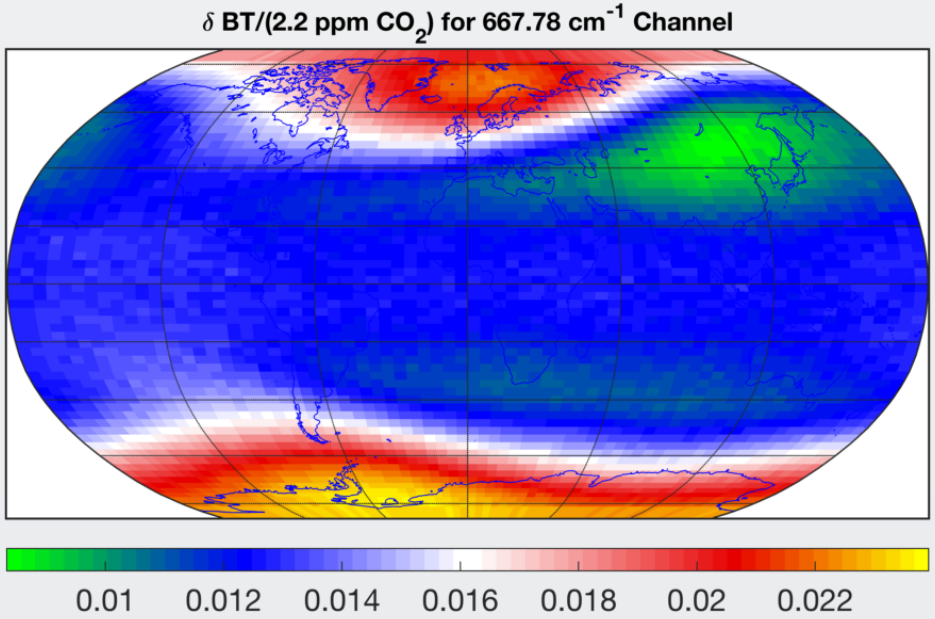


- Low CO_2 sensitivity in polar areas
- Even though peak of Jacobian is 40 mbar, channel still dominated by tropospheric trends in tropics

667.78 cm^{-1} Channel (2 hPa)

