Planetary Boundary Layer Height from AIRS, MERRA-2, and GPS Radio Occultation Data Products at NASA GES DISC, and Insights from Their Profiles Intercomparison

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Atmospheric science and application communities are invited to take advantage of PBL products and the Giovanni tool at NASA GES DISC: https://disc.gsfc.nasa.gov/ & https://giovanni.gsfc.nasa.gov/

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Abstract

The NASA Goddard Earth Sciences Data and Information Services Center (GES DISC) provides archive and distribution services for several data products in the Planetary Boundary Layer (PBL) category. As a new variable added to the Atmospheric Infrared Sounder (AIRS) Version 6 support product, the PBL height from AIRS is derived based on the gradients of the retrieved relative humidity profile, and provides the atmospheric pressure at the top of the PBL over the ocean. The GES DISC also hosts the Modern-Era Retrospective analysis for Research and Applications-2 (MERRA-2) product generated by the Goddard Earth Observing System Model Version 5 (GEOS-5) data assimilation system. The PBL height from MERRA-2 is based on the total eddy diffusion coefficient of heat. The monthly PBL height has been made available in the Giovanni system (Giovanni is a Web-based application developed by the GES DISC providing a simple and intuitive way to visualize, analyze, and access vast amounts of Earth science remote sensing data). Recently, the GES DISC began serving the global PBL height climatology product derived from the COSMIC/FORMOSAT-3 and TerraSAR-X Global Positioning System (GPS) radio occultation (RO) measurements from June 2006 to December 2015.

In a previous study, we presented the monthly PBL height data from AIRS and MERRA-2 and demonstrated the GES DISC services which support data intercomparison, such as access, plotting, subsetting, re-gridding, and generation of a multi-year monthly mean. We also provided intercomparison results, and found that different PBL height definitions contributed to significant differences of PBL height values between AIRS and MERRA-2. In this work, we present the 10-year seasonal climatologies from the AIRS, MERRA-2 and GPS-RO. We also used the cross section and vertical profile services in Giovanni to display and analyze the vertical atmosphere structure over regions where the PBL height derived from the AIRS and MERRA-2 are quite different. The examination of the AIRS and MERRA-2 three-dimensional data found that the relative humidity profiles had larger differences than the temperature profiles. The MERRA-2 gives more details than the AIRS for the vertical distribution of the humidity.

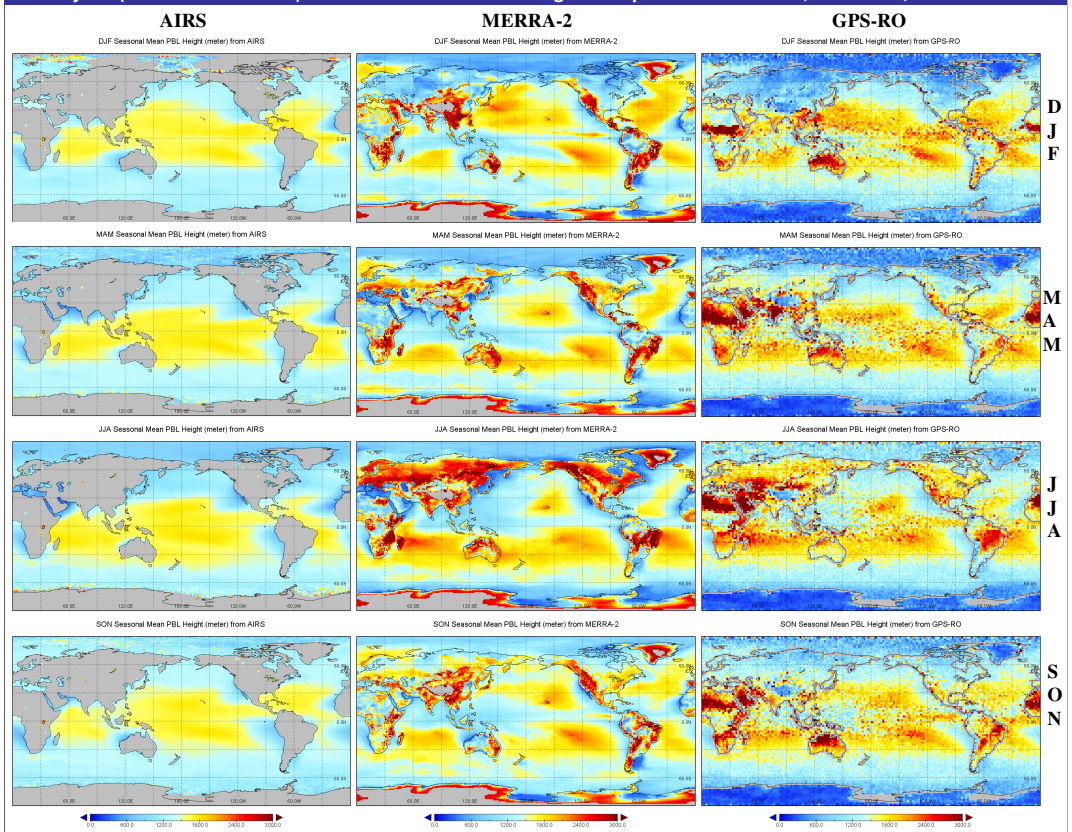
Products with PBL Height in GES DISC

- AIRS Support Product
  Version 6, 09/2009 to present, available over the ocean
  Pressure (hPa) at top of PBL
- MERRA-2
  01/1980 to present, global
  PBL Height/Depth in meters
  Monthly PBL Height in Giovanni
- COSMIC/FORMOSAT-3 & TerraSAR-X GPS-RO
  06/2006 to 12/2015 climatology
  Annual and seasonal mean of PBL Height

