National Oceanography Centre

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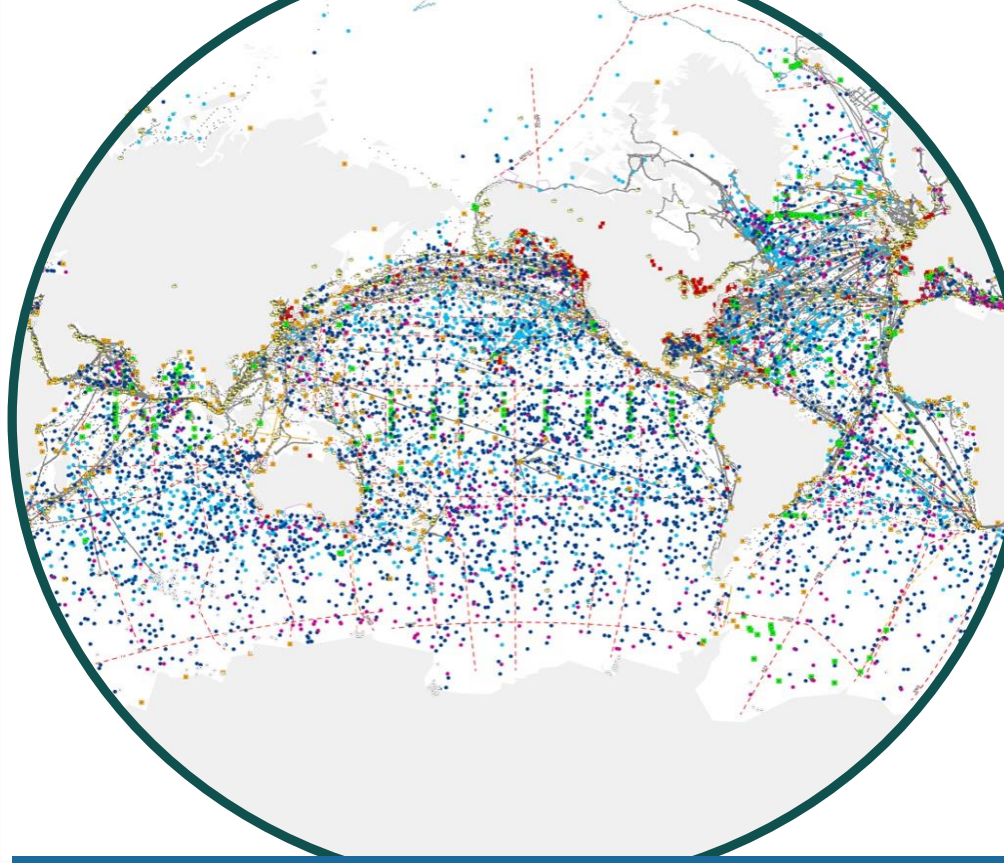
Met Office Hon Fellow

