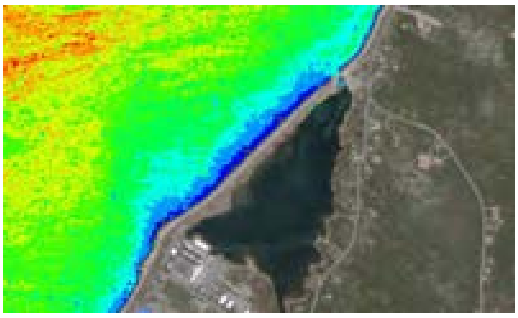


Shallow Water Bathymetry

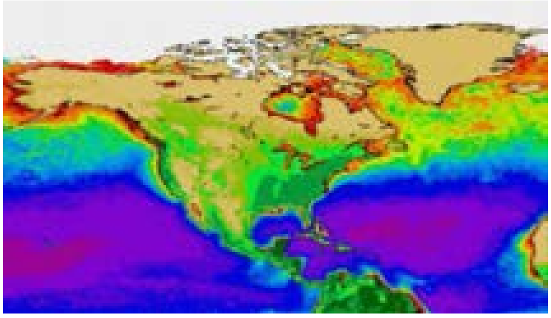
Optical satellite imagery is used to map the bathymetry of shallow water in coastal areas. Satellite-derived bathymetry can support navigation and baseline mapping. Satellite bathymetry is effective for the rapid mapping of clear, shallow water over large, remote areas.

Current Use:

- **Rapid mapping of shallow water bathymetry over large areas**
- **Inventory of baseline conditions**
- **Evaluation of changes over time**
- **Complementary to sonar-derived bathymetry in deeper waters**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.1: Monitoring of landfall site recovery and coastal vegetation • C-CORE _2.11: Monitoring of waste management practices • C-CORE _2.12: Coastal resource mapping of mangroves, coral reefs, wetlands and sandbanks • C-CORE _2.13: Coastal sediment dynamics, estuarine fronts and land-ocean interactions • C-CORE _2.15: Fish and fish habitat • C-CORE _2.2: Submarine landslides and seabed stability • CLS_1.4 Environmental conditions • CLS_2.1 Selection of the drilling rig • CLS_3.2 Coastal morphology • CLS_3.6 Estimation of the Climate Change impact • CLS_4.2 Pollution monitoring • CLS_5.2 Environmental monitoring • CLS_6.2 Site monitoring
Thematic Information Content	Water depth [m]
Spatial Resolution	1 m to 30 m (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10x10 km to 185 x 185 km
Minimum Mapping Unit (MMU)	10 m^2 to 1 ha (depending on user requirements)
Temporal Resolution	Update frequency typically seasonally to multi-year; more frequent updates possible (e.g. monthly); update frequency depends on user requirements
Geographic Coverage	Global: coastal areas
Timeliness	Processing of archival or purpose-acquired imagery
Accuracy	• Thematic accuracy: +/- 15% of water depth • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Gridded or vector format based on user requirements (e.g. GeoTIFF, HDF, IMG, .SHP)
Data Access	Restricted access from commercial suppliers
Validation Approach	• Comparison with ground truth depth measurements • Geometric accuracy assessed with geospatial reference data
Method	• Extraction from reflective spectral bands using ratio of water attenuation coefficients to separate signal into depth-dependent and bottom-dependent components • Calibration with in-situ observations
Degree of Automation	The process is semi-automated and requires some operator involvement
EO Input Data	High and medium-resolution optical imagery (e.g. LANDSAT-8; IKONOS; WorldView; QuickBird; SPOT)
Non-EO Input Data	• Water depth measurements • Water column attenuation coefficients
Contribution of EO	Major: this product is primarily based on EO imagery calibrated with in-situ data
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	• Satellite-derived shallow water bathymetry has matured considerably in recent years, resulting in operational service offerings by several commercial suppliers • Satellite-derived bathymetry does not yet fit into IHO standard, but may be compliant with elements of IHO standards in the future
Maturity and Availability	• The methodology proven and considered mature: TRL = 7 • Product available from commercial suppliers on demand
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Relatively low accuracy without water depth ground truth • Method requires calm conditions and clear water • Typically applied to depths of less than 20 m, although theoretical maximum deoth for extraction is close to 40 m
References	Lyzenga D., 1978. Passive remote sensing techniques for mapping water depth and bottom features. Applied Optics, 17(3), pp. 379-383.
Applicable Standards	IHO S44, S57



Purple, deep blues = low concentrations ; yellow, orange, red = high concentrations (Image Credit: NASA Goddard/Gene Carl Feldman, Compton J. Tucker)

Chlorophyll-a Concentration (Qualitative)

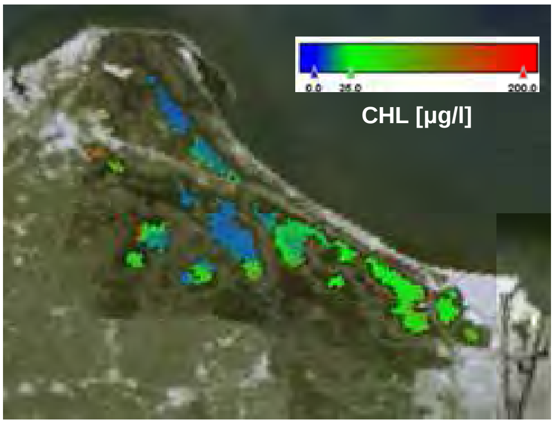
Optical satellite imagery is analyzed to extract quantitative chlorophyll-a concentration from water color which is indicative of phytoplankton biomass. If no reliable in-situ measurements or bio-optical models are available relative concentration levels can be established using spectral indices such as fluorescence line height (FLH) and maximum chlorophyll index (MCI).

Current Use:

- **Broad context is impact of ocean productivity on marine organisms**
- **Possible to correlate wastewater discharge with chlorophyll-a**
- **Understand spatial and temporal variability of algal blooms**
- **Helpful contextual information for the design of field sampling campaigns**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.4: Detection and monitoring of pollutant discharges • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.10: Monitoring of chlorophyll-a • C-CORE_2.11: Monitoring of waste management practices • C-CORE_2.14: Coastal upwelling • CLS_1.4: Environmental conditions • CLS_2.6: Drilling survey preparation: environmental conditions • CLS_3.5: Monitoring of the water quality/turbidity during operations • CLS_3.6: Estimation of climate change impact • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring
Thematic Information Content	Polygon/raster areas of relative chlorophyll concentration levels (e.g. high, medium, low)
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10 x 10 km to 3000 x 3000 km
Minimum Mapping Unit (MMU)	<1 ha to 100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal (dependent on source data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Thematic accuracy: r^2 ranging from 0.7 to 0.9 • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Access	• Open access to some products generated by public sector providers (e.g. NASA) • Restricted access to information products generated by private sector service providers
Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG)
Validation Approach	• Comparison with concurrent in-situ measurements (where available) • Geometric accuracy assessed with geospatial reference data
Method	• Calculation of spectral induces related to chlorophyll concentration • Segmentation and/or unsupervised classification algorithms • Visual image interpretation • Change detection and time series analyses
Degree of Automation	The generation of spectral indices and simple classifications rages from fully automated to semi-automated with significant operator input
EO Input Data	High, medium and low resolution optical imagery (e.g. WORLDVIEW-2; LANDSAT-8; MERIS (archival); MODIS; AVHRR)
Non-EO Input Data	• In-situ measurements of [chl] if goal is calibration and/or validation • Optional: Measured, modeled or estimated atmospheric parameters
Contribution of EO	Major: this product is primarily based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Qualitative products are useful in identifying spatio-temporal characteristics of anomalies, especially in remote, inaccessible areas
Maturity and Availability	• For qualitative products, TRL = 7 • Products are available from commercial suppliers on demand • Products are available from some public sector suppliers (usually systematically generated from low-resolution imagery)
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Images under analysis need to be radiometrically normalized to enable comparison • Artifacts due to atmospheric effects need to be considered
References	• Barnesa, B. B., Hua, C., Holekampb, K. L., Blonskib, S., Spieringe, B. A. and Palandrof, D. (2014) Use of Landsat data to track historical water quality changes in Florida Keys marine environments. Remote Sensing of Environment, Vol. 140, pp. 485–496. • Binding, C. E., Greenberg, T. A. and Bukata, R. P. (2013) The MERIS Maximum Chlorophyll Index; its merits and limitations for inland water algal bloom monitoring. Journal of Great Lakes Research, Vol. 39, Supplement 1, pp. 100–107.



Chlorophyll-a Concentration (Quantitative)

Optical satellite imagery is analyzed to extract quantitative chlorophyll-a concentration from water colour. In most cases, the analysis requires the availability of concurrent in-situ measurements. The retrieval of chlorophyll concentration uses empirical, semi-empirical or analytical models.

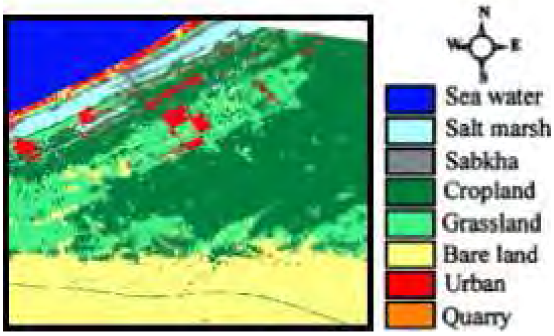
Current Use:

- **Broad context is impact of ocean productivity on marine organisms**
- **In-situ measurement sets context for timing of primary production; goal is understanding the integrated productivity throughout water column**
- **Possible to correlate wastewater discharge with chlorophyll-a**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.4: Detection and monitoring of pollutant discharges • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.10: Monitoring of chlorophyll-a • C-CORE_2.11: Monitoring of waste management practices • C-CORE_2.14: Coastal upwelling • CLS_1.4: Environmental conditions • CLS_2.6: Drilling survey preparation: environmental conditions • CLS_3.5: Monitoring of the water quality/turbidity during operations • CLS_3.6: Estimation of climate change impact • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring
Thematic Information Content	Chlorophyll-a concentration [µg/l]
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from approx. 10 x 10 km to 3000 x 3000 km (dependent on source satellite data)
Minimum Mapping Unit (MMU)	<1 ha to 100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal (dependent on revisit capacity of source satellite data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Thematic accuracy: r^2 ranging from 0.7 to 0.9 • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Access	• Open access to some products generated by public sector providers (e.g. NASA) • Restricted access to information products generated by private sector service providers
Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG)
Validation Approach	• Comparison with concurrent in-situ measurements • Geometric accuracy assessed with geospatial reference data
Method	• Empirical and semi-empirical techniques exploit relationship between EO and in-situ data to retrieve chlorophyll concentration • Analytical methods aim to solve radiative transfer equations; in-situ observations are used for model calibration and parameterization
Degree of Automation	• Setting up model for a water body requires significant operator input • Once set up, the execution of retrieval models is largely automated
EO Input Data	High, medium and low resolution optical imagery (e.g. WORLDVIEW-2; LANDSAT-8; MERIS (archival); MODIS; AVHRR)
Non-EO Input Data	• In-situ measurements of [chl] • Optional: In-situ measurement of inherent optical properties • Optional: Measured, modelled or estimated atmospheric parameters
Contribution of EO	Major: this product is primarily based on EO imagery calibrated with in-situ data
Data Source	• EO data: image providers • Non-EO data: user
Prospects	Use of automated real-time water quality (RTWQ) stations is recommended for the ongoing collection of in-situ observations
Maturity and Availability	• For the open ocean (i.e. Case 1 waters): TRL = 7 • For coastal and inland (i.e. Case 2) waters: TRL varies between 4 to 6 • Products are available from commercial suppliers on demand • Products are available from some public sector suppliers (usually systematically generated from low-resolution imagery)
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Separate empirical models need to be established for different water bodies/regions • Establishing stable empirical model requires several months of concurrent satellite and in-situ data • Chlorophyll retrieval in Arctic waters is object of active, ongoing research • Only near-surface chlorophyll concentration can be captured
References	Odermatt, D., Gitelson, A., Brando, V. E. and Schaepman, M. (2012) Review of constituent retrieval in optically deep and complex waters from satellite imagery. Remote Sensing of Environment 118 (2012), pp. 116-126.
Applicable Standards	User-defined

Coastal Land Cover



(Shalaby & Tateishi, 2007)

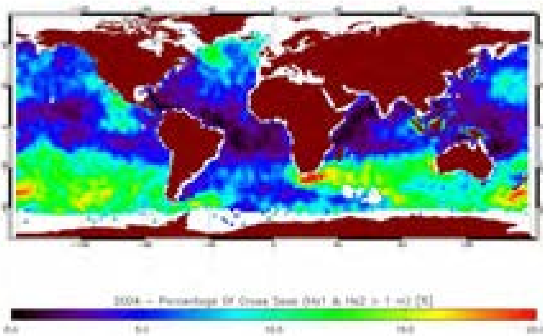
Land cover classification schemes for remotely sensed imagery are well established, whereby the information is primarily extracted using optical imagery. SAR imagery can play an important role in the extraction of specific categories (e.g. fire scars, soil moisture). Coastal land cover can serve as a baseline against which changes can be evaluated.

Current Use:

- **Baseline map of land cover and broad habitat classes**
- **Baseline information is necessary to monitor changes**
- **Critical parameter for applications such as oil spill sensitivity mapping**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.1: Monitoring of landfall site recovery and coastal vegetation • C-CORE_2.11: Monitoring of waste management practices • C-CORE_2.12: Coastal resource mapping of mangroves, coral reefs, wetlands, and sandbanks • C-CORE_2.13: Coastal sediment dynamics, estuarine fronts, and land-ocean interactions • C-CORE_2.4: Detection and monitoring of pollutant discharges • CLS_1.4: Environmental conditions • CLS_3.2: Coastal morphology • CLS_3.6: Estimation of climate change impact • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring • CLS_6.2: Site monitoring
Thematic Information Content	Land cover and/or habitat categories (defined by user and varying across geographic areas of interest)
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements
Minimum Mapping Unit (MMU)	10 m^2 to 100 ha depending on user requirements
Temporal Resolution	Update frequency typically several years (dependent on user requirements)
Geographic Coverage	Global
Timeliness	Non-NRT processing of historical or newly acquired imagery
Accuracy	• Thematic accuracy: classification accuracy ranging from 70 to >95% • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Vector polygons or gridded data format based on user requirements
Data Access	• Some land cover information is freely available from public sources • Restricted access to land cover information from commercial suppliers
Validation Approach	• Comparison with high resolution optical images and/or in-situ measurements • Geometric accuracy assessed with geospatial reference data
Method	• Supervised or unsupervised classification approaches • Multi-temporal imagery may be used in the identification of land cover categories • Visual image interpretation
Degree of Automation	The product generation is semi-automated and requires some operator input.
EO Input Data	• Primary data sources include high- and medium-resolution optical imagery (e.g. LANDSAT-8; MODIS; MERIS; SPOT; Quickbird; IKONOS; ASTER; • Secondary data sources include high- and medium-resolution SAR imagery (e.g. RADARSAT-2; TerraSAR-X; COSMO-SkyMed)
Non-EO Input Data	Reference data for algorithm training and validation (e.g. field photographs, high-resolution imagery, thematic map data, reports, etc.)
Contribution of EO	Major: this product is primarily based on EO imagery calibrated with in-situ data
Data Source	• EO data: image providers • Non-EO data: user
Prospects	Ongoing research investigates the use of multi-sensor EO imagery (e.g. optical + SAR) for increased reliability and accuracy.
Maturity and Availability	• The methodology proven and considered mature: TRL = 7 • Product available from commercial suppliers on demand
Constraints and Limitations	• Separate land cover categories must be established for different regions, which requires significant local knowledge (usually via in-situ observations) • Cloud cover limits acquisition of optical data • In-situ data collected for calibration/validation must be compatible with requirements of image analysis
References	• McDermid, G.J., S.E. Franklin, and E.F. LeDrew. (2005) Remote sensing for large-area habitat mapping. *Progress in Physical Geography.* 29(4). pp. 449-474. • Shalaby, A., R. Tateishi. (2007). Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. *Applied Geography.* 21(1). pp. 29-41.
Applicable Standards	User-defined



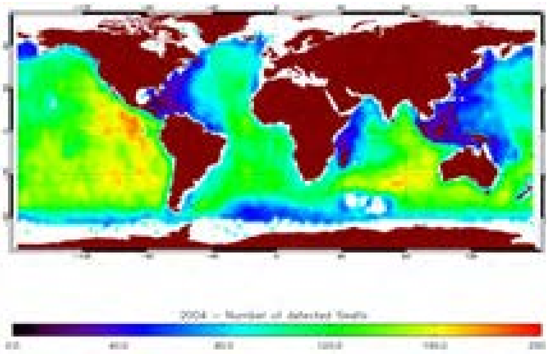
Cross swells maps

Maps showing the percentage of cross swell detected

Current Use:
The maps are currently used for navigation to identify the risky areas.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.2 : Historic records for waves • CLS_OFF.1.1 : Historic Metocean data for high level risk assessment • CLS_OFF.3.6 : Estimation of the Climate Change impact • CLS_OFF.4.4 : Safety of marine operations
Thematic Information Content	Percentage of cross swell (two energetic swell systems (sea surface height >1m) crossing at a significant angle (>45°)
Spatial Resolution	2°
Spatial Coverage	NA
Minimum Mapping Unit (MMU)	2°
Temporal Resolution	The product can be generated per year, per season, per month.
Geographic Coverage	Worldwide [70°N-70°S]
Timeliness	NA
Accuracy	NA
Data Format	NetCDF
Data Access	The access is restricted. The access can be done via FTP, web service (selection via a catalog), or on DVD.

