Initial Implementation Plan for the
Ocean Surface Vector Wind Virtual Constellation[1]
in collaboration with the
Ocean Surface Topography Virtual Constellation[2]

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Goal

Promote the widespread use of scatterometer-derived surface vector winds (SVW) and altimeter-derived significant wave heights (SWH) in operational marine analyses and forecasts worldwide, as a contribution to the protection of life and property at sea.

Motivation

With 90% of international trade carried by more than 30,000 ships with an estimated annual revenue of $9 billion, the safe and efficient transport of these goods is vital to the global economy. And with more than a million mechanized commercial fishing vessels worldwide – 40,000 of which exceed 100 tons – their safe and efficient operations contribute a vital source of protein to the global population.

As part of the International Convention for the Safety of Life at Sea (SOLAS), the International Maritime Organization and the World Meteorological Organization (WMO) have developed a coordinated system of marine forecast and warning services – the Global Maritime Distress and Safety System (GMDSS) – covering both the high seas and coastal areas. More recently, the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of the WMO and Intergovernmental Oceanographic Commission (IOC) is working to ensure that the latest scientific and technical developments that can contribute to the provision of those services – including operational weather and sea-state forecasts, as well as warnings of tropical cyclones and winter storms – via the GMDSS.

As recently as June 2008, the WMO Executive Council:

- *Requested that efforts be made…to ensure that… ocean surface meteorological observations be routinely collected and disseminated via the* GTS [Global Telecommunications System,

[1] Formally established by the CEOS Plenary in November 2008, the *OSVW Virtual Constellation* (VC) is working closely with the international community to harmonize among the different scatterometer systems – agreement on timely, unrestricted and easy access to data products with consensus standards and formats; joint participation in calibration and validation efforts; and collaboration in the use of those products for both research and operational forecasting.

[2] The OSVW VC is partnering with the *Ocean Surface Topography VC* to facilitate access to significant wave height in addition to SVW products; both of these are required for marine analyses and forecasts.

the operational system used to distribute shared meteorological data and upon which operational analyses and forecasts are based]…

- *Requested…participation of space agencies in that scheme.*
- *Recognized that severe coastal inundation events from extreme sea state conditions occurred in many parts of the world…where coastal and ocean surface meteorological observations were…limited or absent.*
- *Requested JCOMM...to address this issue as a matter of priority.*

Satellite Capability

Observations of SVW and SWH are two fundamental sets of observations that are critical for marine warnings and forecasts, and the space agencies have had a capability to observe SVW and SWH – globally – from scatterometers and altimeters, respectively, for a decade and a half. Microwave scatterometry is used to estimate the vector winds, and routine observations of SVW were initiated by ESA's ERS-1 satellite in 1991. Broad-swath coverage began with NASA's QuikSCAT in 1999 and more recently, ASCAT on EUMETSAT's Metop series, operational since early 2007. Adding to this capability in scatterometry, ISRO's Oceansat-2 is planned to launch later this summer, SOA-CNSA's HY-2A is planned for launch next year, and SOA-CNSA/CNES's CFOSat is planned for 2013/14; each will include a scatterometer. Additionally, NOAA is proposing a scatterometer for flight on JAXA's GCOM-W2 in 2016.

Present observational coverage of SWH by satellite altimeters began with ESA's ERS-1 in 1991 and NASA/CNES's TOPEX/Poseidon in 1992; and today observations are available from CNES/NASA's Jason-1 & -2 and ESA's Envisat. Adding to this capability in altimetry, ESA's Cryosat-2 and SOA-CNSA's HY-2A planned for launch next year, ISRO/CNES's SARAL the following year, ESA's Sentinel-3A in 2012, and EUMETSAT/NOAA/CNES's Jason-3 in 2013. Additionally, the U.S. Navy is proposing a GFO-2 for launch in ~2013.

Operational Use of this Satellite Capability

Today, SVW from QuikSCAT & ASCAT scatterometers and SWH from Jason-1, Jason-2 & Envisat altimeters are being used routinely by operational centers in many developed countries of the Northern Hemisphere (~60% covered by oceans) – particularly those with satellite programs. However, they are not in routine use by a number of the corresponding centers in countries of the Southern Hemisphere (~80% oceans) with responsibility for high-seas forecasts in MetAreas of the Global Maritime Distress and Safety System (GMDSS). While the developed countries have relatively easy access to data from the latest space observing systems and associated expertise in the research community, some of operational centers from the developing countries in Southern Hemisphere – for a variety of reasons – are not routinely using these products in their analyses and forecasts.

