DUE eSurge

Report from Workshop on Satellite Data for Storm Surge Modelling and Forecasting (eSurge User Consultation Meeting 1)

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<td>UK EC231827</td>
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<td>eSurge_Workshop 1</td>
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<td>Version/Rev</td>
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<td>Date of Issue</td>
<td>2\textsuperscript{nd} October 2012</td>
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## AMENDMENT HISTORY

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1 INTRODUCTION

The workshop “Satellite Data for Storm Surge Modelling and Forecasting” was held at DMI’s premises in Copenhagen on 10\textsuperscript{th}-11\textsuperscript{th} September 2012.

The aims of this workshop were:

• To update the storm surge community on current and future earth observation data.
• To identify areas where this data could be better used in operational forecasting and mitigation, and to identify strategies for encouraging its uptake.
• To discuss the benefits and challenges of assimilating this data into storm surge models.
• To provide a forum where experts in data provision, modelling and forecasting can interact to exchange ideas and develop new possibilities.

This workshop also constituted the first User Consultation Meeting of the eSurge (ESA Storm Surge Demonstration) project. One of its principle aims was therefore to determine how the eSurge project should go forward while best meeting the needs of the user community.

This report summarises the principle points raised and the main conclusions of the workshop, with a particular emphasis on the impacts for the future directions of the eSurge project.

Slide sets for the presentations given are available at the workshop website: www.storm-surge.info/workshop.
2 MAIN CONCLUSIONS

The main conclusions from this workshop were:

1. There are a range of ways that satellite data could be incorporated into storm surge models; the usefulness of the data is not limited to model validation.

2. Interest in storm surges is not confined to those areas which were initially identified by eSurge; additional areas which could be useful to incorporate include Japanese waters, Australia and the river plate estuary.

3. There is a strong interest in coastal altimetry and blended products, principally but not exclusively for model validation. The main output quantity of interest is TWLE, however other fields are needed for different purposes.

4. Data assimilation is recognised as a particular challenge. This will not be solved within the frame of eSurge, however the project can make considerable progress by identifying promising ways forward. The project can also help by building a data assimilation working group, which can form the basis of a community that can steer future development.

5. The training provided should focus on the end goals which can be achieved with EO data, whilst using the new eSurge service. It should be mainly aimed at forecasters, modellers and others with some existing knowledge. It should be designed incorporating lessons learned from previous courses hosted by WMO and others.

6. Many of the key users who we want to engage, especially operational users, will only become involved once there is data coming through the system. There needs to be a renewed emphasis on outreach after eSurge passes its acceptance review.
3 SUMMARY OF MAIN SESSIONS

The full list of presentations given is listed in annex A, while the slides can be downloaded at www.storm-surge.info/workshop. This summary does not attempt to discuss all presentations, but rather to pull out the main conclusions which impact the future directions of eSurge, or of storm surge research more generally.

Session 1: Satellite Data for Storm Surge Applications

This session began by reviewing the different ways that satellite data can be utilised for storm surges. These are quite wide, and include:

- improving the modelling system, by comparison to satellite observations
- Altimetry has an important role to play in validation as they provide a 2-D view. It can also be used for ensemble pruning.
- There is scope also for hindcasting and nowcasting

It was noted that storm surges is an important and widespread concern; of the 33 largest cities 2015, 21 are coastal (including 8 of the 10 largest). However this also brings challenges too; there are not so many surge forecasting systems in the world – we need to make sure that the user community is fully engaged.

In the overview of eSurge, it was noted that a large part of the sessions agenda was to ask attendees “what can we do for you?”. This might include providing or disseminating particular data, tailoring the training or experiments, or anything else that users wanted.

The measure of success will ultimately be the uptake of data by the users.

Some particular concerns for the Adriatic were also noted; The Adriatic is a coastal sea, so coastal altimetry is needed. SSM initial conditions are strongly influenced by local seiches, which is where the altimeter TWLE has a role to play. However temporal/spatial sampling remains a problem. For winds at least 25 km resolution is needed.

Some data sets of particular interest were discussed. The operational 12.5 km OSI SAF ASCAT Coastal product is one, the new coastal altimetry being created within eSurge is another. Although for altimetry sampling will always be a problem, if you set the boundaries wide enough (e.g. -2 to +1 days and a suitable geographic range) then there is almost always some altimetry data (see Ole Andersen’s presentation).