Dataset and 10-year Seasonal Mean Processing

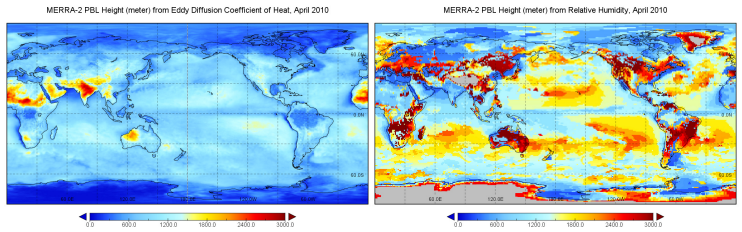
- Comparison of Multi-year Seasonal Mean
  Nearly 10 years of data: 06/2006 to 12/2015
- AIRS-only Monthly Level 3 Support Product
  DOI: 10.5067/Aqua/AIRS/DATA324
  Resolution: 1º x 1º (lat x lon)
  Convert PBL top pressure (hPa) to altitude (meters), using Geopotential Height field.
  Average ascending and descending
- MERRA-2
  DOI: 10.5067/0JRLVL8YV2Y4
  Resolution: 0.5º x 0.625º (lat x lon)
  Re-gridded to 1º x 1º (lat x lon), using L3L4 regridder
  Derived PBL height using the same definition as AIRS and GPS-RO: the level of the largest relative humidity gradient
- COSMIC/FORMOSAT-3 & TerraSAR-X GPS-RO
  DOI: 10.5067/XGL1QBKFBI5B
  Resolution: 2º x 2º (lat x lon)

10-year (06/2006 to 12/2015) Seasonal Mean of PBL Height Comparison from AIRS, MERRA-2, and GPS-RO



- **The 10-year PBL height climatologies from AIRS, MERRA-2, and GPS-RO show different seasonal changes over ocean.**
- **The PBL depths from MERRA-2 and GPS-RO are deeper (higher in altitude) than those from AIRS in every season.**
- **Over the ocean, AIRS shows one whole deeper PBL area covering almost all the tropics and subtropics, whereas MERRA-2 shows a narrow and shallower PBL zone along the equator splitting the deeper PBL area into north and south regions, and GPS-RO gives a deeper PBL belt in an oval shape over the Pacific and Indian Ocean.**

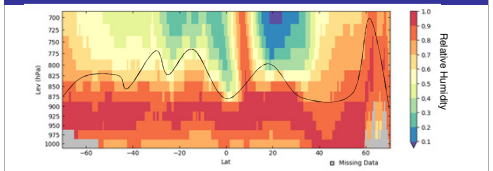
MERRA-2 PBL Comparison with Different PBL Height Definitions



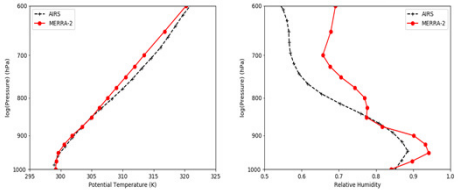
For MERRA-2, PBL depth from the relative humidity gradient is much deeper than that from the total eddy diffusion coefficient of heat (K_h).

- **PBL height in MERRA-2 is based on the total eddy diffusion coefficient of heat (K_h) with a threshold value of 2 m^2s^{-1}.**
- **To compare with AIRS and GPS-RO, compute the PBL height of MERRA-2 based on the same definition as AIRS and GPS-RO, which is: the altitude with the largest relative humidity gradient.**

Cross Section and Vertical Profile Plots



This cross section plot of MERRA-2 relative humidity, July 2010, along the 150º W longitude line illustrates the JJA seasonal PBL height pattern changes from south to north over the central Pacific Ocean.
QR Code: Giovanni Cross Section Plot URL



Potential Temperature and Relative Humidity Profiles from AIRS and MERRA-2 at the grid point 120ºW, 0ºN, for April 2010.

- **AIRS and MERRA-2 have similar vertical structure of temperature, but considerable differences for relative humidity, at a grid point on the equator over the eastern Pacific Ocean. MERRA-2 shows more detailed vertical changes of relativity humidity.**
- **Examination of the vertical profiles of temperature and water vapor may explain the PBL height differences of MERRA-2 from different definitions, and the different PBL height patterns between AIRS and MERRA-2 along the equator over the Pacific Ocean.**

Summary

- GES DISC provides PBL data and services from AIRS, MERRA-2, and GPS-RO for PBL study.
- Comparisons of AIRS-derived PBL height with model reanalysis data over the ocean show different PBL height definitions contribute to significant differences.
- The 10-year seasonal climatologies of PBL depth from AIRS, MERRA-2, and GPS-RO show different seasonal changes over ocean.
- The 10-year seasonal climatology of PBL depth from AIRS is shallower than those from the MERRA-2 and GPS-RO.
- The vertical structure analysis services in the GES DISC, such as cross section and vertical profile plots, are very helpful to examine PBL height differences from different definitions and pattern differences.
- The work supports a use case for the Cloud Analytics Reference Architecture User Working Group in ESDIS.
- More vertical structure analysis work will be done to include GPS-RO data in the future.

Contact Information

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