The Planetary Boundary layer: a Decadal Survey Incubation Challenge

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Program: Strategic Initiative

Assigned Presentation # 036

Jet Propulsion Laboratory
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Introduction

The Planetary Boundary Layer (PBL) was selected as an Incubation Targeted Observable by the 2017 Earth Science Decadal Survey:

TARGETED OBSERVABLE	SCIENCE/APPLICATIONS SUMMARY	CANDIDATE MEASUREMENT APPROACH	Designated	Explorer	Incubation
Atmospheric Winds	**3D winds in troposphere/PBL** for transport of pollutants/carbon/aerosol and water vapor, wind energy, cloud dynamics and convection, and large-scale circulation	Active sensing (lidar, radar, scatterometer); passive imagery or radiometry-based atmos. motion vectors (AMVs) tracking; or lidar**		x	x
Planetary Boundary Layer	**Diurnal 3D PBL thermodynamic properties and 2D PBL structure** to understand the impact of PBL processes on weather and AQ through high vertical and temporal profiling of PBL temperature, moisture and heights.	Microwave, hyperspectral IR sounder(s) (e.g., in geo or small sat constellation), GPS radio occultation for diurnal PBL temperature and humidity and heights; water vapor profiling DIAL lidar; and lidar** for PBL height			x
Surface Topography & Vegetation	**High-resolution global topography** including bare surface land topography ice topography, vegetation structure, and shallow water bathymetry	Radar; or lidar**			x

Incubation: Measurement/ mission approach not mature enough - requiring investment and work during next few years

PBL was considered High Priority across DS panels (Weather and AQ, Climate, Water Resources, Ecosystems) and Integrating Themes

Problem Description

- There are a variety of potential PBL Measurement Approaches: GNSS RO, Hyperspectral IR and MW sounding, SW, Lidar/DIAL, Radar/DAR

→ these are complementary approaches that should be combined

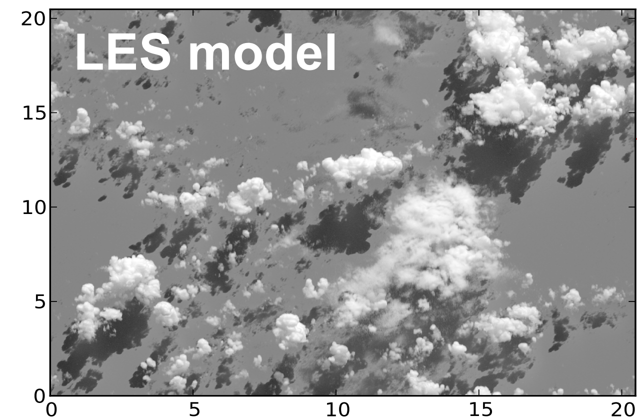
- Essential question: Which approaches and architectures will optimally address PBL science requirements?

- Goal of this project: To develop and implement a simulation methodology to evaluate different PBL measurement approaches and architectures

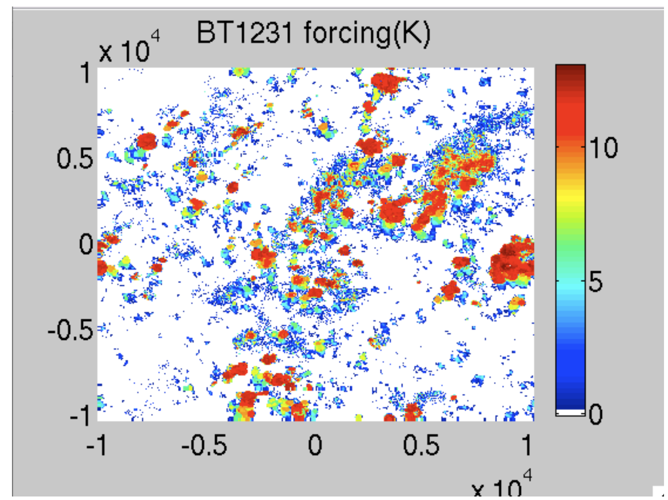
- This project helps position JPL as a leader of the PBL Incubation efforts

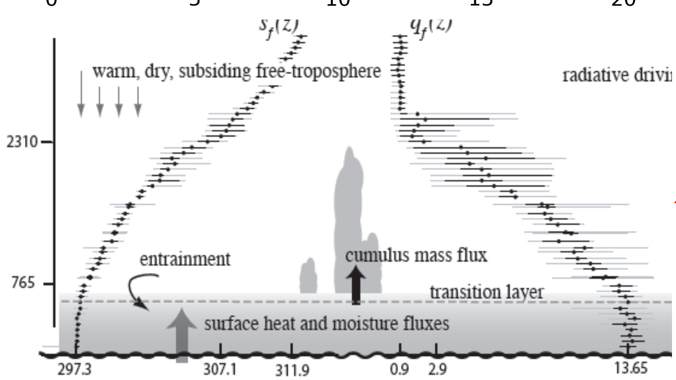
Methodology

1) High-resolution Large Eddy Simulation (LES) models are used to create a variety of PBL virtual cases
2) Based on these virtual fields radiative/instrument forward models are used to create virtual L1 fields
3) Retrievals are performed on L1 and produce geophysical variables that are compared to LES fields



