All-Sky AIRS Anomaly Retrievals using Zonally Gridded, Time Averaged Brightness Temperature Spectra

AIRS Science Team Meeting

Sergio DeSouza-Machado[1,2], L. Larrabee Strow[1,2]

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[1] UMBC Physics Dept.

[2] UMBC JCET

Overview

Overview of talk

- Larrabee's talk establishes high stability of AIRS(LW/MW)
  - we used noise covariance based on <NedT> per latitude bin ($\leq$ 0.001 K at 1231 cm^{-1}, tropical latbins)
  - instead of using SARTA jacobians for anomalies, we used kCARTA with latest spectroscopy (LBLRTM 12.8 for CO2,CH4), HITRAN 2016 for other gases, CKD 3.2
  - plus we also know kCARTA jacobians work fine for any CO2/T combinations
  - Clear Sky scenes have very poor global sampling eg concentrated in Arabian Sea
  - (trace gases uniformly mixed so we retrieve those rates very well)
- Using lessons learned from clear sky spectral anomaly and rate retrievals we are now beginning to work with allsky spectral anomalies and trends.

Overview of talk (cont'd)

- kCARTA can do very similar TwoSlab calcs to SARTA, so no problems using it for allsky T/WV/O3,surftemp jacobians; for this talk we use SARTA for cloud jacobians
- In this talk we work with zonally averaged anomalies
- Long term goal is gridded anomalies, and trends derived from those anomalies
- We also plan to do an "onion peeling" where we use BT1231 observed and ERA surface temperaure to partition data into clear/partly cloudy/very cloudy/DCC; start the retrievals with clear and then move upwards (weighting the retrievals with nuber of points)
- Here we work only with AIRS for proof of principle, plan to do this with CHIRP

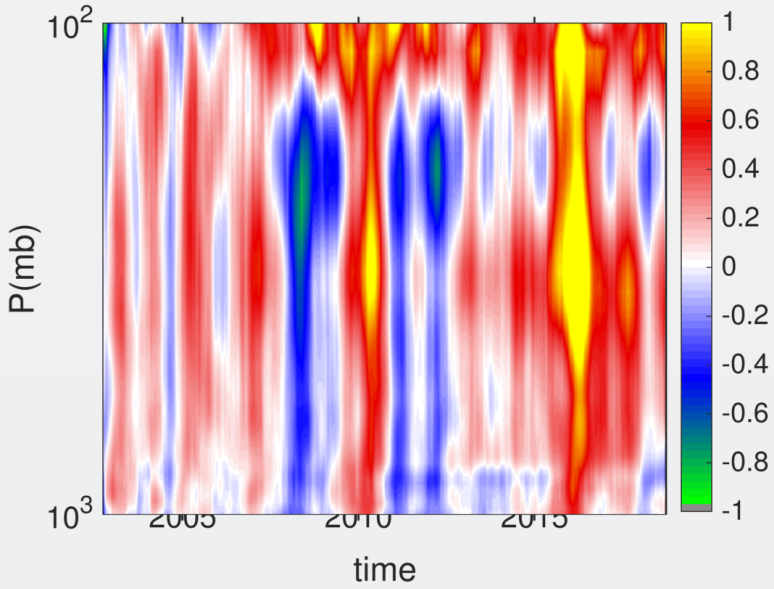
Clear Sky vs ERA Anomalies

Clear Sky Retrievals

- Larrabee's talk gives details (data from 2002/09 to 2018/08)
  - 16 years of data divided into 16 day averages → 365 timesteps
  - AIRS observations sampled for CLEAR scenes in these bins
  - binned into 40 equal area latitude bins (thinner in equator/thicker at polar regions)
  - BT anomalies and average ERA profiles for all 365 timesteps
- kCARTA 97 layer analytic jacobians for surface temperature, T(z), WV(z),O3(z)
- Ran off kCARTA at t=0 to t=T to make "finite difference" column trace gas jacobians (CO2,N2O,CH4,CFC11,CFC12)
- Using these jacobians, we retrieved T(t,z), WV(t,z), O3(t,z), CO2(t), N2O(t), CH4(t), CFC11(t), CFC12(t), surftemp(t) at each of the 40 latbins $\times$ 365 timesteps

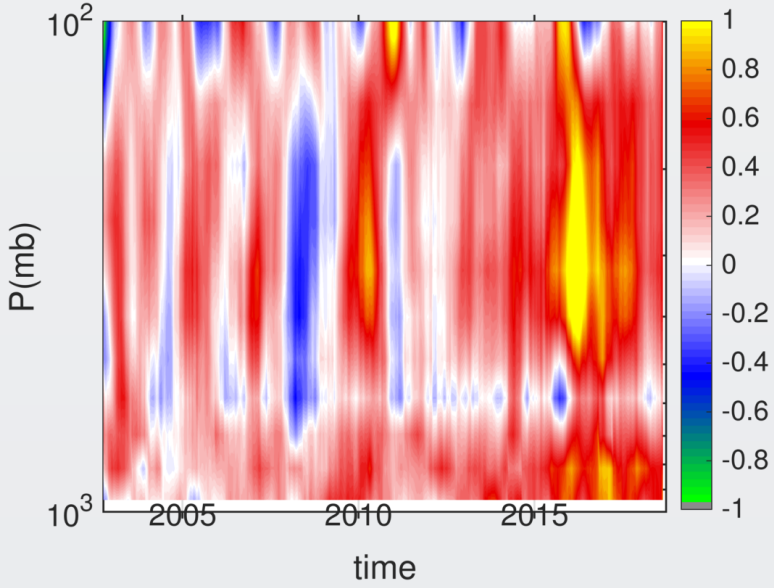
Tropical Clear Sky Geophysical Anomalies : T(z,t)

