BARODAR - Remote Sensing of Surface Air-Pressure Using Differential Absorption Radar

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Alessandro Battaglia, Richard Reeves, Peter Huggard, Hui Wang, Diego Pardo, Daniel Gerber, Judith Jeffery, Manju Henry, Kai Parow-Souchong, John Bradford, James Henderson, Arthur Cunningham, Brett Candy, Christine Gommenginger, Salvatore DAddio, Ishuwa Sikaneta, Mike Trethewey, Ted Brooke, Ediz Tunarli.

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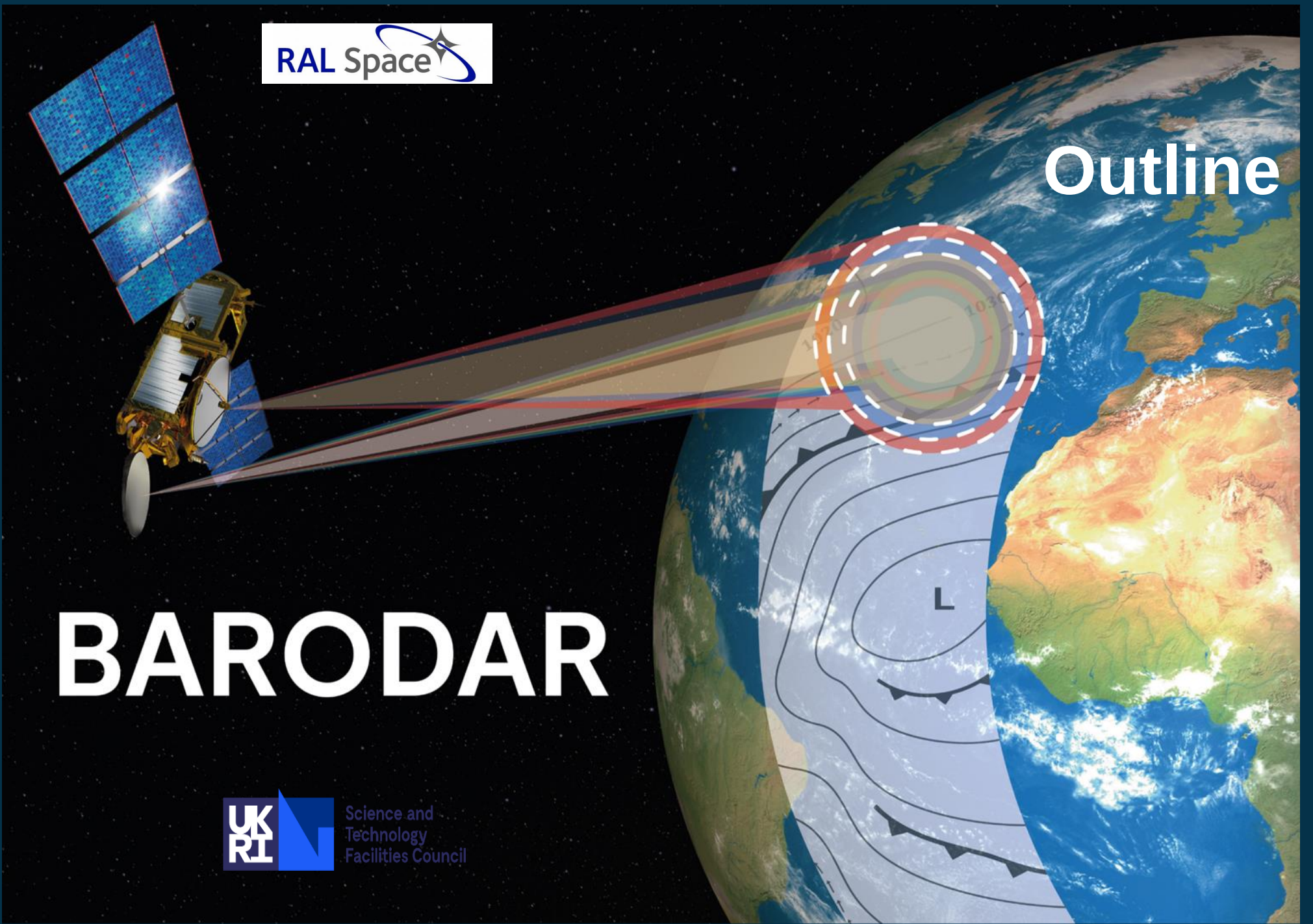


