SINGLE FOOTPRINT ALL-SKY RETRIEVALS MORE PROGRESS

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Overview

Outline

- Cloud Representation : NWP multilayer cloud converted to Two Slab Clouds (ice/water)
- AMT paper published Atmos. Meas. Tech., 11, 529-550, 2018 https://doi.org/10.5194/amt-11-529-2018
- Show and tell
  - One day of data (2011/03/11) done overnight on HPC cluster
  - Sonde comparisons (GRUAN/Lindenberg)
  - Include O3(z) in retrievals (previously only column O3)
  - 12 year nadir trends from our retrievals
- Not using diagonal matrices → DOF lower than you expect

UMBC Single Footprint Retrievals using SARTA TwoSlab

Most of AIRS data contains cloud and/or aerosol effects
D of F calculations show there are typically only 2-5 pieces of liquid or ice cloud information SIMPLE CLOUDS!

Convert *N-level* NWP cloud profiles (CIWC(z),CLWC(z),CC(z)) to two randomly overlapping slab clouds (typically one ice/one liquid)

TOA radiance is weighted sum of at most FOUR radiance streams

$$r(\nu) = C_{11} r_1(\nu) + C_{22} r_2(\nu) + C_{12} r_1 2(\nu) + C_{00} r_{clr}(\nu)$$

where $C_{11} = C_1 - C_{12}$, $C_{22} = C_2 - C_{12}$, $C_{00} = 1 - (C_1 + C_2 - C_{12})$
so on average code is x2 slower than SARTA clear

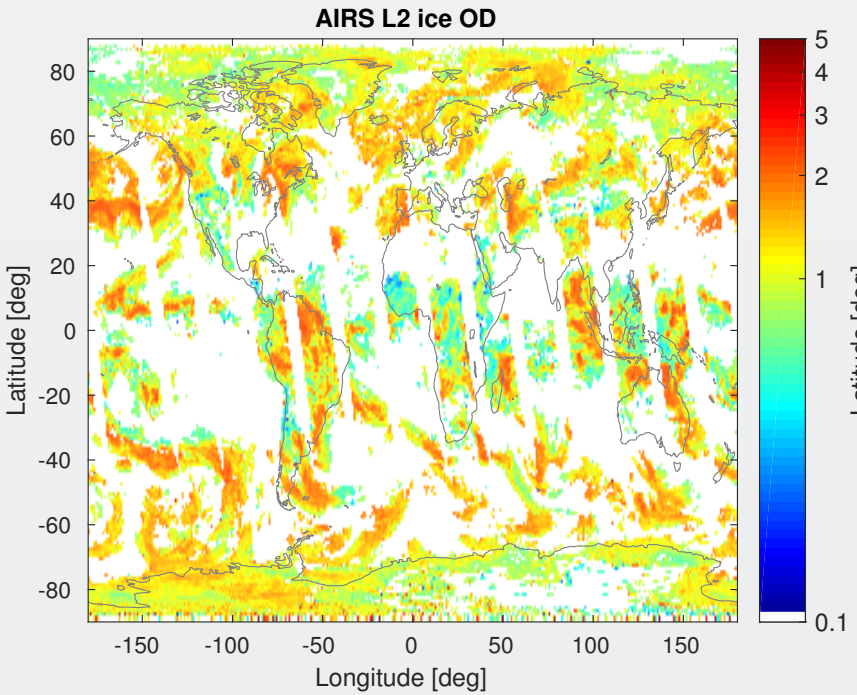
Cirrus : General Habit Model from Ping Yang/ Bryan Baum (2013)
Water : Mie scattering, Particle Size Distribution from MODIS L2

Retrieval cloud *a-priori* comes from matching window channel obs to calcs and using those clouds.

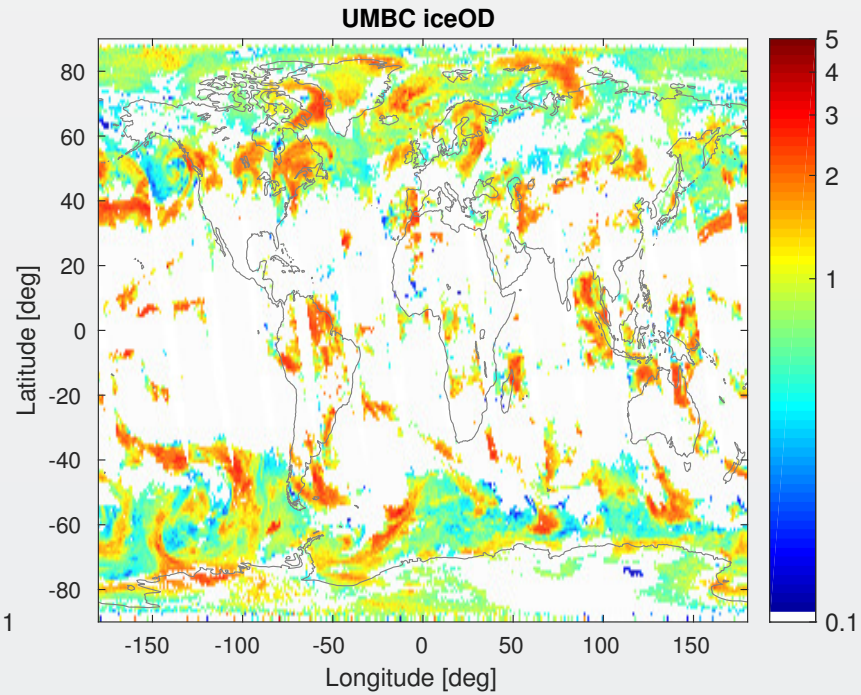
2011/03/11 Global Daytime

Ice Cloud ODs

AIRS L2



UMBC

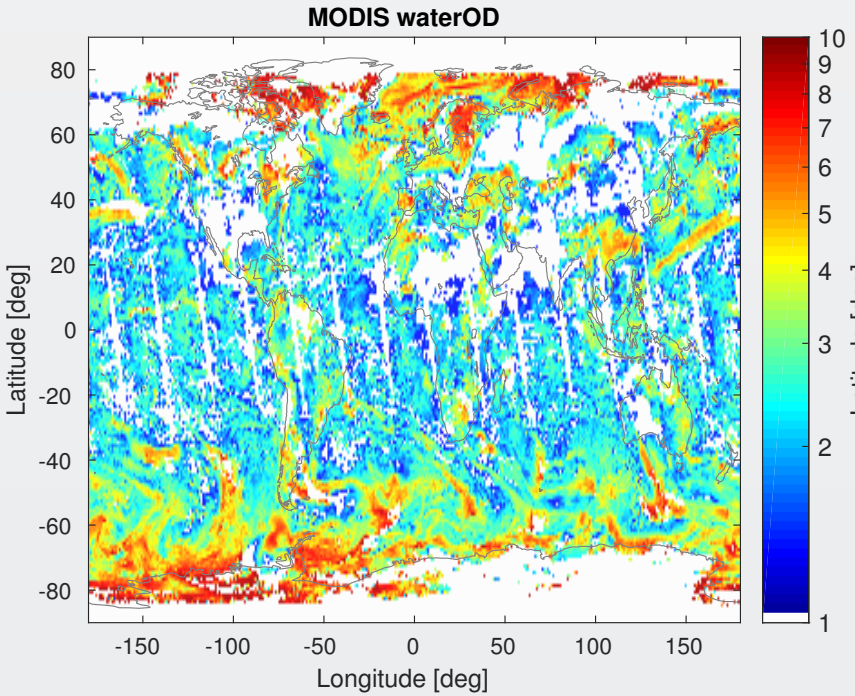


Have looked at cldforcing, and the differences in cloud OD (UMBC vs L2) are typically in regions of "low" forcing, need to investigate further

