Spectroscopic-system for Environmental Monitoring' (SERMON)

Lead Organisation: *RAL Space, STFC*
Partners: *UK Met Office, STAR-Dundee Ltd., JCR Systems Ltd. & ECMWF*

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Science &Technology Facilities Council
Rutherford Appleton Laboratory

Centre for
EO Instrumentation

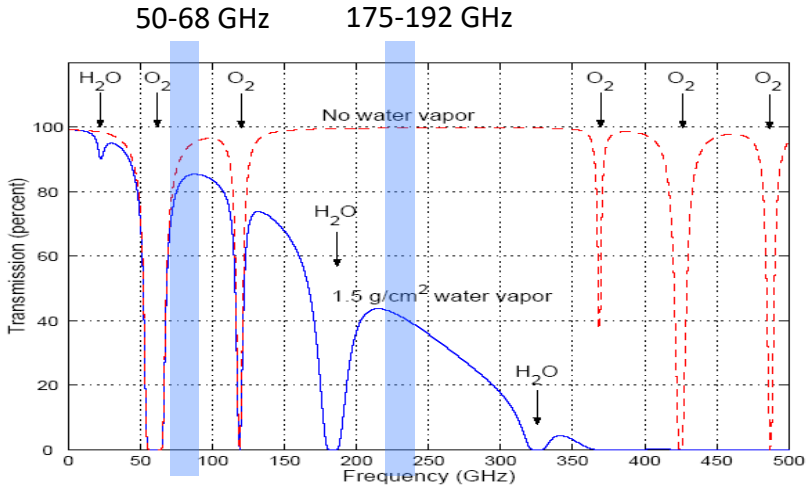
Overview

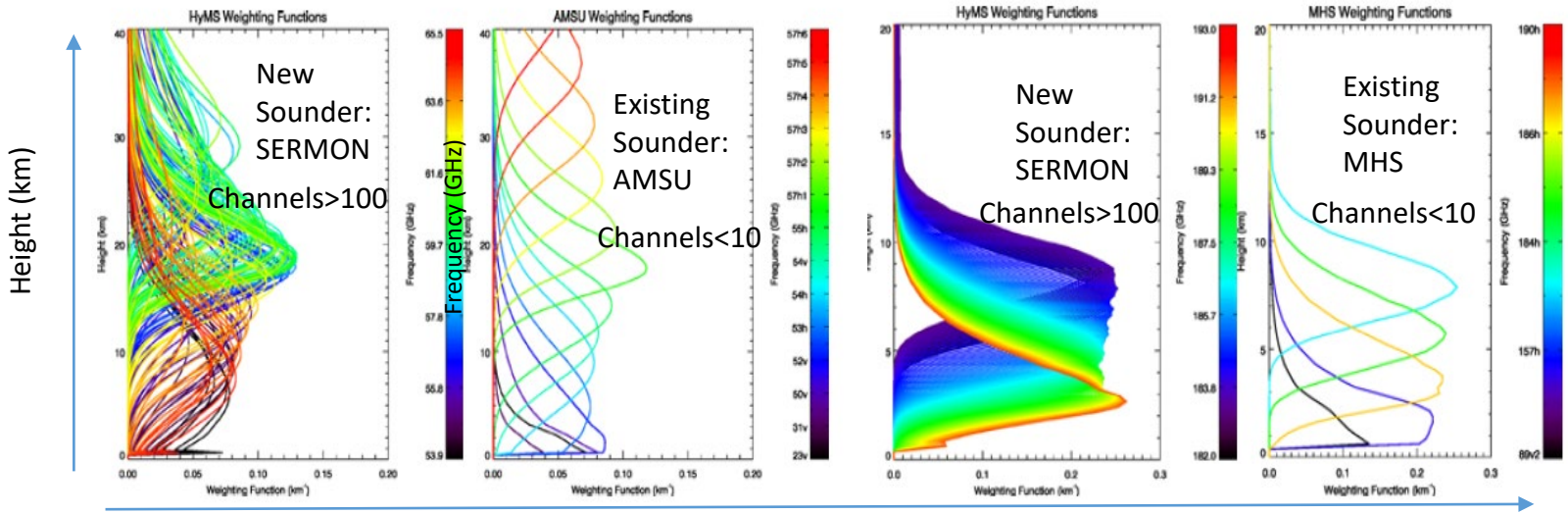
SERMON is the next-generation meteorological sounder instrument (MetOp-3G) which will fly onboard FAAM aircraft later this year.
The instrument is based on Hyperspectral Microwave Sounding Technology.
It will demonstrate the most advanced, fine resolution weather measurements and accurate weather forecasting.

