



Report of the First International Operational Satellite Oceanography Symposium

18 - 20 June 2019

NOAA Center for Weather and Climate Prediction
College Park, Maryland USA

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Executive Summary

The First International Operational Satellite Oceanography (OSO) Symposium, which was organized and sponsored by the National Oceanic and Atmospheric Administration (NOAA) and the European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), was held June 18-20, 2019 at the NOAA Center for Weather and Climate Prediction Center in College Park, Maryland, USA. Approximately 150 people from a total of 30 countries participated in the OSO Symposium. Fifty-two people attended an optional day of training related to satellite oceanographic data processing and use on Monday, June 17. The purpose of the symposium was to bring together, for the first time, the international community of providers and users of operational satellite oceanographic data and products in order to better define and understand the barriers, actual or perceived, hindering the use of satellite oceanographic observations and facilitate the widespread incorporation of satellite data into the value chain across the range of operational applications.

The capability to remotely estimate ocean properties from satellites is continuously increasing in maturity and scope. Sea surface temperature, height and roughness, ocean vector winds and bio-optical properties, such as chlorophyll concentration, are now available on a routine and sustained basis. These products are integral to operational applications for routine and event-driven environmental assessments, predictions, forecasts and management, as well as for research and other exploratory scientific endeavors. Yet these satellite observations are still underutilized and represent a huge potential for contributing to societal needs and to the still emerging “Blue Economy”.

In this inaugural symposium, the focus was on the “upstream” components of the value chain, i.e., the international community of satellite operators, information producers and intermediate to high level users, in order to exchange facts and ideas on how to understand user needs and expectations and develop interoperability standards and establish best practices that will lead to more universal use of ocean satellite data. The symposium consisted of plenary and poster sessions. In the first five plenary sessions, invited speakers presented talks and served on moderated panels to answer questions posed by the audience, with each session loosely covering the following themes:

- redefining the operational paradigm;
- linking data providers to information providers;
- helping users find the information they need;
- facilitating the end-to-end value chain; and, understanding commercial provider needs.

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After a summation of the previous sessions, leaders in economics, the commercial sector and future operational satellite missions offered their perspectives on the future of operational satellite oceanography. The symposium adjourned after closing remarks and recommendations. This document is the symposium report summarizing the symposium contents, the identified challenges and suggested recommendations. Additional information about the OSO Symposium can be found at its website: <https://www.eventsforce.net/osos2019>.

The symposium was a success and marked the beginning of a bi-annual event where those involved at all levels of the value chain, from data providers to end-users, will converge in an effort to foster the use of operational satellite oceanographic data, products, applications and services in order to provide greater societal benefits. The next OSO Symposium will convene in Frankfurt, Germany during Spring 2021 and will focus on topics that include assimilating operational satellite oceanographic data and products into weather and oceanic numerical models to improve their predictive skill, and accelerating user engagement – particularly in coastal zones which are of great socio-economic importance.

The following is a list of key recommendations coming out of the symposium:

- Expand / clarify the definition of operational
- Create sensor agnostic products
- Simplify complex satellite data into straightforward information that is fit-for-purpose
- Generate consistent, accurate long-term and merged time-series and anomalies
- Reduce latency of data and products
- Increase operational in-situ data collection systems for calibration & validation
- Address product uncertainties
- Improve outreach, training and communication
- Compile, establish and socialize best practices for engaging users
- Educate users on what data and products can/will be provided
- Solicit user feedback on product/services/applications on a routine and sustained basis
- Establish a framework and mechanism to better coordinate and integrate among and across data providers, information providers, and end users
- Adopt methodologies to assess the value of satellite observations and apply them consistently and systematically
- Investigate connections between ocean and atmosphere impacts on terrestrial forecasting and weather prediction over land, as well as bidirectional flow of water and exchanges of materials (e.g., sediments, nutrients) across the land-sea interface
- Expand use of satellite observations in models for initialization, data assimilation