As well as the data products foreseen, satellite derived bathymetry was also discussed. This was highlighted as being useful, but potentially out of scope of the current eSurge project.

Session 2: Storm Surge Forecasting and Modelling

This session discussed existing forecasting and modelling systems, to see where satellite data might usefully be utilised. The systems discussed included:

- Those at ISRO, which already includes some altimetry assimilation.
- Various models used for the adriatic waters; those at ICPSM and ISPRA as well as a newer model (Kassandra)
• The DMI operational model.
  Some other models, not used operationally, were also presented. Some common
  issues arose with all of these:
  • Altimetry is a key input, but there are sampling issues; there are not always
    altimeter tracks where they are needed, and so to get enough data we
    need to use all available altimeters. (See also Ole Andersen’s talk in
    session 1).
  • If data is to be assimilated into forecasting systems then making it available
    in NRT is key. (NRT meaning of order 6 hours.)
  • Interaction with tide models is key; for many applications it is best to
    remove the tidal component.
  • Likewise boundary conditions are important. Open-ocean altimetry has an
    important role to play here.
  Some of these issues are discussed further in the splinter session on data
  assimilation.

**Session 3: User Perspectives.**

It is important to start making data available as soon as possible. Once data are
available, people will find uses for them, but not everyone is willing to spend time
detailing their requirements in advance. Emphasised that eSurge is targeting an
acceptance review before the end of 2012, so that data is available after this.

For operational users in particular; Researchers are always looking for something
new, but in operations they ignore anything new because they have to follow
procedures. The only way to get new stuff used by operations teams is to get the
forecasters and operations people communicating. This is something the eSurge
project can help with, especially for the training.

Users are also more likely to engage if this is a long term initiative. The prospects
going forward will depend on the uptake during the project; If there is a huge
usage, then there is potential (certainly in the UK) to keep it running. Once the
system us live and running, there should be pressure to keep it running. It is also
emphasised that all data will be freely available, unless there are third party
restrictions.

It was highlighted that there are potentially more users than the “typical”
forecasters. An example was given of smaller coastal users; see the EU funded
CoastAdapt project.
4 SPLINTER SESSION A: COASTAL ALTIMETRY

The coastal altimetry session centred around discussion of two main questions:

1. Which quantity is relevant for storm surges?
2. How can the supplied data best be used?

Each of these questions is discussed below.

Which quantity is relevant for storm surges?

Simplistically, the answer is Total Water level Elevation (TWLE), as this allows immediate comparison with tide gauges and input to inundation models.

However there are some slightly tricky issues in computation; e.g. whether or not to remove load tides.

In practice, whether or not we remove tides or not depends on the model that we compare it to; for comparison with or assimilation into surge models, we definitely want to remove tides.

Hence, we want to retain flexibility, and to keep a few more fields in the products than just standard TWLE. This does increase the complexity of the products a bit, but is worth it. We also need to carefully document the recipes used to create the products.

We also noted the additional complication that different measurement systems use different reference systems, with adjustments often made empirically, which is not ideal.

How can the supplied data best be used?

Blended data (altimetry plus tide gauges) is most naturally used for assimilation into models and hindcasts/forecasts.

Single altimetric profiles are most useful for verification and ensemble pruning.

NRT data are often not directly usable for assimilation, as there is too much error on NRT orbit. There may also be cases where the relative height profile is still useful in an assimilation exercise. An example is in the Adriatic, to get the correct seiche phase. NRT altimetry data also remain useful for verification in real time.
5 SPLINTER SESSION B: DATA ASSIMILATION

The aims of the eSurge data assimilation activity are to:

- Develop water level assimilation technique.
- Assess the benefit of assimilating satellite water level.
- Create a water level assimilation discussion group.

Current status of assimilating water in coastal seas.

A variety of methods, e.g., OI, 3DVAR, 4DVAR, ENOI, KF and EnKF etc have been reported in assimilating water level data from tidal gauges. Most of the results failed to provide solid improvements in average. A relatively successful assimilation approach may improve the forecasts for the first 6-12 hours but negative effects may appear in forecasts after 12hours.

One successful example is the operational storm surge forecasting system in Netherlands (based on ENKF, with perturbation of winds), which showed solid improvements of surge forecast by about 3-4cm. Most of the existing schemes assimilating surge while DHI scheme assimilates total water level.

