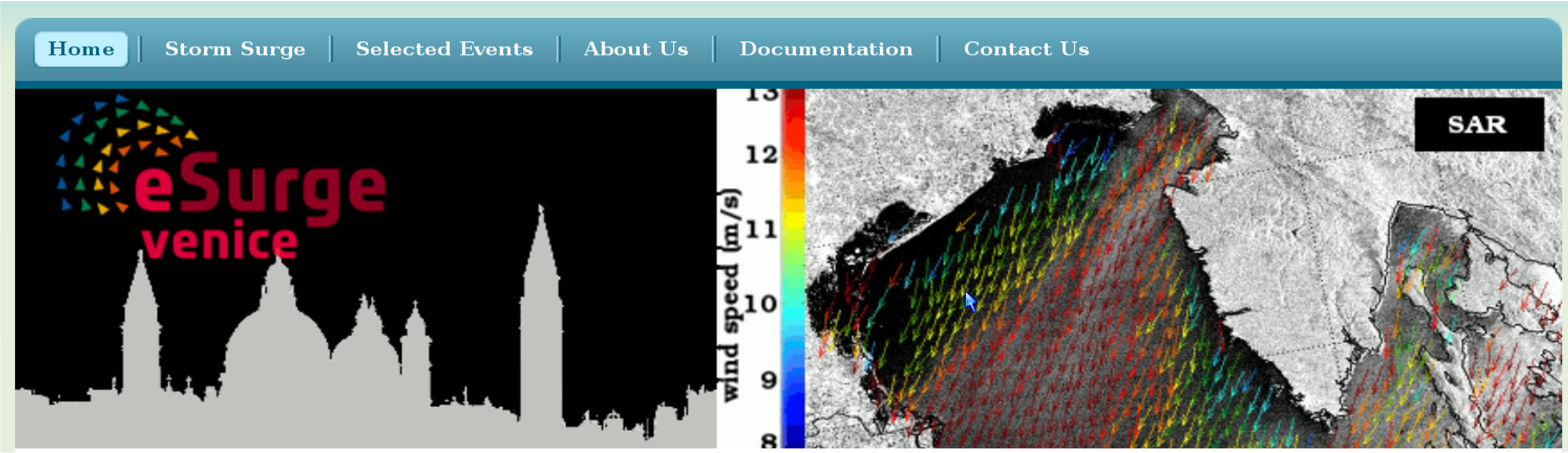
The ESA's DUE project eSurge-Venice: how scatterometer data can improve the storm surge forecasting in the Gulf of Venice

S. Zecchetto[1], F. De Biasio[1], A. della Valle[1], G. Umgiesser[2], M. Bajo[2], S. Vignudelli[3], A. Papa[4], C. Donlon[5]

1 Istituto di Scienze dell'Atmosfera e del Clima (ISAC), Consiglio Nazionale delle Ricerche, Padova, Italy (s.zecchetto@isac.cnr.it)
2 Istituto di Scienze del Mare (ISMAR), Consiglio Nazionale delle Ricerche, Venezia,Italy - 3 Istituto di Biofisica (IBF), Consiglio Nazionale delle Ricerche, Pisa,Italy
4 Istituzione Centro Previsioni e Segnalazioni Maree, Comune di Venezia, Venezia, Italy - 5 European Space Agency (ESA), ESTEC, Noordwijk, The Netherlands



The ESA's DUE project eSurge-Venice:** the figure above is the header of the **eSurge-Venice** project (ESA Storm Surge for Venice) web-site, funded by the European Space Agency's (ESA) DUE programme. The project aims to increase the use of satellite data within the storm surge community. The menu bar on the top gives direct access to the web-site sections**:** the **Storm Surge** section outlines the characteristics of the surges in the Adriatic Sea, while the section **Selected Events** describes the events selected in the project, providing the sea level and the wind speed from several different sources: in-situ, satellite and model. Web-site: **http://www.esurge-venice.eu

INTRODUCTION: The **eSurge-Venice project** (**http://www.esurge-venice.eu**) runs along with the more general **eSurge** ESA DUE project (**http://www.storm-surge.info**), focusing specifically on the northern Adriatic Sea (see Figure 1). One of the objectives is to re-analyse storm surge cases using Earth Observation (EO) data. Among the forces driving the surge in the Adriatic Sea, which is essentially a coastal sea (~900 km x 200 km), the surface wind is the most important. The steep orography surrounding the coasts shapes the wind, limiting sometimes the performance of Numerical Weather Prediction (NWP) models in the simulation of the wind flow. The characteristics of the biases between NWP and scatterometer winds have been studied [***1,2***], suggesting to use scatterometer data to adapt the NWP wind fields forcing the storm surge models.

