



EO4FLOOD

WATER CYCLE HYDROLOGY SCIENCE CLUSTER -
ADVANCING FLOOD FORECASTING

Product Specification Document

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EO4FLOOD

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Table of Content

| | |
|--|----|
| List of acronyms used | 6 |
| 1. Introduction | 7 |
| Purpose and scope | 7 |
| 1.1. Scope of the report..... | 7 |
| 1.2. Applicable documents | 7 |
| 1.3. Document Organization..... | 7 |
| 2. General definitions..... | 10 |
| 2.1. Product overview..... | 10 |
| 2.2. Format file | 10 |
| 2.3. File naming | 11 |
| 3. Data product specification | 12 |
| 3.1. Precipitation | 12 |
| 3.2. Soil Moisture..... | 13 |
| 3.3. Snow | 16 |
| 3.4. Width | 22 |
| 3.5. Surface reflectance..... | 23 |
| 3.6. Water level virtual stations | 25 |
| 3.7. Multi-mission water level time series | 26 |
| 3.8. Multi-mission Water Surface Slope | 28 |
| 3.9. River discharge from Width..... | 30 |
| 3.10. River discharge from Reflectance..... | 31 |
| 3.11. River discharge from Water level | 32 |
| 3.12. Multi-mission river discharge for ungauged sites | 34 |
| 3.13. Multi-mission river discharge at Gauges | 34 |
| 3.14. Flood Extent..... | 36 |
| 3.15. Hydrological models | 38 |
| MGB..... | 39 |
| DHI-GHM..... | 39 |
| HYPE..... | 39 |
| Hybrid-AI..... | 40 |
| MCP probabilistic forecast..... | 40 |
| 3.16. Hydraulic models | 40 |
| Mike+ | 41 |
| HEC-RAS..... | 41 |
| DassFlow 1D/2D..... | 42 |
| LISFLOOD-FP | 42 |



| | |
|--|----|
| Hybrid-AI..... | 42 |
| 4. NRT Data product specification..... | 43 |
| 4.1. Precipitation | 43 |
| 4.2. Water level | 43 |
| 4.3. River discharge | 43 |

List of acronyms used

ASCAT: Advanced Scatterometer
AVHRR: Advance Very High-Resolution Radiometer
CCI: Climate Change Initiative
CHIRPS: Climate Hazards group Infrared Precipitation with Stations ECMWF Scheme for Surface Exchanges over Land
CLMS: Copernicus Land Monitoring Service
DEM: Digital Elevation Model
EASE: Equal-Area Scalable Earth
ECMWF: European Centre for Medium-Range Weather Forecasts
EO: Earth Observation
EPSG: European Petroleum Survey Group
ERA5: ECMWF Reanalysis 5
FSC: Fractional Snow Cover
GFSC: Ground Fraction Snow Cover
GPM: Global Precipitation Measurement
GSMAP-NRT: Global Satellite Mapping of Precipitation Near Real Time
GSMAP-MVK: Global Satellite Mapping of Precipitation Microwave-Infrared combined product using Kalman filter
H SAF: EUMETSAT Satellite Application Facility on support to Operational Hydrology and Water Management
IMERG: Integrated Multi-satellitE Retrievals for GPM
MCP: Model Conditional Processor
MGB: Modelo de Grandes Bacias
METOPA: (MetOp-A) Meteorological Operational satellite (A)
MODIS: Moderate Resolution Imaging Spectroradiometer
NRT: Near Real Time
SAR: Synthetic Aperture Radar
SCE: Snow Cover Extend
SCFG: Snow Cover Fraction Ground
SM2RAIN: Soil Moisture to Rainfall
SMAP: Soil Moisture Active Passive satellite mission
SMOS: Soil Moisture and Ocean Salinity
S-NNP VIIRS: Suomi National-Orbiting Partnership, Visible Infrared Imaging Radiometer Suite
SPP: Satellite precipitation product
SWE: Snow Water Equivalent
SWS: SAR Wet Snow
VIIRS: Visible Infrared Imaging Radiometer Suite
WGS: World Geodetic System
WSE: Water Surface Elevation

1. Introduction

Purpose and scope

The EO4FLOOD project aims at demonstrating the maturity and effectiveness of cutting-edge satellite data in enhancing flood forecasting systems. The project focuses on leveraging advanced satellite technologies and algorithms to improve the accuracy and timeliness of existing hydrological and hydraulic models, resulting in more reliable and precise flood predictions. EO4FLOOD is structured around three key pillars: 1) Development of an Advanced Open Earth Observation Dataset (EO4FLOOD dataset) that leverages the latest products from both ESA and non-ESA satellite missions, ensuring global coverage with high spatial and temporal resolutions; 2) Integration of the EO4FLOOD Dataset into Flood Forecasting Models through the combination of hydrological, hydraulic, and flood models with machine learning techniques; 3) Demonstration of the EO Data and Models for Science and Society to show how the integration of EO data and models can improve flood forecasting and risk management.

1.1. Scope of the report

This document is the Product Specification Document for the EO4FLOOD and represents D2.3 of the project. The document will present the format of the products that are produced in the project.

1.2. Applicable documents

AD-01: Water Cycle Hydrology Science Cluster - Advancing Flood Forecasting – Statement of Work, V1.

1.3. Document Organization

This document is organised as follows:

- Section 1 (this section) is a short introduction defining the scope of this report.
- Section 2 includes the general definition of products, variables and file formats.
- Section 3 includes EO product format specifications and specifications of output from models
- Section 4 includes NRT product specifications.

In Table 1.3.1, we will provide a list of product types and the organizations responsible for supplying each product. Figure 1.3.1 shows the Product Breakdown Structure of the EOdataset.

Table 1.3.1: List of the product type and the responsible organization.

| Product overview | Product type | Responsible organization |
|------------------|-----------------|--------------------------|
| Precipitation | IMERG Early Run | CNR |
| | IMERG Late Run | |
| | IMERG Final Run | |
| | CHIRPS | |
| | SM2RAIN_ASCAT | |
| | ERA5-Land | |
| | GSMAP-NRT | |
| | GSMAP-MVK | |
| | GSMAP-Gauge | |
| Soil Moisture | SMOS | CNR |
| | SMAP | |

| | | |
|---|---|--------------|
| | ASCAT | |
| Snow | CLMS Fractional Snow Cover (FSC) | Magellium |
| | CLMS daily-cumulative Gap-filled Fractional Snow Cover (GFSC) | |
| | CLMS SAR Wet Snow (SWS) | |
| | CLMS Snow Cover Extent (SCE) - 500m - Europe | |
| | CLMS Snow Cover Extent (SCE) - 1km - Northern Hemisphere | |
| | Snow_CCI SCFG MODIS V3.0 | |
| | Snow_CCI SCFG AVHRR METOPA V3.0 | |
| | Snow_CCI SCFG AVHRR NOAA18 V3.0 | |
| | Snow_CCI SCFG AVHRR NOAA19 V3.0 | |
| | Snow_CCI SWE v3.1 | |
| Width | Landsat | GIS |
| | Sentinel-2 | |
| | MODIS | |
| Surface reflectance | Sentinel-2 | CNR |
| | MODIS | |
| Water level virtual stations | Sentinel-3, Sentinel-6, SWOT | TUM |
| Multi-mission water level time series and slope | Sentinel-3, Sentinel-6, SWOT, Cryosat-2, ICESat-2 | DTU |
| River discharge | from Width | GIS |
| | from Reflectance | GIS |
| | from Water level | GIS |
| | From multi mission (gauged) | GIS |
| | From multi-mission (ungauged) | TUM |
| Flood Extent | VIIRS | GMV |
| | Sentinel-1 | GMV |
| | Sentinel-2 | RSS-Hydro |
| Hydrological models | MGB | HydroMatters |
| | DHI-GHM | DHI |
| | HYPE | SMHI |
| | Hybrid-AI | DHI |
| | MCP probabilistic forecast | CNR |
| Hydraulic models | Mike+ | DHI |
| | HEC-RAS | RSS-Hydro |
| | DassFlow 1D/2D | HydroMatters |
| | LISFLOOD-FP (2D) / GVF (1D) | SMHI |
| NRT precipitation | IMERG-ER | CNR |
| | IMERG-LR | |
| | GSMAP-NRT | |
| NRT water level | Sentinel-3 and Sentinel-6 | TUM |
| NRT river discharge | From Water Surface Elevation | GIS |

