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NETWORK OF EUMETSAT SATELLITE APPLICATION FACILITIES

The Network of approved Satellite Application Facilities (SAF) in under development, with Pilot SAFs *on "Nowcasting and Very Short Range Forecasting*" and "*Ocean and Sea Ice*" expected to start the Initial Operations Phase in 2002. This paper describes the status of the 7 active Projects and provides the updated list of planned products.

NETWORK OF EUMETSAT SATELLITE APPLICATION FACILITIES

1 INTRODUCTION

Since CGMS-XXVIII, SAF activities have further evolved. The purpose of this paper is to report on the status of the approved network of SAF projects and to present the current list of the SAF products.

2 THE SAF NETWORK DEVELOPMENT CONTEXT

In November 1992 EUMETSAT adopted the concept of a distributed Applications Ground Segment, including the central Meteorological Products Extraction Facilities (MPEF) and the Unified Meteorological Archive and Retrieval Facility (U-MARF), both located in Darmstadt, Germany, and a network of elements known as Satellite Applications Facilities (SAF). The MPEF produces an agreed set of basic meteorological products, while the Satellite Applications Facilities (SAF) are more specialised development and processing centres, which, based on specific expertise in Member States, will deliver additional meteorological and geophysical products and related services. These services form an integral part of the overall EUMETSAT service.

The SAFs are developed by consortia of organisations from the Member States, based in National Meteorological Services or other agreed entities, and responsible for research, development and operational activities. EUMETSAT contributes up to 50% of the development cost of each SAF, and the EUMETSAT Secretariat coordinates and manages the SAF Network level activities and all activities necessary to integrate the SAFs and the central services into coherent end-to-end systems providing the operational services expected by the end users. It provides also managerial, technical and scientific support to the SAFs, including the organisation of reviews, interface and planning meetings. A SAF Network Management Scheme has been established and agreed for this purpose.

Seven SAFs are currently under development and address the following topics:

- Support to Nowcasting and Very Short Range Forecasting (NWC SAF);
- Ocean and Sea Ice (OSI SAF);
- Ozone Monitoring (O3M SAF);
- Climate Monitoring (CLM SAF);
- Numerical Weather Prediction (NWP SAF);
- GRAS Meteorology (GRM SAF);
- Land Surface Analysis (LSA SAF).

SAFs will use data from Meteosat, MSG and EPS and, in some cases, data from non-EUMETSAT missions. Until such data become available, information from current satellites will be used for development.

The partnership of each SAF project is presented in the following table.

SAF on	Date of kick-off	Hosting Institute	Consortium members
Support to Nowcasting & VSRF	February 1997	INM (Spain)	NMSs of France, Austria and Sweden.
Ocean & Sea Ice	April 1997	Météo France (France)	NMSs of The Netherlands, Denmark, Norway and Sweden; Institute Français de Recherche pour l'Exploitation de la Mer (France).
Ozone Monitoring	October 1997	FMI (Finland)	NMSs of The Netherlands, Belgium, Denmark, Greece, Germany and France; Deutsches Zentrum für Luft- und Raumfahrt (Germany), University of Thessaloniki (Greece).
Climate Monitoring	Dec. 1998	DWD (Germany)	NMSs of The Netherlands, Belgium, Finland and Sweden; Bundesamt für Seeschiffahrt und Hydrographie (Germany).
Numerical Weather Prediction	Feb. 1999	UKMO (UK)	NMSs of The Netherlands and France; ECMWF.
GRAS Meteorology	April 1999	DMI (Denmark)	NMS of United Kingdom; Institut d'Estudis Espacials de Catalunya (Spain).
Land Surface Analysis	Sep. 1999	IM (Portugal)	NMSs of Belgium, France and Sweden; Inst. Of Meteorology & Climate Research (Germany), University of Bonn (Germany), Federal Inst. Of Hydrology (Germany), University of the Aegean (Greece), Inst. of Agrometeorology & Environmental Analysis Applied in Agriculture (Italy), Applied Meteorology Foundation (Italy), Inst. For Applied Science & Technology (Portugal), University of Evora (Portugal), University of Valencia (Spain).