Another topical area is improved wind forcing by using satellite measurements for surge prediction. A constellation of wind scatterometer instruments is being build and regional data assimilation in NWP may result in improved forcing fields and therefore surge predictions.

Very few experiments have been done for assimilating altimetry data in coastal/shelf seas.

What is to be done in eSurge.

NOC plans to assimilate the blended water level using OI method for a few storm surge events in Indian Ocean while DMI is expected to do similar experiments for the Baltic-North Sea. Currently DMI has two assimilation schemes.

For scatterometry, KNMI will provide satellite wind data for selected cases and, when available, NWP fields from the HiRLAM project with and without scatterometer winds assimilated.

Major challenges and potential solutions.

1. Quality control in observations:
   a. In order to assimilate both altimetry and gauge data in coastal sea, either raw data or blended product, the observation error has to be specified for each data sample.

2. Reduce the shock effects: The negative impacts after 12hour of assimilation is believed due to the unbalance among winds, mass and current fields - so-called “shock effects”. It is a wish that the shock effects may be reduced due to:
   a. Assimilating a smoother field (e.g., blended field) rather directly assimilating raw data.
b. Ensemble method may be another way to reduce the shock effects.

c. Implement some dynamic constraint between wind, mass and current fields in the assimilation.

3. Rational and impacts of using de-tide method (difference from using TWLE) should be further investigated

4. It is necessary to compare assimilation results using different schemes, e.g., OI, 3DVAR and EnOI etc.
6 SPLINTER SESSION C: TRAINING NEEDS

This splinter session focussed on the training needs for the storm surge community. The session began with a brief outline of eSurge’s initial ideas for training, followed by a presentation by Dr. Boram Lee (WMO) on their experiences providing training for operators and forecasters.

Through 2 facilitated discussion sessions users informed us what they would like to see in terms of training (summarised below).

**Hands-on training**

**Structure**
- Linear structure needed, with attendees experience a complete run through from requesting data to the output product.
- Scenario & Role-play element to be incorporated (highlighting the utility of satellite info).
- Social aspect of community building to be incorporated into both the training and the training event.

**Content**
1. Subject focus - How can EO data enhance your modelling efforts and forecasting outputs?
2. Clear idea of training and training objectives presented at the start.
3. Case study based - tasks and reviews on real case studies.
4. Users must understand General Process, not Software. This is not a technical modelling workshop, and must not focus on model and data assimilation.
5. Attendees will access data from SEARS, then use that data to deriving a simple informative product/set of parameters for forecasters.
6. Focus on End Goals achieved with EO data, whilst using the new eSurge service.
7. Content and structure shall challenge trainees, but not push them too hard.
8. Shall cater to specific needs with a regional focus - 2 regions:
   i. Tropical (N. Indian Ocean)
   ii. Mid-high latitudes (European Waters)

**Key Audience**
- Forecasters & Modellers
- Target attendees will need to have a minimum level of understanding of storm surges and storm surge modelling
- Initial basic modules of the online course will have to be completed for those novices who wish to attend.
- Novices are a key element for future focus, but not for the initial training workshop in Cork

**Other**
- To be held in Cork (Ireland) in early- to mid-2013.
- Key opportunity to build upon the Storm Surge Community - social aspect and group work for tasks.
- Course will be highly interactive, encouraging team work, and ensuring that everyone leaves with something (new contacts, data, a method, a new piece of knowledge). Kick-off and Round-up session to ensure this.
- The core training element of the event to be outlined and designed for use in the future by other third-party organisations in other regions/countries.
Online & Offline Training

Structure

• Modular in structure, a clear introductory page will introduce the modules
• 2 general subsections within which the modules lie:
  o Volume 1 - Storm Surges, Modelling and Forecasting (the Basics)
  o Volume 2 - Applications of EO data in Storm Surge Research, modelling and forecasting (more advanced)
• Self-assessments spread throughout the training, not all at the end.
• Incorporate checkpoints for trainers who use the course within their own education efforts.