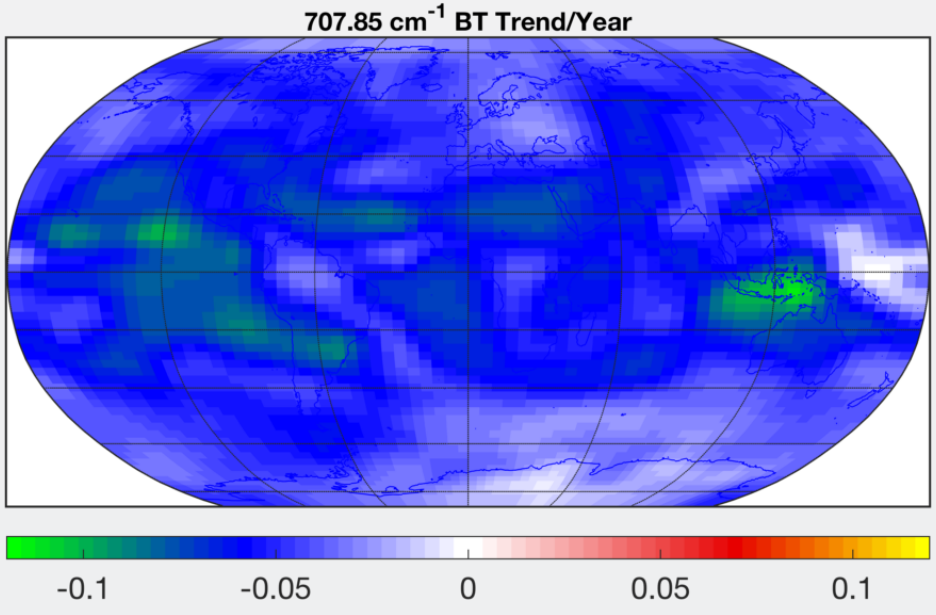


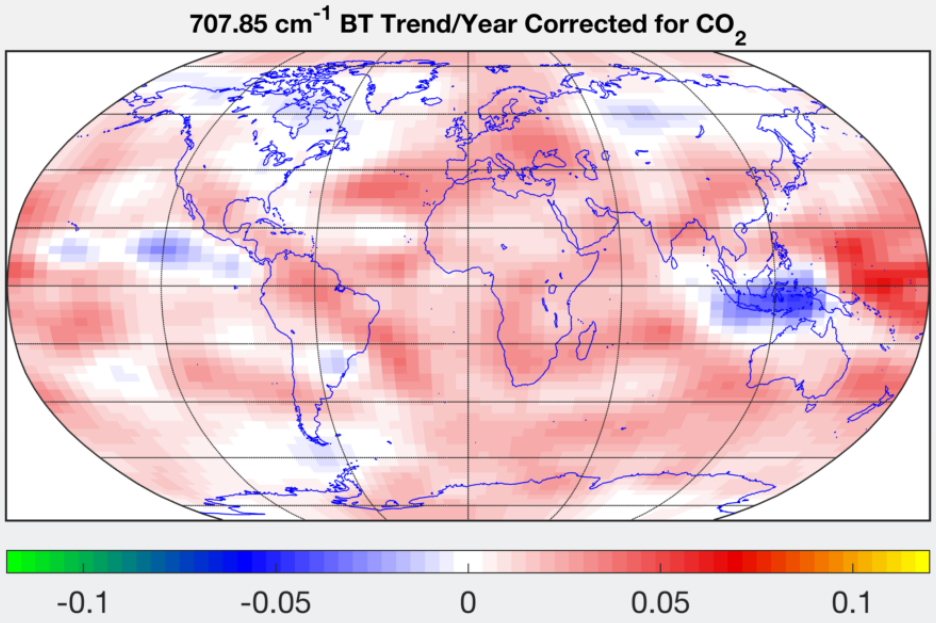




- Quite uniform cooling
- Applying CO_2 correction lowers variability

707.85 cm^{-1} Channel (200 hPa)

