GPS occultation data products from the GRAS SAF

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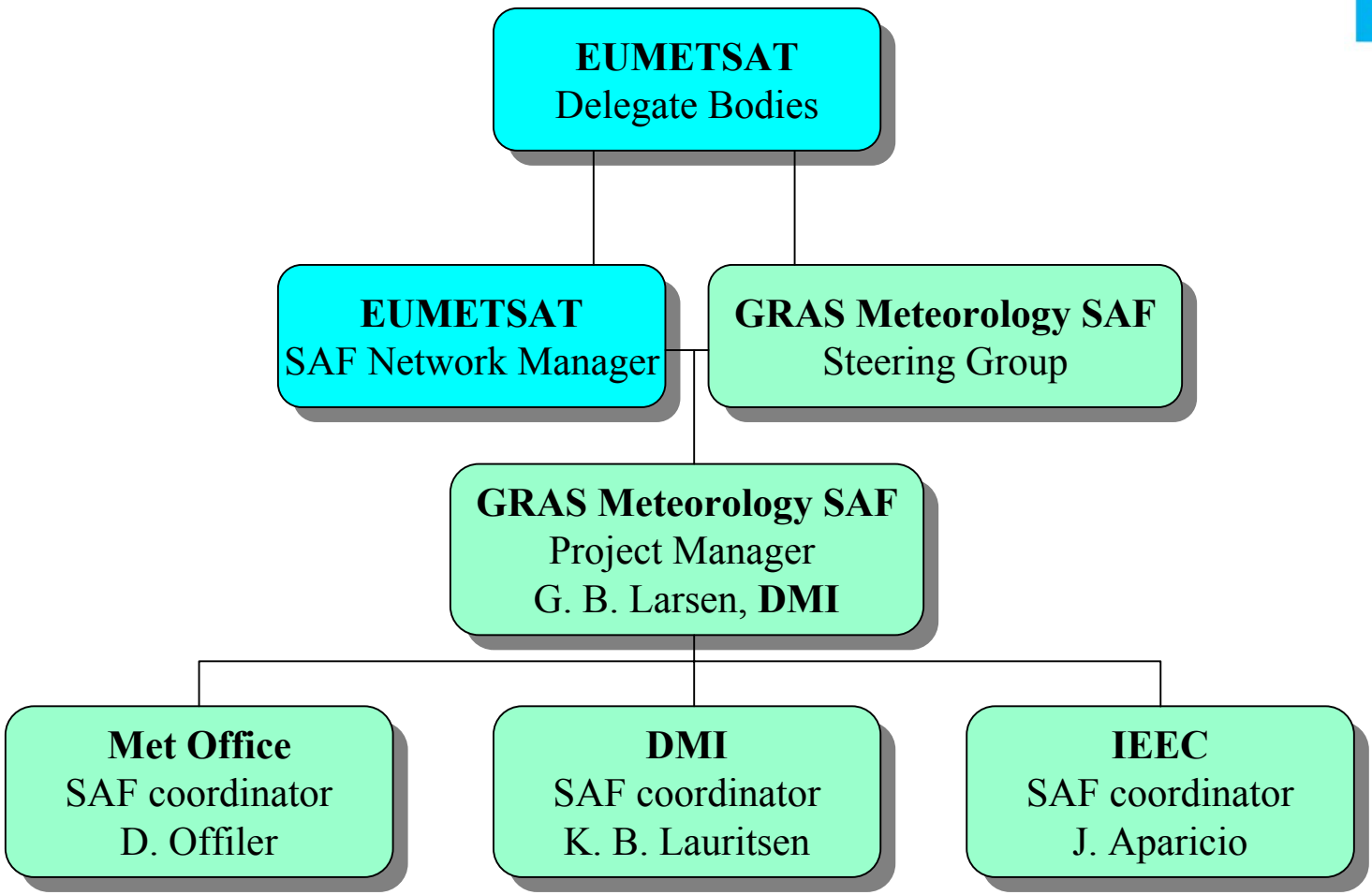
Outline of presentation

- GRAS SAF Project overview and plans
  - Organisation of the project
- Occultation measurement principle
  - Satellites and instrument
  - Distribution of measurements
  - Examples
- User requirements
- Data products
- Overview of the processing system
- Summary

Project overview and plans

- GRAS SAF project started in 1999
  - Operational facility for atmosphere products from GRAS instrument on Metop (Launch planned in late 2005)
  - 5 year developments
- Partner Institutes
  - Danish Meteorological Institute (Host institute)
  - Met Office, UK
  - IEEC, Spain
- Milestones
  - 2000 Requirements review (User and science requirements)
  - 2001 Requirements review (Design requirements)
  - 2003 Mid-Term review (Critical design review)
  - 2007 Operational products from GRAS SAF