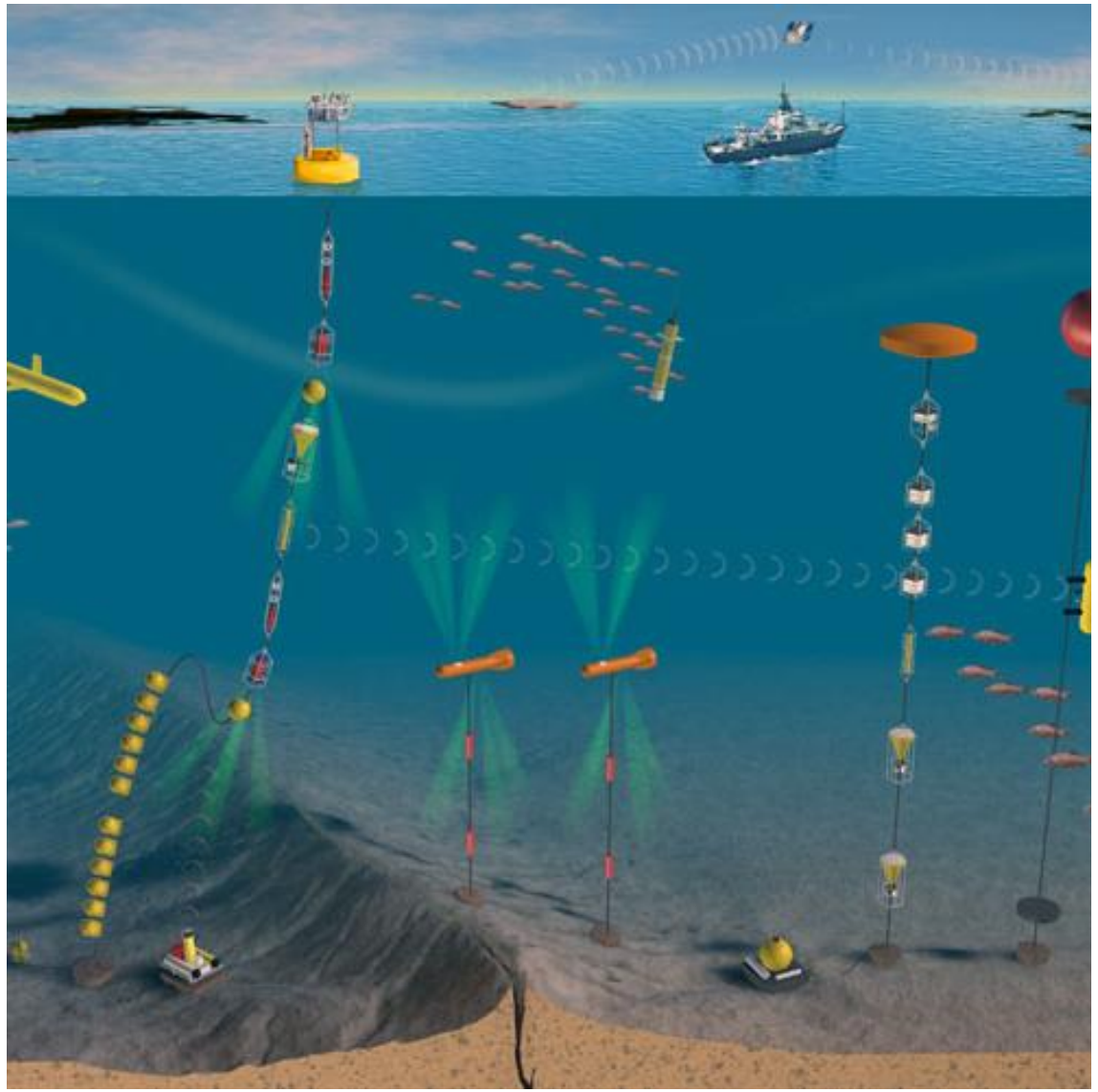


Ocean and wave observations: overview, recent developments and gaps

ECMWF Annual Science Meeting
September 2021

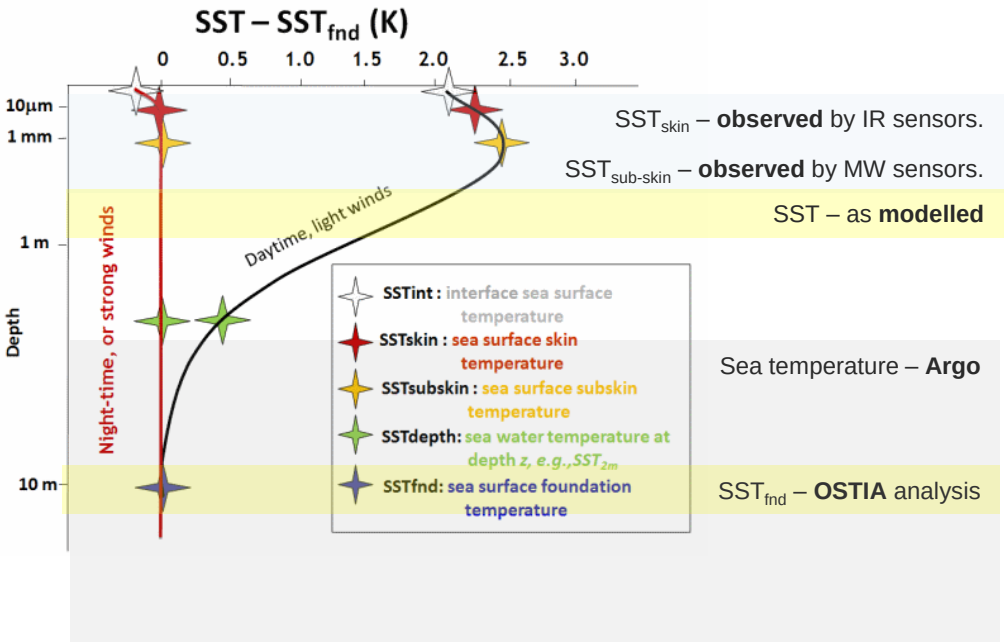
Overview

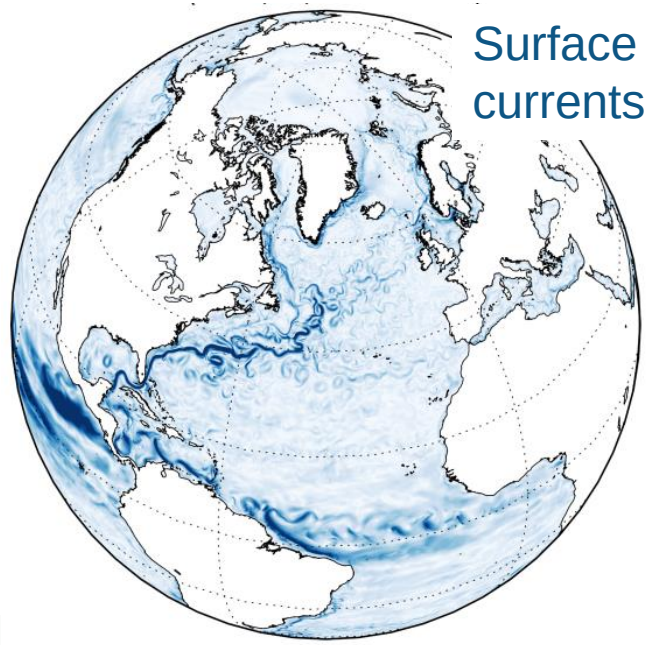
- Ocean observations, with a focus on physical ECVs
- Current state of the global network
- Some thoughts on gaps and why they are critical
- Novel ocean observations and emerging technologies / themes



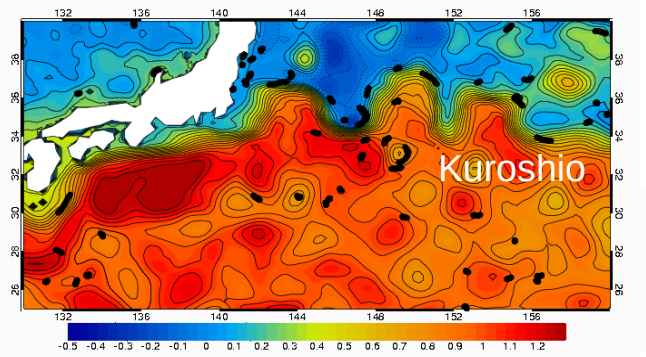
Ocean Observations – the Context

- Oceans are **spatially variable**, with **mesoscale** and **submesoscale** having a direct interaction with atmosphere
- These spatial variabilities are not only surface features, but penetrate to the **mixed layer** and below
- The surface ocean is intimately **connected to the atmosphere**, but responds very differently depending upon the watermasses below
- **Satellites only provide very near surface** – to create a model or observation based analysis need to combine satellite and in situ





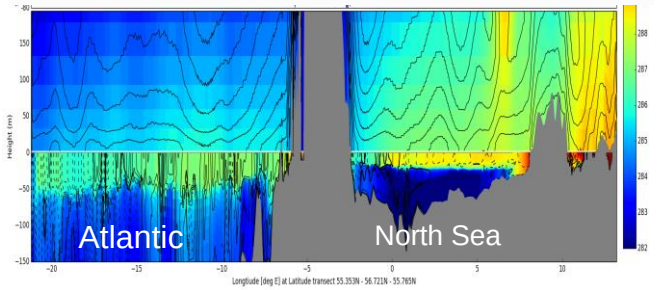
SST (SSH contours)



