CryoRad – strumentazione innovativa a microonde da terra e da aereo per indagini in profondità sulla calotta polare, ghiacciai, ghiaccio marino e permafrost

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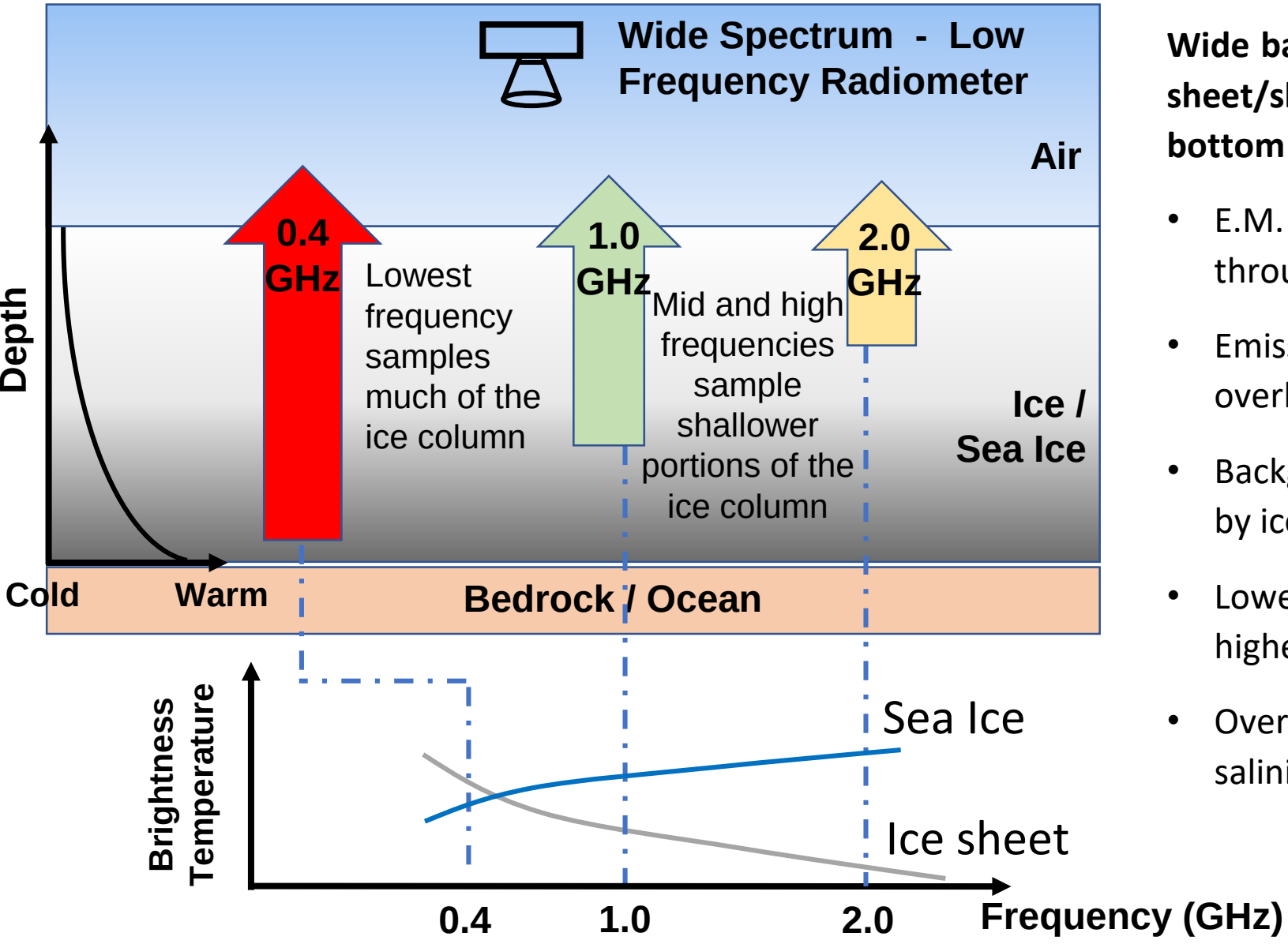
Microwave Radiometry at wide band – the physical basis