Table 1 – SAF Projects Partnership

The overall status of the SAF Projects development is presented in the following diagram, where the major achieved milestones, ongoing and planned reviews are highlighted.

The Review Logic includes the following milestones for the initial phases of the development life cycle:

- **RADR**, Requirements and Architectural Design Review;
- **RAPR**, Requirements and Planning Review (for NWP only, in place of RADR);
- **MTR**, Mid Term Review, as a critical design milestone for all SAFs;
- **IRR**, Integration Readiness Review;
- **IVVRR**, Integration, Verification and Validation Results Review (IVVRR);
- **ORR**, Operational Readiness Review (ORR), formally closing the development life cycles activities.

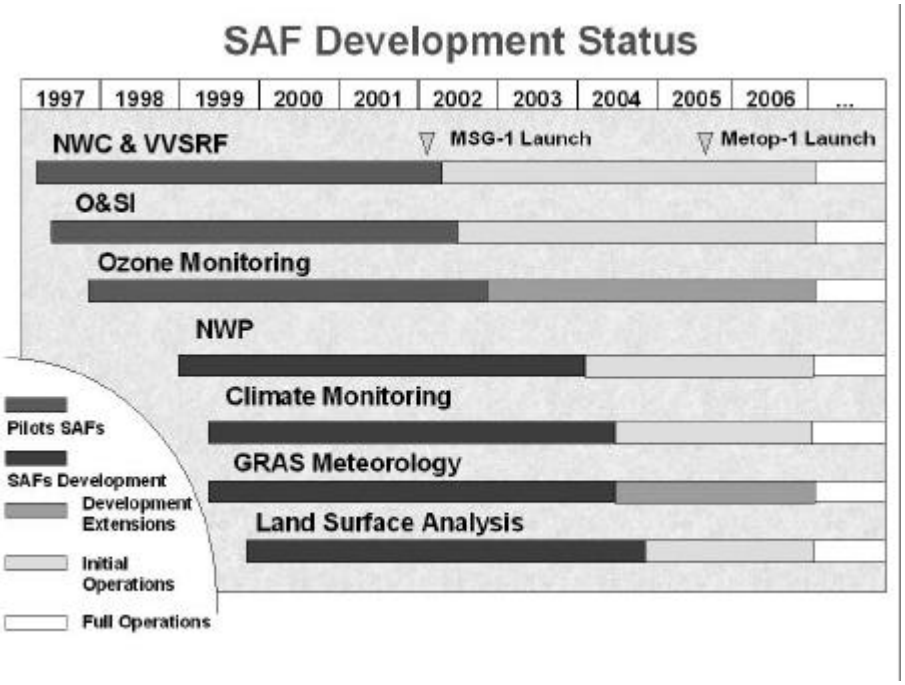

Figure 1 - SAF Projects Overall Schedule

	RADR (RAPR)	MTR	IRR	IVVRR	ORR
NWC	April 1998	April 2000	2001	2001	2002
OSI	March 1999	February 2001	2001	2001/2	2002
O3M	January 1999	January 2001			
CLM	January 2000	End 2001			
NWP	May 2000	Early 2002			
GRM	May 2001	End 2002			
LSA	June 2001	End 2002			

Figure 2 - Achieved Milestones and ongoing Reviews (August 2001 Status)

In consideration of the phasing needs with the MSG and EPS commissioning, the **NWC SAF** and the **OSI SAF** will enter an **Initial Operational Phase** (IOP), which will be concluded with the validation of the EPS related products, following the EPS METOP-1 commissioning. During the IOP, while MSG products will be put into operations after their validation using the real data provided by the MSG-1 instruments, the development for the EPS related products would be finalised. Continuous research and development will take place during IOP to sustain the needs for product improvements and innovation. The Climate Monitoring SAF also plans to start Initial Operations in 2004, at conclusions of the 5-year development phase. The NWP SAF already started preliminary operations, with distribution to selected beta users of the NWP SAF Software libraries. The LSA SAF started its development in late 1999, with plans to consider initial operations for MSG products by the end of 2004. The GRAS Meteorology and Ozone Monitoring SAFs will extend their initial development phase up to the completion of the validation of their EPS related products.

