SINGLE FOOTPRINT ALL-SKY RETRIEVALS MORE PROGRESS

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Overview

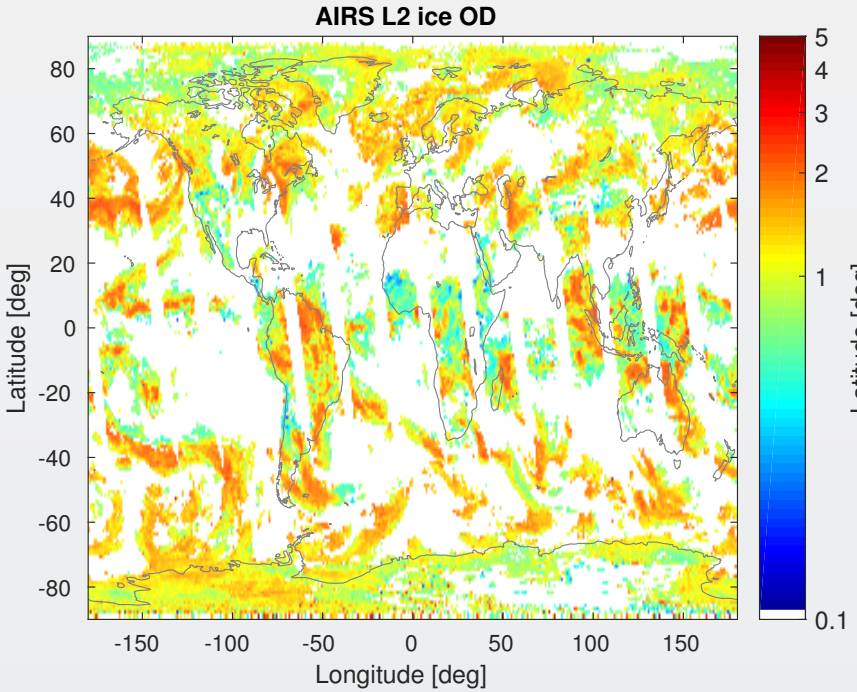
Outline

- Cloud Representation : NWP multilayer cloud converted to Two Slab Clouds (ice/water)
- AMT paper accepted 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

