National Aeronautics and Space Administration Goddard Earth Science Data Information and Services Center (GES DISC)

README Document for the GPS Radio Occultation Boundary Layer Depth Annual and Seasonal Products (GPSROZPBLA and GPSROZPBLS)

Last Revised May 12, 2022

Goddard Earth Sciences Data and Information Services Center (GES DISC)
http://disc.gsfc.nasa.gov
NASA Goddard Space Flight Center
Code 610.2
Greenbelt, MD 20771 USA

Prepared By:

Chi O. Ao, Peter Kalmus	***Thomas Hearty***
Jet Propulsion Laboratory California Institute of Technology	GES DISC GSFC Code 610.2

Reviewed By:

Reviewer Name
GES DISC GSFC Code 613.2

Goddard Space Flight Center
Greenbelt, Maryland

Revision History

Revision Date	Changes	Author
Feb 17, 2022	Updated description of the dataset for V2	C. Ao and P. Kalmus
May 12, 2022	Added reference to algorithm paper	T. Hearty

Table of Contents

1.0 Introduction

This document provides basic information for using the GPSROZPBLA and GPSROZPBLS products.

The GPSROZPBLA and GPSROZPBLS are annually and seasonally averaged products of global planetary boundary layer (PBL) height climatology derived from Global Positioning System (GPS) radio occultation (RO) measurements from multiple missions. Version 1 of these products utilized data from the COSMIC/FORMOSAT-3 and TerraSAR-X missions covering the period of June 2006 to December 2015. The current Version 2 extends the end-date coverage to December 2019 and includes data from the KOMPSAT-5 and PAZ missions.

1.1 Dataset/Mission Instrument Description

The backbone of the dataset comes from GPS RO measurements from the COSMIC/FORMOSAT-3 mission, which consisted of a six-satellite constellation that operated from 2006-2020. Each satellite carried the NASA/JPL-designed Integrated GPS Occultation Receiver (IGOR) GPS receiver and equipped with fore and aft looking antenna to track the L-band microwave signal broadcast by a GPS satellite in both setting and rising limb-viewing geometry. The constellation provides globally distributed measurements across different local times, with about 2500 profiles per day at its peak. Due to the degradation of the constellation starting from about 2013, the COSMIC measurements were complemented with similar measurements from several other missions of opportunity. TerraSAR-X, KOMPSAT-5, and PAZ are all X-band SAR imaging satellites in sun-synchronous dusk-dawn orbits with GPS RO being a secondary measurement. In contrast to earlier RO missions like GPS/MET and CHAMP, the IGOR instruments on all these satellites are capable of tracking the GPS signals in open loop through the middle to lower troposphere, which is essential for obtaining data with high quality for PBL height estimation, especially at low latitudes.

GPS RO data from these missions are routinely processed at JPL and publicly distributed (https://genesis.jpl.nasa.gov). Level 2 products, specifically the JPL-retrieved refractivity profiles, from these missions are used to derive the PBL height products.

1.2 Algorithm Background

For each occultation, the PBL height is calculated as the height where the vertical gradient of the refractivity (dN/dz) is minimum. This algorithm is designed to locate the height where a large vertical change in refractivity occurs, corresponding to the transition from the free troposphere to the PBL. To help characterize the significance of PBL height detection, a sharpness parameter is computed for each profile, which is equal to the negative of the minimum refractivity gradient divided by the root-mean-square of the refractivity gradient averaged over 0-6 km altitudes. Larger sharpness parameter indicates that the determination of PBL height through our algorithm is more robust. The PBLH is obtained from finding the minimum value of this derivative from 0 km up to 6 km mean-sea-level altitude. Over mountainous terrain with extreme elevations, especially the Himalayas, this may lead to erroneous results. For this reason, we exclude profiles over regions with terrain height exceeding 4 km. This leads to no climatology coverage over the Himalayas.

Each PBL height is associated with a time (starting time of the occultation) and location (latitude and longitude of the tangent point at the minimum altitude). The PBL height data are then binned into 2° x 2° latitude/longitude regions and averaged to produce the mean and standard deviation values in the climatology products. The refractivity profile has a vertical resolution of about 200 m and represents an along path horizontal averaging of ~100 km. Thus, occultations with tangent points near the coast may represent averaging over both land and ocean and are currently not included in the gridded products.

