THE EUMETSAT OCEAN AN SEA ICE SAF (OSI SAF) : A CONTRIBUTION TO OPERATIONAL OCEANOGRAPHY

Guenole Guevel

OSI SAF manager, Météo-France, Centre de Météorologie Spatiale, Lannion, Brittany, France

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
1. INTRODUCTION

1.1. Brief history of the OSI SAF

The OSI SAF was created in 1997 in order to complement the in-situ measurement network by offering an unique opportunity to observe the oceans with relevant coverage, sampling and availability in operational conditions.

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.

1.2. 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 (this is now completed),
- 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).

1.3. 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
2. 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

2.1. 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.

The following table 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. In the following table MET means nominal MSG at 0° longitude.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Product acronym</th>
<th>Characteristics and Methods</th>
<th>Input Satellite data</th>
<th>Access and format</th>
<th>Timeliness</th>
<th>spatial coverage</th>
<th>Projection</th>
<th>generation frequency</th>
<th>central time (UTC)</th>
<th>spatial resolution</th>
<th>target accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>NAR Sea Surface Temperature</td>
<td>NAR SST</td>
<td>underskin temperature (°K)</td>
<td>NOAA-17 then MetOp + and NOAA-18 AVHRR</td>
<td>GRIB1 then 2) on EUMETCAST, JMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP</td>
<td>4 h</td>
<td>European</td>
<td>polar stereogr.</td>
<td>4-daily</td>
<td>N/A</td>
<td>polar stereographic</td>
<td>2 km</td>
</tr>
<tr>
<td>LML Sea Surface Temperature</td>
<td>LML SST</td>
<td>underskin temperature (°K)</td>
<td>GOES-E and MET</td>
<td>GRIB1 on EUMETCAST, JMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP</td>
<td>3 h</td>
<td>60°N to 60°S, 45° to 100°W</td>
<td>cylindrical equidistant</td>
<td>8-daily</td>
<td>01:00, 04:00, 07:00, 10:00, 13:00, 16:00, 19:00, 22:00</td>
<td>0.1° lat-lon</td>
<td>monthly bias : 0.5°C, Sdt Deviation : 1°C</td>
</tr>
<tr>
<td>MAP Sea Surface Temperature</td>
<td>MAP SST</td>
<td>underskin temperature (°K)</td>
<td>GOES-E, MET and NOAA AVHRR</td>
<td>GRIB1 on EUMETCAST, JMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP</td>
<td>5 h</td>
<td>60°N to 60°S, 45° to 100°W</td>
<td>cylindrical equidistant</td>
<td>2-daily</td>
<td>00:00, 12:00</td>
<td>0.1° lat-lon</td>
<td>monthly bias : 0.5°C, Sdt Deviation : 1°C</td>
</tr>
<tr>
<td>GLB MetOp Sea Surface Temperature</td>
<td>GLB SST</td>
<td>underskin temperature (°K)</td>
<td>MetOp/AVHRR</td>
<td>GRIB2 via EUMETCAST and UMRARF NetCDF L3P on IFREMER FTP server</td>
<td>4 h</td>
<td>Global</td>
<td>cylindrical equidistant</td>
<td>2-daily</td>
<td>00:00, 12:00</td>
<td>0.05° lat-lon</td>
<td>monthly bias : 0.5°C, Sdt Deviation : 0.8°C</td>
</tr>
<tr>
<td>Full resolution MetOp Sea Surface Temperature metagranules</td>
<td>MGR SST</td>
<td>underskin temperature (°K)</td>
<td>MetOp/AVHRR</td>
<td>NetCDF L2P on IFREMER FTP server</td>
<td>4 h</td>
<td>Global</td>
<td>Satellite swath</td>
<td>Continuous</td>
<td>1.5°</td>
<td>1.5°</td>
<td>monthly bias : 0.5°C, Sdt Deviation : 0.8°C</td>
</tr>
</tbody>
</table>

table 1: Characteristics of current SST products

Figure 1: from left to right: Global MetOp SST; NAR MetOp SST; LML SST.
2.2. 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. Fluxes are continuously validated, SSI against pyranometers stations, and DLI against pyrgeometer stations. All products are operational. The following table provides the characteristics of the SSI and DLI products. In the following table MET means nominal MSG at 0°longitude.

