

PBL Height from AIRS and MERRA-2 Products at GES DISC and Preliminary Intercomparison Result

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NASA Sounder Science Team Meeting
PBL Sounding Workshop
Greenbelt, MD
October 1, 2018

Outline

- Products with Planetary Boundary Layer Height(PBLH) at Goddard Earth Sciences Data and Information Services Center (GES DISC)
 - AIRS and MERRA/MERRA-2
- Data Service at GES DISC for Comparison
 - Giovanni multi-year monthly/seasonal mean, AIRS product subsetting, NCO (NetCDF Operators) for Ascending/Descending average, resolution remap
- Preliminary Comparison Plots
- Summary

Products with PBLH at GES DISC

- AIRS

 - In AIRS support product

 - PBLH only on the ocean

 - Not a highly visible parameter

 - 09/2002 ~ present

- MERRA and MERRA-2

 - NASA Goddard Earth Observing System (GEOS) model reanalysis product

 - MERRA: Modern-Era Retrospective analysis for Research and Applications

 - MERRA-2: second MERRA, GEOS-5 model

 - 1980 ~ present

 - Hourly, daily, monthly

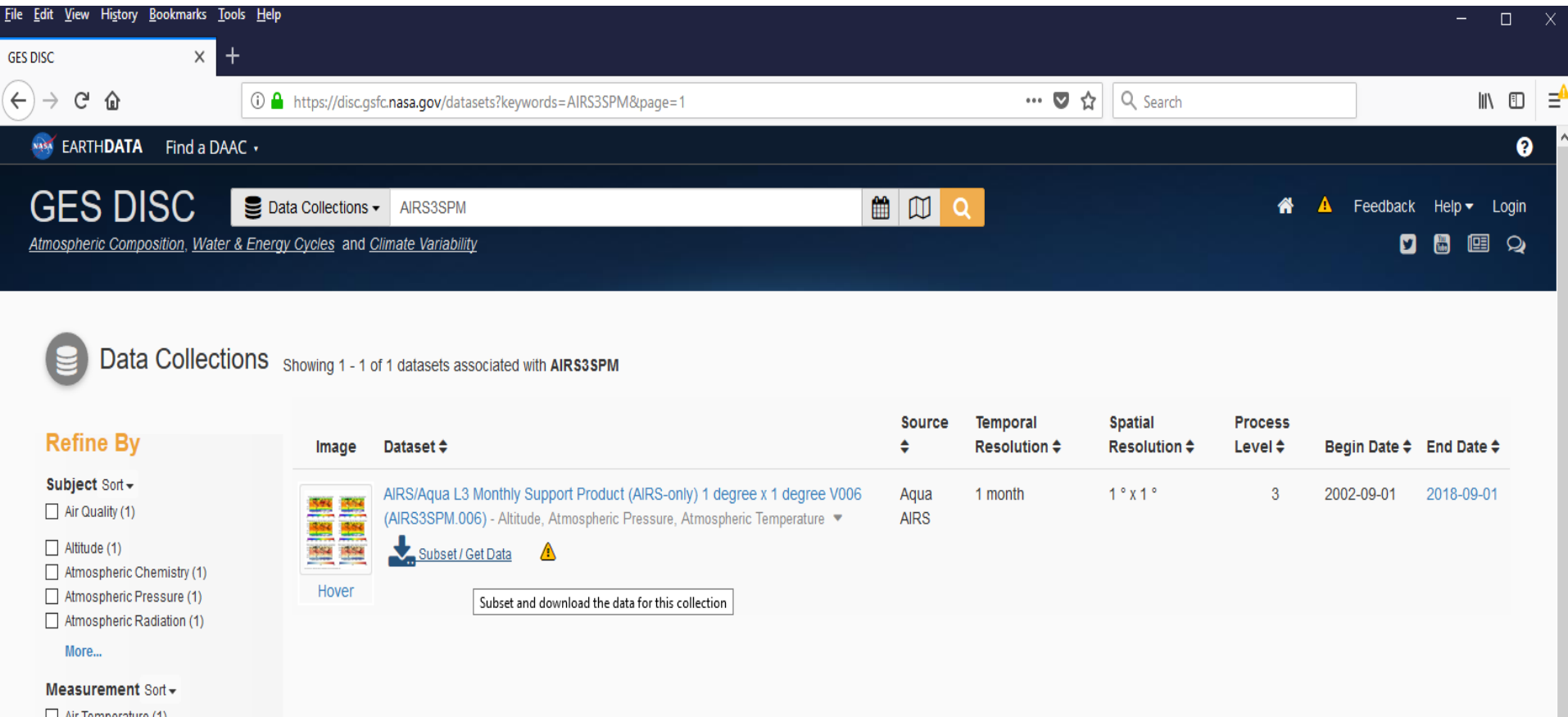
 - Monthly PBLH available in Giovanni

Dataset and Services for PBLH Comparison

- Long Term Monthly Average Comparison
15-year monthly mean: 2003 to 2017, short term climatology
- AIRS
V6 Level-3 AIRS-only monthly support product: AIRS3SPM.006
Resolution: $1^{\circ} \times 1^{\circ}$ (lat X lon)
Ascending/Daytime and Descending/Nighttime
Pressure (hPa) at PBL top
- MERRA-2
Monthly
Resolution: $0.5^{\circ} \times 0.625^{\circ}$ (lat X lon)
PBL height/depth in meter

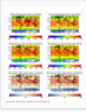
AIRS PBLH from Data Subset Service

- Go to GES DISC homepage <https://disc.gsfc.nasa.gov>
- Search AIRS3SPM



The screenshot shows a web browser window with the URL <https://disc.gsfc.nasa.gov/datasets?keywords=AIRS3SPM&page=1>. The page displays the GES DISC logo and navigation options. The main content area shows a list of data collections for the keyword AIRS3SPM.

Data Collections Showing 1 - 1 of 1 datasets associated with AIRS3SPM

| Image | Dataset | Source | Temporal Resolution | Spatial Resolution | Process Level | Begin Date | End Date |
|---|--|--------------|---------------------|--------------------|---------------|------------|------------|
|  | AIRS/Aqua L3 Monthly Support Product (AIRS-only) 1 degree x 1 degree V006 (AIRS3SPM.006) - Altitude, Atmospheric Pressure, Atmospheric Temperature | Aqua AIRS | 1 month | 1° x 1° | 3 | 2002-09-01 | 2018-09-01 |

Below the table, there is a "Subset / Get Data" button and a warning icon. A tooltip box says "Subset and download the data for this collection".

Refine By

Subject Sort ▾

- Air Quality (1)
- Altitude (1)
- Atmospheric Chemistry (1)
- Atmospheric Pressure (1)
- Atmospheric Radiation (1)

[More...](#)

Measurement Sort ▾

- Air Temperature (1)



GES DISC

Atmospheric Compos



Refine By

Subject

- Air Quality (1)
- Altitude (1)
- Atmospheric Chem
- Atmospheric Pres
- Atmospheric Radi

More...

Measurement

- Air Temperature (1)
- Carbon Monoxide
- Cloud Droplet Concentration/Size
- Cloud Height (1)
- Cloud Liquid Water

More...

Source

- Aqua AIRS (1)

Processing Level

- 3 (1)

Project

- Aqua (1)

Temporal Resolution

- Sort
- 1 month (1)

Get AIRS/Aqua L3 Monthly Support Product (AIRS-only) 1 degree x 1 degree V006 data

Estimated size of results

5,479 days, 221 links, 2.78 TB

Refine Search

Refine Date Range: 2003-01-01 to 2017-12-31

Reset

Refine Spatial Region: -180, -90, 180, 90

Reset

Subset Options

Spatial Subset: -180, -90, 180, 90

Variables: 2 variable(s) selected

NOTE: By default, ALL variables are sent in the subset request.

Expand Tree

- Ancillary and Derived Variables
- Cirrus Cloud Variables
- CO Variables
- Dust and SO2 flags from radiances
- location
- Methane Variables
- Moisture and Precipitation Variables
- Ozone Variables
- Radiation Variables
- Temperature Variables

Dimensions: * * Get all dimensions

Output format

File Format: netCDF 4

Variables: 2 variable(s) selected

NOTE: By default, ALL variables are sent in the subset request.

Expand Tree

- Ancillary and Derived Variables
 - bndry_lyr_top_A
 - bndry_lyr_top_A_ct
 - bndry_lyr_top_A_max
 - bndry_lyr_top_A_min
 - bndry_lyr_top_A_sdev
 - bndry_lyr_top_D
 - bndry_lyr_top_D_ct
 - bndry_lyr_top_D_max
 - bndry_lyr_top_D_min
 - bndry_lyr_top_D_sdev
 - LandSeaMask
 - MODIS_emis_10_hinge_A
 - MODIS_emis_10_hinge_A_ct
 - MODIS_emis_10_hinge_A_max
 - MODIS_emis_10_hinge_A_min

Reset All

Get Data

Processing PBLH in AIRS

- Use NCO (NetCDF Operator)

Powerful open source tools for manipulating netCDF file

- Ascending/Daytime and Descending/Nighttime Average

```
ncrename -v bndry_lyr_top_D,bndry_lyr_top_A PBLDfname PBLDtoAfname  
ncea PBLAfname PBLDtoAfname PBLADAveragefname
```

```
ncrename -v bndry_lyr_top_A,bndry_lyr_top_ADAverage PBLADAveragefname
```

- 15-year Monthly Mean (2003-2017)

```
ncea AIRS.?????.01.xxxxxx.nc AIRS.01.MonthlyMean.xxxxxx.nc
```

- Convert Pressure at PBL Top to Altitude

$$PBLH (m) = 44308 \times (1 - (P_{PBLtop}/P_{Surface})^{0.1903})$$

Surface pressure $P_{Surface}$: AIRS L3 standard product AIRS3STM

From NOAA GFS model

```
ncap2 -s "bndry_lyr_top_ADAverageMeter=44308*(1-  
(bndry_lyr_top_ADAverage/SurfPres_Forecast_ADAverage)^0.1903)"  
inputfname outputfname
```

MERRA-2 PBLH from Giovanni

- Giovanni Monthly and Seasonal Average Service <https://giovanni.gsfc.nasa.gov/>

GIOVANNI The Bridge Between Data and Science v 4.28

Feedback Help Login

... [1 of 1 messages] [Read More](#)

Select Plot

Maps: Monthly and Seasonal Averages Comparisons: *Select...* Vertical: *Select...* Time Series: *Select...* Miscellaneous: *Select...*

Select Seasonal Dates **Select Region (Bounding Box or Shape)**

Month or Season and YYYY range. to

Format: West, South, East, North

Select months or seasons Months Seasons

January July
 February August
 March September
 April October
 May November
 June December

Number of matching Variables: 2 of 1932 Total Variable(s) included in Plot: 1

Keyword:

| Variable | Units | Source | Temp.Res. | Spat.Res. | Begin Date | End Date |
|---|-------|---------------|-----------|---------------|------------|------------|
| <input checked="" type="checkbox"/> Planetary boundary layer height (M2TMNXFLX v5.12.4) | m | MERRA-2 Model | Monthly | 0.5 x 0.625 ° | 1980-01-01 | 2018-08-31 |
| <input type="checkbox"/> Planetary boundary layer height above surface (MATMFXCHM v5.2.0) | | | | | | |