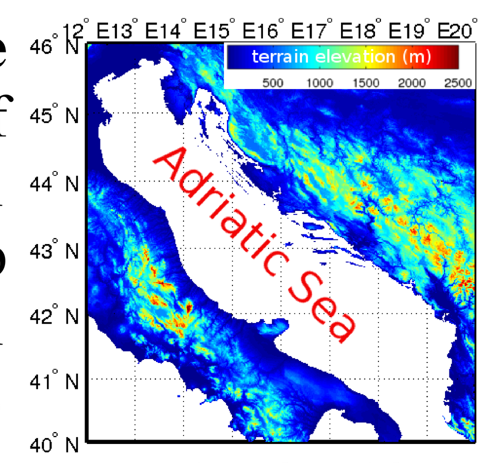


Figure 1: The Adriatic Sea basin.

NWP WIND TUNING METHODOLOGY: Scatterometers have low temporal coverage (1,5 datum/day maximum in the Adriatic Sea) and irregular revisitation time, preventing the direct use of scatterometer wind as forcing into storm surge models. Nevertheless, it is possible to extract information on the NWP model wind biases. We used these information to tune the NWP wind fields forcing the SHYFEM storm surge model (https://sites.google.com/site/shyfem/home). The process is described below.

1) The mean scatt-model wind speed relative bias Δws and direction $\Delta\theta$ bias, i.e.

$$\Delta ws(i,j) = < \frac{ws(i,j)_{scatt} - ws(i,j)_{model}}{ws(i,j)_{scatt}} > \qquad \Delta\theta(i,j) = < \theta(i,j)_{scatt} - \theta(i,j)_{model} >$$

are computed over a 3-day window before the day of forecast. (i,j) identify the geographical grid node; <...> indicates time averaging on the same grid node (Figure 2 shows a graphical representation of the two biases.);

2) The two biases are used to modify the NWP forecast wind field the day after the 3-day window, according to the following formulae:

$$ws(i,j)^{corr}_{model} = ws(i,j)_{model} \cdot \left(1 + \Delta ws(i,j)\right) \qquad \theta(i,j)^{corr}_{model} = \theta(i,j)_{model} + \Delta\theta(i,j)$$

3) The storm surge model is run with the modified NWP field as forcing. The process is repeated day by day, shifting the 3-day window ahead.

