Future Passive Microwave Techniques

Ice Cloud Imager

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Ice Cloud Imager

Table of Contents

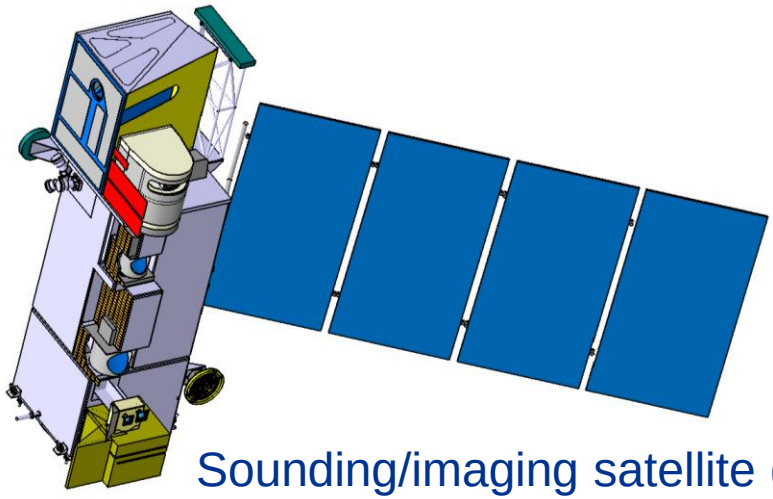
- MetOp - SG
- ICI
- ISMAR – aircraft instrument

MetOp - SG

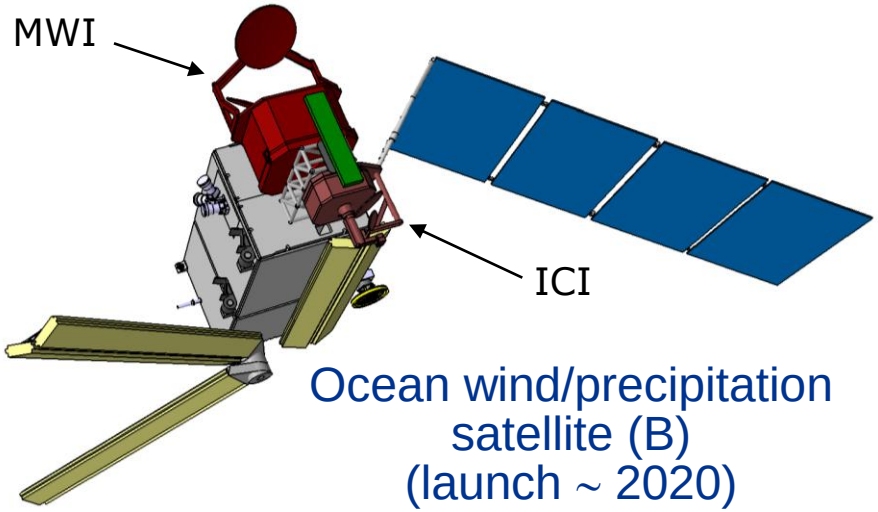
- MetOp – Meteorological Operational observations from polar orbit
  - Start of launches 2006
- MetOp-SG (Second Generation)
  - continuity and enhancement
  - ESA
  - 2020 to 2040
- EPS-SG (EUMETSAT Polar System Second Generation)
  - ground segment, launch, services, operations & recurrent satellites (x~3)

MetOp-SG Satellite Configurations

Two satellites concept: Sun-synchronous orbit (~817 km altitude)
09:30 descending node (*MetOp* orbit)



Sounding/imaging satellite (A)
(launch ~ 2019)



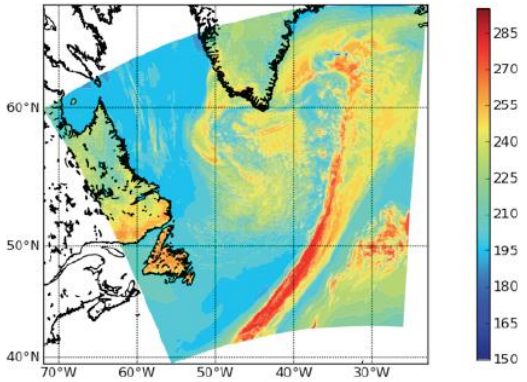
Ocean wind/precipitation satellite (B)
(launch ~ 2020)