z

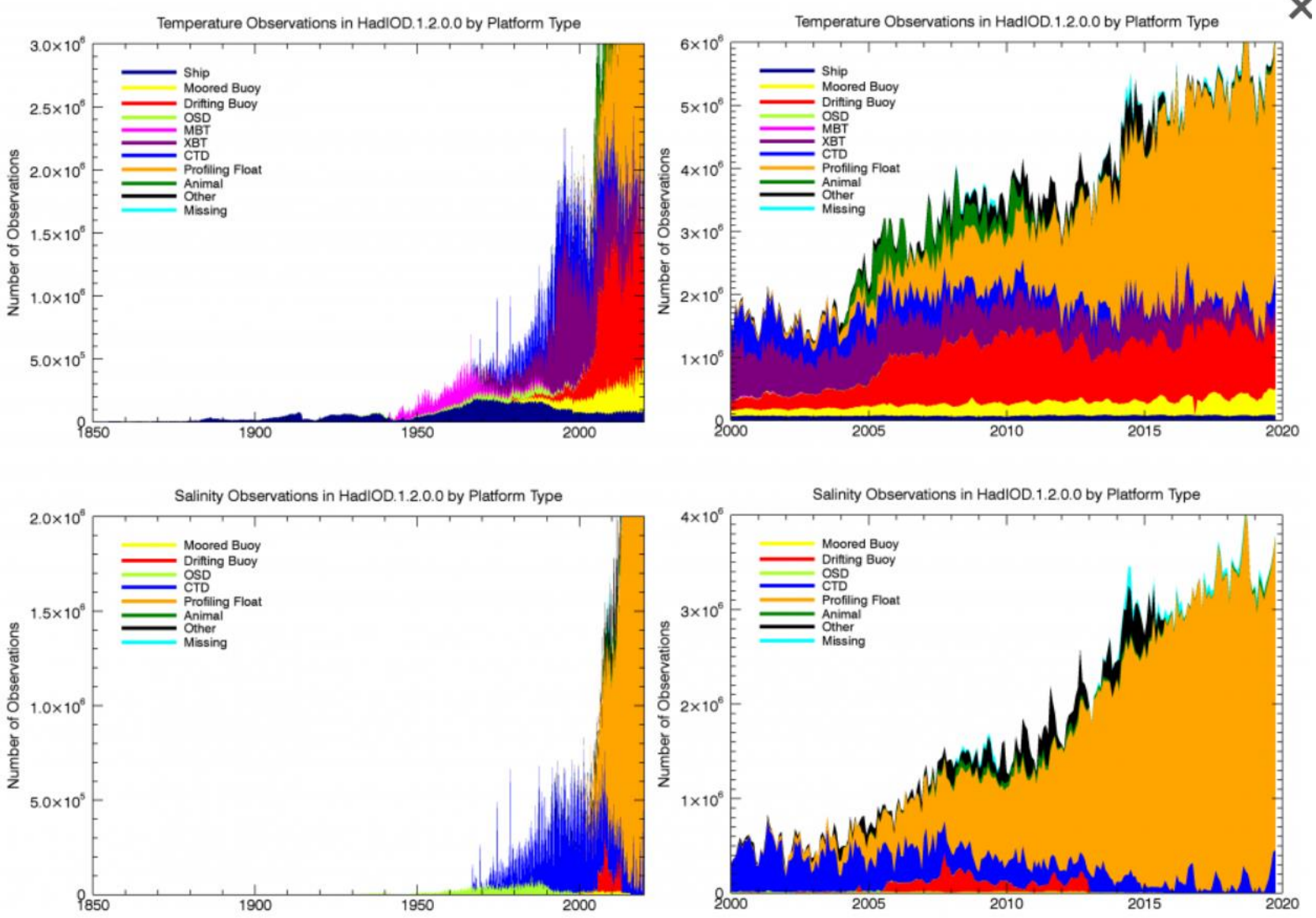
T$_{atm}$

T$_{ocn}$



Observation numbers: temperature and salinity

- HadIOD: the Met Office Hadley Centre Integrated Ocean Database
- There are ~1.2 billion observations in HadIOD (temperature and salinity only)
- Significant increase due to Argo profiling floats

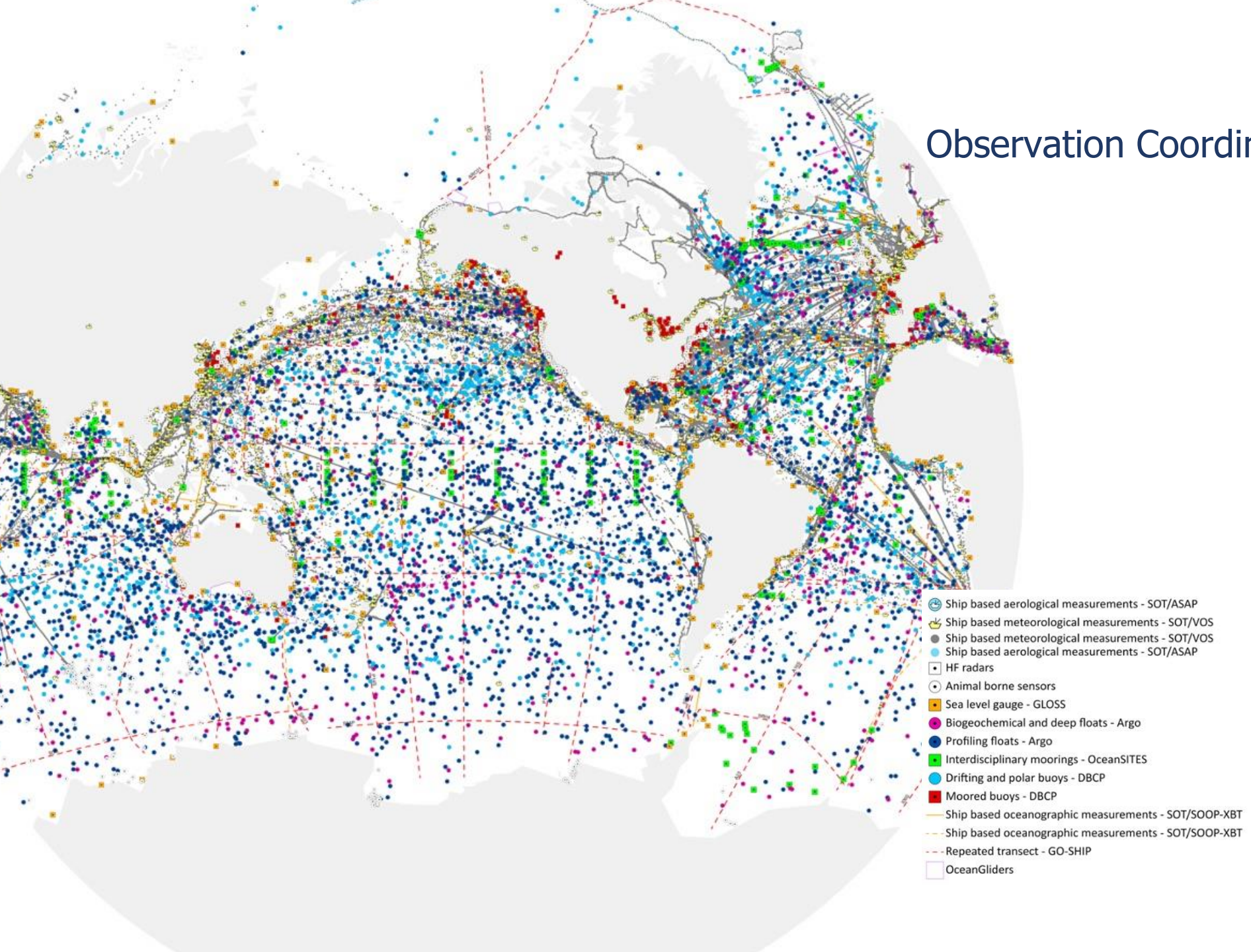


Atkinson et al. 2014, JGR, 119, 10, 7139-7163
DOI:10.1002/2014JC010053

Atkinson, Chris & National Center for Atmospheric Research Staff (Eds). Last modified 16 Sep 2020. **"The Climate Data Guide: HadIOD: Met Office-Hadley Centre Integrated Ocean Database."** Retrieved from https://climatedataguide.ucar.edu/climate-data/hadiod-met-office-hadley-centre-integrated-ocean-database

