sea state cci

Product Specification Document (PSD)

version 1.0, 5 February 2019

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Ifremer	PML Plymouth Marine Laboratory	ECMWF
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1. Introduction

This document presents the Product Specification Document (PSD) for **Sea_State_cci**, deliverable 1.2 of the project. This first version is prepared in order to define the version 1 products that will be produced by mid-March 2019 updating and extending products from the GlobWave project. An updated version of this document, describing further versions of products, will be produced towards the end of the project.

The remainder of this Product Specification Document contains a general description of the version 1 products and provides the specific variable content of the datasets. Annexes describe the detailed netCDF format, differences with GlobWave data, and processing details.

2. General Products Description

2.1 Products overview

The first version (version 1) of CCI Sea State products is inherited from the GlobWave project building on lessons learnt and existing outputs. It will extend and improve these products which were a post-processing over existing L2 altimeter and SAR wave mode agency products with additional filtering, corrections and variables.

Three kind of products will be delivered:

- L2P : Along-track products separated per orbit and satellite, including all measurements with flags and corrections. These are expert products with rich content and no data loss.
- L3 : Edited merged daily products retaining all valid and good quality measurements from all altimeters over one day (one daily file), with simplified content (only a few key parameters). This is close to what is delivered in NRT by CMEMS project.
- L4 : Gridded products averaging valid and good measurements from all available altimeters over a fixed resolution grid (1°x1°) on a monthly basis. These products are meant for statistics and visualization through CCI toolbox.

2.2 Altimeter missions

Data from the following satellite altimeter missions are included in the version 1 data:

Mission	**Altimeter**	**Selected band**
GFO	GFO-RA	Ku
TOPEX/Poseidon	TOPEX, POSEIDON-1	Ku
ERS-1	RA	Ku
ERS-2	RA	Ku
Envisat	RA-2	Ku
Jason-1	POSEIDON-2	Ku
Jason-2	POSEIDON-3	Ku
Jason-3	POSEIDON-3B	Ku
Cryosat-2	SIRAL	Ku
SARAL	AltiKa	Ka

Sentinel-3 A	SRAL	Ku
Sentinel-3 B	SRAL	Ku
HY-2A	ALT	Ku

2.2 Data organisation and file naming

The common directory structure is based on CCI recommendations and is arranged as follows:

/<archive_root>/<cci_project>/<type>/<mission>/<version>/<date>/

Where:

- **<cci_project>** : seastate
- **<type>** : will be different for each ECV, but needs to be defined, and consistent within an ECV, here l2 for along-track altimeter data, l3 for edited merged products and l4 for monthly averaged gridded products)
- **<mission>** : satellite mission (for L2P products only)
- **<date>** : <year as YYYY>/<day in the year as DDD>
- **<version>** is processing version, as in filename

The file nomenclature is based on form 2 of CCI recommendations :

ESACCI-<CCI Project>-<Processing Level>-<Data Type>-<Product String>[-<Additional Segregator>]-<IndicativeDate>[<Indicative Time>]-fv<File version>.nc

Where:

- **<CCI Project>** : SEASTATE
- **<Processing Level>** : here L2P for along-track altimeter data, L3 for edited merged product and L4 for monthly averages
- **<Data Type>** : SWH for Significant Wave Height
- **<Product String>** :
- **<Additional Segregator>** :
- **<Indicative Date>[<Indicative Time>] :** The identifying date for this data set. Format is YYYYMMDDTHHMMSS, where YYYY is the four digit year, MM is the two digit month from 01 to 12 and DD is the two digit day of the month from 01 to 31. The date used should best represent the observation date for the data set. For along-track data it will be the time of the first measurement in the file.
- **<File version>** : File version number in the form n{1,}[.n{1,}] (That is 1 or more digits followed by optional . and another 1 or more digits.)

Example:

L2P product:
ESACCI-SEASTATE-L2P-SWH-JASON2-20170130T145103-fv01.nc

L3 product:
ESACCI-SEASTATE-L3-SWH-MULTI_1D-20170130-fv01.nc

L4 product:
ESACCI-SEASTATE-L4-SWH-MULTI_1M-201701-fv01.nc

2.3 Global attributes

Common Global attributes are listed in the table in Annex A. This includes in white the additional attributes not in CCI standard but recommended by CF or ACDD conventions which GHRSST convention is based on (CCI standard itself being based on GHRSST).

Note that there is a new CCI Data Standard 2.0 and this may incorporate some of the missing GHRSST attributes. See http://cci.esa.int/working-groups.

3. Version 1 Dataset Content

3.1 Version 1 dataset: L2P

This section describes the specific variables contained in the version 1 L2P for Sea State CCI. A full description of the coordinates and variables is provided in Annex A. Differences compared to the GlobWave L2P data are given in Annex B.

	coordinate variables
time	time (in seconds since 1985-01-01)
lat	latitude
lon	longitude
	instrumental variables for 1st band altimeter (usually Ku)
sigma0	Ku band backscatter coefficient (raw)
sigma0_adjusted	Ku band adjusted backscatter coefficient
sigma0_rms	RMS of the Ku band backscatter coefficient (from unadjusted 20 Hz measurements)
sigma0_num_valid	number of valid points used to compute Ku band backscatter coefficient
mss	Mean square slope
	environmental variables for 1st band altimeter (usually Ku)
swh	significant wave height (raw)
swh_adjusted	significant wave height (adjusted)
swh_filtered	significant wave height (adjusted and filtered)
swh_quality	quality level significant wave height measurement
swh_uncertainty	best estimate of significant wave height standard error
swh_rms	RMS of significant wave height (from unadjusted 20 Hz measurements)
swh_num_valid	number of valid points used to compute significant wave height (from unadjusted 20 Hz measurements)
rejection_flag	consolidated instrument and ice flags
	auxiliary variables
instrument/platform	

off_nadir_angle_wf	square of the off nadir angle computed from waveforms
auxiliary measurements	
sea_surface_height	sea level from Sea Level CCI
total_column_liquid_water_content_rad	Total column cloud liquid water content from radiometer
topography	
bathymetry	ocean depth
distance_to_coast	distance to nearest coast
model auxiliary data	
wind_speed_model_u	U component of the model wind vector
wind_speed_model_v	V component of the model wind vector
sea_surface_temperature	sea surface temperature
surface_air_temperature	surface air temperature
surface_air_pressure	surface air pressure
total_column_liquid_water_content	Total column cloud liquid water content

3.2 Version 1 dataset: L3

This section describes the specific variables contained in the version 0 L3 for Sea State CCI. A full description of the coordinates and variables is given in Annex A.

	coordinate variables
time	time (in seconds since 1985-01-01)
lat	latitude
lon	longitude
	instrumental variables for 1st band altimeter (usually Ku)
sigma0	Ku band backscatter coefficient (raw)
sigma0_calibrated	Ku band calibrated backscatter coefficient
	environmental variables for 1st band altimeter (usually Ku)
swh	significant wave height (as available in source GDR product)
swh_adjusted	significant wave height (adjusted)
swh_filtered	significant wave height (filtered)
swh_standard_error	best estimate of significant wave height standard error

3.3 Version 1 dataset: L4

This section describes the specific variables contained in the version 1 L4 for Sea State CCI. A full description of the coordinates and variables is given in Annex A.