ERA

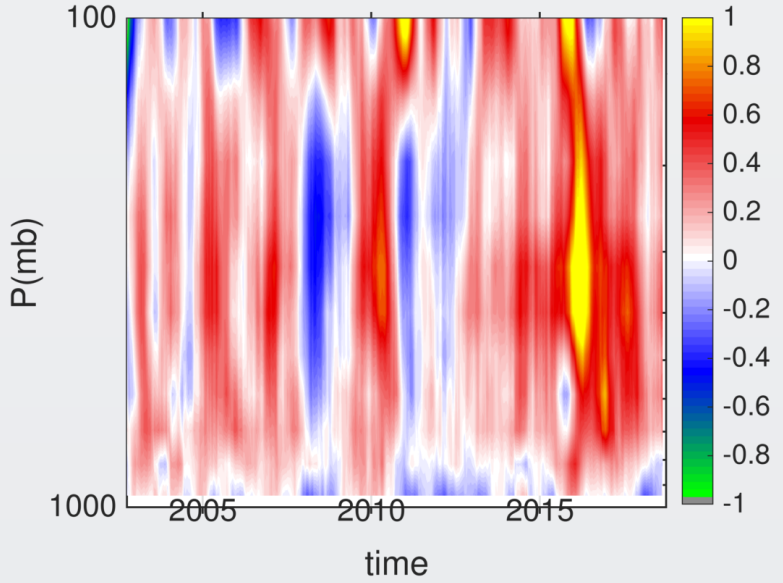


UMBC Retr Calc are retrievals from simulated radiances derived from ERA.

UMBC Retr Obs

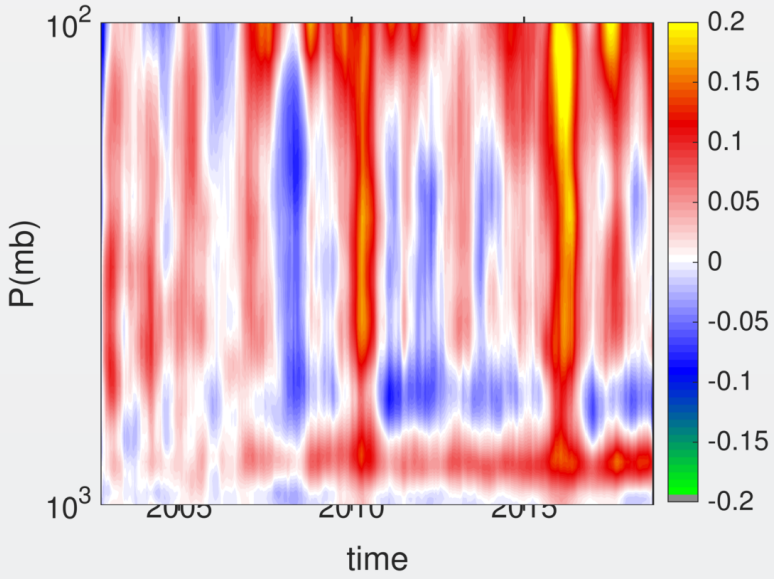


UMBC Retr Calc

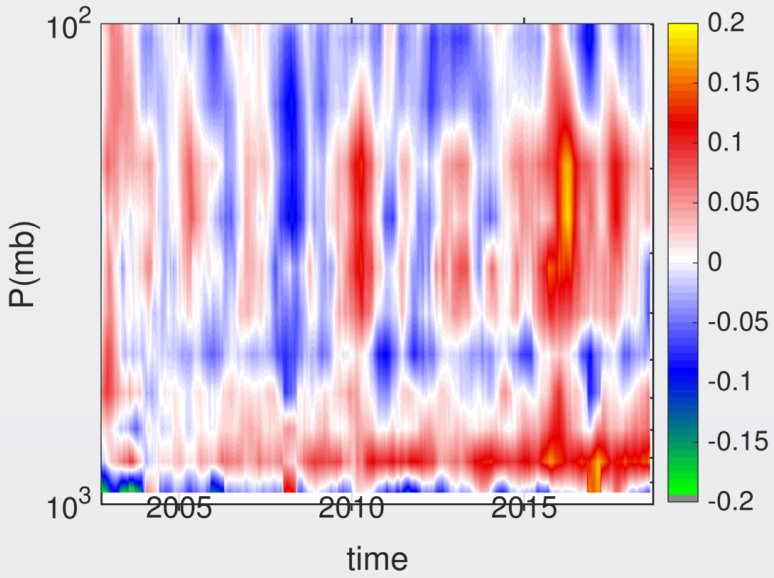


Tropical Clear Sky Geophysical Anomalies : *frac* WV(z,t)