Sea Only 1800x3600 0.1 x 0.1 deg

86°36'N, 93°30'W
45°00'N
00°00'N
45°00'S
135°00'W 90°00'W 45°00'W 00°00'E 45°00'E 90°00'E 135°00'E

Responsible NASA Official: [Angela Li](#) Powered By Contact Us
Web Curator: [M. Hegde](#)

Processing MERRA-2 PBLH

- Generate the 15-year monthly mean from Giovanni download files in netCDF format

- Resolution Match to AIRS

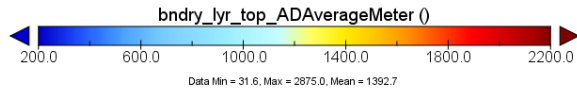
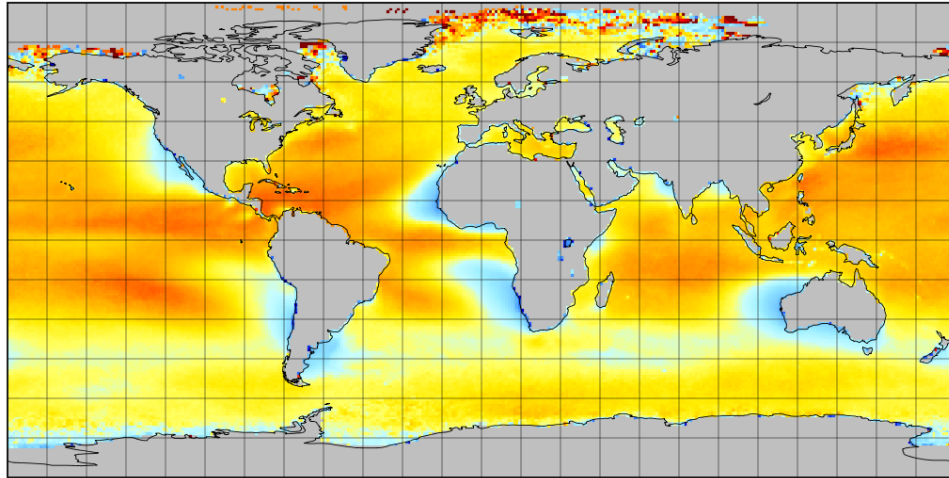
Use NCO to remap MERRA-2 from $0.5^\circ \times 0.625^\circ$ (lat X lon) to $1^\circ \times 1^\circ$ (lat X lon)

```
ncremap -a conserve -i infile -g ./180x360_SCRIP.20150901.nc -O ./rgr
```

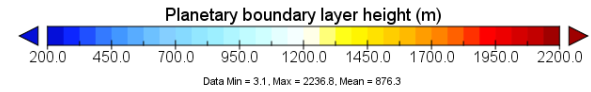
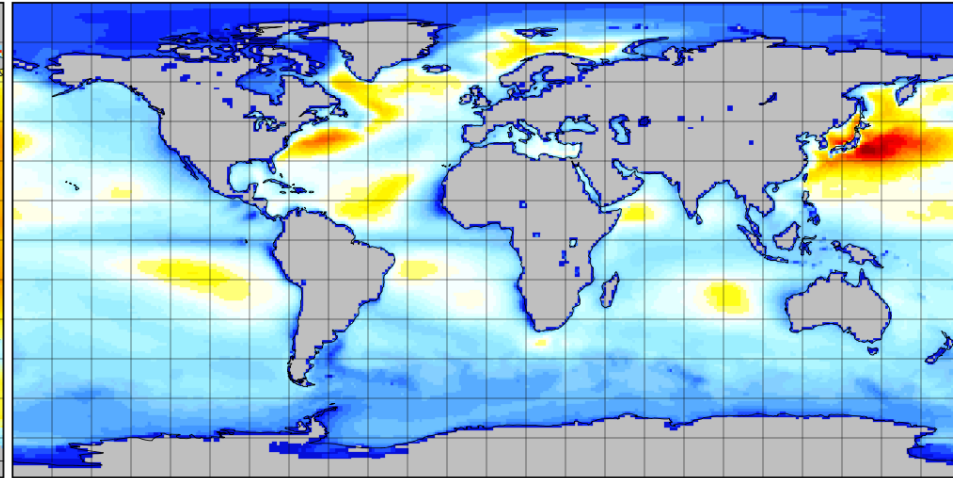
- Use Panoply get plots

Preliminary Comparison Results (Jan & Feb)

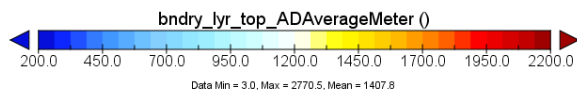
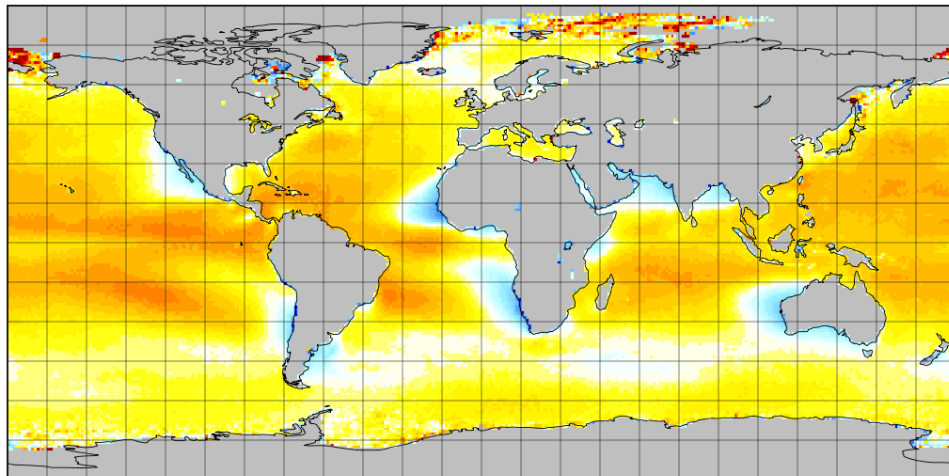
AIRS January PBLH (m)



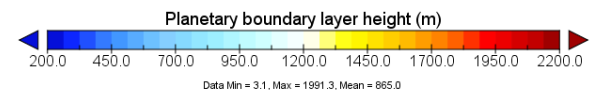
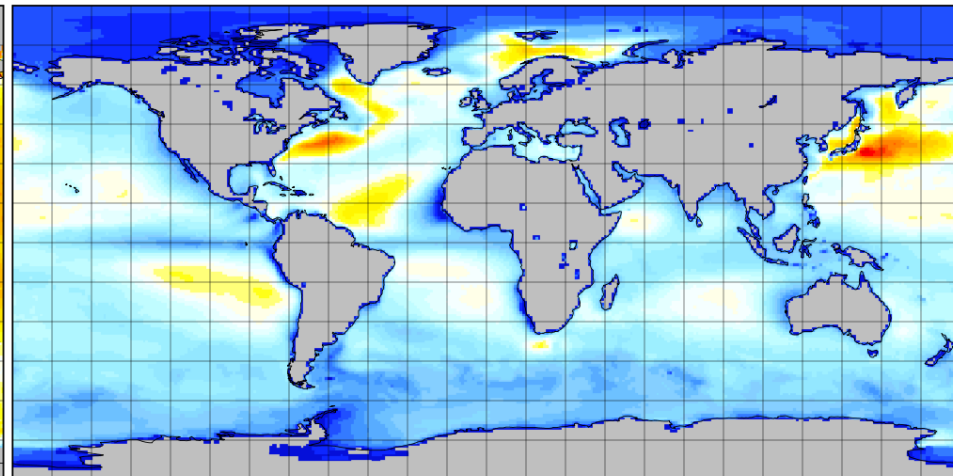
MERRA-2 January PBLH (m)



AIRS February PBLH (m)

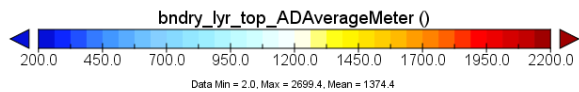
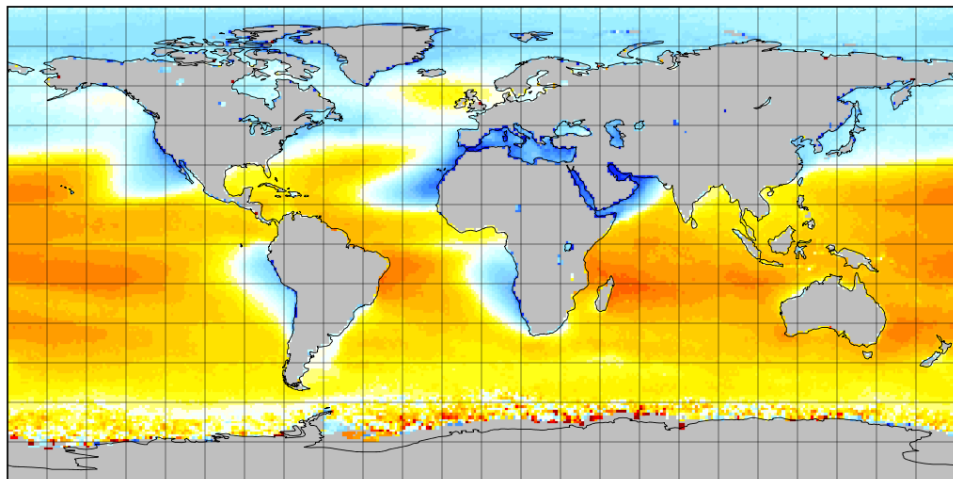


MERRA-2 February PBLH (m)

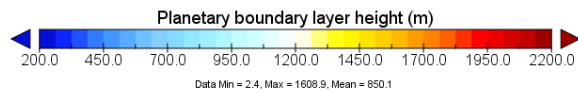
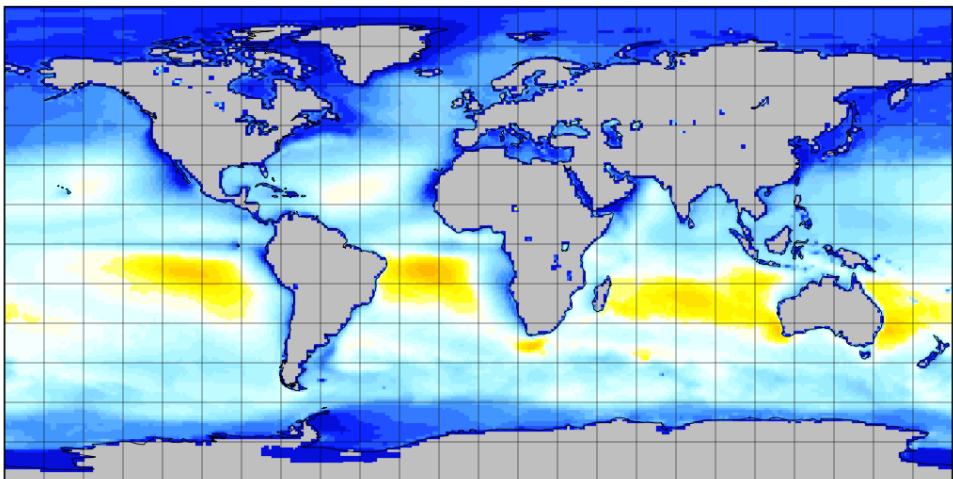


