National Aeronautics and Space Administration

FY24 Topic Areas Research and Technology Development (TRTD)

A Dual-Band Differential Absorption Radar for a Complete Characterization of the Atmospheric State

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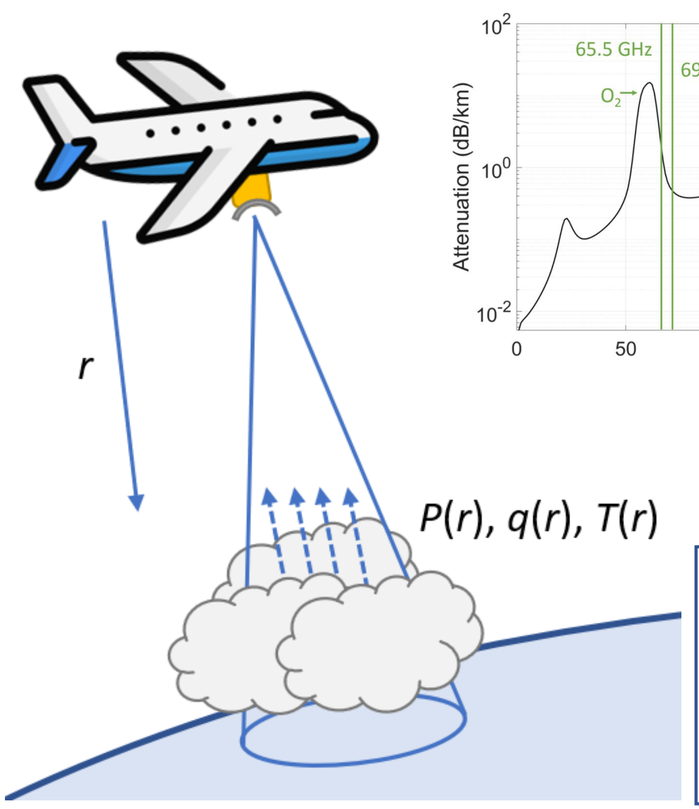
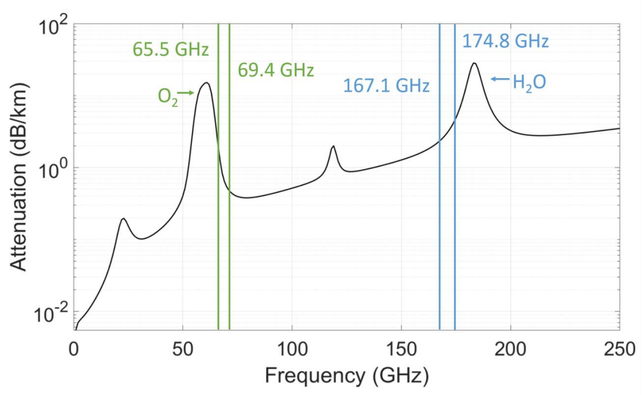
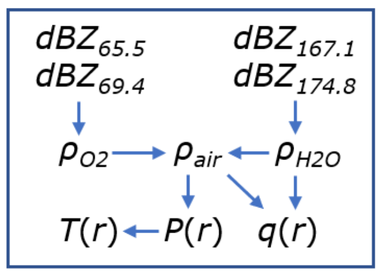
Strategic Focus Area: Atmospheric composition and dynamics

Objectives: The objective of this task is to develop an airborne-ready mm-wave radar system capable of performing simultaneous **Differential Absorption Radar (DAR) measurements at both V-band and G-band frequencies**. The system will undergo ground-based demonstrations to retrieve profiles of oxygen and water vapor density, enabling the simultaneous derivation of key atmospheric parameters: pressure (*P*), specific humidity (*q*), and temperature (*T*).





