WP3
Monitoring network improvement for coastal flooding and extreme weather risk management

Activity 3.1
Satellite monitoring for coastal impacts of flooding and extreme weather

D3.1.2 Trends for total suspended sediment and their statistical significance GBSatAdria

PROJECT AND ACTIVITY DETAILS

Project Acronym	AdriaMORE
Project title	Adriatic DSS exploitation for MOnitoring and Risk management of coastal Extreme weather and flooding
Funding Line	Priority Axis 2, Specific Objective 2.2
Program website address	http://www.italy-croatia.eu
Project Partners	LP Abruzzo Region (Italy) P1 Dubrovnik and Neretva Region (Croatia) P2 Meteorological and hydrological service (Croatia) P3 National Research Council (Italy)
Starting date	January 1, 2018
Project length	18 months

Activity	3.1.
Activity Title	Satellite monitoring for coastal impacts of flooding and extreme weather
Work Package	WP3: Monitoring network improvement for coastal flooding and extreme weather risk management
Executive Summary	Activity 3.1, within Work Package 3, is dedicated to satellite observation and statistical analyses of those parameters, such as suspended terrigenous material (TSM) and chlorophyll (Chl) concentration, that may mark desirable/undesirable effects along coasts.
Main Author	Federico Falcini
Main Author's mail	federico.falcini@cnr.it
Main Author's organization	CNR
Other Author's	Iacobo Vona
Data of issues	January 31, 2019
Total Number of pages	21
Distribution list	Italy-Croatia CBC Programme, AdriaMORE partners

This document has been produced with the contribution of the EU co-financing and the Interreg Italy-Croatia CBC Programme. The contents reflects the author's views; the Programme authorities are not liable for any use that may be made of the information contained therein.

Table of contents

0. INTRODUCTION

Coastal regions are complex environments where geological, biological, and physical processes interact each other. About 50% of the European Union (EU) territory lies on shorelines, 27 member states have coastlines, nearly 50% of its citizens live within 50 km of the coast and 3.5 million EU inhabitants are directly employed in maritime activities. Despite of their importance, several coastal areas have been facing the persistent loss of land due to human interventions and/or natural causes.

Long-term sustainability of coastal regions mostly depends on the maintenance of the fragile balance between sedimentation supply from rivers and erosional processes due to the waves, surges, and currents. Coastal plumes are therefore crucial pathways that need to be monitored and analysed. Their pathways and long-term evolution is a key challenge for a thorough understanding of what drives costal geomorphology. Inferring sediment availability and dynamics along shorelines constitutes therefore the primary need for coastal changes.

2. TRENDS FOR TOTAL SUSPENDED MATTER AND THEIR COASTAL GEOMORPHOLOGY IMPACT

Long-term sustainability of coastal regions mostly depends on the maintenance of the fragile balance between sedimentation supply from rivers and sediment erosion/deposition from marine processes. Sediment-laden coastal plumes are therefore a precious and limited resource. Their pathways and long-term evolution is a key challenge for a thorough understanding of what drives costal morphodynamics. Inferring sediment availability along shorelines constitutes therefore the primary need for coastal changes.

Estimating trends for Total Suspended Matter (TSM) is therefore crucial for quantifying natural and human-made effects on coastal changes by means of remote sensing. Indeed, such an approach will allow us to diagnose sediment mass availability alongthe Adriatic Coasts, which can be envision as a “probe” to quantify the main issue that brings to coastal erosion, i.e., sediment starvation. The proposed research will help to minimize uncertainty of coastal region managements, also providing a better understanding of the coastal factors that affect trapping and dispersal of sediment.

2.1. TSM data

For our application, the water constituent we are interested in is the Total Suspended Matter (TSM), i.e. the concentration, measured in g m^{-3} (or, equivalently, in mg l^{-1}), of suspended material in the water. The TSM is characterised by both its concentration and its granulometry. Typical values for TSM concentration in coastal waters lie in the range 10-100 g m^{-3}, (D'Sa et al. 2007; Myint and Walker 2002).

Calibration of an algorithm with regional datasets always poses the question of its generality or its regionality. TSM features (particle size distribution, concentration, refractive index i.e. composition) may vary greatly from region to region and even among different seasons in the same region. The non-uniqueness of the inverse RTE solution thus implies that assumptions and/or calibrations have to be made. Generally speaking, algorithms that are calibrated for a certain region give poor results if applied unmodified to other regions, where the TSM features could be quite different. This is of course especially true for regression based algorithms, i.e. for algorithm that don't even try to model the light-matter interaction in anyway, but that simply try to map observed reflectances to geophysical variables by means of some regression. Nevertheless, attempts have been made to derive general TSM algorithm, that could work for different sensors, different regions and different seasons: see (Nechad et al. 2010) for an example. Here we use remotely sensed TSM concentration field from the ESA Coastcolour project (http://www.coastcolour.org/), remapped over the Adriatic Sea. The reason for such a choice has been the quality and the ready availability of the dataset, from 2003 to 2012. As