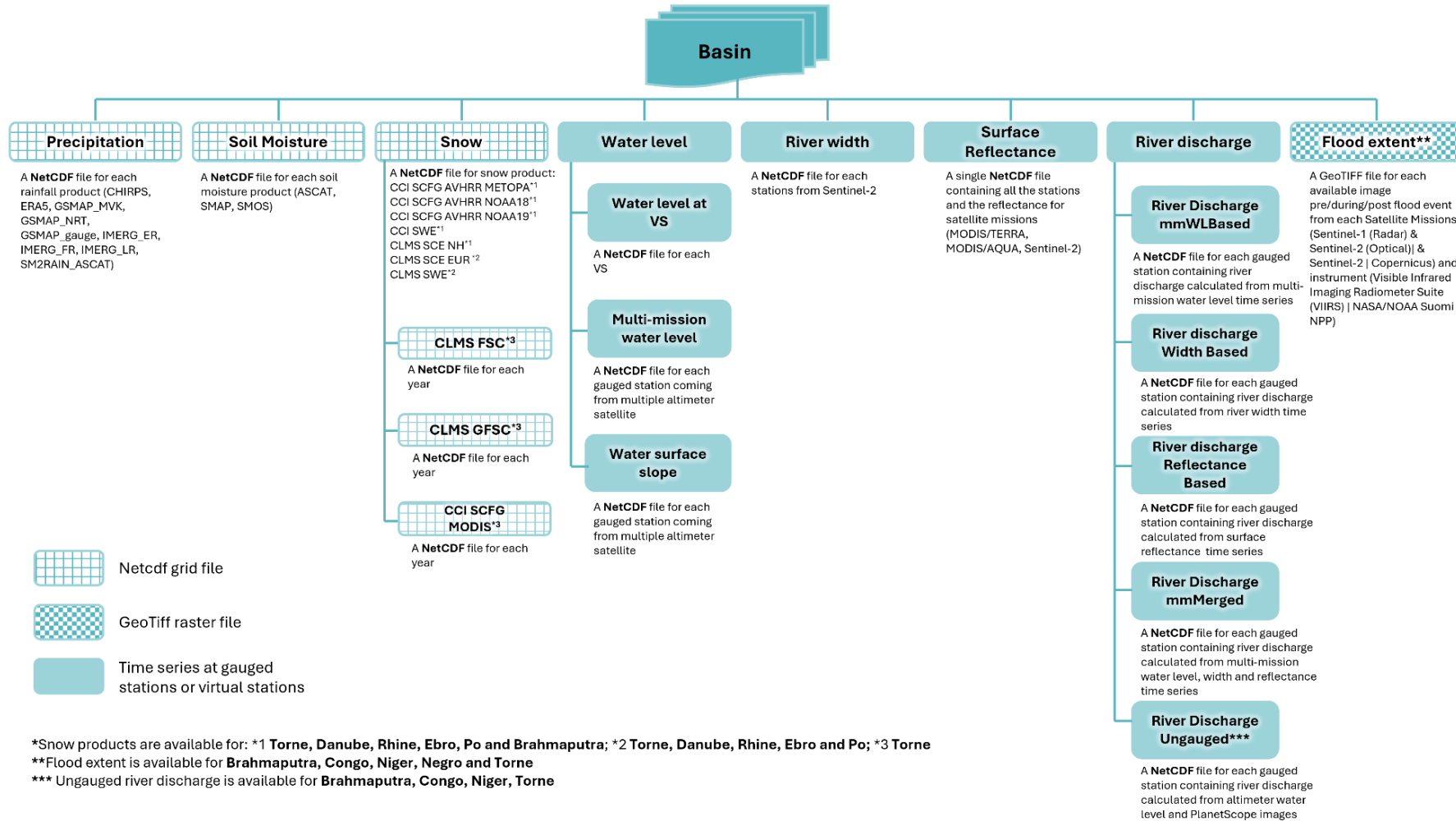


Figure 1.3.1 – Product Breakdown Structure of the EOdataset

2. General definitions

2.1. Product overview

The EO4FLOOD project delivers an integrated portfolio of products to support flood forecasting modelling. The products are classified into two main categories, which together provide both observational data and predictive/simulated outputs:

➤ Earth Observation Data Products

These include both:

- Products directly sourced from Earth Observation missions (e.g. precipitation, snow, soil moisture) which are downloaded, pre-processed and harmonised over the project's areas of interest.
- Internally generated satellite-derived products generated using project-specific algorithms, e.g. for deriving river width, river discharge, multi-mission water level or other geophysical parameters from satellite imagery or radar/altimetry data.

These satellite data products serve as the observational backbone of EO4FLOOD, providing the core Earth Observation datasets for hydrology and, in some cases, near-real-time information on river states, flood extent, and water surface properties

➤ Model Output Products

These are outputs produced by hydrological and hydraulic models, which ingest EO-derived data (from previous step) along with other ancillary inputs (e.g. digital elevation models, land use, meteorological forcing, ground observations). The model outputs include, for example, simulated discharge, flood extent, water levels, flow velocities and scenario or forecast products.

These modelled products complement the observational ones: they allow predicting flood events, scenario analysis, spatial interpolation where observations are sparse, and support decision-making in management and risk mitigation.

2.2. Format file

EO4FLOOD products are distributed in a range of standard formats, selected according to the nature of the data and their intended use. These include:

- **NetCDF:** adopted as the primary format for EO4FLOOD distributed products. NetCDF files provide a flexible, self-describing, and platform-independent structure for storing multidimensional datasets. The NetCDF format has become widely adopted for the distribution of remote sensing data. The NetCDF file is structured into the following elements:
 - *Dimensions:* represent real physical dimensions (e.g., time, latitude, longitude, height) or serve as indices for other quantities (e.g., number of waveforms or samples). Each dimension has a name and a length.
 - *Variables:* store the data arrays within the NetCDF file. A variable is defined by its name, data type and shape (list of dimensions). Scalars are represented as 0-dimensional arrays. Variables may also contain attributes, which can be added, modified or deleted.

- *Attributes*: contain metadata describing the data values. Attributes are usually associated with a specific variable and can include information such as units, scale factors, or offsets.
- *General attributes*: Provide metadata that describe the dataset, supporting its documentation and interpretation.
- **CSV and TXT**: used for the distribution of time series at river reaches or stations, ensuring ease of access and compatibility with common analysis tools.
- **SHP and GeoTIFF**: used for geospatial products such as maps of flood extent, river networks, or water surface variables, ensuring interoperability with GIS platforms.

This multi-format strategy ensures that EO4FLOOD products are accessible, interoperable, and suitable for both scientific analysis and operational applications.

2.3. File naming

In the EO4FLOOD framework the following naming convention is used to distinguish among the different basins. To this end the basin code reported in Table 2.3.1 is used as part of the generated products files.

Table 2.3.1: Overview of the “basin” codes

| Basin name | “basin” code |
|-------------|--------------|
| Po | “po__” |
| Rhine | “rhie” |
| Ebro | “ebro” |
| Danube | “dane” |
| Torne | “tore” |
| Negro | “nego” |
| Niger | “nigr” |
| Congo | “cono” |
| Brahmaputra | “braa” |

3. Data product specification

This section describes the format of the products provided within the project and described in the Algorithm Theoretical Basis Document (EO4FLOOD_D2.2_ATBD_v2.pdf).

3.1. Precipitation

File format and naming convention

The precipitation data are stored in NetCDF files that use the following name convention: “EO4FLOOD_Precipitation_SPP_basin.nc” where *SPP* represents the satellite rainfall product and *basin* the river catchment over which the product has been extracted, as defined in Table 2.3.1. Tables 3.1.1 summarizes the *SPP* characteristics.

Table 3.1.1: Overview of the “SPP” codes

| Precipitation product | “SPP” code | Temporal sampling | Spatial sampling | Temporal coverage | Latency |
|-----------------------|---------------|-------------------|------------------|-------------------|----------|
| IMERG Early Run | “IMERG_ER” | 1 h | 0.1° | 2016-2024 | 4 hours |
| IMERG Late Run | “IMERG_LR” | 1 h | 0.1° | 2016-2024 | 18 hours |
| IMERG Final Run | “IMERG_FR” | 1 h | 0.1° | 2016-2024 | 3 months |
| CHIRPS | “Chirps” | daily | 0.05° | 2016-2024 | 3 weeks |
| SM2RAIN_ASCAT | “SM2RAIN” | daily | 0.1° | 2016-2024 | N/A |
| ERA5-Land | “ERA5” | 1 h | 9 km | 2016-2024 | 5 days |
| GSMAP-NRT | “GMSAP_NRT” | 1 h | 0.1° | 2016-2024 | 4 hours |
| GSMAP-MVK | “GSMAP_MVK” | 1 h | 0.1° | 2016-2024 | 3 days |
| GSMAP-Gauge | “GSMAP_Gauge” | 1 h | 0.1° | 2016-2024 | 3 days |

Product variables

Each NetCDF file contains the precipitation timeseries, the coordinates of the pixel centroids and the time according to the native spatial and temporal resolution of the “raw” estimates as reported in Table 3.1.1. As it can be seen from Table 3.1.2, the precipitation estimates are provided in integer data type. A scale factor of 1000 has been applied to the raw estimates in order to reduce the loss of information in the shift between floating point and integer data type. In this way, all the precipitation estimates have to be divided by 1000 in order to obtain a value in mm.

Table 3.1.2: Description of the variable in the NetCDF file

| Var name | Description | Units | Type | Dimension |
|---------------|--------------------------------------|--------|---------|------------------------------|
| time | Time in hours since 2000-01-01 00:00 | hour | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| Precipitation | Satellite precipitation estimates | mm | integer | Latitude, longitude, time |

Global attributes

The global attributes are summarized in the Table 3.1.3.

Table 3.1.3: Description of the global attribute in the NetCDF file

| Attribute | Description | Units | Type |
|----------------------------|---|-------|------|
| title | ESA EO4FLOOD project Precipitation input | - | text |
| product | Precipitation product name | - | text |
| basin | EO4FLOOD basin name | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Name of institution “National Research Council (CNR)” | - | text |
| creator_institution_e-mail | Contact information | - | text |
| references | Project reference paper | - | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

3.2. Soil Moisture

File format and naming convention

The soil moisture data are stored in NetCDF files that use the following name convention: “EO4FLOOD_soil_moisture_PRODUCT_BBBB.nc” where BBBB represents the basin over which the product has been extracted and PRODUCT represents the SMOS, SMAP or ASCAT file.

Product variables

Each NetCDF file contains time series of soil moisture, along with the corresponding pixel centroid coordinates (latitude and longitude) and time information. To ensure consistency across datasets, SMAP and ASCAT data have been re-gridded onto the CATDS L3 product grid for SMOS, which uses an Equal-Area Scalable Earth (EASE) grid with nominal spacing ≈ 25 km. Full specification of the grid (including cell area, indexing and coverage) is detailed in the SMOS CATDS L3 Soil Moisture ATBD (SO-TN-CBSA-GS-0029¹) and the product description document (SO-TN-CB-CA-0001.4a).

