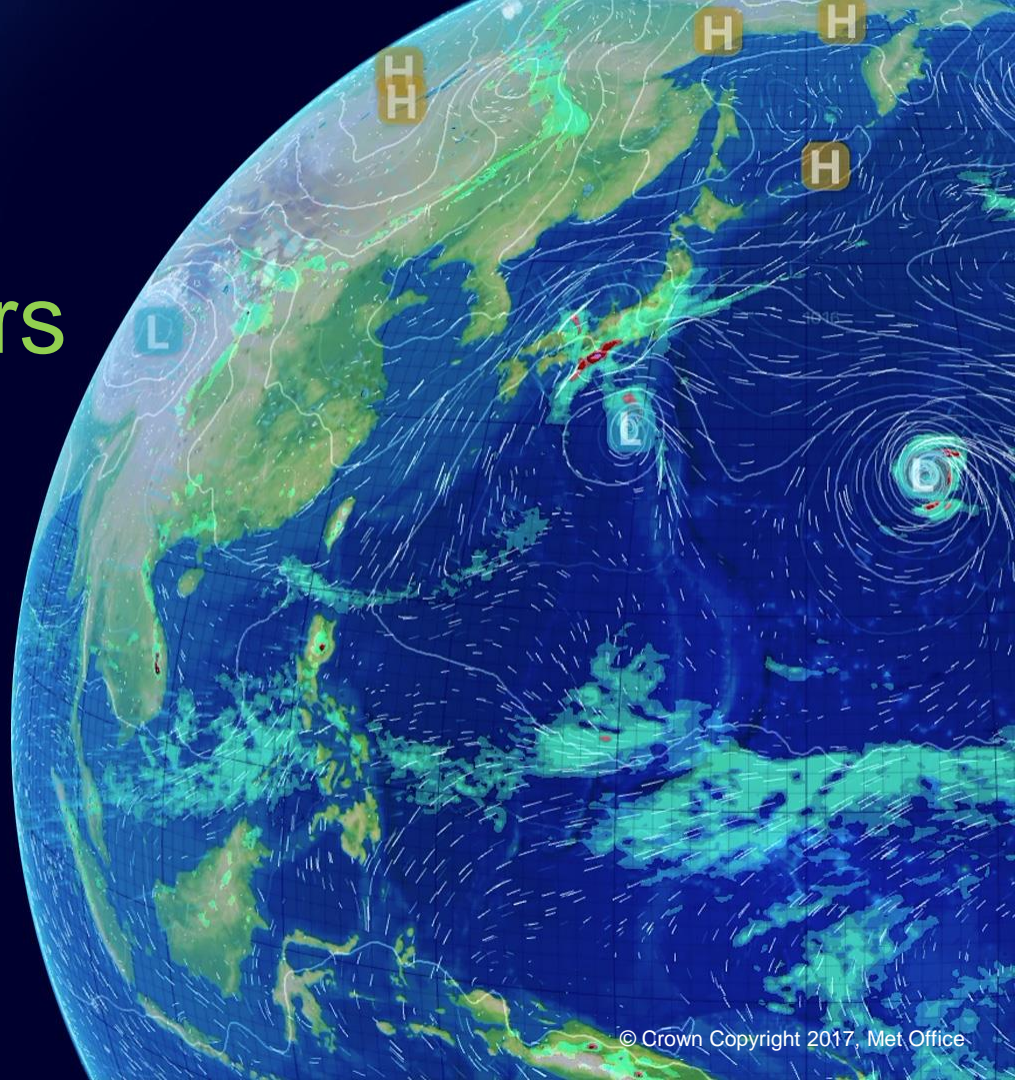


Why FORUM? Feedback from users

*Roger Saunders
Met Office*



FORUM Requirements

How were they gathered?

- ❑ **Baseline requirements from WMO OSCAR and GCOS for climate monitoring and NWP**
- ❑ **On-line survey with 84 responses**
- ❑ **Interviewed several climate scientists**
- ❑ **In depth knowledge of NWP requirements**
- ❑ ***Will also consult during this workshop***

Atmosphere	Surface	Air temperature; Precipitation, Pressure, Surface radn budget, Wind
	Upper Air	Clouds, Wind, Earth Radn Budget Upper air temp, water vapour, lightning
	Composition	Carbon dioxide, methane & GHGs Ozone, Aerosol properties
Ocean	Surface	SST, Sea-level, Sea-ice, Ocean colour Sea state, Salinity, Surface heat flux, Currents, Stress, Marine habitat
	Sub-surface	Temperature, Salinity, Currents, Nutrients, Carbon, Oxygen, Ocean Tracers, Plankton
Terrestrial	Surface temperature, Glaciers & Ice caps, Ice Sheets, Land cover, Fire disturbance, FaPAR, LAI, Albedo, Biomass, Lakes, Snow, Soil moisture, Water use, Ground water, River discharge, Permafrost, Soil carbon, GHG fluxes	

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WMO OSCAR Requirements

NWP higher tropospheric specific humidity

App Area	Uncertainty	Stability / decade	Hor Res	Ver Res	Obs Cyc	Timeliness
Global	2 %		15 km	0.5 km	60 min	6 min
NWP	5 %		50 km	1 km	6 h	30 min
	10 %		250 km	3 km	12 h	6 h

GCOS Earth Radiation Budget Requirements

Atmospheric ECV product requirements

ECV	Product	Frequency	Resolution	Required measurement uncertainty	Stability (per decade)	Standards/ references	Entity (see Part II, section 2.2) ⁹⁴	
							Satellite	In situ
Earth radiation budget	Top-of-atmosphere ERB long-wave	Monthly (resolving diurnal cycle)	100 km/NA	Requirements on global mean: 1 W/m ²	0.2 W/m ² /decade	NOAA Tech. Rep. NESDIS 134	WGClimate	
	Top-of-atmosphere ERB short-wave (reflected)	Monthly (resolving diurnal cycle)	100 km/NA	Requirements on global mean: 1.0 W/m ²	0.3W/m ² /decade	NOAA Tech. Rep. NESDIS 134	WGClimate	

