MI-SAFE architecture

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Introduction

Marine foreshores are currently not included in water safety assessments and in levee design. River floodplains are only managed to maximize river discharge capacity. However, foreshores and floodplains deliver several services, such as increasing sedimentation, reducing erosion and attenuating waves that mitigate flood risk by improving levee stability and lifetime. Including foreshores and floodplains in levee design and safety assessments can result in considerable cost reductions for flood risk management.

The FAST[8] (Foreshore Assessment using Space Technology) project aims to develop a new GMES/Copernicus downstream service by developing products based on Sentinel data to gain spatial information on foreshore and floodplain characteristics, such as morphology, sediment characteristics and vegetation properties. Necessary ground referencing in combination with measurements on wave attenuation and erosion/deposition regimes have been executed in four study areas at eight characteristic case-study sites across Europe (Spain, Romania, United Kingdom and the Netherlands).

From the collected data general relationships between foreshore and floodplain characteristics and flood risk mitigation properties have been derived and implemented in a fully open-source GIS based platform that makes extensive use of the OGC protocols. The platform is named MI-Safe.

1.1 MI-SAFE

The free online tool (**MI-SAFE**)[6] gives a first indication of the presence and potential flood risk reducing effects of foreshores. This version uses global maps of depth, elevation and vegetation derived from Earth Observation (EO) data. Via Bayesian modelling with XBeach the contribution of vegetation is calculated using a representative amount of profiles. This representation of profiles is retrieved from over 20000 profiles across the shorelines of the globe. Users can explore the contribution of vegetation to flood risk reduction at any location.

For the FAST study sites MI-SAFE gives a more detailed indication of the presence and potential effects of foreshores now and in the future under various scenarios thanks to the use of wave modelling software. For the field sites even better results can be presented due to the use of the finest resolution of data that could be extracted from national open data centres. Additionally, the tool can contribute to the decision of establishing (new) flood protection infrastructure and the development of flood protection plans that optimally use existing ecological and landscape attributes of the coastal foreshore. As the tool uses open source data structures, all maps are accessible and downloadable. Procedures have been based on INSPIRE metadata conventions. An active open source community will be ready for any questions related to the tool.

2 Architecture of the MI-Safe IGIS platform

The multi-layered client-server architecture of the MI-Safe platform can be subdivided in three main blocks (Presentation, Logic, Data access) corresponding to a classic *three-tier* system application. The first layer handles user interaction with the web platform with an instance of Delta Data Viewer (DDV) whereas the logic is handled by PyWPS[8] services in the backend. On the expert version of the platform, wave modelling is performed by the XBeach[9] open-source package. Data is stored and accessed by GeoServer[10] and PostgreSQL/PostGIS[11] depending of their nature (raster or vector). GeoNetwork[12] is used to edit and serve metadata of all the datasets involved in the computations. Last but not least, Google Earth Engine[13] cloud services are used to transform Earth Observation (EO) data into global datasets for the project (ex: Sentinel-2 vegetation maps).