BARODAR

RAL Space

esa European Space Agency

UKRI Science and Technology Facilities Council

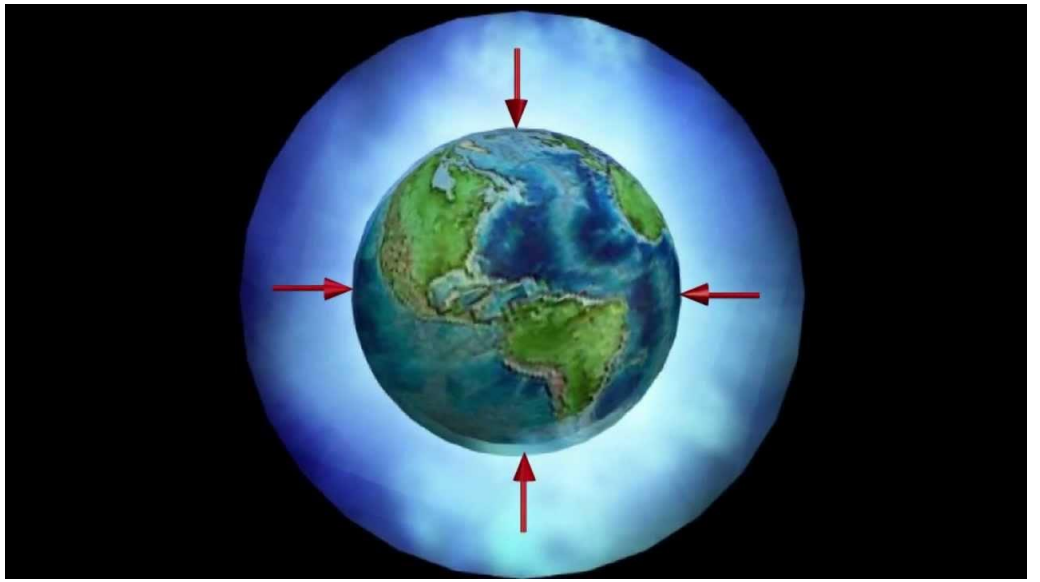
Outline

- Introduction
- Mission Justification
- Mission Concept Design
- Demonstrators Design
- Summary and recommendations

BARODAR: BAROmetric Differential Absorption Radar

BARODAR is an **Earth Observation** mission to provide global, regular, and consistent **surface air pressure** measurements **from space for the first time.**

- **Surface Air-Pressure** is the **mass** of the atmospheric column.
- It is a result of the **fluid-dynamics and thermodynamics** of the **atmosphere**.
- It is therefore **critical** for **assessing the state** of both the **atmosphere** and **oceans**.
- It is an **essential variable** in atmospheric **dynamics** and **weather prediction**.

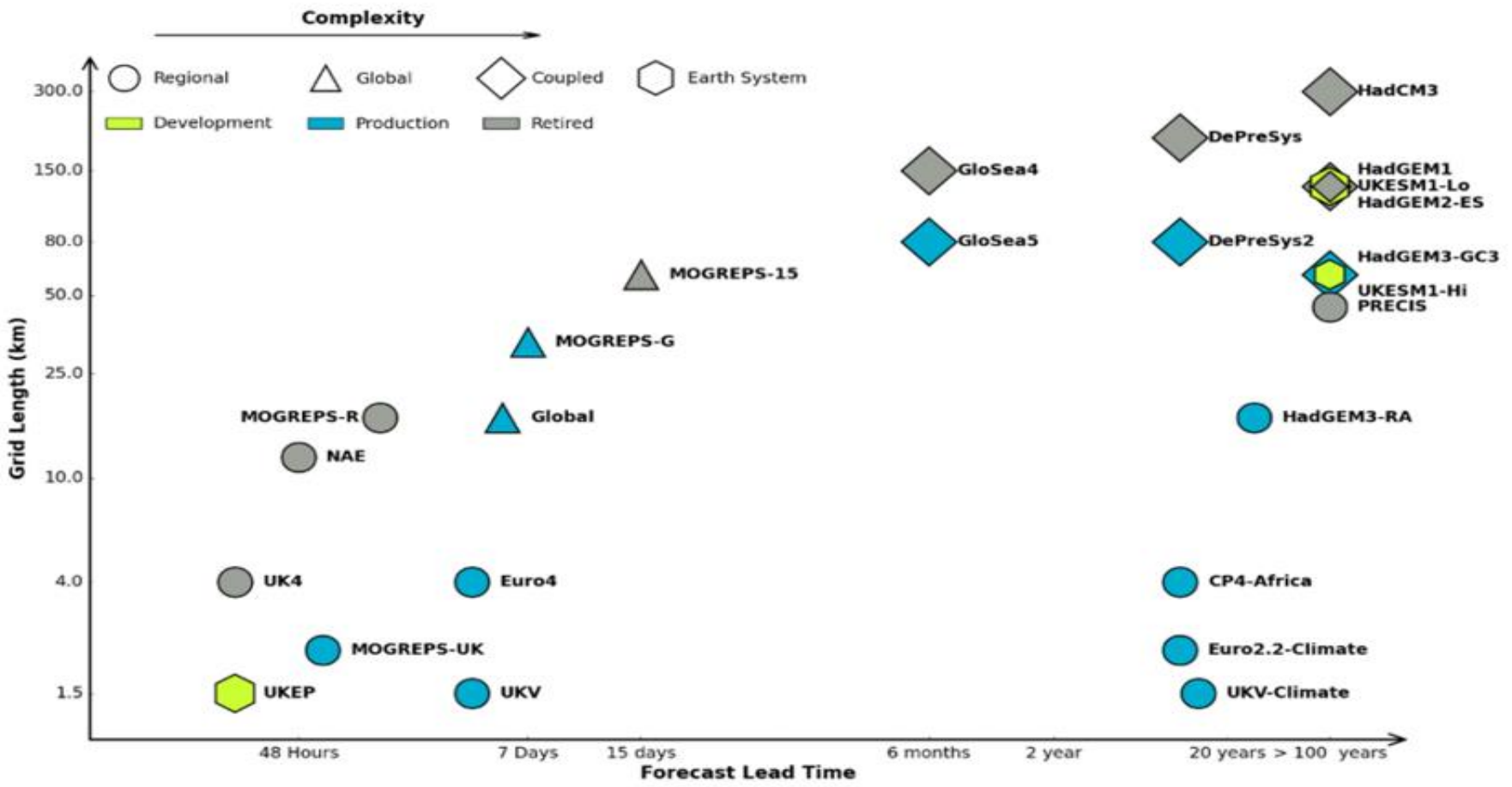


Mission Justification

- Due to **climate change extreme weather events** becoming **more frequent** and **more intense**.
- Extreme events such as **storm surges and hurricanes are significantly underestimated in models, partly due to insufficient data of surface pressure**.
- **Pressure is the most important parameter used in Numerical Weather Prediction (NWP) Models and Climate Models, General circulations model (GCM)** .
- Most EO missions measure **altimetry, wind**, **temperature, gravity** and others require accurate pressure measurement to retrieve accurate results.