2.2. Methods

For TSM trend estimation we coupled the Mann-Kendall test and the Sens's method, which are here applied to a de-seasonalized monthly time series as obtained from the X-11 technique. The dataset covers the time period spanning from 2003-01-04 to 2012-04-07, with a daily temporal resolution and a spatial resolution of 300 m. Because the seasonal component can mask small movements in the trend signal, we remove the seasonal signal from Coastcolour TSM dataset before determining the trend. We use is the X-11 seasonal adjustment methodology (Shiskin, 1978; Dagum, 1980), which is similar to that described in the framework of the X-12-ARIMA seasonal adjustment program of the U.S. Census Bureau (Findley et al., 1998), and that it was already used by Pezzulli et al., (2005) to remove the seasonal signal from Sea Surface Temperature data. The full description of the Mann-Kendall test and the Sens's method, applied to the de-seasonalized dataset is provided in the Deliverable D3.1.3 "Manual on the developed GBSatAdria SW".

2.3. Results

We list below the main results of our analysis

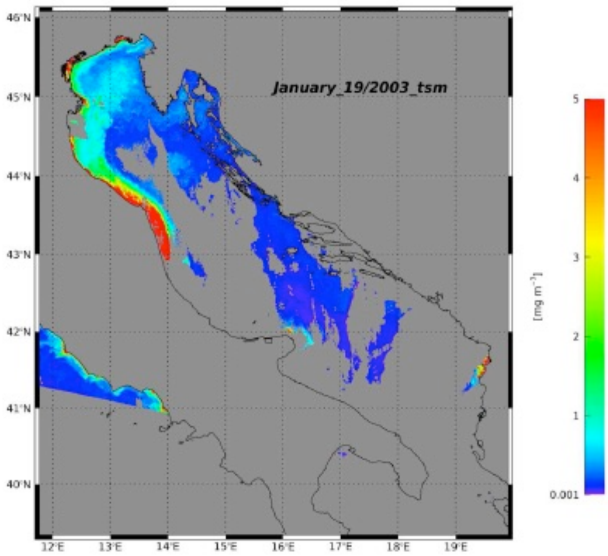

Figure 2.1. Daily TSM map over the Adriatic Sea (19 January 2003). High values of Total Suspended Matter concentration are observed off the Po River Delta and along the Central Italian coast. Daily maps a largely affected by cloud cover.

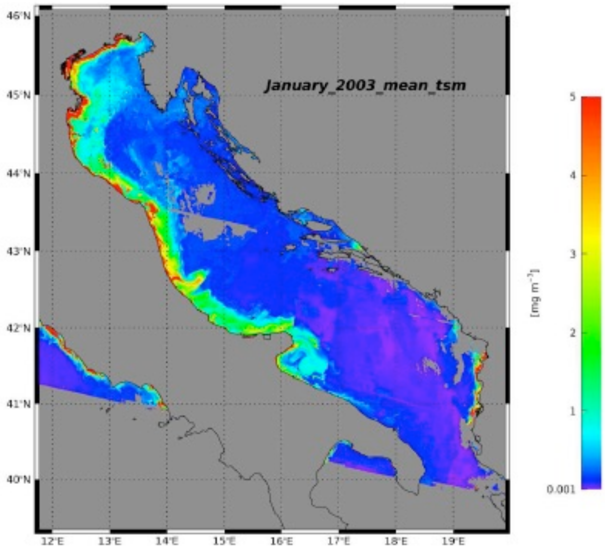

Figure 2.2. Monthly averaged TSM map over the Adriatic Sea (January 2003). The averaging process lowers the cloud cover issue, providing a better view of TSM concentration pattern in the whole Adriatic basin. However, some voids (i.e., missing values) are still present.

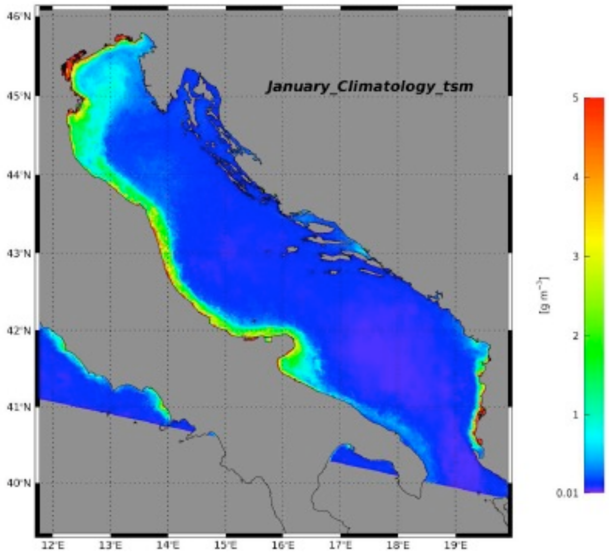

Figure 2.3. TSM concentration map for the climatologic January. Missing pixels, still present in the monthly averaged maps (see Fig. 2.2), are here filled by using climatologic months (e.g., the average value of all Januaries, from 2003 to 2012). This technique will produce L4 monthly maps.