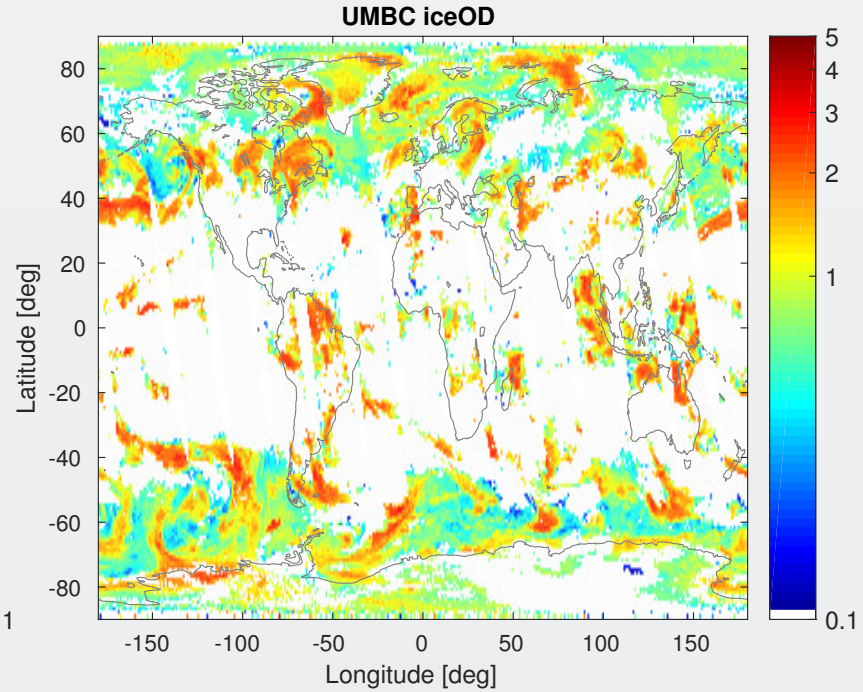
2011/03/11 Global Daytime

Ice Cloud ODs

AIRS L2



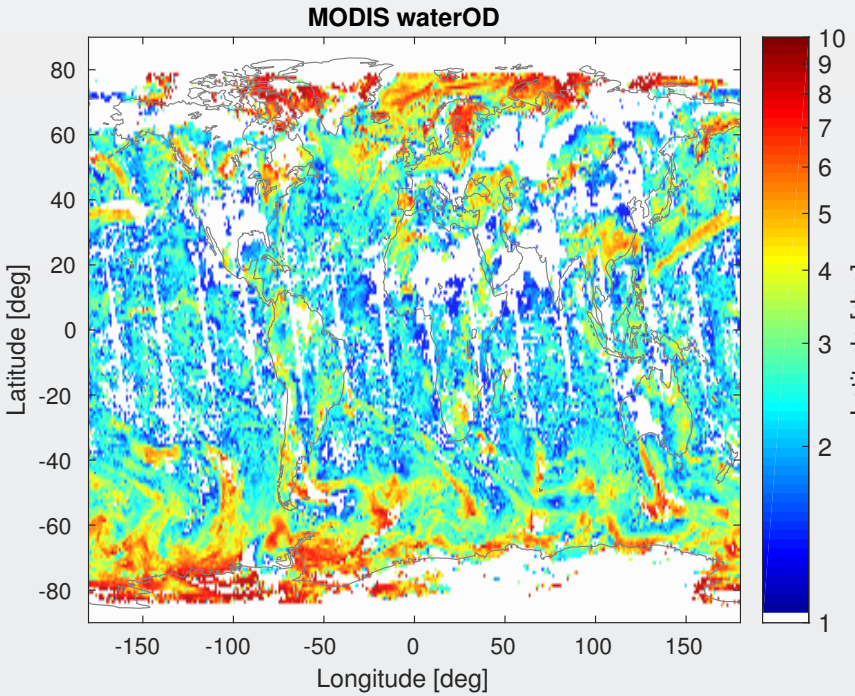
UMBC



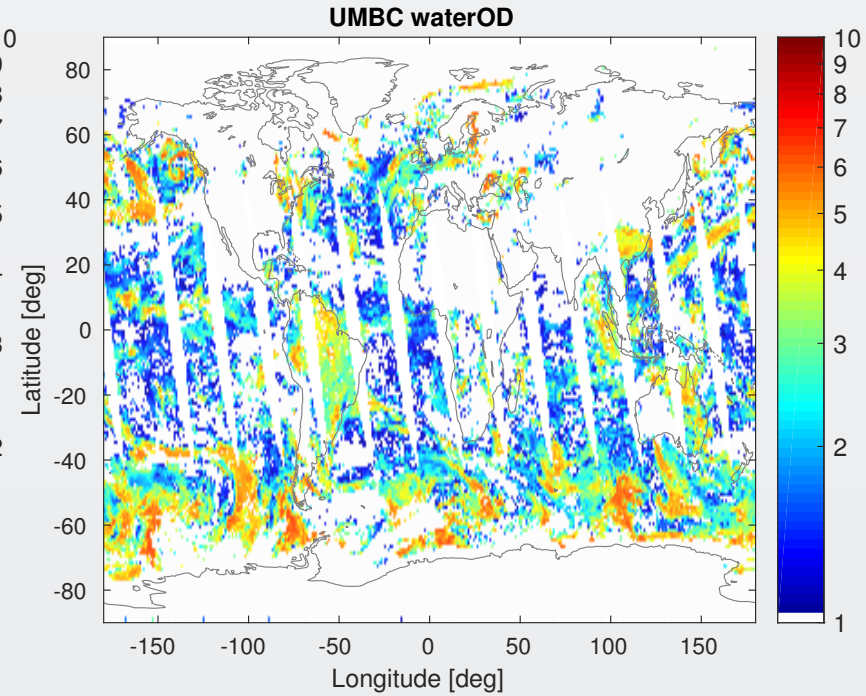
Water Cloud ODs

(different sensor/wavelengths used in retrieval, but patterns are similar)