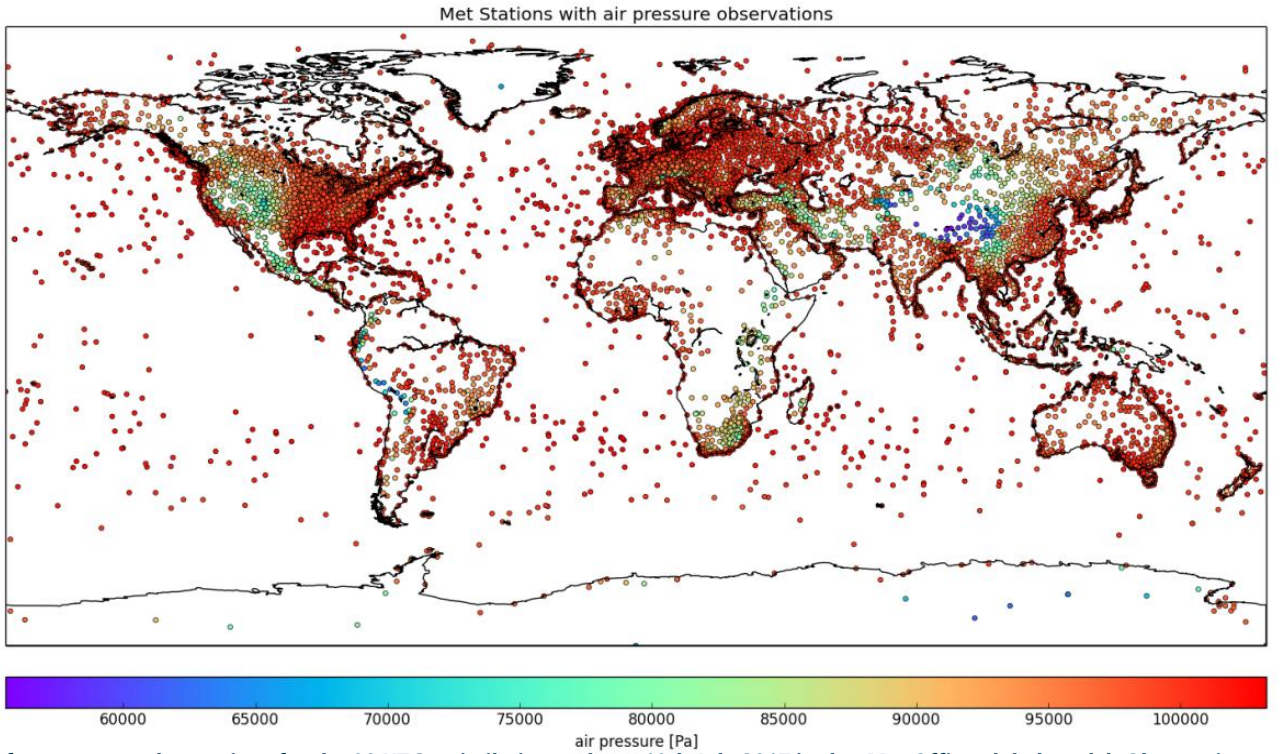
Limited measurements on land, and more importantly at sea, limit forecasting capability.

Weather and Climate Models Used by the Met Office



[www.metoffice.gov.uk]