Atmospheric ECV product requirements

ECV	Product	Frequency	Resolution	Required measurement uncertainty	Stability (per decade)	Standards/ references	Entity (see Part II, section 2.2) ⁹³	
							Satellite	In situ
Surface wind speed and direction	Surface wind speed and direction	3 h	10 km/NA	0.5 m/s and mean quadratic statistics to 10% of the locally prevailing mean wind speed, for speed >20 m/s	0.05 m/s/decade	For stability: International Vector Winds Science Team Meeting (M. Bourassa)	WGClimate	WIGOS
Precipitation	Estimates of liquid and solid precipitation	Monthly (resolving diurnal cycles and with statistics of three-hour values)	25 km/NA	0.5 mm/h	0.02 mm/decade	CMSAF requirements related to the HOAPS release 4.0 (CM-12611)	WGClimate	WIGOS
Temperature (surface)		Hourly	Site	0.1 K	0.02 K/decade	P. Jones		WIGOS
		Daily Tx/Tn		0.1 K				WIGOS
Pressure (surface)		Hourly	Site	0.1 hPa	0.02 hPa/decade	P. Jones		WIGOS
Water vapour (surface)		Hourly	Site	RH 1% DP 0.1 K	0.5%/decade 0.02 K/decade	Kate Willet		WIGOS
Temperature (upper-air)	Tropospheric temperature profile	4 h	25 km/1 km	0.5 K	0.05 K		WGClimate	WIGOS
	Stratospheric temperature profile	4 h	100 km/2 km	0.5 K	0.05 K		WGClimate	WIGOS
	Temperature of deep atmospheric layers	Monthly averages	100 km/5 km	0.2 K		0.02 K		WGClimate

Atmospheric ECV product requirements

ECV	Product	Frequency	Resolution	Required measurement uncertainty	Stability (per decade)	Standards/ references	Entity (see Part II, section 2.2) ⁹⁵	
							Satellite	In situ
Surface radiation budget	Surface ERB long-wave	Monthly (resolving diurnal cycle)	100 km/NA	Requirements on global mean: 1 W/m ²	0.2W/m ² /decade		WGClimate	WIGOS
	Surface ERB short-wave	Monthly(resolving diurnal cycle)	100km/NA	Requirements on global mean: 1 W/m ²	0.2 W/m ² /decade		WGClimate	WIGOS
Water vapour	Total column water vapour	4 h	25 km/NA	2%	0.3%		WGClimate	
	Tropospheric and lower-stratospheric profiles of water vapour	4 h (troposphere), daily (stratosphere)	25 km/2 km 100–200 km/2 km	5%	0.3%		WGClimate	
	Upper tropospheric humidity	Hourly	25 km/NA	5%	0.3%		WGClimate	
Cloud properties	Cloud amount	3 h	50 km/NA	0.01–0.05	0.01/decade	ESA CCI CMUG tables (http://www.esa-cmug-cci.org/)	WGClimate	
	Cloud-top pressure	3 h	50 km/NA	15–50h Pa	3–15 hPa		WGClimate	
	Cloud-top temperature	3 h	50 km/NA	1–5 K	0.25 K/decade		WGClimate	
	Cloud optical depth	3 h	50 km/NA	10%	2%		WGClimate	
	Cloud water path (liquid and ice)	3 h	50 km/NA	25%	5%			
	Cloud effective particle radius (liquid + ice)	3 h	50 km/NA	1 μm;	1 μm/decade			
Lightning		Daily	10 km			MTG EURD ⁹⁶	WGClimate	WIGOS

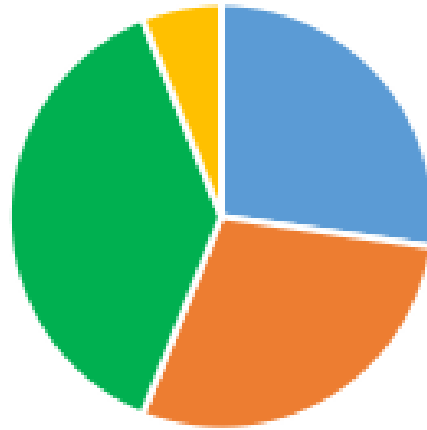


European Global Climate Models

Institute	Model name	Model components					
		ATM	OCEAN	LAND	CARBON BUDGET	CHEM	CMIP5?
Hadley Centre	HadGEM2-ES	◆	◆		◆	◆	Yes
	UKESM-1	◆	◆		◇	◇	
	GLOSEA		◆				
	JULES			◆	◆		
	HadSST		◆				
MPI-M	MPI-ESM, JSBACH			◆	◆		Yes
	MPI-ESM, MPIOM		◆				
	MPI-ESM, HAMOCC		◆		◆		
	MPI-ESM, ECHAM	◆					
<u>MétéoFrance</u>	MOCAGE	◆				◆	Yes
	ALADIN-CLIMAT-V5	◆					
	NEMO						
	CNRM-CM3.3	◆	◆	◆			
IPSL	ORCHIDEE			◆	◆		Yes
	IPSL-CM5	◆	◆	◆	◆	◆	
DLR	EMAC	◆	◆			◆	
SMHI	EC-Earth	◆	◆	◆		◇	Yes
	RCA	◆	(◆)	◆			
	HARMONIE	◆		◆			
ECMWF	ERA	◆	◆	◆		◆	
	MACC-II					◆	
	ORA		◆				