Payload	**METimage (DLR/EUMETSAT)** **IASI-NG (CNES/EUNETSAT)** **MicroWave Imager, MWS (ESA)** **3MI (ESA)** **Sentinel-5 (ESA)** **Radio Occultation, RO (ESA)**

Payload	**Scatterometer, SCA (ESA)** **Microwave Imager, MWI (ESA)** **Ice Cloud Imager, ICI (ESA)** **Radio Occultation, RO (ESA)** **ARGOS-4 (CNES)**

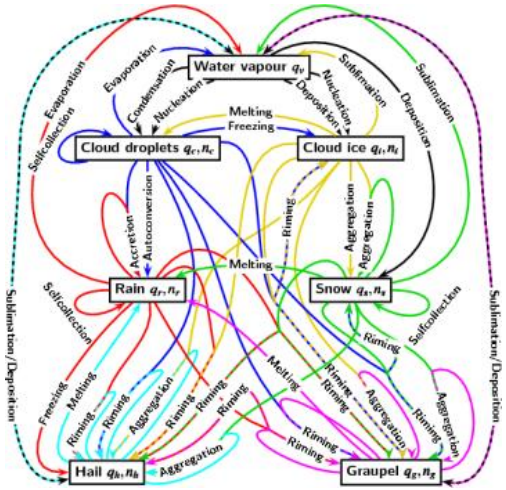
Second Generation aims

Outlook for NWP in 2020:
With better computer power



- Increased resolution to take into account that clouds and precipitation are highly variable
  → 1 km regional NWP, 10 km global NWP

  Already: Δx= 1.5 km 16 km

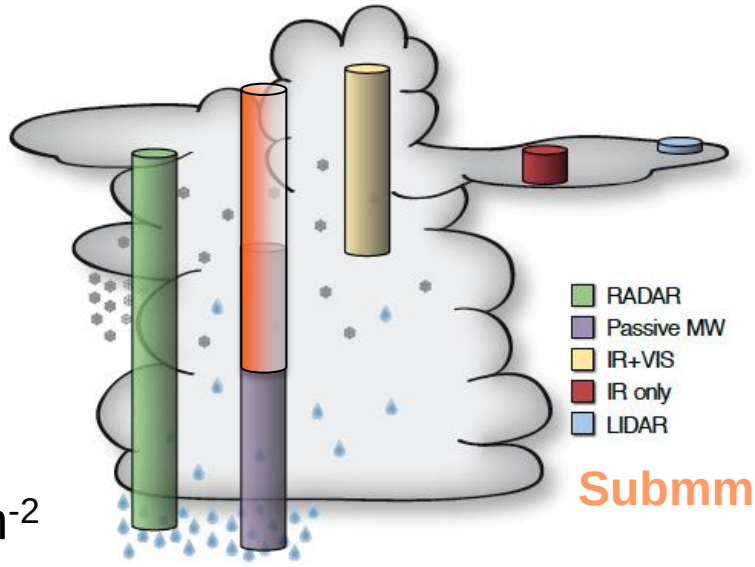


- Improved representation of atmospheric processes
  → multi-moment cloud microphysical schemes
  → prognostic habit prediction

- **Goal:**
  Assimilate satellite radiances obtained in the presence of clouds and precipitation
  → ongoing work at NWP centres