Current distribution of in-situ surface-air pressure sensor



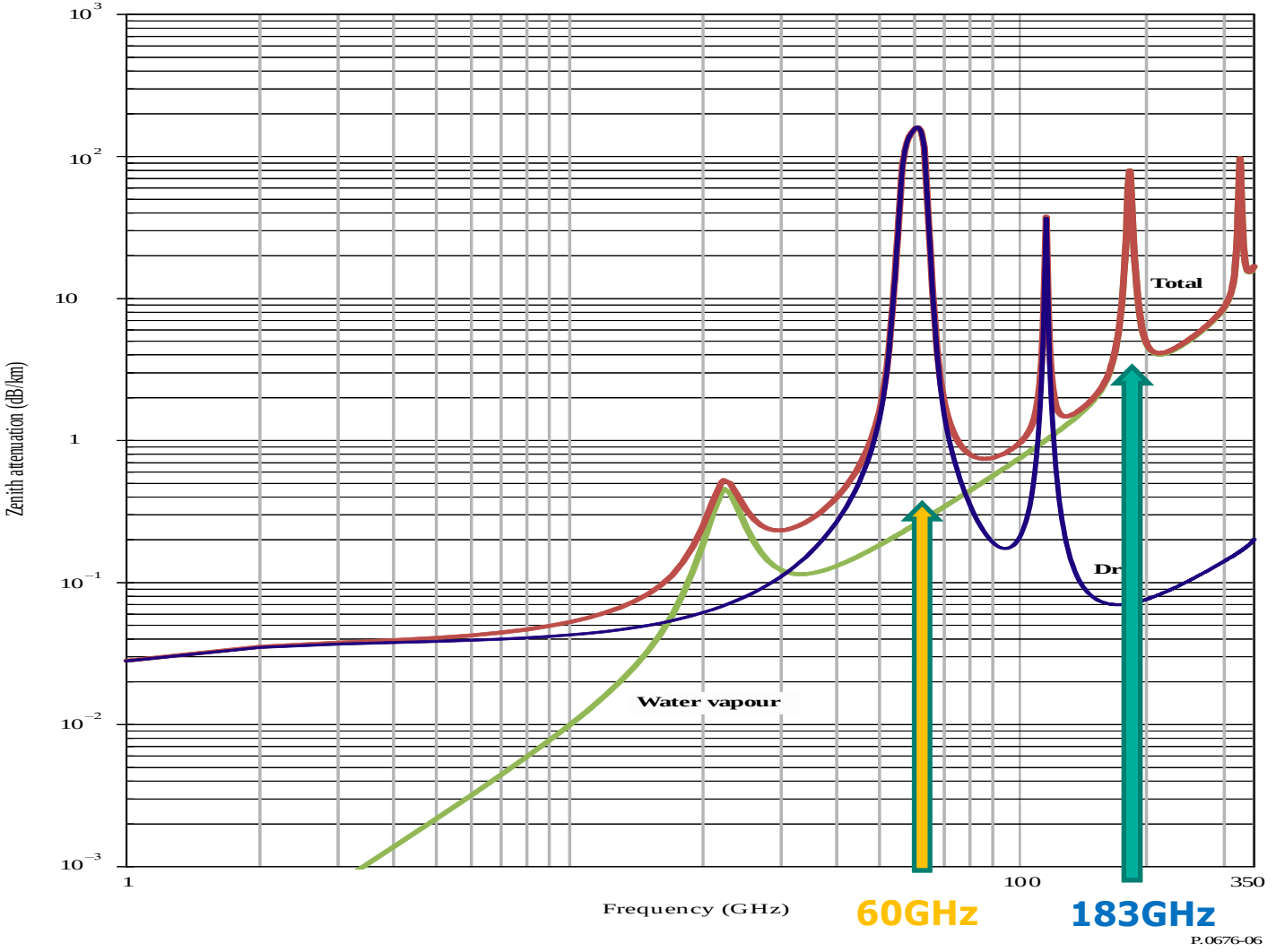
Coverage of surface pressure observations for the 00 UTC assimilation cycle on 19th July 2017 in the Met Office global model. Observations are used from 10 236 stations globally, some reporting hourly, giving approximately 40 000 observations assimilated in a 6 hour window.

- **Only 30% of the Earth is currently measured**.
- **90% of stations** are on **land and concentrated on the Northern Hemisphere**.

Satellite remote sensing is the only way to provide, global consistence and continuous observations.

Mission Design Concept

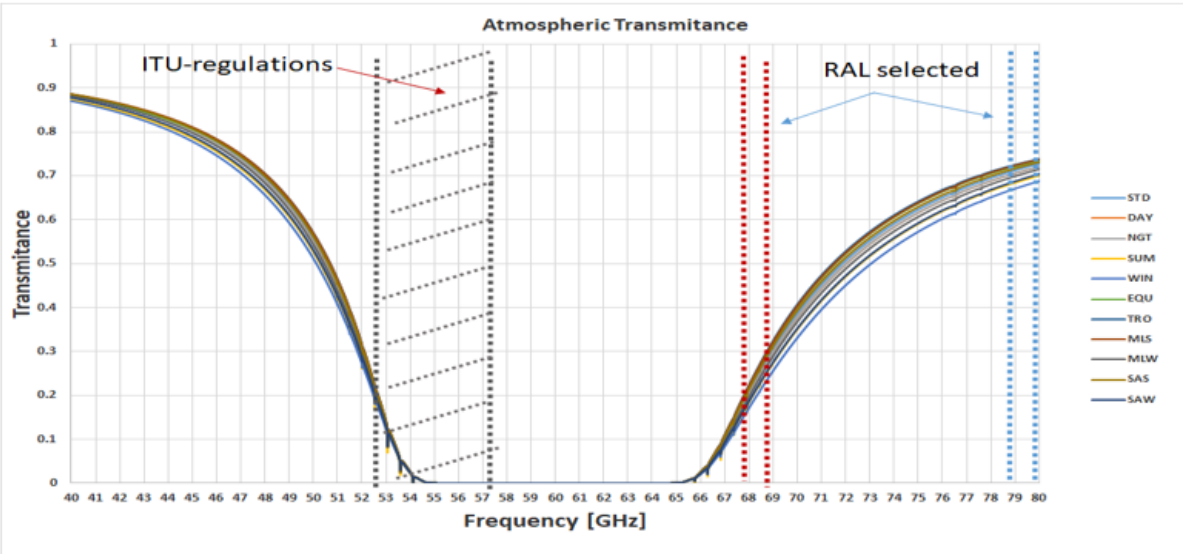
- Oxygen **uniquely** has **a constant mixing ratio** over the full range of atmospheric conditions and latitudes.
- Electromagnetic fields attenuated mainly by Oxygen and water vapour.
- **Total oxygen** is a proxy for atmospheric **pressure measurements.**
- A pair of pressure sensing frequencies on the **lower or the upper wing** of the oxygen absorption band provide **distinctive attenuations**.
- The **differential absorption radar (DAR)** provides potential technique for surface pressure measurements.
- **Water Vapour** measurements with **MWR** is needed to correct for clouds and **precipitation**.