Validation Approach	No direct validation
Method	Combination of several archive wave SAR- derived data
Degree of Automation	This product is not automatically generated.
EO Input Data	Wave mode SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data: imagery providers
Prospects	Improvement in the sea surface height estimation
Maturity and availability	The methodology is proven and considered as mature The product is available from commercial suppliers on demand
Constraints and Limitations	Underestimation of the sea surface height in strong winds areas
References	Collard, Fabrice, Fabrice Ardhuin, and Bertrand Chapron. “Monitoring and Analysis of Ocean Swell Fields Using a Spaceborne SAR: A New Method for Routine Observations.” J. Geophys. Res. 114 (2009): C07023. Husson, R. “Development and Validation of a Global Observation-Based Swell Model Using Synthetic Aperture Radar Operating in Wave Mode.” IUEM - EDSM, 2012.
Applicable Standards	



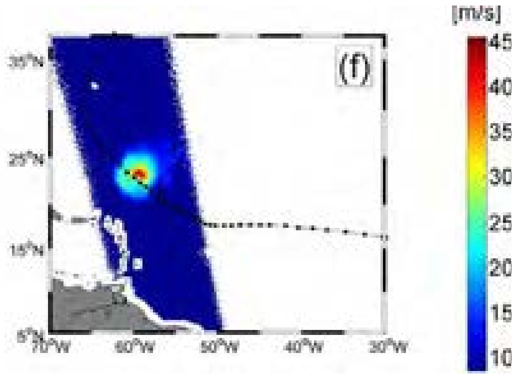
Detected swells maps

Number of detected swells in open ocean

Current Use:
The maps are currently used for navigation, to identify the risky areas.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.2 : Historic records for waves • CLS_OFF.1.1 : Historic Metocean data for high level risk assessment • CLS_OFF.3.6 : Estimation of the Climate Change impact • CLS_OFF.4.4 : Safety of marine operations
Thematic Information Content	Number of detected swells in open ocean
Spatial Resolution	2°
Spatial Coverage	NA
Minimum Mapping Unit (MMU)	2°
Temporal Resolution	The product can be generated per year, per season, per month.
Geographic Coverage	Worldwide [70°N-70°S]
Timeliness	NA
Accuracy	NA
Data Format	NetCDF
Data Access	The access is restricted. The access can be done via FTP, web service (selection via a catalog), or on DVD.

Validation Approach	No direct validation
Method	Combination of several archive wave SAR- derived data
Degree of Automation	This product is not automatically generated.
EO Input Data	Wave mode SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data: imagery providers
Prospects	Improvement in the sea surface height estimation
Maturity and availability	The methodology is proven and considered as mature The product is available from commercial suppliers on demand
Constraints and Limitations	Underestimation of the sea surface height in strong winds areas
References	Collard, Fabrice, Fabrice Ardhuin, and Bertrand Chapron. “Monitoring and Analysis of Ocean Swell Fields Using a Spaceborne SAR: A New Method for Routine Observations.” J. Geophys. Res. 114 (2009): C07023. Husson, R. “Development and Validation of a Global Observation-Based Swell Model Using Synthetic Aperture Radar Operating in Wave Mode.” IUEM - EDSM, 2012.
Applicable Standards	



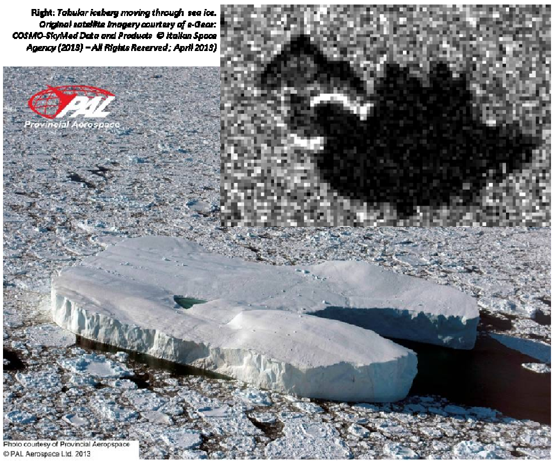
SMOS-derived high wind speed products

SMOS is a radiometer which was at first used to obtain soil moisture and ocean surface salinity. It could also be used to observe high wind speed and thus observe storms and hurricane.

Current Use:
The Soil Moisture and Ocean Salinity (SMOS) mission currently provides multiangular L-band (1.4 GHz) brightness temperature images of the Earth. Because upwelling radiation at 1.4 GHz is significantly less affected by rain and atmospheric effects than at higher microwave frequencies, these new SMOS measurements offer unique opportunities to complement existing ocean satellite high wind observations that are often contaminated by heavy rain and clouds.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.9 : Historical Tropical Storm/Tropical Cyclone probability and tracks • C-CORE.OFF1.10 : Tropical Storm/Tropical Cyclone Observations • C-CORE.OFF1.9 : Historical Tropical Storm/Tropical Cyclone probability and tracks • CLS_OFF.2.4 : Hurricane tracks
Thematic Information Content	Since SMOS has the ability to see through clouds and it is little affected by rain, it can also provide reliable estimates of the surface wind speeds under intense storms.
Spatial Resolution	50 km
Spatial Coverage	600km of swath width
Minimum Mapping Unit (MMU)	50 km
Temporal Resolution	3 days revisit at Equator
Geographic Coverage	Worldwide
Timeliness	This product is not yet generated in operational ways.
Accuracy	NA
Data Format	
Data Access	The data access is restricted and accessible via FTP

Validation Approach	Buoys or aircrafts measuring the winds can be used to validate the wind speed observed by SMOS.
Method	SMOS carries a novel microwave sensor to capture images of ‘brightness temperature’. These images correspond to radiation emitted from the surface of Earth, which are then used to derive information on soil moisture and ocean salinity. Strong winds over oceans whip up waves and whitecaps, which in turn affect the microwave radiation being emitted from the surface. This means that although strong storms make it difficult to measure salinity, the changes in emitted radiation can, however, be linked directly to the strength of the wind over the sea.
Degree of Automation	
EO Input Data	SMOS
Non-EO Input Data	
Contribution of EO	Major: this product is based on SMOS imagery
Data Source	EO data : Image providers
Prospects	Being able to measure ocean surface wind in stormy conditions with the synoptic and frequent coverage of SMOS is paramount for tracking and forecasting hurricane strength.
Maturity and availability	This product is at R&D level.
Constraints and Limitations	No limitation in wind speed.
References	Reul, N., J. Tenerelli, B. Chapron, D. Vandemark, Y. Quilfen and Y. Kerr (2012). « SMOS satellite L-band radiometer: A new capability for ocean surface remote sensing in hurricanes.
Applicable Standards	



Right: *Tabular iceberg moving through sea ice. Original satellite imagery courtesy of e-Geos: COSMO-SkyMed Data and Products © Italian Space Agency (2013) – All Rights Reserved; April 2013)*

Iceberg Monitoring

Different satellite sensors are available to detected and monitor icebergs, including SAR and optical systems, as well as satellite altimeters. Operational monitoring typically involved the analysis of single and multiple images in near real-time (NRT). Historical data are analyzed to provide a statistical perspective of the size distribution and variability of iceberg populations.

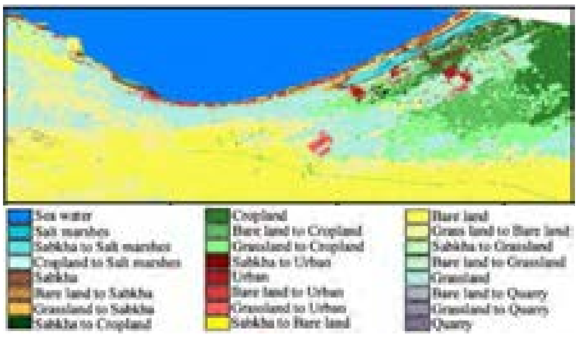
Current Use:

- **Historical analysis for environmental characterization, ice management specifications and platform design**
- **Operational monitoring in NRT for exploration and production**
- **EO especially useful when monitoring large, remote areas with limited infrastructure and surveillance capacity and limited existing information on iceberg occurrence**

Geo-Information Requirements	This product relates to the following challenges: • CLS_4.1: SAR imagery to detect ships and icebergs
Thematic Information Content	Iceberg size [m], location [lat/long], shape characteristics, classification [ship/iceberg], detection and classification confidence [low, medium, high], spatio-temporal size distributions
Spatial Resolution	5 m to 1 km (dependent on user needs and available/selected source satellite data)
Spatial Coverage	Varies depending on user requirements from 20 km swath to transit route exceeding 1500 km
Minimum Mapping Unit (MMU)	Desire to detect icebergs 1 m and larger, but choice of data dictates what size icebergs will be detectable
Temporal Resolution	Range from a single pre-season survey to daily coverage
Geographic Coverage	• Arctic and sub-Arctic areas • Antarctic and Southern Ocean
Timeliness	NRT or archival processing (depending on user requirements); NRT product availability typically within 3 hours of sensing
Accuracy	• Probability of detection and classification <80% to >95% (depends on sea state and imaging mode) • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)
Data Format	• Vector polygons, gridded or plain text formats based on user requirements • Historical analysis typically provided as report
Data Access	Restricted access through commercial suppliers
Validation Approach	• Comparison with high resolution optical images, aerial surveillance and vessel-based observations • Geometric accuracy assessed with geospatial reference data

Method	• CFAR/thresholding technique for detection in open water; principal data source is SAR imagery • Detection in sea ice uses more advanced and non-standard methods (e.g. quad-pol SAR data)
Degree of Automation	• Automated detection followed by manual quality control • Detection in sea ice requires additional analyst interaction
EO Input Data	e.g. LANDSAT-8; MODIS;SPOT; Quickbird; IKONOS; ENVISAT (archival); RADARSAT-2; TerraSAR-X; COSMO SkyMed; CryoSAT, Jason-1/2
Non-EO Input Data	• Training information for supervised detection and classification • Land and space-based AIS data
Contribution of EO	Major: this product is primarily based on EO imagery verified with aerial or other validation data
Data Source	• EO data: imagery providers • Non-EO data: user,
Prospects	High reliance on EO data especially during pre-license and exploration stages. During production EO data will be useful for planning rather than tactical operations
Maturity and availability	• For SAR and optical systems, TRL = 7 • For satellite altimeters, TRL = 5 to 6 • Product available from commercial suppliers on demand and publically available data sources also available
Constraints and Limitations	• Cloud cover limits of ground truth/training data collection and optical image collection • Radar images require interpretation and can be challenging when there are high sea states or precipitation • Altimeter data can only detect larger icebergs, has limited target discrimination capabilities and does not fully cover an area of interest • AIS useful for target discrimination, but only required on larger vessels and vessels may turn AIS transponders off
References	• WMO (World Meteorological Organization) (1970) WMO sea-ice nomenclature. WMO/OMM/BMO No 259.TP.145, Geneva • Power, D., Bobby, P., Howell, C., Ralph, F., Randell, C. (2011). State of the Art in Satellite Surveillance of Icebergs and Sea Ice, Arctic Technology Conference. • Bobby, P., Bruce, J., Power, D., & Fournier, N. (2012, December 3). Historical Analysis of Ice Conditions for Risk Assessment. Offshore Technology Conference
Applicable Standards	WMO 259, WMO 574; products for oil and gas industry are based on augmented versions of existing standards

Coastal Land Cover Change



(Shalaby & Tateishi, 2007)

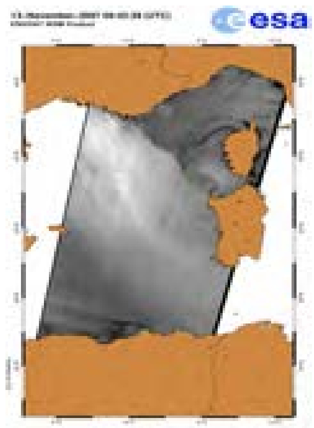
Coastal land cover changes can be assessed using optical or SAR satellite imagery. Major changes (e.g. due to deforestation, fire, infrastructure development, erosion) are readily identified at regional and local scales. Subtle changes (e.g. species composition of vegetated areas) may require a high spectral resolution and specialized tools (e.g. analysis of hyperspectral imagery).

Current Use:

- **Used in assessment of impacts against baseline conditions**
- **EO-based analysis useful when monitoring large, remote areas**
- **Examples include monitoring infrastructure growth, changes in extent and quality of critical habitat (e.g. coastal wetlands), assessment of coastal erosion, etc.**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.1: Monitoring of landfall site recovery and coastal vegetation • C-CORE_2.11: Monitoring of waste management practices • C-CORE_2.12: Coastal resource mapping of mangroves, coral reefs, wetlands, and sandbanks • C-CORE_2.13: Coastal sediment dynamics, estuarine fronts, and land-ocean interactions • C-CORE_2.4: Detection and monitoring of pollutant discharges • CLS_1.4: Environmental conditions • CLS_3.2: Coastal morphology • CLS_3.6: Estimation of climate change impact • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring • CLS_6.2: Site monitoring
Thematic Information Content	• Change in land cover and/or habitat categories (defined by user and varying across geographic areas of interest)
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements
Minimum Mapping Unit (MMU)	10 m^2 to 100 ha depending on user requirements
Temporal Resolution	Update frequency typically seasonally to multi-year; more frequent updates possible (e.g. monthly); update frequency depends on user requirements
Geographic Coverage	Global
Timeliness	Non-NRT processing of historical and newly acquired imagery
Accuracy	• Thematic accuracy: probability of detecting major change >85% • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Vector polygons or gridded data format based on user requirements
Data Access	Restricted access from commercial suppliers
Validation Approach	• Comparison with high resolution optical images and/or in-situ measurements • Geometric accuracy assessed with geospatial reference data
Method	• Change detection algorithms (e.g. differencing, ration, change vector analysis) • Post-classification change detection (i.e. comparison of classified imagery) • Supports use of data from multiple optical and SAR sensors/missions • Major phases of analysis include detection and identification of change
Degree of Automation	• Product generation is semi-automated • Detection of change can be largely automated • Identification of change may require significant operator interpretation
EO Input Data	High- and medium-resolution optical or SAR imagery (e.g. LANDSAT-8; MODIS; AVHRR; SPOT; Quickbird; IKONOS; RADARSAT-2; TerraSAR-X; COSMO-SkyMed)
Non-EO Input Data	Reference data for algorithm training and validation (e.g. field photographs, high-resolution imagery, thematic map data, reports, etc.)
Contribution of EO	Major: this product is primarily based on EO imagery calibrated with in-situ data
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	The detection of subtle changes (e.g. changes in vegetation species composition) is an object of ongoing research.
Maturity and Availability	• For major changes (e.g. deforestation, flooding, urban development) the methodology proven and considered mature: TRL = 7 • For subtle changes (e.g. changes in vegetation composition) TRL varies from 4 to 6 • Product available from commercial suppliers on demand
Constraints and Limitations	• Cloud cover limits acquisition of optical imagert • Accurate identification of changes depends on quality of reference data • Robust estimates of change typically limited to major changes • Increased uncertainty in characterizing subtle changes • Increased risk of artifacts if images are not properly calibrated/normalized
References	• Hussain, M., D. Chen, A. Cheng, H. Wei, and D. Stanley. (2013) Change detection from remotely sensed images: From pixel-based to object-based approaches. *ISPRS Journal of Photogrammetry and Remote Sensing.* 80. pp. 91-106. • Shalaby, A., R. Tateishi. (2007). Remote sensing and GIS for mapping and monitoring land cover and land-use changes in the Northwestern coastal zone of Egypt. *Applied Geography.* 21(1). pp. 29-41.
Applicable Standards	User-defined



SAR-derived metocean features

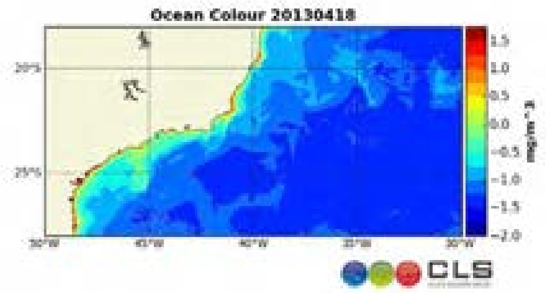
Some features are directly visible on SAR images:

- Upwelling
- Atmospheric front
- Oceanographic front
- Local weather phenomena
- Rain cells
- Internal waves

Current Use:
It is currently used for meteorological applications.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.12 : Visibility (rain cells) • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.3.6 : Estimation of the Climate Change impact
Thematic Information Content	The different metocean features are directly visible on SAR images and require the analyze of a metocean expert to confirm their presence.
Spatial Resolution	It depends on the SAR acquisition mode.
Spatial Coverage	From 20*20 km² to 500*500km² depending on the acquisition mode
Minimum Mapping Unit (MMU)	It depends on the SAR acquisition mode.
Temporal Resolution	Daily
Geographic Coverage	Worldwide
Timeliness	Near real-time (15 min) or archival processing (depending on user requirements)
Accuracy	NA
Data Format	PNG
Data Access	The data can be available via FTP or on DVD.

Validation Approach	An expert has to analyze the SAR image to confirm the presence of a feature
Method	Visual validation
Degree of Automation	The level 1 SAR image can be automatically generated but the expert has to do an analysis.
EO Input Data	SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	NA
Contribution of EO	Major : Major: this product is based on SAR images
Data Source	EO data: imagery providers
Prospects	NA
Maturity and availability	• The methodology proven and considered mature • Product available from commercial suppliers on demand
Constraints and Limitations	Difficulty in observing the metocean features when the winds on the area are too strong.
References	Synthetic Aperture Radar Marine User's Manual, September 2004
Applicable Standards	



Ocean Color Composite

Ocean Color is an optical dataset that is particularly well suited to observing highly dynamical features at the ocean surface.

It can also provide data on phytoplankton concentration, turbidity and suspended particles.

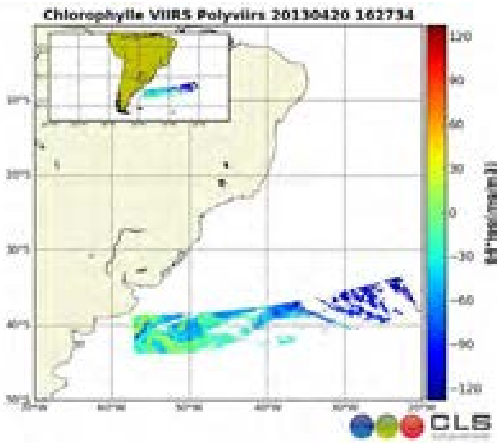
The historical database goes back to 1997 and new missions are expected to be launched in the near future

Current Use:

The Ocean Color product provides information on the phytoplankton concentration in the upper layer of the ocean. It is often used as a passive tracer of the surface currents.

