SUSPENDED SOLID MATERIAL (SSM) MONITORING IN COASTAL AREAS BY SATELLITE DATA

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1. INTRODUCTION

Suspended Solid Materials (SSM) affect **seawater turbidity and** more generally its **quality** because they have a crucial role in nutrients transport and in the reduction of light penetration (e.g. Mirauda et al., 2011). Thanks to the variation of water spectral signature at varying of SSM concentration (Fig. 1), **SSM can be retrieved by different satellite sensors**.

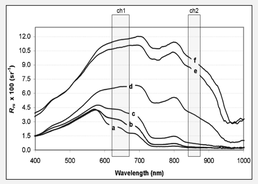
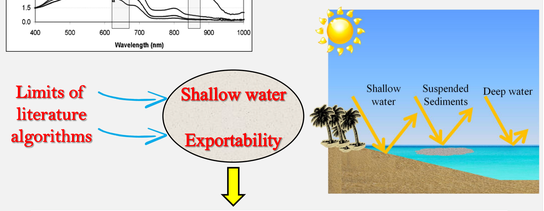


Fig.1: water spectral signature at different SSM concentrations (a: 0.013 gl-1; b: 0.023 gl-1; c: 0.062 gl-1; d: 0.355 gl-1; e: 0.651 gl-1; f: 0.985 gl-1); the two bars show the spectral position of MODIS ch1 (Red) and ch2 (Near Infrared), respectively; (adapted from Doxaran et al., 2002).



To face these issues the **Robust Satellite Technique (RST)** approach (Tramutoli 2005, 2007) was **applied**.

2. THE STUDY AREA

The investigated area is the **Sea Ionian coastal area of Basilicata Region** (southern Italy). It is a typical transitional environment and has a high historical, cultural and economic value for the region. Five rivers have their mouths in this area (from N-E to S-W): Bradano, Basento, Cavone, Agri and Sinni.

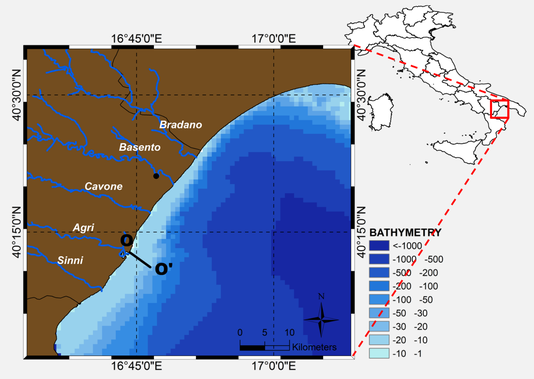


Fig.2: Ionian coast of Basilicata region (Southern Italy). The black circle indicates the position of the Torre Accio gauging station on Basento river. O-O' is a spatial profile that will be used afterwards.

3. METHOD AND DATA

The Robust Satellite Techniques (RST)

RST is a **general multi-temporal methodology of satellite data analysis** which allows the identification of a signal anomaly, **in terms of ALICE index** (Eq. 1), as a statistically significant deviation from the expected value of the investigated signal for a specific condition of observation. Such an expected value is preliminarily identified by **analyzing multi-year homogeneous** (e.g. same area, same spectral channel/s, same month and acquisition time) **series of satellite records** (Fig. 3).

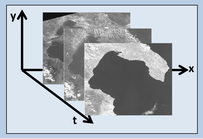


Fig.3: example of historical series of MODIS data homogenous in the spatiotemporal domain.

$$\otimes_V(x,y,t)=\frac{V(x,y,t)-V_{ref}(x,y)}{\sigma_{ref}(x,y)} \quad \text{(Eq.1)}$$

A.L.I.C.E.

*(**A**bsolutely **L**local **I**ndex of **C**hange of the **E**nvironment)*

$$\otimes_{VIS}(x,y,t)=\frac{R_{VIS}(x,y,t)-\min_{VIS}(x,y)}{\sigma_{VIS}(x,y)} \quad \text{(Eq. 2)}$$

Specific for SSM anomalous events identification

$$\otimes_{NIR}(x,y,t)=\frac{R_{NIR}(x,y,t)-\min_{NIR}(x,y)}{\sigma_{NIR}(x,y)} \quad \text{(Eq. 3)}$$

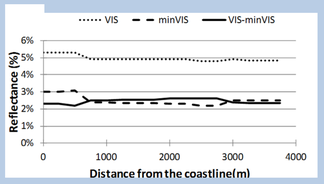


Fig.4: variation of the VIS reflectance, its historical minimum and their difference along the transect O – O' shown in Fig.2, for a MODIS image acquired under unperturbed conditions(i.e. no sediments and clouds, low zenithal angle).

The ALICE indices described by eq. 2 and 3, where **historical temporal minimum** values have been used **as reference for the unperturbed conditions**, both for the VIS and NIR signals, allow to reduce the contribution of sea bottom to the measured reflectance (Fig. 4), especially important in presence of shallow clear waters.

River flow data

Because no direct SSM measurements were available for the study area, information about rivers water levels have been considered to discriminate SSM events of different magnitude. Three events (Fig. 5) characterized by an increase in river discharge (for Basento river), which hit with a different level of intensity the Basilicata region in the past, were studied in this work.

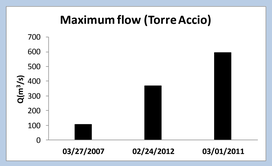


Fig.5: maximum river flow computed at gauging section of Torre Accio (on the Basento river – see Fig. 2 for the position) for the three considered events (adapted from ARPAB* data).