¹ CATDS–SMOS Team. (2021). CATDS Level 3 Data Product Description: Soil Moisture and Brightness Temperature (Technical Note SO-TN-CB-CA-0001.4a). Centre Aval de Traitement des Données SMOS (CATDS), IFREMER. Retrieved from <https://www.catds.fr/content/download/159307/file/SO-TN-CB-CA-0001.4a.pdf>

Table 3.2.1, 3.2.2 and 3.2.3 describe the variable in the NetCDF file for SMAP, SMOS and ASCAT.

Table 3.2.1: Description of the variable in the NetCDF file for SMAP

| Original product name: SMAP L3 Radiometer Global Daily 36 km EASE-Grid Soil Moisture | | | | |
|--|---|--------------------------------|--------|---------------------------|
| Var name | Description | Units | Type | Dimension |
| time | seconds since 1970-01-01 00:00:00 | datetime64[ns] | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| Soil moisture | Soil moisture estimates | m ³ /m ³ | single | Latitude, longitude, time |
| error | <p>Soil moisture error</p> <p>error (float, m³/m³): SMAP's theoretical 1-σ retrieval uncertainty for soil moisture (often called DQX in SMAP docs). It quantifies the expected standard deviation of the retrieval error for that pixel/day (not validation RMSE). Keep it in units of m³/m³. (SMAP user/ATBD documentation consistently refers to this as the retrieval uncertainty used for screening and analysis.)</p> | m ³ /m ³ | single | Latitude, longitude, time |
| Quality_flag | <p>values 0 or 8 indicate <i>high-quality retrievals</i> (8 means the soil-moisture retrieval is fine even though the freeze/thaw retrieval failed). National Snow and Ice Data Center+1</p> <p>Examples you're seeing:</p> <p>0 → 0000b → recommended, attempted, successful</p> <p>5 → 0101b → not-recommended & not-successful (but attempted)</p> <p>7 → 0111b → not-recommended, skipped or not-successful</p> | [-] | single | Latitude, longitude, time |

Table 3.2.2: Description of the variable in the NetCDF file for SMOS

| Original product name SMOS ATDS-PDC L3SM Simple UDP | | | | |
|---|---|-----------------|--------|---------------------------|
| Var name | Description | Units | Type | Dimension |
| time | Seconds since 1970-01-01 00:00:00 | datetime64 [ns] | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| Soil moisture | Surface soil moisture retrieved from SMOS multi-angular L-band observations. Derived via the τ - ω (optical depth–single scattering albedo) radiative transfer model. | m3/m3 | single | Latitude, longitude, time |
| Soil moisture DQX | Estimated uncertainty (standard deviation) associated with Soil_Moisture. Computed from the retrieval error covariance matrix. | m3/m3 | single | Latitude, longitude, time |
| Event_Flags | Indicates external events affecting retrieval (rainfall, snow, or radio frequency interference events). These flags are defined and documented in the SMOS Level-2 Soil Moisture Algorithm Theoretical Basis Document (ATBD). These flags are defined in details and documented in the SMOS Level-2 Soil Moisture Algorithm Theoretical Basis Document (ATBD). https://earth.esa.int/eogateway/documents/20142/37627/SMOS-L2-SM-ATBD.pdf | [-] | single | Latitude, longitude, time |
| Science Flags | Science_Flags is a quality/diagnostic flag layer included in the SMOS Level-2 soil moisture product to indicate retrieval conditions and potential issues that may affect the reliability of the soil moisture estimates (e.g., radio-frequency interference, frozen or snow-covered surfaces, vegetation effects, or other non-ideal conditions). | [-] | single | Latitude, longitude, time |

Table 3.2.3: Description of the variable in the NetCDF file for ASCAT

| Original product name: ASCAT – H SAF H121 | | | | |
|---|--|----------------|--------|---------------------------|
| Var name | Description | Units | Type | Dimension |
| time | Seconds since 1970-01-01 00:00:00 | datetime64[ns] | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| Soil moisture | Surface soil moisture in relative saturation (0-100) | [-] | single | Latitude, longitude, time |

Global attributes

The global attributes and the main product variable are summarized in the Table 3.2.4. Depending on the specific dataset, additional layers may include the uncertainty (error) associated with the soil moisture values and quality control flags.

Table 3.2.4: Description of the global attribute in the NetCDF file

| Attribute | Description | Units | Type |
|----------------------------|---|-------|--------|
| title | ESA EO4FLOOD project soil moisture | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Name of institution “National Research Council (CNR)” | - | text |
| creator_institution_e-mail | Contact information | - | text |
| references | Project publication | - | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| Station coordinates | Central coordinates of the selected reach | - | single |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

Additional flag description can be found in the official Algorithm Theoretical Basis Documents (ATBDs) of the products.

3.3. Snow

A single NetCDF file is provided for each combination of basin and product, containing the complete time series, as long as the product offers data for that specific basin (e.g., some products are limited to the Northern Hemisphere). However, when datasets are too large to store efficiently in a single file, the time series is divided into a few NetCDF files to facilitate handling. For a brief summary of the selected snow products, please refer to the ATBD.

File format and naming convention

Since the time series varies substantially across the different snow products, the snow data are stored in NetCDF files using the following naming convention:

EO4FLOOD_Snow_SP_basin_IYYYYMMDD_FYYYYMMDD.nc

where:

- SP denotes the snow product from which the data are extracted (see Table 3.3.1).
- ‘basin’ indicates the river catchment area over which the data have been extracted (see Table 2.3.1).
- ‘IYYYYMMDD’ and ‘FYYYYMMDD’ represents the initial and final date of the time period covered by the file in the YYYYMMDD format

Typically, each NetCDF file contains snow data for the entire time period, either the selected project period or the full available temporal span of the specific product (as detailed in the ATBD document). However, for datasets that are too large to be stored in a single file, the data are split into shorter time series files.

Tables 3.3.1 summarizes the code SP for the available satellite snow products (SP). Please, note that not all products are available for all basins (refer to ATBD document for further information on the geographical availability of the different products). The snow products have only been delivered

for some basins as indicated in Table 3.3.1.

Table 3.3.1: Overview of the different snow products along with their codes.

| Snow product | “SP” code | Basins |
|---|-------------------------|---|
| CLMS Fractional Snow Cover (FSC) | “CLMS_FSC” | Torne |
| CLMS daily-cumulative Gap-filled Fractional Snow Cover (GFSC) | “CLMS_GFSC” | Torne |
| CLMS Snow Cover Extent (SCE) - 500m - Europe | “CLMS_SCE_EUR” | Torne, Danube, Rhine, Ebro, Po |
| CLMS Snow Cover Extent (SCE) - 1km - Northern Hemisphere | “CLMS_SCE_NH” | Torne, Danube, Rhine, Ebro, Po, Brahmaputra |
| CLMS Snow Water Equivalent (SWE) - 5km – North. Hemisphere - v1 | “CLMS_SWE” | Torne, Danube, Rhine, Ebro, Po |
| Snow_CCI SCFG MODIS V3.0 | “CCI_SCFG_MODIS” | Torne |
| Snow_CCI SCFG AVHRR METOPA V3.0 | “CCI_SCFG_AVHRR_METOPA” | Torne, Danube, Rhine, Ebro, Po, Brahmaputra |
| Snow_CCI SCFG AVHRR NOAA18 V3.0 | “CCI_SCFG_AVHRR_NOAA18” | Torne, Danube, Rhine, Ebro, Po, Brahmaputra |
| Snow_CCI SCFG AVHRR NOAA19 V3.0 | “CCI_SCFG_AVHRR_NOAA19” | Torne, Danube, Rhine, Ebro, Po, Brahmaputra |
| Snow_CCI SWE v3.1 | “CCI_SWE” | Torne, Danube, Rhine, Ebro, Po, Brahmaputra |

Product variables

Each NetCDF file contains the snow variable timeseries according to the type of product (SCFG, SWS, SWE...), the coordinates of the pixel centroids and the time according to the native spatial and temporal resolution of the source data.

The tables 3.3.2, 3.3.3, 3.1.4, 3.1.5 describe the NetCDF variables SWE and SCFG from the CCI and CLMS products.

Table 3.3.2: Description of the variables in the NetCDF file for the CCI SCFG dataset

| Var name | Description | Units | Type | Dimension |
|----------|---|--------|--------|---------------------------|
| time | Time in hours since 1950-01-01 00:00 | hour | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| scfg | Snow cover fraction on-ground (range 0-100) Masked pixels (numbers >200): 205 Clouds 206 (Polar) Night - satellite data available, but large solar zenith angle does not allow classification 210 Water Other numbers >200 different errors on data acquisition. | - | single | Latitude, longitude, time |

Table 3.3.3: Description of the variables in the NetCDF file for the CLMS SCE dataset

| Var name | Description | Units | Type | Dimension |
|----------|---|--------|--------|---------------------------|
| time | Time in hours since 1950-01-01 00:00 | hour | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| sce | <p>Snow Cover Extent in percent (range 0%-100%): SCE = CODE -100 where CODE has a range 100-200 and is the value found in the file.</p> <p>Masked pixels:</p> <ul style="list-style-type: none"> 20 - Sea mask 21 - Lake mask 22 - River mask 30 - Cloud mask 251 - Polar night 254 Input data error 255 No data <p>Note: Pixels that should contain a valid mask value (as defined by the above code) are instead found to contain no data in the original files.</p> | - | single | Latitude, longitude, time |

Table 3.3.4: Description of the variables in the NetCDF file for the CLMS SWE dataset

| Var name | Description | Units | Type | Dimension |
|----------|--|--------|--------|---------------------------|
| time | Time in days since 1970-01-01 00:00 | days | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| swe | <p>Snow water equivalent (range 1-500)</p> <p>Masked pixels (negative numbers):</p> <ul style="list-style-type: none"> -1 land areas on Southern Hemisphere, no SWE data available -10 Masked: water (oceans, or water fraction > 50%) -20 Masked: mountain -30 Masked: Glaciers / permanent ice <p>Note: Pixels that should contain a valid mask value (as defined by the above code) are instead found to contain no data in the original files</p> | mm | single | Latitude, longitude, time |

Table 3.3.5: Description of the variables in the NetCDF file for the CCI SWE dataset

| Var name | Description | Units | Type | Dimension |
|----------|--|--------|--------|---------------------------|
| time | Time in hours since 1950-01-01 00:00 | hour | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| swe | Snow water equivalent (range 1-500) Masked pixels (negative numbers): -1 land areas on Southern Hemisphere, no SWE data available -10 Masked: water (oceans, or water fraction > 50%) -20 Masked: mountain -30 Masked: Glaciers / permanent ice | mm | single | Latitude, longitude, time |

For the CLMS_FSC, CLMS_GFSC and CLMS_SWS products, the corresponding snow variable have been binarized into two variables called the snow mask and the no-data mask, which extract all the relevant information. The following Tables 3.3.6 and 3.3.7 summarize the variables in the NetCDF files for these products: CLMS_FSC and CLMS_GFSC for the first table and CLMS_SWS for the second.