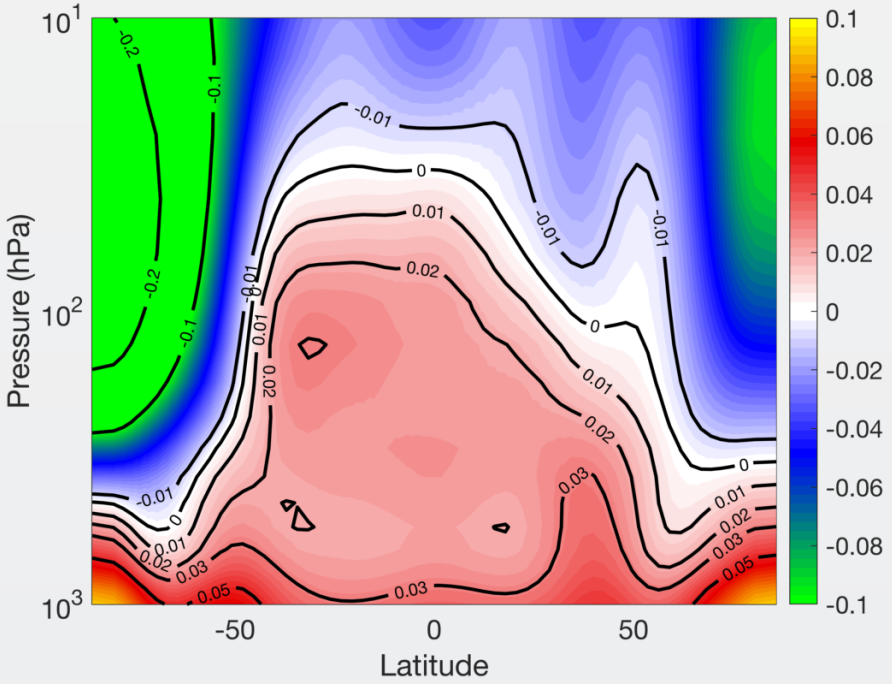




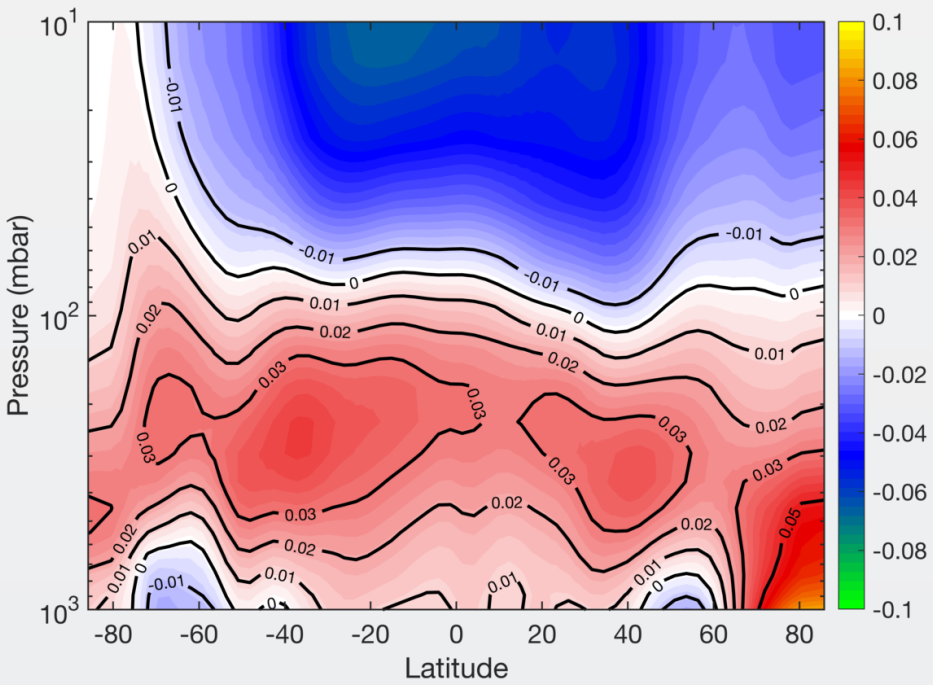
- Extremely uniform BT trends
- Removal of CO_2 trends changes BT trend to positive (warming)
- Some cloud trend contamination in the warm pool

Retrieved Zonal Temperature Trends

ERA 17-Year Trends (K/year)