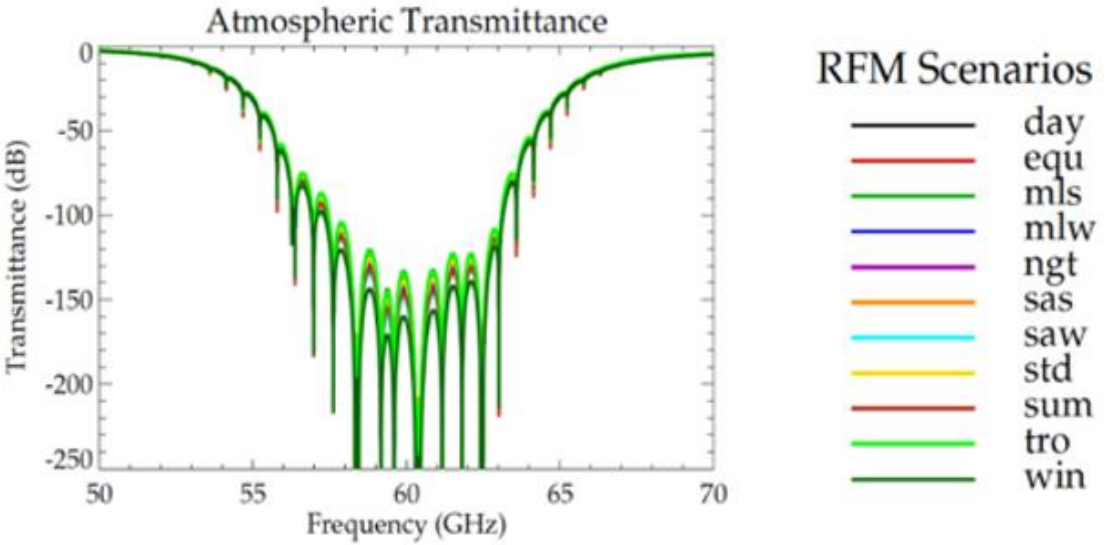


Total, dry air and water-vapour zenith attenuation from sea level (Pressure = 1 013.25 hPa; Temperature = 15°C; Water Vapour Density = 7.5 g/m^3), Rec. ITU-R P.676-11

