G-band Radars: Status and Opportunities for Future Space Missions

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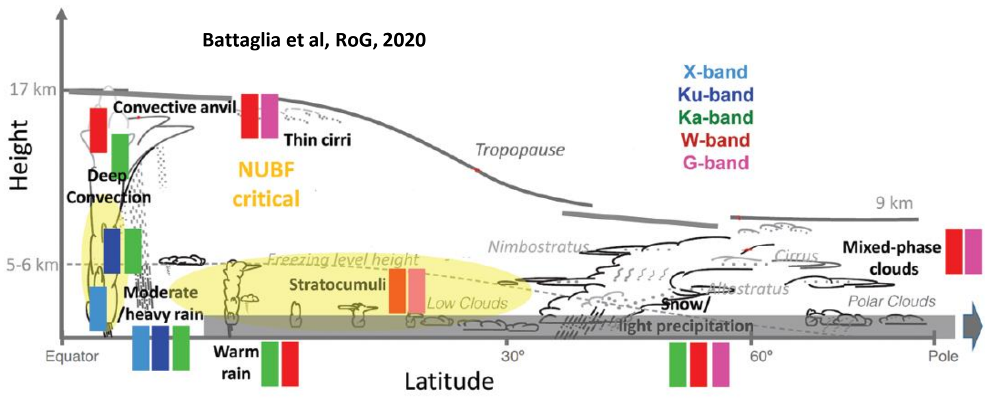
Motivation

Limited understanding of cloud feedbacks is the major source of ***uncertainty in climate sensitivity*** (from 1.5 up to 4.5^{0}C) ➔ better characterization of cloud & precipitation vertical structure and microphysics needed but single frequency retrievals are highly under-constrained ➔ combination of multi-frequency (Doppler) radars with frequencies ranging from 10 to above 200 GHz allows characterizing from heavy precipitation particles to small-size ice crystals need of multi-frequency

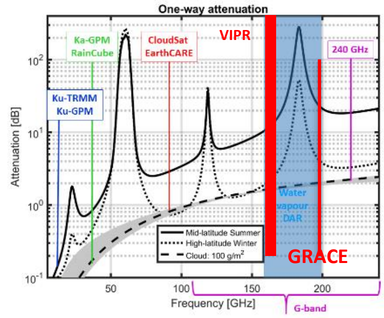


Status

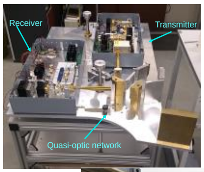
Mm- and sub-mm solid state power devices and low noise amplifiers have recently enabled higher frequency radar capable of achieving sensitivities good enough for cloud studies. Two possibilities:

1) **Window frequencies**➔ Ice and light rain microphysics;

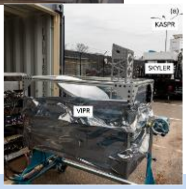
2) Absorption band freq ➔ water vapour profiling



The UK-CEOI G-band Radar for Cloud Experiment (GRACE) has developed a prototype ground-based, zenith looking 200 GHz Doppler cloud radar



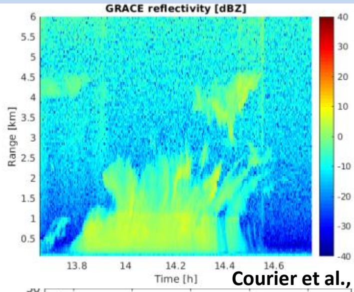
The JPL Vapor In-cloud Profiling Radar (VIPR) demonstrated the possibility of operating a radar system in differential absorption mode with tones within the 183 GHz water vapour absorption band (Cooper et al., 2018, Roy et al., 2018). it will be deployed airborne for IMPACTS in winter 2021-2022.



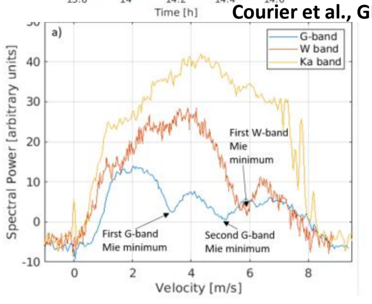
G-band radar first light results

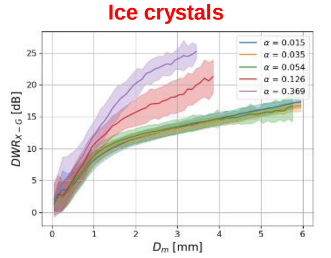
GRACE Ka-W-G Doppler spectra in rain➔ peaks and valleys ➔ raindrops >300 μm are non Rayleigh targets at 200 GHz➔ specific sizes produce constructive or destructive interference of the backscattering cross sections ⍰ "Mie notches"

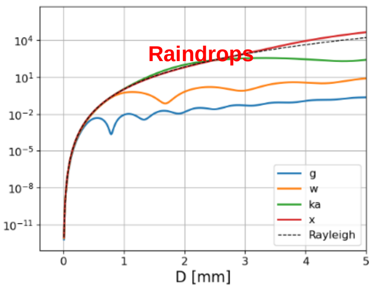
VIPR first triple frequency measurements in ice clouds performed during February 2020 at the Stony Brook Radar facility ➔ evidence of non-Rayleigh effects ➔ useful for sizing ice crystals.



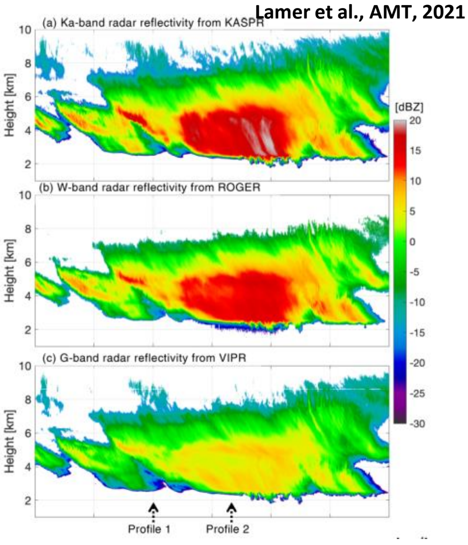
Courier et al., GRL, 2021







Lamer et al., AMT, 2021



Conclusions

Progress in G-band technology is driving sensitivities to levels appropriate for cloud studies➔ G-band cloud radars are now a reality.

First ground-based demonstrators now acquiring measurements, with airborne demonstrators under constructions.

Different applications envisaged for space-borne systems:

1. constellation with lower frequency radars (already planned by NASA/JAXA/ESA) to better characterize ice microphysics and high latitude precipitation processes (Explorer opportunities);
2. constellation with passive microwave radiometers (like those of the Arctic Weather Satellite constellation) for profiling relative humidity (Copernicus/EUMETSAT operational applications)