

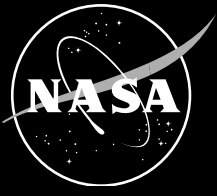
Global Planetary Boundary Layer Temperature and Water Vapor Products from Merged GNSS-RO, IR, and MW Satellite Observations

The Satellite Needs Working Group PBL Project

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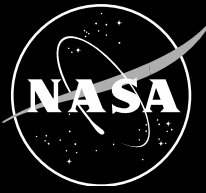


Overview – SNWG PBL Project

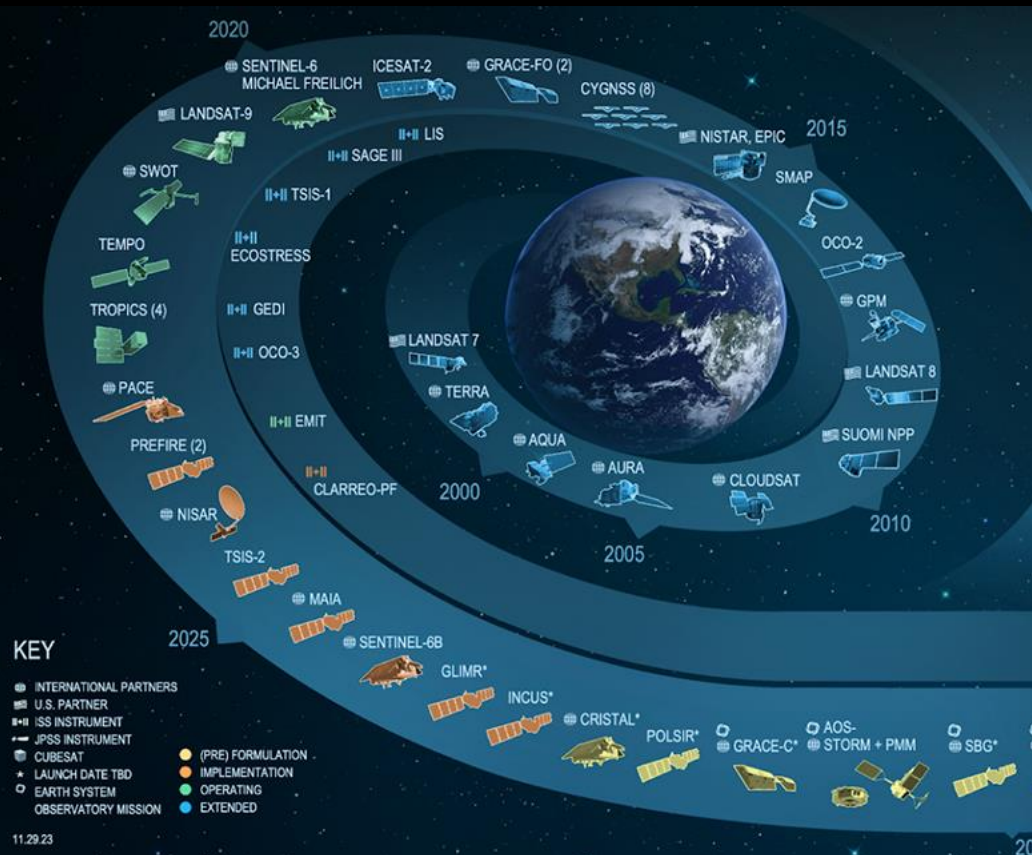
- Satellite Needs Working Group (SNWG) Planetary Boundary Layer (PBL) Project - currently in year 1 of 5
- Addressing needs identified in the 2020 cycle of the SNWG survey
- Developing data products for temperature and water vapor in the PBL
- Merging satellite data from hyperspectral infrared (IR) and microwave (MW) atmospheric sounders with GNSS radio occultations (RO).



