

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}

September 25, 2019

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 $\langle \text{NedT} \rangle$ per latitude bin (≤ 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 number of points)
- Here we work only with AIRS for proof of principle, plan to do this with CHIRP

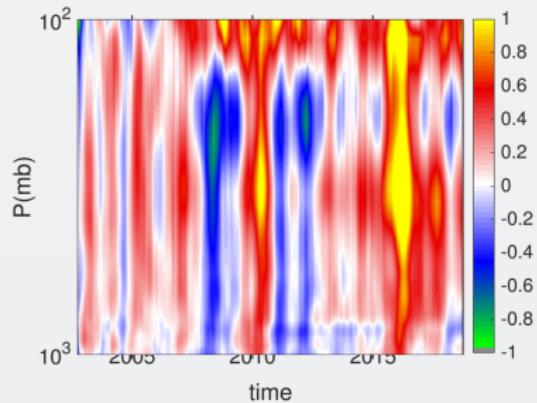
Clear Sky vs ERA Anomalies

Clear Sky Retrievals

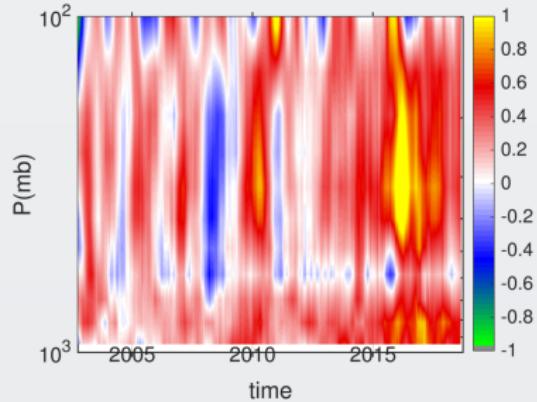
- Larrabee's talk gives details (data from 2002/09 to 2018/08)
 - 16 years of data divided into 16 day averages → 365 timesteps
 - **AIRS observations sampled for CLEAR scenes in these bins**
 - binned into 40 equal area latitude bins (thinner in equator/thicker at polar regions)
 - BT anomalies and average ERA profiles for all 365 timesteps
- kCARTA 97 layer analytic jacobians for surface temperature, $T(z)$, $\text{WV}(z)$, $\text{O}_3(z)$
- Ran off kCARTA at $t=0$ to $t=T$ to make “finite difference” column trace gas jacobians ($\text{CO}_2, \text{N}_2\text{O}, \text{CH}_4, \text{CFC}11, \text{CFC}12$)
- Using these jacobians, we retrieved $T(t,z)$, $\text{WV}(t,z)$, $\text{O}_3(t,z)$, $\text{CO}_2(t)$, $\text{N}_2\text{O}(t)$, $\text{CH}_4(t)$, $\text{CFC}11(t)$, $\text{CFC}12(t)$, $\text{surftemp}(t)$ at each of the 40 latbins \times 365 timesteps

