The EUMETSAT Ocean an sea ICE SAF: production and distribution of operational products for key parameters of the ocean surface - atmosphere interface

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Abstract

The OSI SAF was created in 1997 as an answer to requirements from the meteorological and oceanographic communities of EUMETSAT Member States and Co-operating States for a comprehensive information derived from meteorological satellites at the ocean-atmosphere interface. The OSI SAF consortium is constituted of Météo-France as leading entity, and Met.no (Norske Meteorologiske Institutt), DMI (Danish Meteorological Institute), SMHI (Swedish Meteorological and Hydrological Institute), KNMI (Koninklijk Nederlands Meteorologisch Instituut) and IFREMER (Institut Français de Recherche pour l'Exploitation de la MER) as co-operating entities. During the development phase of the project (1997 to 2002) were developed products related to 4 key parameters of the ocean surface – atmosphere interface (Sea Surface Temperature, Radiative Fluxes, Sea Ice, Wind) on various coverage from regional to global. The Operational production of fully validated and quality controlled near-real time product started during the following phase, the Initial Operational Phase (IOP, 2002 to 2007), with dissemination relying on FTP servers and EUMETCAST. Archive was also implemented in the production centers. The current phase, the CDOP (Continuous Development and Operations Phase), covering from 2007 to 2012 takes into account new requirements at international and European level, in particular those expressed in the framework of GMES initiative, in particular for enhanced products or new products, improved resolution, and use of NetCDF. This paper gives an overview on the project, the products, their access and availability and their usage. Information is also available on www.osi-saf.org

Keywords: Surface - atmosphere interface; EUMETSAT.

Introduction

EUMETSAT

The intergovernmental organisation EU-METSAT (European Organisation for the Exploitation of Meteorological Satellites) was founded in 1986 with as main purpose to deliver weather and climate-related satellite data, images and products 24 hours a day, 365 days a year. This information is supplied to the National Meteorological Services of the organisation's 21 Member and 9 Cooperating States in Europe, as well as other users world-wide.

The SAFs (Satellite Application Facility) were created in order to take benefit from already existing expertise in the Member States. They are delocalised dedicated centres of excellence for processing satellite data and form an

integral part of the distributed EUMETSAT Application Ground Segment.

EUMETSAT supervises and coordinates the overall activities of the SAF network and the integration of the SAFs into the various operations within the EUMETSAT Application Ground Segment. It manages and coordinates interfaces between the SAFs themselves and between SAFs and other EUMETSAT systems, overseeing the integration of SAFs into the overall ground segment infrastructure.

Brief history of the OSI SAF

The OSI SAF was created in 1997 as an answer to requirements from the meteorological and oceanographic communities of EUMETSAT Member States and Co-operating States for a comprehensive information derived from meteorological satellites at the ocean-atmosphere interface. Satellites were expected to offer an unique opportunity to observe the oceans with the necessary coverage, sampling and availability in operational conditions, and to complement the in-situ measurement network.

During the development phase of the project (1997 to 2002) were developed products related to 4 key parameters of the ocean surface – atmosphere interface (Sea Surface Temperature, Radiative Fluxes, Sea Ice, Wind) on various coverage from regional to global.

The Operational production of fully validated and quality controlled near-real time products started during the following phase, the Initial Operational Phase (IOP, 2002 to 2007), using the available satellites, i.e. MSG, NOAA, GOES-E, QuikSCAT and DMSP, with dissemination relying on FTP servers and EUMETCAST. Access to archive was also implemented in the production centers.

The current phase is the CDOP (Continuous Development and Operations Phase), covering the period from 2007 to 2012.

Scope of the current phase, the CDOP

The objectives of the CDOP are:
• to complete all necessary Verification and Validation activities concerning MetOp-A related products, depending on the actual MetOp-A launch date and the actual progress of corresponding OSI SAF development activities at the end of IOP (February 2007),
• to produce, control and distribute operationally in near real-time OSI SAF quality controlled products, with the related Users Support activities,
• to consolidate validation activities of operational products,
• to conduct necessary R&D activities for the enhancement of current OSI SAF products and for new products, taking into account some new user requirements, including ones from the European operational oceanography centres and GMES initiative,
• prepare for the next generation of meteorological satellites (NPP/NPOESS, GOES-R and MTG).