The Satellite Needs Working Group (SNWG)



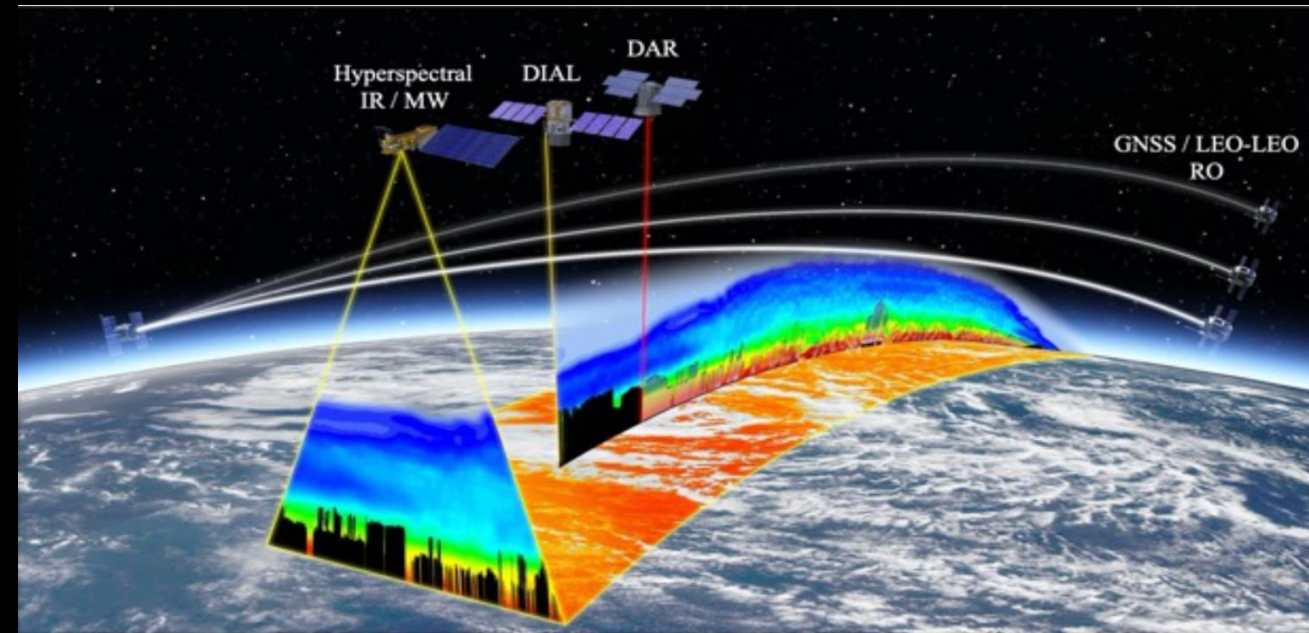
- The SNWG surveys federal civilian agencies biennially to identify high-priority Earth observation data needs.



- SNWG PBL Project at JPL coordinates with SNWG Management Office (MO) at NASA's Interagency Implementation and Advanced Concepts Team (IMPACT), which manages and oversees solution projects with oversight from NASA HQ.

Motivation

- PBL vertical structure of temperature and water vapor
 - Diurnal, seasonal, and climate-scale variations of Earth's atmospheric processes
 - Key to PBL cloud formation and pollution dispersal.
- Combining IR and MW atmospheric sounder data with GNSS-RO data into a merged global product
 - Leverages complementary spatial and vertical resolutions
 - Advances PBL process science, weather forecasting and other applications.