The reasons include a lack of: understanding of existing satellite capabilities, as well as how and where to access derived products from observations collected by those capabilities; sufficient computing capabilities and high-bandwidth communications; and knowledge concerning how to incorporate them into operational analyses and forecasts. Instead, these centers are simply basing high-seas forecasts on model output from Northern Hemisphere centers like NCEP,

FNMOC, UKMO and/or ECMWF. This is unfortunate, given that current numerical weather prediction (NWP) models are unable to fully resolve the spatial structure, as well as the maximum wind speeds, associated with extreme events like hurricanes and winter storms.

Looking to the Future

In the not-too-distant future, there will most likely be a sufficient number of scatterometers in orbit with the potential to provide global coverage of the OSVW field *every six hours!* If the resulting observations could be freely shared in a timely manner, this would enable standard six-hourly surface meteorological analyses over the oceans with comparable accuracy and coverage as currently exists over land in most developed countries. This in turn could have a substantial impact on the improvement of marine forecasts and warnings for the high seas and coastal areas, not only to the benefit of maritime commerce, but also the fishing industry and recreational boaters. However, if SVW and SWH observations collected in the future are to provide such significant benefits to operational marine forecasting, the satellite community[3] needs to ensure that those centers are able to access and utilize similar observations today.

Engaging Operational Users

As a starting point to guide the engagement of users, centers[4] with designated responsibility for operational forecasting in the in GMDSS MetAreas of the Southern Hemisphere were identified. The initial focus is on operational marine analyses & forecasts for the Southern Hemisphere that are enabled by provision of two easily interpretable, satellite-derived products – OSVW & SWH. Efforts were made to establish contact with each of these centers in order to make an assessment of the extent to which that center had timely access to, and a capability to use, these two products.

Why such low operational use?

Looking at the figure below, it is apparent that relevant observations – SVW and SWH – from the satellite capability that has existed for the past decade and a half are not being used universally in operational centers with responsibility for a number of Southern Hemisphere GMDSS MetAreas. There are a variety of issues contributing to this situation.

1. Unaware of the two scatterometers and three altimeters, as well as their capabilities, presently flying on five different satellites.
2. Unable to access the operational meteorological data distribution system, the GTS.
3. Unable to decode the BUFR-formatted files on GTS, and each satellite requires a separate decoder.
4. Computing power and/or bandwidth limits ability to sort through files on the GTS that have little correspondence to areas of interest.

[3] The OSVW VC is partnering with the *Ocean Surface Topography VC* to facilitate access to SWH in addition to SVW products.

[4] While the WMO has designated the Marine Meteorological Service, Brazilian Navy as having responsibility for operational forecasting for MetArea V, please note that the National Institute for Space Research also provides operational forecasts for this general area.

5. Must write a proposal to get FTP access (note that most of the centers access these observations, not via the GTS, but rather via FTP sites).
6. Must go to five different FTP sites, each with different procedures for access.
7. Don't necessarily know when products become available on each FTP site.
8. Difficult to integrate OSVW & SWH products into analyses.
9. Forecasters don't know how to use the products.

Met Area	High-Seas Operational Forecast Responsibility	Data routinely used in operational forecasts? If so, how are they accessed?			
		Surface Vector Winds		Significant Wave Height	
		QuikSCAT (to go on GTS)	ASCAT	Jason-1 & Jason-2	ENIVSAT (to go on GTS)
V	*Marine Meteorological Service, Brazilian Navy*	*Yes FTP*	*No*	*No*	*No*
□	*National Institute for Space Research, Brazil*	*Yes FTP*	*No*	*No*	*No*
VI	*Servicio Meteorológico Nacional, Argentina*	*Some FTP*	*No*	*Some FTP*	*No*
VII	*South African Weather Service*	*Some FTP*	*No*	*No*	*No*
VIII-S	*Mauritius Meteorological Service*	*No*	*No*	*No*	*No*
X	*Australian Bureau of Meteorology*	*Yes FTP*	*Yes FTP*	*Yes GTS*	*Yes FTP*
XIV-N	*Fiji Met Service*	*?*	*?*	*?*	*?*
XIV-S	*Met Service of New Zealand*	*Yes FTP*	*Yes FTP*	*No*	*No*
XV	*Servicio Meteorológico de la Armada, Chile*	*No*	*No*	*No*	*No*

What can be done to address these issues?

