International Webinars on

Advancing Remote Sensing Applications for the Sustainable Development of Ocean, Marine and Coastal Resources

Programme and Abstract

Webinar Series

Week 1 | 22nd November 2022 | 9:00–11:00 UTC+7

Week 2 | 29th November 2022 | 9:00–11:00 UTC+7

Week 3 | 6th December 2022 | 9:00–11:00 UTC+7

Week 4 | 13th December 2022 | 9:00–11:00 UTC+7

Week 5 | 20th December 2022 | 9:00–11:00 UTC+7

Zoom Registration

Week 1 | 22nd November 2022 | 9:00–11:00 UTC+7

Moderator: Arachaporn Anutaliya (Burapha University, Thailand)

Opening	
09:00–09:05	Welcome and Opening Remark **Wenxi Zhu** Head, UNESCO/IOC Regional Secretariat for WESTPAC **Sarawut Siriwong** Dean, Faculty of Marine Technology, Burapha University
Presentations	
09:05–09:35	NOAA's Coral Reef Watch: Three decades of providing decision support tools for coral reef management in a warming world **Derek Manzello** NOAA Center for Weather and Climate Prediction (USA)
09:35–10:05	Aquaculture management in an enclosed inner bay along the Sanriku coast after the Great East Japan Earthquake using remote sensing: the case of Shizugawa Bay **Teruhisa Komatsu** Japan Fisheries Resources Conservation Association (Japan)
10:05–10:35	Operational coastal habitat mapping using satellite imagery in Japan **Tatsuyuki Sagawa** Tottori University of Environmental Studies (Japan)
10:35–10:55	Open Discussion

Week 2 | 29th November 2022 | 9:00–11:00 UTC+7

Moderator: Tachanat Bhatrasataponkul (Burapha University, Thailand)

Presentations	
09:00–09:30	Remote sensing and machine learning techniques for mangrove and coral reef mapping **Werapong Koedsin** Prince of Songkla University (Thailand)
09:30–10:00	Multi-scale remote sensing for monitoring and conservation of microatolls and shallow waters habitat of small islands, Spermonde Archipelago, Indonesia **Nurjannah Nurdin** Hasanuddin University (Indonesia)
10:00–10:30	Long-term coastal wetland mapping using remote sensing and machine learning **Wenting Cao** State Key Laboratory of Satellite Ocean Environment Dynamics (China)
10:30–10:50	Open Discussion

Week 3 | 6th December 2022 | 9:00–11:00 UTC+7

Moderator: Jitraporn Phaksopa (Kasetsart University, Thailand)

Presentations	
09:00–09:30	Ocean color remote sensing data for the climate variability impacts on the marine ecosystem **Myung-Sook Park** Korea Institute of Ocean Science and Technology (South Korea)
09:30–10:00	Remote sensing monitoring and application of coastal zone ecological protection and restoration **Huaguo Zhang** State Key Laboratory of Satellite Ocean Environment Dynamics (China)
10:00–10:30	Estimating water quality metrics, eddies, and shoreline change in the Bay of Bengal utilizing satellite remote sensing applications **K M Azam Chowdhury** University of Dhaka (Bangladesh)
10:30–10:50	Open Discussion

Week 4 | 13th December 2022 | 9:00–11:00 UTC+7

Moderator: Patama Singhruck (Chulalongkorn University, Thailand)

Presentations	
09:00–09:30	Monitoring and assessment of Manila Bay water quality from space **Ariel Blanco** University of the Philippines (Philippines)
09:30–10:00	Surface circulation in the Gulf of Thailand from remotely sensed observations: seasonal and interannual timescales **Arachaporn Anutaliya** Burapha University (Thailand)
10:00–10:20	Open Discussion

Week 5 | 20th December 2022 | 9:00–11:00 UTC+7

Moderator: Wirote Laongmanee (Burapha University, Thailand)

Presentations	
09:00–09:30	Application of satellite-derived chlorophyll-a to coastal eutrophication assessment **Elígio de Raús Maúre** Northwest Pacific Region Environmental Cooperation Center (Japan)
09:30–10:00	Satellite detection of seagrass distribution in Nanao Bay with Seagrass Mapper, an open tool for seagrass mapping using cloud computing on Google Earth Engine **Genki Terauchi** Northwest Pacific Region Environmental Cooperation Center (Japan)
10:00–10:30	Current limitations and challenges for improving remotely sensed essential ocean and climate variables in the tropical Indo-Pacific region **Tachanat Bhatrasataponkul** Burapha University (Thailand)
10:30–10:50	Open Discussion