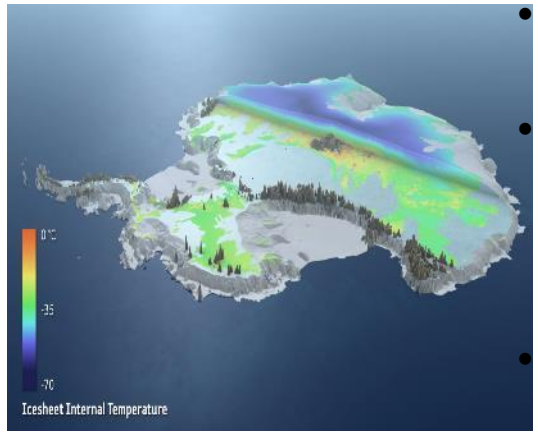


Wide band radiometer → Possibility to observe ice sheet/shelves/glaciers/sea ice from surface to the bottom

- E.M. thermal noise emissions are produced throughout ice sheet /sea ice
- Emission from a given depth is attenuated by overlying ice sheet / sea ice
- Background emission (ocean/rock) is attenuated by ice sheet / sea ice
- Lower frequencies observe greater depths, higher frequencies shallower
- Over ocean, higher sensitivity to sea surface salinity

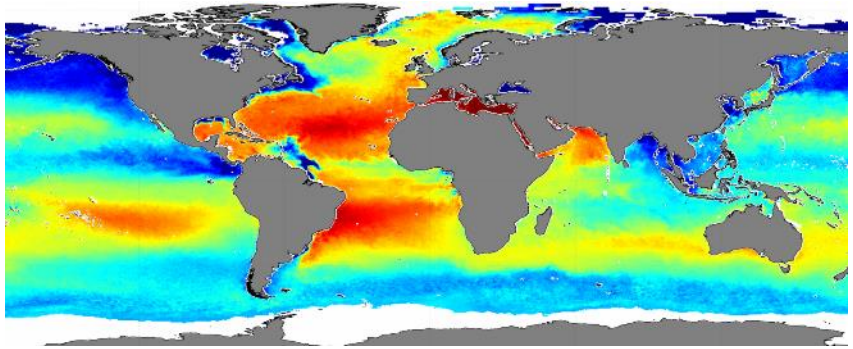
What we can measure ? - Key Questions and Main Products

KQ1: which is the englacial temperature of ice sheet /shelf ? How it affect its stability ? Is the base wet or dry? There is marine ice under ice shelves?



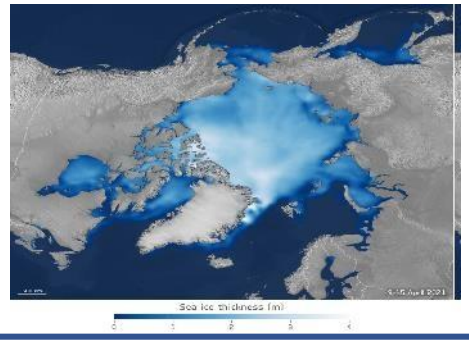
- **Ice sheet and ice shelf temperature profiles**;
- **Presence of intraglacial water** (i.e. aquifers) and **water at the bottom** of ice sheets (i.e. basal melt);
- **Presence of marine ice (shelves)**

KQ: ice sheet –shelves –sea ice ocean interaction : can we provide new insights into the freshwater cycle and water mass formation at high latitudes ?



- **Sea surface salinity** with special focus on high latitudes where there is high uncertainty

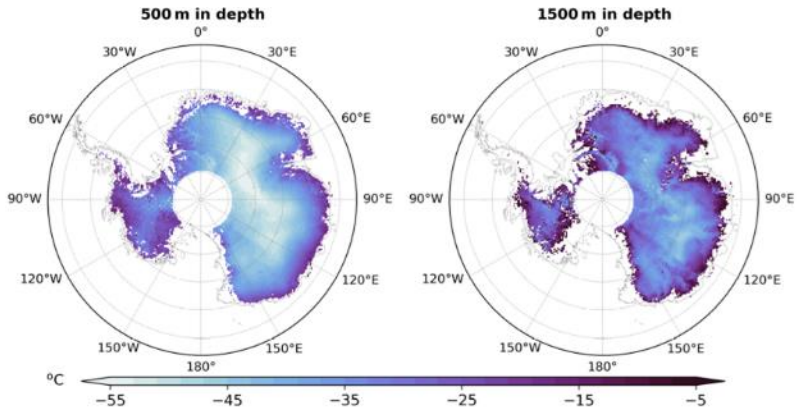
KO3: can we better monitor the decline of sea ice and estimate freshwater fluxes transportation?