Table 3.3.6 - Description of the variables in the NetCDF file for the CLMS_FSC and CLMS_GFSC products, where the original information on the snow variable has been binarized in two main variables snow_mask and no_data_mask.

| Var name | Description | Units | Type | Dimension |
|--------------|--|--------|--------|---------------------------|
| time | Time in days since 1970-01-01 00:00 | days | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| snow_mask | binarized variable indicating snow presence in the pixel: <ul style="list-style-type: none"> 1 if snow present in the pixel, i.e. original variables FSC or GFSC is within the range (0,100] 0 otherwise | NA | single | latitude, longitude, time |
| no_data_mask | binarized variable indicating if the pixel has a mask value or no-data: <ul style="list-style-type: none"> 1 if original variables FSC or GSFC contains a mask value (205:clouds) or has no information (255: no-data). 0 otherwise | NA | single | latitude, longitude, time |

Table 3.3.7 - Description of the variables in the NetCDF file for the CLMS_SWS product, where the original information on the snow variable SWS has been binarized in two main variables snow_mask and no_data_mask

| Var name | Description | Units | Type | Dimension |
|--------------|--|--------|--------|---------------------------|
| time | Time in days since 1970-01-01 00:00 | days | single | time |
| lon | Longitude of the pixel centroid | degree | single | longitude |
| lat | Latitude of the pixel centroid | degree | single | latitude |
| snow_mask | <p>binarized variable indicating wet snow presence in the pixel:</p> <ul style="list-style-type: none"> 1 if wet snow present in the pixel, i.e. original variable SWS has a value of 110 (wet snow). 0 otherwise | NA | single | latitude, longitude, time |
| no_data_mask | <p>binarized variable indicating if the pixel has a mask value or no-data:</p> <ul style="list-style-type: none"> 1 if original value for SWS contains a mask value (200: radar shadow, 210: water, 220: forest, 230: urban area, 240: non-mountain areas or has no information (255:no-data). 0 otherwise, which shall correspond with pixel with value 110 (wet snow) or 125 (dry snow or no-snow) | NA | single | latitude, longitude, time |

For the CLMS_FSC, CLMS_GFSC, and CLMS_SWS products, combining the two binarized mask variables described in the respective tables allows users to determine whether a pixel contains snow or wet snow (snow_mask = 1 and no_data_mask = 0), has no snow or dry snow (snow_mask = 0 and no_data_mask = 0), or contains no useful data due to missing information (snow_mask = 0 and no_data_mask = 1).

Global attributes

All the snow NetCDF files contain a header with the information included in Table 3.3.8.

Table 3.3.8: Description of the common global attributes in the snow NetCDF files

| Attribute | Description | Units | Type |
|-------------------|-----------------------------------|-------|------|
| title | Data description | - | text |
| project | "EO4FLOOD" | - | text |
| basin_name | Name of the selected basin | - | text |
| pdate | Time of NetCDF file generation | - | date |
| producer | "Magellium" | - | text |
| source | Name of the data source | - | text |
| references | Product publication | - | text |
| Temporal_interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| conventions | "CF-1.11-draft" | - | text |
| format | "NetCDF" | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | "ESA EO4FLOOD project" | - | text |

3.4. Width

This section describes the format of the river width time series derived from satellite optical imaging. The methods used to generate this product are detailed in the Algorithm Theoretical Basis Document (EO4FLOOD_D2.2_ATBD_v2.pdf). The product is delivered in NetCDF formats for each river reach. Each file includes time series data, corresponding dates and metadata such as river name, basin name, station ID, geographical coordinates and sensor/source information.

File format and naming convention

The river width time series are provided separately for each satellite sensor to preserve the integrity of each mission's spatial and temporal characteristics. Temporal coverage and sampling frequency differ depending on the satellite's revisit time and cloud-free observation availability. The product files follow the naming format:

EO4FLOOD_<Basin>_<GAUGE_NAME>_<REACHID>_<SAT>.<FORMAT>

Where:

- <BASIN> is the name of the river basin (e.g., *Rhine, Niger, Danube, ... from Table 2.3.1*)
- <GAUGE_NAME> is the name of the corresponding gauge to the reach
- <REACHID> is reach id for the nearest reach from SWORD data set (<https://www.swordexplorer.com/>)
- <SAT> indicates the satellite mission used to derive the width estimates:
 - Landsat for the Landsat series
 - S2 for Sentinel-2
 - MODIS for MODIS Global Water Pack (GWP)
- <FORMAT> is either nc for NetCDF or csv for comma-separated values

Examples:

- EO4FLOOD_Rhine_11122562_GRDC_23229000181_Landsat.nc
- EO4FLOOD_Niger_15156262_GRDC_15140300381_S2.csv
- EO4FLOOD_Danube_656665625_GRDC_22797000191_MODIS.nc

Product variables

The Table 3.4.1 describes the NetCDF content of the river width product.

Table 3.4.1: Description of the NetCDF of the river width product.

| Var name | Description | Units | Type | Dimension |
|------------|--|--------|---------|-----------|
| time | Time in hours since 1984-01-01 00:00 | hour | float64 | time |
| basin | Basin name | - | string | scalar |
| gauge_name | Gauge name | - | string | scalar |
| gauge_lat | Latitude of the corresponding gauge | degree | float32 | scalar |
| gauge_lon | Longitude of the corresponding gauge | degree | float32 | scalar |
| reach_ID | Reach Id from SWORD | - | string | scalar |
| reach_lon | Longitude of the reach (from SWORD) | degree | float32 | scalar |
| reach_lat | Latitude of the reach (from SWORD) | degree | float32 | scalar |
| satellite | Name of the satellite mission (e.g., Landsat, S2, MODIS) | - | string | time |
| w | Estimated river width | m | single | time |

Global attributes

The global attributes are summarized in the Table 3.4.2.

Table 3.4.2: Description of the global attribute in the NetCDF file for the river width product.

| Attribute | Description | Units | Type |
|-------------------|--|---------|------|
| title | ESA EO4FLOOD project river width | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Institute of Geodesy (GIS), University of Stuttgart | - | text |
| contact | saemian@gis.uni-stuttgart.de Omid.elmi@gis.uni-stuttgart.de Tourian@gis.uni-stuttgart.de | - | text |
| pdate | Date of Production | daytime | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

3.5. Surface reflectance

This section describes the format of the Surface Near Infrared Reflectance Indices. The procedures to obtain proxies are described in the Algorithm Theoretical Basis Document (EO4FLOOD_D2.2_ATBD_v2.pdf). Surface reflectance indices are delivered in NETCDF format for each basin. Each file contains the timeseries date, the time series of the surface reflectance indices extracted from the different satellites, together with metadata such as basin name, river name, station name, coordinates and satellite sensors.

File format and naming convention

The Surface reflectance indices are stored in NetCDF files that use the following name convention: “EO4FLOOD_Surface_Reflectance_Index_BASIN_CODE.nc”

where *BASIN_CODE* refers to the river catchment, as defined in Table 2.3.1 is four-characters.

Product variables

Each NetCDF file contains, the coordinates of the sites, the satellite products from which the surface reflectance index is extracted, the timeseries of the surface reflectance indices as described in Table 3.5.1.

Table 3.5.1: Description of the variables in the NetCDF file

| Var name | Description | Units | Type | Dimension |
|--|---|--------|--------|------------|
| time | Time coordinate in ISO-8601 format | hour | single | time |
| siteX | Longitude of the site | degree | single | site |
| siteY | Latitude of the site | degree | single | site |
| Surface_reflectance_MOD | Surface Reflectance Index extracted through MODIS TERRA | - | single | time, site |
| Surface_reflectance_MYD | Surface Reflectance Index extracted through MODIS AQUA | - | single | time, site |
| Surface_reflectance_S2 | Surface Reflectance Index extracted through Sentinel-2 | - | single | time, site |
| Surface_reflectance_MOD_uncertaintiy_max | Surface Reflectance Index extracted through MODIS TERRA max uncertainty | - | single | time, site |
| Surface_reflectance_MYD_uncertaintiy_max | Surface Reflectance Index extracted through MODIS AQUA max uncertainty | - | single | time, site |
| Surface_reflectance_S2_uncertaintiy_max | Surface Reflectance Index extracted through Sentinel-2 max uncertainty | - | single | time, site |
| Surface_reflectance_MOD_uncertaintiy_min | Surface Reflectance Index extracted through MODIS TERRA min uncertainty | - | single | time, site |

| | | | | |
|---|--|---|--------|------------|
| Surface_reflectance_MYD_uncertainty_min | Surface Reflectance Index extracted through MODIS AQUA min uncertainty | - | single | time, site |
| Surface_reflectance_S2_uncertainty_min | Surface Reflectance Index extracted through Sentinel-2 min uncertainty | - | single | time, site |

Global attributes

The global attributes are summarized in the Table 3.5.2.

