Multitemporal observations of extreme met-ocean conditions from Envisat ASAR and Copernicus Optical parameters

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OUTLINE

Introduction
Overview of GMES/COPERNICUS and EO products
Test Case: ‘Added value EO products for Extreme event’

Extreme event characterization:
- Copernicus EO
- Modeling
- WMS implementation
**Context:** For the decision and policy makers knowledge about coastal, response to variations in external conditions and the degree to which a system is able to cope with adverse effects, is mandatory. In order to consolidate and improve existing monitoring approaches in Europe and help to identify and address gaps in currently available data and information, specific tools to support decisions are available from the context of EO and GMES/Copernicus.

**Purpose:** Test Case presented shows how added value products for coastal analysis can be obtained by integrating COPERNICUS core observation products with other EO data and *insitu* measurements. Observing coastal dynamics means observing complex ecosystems with multi parameter interaction and their time- (long-term visions) and space- dependent dynamics. Appropriate governance (multi-purpose) and a sustainable approach requires the implementation of durable, repeatable and self-sustainable infrastructures as well as coaxes of infrastructures.
ESA is developing new satellite missions called *Sentinels* specifically for the operational needs of the GMES/Copernicus program.

The Sentinel missions are based on a *constellation of satellites* to fulfill revisit and coverage requirements from environmental monitoring and provide a unique set of observations for *GMES/Copernicus Services*.

The operational availability of ESA Sentinel satellites has been central in the 2013 FP7 space work programme to support space based applications such as Copernicus.

EU funding schemes have and will strongly support topics aimed at delivering *new and innovative products, processes and services*, with particular attention on the investments in the Sentinel satellites.

The simulations of future Sentinel data are on the way and they represent a challenge for scientists, since accurate technical specifications would be needed.
Downstreaming and Support to Decision Process

COASTS: The interface between Land/Sea Scape
- Field Radiometry
- Algorithm development and research
- Spectral mixing analysis
- SAR processing

Data Processing layer

Preprocessing modules (archive search & new acquisition)

Data Access layer

ESA remote Segment + Data in situ acquisition

Integration layer
GMES Services
Non GMES Services

Publication layer

Data layer

From Space Systems to non EO expert End Users
The strategy of combining high and very high resolution spectral measurements in a multisensory and multi resolution analysis. This includes different ways of data fusion to assimilate spectral and spatial variability in complex coastal mapping and modeling.
Test Case: COASTAL MARINE—NORTHERN ADRIATIC SEA

Offshore Adriatic Sea, marine resources and multiuse platforms

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Earth Observation DATA
COPERNICUS PRODUCTS

MODELS

Non COPERNICUS products

Data & Products Assimilation

COPERNICUS PRODUCTS

Data Processing

Assessment of products quality using *in-situ* data

- SST
- KD490
- TSM
- CHL
- WIND

Spatial series of maps

Temporal series of maps

DATABASE

ADDED VALUE PRODUCTS

DSS

Waves

Currents

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Different approaches for critical event interpretation

CRITICAL EVENT

EVENT OBSERVATION
- REMOTE SENSING OBSERVATION
- IN SITU DATA MEASUREMENT

EVENT INTERPRETATION

EARTH OBSERVATION

MODELING

DATA INTEGRATION
Evaluating Remote Sensed data availability during Bora events in winter 2012

Wind speed and RS data availability
Northern Adriatic sea - 19 January 2012 - 18 February 2012

Wind speed (m/s) ASAR-WideSwath MERIS COSMO-SkyMED
Wind field (intensity and direction) over sea surface can be estimated from Synthetic Aperture Radar (SAR) remotely sensed data, onboard satellite platforms.

There are different retrieval algorithms (XMOD, CMOD5), due to different sensor characteristics.

Spatial resolution of output products can be 300m to 1000m. Temporal resolution is depending on the acquisition platform, 4 to 16 days, and it is not affected by cloud coverage.
Estimated Wind field from medium resolution SAR ASAR Wide-Swath Mode

Wind speed and direction (spatial resolution 800m) estimated using **CMOD5** algorithm from **ENVISAT ASAR** Wide Swath acquired on 02/02/2012

Source: ESA, Soprano CLS

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Estimated Wind field from high resolution SAR COSMO-SkyMED

Software GWW e-GEOS
Estimated Waves from high resolution SAR COSMO-SkyMED

Wave Field (Significant Wave Height and Wave Length)

CosmoSkyMed High resolution

Software GWW e-GEOS
Estimated Currents field from high resolution SAR COSMO-SkyMED