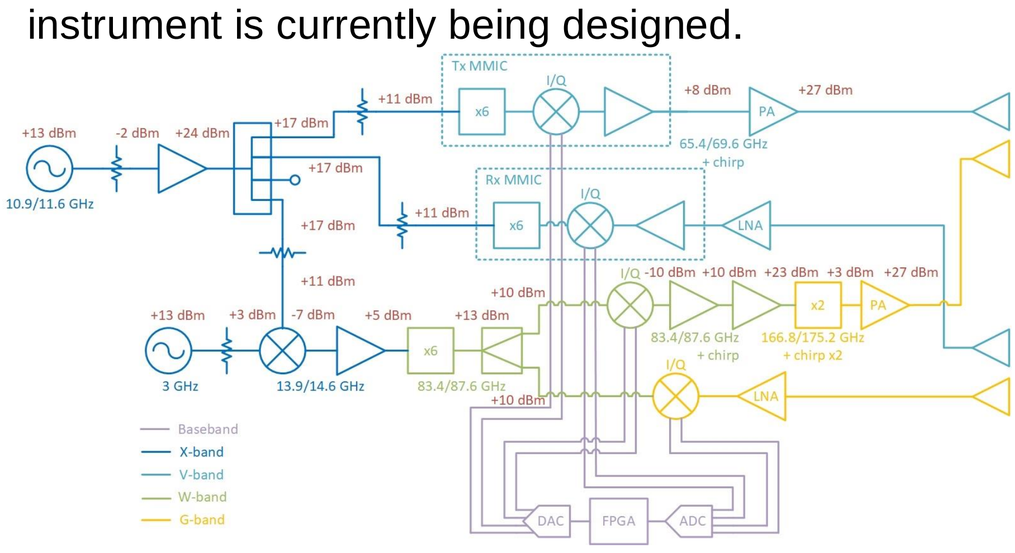


Background: The planetary boundary layer (PBL) is the lowest and most turbulent part of the atmosphere, where convective processes, wind shear, and weather fronts cause temperature and humidity fluctuations at different spatial and temporal scales. Understanding the exchange of energy between Earth's surface and atmosphere is crucial for improving weather forecasts and climate models, as highlighted in the 2017 Decadal Survey for Earth Science. This proposal introduces a novel dual-band DAR system that, for the first time, simultaneously retrieves atmospheric oxygen and water vapor content. By combining a V-band and a G-band radar in a single system, the instrument enables the determination of profiles of pressure, humidity, and temperature in clouds and precipitation.

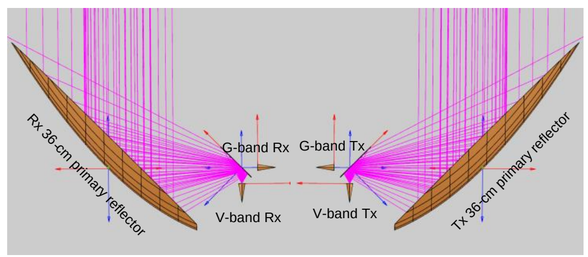
Significance/Benefits to JPL and NASA: The most significant result of this R&TD technology development is the demonstration, for the first time, of a differential absorption measurement at V-band (60-70 GHz) and G-band (157-175GHz), using a compact radar architecture. The development of the first dual-band (V/G-band) Differential Absorption Radar (DAR) introduces a groundbreaking technique for retrieving humidity (*q*), pressure (*P*), and temperature (*T*) within the cloudy planetary boundary layer (PBL). This system represents a major advancement over existing PBL profiling instruments like lidars and radiometers, which are often limited by cloud interference and poor vertical resolution. By pioneering this dual-band technology, JPL positions itself at the forefront of future PBL observing systems, potentially influencing the next Decadal Survey priorities and securing funding for mission development.

Approach and Results:

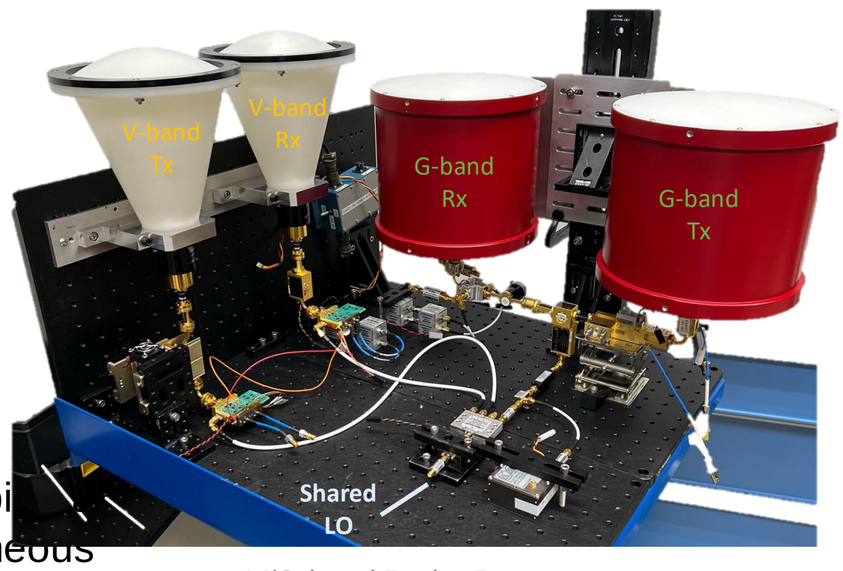
- We have completed the design, assembly, and test of a dual-band differential absorption radar (DAR) breadboard at V-band and G-band. A key development is a new G-band subharmonic I/Q mixer based on Schottky diode technology. Optics for the airborne instrument is currently being designed.



V/G-band radar block diagram

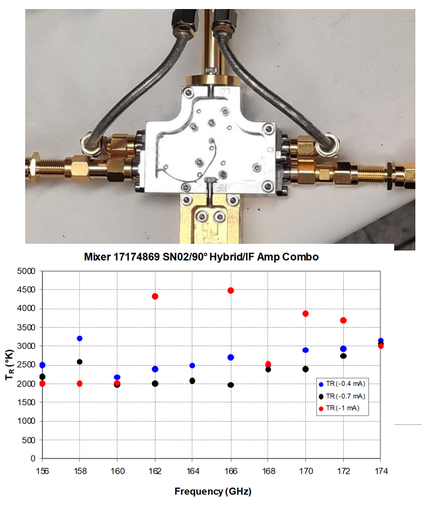


Preliminary airborne optics design



V/G-band Radar Prototype

- In collaboration with Arizona State University, we are developi
  novel digital signal processing system that will allow simultaneous analysis of received signals from both V- and G-bands.
- Carry on initial radar performance analysis and retrieval accuracy simulations to meet the science requirements on PBL temperature and humidity accuracy.



Development of a new G-band subharmonic I/Q mixer based on Schottky diode technology

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