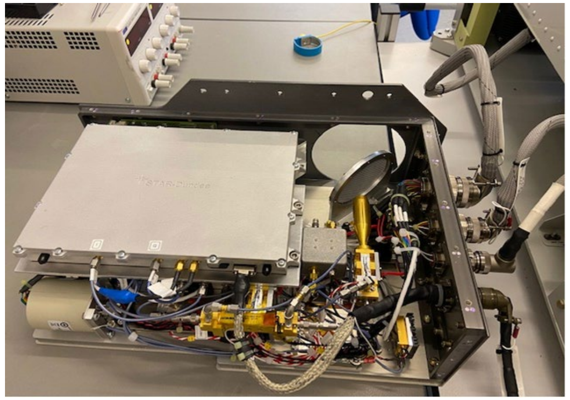
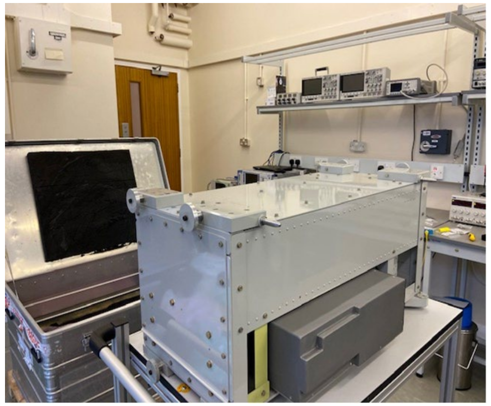
HYMS: Airborne Demonstration

RAL Space

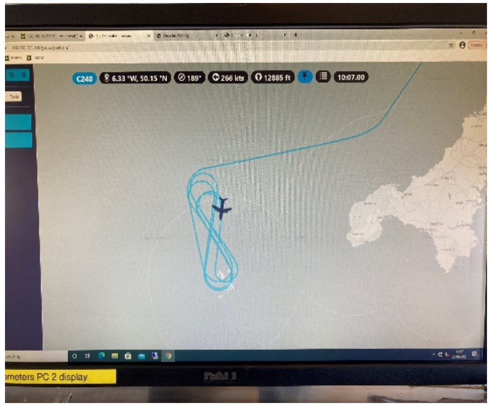


SERMON Front-end Radiometers and WBS



SERMON Full instrument

SERMON on NCAS's FAAM aircraft



First Engineering Test Flight-26th August 2021

Objective: To prove the benefits of hyperspectral measurements over and above the current generation of microwave remote sounders and the required radiometric performance can be met

- Built with three channels (one for temperature, the second one for water vapour, and a third one to demonstrate RFI mitigation.
- **The first Engineering test flight was carried out** on FAAM aircraft and **data analysis is currently ongoing (Level 1B processing)**
- Two more dedicated flights are planned by the end of this year
- On FAAM aircraft ISMAR and MARSS provides complementary instrumentation to ensure accuracy of the retrieved demonstrator products

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HYMS Small Satellite In-Orbit Demonstrator

RAL Space

NE∆T Sensitivity Requirements

- Under contract to ESA, F. Aires identified the original basis for the interest in hyperspectral sounding, and the additional information content remains as the principal driver for the HYMS concept.
- There emerged some inconsistencies between this report and the MetOp-SG MWS specifications, the latter has been reinforced by much simulation. Therefore, in agreement with the users, the HYMS IOD requirements have been derived from the MetOp-SG MWS specification especially for Ne∆T, the radiometric sensitivity.
- The UK Met Office confirmed that HYMS requirement @10MHz should match or exceed MWS prediction for Channel 16 (defined as a quad band of 4 x 3MHz), the nearest equivalent passband. Moreover, the improved spectral capability <10MHz is regarded as additional information content which could be used to further reduce instrument noise.