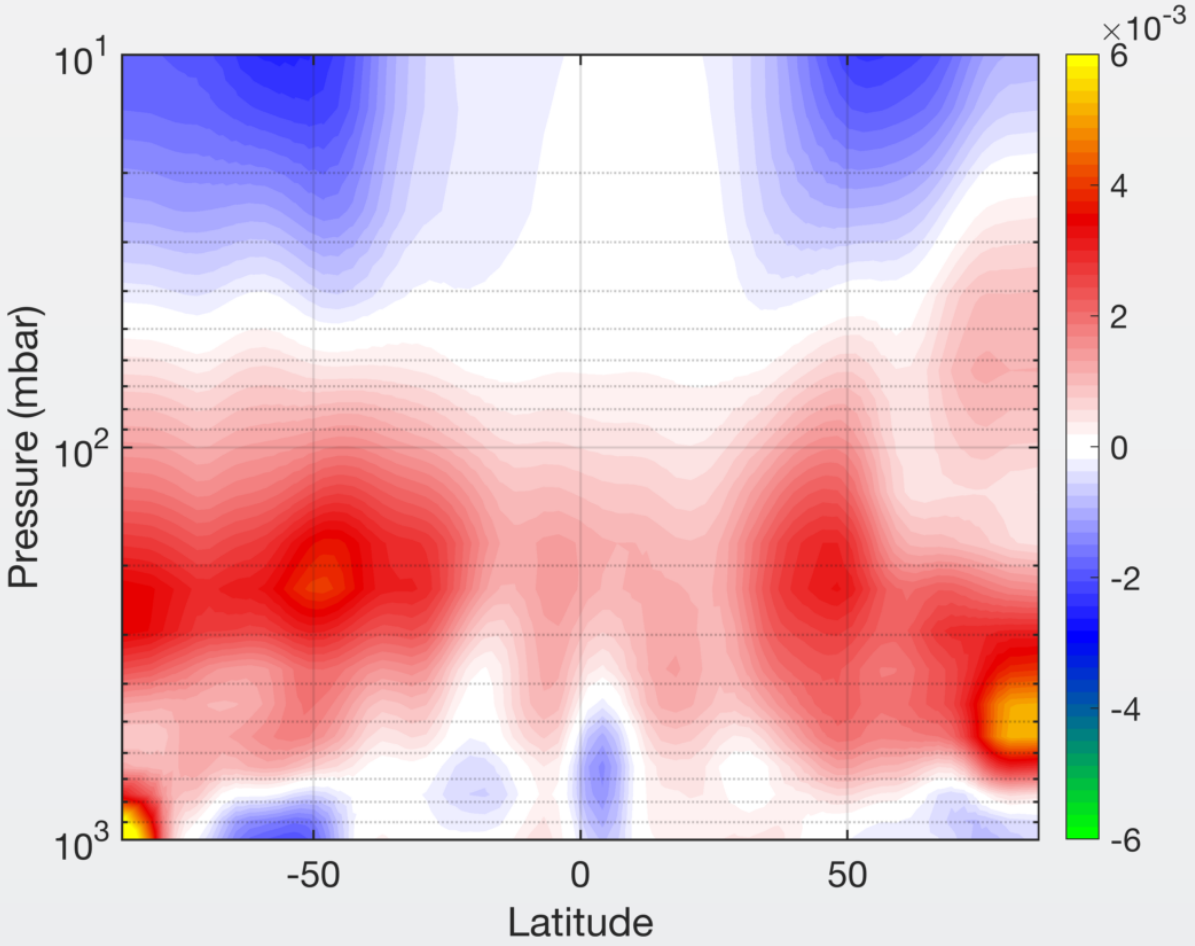


AIRS 17-Year Trends (K/year)



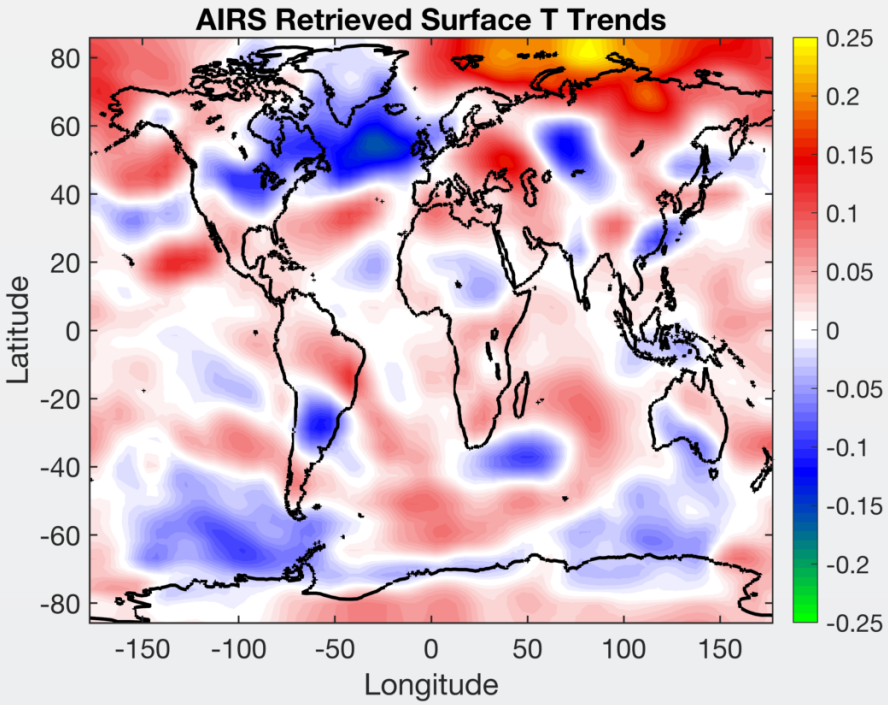
- Reasonable correspondence
- Our AIRS retrievals likely have cloud problems near surface at higher latitudes
- Good agreement for Arctic warming
- ERA has stratospheric warming above the tropical tropopuase, we don't
- Large differences in polar stratospheric cooling, but trend uncertainties there are likely very high (sudden stratospheric warmings, etc.)

