Planetary Boundary Layer Height from AIRS and MERRA-2 Products at NASA GES DISC, and Insights from Data Intercomparison

AMS 99th Annual Meeting
Phoenix, Arizona
January 6– 10, 2019

NASA/Goddard EARTH SCIENCES DATA and INFORMATION SERVICES CENTER (GES DISC)

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 Atmospheric Infrared Sounder (AIRS) is the hyperspectral infrared sounder onboard NASA's Aqua satellite, launched in 2002. The NASA Goddard Earth Sciences Data and Information Services Center (GES DISC), in collaboration with NASA's Sounder Team at JPL, provides processing, archiving, and distribution services for NASA sounders: the Aqua AIRS mission and the subsequent Suomi National Polar-orbiting Partnership (NPP) Cross-track Infrared Sounder (CrIS) mission. The Planetary Boundary Layer (PBL) Height is a new variable added in the AIRS Version 6 support product. It is derived based on gradients of the retrieved atmospheric thermodynamic profile, and gives the pressure at the top of the PBL over the ocean.

The GES DISC also provides services for the second Modern-Era Retrospective analysis for Research and Applications (MERRA-2) product generated by the Goddard Earth Observing System Model Version 5 (GEOS-5) data assimilation system. The monthly PBL Height (PBLH) variable is available in the Giovanni system, which 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.

In this work, we present the monthly PBL Height data from AIRS and MERRA-2 and services to support data intercomparison, such as access, plotting, subsetting, re-gridding, and generation of a multi-year monthly mean. We also show intercomparison results, and evaluate whether AIRS can observe ocean PBL features similar to the reanalysis product at monthly and longer-term scales.

Products with PBL Height at 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

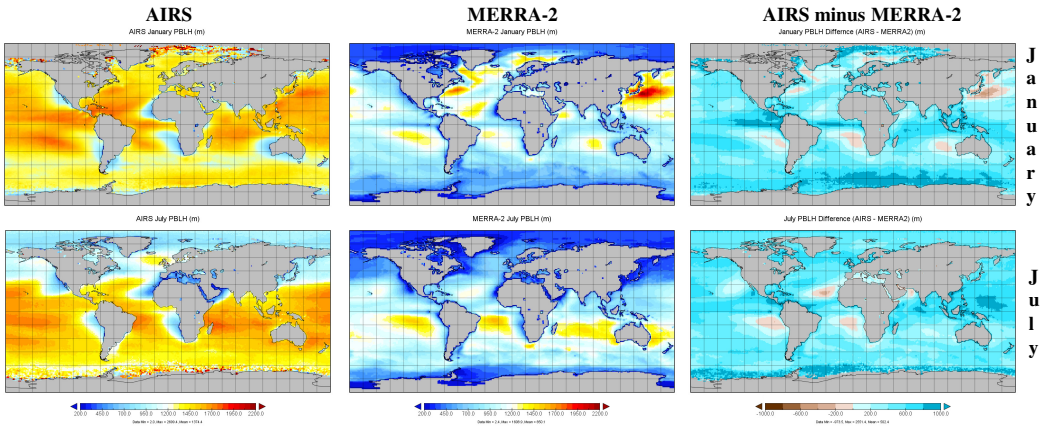
Dataset and 15-year Monthly Mean Processing

- Comparison of Multi-year Monthly Mean
  - 15-year mean: 2003 to 2017
- AIRS-only Monthly Level 3 Support Product (AIRS3STM)
  - Resolution: 1^{O} x 1^{O} (lat x lon)
  - Variable subsetting and format conversion from HDF to NetCDF files
  - Using NetCDF Operator (NCO) toolkit process netCDF files
    - *ncea: netCDF Ensemble Averager*
    - *ncap2: netCDF Arithmetic Processor*
    - *ncremap: netCDF Remapper*
  - Ascending and descending average: *ncea*
  - Convert pressure (hPa) to altitude: *ncap2*

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

  - 15-year average: *ncea*
- MERRA-2 (M2TMNXFLX)
  - Resolution: 0.5^{O} x 0.625^{O} (lat x lon)
  - 15-year monthly mean created with Giovanni
  - Resolution match to AIRS: *ncremap*