Ice Cloud Imager
- to fill observational gap

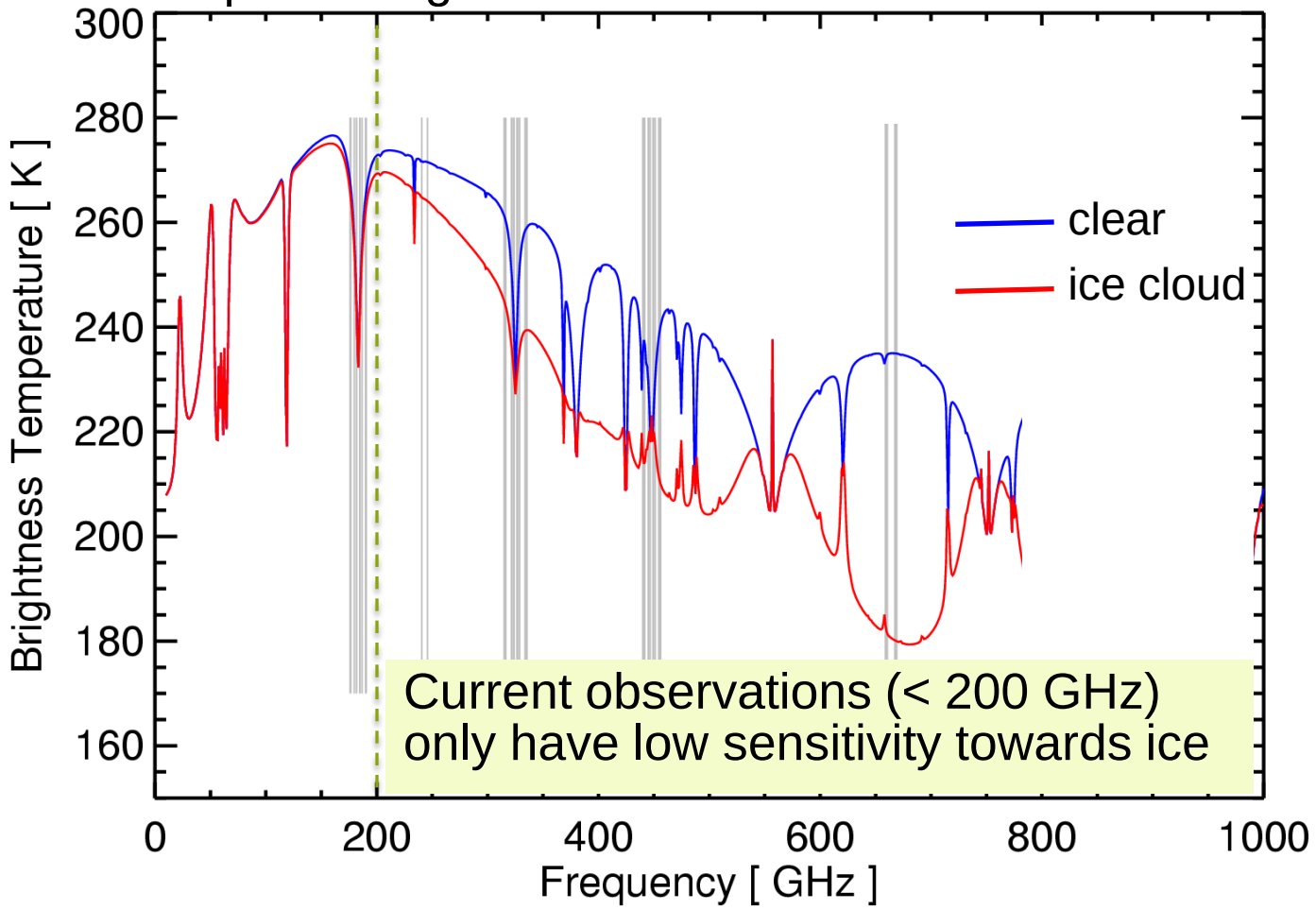
- **Active microwaves** (CloudSat CPR)
  → poor spatial coverage
- **Passive microwaves**
  → only sense precipitating ice
- **VIS / IR techniques**
  → only sense ice water path < 100 gm^{-2}
- **Lidars**
  → only sense optical depths < 3
- **ICI submm channels**
  → sense different altitudes of cloud depending on wavelength
  → estimate ice mass (IWP) and mean ice particle size



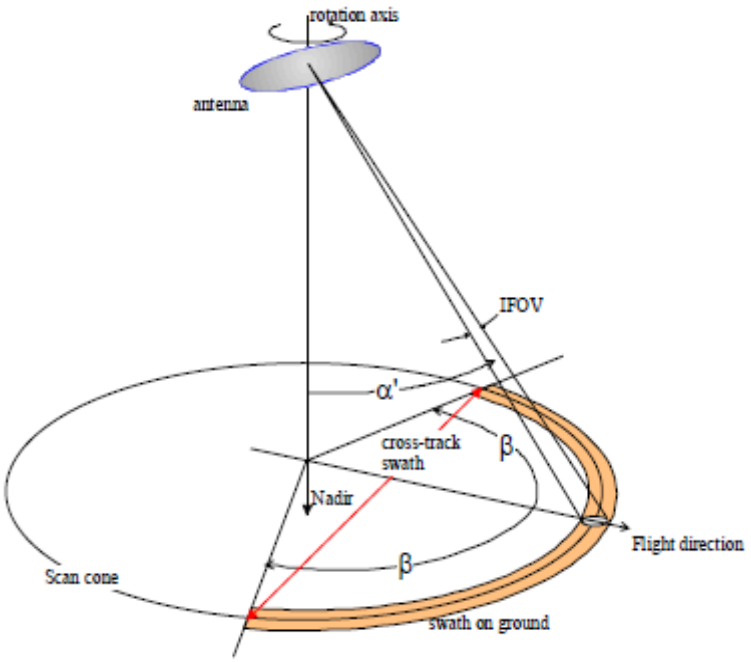
Adapted from
Eliasson et al., 2011

ICI frequencies

- **ICI** is extending the MWI mission to higher frequencies
- **ICI** has a compact design with 11 channels from 183 to 664 GHz