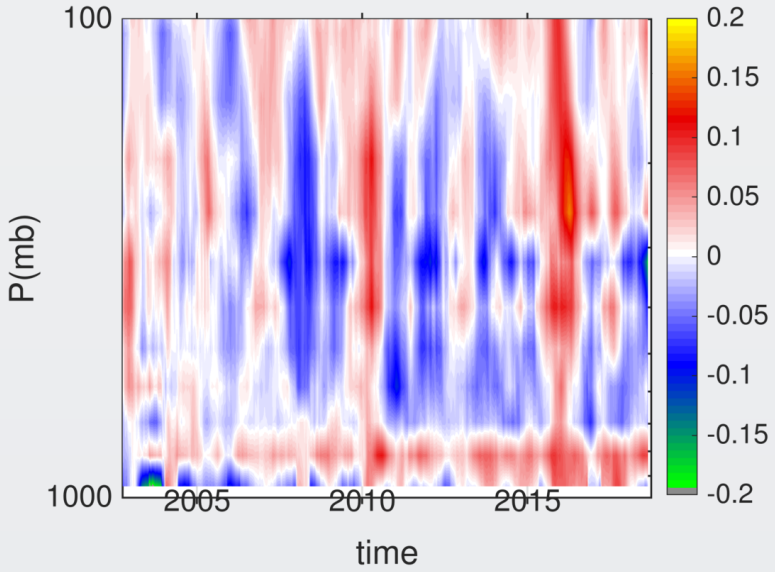
ERA



UMBC Retr Obs

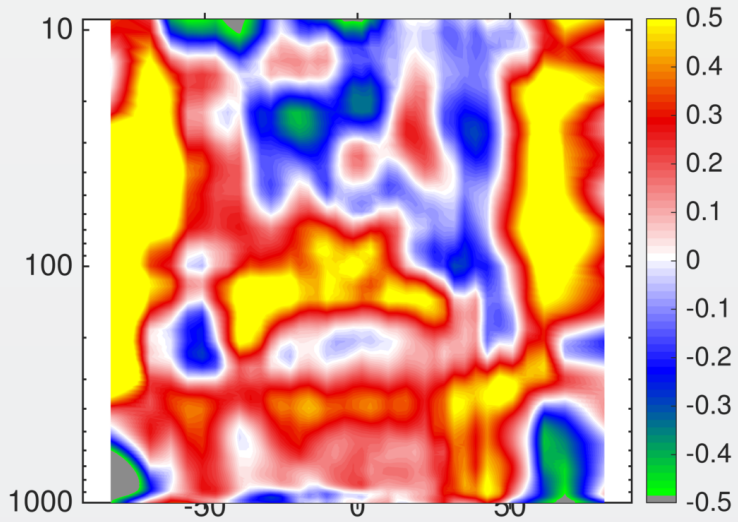


UMBC Retr Calc



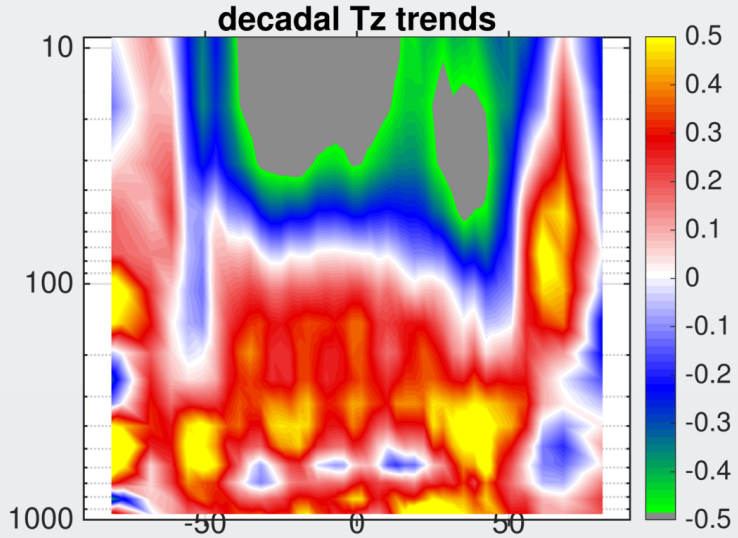
UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : T(z,lat)

ERA

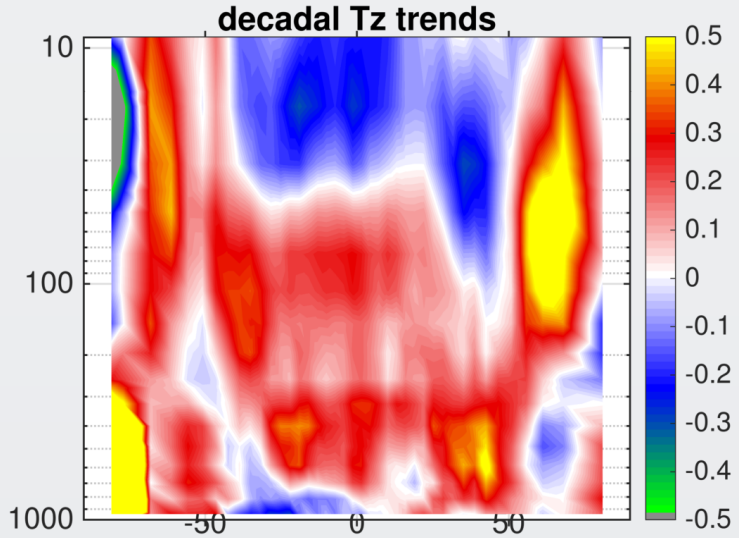


Remember: Clear sampling is extremely non-uniform spatially so expect strange structures.

UMBC Retr Obs

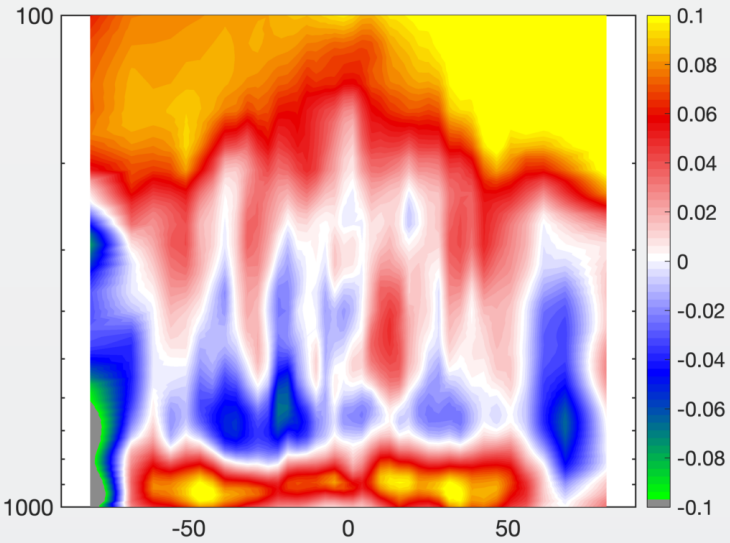


UMBC Retr Calc

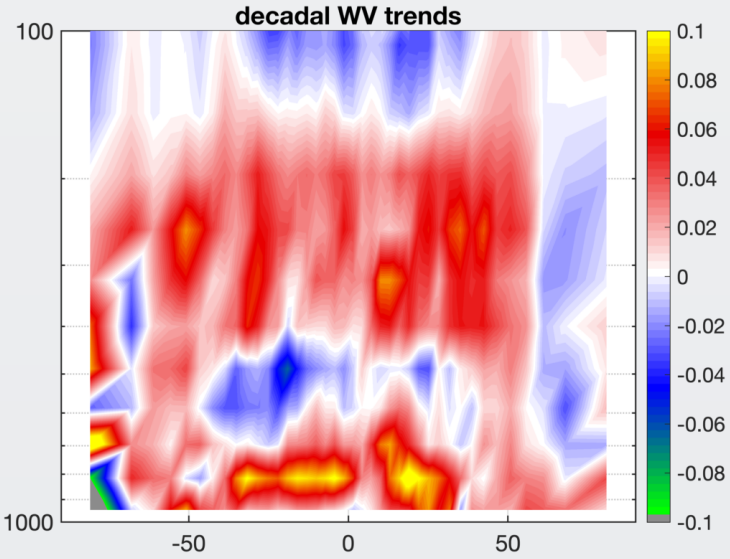


UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : WV(z,lat)