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

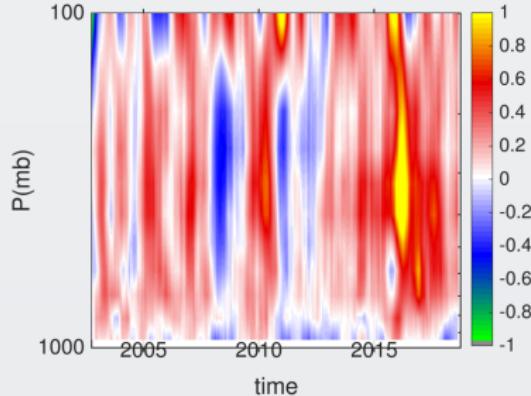
ERA



UMBC Retr Obs

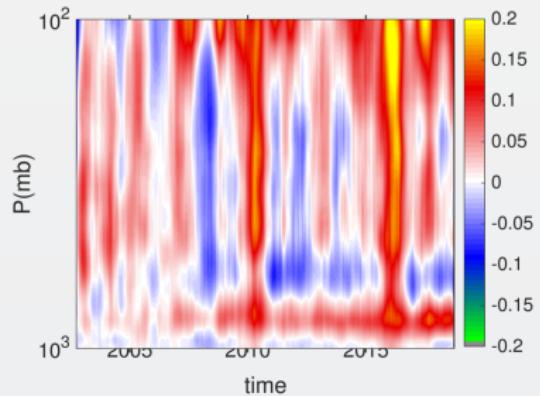


UMBC Retr Calc

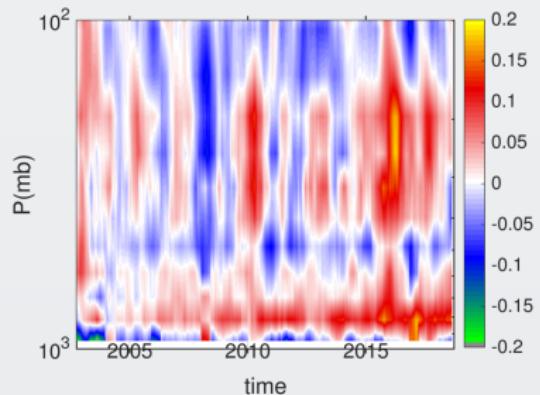


Tropical Clear Sky Geophysical Anomalies : $\text{frac WV}(z,t)$

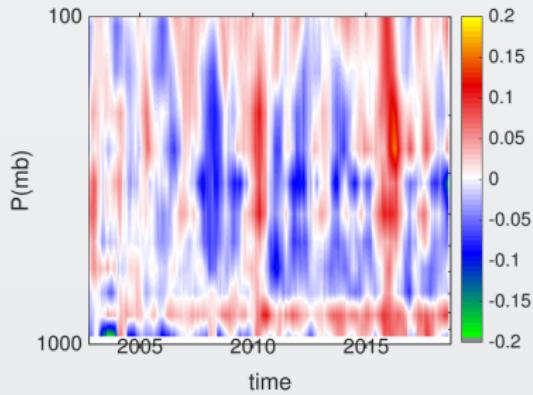
ERA



UMBC Retr Obs

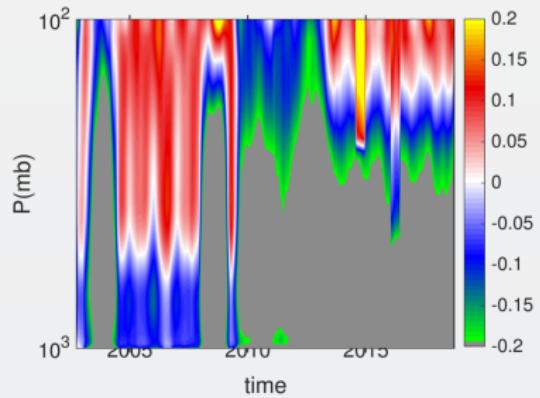


UMBC Retr Calc

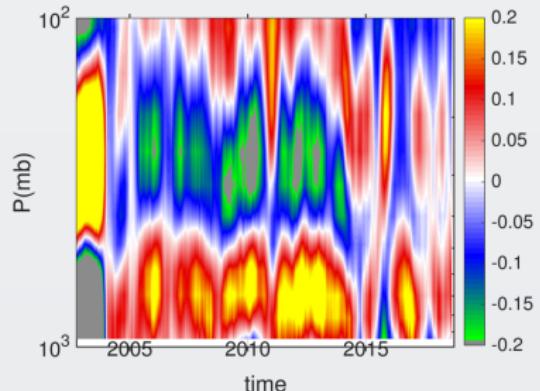


Tropical Clear Sky Geophysical Anomalies : $\text{frac O3}(z,t)$

