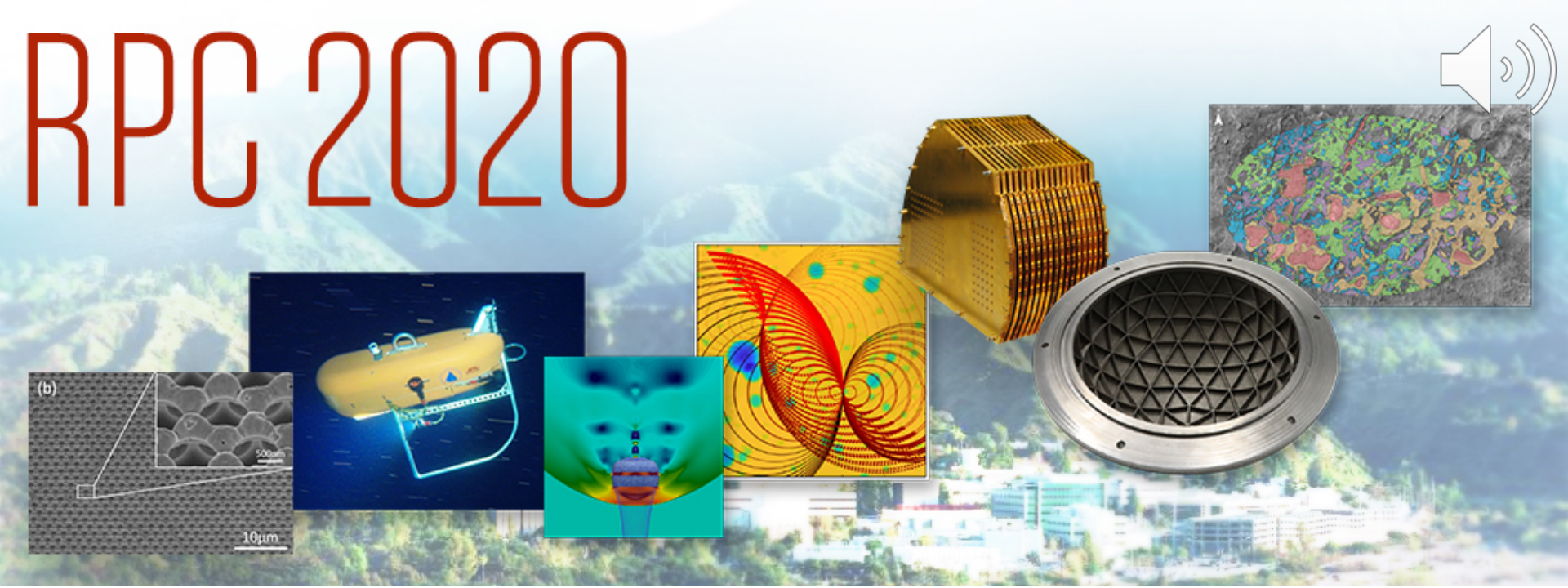


Virtual Research Presentation Conference

Compact Radar for Measurements of Clouds, Convection and Precipitation

Principal Investigator: Raquel Rodriguez Monje (334)
Co-Is: Ken B. Cooper (386); Robert M. Beauchamp (334); Matthew Lebsock (329)
Program: Strategic Initiative