Preliminary Comparison Results (Jul & Aug)

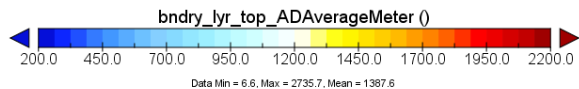
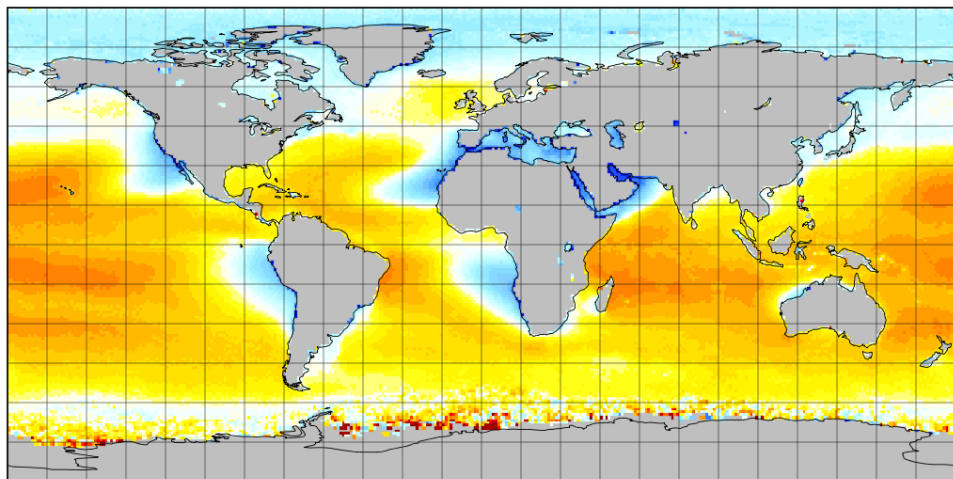
AIRS July PBLH (m)



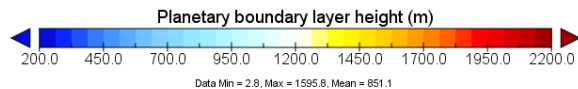
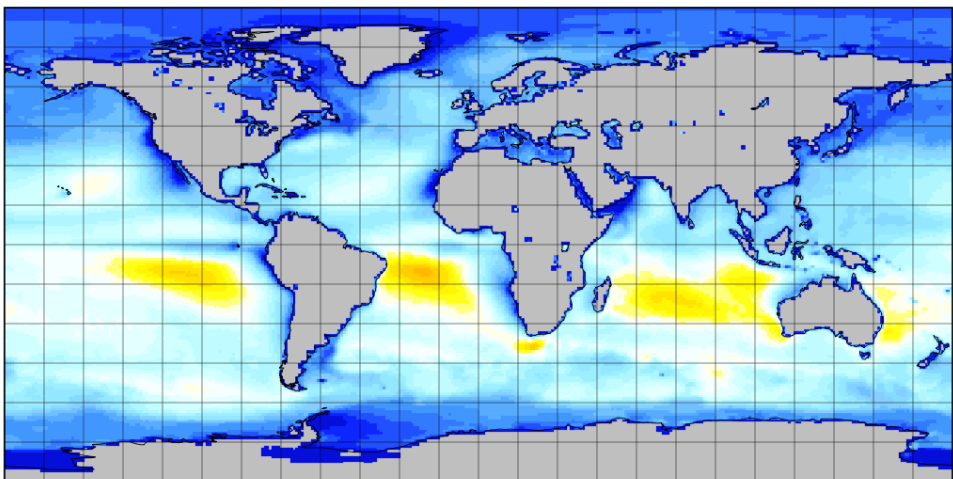
MERRA-2 July PBLH (m)



AIRS August PBLH (m)

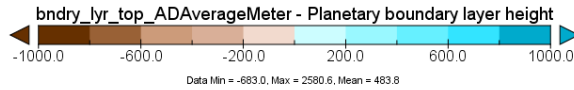
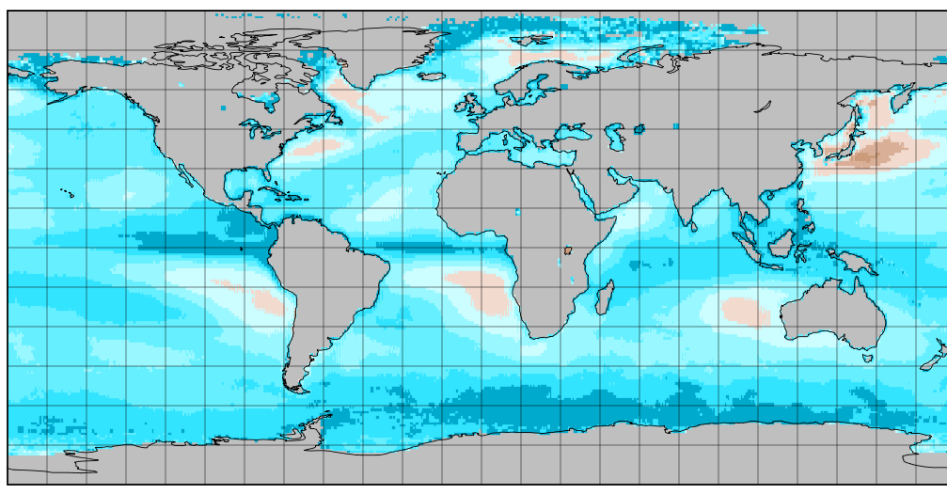


MERRA-2 August PBLH (m)

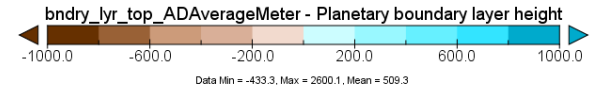
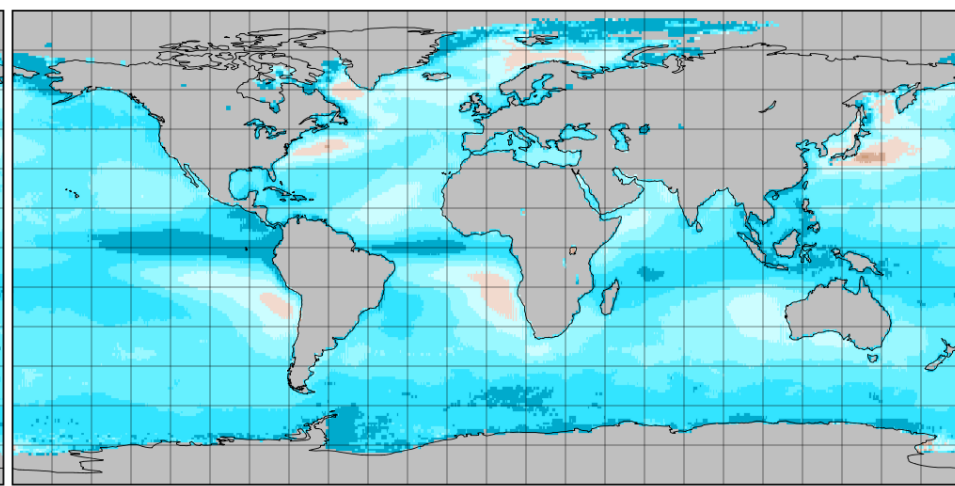


PBLH Difference (AIRS - MERRA2) (Jan, Feb, Jul, Aug)

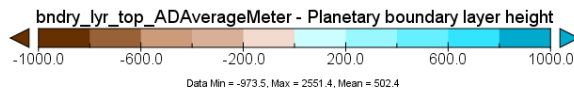
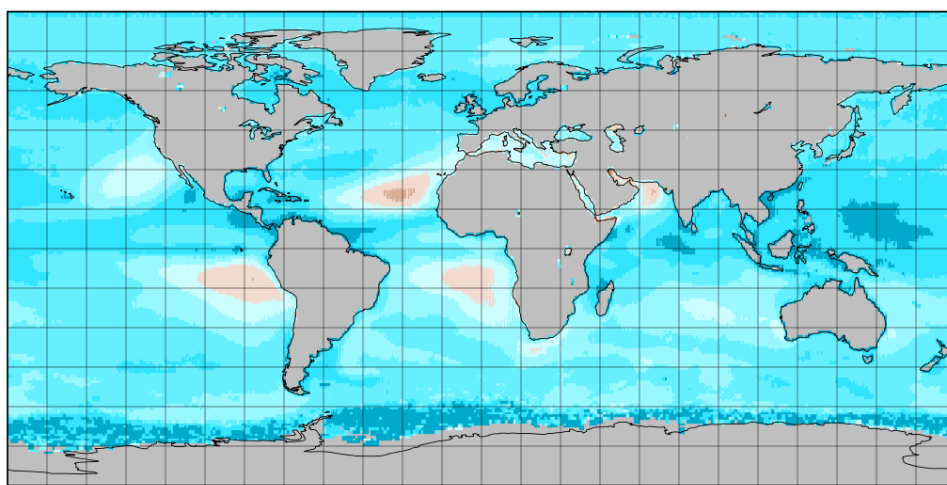
January PBLH Difference (AIRS - MERRA2) (m)



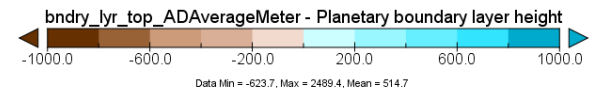
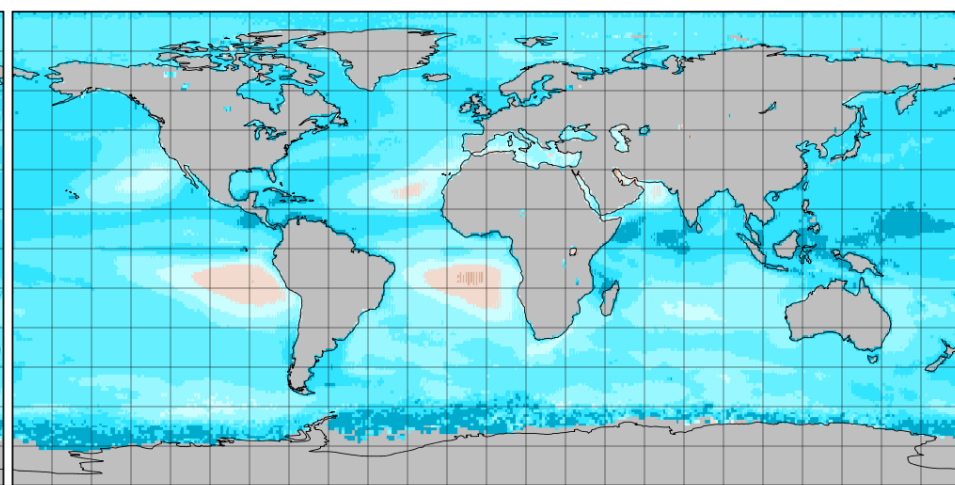
February PBLH Difference (AIRS - MERRA2) (m)



July PBLH Difference (AIRS - MERRA2) (m)



August PBLH Difference (AIRS - MERRA2) (m)



PBLH Difference between AIRS and MERRA-2

- AIRS PBLH much deeper than MERRA-2 in every month

Globally AIRS about 500m higher

- AIRS PBLH

AIRS document: The boundary layer top height is the pressure of the level with the largest gradient of a relative humidity (relative to liquid phase of water) layer profile calculated on the support pressure layer grid.

