Earth Observation (EO) is the gathering of information about planet Earth’s physical, chemical and biological systems via remote sensing technologies, both active (radar, microwave) and passive (mostly long-wave and visible radiation reflected or emitted by the earth system). EO is used to monitor and assess the status of, and changes in, the natural environment and the built environment. In recent years, Earth Observation has become technologically more and more sophisticated and has evolved from a mostly research-oriented to a more service-oriented field. Earth observation services provide a wide variety of possible elements and can serve a wide variety of possible users. Some of the specific applications of Earth observations services are providing data to assist in: forecasting, tracking biodiversity and wildlife trends, measuring land-use change (such as deforestation), monitoring and responding to natural disasters, including fires, floods, earthquakes and tsunamis, managing natural resources, such as energy, freshwater and agriculture, addressing emerging diseases and other health risks, predicting, adapting to and mitigating climate change, among others.

Deltares combines its expert system knowledge with its capacity for complex data processing and analysis into EO services to produce valuable information on the status and the possible future of a water and subsoil systems. Deltares EO services support the interactive visualization through web services or Google Earth for example. Our services provide evaluation of EO data products and extensive validation to assess the quality of the data (i.e. quality flags to the EO products). Furthermore, Deltares has the expertise to integrate different types of information (i.e. in situ measurements, models and EO sources) to provide support to stakeholders and policy makers in their decision making.

Deltares EO downstream services are being setup for the following fields:
- Marine and coastal surveillance.
- Crisis/damage mapping.
- Risk/vulnerability mapping.
- Water quality assessment and monitoring.

Showcases/evidence

The TnuTSM and MoS^2 projects on Model-Supported Monitoring of suspended particulate matter (SPM) provide better insight in the patterns of variation in SPM in the Dutch coastal waters. With the use of ocean colour remote sensing turbidity patterns in time and space can be related to large-scale sand mining activities for construction of the Rotterdam port extension “2nd Maasvlakte” (2009-2013) against the background of natural variations in the coastal system. SPM transport model forecasts combined with Earth observation data supported the Port of Rotterdam in their assessment of the possible trends in SPM in the Dutch coastal waters due to the 2nd Maasvlakte construction.

The added value of ocean colour remote sensing for water quality monitoring for the Dutch Rijkswaterstaat (the Dutch national water management agency) is a recurring topic in Deltares projects that address issues such as EO data quality and validation, robustness of services and
integration into offshore water quality monitoring strategies. Currently the Dutch national government is benefitting from these Deltares results in their involvement with the EU Copernicus services and further use of EO data for broader water-related monitoring applications (water quality in lakes, altimetry) within the Netherlands.

ECOSTRESS (Ecological Coastal Strategies and Tools for Resilient European Societies) is an EU funded project. The project is examining the feasibility and the costs and benefits of risk prevention measures related to the use of wetlands, coastal marine systems and dry lands to naturally mitigate floods. Earth observation data from Sentinel are combined with field studies and statistics in geographic information systems and thematic maps and analyses for coastal zones in the Wadden Sea and Northern Adriatic.

FAST (Foreshore Assessment using Space Technology) is an EU project that is developing down-stream services for Copernicus to support cost-effective, nature-based shoreline protection against flooding and erosion. Using a combination of remote sensing and field data, FAST combines specific characteristics of vegetated foreshores and their effect on wave energy and erosion with the development of novel ways to obtain this information from satellite images in to predicting the flood risk reduction effect of vegetated shorelines in four different EU countries.

Together with the Dutch national met office, KNMI, Deltares has been involved in the MyWave project, improving the ocean wave forecasting service by integrating scatterometer wind-stress measurements with Deltares wave models. The triple collocation of altimeter wave height, buoys data, and wave model forecast will be made available as a service to government, offshore industry and other stakeholders.

Terrafirma (ESA project) and the FP7 SubCoast used Persistent Scatterer Interferometry (PS-InSAR) to detect subsidence. Envisat ASAR data have been processed and analysed to improve information services on dike safety. Remotely sensed information on dike movements (deformation) that previously were not reported or alerted by the Water boards can now be used as point of attention for dike safety inspection.

The objective of the project FP7. GLOWASIS (Global Water Scarcity Information Service) is to pre-validate a GMES Land and Ocean Service for Water Scarcity Information. In European and global pilots it combines hydrological models with in-situ and satellite derived water cycle information, as well as statistical water demand data. GLOWASIS is set up as an open data portal, where water scarcity model time series and relevant satellite derived water cycle parameters can be downloaded. Awareness for the complexity of water scarcity is created on a popular website. GLOWASIS guides earth observation scientists to efficient innovation for the specific purpose of water scarcity assessment and forecasting.

The FP7 project EarthH2Observe “Global Earth Observation for Integrated Water Resource Assessment” contributes to the assessment of global water resources through the use of new Earth Observation datasets and techniques. For this purpose, the project will integrate earth observations, in-situ datasets and models, to construct a consistent global water resources reanalysis dataset of at least 30 years. The resulting datasets will be made available through an open Water Cycle Integrator data portal: the European contribution to the GEOSS/WCI approach. The datasets will be downscaled for application at regional and local levels, and optimized based on identified European and local needs supporting water management and decision making.

The New Zealand SMART Aquifer Characterisation, funded by the New Zealand Ministry of Business, Innovation and Employment, aims at developing a suite of novel techniques for characterisation aquifers in New Zealand. Satellite Remote Sensing plays a vital role in the project: from satellite evapotranspiration (MODIS) and soil moisture (Sentinel-1) nation-wide climate time series are developed that will give more insight in groundwater fluxes, like rainfall recharge, groundwater flow and groundwater discharge to surface (baseflow).

ECOPOTENTIAL (Improving Future Ecosystem Benefits through Earth Observations) is a project funded by the EU Horizon 2020, that will create a new, unified framework for ecosystem studies and management of protected areas (PA). Best use of Earth Observation (EO) and monitoring data will be made possible by new EO open-access ecosystem data services (ECOPERNICUS). Support to transparent and knowledge-based conservation and management policies to improve future ecosystem benefits for humankind, able to include information from EO data, will be the main product.

Several upcoming opportunities target the development of Deltares Earth Observation services for purposes such as monitoring of Wetlands in Africa, and Improving forecasting for fisheries and aquaculture sectors, and for monitoring of climate change adaptation.
Services and Product illustrations

Water Quality Information Services:

Remote sensing snapshots from MERIS for optically detectable water quality parameters Total suspended matter, Chlorophyll-a and Coloured Dissolved Organic Matter (CDOM).


Ocean forecasting service

Forecast of $M_2$ tidal constituent (phase and amplitude) including assimilation of radar altimetry data as part of the Dutch national tide and storm surge forecasting service.

Global Scatterometer tracks used in the MyWave service (Source: Knmi).
**Services on dike safety**

Dike movement (deformation) detected by Sar Image

**Global Water Scarcity Information Service**

Drought Data Portal combining hydrological models with in-situ and satellite derived water cycle information

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**Deltares** is an independent institute for applied research in the field of water, subsurface and infrastructure. Throughout the world, we work on smart solutions, innovations and applications for people, environment and society. **Deltares is based in Delft and Utrecht.**