NOAA's Coral Reef Watch: Three decades of providing decision support tools for coral reef management in a warming world

Derek Manzello[1], Jacqueline De La Cour[2], Gang Liu[1], Erick Geiger[2], Blake Spady[3], Benjamin Marsh[3], William Skirving[3]

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For more than 20 years, the U.S. National Oceanic and Atmospheric Administration's (NOAA) Coral Reef Watch (CRW) program has used satellite, modeled and in-situ data to deliver an online global decision support system that helps marine resource managers, researchers, decision makers, and the public prepare for and respond to coral reef environmental stress, particularly heat stress that leads to mass coral bleaching. This is the only global early-warning system for the reef environment. CRW's latest products are derived from a blend of geostationary and polar-orbiting satellite data to provide near real-time information on changes in sea surface temperature, light and ocean color conditions that drive coral bleaching, disease, and mortality. Weekly to seasonal forecasts project future reef conditions, directly informing: timely, effective conservation planning, adaptation actions and resource allocation; communication with decision makers, the media, and the public leading up to, during and after major stress events; environmental management response; and impact monitoring. An extensive and diverse user community worldwide applies CRW's products to analyze and document mass coral bleaching and mortality on local, regional and global scales; as part of national and international assessments of reef conditions; to identify reef regions potentially resilient to climate change and its impacts; and to support resilience-based management. Decision makers have used CRW's bleaching heat stress forecasts and near real-time satellite monitoring to reduce local stressors in times of high oceanic heat stress, including closing major dive and fishing areas. This presentation will provide a summary of CRW products, highlighting recent scientific advancements and future directions to address stakeholder needs in a warming world.

Aquaculture management in an enclosed inner bay along the Sanriku coast after the Great East Japan Earthquake using remote sensing: The case of Shizugawa Bay

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Sanriku Coast, located in the north-east of Japan and facing the Pacific Ocean, is a series of rias-type semi-enclosed inner bays. These rias-type bays are less affected by waves and have a deep bay mouth, which allows for good seawater exchange, making them suitable for aquaculture. Therefore, before the Great East Japan Earthquake, a number of aquaculture facilities were established there. In some bays with excessive oyster facilities, it took three years for oysters to grow to a size for shipment due to lack of foods for oysters. However, the tsunami of 11 March 2011 destroyed these facilities. In September 2011, to support the recovery of Sanriku fishery, we visited Shizugawa Bay and met Mr Norio Sasaki, Chairperson of Shizugawa Branch Office Management Committee, Miyagi Prefecture Fishery Cooperative. Hearing the branch's desire to reduce the number of aquaculture facilities in order to turn this pinch into an opportunity to convert non-sustainable aquaculture into sustainable one, we proposed to the branch to investigate changes in the arrangement of aquaculture facilities using remote sensing and to use the map of their arrangement for developing a management plan for the bay. We investigated changes in the types of aquaculture facilities and their arrangement from before to after the earthquake conducting field surveys from 2011 and remote sensing of satellite imagery. This study was undertaken as part of the project supported by the Ministry of the Environment named "S13 Development of Coastal Management Method to Realize the Sustainable Coastal Sea" from 2014 FY to 2018 FY. S13 project also included a model study to quantify the environmental impact of aquaculture. Using the map on aquaculture facilities in Shizugawa Bay surveyed with remote sensing, a model analysis was conducted to simulate the amount and value of production of aquaculture in the bay. We presented the results of the model calculations depending on different scenarios of the number of aquaculture facilities to the fishermen for discussing on the aquaculture management with fishermen. Based on the discussion, the fishermen decided to change the target species of aquaculture from scallops and ascidians to seaweed in some area. In this way, remote sensing not only provides a visual representation of the distribution map of the aquaculture facilities, but also, in combination with the simulation, enables the proposal of target species to be farmed and the number of aquaculture facilities, contributing to sustainable coastal zone utilization.

