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eSurge-Venice: eSurge-Venice User Manual

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Acronyms and abbreviations

AAPTF  Aqua Alta Platform
AMI    Aeronautica Militare Italiana
AOI    Area Of Interest
ASCAT  Advanced SCATerometer
AVIS0  Archivage, Validation et Interprétation des données des Satellites Océanographiques
CNES   Centre National d’Études Spatiales
CNR    National Research Council of Italy
CNRS   Centre National de la Recherche Scientifique of France
COASTALT  ESA development of COASTal ALTimetry
CTOH   Centre de Topographie des Océans et de l’Hydrosphère
DT     Delayed Time
ESA    European Space Agency
ECMWF  European Centre for Medium-Range Weather Forecasting
eSV    Esa-storm Surge project for Venice
FDMAR  Fast Delivery Marine Abridged Record
FPDS   Full Processed Data Set
GDR    Geophysical Data Record
GFO-2  Geosat Follow-On
HY-2B  HaiYang satellite mission
IBF-CNR Istituto di Biofisica, National Research Council of Italy
ICPSM-VE Istituzione Centro Previsioni e Segnalazioni Maree, VEnice municipality
IRB    Geophysical Department of Faculty of Science, University of Zagreb, Croatia
ISAC-CNR Istituto di Scienze dell’Atmosfera e del Clima, National Research Council of Italy
ISMAR-CNR Istituto di Scienze Marine, National Research Council of Italy
ISPRRA Institute for Environmental Protection and Research
LAM    Limited area Atmospheric Model
MBSS   National Institute of Biology of Slovenia
MFC    Modelling and Forecasting centre
MSL    Mean Sea Level
MSS    Mean Sea Surface
NASA   National Aeronautics and Space Administration
NetCDF Network Common Data Form
NetCDF-CF Network Common Data Form Climate and Forecast compliant
NOP    Numerical Ocean Prediction
NRT    Near Real Time
NWP    Numerical Weather Prediction
OCEANSAT Indian Remote Sensing satellite for ocean research
OPeNDAP Open-source Project for a Network Data Access Protocol
OSI SAF Ocean and Sea Ice Scatterometer Application Facility
PISTACH CNES Development of “Prototype Innovant de Système de Traitement pour les Applications Côtières et l’Hydrologie”
PO.DAAC Physical Oceanography Distributed Active Archive Centre
QuikSCAT Quick SCATterometer
RADS   Radar Altimeter Database System
Applicable documents
[SOW]: EOP/SM2135 ESA-StormSurgeProject-SoW-ver-2-rev-1-final.doc, 21 October 2010;
ITT AO/1-6594/10/I-LG and ESA-eSurge-Venice-SoW-ver-2-rev-0-final, September 2011;
[PMP]: Project Management Plan, 2 November 2011;
[RB]: eSV Requirement Baseline Document v.2.0, 25 June 2012;
[DARD]: eSV Data Access and Requirements Document v.1.0, 25 June 2012;

Documents Contributions and Responsibility

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1 Introduction

1.1 Purpose and Scope

This document is an user manual describing the eSV system provided by the eSurge-Venice project, funded by ESA. Its purpose is to help the user and to give him information and processing scripts to use the eSV products. Most of the products prepared by the eSurge-Venice project will be made available through the services developed by the eSurge project. This is an ESA DUE program that is being developed in parallel to eSV, but having a larger scope than eSV.

The access to the eSV products will be assured by the eSurge SEARS data service in the framework of the eSurge project through the interface available at http://www.storm-surge.info/data-access. The user is referred to the eSurge project for further information on the use of the SEARS data service.

1.2 Document Structure

The document is structured as follows:

- Section 1 Introduction, the present section;
- Section 2 Physical description of the SEV events and of their forecasting;
- Section 3 Description of the dataset structure and information useful to access it;
- Section 4 Description of the eSurge-Venice web portal.

2 Description of the SEV events

The Storm Surge Events (SEVs) described in this document are those provided by the Test Data Set (TDS). The TDS is a preliminary collection of 15 SEVs among those that will be available to the users of the eSV project in its second phase.

For each SEV a description of the phenomenology is given first, based on meteorological considerations and on the sea level observations. Then, some considerations about the accuracy of the one-day storm surge forecast are made.

2.1 SEV 2004-10-31

Phenomenological description

In October 2004 the mean sea level was higher than in the period from September to December 2004, because of the synoptic weather configuration that favoured the sirocco wind especially in the southern Adriatic, causing an accumulation of water in the north part of the sea. In the days before the SEV occurrence (T -72 h to -8 h), the surge was around 30 cm, supported by the persistence of the sirocco in the southern Adriatic and from the bora wind from the north-east. The sudden strengthening of the bora wind at T=-38 h (bottom Figure 1), led to a surge of 60 cm. Being in phase with the astronomical value, the total level registered in Venice was about 125 cm. The rapid passage of the low pressure
system across the central Adriatic favoured the onset of seiche. Monthly mean sea level = 38 cm.

**Storm surge forecast**

The main surge peak is well predicted, but with a big error in the current MSL. The seiches following the event are underestimated (top Figure 1).
Figure 1: Storm surge event that took place October 31, 2004. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTF (yellow symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.2 SEV 2004-11-10

Phenomenological description

This SEV shows the delicate balance between tide and atmosphere in the marine region of Venice. For the persisting weather conditions in October and November, the average sea level was higher than normal. Although currently there is not clear evidence, it seems that the seiche, generated in the previous days (see SEV 2004-10-31), was not completely damped but perhaps fuelled by the low-pressure centre transited between 2004-11-07 and 2004-11-08 and by the resulting pulse of bora wind. The Adriatic sirocco was recorded in AAPTF up to 22 m/s, while according the scatterometer it was around 15 m/s (see bottom Figure 2). The wind increase at T=-6 cannot be responsible of the water level raising of about 55 cm, since too close to the event. However the maximum surge fell in phase with the highest astronomical tide, albeit not so elevated, causing then a significant flood event with a 125 cm tide level. Monthly average sea level = 35 cm.

Storm surge forecast

The forecast well matches the observed data. Although the top of the modelled surge peak was forecast some hours later, the absolute value was near the observed one (top Figure 2).
Figure 2: Storm surge event that took place November 10, 2004. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTFT (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.3 SEV 2004-12-26

Phenomenological description

The event is characterised by an increase of the surge from a value close to 10 cm up to 70 cm in 7 hours, starting 16 hours after the event, due to the "scontraura" effect (SE sirocco wind in the southern Adriatic Sea and NE bora wind in the northernmost part of the Adriatic Sea).

