The Global Ocean Observing System

BRIEFING NOTE

Covid-19's impact on the ocean observing system and our ability to forecast weather and predict climate change

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Introduction

As the world responded to the Covid-19 pandemic, our ability to observe the global oceans was dramatically impacted in ways not seen before. Governments and oceanographic institutions recalled nearly all oceanographic research vessels to home ports, some commercial ships were unable to contribute vital ocean and weather observations, and ocean buoys and other systems could not be maintained, leading to premature failure. Even autonomous equipment could not be deployed to cover gaps in the system. The observations from these systems are vital to marine, climate, and weather forecasts and warnings. They should be recognized as *essential* and their operations enabled and supported to ensure their continuity.

To gain a global view of this risk, the Global Ocean Observing System (GOOS) launched a Covid-19 impacts survey in April 2020 to assess and forecast the pandemic's impact on global ocean observations. The survey went out to the eleven global *in situ* ocean observing networks[1] - each focused on different observing platforms, ships, autonomous floats, and

[1] Data Buoy Cooperation Panel (DBCP) Global Drifter Array and Moored Buoy network, Argo Profiling Float Programme, Global Ocean Ship-Based Hydrographic Investigations Programme (GO-SHIP), The Ship-of-

coastal based stations - that make up GOOS. The survey assessed the situation across the full range of essential climate and ocean variables that are vital to an array of users, from weather forecasting to commercial shipping, from global policy to addressing climate change.

Immediate impacts on ocean observing activity

The ocean is a harsh environment for scientific instruments. “There is a real risk that equipment will fail, resulting in the loss of both data and potentially the equipment itself, like the moorings,” explains Johannes Karstensen, co-lead of the OceanSITES time-series network. The loss of even a single one of the over 300 operational moorings could mean a gap of two to five years of data. Karstensen said that “30-50% of moorings will be impacted by the pandemic, and some have already ceased to send data. Considering that this equipment not only sends vital information for the ocean economy but monitors long-term climate change, it is clear that maintenance missions need to be prioritized as an essential activity in the context of Covid-19 regulations.”

“There is a real risk that equipment will fail”

Perhaps most strongly affected by the Covid-19 pandemic were the observing operations within the Ships of Opportunity Programme (SOOP), which uses commercial and other non-scientific vessels to take vital ocean measurements. Scientific ‘ship riders’ normally deploy the observing instruments, but Covid-19 restrictions mean that they can no longer operate aboard. Consequently, 90% of the normal flow of data from these ships has stopped.

Four valuable full-depth ocean surveys of over a dozen different water characteristics such as temperature, salinity, and chemistry, completed only once per decade by the GO-SHIP network, were cancelled. Surface carbon measurements from ships, telling us about the evolution and fate of greenhouse gases, have also effectively ceased.

In addition, vital marine meteorological observations taken from ships, often commercial ships of opportunity, that flow to national marine and weather centres have shown a 6-10% decrease in observations, and the Automated Shipboard Aerological Programme (ASAP) which provides a column of atmospheric data above partner vessels, reported a loss of 10-15% of the observations.

The slowdown in deployment and maintenance of autonomous instruments, such as drifting buoys, drifting floats and underwater gliders, is equally challenging. Though these instruments are more resilient, operating autonomously for months to years after being deployed, they need regular maintenance and deployment, and are also impacted by pandemic restrictions. Within the last month a worrying 10% reduction in the flow of data from the Argo profiling float network has been detected. While it is too early to tell to what extent this is due to Covid-19, the very low level of recent Argo float deployment compounds the situation, and this cannot be immediately remedied.

Ocean observing stations at the coast, such as sea level gauges and high-frequency radar, have largely maintained critical functions, with many individual operators maintaining data

Opportunity Programme (SOOP), Voluntary Observing Ships (VOS), Automated Shipboard Aerological Programme (ASAP), Global Sea Level Observing System (GLOSS), International High Frequency Radar (HF-Radar Network), OceanSITES Open-Ocean Timeseries (OceanSITES), OceanGliders, Animal Borne Ocean Sensors (AniBOS).

flow whilst working from home under lockdown restrictions. This is particularly vital as the sea level observations from the Global Sea Level Observing System (GLOSS) provide an underpinning to the tsunami warning system, and data for many coastal marine and climate applications. Many operators have however been prevented from undertaking the routine maintenance that keeps the system running, leading to the premature failure of some monitoring stations. GOOS believes it is crucial that the global ocean observing system operations are considered *essential* so that these operators can deploy and maintain their instruments.