Geo-Information Requirements	This product relates to the following challenges: • CLS_OFF.5.2 : Environmental monitoring • C-CORE.OFF2.10 Monitoring of chlorophyll-a
Thematic Information Content	Ocean Color
Spatial Resolution	2km to 4km
Spatial Coverage	Plankton concentration is derived from measurements of water-leaving radiances made by spaceborne spectroradiometers which have a spatial resolution at nadir of about 1 km. As described above, the spatial resolution of the products varies from 2 km to 4 km.
Minimum Mapping Unit (MMU)	
Temporal Resolution	Many temporal resolutions are proposed, depending on the length of the time period used to merge (average) the sensor images, and on the processing scheme. This time averaging process has the advantage of reducing the gaps due to clouds, but has the drawback of smoothing out some rapidly evolving plankton features. The last product is built by a space-time objective analysis scheme
Geographic Coverage	Global
Timeliness	The product is available each day. The product is available one day after sensing (product of day D-1 available on day D at 08hTU)
Accuracy	Typical product accuracy is about 20% of plankton concentration in open ocean, but may be degraded to 100% near coasts or in shallow waters due to the presence of suspended matter in coastal areas
Data Format	• Gridded maps, NetCDF with CF conventions. • Other binary format available • graphical map (PNG format) • Google Earth format file • GIS compatible

Data access	Data access: restricted (usually by payment).
Validation Approach	
Method	Products are built by a time compositing of VIIRS plankton measurements. VIIRS data are L1A products (containing the top of atmosphere radiances) acquired from NASA/OBPG which are processed to L2 (plankton) using the Polymer software package adapted to VIIRS. The final stage of the processing is the use of a space-time objective analysis scheme of plankton measurements over the last 7 days.
Degree of Automation	Fully automated
EO Input Data	Visible/Near Infra-red Spectroradiometers
Non-EO Input Data	None
Contribution of EO	Major
Data Source	EO data : imagery providers
Prospects	Next use of OLCI sensor on ESA Sentinel-3 satellite.
Maturity and availability	Highly mature (operational use for over 10 years). The use of Polymer began in late 2008 with the MERIS/ENVISAT sensor
Constraints and Limitations	None
References	None
Applicable Standards	



Ocean Color Swath

Ocean Color data is a high resolution earth observation product that is well suited to tracing oceanic dynamic features.

It can also provide data on phytoplankton concentration, turbidity and suspended particles.

The historical database goes back to 1997 and new missions are expected to be launched in the near future

Current Use:
The ocean color product provides information on the phytoplankton concentration in the upper layer of the ocean. Plankton is often used as a passive tracer of the surface currents.

Geo-Information Requirements	This product relates to the following challenges: • CLS_OFF.5.2 : Environmental monitoring • C-CORE.OFF2.10 Monitoring of chlorophyll-a
Thematic Information Content	Ocean Color
Spatial Resolution	Ocean Colour concentration is derived from measurements of water-leaving radiances made by space borne spectroradiometers which have a spatial resolution at nadir of about 1 km. As described above, the spatial resolution of the products varies from 2 km to 4 km
Spatial Coverage	Depending on user requirements
Minimum Mapping Unit (MMU)	
Temporal Resolution	Continuous acquistion
Geographic Coverage	Global
Timeliness	The product is available each day The product is available one day after sensing (product of day D-1 available on day D at 08hTU)
Accuracy	Typical product accuracy is about 20% of plankton concentration in open ocean, but may be degraded to 100% near coasts or in shallow waters due to the presence of suspended matter in coastal areas
Data Format	• Gridded maps, NetCDF with CF conventions. • Other binary format available • graphical map (PNG format) • Google Earth format file • GIS compatible

Data Access	Data access: restricted (usually by payment).
Validation Approach	
Method	The Product is built by processing of VIIRS plankton measurements. VIIRS data are L1A products (containing the top of atmosphere radiances) acquired from NASA/OBPG which are processed to L2 (plankton) using the Polymer software package adapted to VIIRS.
Degree of Automation	Non applicable (i.e.,fully automated)
EO Input Data	Visible/Near Infra-red Spectroradiometers
Non-EO Input Data	None
Contribution of EO	Major: only EO data is used
Data Source	See Production method
Prospects	Next use of OLCI sensor on ESA Sentinel-3 satellite.
Maturity and availability	Highly mature (operational use for over 10 years). The use of Polymer began in late 2008 with the MERIS/ENVISAT sensor
Constraints and Limitations	None
References	None
Applicable Standards	

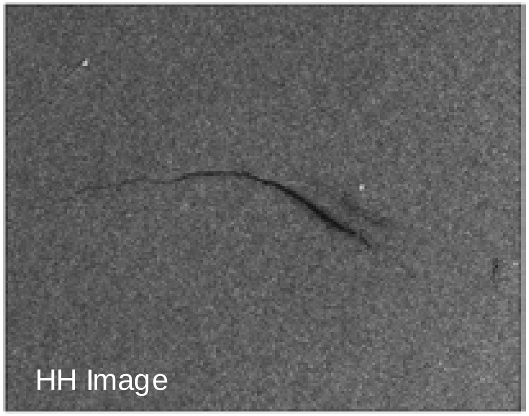
Early warning system for oil spill threats

This product enables its users to be warned when an oil spill is detected and presents risk to drift in a protected area.

Current Use:
It is often use by environmental agencies or companies to prevent some oil disasters.

Geo-Information Requirements	This product relates to the following challenges: • CLS_OFF.5.2 : Environmental monitoring • CLS_OFF.4.2 : Pollution monitoring
Thematic Information Content	The oil spill is detected on the SAR images and its drift is calculated via drifting models. If it presents a high risk of passing by a protected area, the user is warned.
Spatial Resolution	It depends on SAR images resolution and on the resolution of the metocean data in input of the drifting model.
Spatial Coverage	No limitation
Minimum Mapping Unit (MMU)	The smallest oil spill detected is about few meters long.
Temporal Resolution	It depends on the forecast availability for the drifting estimation. The forecast is usually about 3 days.
Geographic Coverage	Worldwide
Timeliness	The drifting estimation of the oil spill can be given every minutes, every hours once the oil spill is detected.
Accuracy	It depends on the metocean data accuracy and on the kind of pollutant. The drifting model doesn't take into account the nature of the pollutant and it can disturb the estimation of the oil spill location and shape.
Data Format	Shapefile XML
Data Access	Web SIG. The data access is restricted and available on request.

Validation Approach	Several SAR images are acquired successively to validate the oil spill drift. Some drifting buoys and in situ data can also be used.
Method	Once the oil spill has been detected, the metocean forecast data (surface wind and wave parameters) are set in input of the drifting model. The advection and diffusion of the oil spill is then estimated.
Degree of Automation	This product is automatically generated once the oil spill is manually detected.
EO Input Data	SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	Metocean (surface wind and wave) forecast data
Contribution of EO	Major : The oil spill detection is done on SAR images
Data Source	EO data: imagery providers Non-EO data : metocean model
Prospects	Possible improvements : • Taking into account the oil spill nature to add this information to the drifting model to improve the estimation • Taking into account the heterogeneity of the oil spill to have a better estimation of its diffusion
Maturity and availability	The methodology is proven and considered as mature The product is available from commercial suppliers on demand
Constraints and Limitations	• The shoreline needs to be well geolocated to avoid miscalculations in the drifting model
References	
Applicable Standards	



Oil Slicks and Spills

Optical and SAR satellite imagery is analyzed to detect and monitor marine oil slicks. Historical databases of imagery and ground truth are required to distinguish true oil slicks from biogenic look-alikes, and to classify the oil type. When applicable, slick detection can be used to help generate drift models and simulations.

Current Use:

Broad context is monitoring of oil pollution and the impact on marine resources.
Current service offerings and research initiatives focus on identifying illegal discharges from ships, monitoring large accidental oil spills and mapping natural seeps.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.1: Monitoring of landfall site recovery and coastal vegetation • C-CORE_2.4: Detection and monitoring of pollutant discharges • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring
Thematic Information Content	Polygon outline of detected oil with identified physical characteristics (e.g. type, thickness, size, etc)
Spatial Resolution	1 m to 1 km (dependent on source satellite data and user requirements)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10x10 km to 2000 x 2000 km
Minimum Mapping Unit (MMU)	0.001 ha to 100 ha (depending on user requirements)
Temporal Resolution	Weekly to daily (dependent on source data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	• Near real-time for surveillance context (e.g. shipping routes, accidental spill) • Archival processing typical for mapping natural seeps
Accuracy	• Thematic accuracy: estimated classification accuracy from 60 to >90% • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)
Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG) Polygon outline format based on user requirements (e.g. Shapefile)
Data Access	Restricted
Validation Approach	• Comparison with concurrent in-situ detections and observations • Geometric accuracy assessed with geospatial reference data

Method	• SAR-based 'Dark object' detection and image segmentation; feature-based classification using ground-truth • Extraction from optical imagery via spectral signature of oil slicks • Optical imagery is also used as ancillary information (e.g. to aid in the identification of biogenic slicks)
Degree of Automation	The product generation is semi-automated and requires significant operator input
EO Input Data	• Primary data sources include high- and medium-resolution SAR imagery (e.g. RADARSAT-2; TerraSAR-X; COSMO-SkyMed) • Seconary data sources include high- and medium-resolution optical imagery (e.g. LANDSAT-8; MODIS; MERIS; SPOT; Quickbird; IKONOS; ASTER)
Non-EO Input Data	• In-situ observations • Shipping routes • Optional: Measurement of atmospheric parameters
Contribution of EO	Major: this product is primarily based on EO imagery with classification based on in-situ data
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Ongoing research focuses on better discrimination of oil slicks and look-alikes (e.g. biogenic slicks, metocean phenomena) and characterization of slick thickness
Maturity and Availability	The detection of oil slicks using SAR imagery is proven and mature: TRL = 7
Constraints and Limitations	• Cloud cover limits acquisition of optical imagery • A significant amount of historical ground-truth data is required for oil slick classification • Distinguishing oil from biogenic look-alikes in SAR can be challenging • Difficult to get robust estimates of classification accuracy due to limited reference data • Robust extraction of slick thickness from satellite imagery is not currently possible
References	• Solberg, A. S., Storvik, G., Solberg, R., & Volden, E. (1999). Automatic detection of oil spills in ERS SAR images. Geoscience and Remote Sensing, IEEE Transactions on, 37(4), 1916-1924. • Hellweger, F. L., Schlosser, P., Lall, U., & Weissel, J. K. (2004). Use of satellite imagery for water quality studies in New York Harbor. Estuarine, Coastal and Shelf Science, 61(3), 437-448.
Applicable Standards	User-defined

Plumes

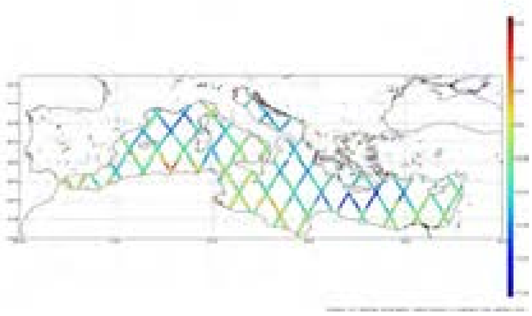
Optical or thermal satellite imagery is analyzed to map the location, extent, drift and dispersal of offshore plumes. Plumes may be caused by thermal gradients or differences in water constituents compared to surrounding waters. Emphasis is placed on detecting and monitoring plume extent and evolution over time.

Current Use:

Satellite observations allow for the rapid spatial and temporal characterization of plumes. The focus may be on characterizing existing processes in the coastal environment or monitoring potential sources of pollution. EO-based monitoring provides a broad spatial context that may guide mode detailed local investigations or direct field sampling activities.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.4: Detection and monitoring of pollutant discharges • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.10: Monitoring of chlorophyll-a • C-CORE_2.11: Monitoring of waste management practices • C-CORE_2.14: Coastal upwelling • CLS_1.4: Environmental conditions • CLS_2.6: Drilling survey preparation: environmental conditions • CLS_3.5: Monitoring of the water quality/turbidity during operations • CLS_3.6: Estimation of climate change impact • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring
Thematic Information Content	Location, extent and composition
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10 x 10 km to 3000 x 3000 km
Minimum Mapping Unit (MMU)	<1 ha to 100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal (dependent on source data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Thematic accuracy: classification accuracy ranging from 85 to >95% • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG) or vector format (e.g., .SHP)
Data Access	• Open access to some products generated by public sector providers (e.g. NASA) • Restricted access to information products generated by private sector service providers
Validation Approach	• Comparison with concurrent in-situ measurements or other remotely sensed information of higher accuracy/precision • Calibration with black body radiators for thermal sensors • Geometric accuracy assessed with geospatial reference data
Method	• Thresholding/classification based on thermal/spectral signature • Identification through visual interpretation
Degree of Automation	The product generation can be fully automated or fully manual, depending on the method selected
EO Input Data	Optical or thermal imagery (e.g. MODIS; AVHRR; SeaWiFS; LANDSAT-8)
Non-EO Input Data	• Background knowledge of local conditions • GIS data • In-situ or remote observations
Contribution of EO	Major: this product is primarily based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	EO provides a robust method for systematically observing plumes over large areas
Maturity and Availability	• The methodology proven and considered mature: TRL = 7
Constraints and Limitations	• Cloud cover limits image acquisition and revisit capability
References	Petus, C., Teixeira da Silva, E., Devlin, M., Wenger, A. S. and Álvarez-Romero, J. G. (2014) Using MODIS data for mapping of water types within river plumes in the Great Barrier Reef, Australia: Towards the production of river plume risk maps for reef and seagrass ecosystems. Journal of Environmental Management, No. 137, pp. 163-177
Applicable Standards	User-defined



Near-Real-Time Global Along-track Absolute Dynamic

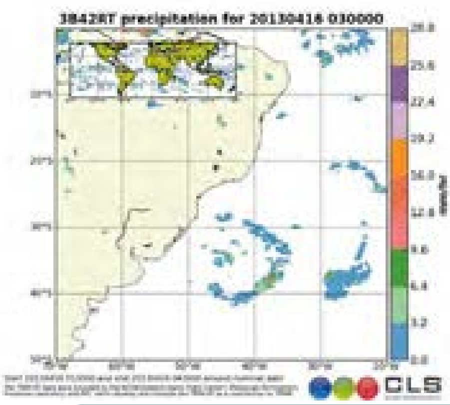
Multimission altimeter data near-real-time along-track Absolute Dynamic Topography product is produced with high level processing which combines data from several altimetry missions (validation, cross calibration, optimal interpolation on a grid).

Current Use:

The along-track Absolute Dynamic Topography product is used to study of ocean general circulation.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.7 Surface current observations • CLS_OFF.1.2 : Model validation
Thematic Information Content	Topography
Spatial Resolution	Along-track (7km or 14 km)
Spatial Coverage	depending on user requirements
Minimum Mapping Unit (MMU)	
Temporal Resolution	One file per day
Geographic Coverage	Global Ocean, enclosed seas
Timeliness	Every 2-3 hours
Accuracy	NA
Data Format	• NetCDF CF • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Restricted. FTP or web Extraction tool.

Validation Approach	
Method	After a validation of input EO data and models, an adjustment onto a reference mission (Topex/Poseidon or Jason-1 or Jason-2) is made for all other missions to produce along-track data for each mission. The MDT is then added.
Degree of Automation	The product is automatically generated
EO Input Data	Altimetry
Non-EO Input Data	Altimetrer and radiometer data: Jason-2, Cryosat-2, HY-2A, SARAL/AltiKa Models: ECMWF wet troposphere, MOG-2D for atmospheric correction, GIM for ionosphere correction, GOT4v8, Wahr, Cartright and Taylor for tidal correction, MSS CNES_CLS_11, MDT CNES_CLS_13
Contribution of EO	Major
Data Source	EO
Prospects	New altimeters available (Jason-3, Sentinal 3A)
Maturity and availability	The methodology proven and considered mature
Constraints and Limitations	Well known in scientific community and underused for commercial purposes. A greater awareness is needed.
References	http://www.aviso.altimetry.fr
Applicable Standards	



Rainfall

Precipitation data is available from the TRMM mission since 1997 The TRMM mission is expected to end in May 2016 and will be followed by the GMP mission.

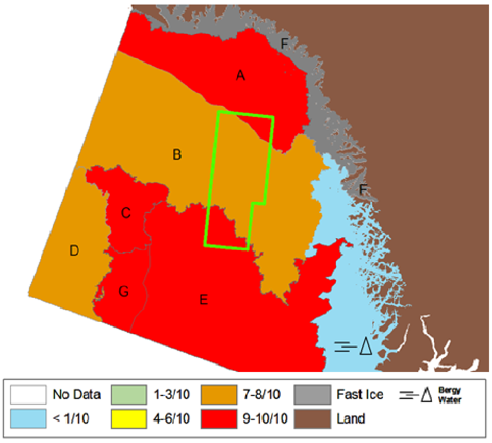
Current Use:

Rainfall data can be used either to build a historic database for a given region or as an input to atmospheric models.

Successive images can also be used to track the movement of rain cell and hence estimate its impact on a point of interest.

Geo-Information Requirements	This product relates to the following challenges: • CLS_OFF.3.3 : evaluation of the efficiency of the structure • C_CORE.OFF1.12 : Visibility
Thematic Information Content	Light rain, moderate and heavy rain, snow
Spatial Resolution	4.3 for TRMM, 5km for GPM
Spatial Coverage	220 for TRMM, 885km for GMI on GPM
Minimum Mapping Unit (MMU)	50 km
Temporal Resolution	Daily for TRMM
Geographic Coverage	Worldwide
Timeliness	Daily data for TRMM
Accuracy	NA
Data Format	• Netdcf gridded data and proprietary binary format for TRMM • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	TRMM data is freely available via FTP GPM data: freely available

Validation Approach	The EO data will be validated through comparisons with ground station data
Method	The TRMM Microwave Imager (TMI) measures microwave energy emitted by the Earth and its atmosphere to quantify the water vapor, the cloud water, and the rainfall intensity in the atmosphere. The GPM carries a microwave imager and a dual-frequency precipitation radar
Degree of Automation	TRMM: fully automated, GPM: under development
EO Input Data	TRMM, GPM
Non-EO Input Data	
Contribution of EO	Major: this product is based TRMM imagery
Data Source	EO data : Image providers
Prospects	The satellite carrying TRMM has no fuel left and re-entry is expected from May 2016 onwards. The GPM mission is scheduled to take over, first satellite launched in March 2014
Maturity and availability	TRMM product is considered mature
Constraints and Limitations	No limitation in wind speed.
References	http://pmm.nasa.gov/TRMM/ground-validation Mathew R. Schwaller and K. Robert Morris, 2011: A Ground Validation Network for the Global Precipitation Measurement Mission. J. Atmos. Oceanic Technol., 28, 301–319. doi: http://dx.doi.org/10.1175/2010JTECHA1403.1
Applicable Standards	



Sea Ice as Habitat Indicator

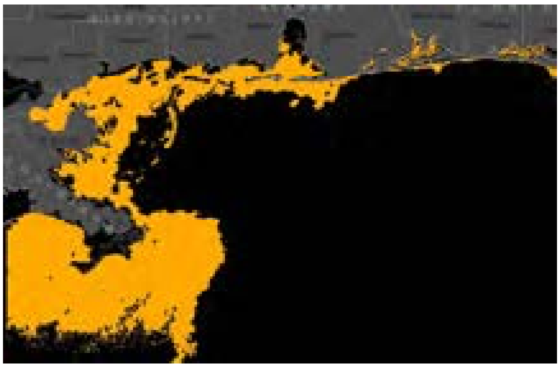
SAR and optical satellite imagery is analyzed to map sea ice extent and classify ice features. The timing of sea ice retreat and advance is an important indicator for ice-dependant marine mammal habitats, fish habitats and seabird habitats. Temporally correlated imagery and ground-truth data is necessary to reliably classify sea ice. Output is relevant for model ling trends.