For the whole April 25 a strong sirocco wind blew in the southern part and a strong bora wind blew in the northern part of the Adriatic Sea (bottom Figure 3), favouring the accumulation of water to the Venice coast and raising the surge of about 20 cm. The day after the wind continued to blow, accumulating water that summed up to the daily maximum of the astronomic tide, causing flooding. The wind then turned to south in the Gulf of Venice, increasing the surge to about 70 cm. The seiche was also present for the following five days. Monthly average sea level = 29 cm.

Storm surge forecast

This storm surge event has two main peaks, one on December 26 and the second on 27th. The second peak is strongly determined by the 22 hours seiche following the first storm surge (top Figure 3). Both peaks are well predicted in time, the first was overestimated, while the second underestimated, but only of a few centimetres.
Figure 3: Storm surge event that took place December 26, 2004. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPT (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.4 SEV 2005-12-03

Phenomenological description

The event is marked by a sharp rise of the surge, from about 10 cm to 60 cm in 30 hours. From $T = -24$ h there was sirocco wind on the whole Adriatic Sea, while in AAPTF bora was recorded initially with modest speed, then increasing to exceed 10m/s at $T = -12$h. From $T = -6$ h the sirocco was recorded also at AAPTF, with speed exceeding 15m/s (bottom Figure 4). The bora at AAPTF caused an accumulation of water in the region, and the subsequent 6 hours of intense sirocco over the whole Adriatic Sea were sufficient to create a major surge in the Lagoon. The sirocco is in fact roughly aligned with the widest inlet of the Venice Lagoon, and it pushes, therefore, straight into the lagoon the tidal and surge waves. The surge was in phase with the astronomical tides, so the total level registered was 115 cm. The last 3 days of the SEV were characterised by the presence of seiche, in phase with the astronomic tides 48, 93 and 114 hours after the event. Monthly average sea level = 30 cm.

Storm surge forecast

This event was very well predicted with errors lower than 10 cm. Forecasts are also accurate in time, presenting no phase shifts (top Figure 4).
Figure 4: Storm surge event that took place December 03, 2005. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTF (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.5 SEV 2008-12-01

Phenomenological description

The rapid passage of the front of perturbation on Nov. 27 and Nov. 28 brought sirocco wind over the lower Adriatic and bora wind on the Gulf of Venice (at the AAPTF, at time $T = -40h$, the registered wind speed was higher than 18m/s), and led to a significant rise in mean sea level. Past the front of the perturbation, the level seemed to depend only by the seiche. But the persistence of meteorological conditions favourable to south-easterlies brought a constant sirocco wind in the central and southern Adriatic since $T=-48h$, while in the Gulf of Venice there were alternatively sirocco and bora winds (bottom Figure 5). From $T = -6h$ also in the north there was sirocco with average speed of about 15m/s and gusts over 20 m/s. On 1 December, the surge was almost 100 cm, bringing the level of the sea among the highest values of the history of Venice (156 cm). The event brought enormous damage to the city. In the time window of the SEV, the threshold of 110cm has been exceeded 5 times ($T=0h$, $T=15h$, $T=39h$, $T=51h$, $T=99h$, in top Figure 5). Monthly average sea level = 41 cm.

Storm surge forecast

This is the highest flood event happened in the last decade in Venice. Observations show that the tidal and the storm surge peaks overlap, moreover there is a strong contribution from seiches triggered by a storm surge event three days before. Looking at the Figure 5, most of the model error seems due to a bad MSL. This error is usually corrected in the final ICPSM forecast.
Figure 5: Storm surge event that took place December 01, 2008. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTFT (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.6 SEV 2008-12-10

Phenomenological description
The day before the event the magnitude of the surge level was low (~10 cm), rising rapidly to 40 cm at the event time and then to 80 cm 12 hours later. The event also features the permanence of a high surge for the following three days and the triggering of the seiche. According to the wind diagram reported below, the sirocco wind blew over 10 m/s 18 hours after the event, turning to bora only in the northernmost part of the Adriatic Sea afterwards, yet blowing from SE almost everywhere (bottom Figure 6), thus keeping high the water level on the Venice Lagoon until 48 hours after the event. For the next few days the seiches continued to sweep the Adriatic Sea, as reported in the plot of the surge (top Figure 6). Monthly average sea level = 41 cm.

Storm surge forecast
In this case the surge was not in phase with tide. Two distinct storm surge peaks were detected on December 10 and 11. The second one influenced by the seiches of the first one. The model performance was good in the prediction of the second peak, while the first peak was underestimated (top Figure 6).
Figure 6: Storm surge event that took place December 10, 2008. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTIF (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.7 SEV 2009-02-02

Phenomenological description

The SEV presents a 70cm surge and a tide level of about 120cm. The event was generated from the push of the sirocco wind in southern and central Adriatic caused by a low over the Gulf of Lions (induced by a low over the Bay of Biscay) on January 31, and a low over the Balearic Islands in the period February 2 to 3 induced by the passage of a low over the Iberian Peninsula. This brought strong sirocco wind (10 to 15 m/s) from the Strait of Otranto up to the Istria peninsula, while at AAPTF in the upper Adriatic, the bora was recorded with speed below 10 m/s from T=-48h until T=-24h, and with speed of about 11 m/s and gust of about 14m/s afterwards (bottom Figure 7). The event is characterised by the severe underestimate of the forecast wind at AAPTF. The perturbations passing over the area raised the average monthly sea level to values substantially higher than in other months. For example, in January and March the monthly average was about 30 cm. Monthly average sea level = 39 cm.

Storm surge forecast

The storm surge at the AAPTF reached a maximum around midnight on February 2 and a second higher level was reached about 24 hour later. Both these even were totally underestimated (top Figure 7), due to a bad wind forcing.
Figure 7: Storm surge event that took place February 02, 2009. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPT (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.8 SEV 2009-03-29

Phenomenological description

This SEV has a peculiarity: in the region of Venice there were no significant meteorological events, and it was produced by the constant sirocco wind in middle-south Adriatic sea (bottom Figure 8).

