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

AIRS Science Team Meeting

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Overview

Overview of talk

- Larrabee's talk establishes high stability of AIRS(LW/MW)
    - we used noise covariance based on <NedT> per latitude bin
    - 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

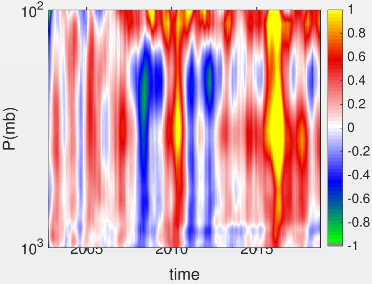
Clear Sky vs ERA Anomalies

Clear Sky Retrievals

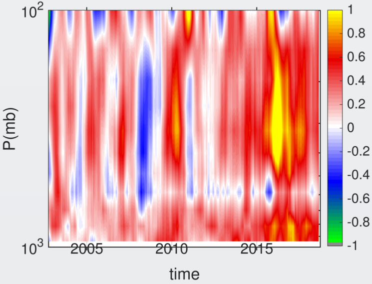
- Larrabee's talk gives details (data from 2002/09 to 2018/08)
  - 16 years of data divided into 16 day averages → 365 timesteps
  - AIRS observations sampled for CLEAR scenes in these bins
  - binned into 40 equal area latitude bins (thinner in equator/thicker at polar regions)
  - BT anomalies and 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)

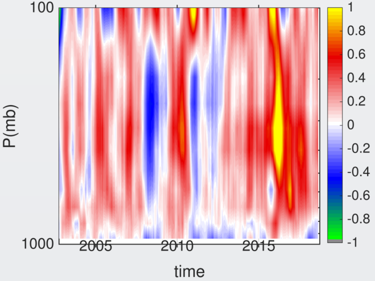
ERA



UMBC Retr Obs

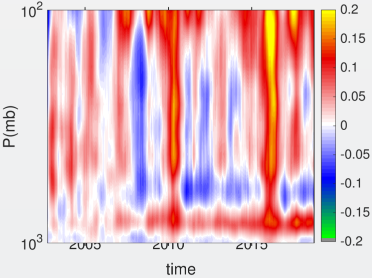


UMBC Retr Calc

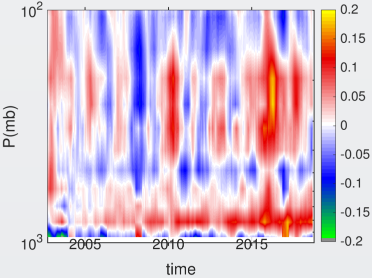


Tropical Clear Sky Geophysical Anomalies : *frac* WV(z,t)

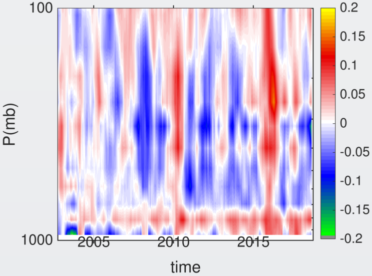
ERA



UMBC Retr Obs

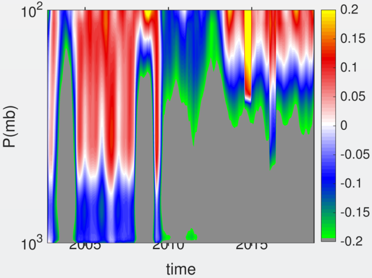


UMBC Retr Calc

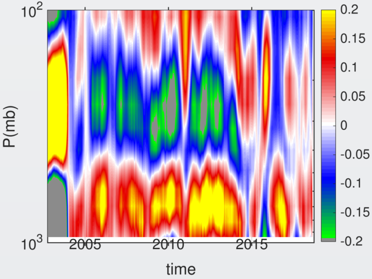


Tropical Clear Sky Geophysical Anomalies : *frac* O3(z,t)

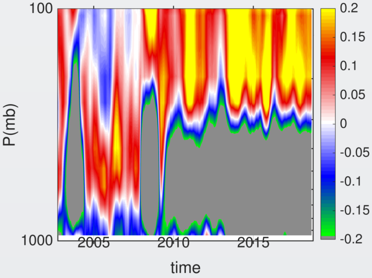
ERA



UMBC Retr Obs

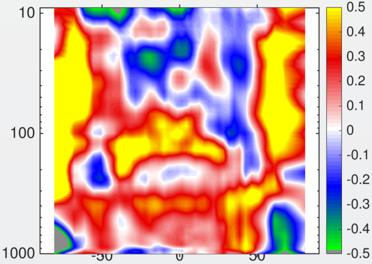


UMBC Retr Calc

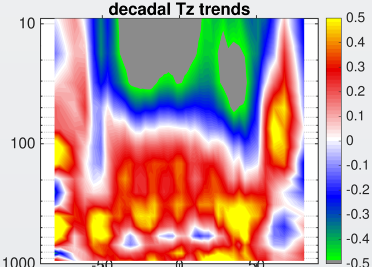


UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : T(z,lat)

