GPS occultation data products from the GRAS SAF

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Introduction

The EUMETSAT network of Satellite Application Facilities (SAFs) will, together with the EUMETSAT central facilities, constitute the future EUMETSAT Application Ground Segments (AGS) for the MSG and EPS/Metop satellites. The developments of the Global Navigation Satellite System (GNSS) Receiver for Atmospheric Sounding (GRAS) Meteorology SAF (hereafter the GRAS SAF) started in 1999 with participation from the Danish Meteorological Institute (DMI), IEEC (Spain), and Met Office (UK). The host institute is the DMI and this will also be the physical location of the operational GRAS SAF data facility. The GRAS SAF will receive raw and preprocessed GPS radio occultation data from the GRAS instrument onboard the Metop satellite, process these into vertical height profiles of refractivity, temperature, pressure, and humidity, and distribute these products continuously in near real time to numerical weather prediction and climate monitoring users. A second objective of the GRAS SAF is to supply software for 4DVAR-assimilation of radio occultation data into numerical weather prediction models. The GRAS SAF will enter into the operational phase and deliver products in the last half of 2006 given the current launch plans for Metop.

The basic principle in the GRAS SAF project is the radio occultation method where a receiver onboard a low-orbiting satellite tracks GNSS signals as the transmitting satellite sets or rises behind the Earth (occultation). Due to refraction in the ionosphere and the neutral atmosphere the signal is delayed and its path bent, enabling calculation of the refractivity and subsequently temperature, pressure and humidity as a function of height. The main users of the GRAS SAF products will be meteorologists doing data assimilation (Near-Real Time Products, delivered less than three hours after measurement) and users from the climate research and atmospheric science communities (improved Offline Products, delivered less than 30 days after measurement) needing comprehensive global maps of temperature, pressure, and humidity. This poster presents the design of the operational GRAS SAF data processing facility and we present initial results of GRAS SAF data processing based on recent GPS occultations measured by the CHAMP satellite.

GRAS SAF Project Team

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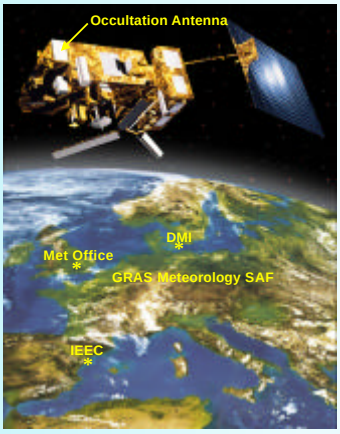
User requirements

GRAS/Metop user requirements for Operational Meteorology (upper table) and for Climate Monitoring (lower table). These tables apply for a single receiver with one velocity and one anti-velocity direction occultation antenna. The near-real-time requirement on the GRAS SAF atmosphere products, level 2, is 3 hours from the measurement. The requirement on the input level 1b is 2 hours and 15 minutes. The climate products have a timeliness requirement of 30 days.

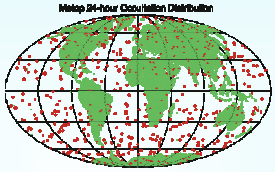
		Temperature	Specific Humidity	Surface Pressure	Refractivity	Bending Angle
Horizontal Domain		Global	Global	Global	Global	Global
Horizontal Sampling		100–2000km	100 – 2000km	100–2000km	100–2000km	100–2000km
Vertical Domain		Sfc–1 hPa	Sfc–100 hPa	Sfc (msl)	Sfc–1 hPa	Sfc–80 km
Vertical Sampling	LT	0.3–3km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

		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



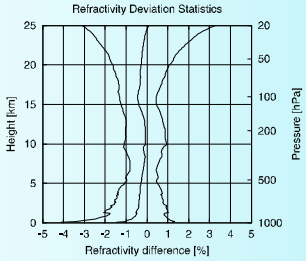
Metop Satellite

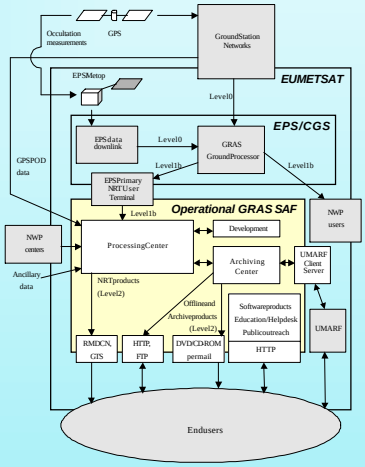
Artistic view of the EPS/Metop satellite. The arrow indicates the GRAS occultation antenna (velocity direction). There is one more occultation antenna on the other side and one navigation antenna on top of the satellite. The locations of the three partner institutes, DMI, The Met. Office and IEEC are indicated.



Global Distribution

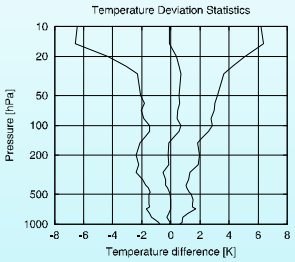
The expected 24 hrs distribution of GRAS SAF profiles measured by the Metop satellite. This plot is based on a simulation using 24 GPS satellites and shows both setting and rising occultations. The distribution is global on a 24 hrs basis, on shorter timescales the measurements are distributed in a scattered pattern following the orbit of the Metop satellite.





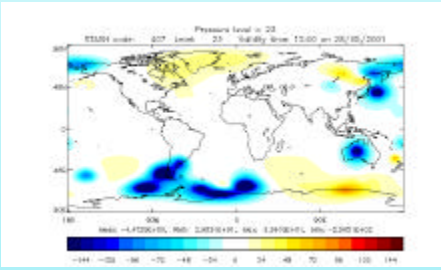
GRAS Meteorology SAF data flow

The GRAS SAF is part of the overall EUMETSAT ground segment. Data down-link will occur one time for each orbit at a high latitude site. Then the data is sent to the central processing site in Darmstadt to produce the level 1b data. This enters as input to the GRAS SAF processing center at DMI to produce the Atmosphere Products (level 2 data) which are subsequently disseminated to the end users.



Initial Results

We have processed approximately 2½ weeks of CHAMP occultation data from the period 6-23 January 2002 (both days included). The total number of measured profiles by CHAMP during that period is 2368. The number of profiles processed to bending angle, refractivity, and dry temperature is 1810 (= 76%). The plots show statistics for refractivity and temperature deviations as a function of height. The solid curve shows the difference between the retreived and ECMWF field whereas the other two curves represent +/- the standard deviation.



Impact on numerical weather prediction

The GRAS SAF will deliver software modules to enable 3D/4DVAR data assimilation of the retrieved bending angle or refractivity profiles. This figure shows the 3D increments in height at a fixed pressure level corresponding to approximately 10 km in height above surface. (Initial results from a forecast impact trail using CHAMP data and the 3D-Var assimilation technique are presented in the contributions by S.B. Healy et al. in session AS6 and G4).