In AAPTF the pressure dropped by only 10hPa in 20 hours; the wind direction there was constant from ESE, and the wind speed was very weak: less than 5 m/s up to T=-36h and, on average, between 6-7 m/s up to T = 0h. It may be seen, however, that in the rest of the Adriatic sea the sirocco was homogeneous from T=-54h, with speed between 10 and 20 m/s. These conditions led the surge in AAPTF to 80 cm (this means that the level rose of about 60 cm in 12 hours). The maximum occurred out of phase to the astronomical tide, so the tide level was only 115 cm (top Figure 8). If the maximum had been in phase with the astronomical tide, the water level would have reached values close to or greater than 150 cm. Monthly average sea level = 31 cm.

Storm surge forecast

This event was totally missed, due to a bad meteorological forcing (top Figure 8).
Figure 8: Storm surge event that took place March 29, 2009. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTFF (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and QuikSCAT wind (blue symbols) are shown.
2.9 **SEV 2009-11-30**

**Phenomenological description**

The event was very rapid, despite the low wind and surge level up to 15 h before the event. On 29 December, the low pressure centre in the Gulf of Biscay generates a cyclonic circulation in the Mediterranean sea, triggering the sirocco on the whole eastern Adriatic Sea with speeds ranging from 16 to 18 m/s along the Croatian coast, in agreement with the data recorded at AAPT (bottom Figure 9). The pressure at AAPT decreased from 1017hPa to 995hPa, from T=-18h to T=+6h. The surge grew up to about 60 cm in 24 hours, and the maximum was almost in phase with the astronomical tide. The total level recorded was 131 cm (top Figure 9). Monthly average sea level = 38 cm.

**Storm surge forecast**

The model performed rather well in all the forecasts, with errors lower than 10 cm at the AAPT, in the main peak. The second peak, happened about 24 hours later, was a bit underestimated in the short forecast (top Figure 9).
Figure 9: Storm surge event that took place November 30, 2009. The top panel shows the observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPT (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and ASCAT wind (blue symbols) are shown.
2.10 SEV 2009-12-22

Phenomenological description

The days before (from December 16 to 18) there was bora wind with speed of 12 to 15 m/s. On day 19, the quick passage of a low pressure centre, with a pressure drop of 15hPa in 12 hours, down to 993hPa, caused a reinforce of the bora wind (>10 m/s) at AAPTFT and in the Gulf of Venice, from T=-76h up to T=-60h (bottom Figure 10). The combined effects of pressure and wind accumulated water in the region, raising the average level of the sea and creating a phenomenon of seiche of about 30cm (and total surge over 60 cm). Since 50 hours before the event, the wind was negligible in the north Adriatic Sea, and the pressure rose to 1016hPa. But from 14 hours before the event until 4 hours after, the pressure decreased by 12 hPa. From T=+16h the atmospheric pressure started again to descend by about 15hPa, down to 990hPa at T = +26h (bottom Figure 10).

From T=-12h until T=+72h throughout the central and southern Adriatic began to blow sirocco wind, with speeds greater than 10m/s (unless in central-northern). But in AAPTFT was recorded bora wind with speed between 10 and 15m/s from T=-12h until T=+6h, thereafter until T=+72h the direction was discontinuous. Due to favourable weather conditions the seiche increased, reaching values greater than 40cm from day 23 to 25 (top Figure 10). The mix of contributions due to meteorological factors, seiches and astronomical tide drove the total sea level maximum values with phase differences of about 1-2 hours maximum for 4 consecutive days: the day 22 the maximum was 111 cm with a surge of about 70 cm. The day 23 the tide level was 144 cm, with a surge of about 100 cm. The day 24 the total level was 133 cm, with a surge of about 80. The day 25 the level rose up to 145 cm, due to a surge of about 90 cm. In the time window of the SEV, the threshold of 110cm had exceeded 4 times (T=-65h, T=0h, T=26h, T=50h, T=72h). Monthly average sea level = 50 cm.

Storm surge forecast

This event is characterised by its persistence, and by the strong influence of the seiches. The model well reproduce the surge oscillations (top Figure 10), but fails to reproduce the mean sea level, which, during this event, was particularly high.
Figure 10: Storm surge event that took place December 22, 2009. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTTF (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and ASCAT wind (blue symbols) are shown.
2.11 SEV 2010-01-07

Phenomenological description

This event is special because at T = 0h both the astronomic tide and the surge were not particularly high: about 60 cm each, but they were in phase, and the effect on the city was important with a total level of 120 cm. The pressure dropped gradually from 1020 hPa at T=-72h down to less than 996 hPa at T=-18h, and then began to rise again very slowly. The wind did not play an important role (bottom Figure 11), and the meteorological conditions of the previous days triggered a seiche of only about 10 cm. The high level of the water was due to the fact that the surge generated by the pressure drop, the seiche and the astronomical tide were almost in phase, rising the sea level up to 120 cm. Monthly average sea level = 44 cm.

Storm surge forecast

The mean sea level was not reproduced. Consequently, the maximum surge was a bit underestimated, but well reproduced in time (top Figure 11).
Figure 11: Storm surge event that took place January 07, 2010. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTFT (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and ASCAT wind (blue symbols) are shown.
2.12 SEV 2010-02-19

Phenomenological description

The SEV is interesting for the persistence of the high surge (greater than about 58-60 cm) for nearly 21 hours from T=-15h to T=+6h, and because the meteorological models have greatly underestimated the wind speed in the Adriatic sea. From T =-21h to T = -2h the atmospheric pressure decreased from 1006hPa to 985hPa. From T = -72h to T = -48h the bora wind blew around AAPTF, and partly also in the northern Adriatic Sea. Since T = -48h, over the Adriatic sea there was sirocco with increasing speed between 10 and 15m/s (bottom Figure 12). In AAPTF instead, from T = -24h to T = -10h, there was bora but from T =-10h the wind changed to sirocco with speed up to 16m/s. The first maximum of the surge (more than 80 cm) was not in phase with the astronomical tide, while the second (slightly lower) surge maximum was nearly in phase with the astronomical tide, raising the level into the city up to 120 cm. A 30-40 cm seiche wave was detected in the following days. Monthly average sea level = 48 cm.

Storm surge forecast

Due to a bad MSL the maximum surge was underestimated (top Figure 12) with rather big error, but the surge peak shape was well reproduced.
Figure 12: Storm surge event that took place February 19, 2010. The top panel shows the observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTTF (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and ASCAT wind (blue symbols) are shown.