GRAS SAF Organisation

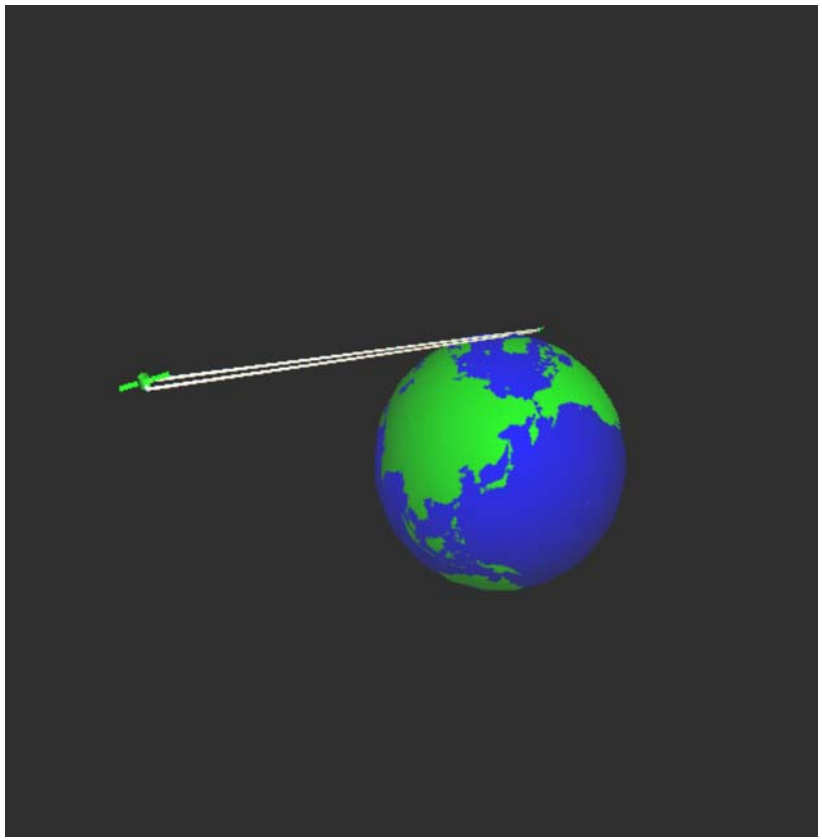


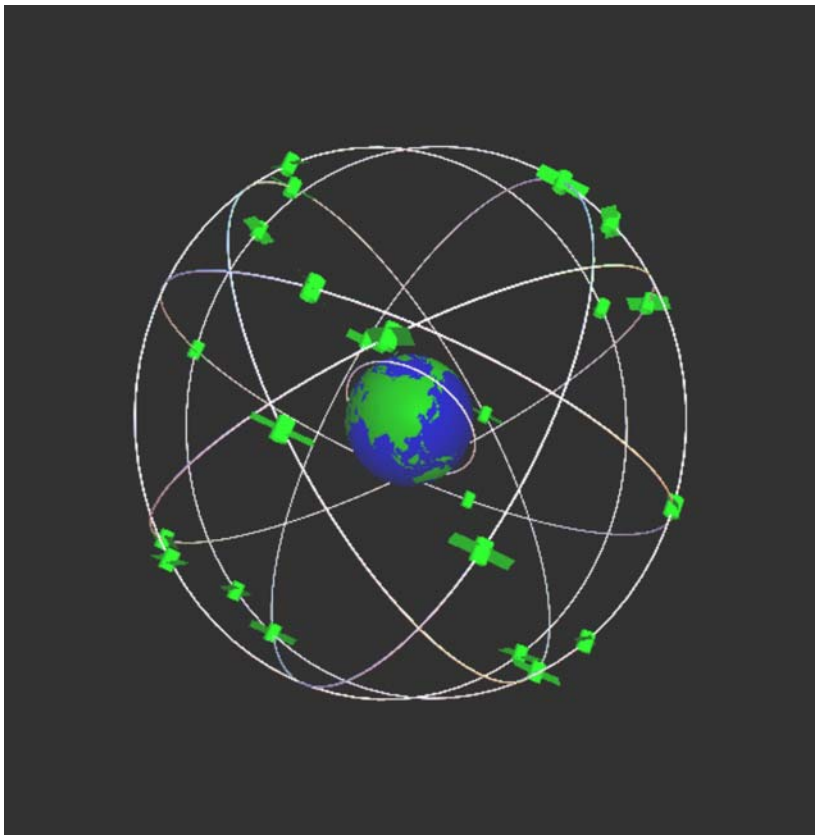
The principle of GPS occultations

GRAS SAF

EUMETSAT