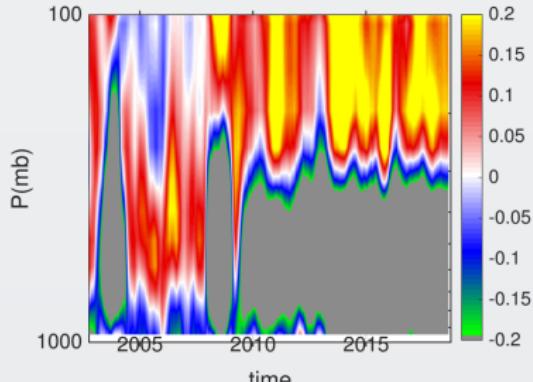
ERA



UMBC Retr Obs

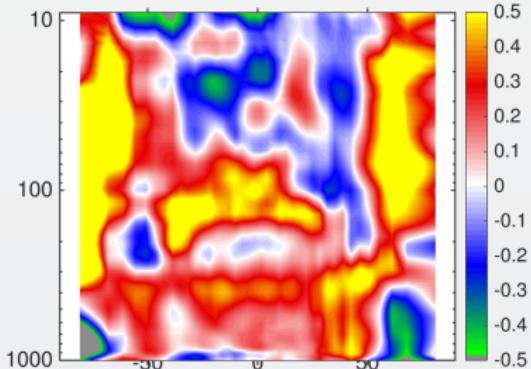


UMBC Retr Calc

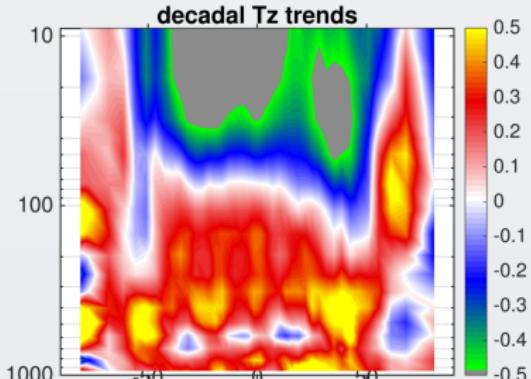


UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : $T(z, \text{lat})$

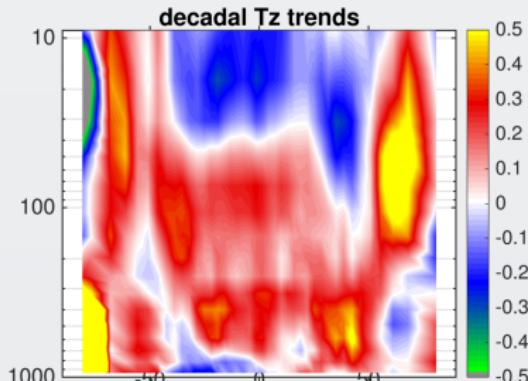
ERA



UMBC Retr Obs

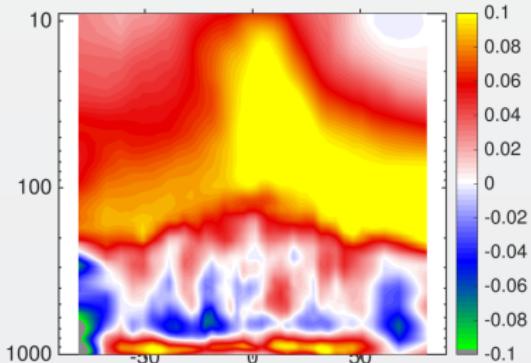


UMBC Retr Calc

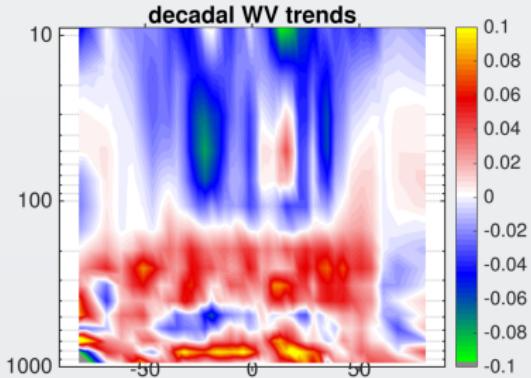


UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : WV(z,lat)