The CDOP consortium and architecture

The CDOP OSI SAF consortium is constituted of Meteo-France (M-F) as leading entity, and Met.no, DMI, SMHI, KNMI and IFREMER as co-operating entities.

The R&D activities are shared among the consortium, with the help of visiting scientists as necessary.

The operations, including also EUMETSAT archive (UMARF) and EUMETSAT dissemination system (EUMETCAST), are based on 3 delocalised sub-systems:
• Sub-system 1 (SS1) under M-F/Centre de Météorologie Spatiale (CMS, Lannion, Brittany, France), with the co-operation of Met.no and DMI for the High Latitude area, processes, archives and distributes the SST and fluxes products. IFREMER is contributing to the products distribution and archiving.
• Sub-system 2 (SS2) under Met.no responsibility, with the co-operation of DMI, processes, archives and distributes the Sea Ice products.
• Sub-system 3 (SS3), under KNMI responsibility, processes, archives and distributes the Wind products

Current Products

The OSI SAF is producing, controlling and distributing operationally in near real-time quality controlled products, related to SST, Radiative Fluxes (SSI and DLI), Sea Ice and Wind. More details on the current products and services are given in Service specification Document and the Product User Manuals available on the OSI SAF web site www.osi-saf.org

SST
The OSI SAF SST is a sub-skin temperature using Brightness temperatures from satellite IR channels (split window algorithm). To each SST field is associated a time field and a quality index field (Fig.1). Table 1 provides the characteristics of the SST products. GLB and NAR SST derived from MetOp and delivered in NetCDF are still under demonstration status (*). Other SST products are operational. SST fields are continuously validated against buoy measurements.

Radiative Fluxes
The OSI SAF is producing a Solar Surface Irradiance (SSI, 0.3 to 4 μm) and a Downward Longwave Irradiance (DLI, 4 to 100μm). To each SSI and DLI field is associated a quality index field (Fig. 2). Fluxes are continuously validated, SSI against pyranometers stations, and DLI against pyrgeometer stations. All products are operational. Table 2 provides the characteristics of the SSI and DLI products.

Sea Ice
Sea Ice products are calculated using a multi-satellite Bayesian approach, but currently only DMSP/SSMI is used operationally. To each Sea Ice field (Concentration, Edge and Type (first year/multi year)), is associated a quality index field. The Global products are split between Northern Hemisphere (North of 50°N) and Southern Hemisphere (South of 50°S) (Fig. 3). All products described in Table 3 are operational and continuously validated against high resolution manual ice charts. Note that Sea Ice Type accuracy is not yet defined, as there is not

yet any satisfying mean of validation.

Winds
Currently, SeaWinds Winds are operational, while ASCAT wind is pre-operational and expected to be operational before end of 2008. Winds have been in a first step quality monitored against NCEP and then ECMWF models (Fig. 4). Since November 2007 their validation is based on triple collocation with NWP and buoys. Their characteristics are described in the Table 4.

Product Timeliness And Availability

Operational OSI SAF products are required to be available for distribution within the specified timeliness in more than 95% of the cases where input satellite data are available with the nominal level of quality, on monthly basis. Figure 5 gives a broad overview on the Products availability compared to the requirement. It shows that 100% are often reached, 98% most of the time, with very few anomalies or disruptions, like in January and April 2005. More details are provided in Quarterly Operations Reports.

Main Aspects Of The Cdop

New Users requirements
Requirements have been consolidated and new ones expressed over recent years, in particular in the context of GCOS, GMES, GODAE/GHRSST, and in the OSI SAF workshops. They can be summarized as following:
- Improved resolution (temporal and geographical)
- Access to full satellite resolution products (SST)
- Specific interfaces allowing flexible access to the products (geographical extraction, remapping …)
- Using of NETCDF, quite a standard format for the Oceanography community.