Needs

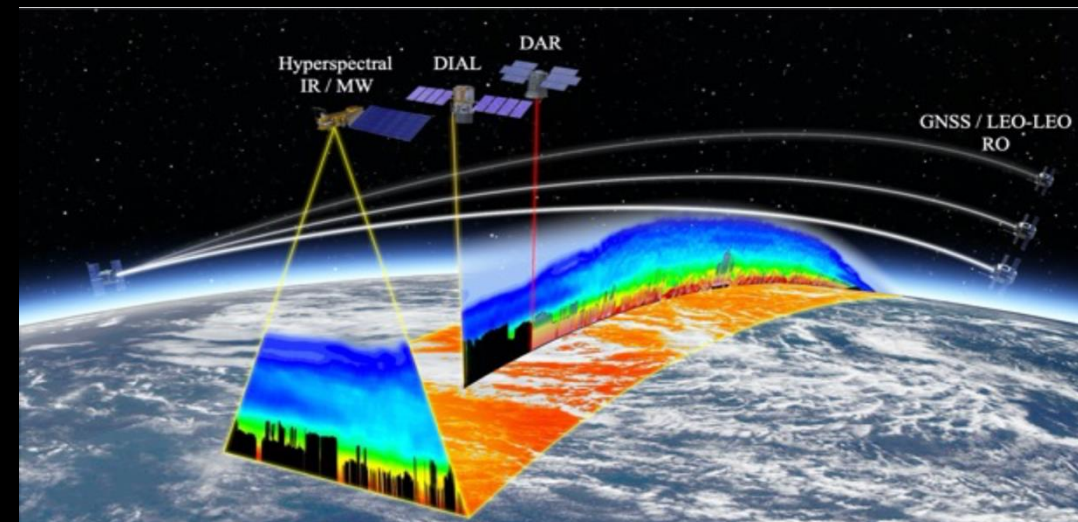


- The merged PBL product is expected to provide substantial benefit to NOAA and the DOE's Office of Science, among other agencies, whose high-priority objectives include:
 - Better initializations of the PBL and land surfaces in weather and climate models
 - Supporting scientific research on atmospheric processes and impacts on the cloud life cycle
 - Obtaining insight into fixed Atmospheric Radiation Measurement (ARM) observation sites
 - Increasing the number of PBL sounding profiles over data-sparse regions, including oceans