Assigned Presentation # RPC-041

Jet Propulsion Laboratory
California Institute of Technology

Introduction

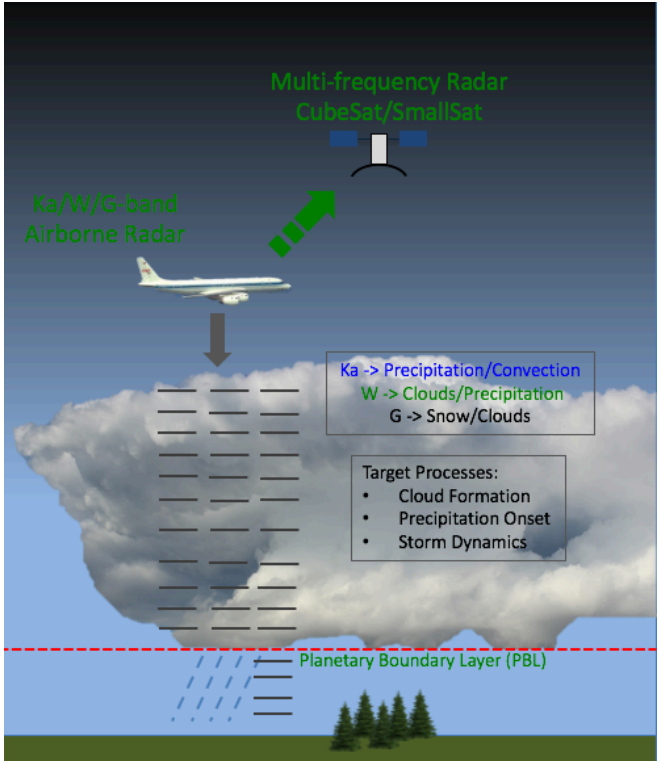
We are developing a multi-frequency millimeter-wave (Ka-, W- and G- band) radar system, named CloudCube, using an architecture that results in small mass, power and size.

The CloudCube instrument will enable unprecedented mission concepts that would fill existing gaps in the observation of a variety of cloud and precipitation processes. These observations are pertinent to NASA's Climate Variability and Change as well as Weather focus areas by directly responding to the ESAS DS 2018 *Clouds, Convection and Precipitation* (CCP) TO and the Planetary Boundary Layer (PBL) incubator TO.

The instrument will facilitate a low-cost CCP mission concept compatible with a small and low-cost spacecraft platform (i.e., max 10 kg, 6U and 50 W for the radar electronics).

The goal of this task is to demonstrate and validate the performance of the multi-frequency operation of the radar system, by carrying out measurements of the different subsystems and the instrument as a whole. We will provide an airborne prototype radar that will be able to demonstrate the instrument capability and will advance the CCP science.

The technology development carried out during this task placed us in a stronger position to succeed towards winning the NASA/IIP-19.

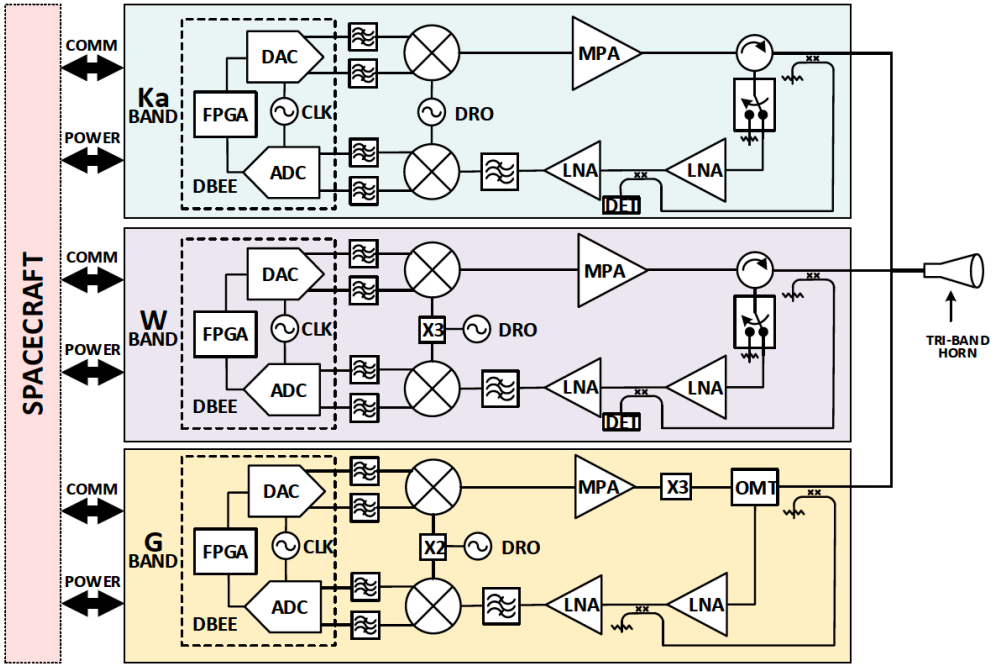


Problem Description

The current state-of-the-art for radar systems on small platforms is RainCube but it is a single band instrument providing only precipitation observations. CloudSat (94 GHz) is the highest performance spaceborne cloud radar, but it requires 270 W and 230 kg of instrument power and mass. Other multi-frequency approaches, such as IIP-16/airMASTR (Multi Application SmallSat Tri-band Radar), are limited to frequencies no higher than W-band and have a more complex architecture that results in a larger size, weight and power.