For all SAFs, the full **Operational Phase** will:

- Put into operations the accepted SAF Products and Services;
- Maintain these products;
- Improve the Products, based on the results of the continuous research and development effort as well as on the users feedback.

3 THE SAF PRODUCTS

The current list of SAF targeted products are presented in the set of tables included at the end of this paper. This list is continuously updated to reflect the progress of SAF developments and algorithms prototyping.

4 TOWARDS SAF OPERATIONS

The EUMETSAT Council is expected to decide on the optimum framework for funding SAF operations by the end of 2001.

5 CONCLUSIONS

The SAF Network development proceeds in line with plans for all approved SAF Projects, with the two pilots SAF (NWC and OSI) planned to enter their Initial Operations Phase already in 2002. The IOP will give a major opportunity for users to initiate their activities based on SAF Products and Services. Lessons learnt would generate benefits for the validation of all other SAF Products, using real satellite data, and would support optimisation of the Operational Phase concept and framework.

Further information on the objectives and status of the SAF Network is available at the following Web address: http://www.eumetsat.de/saf/ .

Targeted SAF Product Lists

Nowcasting SAF Product List
Part 1: Products based on SEVIRI data

Product Name	Characteristics	Coverage Area	Resolution	Frequency	Timeliness
Cloud Mask	Information on the presence of clouds	Rectangular area (in satellite projection) to be selected by the user	SEVIRI IR Pixel resolution	15 min	1 min*
Cloud Type (including fog)	Major cloud types, fractional clouds, semi-transparency, fog & stratus identification, snow or sea-ice occurrence				15 min*
Cloud Top Temperature & Height	Vertical extension of clouds, cloud top temperature				15 min*
Precipitating Clouds	Identification of clouds likely to produce precipitation within predefined precipitation intensity classes				15 min*
Convective Rainfall Rate	Precipitation intensities for convective clouds				15 min*
Total Precipitable Water	Total amounts of precipitable water in clear areas				15 min*
Layer Precipitable Water	Distribution of liquid water and relative humidity per layer				15 min*
Stability Analysis Imagery	Stability classes in clear air				15 min*
High resolution Wind from HRVIS	Winds at high spatial resolution from HRVIS	Area of MSG format 'B' or subset of it	Basic product: 20-25 km; Fine-scale product: 10 km.	15 min (during daylight)	15 min*
Automatic Satellite Image Interpretation	Cloud images with text and objective attributes overlays	Area of MSG 'N' format	Segments of 11x10 SEVIRI IR pixels	15 min	15 min*
Rapidly Developing Thunderstorms	Semi-quantitative image product showing features related to the evolution of convective systems	Rectangular area (in satellite projection) to be selected by the user	Minimum size of convective cells is TBD	15 min	15 min*
Air Mass Analysis	Combination of basic quantities that describe air masses into one integrated classification of the air mass	Rectangular area (in satellite projection) to be selected by the user	Segments of 11x10 SEVIRI IR pixels	15 min	15 min*

* valid for the nominal hardware for a processing area of 512x512 SEVIRI IR pixels

Nowcasting SAF Product List
Part 2: Products based on locally received AVHRR/AMSU data

Product Name	Characteristics	Coverage Area	Resolution	Frequency	Timeliness
Cloud Mask	Information on the presence of clouds	Depends on the location of the local receiving station. The product will be validated for areas north of 50 degrees N and Central Europe.	Full AVHRR resolution	Depends on the latitude of the receiving station: in Northern Europe and Scandinavia about 10-15 scenes per day.	15 min*
Cloud Type (including fog)	Major cloud types, fractional clouds, semi-transparency, fog & stratus identification, snow or sea-ice occurrence				
Cloud Top Temperature & Height	Vertical extension of clouds, cloud top temperature				
Precipitating Clouds	Identification of clouds likely to produce precipitation within predefined precipitation intensity classes				