ON-LINE SURVEY RESULTS

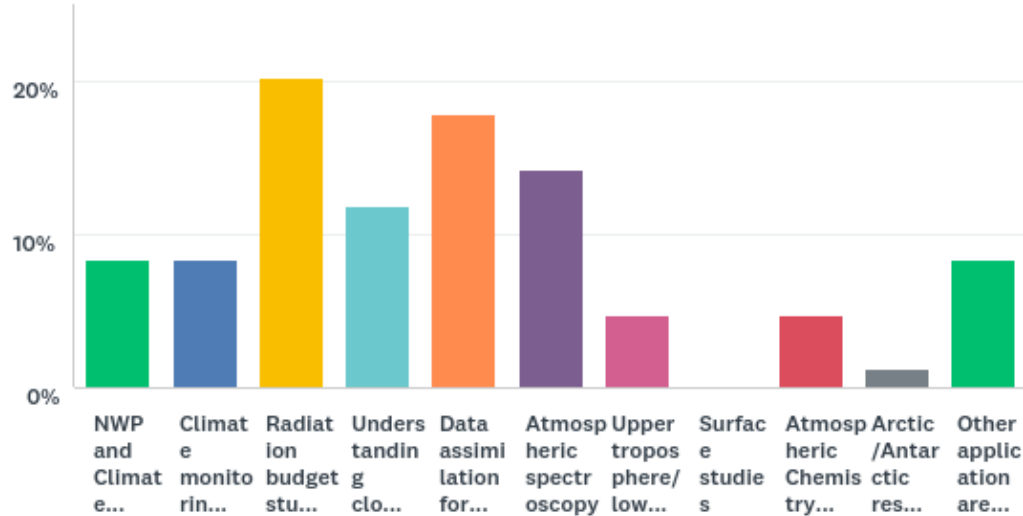
Survey Responses on FORUM applications



■ Spectroscopy ■ NWP ■ Climate ■ Atmos Chemistry

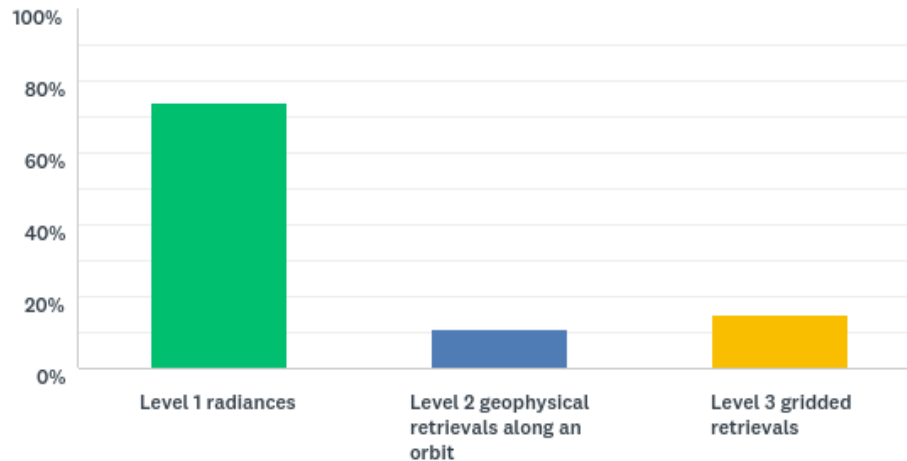
Survey results: Application Area

Q1 What is your primary application area?



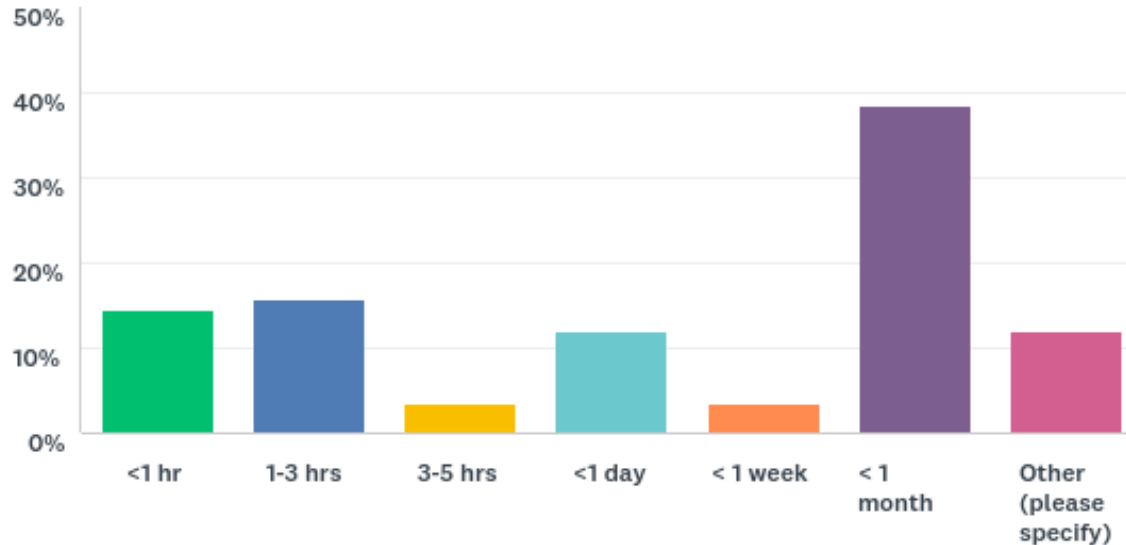
Survey results: Level of Processing

Q2 What processing level of data from FORUM do you require?