ICI specification



- 243 GHz and 664 GHz preferably V & H polarisation, other channels single polarisation
- Footprint requirement 15 km

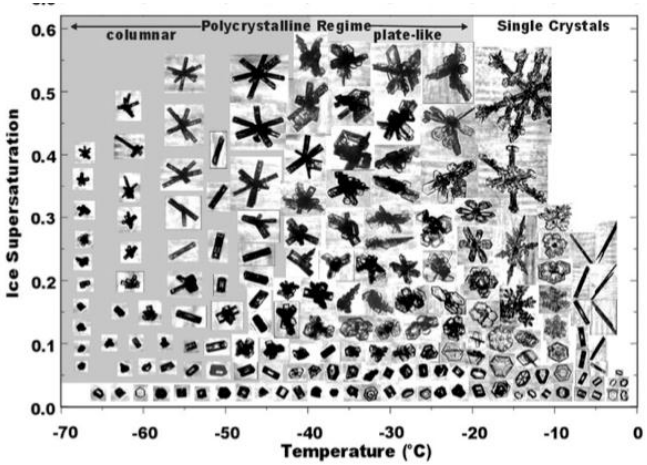
Frequency (GHz)	Bandwidth (GHz)	Utilisation
183.31±8.4	2 × 3	Water vapour profile and snowfall
183.31±3.4	2 × 1.5	
183.31±2.0	2 × 1.5	
243.2±2.5	2 × 3	Quasi-window, cloud ice retrieval, cirrus clouds
325.15±9.5	2 × 3	Cloud ice effective radius
325.15±3.5	2 × 2.4	
325.15±1.5	2 × 1.6	
448±7.2	2 × 3	Cloud ice water path and cirrus
448±3.0	2 × 2	
448±1.4	2 × 1.2	
664±4.2	2 × 5	Cirrus clouds, cloud ice water path

ICI key requirements

Post-EPS Mission Requirements Document (**MRD**) defines instruments key attributes

- **Channel noise**
- **Absolute calibration**
- **Polarisation**
  Threshold: Vertical
  Breakthrough: Vertical and horizontal at window frequencies
- **Footprint size** 15 km

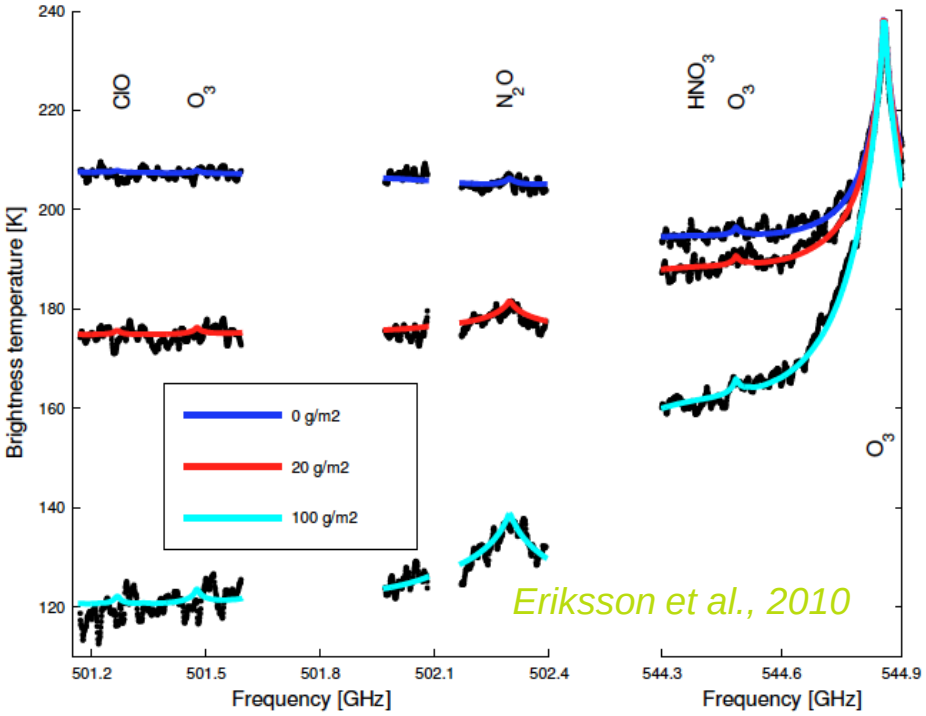
→ submm channels provide better spatial resolution for a more detailed horizontal description of cloud structure