* after the end of the generation of level 1.b products, valid for the nominal hardware for a processing area of 1024x1024 AVHRR IR pixels

Ocean & Sea Ice SAF Product List

Product Name	Characteristics	Coverage Area	Resolution	Frequency	Timeliness
Near- Surface Wind Vector	Wind vector at 10 m height above the ocean surface	Regional (N-E Atlantic and oceans around Europe) and Global	nominal mode: 50 km; research mode: 25 km	Frequency according to orbit repeat cycle	NRT (3 h**)
Atlantic Low and Mid Latitude SST	Composite SST field (skin and bulk temperature) on a regular geographic grid	Atlantic Ocean from 60 S to 60 N and from 45 E to 100 W	10 km	3-hourly	NRT (2 h*)
Merged Atlantic SST	Composite SST field (skin and bulk temperature) on a regular geographic grid	Atlantic Ocean from 60 S to the North Pole and from 45 E to 100 W	10 km	12-hourly (at 0 and 12 UTC)	NRT (2 h*)
Atlantic Low and Mid Latitude Surface Radiative Fluxes	Downward shortwave surface flux (DSSF) and downward longwave surface flux (DLSF) in W/m^2 on a regular geographic grid	Atlantic Ocean from 60 S to 60 N and from 45 E to 100 W	10 km	3-hourly	NRT (2 h*)
Merged Atlantic Surface Radiative Fluxes	Downward shortwave surface flux (DSSF) and downward longwave surface flux (DLSF) in W/m^2 on a regular geographic grid	Atlantic Ocean from 60 S to the North Pole and from 45 E to 100 W	10 km	once per day as an integrated product from 00 to 24 UTC	NRT (2 h*)
Regional SST	High-resolution SST field (skin and bulk temperature) on a regular geographic grid	Six predefined sectors, each 2000x2000 km^2, of the N-E Atlantic including the Mediterranean Sea	2 km	Four times per day correspon-ding to the NOAA/EPS overpasses	NRT (2 h*)
Atlantic Sea Ice Edge	Location separating areas infested my more than 20% ice from open water	N-E Atlantic Ocean and adjacent seas	10 km	once per day	NRT (2 h*)
Atlantic Sea Ice Cover	Sea ice coverage in % occupying the relevant ocean area	N-E Atlantic Ocean and adjacent seas	10 km	once per day	NRT (2 h*)
Atlantic Sea Ice Type	Sea ice type to distinguish between multi-year and first-year ice)	N-E Atlantic Ocean and adjacent seas	10 km	once per day	NRT (2 h*)