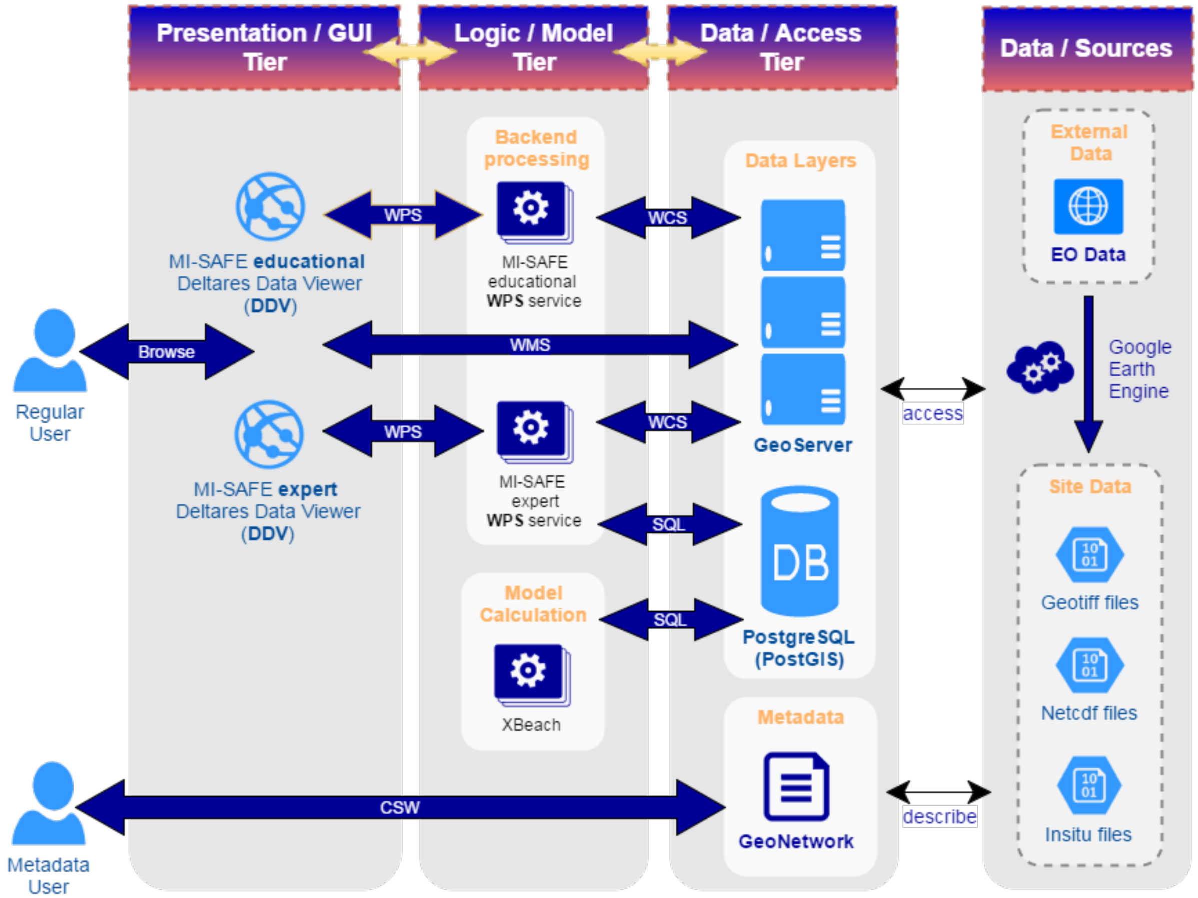

Fig. 1. The three-layered tier architecture of the MI-Safe platform.

2.1 Presentation tier (Deltares Data Viewer)

The MI-SAFE platform makes use of a customized instance of the Delta Data Viewer (DDV) which is an open-source GIS viewer part of the Openearth stack that allows geospatial data visualization and also supports a variety of processes. This viewer makes data requests via the OGC WPS protocol to the backend obtaining the necessary data to produce the plots and reports. The basic information in the viewer is presented via OGC services (WMS). The viewer harvests layer definitions dynamically querying the GeoServer instance of FAST via GetCapabilities (WMS).

The viewer is based on OpenLayers[14] and built up of 3 main parts, the canvas where the maps are shown, the table of contents where a selection of layers can be toggled on or off and the modelling part. Via OGC services (a WPS in this case) data is extracted over the profile which is retrieved through a user defined point. This point is linked with the nearest coastline segment (within a buffer of 1 degree) where a perpendicular line is created. This data is then classified to certain rules and used to query the table of model results. The result is shown in a very basic way indicating whether or not vegetation is existent and or contributes to wave attenuation.

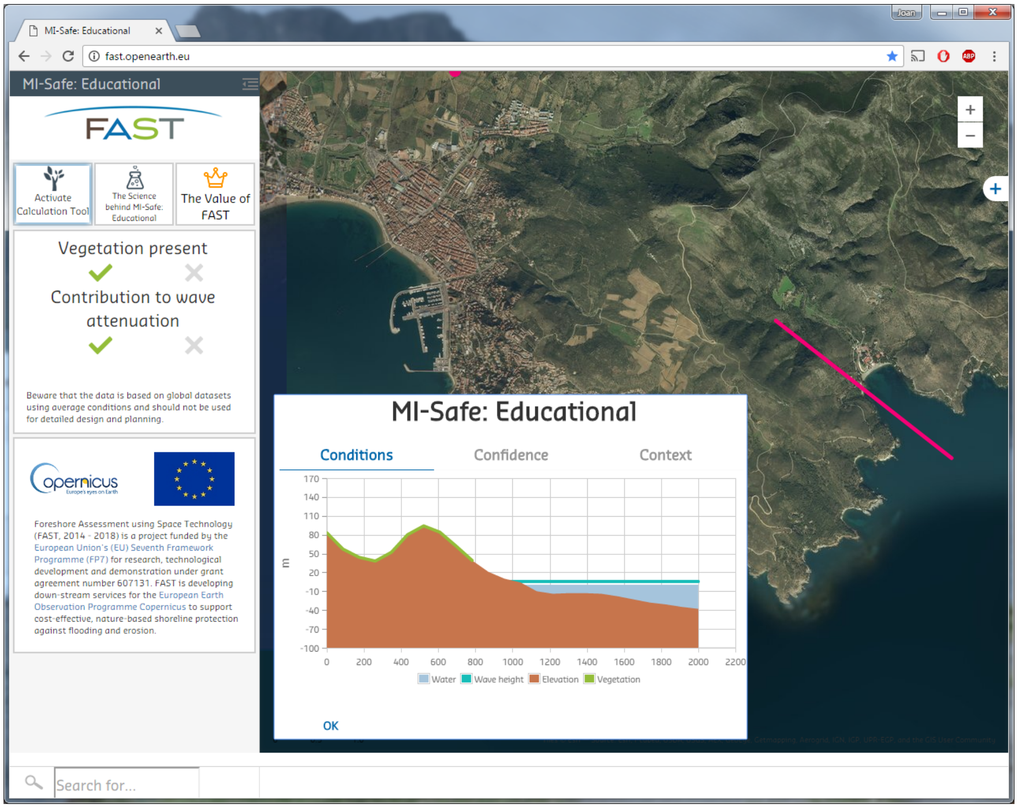

Fig. 2. The Delta Data Viewer (DDV) instance for MI-SAFE.