GOOS today

Observation Coordination Group networks



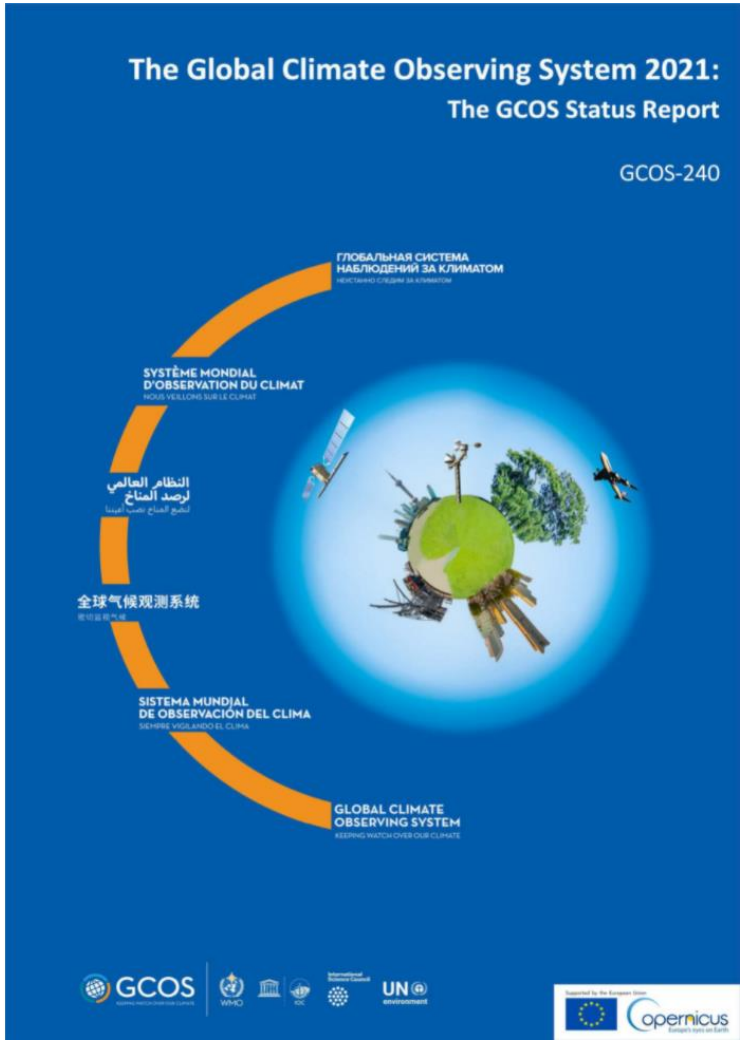
- Established arrays (Argo, DBCP), new networks (gliders, HF Radar)
- **86** countries, **8,933** in situ observing platforms, **170** satellites
- Early focus was on climate and operational services - increasing ocean health and human impacts
- *in situ* ocean observations – 12 global ocean observing networks
- Coordinated by GOOS towards Vision of the 2030 Strategy

www.ocean-ops.org/reportcard2020

Ocean Observing Report Card 2020 - status of the global observing networks

GOOS *in situ* networks[1]	Implementation	Data & metadata			Best practices[6]	GOOS delivery areas[7]		
	Status[2]	Real time[3]	Archived high quality[4]	Meta-data[5]		Opera-tional services	Climate	Ocean health
Ship based meteorological measurements - SOT/VOS	★★☆	★★☆	★★★	★★☆	★★☆	✓	✓	
Ship based aerological measurements - SOT/ASAP	★★☆	★★☆	☆☆☆	★★☆	★☆☆	✓	✓	
Ship based oceanographic measurements - SOT/SOOP	★★☆	★★★	★★★	★★☆	★★☆	✓	✓	✓
Sea level gauges - GLOSS	★★★	★★☆	★★★	★☆☆	★★☆	✓	✓	
Drifting and polar buoys - DBCP	★★★	★★☆	★★☆	★★☆	★★☆	✓	✓	
Moored buoys - DBCP	★★☆	★★★	★☆☆	★★☆	★★☆	✓	✓	
Interdisciplinary moorings - OceanSITES	★★☆	★☆☆	★☆☆	★★☆	★☆☆		✓	✓
Profiling floats - Argo	★★★	★★★	★★★	★★★	★★☆	✓	✓	
Repeated transects - GO-SHIP	★★★	★☆☆	★★★	★★☆	★★★		✓	✓
OceanGliders	★☆☆ Emerging	★★☆	★☆☆	★★☆	★☆☆	✓	✓	✓
HF radars	Emerging	★★★	★★★	★☆☆	★★★	✓	✓	✓
Biogeochemistry & Deep floats - Argo	★☆☆ Emerging	★★★	★☆☆	★★★	★★☆	✓	✓	✓
Animal borne ocean sensors - AniBOS	Emerging	★★★	★☆☆	★☆☆	★★☆	✓	✓	✓

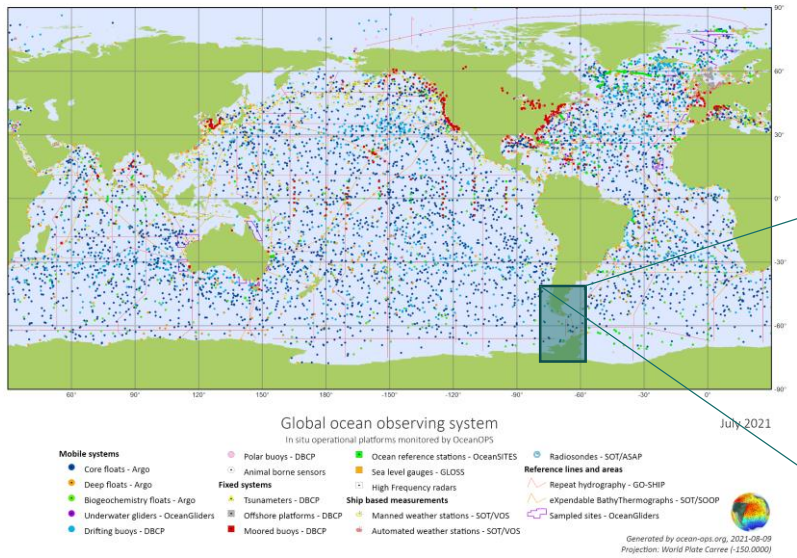
GCOS: Climate Observing System Status Report