MODIS L3



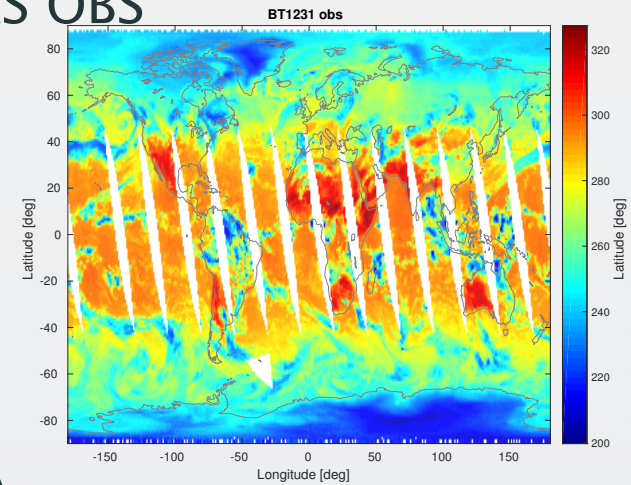
UMBC



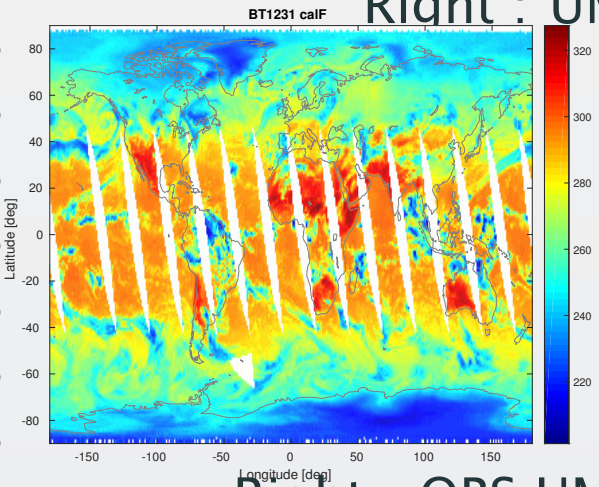
BT1231 (K)

UMBC is after retrieval; ERA is initial matchup

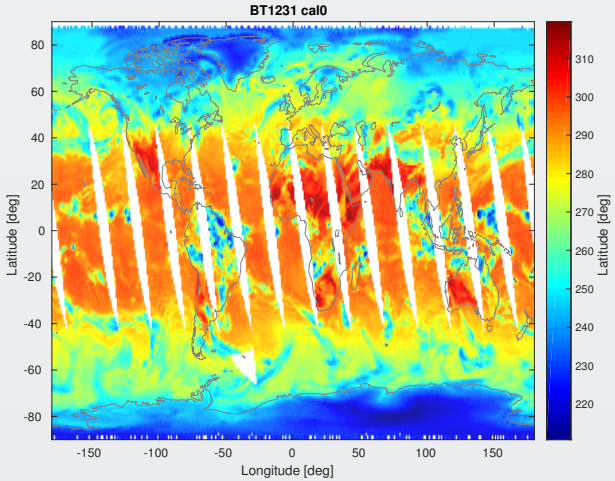
Left : AIRS OBS



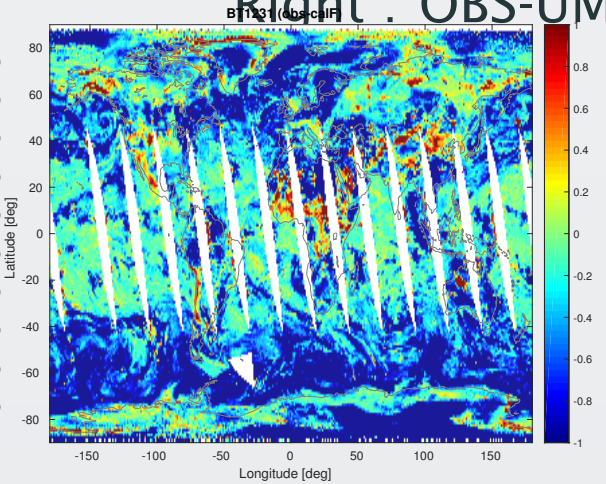
Right : UMBC



Left : ERA

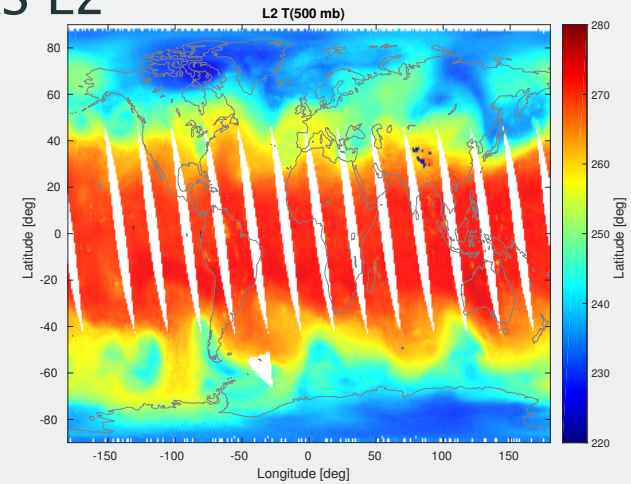


Right : OBS-UMBC

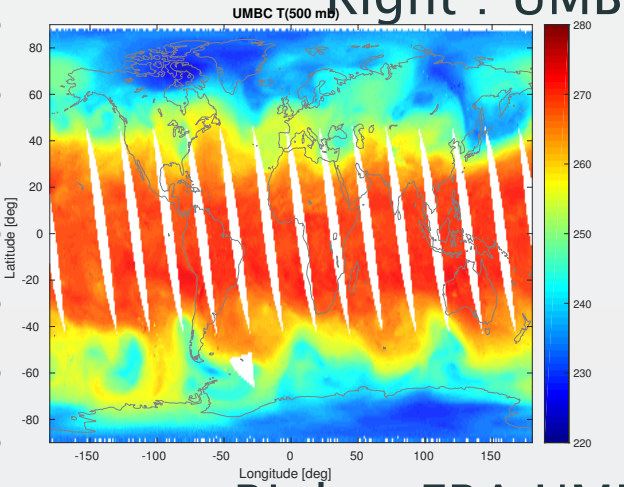


500 mb T(K)