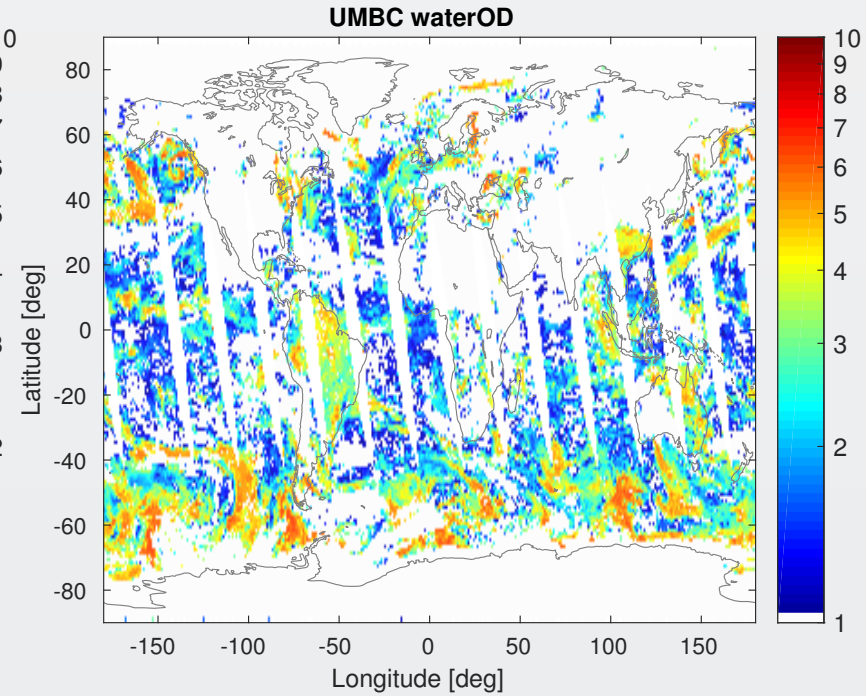
Water Cloud ODs

(different sensor/wavelengths used in retrieval, so expect different magnitude ODs ... but patterns are similar)

MODIS L3



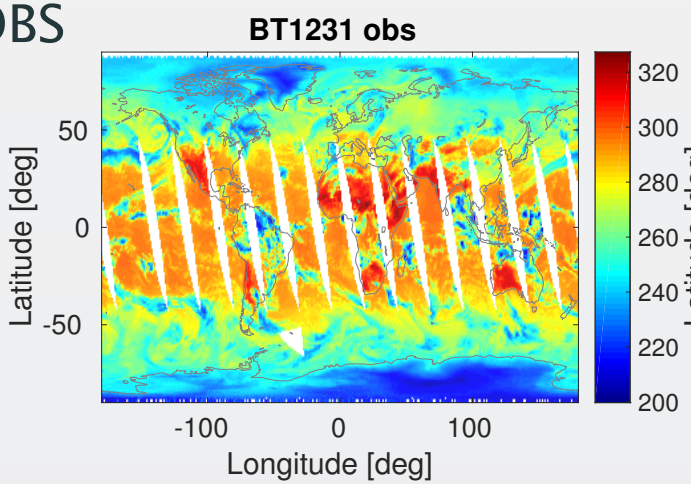
UMBC



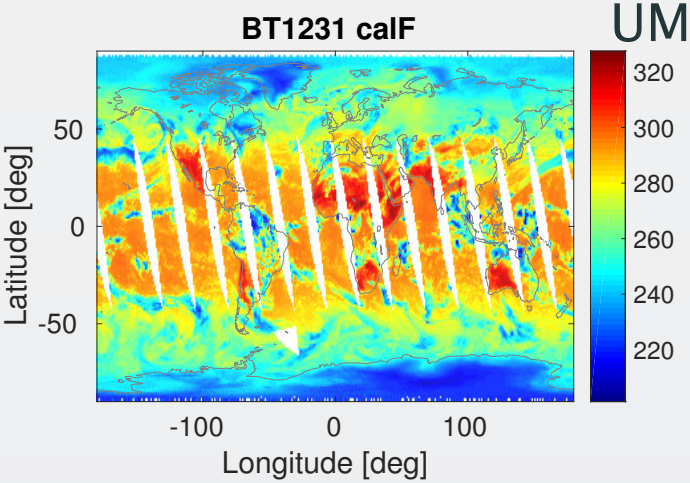
BT1231 (K)

UMBC is after retrieval; ERA is initial matchup

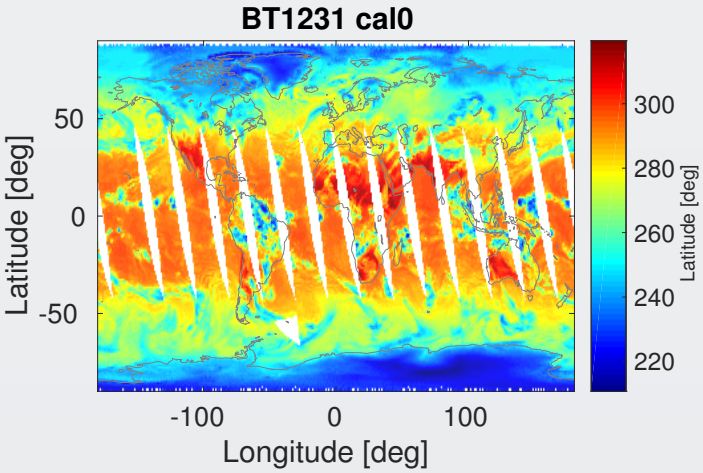
AIRS OBS



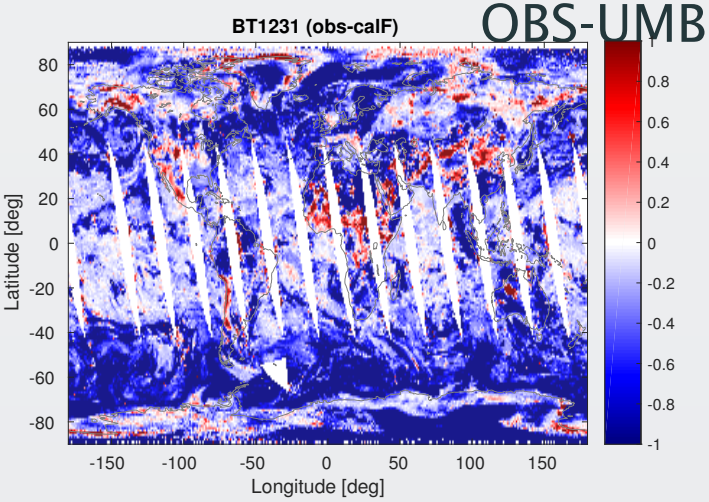
UMBC



ERA

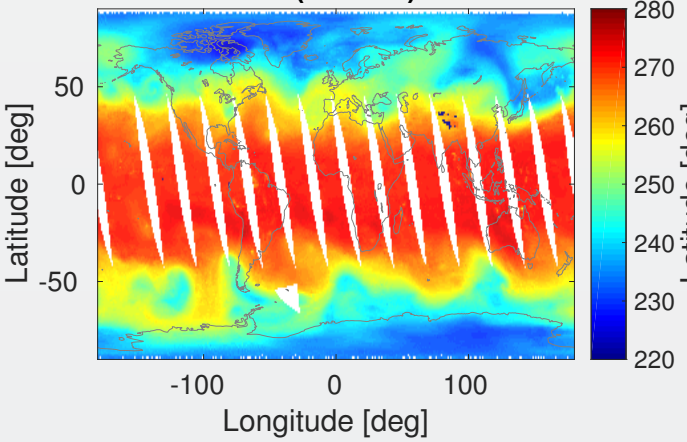


OBS-UMBC

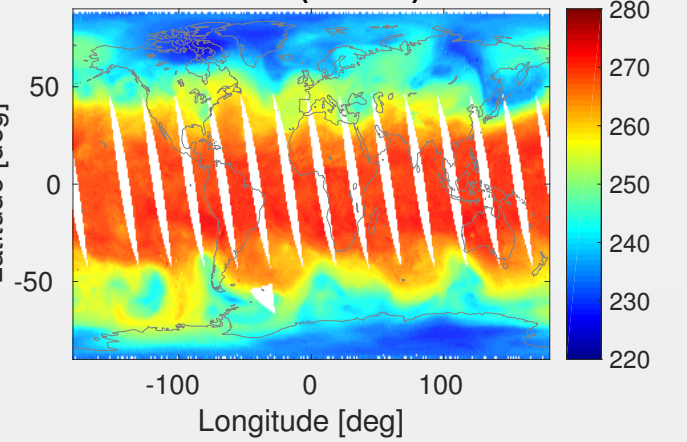


500 mb T(K)