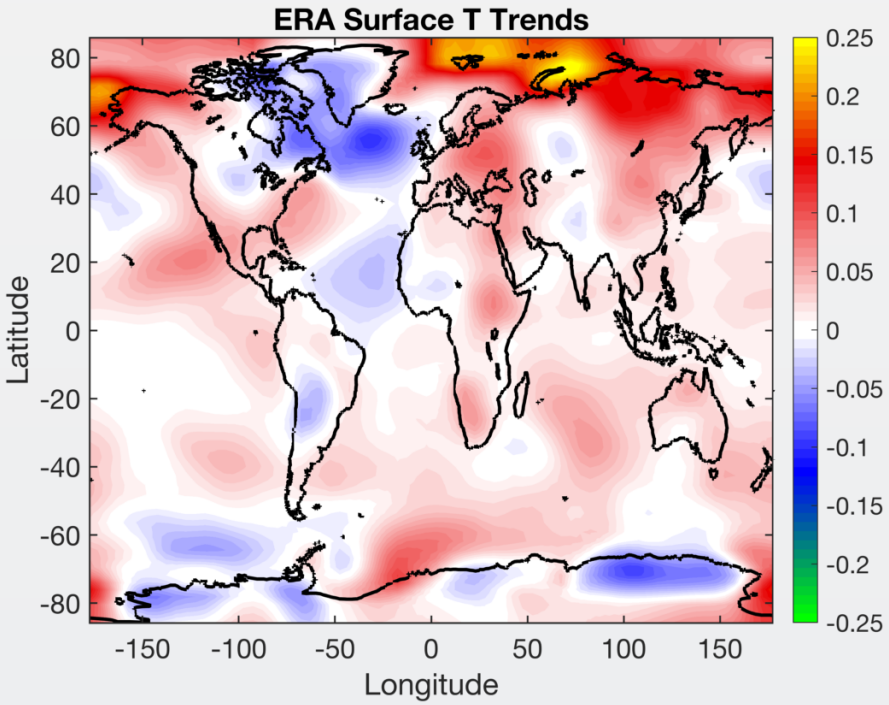
Retrieved Zonal H_2O Trends



- Higher water amounts where temperature is increasing, and vice-versa
- Lowest levels likely incorrect
- Trends are ~0.4% per year. Need to determine change in relative humidity