DMI
IEEC
The Met.Office

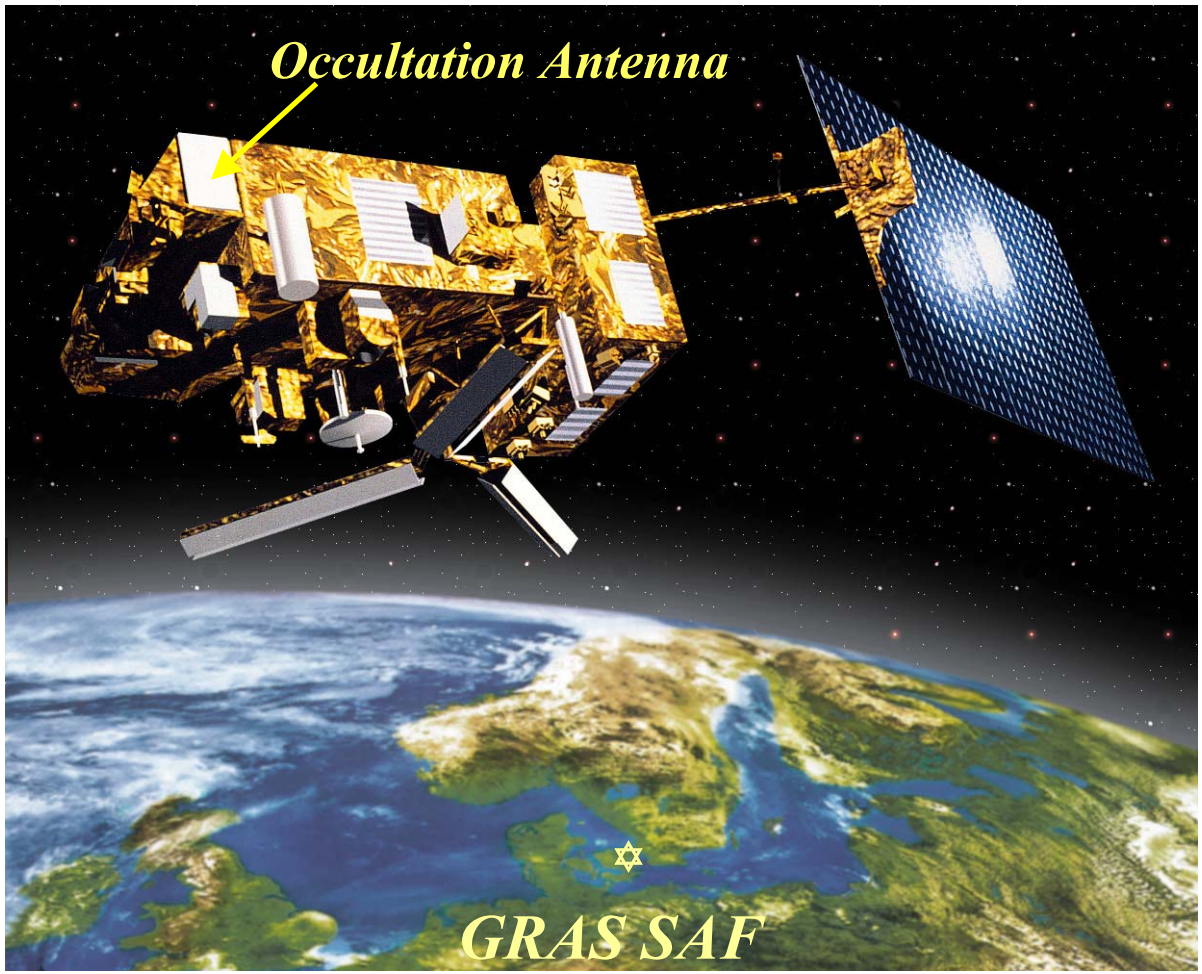
The occultation measurement



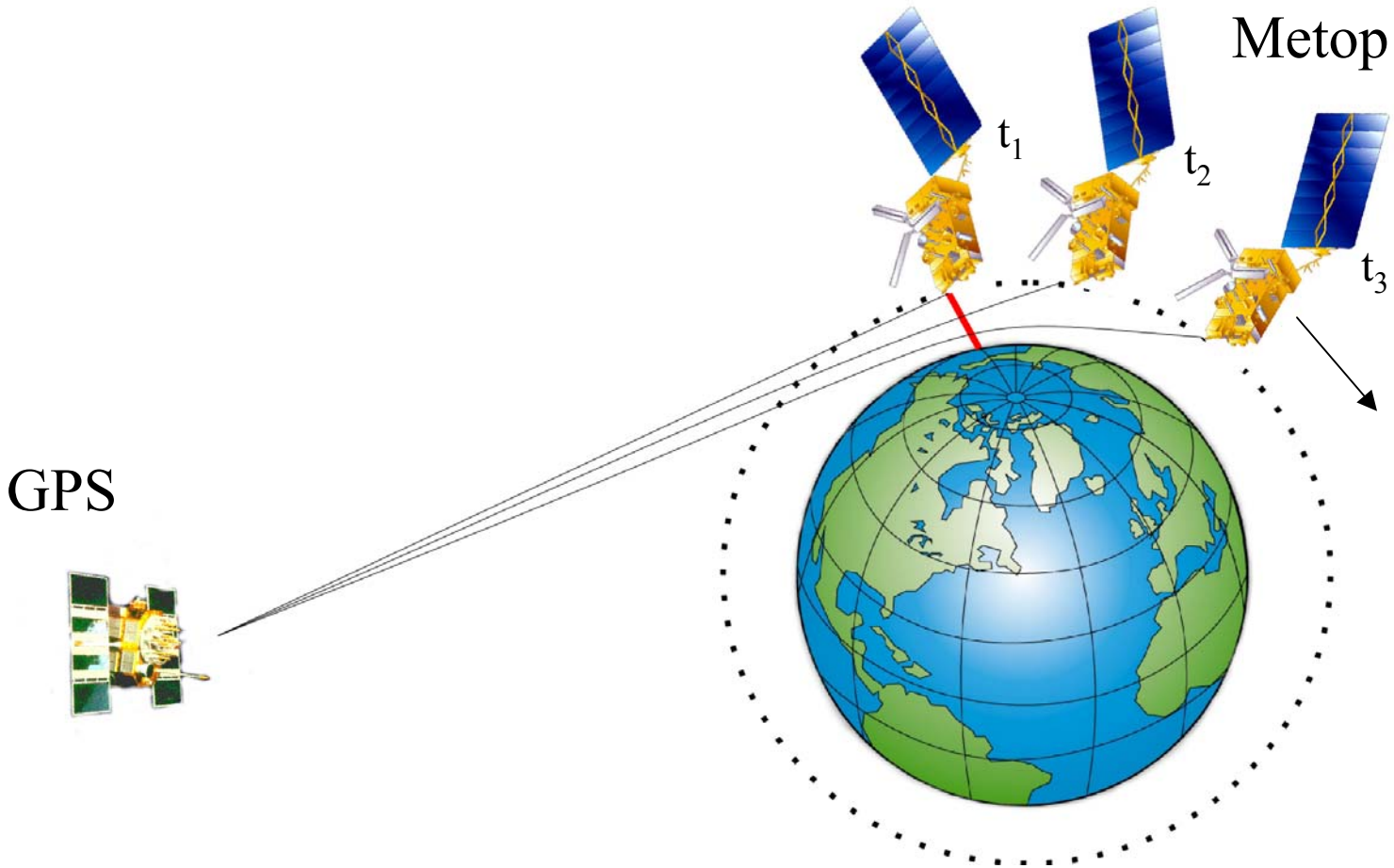


The GPS constellation