Polarisation could provide information on particle habit and intensity of convection (*Nesbitt and Zipser, 2004; Prigent et al., 2005*)

Instrument maturity

- No down-looking **submm satellite instrument** launched yet – technology frequently used in astronomy
- 3 submm limb sounders (Odin-SMR, Aura-MLS, SMILES)
  → only relatively high clouds detectable with limb sounding
- 2 airborne instruments (CoSSIR, PSR) are available
  - to test retrieval algorithms
  - to perform scientific studies
- Met Office & ESA funding airborne instrument: ISMAR (International Submillimetre Aiborne Radiometer)



Eriksson et al., 2010

The Facility for Airborne Atmospheric Measurements

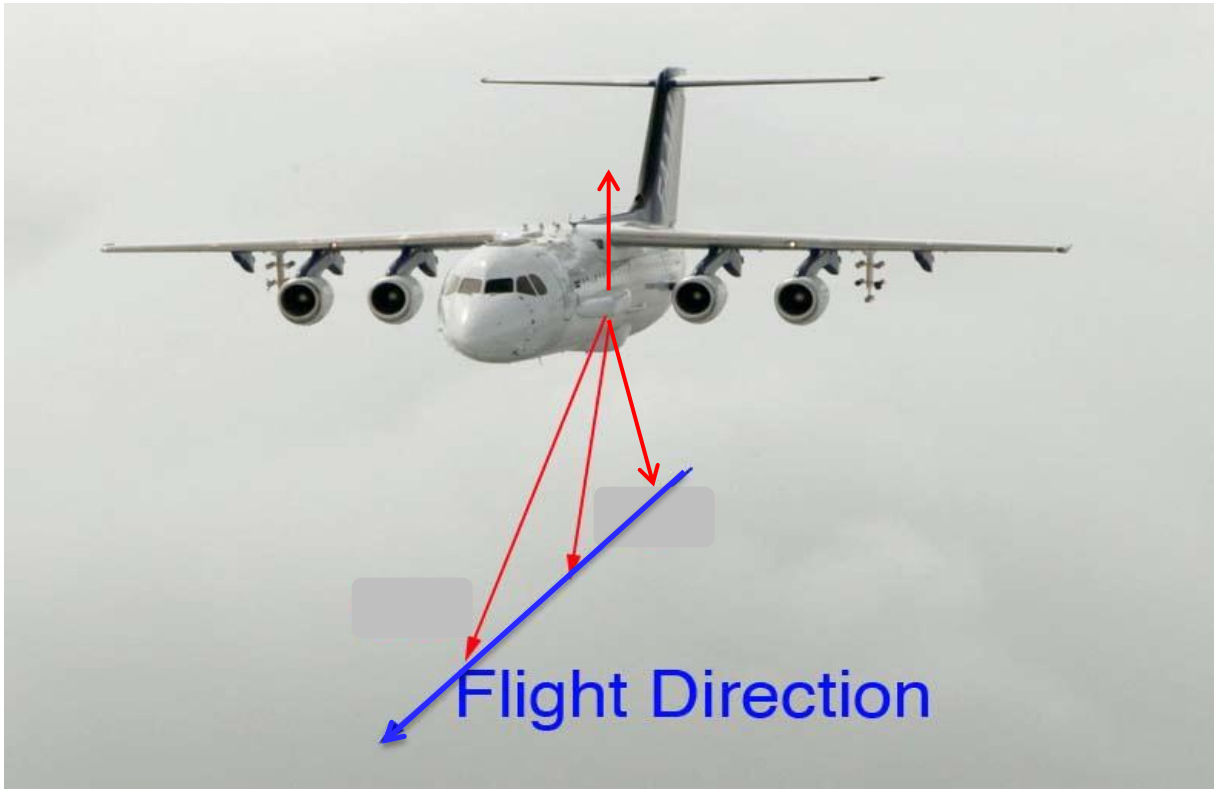
NERC Centres for Atmospheric Science
NATURAL ENVIRONMENT RESEARCH COUNCIL