2.13 SEV 2010-11-21

Phenomenological description

In the days preceding the event, a drop in atmospheric pressure and some episodes of bora wind established a seiche, contained in amplitude, with a growth of the mean sea level in the region. On day 21 the passage of a low-pressure centre lowered the air pressure from 1018 hPa at 11:00 to 998 hPa at 23:30. Throughout the day the sirocco was blowing in the south and central Adriatic, while in the north, following the passage of a low-pressure centre, the wind cycled between bora, sirocco and then bora again, with speed of more than 11 m/s (bottom Figure 13). In the evening the maximum of the surge was in phase with the astronomical tide, rising the level into the city up to 120 cm. The pressure then remained stationary for several days, thus favouring the settling of a high mean sea level and a small seiche. The seiche, however, was no longer in phase with the astronomical tide until the 25 and 26, when it caused two episodes over 110 cm. Monthly average sea level = 53 cm.

Storm surge forecast

This event presents several seiche oscillations the day after the main peak. This was underestimated of about 20 cm due to the MSL error (top Figure 13). The seiches were correctly reproduced in time, but underestimated.
Figure 13: Storm surge event that took place November 21, 2010. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTFF (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and ASCAT wind (blue symbols) are shown.
2.14 SEV 2010-12-01

Phenomenological description

During the month of November 2010 there have been several meteorological event that favoured the high water in Venice. The mean sea level was lower than November, but still of about 46 cm. The passage of a rapid depression on the central Adriatic Sea with pressure values equal to about 995hPa on November 28 triggered a seiche of approximately 20cm at 21:15. The seiche lasted until the event. The depressions on day 30 over the Balearic Islands, and the day after over the Gulf of lions, kept the cyclonic circulation over the Mediterranean basin, feeding the sirocco on the Southern Adriatic Sea.

The instability on central Europe, however, favoured the conditions of strong turbulence in the northern Adriatic, which partially dampened the contribution of the wind (bottom Figure 14). The maximum sea level registered was 110 cm, with a surge value (not in phase with the astronomical tide but delayed of about 6 hours on the maximum tide) of about 65 cm. The first maximum surge after T=0h was at T=8h; these conditions have triggered a evident seiche with a period of 21:15h. Monthly average sea level = 46 cm.

Storm surge forecast

The magnitude of the main storm surge peak was predicted, but not the MSL. (top Figure 14). Moreover, the AAPTF sea level observations did not arrive in time, so that it was not possible to execute the neural network post-processing routine and the MSL correction.
Figure 14: Storm surge event that took place December 01, 2010. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPTFSF (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and ASCAT wind (blue symbols) are shown.
2.15 SEV 2010-12-23

Phenomenological description

This event is interesting for two reasons. The first is the pressure drop from 1008 hPa at T=-9h to less than 989 hPa at T=15h. The second is the persistence of the surge level for about 30 h, from T=-3h until T=+27h. Although not very high (between 60 and 70 cm) the surge remained unchanged for 30 hours, rising the total level over 110 cm for 4 times, of which one to almost 135 cm at AAPTF and 144 cm in town because of the bora wind blowing from T=-6h until T=+15h in the northern Adriatic Sea (bottom Figure 15). Monthly average sea level = 46 cm.

Storm surge forecast

The surge peak was well reproduced (top Figure 15), even if there was a bias due to the high mean sea level that was not reproduced correctly.
Figure 15: Storm surge event that took place December 23, 2010. The top panel shows the Observed SSL (red line), the forecast (blue line), their difference (green line), and the time and level corresponding to the begin of the event. Bottom panel shows, in two sub-panels, the wind speed and direction of the observed wind in AAPT (orange symbols). In the same plots, the corresponding ECMWF forecast wind (red symbols) and ASCAT wind (blue symbols) are shown.
3 Database description and access

The data selected by the eSurge-Venice project will be offered to the users through the SEARS database being developed by the eSurge project.

For each SEV the following data are available:

1. eSV Satellite products: these are altimeter data, selected to cover the considered SEVs.
2. eSV In Situ products: these are data recorded from local stations. At the moment they include sea level measurements from several tide gauges near Venice.
3. NWP Model Products: these products are wind data from satellite scatterometers.
4. eSV Model Output: These are storm surge forecasts executed by the hydrodynamic model SHYFEM, in the configuration running operationally at the ICPSM Centre. For each SEV four forecasts of the preceding days are provided.

General information about the data, the nomenclature and the format of the files containing these data are described in the following sections. Furthermore, the software to read them is also provided.

3.1 Satellite wind, SST and NWP quantities

While the scatterometer wind data are freely distributable and are thus inserted directly inside the NetCDF files produced by ISAC-CNR, wind data from ECMWF are restricted. To bypass this obstacle ISAC-CNR distributes physical quantities derived from ECMWF data and other sources, namely the surface wind stress, the air density and the drag coefficient, but not the original wind data.

For the scatterometer data the available products are the neutral wind and the "adjusted" wind, i.e. the scatterometer wind estimated in real stability conditions.

The wind stress, the adjusted (real) wind and the other parameters given in the ISAC-CNR dataset are calculated using the dry and wet temperature of the air and the surface air pressure (from ECMWF), the sea surface temperature (SST from MODIS and/or GHRSST, see below for more information) and the LKB model of the boundary layer to estimate the bulk quantities.¹

Sea surface temperature (SST) products are those from the MODIS (MODerate Resolution Imaging Spectroradiometer) sensors onboard the NASA Terra and Aqua platforms, or those from the The Group for High-Resolution Sea Surface Temperature (SST) (GHRSST). MODIS SST products are derived from the mid-infrared (IR) and thermal IR channels and are available in various spatial and temporal resolutions. GHRSST supplies SST data in satellite swath coordinates (L2P), gridded data (L3), and gap-free gridded products (L4). Description about GHRSST data are available here.²

² http://www.ghrsst.org/data/data-descriptions
ECMWF analysis data are available every 6 hours, the scatterometer winds fall at non synoptic times. Within the SEV period of 192 hours (3 days before and 5 days after the surge event) there are, in average, no more than ten scatterometer hits when QuikSCAT data are available, and five when ASCAT alone is available. The mean values of the wind speed 48 hours before the SEV are reported in Figure 16, as obtained from in-situ (AAPTF), scatterometer and ECMWF winds: the model winds are seen in average to be underestimated with respect to the scatterometer ones, both in the northern and in the southern Adriatic Sea. The discrepancy between the in-situ and the scatterometer winds is probably due to the different geographical locations of the two data sets: AAPTF site is much closer to coast (15 km) than the area selected to average the scatterometer winds. Figure 17 reports the Scatt-ECMWF wind speed bias for the fifteen SEVs obtained over the whole SEV period.