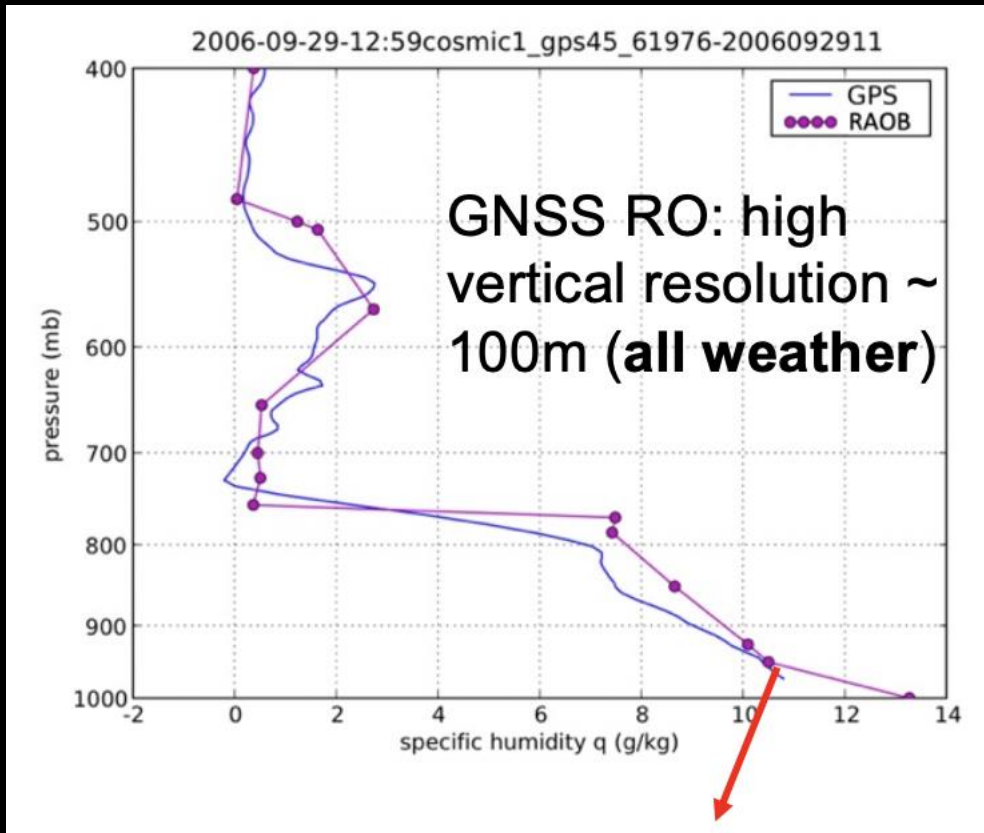
Decadal Survey Incubation

- The 2017 Decadal Survey identified PBL as an Incubation-class targeted observable activity that seeks to identify and develop new technology to improve our understanding of the thermodynamic structure of the PBL.
- The SNWGW-PBL activity would provide needed datasets with current capabilities for requesting agencies as new technical capabilities mature in the Decadal Survey PBL activity.

Teixeira, et al., 2021: Toward a Global Planetary Boundary Layer Observing System: The NASA PBL Incubation Study Team Report. NASA PBL Incubation Study Team.

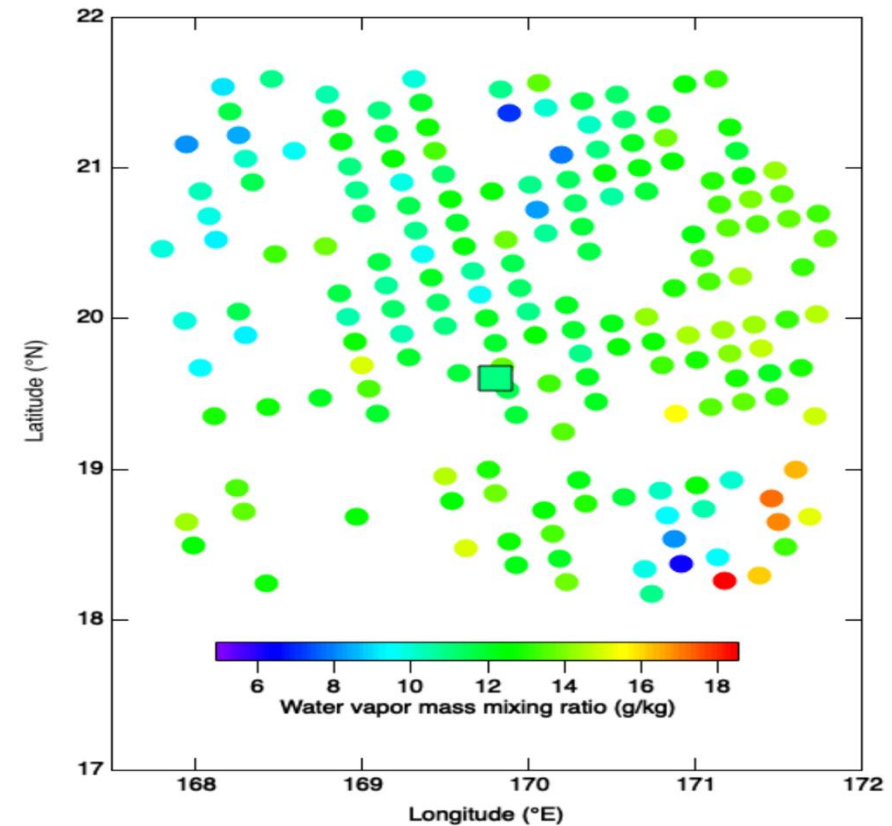


Complimentary IR, MW, and RO



GNSS Radio Occultation (RO) often measures water vapor within 200m of the sea surface

IR sounding data provides 3D context to sparse GNSS-RO profiles



Water vapor @815 hPa from IR soundings in vicinity of RO sounding (square)

Input Data Sources and Characteristics



Measurement Technique	Instrument Sources	Vertical Resolution	Horizontal Resolution
IR Sounders	AIRS, CrIS	~1 km	~15-45 km
MW Sounders	AMSU, ATMS	~1 km	~15-45 km
GNSS-RO	COSMIC-1/2, Spire, Sentinel-6, GRACE-FO	~100 m	~100 km