Joao Martins, Joao Teixeira, and coauthors (2010): Infrared sounding of the trade-wind boundary layer: AIRS and RICO experiment.

Derived from gradient of potential temperature (θ) and relative humidity (RH) vertical profiles.

Threshold of -0.06K/hPa for θ and $0.4\%/hPa$ for RH

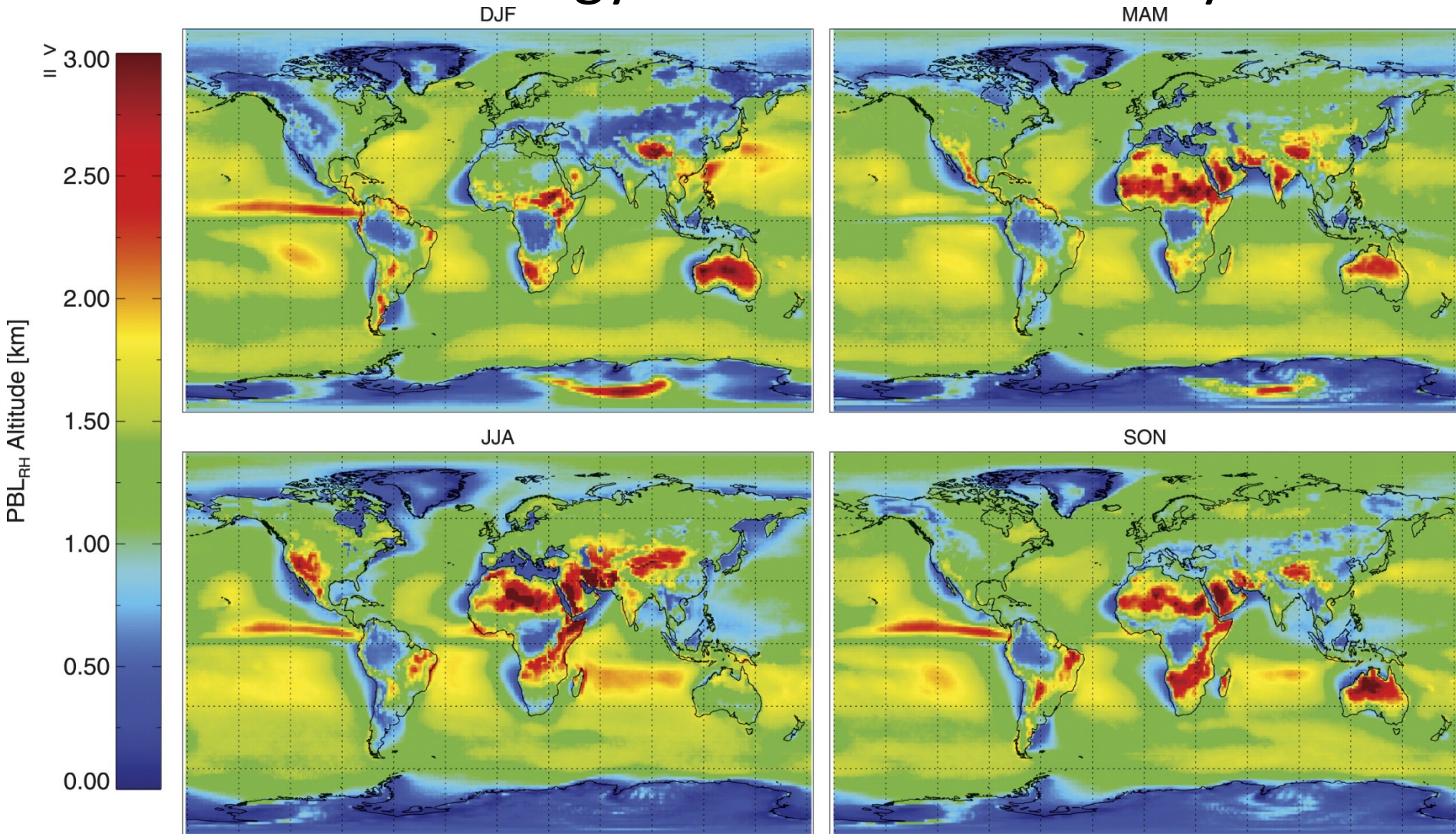
- MERRA-2 PBLH

E. L. McGrath-Spangle and A. Molod (2014): Comparison of GEOS-5 AGCM planetary boundary layer depths computed with various definitions.

Based on the total eddy diffusion coefficient of heat (K_h)

Threshold value $2\text{m}^2\text{s}^{-1}$

PBLH Climatology from ECMWF Reanalysis

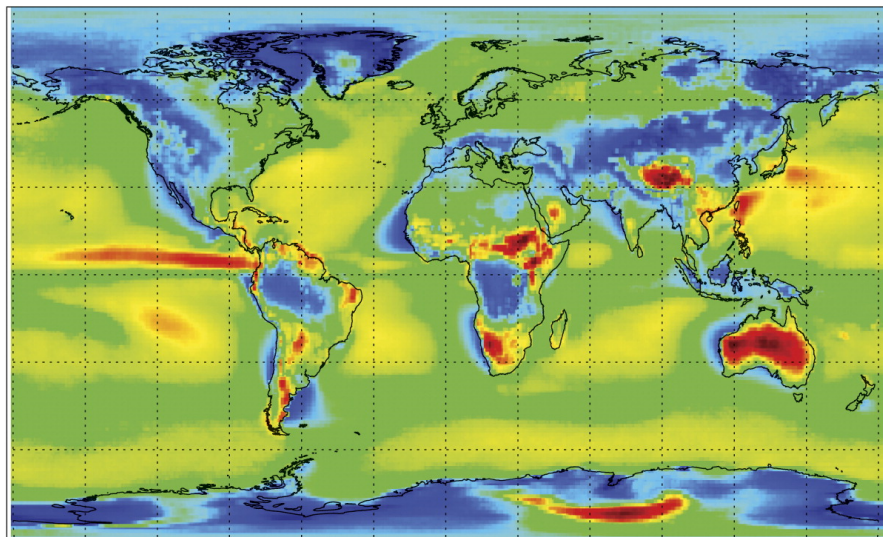


Axel von Engel and Joao Teixeira (2013): A PBLH Climatology derived from ECMWF Reanalysis Data.

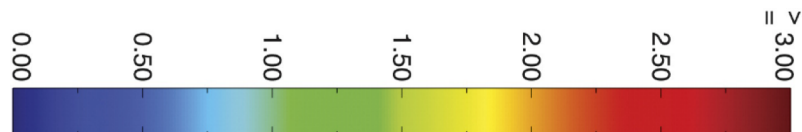
20-year (1990-2009) Seasonal Climatology from ERA-Interim
PBLH derived from minimum gradient of RH vertical profile

ERA, AIRS, MERRA-2 Comparison: DJF Season

DJF

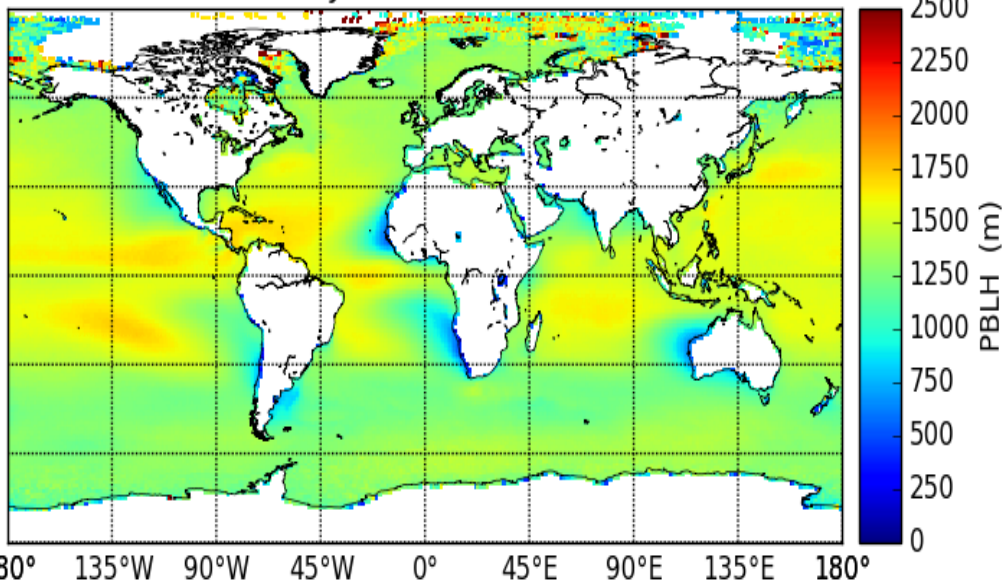


PBL_{RH} Altitude [km]