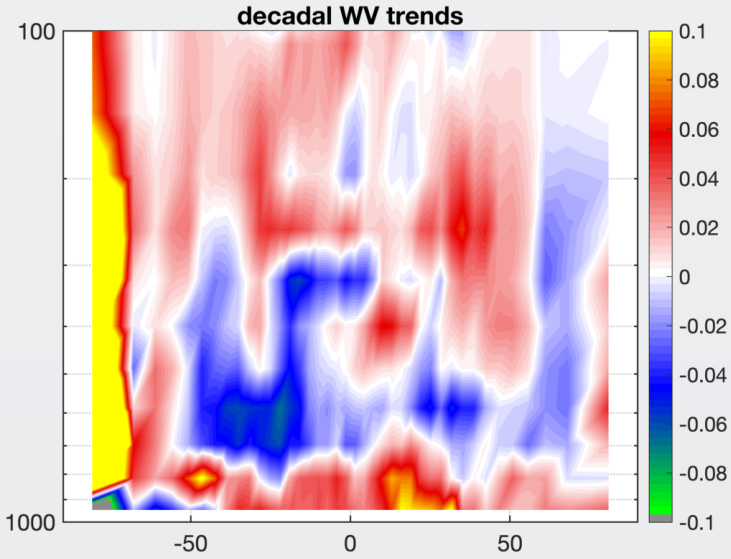
ERA



UMBC Retr Obs



UMBC Retr Calc



AllSky Results

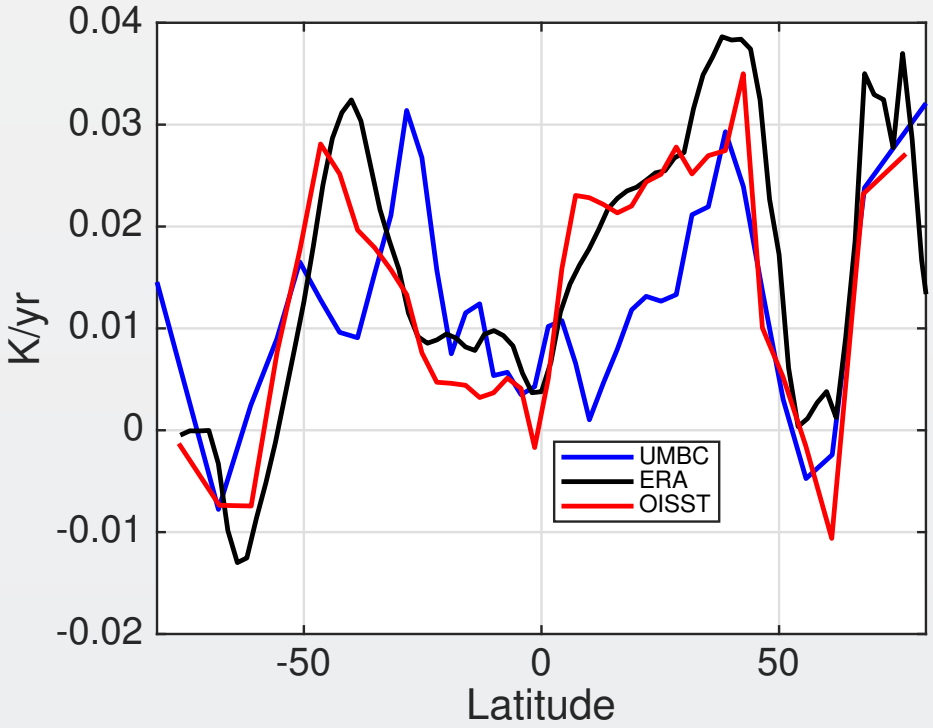
AllSky Retrievals

- Interested in a less specialized sampling, so will now look at allsky rates
- Larrabee's talk gives details (data from 2002/09 to 2018/08)
  - binned into 40 equal area latitude bins (thinner in equator/thicker at polar regions)
  - AIRS observations randomly sampled from these bins
  - 16 years of data divided into 16 day averages → 365 timesteps
  - BT anomalies and average ERA profiles for all 365 timesteps
- kCARTA analytic jacobians for surface temperature, T(z), WV(z),O3(z) using TwoSlab Clouds and also for trace gases(CO2,N2O,CH4,CFC11,CFC12)
- SARTA for cloud jacs (kCARTA and SARTA slightly differ in cloud vertical placement)
- Using these jacobians, we retrieved T(t,z),WV(t,z),O3(t,z),[CO2(t),N2O(t),CH4(t),CFC11(t),CFC12(t),surften [cld amount/cld eff size/ cld top for liquid/ice clouds] at each of the 40 latbins $\times$ 365 timesteps