Centre Freq (GHz)	Preselected BW(MHz)	Ant Loss(dB)	Trec (K)	Tsys (K)	NeΔT (K) frontend	NeΔT (K) cal noise	NeΔT (K) Th ΔG/G	Raw NeΔT (K) Total	Raw NeΔT (K) Total (20% margin)	footprint cross step	footprint along step	Ave NeΔT (K)	MWS Req'mt	MWS (Pred'n)
54	156	0.3	200	235	0.25	0.09	0.04	0.27	0.32	24	24	0.28	0.55	0.5
54	64	0.3	200	235	0.39	0.14	0.04	0.42	0.50	24	24	0.43	0.9	0.7
54	32	0.3	200	235	0.55	0.20	0.04	0.59	0.71	24	24	0.61	1.2	1
54	12	0.3	200	235	0.90	0.32	0.04	0.96	1.15	24	24	1.00	2	1.6
89	3000	0.3	450	503	0.09	0.03	0.06	0.12	0.14	18	18	0.14	0.25	0.15
183	500	0.1	670	692	0.26	0.09	0.08	0.29	0.35	18	18	0.35	0.75	0.6

Radiometric Sensitivity of HYMS compared to MetOp SG MWS.

(for a scan profile feasible on our selected nanosatellite platform giving scene integration time of 27 ms.)

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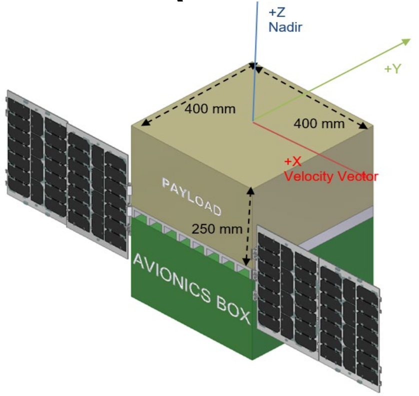
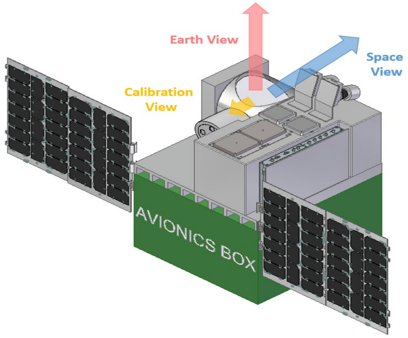
HYMS On-board a Small Satellite

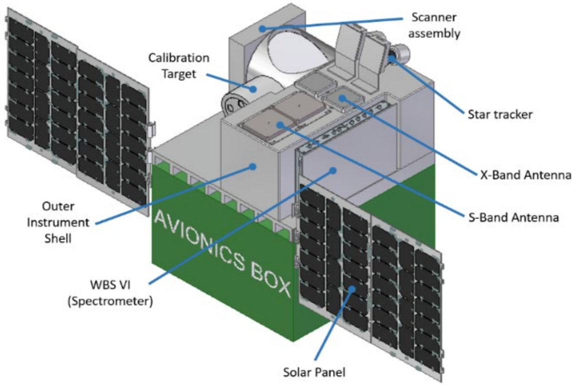
HYMS Demonstrator: **Hy**perspectral **M**icrowave **S**ounder In-Orbit Demonstrator (HYMS IOD)

- Crosstrack scanning radiometer
- Ultra-sensitive radiometers and wideband high-resolution spectrometer meeting system requirements are already demonstrated
- A suitable nanosatellite platform is identified that gives 100% duty cycle operation at 550 km altitude
- Preliminary payload design is completed that meets spectral and geometric requirements as listed below
- Our legacy: RAL Space provides MetOp SG microwave instrument receivers for MWS, MWI and ICI and also the ground calibration rig for MWS

Specification	HYMS-IOD	MetOp SG MWS
Number of channels	>1000	24
Channel Frequencies (GHz)	54, 89, 183	23, 31, 54, 89, 164, 183, 229
Spectral Resolution	10MHz @54 GHz and 400 MHz @183 GHz	12 MHz to 400 MHz @54 GHz 500 MHz to 2000 MHz @183 GHz
Mass	20 Kg	
Power (W)	100	
Altitude	550	830
Resolution at Nadir (km)	24 km at 50 GHz 17 km at 183 GHz	20 km at 50 GHz 17 km at 183 GHz
Scene Integration Time	27 ms (nanosatellite compatible scan profile)	14 ms
Scan Angle	±49°	±49°
Main beam efficiency, Wide beam efficiency	>95%, >97%	>95%, >97%
Instrument Size	400x400x250	1430x1000x522