Contributing to these issues are some actions which fall fully within the domain of the satellite providers and some that also involve operational users. For the satellite providers, these can be summarized as follows, together with some recommended actions.

- A data policy is needed to enable timely operational access; this is an issue for the following:
  - ESA to provide such access to Envisat altimeter data without an operational user having to submit a proposal.

        - At an earlier SIT meeting, ESA had verbally mentioned this as a possibility for SWH via the GTS, but this needs confirmation; would ESA be willing to do the same for access via FTP?
    - ISRO to provide such access to Oceansat-2 and SARAL scatterometer and altimeter data, respectively.
        - CNES is in discussions regarding SARAL data sharing.
        - EUMETSAT has a high-level agreement regarding Oceansat-2 data sharing.
        - NOAA and NASA are in the process of negotiating an agreement regarding Oceansat-2 data sharing.
    - SOA-CNSA to provide such access to altimeter and scatterometer data from HY-2A, as well as scatterometer data from CFOSat that is joint with CNES.
        - CNES, EUMETSAT and NASA have been in discussions with SOA-CNSA about data sharing.
        - NOAA is interested in such discussions as well, but they have not yet been initiated.
- A means is needed to facilitate access by an operational center to data corresponding to that center's area of interest:
    - For data going onto the GTS, a separate BUFR decoder is required for each; this needs to be documented by each satellite provider, as some users may prefer accessing these products via the GTS.
    - For data being made available via FTP, access procedures need to be documented by each satellite provider.
    - For other means, like GeoNetCast, access procedures need to be documented.
    - Note that each new source of satellite observations will require an interface with each user.
- As an alternative to the point just above, if all SVW observations were collected at a central FTP site, a user would only have to go to that site and download one set of data – in effect, providing a single point of access or *one-stop shopping* for all data of that type. This is obviously the preferred approach. A given user would only have to be familiar with one set of procedures to access SVW data from multiple sources; the same could be the case for SWH. NOAA and EUMETAT, as corresponding operational satellite agencies on each side of the Atlantic, would be most appropriate to take the lead in reaching agreement for both SVW and SWH on the following:
    - Agree on one simple, common operational product.
    - Agree on a single, self-describing, hardware-independent format (like NetCDF) to package the data in order to avoid the issue encountered with BUFR encoding used by the GTS.
    - The FTP site should enable a given operational user to download only those data corresponding to a specific area and time period of interest.
        - NOAA has an FTP site[5] for SVW where it offers ASCAT and QuikSCAT SVW products in imagery form.
        - KNMI has an FTP site[6] offering imagery and digital data from both ASCAT and QuikSCAT SVW, in NetCDF and BUFR formats, together with a BUFR decoder for both sensors.

[5] <http://manati. orbit.nesdis.noaa.gov/doc/oceanwinds1.html>
[6] <www.knmi.nl/scatterometer/>

        - A similar FTP site is needed for SWH; CNES supports CLS to operate AVISO (Archiving, Validation and Interpretation of Satellite Oceanographic data) for the distribution of satellite altimetry data from all altimeter missions; the feasibility of using this site for timely access to SWH from all altimeters is being assessed.
    - With a *one-stop shopping* site for each product, as new satellite sources of SVW and SWH become available, data from each could be seamlessly integrated into its respective web site without any involvement on the part of operational users.

Training and Capacity Building

Some actions need to be shared between the satellite providers and the operational users. These are best addressed through an ongoing training and capacity building effort directed at enabling operational forecasters in developing countries to focus on the interpretation and use of these new (at least to many of them) products. This will involve more than a single workshop; it will require ongoing collaboration. Moreover, because some members of the research community in Brazil, Chile, Argentina and South Africa are accessing and using these products in delayed mode, they represent a potentially important *in-country* element for an ongoing training effort for operational forecasters.