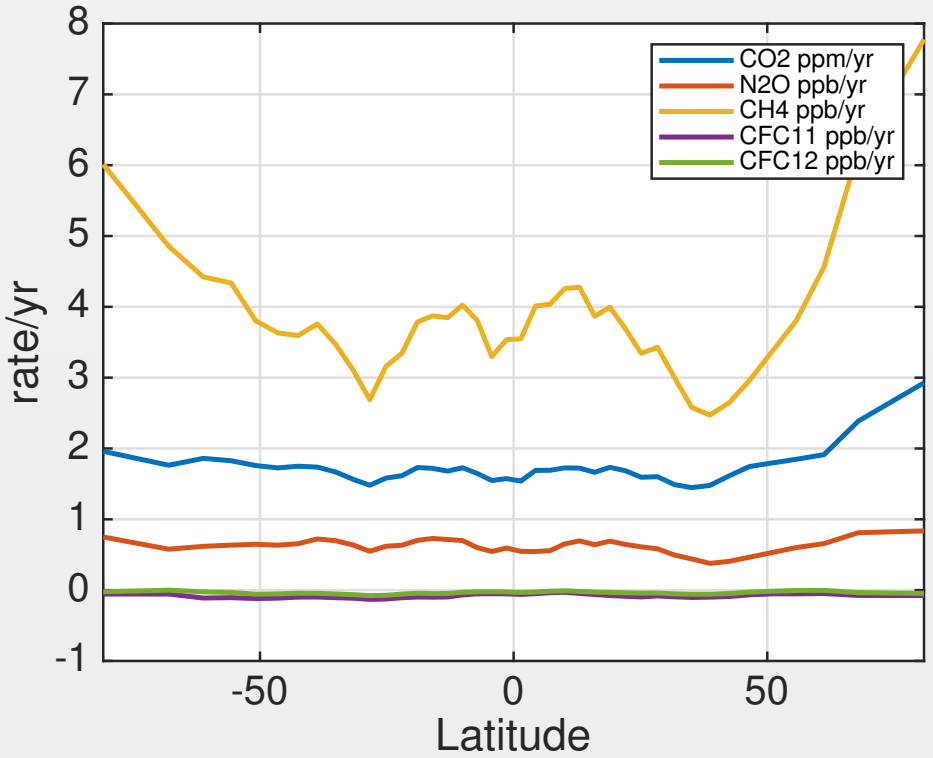
AllSky OCEAN

Trace gas + stemp rates from spectral rates

Stemp Rates



Trace gas rates

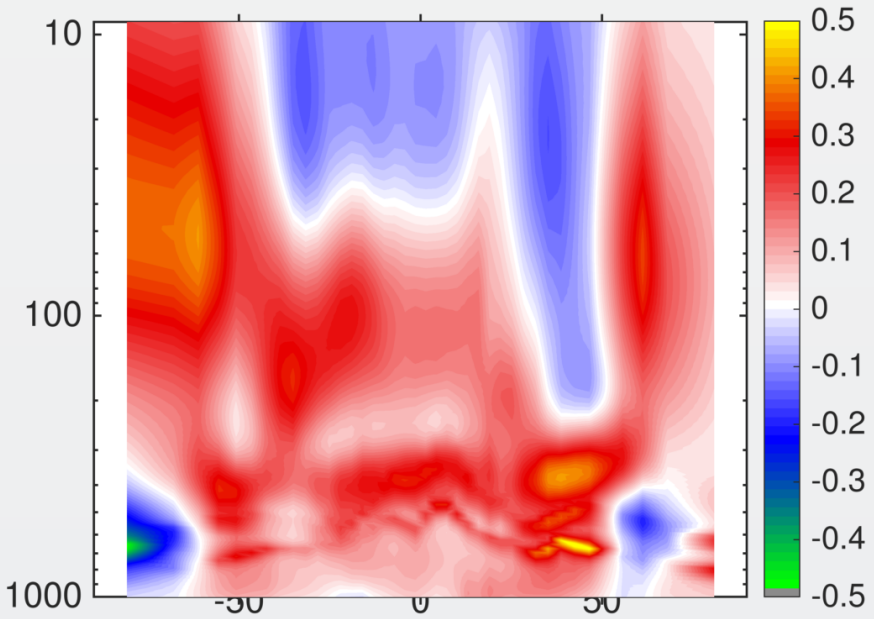


- Ocean only
- -25 deg. lat bump is a cloud problem
- gridded anomalies should remove this problem

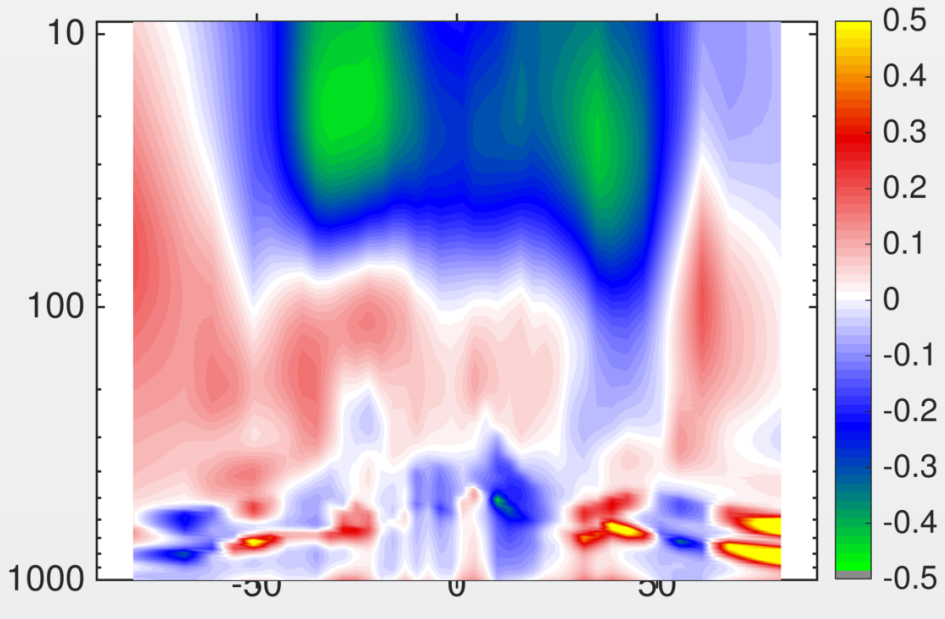
Preliminary work

Comparing ERA versus UMBC AllSky Geophysical Rates : dT(z,lat)/dt

ERA



UMBC

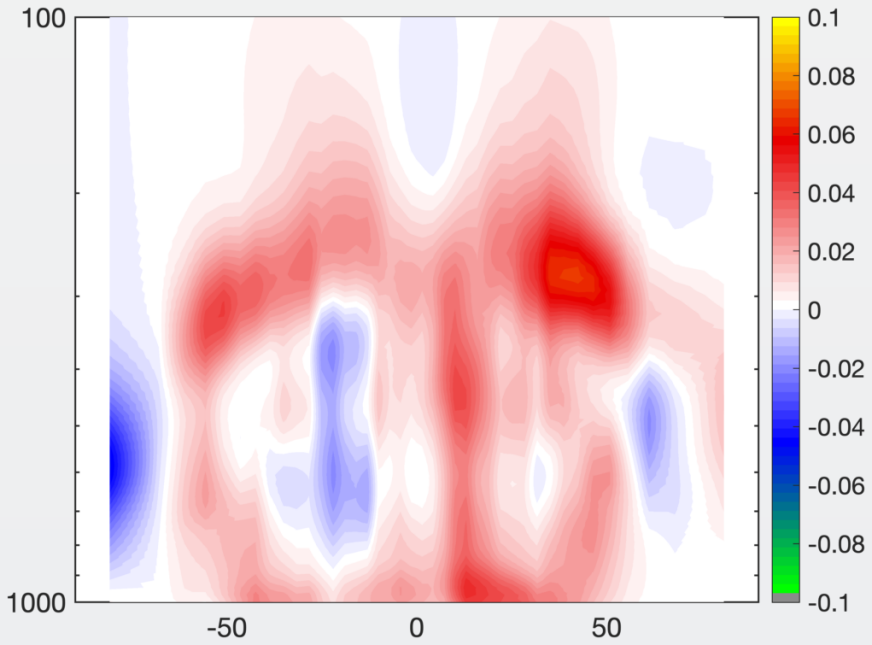


- Again, these are zonal all-sky retrievals that combine greatly variable longitudal trends, mostly due to cloud variability during ENSO periods.