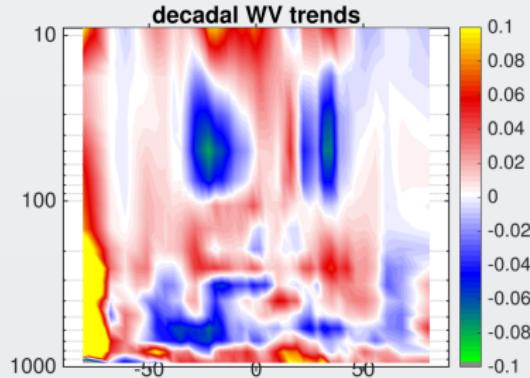
ERA



UMBC Retr Obs

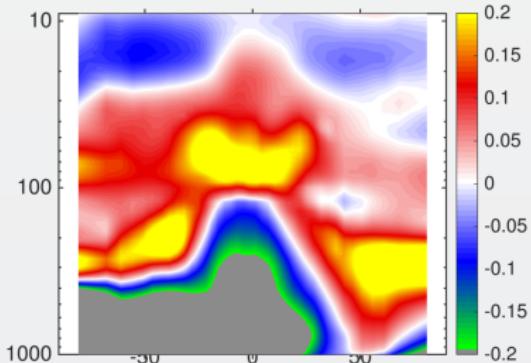


UMBC Retr Calc

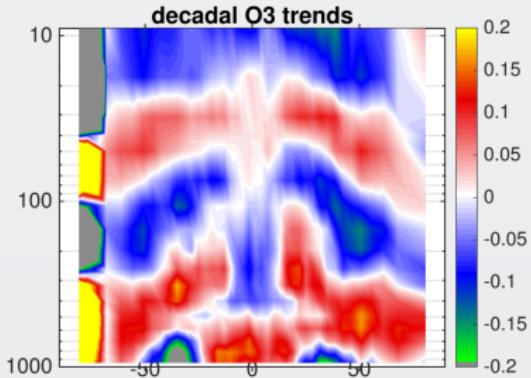


UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : O3(z,lat)

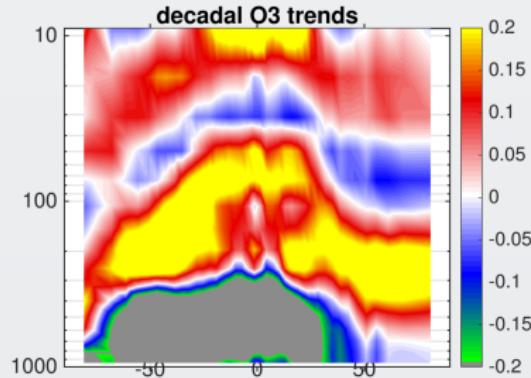
ERA



UMBC Retr Obs



UMBC Retr Calc



AllSky Results

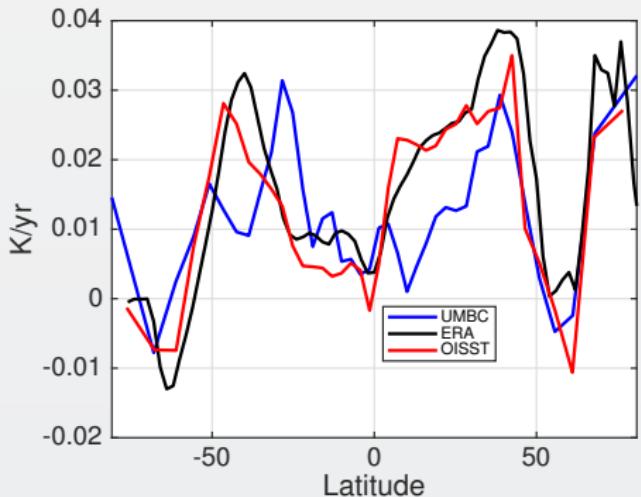
AllSky Retrievals

- 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(CO_2 , $N2O$, $CH4$, $CFC11$, $CFC12$)
- SARTA for cloud jacs (kCARTA and SARTA slightly differ in cloud vertical placement)
- Using these jacobians, we retrieved
 $T(t,z)$, $WV(t,z)$, $O3(t,z)$, $[CO_2(t), N2O(t), CH4(t), CFC11(t), CFC12(t), surften]$
[cld amount/cld eff size/ cld top for liquid/ice clouds] at each of the 40 latbins × 365 timesteps