Table 1
Characteristics of current SST products.

Product Name	Product acronym	Characteristics and Methods	Input Satellite data	Access and format	Timeliness	spatial coverage	Projection	generation frequency	central time (UTC)	spatial resolution	target accuracy
NAR Sea Surface Temperature	**NAR SST**	underskin temperature (°K). multispectral algorithm	NOAA –17 then MetOp*, and NOAA-18 AVHRR	GRIB1 (then 2) on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP	4 h	European Seas	polar stereogr.	4-daily	N/A	polar stereographic 2 km	monthly bias : 0,5°c, Sdt Deviation : 0,8°c
LML Sea Surface Temperature	**LML SST**	underskin temperature (°K). multispectral algorithm	GOES-E and MET	GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP	3 h	60°N to 60°S, 45° to 100°W	cylindrical equidistant	8-daily	01:00, 04:00, …, 22:00	0,1°lat-lon	monthly bias : 0,5°c, Sdt Deviation : 1°c
MAP Sea Surface Temperature	**MAP SST**	underskin temperature (°K). multispectral algorithm	GOES-E , MET and NOAA AVHRR	GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP	3 h	90°N to 60°S, 45° to 100°W	cylindrical equidistant	2-daily	00:00, 12:00	0,1°lat-lon	monthly bias : 0,5°c, Sdt Deviation : 1°c
GLB MetOp Sea Surface Temperature	GLB SST	underskin temperature (°K). multispectral algorithm	MetOp/ AVHRR	GRIB2 via EUMETCAST and UMARF NetCDF L3P on IFREMER FTP server	6h	Global	cylindrical equidistant	2-daily	00:00, 12:00	0.05° lat-lon	monthly bias : 0,5°c, Sdt Deviation : 0,8°c
Full resolution MetOp Sea Surface Temperature metagranules	MGR SST	underskin temperature (°K). multispectral algorithm	MetOp/ AVHRR	NetCDF L2P on IFREMER FTP server	4 h	Global	Satellite swath	Continuous	1 km	monthly bias : 1°c, Sdt Deviation : 1,5°c	monthly bias : 0,5°c, Sdt Deviation : 0,8°c
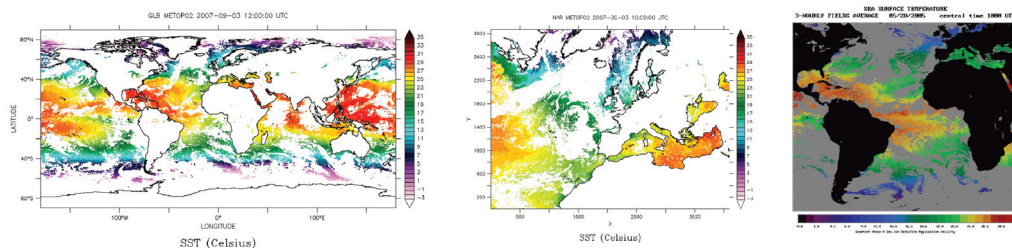
***Fig. 1 :*** from left to right : Global MetOp SST; NAR MetOp SST; LML SST.

Satellites of interest

The OSI SAF aims at optimizing the use of satellites, in priority the European ones, for continuing to derive the already addressed key-parameters, for improving the products, and perhaps for considering new parameters, such as for example Ocean Colour. Currently MET-09, GOES-12, NOAA-17, NOAA-18, DMSP

Table 2
Characteristics of current Radiative Fluxes products.