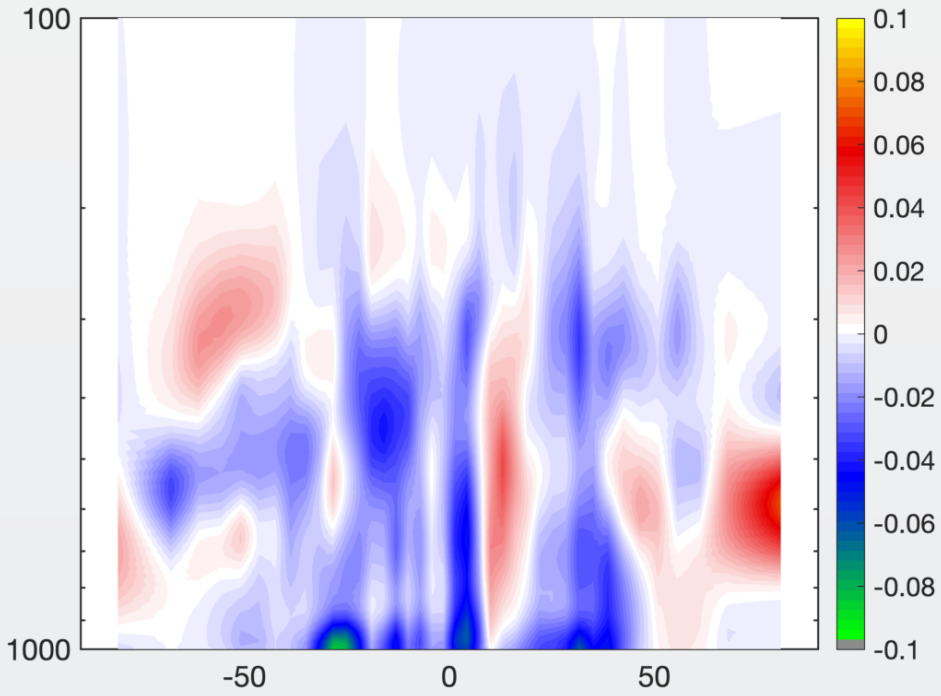
- Switching to gridded retrievals should help improve cloud paramater retrievals.

Comparing ERA versus UMBC AllSky Geophysical Rates : dWV(z,lat)/dt

ERA



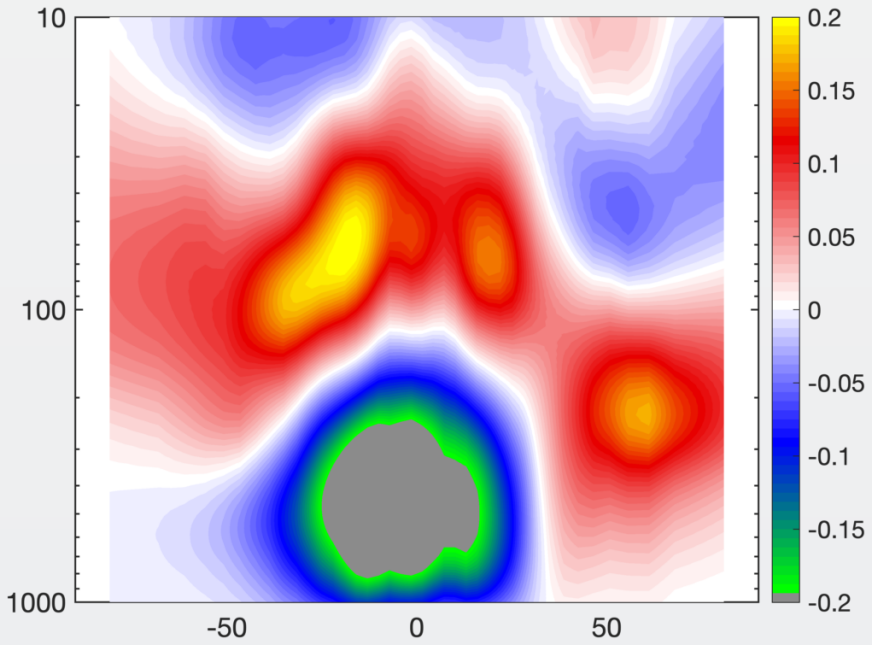
UMBC



Note: global radiance trends suggest AIRS water trends are lower than ERA.