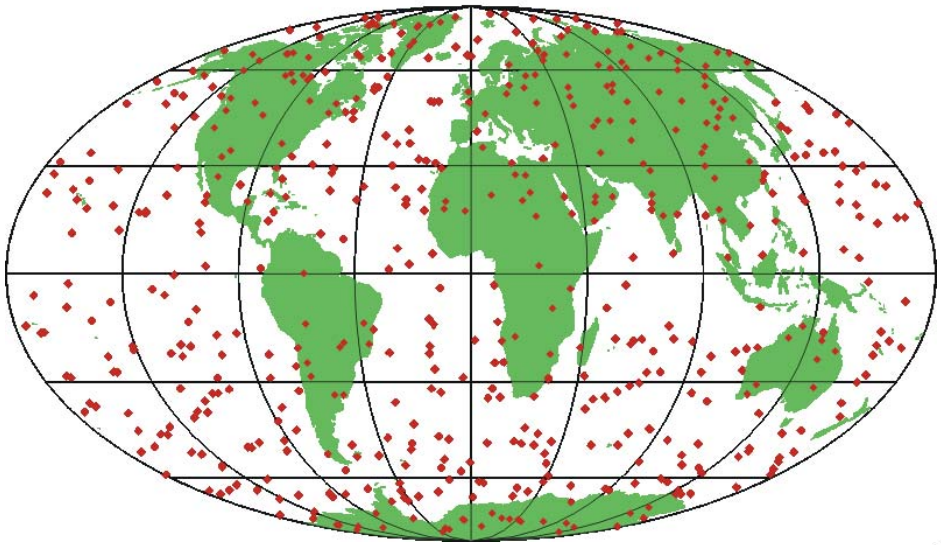
The GRAS instrument on Metop



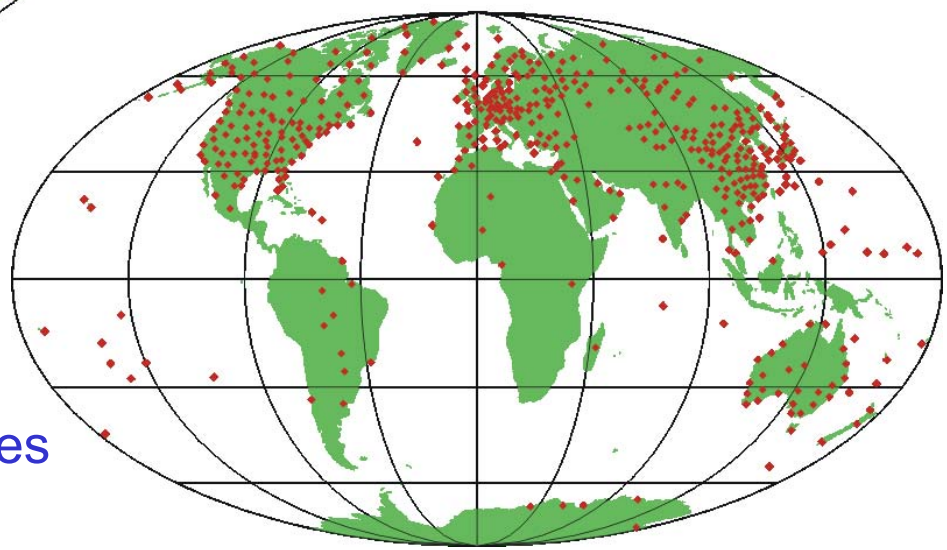
GRAS Atmosphere profiling