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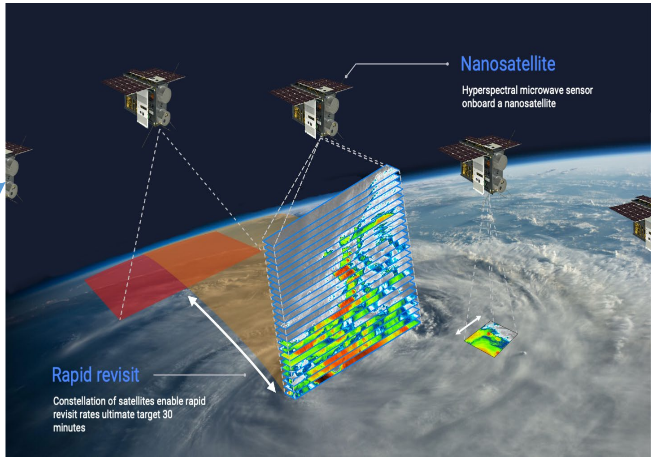
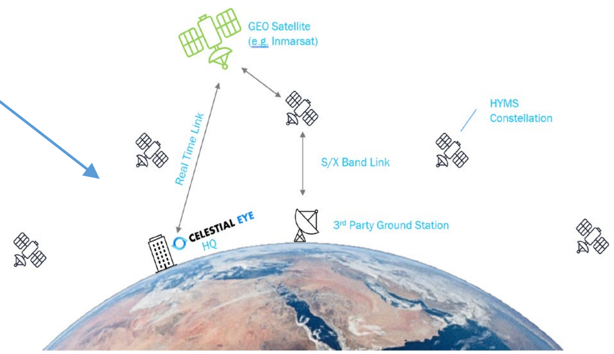
HYMS Future Outlook

A proposed future EO Mission: **Hy**perspectral **M**icrowave **S**ounder **C**onstellation **of** **N**anosatellites for **C**limate Change **a**nd **M**itigation (HYMS CONCAM)

- Deploy a constellation of nanosatellites with HYMS sounders for global observation of temperature and humidity
- Improve the forecast accuracy through increasing observation data content using HYMS retrievals
- Redefine weather through timely delivery of critical event data through a constellation of satellites giving 30 minutes revisit rate
- Provide ultra-low latency nowcasting using inter-satellite real time links
- Develop next generation EO technologies with lower cost and smaller risk
- Obtain highly resolved data from the upper stratosphere and lower mesosphere in order to monitor global circulation patterns (tape-recorder effect)
- Understand stratospheric warmings and atmospheric dynamics
- Use HYMS as a potential boundary layer mission, based on NASA PBL Incubation Team study report (NOAA Microwave sounder Workshop 28th July 2021)



Using Intersatellite links for ultra-low latency nowcasting



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HYMS CONCAM Mission Benefits

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- Through HYMS in a constellation we can achieve **better vertical resolution** (humidity and temperature), **timeliness** and faster download giving **low-latency data**
- As a result of this, better **improved numerical weather forecast** is possible due to the following factors:

  -more observation means **observations are better aligned to forecast models fixed points**

  -**quicker availability of data** through direct download

  -**resolution of localised atmospheric phenomena** (stratospheric warmings, boundary layer fluctuations, dynamical phenomena such as stratosphere-troposphere exchange (deep convection, polar vortex intrusions))
- Better improved numerical weather forecast leads to:

  -**Socio-economic benefits**

  -Big pool of atmospheric data, which scientists will be interested to work on as it has reasonably good vertical resolution and could **make up for the absence of limb sounding measurements** in the near to medium future

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HYMS CONCAM-Why Now?