Comparing ERA versus UMBC AllSky Geophysical Rates : dO3(z,lat)/dt

ERA



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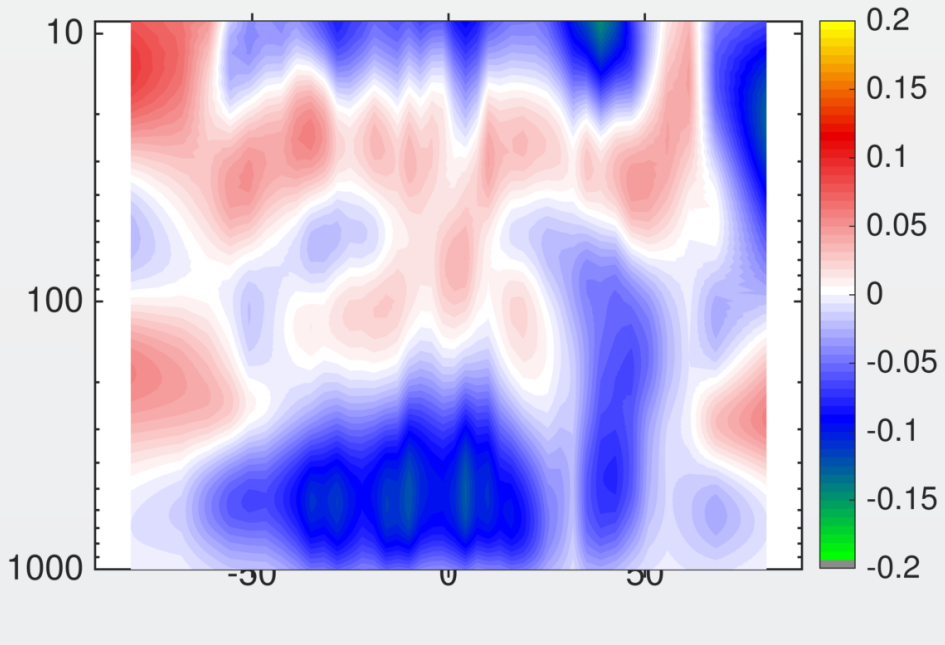
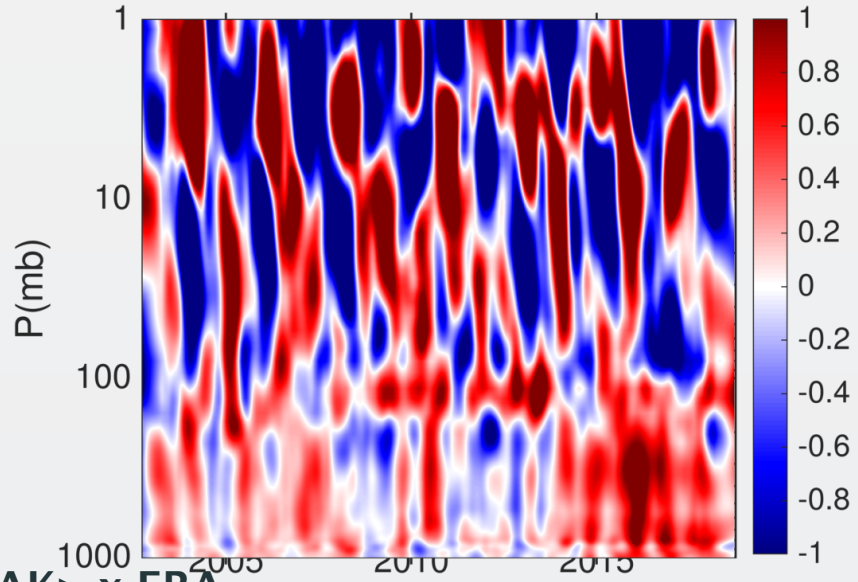


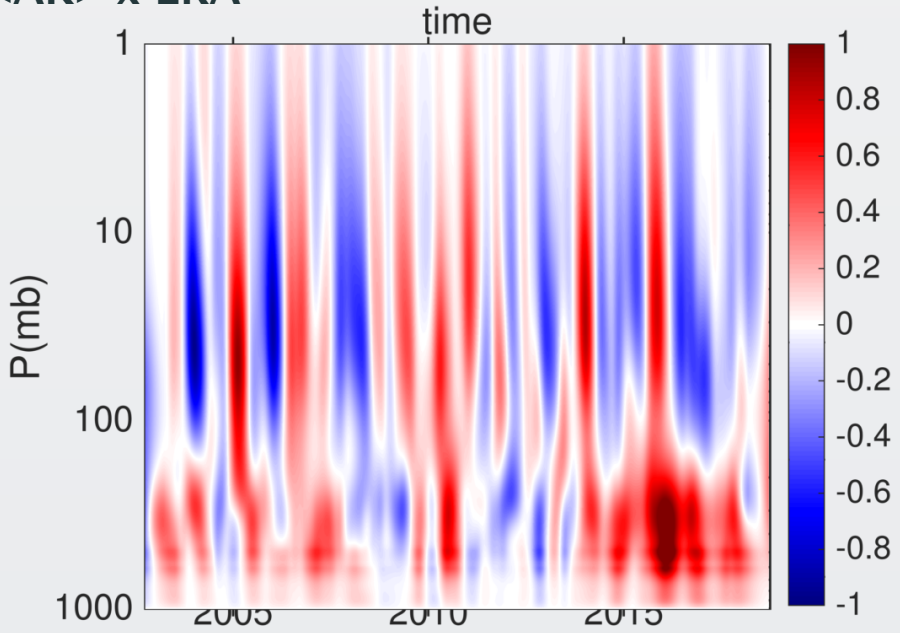
27 N AllSky Ocean Geophysical Anomalies : T(z,t)

ERA

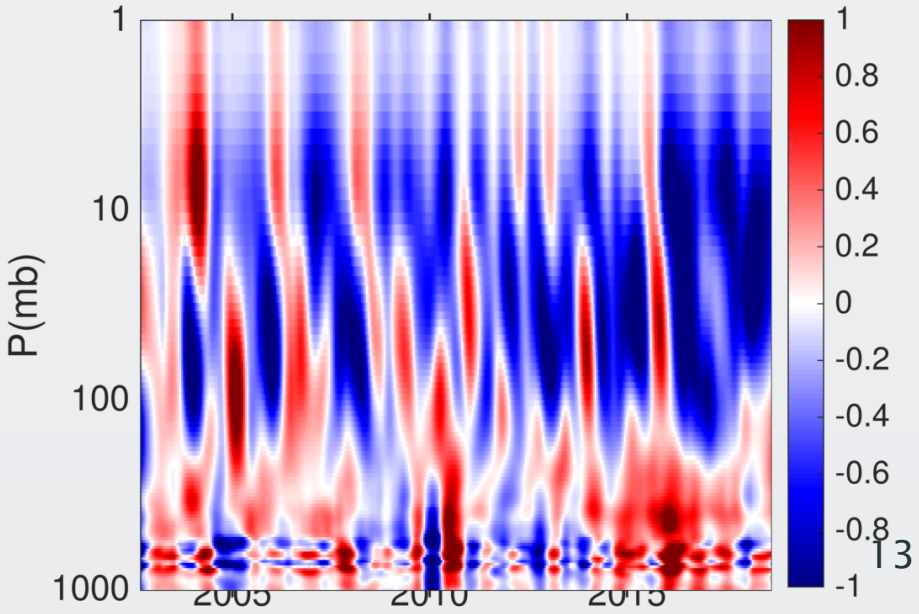


- Appears our AK smoothing is too strong.
- Insufficient regularization low in the atmosphere.