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Program

OSOS 2019 Schedule-at-Glance

	Monday 17 June	Tuesday 18 June	Wednesday 19 June	Thursday 20 June
8:00		Registration*	Executive Committee Meeting	Executive Committee Meeting (as needed)
8:15				
8:30				
8:45		Brown Convenes; Volz Introduces Jacobs	Session 2: Linking Providers & Users: Brown	Session 4: Commercial Provider Forum: Rayner
9:00	Registration, laptop set ups, logins, class logistics, etc.	Welcoming Address: Neil Jacobs	User stories: CW/OW/PW -Cara Wilson	
9:15		Why Are We Here?: Montagner		
9:30		Current Status: Rayner	IFREMER - Bentamy Abderrahim	Session 4 Panel Discussion
9:45		Antonio Reppucci Keynote - 25 mins 5 min Q&A	Univ. of Chittagong - M. Muslem Uddin	
10:00	Training Course 10 am - 4 pm		NOAA - Avichal Mehra	Break
10:15		Break	Break	Session 5: Gov't to High Level Users & End2End Integ'tion: Montagner
10:30		Session 1: Redefining Op. Paradigm:	CMCC - Rita Lecci	ECOWAS - Bennet Foli
10:45		CW/OW/PW - Veronica Lance	MRI - Yosuke Fujii	PORSEC-Gad Levy
11:00		EUMETSAT - Estelle Obligis	NOAA - Jiangtao Xu	BluePlanet - Emily Smail
11:15		NOAA - Paul DiGiacomo	Session 2 Panel Discussion	NOWPAP/Japan - Genki Terauchi
11:30		Group Photo		CLS - Patrick Lehodey
11:45				Session 5 Panel Discussion
12:00		Lunch and Posters	Lunch and Posters	
12:15				Lunch and Posters
12:30				
12:45				
13:00		NOAA Observations - Tom Cuff	Session 3: Helping Users Shop in the Data	
13:15		GHRST - Anne O'Carroll	NOAA - Mark Eakin	Session Summaries & Comments
13:30		BoM - Helen Beggs	USC - Subra Bulusu	
13:45			EUMETSAT - Hayley Evers-King	
14:00		Session 1 Panel Discussion	NOAA - Melanie Abecassis	
14:15			NOAA - Ken Casey	
14:30	Poster Intros	NOAA-Ed Kearns	Break	
14:45	Break	Break	Path Forward Town Hall Paul DiGiacomo Moderator (St. Germain, Bojkov, Lauer, McLean & Rayner)	
15:00			Closing Remarks, Recommendations, Next Symposium and Adjourn	
15:15		Session 3 Panel Discussion		
15:30				
15:45	Poster Session 1			
16:00		Poster Session 2		
16:15				
16:30	Break and Walk to ESSIC			
16:45				
17:00				
17:15	Dinner on your own	Reception with refreshments and vendor/DEMO room	Dinner on your own	
17:30				
17:45				
18:00				
18:15				
18:30				
18:45				
19:00				

Brief Session Summaries

Welcome, Opening Remarks and Keynote Address:

Dr. Stephen Volz, NOAA Assistant Administrator, National Environmental Satellite, Data, and Information Service (NESDIS), followed by Dr. Neil Jacobs, NOAA Acting Administrator, provided broad perspective and articulated challenges and opportunities. Significant progress to date in developing, maturing and utilizing satellite oceanographic data products was noted, as were the rapidly expanding opportunities for these data to provide even greater societal benefits (e.g., Blue Economy) in the coming decade. Identifying effective ways to acquire and manage these large data sets and more so extract and distribute actionable information for diverse stakeholders is crucial. Collaborative efforts across global, regional, national and local entities (e.g., agencies, academia, non-profits, private sector) are key to realizing these opportunities.

