A SCOR Proposal for an Observing Air-Sea Integrated Strategy (OASIS) and/or a GOOS proposal for a GOOS Air-Sea Flux Task Team ??

DRAFT

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OVERVIEW

The surface of the ocean is the portion of the ocean felt by the atmosphere, viewed from space, and experienced most directly by people and most other life on Earth. The ocean influences weather and climate through exchanges of heat, moisture, momentum, greenhouse gasses, and organic Dimethyl Sulfide aerosols; its influence on the Earth's water cycle, carbon cycle, and energy cycle is a critical element of the support of life on Earth. It is therefore imperative that the air-sea exchanges of heat, moisture, momentum, important greenhouse gasses, and organic DMS be monitored globally. To understand these air-sea exchanges and how they couple the atmosphere and ocean, it is equally imperative to understand the fundamental causes, impacts and feedbacks in the ocean and atmospheric boundary layer's chemical, biological, physical and geological components.

The surface of the ocean is observed by satellites and a set of regional and thematic ocean observing networks that provide essential data for addressing critical scientific, societal, policy, and economic issues. Despite many successes, the need for this surface oceanic and atmospheric boundary layer information has outstripped the capabilities of these networks. The surface observations of the Global Ocean Observing System (GOOS) must be enhanced and integrated to be ~~form an Integrated Surface Ocean Observing System (ISOOS) that is~~ "fit for purpose" for a core set of *UN Decade of Ocean Science for Sustainable Development* outcomes, including "a predictable ocean", "a safe ocean", "a clean ocean", "a healthy and resilient ocean", "a sustainably harvested ocean", and "a transparent ocean". A system-as-a-whole approach is called for, and such a task can only be undertaken by a multidisciplinary team.

At present, the GOOS and the Global Climate Observing System (GCOS) rely upon air-sea flux working groups within three separate discipline panels of the GOOS for the definitions of appropriate Essential Ocean Variables (EOVs), Essential Climate Variables (ECVs) and best practices, or standard operating practices, for their observation. These GOOS panels are the Ocean Observations for Physics and Climate (OOPC); biogeochemistry (BGC) and carbon; and biology and ecosystem (Bio-Eco). As an example, the OOPC air-sea flux working group, co-sponsored by the GCOS Atmospheric Observations for Physics and Climate (AOPC), has historically considered only the air-sea heat, water and momentum (wind stress) capabilities (see https://www.goosocean.org/index.php?option=com_content&view=article&layout=edit&id=236).

Here we propose a multidisciplinary air-sea flux Task Team that would combine and expand these GOOS panel efforts into one collaborative GOOS activity. This Task Team, which will

Comment [1]: Do we want a GOOS Air-Sea Flux Task Team? or a SCOR working group for developing an Observing Air-Sea Integrated Strategy (OASIS)? Or both?

I kind of like having both, but it would need to be done carefully to make sure that SCOR has "ownership" over its part. Connecting with "GOOS liaisons" who are not SCOR members might work. It won't get funded though if it is viewed as an arm of GOOS.

Right now this is written as a GOOS TT proposal.

For a SCOR proposal, we would need to have a different title that doesn't reference GOOS and addresses a science question. Language about GOOS would need to be softened to change focus. It would also need to connect to other SCOR activities.

Comment [2]: There is a lot of confusion about what is meant by surface. I get repeated questions about how deep this boundary layer is. Is it to 200 m, with everything below being part of the DOOS and everything above it being part of the integrated surface ocean observing system? Or is it defined in terms of some process, perhaps dependent upon what the property is? This ambiguity is very unsettling to some people.