Operational coastal habitat mapping using satellite imagery in Japan

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Management of coastal habitats such as seagrass/seaweed beds, tidal flats and coral reefs is important for maintaining healthy coastal ecosystems. In Japan, the distribution of these habitats has been surveyed by the Environment Agency since 1980; until the early 2000s, habitats were mainly identified through interviews and visual observation in the field. Aerial photographs were also used to visually identify the boundaries of habitats. Satellite remote sensing research progressed in the mid-2000s, and its application to coastal habitat mapping was considered in Japan. The National Institute for Environmental Studies started mapping coral reefs using satellite imagery in FY2007 and achieved a classification accuracy of more than 70% in mapping major coral reefs in Japan in FY2008. Mapping of seagrass/seaweed beds and tidal flats using satellite imagery was started in FY 2015 for enclosed bays such as the Seto Inland Sea, with a classification accuracy of more than 70%. Since then, satellite remote sensing has been adopted as the main mapping method for coastal habitats in Japan and the results are available on the web. In this presentation, satellite remote sensing-based coastal habitat mapping in Japan will be introduced and future challenges will be discussed.

Remote sensing and machine learning techniques for mangrove and coral reef mapping

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Mapping coastal habitats is important to assist in strategic decisions regarding the use and protection of mangrove and coral reef areas. Coupled with machine learning (ML) algorithms, remote sensing has allowed detailed mapping of the mangroves at species level and the coral reef area. In the first part, the study uses the Landsat 8 OLI data coupled with Sentinel-1 data to classify the five mangrove species. Random Forests (RFs) and Gradient Boosting Classification (GBC) machine learning were used to classify mangroves. The results showed that both machine learning techniques possess an accuracy of more than 80 %. In the second part, the study shows the Convolutional Neural Network (CNNs) for coral reef (i.e., *Acropora* spp.) classification in high-resolution (i.e., UAV) remote sensing imagery. The coral reef image was accompanied by their ground truth annotations. Coastal ecosystems are complex scenes and hence quite difficult to tackle from a computer vision perspective. This study shows the potential of solving this problem efficiently by yielding the target accuracy of more than 91%.

Multi-scale remote sensing for monitoring and conservation of microatolls and shallow waters habitat of small islands, Spermonde Archipelago, Indonesia

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Archipelago, a form of adaptation carried out by coral colonies that live with extreme environmental conditions. They are Barrang Lompo, Panambungan, Sanane, Bone Batang, Kodingareng Keke, Sanrobengi, Suranti, and Tambakulu islands. A spatial analysis was carried out to calculate the diameter of the microatolls on the UAV (Unmanned Aerial Vehicle aerial) photo acquisitions in 2020 and 2022 of the mosaic result, orthophoto, object-based classification (OBIA), and supervised classification. Calculation of each sample in the classification results uses UAV acquisitions in 2020 and 2022. High-resolution satellite images were also used to compare their accuracy in estimating the size of micro atolls. Some of the important steps carried out are field surveys, classification with segmentation based on, shape and color, texture, and shape of object proximity. The average growth rate of microatolls with UAV images for two years (2020-2022) was 6.4 cm per year. UAV is an alternative technology to obtain images with a high spatial and temporal resolution, a relatively low cost, and avoid cloud cover. This technology allows it to be used for monitoring and conservation shallow water ecosystems bordering community activities on small islands.

Long-term coastal wetland mapping using remote sensing and machine learning

Wenting Cao

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Coastal wetland ecosystems, the area between marine and terrestrial environments, play an important role in maintaining shoreline stability and preserving biodiversity. However, the sea level rise and human activities threatened the sustainability of coastal wetlands. Therefore, it is necessary to continuously map the long-term evolution of coastal wetlands for coastal protection and sustainable development. This talk will first introduce the advanced methods for coastal wetlands mapping by integrating long-term time remote sensing and machine learning algorithms, thereafter present several typical applications for mapping the long-term changes of coastal wetlands, including the long-term mapping of mangroves in Southeast Asia, the rapid loss of tidal flat in the largest archipelago of China, the succession of salt marsh vegetation in estuarine areas, and finally discuss the future research directions.