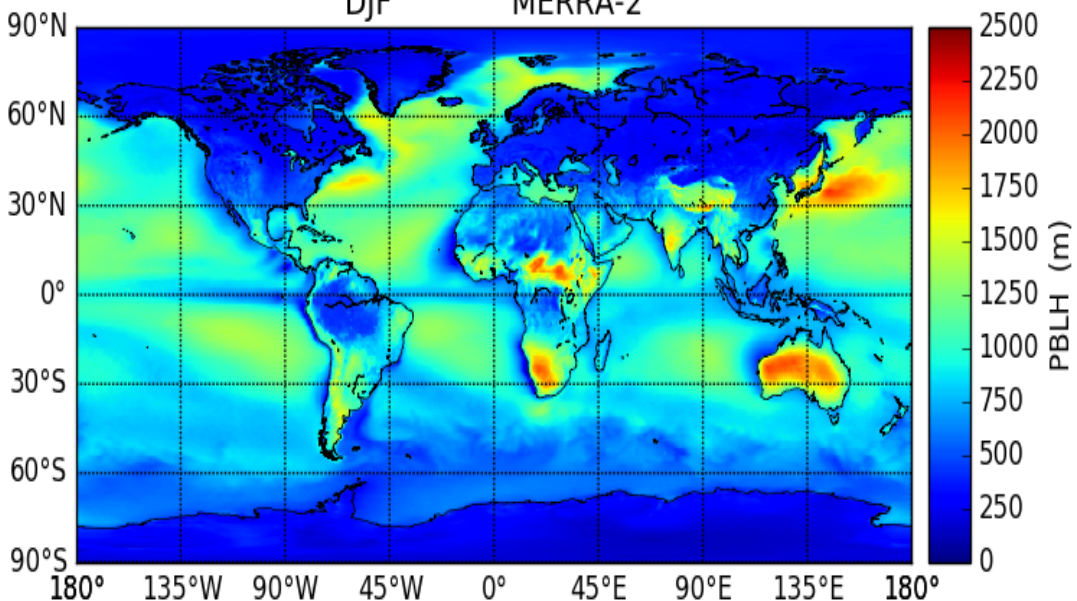
DJF

AIRS



180° 135°W 90°W 45°W 0° 45°E 90°E 135°E 180°

DJF MERRA-2



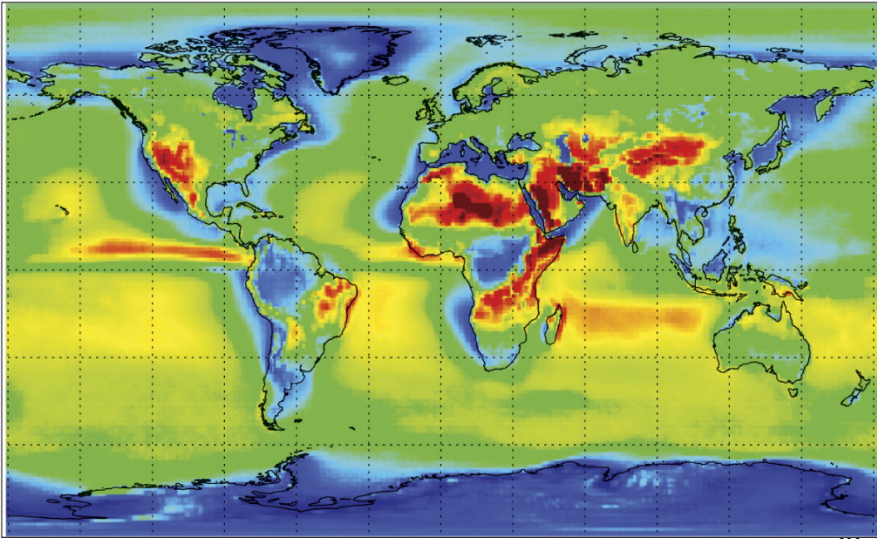
180° 135°W 90°W 45°W 0° 45°E 90°E 135°E 180°

ERA vs AIRS: 500m deeper
 AIRS vs MERRA-2: 500m deeper
 Indian and Atlantic Ocean:
 best pattern match
 ITCZ: very deep PBL
 50°S ~ 65°S Zone

AIRS: 2003 ~ 2017 Others: 1990 ~ 2009

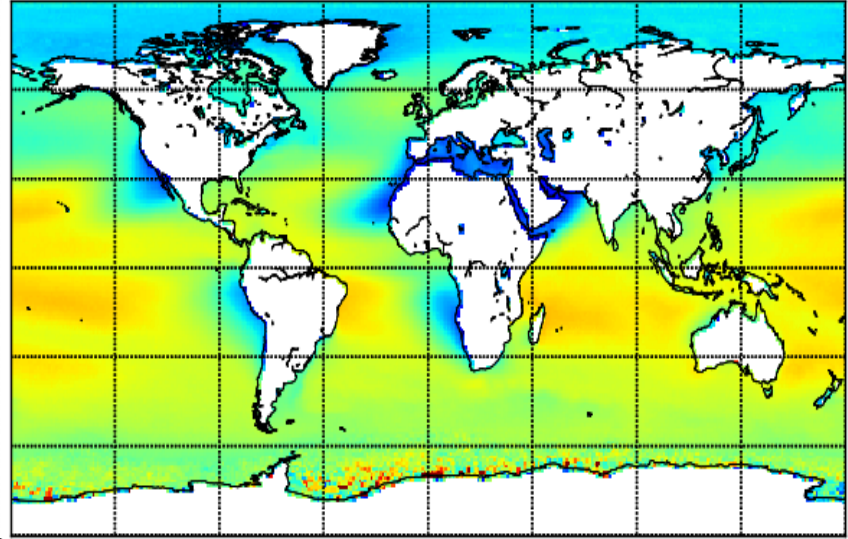
ERA, AIRS, MERRA-2 Comparison: JJA Season

JJA



JJA

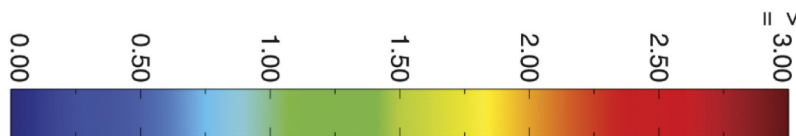
AIRS



2500
2250
2000
1750
1500
1250
1000
750
500
250
0
PBLH (m)

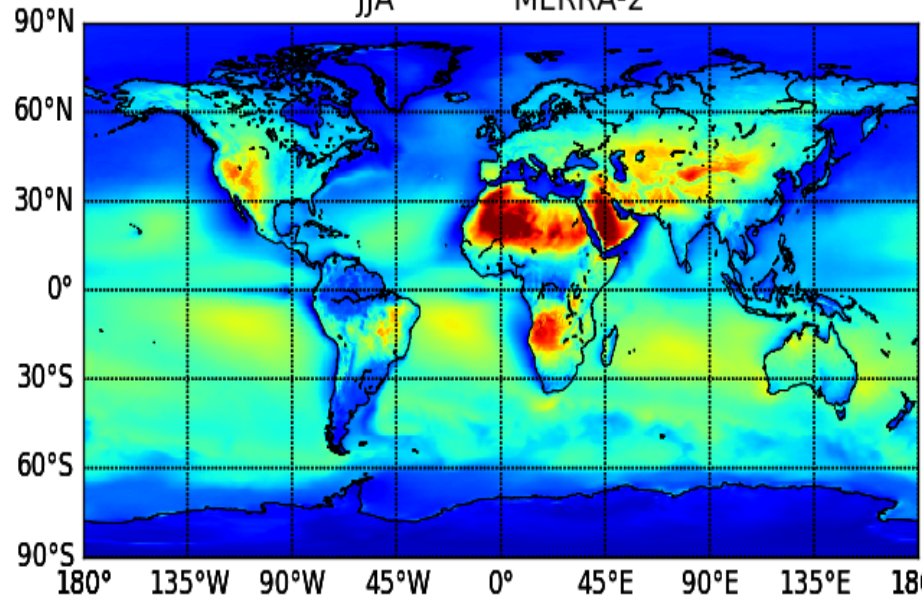
180° 135°W 90°W 45°W 0° 45°E 90°E 135°E 180°

PBL_{RH} Altitude [km]



JJA

MERRA-2



2500
2250
2000
1750
1500
1250
1000
750
500
250
0
PBLH (m)

180° 135°W 90°W 45°W 0° 45°E 90°E 135°E 180°

ITCZ: very deep PBL
50°S ~ 65°S Zone

Summary

- GES DISC provides data and services for PBL study
- Preliminary comparison of AIRS derived PBLH with model reanalysis data show obvious difference, but AIRS can capture long-term PBL signals on the ocean.
- Different PBLH definitions may contribute to the differences.
- Next step: look at the vertical profiles .

<https://giovanni.gsfc.nasa.gov/>

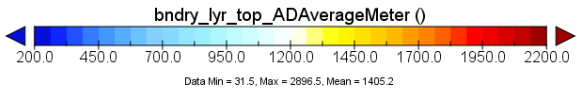
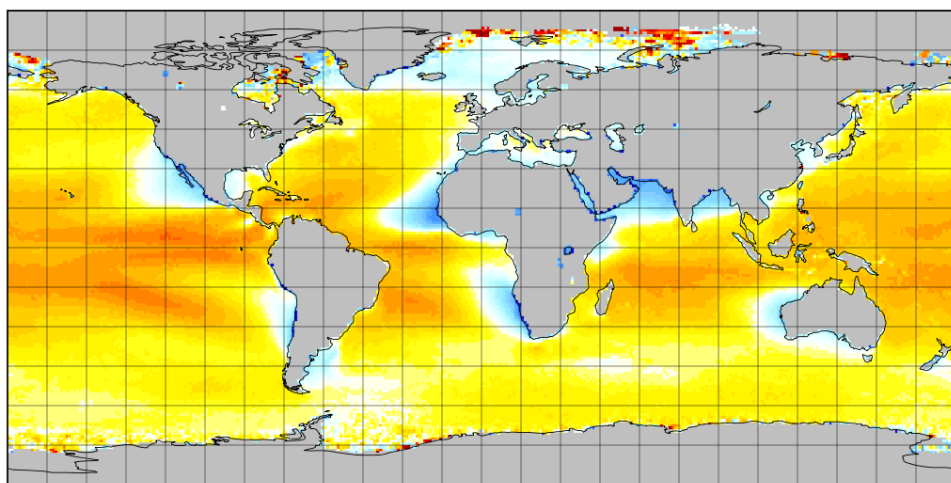
<https://disc.gsfc.nasa.gov/>

gsfc-help-disc@lists.nasa.gov

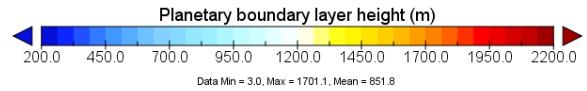
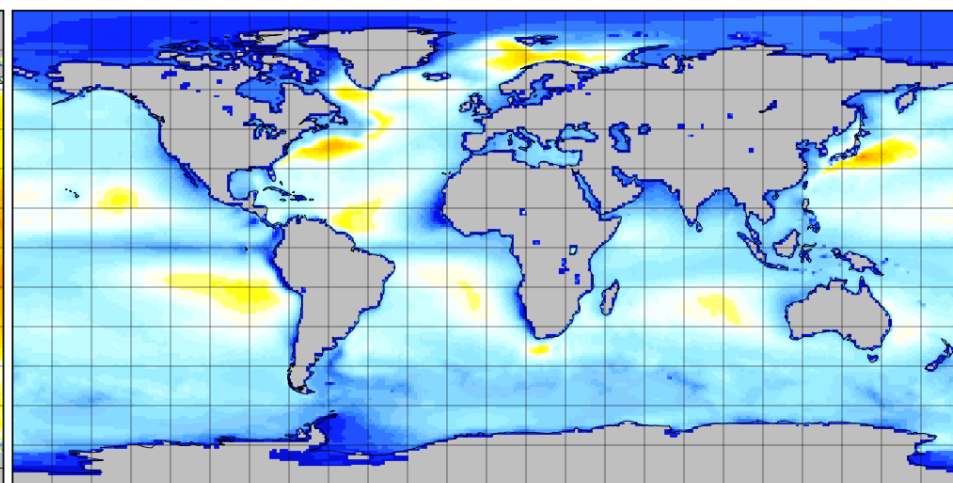
Backup Slides

Preliminary Comparison Results (Mar & Apr)

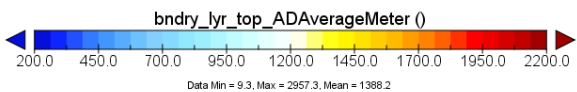
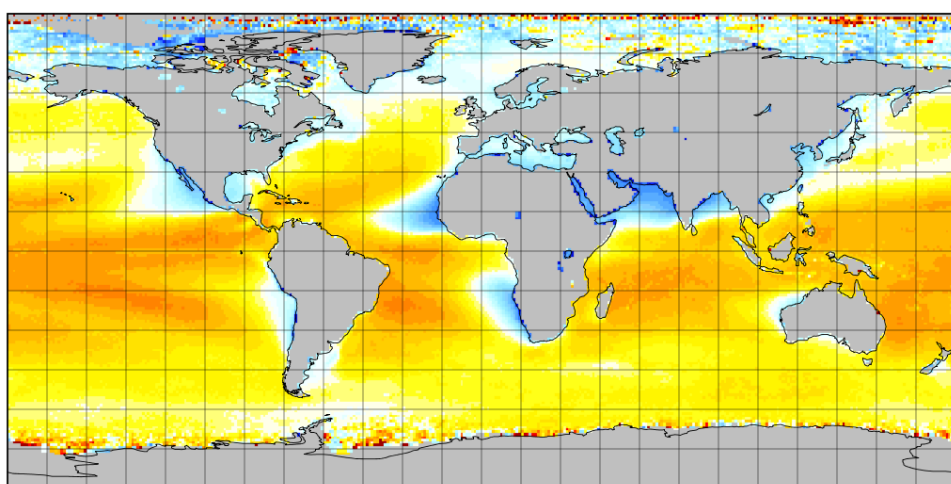
AIRS March PBLH (m)