Content

a. Subject focus is wider than for the hands-on training. Modular approach will allow variety to be achieved. Each module is essentially a tool to get a clear introduction to a particular area of storm surge modelling and forecasting using EO data.

b. Subjects should:
  i. Show the benefits of using EO data, giving trainees experience in interpreting data
  ii. Can focus in more detail than the hands-on training
  iii. Introduce data for validation & Now-casting
  iv. Incorporate a module on the different data types, their characteristic uses, and benefits/drawbacks
  v. Not detail the instruments that collect the data, more highlight the links to where further information can be found.

c. Exercises to ensure the student has done the processing themselves, and can get a practical grasp of it.

d. Comet training (WMO) subject matter can support the eSurge training development here.

Key Audience

• Undergraduates
• Lecturers (training the trainers)
• Forecasters
• Modellers
• Modular approach, and the use of basic and advanced levels shall allow the training course to cater to these audiences.

Other

• A number of good and bad training efforts were cited & noted
• Balance is needed in the forms of media we use for training (videos, presentations, assessments, font sizes etc.) Sparing use of video can be incorporated within modules.
• Technical considerations for training programs were also noted (e.g. the use of flash)
• Clear introduction page should outline the modules, & how long they should take.
• Basic training component to be constructed in time to support the hands-on training.
• Feedback element should be incorporated (perhaps in the form of an online blog tied into the eSurge Community pages.)
The training should ultimately feed into WMO training efforts and Ocean Teacher, ESA Summer Schools, University training courses etc. Material must be made available to achieve this (licenses, promotion, outreach etc.).
## ANNEX A LIST OF PARTICIPANTS

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ANNEX B FINAL WORKSHOP AGENDA

The final workshop agenda is shown below. Slide sets for the presentations given are available at the workshop website: www.storm-surge.info/workshop.

Day 1, Monday 10th September

09:00 Arrival and Registration
09:30 Welcome address; Erik Buch, DMI.

Session 1: Satellite Data for Storm Surge Applications
Chair: Kevin Horsburgh, NOC.

09:40 Satellite Data for Storm Surge Modeling and Forecasting; a review.
Kevin Horsburgh, NOC.
10:00 Satellite Data for the Storm Surge Community: The eSurge Project.
Phillip Harwood, Logica.
10:20 Needs for the storm surge forecast in the Adriatic Sea: the eSurge-Venice project.
Stefano Zecchetto, ISAC.
10:40 Discussion; workshop aims and objectives.
11:15 Coastal Altimetry: Recent Progress and Application to Storm Surge Research.
Paolo Cipollini, NOC.
11:40 Scatterometry Winds at KNMI.
Ad Stoffelen, KNMI
12:05 The use of Satellite Altimetry for Storm Surge Warning.
Ole B. Andersen, DTU.
12:30 Summary.

Session 2: Storm Surge Forecasting and Modelling
Chair: Jacob Høyer, DMI.

13:40 Spaceborne observation systems and their role in monitoring and predictions of extreme ocean conditions.
Raj Kumar, ISRO.
14:05 The operational DMI storm surge warning system for the Danish waters.
Jacob Woge Nielsen and Vibeke Huess, DMI.
14:30 Operational Storm Surge Systems in Venice.
Marco Bajo, ISMAR-CNR.
14:55 High Seas from SBWR and Altimeter Measurements in Northeastern Atlantic.
Xiangbo Feng, University of Southampton.
16:00 Characteristics of the storm surge forcing winds as derived from NWP model and
scatterometer observations in the Adriatic Sea.
F. De Biasio, ISAC

16:25 Return period estimates of extreme sea level along the least coast of India from observations and modeling.
A.S. Unnikrishnan, NIO.

16:50 Summary and discussion: the current state of the field.

Day 2, Tuesday 11th September

Session 3: User Perspectives
Chair: Phillip Harwood, Logica.

09:00 Introduction and plan for the day
Phillip Harwood, Logica

09:10 Title TBC.
Craig Donlon, ESA.

Robert Devoy, University College Cork. (Presented by Ned Dwyer, CMRC.)

10:30-12:30

Session 4A: Coastal Altimetry for Storm Surge Applications
Chair: Paolo Cipollini, NOC

Session 4B: Assimilation of EO Data into Storm Surge Models
Chair: Jun She, DMI

Session 4C: Training needs for the Storm Surge community
Chair: Ned Dwyer, CMRC, and Boram Lee, WMO

Session 5: Future Directions
Chair: Phillip Harwood, Logica.

14:00 Summaries of the breakout sessions.

14:30 Discussion; future directions for utilizing satellite data in storm surge research.

16:00 Summary and Conclusions.

16:30 Close.
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