* after acquisition of satellite input data ** after the time of observation

Ozone Monitoring SAF Product List

Product Name	Characteristics	Coverage Area	Resolution	Frequency	Timeliness
Total Ozone (from GOME-2)	Vertical column densities of ozone given in Dobson Units	Global	GOME-2 instrument resolution, i.e. 40x40 km2 at 960 km swath or 80x40 km2 at 1920 km swath	Frequency according to orbit repeat cycle	NRT (3 h*) and off-line
Total Ozone (from HIRS)	Integrated vertical column densities of ozone above 400 hPa given in Dobson Units	Global	HIRS/4 instrument resolution, i.e. 40x40 km2 in the average over the 2160 km swath	Frequency according to orbit repeat cycle	NRT (3 h*) and off-line
Ozone Profiles	Ozone mixing ratio in ppm from surface to 50 km in 11 layers	Global	GOME-2 instrument resolution, i.e. 40x40 km2 at 960 km swath or 80x40 km2 at 1920 km swath	Frequency according to orbit repeat cycle	NRT (3 h*) and off-line
Trace Gases	Vertical column densities of minor trace gases in mol·cm-2 (BrO, NO2, OclO, HCHO, SO2)	Global	GOME-2 instrument resolution, i.e. 40x40 km2 at 960 km swath or 80x40 km2 at 1920 km swath	Frequency according to orbit repeat cycle	off-line
Aerosols	Absorbing Aerosol Indicator (AAI), Aerosol Optical Depth (AOD, only for AAI>1) and Aeosol Type (desert dust, smoke, volcanic ash)	Global	GOME-2 instrument resolution, i.e. 40x40 km2 at 960 km swath or 80x40 km2 at 1920 km swath	Frequency according to orbit repeat cycle	NRT (3 h*)
UV Fields (clear-sky)	Surface level spectral UV irradiance and/or this irradiance weighted with an appropriate weighting function provided as diurnal UV dose rates and diurnal dose for clear-sky conditions	Global	0.25 x 0.25 degrees	at least daily	NRT (30 min**)
UV Fields (with Clouds and Albedo)	Surface level UV doses (and optionally dose rates) weighted with appropriate action spectra for clear and cloudy conditions	Global and Regional	100 x 100 km2 or better	daily for diurnal doses; once per hour for dose rates and daily for full spectra	off-line

* after the time of observation ** after availability of total ozone input data

Climate Monitoring SAF Product List

Product Name	Characteristics	Coverage Area	Resolution	Frequency	Timeliness
Cloud Parameters	Fractional Cloud Cover, Cloud Classification, Cloud Top Temperature, Cloud Top Height, Cloud Phase, Cloud Optical Thickness and Cloud Water Path	Regional [30N-80N, 60W-60E]	gridded fields, 15 x 15 km2	hourly, daily, monthly, monthly mean diurnal cycle	off-line
Components of the Surface Radiation Budget (SRB)	Surface Incoming Shortwave Radiation, Surface Albedo, Surface Net Shortwave Radiation, Surface Outgoing Longwave Radiation, Surface Downward Longwave Radiation, Surface Net Longwave Radiation, Surface Radiation Budget in W/m2	Regional [30N-80N, 60W-60E]	gridded fields, 15 x 15 km2	hourly, daily, monthly, monthly mean diurnal cycle	off-line
Components of the Radiation Budget at the Top Of the Atmosphere (TOA)	Incoming Solar Radiative Flux, Reflected Solar Radiative Flux and Emitted Thermal Radiative Flux in W/m2	Regional (WMO Region VI)	South: GERB resolution (50 km x 100 km); North: CERES synoptic resolution (150x150 km2)	daily, monthly	off-line
Ocean State Parameters	Homogeneous global data sets of Sea Surface Temperature, Sea Ice Cover, Sea Surface Height, Salinity and Velocities	Global	Variable resolution given by the HOPE-C model (max. res. 30x30 km2)	monthly	off-line
Humidity Composite Product	Total and Layer (3 layers) Precipitable Water by blending of level 2 water vapour products	Regional [30N-80N, 60W-60E]	gridded fields, 1 x1 degree	daily, monthly, yearly	off-line