Current Use:

Broad context is monitoring of sea ice as a habitat indicator in terms of climate variability and change. Seasonal and annual variation in sea ice extent directly affects the breeding and feeding habitats for marine life. Retreating coastal sea ice has major consequences for coastal environments including increased shoreline erosion. The information is relevant for seasonal or annual changes to shipping routes and expansion of shipping routes and exploration opportunities.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.6: Distribution and abundance of seabirds • C-CORE_2.15: Fish and fish habitat • CLS_1.4: Environmental conditions • CLS_5.2: Environmental monitoring • CLS_6.2: Site monitoring
Thematic Information Content	• Sea ice extent and changes in sea ice extent • Sea ice type, size and concentration
Spatial Resolution	30 m to >>1 km (dependent on source satellite data and application)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 185 x 185 km to 2400 x 2400 km
Minimum Mapping Unit (MMU)	1 ha to >>100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal/annual change (dependent on source data and cloud cover)
Geographic Coverage	Global: areas affected by sea ice
Timeliness	Near real-time or archival access (depending on user requirements)
Accuracy	• Thematic accuracy: classification accuracy ranging from 80 to >95% • Geometric accuracy: +/- 1 to 3 pixels (depending on geospatial reference data and sensor spatial resolution)
Data Format	• Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG) • Polygon format based on user requirements (e.g. Shapefile) • Classified map products (e.g. Egg maps)

Data Access	• Open access to regional and hemispheric products from public sector providers • Restricted access to products generated (typically from high-resolution imagery) by commercial suppliers
Validation Approach	• Comparison with in-situ observations (aerial reconnaissance, ship/shore reports) • Geometric accuracy assessed with geospatial reference data
Method	• Segmentation, backscatter analysis and classification • Visual interpretation by a trained operator
Degree of Automation	The product generation is semi-automated and requires significant operator input
EO Input Data	High, medium and low-resolution SAR and optical imagery, as well as passive microwave imagery (e.g. Cosmo-SkyMed; Radarsat-2; TerraSAR-X; Sentinel-1, GeoEye-1; QuickBird; IKONOS; WorldView-2; RapidEye; SPOT-5; LANDSAT-7; LANDSAT-8; MODIS, AMSR-2)
Non-EO Input Data	• Shipping routes and areas of commercial fishing • Location of O&G infrastructure • Significant habitat locations (breeding areas, migration routes, etc)
Contribution of EO	Major: this product is primarily based on EO imagery; operator knowledge is also required depending on the output products
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Extensive historical data is available for trend analysis and model development
Maturity and Availability	The methodology is proven and considered mature: TRL = 7
Constraints and Limitations	• Cloud cover limits acquisition of optical imagery • Historical ground-truth data and/or comprehensive operator knowledge is required for classification • Limited spatial resolution (i.e. several km) for information derived from passive microwave data
References	Kovacs, K. M., Lydersen, C., Overland, J. E., & Moore, S. E. (2011). Impacts of changing sea-ice conditions on Arctic marine mammals. Marine Biodiversity, 41(1), 181-194.
Applicable Standards	• WMO 259, WMO 574 • User-defined standards



(Image Credit : http://ghrc.nsstc.nasa.gov/)

Sediment Concentration (Qualitative)

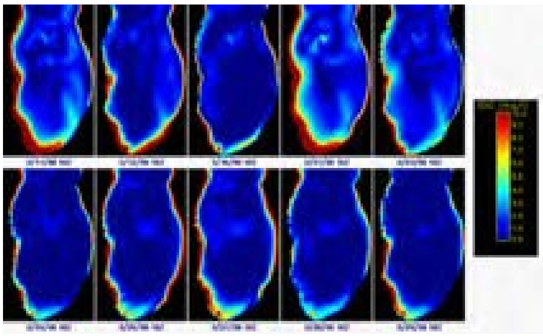
Optical satellite imagery is analyzed to detect and map suspended sediment concentrations. Suspended sediment may be indicative of estuarine processes, re-suspension or pollution. In cases where insufficient in-situ data is available, water color values can be used to identify areas of suspended sediment and provide relative levels of sediment concentration.

Current Use:

- **Broad context is monitoring of water quality;**
- **EO-based monitoring provides information related to environmental characterization and baseline conditions, effects of infrastructure development and contaminants associated with suspended materials**
- **Characterization of coastal environments**

Geo-Information Requirements	This product relates to the following challenges: • OFF_2.4: Detection and monitoring of pollutant discharges • OFF_2.5: Distribution and abundance of marine mammals (Water quality) • OFF_2.11: Monitoring of waste management practices • OFF_2.13: Coastal sediment dynamics, estuarine fronts and land-ocean interactions • OFF_2.15: Fish and fish habitat (Water quality as habitat indicator) • CLS_2.7: Monitoring water discharge/drill cuttings • CLS_3.2: Coastal morphology • CLS_3.5: Monitoring of the water quality/ turbidity during operations • CLS_3.6: Estimation of climate change impact • CLS_5.2: Environmental Monitoring
Thematic Information Content	Polygon/raster areas of suspended sediment; relative levels of suspended sediment (e.g. high, medium, low)
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10 x 10 km to 3000 x 3000 km
Minimum Mapping Unit (MMU)	<1 ha to 100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal (dependent on source data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Thematic accuracy: r^2 ranging from 0.7 to 0.9 • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG)
Data Access	Restricted access to information products generated by private sector service providers
Validation Approach	• Comparison with concurrent in-situ measurements (where available) • Geometric accuracy assessed with geospatial reference data
Method	• Calculation of spectral induces related turbidity • Segmentation and/or unsupervised classification algorithms • Visual image interpretation • Change detection and time series analyses
Degree of Automation	The generation of spectral indices and simple classifications rages from fully automated to semi-automated with significant operator input
EO Input Data	High, medium and low resolution optical imagery (e.g. WORLDVIEW-2; LANDSAT-8; MERIS (archival); MODIS; AVHRR)
Non-EO Input Data	• In-situ measurements of turbidity if goal is calibration and/or validation • Optional: Measured, modeled or estimated atmospheric parameters
Contribution of EO	Major: this product is primarily based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Qualitative products are useful in identifying spatio-temporal characteristics of anomalies, especially in remote, inaccessible areas
Maturity and Availability	• For qualitative products, TRL = 7 • Products are available from commercial suppliers on demand
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Images under analysis need to be radiometrically normalized to enable comparison • Artifacts due to atmospheric effects need to be considered
References	• Miller, R. L., & McKee, B. A. (2004). Using MODIS Terra 250 m imagery to map concentrations of total suspended matter in coastal waters. Remote sensing of Environment, 93(1), 259-266. • Doxaran, D., Froidefond, J. M., Lavender, S., & Castaing, P. (2002). Spectral signature of highly turbid waters: Application with SPOT data to quantify suspended particulate matter concentrations. Remote sensing of Environment, 81(1), 149-161. • Sediment Analysis Network for Decision Support (SANDS) MODIS Geological Survey of AL (GSA) Analysis obtained from http://ghrc.nsstc.nasa.gov/hydro/, maintained by NASA EOSDIS Global Hydrology Resource Center (GHRC) DAAC, Huntsville, AL. 2011. Data for the image were provided by the NASA EOSDIS GHRC DAAC.
Applicable Standards	User-defined



(Image Source: http://www.glerl.noaa.gov/eegle/projects/p05/p05.html)

Sediment Concentration (Quantitative)

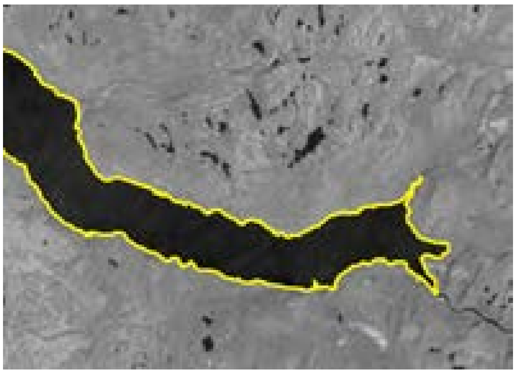
Optical satellite imagery is analyzed to detect and map suspended sediment concentrations. Suspended sediment may be indicative of estuarine processes, re-suspension or pollution. In most cases, the analysis requires the availability of concurrent in-situ measurements. The retrieval of sediment concentration uses empirical, semi-empirical or analytical models.

Current Use:

- **Broad context is monitoring of water quality;**
- **EO-based monitoring provides information related to environmental characterization and baseline conditions, effects of infrastructure development and contaminants associated with suspended materials**
- **Characterization of coastal environments**

Geo-Information Requirements	This product relates to the following challenges: • OFF_2.4: Detection and monitoring of pollutant discharges • OFF_2.5: Distribution and abundance of marine mammals (Water quality) • OFF_2.11: Monitoring of waste management practices • OFF_2.13: Coastal sediment dynamics, estuarine fronts and land-ocean interactions • OFF_2.15: Fish and fish habitat (Water quality as habitat indicator) • CLS_2.7: Monitoring water discharge/drill cuttings • CLS_3.2: Coastal morphology • CLS_3.5: Monitoring of the water quality/ turbidity during operations • CLS_3.6: Estimation of climate change impact • CLS_5.2: Environmental Monitoring
Thematic Information Content	Suspended sediment concentration [g/m^3], [mg/l]
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from approx. 10 x 10 km to 3000 x 3000 km (dependent on source satellite data)
Minimum Mapping Unit (MMU)	<1 ha to 100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal (dependent on revisit capacity of source satellite data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Thematic accuracy: r^2 ranging from 0.7 to 0.9 • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG)
Data Access	Restricted access to information products generated by private sector service providers
Validation Approach	• Comparison with concurrent in-situ measurements • Geometric accuracy assessed with geospatial reference data
Method	• Empirical and semi-empirical techniques exploit relationship between EO and in-situ data to retrieve chlorophyll concentration • Analytical methods aim to solve radiative transfer equations; in-situ observations are used for model calibration and parameterization
Degree of Automation	• Setting up model for a water body requires significant operator input • Once set up, the execution of retrieval models is largely automated
EO Input Data	High, medium and low resolution optical imagery (e.g. WORLDVIEW-2; LANDSAT-8; MERIS (archival); MODIS; AVHRR)
Non-EO Input Data	• In-situ suspended sediment measurements • Optional: In-situ measurement of inherent bio-optical properties • Optional: Measurement of atmospheric parameters
Contribution of EO	Major: this product is primarily based on EO imagery using in-situ data as ground-truth
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Use of automated real-time water quality (RTWQ) stations is recommended for the ongoing collection of in-situ observations
Maturity and Availability	• For the open ocean (i.e. Case 1 waters): TRL = 7 • For coastal and inland (i.e. Case 2) waters: TRL varies between 4 to 6 • Products are available from commercial suppliers on demand
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Separate models need to be developed for different regions • Establishing a stable empirical model requires several months of concurrent satellite and in-situ data • Only surface water information is captured by the satellite imagery • Artifacts due to atmospheric effects need to be considered
References	• Miller, R. L., & McKee, B. A. (2004). Using MODIS Terra 250 m imagery to map concentrations of total suspended matter in coastal waters. Remote sensing of Environment, 93(1), 259-266. • Doxaran, D., Froidefond, J. M., Lavender, S., & Castaing, P. (2002). Spectral signature of highly turbid waters: Application with SPOT data to quantify suspended particulate matter concentrations. Remote sensing of Environment, 81(1), 149-161.
Applicable Standards	User-defined



Shoreline

SAR and optical satellite imagery is analyzed to map shorelines. Simple shoreline features and shoreline types can be extracted from imagery based on visual interpretation and semi-automated approaches.

Current Use:

- **Mapping coastal areas and shoreline changes (environmental change analysis);**
- **Extracting onshore elevation and near-shore bathymetry**
- **Production of coastal terrain models (CTM) for modelling watersheds and coastal morphology, and studying marine and terrestrial interactions.**
- **Monitoring the effects of infrastructure and human activity on coastal environments**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.1: Monitoring of landfall site recovery and coastal vegetation • C-CORE_2.6: Distribution and abundance of seabirds • C-CORE_2.12: Coastal resource mapping of mangroves, coral reefs, wetlands, and sandbanks • C-CORE_2.13: Coastal sediment dynamics estuarine fronts, and land-ocean interactions • CLS_3.2: Coastal morphology
Thematic Information Content	Linear shoreline vector
Spatial Resolution	1 m to 1 km (dependent on source satellite data and application)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10x10 km to 2000 x 2000 km
Minimum Mapping Unit (MMU)	10 m to >1km (depending on user requirements)
Temporal Resolution	User-defined update frequency, depends on expected rates of coastal change
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	• Typically archival access (depending on user requirements) • Near real-time processing for areas of rapid change
Accuracy	Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	• Vector format based on user requirements (e.g. shape file)
Data Access	• Open access via public sector providers (e.g. national mapping agencies) • Restricted access to products generated commercial suppliers
Validation Approach	• Comparison with in-situ observations • Geometric accuracy assessed with geospatial reference data
Method	• Visual interpretation • Semi-automated segmentation and classification
Degree of Automation	The product generation is typically semi-automated and requires significant operator input
EO Input Data	High, medium and low-resolution SAR and optical imagery (e.g. Cosmo-SkyMed; Radarsat-2; TerraSAR-X; Sentinel-1; GeoEye-1; QuickBird; IKONOS; WorldView-2; RapidEye; SPOT-5; LANDSAT-7; LANDSAT-8; MODIS)
Non-EO Input Data	• Ground-based observations and measurements • Aerial reconnaissance observations • Digital topographic maps and nautical charts
Contribution of EO	Major: this product is primarily based on EO imagery augmented by reference data for calibration and validation
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Archive data is available for trend analysis and model development
Maturity and Availability	The methodology is proven and considered mature: depending on user needs and complexity of the area of interest, TRL ranges from 5 to 7
Constraints and Limitations	• Cloud cover limits acquisition of optical imagery • Potentially complex relationship between image-derived information and physical quantities (e.g. mean sea level, local astronomic tide)
References	Boak, E. H. and Turner, I. L. (2005) Shoreline Definition and Detection: A Review. Journal of Coastal Research, Vol. 21, No. 4, pp. 688-703
Applicable Standards	• IHO standards • National mapping standards • User-defined standards

Shoreline Change

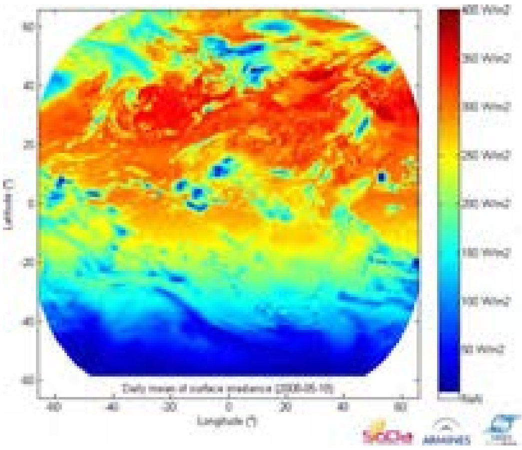
Shoreline changes can be detected through a variety of satellite data types. Using optical or SAR imagery, changes to a coastal shoreline can be observed daily, seasonally, or after events that may disturb the shoreline's original morphology. Representing this information can be completed by mapping affected area changes or by using polygon features.

Current Use:

- **Assess impacts of changing sea level and erosion (e.g. due to climate change)**
- **Evaluate morphological change over time to identify coastal processes or anomalies**
- **Monitoring impacts and degradation caused by anthropogenic activity**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.1: Monitoring of landfall site recovery and coastal vegetation • C-CORE_2.6: Distribution and abundance of seabirds • C-CORE_2.12: Coastal resource mapping of mangroves, coral reefs, wetlands, and sandbanks • C-CORE_2.13: Coastal sediment dynamics estuarine fronts, and land-ocean interactions • CLS_1.4: Environmental conditions • CLS_3.2: Coastal morphology • CLS_3.6: Estimation of climate change impact • CLS_5.2: Environmental monitoring • CLS_6.2: Site monitoring
Thematic Information Content	Location and characteristics of change
Spatial Resolution	1 m to 1 km (dependent on source satellite data and application)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10x10 km to 2000 x 2000 km
Minimum Mapping Unit (MMU)	2 m to 2 km (depending on source satellite data)
Temporal Resolution	Update frequency de[ends on user requirements (e.g. weekly, seasonally, yearly, event-driven)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Varies depending on user requirements, near real-time or archival processing
Accuracy	• Thematic accuracy: probability of detecting major shoreline change >95% • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Vector or gridded formats, depending on user requirements (e.g. GeoTIFF, shape file)
Data Access	Restricted access to products generated commercial suppliers
Validation Approach	• High resolution optical images • Aerial surveillance • In-situ observations
Method	• Visual interpretation • Semi-automated segmentation and classification • Time series analysis
Degree of Automation	Automated change detection and segmentation
EO Input Data	High, medium and low-resolution SAR and optical imagery (e.g. Cosmo-SkyMed; Radarsat-2; TerraSAR-X; Sentinel-1; GeoEye-1; QuickBird; IKONOS; WorldView-2; RapidEye; SPOT-5; LANDSAT-7; LANDSAT-8; MODIS)
Non-EO Input Data	• Ground-based observations and measurements • Aerial reconnaissance observations • Digital topographic maps and nautical charts
Contribution of EO	These products are based primarily on EO imagery, to be verified with ground-truth data
Data Source	• EO data: imagery providers • Non-EO data: user provided
Prospects	Archive data is available for trend analysis and model development
Maturity and Availability	The methodology is proven and considered mature: depending on user needs and complexity of the area of interest, TRL ranges from 5 to 7
Constraints and Limitations	• Cloud cover limits acquisition of optical imagert • Accurate identification of changes depends on quality of reference data • Robust estimates of change typically limited to major changes • Increased uncertainty in characterizing subtle changes • Increased risk of artifacts if images are not properly calibrated/normalized
References	Alesheikh, A.A, Ghorbanali, A. and Nouri, N., 2007. Coastline Change Detection Using Remote Sensing. International Journal of Environmental Science and Technology, 4 (1), 61-66.
Applicable Standards	User-defined



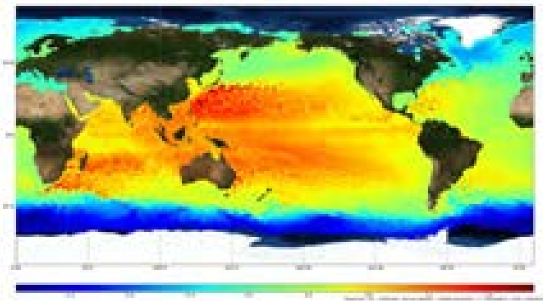
Solar Radiation

The Surface Solar Irradiance is a measure of Solar Radiation. It has virtually global coverage with high temporal resolution.