AIRS L2



UMBC



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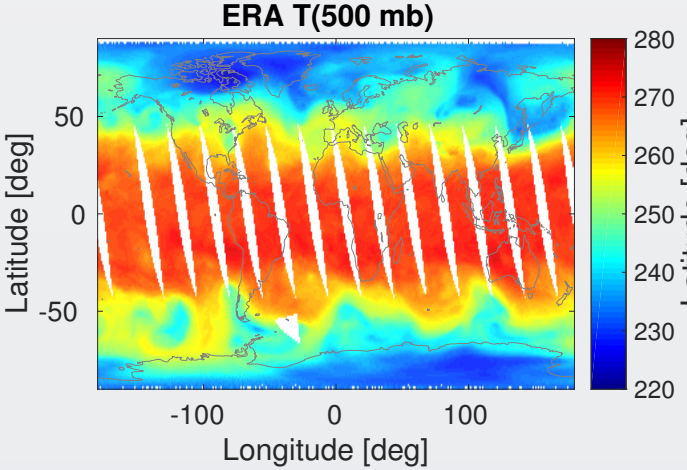
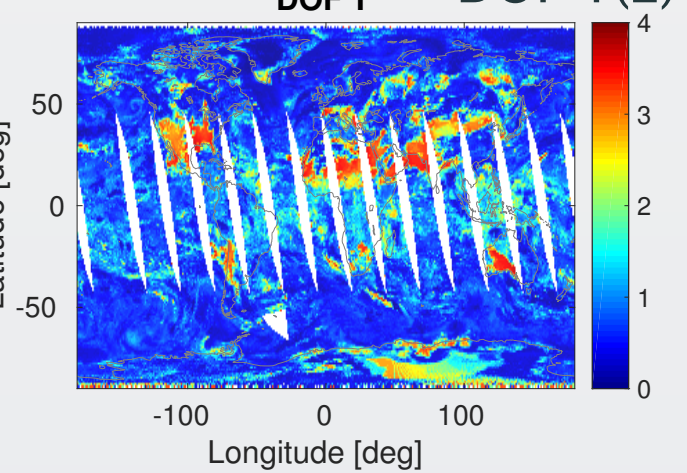
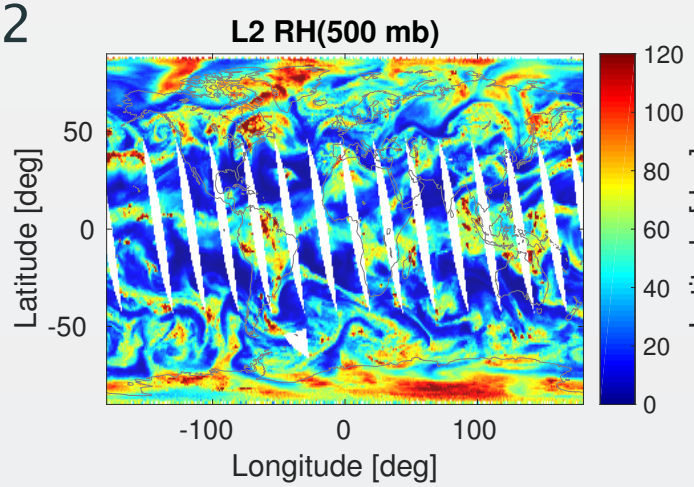


DOF T(z)

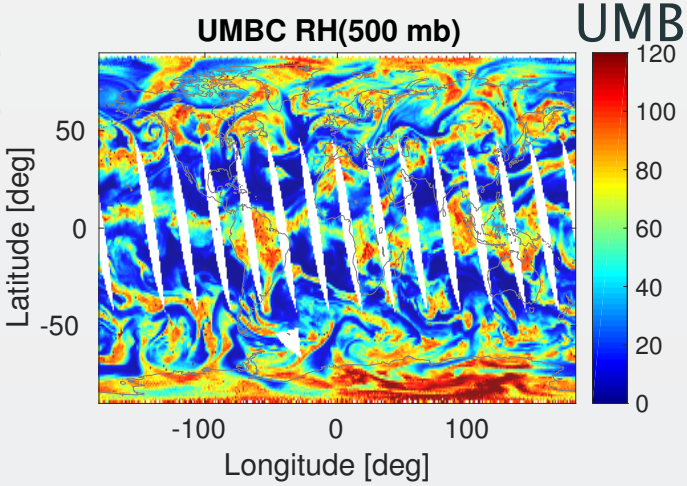


500 mb RH(%)

AIRS L2



UMBC



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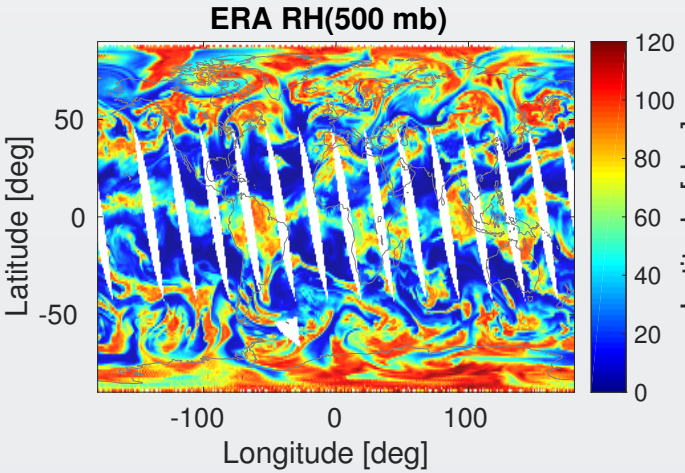
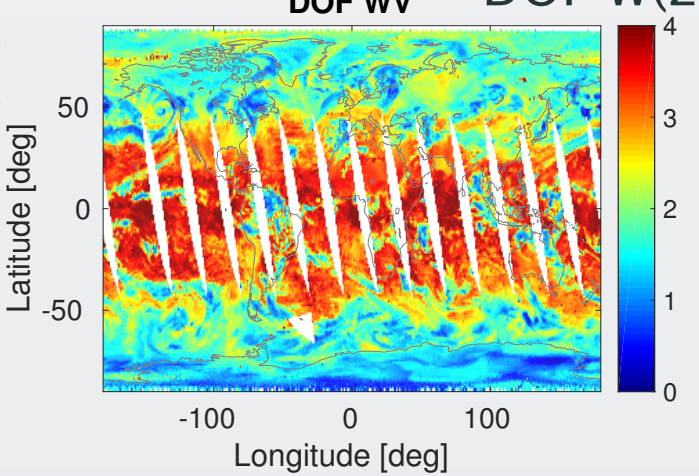


DOF W(z)

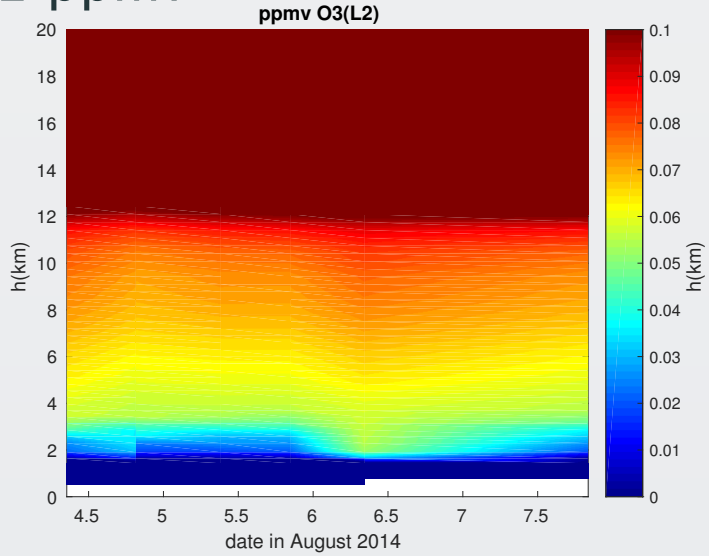


Ozone

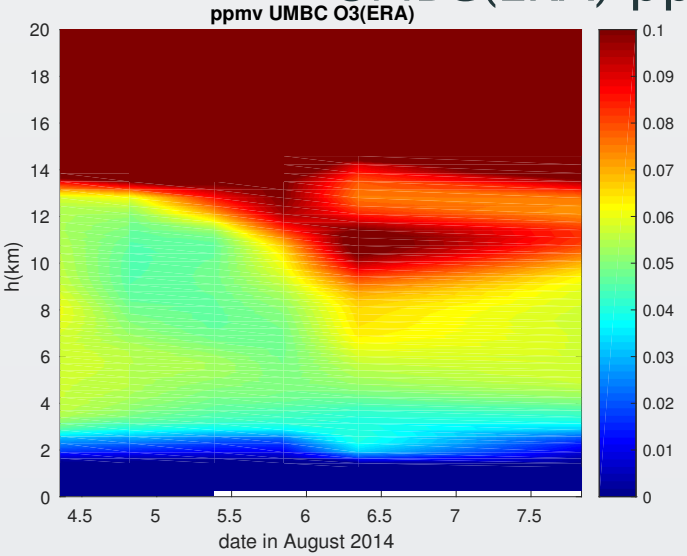
Preliminary O3 retrievals Aug 2014

- strat/trop exchange event Fort Collins, CO Aug4-8, 2014
- matched AIRS L1b to ERA
  - the ERA profiles showed this intrusion
  - retrieval slightly altered profiles from 9-12 km
- matched AIRS L1b to climatology
  - the initial guess was smooth
  - my retrieval could not get the intrusion
- no evidence of intrusion in AIRS L2

