National Aeronautics and Space Administration

SURFACE PRESSURE SENSING RADAR USING V-BAND (65-70 GHZ)

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Program: FY22 R&TD Topics
Strategic Focus Area: Atmospheric composition and dynamics

Objectives: The objective of this proposal is to develop and demonstrate a differential absorption radar instrument in a compact low-cost package that will enable the estimation of surface pressure anywhere, under any conditions for enhanced weather forecasting modeling.

Radar echo power has a strong gradient with frequencies as a result of absorption of atmospheric O_2 around 60 GHz. This technique makes radar measurements at two frequencies with similar water vapor and liquid water characteristics; - one sufficiently far into the O2 band and the other on the wing of the band. The ratio of these measurements, or the differential absorption, is a measure of the O2 column abundance, which is an accepted proxy for air density and in turn surface pressure. The technology developed will enable a new global measurement capability for enhanced weather forecasting modeling.

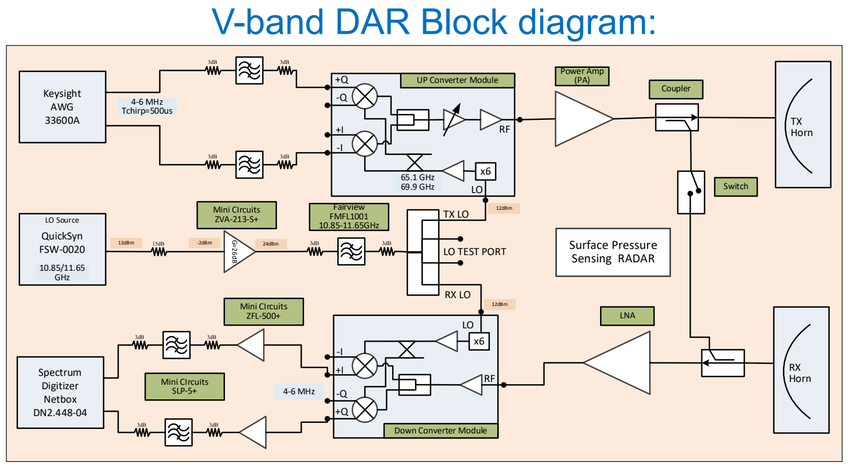
Background: Surface pressure is the main driver behind atmospheric dynamics and is important for studying weather forecasting, prediction of strength and path of storms. Despite its importance, remote sensing measurements of surface pressure are currently of limited availability and quality. Existing passive techniques to measure surface pressure remotely cannot penetrate clouds and are therefore not useful precisely where this intelligence is needed. The radar presented here will allow the global estimation of surface pressure under any conditions.

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 60-75 GHz, using a compact radar architecture. The V-band DAR uses the direct up/down-conversion architecture with pulse compression that reduces the overall instrument SWaP. The inherent low mass and volume architecture of the proposed instrumentation provides many possible avenues to space including future InVEST and Earth Ventures calls.

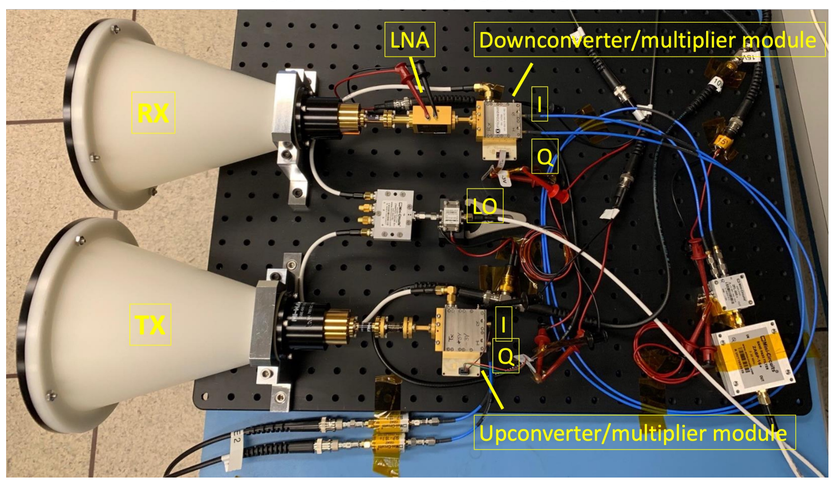
Approach and Results:

We have completed the design, assembly and test of a differential absorption radar (DAR) breadboard at V-band and performed, for the first time at JPL, a DAR demonstration at these frequencies.

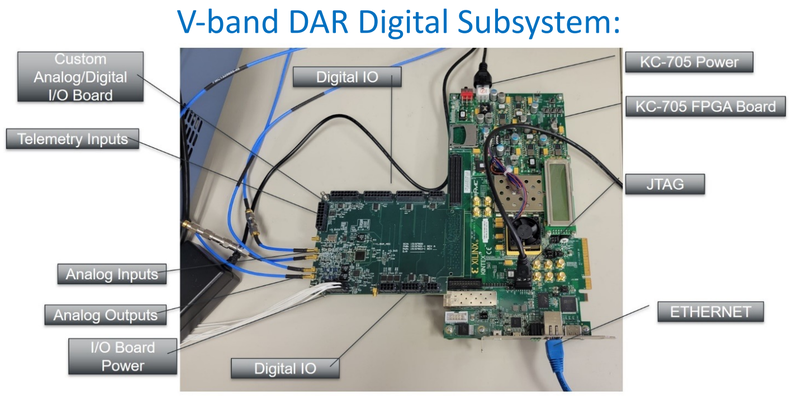
V-band DAR Block diagram:



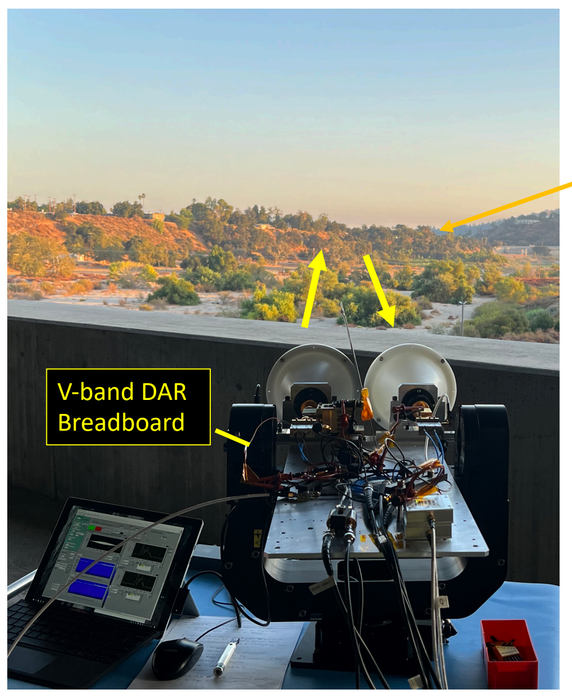
V-band DAR Breadboard:

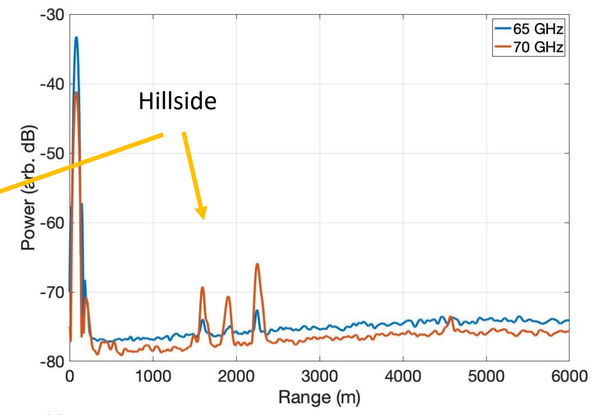


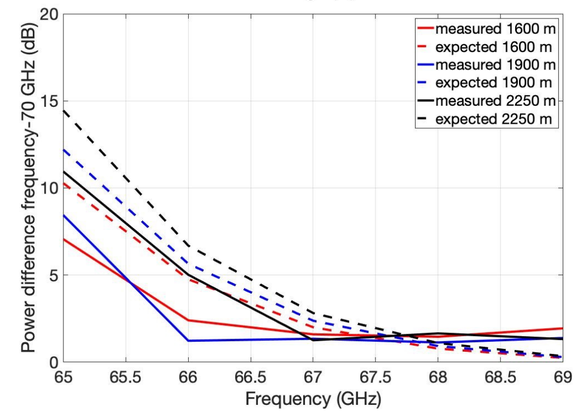
V-band DAR Digital Subsystem:



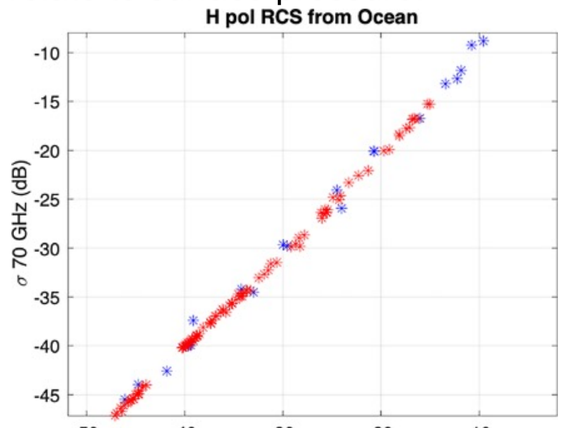
We have carried out outdoor measurements of the V-band DAR instrument during different days with diverse atmospheric conditions pointing in the horizontal direction through the hills outside JPL. The received power is lower at 65 GHz compared to 70 GHz given the higher atmospheric oxygen absorption at that frequency. The differential measurement results follow the same trend as simulation values.

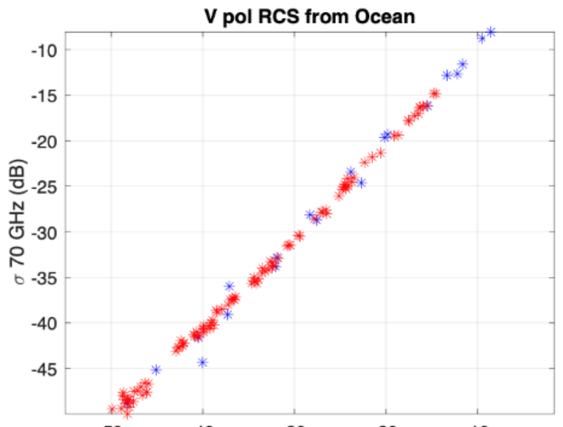






Numerical simulations show that the difference in backscattering from random roughness ocean with various conditions of windspeed, incidence angle, sea surface temperature and salinity at 65 and 70 GHz are dominated by the the absorption from atmosphere, which directly relate to surface pressure.





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