Survey results: Data Latency

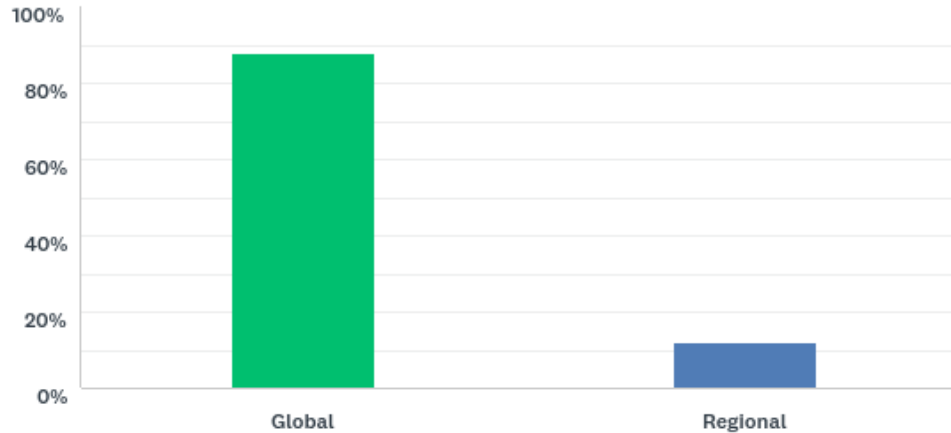
Q3 How timely do you require the data





Survey results: Data Coverage

Q4 Do you require Global or Regional data?





Survey results: Data Use

Q5 How do you plan to use FORUM data?

comparison properties validation Improve NWP Research use ice data
studies model measurements cloud compare
assimilation far IR atmospheric surface retrievals FORUM



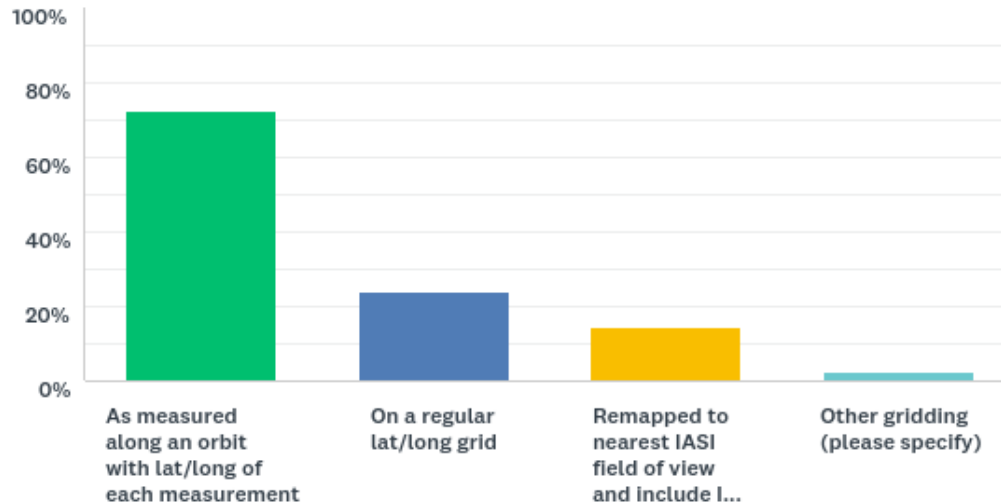
Survey results: Data Formats

Q6 What is your preferred data format for FORUM data and delivery mechanism?

delivery similar Via h5 BUFR mechanism ftp web netcdf preference
HDF format HDF5 EUMETCAST data NetCDF4 download

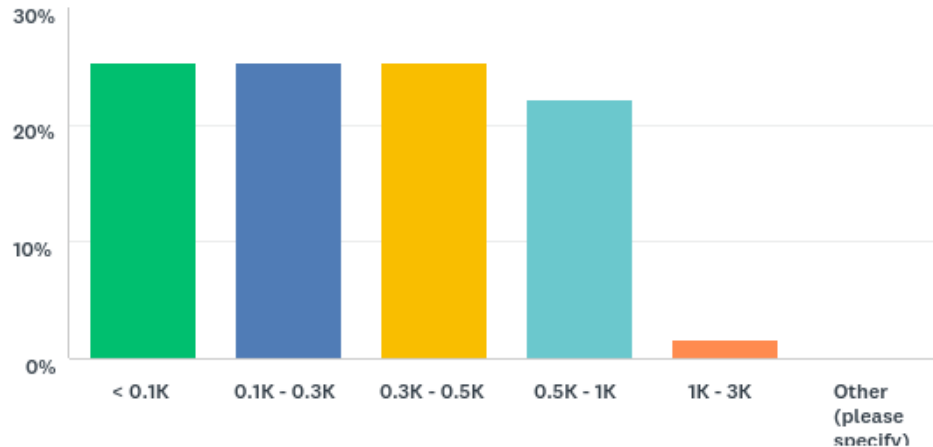
Survey results: Data gridding

Q7 On what grid do you want the data provided ?



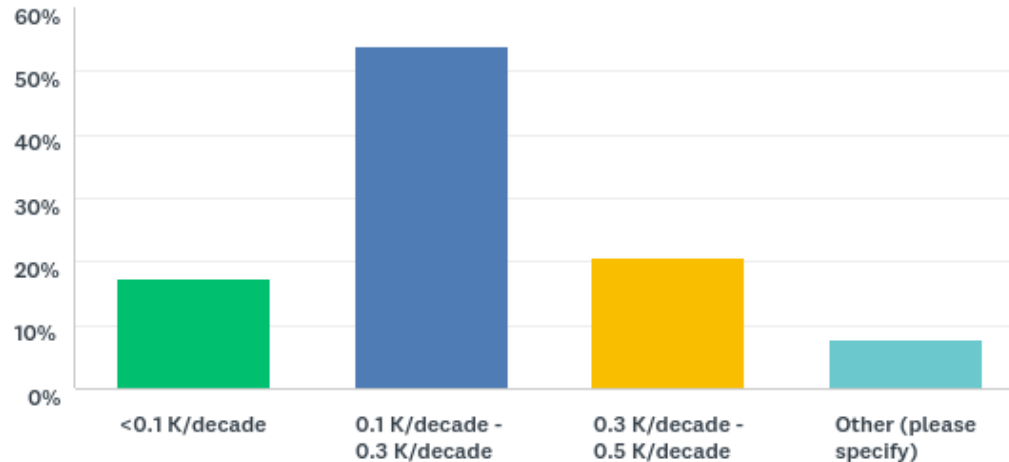
Survey results: Data Formats

Q9 What is your requirement for the maximum bias in measured brightness temperature you can tolerate?