Met Office

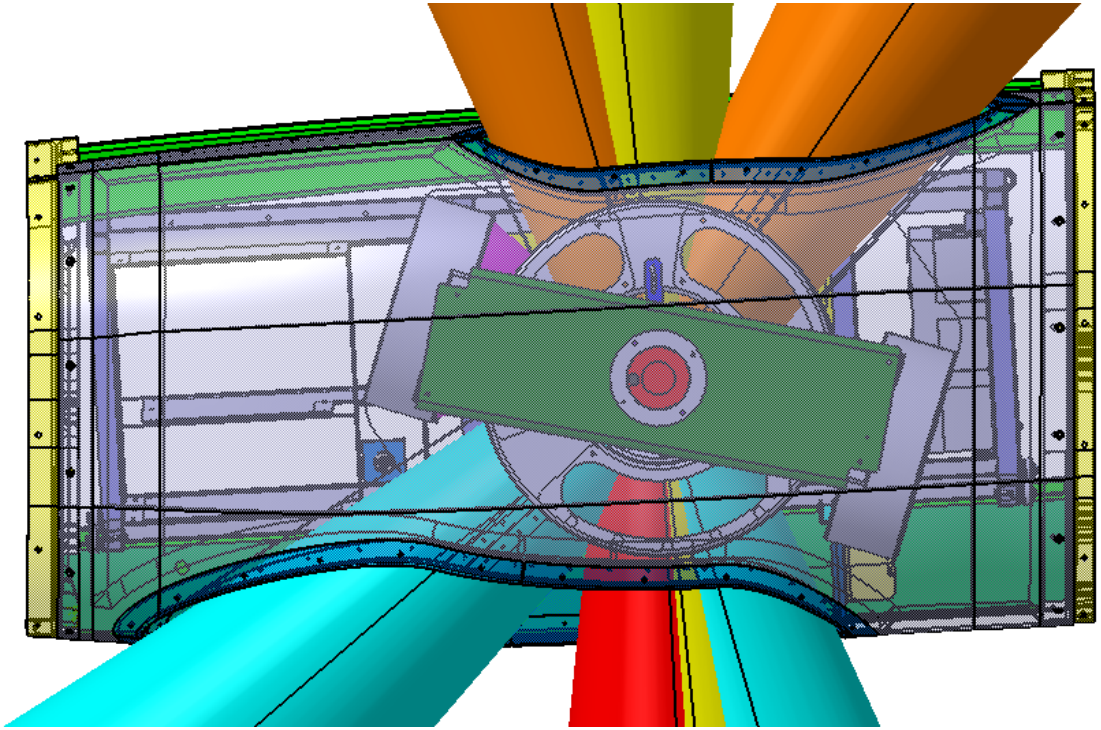
ISMAR Frequencies

Channels (GHz)		BW (GHz)	polarisation	Feature	Aircraft Instrument
23.8	±0.07	0.127	V&H	H2O	Deimos A (ch1)
50.1	±0.05	0.082	V&H	O_2	Deimos B (ch3)
88.992	±1.1	0.65	V&H	window	MARSS 1 (ch 16)
118.75	**±1.1 ±1.5 ±2.1 ±3.0 ±5.0**	**0.4 0.4 0.8 1 2**	**no**	**O_2**	**ISMAR**
157.05	±2.6	2.6	V&H	window	MARSS 2 (ch17)
183.31	±1 ±3 ±7	0.45 1 2	no	H_2O	MARSS 3 (ch18) MARSS 4 (ch19) MARSS 5 (ch20)
243.2	**±2.5**	**3**	**V&H**	**window**	**ISMAR**
325.15	**±1.5 ±3.5 ±9.5**	**1.6 2.4 3.0**	**no**	**H_2O**	**ISMAR**
424.7	±1.0 ±1.5 ±4.0	0.4 0.6 1	no	O_2	Awaiting funding
448	**±0.8 ±2.0 ±4.5 ±11.5**	**1.2 2 3 3**	**no**	**H_2O**	**ISMAR**
664	**±4.2**	**3**	**V&H**	**window**	**ISMAR**
874.4	±6.0	3	V&H	window	Awaiting funding

