# 15 years of Longwave Flux Trends : Roles of CO2, WV, Temperature and clouds, using ERA and AIRS data

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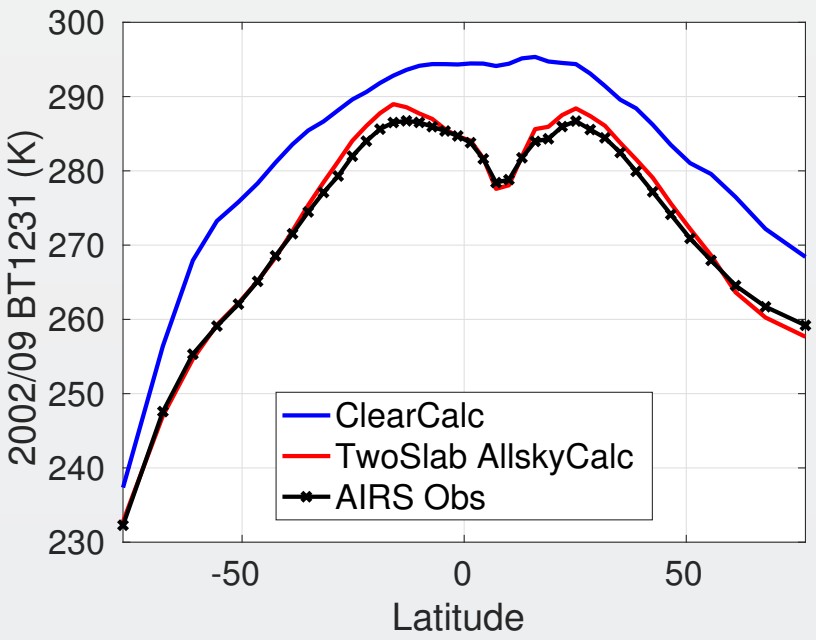
# Overview

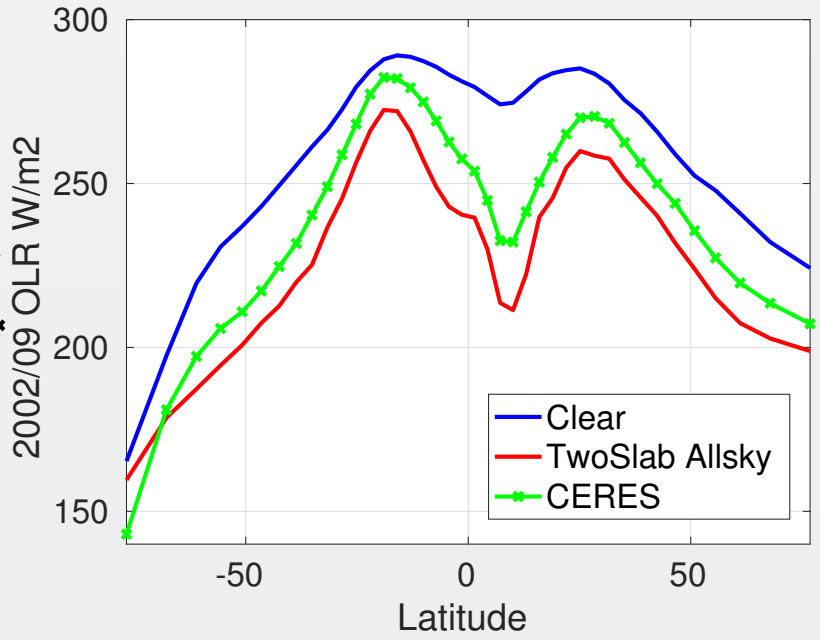
- We are starting to produce long-term trends directly from gridded (time and space) radiances.
- Using an OLR fast model (AER's RRTM) we can compute OLR trends from our retrieved T/Q/cloud, etc trends, and partially validate our observed trends.
- This minimizes bias errors in RRTM (and in our cloud trend assumptions). potentially validate our trends by comparing to CERES OLR trends
- This process is very fast and easy to test in many ways.
- Details on our retrieved thermodynamic and cloud rates (3.20 pm talk by Larrabee Strow)
- Recent interest in Antarctic Fluxes "Unmasking the negative greenhouse effect over the Antarctic Plateau" by Seijas, Taylor, Cai, *Nature 2018* prompted this work as well.