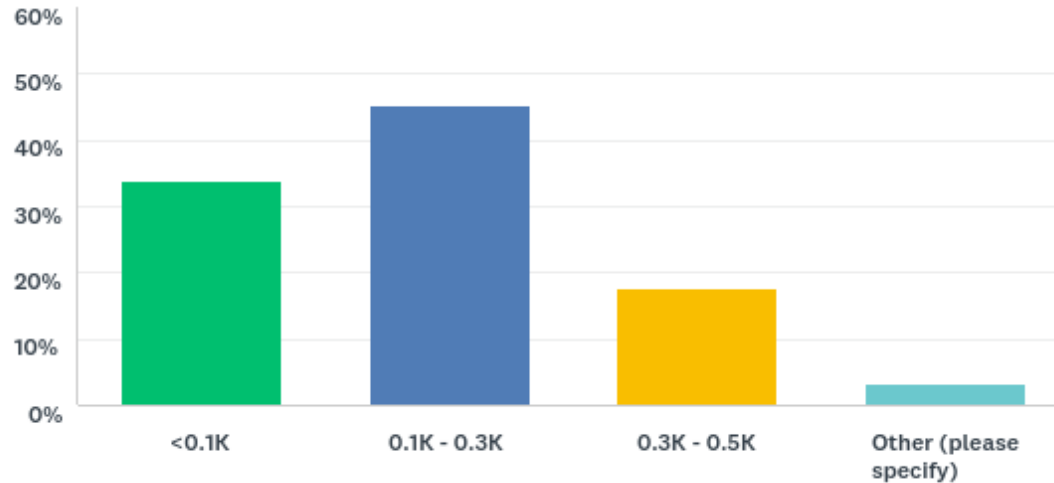
Survey results: Long term stability

Q10 What is your requirement for the long term stability of the measured radiance?



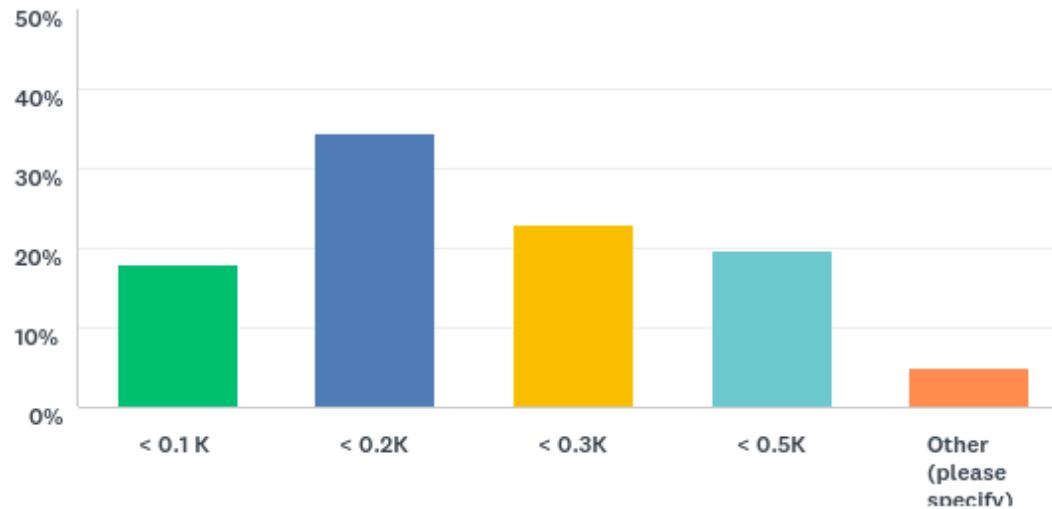
Survey results: Stability around orbit

Q11 What is your requirement for stability around an orbit?



Survey results: Random error NeDT

Q12 What is your requirement for random error (NeDT) at 280K ?





INTERVIEWS WITH EXPERTS



Interviews 1: Climate Model

[A.Bolcedo \(Hadley Centre\)](#): Validating climate model processes for clouds and radiation

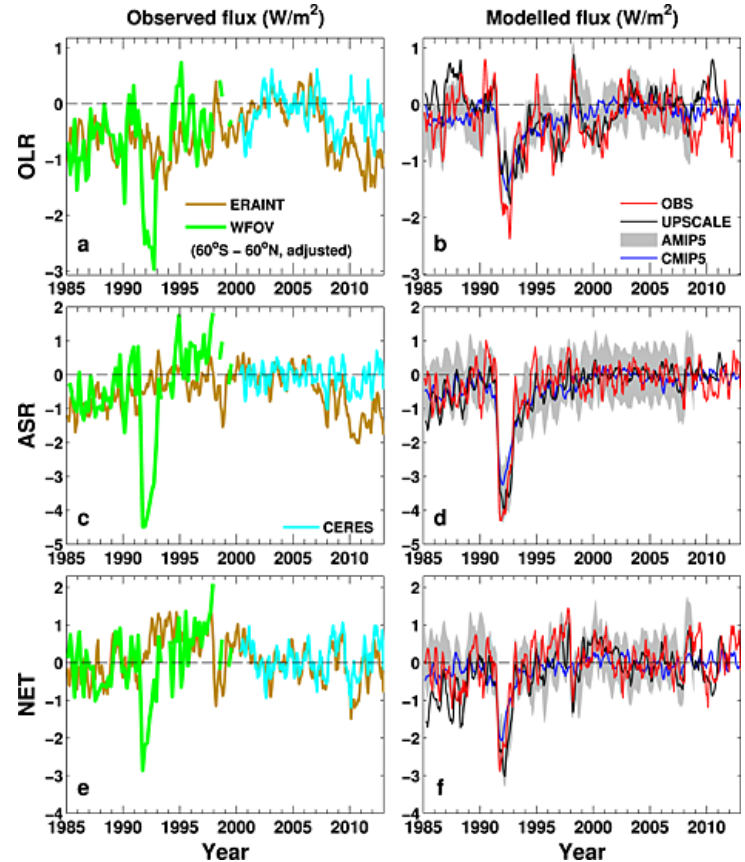
Example (i) is fixed anvil temperature hypothesis in a warming world. FORUM can monitor cirrus from tropical convection.