* Regional Agency for the Environmental Protection

Satellite Data

MODIS (Moderate Resolution Imaging Spectroradiometer), among the sensors currently operational at global scale, is the one with the best trade-off between spectral, spatial and temporal resolution for SSM retrieval. Being on board of Terra and Aqua satellites, it allows two acquisition per day, mostly all over the world. The ones in the VNIR spectral region (VIS, 620 – 670 nm, NIR, 841 – 876 nm) is at 250 meters of spatial resolution.

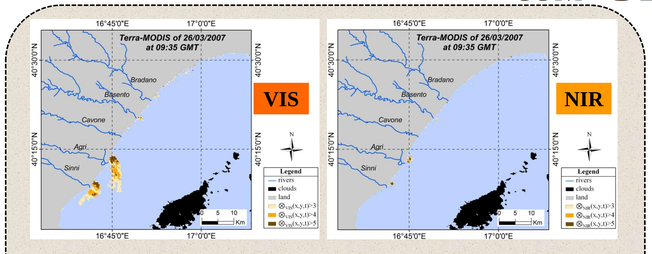
A total of about **2.000 MYD/MOD02QKM (Level 1B Calibrated Radiances – 250m)** products (Table 1) acquired in the period 2003 -2012 during the months of February and March over the investigated sit have been processed.

	Terra	Aqua
February	556	508
March	408	542

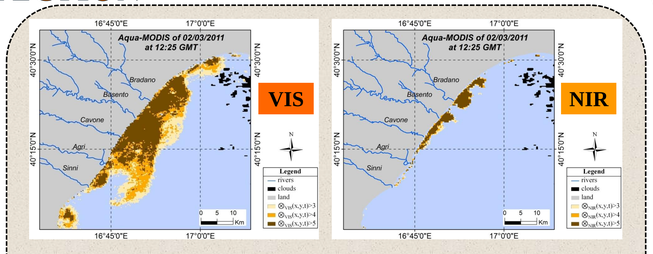
Table 1: number of MODIS data used for implementing the RST approach. Two different datasets were generated for each month: a first one was composed only by imagery acquired by Terra around 10:30 GMT ±2 hours and the second by those acquired by Aqua around 13:30 GMT ±2 hours, considering only the months of February and March from 2003 to 2012.

4. RESULTS

SSM DETECTION

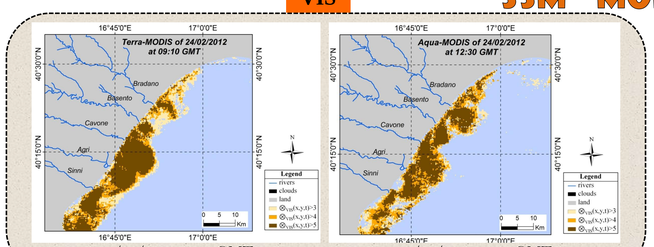


During the **low intensity event of March 2007** only the VIS based ALICE index (Eq. 2) was able to identify the presence of anomalous levels of SSM at the mouth of Agri and Sinni rivers.



During the **high intensity event of March 2011** both the ALICE indices (Eq. 2 and Eq.3) were able to identify the presence of large areas characterized by anomalous signals due by the presence of SSM.

SSM MONITORING



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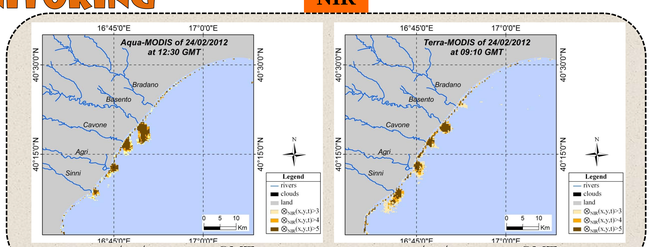

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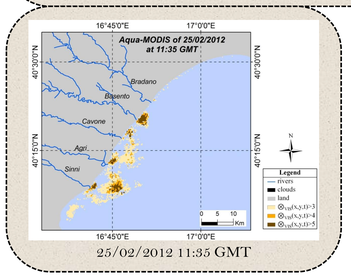
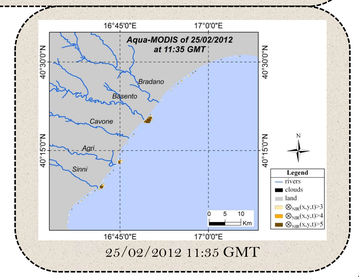


25/02/2012 11:35 GMT

Combining the potential of a robust and exportable approach for SSM identification, like the one here presented, with the high temporal capability of the EOS satellites constellation, allows for an **effective monitoring of the evolution of SSM in the spatiotemporal domain**.

The analysis carried out for the February 2012 event (mid intensity) clearly highlights such a capability, showing first, at the beginning of the event, a sort of time delay between the response of the northern rivers (i.e. Basento and Bradano) respect to the southern ones. Afterwards, a quite fast restoring of almost normal conditions is observable on the following day. Also in this case, the NIR based index (Eq.3) seems able to provide information only when high levels of SSM concentration are expected.



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5. CONCLUSIONS

Results achieved by implementing the proposed MODIS RST-based approach (easily exportable on whatever geographic location) for SSM identification and monitoring confirm its potential in providing a reliable and accurate description of sea water status after extreme hydrological events. In detail, the index based on VIS data (Eq. 2) shows good sensitivity to the presence of SSM at different levels of concentration, while the one implemented on NIR data can be used only when high levels of SSM concentration are present.

References:

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