Distribution of GRAS SAF profiles

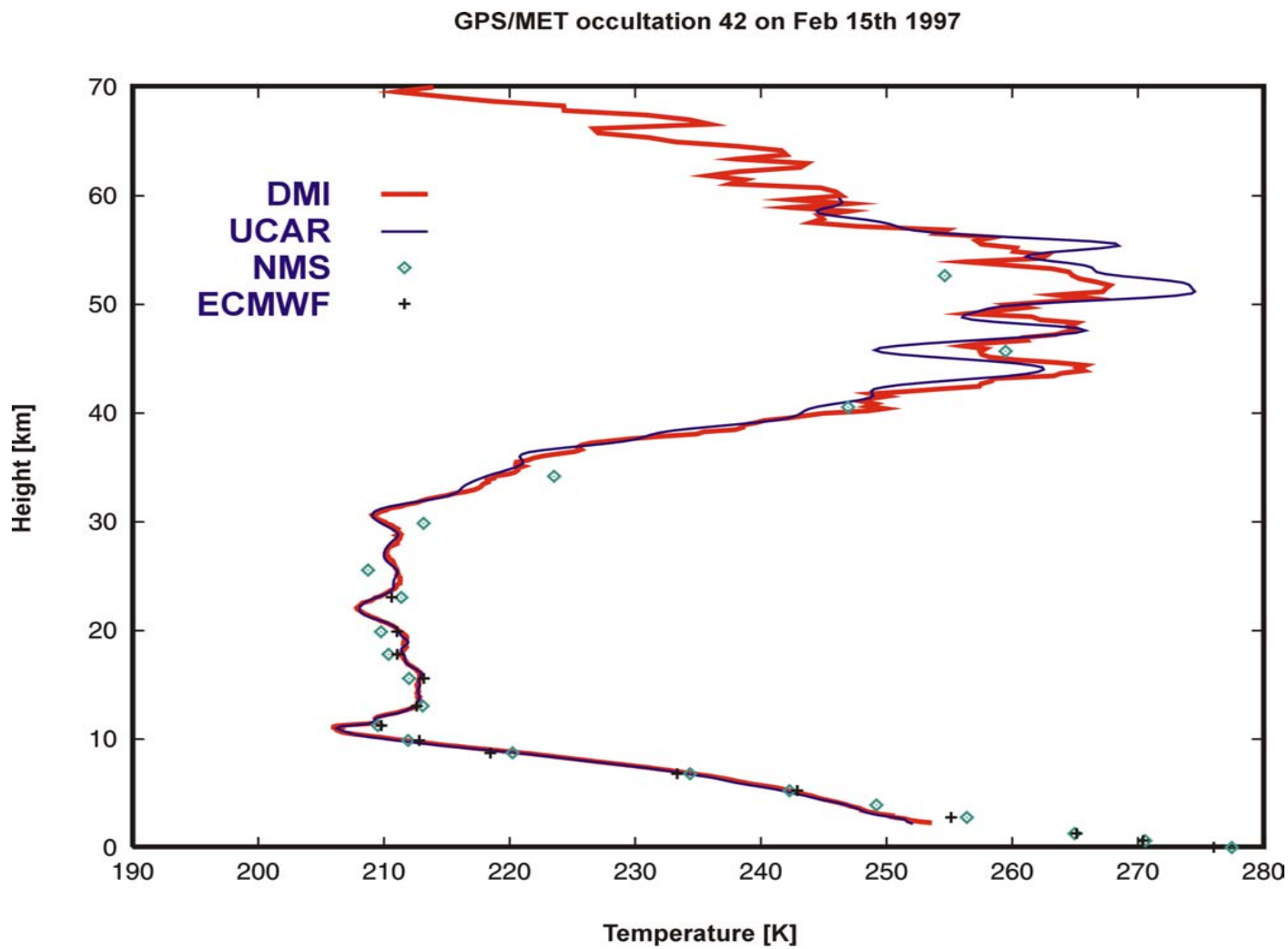


GRAS occultations during 24 hrs.
Approximately 600 atmosphere profiles distributed globally