Approach



- The PBL product will utilize a combination of publicly available atmospheric sounding data from IR, MW, and GNSS-RO from multiple satellite missions
- First version: Simple data fusion on RO, IR, and MW retrievals
 - Over the subtropical and tropical oceans and then globally.
- Second version: Joint retrieval, combining the measurements more optimally
 - Potentially more accurate product with higher spatial resolution.
- Basis for the development of merged products
 - Characterizing uncertainties of input sounding datasets
 - Creating a dataset of collocated sounder products
- Generate higher-level science products
 - Temperature and water vapor profiles, projected to a common grid for the requesting SNWG agencies, and made publicly available through the Goddard Earth Sciences Data and Information Services Center (GES DISC)

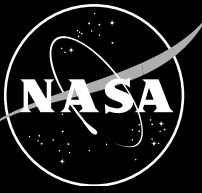
Product	Threshold (Version 1)		Baseline (Version 2)	
Input Sources	AIRS, CrIS, AMSU, ATMS, COSMIC-1/2, Sentinel-6, GRACE-FO, Spire (Additional RO datasets will likely be included subject to availability)			
Output Variables	Temperature profiles and water vapor profiles at vertical height grids of 100 m within the PBL and above (0 to ~3 km altitudes)			
Processing Level	2	3	2	3
Temporal Coverage	2014-2023		2006-present	
Temporal Sampling	Dependent on GNSS-RO sounding sampling (varies over the time period but up to 10,000 profiles per day globally)	Monthly	Dependent on GNSS-RO sounding sampling (varies over the time period but up to 10,000 profiles per day globally)	Monthly
Latency	None required (potential real-time processing possible)	None required but potentially ~1 month	None required (potential real-time processing possible)	None required but potentially ~1 month
Spatial Coverage	Global			
Spatial Resolution	Horizontal: 50 km Vertical: 200 m	Horizontal: ~2 deg Vertical: ~200 m	Horizontal: 15 km Vertical: 200 m	Horizontal: ~1 deg Vertical: ~200 m

Stakeholder Engagement



- A Stakeholder Engagement Program including sessions with the stakeholder community will be active throughout the project life cycle.
- We work with NASA SPoRT/Marshall to coordinate the engagement - see Ryan Wade's presentation: *Infusing Co-Development and Research-to-Operations/Applications into Satellite Sounder Science for Boundary Layer Applications*

Satellite Needs Working Group Planetary Boundary Layer Project



Implementation Leads: Joao Teixeira, Chi Ao (JPL). Project Manager: Heidar Thor Thrastarson (JPL)

Overview

To address needs identified in the 2020 cycle of the Satellite Needs Working Group (SNWG) survey, the Planetary Boundary Layer (PBL) Project is established to develop global products for PBL temperature and water vapor, by merging data from hyperspectral infrared (IR) and microwave (MW) sounders with GNSS radio occultation (RO).

Deliverables

Two versions of the merged PBL products will be obtained. For version 1, a simple data fusion will be performed on the RO and IR/MW sounder retrievals. For version 2, a joint retrieval will be developed to combine different measurements more optimally and offer a more accurate product with higher spatial resolution.

Deliverable	Due Date
Processing software with documentation for Version 1 of PBL data products for generation/publication at GES DISC	May 2026
Processing software with documentation for Version 2 of PBL data products for generation/publication at GES DISC	May 2028

Product Utility

Characterization of the PBL vertical structure of temperature and water vapor is vital to understand the diurnal, seasonal, and climate-scale variations of Earth's atmosphere and is key to PBL cloud formation and pollution dispersal.

The merged PBL product is expected to provide substantial benefits to NOAA, DOE, and other organizations, whose high-priority objectives include:

- Better initializations of the PBL in weather prediction and air quality models
- Better PBL observations for weather, climate and air quality model validation
- Supporting scientific research on atmospheric processes
- Obtaining insight into DOE Atmospheric Radiation Measurement (ARM) observation sites
- Increasing the number of PBL sounding profiles over data-sparse regions, including oceans

The SNWG PBL project will also help prepare for a potential NASA PBL mission that was recommended as DSI in DS17