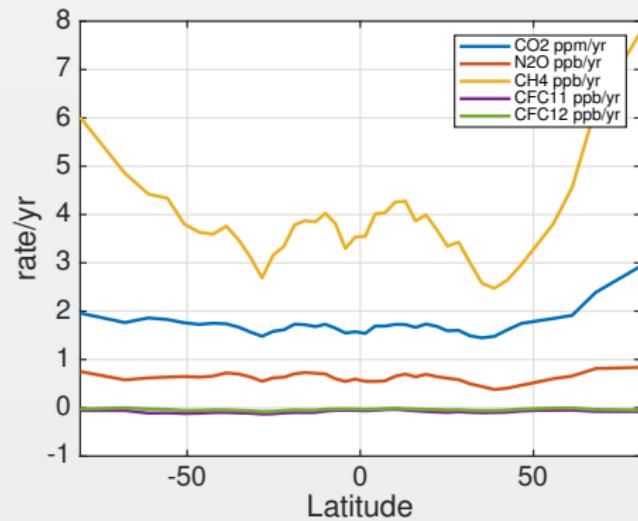
AllSky OCEAN

Trace gas + stemp rates from spectral rates

Stemp Rates



Trace gas rates

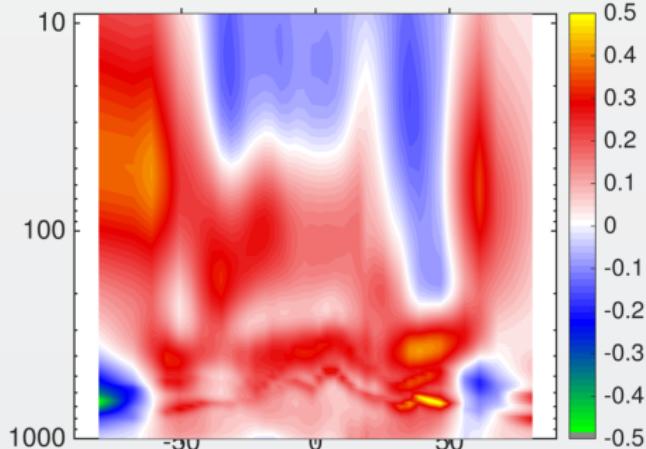


This is over ocean only

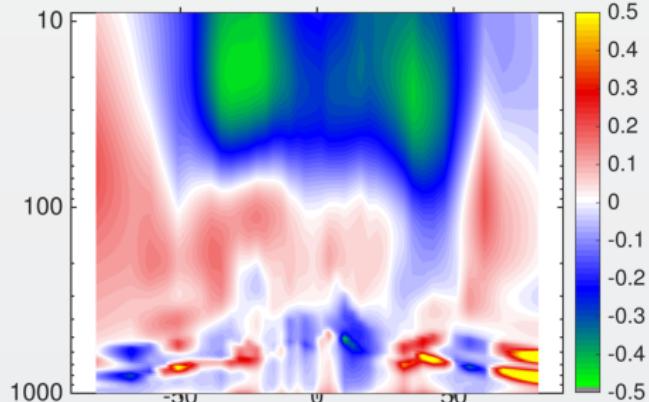
Preliminary work

Comparing ERA versus UMBC AllSky Geophysical Rates : $dT(z,\text{lat})/dt$

ERA

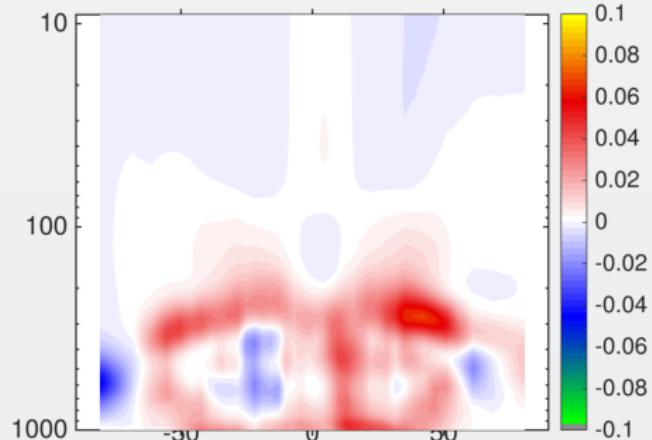


UMBC

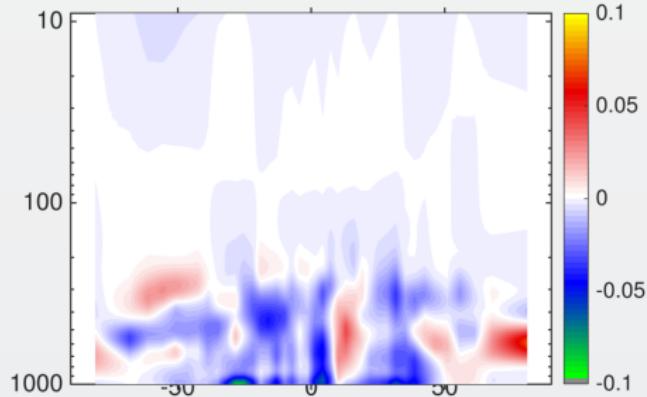


Comparing ERA versus UMBC AllSky Geophysical Rates : $dWV(z, \text{lat})/dt$