Compact and affordable radar instruments facilitate the deployment of constellations of identical instruments flying in Low Earth Orbit (LEO). Low cost constellations can fly in formation to observe the evolution of weather processes with high-vertical resolution profiling capabilities or in diverse orbits to increase sampling across the diurnal cycle. This work will facilitate proposals to the upcoming EVM and EVI instrument calls, as well as offer competitive and timely “out of the box” candidate solutions for the implementation of specific aspects of the CCP Designated Observable and PBL Targeted Observables. Successful completion of the current task will permit a variety of mission architectures including any combination of the Ka/W/G band channels on a small satellite platform.

Methodology

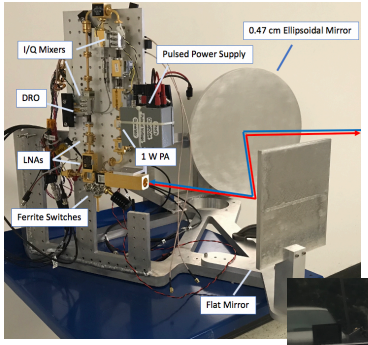


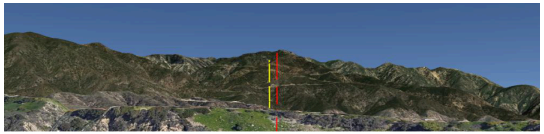
- Develop a multi-frequency millimeter-wave (Ka-, W- and G- band) radar system using an architecture that will result in small mass, power and size.
- The instrument will facilitate a low-cost CCP (Ka- and W-band channel) mission concept with profiling of cirrus and mid-level ice capabilities (G-band channel) compatible with a small and low-cost spacecraft platform.
- CloudCube will be built from extensive heritage of JPL technology developed for NASA.

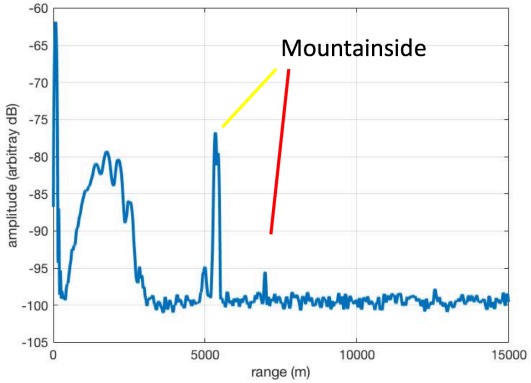
Results

- Compete W-band radar prototype using as primary mirror an already existing ellipsoidal mirror with discrete radar components and one of JPL's designed PA (1 Watt peak power) and pulsed power supply.

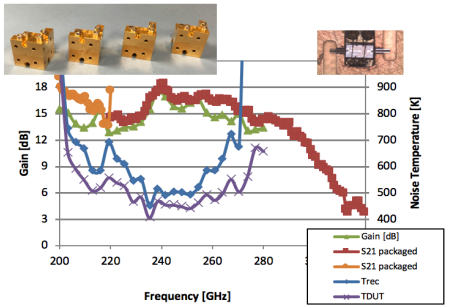
- Outdoor radar test showing the return from two mountain ridges at different ranges (~5.5 km and ~7 km)



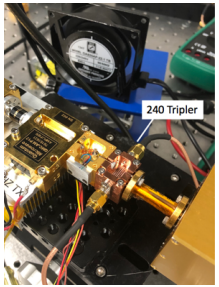




- We have procure some of the Ka-band subassemblies: MPA-power bricks, FESA.
- We have also advanced the development of the G-band channel finalizing the block diagram and design of key components such as the single 240 GHz triplers and the assembly of four 240 GHz LNAs.