- **Sea Ice Thickness** in the range 0-2 m
- **Sea Ice Salinity** in the range 0 - 20 g/kg not presently available from space
- Relative **error expected ≈ 10%**

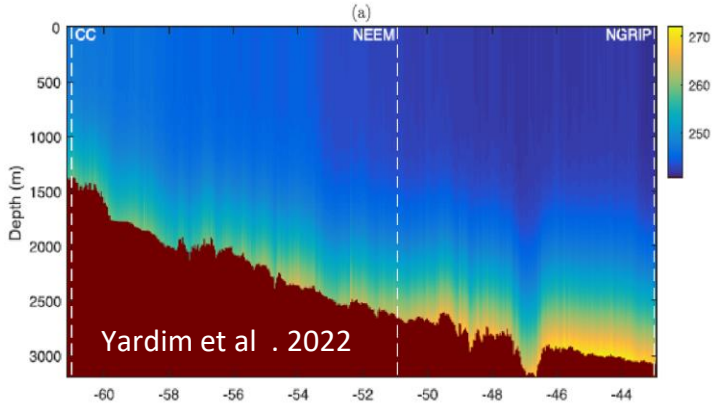
How to measure – the single parameters

Ice sheet temperature



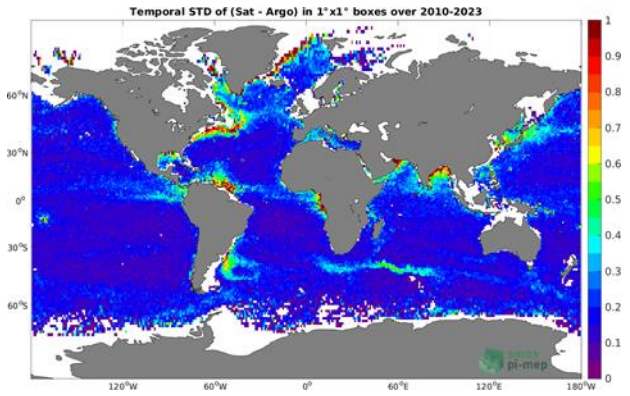
Macelloni et al . 2019

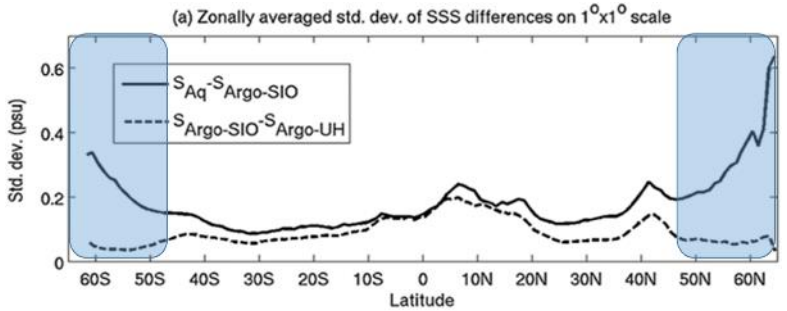
Done at L-band but high uncertainty at the bottom increases