Example (ii) comparing broad-band radiative fluxes and the spectral bands. FORUM provides new spectral regions to compare in FIR.

Monitoring

- Long-term records allow evaluation of variability in models
- Example shows Earth radiation budget since 1985
- Provides another perspective on model performance
- Also need long time series to examine trends and extremes

Source: R.P. Allan et al (2014). Geophys. Res. Lett.





Interviews 2: Climate Model

[N. Butchard \(Hadley Centre\)](#): Stratospheric water vapour

Transfer of water vapour from the troposphere to the stratosphere needs better monitoring and operational NWP/Climate models and reanalyses show a wide spread in how this represented. Role of monsoon regions, dehydrated polar regions and methane oxidation need to be studied. Do transfers occur at high latitudes?

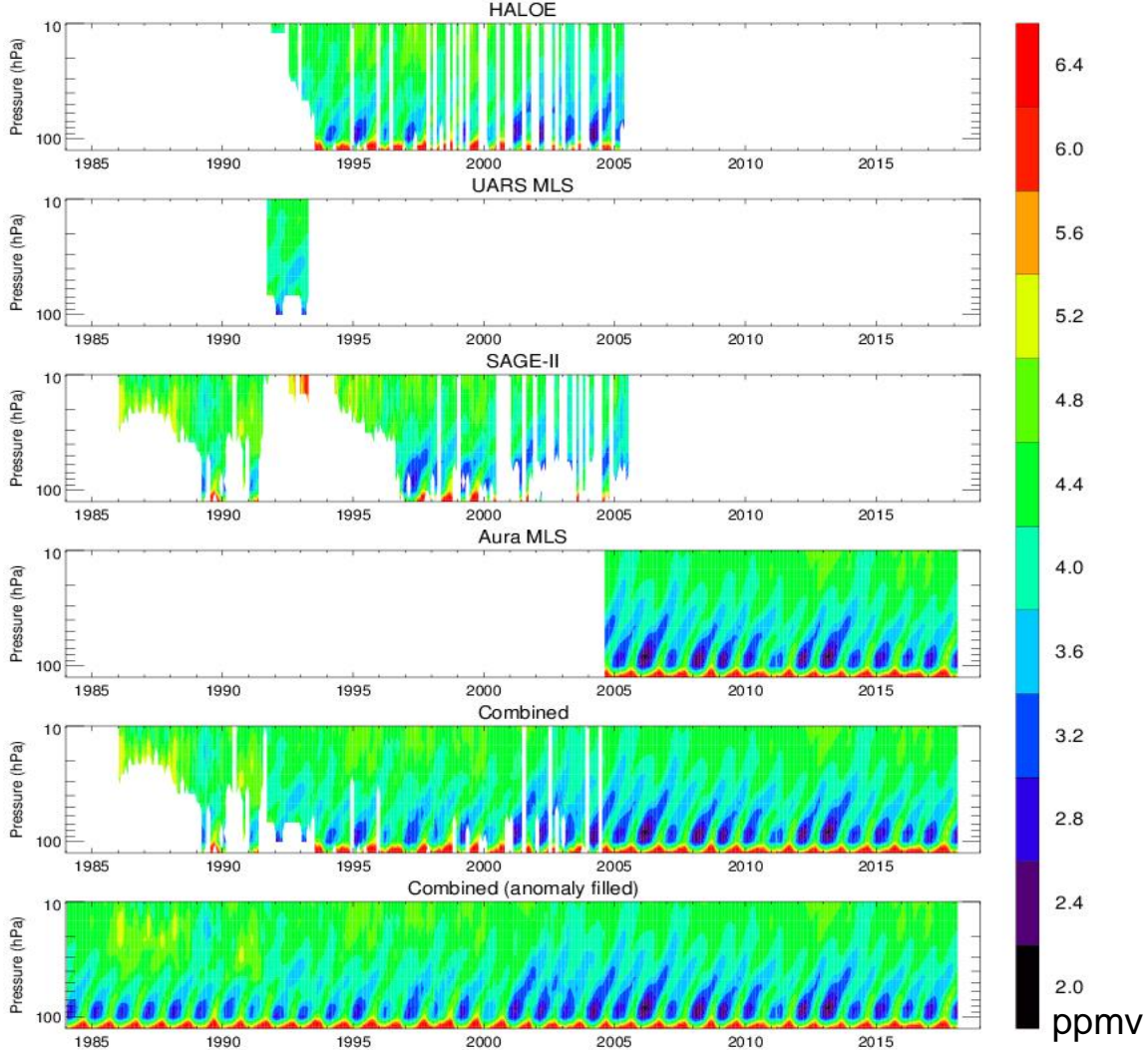
Spectral fingerprints important to monitor anomalies in stratospheric water vapour.



Met Office

SWOOSH dataset

Used by climate modellers showing “water vapour tape recorder”





Interviews 3: Cirrus cloud

A. Baran(Met Office): Cirrus cloud

The radiative properties of cirrus cloud are different at far IR wavelengths and more dependent on the mass of the ice crystal than the cross-section area (geometric optics limit). 20-30 micron is key spectral band for ice crystal scattering so should give more information than IASI-NG.

Note important to link to ICI as well as IASI-NG.