Product Name	Product acronym	Characteristics and Methods	Input Satellite data	Format	Timeliness	spatial coverage	Projection	generation frequency	central time (UTC)	spatial resolution	target accuracy
LML Downward Longwave Irradiance	**LML DLI**	W/m².Bulk parameterization	GOES-E and MET	GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP	3 h	60°N to 60°S, 45° to 100°W	cylindrical equidistant	8-daily	02:30, 05:30, …, 23:30	0,1°lat-lon	monthly relative bias : 5%, monthly relative Std. Deviation :10%
MAP Downward Longwave Irradiance	**MAP DLI**	W/m².Bulk parameterization	GOES-E, MET and NOAA AVHRR	GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP	3 h	90°N to 60°S, 45° to 100°W	cylindrical equidistant	daily	12:00	0,1°lat-lon	monthly relative bias : 5%, monthly relative Std. Deviation :10%
LML Surface Solar Irradiance	**LML SSI**	W/m². physical parameterization	vvv	GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP	3 h	60°N to 60°S, 45° to 100°W	cylindrical equidistant	7-daily in average	05:30, 08:30, …, 23:30	0,1°lat-lon	monthly relative bias : 10%, monthly relative Std. Deviation :30%
MAP Surface Solar Irradiance	**MAP SSI**	W/m². physical parameterization	GOES-E , MET and NOAA AVHRR	GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP	3 h	90°N to 60°S, 45° to 100°W	cylindrical equidistant	daily	12:00	0,1°lat-lon	monthly relative bias : 10%, monthly relative Std. Deviation :30%
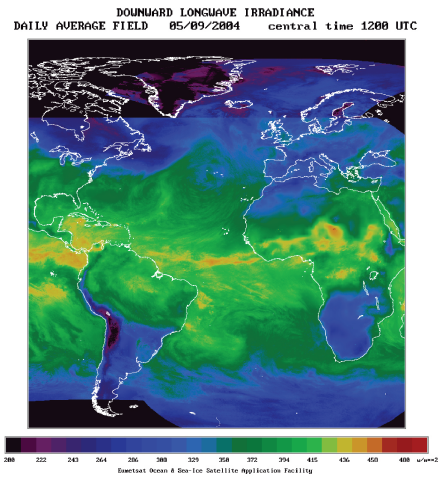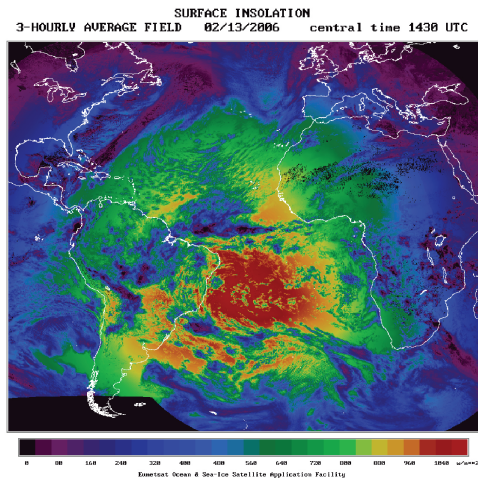
Fig. 2 : left : LML Surface Solar Irradiance; right : MAP Downward Longwave Irradiance.

and QuikSCAT, and MetOp-A are used operationally. AQUA/AMSR use is in development and testing. NPP should be used from 2010 onwards for replacing NOAA-17 and for pre-paring the use of future NPOESS. The use of SENTINEL-3, which is scheduled in 2012, is also considered. Figure 6 shows the satellites of interest in the CDOP timeframe.

Table 3
Characteristics Sea Ice products.