Comment [3]: Toste Tanhua wrote: I think that we/you should think carefully about the "S" as "strategy" rather than "System".
There is a reason to keep the number of observing "systems" to a reasonable number; there are, as you point out, already observing elements, networks, platforms etc in place for the surface ocean.
A strategy can propose improvements to the current system, and, in the end, maybe suggest a new "system", or improvements to the current system. I think ISOOS is well comparable to DOOS (where "S" is strategy).
This is not set in stone. For instance, for GO-SHIP, the "P" was initially "project" which became ...

report to GOOS Steering Committee, will have a mandate to design the Observing Air-Sea Integrated Strategy (OASIS) that would make the GOOS fit for purpose for the UN Decade of Ocean Science for Sustainable Development 2030 outcomes. The Task Team would also create a strategy for building a community that will create and use the GOOS surface observations, which would be built by and serve a wide range of actors including research institutes, UN agencies, the private sector, NGOs, educators, community groups or individuals (e.g. via citizen science initiatives), indigenous peoples, Small Island Developing States (SIDS) and Least Developed Countries (LDCs), the diversity of which will be reflected within the Task Team.

With this mandate, the primary aim of the multidisciplinary air-sea flux Task Team will be to draft a plan for global multidisciplinary surface and boundary layer observations which GOOS could embrace and support. It is envisioned that GOOS would serve as an umbrella organization for ISOOS air-sea flux measurements. Target air-sea fluxes include heat, momentum, moisture, CO_2, N_2O, and DMS. While the focus of the Task Team will primarily be upon boundary layer observations that are required for estimation of the air-sea exchanges, the infrastructure and logistics needed to collect these observations will facilitate and benefit the observation of other key boundary layer variables, such as those associated with ocean acidification, biodiversity, and ocean health. In turn, the collection of such variables is needed to properly interpret, understand, and model the target air-sea gas and heat fluxes, and to help shape relevant policy options.

The initial core drivers for the strategy considered by the task team, include:

(1) **monitoring and predicting the ocean's influence on global climate on subseasonal-seasonal-interannual-decadal timescales** [This addresses the *UN Decade of Ocean Science for Sustainable Development* outcomes of "a safe ocean", "a predictable ocean"]. This requires sustained observations of the heat, freshwater and momentum exchange between the ocean and atmosphere, which have many of the same requirements as for air-sea gas fluxes.

Comment [4]: I thought that the draft documents on the UN Decade have been a light on air-sea fluxes and their applicability to weather and climate. I think those documents are still in the comment period.

(2) **monitoring and predicting marine weather in the ocean and atmosphere** [*Decade* outcomes: "a safe ocean", "a predicted ocean"]. This requires a subset of the above Essential Ocean Variables, but observed at higher resolution. We note that better ocean eddy and atmosphere weather fields could lead to **improved mapping of marine debris** [*Decade* outcome: "a clean ocean"].

(3) **tracking ocean uptake of carbon dioxide and deoxygenation and denitrification of the ocean** [*Decade* outcomes: "a healthy & resilient ocean", "a sustainable productive ocean"]. These processes and consequent ocean acidification, depend upon not only the physics and chemistry of the ocean, but also strongly depend upon and affect the biology, ecosystem and biodiversity in the ocean. Thus a core driver also includes

(4) **studying how changes in the biology, biodiversity and the surface ecosystems affect surface concentrations of CO_2, DMS, and N_2O and their fluxes** [*Decade* outcomes: "a healthy & resilient ocean", "a sustainable productive ocean"]. The goal would be to provide information

needed to better understand air-sea exchanges of properties. This effort, however, would be a step towards the ultimate goal of sound management of human activities to maximize societal benefits, including a robust blue economy, improved human health, protection of property, and the wise conservation of marine resources.

We envision a multi-scale integrated observing system, with satellites that are optimized for marine boundary layer observations, tuned and validated against a global network of regional in situ platforms. Global coverage of air-sea fluxes at the desired resolution and accuracy will be achieved through consolidation and expansion of the existing networks and introduction of new sustainable ocean technologies, such as autonomous surface vehicles and a new generation of chemical, biological and physical sensors. This will result in a sea-change increase of boundary layer data that will lead to revolutionary improvement in understanding of air-sea interactions and its representations in forecast models and will be used to constrain these improved numerical models.