Met Office Spectral LW heating and scattering

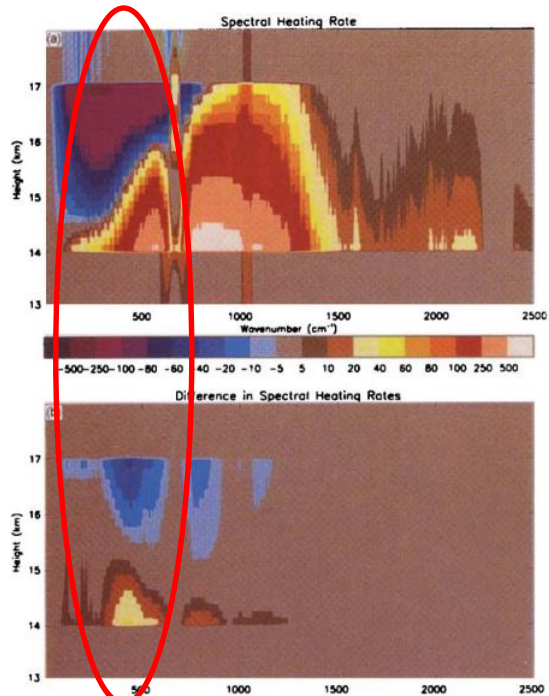


Figure 12. (a) The vertical and spectral variation of the long-wave heating rate for the tropical cloud considered in Fig. 11, and (b) the change in the heating rate arising from the introduction of scattering. The units on the colour scales are tenths of $1 \text{ mK}(\text{day cm}^{-1})^{-1}$.

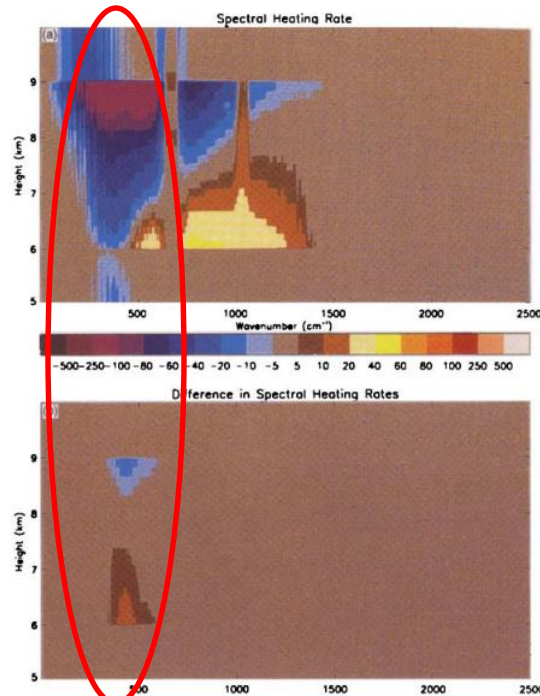


Figure 13. As Fig. 12, but for the sub-arctic winter cloud of Fig. 11.

The panels show the largest effect is around 400 cm^{-1} , where the contribution to OLR is 15% for the tropical case. Several reasons:

1. OLR peaks at 400 cm^{-1} rather than in the window, because of the low temp of the cloud top (195.6 K for the tropical cloud and 217.1 K for the sub-arctic winter cloud).
2. Water vapour absorption decreases steadily; with increasing wave number from the rotation band to the 1000 cm^{-1} window so at the low water vapour mixing ratios typical of cirrus levels there is a partial window between the rotation band and the main CO_2 band.
3. Scattering by cirrus has a maxima at about 400 cm^{-1}



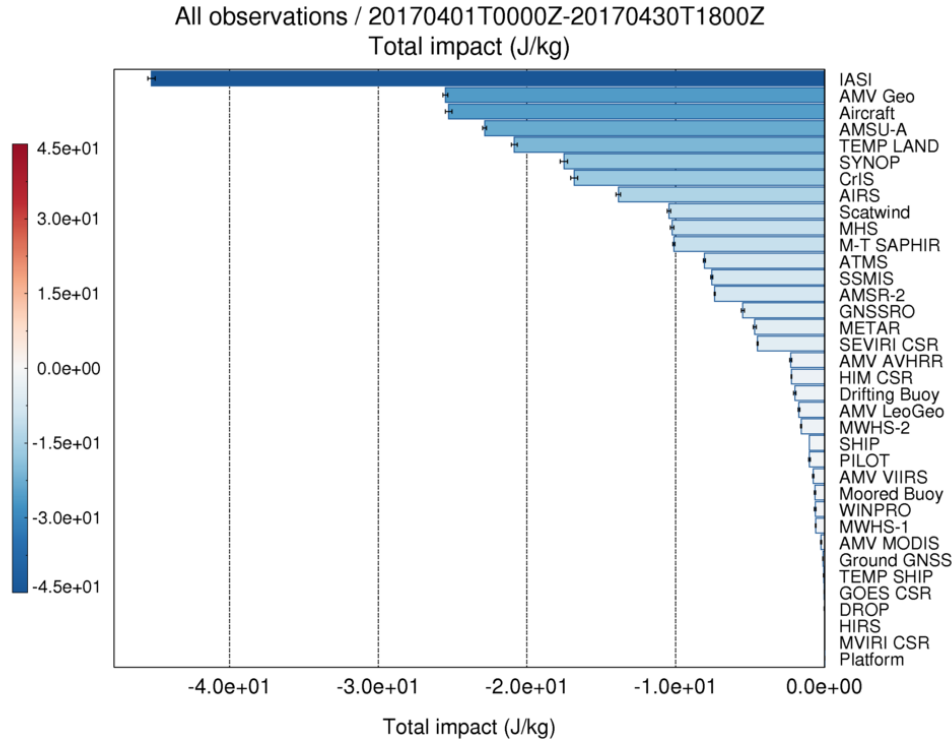
Met Office

Interviews 4: Spectroscopy

Claude Camy-Peyret (IPSL): Spectroscopy

- cross-comparison between IASI-NG and FORUM for the L1 radiometry
- monthly averages of FORUM L1 spectra after deciding for "categories" as I am doing for IASI (latitude bins, land/sea, homogeneous IFOVs, clear and possibly several types of fully overcast IFOVs) (hence my interest in the companion imager of FORUM)
- spectroscopy of H₂O line-by-line (line shape parameters) and checking their consistency
- comparisons of XCO₂ retrieved from FORUM (from the full 15 μm band) and XCO₂ retrieved from IASI-NG
- other species like HNO₃ and N₂O (with some very narrow Q branches in the FIR)