AIRS L2 ppmv



UMBC(ERA) ppmv

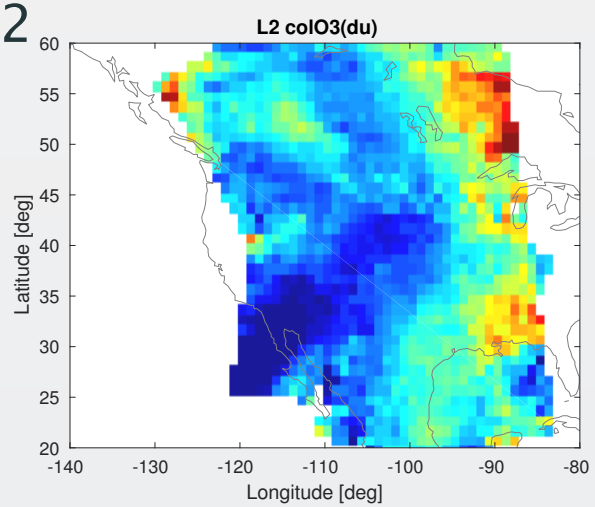


Col O3 amounts (du)

Averaged over Aug 4-7, 2014

Remember climatology start was very smooth (used in lower left)

AIRS L2



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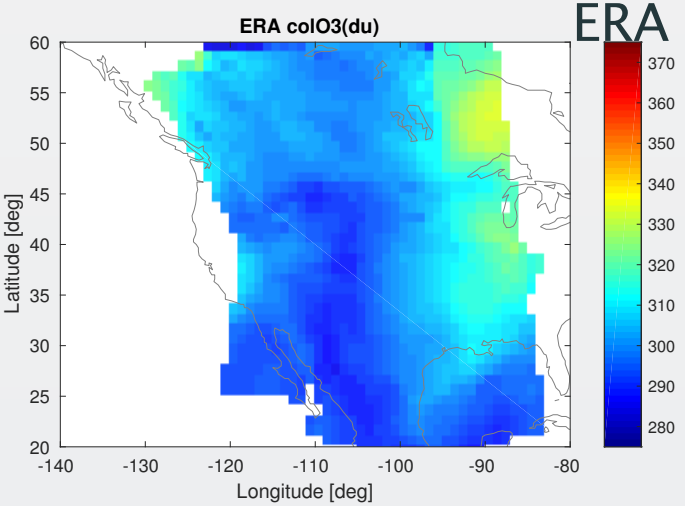
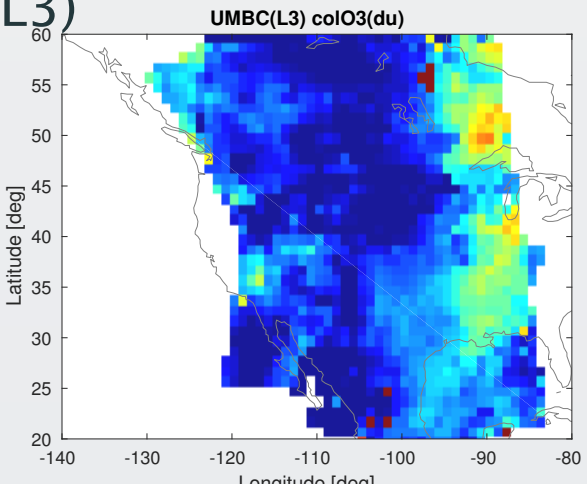
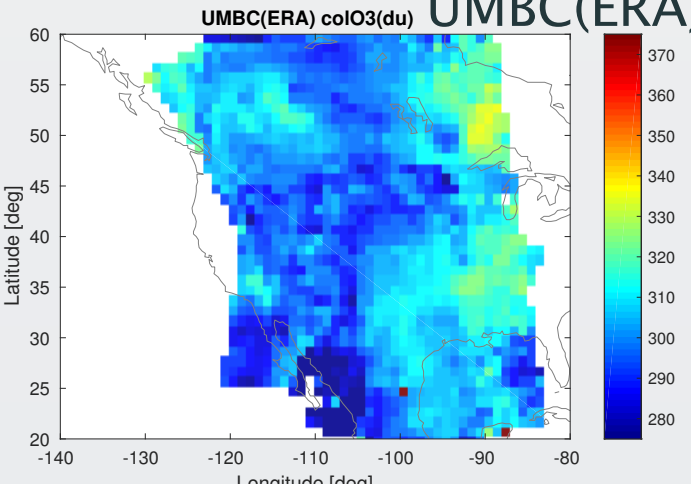


UMBC(L3)



UMBC(ERA)



12+ years

Climate : 12 years of AIRS data (09/2002-08/2014)

- Larrabee and I present talks on deriving geophysical rates from 14+ years of AIRS radiance trends
- Take the SAME 1-2% of AIRS data, from daily random allsky nighttime area weighted nadir AIRS observations
- Start with monthly climatology (with temporal and spatial varying CO2 amount), do OEM retrieval on EACH of these 8000 obs/day, bin the results and find geophysical trends from retrieval
- Have only done one set of retrievals, took about 2-3 weeks
- Plan is to reprocess the retrieval of both the binned radiance trends and these actual physical retrievals, to understand how to improve overall climate product.