Table 3.5.2: Description of the attributes in the NetCDF file

| Attribute | Description | Units | Type |
|----------------------------|---|-------|------|
| title | ESA EO4FLOOD project soil moisture | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Name of institution “National Research Council (CNR)” | - | text |
| creator_institution_e-mail | Contact information | - | text |
| references | Project publication | - | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

3.6. Water level virtual stations

The water level time series at virtual stations are available from DAHITI and provided for DAHITI in NetCDF format. Each virtual station is stored in one file and contains metadata like coordinates and target name. The time series can also be downloaded in different formats from the DAHITI website or through the DAHITI API, which is documented at <https://dahiti-api.readthedocs.io/>.

File format and naming convention

The filename convention is defined as “{EO4FLOOD_DAHITI_ID}_water_level_altimetry.nc” where the DAHITI_ID is the identifier of the virtual station in DAHITI.

Product attributes variables

The table below describes the attributes and variables of the NetCDF file.

Table 3.6.1: Description of DAHITI attributes and variables

| Attribute | Description | Units | Type | Dimension |
|---------------|--|-----------------|---------|-----------|
| dahiti_id | Virtual Station Identifier | - | integer | - |
| dataset | Product type "water-level-altimetry" | - | text | - |
| target_name | Name of the water body | - | text | - |
| country | Country of the virtual station | - | text | - |
| continent | Continent of the virtual station | - | text | - |
| longitude | Longitude of the virtual station | Decimal degrees | double | - |
| latitude | Latitude of the virtual station | Decimal degrees | double | - |
| geoid | Applied geoid height above ellipsoid | m | text | - |
| software | DAHITI software version used in processing | - | text | - |
| institution | Name of institution "DGFI-TUM" | - | text | - |
| source | Name of data source "DAHITI" | - | text | - |
| url | url to the virtual station page | - | text | - |
| creation_date | Datetime of the data download | datetime | text | - |

Table 3.6.2: Description of DAHITI attributes and variables

| Variable | Description | Units | Type | Dimension |
|------------|--|----------|-------|-----------|
| datetime | Date and time of the record | datetime | text | time |
| wse | Water level from altimetry | m | float | time |
| wse_u | Water level error | m | float | time |
| mission | Used altimeter mission per measurement. | - | Text | time |
| timeliness | Shows latency of the input data per measurement (NRT, STC, or NTC) | - | Text | time |

3.7. Multi-mission water level time series

This section describes the format of the multi-mission water level time series. The NetCDF file stores a grid-based solution where a water level time series is provided in each column of the grid. Additionally, a water level time series is provided at the location of the listed gauge station or virtual station. Details of data filtering and the algorithm to reconstruct the multi-mission water level time series are provided in the ATBD (EO4FLOOD_D2.2_ATBD_v2.pdf).

File format and naming convention

The multi-mission water level time series are stored in NetCDFv4 files with a filename convention of "EO4FLOOD_BBBB_HHHH_SN_mmwl.nc". Here "BBBB" is a 4-character code representing the hydrological basin name, "HHHH" is the HydroSHED (<https://www.hydrosheds.org/products/hydrobasins>) level 4 basin pfaf id, and "SN" is a 2-digit code for the given station. An example of a filename in the Niger basin could be: "nigr_1427_01_mmwl.nc"

Product variables

The product variables are summarized in the Table 3.7.2.

Table 3.7.2: Description of attributes in the NetCDF file

| Var name | Description | Units | Type | Dimension |
|-----------|---|--------------|--------|----------------|
| chainage | Distance along the river centre line from downstream to upstream | m | double | chainage |
| time | Time in decimal years, where the multi-mission solution is predicted | Decimal year | double | time |
| lon | Longitude of chainage point | degree | double | chainage |
| lat | Latitude of chainage point | degree | double | chainage |
| wl_grid | Grid with water level as a function of time and chainage | m | double | time, chainage |
| wlsd_grid | Grid with water level standard deviation as a function of time and chainage | m | double | time, chainage |
| wl_vs | Water level time series at the VS/gauge location | m | double | time |
| wlsd_vs | Standard deviation of water level at the VS/gauge location | m | double | time |

Global attributes

The global attributes are summarized in the Table 3.7.3.

Table 3.7.3: Description of global attributes

| Var name | Description | Units | Type | Dimension |
|-------------|--|-----------------|--------|-----------|
| title | Name of product “Multi-mission water level time series” | - | text | - |
| producer | Name of institution “DTU Space, Denmark” | - | text | - |
| project | Name of project “EO4FLOOD” | - | text | - |
| contact | Contact information and date of production | - | text | - |
| pdate | Date of production | - | date | - |
| SN | Station number, equivalent to SN in the filename | - | text | - |
| VSlon | Longitude of the virtual station | Decimal degrees | double | - |
| VSlat | Latitude of the virtual station | Decimal degrees | double | - |
| VSchainage | Chainage of Virtual station | m | double | - |
| VSwidth | River Width at the virtual station | m | int | - |
| VSReachID | Reach ID (SWORDv17) containing the virtual station | - | text | - |
| VSgauge | Name of the Virtual station/gauge station | - | text | - |
| reachLength | Length of the reaches used to reconstruct the multi-mission water level time series | km | double | - |
| meantime | The average time in days between the original observation that was used to reconstruct the multi-mission water level time series | Decimal year | double | - |
| Convention | ncdf4 | - | text | - |

3.8. Multi-mission Water Surface Slope

This section describes the format of the multi-mission water surface slope time series. The NetCDF file stores a grid-based solution where a water surface slope time series is provided in each column of the grid. Additionally, a water surface slope time series is provided at the location of the listed gauge station or virtual station. Details of data filtering and the algorithm to reconstruct the multi-mission water level time series are provided in the ATBD (EO4FLOOD_ D2.2_ATBD_v2.pdf).

File format and naming convention

The multi-mission water surface slope time series are stored in NetCDFv4 files (the format is described in the subsections below) with a filename convention of “EO4FLOOD_BBBB_HHHH_SN_mmwss.nc”. Here “BBBB” is a 4-character code representing the hydrological basin name, “HHHH” is the HydroSHED level 4 basin pfaf id, and “SN” is a 2-digit code for the given station. An example of a filename in the Niger basin could be: “EO4FLOOD_nigr_1427_01_mmwss.nc”

Product variables

The product variables are summarized in the Table 3.8.1.

Table 3.8.1: Description of attributes in the NetCDF file

| Var name | Description | Units | Type | Dimension |
|--------------|---|--------------|--------|----------------|
| chainage | Distance along the river centre line from downstream to upstream | m | double | chainage |
| time | Time in decimal years, where the multi-mission slope product is predicted | Decimal year | double | time |
| lon | Longitude of chainage point | degree | double | chainage |
| lat | Latitude of chainage point | degree | double | chainage |
| slope_grid | Grid with slope (over 4 km) as a function of time and chainage | cm/km | double | time, chainage |
| slopesd_grid | Grid with surface water slope standard deviation as a function of time and chainage | cm/km | double | time, chainage |
| slope_vs | Surface water slope time series at the VS/gauge location | cm/km | double | time |
| slopesd_vs | Standard deviation of surface water slope at the VS/gauge location | cm/km | double | time |

Global attributes

The global attributes are summarized in the Table 3.8.2.

Table 3.8.2: Description of global attributes in the NetCDF file

| Var name | Description | Units | Type | Dimension |
|-------------|--|-----------------|--------|-----------|
| title | Name of product "multi-mission surface water slope time series" | - | text | - |
| producer | Name of institution "DTU Space, Denmark" | - | text | - |
| project | Name of project "EO4FLOOD" | - | text | - |
| contact | Contact information and date of production | - | text | - |
| pdate | Date of production | - | date | - |
| SN | Station number, equivalent to SN in the filename | - | text | - |
| VSlon | Longitude of the virtual station | Decimal degrees | double | - |
| VSlat | Latitude of the virtual station | Decimal degrees | double | - |
| VSchainage | Chainage of Virtual station | m | double | - |
| VSwidth | River Width at the virtual station | m | int | - |
| VSReachID | Reach ID (SWORDv17) containing the virtual station | - | text | - |
| VSgauge | Name of the Virtual station/gauge station | - | text | - |
| reachLength | Length of the reaches used to reconstruct the multi-mission water level time series | km | double | - |
| meantime | The average time in days between the original observation that was used to reconstruct the multi-mission water level time series | Decimal year | double | - |
| Convention | ncdf4 | - | text | - |

3.9. River discharge from Width

This section describes the format of the river discharge estimated from the width time series. The methods used to generate this product are detailed in the Algorithm Theoretical Basis Document (EO4FLOOD_D2.2_ATBD_v2.pdf). The product is delivered in NetCDF formats for gauge. Each file includes time series data, corresponding dates and metadata such as gauge name, basin name, station ID, geographical coordinates and sensor/source information.

File format and naming convention

The river discharge time series at each gauge is provided as a merged of all the available width-based discharge. Like the width time series, the temporal coverage and sampling frequency among gauges differ depending on the satellite's revisit time and cloud-free observation availability. The product files follow the naming format:

EO4FLOOD_<Basin>_<GAUGE_NAME>_<Discharge>_<WidthBased>.<FORMAT>

Where:

- <BASIN> is the name of the river basin (e.g., *Rhine, Niger, Danube, ... from Table 2.3.1*)
- <GAUGE_NAME> is the name of the corresponding gauge to the reach
- <FORMAT> is nc for NetCDF

Examples:

- EO4FLOOD_Rhine_11122562_GRDC_Discharge_WidthBased.nc
- EO4FLOOD_Niger_15156262_GRDC_Discharge_WidthBased.csv
- EO4FLOOD_Danube_656665625_GRDC_Discharge_WidthBased.nc

Product variables

The Table 3.9.1 describes the NetCDF content of the width-based discharge product.