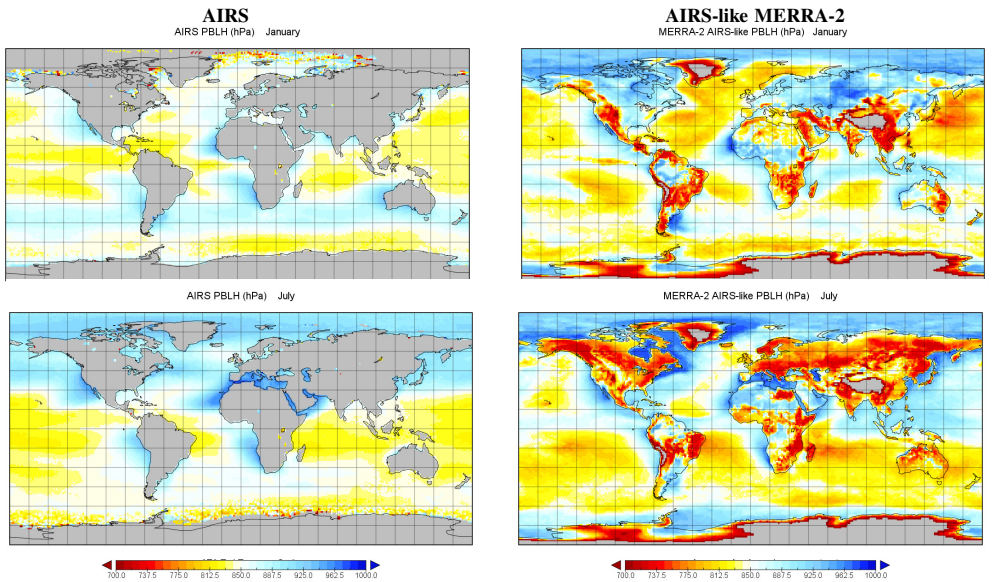
15-year (2003 to 2017) Monthly Mean of PBL Height Comparison from AIRS and MERRA-2



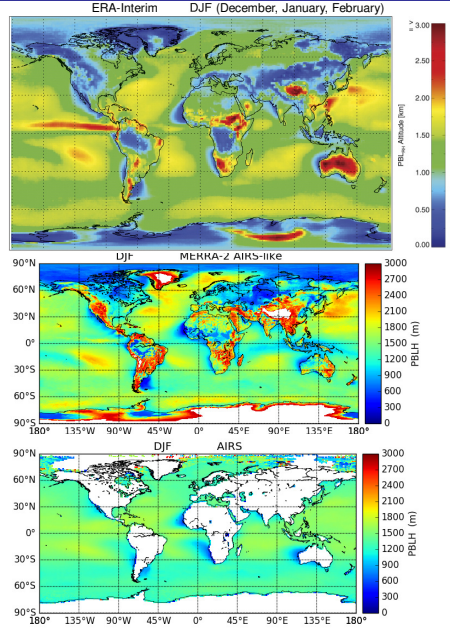
- **AIRS PBL Height/Depth deeper than MERRA-2 in every month, and globally about 500m deeper.**
- **Different definition of PBL Height:**
  - **AIRS: the pressure of the level with the largest relative humidity gradient.**
  - **MERRA-2: based on the total eddy diffusion coefficient of heat (K_h) with threshold value $2m^2s^{-1}$.**

15-year Monthly Mean of PBL Height Comparison with Same Definition

- **Applied the AIRS PBL Height definition scheme (the largest gradient of relative humidity) to MERRA-2 (M2TMNPCLD) relativity humidity profile data and generated *AIRS-like* MERRA-2 PBL Height.**
- **PBL Heights over the ocean from two datasets with the same definition show much more similar patterns, especially near the equator and Antarctic.**
- **MERRA-2 has deeper PBL Height/Depth than AIRS if defined with relative humidity profile as for AIRS.**



Seasonal Data Comparison with ERA-Interim



- **ERA-Interim seasonal climatology is 20 years (1990 to 2009). *Reference*: Axel von Engeln and Joao Teixeira (2013): A PBLH Climatology Derived from ECMWF Reanalysis Data**
- **Over the ocean, patterns are similar, except ERA-Interim shows deeper PBL, especially a narrow, very deep PBL zone (0–10°N, 160°W–70°W) just north of the equator over eastern Pacific Ocean.**

Summary

- GES DISC provides data and services 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.
- AIRS observes a lower PBL height than model reanalysis data, but can capture long-term PBL signal over the ocean.
- GES DISC recently released annual and seasonal PBL Height climatology product from GPS Radio Occultation. More services can be provided for this new product, and additional comparisons to it will be performed in the future.
- The work supports a use case for the Cloud Analytics Reference Architecture User Working Group in ESDIS.

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Giovanni