# Total TOA Radiances and Fluxes

TOA BT1231




Fluxes

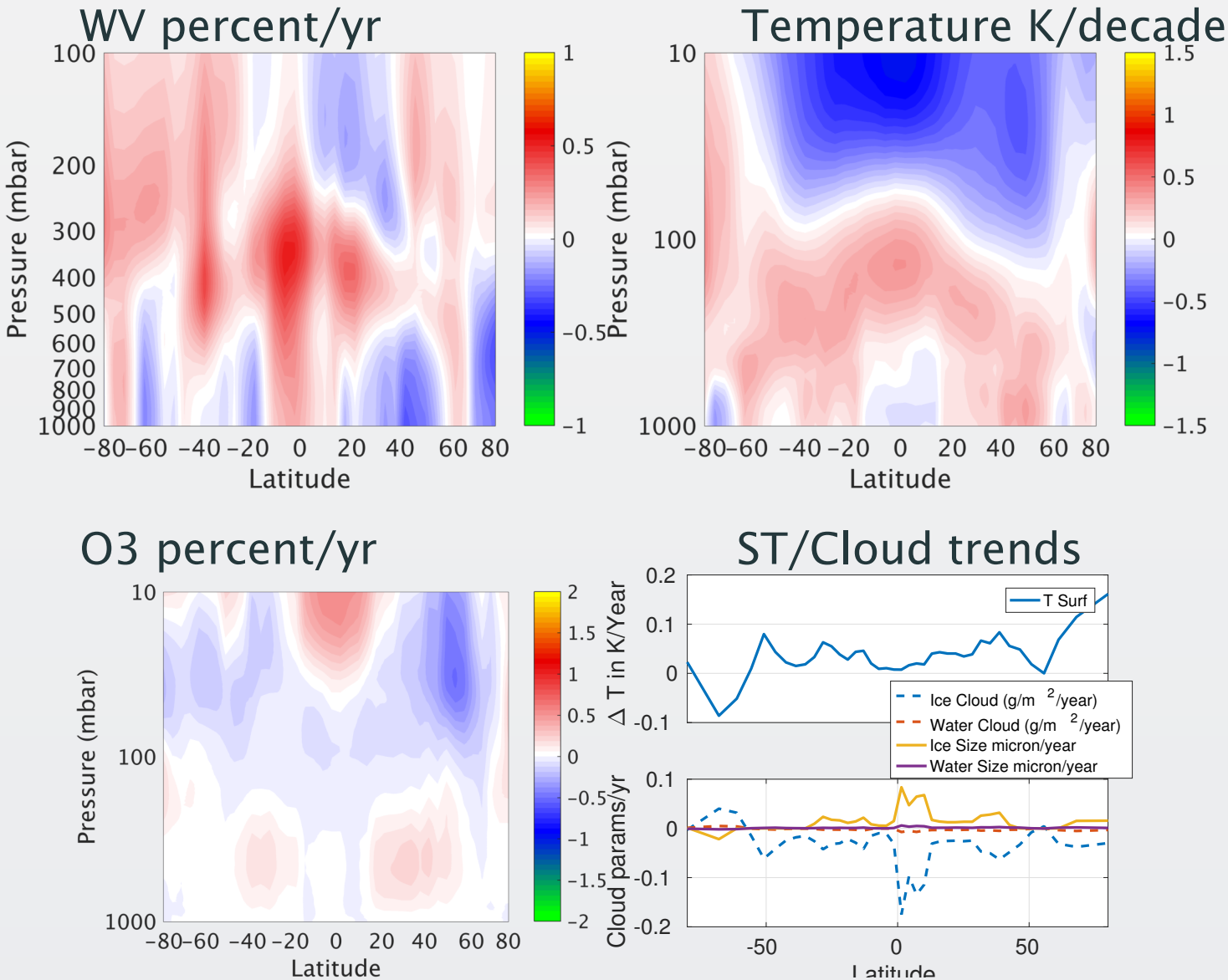



- RRTM : Using TwoSlab clouds, quite approximate.
- $r(\nu) = f_{ice} r_{ice}(\nu) + f_{water} r_{water}(\nu) + f_{overlap} r_{overlap}(\nu) + f_{clear} r_{clear}(\nu)$
- Computed flux has a 10 W/m2 bias relative to CERES, mostly latitude independent