Along track scanning

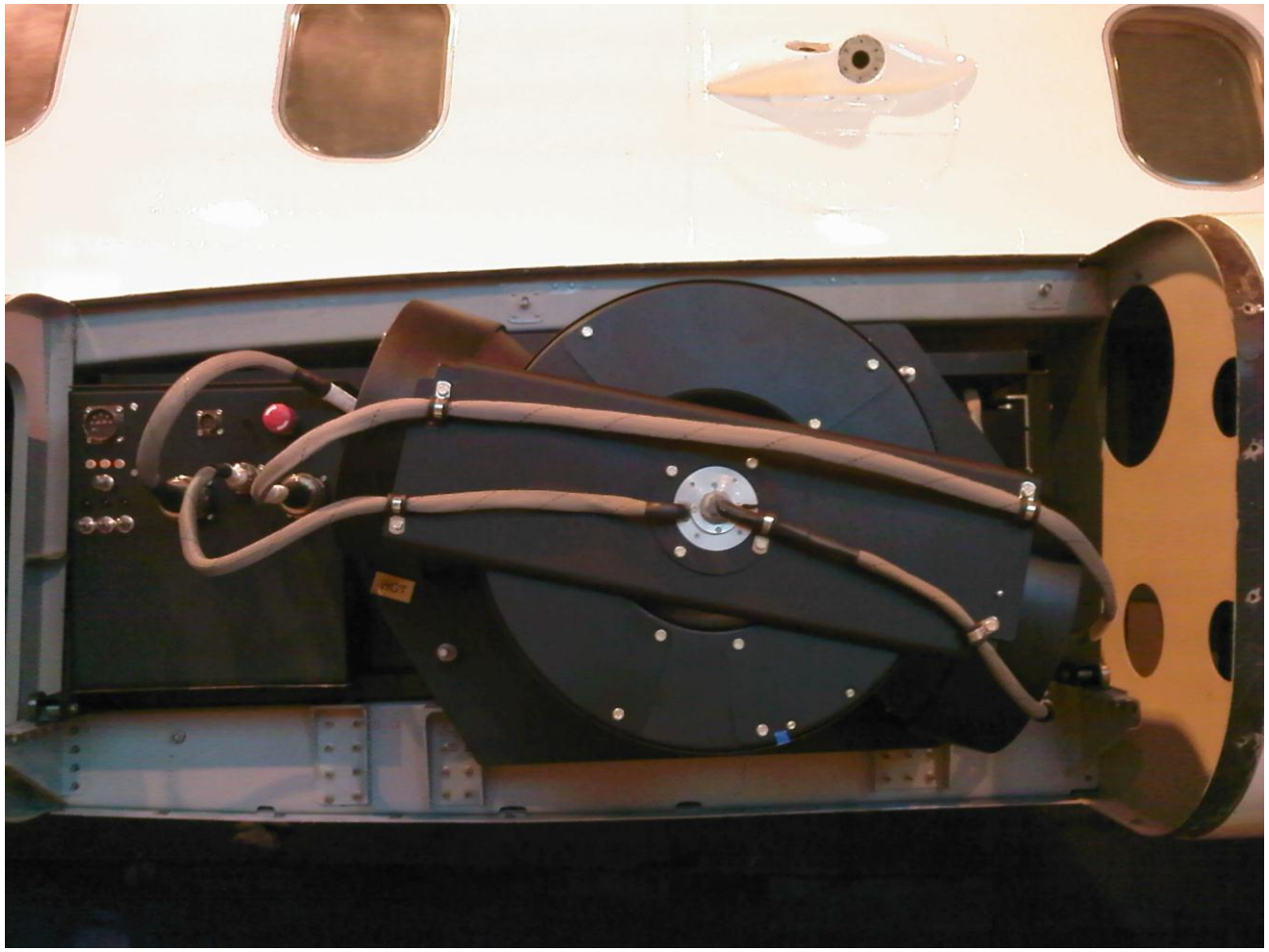


ISMAR Viewing angles



+55 deg to -10 deg nadir
+10 deg to -40 deg zenith

ISMAR in large radiometer blister on FAAM 146



Conclusions

- Ice Cloud Imager will provide important additional cloud information.
- Fills gap above 200GHz.
- Operational (NWP & climate) plus scientific research.
- Airborne version instrument for retrieval algorithm testing, scientific studies, satellite calibration/validation.