	coordinate variables
time	time (in seconds since 1985-01-01)
lat	latitude
lon	longitude
	environmental variables for 1st band altimeter (usually Ku)
swh_mean	mean of median significant wave height values
swh_rms	rms of median significant wave height values
swh_num	number of median significant wave height values
swh_sum	total of median significant wave height values
swh_squared_sum	total of median significant wave height squared values
swh_log_sum	total of median significant wave height log values
swh_log_squared_sum	total of median significant wave height log squared values
swh_num_gt0050	number of median significant wave height values greater than 0.5m
swh_num_gt0100	number of median significant wave height values greater than 1.0m
swh_num_gt0150	number of median significant wave height values greater than 1.5m
swh_num_gt0200	number of median significant wave height values greater than 2.0m
swh_num_gt0250	number of median significant wave height values greater than 2.5m
swh_num_gt0300	number of median significant wave height values greater than 3.0m
swh_num_gt0350	number of median significant wave height values greater than 3.5m
swh_num_gt0400	number of median significant wave height values greater than 4.0m

swh_num_gt0500	number of median significant wave height values greater than 5.0m
swh_num_gt0600	number of median significant wave height values greater than 6.0m
swh_num_gt0800	number of median significant wave height values greater than 8.0m
swh_num_gt1000	number of median significant wave height values greater than 10.0m
swh_max	maximum median significant wave height value

3.4 Quality control; calibration; error analysis

Quality control of individual altimeter measurements is undertaken with checks on instrument flags and ancillary variables. Full details are available on request in a separate CCI Sea State Format description document.

Calibration and error analysis are included in the data products where available, based on the following sources:

- Calibration derived from GlobWave error analysis [Ash E R & Carter D J T, September 2010, Satellite wave data quality report, GlobWave Deliverable D.16] http://globwave.ifremer.fr/download/GlobWave_D.16_SWDQR.pdf
- Queffeulou, Pierre - ftp://ftp.ifremer.fr/ifremer/cersat/products/swath/altimeters/waves/documentation/altimeter_wave_merge__11.4.pdf
- GlobWave Product User Guide Phase 3, Deliverable D.7

Full details are available in Annex C.

Annex A: Detailed NetCDF format

L2P product format

Coordinates

time

```
int64 time(time) ;
        time:_FillValue = 9.96921e+36f ;
        time:long_name = "time of measurement" ;
        time:standard_name = "time" ;
        time:units = "seconds since 1985-01-01 00:00:00.0" ;
        time:calendar = "gregorian" ;
        time:axis = "T" ;
         time:coverage_content_type = "coordinate" ;
```

Latitude [lat]

```
double lat(time) ;
        lat:_FillValue =9.96921e+36f ;
        lat:long_name = "latitude" ;
        lat:standard_name = "latitude" ;
        lat:units = "degrees_north" ;
         lat:axis = "Y" ;
         lat:valid_range = -90, 90 ;
        lat:comment = "Positive latitude is North latitude, negative latitude is
South latitude" ;
         lat:coverage_content_type = "coordinate" ;
```

Longitude [lon]

```
double lon(time) ;
        lon:_FillValue = 9.96921e+36f ;
        lon:long_name = "longitude" ;
        lon:standard_name = "longitude" ;
        lon:units = "degrees_east" ;
         lon:axis = "X" ;
         lon:valid_range = -180, 180 ;
        lon:comment = "East longitude relative to Greenwich meridian" ;
         lon:coverage_content_type = "coordinate" ;
```

Environmental variables

Significant wave height [swh]
Hs as provided by the original data producer [no calibration, no editing].

```
double swh(time) ;
```

```
        swh:_FillValue = 9.96921e+36f ;
        swh:long_name = "Ku band significant wave height" ;
        swh:standard_name = "sea_surface_wave_significant_height" ;
        swh:units = "m" ;
        swh:ancillary_variables = "swh_quality rejection_flag" ;
        swh:coordinates = "time lon lat" ;
        swh:comment = "All instrumental corrections included. As available in
source GDR product and unedited" ;
        swh:band = "Ku" ;
         swh:coverage_content_type = "physicalMeasurement" ;
```

adjusted significant wave height [swh_adjusted]

```
double swh_adjusted(time) ;
        swh_adjusted:_FillValue = 9.96921e+36f  ;
        swh_adjusted:long_name = "Ku band adjusted significant wave height" ;
        swh_adjusted:standard_name = "sea_surface_wave_significant_height" ;
        swh_adjusted:units = "m" ;
        swh_adjusted:calibration_formula = "1.0149*swh + 0.0277" ;
        swh_adjusted:calibration_reference = "Ash E R & Carter D J T, September
2010, Satellite wave data quality report, GlobWave Deliverable D.16" ;
        swh_adjusted:ancillary_variables = "swh_quality swh_uncertainty
rejection_flag" ;
        swh_adjusted:coordinates = "time lon lat" ;
        swh_adjusted:comment = "All instrumental corrections included. adjusted
and unedited" ;
        swh_adjusted:band = "Ku" ;
         swh_adjusted:coverage_content_type = "physicalMeasurement" ;
```

Filtered significant wave height [swh_filtered]

```
double swh_filtered(time) ;
        swh_filtered:_FillValue = 9.96921e+36f ;
        swh_filtered:long_name = "Ku band filtered significant wave height" ;
        swh_filtered:standard_name = "sea_surface_wave_significant_height" ;
        swh_filtered:units = "m" ;
        swh_filtered:coordinates = "time lon lat" ;
        swh_filtered:comment = "All instrumental corrections included. adjusted,
filtered with EMD and unedited" ;
        swh_filtered:band = "Ku" ;
         swh_filtered:coverage_content_type = "physicalMeasurement" ;
```

significant wave height quality [swh_quality]

```
byte swh_quality(time) ;
        swh_quality:valid_min = 0b ;
        swh_quality:valid_max = 2b ;
        swh_quality:long_name = "quality of Ku band significant wave height
measurement" ;
```

```
        swh_quality:flag_values = 0b, 1b, 2b, 3b ;
        swh_quality:flag_meanings = "undefined bad acceptable good" ;
         swh_quality:coverage_content_type = "qualityInformation" ;
```

significant wave height uncertainty [swh_uncertainty]

```
double swh_uncertainty(time) ;
        swh_uncertainty:_FillValue = 9.96921e+36f  ;
        swh_uncertainty:long_name = "best estimate of significant wave height
standard error" ;
        swh_uncertainty:units = "m" ;
        swh_uncertainty:source = "GlobWave Wave Data Quality Report" ;
        swh_uncertainty:coordinates = "time lon lat" ;
        swh_uncertainty:comment = "Standard error calculated from buoy
colocations” ;
         swh_uncertainty:coverage_content_type = "qualityInformation" ;
```

significant wave height rms [swh_rms]

```
double swh_rms(time) ;
        swh_rms:_FillValue = 9.96921e+36f  ;
        swh_rms:long_name = "RMS of the Ku band significant wave height (from 20
Hz measurements)" ;
        swh_rms:units = "m" ;
        swh_rms:coordinates = "time lon lat" ;
         swh_rms:band = "Ku" ;
         swh_rms:coverage_content_type = "auxiliaryInformation" ;
```

number of valid points used to compute 1st band significant wave height [swh_num_valid]

```
byte swh_num_valid(time) ;
        swh_num_valid:_FillValue = 127b ;
        swh_num_valid:long_name = "number of 20 Hz valid points used to compute
Ku band significant wave height" ;
        swh_num_valid:units = "1" ;
        swh_num_valid:coordinates = "time lon lat" ;
         swh_num_valid:coverage_content_type = "auxiliaryInformation" ;
```