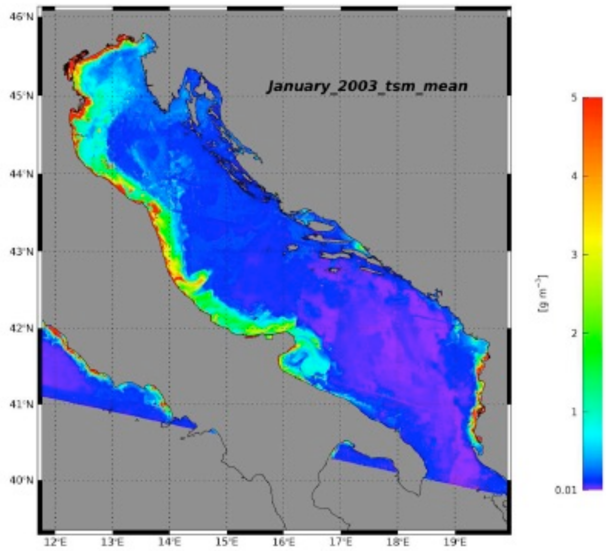

Figure 2.4. L4 monthly map of TSM concentration for January 2003, with no missing values. This L4 product can be used to evaluate statistical trends.

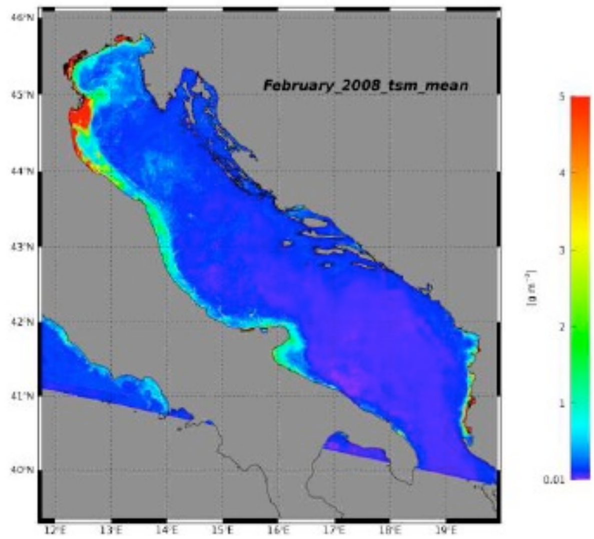

Figure 2.5. L4 monthly map of TSM concentration for February 2008, with no missing values. This L4 product highlights the high values of TSM concentration off the Po River Delta due to sediment input of the river runoff, which is crucial for coastal geomorphological maintenance.

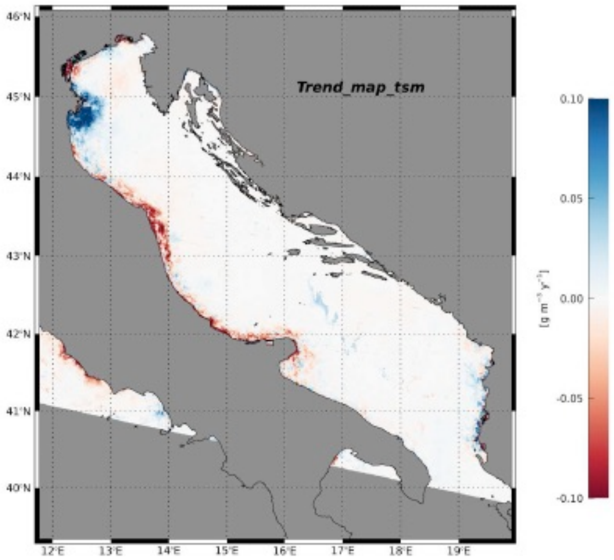

Figure 2.6. Statistical trend for TSM concentration over the period 2003-2012. We observe a general positive trend off the Po River Delta, due to sediment input of the river runoff, which confirms the coastal geomorphological maintenance in this particular area. However, the North and Central portion of the Italian coats is marked by a negative trend, which indicates sediment starvation and, I turn, may relate to coastal erosion at large spatial and temporal scale.