<table>
<thead>
<tr>
<th>Product Name</th>
<th>Product acronym</th>
<th>Characteristics and Methods</th>
<th>Input Satellite data</th>
<th>Format</th>
<th>Timeliness</th>
<th>spatial coverage</th>
<th>Projection</th>
<th>generation frequency</th>
<th>central time (UTC)</th>
<th>spatial resolution</th>
<th>target accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>LML Downward Longwave Irradiance</td>
<td>LML DLI</td>
<td>W/m².Bulk parameterization</td>
<td>GOES-E and MET</td>
<td>GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP</td>
<td>3 h</td>
<td>60°N to 60°S, 45° to 100°W</td>
<td>cylindrical equidistant</td>
<td>daily</td>
<td>02:30, 05:30, …, 23:30</td>
<td>0.1°lat-lon</td>
<td>monthly relative bias : 5%, monthly relative Std. Deviation :10%</td>
</tr>
<tr>
<td>MAP Downward Longwave Irradiance</td>
<td>MAP DLI</td>
<td>W/m².Bulk parameterization</td>
<td>GOES-E, MET and NOAA AVHRR</td>
<td>GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP</td>
<td>3 h</td>
<td>60°N to 60°S, 45° to 100°W</td>
<td>cylindrical equidistant</td>
<td>daily</td>
<td>09:00, 12:00, …, 23:00</td>
<td>0.1°lat-lon</td>
<td>monthly relative bias : 5%, monthly relative Std. Deviation :10%</td>
</tr>
<tr>
<td>LML Surface Solar Irradiance</td>
<td>LML SSI</td>
<td>W/m². physical parameterization</td>
<td>GOES-E, MET and NOAA AVHRR</td>
<td>GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP</td>
<td>3 h</td>
<td>60°N to 60°S, 45° to 100°W</td>
<td>cylindrical equidistant</td>
<td>7-daily in average</td>
<td>06:30, 09:30, …, 23:30</td>
<td>0.1°lat-lon</td>
<td>monthly relative bias : 10%, monthly relative Std. Deviation :30%</td>
</tr>
<tr>
<td>MAP Surface Solar Irradiance</td>
<td>MAP SSI</td>
<td>W/m². physical parameterization</td>
<td>GOES-E, MET and NOAA AVHRR</td>
<td>GRIB1 on EUMETCAST, UMARFand Météo-France FTP, NetCDF and HDF5 on IFREMER FTP</td>
<td>3 h</td>
<td>60°N to 60°S, 45° to 100°W</td>
<td>cylindrical equidistant</td>
<td>daily</td>
<td>12:00</td>
<td>0.1°lat-lon</td>
<td>monthly relative bias : 10%, monthly relative Std. Deviation :30%</td>
</tr>
</tbody>
</table>

Table 2: Characteristics of current Radiative Fluxes products

![Figure 2: LML Surface Solar Irradiance](left) ; right : MAP Downward Longwave Irradiance.