Rejection flags [rejection_flags]

```
uint8 rejection_flag(time) ;
        rejection_flag:long_name = "consolidated instrument and ice flags" ;
        rejection_flag:flag_masks = 0b, 1b, 2b, 4b, 8b, 16b, 32b, 64b ;
        rejection_flag:flag_meanings = "unused altimeter_land_flag
sig0_ku_mle3_lower_than_5 sdmax_flag_0_4.5m sdmax_flag_4.5_8m sdmax_flag_over_8m
extreme_point_flag 5m_test" ;
         rejection_flag:coverage_content_type = "qualityInformation" ;
```

Instrumental variables

1st band sigma0 [sigma0]
`` double sigma0(time) ;   sigma0:_FillValue = 9.96921e+36f ;   sigma0:long_name = "Ku band backscatter coefficient" ;   sigma0:band = "Ku" ;   sigma0:units = "dB" ;   sigma0:quality_flag = "sigma0_quality" ;   sigma0:coordinates = "time lon lat" ;   sigma0:comment = "All instrumental corrections included. Unadjusted" ;   sigma0:coverage_content_type = "physicalMeasurement" ; ```

1st band adjusted sigma0 [sigma0]
`` double sigma0_adjusted(time) ;   sigma0_adjusted:_FillValue = 9.96921e+36f ;   sigma0_adjusted:long_name = "Ku band adjusted backscatter coefficient" ;   sigma0_adjusted:band = "Ku" ;   sigma0_adjusted:units = "dB" ;   sigma0_adjusted:quality_flag = "sigma0_quality" ;   sigma0_adjusted:coordinates = "time lon lat" ;   sigma0_adjusted:comment = "All instrumental corrections included. Adjusted." ;   sigma0_adjusted:coverage_content_type = "physicalMeasurement" ; ```

1st band sigma0 RMS [sigma0_rms]
`` double sigma0_rms(time) ;   sigma0_rms:_FillValue =9.96921e+36f ;   sigma0_rms:long_name = "RMS of the Ku band backscatter coefficient" ;   sigma0_rms:band = "Ku" ;   sigma0_rms:units = "dB" ;   sigma0_rms:coordinates = "time lon lat" ;   sigma0_rms:coverage_content_type = "auxiliaryInformation" ; ```

number of valid points used to compute 1st band backscatter coefficient [sigma0_num_valid]
`` byte sigma0_num_valid(time) ;   sigma0_num_valid:_FillValue = 127b ;   sigma0_num_valid:long_name = "number of valid points used to compute Ku band backscatter coefficient" ;   sigma0_num_valid:band = "Ku" ;   sigma0_num_valid:units = "1" ;   sigma0_num_valid:valid_range = 0b, 10b ;   sigma0_num_valid:coordinates = "time lon lat" ;   sigma0_rms:coverage_content_type = "auxiliaryInformation" ; ```

Mean square slope [mss]

```
double mss(time) ;
        mss:_FillValue = 9.96921e+36f ;
        mss:long_name = "mean square slope from Ku band backscatter" ;
         mss:band = "Ku" ;
         mss:method = "(0.64/exp((sigma0_adjusted-2.5)*(0.1*ALOG(10.))))/10" ;
         mss:standard_name = "sea_surface_wave_mean_square_slope" ;
        mss:units = "m2" ;
        mss:coordinates = "time lon lat" ;
         mss:coverage_content_type = "physicalMeasurement" ;
```

Square of the off nadir angle computed from waveforms [off_nadir_angle_wf]

```
double short off_nadir_angle_wf(time) ;
        off_nadir_angle_wf:_FillValue = 9.96921e+36f ;
        off_nadir_angle_wf:long_name = "square of the off nadir angle computed
from waveforms" ;
        off_nadir_angle_wf:units = "degree2" ;
        off_nadir_angle_wf:coordinates = "time lon lat" ;
         off_nadir_angle_wf:coverage_content_type = "auxiliaryInformation" ;
```

RMS of the Ku band range [range_rms]

```
float range_rms(time) ;
        range_rms:_FillValue = 9.96921e+36f ;
        range_rms:long_name = "RMS of the Ku band range" ;
        range_rms:units = "m" ;
        range_rms:coordinates = "time lon lat" ;
         range_rms:coverage_content_type = "auxiliaryInformation" ;
```

Ancillary variables

Ocean depth [bathymetry]

```
double bathymetry(time) ;
        bathymetry:_FillValue = 32767s ;
        bathymetry:long_name = "ocean depth" ;
        bathymetry:units = "m" ;
        bathymetry:source = "The GEBCO_2014 Grid, version 20150318,
www.gebco.net,  doi:10.1002/2015EA000107" ;
        bathymetry:institution = "IOC/IHO" ;
        bathymetry:coordinates = "time lon lat" ;
         bathymetry:coverage_content_type = "auxiliaryInformation" ;
```

Distance to nearest coast [distance_to_coast]

```
double distance_to_coast(time) ;
        distance_to_coast:_FillValue = 32767s ;
        distance_to_coast:long_name = "distance to nearest coast" ;
        distance_to_coast:units = "km" ;
        distance_to_coast:source = "GSHHS/DTM2000.1" ;
        distance_to_coast:institution = "University of Hawai SOEST" ;
        distance_to_coast:coordinates = "time lon lat" ;
        distance_to_coast:coverage_content_type = "auxiliaryInformation" ;
```

Model wind speed zonal component [wind_speed_model_u]

```
double wind_speed_model_u(time) ;
        wind_speed_model_u:_FillValue = 9.96921e+36f  ;
        wind_speed_model_u:long_name = "U component of the model wind vector" ;
        wind_speed_model_u:standard_name = "eastward_wind" ;
        wind_speed_model_u:units = "m s-1" ;
        wind_speed_model_u:source = "atmospheric model ERA5" ;
        wind_speed_model_u:institution = "ECMWF" ;
        wind_speed_model_u:coordinates = "time lon lat" ;
        wind_speed_model_u:coverage_content_type = "modelResult" ;
```

Model wind speed meridional component [wind_speed_model_v]

```
double wind_speed_model_v(time) ;
        wind_speed_model_v:_FillValue = 9.96921e+36f  ;
        wind_speed_model_v:long_name = "V component of the model wind vector" ;
        wind_speed_model_v:standard_name = "northward_wind" ;
        wind_speed_model_v:units = "m s-1" ;
        wind_speed_model_v:source = "atmospheric model ERA5" ;
        wind_speed_model_v:institution = "ECMWF" ;
        wind_speed_model_v:coordinates = "time lon lat" ;
        wind_speed_model_v:coverage_content_type = "modelResult" ;
```