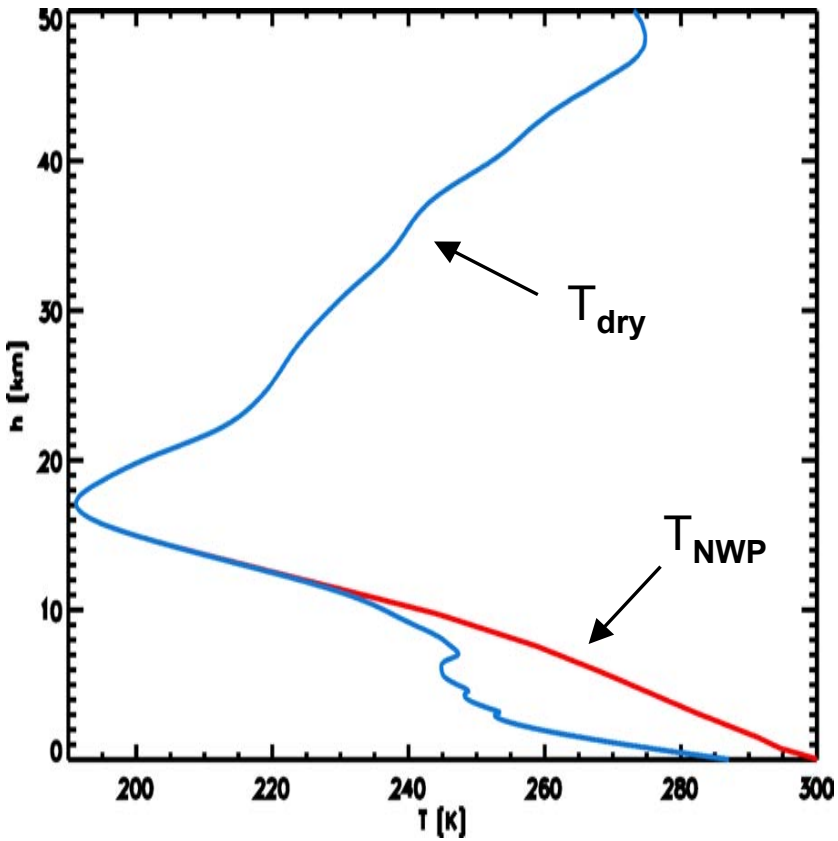
Distribution of NWP Radio sondes

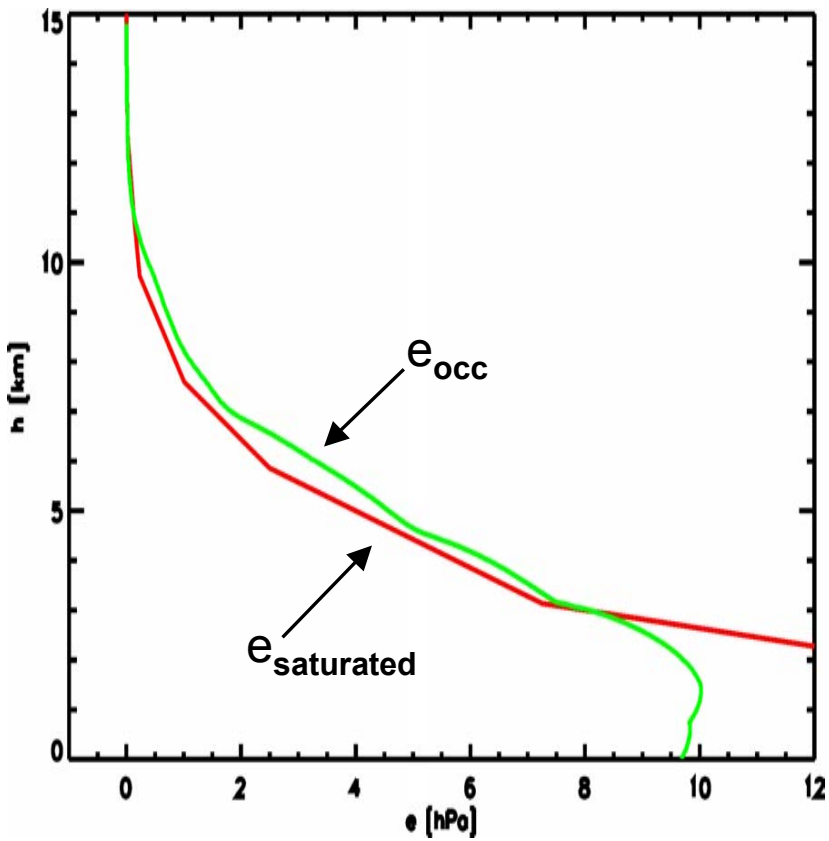
Retrieved Temperature Profile



Retrieved Water Vapour Profile

GPS/MET occultation Feb 9, 1997 at UT 16:15 lat: –14 lon: 141





Data products from the GRAS SAF

DMI, IEEC

- **Data products (Level 2)**
  - **Refractivity profiles**
  - **Temperature profiles**
  - **Pressure profiles**
  - **Water vapor profiles**
  - **Surface pressure**
  - **Geographical location**
  - **Bending angle (Offline, Level 1)**