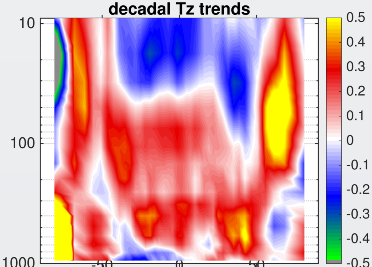
ERA



UMBC Retr Obs

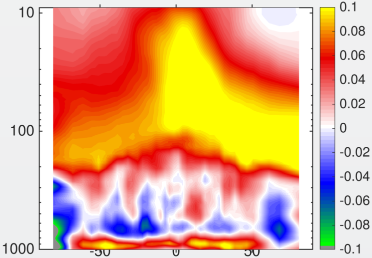


UMBC Retr Calc

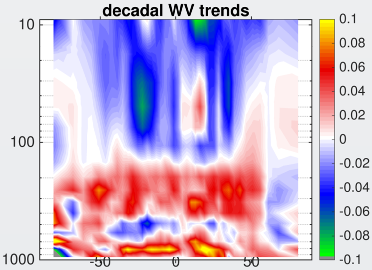


UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : WV(z,lat)

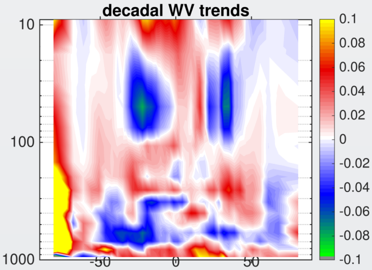
ERA



UMBC Retr Obs

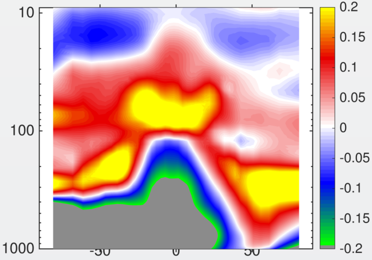


UMBC Retr Calc

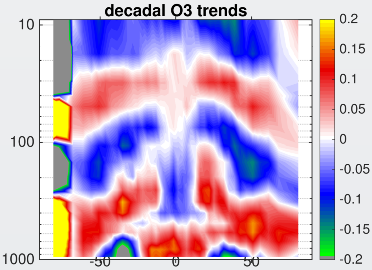


UMBC Retrieved Clear Sky Geophysical Anomalies → Decadal Geophysical Rates : O3(z,lat)

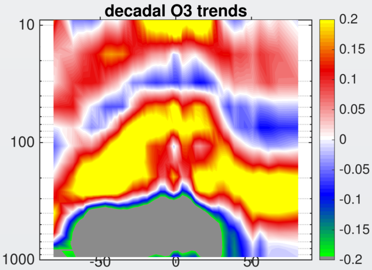
ERA



UMBC Retr Obs



UMBC Retr Calc



AllSky Results

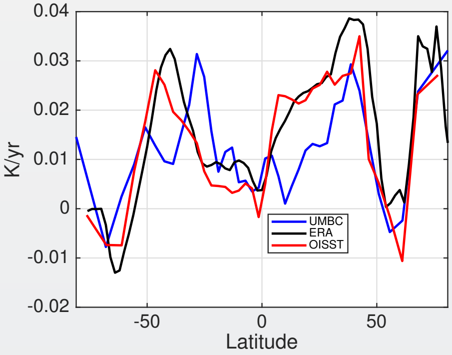
AllSky Retrievals

- 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(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

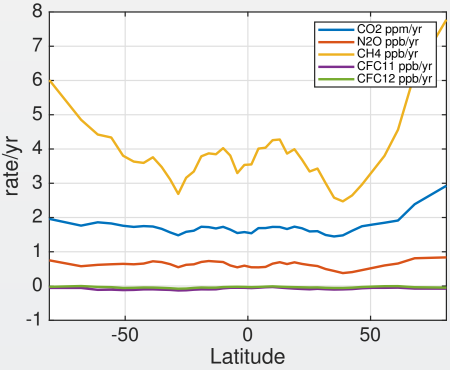
Geophysical rates from spectral rates (contd)