# Flux Changes : Method

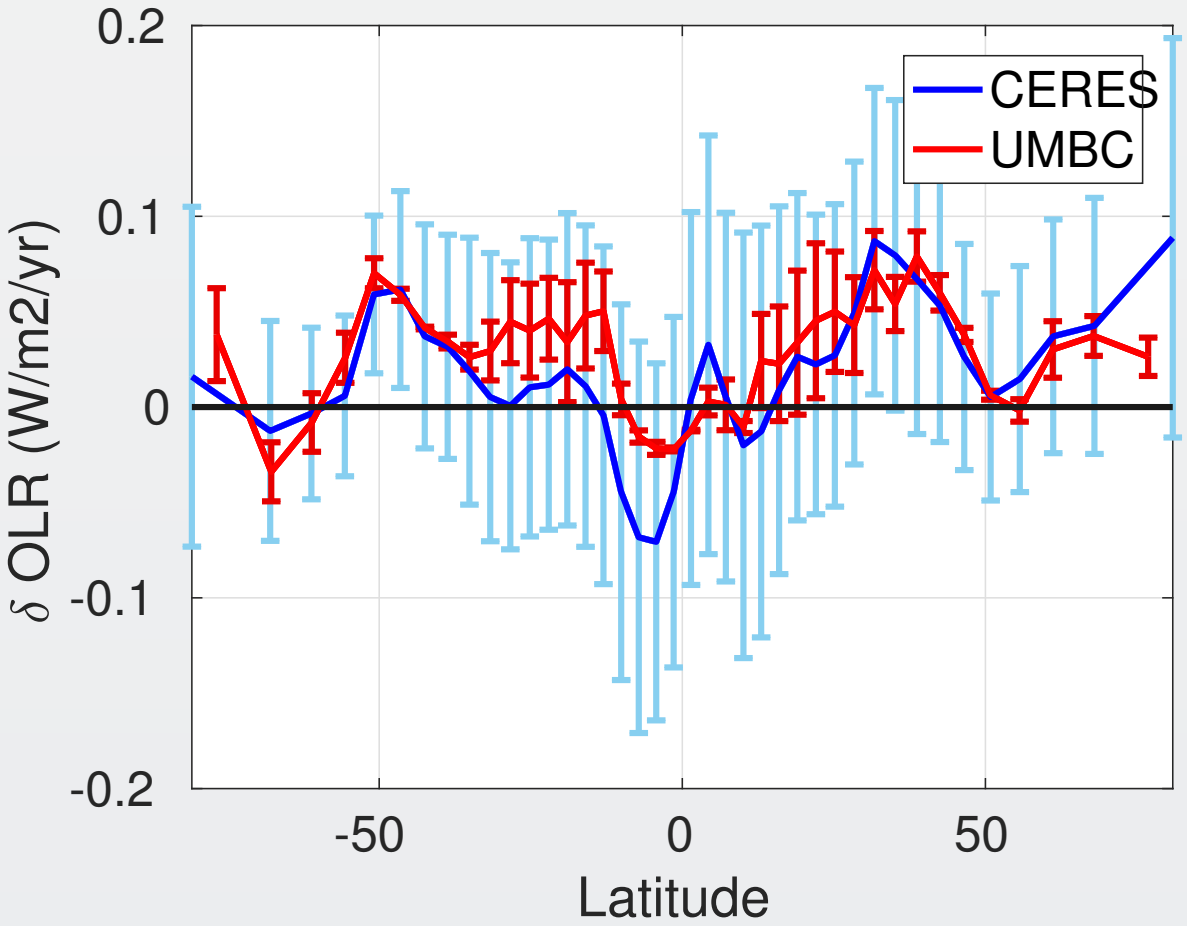
- Start with one averaged profile per zonal latbin, 370 ppm $CO_2$, 1800 ppb $CH_4$, 320 ppb $N_2O$
- Now for next 15 years (180 months between 2002/09 to 2017/08)
  - include UMBC T/ST/Q/O3/cloud trends derived from radiance trends.
  - Add in CO2 change $CO_2(t) = 370 + 2.2/12\delta t$ where $\delta t = (t - 2002/08)$ in months, same for CH4, etc.
- Compute RRTM Clear sky and TwoSlab fluxes for all latitude bins/180 months
- Can take the differences to get $\delta$ OLR