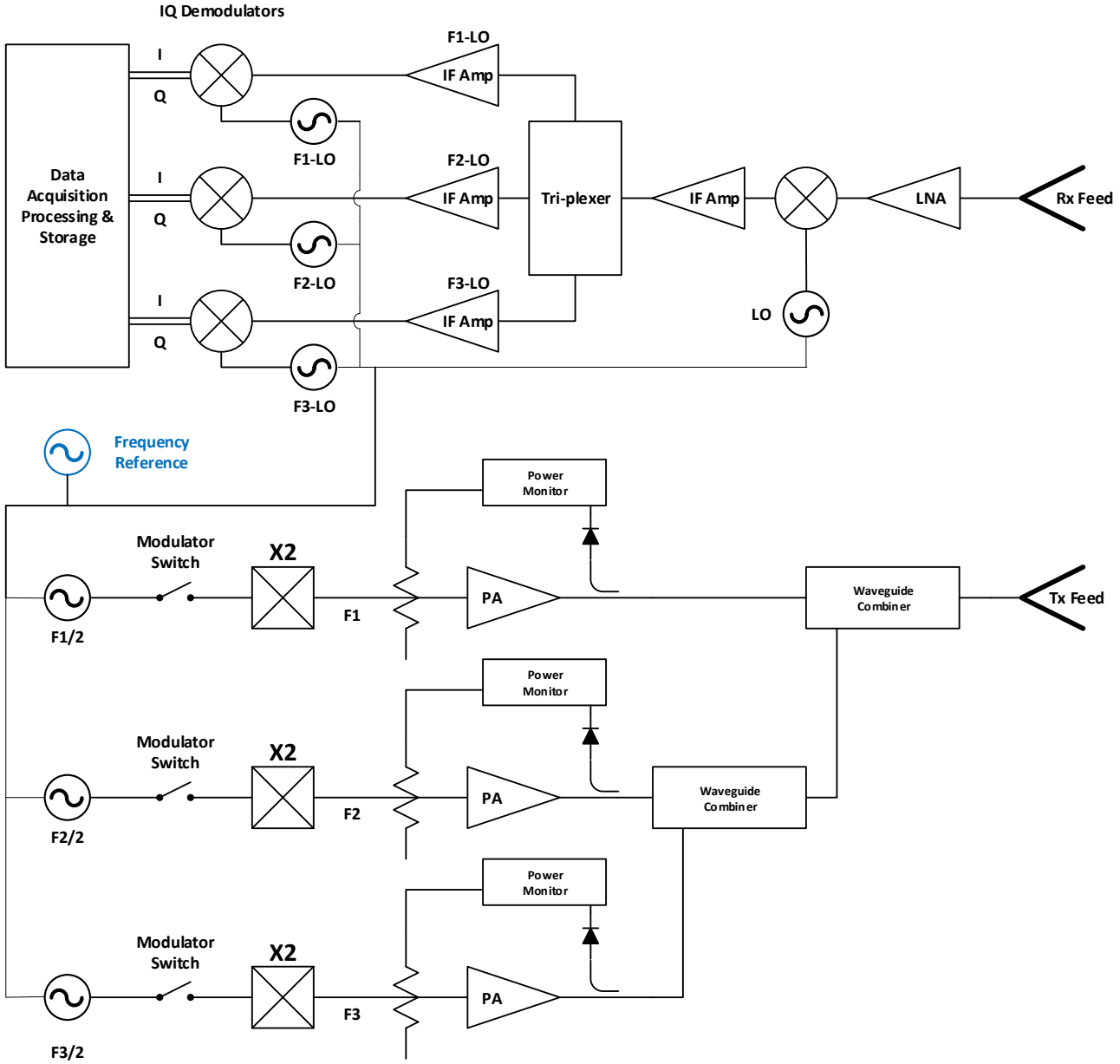
Selected frequencies

- RFM radiative transfer model with 11 scenarios
- The upper wing and the lower (V band) wing of the oxygen bands were studied.
- Transmittance drops faster around the O2 band in V-band than the upper wing.
- Absorption difference is higher within one pair on the left wing.
- Outside the ITU restricted bands,
- Three frequencies in the V-band were selected.

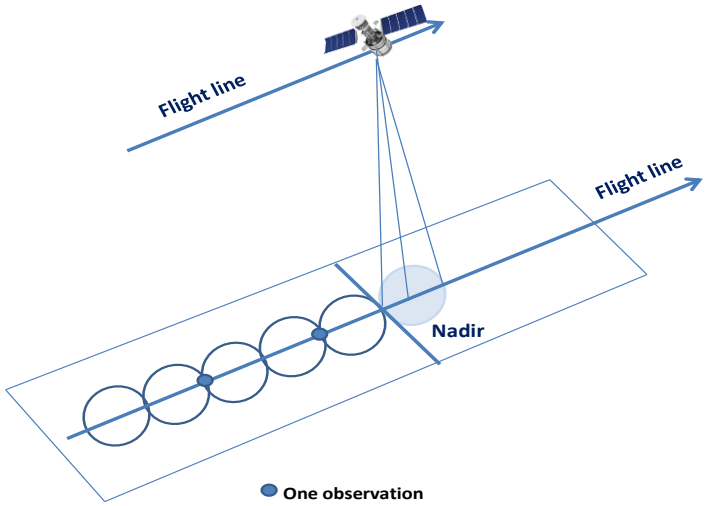




Three channels radar transceiver

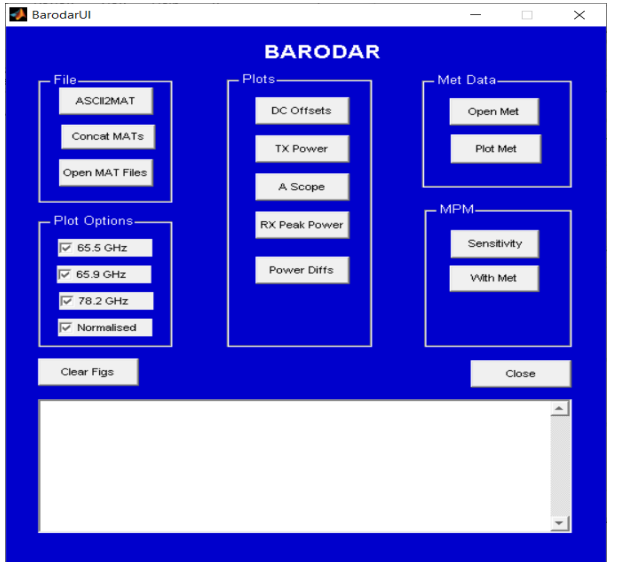


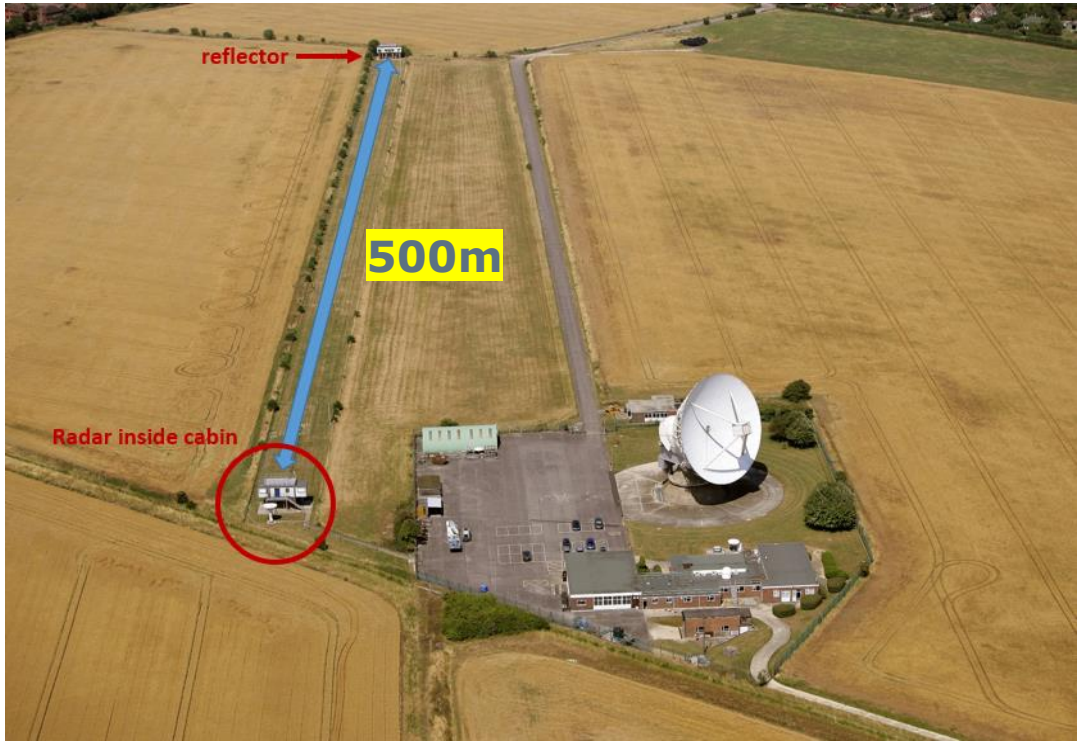
One antenna for transmit and receive of the 3 channels.