Product Name	Product acronym	Characteristics and Methods	Input Satellite data	Dissemination Means	Access and Format	Timeliness	spatial coverage	Projection	generation frequency	central time (UTC)	spatial resolution	target accuracy
GBL Sea Ice Concentration	**GBL SIC**	in percentage. Multisensor analysis	DMSP/ SSM/I	EUMETCast FTP UMARF	GRIB NetCDF HDF5	5 h	Global	polar stereogr.	daily	12:00	10km	10% for NH-product. 15% for SH-product (yearly average)
GBL Sea Ice Edge	**GBL SIE**	discrimination Open Ice/ closed Ice/ no Ice. Multisensor analysis	DMSP/ SSM/I	EUMETCast FTP UMARF	GRIB NetCDF HDF5	5 h	Global	polar stereogr.	daily	12:00	10 km	20 km (yearly average)
GBL Sea Ice Type	**GBL SIT**	discrimination First year, multi year. Multisensor analysis	DMSP/ SSM/I	EUMETCast FTP UMARF	GRIB NetCDF HDF5	5 h	Global	polar stereogr.	daily	12:00	10 km	TBD
HL Sea Ice Concentration	**HL SIC**	in percentage. Multisensor analysis	DMSP/ SSM/I	EUMETCast FTP UMARF	GRIB NetCDF HDF5	5 h	Atlantic 50N to North Pole	polar stereogr.	daily	12:00	10km	10% for NH-product. 15% for SH-product (yearly average)
HL Sea Ice Edge	**HL SIE**	discrimination Open Ice/ closed Ice/ no Ice. Multisensor analysis	DMSP/ SSM/I	EUMETCast FTP UMARF	GRIB NetCDF HDF5	5 h	Atlantic 50N to North Pole	polar stereogr.	daily	12:00	10 km	20 km (yearly average)
HL Sea Ice Type	**HL SIT**	discrimination First year, multi year. Multisensor analysis	DMSP/ SSM/I	EUMETCast FTP UMARF	GRIB NetCDF HDF5	5 h	Atlantic 50N to North Pole	polar stereogr.	daily	12:00	10 km	TBD
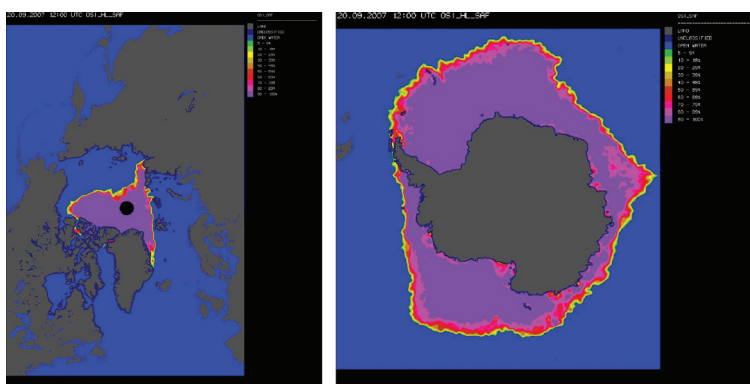
Fig. 3: Sea Ice concentration : left, on Northern Hemisphere ; right, on Southern Hemisphere.

New Products And Services

Products and services to be implemented during the CDOP are described in the Product Requirement Document (PRD), available on the OSI SAF web site www.osi-saf.org

Table 4
Characteristics of Wind products.

Product Name	Product acronym	Characteristics and Methods	Input Satellite data	Acces and Format	Timeliness	spatial coverage	Projection	generation frequency	central time (UTC)	spatial resolution	target accuracy
SeaWinds 25km Wind	SeaW25	wind speed (m/s) and direction (degrees). Sigma0's and swath winds	SeaWinds	BUFR via EUMETCast, UMARF and KNMI FTP server	3 h 30	Global	swath	Continuous	N/A	25 km	Better than 2 m/s in wind component RMS with a bias of less than 0.5 m/s in wind speed
ASCAT 25 km Winds	ASCAT25	wind speed (m/s) and direction (degrees). Sigma0's and swath winds	ASCAT	BUFR via EUMETCast, UMARF and KNMI FTP server	2 h 45	Global	swath	Continuous	N/A	25 km	Better than 2 m/s in wind component RMS with a bias of less than 0.5 m/s in wind speed
SeaWinds 100km Wind	SeaW100	wind speed (m/s) and direction (degrees). Sigma0's and swath winds	SeaWinds	B BUFR via EUMETCast, UMARF and KNMI FTP server	3 h 30	Global	swath	Continuous	N/A	100 km	Better than 2 m/s in wind component RMS with a bias of less than 0.5 m/s in wind speed
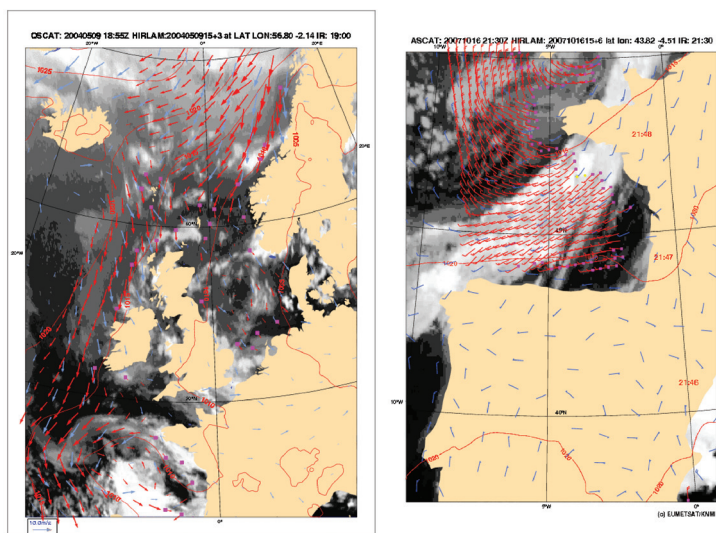
Fig. 4 : left : SeaWinds 100 km Wind; right : ASCAT 25 km Wind