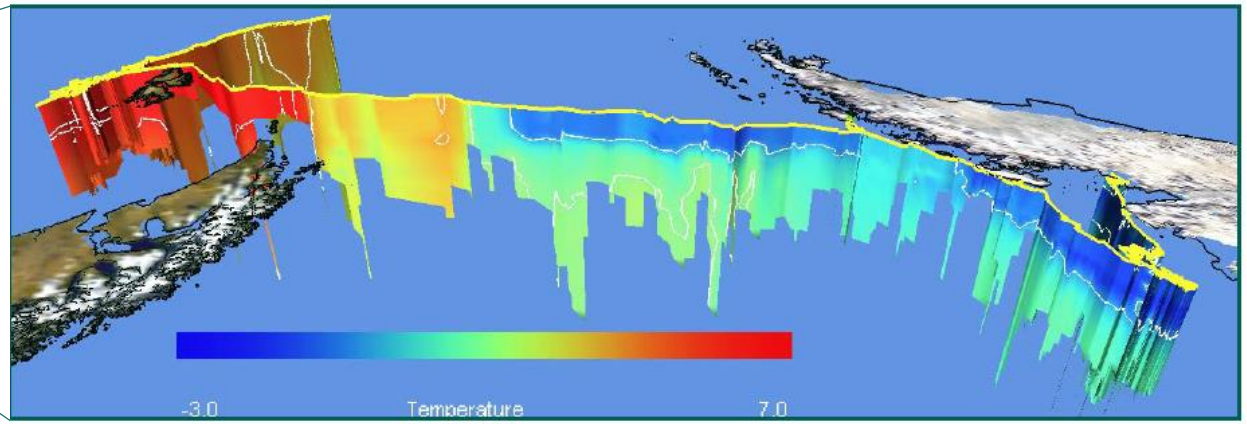
- There is a demand for more detailed information on climate change, both **to explain and project changes** and to help **planning and implementing adaptation and mitigation**.
- **physical ECVs meet requirements** in the **open ocean at the surface**
  - still **inadequate** at **depth** and **in marginal seas**, **over the continental slopes, coastal zones and polar areas.**
- **Funding** for sustained ocean observing **remains very fragile** and is largely **supported by limited-duration research projects**.
  - Argo (the most sustained network) funded 5% / 95% operational / research
- Overall, there are four main areas still needing improvements:
  - ensuring the **sustainability of observations**,
  - addressing of **gaps in the system**,
  - ensuring **permanent, free and unrestricted access to the observations**,
  - increasing support for policies driven by the UNFCCC Paris Agreement.

GCOS Status Report: https://gcos.wmo.int/en/gcos-status-report-2021

Marine mammal observations



Significant gaps in polar regions
Challenging environment



Southern elephant seal (yellow track) crossing the Drake Passage

Southern Elephant Seal

Weddell Seal

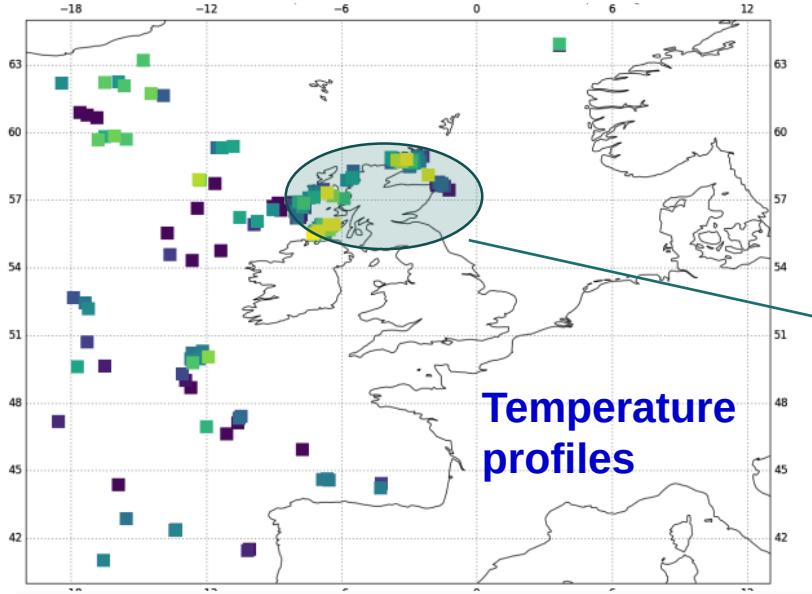
Seals dive deep and travel significant distances:

Some profiles >1200m

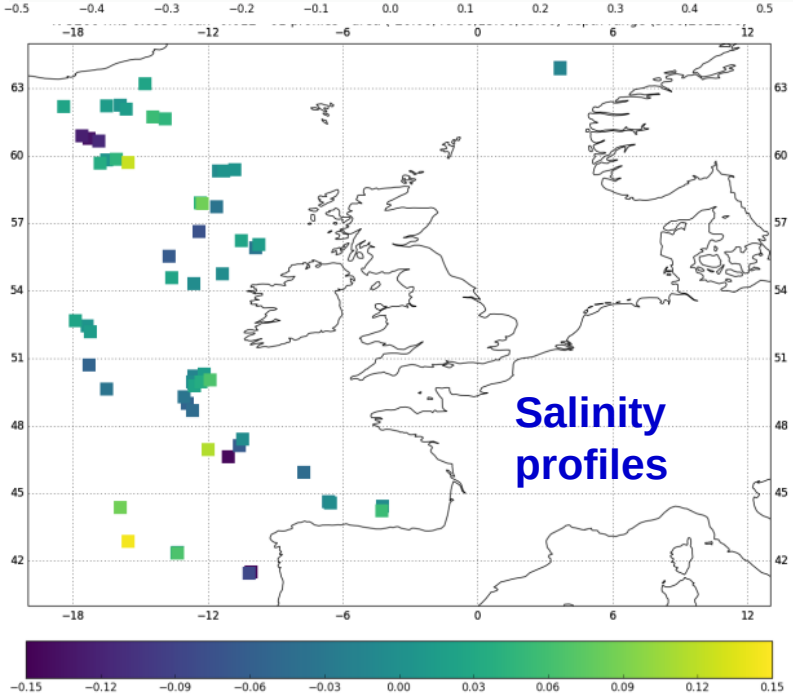
Automatic ice avoidance!