Dr. François Montagner (EUMETSAT) articulated the goals of the conference:

- Understand barriers to increased satellite data usage
- Identify opportunities for increasing data usage
- Understand needs/expectations of value chain actors (Satellite operators, Ocean model operators, Value added providers, and End users)

Dr. Ralph Rayner (London School of Economics) summarized the current status of Operational Oceanography. He indicated there are diverse operational processing chains that leverage space-based continuity of key parameters, including assimilation of these data into operational forecasts (ocean/atmosphere), and provided several examples of operational delivery mechanisms and services. Challenges include addressing transitioning new observing technology into long-term sustained capabilities, increasing spatial and temporal resolution of satellite observations, and efficiently and effectively distributing and more so distilling the large volumes of data currently available to a diverse set of users.

The five overarching questions for presenters to answer in their presentations were discussed:

- *What do you use the data/products for? What is its purpose?*
- *What data / products are you using and are they described adequately?*
- *What are the barriers and problems you encountered?*
- *What is easy and useful?*
- *What would you like to see done differently?*

Concluding this introductory session was a keynote address by Dr. Antonio Reppucci (Mercator Ocean International) on the crucial need for sustained ocean monitoring to better understand and predict changes in climate and weather and the operational role played by the Copernicus Marine Environmental Monitoring Service (CMEMS) in this context.

Redefining the Operational Paradigm

Session Facilitator: Veronica Lance

This initial session provided the context and foundation for the entire symposium. Detailed overviews of operational ocean data providers and related programs were provided by V. Lance, E. Obligis, P. DiGiacomo, G. Nolan, T. Cuff, A. O’Carroll, L. Santoleri and H. Beggs.

Operational (satellite) oceanography data has traditionally been interpreted to mean data delivered in near real-time with high reliability, but potentially of lower quality; this is a misinterpretation. Instead, operational data are routine and sustained, accurate and fit for purpose, well-described and readily discoverable, offered with different latencies, quality, assurance models, formats and product types for diverse users – spanning researchers to resource managers. Users ultimately seek “Environmental Intelligence”, and depending upon their specific needs require products on a near real-time basis - best possible quality data, time permitting, and/or on a delayed mode, time-series (climatological) basis - highest quality data available, time-independent; this better reflects the broader, holistic definition of operational.

Operational agencies and entities are shifting to a source agnostic approach, i.e., products generated on a routine, sustained and consistent basis using enterprise algorithms. Products are increasingly being merged (Level 3) and blended (Level 4, Gap Free) across sensors. As such product development must be consistent, interoperable and fit for purpose, e.g., analysis ready data. Greater cross-parameter analyses as well as enhancements to data assimilation and forecasting are also required, especially in the biological and biogeochemical realms.

Cooperative division of tasks should be leveraged among partnerships whenever and wherever possible; agencies should not ‘do it all’. For example, international scientific bodies like GHRSSST help enable ‘operational exploitation’ of satellite data, striving for nimble approaches and enhanced coordination between providers and users. Satellite data validation as well as quality assurance/control efforts must also increase in frequency and expand in scope. Most validation efforts come out of the “Global North”, particularly the US and Europe. Data providers and representatives of users in under-validated areas must work together to tackle this challenge.

The balance between innovation and the ability to provide sustained and consistent services to users is difficult. A sustained process is necessary to understand, evaluate and address user needs. Data providers should not overestimate, nor judge, users’ potential understanding about the data sets they (wish to) utilize. Some users might want Level 1 data, others gap-free data sets. Outreach and engagement efforts are crucial to getting data out to the community and used in a fit for purpose manner. Some users will be able to pick up the data and readily utilize it, but some might lack certain skills or knowledge or be too intimidated to try, so different approaches are required. Hands-on classes are one highly effective method but limited in scope and coverage; virtual training, especially for developing regions, will soon be de rigueur.

Linking Providers & Users

Session Facilitator: Christopher Brown

The focus of this session was primarily on operational ocean forecasting systems and services. These included discrete ocean systems (R. Lecci, J. Xu) as well as coupled systems for weather and climate prediction (A. Mehra, Y. Fujii), complemented by views of specialized value-added services (C. Wilson), with broader perspectives on large ocean analyses (B. Abderrahim) and enhancing ocean knowledge and its dissemination to benefit the general public (M. Uddin).