# Geophysical/cloud rates from L1b spectral rates



# Comparison to CERES L3 rates

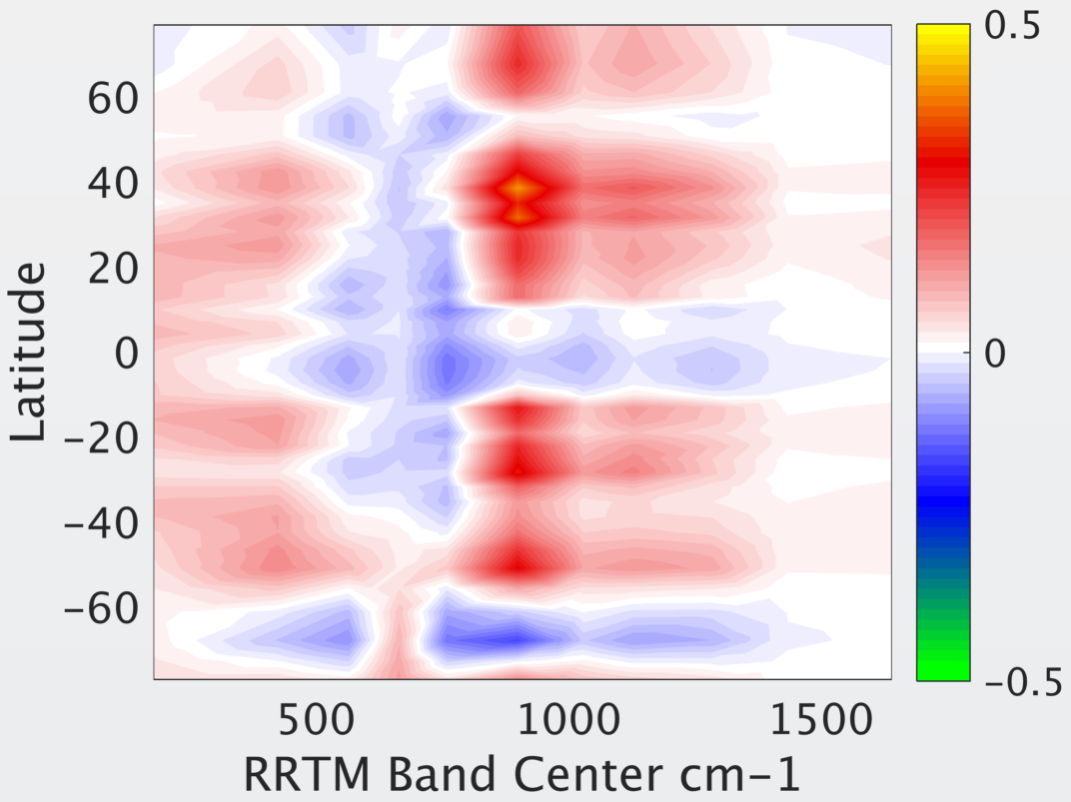
RRTM OLR differences using UMBC trend retrievals.