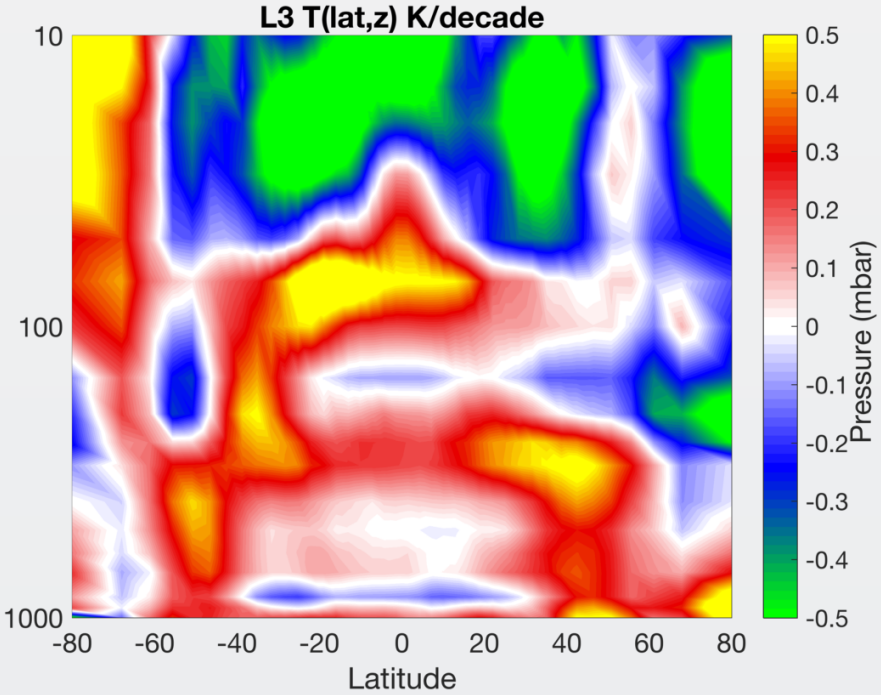
Processing times

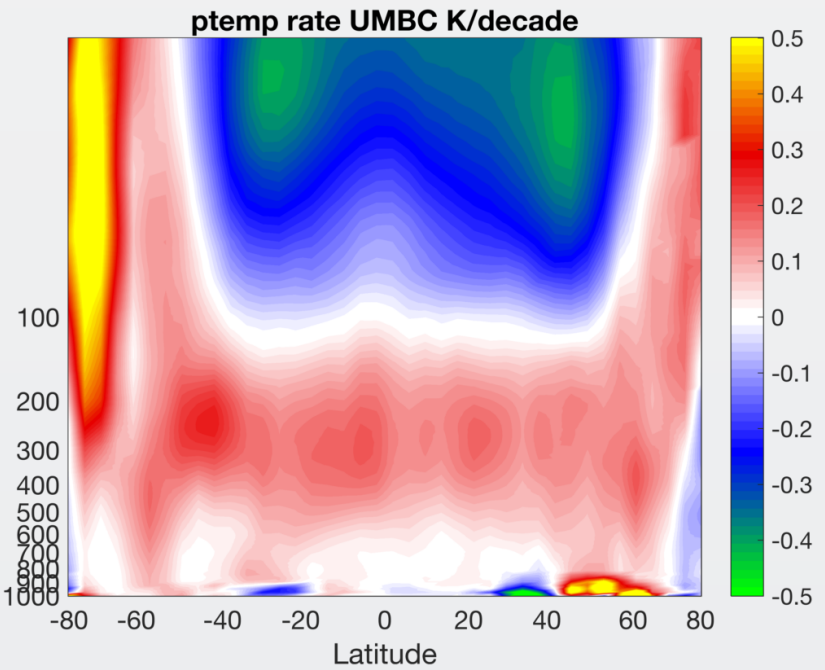
Task (Granule)	Language	Run time
Pre-Processing L1B data		
co-locate NWP fields to AIRS	Matlab	30 secs
change NWP fields to slab clouds	Matlab	70 secs
change levels to layers	f77	8 secs
compute SARTA clear radiances	f77	3.9 mins
compute SARTA allsky radiances	f77	6.1 mins $\sim$ 0.03 secs/FOV
Actual OEM 100 layer retrieval	Matlab/f77	8 hours < 2.5 secs/FOV

- AIRS L2 = 1.5 s/FOR, , NUCAPS = 0.3 s/FOR, UMBC < 2.5 s/FOV
- Typical area weighted sampling of daily AIRS $\sim$ 10000 FOVs
- Multiple days can easily be processed on a High Performance Cluster (HPC) in an embarrassingly parallel mode
- Following results produced in 2-3 weeks (processed 12 years of the sub-sampled ($\sim$ 8000 night-time observations per 24 hour) AIRS data on 128 processors)

UMBC decadal temperature trends

Start with ERA thermodynamic/cloud fields
Colorbar dT(z)/dt K/decade)





AIRS L3 trends

UMBC retrieval trends

One Trial Run Only!!

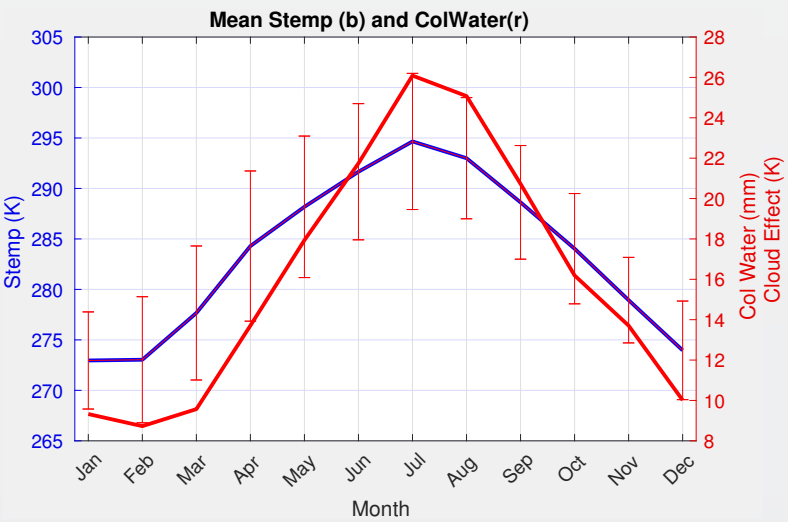
Sondes

Lindenberg, Germany GRUAN sondes
52.21N, 14.12 E, 98 m asl

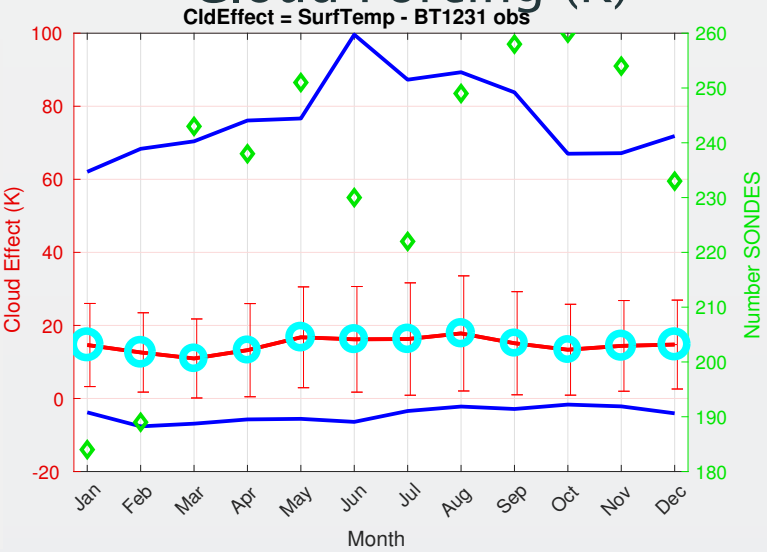
- 3200 sonde launches over a few years, ($\sim$ 220 each month)
- Select AIRS ovepasses within $\pm$ 1 hour and 100 km of sonde launch, gives 80-100 "nearest" AIRS obs per sonde
- Match AIRS observations to ERA thermodynamic/cloud profiles (252455 "nearest" AIRS obs)
- Compare retrievals to sonde, sonde*AK and ERA
- Look at results as function of DOF

Monthly surface and cloud variability

Surf temp and col water



Cloud Forcing (K)

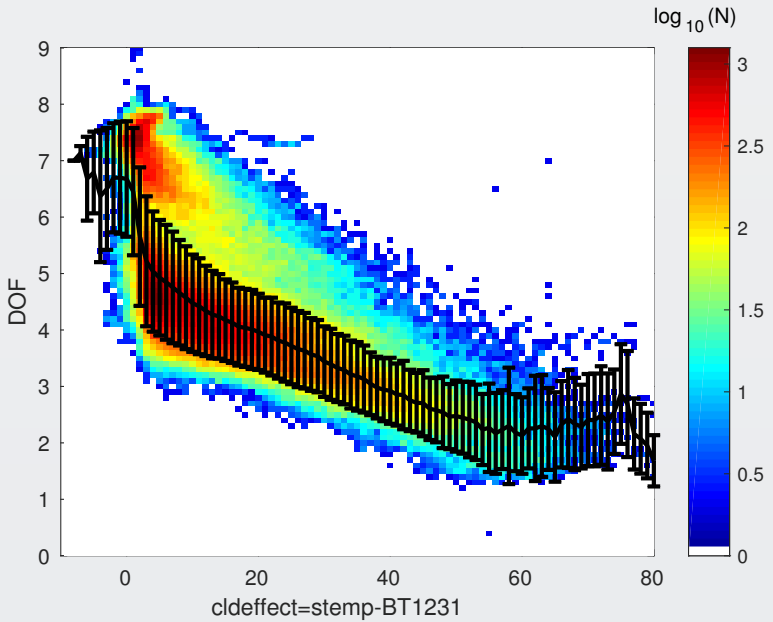


- left panel - average surface temps varying over 265-300 K
- left panel - average column water varies over 8-28 mm
- green circles on right panel show about 220 sondes per month total launches over the years
- cyan circles on right panel show mean cloud effect (stemp-BT1231 obs) of about 16 K, while there could be very thick high clouds (cld effect ~ 100 K)

Sonde-UMBC Retrieval

Divide the retrievals in quantiles of DOF, look at 4 quantile ranges

Cloud condition	Quantile range	DOF range	CldEffect(K) (rough)	Number AIRS obs
Very Thick cloud	0.0-0.1	0.00-3.12	> 50	2769
Thick cloud	0.1-0.5	3.12-4.29	20-50	43699
Medium Cloud	0.5-0.9	4.29-6.84	2-20	84579
Thin/no cloud	0.9-1.0	6.38-8.65	< 2	24742