Radiative / instrument forward model



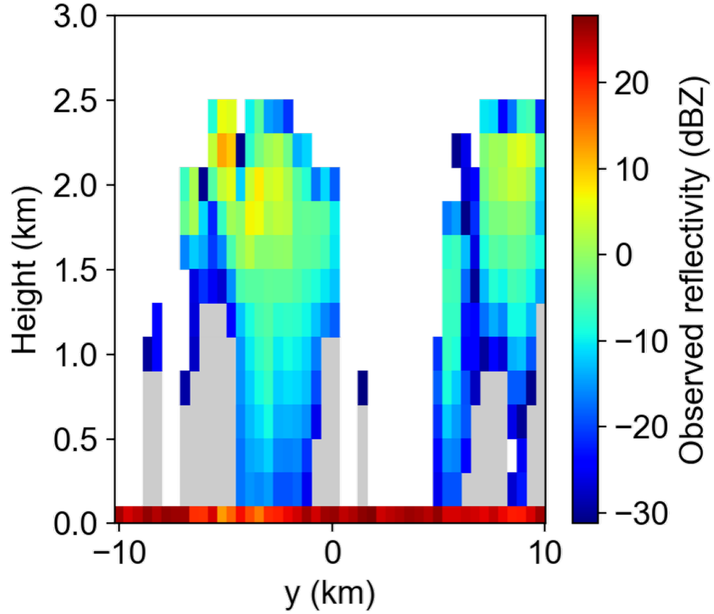


Retrieval of geophysical variables (and/or data assimilation)

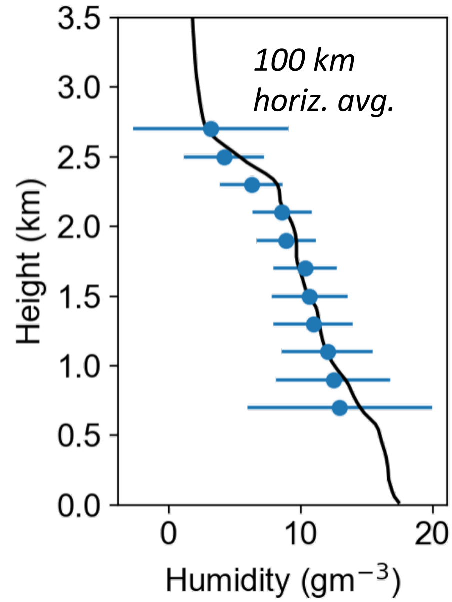
Results – Example I

Differential absorption radar (DAR)

Shallow precipitating cumulus (RICO case)



Simulated Radar Obs.



Retrieved humidity profile

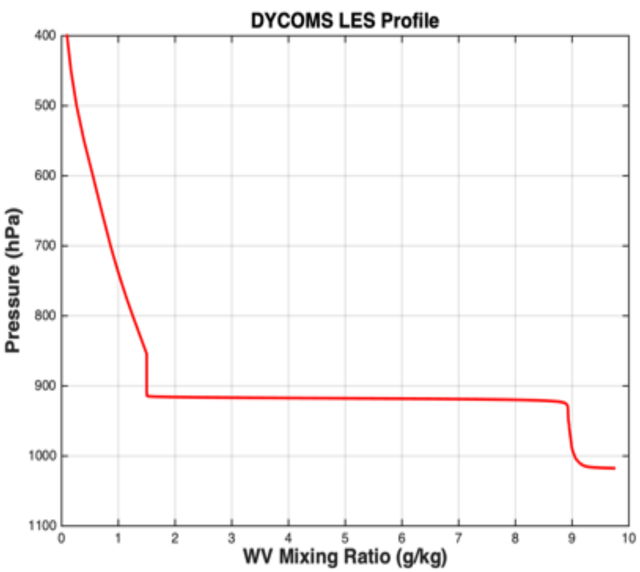
<u>What kind of profiles are measurable with DAR?</u>

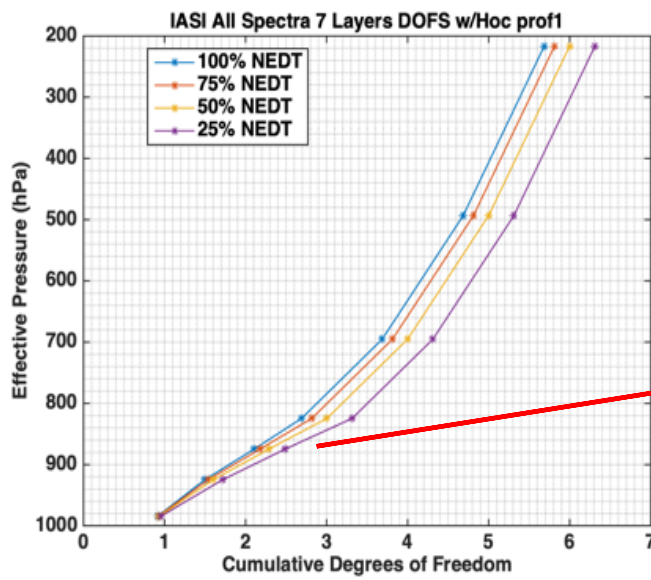
Mean profile of inside-cloud humidity with 200 m vertical resolution representative of the mean on a horizontal scale of 100 km with 2-3 gm^{-3} uncertainty