Users are increasingly being presented with rich, diverse, and ever-expanding data sets. They need education, powerful tools and assistance to navigate through that space and determine which products best fit their needs. When those needs remain unmet, there is a strong drive by data providers to enhance and augment their offerings, eventually adding to the existing wealth and diversity of products. The challenge of data discovery thus becomes reinforced. Responding to that challenge would be addressed in the following session.

Two aspects emerged prominently from the presentations and panel discussion: the users' need for knowledge of the data, and the users' need for knowledge of the data uncertainty. In order to assess if a product is useful or not, users need some knowledge about the uncertainty of the data products. Operational users, such as the operators of models assimilating data, require details about the scope and validation of those data, and associated pre-processing quality assurance and quality control schema. Furthermore, assimilation schemes and multi-parameter analyses require specific definition of uncertainties in terms of accuracy, precision, and error covariance.

Standardization is also often lacking with these and other important details frequently missing, and significant variability observed across data providers and products. Data sets are frequently far from being analysis-ready or ingest-ready. Improved adherence to standards and product consistency are required to ensure interoperability across observing systems, with greater attention paid to data formats and metadata structures, variables, and services for implementation, including the availability of uncertainty measurements, transformation capabilities, and data quality flagging as appropriate.

Responding to these diverse user needs represents a significant challenge, as well as a valuable opportunity, for satellite data providers to facilitate greater and more effective and timely use of their data. Similarly, users are strongly encouraged to provide more (substantive) feedback to data providers on a routine basis and to clearly indicate their needs and specify their requirements and the extent to which they are being met.

Helping Users Shop in the Data Supermarket

Session Facilitators: Avichal Mehra & Mohammad Muslem Uddin

The presentations in this session highlighted the wealth and diversity of the data available for operational oceanography, and of the efforts made by agencies to facilitate discovery and access for their users.

NOAA's Coral Reef Watch (M. Eakin) and OceanWatch Pacific (M. Abecassis) gave examples of focused, tailored services for specific types of users and applications, integrating and curating data sets and adapted tools for optimal use. The effective interactions and dynamics of the continuous exchange between these data and service providers and their users is dependent upon the common understanding of mission and needs and likewise shared expertise across those groups.

The presentation on Copernicus marine service (H. Evers-King) illustrated a broad range of data, services and applications. There, user support rests on a vast offering of training and outreach service, implemented jointly by the space component and the service component. The closest analogue at NOAA, the overarching CoastWatch/OceanWatch/PolarWatch Program, was highlighted in the earlier operational session (V. Lance). The presentation of NOAA's strategy for "moving data and apps to the cloud" (K. Casey) focused on the reflections and issues regarding the application of emerging technical solutions to a very large and diverse collection of data, serving a very diverse population of users.

Discussions focused on the fitness for purpose of operational data services: establishing, documenting, and using that notion of fit-for-purpose as a criterion for selection. Approaches incorporating user feedback to the meta-data, such as notation or tagging of data sets, are in progress. CMEMS is displaying a growing collection of showcase applications, each one as a "story" explaining which data and models are used in response to an individual need.

Discussions on "one-stop" shopping approaches vs. interoperability of diverse data services raised issues such as the heterogeneity of data policies across providers, or the logics of data selection and merging, e.g. regional, or temporal, or just "seen as useful for a given purpose". Agencies tend to endorse responsibility for ensuring that their data are used correctly, this can be implemented by training, distribution of tool kits, etc. and varies across agencies.

Artificial intelligence is anticipated to assist agencies in supporting their users, e.g. by implementing expert "personal shoppers" or applying service usage analytics to know better how data are selected and combined by users and applications. Approaches such as knowledge hubs are also anticipated to support both expert as well as general uses dependent upon their specific needs and applications – ideally supported by expert curation from the data providers.