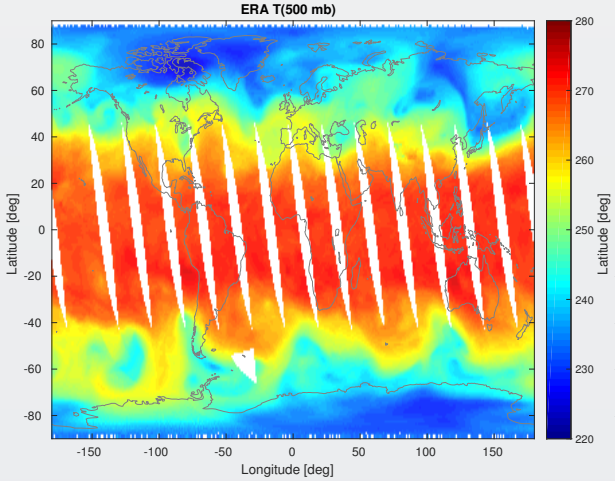
Left : AIRS L2



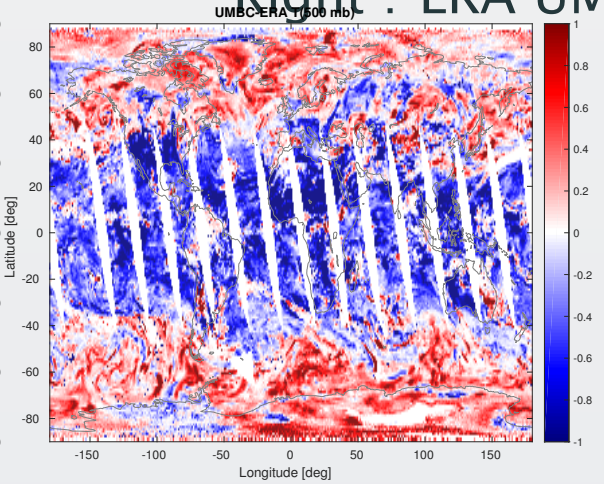
Right : UMBC



Left : ERA

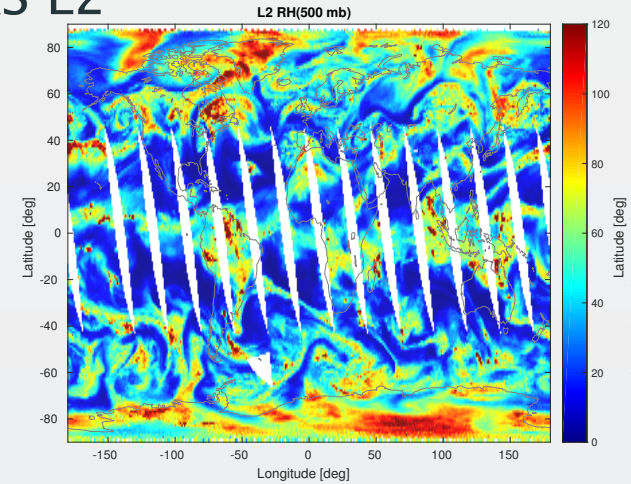


Right : ERA-UMBC

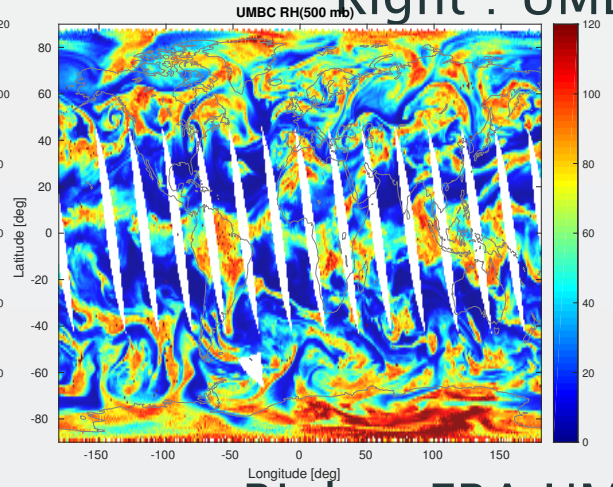


500 mb RH(%)