The refractivity gradient method used here is not the only method that can be used to estimate the PBL height. Other algorithms have been proposed, including looking at "breakpoint" instead of minimum gradient, wavelet covariance transform, and using variables like bending angles or specific humidity instead of refractivity. However, the basic principle is the same. The difference between the different algorithms is small where the PBL is well-defined, with a strong capping inversion. More details on the PBL height algorithm, discussion of the sharpness parameter, and creation and validation of these products can be found in Ao et al. (2012) and Kalmus et al. (2022).

1.3 Data References

The following DOIs point to the dataset landing pages which include examples for how to cite the datasets:

Shortname	DOI
GPSROZPBLA	http://dx.doi.org/10.5067/XKO8DCSRTPUZ
GPSROZPBLS	http://dx.doi.org/10.5067/DKDMKV7IOB1P

2.0 Data Organization

The GPSROZPBLA and GPSROZPBLS data products are annual and seasonal climatologies of the boundary layer height.

2.1 File Naming Convention

Each dataset has only 1 file that indicates the year range, the resolution, and temporal frequency.

Shortname	**Filename**
GPSROZPBLA	pblh_gps_2006-2019_2x2_annual.nc
GPSROZPBLS	pblh_gps_2006-2019_2x2_season.nc

2.2 File Format and Structure

The data files are in netCDF-4 format and follow the CF 1.7 conventions.

2.3 Key Science Data Fields

The key science data fields are "*atmosphere_boundary_layer_thickness*" and "*atmosphere_boundary_layer_thickness_sd*" which provide the mean value of the atmospheric boundary layer and the standard deviation respectively. In addition, the fields "*pbl_sharpness_parameter*" and "*pbl_sharpness_parameter_sd*" provide the mean and standard deviation of the sharpness parameter and can be used as a measure of the robustness of the PBL height determination.

3.0 Data Contents

3.1 Dimensions

The annual product (GPSROZPBLA) provided the mean value of the atmospheric boundary layer thickness for each latitude and longitude. The *seasonal product* (GPSROZPBLS) has an additional dimension for each of the four seasons (DJF, MAM, JJA, SON).

3.2 Products/Parameters

Data Field Name	Description	Units
lat	latitude of the center of the grid element	degrees_north
lon	longitude of the center of the grid element	degrees_east
atmosphere_boundary_layer_thickness	atmosphere boundary layer thickness mean value	meters
atmosphere_boundary_layer_thickness_sd	atmosphere boundary layer thickness standard deviation	meters
pbl_sharpness_parameter	PBL sharpness parameter mean value	none
pbl_sharpness_parameter_sd	PBL sharpness parameter standard deviation	none
number_of_soundings	Number of soundings	count
season	0=DJF, 1=MAM, 2=JJA, 3=SON	Not Applicable
surface_type	0 (ocean); 1 (land); 2 (coast)	Not Applicable

4.0 Options for Reading the Data

This data may be read many different program languages that are able to read netCDF-4 or HDF-5 files as well as hdfview and panoply. For python code, we recommend the Xarray package for reading the data.

5.0 Data Services

These data are available for download via https and opendap.

If you need assistance or wish to report a problem you may contact the GES DISC using the Feedback or Help links at https://disc.gsfc.nasa.gov.

6.0 Acknowledgements

This research was carried out at the Jet Propulsion Laboratory (JPL), California Institute of Technology, under a contract with the National Aeronautics and Space Administration. We acknowledge the NASA MEaSUREs program that funded a significant amount of this research. GNSS-RO processing at JPL for multiple missions was supported by NASA Earth Science Division (ESD). We thank Drs. Joao Texeira and Matthew Lebsock from JPL for guidance and helpful discussions in the generation of these products.

References

Ao, C. O., D. E. Waliser, T. K. Chan, J.-L. Li, B. Tian, A. J. Mannucci (2012). Planetary boundary layer heights from GPS radio occultation refractivity and humidity profiles. *J. Geophys. Res.*, 117, D16117, doi:10.1029/2012JD017598

Kalmus, P., Ao, C. O., Wang, K.-N., Manzi, M. P., and Teixeira, J., A high-resolution planetary boundary layer height seasonal climatology from GNSS radio occultations, R*emote Sensing of Environment*, vol. 276, p. 113037, 2022. doi:10.1016/j.rse.2022.113037