Both the Meteorology Department of the University of Buenos Aires, Argentina and the IOC Training Facility in Oostend, Belgium have offered to host training workshops for operational marine forecasters. Both have computer labs and appear suitable for hosting a training course. The former offers the prospect for broader participation from forecasters and researchers in South America; however, the latter has offered pay the travel for a dozen participants from the Southern Hemisphere to come to Belgium for training. Since such a workshop has not been conducted before, a decision was made to take advantage of the IOC Training Facility to organize an initial workshop for a smaller group of participants. This would enable using it to develop the curriculum, understand specific issues facing operational forecasters, identify problems encountered, and take corrective action. Then once organized, and depending on lessons learned, the course would be taken to venues like the University of Buenos Aires for subsequent workshops.

Consequently, the initial workshop will be held as follows:

- Date and Venue. The week of Dec 14-18, 2009 has been selected, and the venue is the IOC Training Facility[7] in Oostend, Belgium.
- Organizing Committee
    - Membership (in addition to the Constellation Co-chairs (Stan Wilson, Hans Bonekamp & B.S. Gohil)
        - Julia Figa Saldana, EUMETSAT
        - Paul Chang and Zorana Jelenak, NOAA NESDIS
        - Murray Brown, IOC IODE
        - Ad Stoffelen, KNMI
        - Joe Sienkiewicz, NOAA NWS

[7] http://www.oceanteacher.org/oceanteacher/index.php/Operational_MarineResources_Articles_Format

        - Kerry Sawyer, NOAA NESDIS
    - Terms of Reference
        - Assume responsibility for organizing the initial workshop.
        - Identify criteria for identifying instructors and students, and make suggestions, as appropriate.
        - Participate in the preparation of course materials, as well as the conduct of the workshop, as appropriate.
        - Provide a critique of the initial workshop for use in organizing follow-on workshops.
- Trainers. We would tentatively like a pair of operational marine forecasters, as well a pair of instrument scientists; these are being finalized.
    - Joe Sienkiewicz of NOAA/NCEP's Ocean Prediction Center; travel funds will be required for Joe.
    - Either Paul Chang or Zorana Jelenak of NOAA/NESDIS is interested and available.
    - We need someone with operational experience in forecasting for tropical regions; Rick Knabb is unavailable and has suggested Mike Brennan at TPC; travel funds would be required for Mike as well, assuming that he is available.
    - We need European representation to balance that of the U.S.
        - Ad Stoffelen is interested and available.
        - Julia Figa is inquiring about the availability of an operational forecaster from Europe.
    - Murray Brown at the IOC IODC Training Facility in Oostend has extensive experience organizing and running training courses in a variety of ocean-related topics, so he will be an invaluable source helping assemble the curriculum.
    - We are also seeking an instructor from Australia and/or New Zealand.
- Participants. An operational forecaster and a researcher from each of these countries: Argentina, Brazil, Chile, South Africa, Fiji and Mauritius.
    - Candidates are in the process of being identified, with invitations subsequently to be sent out.
- Curriculum. Note that Mike Freilich, Paul Chang and colleagues have already prepared a set of web-based instructional materials from which this training and capacity building course can draw. An instructor-in-charge needs to be identified and start outlining the course, building on the existing materials noted below.
    - Comet QuikSCAT module http://www.meted.ucar.edu/npoess/scatterometry/
    - Visit QuikSCAT module http://rammb.cira.colostate.edu/visit/qswinds.html
    - Visit ASCAT Module http://rammb.cira.colostate.edu/visit/ascat_winds.html

Implementation Plan – Summary of Actions.

Action 1. Identify or establish a central FTP site to provide a single point of access for operational SWH products from Jason-1, Jason-2 and ENVISAT. NOAA and EUMETSAT, as corresponding operational satellite agencies on each side of the Atlantic, to take the lead for this action.