Demonstrated by wide band radiometers in airborne campaigns

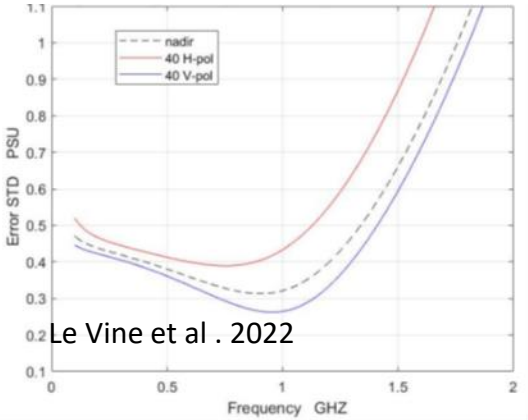
Sea Surface Salinity



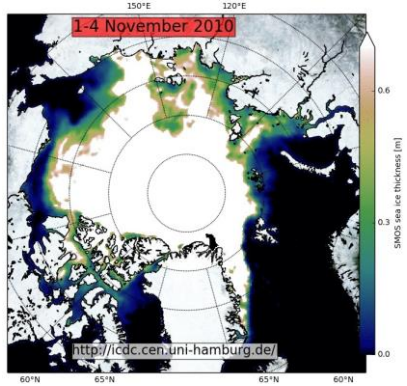


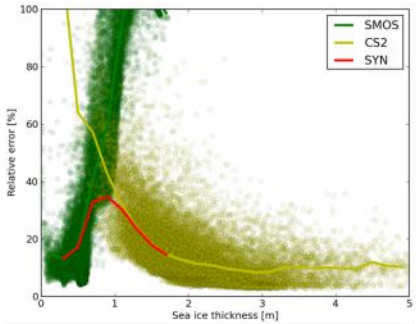
SSS: ECV from L – Band radiometers but higher uncertainty at the poles

Improved results with wideband radiometers from theoretical papers

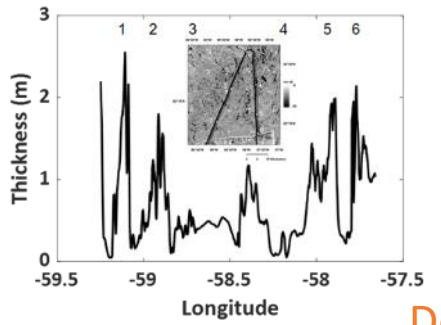


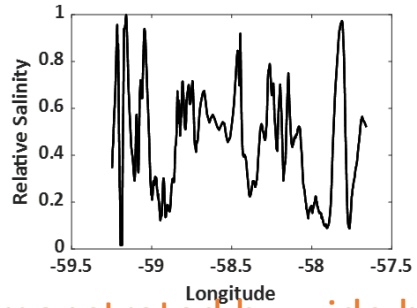
Sea Ice





SIT: ECV from L – Band radiometers but higher uncertainty in the range 0.5 – 1.5 m (FYI)