Commercial Providers Forum

Session Facilitator: Ralph Rayner

Presentations from the added value intermediaries – some fully commercial, some public-private-partnerships – demonstrated how they focused on end-users who need information in support of decision making.

Fisheries management, in particular helping fisher fleets to fish more sustainably, effectively and safely (T. Strub, J. Li), is a widespread and rapidly evolving topic, with interest from both fisheries and regulating authorities. Marine infrastructure developers and operators, including local/regional/national authorities, are also catered to by diverse intermediaries, e.g. Collecte Localisation Satellites (CLS) (C. Dufau).

Public and private sector complement each other well. By and large, the public sector maintains responsibility for large infrastructures, e.g., satellite, ground segment, data portals, etc. and for the quality of their products. The added value providers respond to specific needs with tailored services on top of/beyond those from the public sector.

Value added providers appear to be more agile and good at customization. As long as they foster and maintain dialogue with their users, they also feel they get to know faster about the value of their services. The public sector also strives to establish the value of its services, and the infrastructures they are based upon, as an essential justification of its activity.

Feed-back loops are often looser and specific outreach efforts are deployed to improve them, e.g., the service uptake “Invitation-To-Tenders” that are issued by Copernicus. The value-added sector largely relies on a public service providing quality data including *in situ* measures, and free access to those data remains a necessary condition for their economic model. However, if private satellite ventures began catering to the market, value added providers would still be the best placed to identify whether their data bring added value and to put them to use.

End-to-End Integration

Session Facilitator: François Montagner

The session on end-to-end integration highlighted the variety of approaches constituting the state of the art and the attendant transitions into routine and sustained operations.

A Global Monitoring for Environment and Security (GMES) and Africa marine and coastal areas management project in Ghana was presented (B. Foli) that integrates satellite and model data to address the needs of local authorities as well as those of the local communities of fishermen. The widely differing needs result in a range of products produced. These include fully documented reports created for local authorities, whereas at the other end of the spectrum are the daily Short Message Service (SMS) messages sent to fishermen to alert them to the predicted sea state.

An aid to fisheries management in the Caribbean (P. Lehodey) illustrated how an application can be progressively enhanced by adding in-situ and satellite observations and model data. A climate project (G. Levy) aiming to improve monsoon prediction in the Indian ocean harnesses "big data " tools to exploit a large collection of observational and model data covering several years, reducing them to simple indicators of known reliability. A water quality project explained its methodology for deriving satellite products fit for their regional purposes: assessing phytoplankton health and productivity in different regions of the Pacific Ocean (G. Terauchi).

A strong overlap exists between the success factors in the examples presented at the Symposium and those identified by the Group on Earth Observation (GEO) and its Blue Planet Initiative (E. Smail):

- Engagement of all parties along the whole project;
- Continuity of the service and iterative approach to improve it progressively;
- User support, education and outreach;
- Importance of time series and good quality in situ reference data.

Data providers need to improve the information about uncertainty supplied with products – making this aspect a prominent attribute constituting "fitness for purpose". Also, considerable effort is spent by information integrators in pre-processing the various data sets they use to create their application specific integrated products, and they have a general request for better support for the merging and fusion of data through the implementation of standards and the distribution of adequate tools as discussed earlier.

The discussion of the development cycles and iterative approach, and of improving their agility, triggered a discussion about access by integrators to satellite products that are still experimental or under initial validation; the debate revolved around how the risks associated with using immature data may offset the gain of time in bringing the application to market.