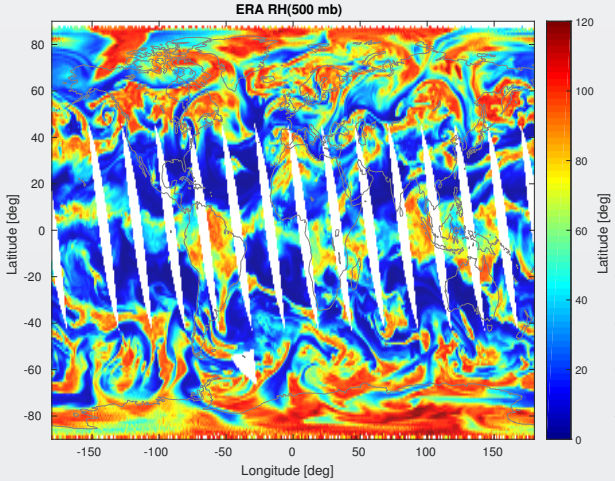
Left : AIRS L2



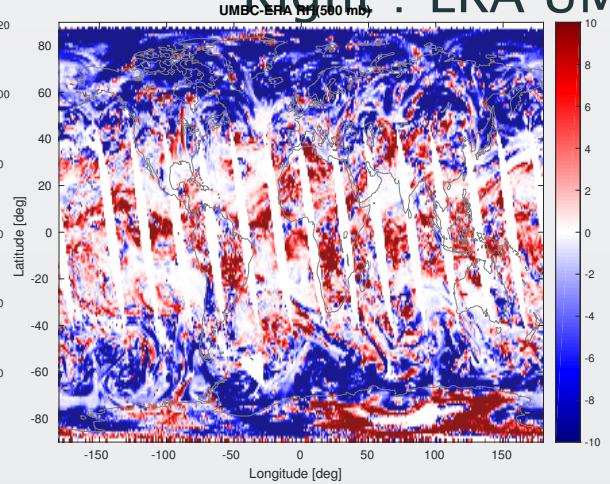
Right : UMBC



Left : ERA



Right : ERA-UMBC

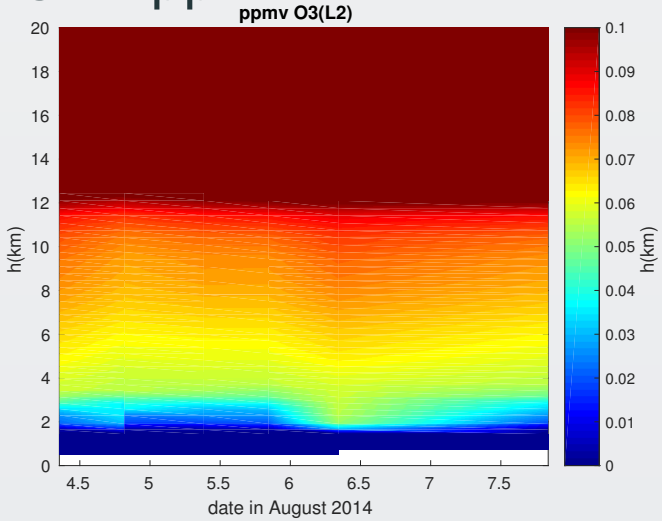


Ozone

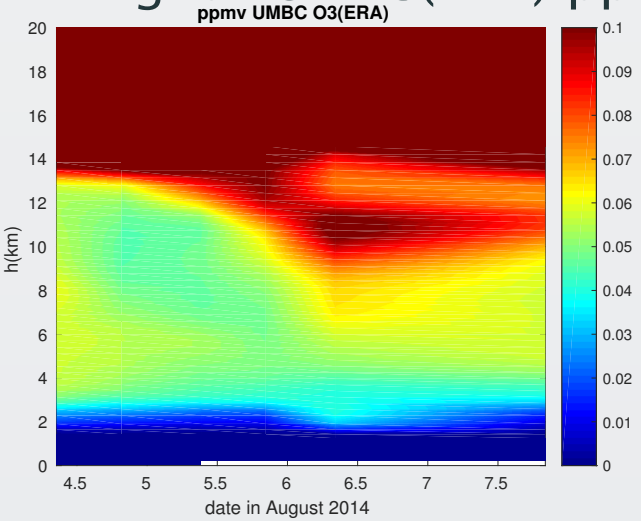
Preliminary O3 retrievals Aug 2014

- 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 averaged AIRS L3 climatology
  - the initial guess did not have this intrusion
  - retrieval did not catch the intrusion
- no evidence of intrusion in AIRS L2