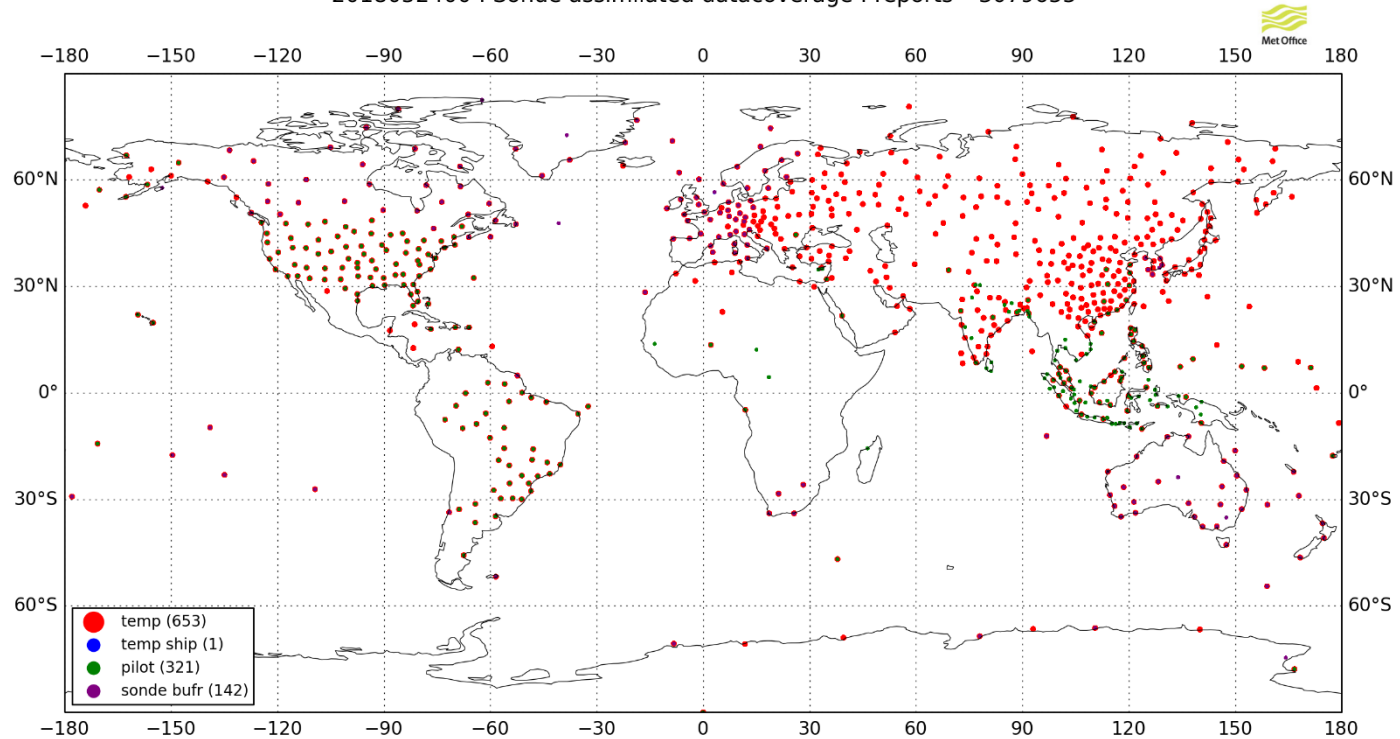
Impact of satellite data in global NWP



FSOI results showing impact of observations from different types of measurements for 24hr forecasts in global model

c.f. balloon observations used

2018052400 : Sonde assimilated datacoverage : reports =3079655



- Sonde coverage is more dense over **land** and **NH**
- Satellite data has largest impact over **sea** and in **SH** where conventional observations are relatively sparse

Applications for FORUM

GCOS ECV	Improve Spectroscopy	Prescribe Boundary Conditions	NWP Data Assimilation	Model Development and Validation	Climate Monitoring/ Attribution	Q/C in situ data
Atmospheric						
TOA radn budget				X	X	
Temp profile			x	x	X	
Water vapour profile	X		X	X	X	X
Cloud properties				X		
Carbon dioxide	X		x	x	X	
Methane	X		x	x	X	
Ozone	X		x	x	X	x
Other GHG	X			x	X	
Terrestrial						
LST (emissivity)		X			x	
Snow cover		x			x	



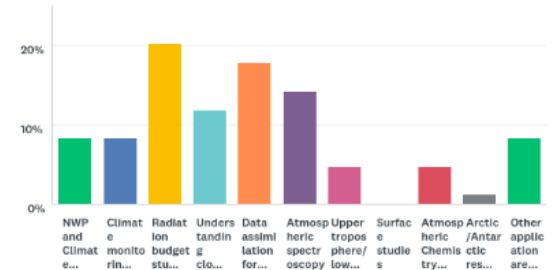
Summary of applications

Based on FORUM user survey:

1. Radiation Budget Studies
2. Data Assimilation
3. Atmospheric Spectroscopy
4. Understanding Cloud radiative processes
5. NWP and climate model validation
6. Climate monitoring

Please come and talk to me about your applications

Q1 What is your primary application area?



Any Questions?