Land Surface Analysis SAF Product List

Product Name	**Characteristics**	**Coverage Area**	**Resolution**	**Frequency**	TIMELINESS
Surface Albedo (incl. snow albedo)	Daily averaged mean value of the surface reflectance over the angular hemisphere	Global, using SEVIRI data for low-mid lat. and AVHRR data for the other areas	Full instrument and degraded (10 to 50 km) resolution	daily, every decade	3 h*
Downward Surface Short-wave Fluxes	Downward surface solar radiative fluxes in W/m2	Global, using SEVIRI data for low-mid lat. and AVHRR data for the other areas	gridded fields at 10 km resolution	3-hourly, daily and weekly	3 h*
Downward Surface Long-wave Fluxes	Downward surface thermal radiative fluxes in W/m2	Global, using SEVIRI data for low-mid lat. and AVHRR data for the other area	gridded fields at 10 km resolution	3-hourly, daily and weekly	3 h*
Land Surface Temperature (LST)	Land Surface Temperature in K and diurnal LST variation in K/h	Global, using SEVIRI data for low-mid lat. and AVHRR data for the other areas; Diurnal cycle only for MSG disk	Full SEVIRI and AVHRR resolution	LST every 15 min; diurnal cycle daily	3 h*
Soil Moisture	Root-zone Soil Moisture (RSM) over more densely vegetated surfaces in 3-5 classes	Regional (Europe) and possibly Africa	Full SEVIRI pixel resolutionx	daily	3 h*
Snow Cover	Information on the possible occurrence of snow and the related snow albedo	Regional: one product for N. Europe (from AVHRR) and one for Central and S. Europe (from SEVIRI)	3 x 3 km2 for N. Europe; Full SEVIRI resolution for Central and S. Europe	daily for N. Europe; twice per day for Central and S. Europe	3 h*
Vegetation Indices	SEVIRI Vegetation Index	Regional (Europe)	Full instrument resolution	daily, every decade, monthly	off-line
Biophysical Parameters	Leaf Area Index (LAI) in %	Regional (Europe)	Full instrument resolution	daily, every decade, monthly	off-line
Evapotranspira-tion Rate	Evapotranspiration in mm/h	Regional (Europe)	Full instrument resolution	every 15 min	3 h*

* after acquisition of satellite data

GRAS Meteorology SAF Product List

Product Name	Characteristics	Coverage Area	Resolution	Frequency	Timeliness
Refractivity Profile	Refractivity profile as function of height and location of the occultation.	Global	Variable	Irregular**	NRT (3 h*) and off-line
Observation Characteristics	• Error profiles and covariance matrices of the observables. • Time information for the occultation data. • Latitude, longitude and radial position of the occultation products in geodetic coordinates.	Global	Variable	Irregular**	NRT (3 h*) and off-line
Temperature Profile	Temperature profile and error estimate profile of the temperature for each occultation as function of altitude and location of the occultation.	Global	Variable	Irregular**	NRT (3 h*) and off-line
Humidity Profile	Humidity profile and error estimate profile for each occultation as function of altitude and location of the occultation.	Global	Variable	Irregular**	NRT (3 h*) and off-line
Pressure Profile	Pressure profile and error estimate profile for each occultation as function of altitude and location of the occultation.	Global	Variable	Irregular**	NRT (3 h*) and off-line

* after the time of observation ** about 500 occultations per day from GPS

NWP SAF Product List

INSTRUMENT	#	NWP SAF PRODUCTS
General	1	A regularly updated statement of the user requirements for the interfaces between satellite data and European NWP systems, and a regularly updated statement of current capabilities.
ATOVS	2	Improved versions of the radiative transfer models and observation operators currently available, including development of a generic fast radiative transfer model.
	3	Iimproved versions of the AAPP processing package, making more effective use of the full range of AMSU channels and of AVHRR data.
	4	Improved exchange of monitoring and tuning information between centres, resulting in regular, integrated reports.
IASI	5	A detailed specification of the NWP interface options for European NWP users.
	6	Fast radiative transfer models for IASI and associated observation operators.
	7	A "Day 1" processing package for IASI+ATOVS, suitable for implementation at NWP centres.
MVIRI/SEVIRI (and other geostationary imagery)	8	Enhanced and systematic feedback from NWP users to EUMETSAT (and other wind producers) to improve the quality of satellite wind products.
	9	Improved observation operators for satellite winds, including radiative transfer models required for direct assimilation of time sequences of radiances from geostationary imagery.
Scatterometers	10	Improved/new observation operators for use in retrieval and assimilation systems, for SCAT, ASCAT and SeaWinds, and associated information to improve the assimilation of these data.
SSM/I	11	Improved radiative transfer models and observation operators.
	12	A software package for retrieval of water vapour, surface wind speed and cloud liquid water, within a NWP framework.
GOME	13	An observation operator for assimilation of GOME data.