Sea surface temperature [sea_surface_temperature]

```
double sea_surface_temperature(time) ;
        sea_surface_temperature:_FillValue = 32767s ;
        sea_surface_temperature:long_name = "sea surface temperature" ;
        sea_surface_temperature:standard_name = "sea_surface_temperature" ;
        sea_surface_temperature:units = "K" ;
        sea_surface_temperature:source = "atmospheric model ERA5" ;
        sea_surface_temperature:institution = "ECMWF" ;
        sea_surface_temperature:coordinates = "time lon lat" ;
        sea_surface_temperature:coverage_content_type = "modelResult" ;
```

Surface air temperature [surface_air_temperature]

```
double surface_air_temperature(time) ;
```

```
        surface_air_temperature:_FillValue = 32767s ;
        surface_air_temperature:long_name = "surface air temperature" ;
        surface_air_temperature:standard_name = "air_temperature" ;
        surface_air_temperature:units = "K" ;
        surface_air_temperature:source = "atmospheric model ERA5" ;
        surface_air_temperature:institution = "ECMWF" ;
        surface_air_temperature:coordinates = "time lon lat" ;
         surface_air_temperature:coverage_content_type = "modelResult" ;
```

Surface air pressure [surface_air_pressure]

```
double surface_air_pressure(time) ;
        surface_air_pressure:_FillValue = 32767s ;
        surface_air_pressure:long_name = "surface air pressure" ;
        surface_air_pressure:standard_name = "air_pressure_at_mean_sea_level" ;
        surface_air_pressure:units = "Pa" ;
        surface_air_pressure:source = "atmospheric model ERA5" ;
        surface_air_pressure:institution = "ECMWF" ;
        surface_air_pressure:coordinates = "time lon lat" ;
         wind_speed_model_u:coverage_content_type = "modelResult" ;
```

Total column liquid water [total_column_liquid_water_content]

```
double total_liquid_water_content(time) ;
        total_liquid_water_content:_FillValue = 32767s ;
        total_liquid_water_content:long_name = "total column liquid water" ;
        total_liquid_water_content:standard_name =
"atmosphere_cloud_liquid_water_content" ;
        total_liquid_water_content:units = "kg m-2" ;
        total_liquid_water_content:source = "atmospheric model ERA5" ;
        total_liquid_water_content:institution = "ECMWF" ;
        total_liquid_water_content:coordinates = "time lon lat" ;
         total_liquid_water_content:coverage_content_type = "modelResult" ;
```

L3 product format

Significant wave height [swh]
Hs as provided by the original data producer [no calibration, no editing].

```
double swh(time) ;
        swh:_FillValue = 9.96921e+36f ;
        swh:long_name = "Ku band significant wave height" ;
        swh:standard_name = "sea_surface_wave_significant_height" ;
        swh:units = "m" ;
        swh:ancillary_variables = "swh_quality rejection_flag" ;
        swh:coordinates = "time lon lat" ;
        swh:comment = "All instrumental corrections included. Unadjusted and unedited" ;
```

```
        swh:band = "Ku" ;
    swh:coverage_content_type = "physicalMeasurement" ;
```

adjusted significant wave height [swh_adjusted]
double swh_adjusted(time) ;   swh_adjusted:_FillValue = 9.96921e+36f ;   swh_adjusted:long_name = "Ku band adjusted significant wave height" ;   swh_adjusted:standard_name = "sea_surface_wave_significant_height" ;   swh_adjusted:units = "m" ;   swh_adjusted:calibration_formula = "1.0149*swh + 0.0277" ;   swh_adjusted:calibration_reference = "Ash E R & Carter D J T, September 2010, Satellite wave data quality report, GlobWave Deliverable D.16" ;   swh_adjusted:ancillary_variables = "swh_quality swh_uncertainty rejection_flag" ;   swh_adjusted:coordinates = "time lon lat" ;   swh_adjusted:comment = "All instrumental corrections included. adjusted and unedited" ;   swh_adjusted:band = "Ku" ;   swh_adjusted:coverage_content_type = "physicalMeasurement" ;

Filtered significant wave height [swh_filtered]
double swh_filtered(time) ;   swh_filtered:_FillValue = 9.96921e+36f ;   swh_filtered:long_name = "Ku band filtered significant wave height" ;   swh_filtered:standard_name = "sea_surface_wave_significant_height" ;   swh_filtered:units = "m" ;   swh_filtered:coordinates = "time lon lat" ;   swh_filtered:comment = "All instrumental corrections included. adjusted, filtered with EMD and unedited" ;   swh_filtered:band = "Ku" ;   swh_filtered:coverage_content_type = "physicalMeasurement" ;

significant wave height standard deviation [swh_std]
double swh_std(time) ;   swh_std:_FillValue = 9.96921e+36f ;   swh_std:long_name = "standard deviation of the Ku band significant wave height" ;   swh_std:units = "m" ;   swh_std:coordinates = "time lon lat" ;   swh_std:coverage_content_type = "auxiliaryInformation" ;

sigma0 [sigma0]

```
double sigma0(time) ;
        sigma0:_FillValue = 9.96921e+36f ;
        sigma0:long_name = "Ku band backscatter coefficient" ;
    sigma0:band = "Ku" ;
        sigma0:units = "dB" ;
        sigma0:quality_flag = "sigma0_quality" ;
        sigma0:coordinates = "time lon lat" ;
        sigma0:comment = "All instrumental corrections included. Unadjusted" ;
    sigma0:coverage_content_type = "physicalMeasurement" ;
```

adjusted sigma0 [sigma0_adjusted]

```
double sigma0_adjusted(time) ;
        sigma0_adjusted:_FillValue = 9.96921e+36f ;
        sigma0_adjusted:long_name = "Ku band adjusted backscatter coefficient" ;
    sigma0_adjusted:band = "Ku" ;
        sigma0_adjusted:units = "dB" ;
        sigma0_adjusted:quality_flag = "sigma0_quality" ;
        sigma0_adjusted:coordinates = "time lon lat" ;
        sigma0_adjusted:comment = "All instrumental corrections included. Adjusted" ;
    sigma0_adjusted:coverage_content_type = "physicalMeasurement" ;
```

Global Attributes

Global Attribute	Example content
title	ESA CCI Sea State L2P derived from Jason-2 GDR
institution	Institut Francais de Recherche pour l'Exploitation de la mer / CERSAT, European Space Agency
institution_abbreviation	Ifremer/Cersat, ESA
source	CCI Sea State Jason-2 GDR to L2P Processor 1.0
history	2018-06-18T14:17:10 UTC -- Creation from processor version v1.0
references	http://cci.esa.int/seastate
Conventions	CF-1.6, ACDD-1.3, ISO 8601
product_version	1.0
summary	This dataset contains along-track significant wave height measurements from Jason-2 altimeter, cross-calibrated with other altimetry missions and reference in situ measurements.