Results – Example II

Infrared (IR) Sounding

Stratocumulus (DYCOMS case)





3 degrees of freedom in first 1.5 km for water vapor

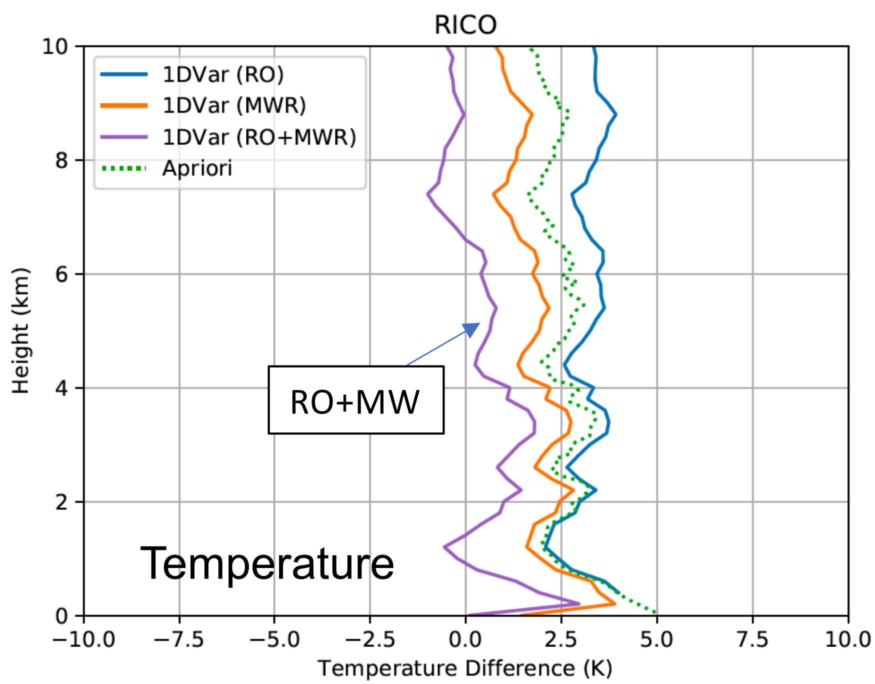
Left) Simulated water vapor profile for a well-mixed PBL over the subtropical ocean from a Large-Eddy Simulation (LES) model.

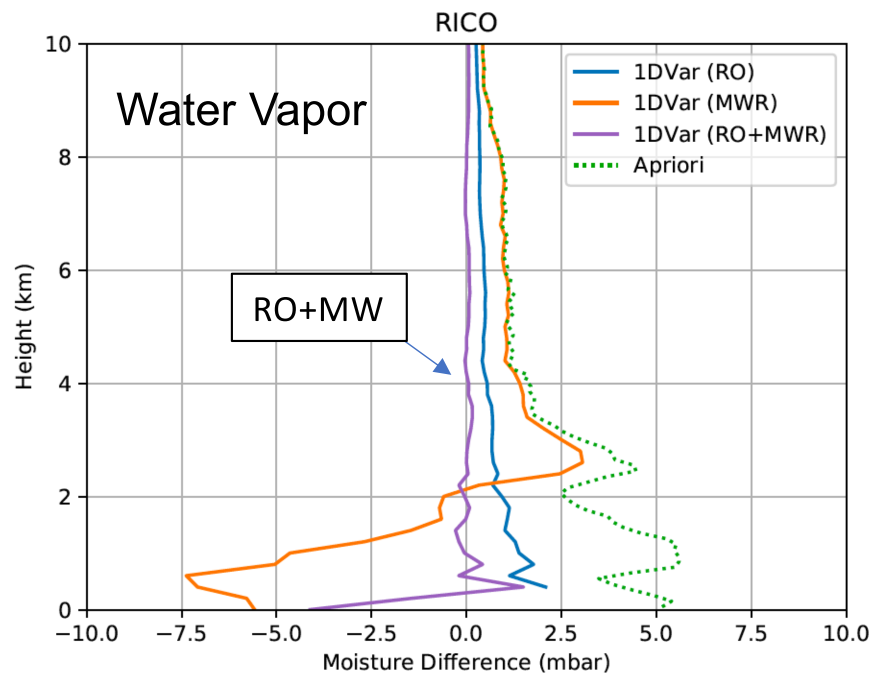
Right) Cumulative degrees of freedom with different levels of noise.

Results – Example III

Joint GNSS-RO and MW Retrievals

Shallow convection (RICO case)





Preliminary results show that the combined RO and MW yield improved temperature and water vapor solutions than either observation alone

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