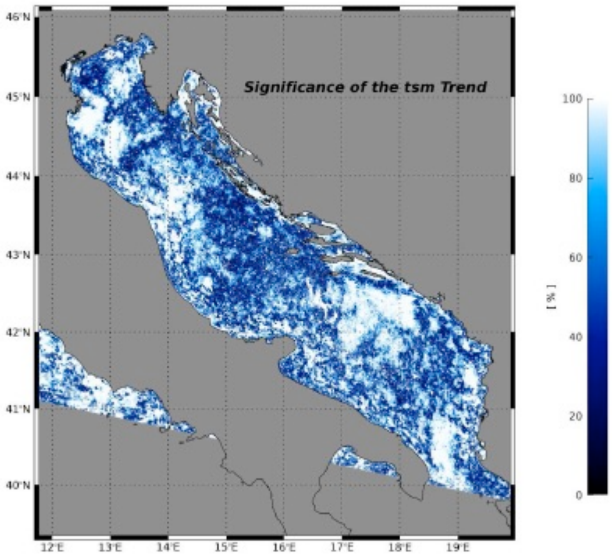

Figure 2.7. Statistical significance of the TSM trend. White pixels mark significant values of Chl concentration trend (Fig. 2.6). We note that the majority of coastal pixels are statistically significant.

2. REFERENCES

Aziz OIA, and Burn DH. (2006). Trends and variability in the hydrological regime of the Mackenzie River Basin. Journal of Hydrology 319 (1–4): 282–294.

Barale, V., Jaquet, J.-M., Ndiaye, M (2008). Algal blooming patterns and anomalies in the Mediterranean Sea as derived from the SeaWiFS data set (1998–2003). Remote Sens. Environ 112, 3300–3313.

Behrenfeld, M.J., O'Malley, R.T., Siegel, D.A., McClain, C.R., Sarmiento, J.L., Feldman, G.C., Milligan, A.J., Falkowski, P.G., Letelier, R.M., Boss, E.S., (2006). Climate driven trends in contemporary ocean productivity. Nature 444, 752–755.

Boyce D.G., Lewis M.R., Worm B. (2010). Global phytoplankton decline over the past century. Nature 466:591–96.

Bulut, H., Yesilata, B., Yesilnacar, M. I. (2008). Trend Analysis for Examining the Interaction between the Atatürk Dam Lake and Its Local Climate. IJNES 1(3), 115-123.

Colella, S., Falcini, F., Rinaldi, E., Sammartino, M., & Santoleri, R. (2016). Mediterranean ocean colour chlorophyll trends. PloS one, 11(6), e0155756.

Dagum, E. B., 1980. The X-11-ARIMA Seasonal Adjustment Method. Number 12–564E. Statistics Canada, Ottawa.

European Environment Agency, EEA (2005) Source apportionment of nitrogen and phosphorus inputs into the aquatic environment. EEA Report no. 7/2005, 48 pp.

Findley, D.F., Monsell, B.C., Bell, W.R., Otto, M.C., Chen, B., (1998). New Capabilities and Methods of the X-1 2-ARIMA Seasonal-Adjustment Program. J. Bus. Econ. Stat. 16, 127–152.

Gasith, A., Resh, V. H. (1999). Streams in Mediterranean climate regions: abiotic influences and biotic responses to predictable seasonal events. Annu Rev Ecol Syst, 51-81.

Gregg, W. W., Casey, N. W., & McClain, C. R. (2005). Recent trends in global ocean chlorophyll. Geophysical Research Letters, 32(3).

Kendall, M. G., Rank Correlation Methods, Oxford Univ. Press, New York, 1975.

Mann, H. B., Nonparametric tests against trend, Econometrica, 13, 245–259, 1945.

Nixon S.W. (1995). Coastal marine eutrophication: a definition, social causes, and future concerns. Ophelia, 41, pp. 199–219.

Pezzulli, S., Stephenson, D., Hannachi, A., (2005). The variability of seasonality. J. Clim. 71–88.

Roemmich, D. & McGowan, J. (1995). Climatic warming and the decline of zooplankton in the California current. Science 267, 1324–1326.

Sabine C.L., Feely R.A., Gruber N., Key R.M., Lee K., Bullister J.L. et al., (2004). The oceanic sink for anthropogenic CO2.Science, 305, 367–371.

Sen, P. K., Estimates of the regression coefficient based on Kendall's tau, J. Am. Stat. Assoc., 63, 1379–1389, 1968.

Shiskin, J., (1978): Seasonal adjustment of sensitive indicators. Sea- sonal Analysis of Economic Time Series, A. Zellner, Ed., U.S. Department of Commerce, Bureau of the Census, 97–103.

Yue, S., Pilon, P., Cavadias, G., (2002). Power of the Mann–Kendall and Spearman's rho tests for detecting monotonic trends in hydrological series. J. Hydrol. 259, 254–271.