<AK> x ERA

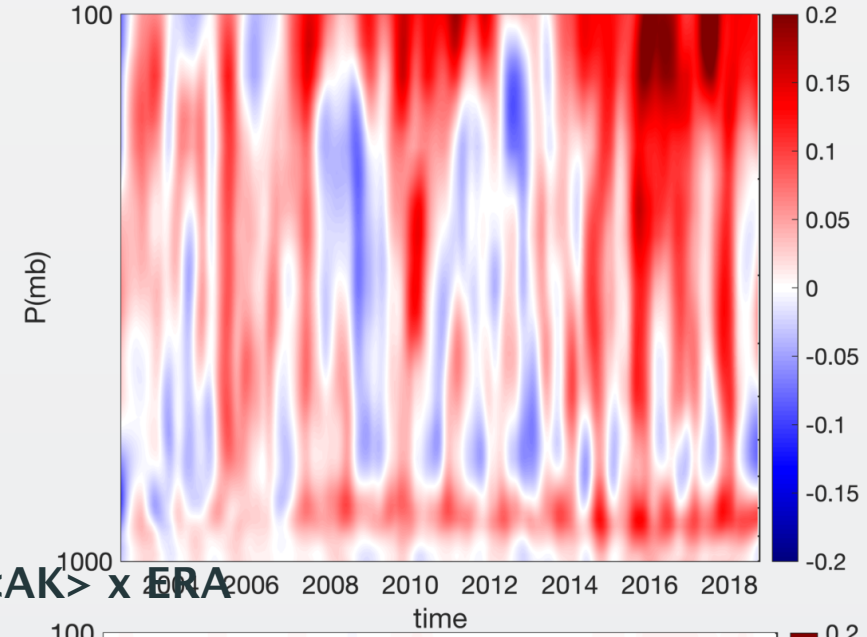


UMBC

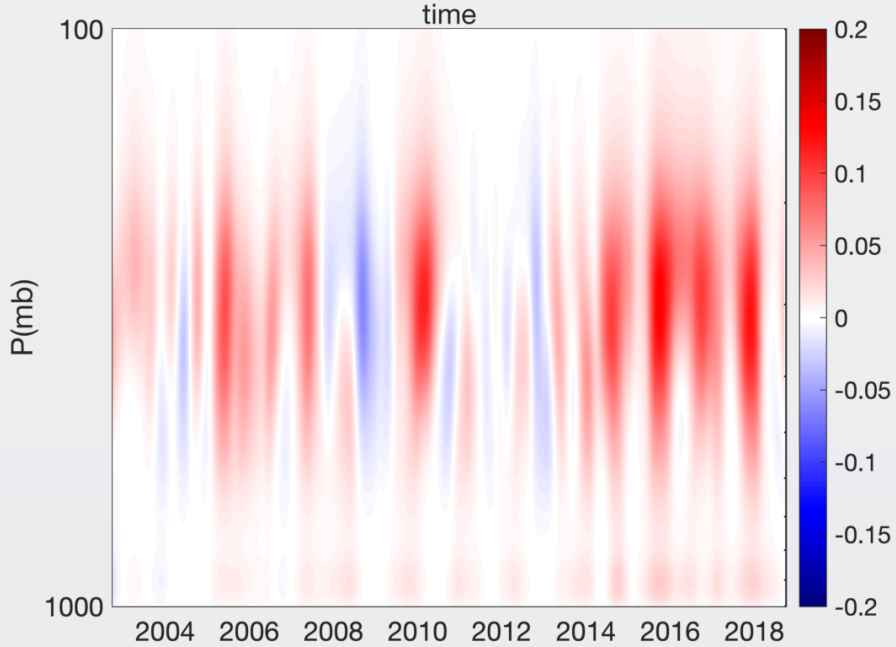


27 N AllSky Ocean Geophysical Anomalies : WV(z,t)

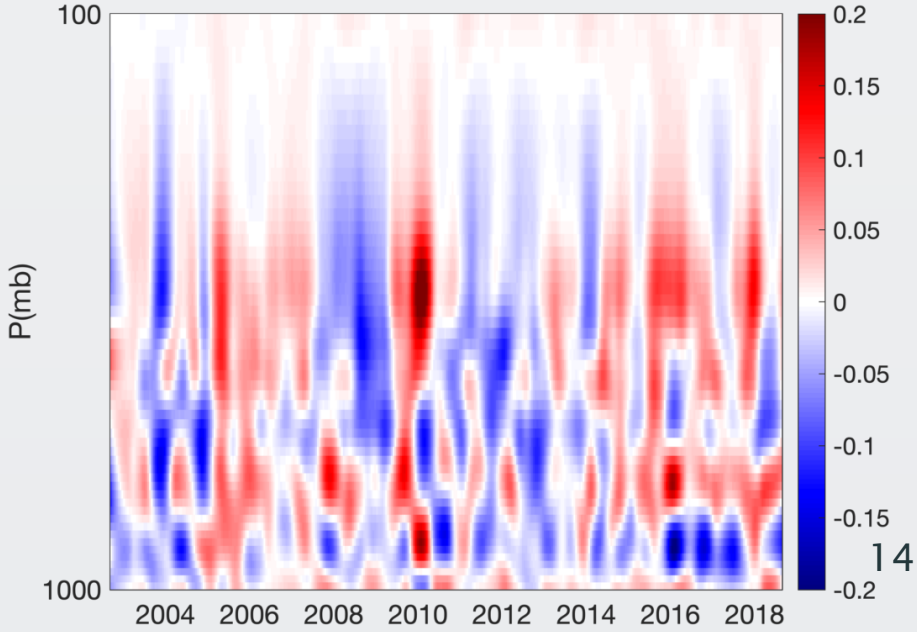
ERA



<AK> x ERA



UMBC



Conclusions

Conclusions

- Started to work with 16 year AIRS zonally averaged allsky spectra
  - too much cloud variability across latitude bins, especially with large 2016 ENSO
  - at surface difficult to separate low cloud from surface temparature
- From allsky spectral rates and anomalies we can get
  - decent trace gas rates; but not from anomalies (so we tie the trace gases to known “trends”)
  - using either spectral rates or anomalies, we are obtaining ballpark T/WV/O3 trends
  - we see recognizable features in anomalies eg QBO in tropical latbins
- We will now transition to retrieving gridded anomalies
- And, transition to CHIRP radiances once RTA is finishe