Sea Mammal Research Unit

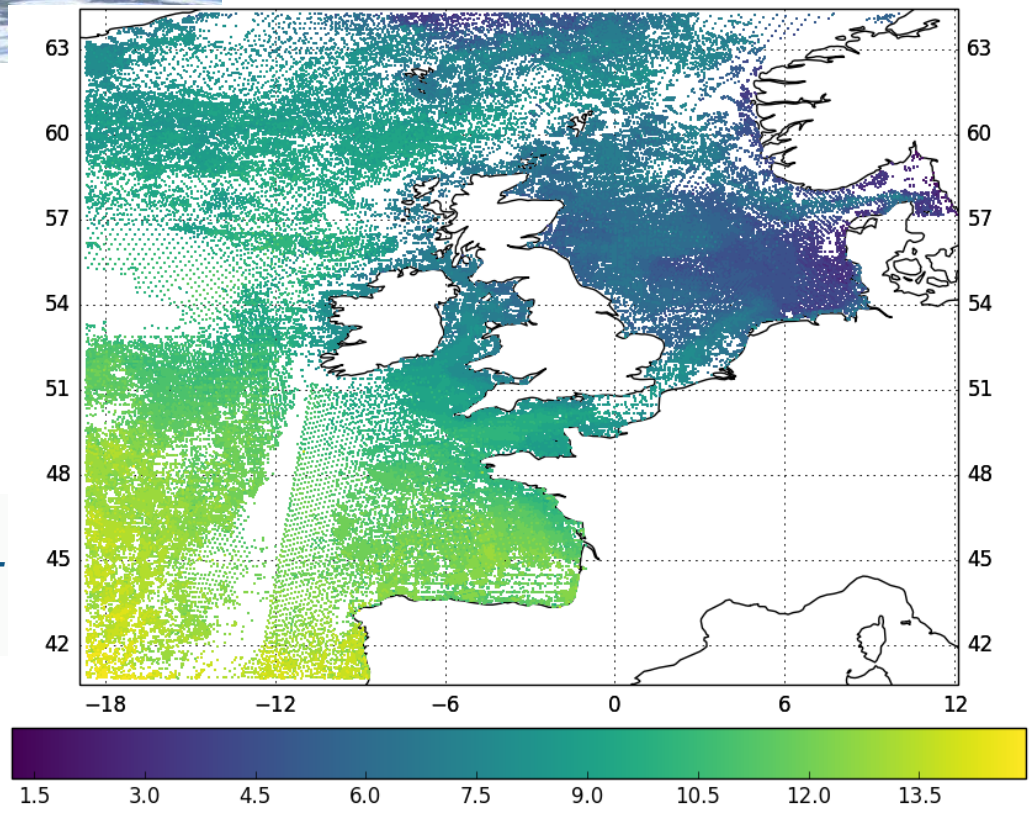
Observations Assimilated on Shelf Region



Example monthly coverage of T/S



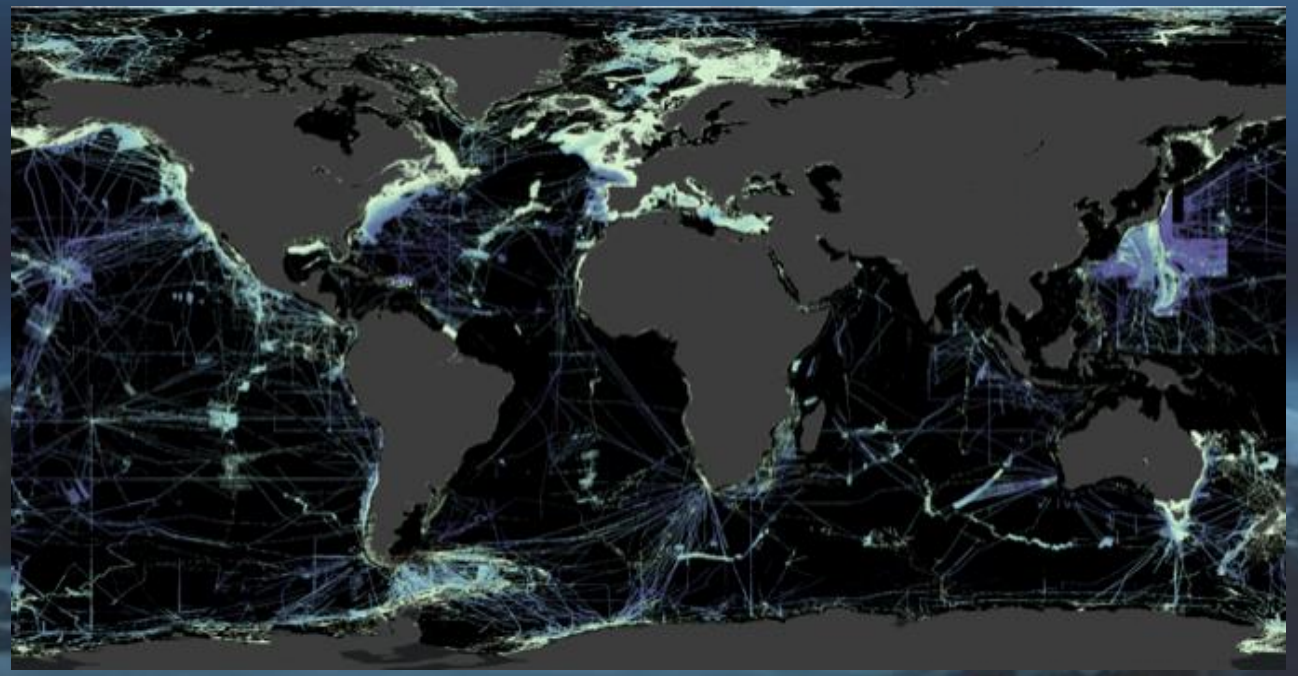
Example daily coverage of SST obs



The Nippon Foundation - GEBCO Seabed 2030 Project

Mapping of the world's ocean by 2030 to be freely available via GEBCO Ocean Map.

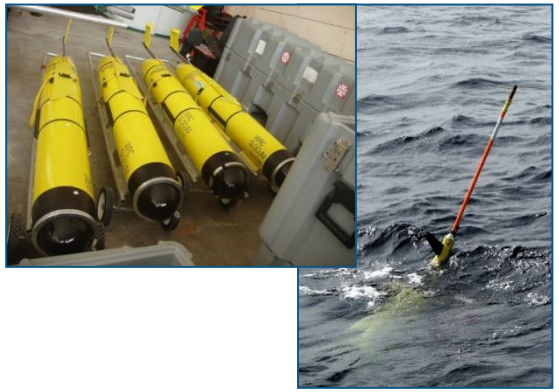
- Only ~20% of the ocean has been mapped directly
- Bathymetry data is an essential ocean observation, and is often a first order limiter for modelling



THE NIPPON FOUNDATION-GEBCO SEABED 2030

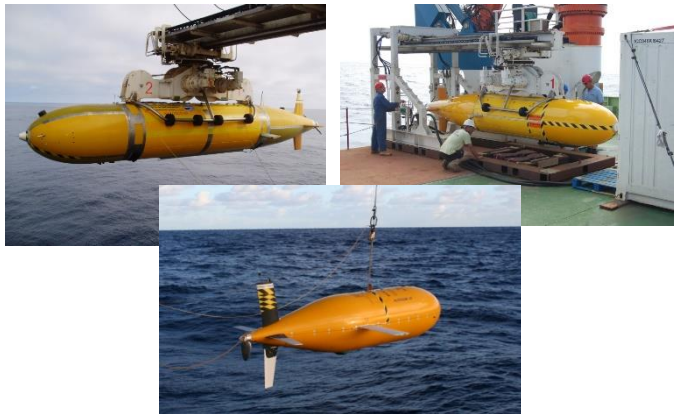
Equipment and Infrastructure

Underwater Gliders



- Teledyne Webb Slocum (1000m) x 12
- Teledyne Webb Slocum (200m) x 10
- Kongsberg Seagliders x 9
- Uni. Washington DeepGlider x 1