Triple Channel DAR

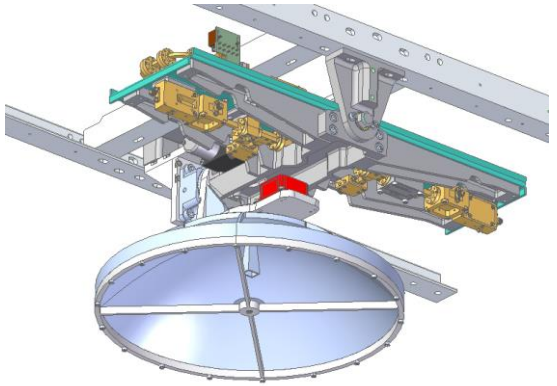
- **Three channel radar**
- **Data processing SW**
- **Field trial at Chilbolton Observatory**

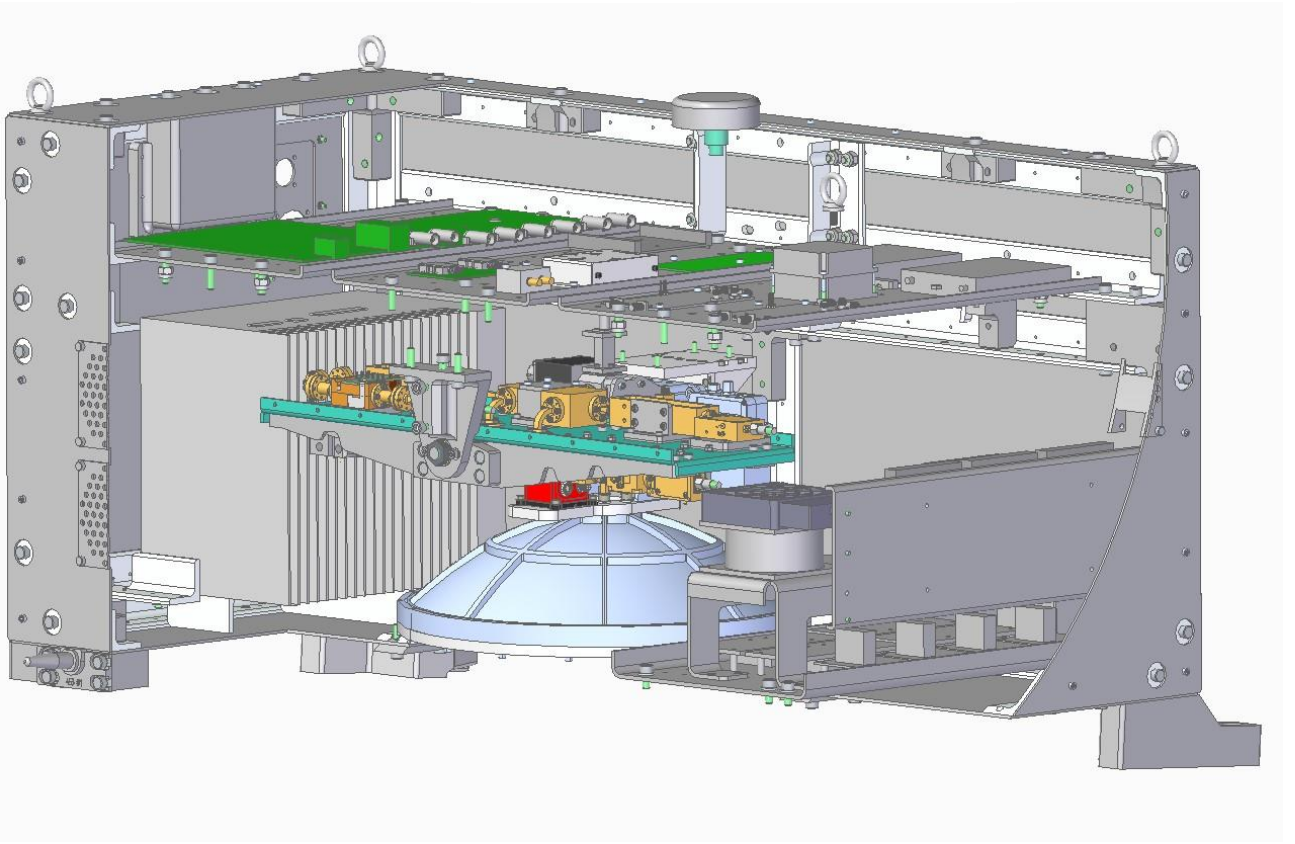




ESA Funded Airborne Demonstrator

FAAM: Facility for Airborne Atmospheric measurements





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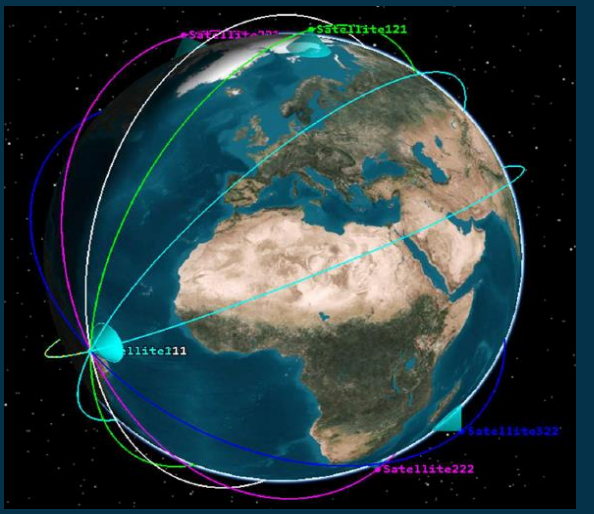
Summary

- **BARODAR** provides, regular, consistence, and greatly enhanced coverage over the oceans and polar regions compared to what is currently available.

FAAM: Facility for Airborne Atmospheric measurements