keywords	satellite,observation,ocean
id	ESACCI-SEASTATE-L2P-SWH-JASON2-20170130T145103-fv01.nc
naming authority	fr.ifremer.cersat
keywords_vocabulary	NASA Global Change Master Directory (GCMD) Science Keywords
cdm_data_type	trajectory
featureType	trajectory
comment	These data were produced at ESACCI as part of the ESA SST CCI project.
date_created	20120131T120000Z
date_modified	20160111T181628Z
creator_name	Ifremer / Cersat
creator_url	http://cersat.ifremer.fr
creator_email	cersat@ifremer.fr
creator_institution	Ifremer / Cersat
project	Climate Change Initiative - European Space Agency
geospatial_lat_min	-80
geospatial_lat_max	80
geospatial_lat_units	degrees_north
geospatial_lon_min	-180
geospatial_lon_max	180
geospatial_lon_units	degrees_east
time_coverage_start	20170130T145103Z
time_coverage_end	20170130T154708Z
time_coverage_duration	PT1H2M5S
time_coverage_resolution	PT1S
geospatial_bounds	POLYGON ((-180. -90., -180. 90., 180. 90., 180. -90., -180. -90.))
standard_name_vocabulary	NetCDF Climate and Forecast (CF) Metadata Convention version 1.6
license	ESA CCI Data Policy: free and open access

platform	Jason-2
platform_vocabulary	CEOS
sensor	POSEIDON-3
instrument	POSEIDON-3
instrument_vocabulary	CEOS
spatial_resolution	11.2 km x 5.1 km
cycle_number	316
pass_number	157
equator_crossing_time	2017-01-30T15:19:10.105000 UTC
equator_crossing_longitude	47.48
netcdf_version_id	4.3.0 of Jul 8 2013 12:17:12 $
metadata_link	
acknowledgement	Please acknowledge the use of these data with the following statement: these data were obtained from the ESA CCI Sea State project
format_version	Data Standards Requirements for CCI Data Producers, v2.0, 17 Septembre 2018
processing_software	Jason-2 GDR to L2P Processor 1.0
processing_level	L2P
uuid	57822220-4F3C-11E8-B351-0024E836CC1A
publisher_name	Ifremer/Cersat
publisher_url	cersat.ifremer.fr
publisher_email	cersat@ifremer.fr
publisher_institution	Ifremer/Cersat
scientific_support_contact	Guillaume.Dodet@ifremer.fr
technical_support_contact	cersat@ifremer.fr

Annex B: Differences with GlobWave L2P products

The following tables summarizes the differences between GlobWave and CCI L2P products : in black: common variables between GlobWave and CCI, in red: removed wrt GlobWave, in green: additions to GlobWave.

	coordinate variables
time	time (in seconds since 1985-01-01)
lat	latitude
lon	longitude
	sensor variables for each altimeter band
1st band backscatter	
sigma0	Ku band backscatter coefficient (1st band)
sigma0_rms	RMS of the Ku band backscatter coefficient
sigma0_num_valid	number of valid points used to compute Ku band backscatter coefficient
mss	Mean square slope
2nd band backscatter	
sigma0_2nd	C-band backscatter coefficient (2nd band)
sigma0_rms_2nd	RMS of the C band backscatter coefficient
sigma0_num_valid_2nd	number of valid points used to compute C band backscatter coefficient
	environmental variables for each altimeter band (usually: 1st band = Ku, 2nd band = C or S)
1st band wave variables	
swh	significant wave height (1st band, uncalibrated)
swh_corrected	significant wave height (1st band, calibrated)
swh_filtered	significant wave height (1st band, calibrated, filtered)
swh_quality	quality level significant wave height measurement (1st band)
swh_standard_error	best estimate of significant wave height standard error

swh_rms	RMS of significant wave height (1st band)
swh_num_valid	number of valid points used to compute significant wave height (1st band)
rejection_flags	consolidated instrument and ice flags
2nd band wave variables	
swh_2nd	corrected significant wave height (2ns band, uncalibrated)
swh_rms_2nd	RMS of significant wave height (2nd band)
swh_num_valid_2nd	number of valid points used to compute significant wave height (2nd band)
swh_2nd_quality	quality level significant wave height measurement (2nd band)
	auxiliary variables
instrument/platform	
off_nadir_angle_wf	square of the off nadir angle computed from waveforms
off_nadir_angle_pf	Off nadir angle from platform
Auxiliary measurements	
wind_speed_alt	altimeter wind speed
wind_speed_alt_calibrated	Calibrated Altimeter wind speed.
wind_speed_rad	radiometer wind speed
sea_surface_height	sea level
range_rms	RMS of the Ku band range
range_rms_2nd	RMS of the C band range
topography	
bathymetry	ocean depth
distance_to_coast	distance to nearest coast
Model auxiliary data	

wind_speed_model_u	U component of the model wind vector
wind_speed_model_v	V component of the model wind vector
sea_surface_temperature	sea surface temperature
surface_air_temperature	surface air temperature
surface_air_temperature	surface air pressure
total_column_liquid_water_content	Total column cloud liquid water content

Annex C : Processing details

Processing details

Missions

Mission	Altimeter	Selected band
GFO	GFO-RA	Ku
Topex-Poseidon	POSEIDON-1	Ku
ERS-1	RA	Ku
ERS-2	RA	Ku
Envisat	RA-2	Ku
Jason-1	POSEIDON-2	Ku
Jason-2	POSEIDON-3	Ku
Jason-3	POSEIDON-3B	Ku
Cryosat-2	SIRAL	Ku
SARAL	AltiKa	Ka
Sentinel-3 A	SRAL	Ku
Sentinel-3 B	SRAL	Ku
HY-2A	ALT	Ku

Editing

Editing is applied to original L2 data in order to qualify measurements (in L2P) and retain only good measurements (in L3).

Geosat

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad

(ii) Acceptable if it passes all of the following: • 0 < SWH < 2500 # cm • 500 < SIG_0 < 2000 # 0.01dB • 0 < SIG_H < 10 # cm • 0 < ATT < 70 # 0.01deg • FLAGS bit 0=1 # ocean (5-minute CSR land mask) • FLAGS bit 3=0 # all 10/sec heights valid • FLAGS bit 6=0 # if VATT estimate used <60 raw samples		Acceptable
(iii) Good if it passes checks in (ii) above and: • Cycle < 40 # Quality degraded		Good
Notes 1. Using: Geosat Altimeter JGM-3 GDRs on CD-ROM 2. SWH values increased by 13% from earlier version using Carter D J T, Challenor P G and Srokosz M A 1992 An assessment of Geosat wave height and wind speed measurements. J. Geophys. Res., 97, 11383-11392. 3. Wind speeds calculated using Freilich M H, and Challenor P 1994 A new approach for determining fully empirical altimeter wind speed model functions. J. Geophys. Res., 99, 25051-25062.		

Topex/Poseidon - Topex

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad
(ii) Acceptable if it passes all of the following: • 0<SWH_K < 65534 # cm # unsigned integer • SWH_Pts_Avg > 7 • 0<SWH_RMS_K < 100 or 0.1*SWH_K # cm • Sigma0_K < 65535 # 0.01dB • AGC_Pts_Avg > 15 • AGC_RMS_K < 20 # 0.01dB • RMS_H_Alt < 80 # mm • Att_Wvf < 20 # 0.01dB • Geo_Bad_1 bit 1 =0 # water (not land) • Geo_Bad_1 bit 3 =0 # no ice • Alt_Bad_2 bit 6 =0 # check AGC correction and sigma0		Acceptable
(iii) Good if it passes checks in (ii) above and: • Geo_Bad_2 bit 0 = 0 # no rain/excess liquid detected		Good

Notes • Maximum wind speed is 255 (25.5 m/s) which is also the default value.		