**Figure 16:** The mean wind speed in the 48 hours before the SEV occurrence.

**Figure 17:** The SCATT-ECMWF wind speed bias for the fifteen SEVs.
3.1.1 Nomenclature

The nomenclature for the NetCDF file containing the data related to wind, SST and NWP variables follows a general rule provided by eSV, which is:

\[ \text{eSV\_SEV} \text{yyyyymmdd\_AAABB BBBB\_yyyyymmddThhmmss+NNN.nc} \]

with the fields in colour having the following meaning:

- **yyyyymmdd**: is the SEV date;
- **AAA**: three characters referring to the source of the data, and coded as follows:
  - QKS: NASA QuikScat satellite scatterometer data;
  - ASC: EUMETSAT MetOP Ascat satellite scatterometer data;
  - WST: U.S.Navy/NOAA WindSat satellite radiometer data;
  - GCM: global circulation model (ECMWF model) data;
  - LAM: limited Area Model data;
  - MDS: NASA MODIS radiometer satellite data;
  - GHR: Group for High Resolution Sea Surface Temperature (GHRSST) data.
- **BBBBB**: 5 characters. Their meaning depends on the first three characters (**AAA**):
  - if **AAA** = [QKS|ASC|WST], **BBBBB** is the orbit number;
  - if **AAA** = [GCM|LAM], **BBBBB** is the declared model grid spacing (in km);
  - if **AAA** = [MDS|GHR], **BBBBB** is set to SST00.
- **yyyyymmddThhmmss**: is the base date+time for the data contained in the file. For model analysis fields it is equal to the time of validity of the analysis field; for model forecast fields it is equal to the base time (the time of the model run producing the forecast). For satellite data it is the central value of the acquisition time of the data in the file;
- **NNN** is the number of hours to obtain the instant in which the data in the file are valid, starting from the base date+time. It is used only for forecast or hindcast data. It is set to 000 otherwise.

Example file name: eSV\_SEV20041031\_GCM00040\_20041104T060000+000.nc.

This nomenclature has been adopted, with proper modifications, for all the eSV NetCDF files. Departures and exceptions from the rules expressed here are signalled in the following "Nomenclature" sections.

3.1.2 NetCDF file format

The NetCDF files supplying wind, SST and wind related quantities from GCM and satellites correspond to the nomenclature described above, and reported below for clarity:
where the field **AAA** can take four different values corresponding to several types of source:

- **AAA** = [QKS|ASC]: QuikSCAT and ASCAT satellite winds;
- **AAA** = [WST]: WindSAT satellite winds;
- **AAA** = [GCM|LAM]: model wind stress and drag coefficient;
- **AAA** = [MDS|GHR]: satellite-derived sea surface temperature.

All the NetCDF files for these four different types of source follow the NetCDF Climate and Forecast (CF) Metadata Convention version 1.4\(^3\). Moreover, all the NetCDF files contain the geophysical quantities expressed as spatial fields of the same structure: the values of the geophysical quantities are given at the nodes of the same structured latitude-longitude grid with limits 40°N-46°N, 12°E-20°E, inside the 40th Area Of Interest (AOI) AOI-40: 39°N-46°N, 11°E-21°E.

The correspondence between the different sources and the eSurge-Venice product names is expressed in the following table:

<table>
<thead>
<tr>
<th>Product ID</th>
<th>Variables</th>
<th>Feature</th>
<th>Correspondence with the Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>eSV-W1</td>
<td>scatterometer wind</td>
<td>12.5 or 25 km grid</td>
<td>[QSC</td>
</tr>
<tr>
<td>eSV-W2</td>
<td>ECMWF</td>
<td>0.25° x 0.25° or 0.125° x 0.125° gridded, 3-6 h interval gridded wind stress, air density and drag coefficient fields (analysis and forecasts)</td>
<td>[GCM]</td>
</tr>
<tr>
<td>eSV-W3</td>
<td>WRF winds for re-analysis</td>
<td>10 km grid, 1 h interval gridded wind stress fields, air density and drag coefficient (forecasts)</td>
<td>[LAM]</td>
</tr>
<tr>
<td>eSV-SST</td>
<td>SST (multi satellite)</td>
<td>Daily, 6.5 km grid</td>
<td>[MDS</td>
</tr>
<tr>
<td>eSV-NRT1</td>
<td>NRT winds</td>
<td>3 hours for ASCAT, 1 day for WindSAT</td>
<td>[QSC</td>
</tr>
<tr>
<td>eSV-NRT4</td>
<td>NRT SST maps</td>
<td>L4, daily, 6.5 km grid</td>
<td>[MDS</td>
</tr>
</tbody>
</table>

The fields contained in the NetCDF files come into three different groups, one for each of the four sources, following the scheme reported below:

- **AAA** = [QKS|ASC] (source is satellite scatterometer):

° eastward_wind_neutral: scatterometer 10 m eastward wind in neutral stability conditions;
° northward_wind_neutral: scatterometer 10 m northward wind in neutral stability conditions;
° eastward_wind_adjusted: scatterometer 10 m eastward wind corrected for actual stability conditions;
° northward_wind_adjusted: scatterometer 10 m northward wind corrected for actual stability conditions;
° air_density: air density;
° surface_drag_coefficient_for_momentum_in_air: Cd - surface drag coefficient of momentum;
° surface_downward_eastward_stress: sea surface downward eastward wind stress;

• AAA = [WST] (source is satellite radiometer):
  ° wind_speed_neutral: radiometer 10 m wind speed in neutral stability conditions;
  ° wind_speed_adjusted: radiometer 10 m wind speed corrected for actual stability conditions;

• AAA = [GCM|LAM] (source is numerical model):
  ° surface_downward_eastward_stress: sea surface downward eastward wind stress;
  ° surface_downward_northward_stress: sea surface downward northward wind stress;
  ° air_density: air density;
  ° surface_drag_coefficient_for_momentum_in_air: Cd - surface drag coefficient of momentum.

• AAA = [MDS|GHR] (source is satellite radiometer):
  ° sea_surface_temperature: sea surface temperature.

All the fields are functions of the following variables:

• height: height of the observation;
• latitude: latitude of the observation;
• longitude: longitude of the observation;
The time is fixed inside each NetCDF file, and is expressed by the variable:

- **time**: time of the observation.