"In situ observations and ocean forecasts are saving lives"

Enrique Alvarez Fanjul, Head of Physical Oceanography Department at Puertos del Estado in Spain says that "in situ observations and ocean forecasts are vital information that we need to provide daily to our ports. This is saving lives and allowing us to avoid risky situations during storms."

Outlook and risk through 2020

The global ocean observing system has shown resilience to the immediate impacts of pandemic-related shutdowns, as global observing networks were well-maintained going into the crisis and increasingly reliant on autonomous observing instruments. However, Covid-19 restrictions have already reduced the level of deployments needed to maintain a sustained flow of weather and climate forecast data (see table). Without urgent international action to support ocean observing operations, by the end of the year, we could see further significant disruptions with potentially devastating consequences.

Almost all work to maintain vital mooring arrays that monitor major ocean currents and critical air-sea exchanges for ocean and weather prediction and climate have been cancelled since mid-March. Although some operators have been able to reduce the frequency of observation to preserve battery life, a number of moorings are still at risk of failure in the coming months.

''The tropical moored buoys are indeed important for both our analysis and coupled weather forecasts" says Magdalena Alonso Balmaseda, Head of Earth Predictability Section at the European Centre for Medium-Range Weather Forecasts (ECMWF), "including our ability to accurately predict ENSO and its consequences."[2]

The data flow from Animal Bourne Ocean Sensors (AniBOS) network in the Southern Ocean will suffer a decline of order 70-80 % next year, as countries that normally undertake missions in Antarctica have limited their operations due to resource and health considerations. The Southern Ocean is a harsh environment and sparsely sampled, and the reduction in observations from marine animals will impact weather prediction models.

Autonomous observing platforms such as the drifting buoys (DBCP), drifting floats (Argo) and underwater gliders (OceanGliders) are also affected by the cancellation of research vessel missions. Although autonomous platforms can remain active for months to years[3], the

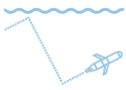
[2] See Fujii et al., 2015 and Zuo et al., 2019.

[3] Nature GeoScience - https://doi.org/10.1038/s41561-020-0597-y

constellation of global observing arrays requires continuous deployments to maintain their levels of service.

The Argo network is reliant on research vessel cruises for reseeding the array, and rates of deployment have significantly decreased in recent months (see table). In May, only ten floats were deployed, against the eighty per month required to maintain the array. If current levels of deployment continue the network could decline 10-15% by year end, with potentially sparse coverage in areas where more floats are close to the end of their lifespan (map).

"A 10% drop of Argo could really hurt us in ocean analysis but also in our coupled ocean-atmosphere forecasting system," says Hao Zuo, Senior Scientist at ECMWF.

Networks		**Deployment 2020**			**Deployment required to maintain array**	**Predicted status of array Dec 2020**	
		Mar	**Apr**	**May**	**Monthly**	**50% normal deployments**	**No deployments**
	Global surface drifters	58	41	25	80	-20%	-40%
	Argo floats	51	21	10	81	-10%	-15%
	Underwater gliders	10	1	5	20	-50%	-100%

Data source, www.jcommops.org

The global drifter array, which provides vital sea surface measurements to national weather prediction centres, was at full capacity when the pandemic took hold and is not solely dependent on research vessels for deployments. In the last 2 months it has deployed instruments from Navy vessels and is also planning to use private sector vessels, however only 31% of the drifters typically required to maintain critical function were deployed in May. If this continues the network could decline by 20% by the end of the year, with greater potential for regional gaps near strong ocean currents (drifter array forecast).

"The weather forecasting systems will run off the rails if they don't have the surface pressure information over the ocean to constrain them"

"The weather forecasting systems will run off the rails if they don't have the surface pressure information over the ocean to constrain them," said Lars Peter Riishojgaard, Director of the Earth System Branch at the World Meteorological Organization (WMO). "We cannot do reliable forecasting without this piece of information coming straight from the ocean via these drifting buoys."

The Atlantic may not be impacted as quickly as other areas, in part due to the mitigation action of the Ronald H Brown *(see box)*. However, we need careful re-seeding of the Argo and DBCP networks, especially in the tropical and southern ocean where gaps can rapidly develop.