Session Summaries & Comments

Session Facilitator: Paul DiGiacomo

A) Desired focus areas as outcome of the First Symposium

Session 1 - Redefining the Operational Paradigm

- Merged sensor-agnostic data sets/products for long-term series for all parameters
- More training and outreach

Session 2 – Linking Data Providers & Users

- Compile and/or establish best practices for engaging and enabling users
- Data providers should sensitize users to limitations and “fit-for-purpose” uses by giving users more metadata and information about product uncertainties

Session 3 – Helping Users Shopping the Data Supermarket

- Better curation; getting the “right” data to the right users and avoid having the “wrong” data going to users relative to their specific needs and applications
- See also 2nd bullet under Theme 2 above

Session 4 - Commercial Providers

- Make the case for sustaining observing systems by demonstrating the benefits and outcomes benefiting society
- Suggested reading: [OECD Report, Rethinking Innovation for a Sustainable Ocean Economy](#) (the chapter on ocean observations - p 155) and the [NOAA IOOS Ocean Enterprise study](#)

Session 5 – End to End Integration

- Reliability of satellite products hinges on the accuracy of, and information associated with, the products

B) Missed Opportunities for Discussion – topics that should be revisited in future

- Deciding which algorithms to use for a product. This is a science community question, but it is germane to what is “fit-for-purpose”. Revisit role of data providers as curators of data and helping to match or brokers user needs and data/products.
- Data provenance and fidelity is an area of need (e.g., potential role of blockchains).
- Assimilate satellite data into models instead of just ‘looking at the surface’ of the ocean; providing routine and sustained three/four-dimensional characterizations of state and forecasts/predictions.
- Potential for small (e.g., micro/CubeSats) satellite missions; examine trade-offs in coverage, accuracy and cost.

- How to best ensure consistency in data records and interoperability across missions from different providers (agencies, private sector et al.) – ensuring trends are real and not spurious artifacts.
- Need to build trust with users. They will cooperate and share more when you reciprocate; promote and engage in co-design and co-develop principles.
- Need to bring on training and education professionals in curriculum development.

The Path Forward Town Hall

Invited Expert Panel: Bojan Bojkov (EUMETSAT), Chris Lauer (NOAA), Craig McLean (NOAA), Ralph Rayner (LSE), Karen St Germain (NOAA)

Moderator: Paul DiGiacomo

Each panelist spoke to the priorities and desired outputs and outcomes that had been raised during the Symposium, with additional feedback and comments from the perspective of their organizations, inter/national roles and responsibilities, and their respective experience and expertise. Selected highlights from the panel, and subsequent participant discussion, included:

- The need to effectively bridge in situ and satellite oceanography through international collaborations between data providers (e.g., GOOS, CEOS) in support of diverse users.
- Significant opportunities exist to increase technology transfer, capacity building and broader utilization of satellite data for societal benefits, particularly identifying and transitioning best practices and solutions, e.g., from developed to developing nations.
- An important recent development is the United Nations (UN) Decade of Ocean Science 2021-2030. The Intergovernmental Oceanographic Commission (IOC) is responsible for producing the implementation plan for this Decade of Ocean Science that will also include a science plan. One particular challenge is how will the UN Decade be leveraged to engage and support all contributors and stakeholders.
- Measurement capabilities have greatly improved since the early days of Earth observations, and instruments are increasingly providing invaluable information which is not just an approximation anymore. That said greater clarity and transparency are needed to more fully describe the data that we are providing to our users, including any limitations or constraints.
- Agencies have already committed to missions and sensors that are going to be sustained for the coming decade and beyond, coupled with significant opportunities to infuse new and improved capabilities and techniques, e.g., higher resolution, in the coming years.