Current Use:
SSI was identified as an essential climate variable by the Global Climate Observing System meaning that it is a parameter of key importance for understanding and monitoring the global climate system. In addition to such climatology applications, SSI is of high interest in domains as varied as solar energy, health, architecture, agriculture, and forestry.

Geo-Information Requirements	This product relates to the following challenges: • CLS_OFF.3.3 : evaluation of the efficiency of the structure
Thematic Information Content	Surface Solar Irradiance
Spatial Resolution	3km at the Nadir
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	NA
Temporal Resolution	15 min
Geographic Coverage	Worldwide, in open ocean, from 66°S to 66°N
Timeliness	One day after acquisition
Accuracy	10 W/m^2 or 5%
Data Format	• Gridded maps, NetCDF with CF conventions. • Grib • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	The access is free for historic data and through subscription for opertaionnal data. It is accessed via a web map service (WMS) http://www.webservice-energy.org/, http://www.soda-pro.com/web-services/radiation/helioclim-3-for-free

Validation Approach	The measurements were validated against ground station data
Method	The calculation is done via the heliosat processing that combines cloud data, water vapour content and other inputs to determine the solar irradiance
Degree of Automation	This product can be generated automatically
EO Input Data	Microwave data from meteorological satellites (cloud data, water vapour
Non-EO Input Data	Geographic data and other
Contribution of EO	Major : this product is based on EO imagery
Data Source	EO Data : imagery providers
Prospects	New algorithm being developed and validated
Maturity and availability	The methodology is proven and considered as mature
Constraints and Limitations	
References	http://www.oie.mines-paristech.fr/Valorisation/Outils/Heliosat/
Applicable Standards	



Delayed-Time Global Gridded Absolute Dynamic Topography

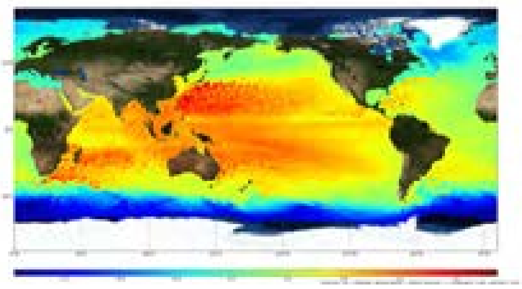
Multimission altimeter data delayed-time gridded Absolute Dynamic Topography product are high level processed products combining data from several altimetry missions (validation, cross calibration, filtering, optimal interpolation on a grid) and a Mean Dynamic Topography (MDT).

Current Use:

The gridded Absolute Dynamic Topography product is used to study the ocean dynamics (general circulation).

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.7 Surface current observations • CLS_OFF.1.2 : Model validation
Thematic Information Content	Absolute Dynamic Topography
Spatial Resolution	Cartesian grid of ¼°x¼° .
Spatial Coverage	Worldwide
Minimum Mapping Unit (MMU)	
Temporal Resolution	One map is produced every day taking into account a window of -42,+42 days of data.
Geographic Coverage	Global Ocean, enclosed seas
Timeliness	One reprocessing every 3-4 years. Extension of the time series every 3-4 months
Accuracy	Error of maps of SLA + error of MDT: some centimeters
Data Format	• Gridded maps produced in NetCDF CF • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Restricted. FTP or web Extraction tool.

Validation Approach	
Method	The sum of the Maps of Sea Level Anomalies and Mean Dynamic Topography (MDT)
Degree of Automation	The product is automatically generated
EO Input Data	Altimetrer and radiometer data: Topex/Poseidon, ERS-1&2, GFO, Envisat, Jason-1&2, Cryosat-2, HY-2A, SARAL/AltiKa
Non-EO Input Data	Models: ECMWF wet troposphere, MOG-2D for atmospheric correction, GIM for ionosphere correction, GOT4v8, Wahr, Cartright and Taylor for tidal correction, MSS CNES_CLS_11, MDT CNES_CLS_13
Contribution of EO	Major
Data Source	EO data : imagery providers
Prospects	New altimeters available (Jason-3, Sentinal 3A)
Maturity and availability	The methodology proven and considered mature
Constraints and Limitations	Well known in scientific community and underused for commercial purposes. A greater awareness is needed.
References	http://www.aviso.altimetry.fr
Applicable Standards	



Near-Real-Time Global Gridded Absolute Dynamic Topography

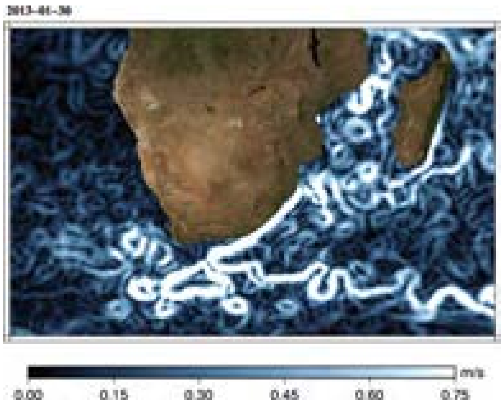
Multimission altimeter data near-real-time gridded Absolute Dynamic Topography product are high level processed products combining data from several altimetry missions (validation, cross calibration, filtering, optimal interpolation on a grid) and a Mean Dynamic Topography (MDT).

Current Use:

The gridded Absolute Dynamic Topography product is used to study the ocean dynamics (general circulation).

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.7 Surface current observations • CLS_OFF.1.2 : Model validation
Thematic Information Content	Absolute Dynamic Topography
Spatial Resolution	Cartesian grid of ¼°x¼° .
Spatial Coverage	Worldwide
Minimum Mapping Unit (MMU)	Cartesian grid of ¼°x¼° .
Temporal Resolution	One map is produced every day taking into account a window of -42, +6 days of data maximum.
Geographic Coverage	Global Ocean, enclosed seas
Timeliness	3 maps are produced: days D, D-3 and D-6. D-6 map being the more precise. Near Real Time (daily).
Accuracy	Error of maps of SLA + error of MDT: some centimeters
Data Format	• Gridded maps produced in NetCDF CF • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Restricted. FTP or web Extraction tool.

Validation Approach	
Method	The sum of the Maps of Sea Level Anomalies and Mean Dynamic Topography (MDT)
Degree of Automation	The product is automatically generated
EO Input Data	Altimeter and radiometer data: Jason-2, Cryosat-2, HY-2A, SARAL/AltiKa
Non-EO Input Data	Models: ECMWF wet troposphere, MOG-2D for atmospheric correction, GIM for ionosphere correction, GOT4v8, Wahr, Cartright and Taylor for tidal correction, MSS CNES_CLS 11, MDT CNES_CLS_13
Contribution of EO	Major
Data Source	EO data : image providers
Prospects	New altimeters available (Jason-3, Sentinal 3A)
Maturity and availability	The methodology proven and considered mature
Constraints and Limitations	Well known in scientific community and underused for commercial purposes. A greater awareness is needed.
References	http://www.aviso.altimetry.fr
Applicable Standards	



Delayed-Time Regional Gridded Absolute Geostrophic Velocities

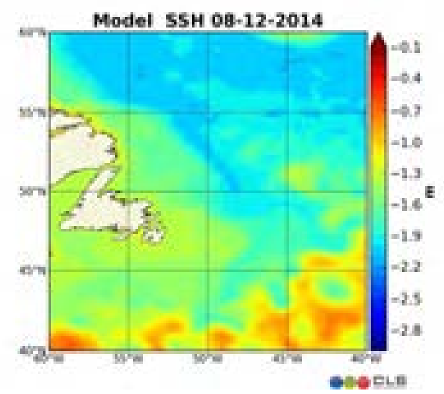
Multimission altimeter data delayed-time gridded Absolute Geostrophic Velocities products are high level processed products combining data from several altimetry missions (validation, cross calibration, filtering, optimal interpolation on a grid) and a Mean Dynamic Topography (MDT).

Current Use:

The gridded Absolute Geostrophic Velocities product is used to study of ocean general circulation

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.7 Surface current observations • CLS_OFF.1.2 : Model validation
Thematic Information Content	Absolute Dynamic Topography
Spatial Resolution	Cartesian grid of 1/8°x1/8°.
Spatial Coverage	Depending on user requirements
Minimum Mapping Unit (MMU)	
Temporal Resolution	One map is produced every day taking into account a window of -42,+42 days of data.
Geographic Coverage	Regional area (Mediterranean, Black Sea, Bresilian area,…)
Timeliness	One reprocessing every 3-4 years. Extension of the time series every 3-4 months
Accuracy	Not evaluated
Data Format	• Gridded maps produced in NetCDF CF • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Restricted. FTP or web Extraction tool.

Validation Approach	
Method	The sum of the Maps of Sea Level Anomalies and Mean Dynamic Topography (MDT) gives the mpas of ADT. The absolute currents are calculated using the 9-point stencil width method (Arbic B. K, R. B. Scott, D. B. Chelton, J. G. Richman and J. F. Shriver, 2012, Effects on stencil width on surface ocean geostrophic velocity and vorticity estimation from gridded satellite altimeter data, J. Geophys. Res., vol117, C03029, doi:10.1029/2011JC007367.)
Degree of Automation	The product is automatically generated
EO Input Data	Altimetry
Non-EO Input Data	Altimetrer and radiometer data: Topex/Poseidon, ERS-1&2, GFO, Envisat, Jason-1&2, Cryosat-2, HY-2A, SARAL/AltiKa Models: ECMWF wet troposphere, MOG-2D for atmospheric correction, GIM for ionosphere correction, GOT4v8 or dedicated tidal model depending on the region, Wahr, Cartright and Taylor for tidal correction, MSS CNES_CLS_11, MDT CNES_CLS_13
Contribution of EO	Major
Data Source	EO
Prospects	New altimeters available (Jason-3, Sentinal 3A)
Maturity and availability	The methodology proven and considered mature
Constraints and Limitations	Well known in scientific community and underused for commercial purposes. A greater awareness is needed.
References	http://www.aviso.altimetry.fr
Applicable Standards	



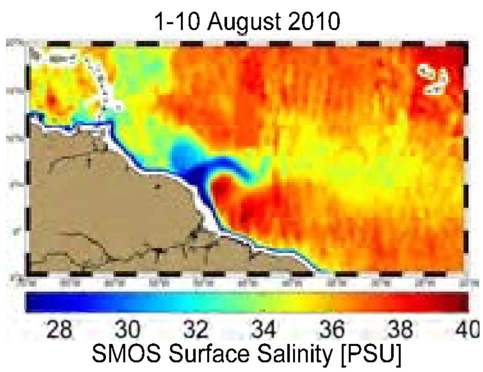
Sea Surface height Model

SSH model is a high resolution dataset that has global coverage. It is an output of ocean general circulation models that incorporate EO data (altimetry and SST) as well as in situ sensors.

Current Use:
The SSH product provides information on the ocean dynamics. It is often used together with other products like sea surface salinity to better identify the position of eddies and frontal areas.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.7 Surface current observations
Thematic Information Content	Sea Surface Height
Spatial Resolution	The spatial resolution is of the order of 8km (1/12°) for global products
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	Depending on user requirements
Temporal Resolution	Hourly with forecast
Geographic Coverage	Worldwide
Timeliness	The product is updated every day as standard
Accuracy	Typical product accuracy is highly variable, depending on the region of interest and the amount of observation available and assimilated. In particular, the accuracy is low and the vicinity of fronts
Data Format	• Gridded maps, NetCDF with CF conventions. • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted for the hourly data. The daily data is often free

Validation Approach	This product has been validated thoroughly by Researchers
Method	The product is an output of ocean general circulation model. These models assimilate temperature and altimetry data from satellites and in situ sensors. The models have a governing set of fluid dynamic equations which are used to pogress to the next time step
Degree of Automation	fully automated
EO Input Data	AVHRR on NOAA and EUMETSAT satellites, MODIS on NASA satellites Sea surface height anomaly from Jason satellite
Non-EO Input Data	Atmospheric forcing, boundary conditions, bathymetry
Contribution of EO	Low: used through data assimilation schemes
Data Source	EO data : image providers
Prospects	Models are likely to improve in terms of resolution and the amount of observational data assimilated.
Maturity and availability	Highly mature (operational use for over 10 years)
Constraints and Limitations	None
References	
Applicable Standards	



Sea Surface Salinity Composite

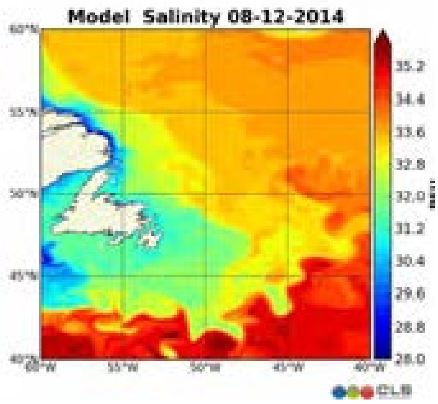
SSS Swath composite is a medium resolution daily dataset with worldwide coverage. It is build by using all swath data available, from either the SMOS or the Aquarius mission. As a result, it has no gaps due to clouds.

Current Use:

The SSS product provides information on the ocean dynamics. It is often used together with other products like sea level anomaly to better identify the position of eddies and frontal areas

Geo-Information Requirements	This product relates to the following challenges: • CLS_OFF.2.3 : Seismic survey: sound propagation properties • CLS_OFF.2.6 : Drilling Suvrey preparation : Environmental conditions
Thematic Information Content	Sea Surface Salinity
Spatial Resolution	43km
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	
Temporal Resolution	Daily
Geographic Coverage	Worldwide
Timeliness	The product is usually available a day after acquisition
Accuracy	0.5 PSU to 1.0 PSU
Data Format	• Gridded maps, NetCDF with CF conventions. • Grib • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted, the product is not as yet operational.

Validation Approach	This product has been validated thoroughly by Researchers
Method	Product is built by a time compositing of SSS measurements. The dielectric constant for seawater is influenced, among other variables, by salinity. It is therefore possible to estimate sea-surface salinity from passive microwave observations, as long as other variables influencing the brightness-temperature signal can be accounted for
Degree of Automation	fully automated
EO Input Data	Microwave Imaging Radiometer Data using Aperture Synthesis – MIRAS L band interferometric synthetic aperture Radiometer (1.4 GHz)
Non-EO Input Data	None
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data : image providers
Prospects	
Maturity and availability	Prototype stage
Constraints and Limitations	Other variables such a Sea-Surface Temperature (SST), surface roughness, foam coverage, sun glint, rainfall, ionospheric effects and galactic/cosmic background radiation need to be acquired in order to obtain an SSS value
References	http://www.esa.int/esapub/bulletin/bullet111/chapter19_bul111.pdf
Applicable Standards	



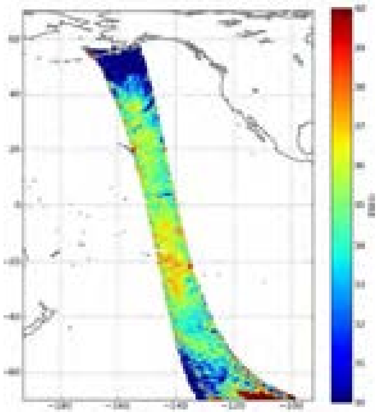
Sea Surface Salinity Model

SSS model is a high resolution dataset that has global coverage. It is an output of ocean general circulation models that incorporate EO data (altimetry and SST) as well as in situ sensors.

Current Use:
The SSS product provides information on the ocean dynamics. It is often used together with other products like sea level anomaly to better identify the position of eddies and frontal areas.

Geo-Information Requirements	This product relates to the following challenges: • CLS_OFF.2.3 : Seismic survey: sound propagation properties • CLS_OFF.2.6 : Drilling Suvrey preparation : Environmental conditions
Thematic Information Content	Sea Surface Salinity
Spatial Resolution	The spatial resolution is of the order of 8km (1/12°) for global products
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	
Temporal Resolution	Hourly with forecast
Geographic Coverage	Worldwide
Timeliness	The product is updated every day as standard
Accuracy	Typical product accuracy is highly variable, depending on the region of interest and the amount of observation available and assimilated. In particular, the accuracy is low and the vicinity of fronts
Data Format	• Gridded maps, NetCDF with CF conventions. • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted for the hourly data. The daily data is often free

Validation Approach	This product has been validated thoroughly by Researchers
Method	The product is and output of ocean general circulation models. These models assimilate temperature and altimetry data from satellites and in situ sensors. The models have a governing set of fluid dynamic equations which are used to pogress to the next time step
Degree of Automation	fully automated
EO Input Data	AVHRR on NOAA and EUMETSAT satellites, MODIS on NASA satellites Sea surface height anomaly from Jason satellite
Non-EO Input Data	Atmospheric forcing, boundary conditions, bathymetry
Contribution of EO	Low: used through data assimilation schemes
Data Source	EO data : image providers
Prospects	Models are likely to improve in terms of resolution and the amount of observational data assimilated.
Maturity and availability	Highly mature (operational use for over 10 years)
Constraints and Limitations	None
References	
Applicable Standards	



Sea Surface Salinity Swath

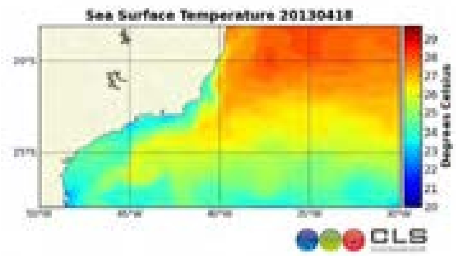
SSS Swath is a medium resolution daily dataset with worldwide coverage. It is build by using data available from either the SMOS or the Aquarius mission.