ERA

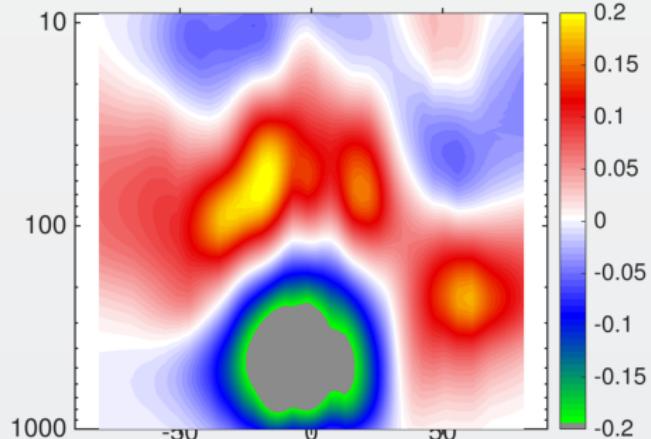


UMBC

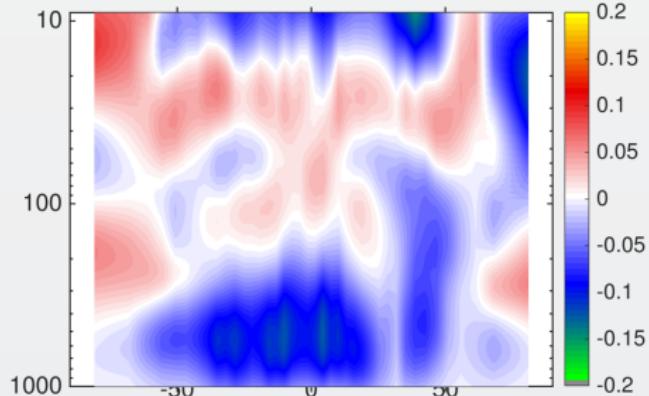


Comparing ERA versus UMBC AllSky Geophysical Rates : $dO_3(z, \text{lat})/dt$

ERA

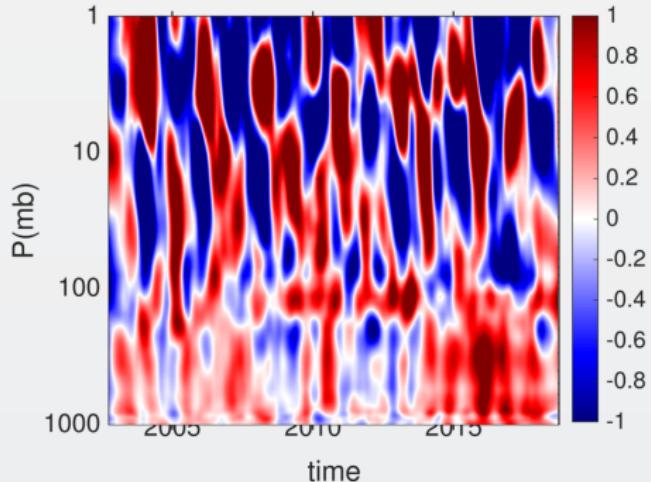


UMBC

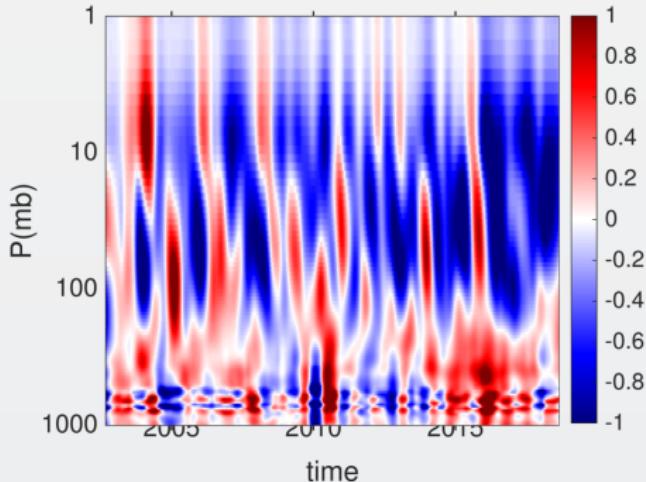


27 N AllSky Ocean Geophysical Anomalies : $T(z,t)$

ERA

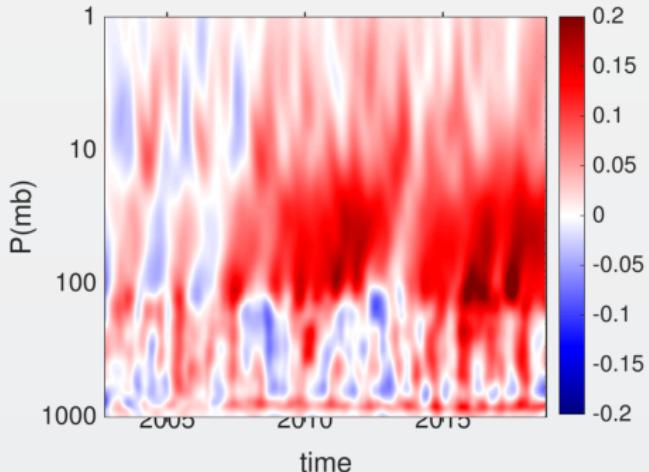


UMBC

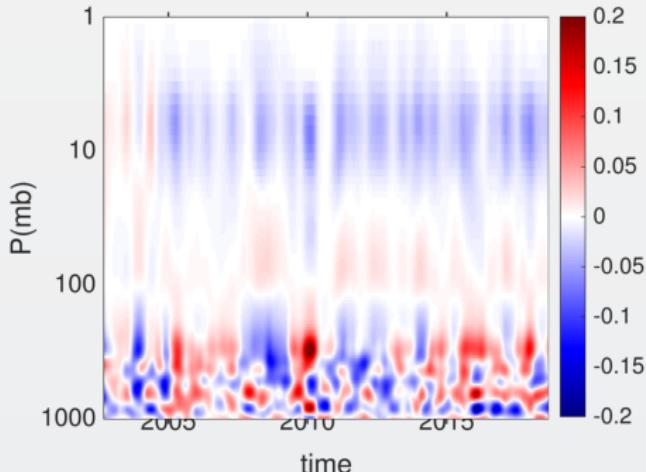


27 N AllSky Ocean Geophysical Anomalies : WV(z,t)

ERA



UMBC



Conclusions

Conclusions

- Started to work with zonally averaged allsky spectra, rather problematic because of
 - too much cloud variability across latitude bins, especially with large 2016 ENSO
 - on surface rather hard to separate low cloud from surface temperature
- But using allsky spectral rates, we actually 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
- Reminder : Long term goal is gridded anomalies, and trends derived from those anomalies
- Reminder : Slowly working towards doing this with CHIRP