The GOOS Air-Sea Flux Task Team would build on the work leading up to and following the OceanObs'19 Conference, which assembled more than 1,500 ocean scientists, engineers, and users of ocean observing technologies from 74 countries and across many disciplines. The ocean observing community submitted 140 community white papers (CWPs) with over 2500 contributing authors to OceanObs'19. Numerous CWP addressed concepts associated with surface observing, but were largely siloed by single discipline, network, Essential Ocean Variable, or stakeholder need. The proposed GOOS Air-Sea Flux Task Team would integrate these recommendations into a unified vision for a multifunctional, multidiscipline, Integrated Global Ocean Observing System that will allow near-realtime quantification of the air-sea exchanges throughout the global ocean.

TASK TEAM TERMS OF REFERENCE

- Develop a unified vision for an Ocean-Atmosphere Surface Integrated Strategy (OASIS) that incorporates OceanObs19 community-driven recommendations and roadmaps for obtaining breakthrough accuracy of air-sea exchanges of heat, moisture, momentum, CO_2, N_2O, and DMS
- Initiate, coordinate, and leverage GOOS activities that would lead to improved understanding, observations, and model representation of surface Essential Ocean Variables (EOVs) and Essential Climate Variables (ECVs) needed for evaluating air-sea fluxes
- Liaise with other national and international air-sea interaction working groups and observational coordination groups (e.g., AOPC,WCRP/WDAC Flux Working Group, JCOMM Observations Coordination Group, CLIVAR basin panels, TPOS-2020, SOFLUX, SOLAS, US CLIVAR Air-Sea Interactions Working Group, …) to help promote integration and expansion of the sustained surface ocean observing system.
- Assess existing intercomparisons of in situ and remotely-sensed observations and model estimates of surface air- and sea multidisciplinary EOVs and ECVs, to ensure interoperability. Initiate and coordinate new intercomparisons as needed.

- Promote community best practices for quantifying, measuring, and modeling air and sea surface essential ocean variables, and air-sea fluxes.
- Identify and work with developing nations to create strategies and opportunities for contributing to the Integrated Surface Ocean Observing System observations for quantifying air-sea exchanges and using those observations/information to improve operational weather, climate, and ocean products and services.
- Assess existing surface ocean observing capabilities for measuring air-sea fluxes and provide expert guidance on surface ocean observations for regional observing systems, including guidance on array design and help with setting priorities. Liaise with OceanPredict and other working groups focused on optimizing array design to provide recommendations for surface ocean observations within the global ocean observing system.
- Promote cross-discipline analyses and observational opportunities for enhancing and integrating the air-sea flux and surface boundary layer observations of the GOOS
- Identify and engage stakeholders for the air-sea flux and surface boundary layer observations from GOOS (e.g. WGNE) and initiate communication and feedback

TIMELINE & DELIVERABLES

- **Literature Review (3 months):** Compilation of recommendations from OceanObs19 and a strategy document for determining areas of commonality that can form basis of integrated observing system
- **Workshop (6 months and at 24 months):** Plan and execute two task team workshops for bridging various observing communities, with invited program managers, observers, private and academic sector representatives, including from developing nations. The first workshop will be virtual and help guide the team's efforts. The final workshop will showcase plans for implementing the OASIS. Each workshop will have a capacity building component.
- **Assessment of interoperability of different observing platforms (12-15 months):** There are a wide range of in situ and satellite platforms for measuring EOVs, and even within each type of platform, the technologies can be diverse. Assessments of platform intercomparisons are needed to ensure specification of their measurement uncertainty, a key factor when determining appropriate platforms for a given sampling strategy. These assessments are likely to be ongoing, but are required for developing the OASIS implementation plan.
- **Assessment of array designs (12-15 months):** Begin array design studies, which will serve as a basis for an implementation plan and culminate in a final task team report. Following the Framework for Ocean Observations, array design studies can be based upon prioritizations of phenomena needing monitoring and evaluation of the ability of an array to measure key phenomena; adequacy for cal/val of satellite measurements; Observing System Simulation Experiments/Observing System Experiments modeling and observational decorrelation scale studies; and other types of studies for optimizing the ISOOS both regionally and globally. This effort will work with existing regional groups (e.g. TPOS-2020, CLIVAR basin panels, SOOS and SOFLUX) to provide recommendations

that take into consideration unique conditions for each region, and different requirements for applications with different objectives.