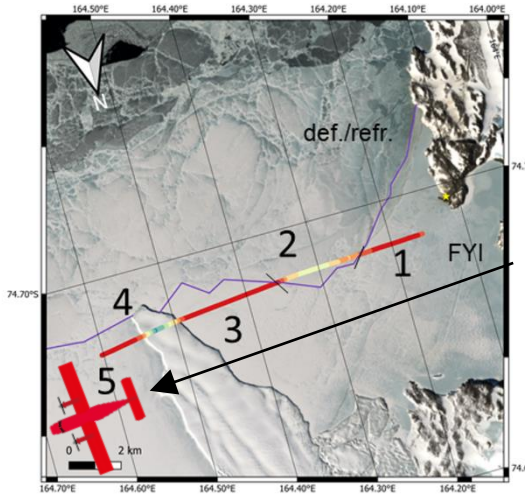


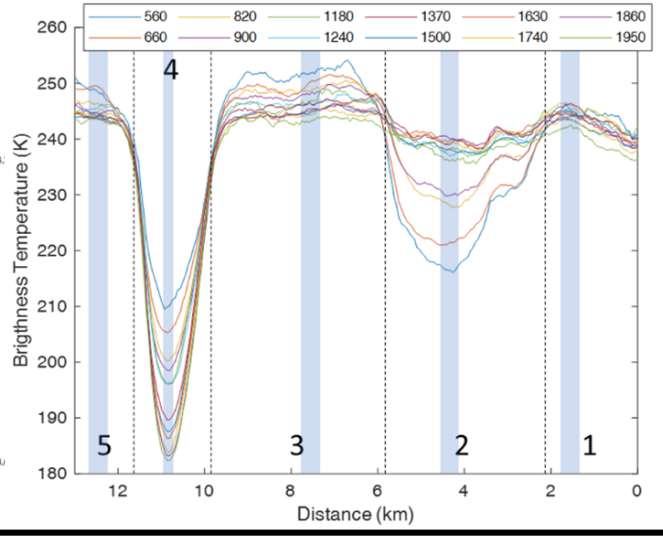


Jezek et al . 2019

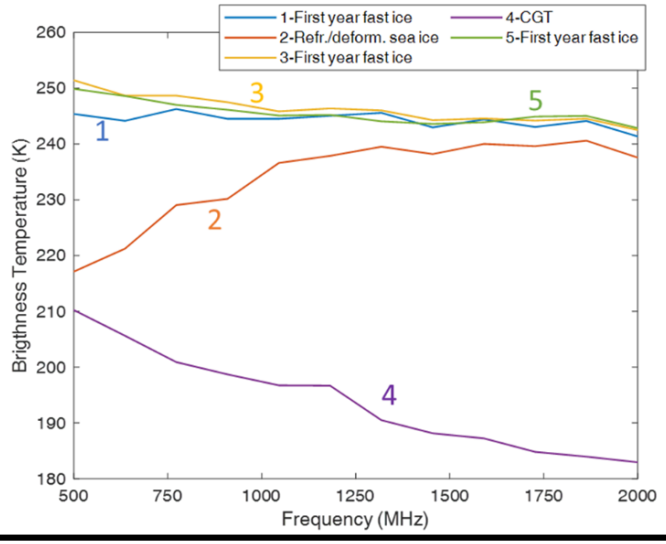
Demonstrated by wide band radiometers in airborne campaigns