The height variable assumes only two values: 0 m for the source **AAA = [MDS|GHR]**, and 10 m for the remaining sources.

The latitude and longitude variables varies inside the ranges given above with either 0.125° or 0.25°, depending on the original grid spacing of the data. All the fields have been gridded on a regular 0.125°x0.125° or 0.25°x0.25° grid.

Missing values are coded as "NaN" (Not a Number).

### 3.1.3 Reading software

The NetCDF files are downloaded via the eSurge SEARS system. To read/import the NetCDF files the eSurge-Venice project supplies some tools that can be downloaded from this page:

- [http://www.esurge-venice.eu/node/59](http://www.esurge-venice.eu/node/59)

The software to import NetCDF data produced by the ISAC-CNR team into the Matlab® environment can be found here:

- [http://www.esurge-venice.eu/sites/default/files/netCDF2data.m](http://www.esurge-venice.eu/sites/default/files/netCDF2data.m)

The script `netCDF2data.m` is a general-purpose reading software for the Matlab® environment. `netCDF2data` has been designed to import into Matlab® the data contained in the NetCDF files produced by the ISAC-CNR team, but it works equally well for the NetCDF files produced by the other team and for the NetCDF files in general. It is intended specifically for use with data from the following sources: [QKS|ASC|WST|GCM|LAM|MDS|GHR] (sources are indexed in the "AAA" field of the NetCDF filename `eSV_SEV_yyyymmdd_AAAABB BBB_yyyymmddThhmmss+NNN.nc`.

The Intellectual property of the code is of Harish Sangireddy <harish2rb@gmail.com>⁴. The code has been (lightly) modified by Francesco De Biasio <f.debiasio@isac.cnr.it>.

The usage of the `netCDF2data.m` script from the Matlab® command-line is simple:

```matlab
>> [DATASTRUCT] = netCDF2data('filename.nc');
```

All the information contained in the “filename.nc” NetCDF file are stored inside the structure “DATASTRUCT”. More information about Matlab® structures can be found here⁵.

The main parts of the DATASTRUCT structure are:

1. **DATASTRUCT.dataset_info**: contains the general attributes stored in the netcdf file;
2. **DATASTRUCT.dimensions**: contains the information about the dimensions in the NetCDF structure;

---

⁴ [https://webspace.utexas.edu/hs8238/www/surfacehydrology/surfacehydrology_Project.htm](https://webspace.utexas.edu/hs8238/www/surfacehydrology/surfacehydrology_Project.htm)

⁵ [http://www.mathworks.it/help/matlab/ref/struct.html;jsessionid=ce062bc08f5a686a3b257c450ecf](http://www.mathworks.it/help/matlab/ref/struct.html;jsessionid=ce062bc08f5a686a3b257c450ecf)
3. DATASTRUCT.<var_name_info>: contains the metadata information about the variable <var_name>;

4. DATASTRUCT.<var_name>: contains the data of the variable <var_name>.

To import the content of a NetCDF file produced by ISAC-CNR, containing the wind field derived from the QuikSCAT scatterometer, use this command from the Matlab® command-line:

```
>> [D] = netCDF2data('eSV_SEV20041031_QKS27975_20041102T034926+000.nc');
```

**USE-example**: to actively use the data just read, follow this example: plot the data of the “surface downward eastward stress” variable, which is contained in the field "surface_downward_eastward_stress" of the structure "D" (D.surface_downward_eastward_stress):

```
>> figure;
>> imagesc(D.longitude,D.latitude,D.surface_downward_eastward_stress); colorbar; axis xy;
>> title('surface downward eastward stress (Pa)');
>> xlabel('longitude'); ylabel('latitude')
```

You should see the image reported in figure 18.

![Figure 18: Graphical rendering of the content of a field in a NetCDF file. Image given as an example to compare the result of the extraction of the data from the NetCDF file.](image)
3.2 Altimeter data

While in-situ measurements are typically taken at hour or less intervals at a fixed location, the satellite altimetry system produces data that are spaced about every 7 km along the motion of the satellite with a return to the same position after 10 days or more. The satellite altimetry system provides SSH (Sea Surface Height), which is a measure of the height of the sea surface in open ocean at a given instant along a track with respect to the ellipsoid. The computation of SSH requires independent measurements of the satellite orbital trajectory and corrections for various effects (instrument errors, atmospheric refractions, perturbations caused by the surface interaction). SSH can be decomposed into a MSSH (Mean Sea Surface Height) and a SLA (Sea Level Anomaly), which takes into account the variation of the SSH around the MSSH. The MSSH is computed averaging SSH over several years at a fixed along track ground point over the mission time period. Some applications also require the application of additional geophysical corrections that account for “unwanted” effects. These effects include tides and the ocean's response to atmospheric forcing.

In the Adriatic Sea SEVs are usually monitored in an eight day window (3 days before and five days after the event). The SEV temporal evolution is generally hard to detect in stand-alone altimeter data due to the poor temporal sampling and sparse coverage of the current configurations. However, satellite altimetry data is still useful when combined with modelling tools and in situ measurements to potentially improve the accuracy of storm surge forecasting. While in situ measurements provide a time series at a fixed location within the SEV window, on the contrary, satellite altimetry gives an instantaneous measurement that extends spatially offshore along a track.

A typical scenario for the user of SEARS is to have access to a number of tracks for each SEV. For each track the user can extract latitude and longitude and make a plot to see where the track crosses the Adriatic Sea. The user can also extract the time for each SLA measurement along the track. It is of worth to note the substantial synoptic coverage (the satellite takes few seconds to cross the Adriatic Sea along the minor axis and just more than one minute along the major axis). Finally the user can extract the SLA profile along track. The total water level envelope (TWLE) can be computed by adding to SLA the ocean tidal signal and the contribution due to the atmospheric forcing effects. Figure 19 shows a snapshot of the TWLE (that takes into account all oceanographic, tidal and atmospheric effects) in an eight day window for a selected SEV (31 October 2004).
3.2.1 Nomenclature

File names in SEARS take the form eSV_SEV"date"_"mission"_"orbit"_"date"_"time"+000.nc with the fields having the following meaningful:

- **Mission** is the name of the satellite (TOP for TOPEX/Poseidon; JA1 for Jason 1; JA2 for Jason-2 and ENV for Envisat);
- **Date** is in the form yyyyymmdd (yyyy is the year in four digits, mm is the month number from 1 to 12 and dd is the day number from 1 to 31);
- **Orbit** is the number of the satellite ground track in four digits;
- **Time** is in the form hhmmss (hh is the hour from 1 to 23, mm is the minute from 1 to 59 and ss is the second from 1 to 59)

Example file name: eSV_SEV20041031_ENV0743_20041030T201306+000.nc

3.2.2 NetCDF file format

Each NetCDF file contains seven fields. Each field has a dimension, which is the number of along track samples. The fields are as follows:

1. Longitude in degrees: Longitude (1 dimension) ;
2. Latitude in degrees: Latitude (1 dimension);
3. Time in Elapsed days: Time (1 dimension);
4. Sea Level Anomaly (SLA) along the reference track in meters: SeaLevelAnomaly (1 dimension);
5. Mean Sea Surface Height (MSSH) along the reference track in meters: MeanSeaSurface (1 dimension). It is computed averaging SSH over several years at a fixed along track ground point;
6. Ocean tide correction term in meters: OceanTideCorrection (1 dimension). The ocean tide correction is computed from the T-UGO 2D model in a regional configuration for the Mediterranean Sea;
7. Wind and pressure correction term in meters: WindPressureCorrection (1 dimension). The wind and pressure correction term is the sum of the T-UGO 2D model (computed for periods smaller than 20 days) and the inverted barometer effect (computed for periods greater than 20 days).

N.B: Time is expressed in days elapsed from reference time (1900-01-01 00:00:00) UTC

Missing values are filled by NaN

The SLA which is available in the file has the corrections of tide, wind and pressure already applied by default. The MSSH as well as the tide and wind & pressure corrections are also provided at each point of the track. These additional fields permit to compute the SSH (Sea Surface Height) or the total water level envelope (TWLE). The user can replace default corrections with specific corrections developed for the area of investigation.

In summary, the various quantities are computed as follow:

- SSH=SLA+MSSH+ OceanTideCorrection + WindPressureCorrection;
- SLA with tide effects =SLA+ OceanTideCorrection;
- SLA with Wind&Pressure effects =SLA+ WindPressureCorrection;
- TWLE=SLA + OceanTideCorrection + WindPressureCorrection.

### 3.2.3 Reading software

These NetCDF files can be read with the same script described in Section 3.1.3.

### 3.3 In-situ data

ICPSM provides observed data at the “Acqua Alta” Platform (AAPTF). These are: total water level, atmospheric pressure, wind speed and direction. AAPTF it is located 10 miles offshore, in front of the Venice lagoon.

For each storm surge event, ICPSM made a data stream with in-situ observations sampled every 10 minutes.
3.3.1 Nomenclature

The in-situ data will be provided in a single file named:

```
eSV_SEV"dateA"_ISDCCSTZ_{"dateB""timeB""}+NNN.nc
```

- **dateA**: is the date of the SEV event. The form is `yyyyymmdd` (`yyyy` is the year in four digits, `mm` is the month number from 1 to 12 and `dd` is the day number from 1 to 31);
- **ISD**: In-situ Data;
- **CC**: code of SEV status;
  - 00 false alarm;
  - 01 SEV in progress, increasing file;
  - 10 completed file;
- **STZ**: ICPSM station code;
- **dateBTtimeB**: these are the date and time of the first record of the file;
- **NNN**: these are the hours, from the first record, covered by the data contained in the file.

Example:

```
eSV_SEV20101223_ISD10021_20101220T090000+192.nc
```

3.3.2 NetCDF file format

The files produced by ICPSM have always the same name format. One file contains all the values observed at AAPTF for a single SEV.

The following table shows the variables and their main characteristics:

<table>
<thead>
<tr>
<th>Variables</th>
<th>type</th>
<th>standard_name</th>
<th>long_name</th>
<th>characteristic</th>
<th>units</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>double</td>
<td>time</td>
<td>time of measurement - GMT</td>
<td>Calendar Gregorian</td>
<td>seconds</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>since 1970-01-01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>00:00:00</td>
</tr>
<tr>
<td>sea_surface_height</td>
<td>float</td>
<td>sea_surface_height</td>
<td>referred to mean sea level Punta Salute 1897</td>
<td>Missing value -999</td>
<td>meters</td>
</tr>
</tbody>
</table>


The global attributes defined in the NetCDF file are:

- **NetCDF conventions** = "CF-1.4";
- **title** = "In-situ data for SEV and date";
- **institution** = "Istituzione Centro Previsione e Segnalazione Maree Venice, Italy";
- **source** = "In-situ data from ICPSM Station: Acqua Alta Platform lat: 45° 18’ 51.29’’ North; lon: 12° 30’ 29.69’’ East";
- **references** = "http://www.comune.venezia.it/maree";
- **contact** = "email: maree@comune.venezia.it";
- **comment** = "Sea level is referred to the mean sea level in Punta Salute (1897)".

### 3.3.3 Reading software

These NetCDF files can be read with the same script described in Section 3.1.3.

### 3.4 Storm surge forecast data

Each run of the hydrodynamic model is forced with ECMWF wind and pressure fields, with a resolution of 0.5 degrees on latitude and longitude. The forcing fields are provided every six hours.

Since ECMWF’s files are downloaded first by the Italian Air Force and then to the ICPSM Centre, the ECMWF analysis of 12 UTC, with the relative forecast fields, are available at about 4 UTC of the following day. The storm surge simulations used these data but, in order to have a convenient reference time, we set the zero of each simulation at the 00 UTC of the day when the simulation is run. The forecast hours are counted from this time forward.

Moreover, each simulation has a spin-up time of two days before the reference zero time, during which the model is forced with synoptic analysis ECMWF fields.

The model computes the surge and the barotropic transports, which are provided in three
different file types for each model run. The first file contains just the surge extracted in a
node near Venice (at the AAPTF) and the tide, computed by means of a harmonic
analysis. The second file contains the raw data, i.e. the surge and the barotropic transports
extracted from the nodes of the original finite element grid, over the whole Mediterranean
Sea. The third type contains the same data interpolated into a regular grid, at 0.05
degrees, restricted to the Adriatic Sea.

The modelled surge, provided with the files, is not post-processed with any routine.
Operationally, a MSL correction, based on the observed MSL of one day before the
forecast, is made for the surge at the AAPTF.