Surface Temperature Trends





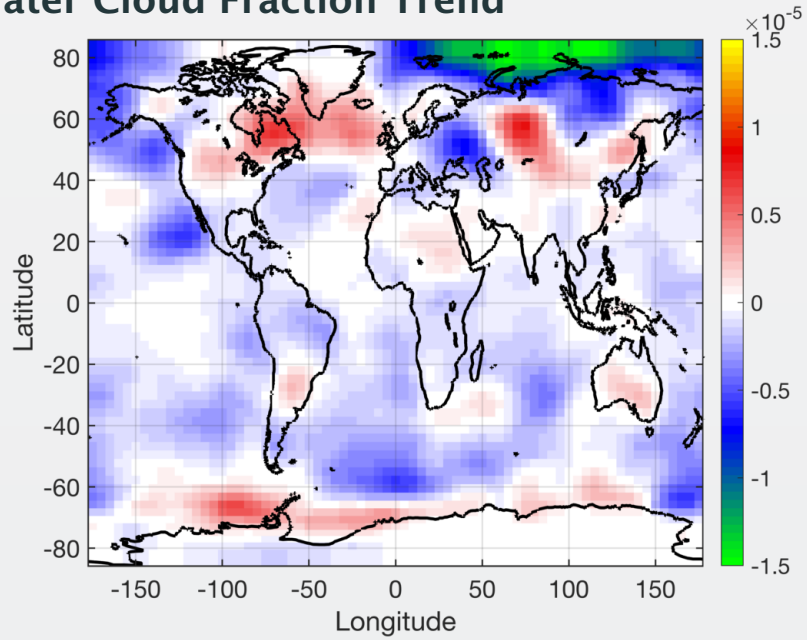
ERA Mean Trend: 0.019 K/year

AIRS Mean Trend: 0.014 K.year

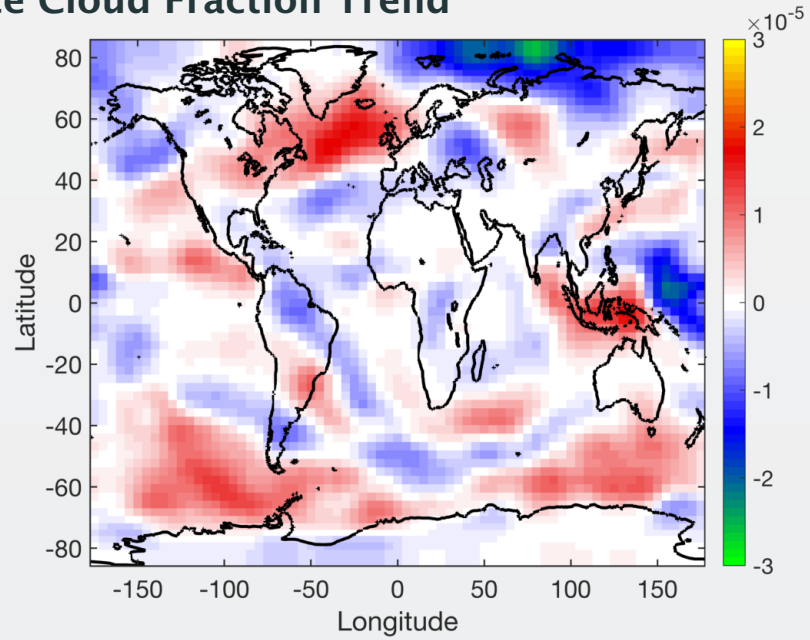
- Our AIRS trend is likely too low
- Cloudy region surface T trends are too negative
- Less cloudy regions with increasing T surface seem OK
- Note: this computation takes ~30 minutes max using 72 nodes

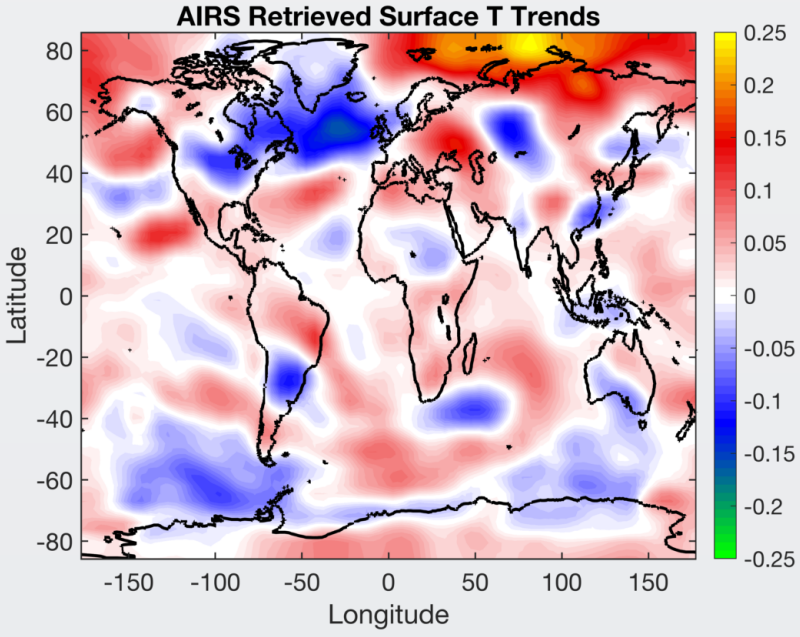
Clouds Fraction Trends

Water Cloud Fraction Trend



Ice Cloud Fraction Trend





- Ice cloud variability in regions of deep convection
- Inverse relationship of cloud fraction to surface T trends (an artifact?)

Conclusions

- Generally robust trends retrieved from large-scale spatial and temporal gridding of AIRS radiances
- Clearly climate quality retrievals near the surface should use gridded data that removes thick clouds
- Retrieval of gridded anomaly trends appear to be quite accurate, and trends are largely quite smooth with altitude.
- Clear signals for stratospheric cooling and tropspheric warming seen, extreme warming in the Arctic
- The minor gas retrievals (especially CO_2) were not perfect, ranging from 1-2 ppm/year.

Future

- Generate new transpose database of radiances
- Grid some percentage of hotter scenes and perform anomaly and trend retrievals and look for any artifacts
- Experiment with anomaly retrievals using gridded data that is cloudier, and likely use clear scene retrievals as a-priori information for cloudier grids.
- Start to experiment with CHIRP radiance data sets to determine quality of gridded CHIRP data that we hope to eventually produce at the GSFC DIS.