Table 3.9.1: Description of the NetCDF of the river width product.

| Var name | Description | Units | Type | Dimension |
|------------|---------------------------------------|-------------------|---------|-----------|
| time | Time in hours since 1984-01-01 00:00 | hour | float64 | time |
| basin | Basin name | - | string | scalar |
| gauge_name | Gauge name | - | string | scalar |
| gauge_lat | Latitude of the corresponding gauge | degree | float32 | scalar |
| gauge_lon | Longitude of the corresponding gauge | degree | float32 | scalar |
| Q | Estimated river discharge | m ³ /s | float32 | time |
| Q_unc | Estimated river discharge Uncertainty | m ³ /s | float32 | time |

Global attributes

The global attributes are summarized in the Table 3.9.2.

Table 3.9.2: Description of the global attribute in the NetCDF file for the river width product.

| Attribute | Description | Units | Type |
|-------------------|--|---------|------|
| title | ESA EO4FLOOD project river width | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Institute of Geodesy (GIS), University of Stuttgart | - | text |
| contact | saemian@gis.uni-stuttgart.de Omid.elmi@gis.uni-stuttgart.de Tourian@gis.uni-stuttgart.de | - | text |
| pdate | Date of Production | daytime | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

3.10. River discharge from Reflectance

This section describes the format of the river discharge estimated from the surface reflectance time series. The methods used to generate this product are detailed in the Algorithm Theoretical Basis Document (EO4FLOOD_D2.2_ATBD_v2.pdf). The product is delivered in NetCDF formats for gauge. Each file includes time series data, corresponding dates and metadata such as gauge name, basin name, station ID, geographical coordinates and sensor/source information.

File format and naming convention

The river discharge time series at each gauge is provided as a merged of all the available reflectance-based discharge. The product files follow the naming format:

EO4FLOOD_<Basin>_<GAUGE_NAME>_<Discharge>_<ReflectanceBased>.<FORMAT>

Where:

- <BASIN> is the name of the river basin (e.g., *Rhine, Niger, Danube, ... from Table 2.3.1*)
- <GAUGE_NAME> is the name of the corresponding gauge to the reach
- <FORMAT> is nc for NetCDF

Examples:

- EO4FLOOD_Rhine_11122562_GRDC_Discharge_ReflectanceBased.nc
- EO4FLOOD_Niger_15156262_GRDC_Discharge_ReflectanceBased.csv
- EO4FLOOD_Danube_656665625_GRDC_Discharge_ReflectanceBased.nc

Product variables

The Table 3.10.1 describes the NetCDF content of the width-based discharge product.

Table 3.10.1: Description of the NetCDF of the river width product.

| Var name | Description | Units | Type | Dimension |
|------------|---------------------------------------|-------------------|---------|-----------|
| time | Time in hours since 1984-01-01 00:00 | hour | float64 | time |
| basin | Basin name | - | string | scalar |
| gauge_name | Gauge name | - | string | scalar |
| gauge_lat | Latitude of the corresponding gauge | degree | float32 | scalar |
| gauge_lon | Longitude of the corresponding gauge | degree | float32 | scalar |
| Q | Estimated river discharge | m ³ /s | float32 | time |
| Q_unc | Estimated river discharge Uncertainty | m ³ /s | float32 | time |

Global attributes

The global attributes are summarized in the Table 3.10.2.

Table 3.10.2: Description of the global attribute in the NetCDF file for the river width product.

| Attribute | Description | Units | Type |
|-------------------|--|---------|------|
| title | ESA EO4FLOOD project river width | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Institute of Geodesy (GIS), University of Stuttgart | - | text |
| contact | saemian@gis.uni-stuttgart.de Omid.elmi@gis.uni-stuttgart.de Tourian@gis.uni-stuttgart.de | - | text |
| pdate | Date of Production | daytime | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

3.11. River discharge from Water level

This section describes the format of the river discharge estimated from the multi-mission water level time series. The methods used to generate this product are detailed in the Algorithm Theoretical Basis Document (EO4FLOOD_D2.2_ATBD_v2.pdf). The product is delivered in NetCDF formats for gauge. Each file includes time series data, corresponding dates and metadata such as gauge name, basin name, station ID, geographical coordinates and sensor/source information.

File format and naming convention

The product files follow the naming format:

EO4FLOOD_<Basin>_<GAUGE_NAME>_<Discharge>_<mmWLBased>.<FORMAT>

Where:

- <BASIN> is the name of the river basin (e.g., *Rhine*, *Niger*, *Danube*, ... from Table 2.3.1)

- <GAUGE_NAME> is the name of the corresponding gauge to the reach
- <FORMAT> is nc for NetCDF

Examples:

- EO4FLOOD_Rhine_11122562_GRDC_Discharge_mmWLBased.nc
- EO4FLOOD_Niger_15156262_GRDC_Discharge_mmWLBased.csv
- EO4FLOOD_Danube_656665625_GRDC_Discharge_mmWLBased.nc

Product variables

The Table 3.11.1 describes the NetCDF content of the width-based discharge product.

Table 3.11.1: Description of the NetCDF of the river width product.

| Var name | Description | Units | Type | Dimension |
|------------|---------------------------------------|-------------------|---------|-----------|
| time | Time in hours since 1984-01-01 00:00 | hour | float64 | time |
| basin | Basin name | - | string | scalar |
| gauge_name | Gauge name | - | string | scalar |
| gauge_lat | Latitude of the corresponding gauge | degree | float32 | scalar |
| gauge_lon | Longitude of the corresponding gauge | degree | float32 | scalar |
| Q | Estimated river discharge | m ³ /s | float32 | time |
| Q_unc | Estimated river discharge Uncertainty | m ³ /s | float32 | time |

Global attributes

The global attributes are summarized in the Table 3.11.2.

Table 3.11.2: Description of the global attribute in the NetCDF file for the river width product.

| Attribute | Description | Units | Type |
|-------------------|--|---------|------|
| title | ESA EO4FLOOD project river width | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Institute of Geodesy (GIS), University of Stuttgart | - | text |
| contact | saemian@gis.uni-stuttgart.de Omid.elmi@gis.uni-stuttgart.de Tourian@gis.uni-stuttgart.de | - | text |
| pdate | Date of Production | daytime | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

3.12. Multi-mission river discharge for ungauged sites

River discharge timeseries from multi-mission surface area, slope, and water level observations for ungauged sites are provided in NetCDF format. Each site is stored in one file and contains metadata like coordinates and target name.

File format and naming convention

The filename convention is defined as “{basin}_{river}_{DAHITI_ID}_discharge_multi-mission.nc” where the DAHITI_ID is the identifier of the DAHITI virtual station used as water level input.

Product attributes variables

The Table 3.12.1 describes the attributes and variables of the NetCDF file.

Table 3.12.1: Description of the global attribute in the NetCDF file for the river width product

| Attribute | Description | Units | Type | Dimension |
|---------------|---|-------------------|--------|-----------|
| dataset | Product type "multi-mission-river-discharge" | - | text | - |
| name | Name of the basin, water body, and DAHITI ID | - | text | - |
| longitude | Longitude of the reference location | Decimal degrees | double | - |
| latitude | Latitude of the reference location | Decimal degrees | double | - |
| institution | Name of institution “DGFI-TUM” | - | text | - |
| creation_date | Datetime of the data creation | datetime | text | - |
| comment | Comment on the quality of the data based on the optimization processing independent from in-situ data | - | text | - |
| Variable | Description | Units | Type | Dimension |
| datetime | Date and time of the record | datetime | text | time |
| q | Discharge | m ³ /s | float | time |
| q_u_lower | Lower discharge uncertainty | m ³ /s | float | time |
| q_u_upper | Upper discharge uncertainty | m ³ /s | float | time |

3.13. Multi-mission river discharge at Gauges

This section describes the format of the river discharge estimated from the multi-mission river discharge time series (width-based, reflectance-based, water-level-based). The methods used to generate this product are detailed in the Algorithm Theoretical Basis Document (EO4FLOOD_D2.2_ATBD_v2.pdf). The product is delivered in NetCDF formats for gauge. Each file includes time series data, corresponding dates and metadata such as gauge name, basin name, station ID, geographical coordinates and sensor/source information.

File format and naming convention

The product files follow the naming format:

EO4FLOOD_<Basin>_<GAUGE_NAME>_<Discharge>_<mmMerged>.<FORMAT>

Where:

- <BASIN> is the name of the river basin (e.g., *Rhine, Niger, Danube, ... from Table 2.3.1*)
- <GAUGE_NAME> is the name of the corresponding gauge to the reach
- <FORMAT> is nc for NetCDF

Examples:

- EO4FLOOD_Rhine_11122562_GRDC_Discharge_mmMerged.nc
- EO4FLOOD_Niger_15156262_GRDC_Discharge_mmMerged.csv
- EO4FLOOD_Danube_656665625_GRDC_Discharge_mmMerged.nc

Product variables

The Table 3.13.1 describes the NetCDF content of the width-based discharge product.

Table 3.13.1: Description of the NetCDF of the river width product.

| Var name | Description | Units | Type | Dimension |
|------------|---------------------------------------|-------------------|---------|-----------|
| time | Time in hours since 1984-01-01 00:00 | hour | float64 | time |
| basin | Basin name | - | string | scalar |
| gauge_name | Gauge name | - | string | scalar |
| gauge_lat | Latitude of the corresponding gauge | degree | float32 | scalar |
| gauge_lon | Longitude of the corresponding gauge | degree | float32 | scalar |
| Q | Estimated river discharge | m ³ /s | float32 | time |
| Q_unc | Estimated river discharge Uncertainty | m ³ /s | float32 | time |

Global attributes

The global attributes are summarized in the Table 3.13.2.