Ocean color remote sensing data for the climate variability impacts on the marine ecosystem

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Among the global oceans, the western Pacific is one of the areas to encounter the most rapid changes in population growth, industrialization, and climate change. The quality maintenance of the long-term ocean color remote sensing data is fundamental to quantifying the global warming impact on the marine ecosystem. The world's first ocean color sensor on a geostationary orbit, GOCI (onboard for 2010-2021), was accumulated for over ten years. The recent launch of the GOCI-II enables South Korea to have the world's first capability in deriving ocean color data from a geostationary satellite orbit for about 20 years. This speech presents the current knowledge and our efforts on sensor calibration, algorithm update, and level 3 algorithm development. The goal of these efforts will be to upgrade the two decadal ocean color records to the climate-quality dataset. In addition, we show the recent investigation on the climate trend and variability impacts on ecologically relevant ocean color products (chlorophyll-a concentration, Colored dissolved organic matter and spectrum of remote sensing reflectance). The efforts seek to answer how the ocean color spectrum and marine ecological systems in the future Earth will change.

Estimating water quality metrics, eddies, and shoreline change in the Bay of Bengal utilizing satellite remote sensing applications

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Remote Sensing technologies are advancing day by day and globally different satellites are launching nowadays to explore the ocean surface states. Despite Bangladesh's lack of domestic satellites, scientists are using regional and global satellites to understand the Bay of Bengal's sustainable development of ocean, marine, and coastal resources.

Chlorophyll-a (Chl-a), total suspended matter (TSM) and colored dissolved organic matter (CDOM) are the principal water quality parameters that can be retrieved from ocean color remote sensing satellite data. Thus, an accurate measurement of these metrics is necessary for the assessment of water quality, phytoplankton biomass, fish abundance and primary productivity, monitoring the level of pollution, ecological functioning and the sustainability of the water in the coastal and oceanic environment. The spatial and seasonal distribution of Chl-a, TSM, and CDOM have been evaluated in this work, and the field data have been used to validate the remote sensing results.

The influence of El Nino Southern Oscillation and Indian ocean dipole on the variability of mesoscale eddies in the Bay of Bengal is also studied in this work utilizing satellite altimetry datasets. Ocean mesoscale eddies are ubiquitous rotating bodies of water that are frequently called the "weather" of the ocean. Mesoscale eddies not only contribute to atmospheric events including air-sea heat fluxes, convection and rainfall but also transport biogeochemical properties through upwelling and downwelling processes over long distances. This study suggests that combined effect of strong monsoon, El Nino, and positive IOD significantly reduced the eddying in 1995 and 2020, particularly during the spring season of these years. The finding has implications for validating ocean-climate interactions and therefore can be incorporated into forecasting models for the ocean and atmosphere.

Three important islands from Bangladesh's east coast—Kutubdia, Sandwip, and Matarbari have taken into consideration (1992-2022) to study shoreline change analysis of the past 30 years. Tide synchronous, cloud free, and pre-processed Landsat satellite images are used in this analysis. Among the three islands, Kutubdia is dominated by erosion (-0.243 km^2/yr), Sandwip experiences both erosion and accretion, and the rate of change for both parameters is high in the past three decades. Notably, the rate of accretion in Matarbari is very high (0.37 km^2/yr). The outcome of this analysis will be useful for future shoreline prediction and for coastal management planners to implement an appropriate plan to address the vulnerability associated with shoreline change.

Monitoring and assessment of Manila Bay water quality from space

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In response to the Philippines' Supreme Court Mandamus on Manila Bay, the University of the Philippines Diliman and the Department of Science and Technology implemented the Integrated Mapping, Monitoring, Modelling, and Management System for Manila Bay and Linked Environments (IM4ManilaBay) Program. This is an R&D program to support the rehabilitation of Manila Bay. One of the component projects is the Development of Integrated Mapping, Monitoring, and Analytical Network System for Manila Bay and Linked Environments (MapABLE) Project. This completed project developed an integrated system for mapping and monitoring the water quality of Manila Bay and linked systems using geospatial technologies and citizen science. MapABLE utilized Sentinel-3 images to assess the spatiotemporal variations of total suspended matter and chl-a in the bay. The models used include the ANN-based C2RCC model and the WASI2D bio-optical model. Manila Bay was zoned using optical water type classification of Sentinel-3 images. The Project also developed transformed or calibrated versions of the normalized difference chl index and the single-band turbidity index. For near real-time water quality monitoring from space, ML-based models utilizing Himari-8 images were developed. Remote sensing methodologies were also developed for mapping oil and surfactants in Manila Bay.