RAL Space
STAR-Dundee
JCR SYSTEMS
Met Office
ECMWF
FAAM

Background

Hyperspectral sounding enables ultra-fine resolution temperature and water vapour profile retrievals





Oxygen (Temperature) and Water Vapour (Precipitation) sensing are key for Weather Forecasting.

Weighting Functions

SERMON uses 100s of detection channels

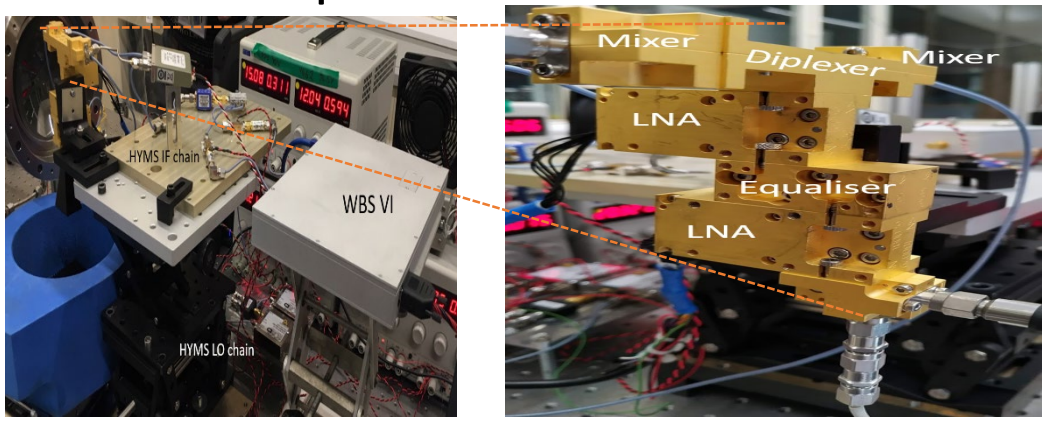
First-time demonstration of the benefits of increased vertical resolution microwave sounding

Accurate Weather Forecasting

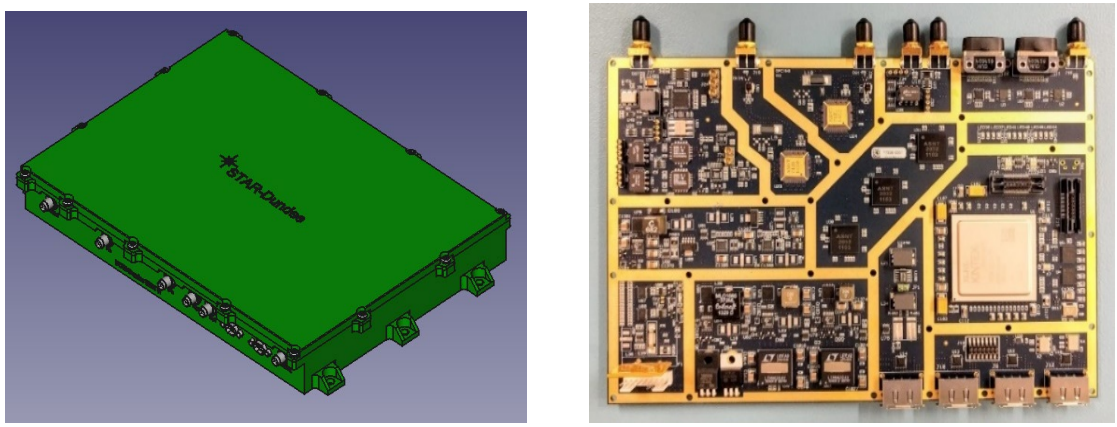
RAL Space · STAR-Dundee · JCR SYSTEMS · Met Office · ECMWF · FAAM

SERMON Instrument Development Technological Challenge

- Radiometric precision (NEΔT) <0.4 K for 10 MHz spectral resolution is technically challenging.
- E.g., four fold higher requirement than MWS, the most sensitive microwave instrument on MetOp SG.