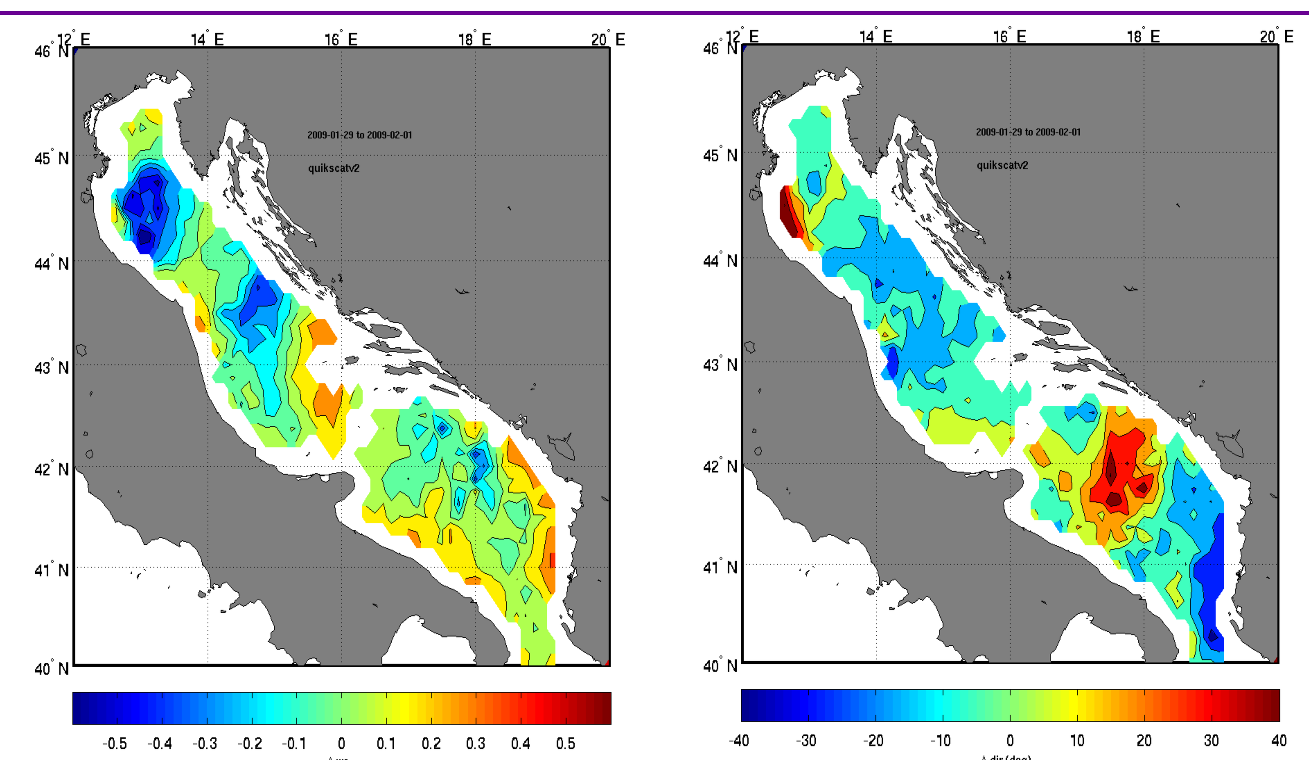


Figure 2: Graphical representation of the mean wind speed relative bias (left) and wind direction bias (right) between ECMWF wind forecast and scatterometer observations during 3 day before the surge event of 02/02/2009 23:00 GMT, which reached a total level of 120 cm a.s.l., and a surge of 70 cm. Zones of negative and positive bias are visible for both wind speed and direction: these negative and positive zones vary with time (not shown). The wind speed relative bias reaches ±50%, while the wind direction bias ranges between ±40°.

The sensitivity of the surge model has also been tested against the NWP grid spacing.

RESULTS: Figure 3 shows the correlation, the RMSE and the peak error between the observed and modeled surge for 12 storm surge events [***3***]. All these statistical parameters are improved by the NWP wind modified with the methodology depicted above:

- the peak error (obs-mod surge difference on the maximum peak) drops to 6 cm from 10 cm;
- the RMSE between observed and modeled surge decreases by 8%;
- the correlation between observed and modeled surge rises by 1%;
- no dependence of the modeled surge on the wind grid spacing in the range 50 km – 16 km.

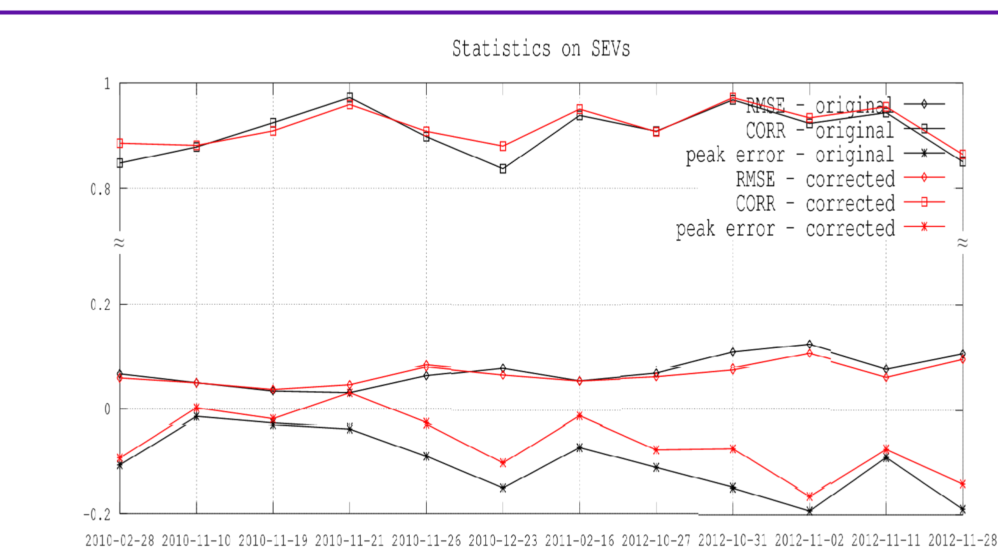


Figure 3: Correlation, RMSE and peak error between the observed and modeled surge for 12 storm surge events. Black: unmodified NWP wind. Red: NWP wind modified with the methodology described above. With the modified wind the peak error is always better. correlation and RMSE show very little differences, an overall small improvement but alternate results in some of the 12 cases.

CONCLUSIONS: These encouraging results are however preliminary. Several issues have still to be examined in depth: among others, the width of the time window used to evaluate the wind speed and direction biases, and the optimal form of the factor (1+Δws) used to modify the NWP wind speed. They will be the object of forthcoming studies.

1) S. Zecchetto and C. Accadia (2014), Diagnostics of T1279 ECMWF analysis winds in the Mediterranean basin by comparison with ASCAT 12.5 km winds, Q.J.R. Meteorol. Soc.. doi: 10.1002/qj.2315.
2) F. De Biasio, M. M. Miglietta, S. Zecchetto, and A. della Valle (2014), Numerical models sea surface wind compared to scatterometer observations for a single Bora event in the Adriatic Sea, Adv. Sci. Res., 11, 41–48, doi:10.5194/asr-11-41-2014.
3) G. Umgiesser, M. Bajo, S. Zecchetto, F. De Biasio, and D. Bellafiore, (2014), Use of Satellite data to improve the storm surge forecast in Venice, Geophysical Research Abstracts, Vol. 16, doi: EGU2014-7315-1, 2014.