- **Assessment of existing air-sea flux observing system (12-15 months):** Before implementing the OASIS, the existing GOOS should be assessed to identify capability gaps for obtaining air-sea exchange information from the integrated in situ and satellite observing system. This assessment should extend throughout the global ocean (including at ice margins and coastal zones) to examine gaps in regional coverage as well as spatiotemporal sampling gaps. In particular, the assessment should include the ability of developing nations weather, climate, and ocean services to provide and access air-sea exchange information
- **Strategy Document (18-24 months):** Develop a unified vision for the integrated surface observations of the GOOS that identifies gaps in the present system, activities required for implementation, and potential leveraging opportunities that would accelerate implementation. The strategy will also explain how these GOOS data will be Findable-Accessible-Interoperable-and Reusable (FAIR) and how the enhanced and integrated surface observations of the GOOS will contribute to sustainable development, identifying capacity building opportunities. To the extent possible, the strategy will include costs and prioritizations for implementing recommendations.
- **Communications (Ongoing):** Find host or develop independent OASIS website for promoting coordination activities, solicit engagement or feedback at community meetings and conferences that would include partners from around the world, including from developing nations.

RESOURCE REQUIRED

Staff and Facilities: WMO/IOC GOOS support staff will provide international coordination and communication within WMO, GOOS, and international partners.
IOOC support staff with the assistance of the Consortium for Ocean Leadership will provide basic logistical requirements to facilitate meetings and conference calls and website development.
Budget: Up to $40,000 initial request from IOOC for potential travel support for expert workshop participants and to cover facilitation services for design and implementation of assessments.

APPROVAL PROCESS & REPORTING

The multidisciplinary GOOS Air-Sea Flux Task Team will be a GOOS activity and thus will report to the GOOS Steering Committee and the Task Teams sponsors, e.g. IOOC. Sponsors of the Task Team, working together with the GOOS SC, will have final approval authority for the scope of work and products to be delivered, providing approval at various stages from start to finish. During the time the task team is active, any questions and issues that cannot be resolved by internal consensus will be presented to the full IOOC for resolution. Upon request, the task team will provide written or verbal updates to the GOOS SC and the Task Team sponsors.

MEETING FREQUENCY

The frequency of meetings will be as agreed by the group to achieve the activities in a timely manner. The frequency of meetings should be reviewed by the GOOS Steering Committee and sponsors within a three-month period initially, and as part of a periodic review thereafter.

Comment [5]: In the current pandemic situation, we're seeing the real value of webinars. JB Sallée's SO-CHIC seminar (April 7) attracted a real-time audience of 200. We all hope that travel will be possible again, but we might also imagine that people will emerge from this with a better understanding of how to make remote meetings work effectively. I'm not sure if there's a way to build this perspective into the planning now.

PERIOD OF PERFORMANCE

Task team will remain constituted for two years, unless disbanded sooner or extended. A review of the Scope of Work will be undertaken after the first six months initially, and then extended as agreed to upon review thereafter, to ensure continuing relevance to GOOS and sponsor goals.

MEMBERSHIP & REPRESENTATION

This prospectus was drafted by Meghan Cronin (GOOS/OOPC), Rik Wanninkhof (GOOS/Carbon-BGC), Frank Muller-Karger (GOOS/BIO-ECO), and Tony Lee (GOOS/OOPC), with contributions from many experts in the community. **Task Team Members would include liaisons with the GOOS Panels and Partner Panels/Programmes, and leaders for each deliverable.** Members would reflect discipline expertise, gender, generational, and geographical diversity, including from developing nations and/or LDCs, and indigenous peoples.