Topex/Poseidon - Poseidon

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad
(ii) Acceptable if it passes all of the following: • 0 <SWH_K < 65534 # cm # unsigned integer • 700<Sigma0_K < 2500 # 0.01dB • RMS_H_Alt < 200 # mm • 0<Att_Wvf < 30 # 0.01deg • Geo_Bad_1 bit 1 = 0 # water (not land) • Geo_Bad_1 bit 3 = 0 # no ice • Alt_Bad_1 bits 2-3 = 0 # SWH OK • Alt_Bad_1 bits 4-5 = 0 # backscatter OK		Acceptable
(iii) Good if it passes checks in (ii) above and: • Geo_Bad_2 bit 0 =0 # no rain/excess liquid detected		Good
Notes 1. Default wind speed is 255 (25.5 m/s). 2. Poseidon records include Nval_H_Alt values (but not SWH_Pts_Avg or AGC_Pts_Avg) with a maximum of 20. So an additional check might be Nval_H_Alt>15 say, if Nval_H_Alt were stored in the location for Topex SWH_Pts_Avg.		

ERS-1

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad
		Acceptable
(ii) Acceptable if it passes all of the following: • Nval>16 • Std_H_Alt<400 • 0<SWH<3000 # 10-2m • 0<Std_SWH<200 # 10-2 m • 0<Std_Sigma0<30 # 10-2dB • MCD bits 0,7,8 =0		Good

○ Bit 0: Measurement valid ○ Bit 7: SWH valid ○ Bit 8: sig0 valid (in range 700-1960)		
Notes 4. there is no satisfactory way of deriving a 'rain flag'. 5. If sig0<7dB then wind speeds put to 20.15 m/s; if sig0>19.6dB then wind speed put to 0.01 m/s.		

ERS-2

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad
		Acceptable
(ii) Acceptable if it passes all of the following: ● Nval>16 ● Std_H_Alt<400 ● 0<SWH<3000 # 10-2m ● Std_SWH<200 # 10-2 m ● 500<Sigma0<3000 # 10-2dB ● 0<Std_Sigma0<30 # 10-2dB ● -2 10^5<Square_Off_Nad< 2 10^5 # 10-6deg2 ● MCD bits 0,7,8 =0 ○ Bit 0: Measurement valid ○ Bit 7: SWH valid ○ Bit 8: sig0 valid (in range 700-1960)		Good
Notes 6. there is no satisfactory way of deriving a 'rain flag'. 7. If sig0<7dB then wind speeds put to 20.15 m/s; if sig0>19.6dB then wind speed put to 0.01 m/s.		

GFO

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad
(ii) Acceptable if it passes all of the following: ● NVals_SWH > 8 # Not available? ● 0< SSHU_STD < 110 # mm		Acceptable

• SWH_STD >0 and (SWH_STD < 10 OR SWH_STD <0.1* SWH) (SWH: cm SWH_STD: cm) • 0< sigma0 < 3000 # 0.01dB • 0< AGC_STD < 30 # 0.01dB • q1_n flags 4,6,10,11,19,20,21 = 0 ○ 4 : backscatter error ○ 6 : VATT estimate error ○ 10 : SWH bounds error ○ 11 : AGC bounds error ○ 19 : SWH STD error ○ 20 : AGC STD error ○ 21 : height STD error		
(iii) Good if it passes checks in (ii) above and: • q2_n flag 12 = 0 # rain		Good
Notes:		

Envisat

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad
(ii) Acceptable if it passes all of the following: • range_rms_ku < 200 # mm Unsigned integer • 18 < swh_numval_ku < 255 # Unsigned integer • 0 < swh_ku < 32767 # 10-3m • 0 < swh_rms_ku < 32767 # 10-3 m • swh_rms_ku < (845.7-0.050*swh_ku+0.0000384*swh_ku^2) • 0 < sig0_ku < 32767 # 10-2dB • 0 < sig0_rms_ku < 300 # 10-2 dB • wind_speed_alt < 32767 # 10-3m/s • 1500 < peakiness < 1800 • abs(sq_off_nadir_angle_ku_wvf)<1000 # 10-4deg2 • mcd bit 16 = 0 • 16:Ku Ocean retracking • alt_surface_type <=1 # open ocean, enclosed seas or lakes		Acceptable
(iii) Good if it passes checks in (ii) above and: • rain_flag= 0		Good
Notes		

8. S-band altimeter failed on 17 January 2008. 9. Wind speed algorithm gives an upper limit of 21.3 m/s 10. There is no ice flag at present but Tran N, Girard-Ardhuin F, Ezraty R, Feng H, and Féménias P 2009 Defining a Sea Ice Flag for Envisat Altimetry Mission IEEE GEOSCIENCE AND REMOTE SENSING LETTERS, Vol. 6, No. 1. states that "a flag derived from this classifier will be made available in the coming soon reprocessed products of Envisat altimetry mission." But the loss of S-band might be a problem. 11. Queffeulou (2009b) suggests that the relationship between swh_rms_kuswh_ku needs to be re-evaluated.		

Jason-1

GlobWave editing	CCI editing	QL
(i) Bad if it fails any of the checks in (ii)		Bad
(ii) Acceptable if it passes all of the following: • range_rms_ku <= 1500 # 10-4m • 18 < swh_numval_ku < 255 # Unsigned integer • swh_ku < 65535 # Unsigned integer • swh_rms_ku > 0 # 10-3m • swh_rms_ku < 65535 • swh_rms_ku < (996.1-0.0398*swh_ku+0.0000132*swh_ku^2) # (swh_ku: 10-3 m) • sig0_rms_ku <= 100 # 10-2dB • wind_speed_alt < 65535 # cm/s • off_nadir_angle_ku_wvf >= -200 and off_nadir_angle_ku_wvf <=2500 # 10-4deg2 • qual_1hz_alt_data bits 0,2,4 = 0 (Ku band range, Ku band SWH and Ku band backscatter coefficient) • surface_type <=1 # open ocean, nclosed seas or lakes • alt_echo_type = 0 # ocean-like		Acceptable
(iii) Good if it passes checks in (ii) above and: • rain_flag=0 • ice_flag = 0		Good
Notes 12. Jason-1 has a relatively large number of records with swh_ku=0 some of which are probably bad. Queffeulou P & Croizé-Fillon D (2009) recommend		

discarding all swh_ku=0. 13. Ice_flag may be set if climate map predicts ice and wind speed < 1m/s. 14. Queffeulou (2009b) suggests that the relationship between swh_rms_ku and 15. swh_ku needs to be re-evaluated.		