Left : AIRS L2 ppmv



Right : UMBC(ERA) ppmv

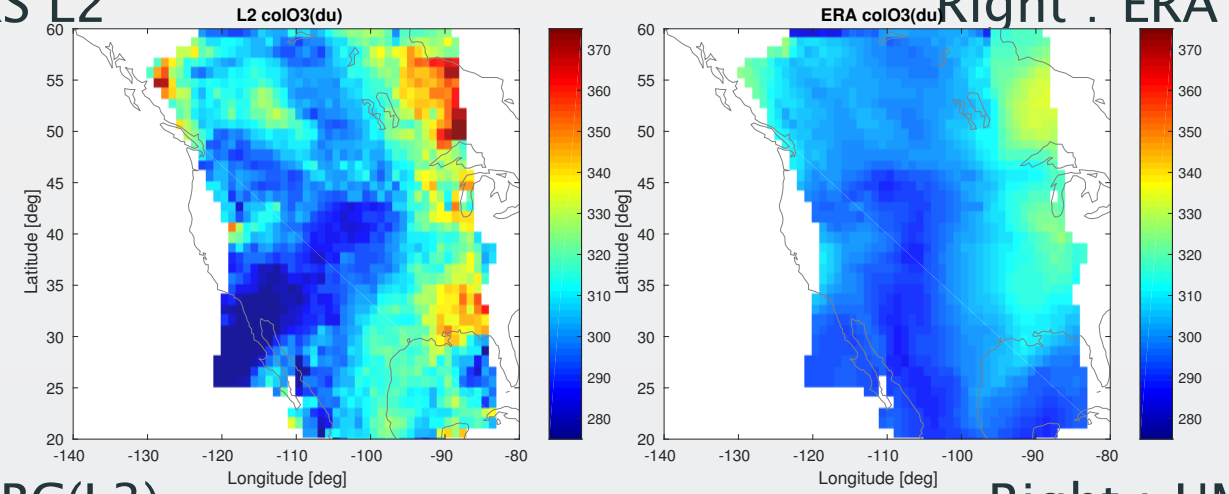


Col O3 amounts (du)

Averaged over Aug 4-7, 2014

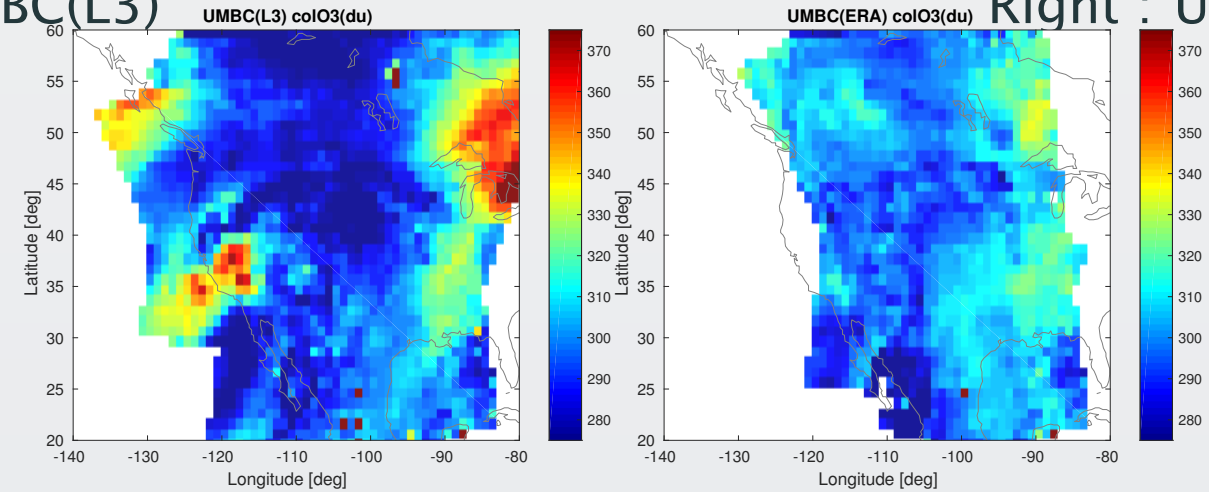
Note Starting AIRS L3 was very smooth (used in lower left)

Left : AIRS L2



Right : ERA

Left : UMBC(L3)



Right : UMBC(ERA)

Profiles(ppmv)