Surface circulation in the Gulf of Thailand from remotely sensed observations: seasonal and interannual timescales

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The Gulf of Thailand (GoT), a shallow semi-enclosed basin located in the western equatorial Pacific, undergoes high wind variabilities on both seasonal and interannual timescales. The study utilizes various remotely-sensed observations to examine variability of the local circulation and the influence of the local and remote winds. The results show that the basin-averaged sea level responds spontaneously to the basin-averaged wind stress curl which is different from the rest of the South China Sea. Still, the surface current at different regions responds to the wind variability differently. The local Ekman pumping modifies sea level in the northern GoT, while remote wind forcing influences sea level variability at the GoT western boundary potentially through the coastal trapped Kelvin waves. The importance of wind-driven Ekman current on the ageostrophic current is also important; higher correlation between the ageostrophic and Ekman current is found toward the southern part of the GoT. The GoT circulation generally reverses its direction seasonally following the monsoon wind reversal; the pattern is well-captured by the most dominant complex empirical orthogonal function that explains 28% of the total circulation variance. During the monsoon transition, the circulation highlights the presence of strong meridional current along the western boundary that connects to the flow at the GoT southeastern entrance implying high exchange between the GoT and the South China Sea, and thus modification of the GoT water. On interannual timescale, the GoT circulation is directly impacted by both El Niño Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD). Interestingly, the two climate modes have different spatial influence on the GoT circulation. The IOD highly dominates the interannual current along the GoT western boundary and the southern boundary of the observing domain (8° N) due to the change of zonal wind. On the contrary, the ENSO influences circulation pattern in the GoT interior linked to the change of sea level.

Application of satellite-derived chlorophyll-a to coastal eutrophication assessment

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Coastal ecosystems are increasingly threatened by eutrophication caused by human-related excessive or disproportionate nutrient loading. This nutrient enrichment triggers a series of undesirable ecological effects that can also be harmful to human health. As such, assessment of coastal eutrophication is vital to help coastal water managers identify regions in need of management interventions. So far, the impacts and extent of coastal eutrophication have been limited to regions with dedicated water quality monitoring programmes. Maúre et al., (2021) introduced a tool for global eutrophication assessment solely based on satellite-derived chlorophylla (CHL, mg m^{-3}) data. Commonly used as an indicator of eutrophication, CHL data—a proxy for phytoplankton biomass—link nutrient enrichment and the stimulated phytoplankton productivity. Satellite data, in particularly, offers an unprecedented opportunity for a synoptic assessment of eutrophication which overcome the spatiotemporal limitations of in situ observations. Here we adopt the terms eutrophic/eutrophication potential or oligotrophic/oligotrophication potential to associate the assessment maps derived from the use of satellite-derived CHL. The assessment maps we introduce are based on the multisensor CHL data and evaluate the long-term changes in satellite-derived CHL to classify waters as having a decreasing trend (D, oligotrophication), no trend (N), or an increasing (I, eutrophication) trend. Moreover, a temporal mean value corresponding to the recent 3-year period is used to separate waters associated with high CHL (H, eutrophic) from those with low CHL (L, oligotrophic) based on a given threshold (5 mg m^{-3}). As a result, a composite map of six classes can be generated, viz. LD, LN, LI, and HD, HN, HI. Hence, pixels flagged LD, LN, LI are oligotrophic potential while HD, HN and HI are eutrophic potential. HD and LD are oligotrophication potential with HD indicative of systems under recovery, whereas HI and LI are eutrophication potential with HI indicative of worsening conditions. In this presentation we discuss eutrophication assessment based on historical ocean colour data as well as using recent sensor's CHL data such as SGLI/GCOM-C with higher (250 m) spatial resolution. The limitations and challenges of applying ocean colour data to eutrophication assessment and the relevance to sustainable development goals will be discussed.