GOOS Panels include: OOPC, Carbon-BGC, and BIO-ECO

Partner Panel/Programmes include: AOPC, GAW, OceanPredict, POGO, WCRP, WGNE, WWRP

The following scientists, listed by expertise, have indicated interest in participating in the task team and/or have signed a letter advocating for ISOOS:

- Sarah Gille (US), Tom Farrar (US), Santha Akella (US), Fabrice Ardhuin (US), Mark Bourassa (US), Luca Centurioni (US), Zhaohui Chen (China), Jim Edson (US), Chelle Gentemann (US), Juliet Hermes (South Africa), Alexander Ignatov (US), Luc Lenain (US), Rick Lumpkin (US), Renellys Perez (US), Shawn Smith (US), Seb Swart (Sweden), R. Venkatesan (India), Bia Villas Boas (US), Chris Zappa (US), Liz Kent (UK)

- Thanos Gkritzalis (Belgium), Christine Gommenginer (UK), Warren Joubert (South Africa), Penelope Pickers (UK), Richard Sanders (UK), Ute Schuster (UK), Tobias Steinhoff (Germany), Adrienne Sutton (US)

- Clarissa Anderson (US), Maury Estes (US), Maria Kavanaugh (US), Fabien Lombard (France), Hassan Moustahfid (US), Frank Muller-Karger (US), Jorn Schmidt (Germany), Ana Sequiera (US)

LIST OF OCEANOBS'19 CWP RELEVANT TO ISOOS (PLEASE ADD TO THIS LIST):

Cronin et al. (2019) "Air-Sea Fluxes with focus on Heat and Momentum"
https://www.frontiersin.org/articles/10.3389/fmars.2019.00430/full

Centurioni, et al. (2019) "Multidisciplinary Global In-Situ Observations of Essential Climate and Ocean Variables at the Air-Sea Interface in Support of Climate Variability and Change Studies and to Improve Weather Forecasting, Pollution, Hazard and Maritime Safety Assessments"
https://www.frontiersin.org/articles/10.3389/fmars.2019.00419/full

Wanninkhof et al. (2019) "A surface ocean CO_2 reference network, SOCONET and associated marine boundary layer CO_2 measurements"
https://www.frontiersin.org/articles/10.3389/fmars.2019.00400/full

Ardhuin, et al. (2019) "Observing sea states" https://doi.org/10.3389/fmars.2019.00124

Ardhuin, et al. (2019) "SKIM, a candidate satellite mission exploring global ocean currents and waves" https://doi.org/10.3389/fmars.2019.00209

Bax, Nicholas J, Patricia Miloslavich, Frank Edgar Muller-Karger, Valerie Allain, Ward Appeltans, Sonia Dawn Batten, Lisandro Benedetti-CecchiPier Luigi Buttigieg, Sanae Chiba, Daniel Paul Costa, J. Emmett Duffy, Daniel C. Dunn, Craig Richard Johnson, Raphael M Kudela, David Obura, Lisa-Maria Rebelo, Yunne-Jai Shin, Samantha Elisabeth Simmons and Peter Lloyd Tyack. 2019. A response to scientific and societal needs for marine biological observations. Frontiers in Marine Science. https://doi.org/10.3389/fmars.2019.00395

Bax, Nicholas J, Ward Appletans, Russell Brainard, J. Emmett Duffy, Piers Dunstan, Quentin Hanich, Harriet Harden Davies, Jeremy Hills, Patricia Miloslavich, Frank Edgar Muller-Karger, Samantha Simmons, O. Aburto-Oropeza, Sonia Batten, Lisandro Benedetti-Cecchi, David Checkley, Sanae Chiba, Albert Fischer, Melissa Andersen Garcia, John Gunn, Eduardo Klein, Raphael M Kudela, Francis Marsac, David Obura, Yunne-Jai Shin, Bernadette Sloyan, Toste Tanhua, and John Wilkin. 2018. Linking capacity development to monitoring networks to achieve sustained ocean observation. Frontiers in Marine Science, section Ocean Observation. Perspective. https://doi.org/10.3389/fmars.2018.00346.

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