Current Use:
The SSS product provides information on the ocean dynamics. It is often used together with other products like sea level anomaly to better identify the position of eddies and frontal areas.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.14: Coastal upwelling • C-CORE_2.15: Fish and fish habitat • CLS_1.2: Model validation • CLS_1.4: Environmental conditions • CLS_2.1: Selection of the drilling rig • CLS_2.3: Seismic survey (sound propagation properties) • CLS_2.6: Drilling Survey preparation (Environmental conditions) • CLS_5.2: Environmental monitoring
Thematic Information Content	Sea Surface Salinity
Spatial Resolution	43km
Spatial Coverage	1000km swath
Minimum Mapping Unit (MMU)	depending on user requirements
Temporal Resolution	Continuous acquisition
Geographic Coverage	Global, in 3 Day
Timeliness	The product is usually available a day after acquisition
Accuracy	0.5 PSU to 1.0 PSU
Data Format	• Gridded maps, NetCDF with CF conventions. • Grib • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted, the product is not as yet operational.

Validation Approach	This product has been validated thoroughly by researchers
Method	The dielectric constant for seawater is influenced, among other variables, by salinity. It is therefore possible to estimate sea-surface salinity from passive microwave observations, as long as other variables influencing the brightness-temperature signal can be accounted for.
Degree of Automation	fully automated
EO Input Data	Microwave Imaging Radiometer Data using Aperture Synthesis – MIRAS L band interferometric synthetic aperture Radiometer (1.4 GHz)
Non-EO Input Data	None
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data : image providers
Prospects	
Maturity and availability	Prototype stage
Constraints and Limitations	Other variables such a Sea-Surface Temperature (SST), surface roughness, foam coverage, sun glint, rainfall, ionospheric effects and galactic/cosmic background radiation need to be acquired in order to obtain an SSS value.
References	http://www.esa.int/esapub/bulletin/bullet111/chapter19_bul111.pdf
Applicable Standards	User-defined

Sea Surface Temperature Composite



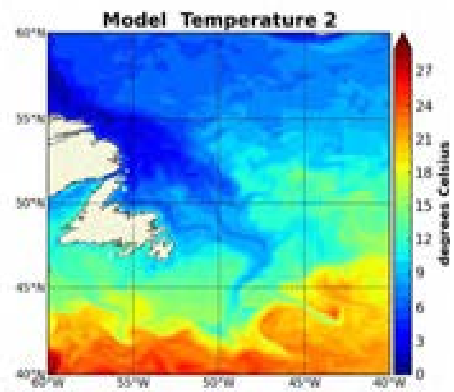
SST Swath composite is a medium resolution daily dataset with worldwide coverage. It is build by using all swath data available, microwave and radiometer. As a result, it has no gaps due to clouds.

Current Use:

- Providing information on Ocean dynamics. It is often used together with other products like sea level anomaly to better identify the position of eddies and frontal areas.
- Monitoring of SST and changes in SST in relation to its effect on marine habitats;
- Analysing long term changes in SST which can affect circulation patterns, nutrient upwelling and influence marine animal populations;
- Impact on weather patterns and storm tracks
- Used as input for climate change models

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.15 Sea surface temperatures • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.14: Coastal upwelling • C-CORE_2.15: Fish and fish habitat • CLS_1.2: Model validation • CLS_1.4: Environmental conditions • CLS_2.1: Selection of the drilling rig • CLS_2.3: Seismic survey (sound propagation properties) • CLS_2.6: Drilling Survey preparation (Environmental conditions) • CLS_5.2: Environmental monitoring
Thematic Information Content	Sea Surface Temperature (SST) directly affects the species of plants and animals that are present in a location. Long term change in SST is an indicator of climate change and affects numerous environmental variables.
Spatial Resolution	The spatial resolution is of the order of 10km
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	Depending on user requirements
Temporal Resolution	daily
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	The product is usually available a day after acquisition
Accuracy	Typical product accuracy varies between 0.4 °C in clear sky areas, and may degrade up to 1°C in cloudy areas depending on the type of measurement avaialble

Data Format	• Gridded maps, NetCDF with CF conventions. • Grib • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted (usually by payment). Products typically available online with some temporal delay.
Validation Approach	This product has been validated thoroughly by researchers.
Method	Product is built by a time compositing of SST measurements of several sensors (AVHRR/NOAA19, AVHRR/METOP-A, AVHRR/METOP-B, MODIS/TERRA, MODIS/AQUA). AVHRR data are L0 data (counts) acquired from NOAA/CLASS and are processed to L2 using the AAPP software package and a dedicated cloud masking procedure. MODIS data are L2 products acquired from NASA/OBPG.
Degree of Automation	fully automated
EO Input Data	Infra-red or microwave radiometers AVHRR on NOAA and EUMETSAT satellites, MODIS on NASA satellites
Non-EO Input Data	None
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data : image providers
Prospects	Next use of VIIRS sensor on NASA/NOAA Suomi-NPP satellite.
Maturity and availability	Highly mature (operational use for over 10 years). The methodology is proven and considered mature: TRL = 7
Constraints and Limitations	None
References	Reynolds, R. W., & Smith, T. M. (1994). Improved global sea surface temperature analyses using optimum interpolation. Journal of climate, 7(6), 929-948.
Applicable Standards	User-defined



Sea Surface Temperature Model

SST model is a high resolution dataset that has global coverage. It is an output of ocean general circulation models that incorporate EO data (altimetry and SST) as well as in situ sensors.

Current Use:

- Providing information on Ocean dynamics. It is often used together with other products like sea level anomaly to better identify the position of eddies and frontal areas.
- Monitoring of SST and changes in SST in relation to its effect on marine habitats;
- Analysing long term changes in SST which can affect circulation patterns, nutrient upwelling and influence marine animal populations;
- Impact on weather patterns and storm tracks
- Used as input for climate change models

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.15 Sea surface temperatures • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.14: Coastal upwelling • C-CORE_2.15: Fish and fish habitat • CLS_1.4: Environmental conditions • CLS_2.1: Selection of the drilling rig • CLS_2.3: Seismic survey (sound propagation properties) • CLS_2.6: Drilling Survey preparation (Environmental conditions) • CLS_5.2: Environmental monitoring
Thematic Information Content	Sea Surface Temperature (SST) directly affects the species of plants and animals that are present in a location. Long term change in SST is an indicator of climate change and affects numerous environmental variables.
Spatial Resolution	The spatial resolution is of the order of 8km (1/12°) for global products
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	Depending on user requirements
Temporal Resolution	Hourly with forecast
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	The product is updated every day as standard
Accuracy	Typical product accuracy is highly variable, depending on the region of interest and the amount of observation available and assimilated. In particular, the accuracy is low and the vicinity of fronts

Data Format	• Gridded maps, NetCDF with CF conventions. • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted for the hourly data. The daily data is often free
Validation Approach	This product has been validated thoroughly by researchers
Method	The product is and output of ocean general circulation models. These models assimilate temperature and altimetry data from satellites and in situ sensors. The models have a governing set of fluid dynamic equations which are used to pogress to the next time step
Degree of Automation	Fully automated
EO Input Data	AVHRR on NOAA and EUMETSAT satellites, MODIS on NASA satellites Sea surface height anomaly from Jason satellite
Non-EO Input Data	Atmospheric forcing, boundary conditions, bathymetry
Contribution of EO	Low: used through data assimilation schemes
Data Source	EO data : image providers
Prospects	Models are likely to improve in terms of resolution and the amount of observational data assimilated.
Maturity and availability	Highly mature (operational use for over 10 years). The methodology is proven and considered mature: TRL = 7
Constraints and Limitations	None
References	
Applicable Standards	User-defined

Sea Surface Temperature Swath Microwave

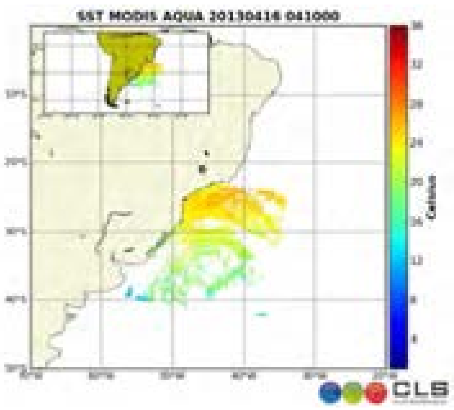
SST Swath microwave is a medium resolution daily dataset with worldwide coverage. It greatest asset is the fact that it can see through clouds

Current Use:

- Providing information on Ocean dynamics. It is often used together with other products like sea level anomaly to better identify the position of eddies and frontal areas.
- Monitoring of SST and changes in SST in relation to its effect on marine habitats;
- Analysing long term changes in SST which can affect circulation patterns, nutrient upwelling and influence marine animal populations;
- Impact on weather patterns and storm tracks
- Used as input for climate change models

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.15 Sea surface temperatures • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.14: Coastal upwelling • C-CORE_2.15: Fish and fish habitat • CLS_1.2: Model validation • CLS_1.4: Environmental conditions • CLS_2.1: Selection of the drilling rig • CLS_2.3: Seismic survey (sound propagation properties) • CLS_2.6: Drilling Survey preparation (Environmental conditions) • CLS_5.2: Environmental monitoring
Thematic Information Content	Sea Surface Temperature (SST) directly affects the species of plants and animals that are present in a location. Long term change in SST is an indicator of climate change and affects numerous environmental variables.
Spatial Resolution	The spatial resolution is of the order of 10km
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	Depending on user requirements
Temporal Resolution	Daily
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	The product is available each day and is available a few hours after acquisition
Accuracy	Typical product accuracy varies between 0.4 °C in clear sky areas, and may degrade up to 1°C in cloudy areas. Microwave radiometers measure through clouds but are less accurate than infra-red technology.

Data Format	• Gridded maps, NetCDF with CF conventions. • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted (usually by payment).
Validation Approach	This product has been validated thoroughly by researchers.
Method	The Product is built through the processing of the data received by the satellite. This processing includes corrections for atmospheric effects. In order to avoid the skin effect, only night time measurements are used.
Degree of Automation	Fully automated
EO Input Data	Infra-red or microwave radiometers AVHRR on NOAA and EUMETSAT satellites, MODIS on NASA satellites
Non-EO Input Data	None
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data : image providers
Prospects	Next use of VIIRS sensor on NASA/NOAA Suomi-NPP satellite.
Maturity and availability	Highly mature (operational use for over 10 years). The methodology is proven and considered mature: TRL = 7
Constraints and Limitations	None
References	Reynolds, R. W., & Smith, T. M. (1994). Improved global sea surface temperature analyses using optimum interpolation. Journal of climate, 7(6), 929-948.
Applicable Standards	User-defined



Sea Surface Temperature Swath Radiometer

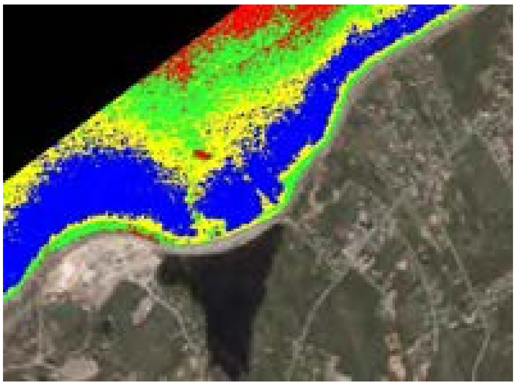
SST Swath radiometer is a high resolution daily dataset with worldwide coverage. It greatest asset is the high resolution of the dataset

Current Use:

- Providing information on Ocean dynamics. It is often used together with other products like sea level anomaly to better identify the position of eddies and frontal areas.
- Monitoring of SST and changes in SST in relation to its effect on marine habitats;
- Analysing long term changes in SST which can affect circulation patterns, nutrient upwelling and influence marine animal populations;
- Impact on weather patterns and storm tracks
- Used as input for climate change models

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.15 Sea surface temperatures • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.14: Coastal upwelling • C-CORE_2.15: Fish and fish habitat • CLS_1.2: Model validation • CLS_1.4: Environmental conditions • CLS_2.1: Selection of the drilling rig • CLS_2.3: Seismic survey (sound propagation properties) • CLS_2.6: Drilling Survey preparation (Environmental conditions) • CLS_5.2: Environmental monitoring
Thematic Information Content	Sea Surface Temperature (SST) directly affects the species of plants and animals that are present in a location. Long term change in SST is an indicator of climate change and affects numerous environmental variables.
Spatial Resolution	The spatial resolution can go down to 1km. 2km and 4km products are also available
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	Depending on user requirements
Temporal Resolution	Daily
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	The product is available each day and is available a few hours after acquisition
Accuracy	Typical product accuracy varies between 0.4 °C in clear sky areas, and may degrade up to 1°C in cloudy areas. SST loss of accuracy occurs with infra-red radiometers is due to the uncertainty to correctly identify the cloud.

Data Format	• Gridded maps, NetCDF with CF conventions. • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted (usually by payment).
Validation Approach	This product has been validated thoroughly by researchers
Method	The Product is built through the processing of the data received by the satellite. This processing includes corrections for atmospheric effects. In order to avoid the skin effect, only night time measurements are used.
Degree of Automation	Fully automated
EO Input Data	Infra-red radiometers AVHRR on NOAA and EUMETSAT satellites, MODIS on NASA satellites
Non-EO Input Data	None
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data : image providers
Prospects	Next use of VIIRS sensor on NASA/NOAA Suomi-NPP satellite.
Maturity and availability	Highly mature (operational use for over 10 years) The methodology is proven and considered mature: TRL = 7
Constraints and Limitations	None
References	Reynolds, R. W., & Smith, T. M. (1994). Improved global sea surface temperature analyses using optimum interpolation. Journal of climate, 7(6), 929-948.
Applicable Standards	User-defined



Subtidal Habitat

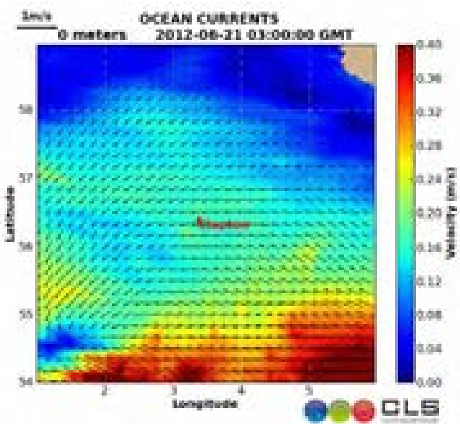
Optical satellite imagery is analyzed to extract bottom type in shallow water. The method is applicable to clear, shallow water, typically with water depths of less than 20 meters. In some cases, the extraction of bottom at water depths of close to 40 meters may be possible.

Current Use:

- **Broad context is monitoring of coastal environments**
- **Mapping and inventory of critical subtidal habitat**
- **Input to environmental sensitivity mapping**
- **Evaluation of changes over time due to natural or anthropogenic causes**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.1: Monitoring of landfall site recovery and coastal vegetation • C-CORE _2.11: Monitoring of waste management practices • C-CORE _2.12: Coastal resource mapping of mangroves, coral reefs, wetlands and sandbanks • C-CORE _2.13: Coastal sediment dynamics, estuarine fronts and land-ocean interactions • C-CORE _2.15: Fish and fish habitat • C-CORE _2.2: Submarine landslides and seabed stability • CLS_1.4 Environmental conditions • CLS_2.1 Selection of the drilling rig • CLS_3.2 Coastal morphology • CLS_3.6 Estimation of the Climate Change impact • CLS_4.2 Pollution monitoring • CLS_5.2 Environmental monitoring • CLS_6.2 Site monitoring
Thematic Information Content	Bottom type categories (e.g. sand, seagrass, coral)
Spatial Resolution	1 m to 30 m (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10 x 10 km to 185 x 185 km
Minimum Mapping Unit (MMU)	10 m^2 to 1 ha (depending on user requirements)
Temporal Resolution	Update frequency typically seasonally to multi-year; more frequent updates possible (e.g. monthly); update frequency depends on user requirements
Geographic Coverage	Global: coastal areas
Timeliness	Processing of archival or purpose-acquired imagery

Accuracy	• Thematic accuracy: classification accuracy ranging from 80 to >95% • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)
Data Format	Gridded or vector format based on user requirements (e.g. GeoTIFF, HDF, IMG, .SHP)
Data Access	Restricted access from commercial suppliers
Validation Approach	• Comparison with ground validation field data • Geometric accuracy assessed with geospatial reference data
Method	• Extraction from reflective spectral bands using ratio of water attenuation coefficients to separate signal into depth-dependent and bottom-dependent com • Image classification • Visual interpretation
Degree of Automation	The process is semi-automated and requires some operator involvement
EO Input Data	High and medium-resolution optical imagery (e.g. LANDSAT-8; IKONOS; WorldView; QuickBird; SPOT)
Non-EO Input Data	• Water depth measurements • Water column attenuation coefficients
Contribution of EO	Major: this product is primarily based on EO imagery calibrated with in-situ data
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Satellite-derived bottom type mapping has matured considerably in recent years, resulting in operational service offerings by several commercial
Maturity and Availability	• The methodology proven and considered mature: TRL = 7 • Product available from commercial suppliers on demand
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Relatively low accuracy without water depth ground truth • Method requires calm conditions and clear water • Typically applied to depths of less than 20 m, although theoretical maximum deoth for extraction is close to 40 m
References	Lyzenga D., 1978. Passive remote sensing techniques for mapping water depth and bottom features. Applied Optics, 17(3), pp. 379-383.
Applicable Standards	User-defined



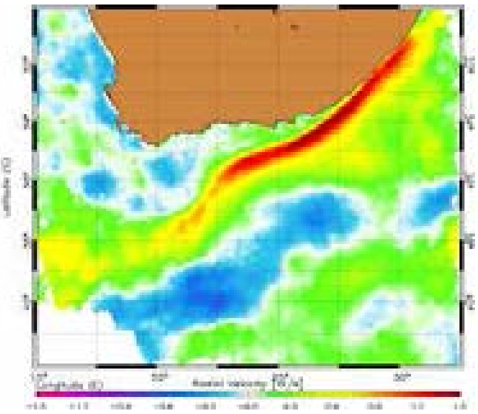
Surface Current Model

Surface Current model is a high resolution dataset that has global coverage. It is an output of ocean general circulation models that incorporate EO data (altimetry and SST) as well as in situ sensors.