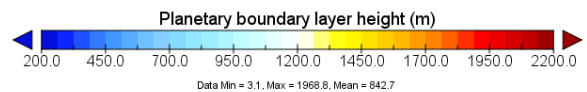
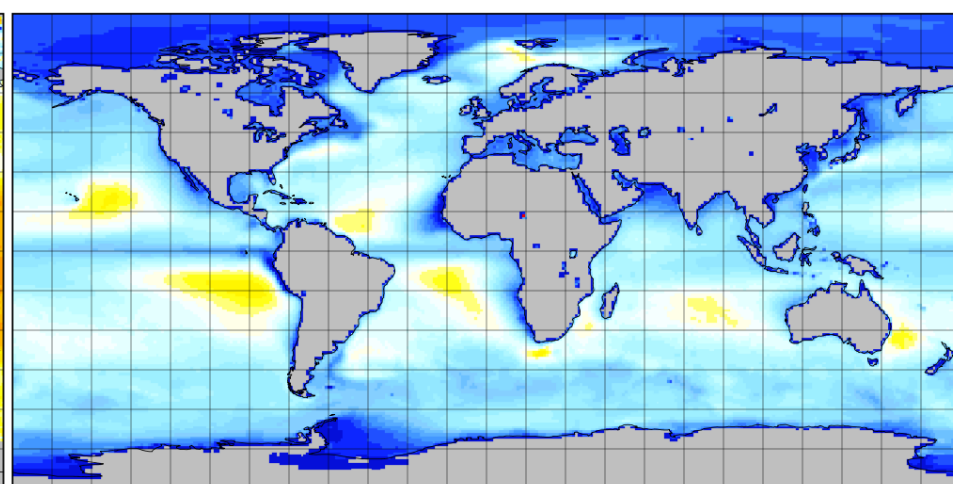
MERRA-2 March PBLH (m)



AIRS April PBLH (m)

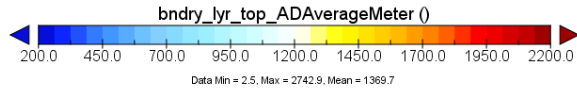
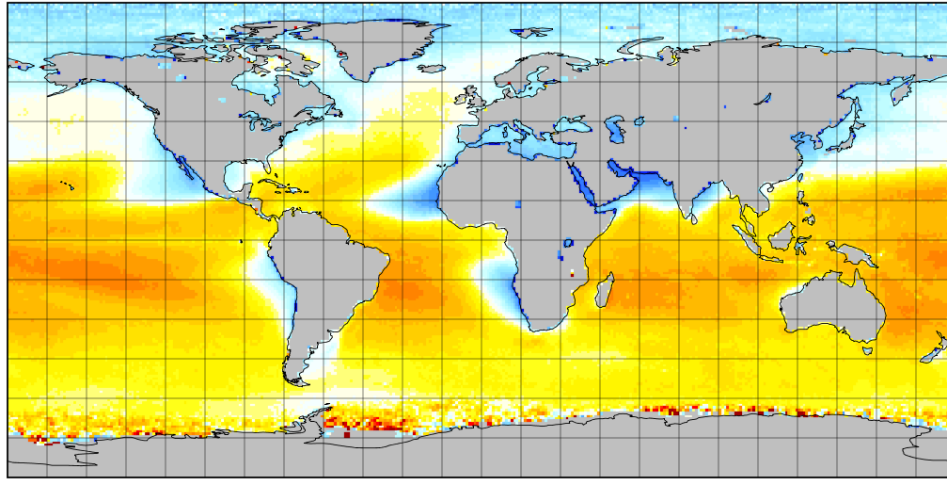


MERRA-2 April PBLH (m)

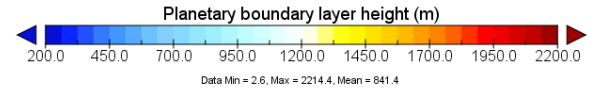
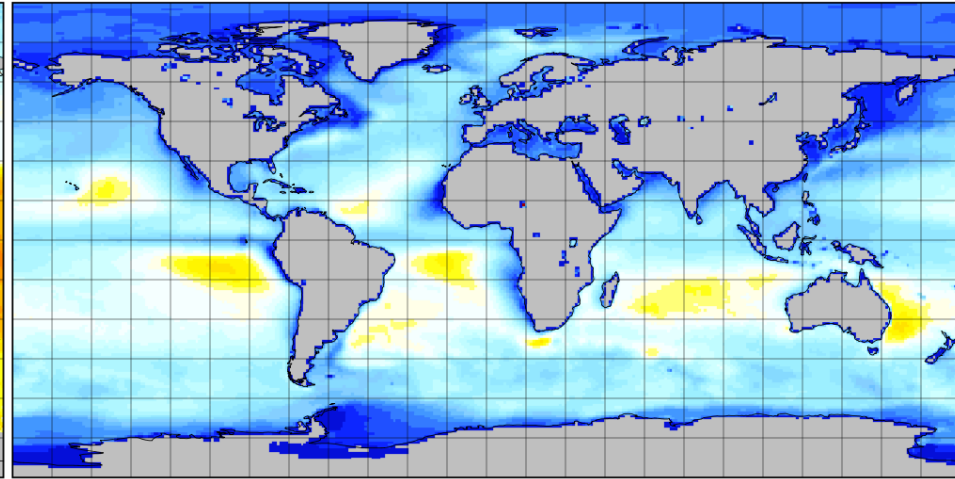


Preliminary Comparison Results (May & Jun)

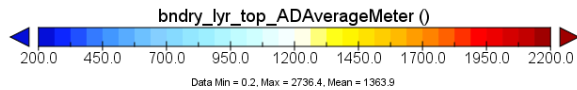
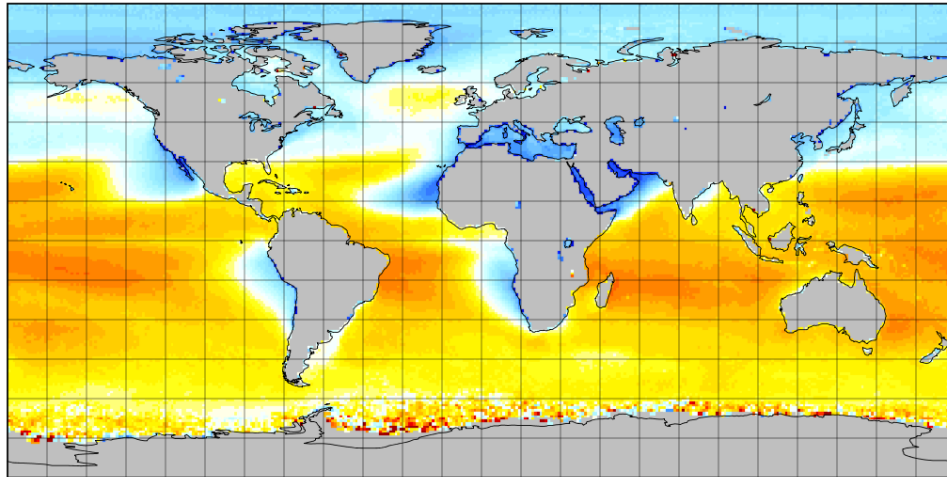
AIRS May PBLH (m)



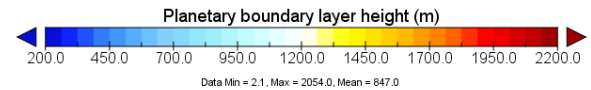
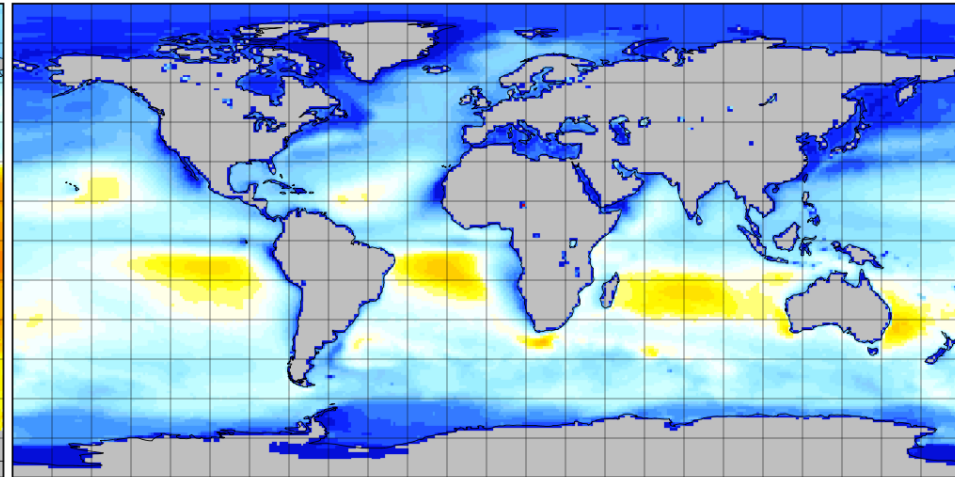
MERRA-2 May PBLH (m)



AIRS June PBLH (m)

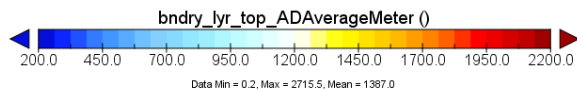
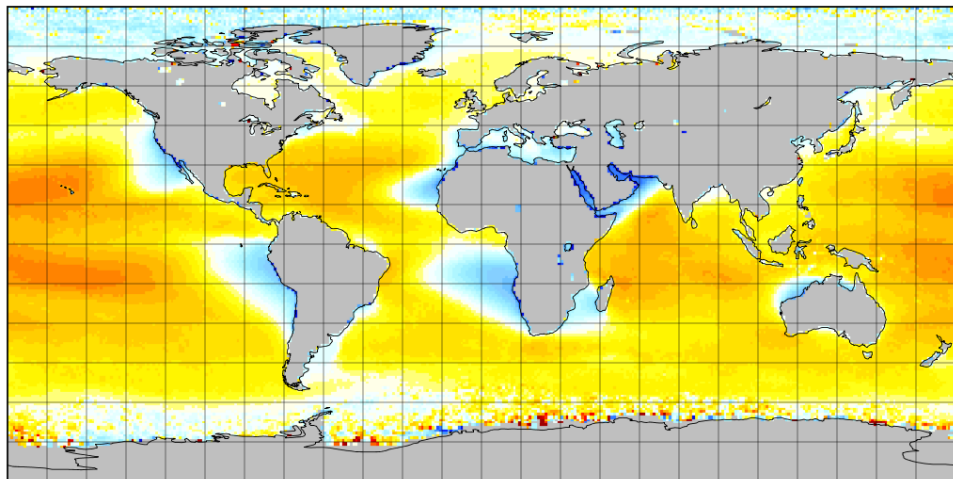