SST

All SST products derived from MetOp are already, or will be soon, operational. The NAR SST, still declined over 7 sub-areas concerning NOAA, will soon cover one unique area. End of 2009 the current merged product MAP SST at 0.1°lat-lon will be split in geostationary SST at 0.05° and polar SST at 5km polar strereogr. projection. A full resolution 1km NOAA/EARS SST will cover the high latitudes in 2009.
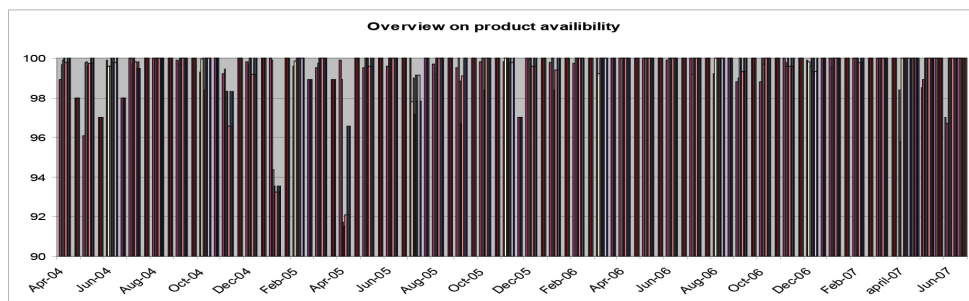
Fig. 5 : Broad overview on product availability.

Radiative fluxes

The 3-hourly geostationary Radiative Fluxes (LML SSI and DLI) will become hourly in 2009 (ATL SSI and DLI). The daily integrated MAP SSI and DLI will be split into Atlantic (ATL) with the same resolution on 0.1° lat-lon on the one side, and on the other side Atlantic High Latitude (AHL) on polar stereographic projection at 5km resolution, derived from NOAA and MetOp.

Sea Ice

AMSR, AVHRR, ASCAT and SSMI/S will also be used, complementing the current use of SSM/I. The Sea Ice drift under development is expected to be operational in 2008. A Sea Ice emissivity product will be developed in view of operational production in 2010.

A regional edge product at 5km is expected for 2009.

Wind

An operational ASCAT 12.5km Wind is expected for 2009, and a Coastal ASCAT Wind at 12.5 km for 2011, with as final objective to produce an unique merged Wind.

Flexible access to full resolution products

The distribution of high resolution satellite swath data is an issue for both data providers and users, mostly because of the high volume of data to archive and to transfer to users (who
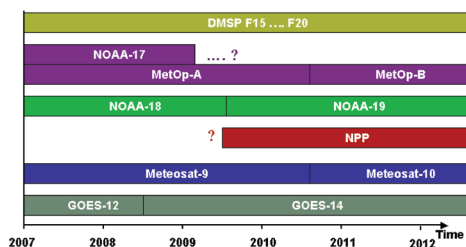

Fig. 6 : Satellites of interest in the OSI SAF CDOP timeframe

have not the storage capabilities of the data providers). It is thus of high importance to supply users with data sized and suited to their needs, in terms of resolution and coverage. The processing in the OSI SAF was based up to now on a set of fixed product areas.