60 GHz Hyperspectral Lab Prototype System

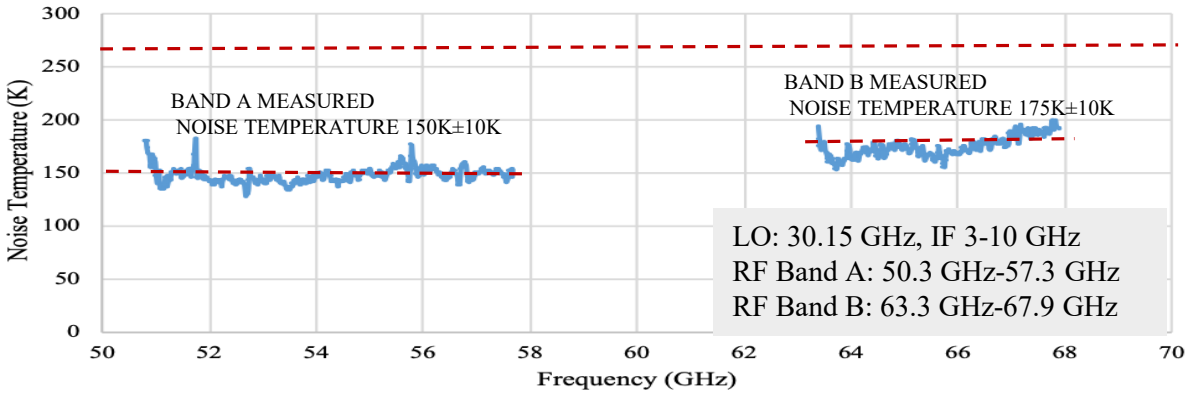


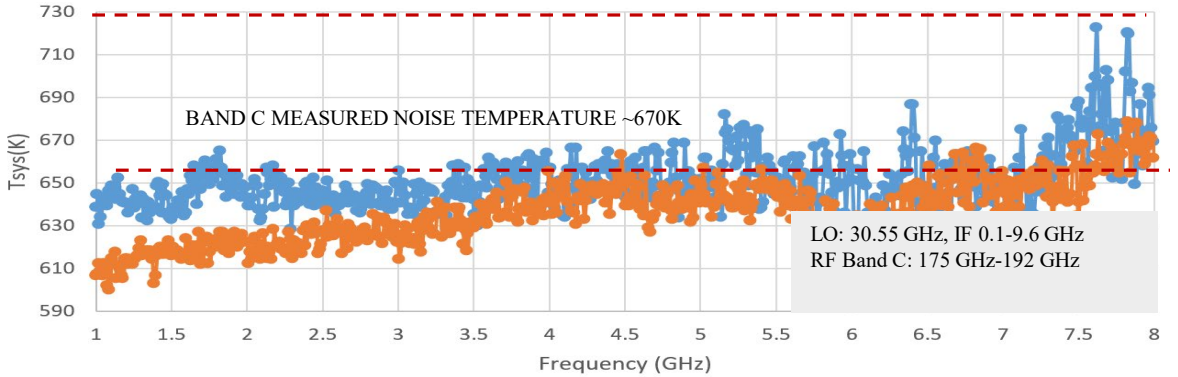
Ultra-Wideband High-Resolution Spectrometer (STAR)
Instantaneous BW:9.6 GHz, spectral resolution 1 MHz

SERMON Instrument Requirements and Performances

Hyperspectral Sounder Requirements:

Parameter	58 GHz Channel	183 GHz Channel
RF Input (GHz)	50.0 - 57.3, 63.3 - 67.9	175 - 192
IF Output (GHz)	0.1-9.6 GHz	0.1-9.6 GHz
T_{rec} (K)	≤ 260	≤ 810
Out of band rejection/image band separation (dB)	≥ 40	≥ 40
Thermal gain stability (dB/°C)	0.02	0.02
Non-thermal gain stability (dB)	1.5 x10^{-4}	1.5 x10^{-4}
Frequency stability (MHz)	± 0.1	± 0.1
RF Input return loss (dB)	≥ 15	≥ 15
IF output return loss (dB)	≥ 20	≥ 20





Band A: 50-58 GHz Tsys:150K
Band B:63-68 GHz Tsys:175 K
Band C: 175-192 GHz Tsys:670K

Achievements and Current Status

Achievements to date:

- Critical front-end components for SERMON instrument developed and demonstrated.
- Radiometer system noise temperature <200K achieved across the measured bands (50 GHz-68 GHz) - state-of-the-art performance for a room temperature atmospheric sounder of this type.
- Radiometric precision (NEΔT) of ~0.25 K and ~0.45 K in a 10 MHz and 3 MHz spectral bandwidth respectively for 300ms Integration time.
- Wide band spectrometer (WBS-V1) demonstrated with a factor of improvement of 40 compared to the baseline (WBS-V)

Current Status:

- Instrument integration and testing progressing and test flights planned for later this year.

Future Plan- A CubeSat Constellation

(Weather Events happen in order of hours)

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Fine Temporal and Spatial Resolution

Using a constellation orbiting close to the earth, the satellites will offer rapid revisit rates and fine spatial resolution enabling high accuracy nowcasting / short range weather forecasting

Hyperspectral

First of its kind in the microwave region, providing 100's of channels to gain unprecedented vertical resolution and all-weather operation

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Radio Frequency Interference Resilience

Onboard processing using AI and machine learning techniques to identify and mitigate against radio frequency interferences (Rollout of 5G is a major threat to meteorological satellites)