AUVs



- Autosub6000
- Autosub2KUI
- ALR6000 x 3
- ALR1500 x 3

ROV & Deep Tow Equipment

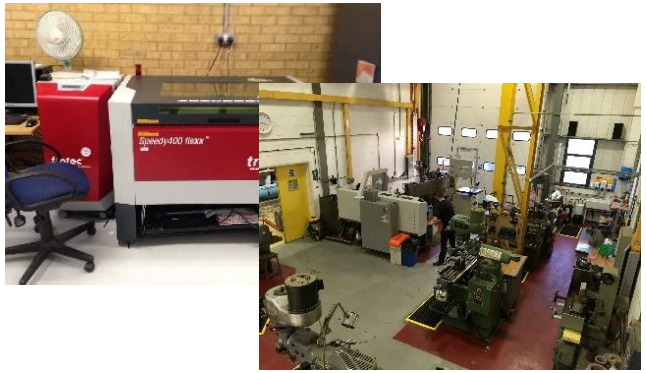
- Isis ROV
- HyBIS
- *MPUS*

USVs

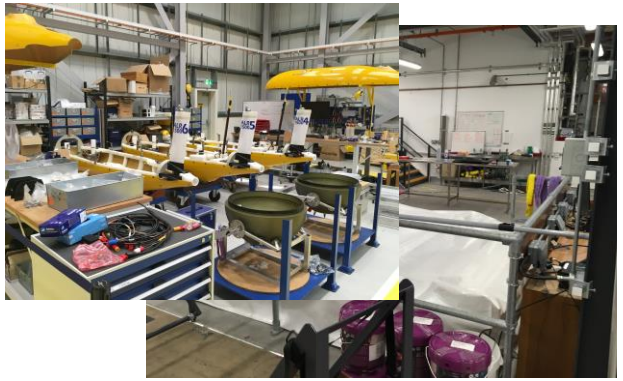
- Waveglider x 2
- C-Worker 4 x 0 (2)