Table 3.13.2: Description of the global attribute in the NetCDF file for the river width product.

| Attribute | Description | Units | Type |
|-------------------|--|---------|------|
| title | ESA EO4FLOOD project river width | - | text |
| creation_time | Time of NetCDF file generation | - | text |
| institution | Institute of Geodesy (GIS), University of Stuttgart | - | text |
| contact | saemian@gis.uni-stuttgart.de Omid.elmi@gis.uni-stuttgart.de Tourian@gis.uni-stuttgart.de | - | text |
| pdate | Date of Production | daytime | text |
| Temporal interval | Time window of the extracted data | - | text |
| version | File version | - | text |
| Conventions | CF-1.11-draft | - | text |
| DOI | Digital Object Identifier | - | text |
| Acknowledgements | ESA EO4FLOOD project reference | - | text |

3.14. Flood Extent

This section describes the key technical specifications and format of the flood extent files. It should be specified that the flood extent product is provided only for the basins where flood forecasting analyses are performed: Congo, Torne, Niger, Negro, and Brahmaputra. In EO4FLOOD, flood extent has been derived using three different remote sensing sensors: Sentinel-1, Sentinel-2 and VIIRS-Flood 5-day product. For the full methodology of each product, the reader is referred to the EO4FLOOD ATBD deliverable (EO4FLOOD_D2.2_ATBD_v2.pdf).

Table 3.14.1: Technical specifications of the Flood Extent.

| Attribute | Description |
|-------------------------------|--|
| Project | EO4FLOOD |
| Name of Parameter | Flood Extent |
| Sensor (SS) | Visible Infrared Imaging Radiometer Suite (VIIRS), Sentinel-1 (S1), or Sentinel-2 (S2) |
| Area of Interest (BBBB) | 5 AOIs within Congo, Negro, Niger, Brahmaputra and Torne river basins (Table 3.7.1). The areas match the hydraulic model's area provided. In case of more than one area/polygon per AOI, the combined area has been used for deriving the flood extent maps. |
| Acquisition date (YYYYMMDD) | Data format as YYYYMMDD. |
| Service Provider | GMV (VIIRS & S1 derived products), RSS-Hydro (S2 derived products) |
| Service description | Flood extent (area) maps derived independently from different sensors and images for specific flood events. Full methodology explained in EO4FLOOD Deliverable ATBD v2. |
| Product content | Flood extent map derived from each sensor: VIIRS: VIIRS-Flood 5-day products include Flood (downscaled to 30 m) [value: 200] and Normal Open Water (375 m) [value: 99]. Additional values represent clouds, snow, and other classes; for more details, see the ATBD v2 document. S1: Sentinel-1 flood detections aligned to the DEM grid (30m). Flood ([1] detected in a single band (VV or VH) or [2] detected in both bands), Threshold and dry reference period used for Sentinel-1 to classify water depends of the AOI and S1 band used (see Table 3.12.2). S2: Sentinel-2 flood detections processed using FloodSENS. |
| Input data | DEM: FathomDEM (v1-0, 30m), SRTM and derivatives (30m) HydroSHEDS (v2) river channels and lake outlines. VIIRS: VIIRS 5-day composite flood product (375m) S1: Sentinel-1 GRD imagery (VH and VV polarizations, 10 m resolution), including both ascending and descending orbits. S2: Sentinel-2 Level-2A. |
| Data temporal coverage | Flood extent derived from 12 flood events (2019-2024) across the 5 AOIs + an additional time window to maximise the imagery available for mapping before/during/after the flood event. This time window depends on the sensor used: S1: +/-12 days, VIIRs & S2: +/-5days. |
| Horizontal spatial resolution | 30m (VIIRS downscaled), 30m (S1), 10m (S2) |
| Frequency | Variable across AOIs: 1 day (VIIRS), 6-12 days (S1), 5 days (S2) |
| Spatial coverage | Potentially global, but tailored to the EO4FLOOD AOIs |

| | |
|------------------------|--|
| Delivery format | GeoTIFF (.tif) |
| File names | [PROJECT]_[Sensor]_[NameofParameter]_[HorizontalRes]_[AOIName]_[Acquisition_Date(YYYYMMDD)]_[ProductionDate].tif |
| Projection | WGS84 (EPSG 4326) |
| Validation | Quality checked for format and mapping specifications following ISO-conform QC/QA procedures and cluster requirements. |

Table 3.14.2: Thresholds used for S-1 flood maps to classify water in reference S1 and reference dry period

| AOI | Threshold | Reference dry period |
|--------------------|--------------------------------|----------------------|
| Torne | Band VH: 0.70 Band VV: 1.29 | 20220901-20221101 |
| Negro | Band VH: 0.59 Band VV: 1.41 | 20230901-20231101 |
| Niger | Band VH: 0.70 Band VV: 1.36 | 20221101-20230601 |
| Congo | Band VH: 0.68 Band VV: 1.29 | 20240601-20240901 |
| Brahmaputra | Band VH: 0.60 Band VV: 1.32 | 20201201-20210501 |

Table 3.14.3: Flood events

| AOI | Flood events date |
|--------------------|---|
| Congo | 12/12/2022 & 11-12/01/2024 |
| Negro | 16/06/2021 & 10-19/05/2022 |
| Niger | 21/01/2019 (Tillaberi), and 01/09/2019 (Niamey), 15/09/2020, 26/08/2022 & 22/08/2024 |
| Brahmaputra | 30/06/2020 & 10/10/2024 |
| Torne | 17-26/05/2024 |

The flood extent maps are stored as GeoTIFF files with a filename convention of “

[PROJECT]_[NameOfProduct/Sensor]_[NameofParameter]_[HorizontalRes]_[AOIName]_[YYYYMMDD-YYYYMMDD]_[ProductionDate].tif” .

Here The AOI Name is a 4-character code representing the hydrological basin name (see Table 2.3.1), and “YYYYMMDD” is the date of the scene acquisition. An example of a filename in the Congo basin could be:

VIIRS Product Names:

[PROJECT]_[NameOfProduct]_[NameofParameter]_[HorizontalRes]_[AOIName]_[YYYYMMDD-YYYYMMDD]_[ProductionDate].tif

E.g. EO4FLOOD_VIIRS-Flood-5day_Flood_Extent_30m_cono_20221203-20221207_20250707.tif

YYYYMMDD-YYYYMMDD: 5 days period (start-end) as we use the 5-day composite product from

VIIRs.

S1 Product Names:

[PROJECT]_[NameOfProduct]_[NameofParameter]_[HorizontalRes]_[AOIName]_[YYYYMMDD]_[ProductionDate].tif

E.g. EO4FLOOD_S1_Flood_Extent_30m_cono_20221218_20250707.tif

S2 Product Names:

[PROJECT]_[NameOfProduct]_[NameofParameter]_[HorizontalRes]_[AOIName]_[YYYYMMDD]_[ProductionDate].tif

E.g. EO4FLOOD_S2_Flood_Extent_10m_nigr_20200915_20250701.tif

The products are provided with metadata following INSPIRE guidance and STAC requirements.

3.15. Hydrological models

The outputs of the hydrological simulations are maps that are stored with a filename that reflects the following structure “PJ_NM_PT_BBBB_ISD_SD.FFF”.

Table 3.15.1: Technical specifications of the hydrological models' outputs.

| Attribute | Description |
|-------------------------------|--|
| Area of Interest (BBBB) | 5 AOIs (Table 3.7.1). |
| Numerical model (NM) | MGB (MB), DHI-GHM (DG), HYPE (HE), Hybrid-AI (HA), MCP probabilistic forecast (MP) |
| Service Provider (NM) | DHI (DG, HA), HydroMatters (MB), SMHI (HE), CNR (MP) |
| Initial simulation date (ISD) | Date of the start of the event simulated as YYYYMMDD |
| Simulation duration (SD) | Duration of the simulation in days |
| Product type (PT) | Discharge (q), Runoff (r), Base Flow (bf), Rootzone storage (rs), Snow storage (sns), Surface storage (ss), Evapotranspiration (et), Local flow (lq), Local runoff (lr), Snow water equivalent (swe), Snowmelt (snm), Soil moisture content (smc), Soil moisture deficit (smd), Ground water (gw), Expected value of probabilistic discharge (eq), Percentile of the probabilistic discharge estimate identifying the 90% confidence band (pq90), Percentiles of the probabilistic discharge estimate from 5 th to 95 th (pq5) |
| Temporal resolution | TBD |
| Product ID | PJ_NM_PT_BBBB_ISD_SD.FFF |
| Delivery format (FFF) | CSV (.csv), NETCDF (.nc), text (.txt) |
| Projection | WGS84 (EPSG 4326) |
| Service description | Simulation outcomes are derived from different hydrological models. Full methodology explained in EO4FLOOD Deliverable ATBD v2. |
| Project (PJ) | EO4FLOOD |

Hydrological model product name:

PJ_NM_PT_BBBB_ISD_SD.FFF

E.g. for DHI-GHM river discharge product:

EO4FLOOD_nigr_DG_q_20200915_15.csv

MGB

The outputs of MGB include:

- River discharge timeseries in m³/s at basin outlets along river network (.csv &/or .nc). Product type (PT): “q”
- Base Flow in m³/s for each elementary catchment (.nc). Product type (PT): “bf”
- Evapotranspiration in mm/timestep for each elementary catchment (.nc). Product type (PT): “et”
- Total water storage in mm for each elementary catchment (.nc). Product type (PT): “tw”

DHI-GHM

The outputs of DHI-GHM include:

- River discharge timeseries in m³/s at basin outlets along river network (.csv). Product type (PT): “q”
- Runoff in mm/timestep from each grid cell (.nc). Product type (PT): “r”
- Base Flow in m³/s for each grid cell (.nc). Product type (PT): “bf”
- Rootzone storage in mm/timestep for each grid cell (.nc). Product type (PT): “rs”
- Snow storage in mm/timestep for each grid cell (.nc). Product type (PT): “sns”
- Surface storage in mm/timestep for each grid cell (.nc). Product type (PT): “ss”
- Evapotranspiration in mm/timestep for each grid cell (.nc). Product type (PT): “et”

HYPE

The outputs of HYPE are, among many others:

- River discharge timeseries in m³/s from the upstream areas at the outlet of each subcatchment (.txt). Product type (PT): “q”
- Local flow from each subcatchment in m³/s (.txt). Product type (PT): “lq”
- Local runoff in mm/timeperiod for each subcatchment (.txt). Product type (PT): “lr”
- Subcatchment average snow water equivalent in mm (.txt). Product type (PT): “swe”
- Subcatchment average snowmelt in mm/timeperiod (.txt). Product type (PT): “snm”
- Subcatchment average soil moisture content in mm for the root zone and for the whole soil profile (.txt). Product type (PT): “smc”
- Subcatchment average soil moisture deficit to field capacity in the upper two soil layers in mm (mm). Product type (PT): “smd”
- Subcatchment average ground water in m (.txt). Product type (PT): “gw”
- Subcatchment average evapotranspiration in mm/timeperiod (.txt). Product type (PT): “et”

Hybrid-AI

The outputs of Hybrid-AI model are of a similar format to the DHI-GHM and include:

- River discharge timeseries in m^3/s at basin outlets along river network (.csv). Product type (PT): “q”
- Runoff in mm/timestep from each grid cell (.nc). Product type (PT): “r”
- Base Flow in m^3/s for each grid cell (.nc). Product type (PT): “bf”
- Rootzone storage in mm/timestep for each grid cell (.nc). Product type (PT): “rs”
- Snow storage in mm/timestep for each grid cell (.nc). Product type (PT): “sns”
- Surface storage in mm/timestep for each grid cell (.nc). Product type (PT): “ss”
- Evapotranspiration in mm/timestep for each grid cell (.nc). Product type (PT): “et”

The Hybrid-AI model additionally includes an integrated hydraulic solver, which provides the following outputs:

- Water surface elevation timeseries in m a.s.l. along river channel (.csv). Product type (PT): “wse”
- Discharge timeseries in m^3/s along river channel (.csv). Product type (PT): “q”

MCP probabilistic forecast

The outputs of MCP model are provided as follows:

- Expected value (mean) of probabilistic discharge estimate in m^3/s (.txt or .csv). Product type (PT): “eq”
- 5th and 95th percentile of the probabilistic discharge estimate in m^3/s , identifying the 90% confidence band (.txt or .csv). Product type (PT): “pq90”
- Percentiles of the probabilistic discharge estimate from 5th to 95th in increments of 5 (.txt or .csv). Product type (PT): “pq5”

3.16. Hydraulic models

The outputs of the hydrodynamic simulations are maps that are stored with a filename that reflects the following structure “PJ_NM_PT_BBBB_ISD_SD.FFF”.

Table 3.15.1: Technical specifications of the hydraulic models' outputs.

| Attribute | Description |
|-------------------------------|--|
| Area of Interest (BBBB) | 5 AOIs (Table 3.7.1). |
| Numerical model (NM) | Mike+ (MK), HEC-RAS (HR), DassFlow (DF), LISFLOOD-FP (LF) |
| Initial simulation date (ISD) | Date of the start of the event simulated as YYYYMMDD |
| Simulation duration (SD) | Duration of the simulation in days |
| Product type (PT) | Flood Depth (fd), Flood Velocity (fv), Flood Water Level (fl), Flood Extent (fe), Water Surface Elevation (wse), Discharge (q) |
| Product ID | PJ_NM_PT_BBBB_ISD_SD.FFF |
| Service Provider (NM) | DHI (MK), RSS-Hydro (HR), HydroMatters (DF), SMHI (LF) |
| Spatial resolution | 30m (for 2D simulations) |
| Temporal resolution | TBD |
| Delivery format (FFF) | GeoTIFF (.tif), ARC ascii raster format, Shapefile (.shp), CSV (.csv) |
| Projection | WGS84 (EPSG 4326) |
| Service description | Simulation outcomes are derived from different hydraulic models. Full methodology explained in EO4FLOOD Deliverable ATBD v2. |
| Project (PJ) | EO4FLOOD |

Hydraulic model product name:

PJ_NM_PT_BBBB_ISD_SD.FFF

E.g. for HEC-RAS flood velocity map product:

EO4FLOOD_HR_fv_nigr_20200915_15.csv

Mike+

The outputs of the 1D hydrodynamic simulations are:

- Water surface elevation timeseries in m a.s.l. along river channel (.csv). Product type (PT): "wse"
- Discharge timeseries in m³/s along river channel (.csv). Product type (PT): "q"

The outputs of the 2D hydrodynamic simulations are:

- Maximum flood depth in m calculated during the simulation, stored as a GeoTIFF (.tif) file. Product type (PT): "fd"
- Maximum flood velocity in m/s calculated during the simulation, stored as a GeoTIFF (.tif) file. Product type (PT): "fv"
- Maximum flood water level in m a.s.l. calculated during the simulation, stored as a GeoTIFF (.tif) file. Product type (PT): "fl"

HEC-RAS

The outputs of the 2D hydrodynamic simulations are:

- Flood depth map: maximum water depth in m calculated during a simulated flood event. The result is provided in a grid format as "Max Flood Depth Grid" stored as a GeoTIFF (.tif) file. Product type (PT): "fd".
- Flood velocity map: highest velocity of floodwater in m/s calculated during a simulated flood event. The result is provided in a grid format as "Max Flood Velocity Grid" stored as a GeoTIFF (.tif) file. Product type (PT): "fv".

- Flood water level map: highest water surface elevations in m a.s.l. calculated during a simulated flood event. The result is provided in a grid format as "Max Flood Level Grid" stored as a GeoTIFF (.tif) file. Product type (PT): "fl".
- Flood extent: maximum flood extent reached during a simulated flood event. The result is provided as a vector layer in a shapefile format (.shp). Product type (PT): "fe".

DassFlow 1D/2D

The outputs of the 1D hydrodynamic simulations are:

- Water surface elevation timeseries in m a.s.l. (.csv). Product type (PT): "wse"
- Discharge timeseries in m³/s (.csv). Product type (PT): "q"

The outputs of the 2D hydrodynamic simulations are:

- Flood depth map in m (.tif). Product type (PT): "fd"
- Flood velocity map in m/s (.tif). Product type (PT): "fv"
- Flood water level map in m a.s.l. (.tif). Product type (PT): "fl"

LISFLOOD-FP

The outputs of the 1D hydrodynamic simulations are:

- Channel water surface profile in m a.s.l. (.profile) at user-defined time interval in text format. Product type (PT): "wse".
- Channel flow in m³/s (.profile) at user-defined time interval in text format. Product type (PT): "q".

The outputs of the 2D hydrodynamic simulations are:

- Water depth in m at user defined interval (.wd) in ARC ascii raster format. Product type (PT): "fd".
- Maximum water depth in m calculated during a simulated flood event (.max) in ARC ascii raster format. Product type (PT): "fd".
- Flood velocity in m/s at the cell interface in the x and y directions at specified intervals (.Vx, .Vy) in ARC ascii raster format. Product type (PT): "fv".
- Flood discharge in m³/s at the cell interface in the x and y directions at specified intervals (.Qx, .Qy) in ARC ascii raster format. Product type (PT): "q".
- Maximum velocity of floodwater in m/s calculated during a simulated flood event in the x and y directions as well as the combined cell velocity (.maxVx, .maxVy, maxVc) in ARC ascii raster format. Product type (PT): "fv".

Hybrid-AI

Please refer to the Hybrid-AI paragraph in the hydrological model section.

4. NRT Data product specification

4.1. Precipitation

The Near Real-Time precipitation data over the selected test basins are obtained from the IMERG-ER, IMERG-LR and GSMAP-NRT products. They follow the file format, naming and variables specification described above in Section 3.1 (Precipitation). The products are provided at their native spatial resolution (0.1°) and at hourly temporal resolution. For any additional details the reader is referred to the products ATBD document. More in details, the latency associated with each product is summarized in Table 3.26.

Table 4.1.1: Precipitation products available in near real-time and associated latency.

| Product name | Latency (hours) |
|--------------|-----------------|
| IMERG-ER | 4 |
| IMERG-LR | 18 |
| GSMAP-NRT | 4 |

4.2. Water level

The NRT water level data at virtual stations follow the file format, naming, and variables specification described in Section 3.6 (Water level virtual stations). NRT data are available within the project (not public) for the S3A/B and S6A missions.

In the operational DAHITI processing, NRT data are replaced by NTC data once available. Accuracy differences between the raw NTC and NRT waveforms and retracked ranges are negligible. DAHITI applies its own geophysical corrections, most of which can be applied to NRT data, regardless of the latency. The main differences between DAHITI NRT and NTC are the applied troposphere and ionosphere corrections. For NRT, mission-specific corrections are applied. For NTC, consistent corrections (which are not available NRT) across all DAHITI data can be applied. Therefore, the main advantage of NTC data is the consistency within DAHITI and not accuracy-related.

In the NRT time series specifically obtained for EO4Flood, the NRT data are preserved. The NRT time series starts later than the NTC time series, because the raw NRT data from the mission are only temporarily available for download from Copernicus.

The type of data (NRT or NTC) can be derived from the mission name variable. NRT water level data have a latency of one day.

4.3. River discharge

The NRT river discharge data will follow the procedure described in the Section 3.11 referring to the NRT product of water level described in Section 4.2.