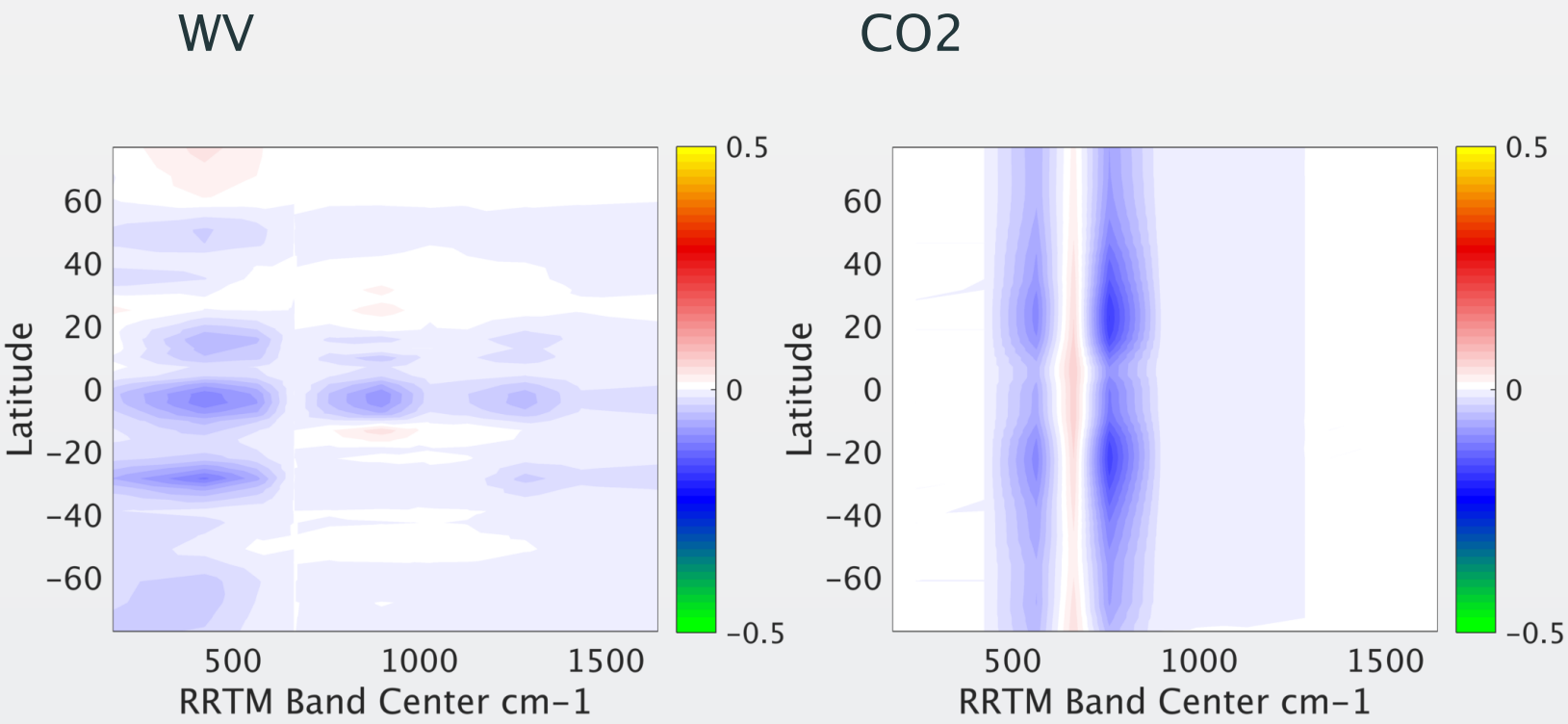

Errorbars : Put in 5% uncertainity for CO2 rates, and errorbars for T/WV/O3/ST/clouds from Larrabee; will improve this

# Flux Changes by RRTM bands: 15 Years

RRTM allows us to break down trends by wavenumber.