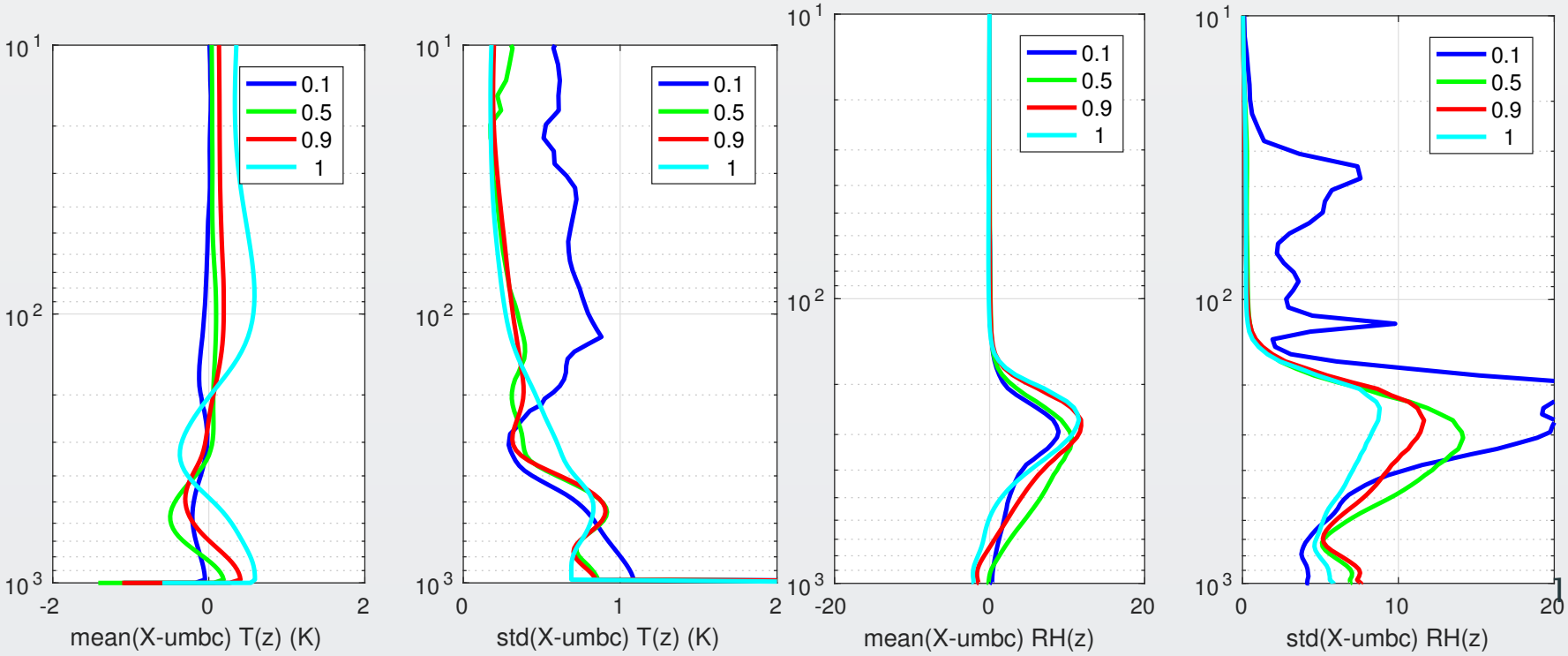
Sonde-UMBC Retrieval

Divide the retrievals in quantiles of DOF, look at 4 quantile ranges

As expected biggest problems when clouds are thickest (low DOF);

otherwise <sonde-retrieval> is typically within 1 K, 20% RH

T(z) RH(z)



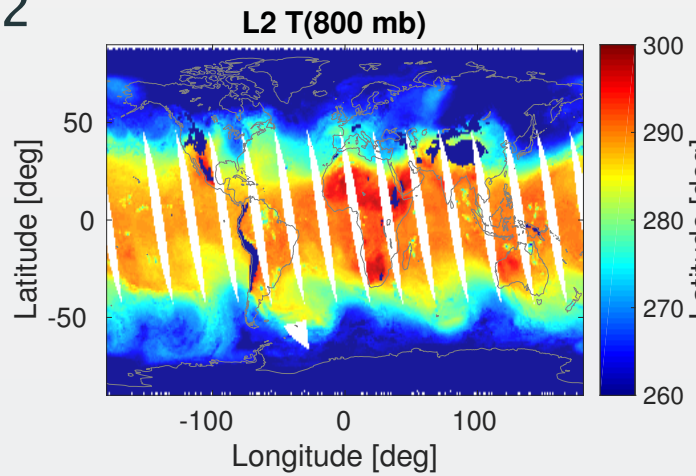
Conclusions

- PROS
  - Reasonable use of re-analysis a-priori, incl. cloud fields
  - Cloud a-priori allows most retrievals to converge
  - Retrieval agorithm is fast (coupled to scattering RTA)
  - typically have about 90% yield ECM and 80% yield CLIM
- CONS (aka not enough time to do myself!)
  - no work done to optimize eg regularization
  - need YOUR help in validating
  - QA is still rather ad-hoc
- Improvements (TBD)
  - Larrabee/Howard have the AIRS → CrIS conversion in great shape, so can use same AIRS2CRIS algorithm to get long term radiance time series
  - AIRS observation noise covariance
  - further tune parameter covariance matrices and channels, trapezoid jacs?
    - looser constraints for climatology than ERA/ECM/MERRA

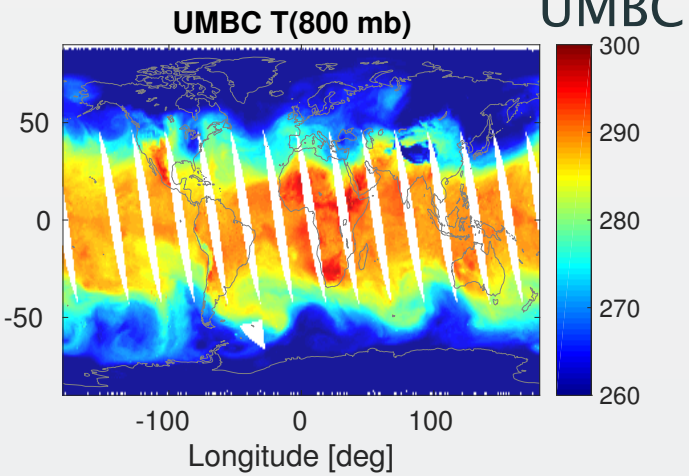
Extra Slides

800 mb T(K)