A number of nations are planning to restart research vessel operations in July and August (e.g. Australia, Finland, Belgium, Netherlands, New Zealand, Germany and US) as restrictions ease. However, there is real concern that research vessel operations may not resume in some regions. In addition, vessel operators are also now working with new Covid-19 protocols - for example quarantine periods, operating to and from the same home port, and operating with minimal crew - greatly limiting vessel capabilities.

The observing system is working actively to secure operations: the DBCP drifter network has a number of deployments planned and the SOOP network is in dialogue with the shipping companies to potentially train their personnel to launch the XBT instruments. Even so, with research vessel operations likely impacted through 2020 and possibly into 2021, it is vital that careful prioritisation and planning be undertaken across national research vessel fleets to ensure we do not compromise essential climate and weather prediction datasets.

Other impacts not yet fully quantified are in the supply chain of instruments and sensors, due to the closure of instrument manufacturers and border restrictions. GOOS and the global ocean observing networks will work together to assess these risks more fully and develop actions to maintain function and strengthen the system moving forward.

Action by observing system operators to reduce the immediate impacts of Covid-19 on the ocean observing system - some examples

- The science team aboard the oceanographic research vessel *Ronald H. Brown* proactively prepared and deployed over fifty autonomous instruments, including ocean drifters and profiling floats, across the South Atlantic and Caribbean, to ensure that measurements vital to climate and weather prediction would continue to flow as the vessel received instructions to return immediately and directly from Cape Town, South Africa, to home port Norfolk, VA, USA.
- The Continuous Plankton Recorder (CPR) activity has remained partially operational, as implementers pre-prepared CPR cassettes and took them home during lockdown.
- The GLOSS sea-level network worked to ensure continuous data flow from home. "We hope we can continue delivering the operational services as we have done for the last 25 days since the state of emergency was declared, provided there are no relevant problems at the stations. Data are transmitted each minute to harbor operators, tsunami warning systems and the storm surge forecast system."
- Some sampling is remotely configurable for the open ocean moorings "we have slowed the sampling rates and have begun to identify the hardware at risk, but do not yet have full mitigation strategies."
- Voluntary Observing Ships (VOS) Port Meteorological Officers (PMO's) have worked with Ships Officers via email to remotely calibrate their instruments.

What we need to do

To date, the global ocean observing system shows some resilience to the shock from the Covid-19 pandemic. However, there is a need to act now in order to ensure continued critical function and to avoid significant long-term loss.

GOOS recommends the following:

- Increased international coordination across national research vessel operations to address risks to the global system with maximum efficiency
- Global Ocean Observing System activities to be to be prioritized as *essential*
- Coordinated reseeding of autonomous arrays
- Flexibility in operations through increased partnership with independent and local operators: e.g. special charters, local and indigenous populations
- Expand consideration of autonomous platforms

Partnerships across political borders and operational flexibility may be what it takes to carefully organize the various actors undertaking ocean observations in the face of ongoing disruptions. Moreover, international agreement to classify global ocean observing operations as essential activities could ensure that the global observing system better delivers critical information to weather forecast, warning systems, climate and ocean health applications. We need to allow operators to return to maintenance, calibration and deployment work as soon as possible.

In Europe a successful model for ship cooperation exists, called Ship Barter,[4] that enables participating fleets to share ship time. A scheme like this could be explored on a global scale. The observing enterprise should also assess operations flexibly, using ships of opportunity, navy vessels or contracting commercial vessels, to provide additional support for some missions, such as the reseeding of floats and drifters. And all of this needs to be understood in the context of the safety of vessels, crews and other operators.

"The Covid-19 crisis can also be an opportunity to build greater resilience"

"Despite its significant impacts on the ocean observing system, the Covid-19 crisis can also be an opportunity for us to look at how to build greater resilience into the system," argues Toste Tanhua, Co-Chair of the Global Ocean Observing System. "The impacts of Covid-19 have brought to light the inter-reliance of systems and some clear weak points that we can now work on to increase system efficiency and robustness."

"Now more than ever, we need to act collectively if we want to maintain critical function and data flow for weather, climate, and ocean health services on a global scale," says Emma Heslop, at the Global Ocean Observing System.

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[4] http://www.ofeg.org/np4/11.html