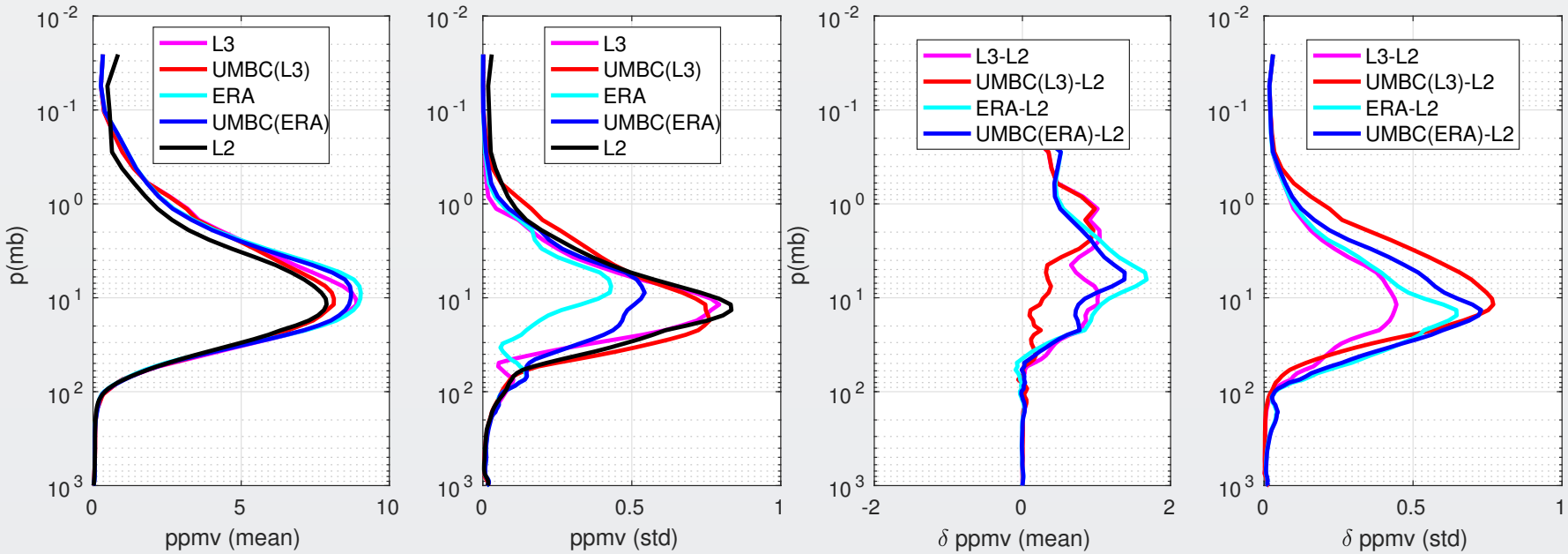
2014/08/06 g083

11522 L2 profiles had totalO3 QA = 0,1

28 of my ERA/L3 retrievals were "bad"

Left : Mean/std O3 profiles

Right : Profiles-L2 mean/std



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
- They come from daily random allsky nighttime nadir AIRS obsservations, spectral linear trends, binned zonally and daily averaged
- Then do geophysical rate retrieval on resulting linear spectral trends, comare to AIRS L3, ECM
- Take same random AIRS obs, start with monthly AIRS L3 climatology (with temporal and spatial varying CO2 amount
- Do OEM retrieval on these 10000 obs/day, find geophysical trends from retrieval