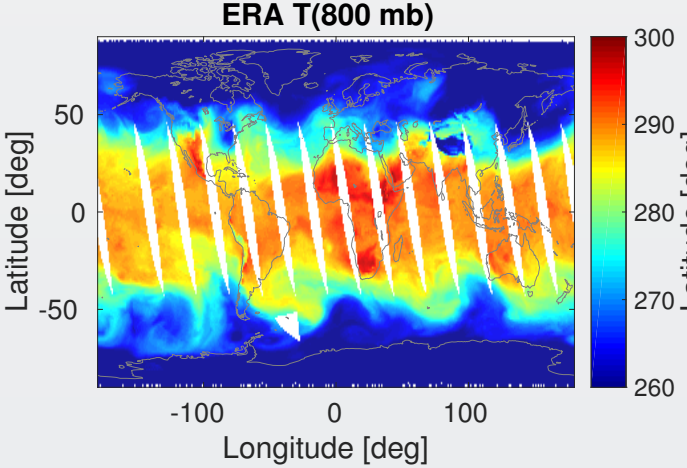
AIRS L2



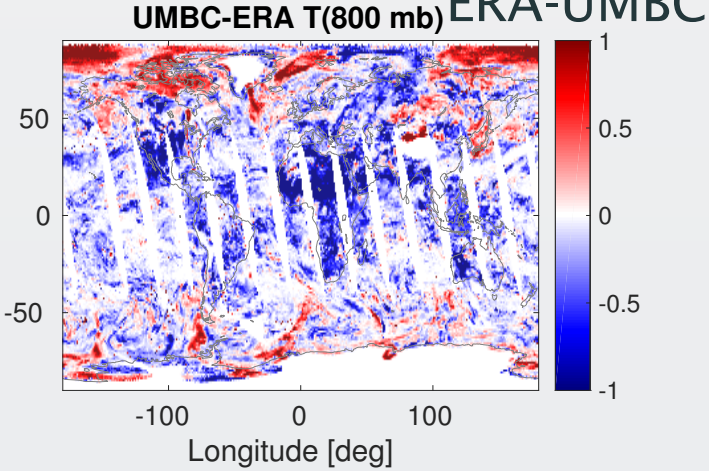
UMBC



ERA

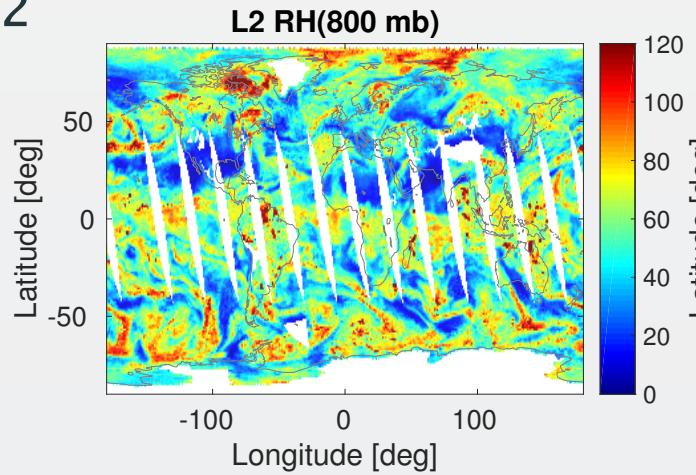


ERA-UMBC

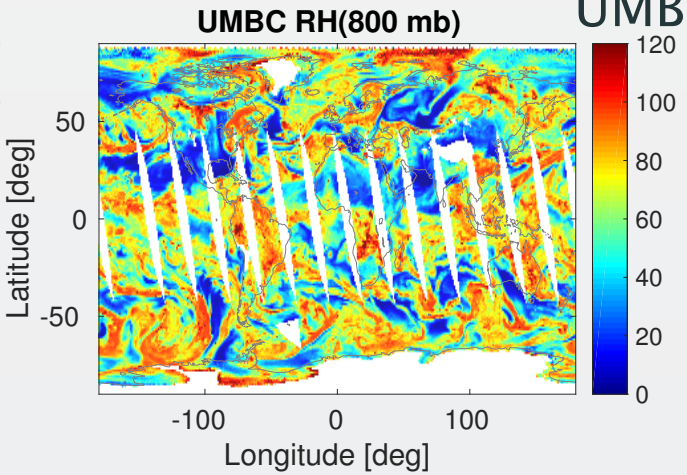


800 mb RH(%)

AIRS L2



UMBC



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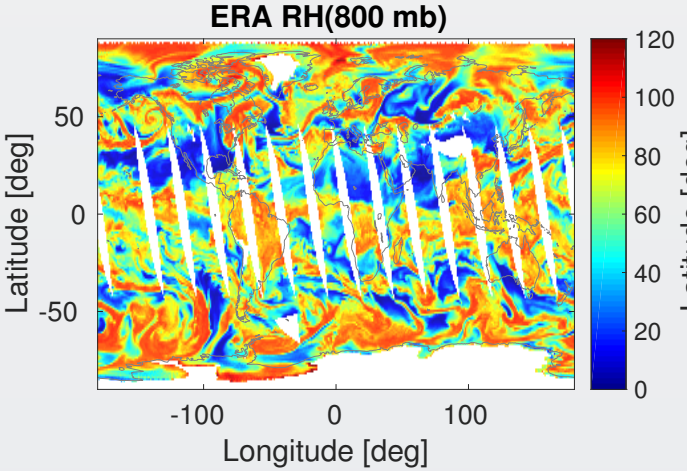
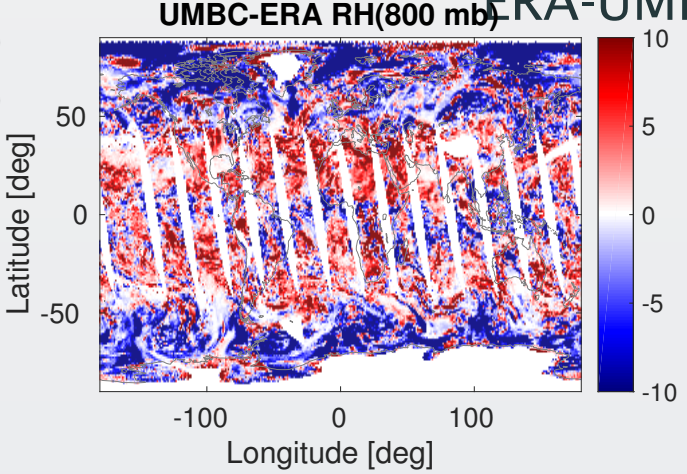
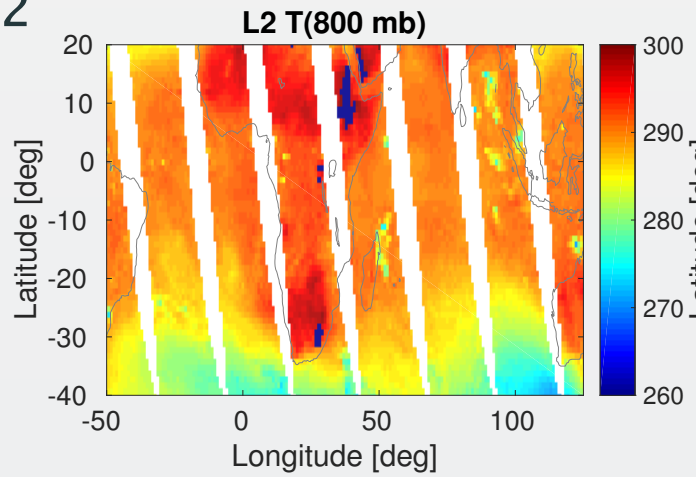


ERA-UMBC



800 mb T(K) zoom

AIRS L2



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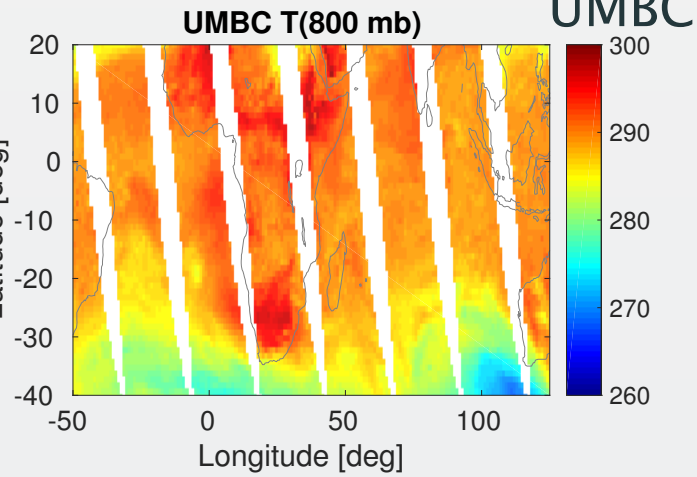