2.2 Logic tier (PyWPS and XBeach)

PyWPS is used to communicate all the necessary information to the presentation tier. This python open-source implementation of the OGC WPS protocol makes use of owslib and GDAL libraries to retrieve data values via WCS with the GeoServer instance that holds the layer data. For the expert mode, PyWPS queries a PostgreSQL/PostGIS database in order to obtain the XBeach wave propagation results for the sites. XBeach is a two-dimensional community driven model for wave propagation, long waves and mean flow, sediment transport and morphological changes of the near shore area, beaches, dunes and back barrier during storms.

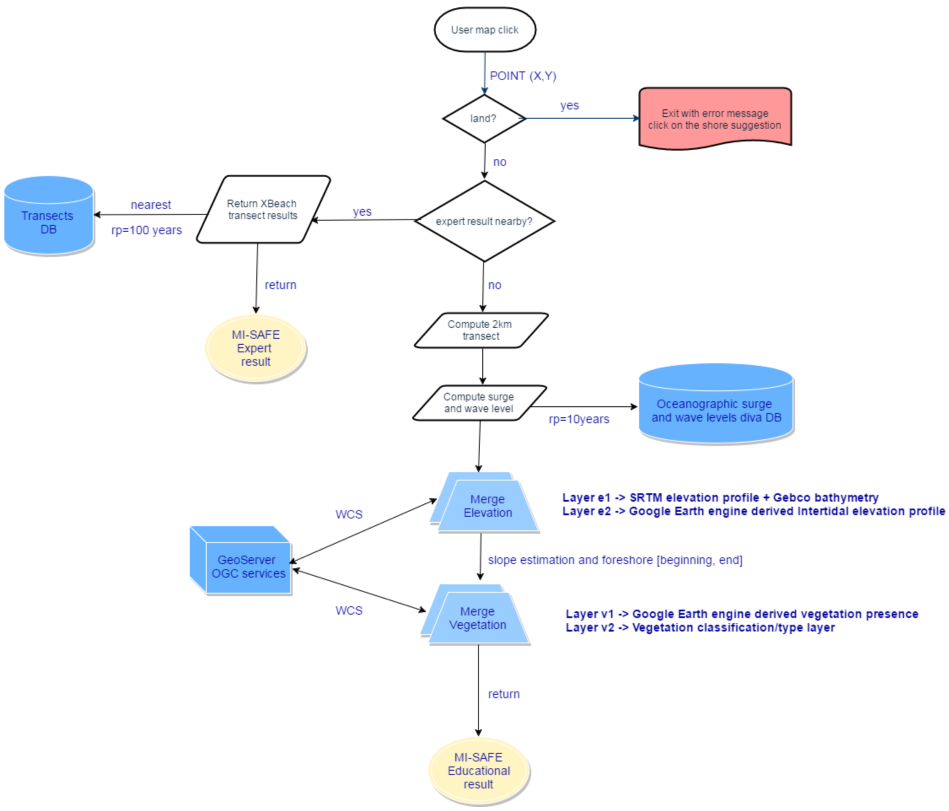

Fig. 3. The logic behind the pywps service

2.3 Data tier (GeoNetwork, GeoServer and PostGIS)

On the data layer OGC compliant solutions are used to handle raster and vector layers and the corresponding metadata. GeoServer was chosen as the solution to handle global and local raster layers in GeoTiff format and provide WMS access for visualization and WCS for coverage queries. GeoNetwork is deployed as a catalogue solution to cover the metadata editing and search part through CSW protocol. The vector outputs produced by XBeach modelling are stored into a PostGIS database that enables fast queries from the PyWPS instance of the MI-SAFE expert version. Earth observation data from the Sentinel-2 mission has been processed with the Google Earth Engine in order to obtain higher resolution vegetation maps.

Conclusions

The MI-Safe platform is a good example of a marine IGIS assembled uniquely with open-source components that provide a fully OGC compliant solution. The purpose of the tool is to help users understand how vegetated foreshores reduce coastal flood risk on any given location worldwide. This knowledge may help to reduce the cost of flood protection as well as may deliver inputs to a more wide-spread, successful restoration and conservation of coastal ecosystems.

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