Jason-2

GlobWave editing	**CCI editing**	**QL**
(i) Bad if it fails any of the checks in (ii)	(i) Bad if it fails any of the checks in (ii)	Bad
(ii) Acceptable if it passes all of the following: ● 18 < swh_numval_ku < 127 ● swh_ku < 32767 # 10-3m ● -30 < swh_rms_ku < 32767 # 10-3 m ● sig0_rms_ku <= 100 # 10-2dB ● wind_speed_alt < 32767 # 10 m/s ● -200 <= off_nadir_angle_wf_ku <=2500 # 10-4deg2 ● qual_alt_1hz_range_ku = 0b ● qual_alt_1hz_swh_ku = 0b ● qual_alt_1hz_sig0_ku = 0b ● surface_type <=1 # open ocean, enclosed seas or lakes ● alt_echo_type = 0 # ocean-like		Acceptable
(iii) Good if it passes checks in (ii) above and: ● rain_flag=0 ● ice_flag = 0	(ii) Good if it passes all of the following: ● surface_type < 2 ● hk > 0 ● swh_num_val > 10 ● sigk >= 5 (sigk =sig0_ku_mle3) ● abs(swh_ku - mean(swh_ku)) <= 5m with the mean calculated over a 100km window, 4 points minimum ● abs(swh_ku - mean(swh_ku)) > (5 * std(swh_ku)) with the mean and std calculated over a 100km window, 4 points minimum ● swh_rms_ku > sdmax with: ○ sdmax in LUT for 0 < swh_ku < 4.5m ○ sdmax = poly(swh_ku) for 4.5m < swh_ku < 8m [y=(0.00854127 * x^4) + (-0.16602944 * x^3) + (1.21803198 * x^2) + (-3.73409038 * x) + 5.00280091] ○ sdmax = 3.06 for swh_ku > 8m	Good
Notes 16. Jason-1 has a relatively large number of records with swh_ku=0 some of	Notes 1. The swh selected is from MLE4 retracker (while sigma0 is	

which are probably bad. Queffeulou P & Croizé-Fillon D (2009) recommend discarding all swh_ku=0. 17. Ice_flag may be set if climate map predicts ice and wind speed < 1m/s. 18. Queffeulou (2009b) suggests that the relationship between swh_rms_ku and swh_ku needs to be re-evaluated.	selected from MLE3 retracker)	

Jason-3

GlobWave editing	CCI editing	QL
	(i) Bad if it fails any of the checks in (ii)	Bad
	•	Acceptable
	(iii) Good if it passes the following checks: • surface_type < 2 • hk > 0 • swh_num_val > 10 • sigk >= 5 (sigk = sig0_ku_mle3) • abs(swh_ku - mean(swh_ku)) <= 5m with the mean calculated over a 100km window, 4 points minimum • abs(swh_ku - mean(swh_ku)) > (5 * std(swh_ku)) with the mean and std calculated over a 100km window, 4 points minimum • swh_rms_ku > sdmax with: ○ sdmax in LUT for 0 < swh_ku < 4.5m ○ sdmax = poly(swh_ku) for 4.5m < swh_ku < 8m [y=(0.00245436 * x^4) + (-0.04199479 * x^3) + (0.28811371 * x^2) + (-0.77121584 * x) + 1.66388247] ○ sdmax = 2.4851 for swh_ku > 8m	Good
	Notes 2. The swh selected is from MLE4 retracker (while sigma0 is selected from MLE3 retracker)	

Cryosat-2

GlobWave editing	CCI editing	QL
	(i) Bad if it fails any of the checks in (ii)	Bad

		Acceptable
	(ii) Good if it passes checks in (ii) above and: ● Flags ○ Bit 13 = 0 # backscatter quality ○ Bit 12 = 0 # swh quality ○ Bit 11 = 0 # ssh quality ○ Bit 4 = 0 # land ● abs(swh_ku - mean(swh_ku)) <= 5m with the mean calculated over a 100km window, 4 points minimum ● abs(swh_ku - mean(swh_ku)) > (3.9 * std(swh_ku)) with the mean and std calculated over a 100km window, 4 points minimum ● swh_rms_ku > sdmax with: ○ sdmax in LUT for 0 < swh_ku < 4.5m ○ sdmax = poly(swh_ku) for 4.5m < swh_ku < 8m [y=0.003712808782105 * x3 -0.022959435041166 * x3 + 0.155517950243010 * x2 + 0.484687460175769] ○ sdmax = 2.1604 for swh_ku > 8m	Good
	Notes	

AltiKa

GlobWave editing	CCI editing	QL
	TBD	Bad
	TBD	Acceptable
	TBD	Good

Sentinel-3A

GlobWave editing	CCI editing	QL
	TBD	Bad
	TBD	Acceptable
	TBD	Good

Sentinel-3B

GlobWave editing	CCI editing	QL
	TBD	Bad
	TBD	Acceptable
	TBD	Good
	Notes	

HY2A

GlobWave editing	CCI editing	QL
	TBD	Bad
	TBD	Acceptable
	TBD	Good
	Notes	

Calibration

The table below provides the calibration table for SWH used in GlobWave for GDR L2 products.The underlined formula are what was implemented in GlobWave.

Sources:

- Calibration derived from GlobWave error analysis [Ash E R & Carter D J T, September 2010, Satellite wave data quality report, GlobWave Deliverable D.16] http://globwave.ifremer.fr/download/GlobWave_D.16_SWDQR.pdf

- Queffeulou, Pierre - ftp://ftp.ifremer.fr/ifremer/cersat/products/swath/altimeters/waves/documentation/altimeter_wave_merge__11.4.pdf
- GlobWave Product User Guide Phase 3, Deliverable D.7

Satellite	**Calibration derived from GlobWave error analysis [Ash E R & Carter D J T, September 2010, Satellite wave data quality report, GlobWave Deliverable D.16]**	**Queffeulou [2004] [2009] [2011] [2013] [2016]**
Geosat	No calibration. JGM-3 version has calibrations applied.	
ERS-1 *OPR*	[swh >= 1m] swh_error = 0.094 + swh*0.052 [swh < 1m] swh_error = 0.146	swh_adjusted = 1.1259 x swh + 0.1854
REAPER	TBD	TBD
ERS-2 *OPR*	[swh >= 1m] swh_error = 0.080 + swh*0.059 [swh < 1m] swh_error = 0.139	swh_adjusted = 1.0642 x swh + 0.0006 swh_adjusted [2016] = 1.0541 x swh + 0.0391
REAPER	TBD	TBD
Envisat *Version 2.1 [2010]*	[swh >= 1m] swh_error = 0.004 + swh*0.076 [swh < 1m] swh_error = 0.080	[swh > 3.41m] swh_adjusted = 1.0095 x swh + 0.0192 [swh < 3.41m] swh_adjusted = -0.021 x swh^3 + 0.1650 x swh^2 + 0.5693 x swh + 0.4358
AltiKa	TBD	No swh correction needed
GFO *Version b*	[swh >= 1m] swh_error = 0.022 + swh*0.058 [swh < 1m] swh_error = 0.080	swh_adjusted = 1.0625 x swh + 0.0754
Jason-1 *Version B*	[swh >= 1m] swh_error = 0.055 + swh*0.052 [swh < 1m] swh_error = 0.107	swh_adjusted = 1.0250 x swh + 0.0588