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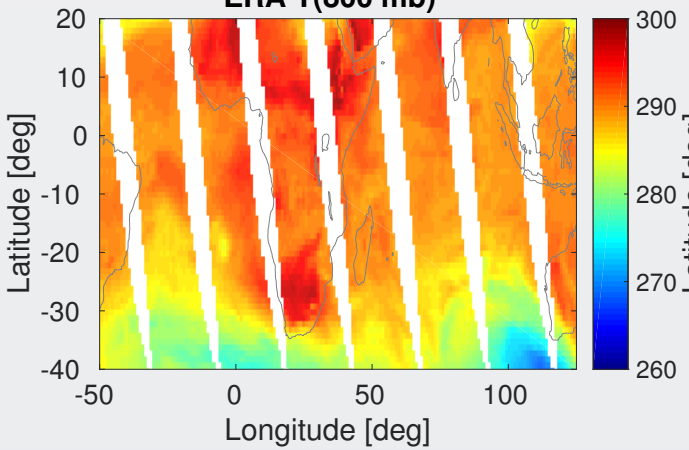
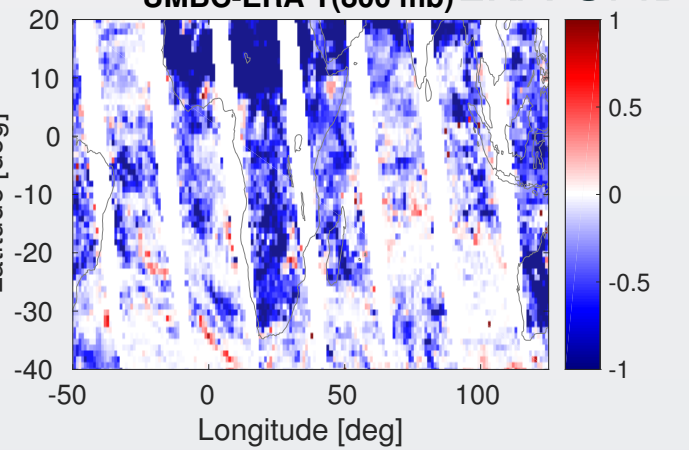
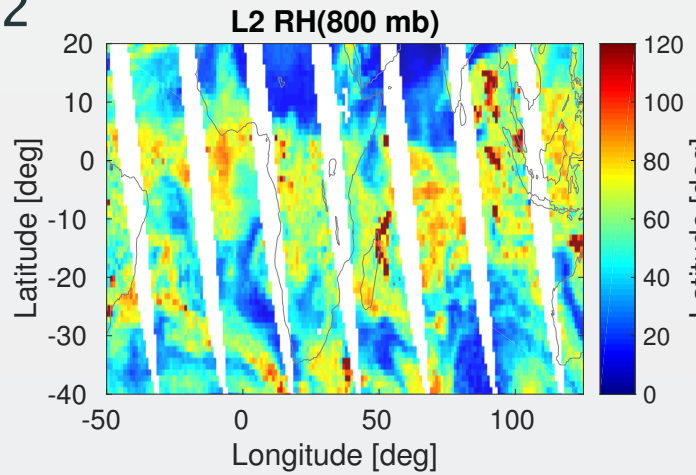


ERA-UMBC

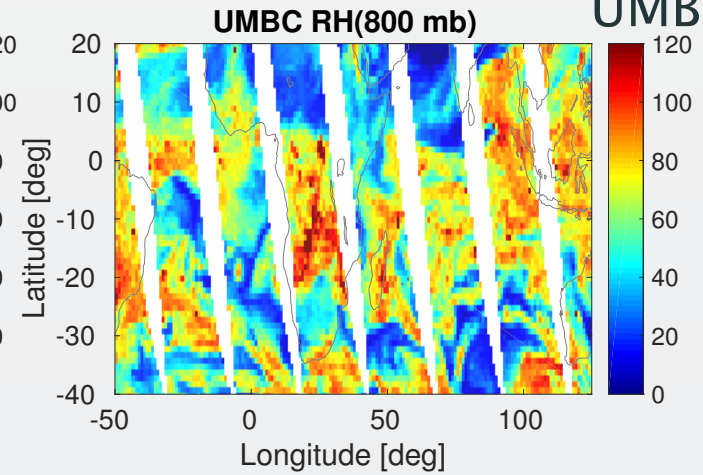


800 mb RH(%) zoom

AIRS L2



UMBC



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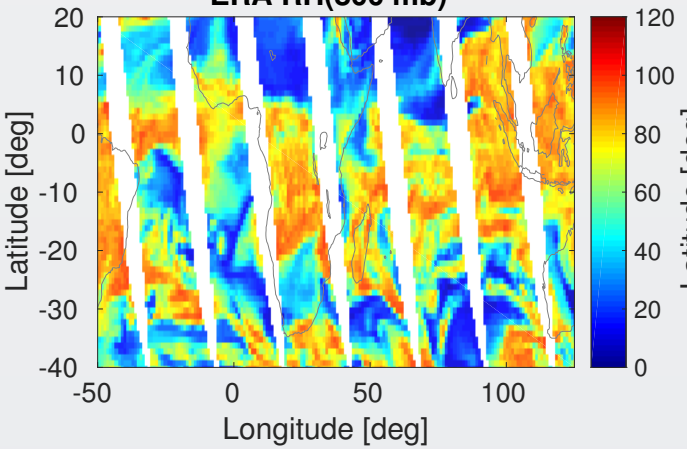

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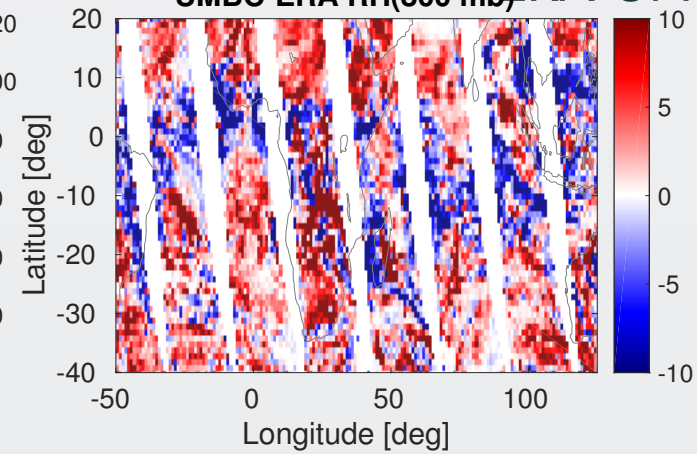
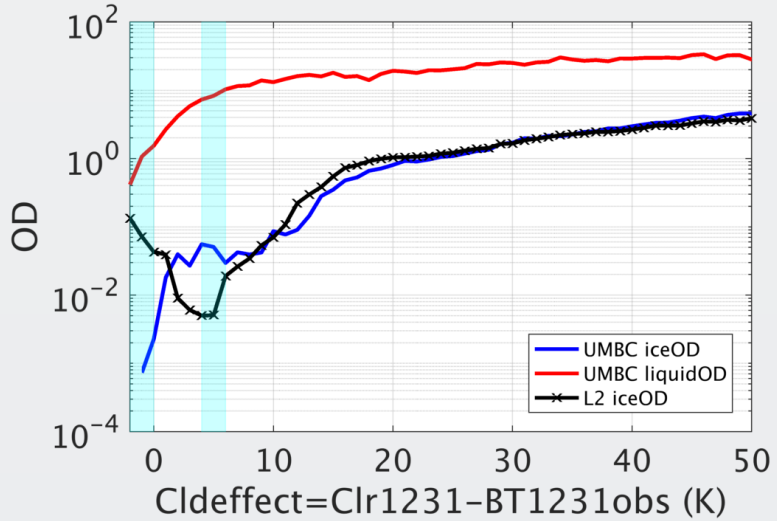


Cloud Forcing and Cloud OD

L2 iceODs turns around at low cloud forcing???
Cld Forcing = Clrsky calcs (using ERA) - BT1231 obs

- using region included in above zooms
- this should include surface temp and take out effects of water vapor



Cloud Top Hgt

Have pruned for daytime, ocean, cloud OD > 0.10 ... I have a anomously high count at 9 km, even accounting for his stats being nadir (CLoudSat/Calipso) for one week (of Jan 2007) and mine are for one day/all angles (2011/03/11).

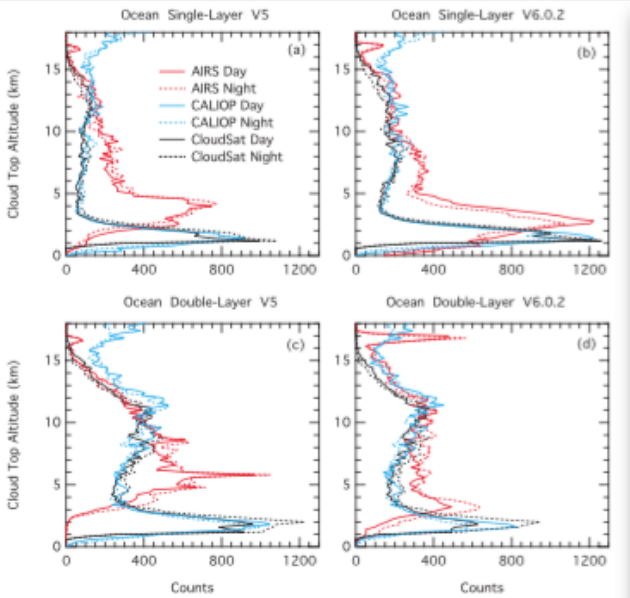


Fig. 3. Cloud top height Z_C frequency for AIRS v5 (left column) and v6 (right column) over the ocean for single-layered cases (upper row) and two-layered cases (lower row) for a one-week period in January 2007. The CloudSat and CALIOP collocated Z_C is also shown on each panel. The CloudSat and CALIOP observations are very similar, but not exactly equal to each other, between the different panels because of slight changes in the AIRS cloud detection between v5 and v6.