Current Use:
The Surface Current product provides information on the ocean dynamics. It allows the identification of eddies, current veins and other dynamic features.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.3 : Historic records for surface currents • C-CORE.OFF1.7 : Surface current observations • CLS_OFF.1.1 : Historic Metocean data for high level risk assessment • CLS_OFF.1.3 : Inputs for numerical model • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.2.2 : seismic survey: current velocities (3D and 4d surveys) • CLS_OFF.2.5 : Drilling Survey preparation : Metocean conditions, hindcast & forecast • CLS_OFF.3.1 : Recommendations on the design of the structure • CLS_OFF.3.3 : evaluation of the efficiency of the structure
Thematic Information Content	Surface Currents
Spatial Resolution	The spatial resolution is of the order of 8km (1/12°) for global products
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	
Temporal Resolution	Hourly with forecast
Geographic Coverage	Worldwide
Timeliness	The product is updated every day as standard
Accuracy	Typical product accuracy is highly variable, depending on the region of interest and the amount of observation available and assimilated. In particular, the accuracy is low and the vicinity of fronts
Data Format	• Gridded maps, NetCDF with CF conventions. • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted for the hourly data. The daily data is often free

Validation Approach	This product has been validated thoroughly by Researchers
Method	The product is an output of ocean general circulation model. These models assimilate temperature and altimetry data from satellites and in situ sensors. The models have a governing set of fluid dynamic equations which are used to progress to the next time step
Degree of Automation	Fully automated
EO Input Data	AVHRR on NOAA and EUMETSAT satellites, MODIS on NASA satellites Sea surface height anomaly from Jason satellite
Non-EO Input Data	Atmospheric forcing, boundary conditions, bathymetry
Contribution of EO	Low: used through data assimilation schemes
Data Source	EO data : image providers
Prospects	Models are likely to improve in terms of resolution and the amount of observational data assimilated.
Maturity and availability	Highly mature (operational use for over 10 years)
Constraints and Limitations	None
References	
Applicable Standards	



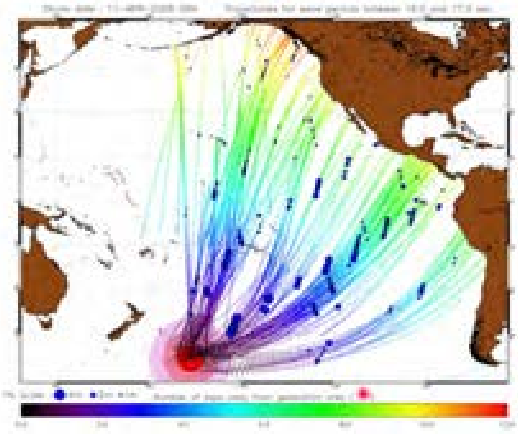
Radial Surface current

This product gives information on the surface current in the range direction based on SAR images. It gives information on the global ocean surface circulation.

Current Use:
This product has no currently operational application.

Geo-Information Requirements	This product relates to the following challenges: • C-Core.OFF1.3 : Historic records for surface currents • C-Core.OFF1.7 : Surface current observations • CLS_OFF.1.1 : Historic Metocean data for high level risk assessment • CLS_OFF.1.3 : Inputs for numerical model • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.2.2 : seismic survey: current velocities (3D and 4d surveys) • CLS_OFF.2.5 : Drilling Survey preparation : Metocean conditions, hindcast & forecast • CLS_OFF.3.1 : Recommendations on the design of the structure • CLS_OFF.3.3 : evaluation of the efficiency of the structure
Thematic Information Content	Surface current in the range direction.
Spatial Resolution	1/8
Spatial Coverage	It depends on the SAR images
Minimum Mapping Unit (MMU)	NA
Temporal Resolution	Daily
Geographic Coverage	Worldwide
Timeliness	NA
Accuracy	NA
Data Format	NetCDF, PNG
Data Access	The access is restricted The access can be done via FTP, web service (selection via a catalog), or on DVD

Validation Approach	Drifting buoys, model and altimetry current are used to validate the radial surface current data
Method	The doppler signal contained in the SAR images is used to extract the contribution from the sea surface current Wind model are used to remove the wind effect on the doppler signal
Degree of Automation	The product can be generated automatically
EO Input Data	SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	Wind model to remove the contribution of wind in the Doppler signal extracted from SAR images
Contribution of EO	Major: this product is based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data : ECMWF
Prospects	Radial surface current measurement can be mixed with current from altimetry to have an higher resolution current product
Maturity and availability	This product is at R&D stage
Constraints and Limitations	Only can the radial velocity be measured
References	Johannessen, J. A., B. Chapron, F. Collard, V. Kudryavtsev, A. Mouche, D. Akimov, and K.-F. Dagestad. “Direct Ocean Surface Velocity Measurements from Space: Improved Quantitative Interpretation of Envisat ASAR Observations.” Geophys. Res. Lett. 35 (2008): L22608. doi:10.1029/2008GL035709. Hansen, M.W., F. Collard, K. Dagestad, J.A. Johannessen, P. Fabry, and B. Chapron. “Retrieval of Sea Surface Range Velocities From Envisat ASAR Doppler Centroid Measurements.” IEEE Transactions on Geoscience and Remote Sensing 49, no. 10 (October 2011): 3582–92. doi:10.1109/TGRS.2011.2153864.
Applicable Standards	



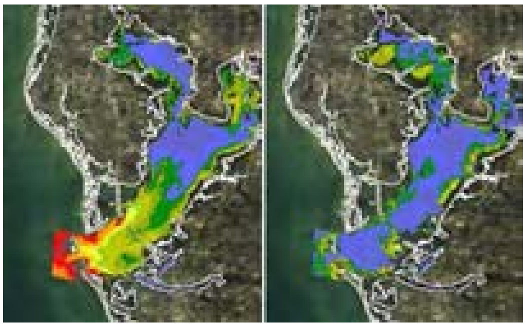
Swell SAR

Estimation of swell characteristics in Open Ocean.

Current Use:
This product is currently used for assimilation in numerical wave models.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.6 : Wave observations • CLS_OFF.1.2 : Model validation • CLS_OFF.1.3 : Inputs for numerical model • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.2.5 : Drilling Survey preparation : Metocean conditions, hindcast & forecast • CLS_OFF.3.4 : Metocean forecast to avoid down time • CLS_OFF.4.4 : Safety of marine operations • CLS_OFF.5.1 : Metocean monitoring
Thematic Information Content	This products contains the following parameters for each swell system: • Significant wave height • Wavelength • Direction
Spatial Resolution	1°
Spatial Coverage	NA
Minimum Mapping Unit (MMU)	NA
Temporal Resolution	3 hours
Geographic Coverage	Worldwide, in open ocean
Timeliness	Generated daily
Accuracy	• Significant wave height : 30cm • Wavelength : 36m • Direction : 15°
Data Format	NetCDF
Data Access	The access is restricted. The data are available via FTP.

Validation Approach	The estimation is validated with in situ measurement of directional wave spectra from moored buoys
Method	The forecast is the result of a combination of different SAR images from which is measured the directional swell spectra.
Degree of Automation	This product can be generated automatically
EO Input Data	SAR Images from : • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	NA
Contribution of EO	Major : this product is based on EO imagery
Data Source	EO data: imagery providers
Prospects	Assimilation into numerical model for better swell estimation
Maturity and availability	The methodology is proven and considered as mature The product is available from commercial suppliers on demand
Constraints and Limitations	This product is only available in open ocean and cannot be produced in the island shadows (depending on swell direction).
References	Collard, Fabrice, Fabrice Ardhuin, and Bertrand Chapron. “Monitoring and Analysis of Ocean Swell Fields Using a Spaceborne SAR: A New Method for Routine Observations.” J. Geophys. Res. 114 (2009): C07023. Husson, R. “Development and Validation of a Global Observation-Based Swell Model Using Synthetic Aperture Radar Operating in Wave Mode.” IUEM - EDSM, 2012.
Applicable Standards	



Red, yellow, orange = high turbidity; blue, green = low turbidity (Image Source: http://coastal.er.usgs.gov/pontchartrain/imagery/water.html)

Turbidity (Qualitative)

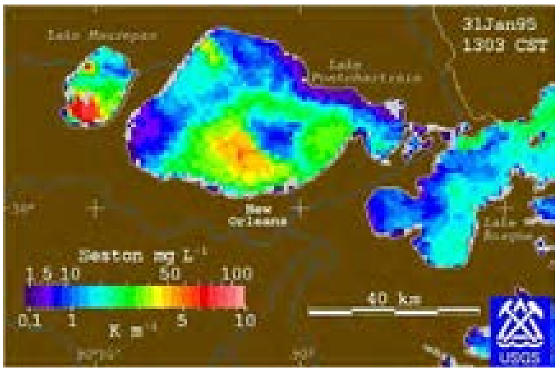
Optical satellite imagery is analyzed to extract qualitative turbidity levels from water color. Areas of turbidity are detected, delineated and assigned turbidity levels (e.g. high, medium, low) derived from image values. Turbidity increases the backscatter of light and can be estimated based on image tone and hue.

Current Use:

- **Broad context is monitoring of water quality; turbidity may be caused by phytoplankton or suspended sediment**
- **EO-based monitoring provides information related to environmental characterization and baseline conditions, effects of infrastructure development and contaminants associated with suspended materials**
- **Helpful contextual information for the design of field sampling campaigns**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.4: Detection and monitoring of pollutant discharges • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.10: Monitoring of chlorophyll-a • C-CORE_2.11: Monitoring of waste management practices • C-CORE_2.14: Coastal upwelling • CLS_1.4: Environmental conditions • CLS_2.6: Drilling survey preparation: environmental conditions • CLS_3.5: Monitoring of the water quality/turbidity during operations • CLS_3.6: Estimation of climate change impact • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring
Thematic Information Content	Delineated areas of turbidity; classes can defined by a range of terminology (e.g.High, medium low) (e.g. None, slight, moderate, heavy)
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10 x 10 km to 3000 x 3000 km
Minimum Mapping Unit (MMU)	<1 ha to 100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal (dependent on source data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Thematic accuracy: r^2 ranging from 0.7 to 0.9 • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Access	• Restricted access to information products generated by private sector service providers
Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG)
Validation Approach	• Comparison with concurrent in-situ measurements (where available) • Geometric accuracy assessed with geospatial reference data
Method	• Calculation of spectral induces related turbidity • Segmentation and/or unsupervised classification algorithms • Visual image interpretation • Change detection and time series analyses
Degree of Automation	The generation of spectral indices and simple classifications rages from fully automated to semi-automated with significant operator input
EO Input Data	High, medium and low resolution optical imagery (e.g. WORLDVIEW-2; LANDSAT-8; MERIS (archival); MODIS; AVHRR)
Non-EO Input Data	• In-situ measurements of turbidity if goal is calibration and/or validation • Optional: Measured, modeled or estimated atmospheric parameters
Contribution of EO	Major: this product is primarily based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Qualitative products are useful in identifying spatio-temporal characteristics of anomalies, especially in remote, inaccessible areas
Maturity and availability	• For qualitative products, TRL = 7 • Products are available from commercial suppliers on demand
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Images under analysis need to be radiometrically normalized to enable comparison • Artifacts due to atmospheric effects need to be considered
References	• Moore, G. K. (1980). Satellite remote sensing of water turbidity/Sonde de télémesure par satellite de la turbidité de l'eau. Hydrological Sciences Journal, 25(4), 407-421. • Hellweger, F. L., Schlosser, P., Lall, U., & Weissel, J. K. (2004). Use of satellite imagery for water quality studies in New York Harbor. Estuarine, Coastal and Shelf Science, 61(3), 437-448.
Applicable Standards	User-defined



http://coastal.er.usgs.gov/pontchartrain/imagery/water.html

Turbidity (Quantitative)

Optical satellite imagery is analyzed to extract quantitative turbidity levels from water color. The analysis requires the availability of concurrent in-situ measurements to establish an empirical relationship with remotely sensed radiance or reflectance.

Current Use:

- **Broad context is monitoring of water quality**
- **Turbidity may be caused by phytoplankton or suspended sediment**
- **EO-based monitoring provides information related to environmental characterization and baseline conditions, effects of infrastructure development and contaminants associated with suspended materials**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.4: Detection and monitoring of pollutant discharges • C-CORE_2.5: Distribution and abundance of marine mammals • C-CORE_2.10: Monitoring of chlorophyll-a • C-CORE_2.11: Monitoring of waste management practices • C-CORE_2.14: Coastal upwelling • CLS_1.4: Environmental conditions • CLS_2.6: Drilling survey preparation: environmental conditions • CLS_3.5: Monitoring of the water quality/turbidity during operations • CLS_3.6: Estimation of climate change impact • CLS_4.2: Pollution monitoring • CLS_5.2: Environmental monitoring
Thematic Information Content	• Nephelometric Turbidity Units (NTU) • Formazin Nephelometric Unit (FNU)
Spatial Resolution	1 m to 1 km (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from approx. 10 x 10 km to 3000 x 3000 km (dependent on source satellite data)
Minimum Mapping Unit (MMU)	<1 ha to 100 ha (depending on user requirements)
Temporal Resolution	Daily, monthly, seasonal (dependent on revisit capacity of source satellite data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Thematic accuracy: r^2 ranging from 0.7 to 0.9 • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)

Data Format	Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG)
Data Access	Restricted access to information products generated by private sector service providers
Validation Approach	• Comparison with concurrent in-situ measurements • Geometric accuracy assessed with geospatial reference data
Method	Empirical relationship between EO and in-situ data to retrieve turbidity
Degree of Automation	• Setting up model for a water body requires significant operator input • Once set up, execution of retrieval model is largely automated
EO Input Data	High, medium and low resolution optical imagery (e.g. WORLDVIEW-2; LANDSAT-8; MERIS (archival); MODIS; AVHRR)
Non-EO Input Data	• In-situ measurements of turbidity • Optional: In-situ measurement of related water constituents and/or inherent optical properties • Optional: Measurement of atmospheric parameters
Contribution of EO	Major: this product is primarily based on EO imagery calibrated with in-situ data
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Use of automated real-time water quality (RTWQ) stations is recommended for the ongoing collection of in-situ observations
Maturity and availability	• For the open ocean (i.e. Case 1 waters): TRL = 7 • For coastal and inland (i.e. Case 2) waters: TRL varies between 4 to 6 • Products are available from commercial suppliers on demand
Constraints and Limitations	• Cloud cover limits acquisition of imagery and dictates effective revisit capability • Separate empirical models need to be established for different water bodies/regions • Establishing stable empirical model requires several months of concurrent satellite and in-situ data • Only near-surface turbidity can be captured • Artifacts due to atmospheric effects need to be considered
References	• Nechad, B. Ruddick, K.G. and Park, Y. (2010) Calibration and validation of a generic multisensor algorithm for mapping of total suspended matter in turbid waters, Remote Sensing of Environment, vol. 114, pp. 854-866. • Hellweger, F. L., Schlosser, P., Lall, U., & Weissel, J. K. (2004). Use of satellite imagery for water quality studies in New York Harbor. Estuarine, Coastal and Shelf Science, 61(3), 437-448.
Applicable Standards	User-defined

Vessel Monitoring

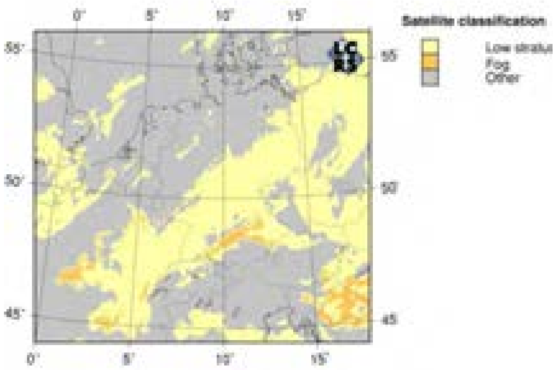
SAR and optical satellite imagery is analyzed to detect and classify marine vessels. Temporally correlated imagery and ground-truth data is required to build a reliable classification system. High-resolution data is also necessary in order to capture small vessels.