2.3. 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). All products described in the following table 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.
<table>
<thead>
<tr>
<th>Product Name</th>
<th>Product acronym</th>
<th>Characteristic Methods</th>
<th>Input Satellite data</th>
<th>Dissemination Means</th>
<th>Access and Format</th>
<th>Timeliness</th>
<th>Spatial Coverage</th>
<th>Projection</th>
<th>Generation Frequency Time (UTC)</th>
<th>Spatial Resolution</th>
<th>Target Accuracy</th>
</tr>
</thead>
<tbody>
<tr>
<td>GBL Sea Ice Concentration</td>
<td>GBL SIC</td>
<td>In percentage, Multisensor analysis</td>
<td>DMSP/SSM/I</td>
<td>EUMETCast FTP</td>
<td>GRIB NetCDF HDF5</td>
<td>5 h</td>
<td>Global</td>
<td>polar stereogr.</td>
<td>daily</td>
<td>10km</td>
<td>10% for NH-product, 15% for SH-product (yearly average)</td>
</tr>
<tr>
<td>GBL Sea Ice Edge</td>
<td>GBL SIE</td>
<td>Discrimination Open Ice/closed Ice/no Ice, Multisensor analysis</td>
<td>DMSP/SSM/I</td>
<td>EUMETCast FTP</td>
<td>GRIB NetCDF HDF5</td>
<td>5 h</td>
<td>Global</td>
<td>polar stereogr.</td>
<td>daily</td>
<td>10km</td>
<td>20 km (yearly average)</td>
</tr>
<tr>
<td>GBL Sea Ice Type</td>
<td>GBL SIT</td>
<td>Discrimination First year, multi year, Multisensor analysis</td>
<td>DMSP/SSM/I</td>
<td>EUMETCast FTP</td>
<td>GRIB NetCDF HDF5</td>
<td>5 h</td>
<td>Global</td>
<td>polar stereogr.</td>
<td>daily</td>
<td>10km</td>
<td>10% for NH-product, 15% for SH-product (yearly average)</td>
</tr>
<tr>
<td>HL Sea Ice Concentration</td>
<td>HL SIC</td>
<td>In percentage, Multisensor analysis</td>
<td>DMSP/SSM/I</td>
<td>EUMETCast FTP</td>
<td>GRIB NetCDF HDF5</td>
<td>5 h</td>
<td>Global</td>
<td>polar stereogr.</td>
<td>daily</td>
<td>10km</td>
<td>20 km (yearly average)</td>
</tr>
<tr>
<td>HL Sea Ice Edge</td>
<td>HL SIE</td>
<td>Discrimination Open Ice/closed Ice/no Ice, Multisensor analysis</td>
<td>DMSP/SSM/I</td>
<td>EUMETCast FTP</td>
<td>GRIB NetCDF HDF5</td>
<td>5 h</td>
<td>Global</td>
<td>polar stereogr.</td>
<td>daily</td>
<td>10km</td>
<td>20 km (yearly average)</td>
</tr>
<tr>
<td>HL Sea Ice Type</td>
<td>HL SIT</td>
<td>Discrimination First year, multi year, Multisensor analysis</td>
<td>DMSP/SSM/I</td>
<td>EUMETCast FTP</td>
<td>GRIB NetCDF HDF5</td>
<td>5 h</td>
<td>Global</td>
<td>polar stereogr.</td>
<td>daily</td>
<td>TBD</td>
<td>TBD</td>
</tr>
</tbody>
</table>

table 3: Characteristics Sea Ice products

Figure 2: Sea Ice concentration: left, on Northern Hemisphere; right, on Southern Hemisphere.

2.4. 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. Since November 2007 their validation is based on triple collocation with NWP and buoys. Their characteristics are described in the following table.
3. 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. The following figure 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. ASCAT 25km wind and Global Sea Ice availability are monitored since 2nd quarter of 2007, SeaWinds 25km wind since 1st quarter 2008.

![Overview on product availability](image)

**Figure 6**: Broad overview on product availability.

### Table 4: Characteristics of Wind products

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

**Figure 4**: left: SeaWinds 100 km Wind; right: ASCAT 25 km Wind
4. THE CDOP BACKGROUND

4.1. 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.

4.2. 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 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 preparing the use of future NPOESS. The use of SENTINEL-3, which is scheduled in 2012, is also considered.

The following figure shows the satellites of interest in the CDOP timeframe.

*Figure 6 : Satellites of interest in the OSI SAF CDOP timeframe*
5. OVERVIEW ON CDOP 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

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°lat-lon and polar SST at 5km polar stereographic projection. A full resolution 1km NOAA/EARS SST covering the high latitudes is expected end of 2009.

Radiative fluxes
The 3-hourly geostationary Radiative Fluxes (LML SSI and DLI) will become hourly in 2009 (ATL SSI and DLI) at the same resolution of 0.1°lat-lon. The daily integrated MAP SSI and DLI will be split into Atlantic (ATL) with the same resolution of 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 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 remapping 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 (MetSis) is developed at Met.no for the High Latitude portal.

Formats and access
The access to the products via EUMETCAST 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.

6. 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, GHRSSST, GMES/MyOcean, MERCATOR, OSTIA, 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 their products, to have a complete view on the use of its products by end users, although users are invited to register on the Web site www.osi-saf.org . The following figure illustrates the evolution of registered users since April 2004.

![registered users](image)

**Figure 10**: number of registered users on the OSI SAF Web site.

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

7. 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. It offers also associated User support, including the OSI SAF Web Site : [www.osi-saf.org](http://www.osi-saf.org), on which users are invited to register.

The access to the products is being improved, by new formats such as 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.