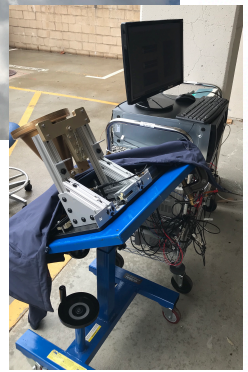


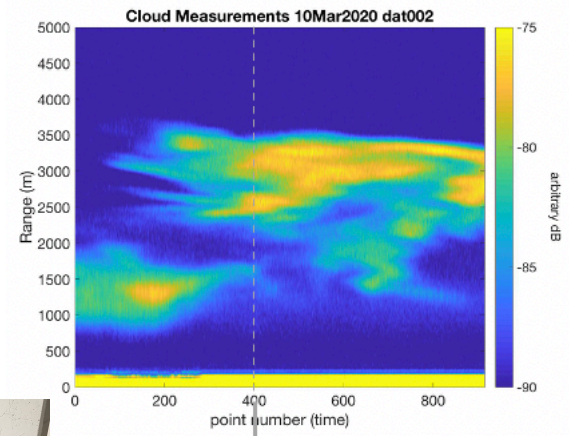
240 GHz LNA

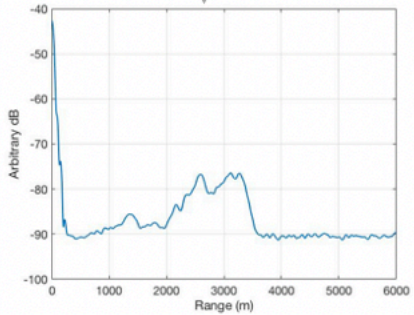


240 GHz Tripler

Significance of Results





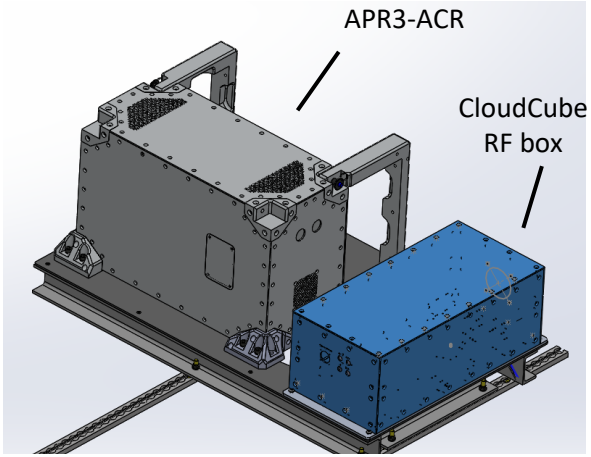


- **The demonstration, for the first time, of the direct up/down-conversion radar architecture with pulse compression at W-band**. This will enable ultra-compact and low-power radar architecture for future Cloud and precipitation mission concepts.

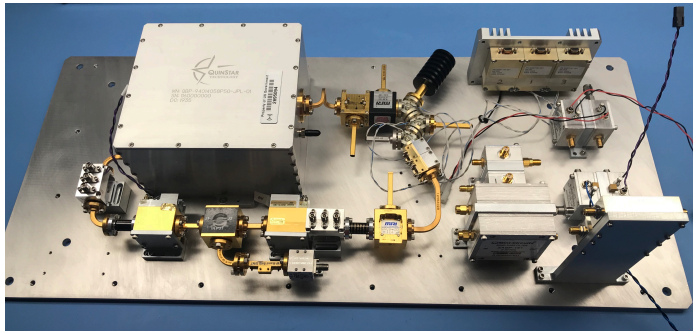
- The technology development carried out during this task placed us in a stronger position to succeed towards **winning the NASA ESTO's Instrument Incubator Program IIP.**

Next Steps

- During FY20 we design the hardware interface to flight together with APR3 on the NASA P3. Due to COVID-19 the CPEX-AW field campaign got postponed for summer 2021.
- On FY21 we will continue preparations for an airborne rideshare opportunities on the upcoming CPEX-AW field campaign on the DC-8.



CloudCube's RF box installation setup onto the APR3 plate



CloudCube's RF base plate to fit within 10.5" x 24".

Publications and References

Publications:

- Raquel, Rodriguez Monje, Robert, Beauchamp, Ken, Cooper, Shivani Joshi and Simone, Tanelli, “A Compact W-band Breadboard Radar for Atmospheric Measurements,” to be published at the IEEE Radar conference proceedings, Florence, September 22-25, 2020.