Future plans:

- **Complete the airborne demonstrator.**
- Fly on-board **FAAM** including **MWR** to verify retrieval methodology, water vapour correction algorithms, and to optimise the selected frequencies



Recommendations:

- **Urgently enable global surface-pressure measurement from space.**
- **Urgently enable consistence long term measurements and records of surface pressure.**

Thank you

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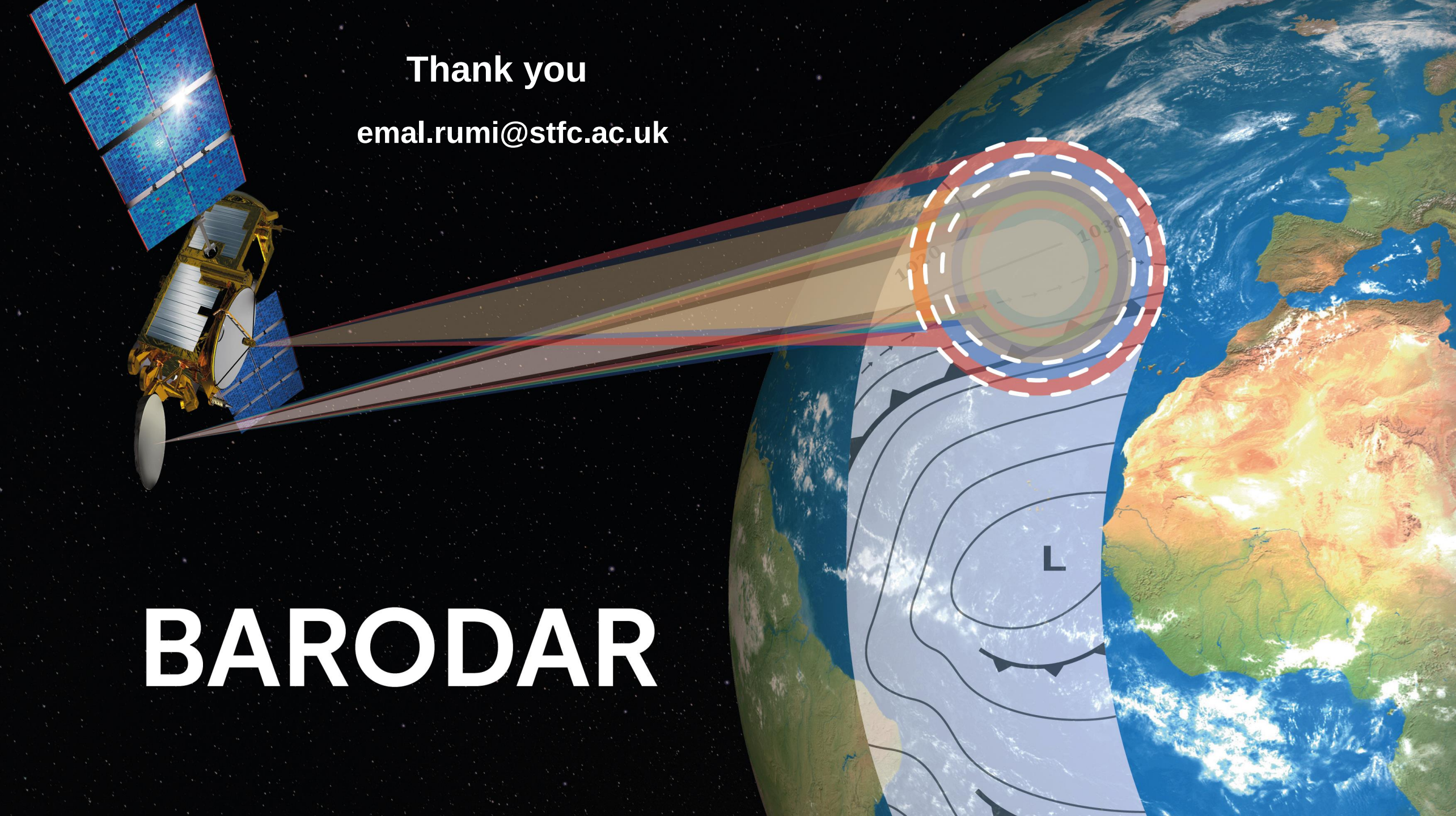

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