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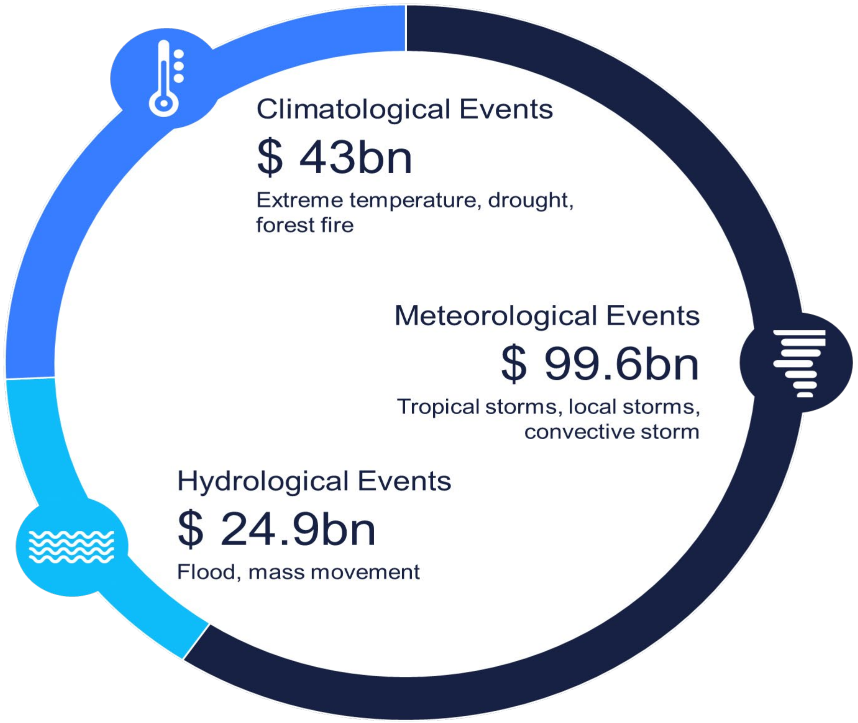
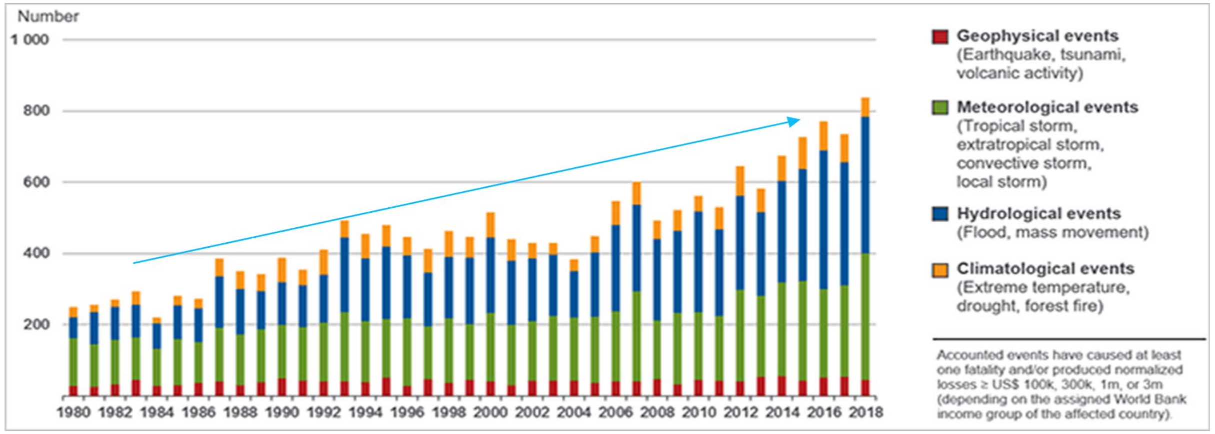
Extreme events are on the rise, catastrophes result in several £bn's losses.
Since 1980 these events have almost doubled



Losses by Event Category 2018

*Data from NatCastService – Munich Re



Number of Natural Loss Events Worldwide

*Data from NatCastService – Munich Re

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HYMS Impact

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Mitigating catastrophes, avoiding deaths, more intelligent energy systems

Mitigating Against Catastrophes

£168 Bn in losses in 2018, rapid increase in events

Solution
Accurate picture of weather data

Bridging the Protection Gap

1M farmers go bankrupt daily

Solution
Intelligent agriculture and insurance products

Reducing Fuel Use & Emissions

915 Million tonnes CO_2 emissions annually

Solution
Wind profiling and efficient route planning

Managing Future Energy Resources

Managing the variable nature of wind and solar

Solution
Accurate forecast of cloud cover and wind

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