CosmoSkyMed High resolution

Currents experiment (Direction and velocity) from COSMO-SkyMed image
Calculated from wind and waves

Software GWW e-GEOS
RS data processing from optical sensors

MERIS full resolution processing chain

PROCESSING:
- MERIS L1b DATA DOWNLOAD (CAT-1 ESA)
- ODESA processing L1b -> L2 (MEGS 8.1 processor)
- Product masking and quality assessment
- BEAM binning processor L2 -> L3
- netCDF product assembling

ADDED VALUE:
- Full Resolution processing
- Non-standard product improvements (Kd490)
- Experimental algorithm (Neural Network in Case 2 water SPM-CDOM-CHL)
- Assessment of quality levels for accurate product selection and masking
- Extent and product selection
- Metadata
- Processing information
RS data processing from optical sensors

Chlorophyll-a

Sea Surface Temperature

Diffuse attenuation coefficient (KD) for downwelling irradiance at 490 nm

Suspended Particulate Matter

L3 binned Geophysical parameters from ENVISAT MERIS and MODIS Terra data acquired on 08/05/2011

Source: ISPRA
Interpreting critical events using Earth Observation products

REMOTE SENSING DATA ACQUISITION

EO PRODUCTS GENERATION
- Optical
- TSM
- Kd490

IN SITU DATA MEASUREMENT
- Radar
- Wind
- SWH

CRITICAL EVENT IDENTIFICATION

VALIDATION

EVENT INTERPRETATION

EARTH OBSERVATION PRODUCTS
Estimated Wind intensity during Bora events in winter 2012

Source: Soprano CLS
Estimated Suspended Particulate Matter during Bora events in winter 2012
Comparing Earth Observation products estimated from different sensor acquired contemporary during Bora events in winter 2012

Data acquired on 02/02/2012
Source: Soprano CLS, ISPRA

Wind Speed and direction

Suspended Particulate Matter
Analysing Earth Observation product

Suspended Particulate Matter

Data acquired on 02/02/2012
Source: ISPRA
Interpreting critical events using Models

- **EVENT MODELING**
  - **Interpreting** critical events using Models
  - **DATA ASSIMILATION**
  - **IN SITU DATA MEASUREMENT**
  - **COUPLED MODELING SYSTEM**
  - **EVENT MODELING**
  - **EARTH OBSERVATION PRODUCTS**
    - **CRITICAL EVENT IDENTIFICATION**
    - **VALIDATION**

- **MODEL OUTPUT**
- **EVENT INTERPRETATION**

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Comparing estimation of wind field from model and Earth Observation

Wind field estimated from COSMO-I7 model

Wind field estimated from ASAR WSM

Data acquired on 02/02/2012
Source: Soprano CNR-ISMAR, CLS
Comparing estimation of suspended sediment from model and Earth Observation

Suspended Sediment Concentration (SSC) estimated by ROMS-SWAN

Total Suspended Matter (TSM) estimated from ENVISAT MERIS

Source: CNR-ISMAR, ISPRA
Comparing estimation of suspended sediment from model and Earth Observation

Suspended Sediment Concentration (SSC) estimated by ROMS-SWAN

Diffuse Attenuation coefficient at 490nm (KD490) estimated from MODIS Terra

Source: CNR-ISMAR, ISPRA
Combining two different approaches: Earth Observation and Modeling

- **Meteorological Model Output**
- **In Situ Data Measurement**
- **Earth Observation Products**
- **Data Assimilation**
- **Coupled Modeling System**
- **Event Modeling**
- **Validation**
- **Critical Event Identification**
- **Critical Event**
- **Event Interpretation**

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Value Added Products
A Web Mapping Service (WMS) implemented to deliver products generated to supply the main and downstreaming of Copernicus Earth Observation products for coastal analysis. The deliverables will include series of maps based on existing MyOcean and GeoLand services integrated with Earth Observation and in-situ data with both biological and physical layers/indicators at different spatial and temporal scales.
Data assimilation sources

**Strengths**
- Continuous data acquisition
- Accurate measurement

**Weaknesses**
- Punctual data, not spatially distributed

**Strengths**
- Spatially distributed data
- Continuous data acquisition

**Weaknesses**
- Modeled data, not measured
- Low spatial resolution

**Strengths**
- Spatially distributed data
- High spatial resolution

**Weaknesses**
- Not continuous data acquisition
- Estimated data, not measured
- Cloud affected (optical sensors)
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