Some preliminary results

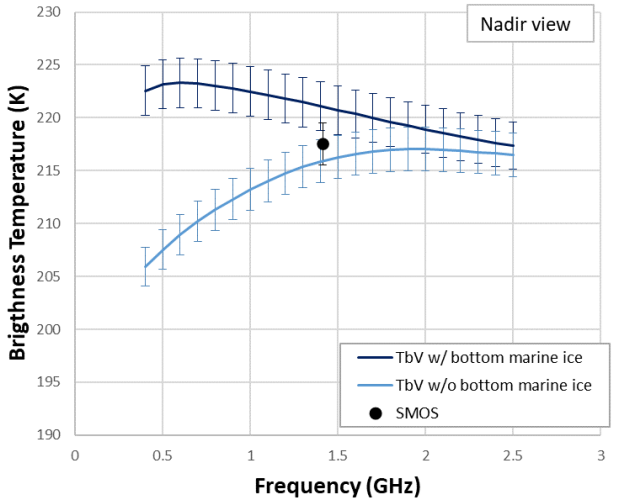




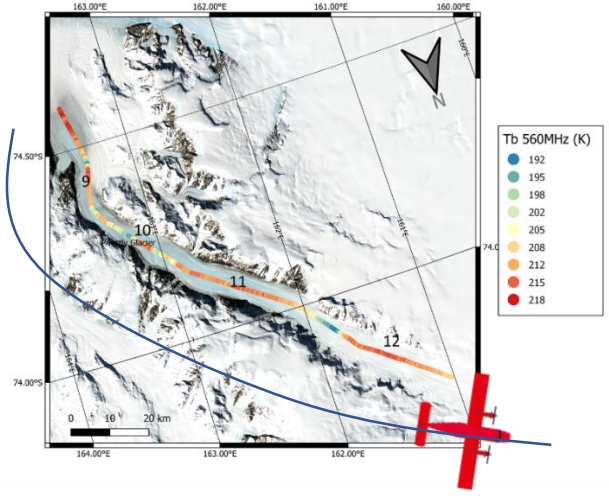
Ice signatures

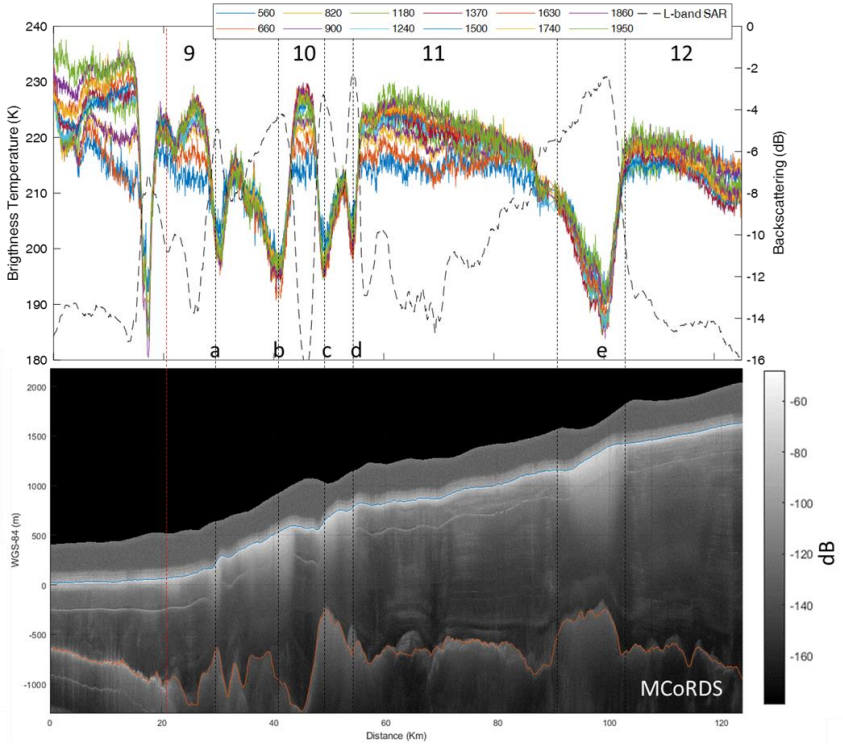


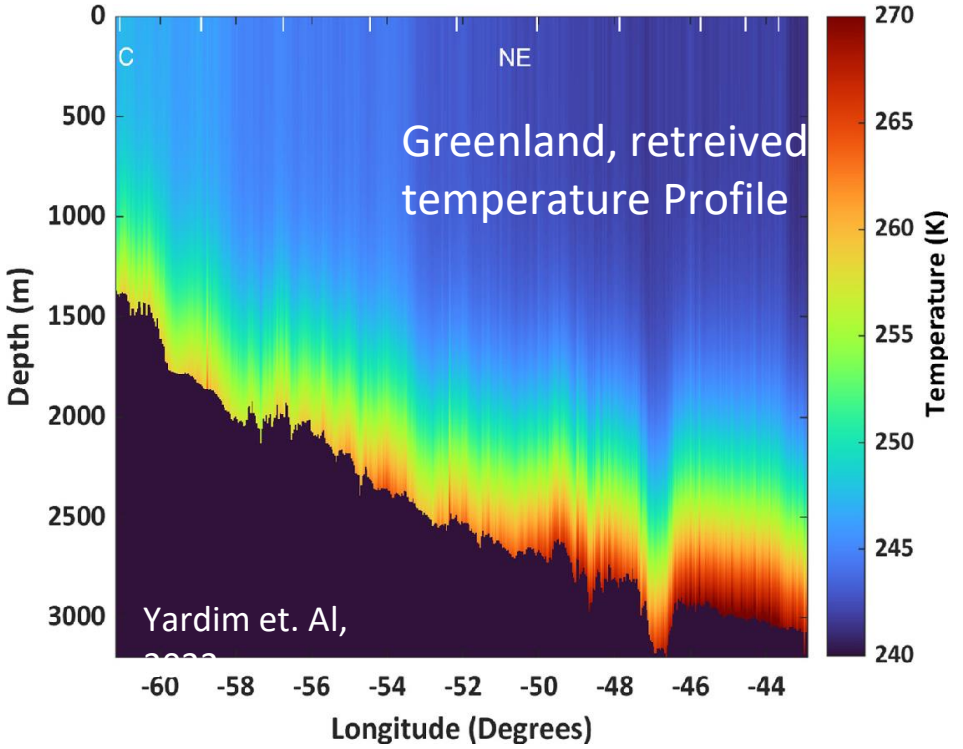
J-9 @ Ross Ice Shelf, effects of marine ice accretion



Priestley Gl, info on structure and bedrock







Airborne/Ground base – Demonstrators available

UWBRAD
USA

- Developed in a 2014 NASA/ESTO project
- operated by Ohio State University
- frequency 500-2000 MHz
- rack mounted – 200kg
- certified on **Basler and Twin Otter**
- 2 campaigns in Greenland and 1 in Antarctica **(PNRA)**