MERRA-2 June PBLH (m)

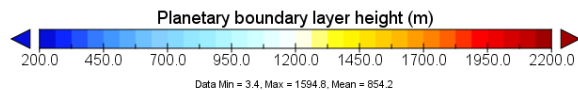
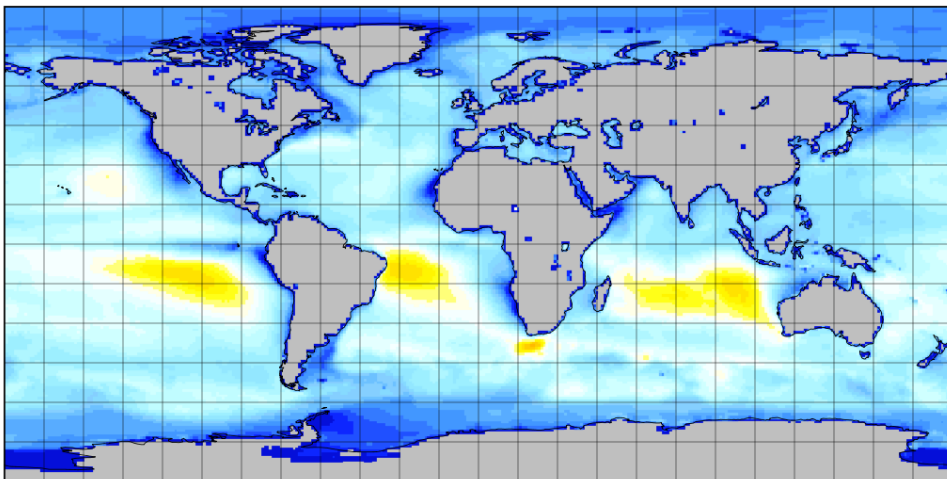


Preliminary Comparison Results (Sep & Oct)

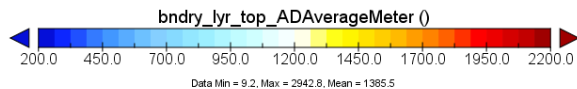
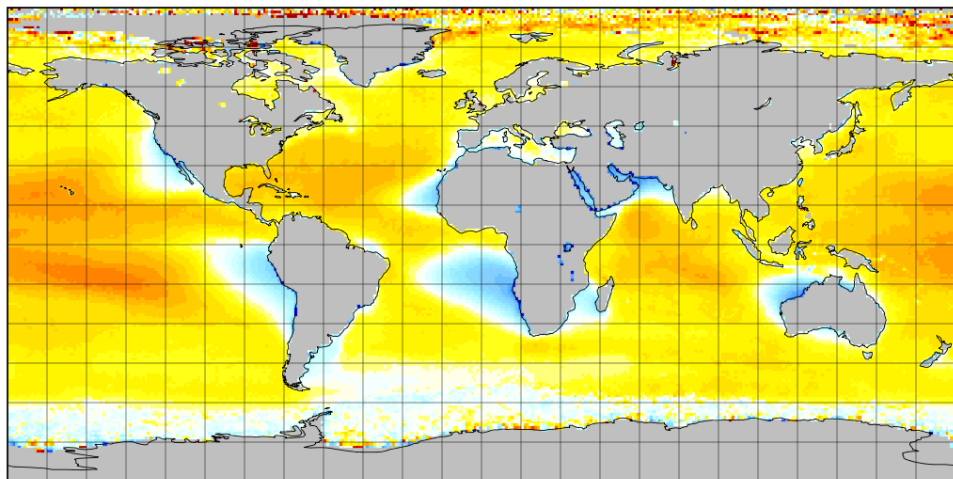
AIRS September PBLH (m)



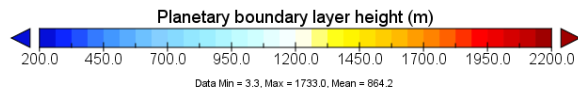
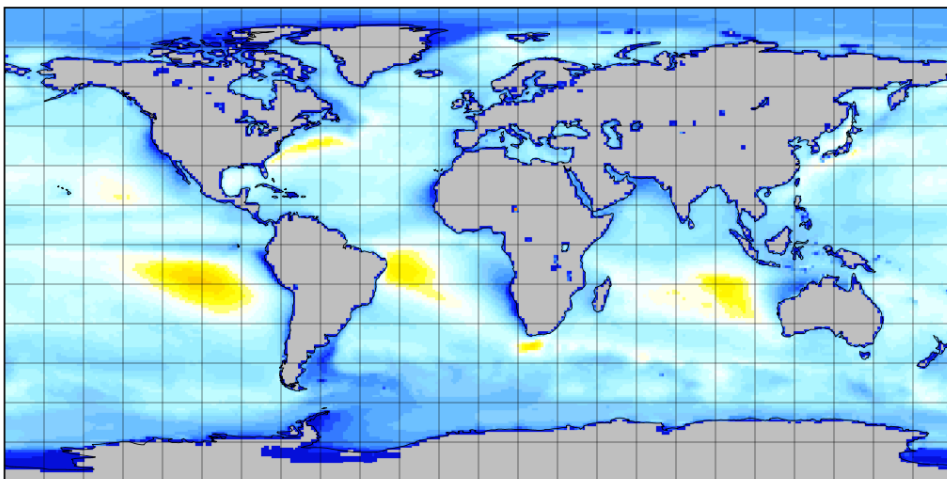
MERRA-2 September PBLH (m)



AIRS October PBLH (m)

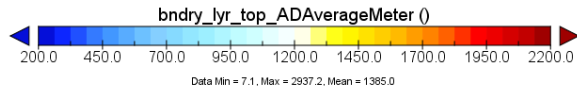
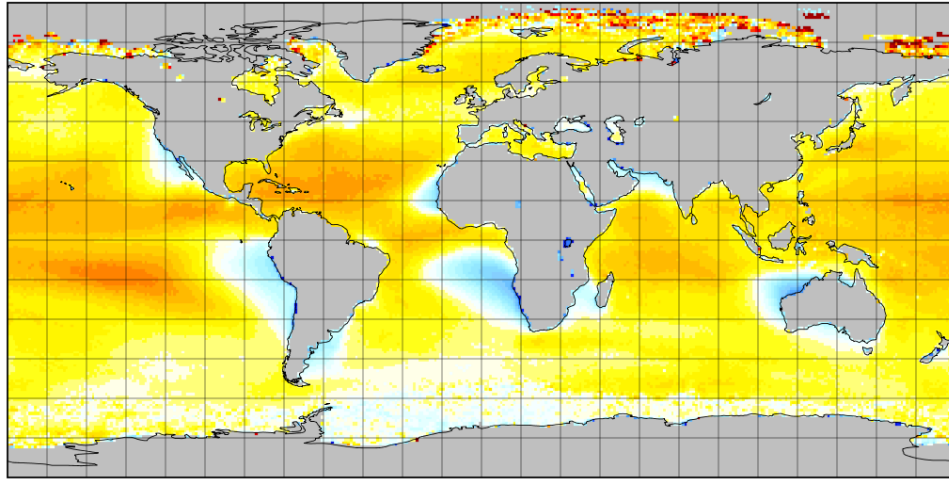


MERRA-2 October PBLH (m)

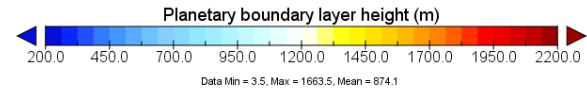
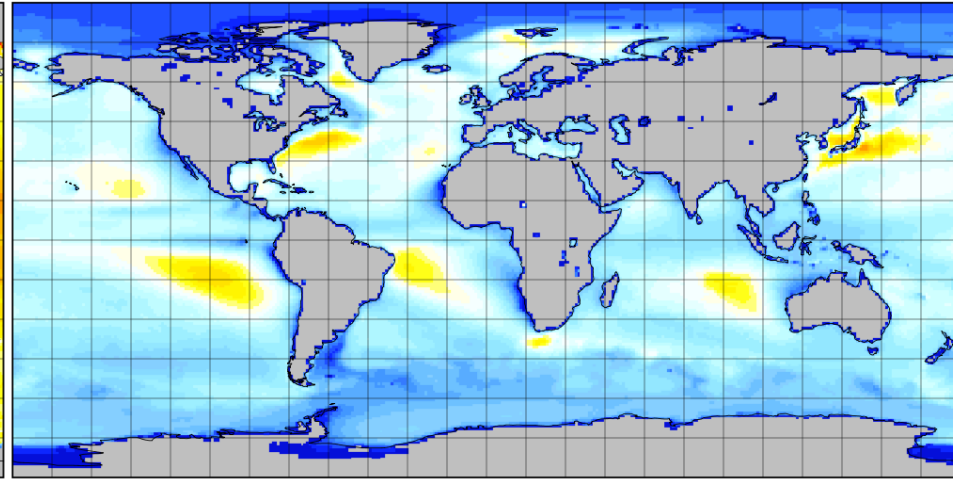


Preliminary Comparison Results (Nov & Dec)

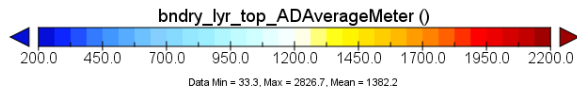
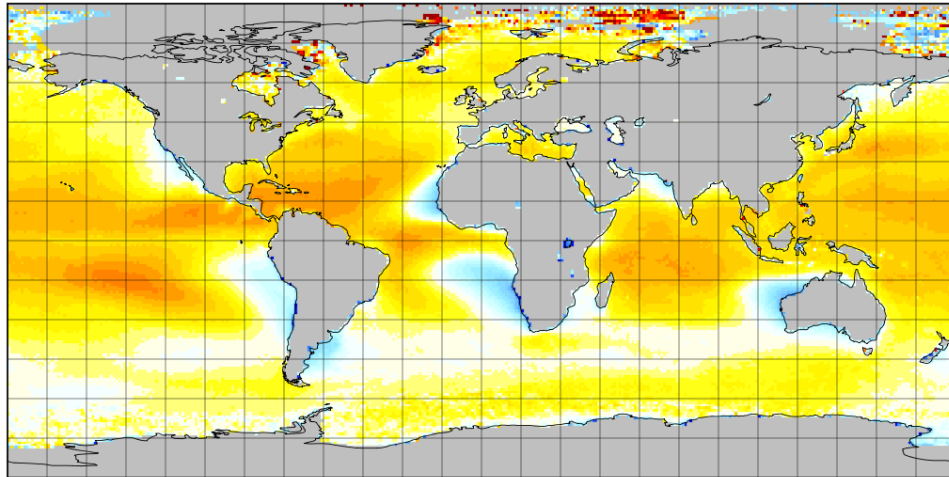
AIRS November PBLH (m)