Satellite detection of seagrass distribution in Nanao Bay with Seagrass Mapper, an open tool for seagrass mapping using cloud computing on Google Earth Engine

Genki Terauchi

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Seagrasses provide important ecological functions and ecosystem services in coastal ecosystems. However, widespread and accelerated losses have been reported worldwide and some seagrass species are now under threat of extinction. Asia coastal area are parts of the most densely populated areas in the world, and their coastal ecosystems including seagrass beds are under pressure from human activities. Although seagrasses have attracted much attention for their functions to maintain marine biodiversity and mitigate climate change, information on their distribution and threats in Asia region is very limited.

Seagrass Mapper is a web tool to map marine ecosystems such as seagrass beds in coastal waters. It was developed as a project of the Northwest Pacific Action Plan of the United Nation Environment Programme with collaboration with Ocean Remote Sensing for Coastal Habitat Mapping Project of UNESCO IOC Sub-Commission for Western Pacific. Seagrass Mapper is now registered as one of the services of the NOWPAP Marine Environmental Watch of the Ministry of the Environment, Japan, which is operated by the Northwest Pacific Region Environmental Cooperation Center (NPEC).

To demonstrate usefulness of the Seagrass Mapper, it was applied to detect seagrass distribution of Western Nanao Bay, an enclosed bay, located on the east side of Noto Peninsula, Ishikawa Prefecture, with one of the largest (more than 1,000 ha) seagrass habitats in the Sea of Japan. Due to its topographical features that are surrounded by the land, water remains relatively calm throughout the year. A large-scale die-off of seagrass from late summer to early autumn has been reported in western Nanao Bay in recent years. Field surveys to study sea floor substrates were carried out with an underwater video camera in June and October of the years 2015 and 2019 in western Nanao Bay. Sea floor substrates were then classified into 5 types; dense seagrass, sandy bottom, seaweed, spare seagrass, dense seagrass mixed with seaweed. This information was used as training data to classify sea floor substrates from satellite imagery using the GEE. The obtained results showed that seagrasses have disappeared from June to October in both 2015 and 2019. However, the area of the seagrass disappearance was greater in 2019 than that of 2015, and it was possibly due to higher sea surface temperature in 2019.

During the webinar, participants will also work with sample datasets in Nanao Bay, Japan to classify sea floor substrates for mapping seagrass habitats and learn how to prepare of training data based from field-based information.

Current limitations and challenges for improving remotely sensed essential ocean and climate variables in the tropical Indo-Pacific region

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Satellite observations play a substantial role as part of the global ocean observing system (GOOS) and global climate observing system (GCOS). The GOOS essential ocean variables (EOVs) and GCOS essential climate variables (ECVs) have been prioritized and broadly implemented for ocean monitoring and forecasting. Operational oceanography in the tropical Indo-Pacific region remains a challenge primarily due to intense and complex air-sea coupling ranging from turbulent instability to diurnal fluctuation and intraseasonal to interannual variability. In the meanwhile, surface air-sea turbulent fluxes determine the exchange of momentum, heat, moisture, and gas between the atmosphere and ocean. Those involving parameters require technological advances in space-based multi-platform measurements as well as better understandings of parameterizations and retrieval algorithms. Here, we will demonstrate present-day limitations of satellite data in terms of spatio-temporal coverage and systematic bias behind different sensors and/or instruments and different constraints for the choice of frequencies. Some selected EOVs and ECVs include (i) ocean vector winds from the Cross-Calibrated Multi-Platform (CCMP); (ii) ocean surface currents from the Ocean Surface Current Analysis Real-time (OSCAR); (iii) sea surface temperature from thermal infrared (TIR) and passive microwave (PMW); (iv) sea surface salinity from the National Aeronautics and Space Administration (NASA)'s Aquarius and the European Space Agency's Soil Moisture and Ocean Salinity (ESA/SMOS); (v) mean sea level anomaly from the Archiving, Validation and Interpretation of Satellite Oceanographic Data (AVISO); (vi) liquid water equivalent thickness from the Gravity Recovery and Climate Experiment (GRACE); and (vii) atmospheric carbon dioxide from the Orbiting Carbon Observatory (OCO–2 & OCO–3). Last but not least, we will shed light on the needs for improving the accuracies of these remotely sensed geophysical variables towards achieving the GOOS 2030 Strategy.