To take this requirement into account, the OSI SAF (IFREMER) is developing a specific access and distribution tool, based on original products on the native satellite swath grid, and benefiting from the current experience with advanced data servers in the oceanographic community. The new tool, adapted from NAIAD, will allow in particular retrieval and re-mapping of the swath sections matching a geographical area, a time period, and statistical thresholds (such as cloud coverage, rate of valid data,…) as defined by the user. A similar interface (FEDT) is developed at Met.no for the High Latitude portal.
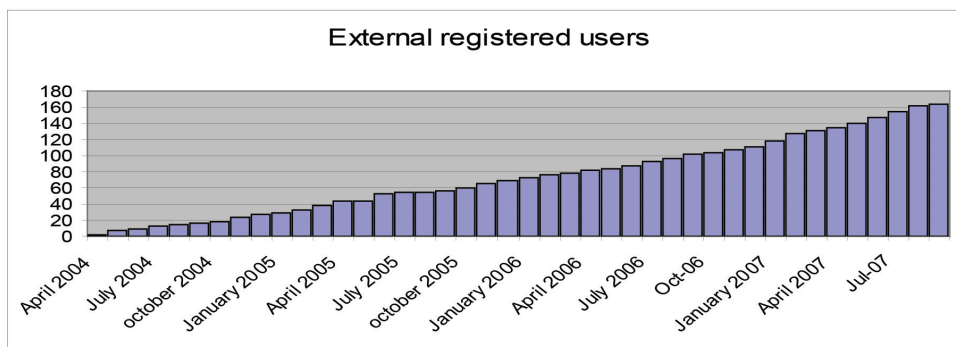
External registered users

Fig.7 : Number of registered users on the OSI SAF Web site.

Formats and access

The access to the products via EUMET-CAST and EUMETSAT central Archive (UMARF), at the intention of the meteorological community, will continue to be produced in BUFR concerning the wind, and will rely preferably on GRIB for other products, GRIB02 replacing gradually GRIB01. The access to the SST, DLI, SSI and Sea Ice products via the OSI SAF dedicated FTP servers is relying more and more on NetCDF format. It is also considered to produce the Wind in NetCDF.

Product Usage And Interactions With Users

Products are used for ocean modelling, atmosphere modelling, climate monitoring, forecasting, research, marine services, environment monitoring, security, defense, etc., by the meteorological community, mostly National Meteorological Services, and by the oceanographic community, directly or through projects such as MERSEA, MEDSPIRATION, GHRSST, GMES/MyOcean, MERCATOR, etc.

Some OSI SAF products are re-distributed through FTP servers, like at NASA for instance. It is difficult for the OSI SAF, perhaps like for other product providers having the same data policy and offering free access, to have a complete view on the use of its products by end us-

ers, although users are invited to register on the Web site www.osi-saf.org

Figure 7 illustrates the evolution of registered users.

The best ways to better know the users and to interact with them are through workshops and conferences, but also through the Web site www.osi-saf.org, that offers to the registered users a help desk service and a permanent user enquiry.

Conclusion

The OSI SAF is producing and distributing operationaly quality controled products related to key parameters of the ocean-atmosphere interface (SST, Radiative Fluxes, Sea Ice and Wind) with the necessary R&D effort for improving the products and the validation methods, and developing new products, as well as the associated User support. The access to the products is being improved, by adapted formats (NetCDF), complementary means of dissemination, and access to full satellite resolution products. The OSI SAF is open to new Users requirements, in particular through GMES / MyOcean where members of the consortium are already involved .

Users are invited to register, not all of them do and the actual product usage is quite difficult to appreciate precisely.