3.4.1 Nomenclature

For each run of the model the following files are provided:

- eSV_SEV"date1"_SHY1ZsZa_"date2"T"time2"000000_"date3"T"time3".nc
- eSV_SEV"date1"_SHY2ZUVu_"date2"T"time2"000000_"date3"T"time3".nc
- eSV_SEV"date1"_SHY2ZUVr_"date2"T"time2"000000_"date3"T"time3".nc

The first, labelled “1ZsZa”, contains the timeseries of predicted surge and the astronomic
tide, computed by means of an harmonic analysis, in AAPTF. The second contains the
surge and the water transports computed by the model over the whole Mediterranean Sea
in the unstructured grid, originally used for the computation. The third file contains the data
interpolated in a regular grid with a step of 0.05 degree both in longitude and latitude.
While the unstructured data cover the whole Mediterranean basin, these data cover only
the Adriatic Sea. The blue fields have the following meaning:

- **date1** is the date of the SEV event. The form is *yyyyymmdd* (yyyy is the year in four
digits, *mm* is the month number from 1 to 12 and *dd* is the day number from 1 to
31);

- **date2** is the date when the simulation starts (two days of analysis are always in-
cluded, while the next days are all forecast). The form is *yyyyymmdd*;

- **time2** is the time when the simulation starts. The form is *hhmmss* (hh is the hour
from 1 to 23, *mm* is the minute from 1 to 59 and *ss* is the second from 1 to 59);

- **date3** is the date when the simulation ends (two days of analysis are always in-
cluded, while the next days are all forecast). The form is *yyyyymmdd*;

- **time3** is the time when the simulation ends. The form is *hhmmss* (hh is the hour
from 1 to 23, *mm* is the minute from 1 to 59 and *ss* is the second from 1 to 59).

Example file names:
eSV_SEV20041226_SHY1ZsZa_20041224T000000_20041231T120000.nc
eSV_SEV20041226_SHY2ZUVu_20041224T000000_20041231T120000.nc
eSV_SEV20041226_SHY2ZUVr_20041224T000000_20041231T120000.nc
3.4.2 NetCDF file format

The file format differs depending on the file types described in the previous section. Here follows the formats used:

- eSV_SEV"date1"_SHY1ZsZa_"date2"T"time2"000000_"date3"T"time3".nc
  - lon: longitude;
  - lat: latitude;
  - time: time in seconds since 2004-10-31 00:00:00 UTC;
  - storm_surge: Storm surge forecast;

- eSV_SEV"date1"_SHY2ZUVu_"date2"T"time2"000000_"date3"T"time3".nc
  - lon: longitude;
  - lat: latitude;
  - level: bottom of vertical layers;
  - total_depth: total depth at nodes;
  - element_index: maps every element to its three vertices;
  - topology: topology data of 2D unstructured mesh;
  - time: time in seconds since 2004-10-31 00:00:00 UTC;
  - water_level: water surface height above reference datum;
  - u_velocity: eastward_sea_water_velocity_assuming_no_tide;
  - v_velocity: northward_sea_water_velocity_assuming_no_tide.

- eSV_SEV"date1"_SHY2ZUVr_"date2"T"time2"000000_"date3"T"time3".nc
  - lon: longitude;
  - lat: latitude;
  - level: bottom of vertical layers;
  - total_depth: total depth at nodes;
  - time: time in seconds since 2004-10-31 00:00:00 UTC;
  - water_level: water surface height above reference datum;
  - u_velocity: eastward_sea_water_velocity_assuming_no_tide;
  - v_velocity: northward_sea_water_velocity_assuming_no_tide.
3.4.3 Reading software

To read the NetCDF files produced by the ISMAR-CNR into the Matlab® or Octave environments, three scripts can be found at the following web-pages:

- [http://www.esurge-venice.eu/sites/default/files/shyfem_ts.m](http://www.esurge-venice.eu/sites/default/files/shyfem_ts.m)
- [http://www.esurge-venice.eu/sites/default/files/shyfem_unstr.m](http://www.esurge-venice.eu/sites/default/files/shyfem_unstr.m)
- [http://www.esurge-venice.eu/sites/default/files/shyfem_reg.m](http://www.esurge-venice.eu/sites/default/files/shyfem_reg.m)

The first script reads a file with the first format, described in the previous section, the second script reads the second format, and the third script the third one.

The usage of the scripts is simple and is explained in the help text contained in each script.

4 eSurge-Venice web-site

One of the services provided by the eSV team is a website accessible at the following address: [www.esurge-venice.eu](http://www.esurge-venice.eu). The web-site is built on Drupal, which provides an easy readable and friendly layout, and it is linked to the eSurge project web-site.

The eSurge-Venice portal was built with the following purposes:

- public access without restrictions to the web site public content;
- exhaustive but concise information about the aims of eSV project;
- information about the main facts concerning the storm surge in Adriatic Sea;
- list of the Selected Events;
- information about the eSurge-Venice Consortium;
- Private Page for ESA access to deliverables;
- link to eSurge;
- link to eSurge SEARS through the list of selected SEVs will be provided when the eSurge SEARS database will be available.

The home page provides a description of the eSurge-Venice Project underlying the aims and the outcomes and giving the list of the project partners. On the top of the home page there is a list of further contents, with thematic pages. Clicking of the “Storm Surge” page a wide and exhaustive description of the storm surge phenomenon is presented, focusing on the specific processes characterising the Adriatic Sea.

Further statistics of storm surge occurrence are discussed and, opening several links to hypertexts graphs and images, can be seen. Moreover, the storm surge contribution to the total water level is discussed. A bibliography is also reported in a web-page linked to the main one.

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6 In Debian or Debian-like Linux Operating Systems you need the package `octave-octcdf` to use the provided scripts with Octave.
Another web page, which is accessible from the link “Selected Events”, is devoted to the description of the selected storm surge cases (SEVs). Each SEV is described first looking at the atmospheric conditions, then looking at the sea conditions and at the storm surge forecast quality.

A further description of the eSurge-Venice consortium and on the institutions involved in the project is provided clicking on “about us”.

The unclassified documentation produced within the project is uploaded to the web-page “Documentation” and can be downloaded without restrictions.

Finally, contacts are shown in the web-page “contact us”, in order to obtain more informations about the project and to contact the eSurge-Venice partners. Once the SEARS system will be completed and online, it will be linked in the eSurge-Venice website, in order to allow the navigation through datasets, analysis and elaborations provided within the project.