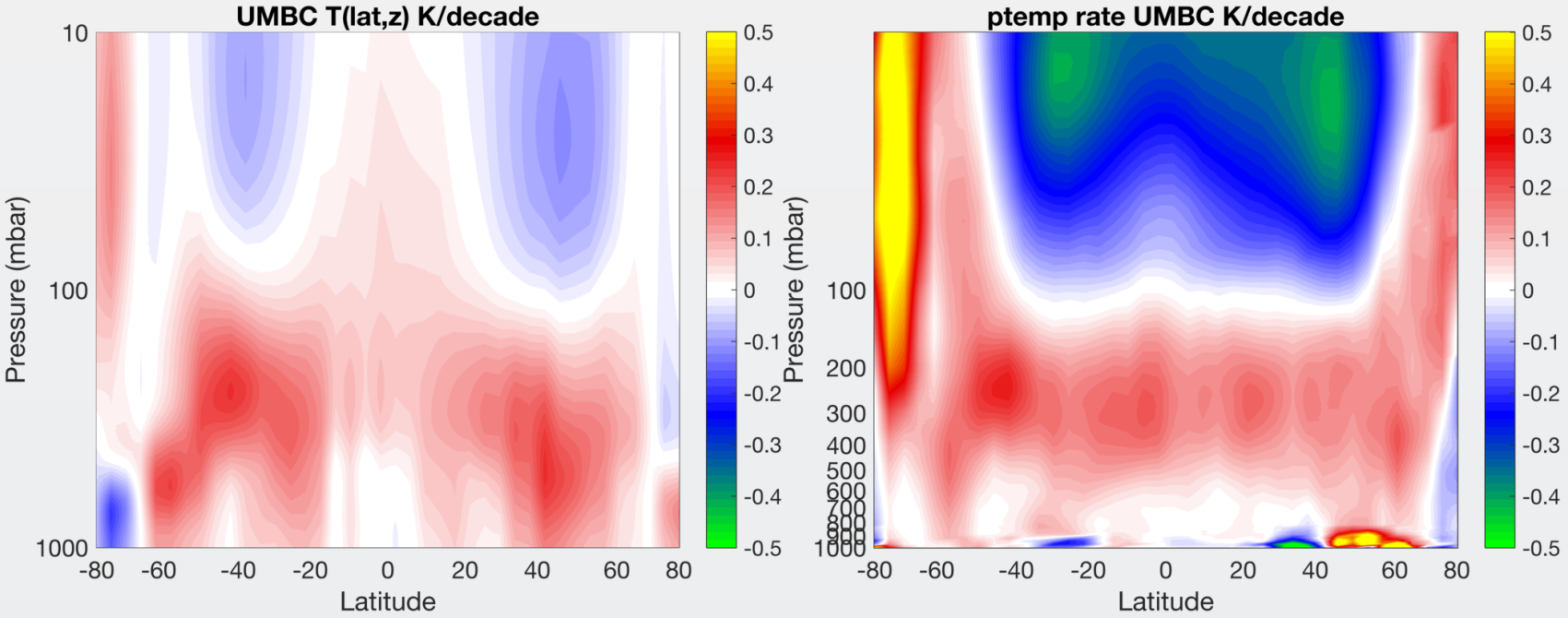
Processing times

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 $\sim$ 20000 FOVs
- Multiple days can easily be processed on a High Performance Cluster (HPC) in an embarrassingly parallel mode
- Following results produced in half a month (processed 14 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



Left : from spectral rates
Colorbar dT(z)/dt K/decade)

Right : from daily retrievals
One Trial Run Only!!

Conclusions

- PROS
  - AIRS cloud clearing : problems under almost clear conditions, loses horizontal res
  - TwoSlab is very fast method, computes finite diff jacobians
  - Use NWP thermodynamic and *reasonably accurate cloud fields*
  - Retrieve thermodynamic profiles, surf temp, col trace gases, ice and water cloud parameters
  - typically have about 90% yield ECM and 80% yield CLIM (problems usually for very thick clouds)
- CONS (aka not enough time to do myself!)
  - 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 algorithm for AIRS → CrIS
  - further tune covariance matrices and channels, trapezoid jacs?
  - work on trace gases (CO, CH4) (started preliminary work)

Extra Slides

UMBC Single Footprint Retrievals

- Most of AIRS data contains cloud and/or aerosol effects
- Cloud retrievals can be complicated (need to guesstimate cloud top, amount, particle size,fraction, phase) typically for $N \leq 3$ cloud decks
- With a good first guess for ice/water clouds, our simple scattering model allows us to retrieve thermodynamic and ice and water clouds
- We use SARTA TwoSlab, with first guess from NWP (ERA/ECM/MERRA/GFS) in an Optimal Estimation Retrieval to improve retrieval yield on single footprints, with error diagnostics as part of output
- NOTE : L3/clim start is L3 profile for that region averaged over 10 years

SARTA TwoSlab

D of F calculations show there are typically only 2-5 pieces of cloud information SIMPLE CLOUDS!

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 Idea

- Will use co-located ERA geo/cloud fields (more stable) to initialize
  - Here used ECM and climatology for testing
- For each pixel, initial guess is as follows
  - Clouds : Match "closest window BT simulation" to AIRS obs
  - Keep thermodynamic fields (clim, NWP,....)
  - In future may adjust cloud top, particle size (MBL and DCC)
- OEM retrieval, *simultaneously* solves cloud amounts for ice/water clouds, and T(z), WV(z), stemp(z), col O3, col CH4
- roughly 8 hours to do 12150 FOVS on one processor (2.0 sec per FOV), 100 layer jacs for WV and T, $\simeq$ 300 channels (from L2 neural net, T(z),WV(z),surf temp list)

A few Retrieval Details

- Cost function
  $J = (y - F(x))^T S_\epsilon^{-1} (y - F(x)) + (x - x_a)^T R(x)^{-1} (x - x_a) + J_{sat}$
  (Rodgers textbook, Phalippou 1996 QJRMS)
- nonlinear Gauss-Newton iterative solution (Rodgers textbook)
- use about 300 channels (so 5 min SARTA run → 1 min)
- Smoothing
  - right now using sum of Tikonov + exp decay covariance
- Run off OEM, for N=5 iterations at most, save AK, dofs etc
- throw out retrievals ($\leq$ 10%) where calcs are obviously wrong, RH > 150% etc (usually colocated with thick clouds)