Calibration & environmental test labs

Rapid Prototyping, machining facilities



Labs, Vehicle Preparation, Ballasting tanks & Storage Areas



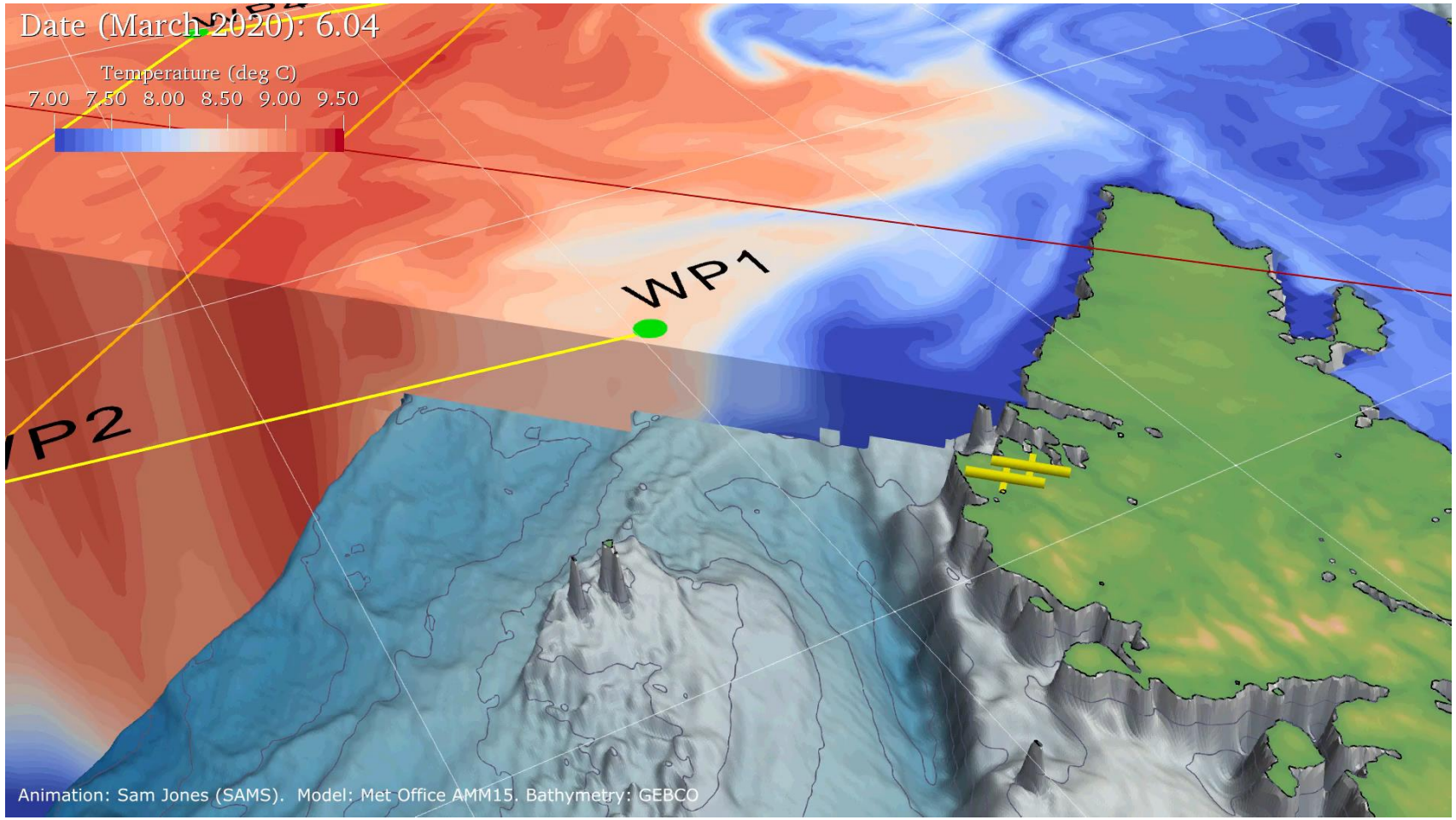
Software infrastructure & Websites

Procedures

Support IT

Glider – Model trials

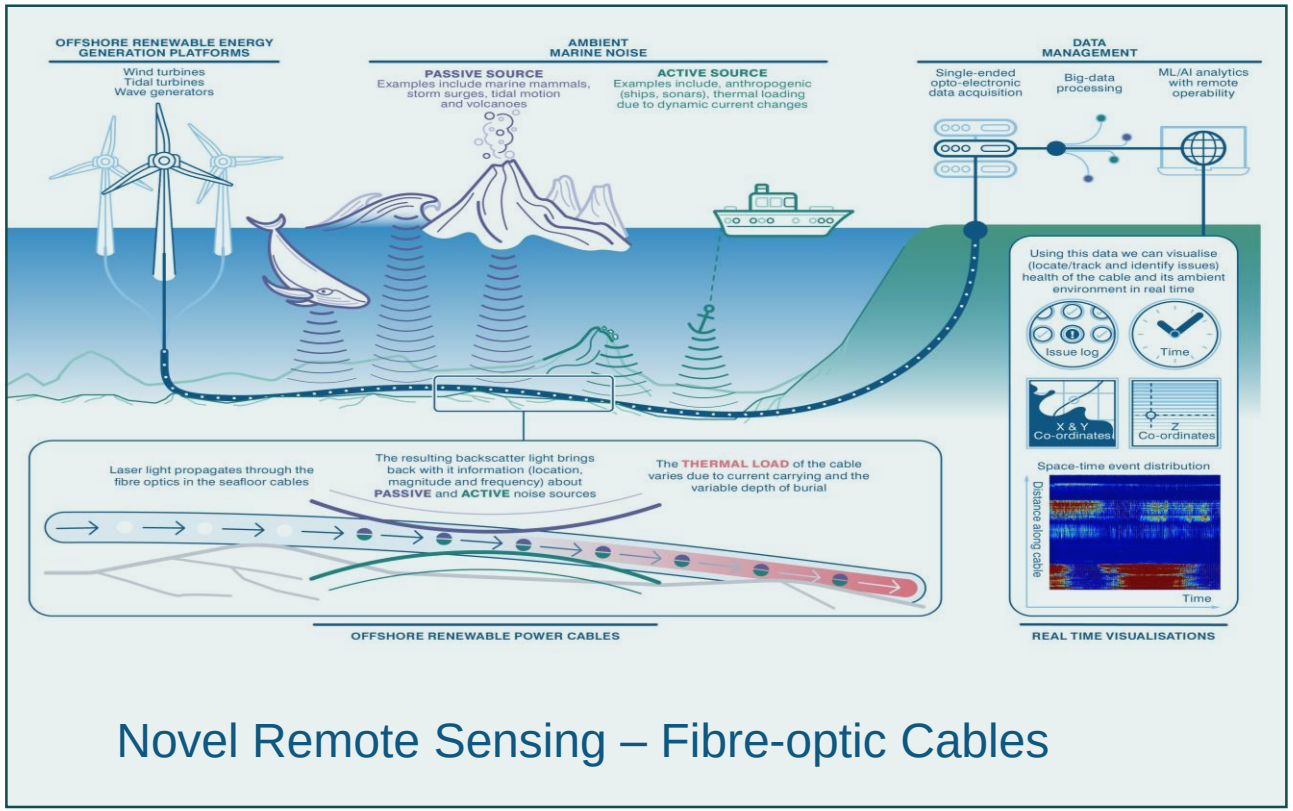
HECLA Project



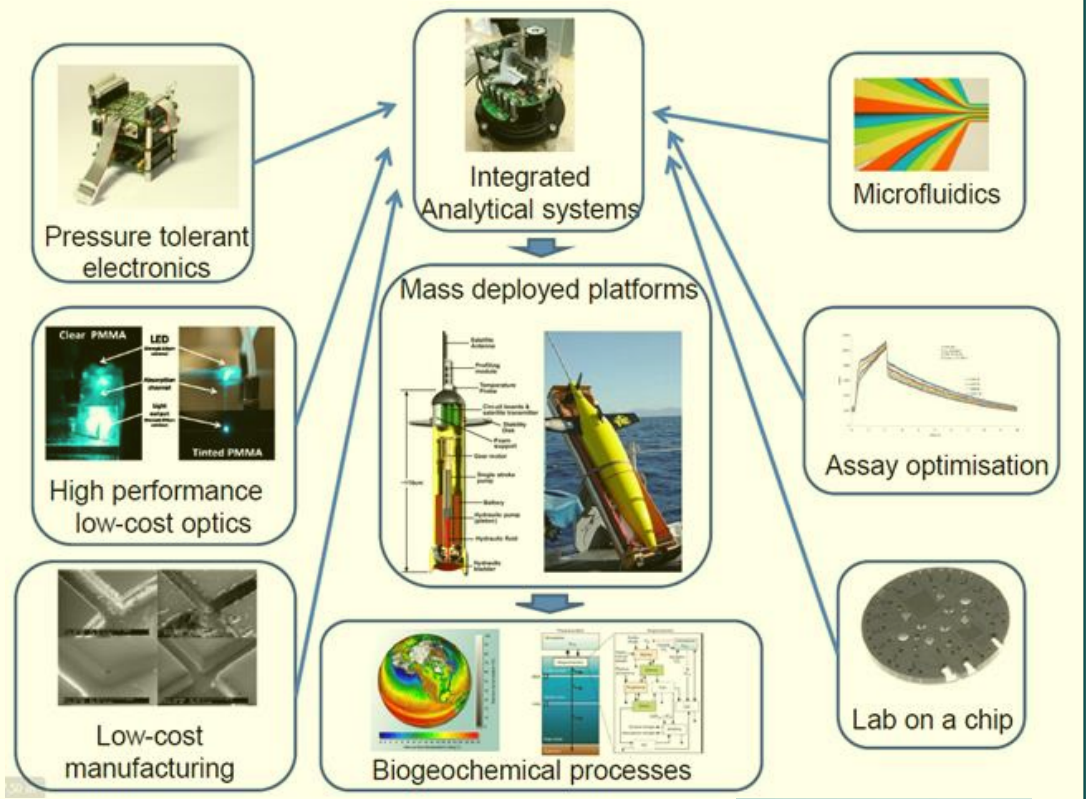
AMM15 modelled temperature (Met Office) and gliders

Thanks to Sam Jones (SAMS) for animations

Filling the Gaps – spatially and in parameter space

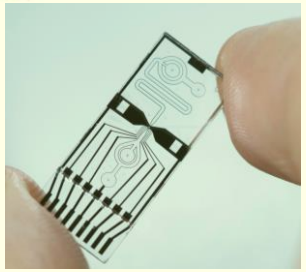


Novel Remote Sensing – Fibre-optic Cables



*** Data infrastructure to handle big data from diverse sources also needs developing

Novel Sensors:
Lab on a chip
Quantum sensors



Concluding Remarks

- Marine observations are **crucial** for improving the performance of analyses and numeric modelling for ocean monitoring, forecast and prediction
- In situ and satellite observations have their own advantages and limitations, a good combination of both kinds of observations are key to make best use of available observations
- **Calibration and validation** are very important for both in situ and satellite observations
- Importance of standards, references, and consistency of measurements in time
- More in situ data in coastal regions and also less reliable satellite data
- Quality control is important
- Real time in situ data are often not corrected (Delayed time data not always provided)

National Oceanography Centre