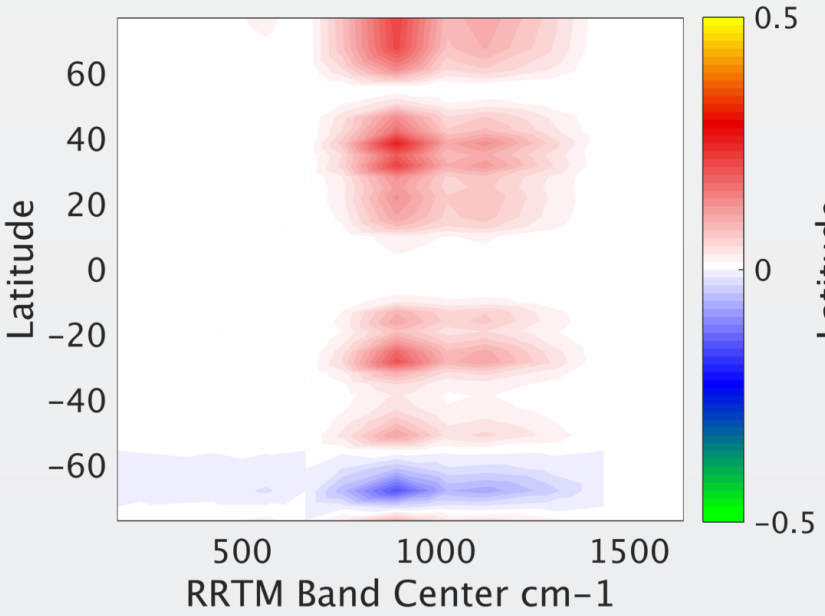


# Breakdown of OLR Differences by Cause: A

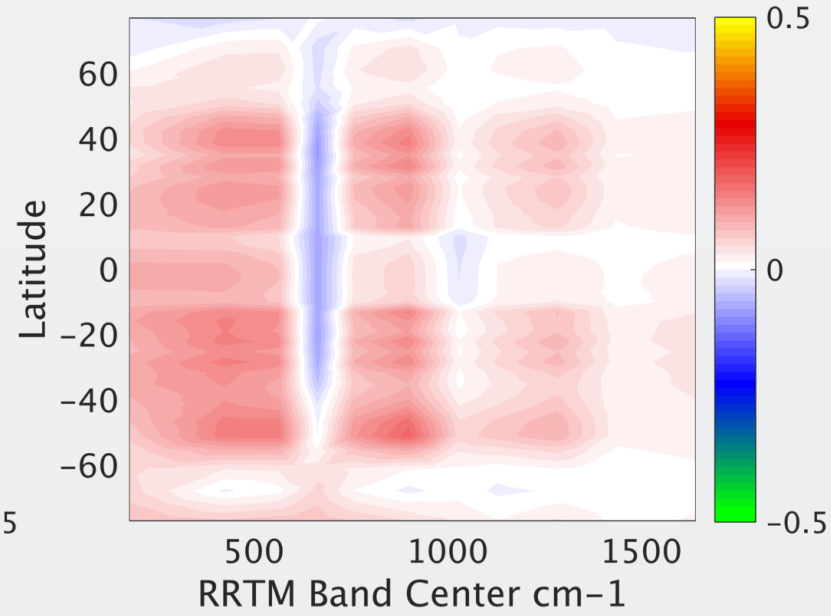


# Breakdown of OLR Differences by Cause: B

Surf. Temp



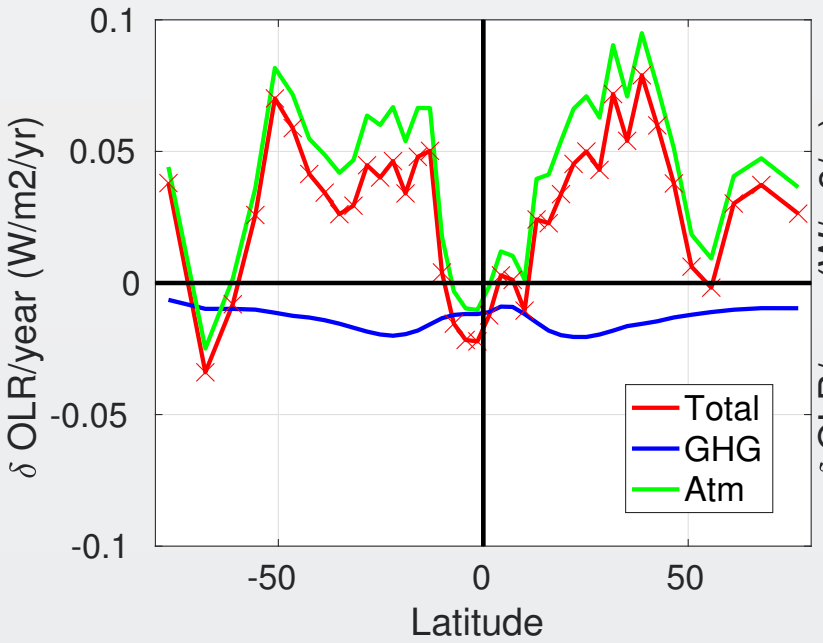

Atm. Temp



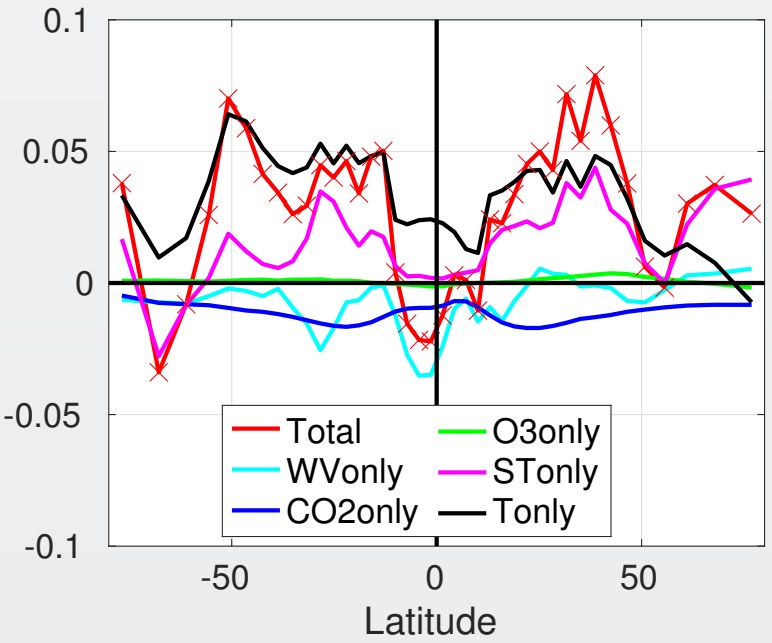
# Breakdown of OLR Differences by Latitude

Integrate the previous results over spectral band to get OLR change versus latitude

Clouds/Atmos/GHG




Ind. Gases




Total = Cloud/Atm/GHG where

Cloud=Water+Ice, GHG=$CO_2$,$CH_4$,$N_2O$, Atm=SurfTemp,T,$H_2O$,$O_3$

Errorbars : TBD for next AIRS STM, cloud signal pretty small

# Discussion

- This is a validation of our spectral trend → geophysical rates
- Need to improve error estimates and cloud geophysical rates
- CO2 flux change contribution < -0.5 of the total flux change (ie reducing the OLR)
- WV flux change contribution is typically very small except at -30 S (-0.5 of the total flux change (ie reducing the OLR)) and at equator where is it -2 of total flux change, leading to overall OLR reduction here
- SurfTemp flux change contribution ~ +0.5 of total flux change (ie increasing the OLR)
- AtmTemp flux change contribution ~ > +1.0 of total flux change (ie increasing the OLR)

Tatm, Tsurf emit more OLR than what GHG (CO2/WV) are trapping
In Southern Ocean region, lowered Surf Temps causing net reduction in OLR

# Conclusions

- Comparison of our trend retrievals to CERES OLR provides partial validation of our trends.
- RRTM allows us to dissect changes to OLR according to spectral region
- TwoSlab fluxes "not too bad"!
- UMBC Spectral Rates → Thermodynamic+Cloud rates good agreement with OLR rates from CERES.
- Need to work more on errors Note the rates are on order of 0.05 W/m2/yr while initial error estimate is about 5-10 times smaller
- To do list : try MRO clouds in RRTM ....