Met Office

- **4DVAR Assimilation Software**
  - **Forward operators**
  - **Error covariance matrix**

Data products description

- Data products description document
  - Near real time data products
  - Offline data products
  - Error covariance products
  - Validation products
  - Software products (4DVAR assimilation)
- Description of the data products
- Supporting data (Level 1)

- User questionnaire
- User workshop

Temperature product

Quantity	Values		Remarks
Requirement	RTS-1060 OLS-1070		
Units	Kelvin (K)		
Domain	0–50 km (NRT) 0–80 km (Offline)		Surface to 1 hPa Surface to 0.01hPa
Range	180–350 K		
Precision	0.1 K		
Vertical sampling	0.5 km		depends on background pressure levels
Accuracy 0–5 km 5–30 km 30–40 km 40–50 km 50–80 km	NRT 2–3 K 1 K 1–5 K 5–10 K N/A	Offline 2 K <1 K 1–3 K 5–10K 5–10 K	'Dry' temperatures are unlikely to meet accuracy requirements at the lowest levels except in regions of very low humidity.

Humidity product

Quantity	Values	Remarks
Requirement	RTS-1070 OLS-1080	
Units	$kg.kg^{-1}$	Specific humidity
Domain	0–15 km	Surface to 100 hPa
Range	0–50 $g.kg^{-1}$	
Precision	0.001 $g.kg^{-1}$	
Vertical sampling	0.5 km	depends on background pressure levels
Accuracy	10% or 0.2 $g.kg^{-1}$ (NRT) 5% or 0.1 $g.kg^{-1}$ (Offline)	whichever is greatest

Generic User requirements

		Temperature	Specific Humidity	Surface Pressure
Horizontal Domain		Global	Global	Global
Horizontal Resolution		50–500 km	50–250 km	50–250km
Vertical Domain		Sfc to 1 hPa	Sfc to 100 hPa	Sfc (msl)
Vertical Resolution	**LT**	0.3–3 km	0.4–2 km	–
	HT	1–3 km	1–3 km	–
	LS	1–3 km	–	–
	HS	1–3 km	–	–
Time Resolution		1–12 hrs	1–12 hrs	1–12hrs
RMS Accuracy	**LT**	0.5–3 K	0.25–1 g/kg	0.5–2 hPa
	HT	0.5–3 K	0.025–0.1 g/kg	–
	LS	0.5–3 K	–	–
	HS	0.5–5 K	–	–
Timeliness		1–4 hrs	1–4 hrs	1–4hrs

Generic User Requirements for global NWP
(Source: WMO TD No. 913, SAT-21, 28/9/1998)