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- Agencies need to create room to onramp new capabilities on satellite architecture, as well as explore more low earth orbit options and highly elliptical orbits.
- A compelling need exists to bring in more partner data than ever before, particularly commercial observations, rideshares for launch capacity to try out other capabilities (private or public), and building payloads. This also requires more secure ingest and expanded/improved data services, including pilot programs for product generation and product demonstrations.
- Whatever progress in capacity and products achieved so far must be at least maintained or preferably enhanced, and the 'free and open access' paradigm must be retained, despite potential challenges to this model.
- New capabilities increasingly coming online will facilitate moving toward fully coupled systems of ocean-atmospheric modelling and synergistic terrestrial and ocean modeling applications.
- The value of (satellite) data products, e.g. it's impact, must be advertised and promoted to justify budgets and prioritize limited resources. Creating data does not guarantee its use. Processing, curation, interpretation and other expert support encourage initial and sustained data use, so the community must build and maintain a value chain.
- Identify what product is used, who uses it, and for what purpose, as well as document what decisions improve or were changed by the information. Economists, scientists, and users/decision-makers need to collaborate to achieve optimal results.
- Know your users, what they need, and why they use it, and create a consistent and robust catalogue of products and benefits, developing examples and sharing case studies to justify and support observations and infrastructure.
- Be interdisciplinary and look for synergies across as well as within user groups.
- As we start planning future architecture, help is needed to define requirements of what should and will be built. It cannot be simply additive - it must be comprehensive. Trade-offs will have to be made, identifying thoughtful trades between cost and benefits, novel vice mature, particularly to enable better outcomes and not just greater outputs. The tradeoffs in capability may justify a high impact investment rather than simply maintaining and sustaining the continuity of existing capabilities and operations.
- Innovation and applied research is crucial to create new and improve products within the framework of our mandate and obligations. Agencies need to engage users, and agencies need more direct and continuous feedback from (intermediate and end) users about products offered, needed etc. Significant efforts, marked by routine and sustained engagement, are required on both parts

Recommendations for Agencies

1. Take outcomes and actions to the Committee on Earth Observation Satellites (CEOS) and the Coordination Group for Meteorological Satellites (CGMS) regarding satellite observations and requirements. Also, it is noted that NOAA and EUMETSAT have similar responsibilities, interests, product suites and users. To this end identify common intermediate providers and leverage the existing NOAA-EUMETSAT partnership to jointly assess and advance agency knowledge of user requirements.
2. Establish better linkages with Ocean Predict vis-à-vis satellite observations to facilitate their greater assimilation and support for improved ocean forecasting.
3. Construct a framework and mechanism to better coordinate and integrate among data providers, information providers, and end users.
4. Tangible needs are now being fulfilled: Long term merged time series for all parameters, as well as compile training resources and best practices. However, gaps and limitations still exist. For example, while we increasingly have accurate measurements of surface ocean currents, the deeper ocean component is still largely bereft of sustained measurements.
5. Improve connections between the ocean, atmosphere & terrestrial domains, and establish connections to socio-economic drivers with global to local anthropogenic influences.
6. Potential foci for future Symposia: Extracting information from products toward development of improved indicators and indices; synergistic ocean forecasting, including linking ocean to weather prediction - in cooperation with large weather organizations; application support, especially for the coastal zone and its diverse users – which have significant socio-economic ramifications.

Next Operational Satellite Oceanography Symposium

The next OSO Symposium will convene in Darmstadt, Germany (25-27 May 2021) and will focus on accelerating user engagement and assimilating operational satellite oceanographic data and products into weather and oceanic numerical models to improve their predictive skill.

Symposium Links

[First International Operational Satellite Oceanography Symposium Web Site](#)

[Organizing Committees](#)

[Oral Presentations](#)

[Posters](#)

Acknowledgements

NOAA hosted the OSOS Symposium in College Park, Maryland USA and provided dedicated onsite staff and support. EUMETSAT kindly sponsored participant lunches, breaks and the Symposium reception. We also thank the hard-working support personnel, including note takers, AV staff, and many other “behind the scenes” folks who carried off this Symposium with aplomb.

Special thanks to Dr. Merrie Beth Neely who participated and coordinated in the various components of the symposium from beginning to end, and gently cajoled us to complete each task. The symposium and this report would not have been completed without her amazing organizational skills and constant oversight.

The views, opinions, and findings contained in this report are those of the author(s) and should not be construed as an official National Oceanic and Atmospheric Administration or U.S. Government position, policy, or decision.