Current Use:

- **Broad context is monitoring of vessel activity and vicinity to marine resources.**
- **The majority of existing services are related to oil spill detection and monitoring, and maritime traffic surveillance in the fisheries and transportation sectors**

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_2.6: Distribution and abundance of sea birds • C-CORE _2.9: Security and safety • C-CORE _2.11: Monitoring of waste management practices • C-CORE _2.16: Commercial shipping • C-CORE _2.18: Commercial and recreational fisheries • CLS_4.1: SAR imagery to detect ships and icebergs
Thematic Information Content	Geographic point location with vessel size and classification
Spatial Resolution	1 m to 30 m (dependent on source satellite data)
Spatial Coverage	Varies depending on user requirements; single-image coverage from 10x10 km to 500 x 500 km
Minimum Mapping Unit (MMU)	10 m^2 to 1 ha (depending on user requirements)
Temporal Resolution	Daily to weekly (dependent on source data and cloud cover)
Geographic Coverage	Global: open ocean, coastal areas, inland water bodies (lakes)
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	• Probability of detection and classification <80% to >95% (depends on sea state and imaging mode) • Geometric accuracy: +/- 1 to 5 pixels (depending on geospatial reference data and sensor spatial resolution)
Data Format	• Gridded data format based on user requirements (e.g. GeoTIFF, HDF, IMG) • Point targets format based on user requirements (e.g. Shapefile) • Text file or spreadsheet format based on user requirements
Data Access	Restricted access through commercial suppliers

Validation Approach	• Comparison with known vessel locations (AIS, etc) • Geometric accuracy assessed with geospatial reference data
Method	• Point target detection algorithms • Target signature analysis and classification
Degree of Automation	The product generation is semi-automated and requires significant operator input
EO Input Data	High and medium-resolution SAR and optical imagery (e.g. GeoEye-1; QuickBird; IKONOS; WorldView-2; LANDSAT-8; Cosmo-SkyMed; Radarsat-2; TerraSAR-X; Sentinel-1)
Non-EO Input Data	• Vessel locations (e.g. AIS data) • Shipping routes
Contribution of EO	Major: this product is primarily based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	Spatial and temporal coverage can be maximized by using imagery from multiple optical and SAR missions; high costs associated with large volumes of high-resolution imagery can be mitigated throughdata-sharing with other organizations
Maturity and Availability	• The methodology is proven and considered mature: TRL = 7
Constraints and Limitations	• Cloud cover limits acquisition of optical imagery • A significant amount of historical ground-truth data is required to set up effective ship classification algorithms
References	• Vachon, P. W., Campbell, J. W. M., Bjerkelund, C. A., Dobson, F. W., & Rey, M. T. (1997). Ship detection by the RADARSAT SAR: Validation of detection model predictions. Canadian Journal of Remote Sensing/Journal Canadien de Teledetection, 23(1), 48-59. • Corbane, C., Najman, L., Pecoul, E., Demagistri, L., & Petit, M. (2010). A complete processing chain for ship detection using optical satellite imagery. International Journal of Remote Sensing, 31(22), 5837-5854.
Applicable Standards	User-defined



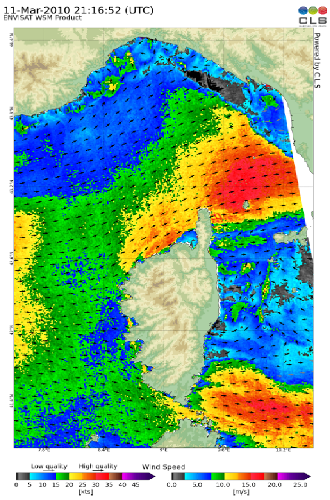
Visibility

Different Infrared channels of satellite imagery are analyzed to detect Fog / Low cloud presence. Where applicable, this technology is developed for night-time detection.

Current Use:
Detect the presence of fog conditions at sea and where in-situ measurement are not existing

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.12 : Visibility • CLS_OFF.3.7 : Visibility during operations • CLS_OFF.4.3 : Efficiency of vessels and helicopters operations
Thematic Information Content	Fog detection
Spatial Resolution	3 km
Spatial Coverage	70N-70S / 70E-070W
Minimum Mapping Unit (MMU)	NA
Temporal Resolution	15 minutes
Geographic Coverage	Global
Timeliness	Near real-time or archival processing (depending on user requirements)
Accuracy	NA
Data Format	Gridded data format
Data Access	Restricted to EUMETSAT user license

Validation Approach	• Comparison with concurrent in-situ measurements • Geometric accuracy assessed with geospatial reference data
Method	The Fog / Low Clouds RGB is composed from data from a combination of the SEVIRI IR3.9, IR10.8 and IR12.0 channels
Degree of Automation	The product generation is fully-automated
EO Input Data	MSG satellite
Non-EO Input Data	NA
Contribution of EO	Major: this product is primarily based on EO imagery calibrated with in-situ data
Data Source	• EO data: imagery providers • Non-EO data: user
Prospects	NA
Maturity and availability	• The methodology proven and considered mature • Product available from commercial suppliers on demand
Constraints and Limitations	• Medium/high level Cloud cover limits acquisition of imagery and dictates effective revisit capability
References	
Applicable Standards	



SAR-Derived Wind

SAR wind output products generated by SARTool© represent the 10-m height neutral equivalent wind.

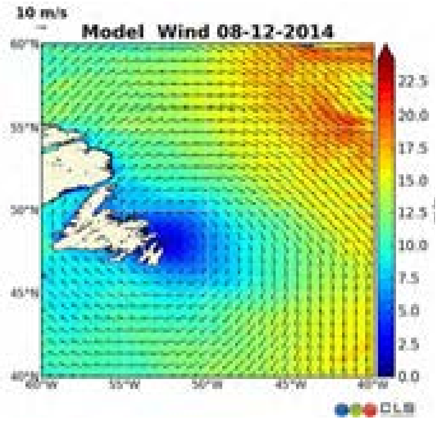
Neutral wind speed is defined as the mean wind speed that would be observed if there was neutral atmospheric stratification.

Current Use:

The SAR-derived wind product is currently used for meteorological applications.
It is useful to determine the wind resource assessment on a specific area.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_OFF1.5 : Wind observations • CLS_OFF.1.2 : Model validation • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.2.5 : Drilling Survey preparation : Metocean conditions, hindcast & forecast • CLS_OFF.3.1 : Recommendations on the design of the structure • CLS_OFF.3.3 : evaluation of the efficiency of the structure • CLS_OFF.5.1 : Metocean monitoring
Thematic Information Content	Variables describing the detected winds (speed, direction, and quality flag)
Spatial Resolution	SAR-derived wind products can be generated at any desired cell size Cell size in range and azimuth directions are multiples of the pixel size of the underlying SAR level-1 products. We usually recommend that the wind cell size ranges of 1 kilometer
Spatial Coverage	From 20*20 km² to 500*500km² depending on the acquisition mode of the SAR image
Minimum Mapping Unit (MMU)	Cell size usually of 1 kilometer
Temporal Resolution	Daily
Geographic Coverage	Worldwide
Timeliness	Near real-time (15 min) or archival processing (depending on user requirements)
Accuracy	• Wind speeds are generally retrieved with a typical RMS error of 2 m/s. • Wind directions are generally retrieved with a typical RMS error of 20°.
Data Format	• graphical map (PNG format) • Google Earth format file • NetCDF Format
Data Access	The access is restricted. The access can be done via FTP, web service (selection via a catalog), or on DVD.

Validation Approach	Field validation by systematic comparisons with two independent sources: - In situ buoys - Reanalysis outputs of models
Method	As the wind blows over the sea surface, it generates gravity-capillary waves which increase sea surface roughness. Those waves respond instantaneously to the wind speed and direction. As the radar backscatter results from interactions between the incidence electromagnetic wave emitted by the radar and the small scales at the sea surface, it is directly related to the wind conditions at the time of the measurement.
Degree of Automation	The product is automatically generated
EO Input Data	SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • COSMO-SkyMed • TerraSAR-X
Non-EO Input Data	10 meters sea surface wind form model outputs : ECMWF, NCEP
Contribution of EO	Major: this product is based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data : o NCEP : Free dat o ECMWF company
Prospects	Improvement in the estimation of strong winds (>25m/s)
Maturity and availability	• The methodology proven and considered mature • Product available from commercial suppliers on demand
Constraints and Limitations	Potential underestimation of the wind speed for strong winds
References	Collard, F., F. Ardhuin, and B. Chapron. “Extraction of Coastal Ocean Wave Fields from SAR Images.” Oceanic Engineering, IEEE Journal of 30, no. 3 (2005): 526–33.
Applicable Standards	



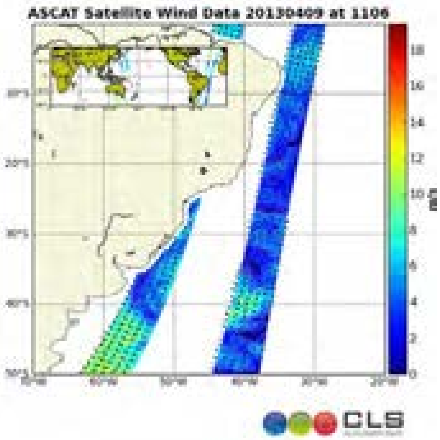
Wind Open Ocean Model

Wind data is an output from meteorological models. They provide useful info for the planning of operations through historical and forecast data.

Current Use:
Wind data is used regularly for design and operations. They are also used as an input to ocean models and for the calculation of statistics and extreme analysis.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_OFF1.5 : Wind observations • CLS_OFF.1.2 : Model validation • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.2.5 : Drilling Survey preparation : Metocean conditions, hindcast & forecast • CLS_OFF.3.1 : Recommendations on the design of the structure • CLS_OFF.3.3 : evaluation of the efficiency of the structure • CLS_OFF.5.1 : Metocean monitoring
Thematic Information Content	Wind Open Ocean Model
Spatial Resolution	The spatial resolution is of the order of 12km (1/8°) for global products
Spatial Coverage	Global
Minimum Mapping Unit (MMU)	
Temporal Resolution	3 hours with forecast
Geographic Coverage	Worldwide
Timeliness	The product is updated every day as standard
Accuracy	Typical product accuracy is highly variable, depending on the region of interest and the amount of observation available and assimilated.
Data Format	• Gridded maps, NetCDF with CF conventions. • graphical map (PNG format) • Google Earth format file • GIS compatible
Data Access	Data access: restricted for the hourly data. The daily data is often free

Validation Approach	This product has been validated thoroughly by researchers
Method	The product is an output of atmospheric general circulation model. These models assimilate data from in situ sensors. The models have a governing set of fluid dynamic equations which are used to progress to the next time step
Degree of Automation	Fully automated
EO Input Data	SST as well as surface soil moisture and other data
Non-EO Input Data	Boundary conditions, topography
Contribution of EO	Low: used through data assimilation schemes
Data Source	EO data : image providers
Prospects	Models are likely to improve in terms of resolution and the amount of observational data assimilated.
Maturity and availability	Highly mature (operational use for over 10 years)
Constraints and Limitations	None
References	
Applicable Standards	



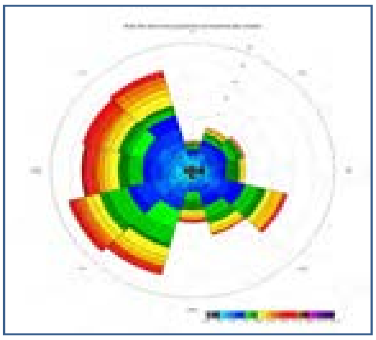
Surface wind products scatterometer

Scatterometer wind output products represent the 10-m height neutral equivalent wind.
The data is provided by the Ascat instyrument on board the Metop-A satellite.

Current Use:
The Ascat derived wind product is currently used for meteorological applications.
It is useful to determine the wind resource assessment on a specific area.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE_OFF1.5 : Wind observations • CLS_OFF.1.2 : Model validation • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.2.5 : Drilling Survey preparation : Metocean conditions, hindcast & forecast • CLS_OFF.3.1 : Recommendations on the design of the structure • CLS_OFF.3.3 : evaluation of the efficiency of the structure • CLS_OFF.5.1 : Metocean monitoring
Thematic Information Content	Variables describing the detected winds (speed, direction, and quality flag)
Spatial Resolution	25km
Spatial Coverage	Two 550km Swaths
Minimum Mapping Unit (MMU)	
Temporal Resolution	Daily
Geographic Coverage	Worldwide
Timeliness	Near real-time
Accuracy	• Wind speeds are generally retrieved with a typical RMS error of 2 m/s and a wind speed bias of 0.5m/s
Data Format	• graphical map (PNG format) • Google Earth format file • GIS compatible • NetCDF Format
Data Access	The access can be done via FTP, web service (selection via a catalog).

Validation Approach	Two major validation efforts have been carried out. The first one is connected with the Metop commissioning phase and enabled us to declare the Level 1b products operational. The results can be found her: http://oiswww.eumetsat.org/WEBOPS/eps-pg/ASCAT/ASCAT-PG-2Refdoc.htm#TOC2
Method	The ASCAT system geometry is based on the use of fan-beam antennas. It covers two 550-km swaths which are separated from the satellite ground track by about 336 km for the minimum orbit height. The ASCAT incidence angle ranges from 25° to 65°. For each swath, three antennas illuminate the sea surface at three different azimuth angles, measuring the backscattered signal. At such incidence angles, the main backscattering mechanism is considered to be Bragg resonance, which describes the interaction of the radar signal with short sea surface waves having a wavelength of a few centimetres. The wind speed and direction near the ocean surface with respect to the antenna viewing angles are determined by using an empirical Geophysical Model Function (GMF), which relates these parameters to the observed backscatter normalised radar cross section.
Degree of Automation	The product is automatically generated
EO Input Data	ASCAT scatterometer data
Non-EO Input Data	None
Contribution of EO	Major: this product is based on EO imagery
Data Source	EO data : imagery providers
Prospects	Improvement in the estimation of strong winds (>25m/s) Integration of ISS Rapidscat data
Maturity and availability	The methodology proven and considered mature Raw data available from Eumetsat on demand (via the KNMI site) Processed data available from commercial providers
Constraints and Limitations	Potential underestimation of the wind speed for strong winds
References	http://oiswww.eumetsat.org/WEBOPS/eps-pg/ASCAT/ASCAT-PG-0TOC.htm
Applicable Standards	



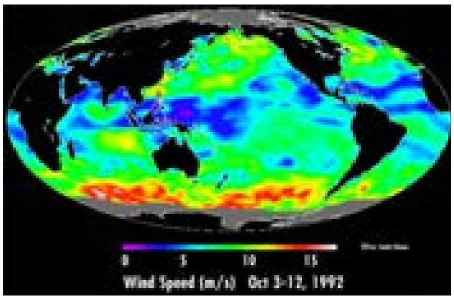
Wind roses

Wind rose is estimated from a large wind products database. It gives a succinct view of how wind speed and direction are distributed at a particular location

Current Use:
These statistical products are often used in the renewable marine energy field to do a wind resource assessment in the case of a project for an offshore wind farm.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.1 : Historic records for winds • CLS_OFF.1.1 : Historic Metocean data for high level risk assessment • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.3.1 : Recommendations on the design of the structure • CLS_OFF.3.3 : evaluation of the efficiency of the structure • CLS_OFF.3.6 : Estimation of the Climate Change impact
Thematic Information Content	The wind roses are estimated from a database of wind SAR-derived products. It gives wind speed and direction probability at a particular location.
Spatial Resolution	These products can be delivered for a specific location, for example in a case of a site study.
Spatial Coverage	NA
Minimum Mapping Unit (MMU)	NA
Temporal Resolution	The statistics can be done per year, per season, per month…
Geographic Coverage	Worldwide, depending on the SAR archive.
Timeliness	NA
Accuracy	• Wind speeds are retrieved with a typical RMS error of 2 m/s. • Wind directions are retrieved with a typical RMS error of 20°.
Data Format	NetCDF
Data Access	The access is restricted. It can be delivered on request via FTP or DVD.

Validation Approach	Wind field validation by systematic comparisons with independent sources: in situ buoys, mast and reanalysis outputs of models.
Method	Several archive data are used, over thehe same location point to produce the wind statistics
Degree of Automation	These products are not generated automatically and need an expert intervention.
EO Input Data	SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	• Model inputs : ECMWF, NCEP
Contribution of EO	Major: the archive product is primarily based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data: NCEP (Free data), ECMWF
Prospects	Increasing the SAR archive volume to obtain better statistics.
Maturity and availability	• The methodology proven and considered mature • Product available from commercial suppliers on demand
Constraints and Limitations	Underestimation of the speed for strong winds Sensitivity to diurnal wind regime
References	Kerbaol V., Improved Bayesian Wind Vector Retrieval Scheme using ENVISAT ASAR Data: Principles and Validation Results, ENVISAT Symposium, Montreux, Switzerland, 23-27 April, 2007 Mouche, Alexis A., Fabrice Collard, Bertrand Chapron, K. Dagestad, Gilles Guitton, Johnny A. Johannessen, Vincent Kerbaol, and Morten Wergeland Hansen. “On the Use of Doppler Shift for Sea Surface Wind Retrieval from SAR.” Geoscience and Remote Sensing, IEEE Transactions on 50, no. 7 (2012): 2901–9.
Applicable Standards	



Wind speed distribution

The Wind speed distribution is estimated from a large wind products database

Current Use:
These statistical products are often used in the renewable marine energy field to do a wind resource assessment in the case of a project for an offshore wind farm.

Geo-Information Requirements	This product relates to the following challenges: • C-CORE.OFF1.1 : Historic records for winds • CLS_OFF.1.1 : Historic Metocean data for high level risk assessment • CLS_OFF.2.1 : Selection of the drilling rig • CLS_OFF.3.1 : Recommendations on the design of the structure • CLS_OFF.3.3 : evaluation of the efficiency of the structure • CLS_OFF.3.6 : Estimation of the Climate Change impact
Thematic Information Content	The wind roses are estimated from a database of wind SAR-derived products
Spatial Resolution	These products can be delivered for a specific location, for example in a case of a site study.
Spatial Coverage	NA
Minimum Mapping Unit (MMU)	NA
Temporal Resolution	The statistics can be done per year, per season, per month…
Geographic Coverage	Worldwide, depending on the SAR archive.
Timeliness	NA
Accuracy	Wind speeds are retrieved with a typical RMS error of 2 m/s.
Data Format	NetCDF
Data Access	The access is restricted. It can be delivered on request via FTP or DVD.

Validation Approach	Wind field validation by systematic comparisons with independent sources: in situ buoys, mast and reanalysis outputs of models.
Method	Several archive data are used, over thehe same location point to produce the wind statistics
Degree of Automation	These products are not generated automatically and need an expert intervention.
EO Input Data	SAR Images from : • ENVISAT (Archive) • Radarsat-2 • Sentinel-1 • Cosmo-Skymed • TerraSAR-X
Non-EO Input Data	Model inputs : ECMWF, NCEP
Contribution of EO	Major: the archive product is primarily based on EO imagery
Data Source	• EO data: imagery providers • Non-EO data: NCEP (Free data), ECMWF
Prospects	Increasing the SAR archive volume to obtain better statistics.
Maturity and availability	• The methodology proven and considered mature • Product available from commercial suppliers on demand
Constraints and Limitations	Underestimation of the speed for strong winds Sensitivity to diurnal wind regime
References	Kerbaol V., Improved Bayesian Wind Vector Retrieval Scheme using ENVISAT ASAR Data: Principles and Validation Results, ENVISAT Symposium, Montreux, Switzerland, 23-27 April, 2007 Mouche, Alexis A., Fabrice Collard, Bertrand Chapron, K. Dagestad, Gilles Guitton, Johnny A. Johannessen, Vincent Kerbaol, and Morten Wergeland Hansen. “On the Use of Doppler Shift for Sea Surface Wind Retrieval from SAR.” Geoscience and Remote Sensing, IEEE Transactions on 50, no. 7 (2012): 2901–9.
Applicable Standards	