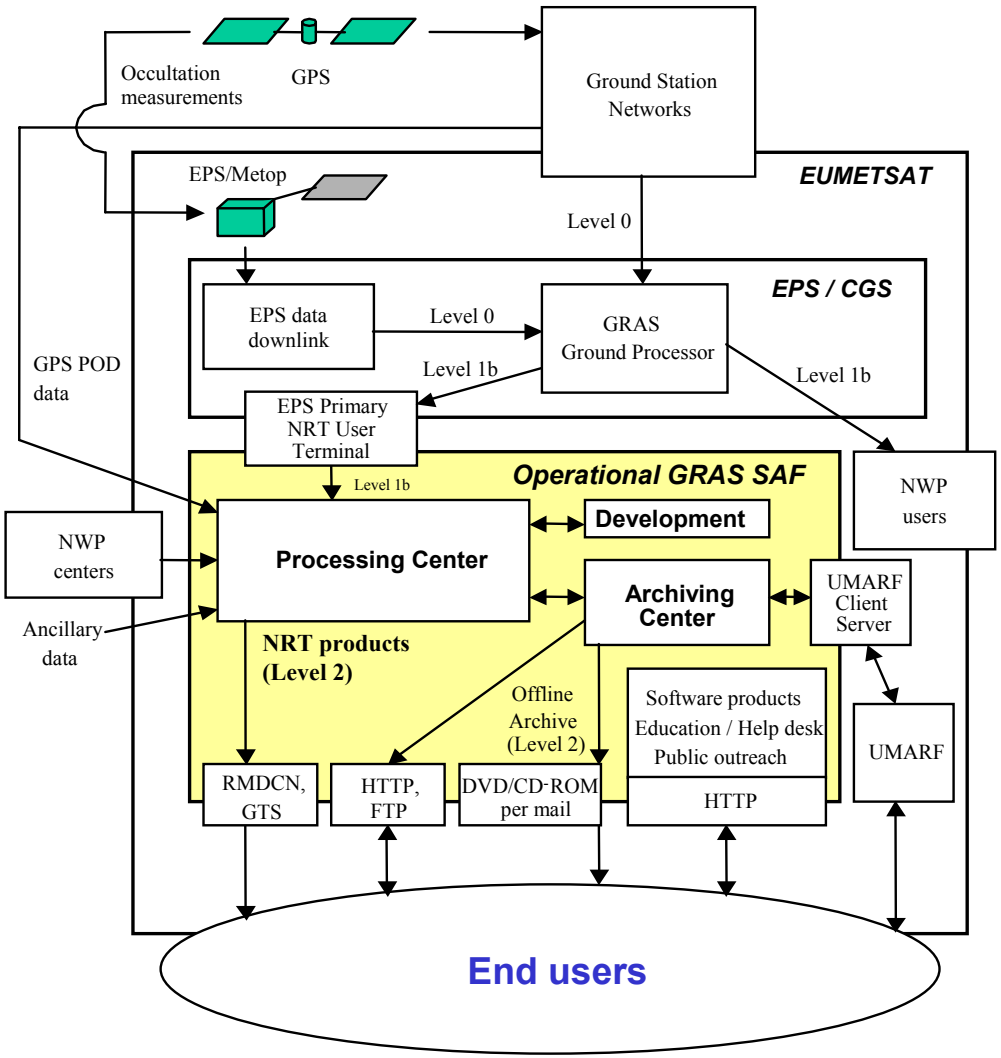
GRAS/Metop User Requirements

		Temperature	Specific Humidity	Surface Pressure	Refractivity	Bending Angle
Horizontal Domain		Global	Global	Global	Global	Global
Horizontal Sampling		100–2000km	100 – 2000km	100–2000km	100–2000km	100–2000km
Vertical Domain		Sfc–1 hPa	Sfc–100 hPa	Sfc (msl)	Sfc–1 hPa	Sfc–80 km
Vertical Sampling	**LT**	0.3–3km	0.4–2 km	–	0.3–3 km	2–5 Hz
	HT	1–3 km	1–3 km	–	1–3 km	
	LS	1–3 km	–	–	1–3 km	
	HS	1–3 km	–	–	1–3 km	
Time Window		1–12 hrs	1–12 hrs	1–12 hrs	1–12 hrs	1–12 hrs
RMS Accuracy	**LT**	0.5–3 K	0.25–1 g/kg	0.5–2 hPa	0.1–0.5%	1 μrad or 0.4%
	HT	0.5–3 K	0.05–0.2g/kg	–	0.1–0.2%	
	LS	0.5–3 K	–	–	0.1–0.2%	
	HS	0.5–5 K	–	–	0.2–2%	
Timeliness		1-3 hrs	1–3 hrs	1–3 hrs	1–3 hrs	1–3 hrs

GRAS Metop User Requirements
Climate Monitoring

		Temperature	Specific Humidity
Horizontal Domain		Global	Global
Horizontal Sampling		100–1000 km	100–1000 km
Vertical Domain		Surface to 1 hPa	Surface to 1 hPa
Vertical Resolution	**LT**	0.3–3 km	0.5–2 km
	HT	1–3 km	0.5–2 km
	LS	1–3 km	0.5–2 km
	HS	5–10 km	1–3 km
Time Resolution		3–24 hrs	3–24 hrs
RMS Accuracy	**LT**	0.5–3 K	0.25–1 g/kg
	HT	0.5–3 K	0.05–0.2 g/kg
	LS	0.5–3 K	–
	HS	1–3K	–
Timeliness		30–60 days	30–60 days
Time Domain		> 10 years	> 10 years
Long-term Stability		< 0.1 K/decade	< 2% RH/decade
No. of profiles/ grid box/month		> 10	> 10

GRAS SAF Data Flow Model



Advantages of GPS Atmosphere Profiling

- **Absolute measurement**
  - The basics of the observations are a measurement of time.
- **Global coverage**
  - The geometry of the observation leads for one satellite to evenly distributed data on a 24-hour interval. Observations over seas and oceans (covering 70% of the Earth) minimize the major error source concerning accuracy of weather forecast and climate models.
- **High vertical resolution**
  - The vertical resolution limited by the Fresnel zone of the observation leads to information of atmosphere phenomena with scale sizes less than 1 km.
- **Insensitive to clouds and precipitation**
  - The wavelengths applied makes the measurement transparent to clouds and rain hampering other space techniques.

Summary

- GRAS SAF processing system
- Data products
  - Vertical profiles of temperature and humidity
  - Near real time dissemination, requirement 3 hrs
  - Distributed globally
- Software product for 4DVAR assimilation
- User requirements
- Expected number of atmospheric profiles per day 600
- Available to users from beginning of 2007

www.dmi.dk/pub/GRASSAF