Stemp Rates



This is over ocean only

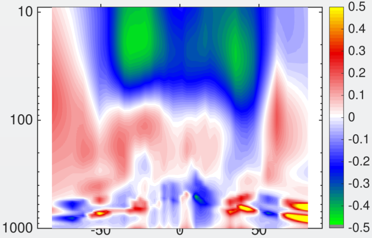
Trace gas rates



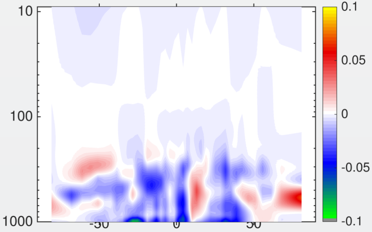
Preliminary work

UMBC AllSky OCEAN Spectral Rates → AllSky Geophysical Rates

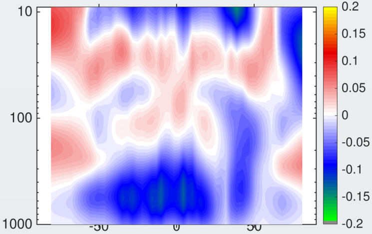
dT(z,t)/dt



frac **dWV(z,t)/dt**

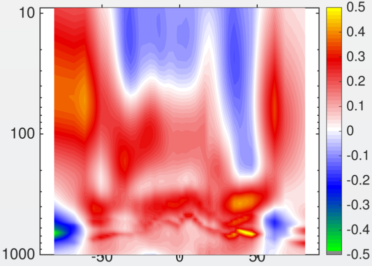


frac **dO3(z,t)/dt**



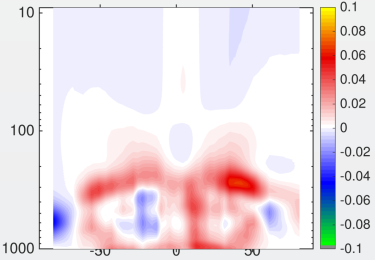
ERA AllSky OCEAN Rates → AllSky AK × Rates

dT(z,t)/dt

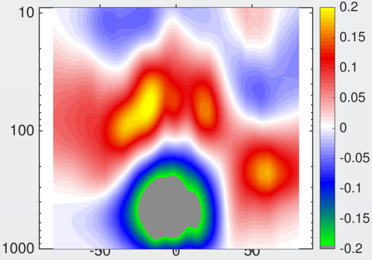


frac dWV(z,t)/dt

X

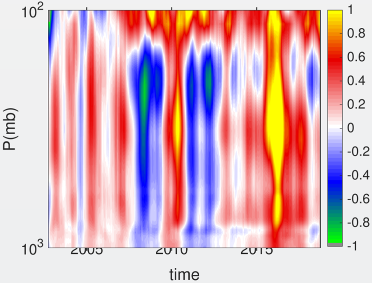


frac dO3(z,t)/dt

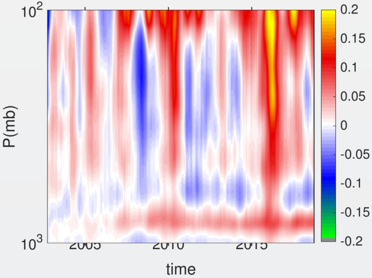


Tropical ERA AllSky Ocean Geophysical Anomalies

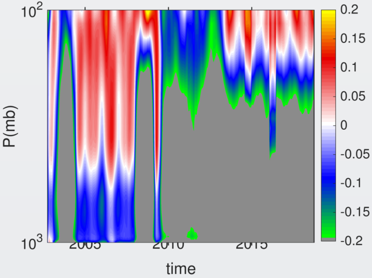
T(z,t)



frac **WV(z,t)**

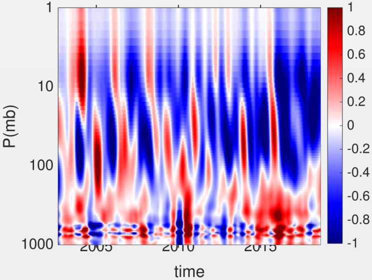


frac **O3(z,t)**

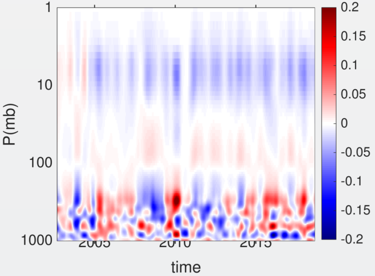


27 N AllSky Ocean Retrieved Geophysical Anomalies

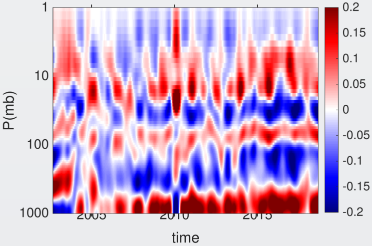
T(z,t)



frac **WV(z,t)**



frac **O3(z,t)**



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 sepearate low cloud from surface temparature
- 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 ballpart 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