Version C	TBD	swh_adjusted = 1.0211 x swh + 0.0139
Jason-2 *Version T & D*	swh_adjusted = 1.041 x swh - 0.042 [swh >= 1m] swh_error = 0.058 + swh*0.052 [swh < 1m] swh_error = 0.110	swh_adjusted = 1.0149 x swh + 0.0277
Jason-3	TBD	No SWH correction ? TBD ?
CryoSat-2	TBD	[swh <= 2.45] swh_adjusted = 0.4889 + 0.4712 x swh + 0.1546 x swh^2 - 0.0145 x swh^3 [swh > 2.45] swh_adjusted = -0.1057 + 1.0058 x swh
Topex-Poseidon/Topex Side A (up to cycle 235):	[swh >= 1m] swh_error = 0.043 + swh*0.057 [swh < 1m] swh_error = 0.101	swh_adjusted = 1.0539 x swh - 0.0766 + dh with: ● dh = 0 for cycle < 98 ● dh = poly3(98) - poly3(cycle) for 98 <= cycle <= 235 with ○ a0 = 0.0864 ○ a1= -6.0426 x 10-4 ○ a2 = -7.7894 x 10-6 ○ a3 = 6.9624 x 10-8
Side B (from cycle 236):	[swh >= 1m] swh_error = 0.039 + swh*0.055 [swh < 1m] swh_error = 0.094	swh_adjusted = 1.0237 x swh - 0.0476
Topex-Poseidon/Poseidon	TBD	swh_adjusted = 0.9914 x swh – 0.0103
Sentinel-3A	TBD	TBD
Sentinel-3B	TBD	TBD

The next table gives details of the calibrations applied to the GDR sigma0 data, and of the corrections to get a new altimeter wind speed. The content is subject to change with time.

Sigma0 calibration
A first calibration is obtained from informations published by the agencies or by people involved in the monitoring of this measurements – sources are indicated for each altimeter.

A second calibration (indicated in the following by [ENVISAT] in green) is obtained from comparison with the ENVISAT sigma0, which seems to be stable with time: for each altimeter a bias was estimated relative to ENVISAT, comparing mean values of sigma0, over the global oceans, between 66.15° S and 66.15° N, and over the common time period with ENVISAT, for TOPEX, ERS-2, Jason-1 & 2 and GFO. ERS-1 was adjusted indirectly by a first comparison with ERS-2, itself adjusted relatively to ENVISAT.

These two calibration values are applied to the GDR sigma0, resulting in the adjusted sigma0 parameter given in the data set.

Sigma0 correction
A correction to the above adjusted value of sigma0 is then estimated to get a best fit when comparing wind buoy data with altimeter wind speed inferred from a unique algorithm. Presently the Abdalla (2007) algorithm is used. The corrected sigma0 is not given in the data set. A adjusted wind speed value is given. The adjusted wind speed is estimated using the adjusted and corrected sigma0 as input in the Abdalla algorithm.

Source:
ftp://ftp.ifremer.fr/ifremer/cersat/products/swath/altimeters/waves/documentation/altimeter_wave_merge__9.0__annexe_II.pdf

satellite	**Sigma0 calibration**	**Sigma0 correction for wind speed calculation**	**Comment**
Geosat	TBD	TBD	
ERS-1 *OPR*	+0.0976 dB +0.0465 + 0.0511 [ENVISAT]	- 0.140 dB	adjusted sigma0 Ku-band and adjusted wind speed set to NaN before 01-Aug-1991 02:15:18
REAPER			
ERS-2 *OPR*	+0.15 dB from January 16 to February 7, 2000 +0.35 dB from February 10 to March 2, 2000 +0.25 dB from 3 Mar 2000 to 7 Oct 2000 +0.35 dB from 8 Oct 2000 (anomaly occurs) to 5 Feb 2001	-0.140 dB	calibrations were obtained from Dorandeu et al. 2000, and Scharroo, personal communication. Extra Backup Mode (extended further...): do not use sigma0 ERS-2 from 17 Jan

	+0.45 dB from 6 Feb 2001 (Extra backup mode starts) to 29 Apr 2001 +0.25 dB since 30 Apr 2001 (Zero Gyro mode implemented) +0.0511 dB [ENVISAT]		2001 to 31 March 2001, included; calibrated sigma0 Ku-band and adjusted wind speed set to NaN over this time period
REAPER	TBD	TBD	
Envisat *Version 2.1 [2010]*	+0. dB [ENVISAT]	-0.138 dB (as in Zieger et al. 2009)	
AltiKa	TBD	TBD	
GFO *Version b*	+0.32 dB from 11 January 2000 to 6 December 2000 (included) -0.4322 dB [ENVISAT]	-0.140 dB to be verified	Do not use sigma0 GFO after 2 Aug 2006. Calibrated sigma0 Ku-band and adjusted wind speed set to NaN over this time period.
Jason-1 *Version B*			
Version C	-2.8165 dB [ENVISAT]	-0.30 dB	
Jason-2 *Version T & D*	-2.7668] + 0.2024 (version D) dB [ENVISAT	-0.225 dB	
Jason-3	TBD	TBD	
CryoSat-2	none	none	
Topex-Poseidon/Topex Side A (up to cycle 235):	correction as a function of cycle number: for side-A: • table 2-b for cycle numbers lower than 133 • table 2-a for cycle 133 and greater, from Hayne and Hancock, July 1999. -0.4739 dB [ENVISAT]	-0.15 dB	Do not use the 10 first TOPEX cycles, date lower than or equal to 31 Dec 1992. Do not use TOPEX miss-pointing cycles 433-437 included, i.e. data between June 15, 2004 and August 2, 2004, included. Calibrated sigma0 Ku-band and adjusted wind speed set to NaN over this time periods.

Side B (from cycle 236):	for side-B : Table G-1 of Lockwood et al., July 2006. -0.4739 dB [ENVISAT]		
Topex-Poseidon/Poseidon	– 0.4141 dB (still to be verified)	-0.15 dB	
Sentinel-3A	TBD	TBD	
Sentinel-3B	TBD	TBD	

Calculated variables

MSS

MSS = (0.64/exp((sigma0_adjusted-2.5)*(0.1*ALOG(u10))))/10

Filtered SWH

A non-parametric denoising method based on Empirical Mode Decomposition (EMD, Huang et al., 1998) implemented by Kopsinis and McLaughlin (2009) is applied to the parameter swh_adjusted (see Quilfen et al., 2018).

Huang, N.E., Shen, Z., Long, S.R., Wu, M.C., Shih, H.H., Zheng, Q., Yen, N.-C., Tung, C.C., Liu, H.H., 1998. The empirical mode decomposition and the Hilbert spectrum for nonlinear and non-stationary time series analysis. Proceedings of the Royal Society of London A: Mathematical, Physical and Engineering Sciences 454, 903–995. https://doi.org/10.1098/rspa.1998.0193

Kopsinis, Y., McLaughlin, S., 2009. Development of EMD-Based Denoising Methods Inspired by Wavelet Thresholding. IEEE Transactions on Signal Processing 57, 1351–1362. https://doi.org/10.1109/TSP.2009.2013885

Quilfen, Y., Yurovskaya, M., Chapron, B., Ardhuin, F., 2018. Storm waves focusing and steepening in the Agulhas current: Satellite observations and modeling. Remote Sensing Of Environment 216, 561–571. https://doi.org/10.1016/j.rse.2018.07.020

Wind speed

Currently wind speed is calculated on adjusted sigma0 using Abdalla (2007). This should be improved in future. In particular AltiKa would require two parameter formulation.

Ancillary variables

Model data

The selected source for model is ERA5 : currently it is only available from 2000 to 2018, but it is being extended backward.

Sea Surface Height

Use CCI Sea Level data.

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