Steps:

- NOAA and EUMETSAT to agree on one simple, common operational SWH product, as well as a single, self-describing, hardware-independent format (like NetCDF) to package the products for access via FTP.
- The FTP site should enable a given operational user to download only those data corresponding to a specific area and time period of interest.
    - A query is pending with the CNES-sponsored AVISO facility operated by CLS in Toulouse.
    - If such a capability is not available, use the KNMI FTP site as a guide to estimate associated cost to establish one.
- September 9 – Review status during the meeting of the NOAA-EUMETSAT High Level Working Group in Darmstadt.
- October 1 – Either identify an FTP site for SWH access or deliver a proposed plan with cost estimates to establish such a site.
- November 1 – If no FTP site can be identified, either implement the proposed plan or – if no funds can be acquired for implementation – develop an alternative plan whereby each satellite provider of SWH supplies (1) a BUFR decoder with suitable documentation for each source of SWH data going onto the GTS, and (2) suitable documentation for each source of SWH being made available by FTP.

Action 2: Address and, to the extent feasible, resolve data policy issues to enable timely operational access to SWH data products. NOAA and EUMETSAT to take the lead for this action.

Steps:

- September 9 – Arrange side meeting between NOAA-EUMETSAT and ESA during SIT-24 in Darmstadt to determine if it is willing to provide timely access to Envisat altimeter SWH products – both via GTS and FTP – without an operational user having to submit a proposal. Note: At an earlier SIT meeting, ESA had verbally mentioned this as a possibility for ENVISAT SWH via the GTS, but this needs confirmation; would it do the same for access via FTP?
- September 9 – Arrange a similar side meeting between NOAA-EUMETSAT and ISRO during SIT-24 to determine if it is willing to provide similar timely access to Oceansat-2 scatterometer SVW products – both via GTS and FTP; if ISRO is not represented at SIT-24, NOAA and EUMETSAT convene separate meetings with ISRO on their next trip to India.
- September 9 – Arrange a meeting between those agencies interacting with SOA-CNSA – CNES, EUMETSAT, NASA and NOAA – to discuss the most appropriate approach regarding timely access to HY-2A altimeter and scatterometer products.

Action 3: Organize a Training Workshop in concert with the IOC Training Facility in Oostend, Belgium. NOAA and EUMETSAT, working through the IOC Training Facility, to take the lead for this action.

Steps:

- Completed – Establish a Steering Committee (SC) with Terms of Reference for the organization of the workshop. The committee includes representation from NOAA, EUMETSAT (especially its User Service Division), and the IOC Training Facility – as well as operational marine forecast services.
- September 15 – SC identifies trainers for the workshop: operational forecasters and instrument scientists, with a view toward balancing U.S. and European contributions. Candidates include:
    - Joe Sienkiewicz, NOAA/NCEP Ocean Prediction Center; he is committed, but travel funds likely required.
    - Either Paul Chang or Zorana Jelenak of NOAA/NESDIS is committed for QuikSCAT.
    - Ad Stoffelen of KNMI is committed for ASCAT.
    - Mike Brennan of NOAA/NCEP's Tropical Prediction Center is under consideration, but would require travel funds.
    - Julia Figa is inquiring about the availability of an operational forecaster with the Norwegian Meteorological Service
    - Stan is checking on an operational forecaster with tropical experience from Australia BoM or New Zealand.
    - Someone with experience using SWH is needed.
- September 15 – SC outlines prerequisites and issues invitations to an operational forecaster and a researcher from each of these countries: Argentina, Brazil, Chile, South Africa, Fiji and Mauritius.
- October 1 – SC designates a lead trainer who, together with the additional trainers, will start development of the curriculum by building on existing web-based instructional materials, as well as existing IOC training courses.
- November 15 – Trainers finalize the curriculum and provide reading and homework assignments, as well as the IOC [who will cover travel costs for as dozen students] finalizes invitational travel for prospective students.
- December 14-17 – Conduct the workshop.
- December 17 – Trainers and students to capture lessons learned and make recommendations for follow on workshops.
- January 15 – Building on lessons learned, SC outlines a follow-on workshop to be conducted in the Southern Hemisphere at a venue such as the University of Buenos Aires.

Performance Metric/Success Criteria

All Southern Hemisphere centers with responsibility for operational forecasts for GMDSS MetAreas routinely utilize SVW from all current scatterometers and SWH from all current altimeters in all marine analyses and forecasts (ie, all of the boxes in the table on page 4 are colored *green*).