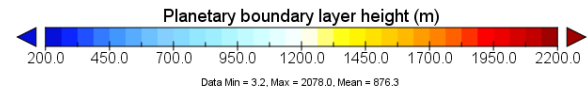
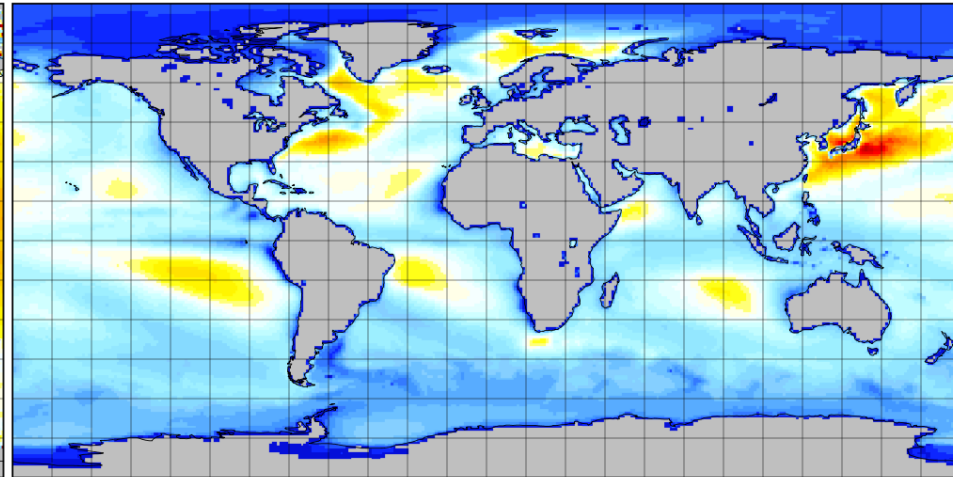
MERRA-2 November PBLH (m)



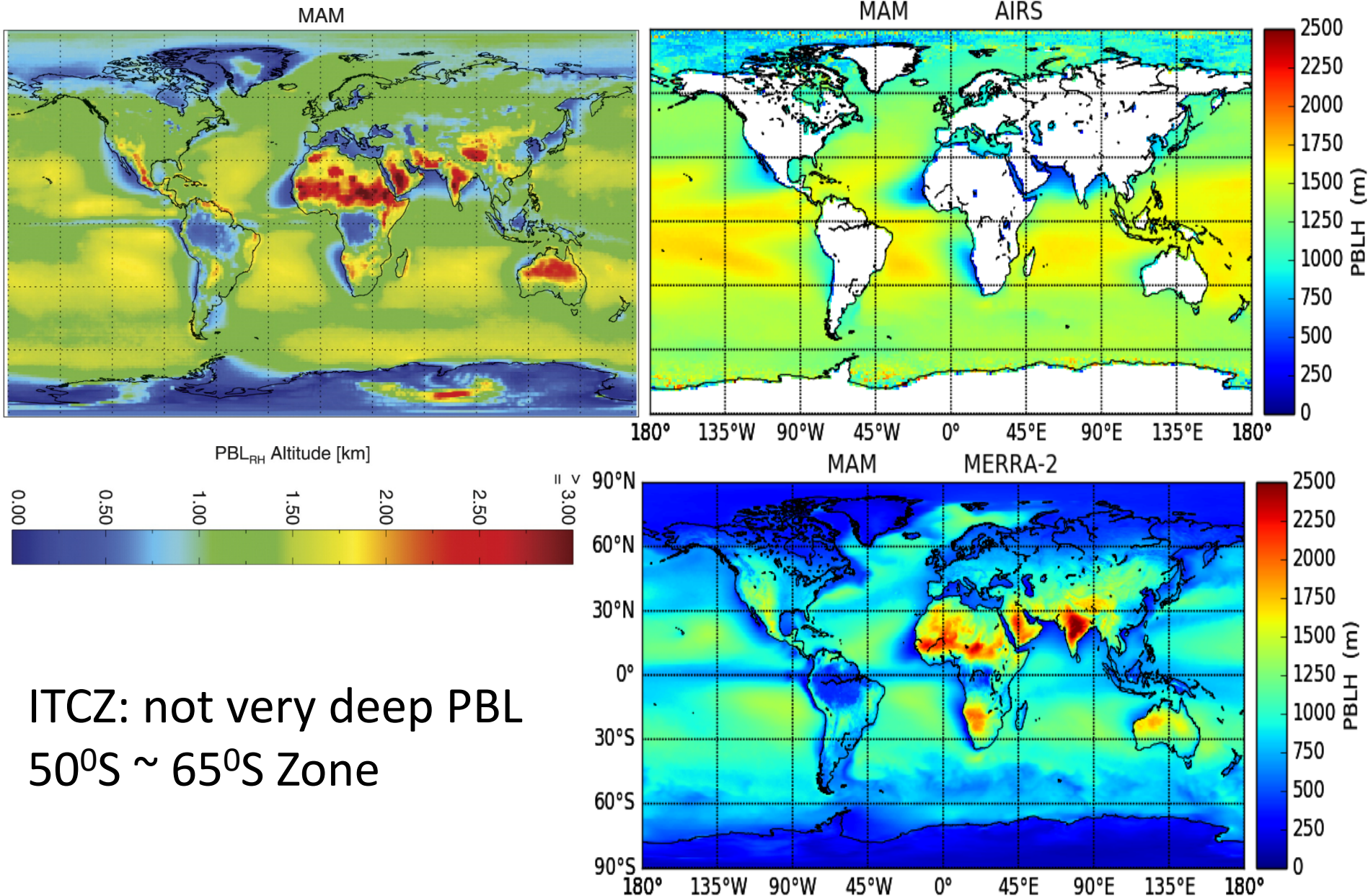
AIRS December PBLH (m)



MERRA-2 December PBLH (m)



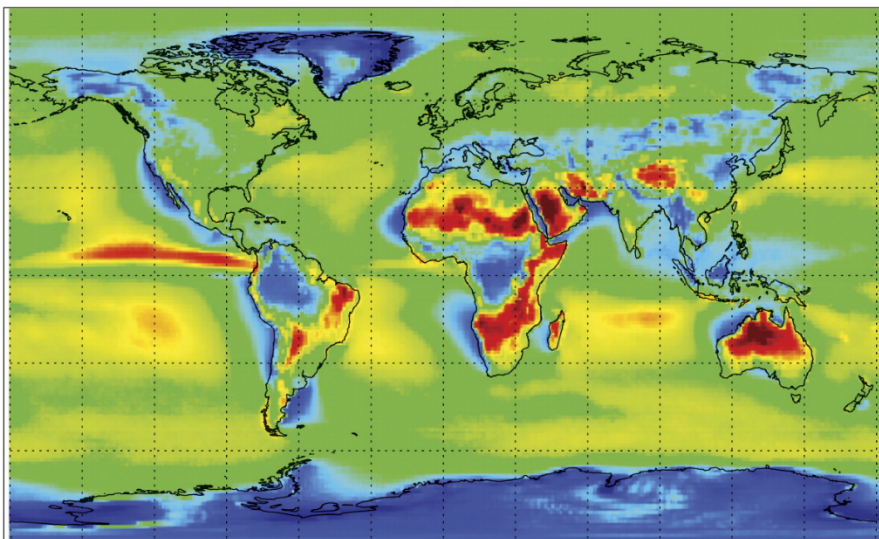
ERA, AIRS, MERRA-2 Comparison: MAM Season



ITCZ: not very deep PBL
50°S ~ 65°S Zone

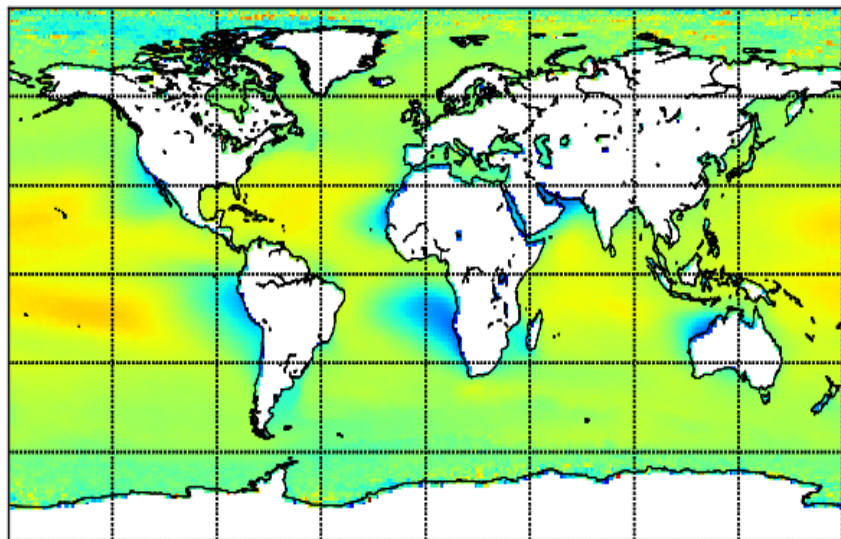
ERA, AIRS, MERRA-2 Comparison: SON Season

SON



SON

AIRS



2500
2250
2000
1750
1500
1250
1000
750
500
250
0

PBLH (m)

180° 135°W 90°W 45°W 0° 45°E 90°E 135°E 180°

PBL_{RH} Altitude [km]

≥ 3.00

2.50

2.00

1.50

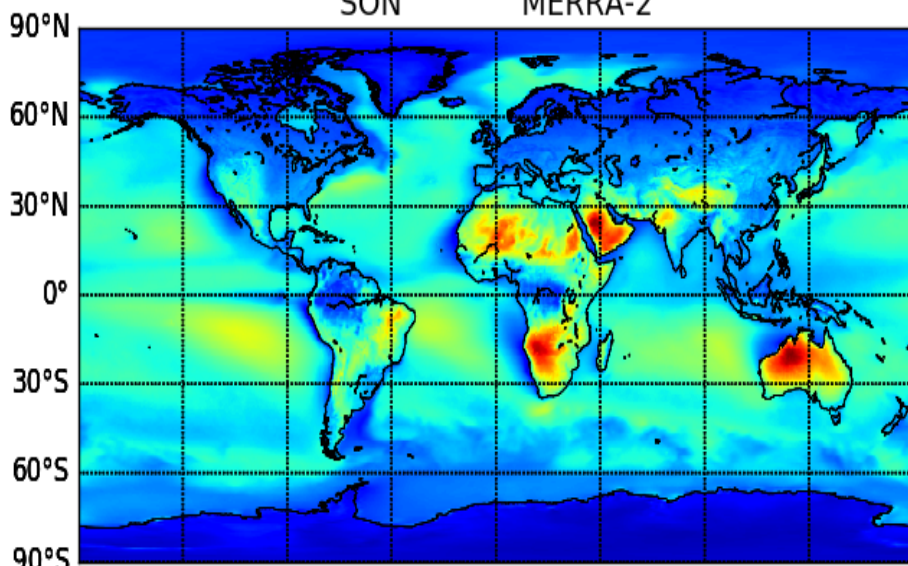
1.00

0.50

0.00

SON

MERRA-2



2500
2250
2000
1750
1500
1250
1000
750
500
250
0

PBLH (m)

180° 135°W 90°W 45°W 0° 45°E 90°E 135°E 180°

ITCZ: very deep PBL
50°S ~ 65°S Zone