Cryorad – D
Italy

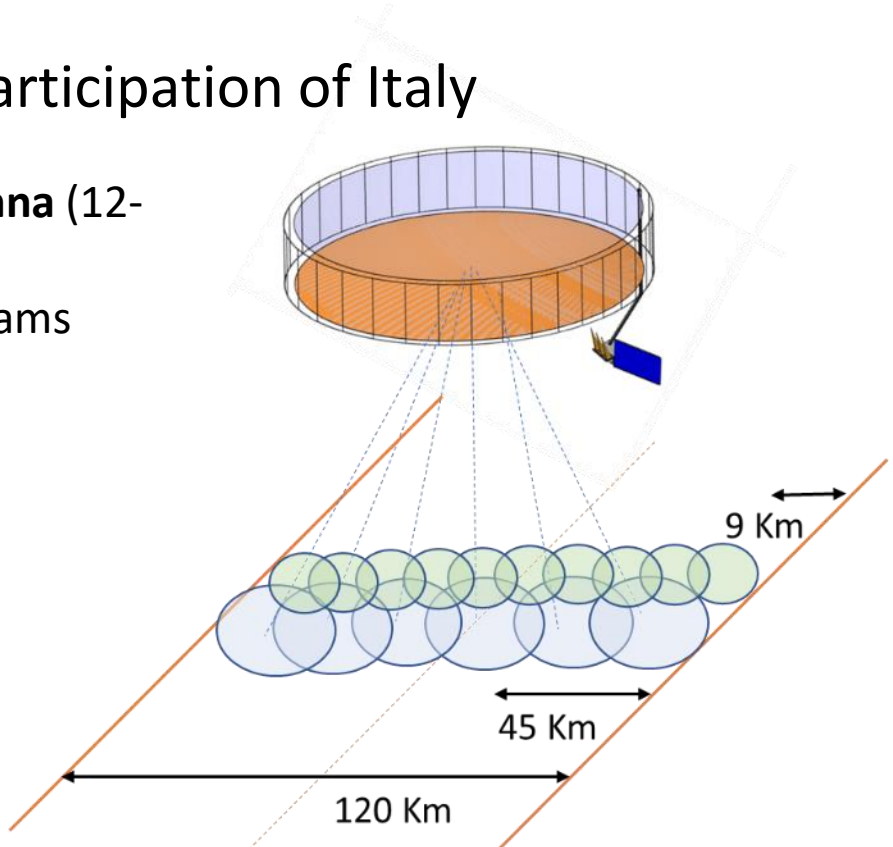
- Developed in a 2020 ASI project
- operated by CNR-IFAC
- frequency 400-2000 MHz
- rack mounted – 50kg
- designed for truck and aeronautic deployment
- software under finalization

The future : a new spaceborne mission

The potential of this approach has been demonstrated and mission's proposals are in preparation

- **CRYORAD** – submitted to ESA – leaded by Italy – supported by ASI – decision spring 2024
- **POLARRAD** – pre-proposed to NASA – leaded by US but participation of Italy

Large Antenna (12-15m)
Multiple Beams



➢ Wideband **microwave radiometer** operating in frequency range 0.4- 2 GHz with continuous sampling of the spectrum.

Resolution:
- 45 Km 0.4 GHz
- 9 Km 2 GHz

Revisit Time:
- **3 days** at the **poles**
- 10 days at the equator

Possible future PNRA projects

Antarctic Plateau:

- miglioramento della stima del geothermal heat flux
- stima del profilo di temperatura ad “alta risoluzione” (in connessione con gli ice cores)
- survey per lo stato bagnato/asciutto del bedrock
- monitoraggio degli acquiferi (e.g. Aurora Basin)

Coastal regions:

- stima del sea ice volume and salinity
- sea surface salinity, scambi ghiaccio/oceano in particolare sugli edge del ghiaccio marino (eventuali plume degli acquiferi?)
- Profilo di temperature degli ice shelves e loro struttura basale (ghiaccio marino al fondo)
- Studio degli acquiferi sub-superficiali
- Monitoraggio delle grounding lines
- Struttura e reologia dei ghiacciai

Synergies with other instruments

- microwave sounders (e.g. OIB MCoRDS) e GPRs
- Gravimetri
- Lidar / optical sensori
- …..

In case of approval of Cryorad proposal to ESA EE12, PNRA can play a leading role for cal/val activities