BIOGRAPHRIES AND ABSTRACTS

From HMS Challenger to Argo and Beyond - Introduction
Prof Chris Folland, Met Office

Abstract | The purpose of this introductory talk is first to welcome all speakers and participants followed by a brief mention of the backgrounds of the organisers, and how they relate to the topic of the meeting. The revolutionary nature of the ARGO program for oceanography, and climate applications in particular, will be emphasised helped by selected update to date information from the ARGO web site. Finally, the structure of the meeting will be summarised. I will then introduce the next speaker, John Gould.

Biography | Professor Chris Folland headed the Met Office Hadley Centre's Climate Variability and Seasonal Forecasting Group (1990-2008), retiring as a Research Fellow in 2017. Chris was a Lead Author for four reports of the Intergovernmental Panel on Climate Change (IPCC) where, like other Lead Authors, he shared in the Nobel Peace Prize awarded to IPCC in 2007. He has several fellowships and has won a number of national and international awards. Chris remains Honorary Professor at the University of East Anglia, Guest Professor of Climatology at the University of Gothenburg, Sweden and Adjunct Professor at the University of Southern Queensland, Australia.

From thermometers to Robots - evolution and revolution
Dr W John Gould, National Oceanography Centre

Abstract | The talk will show how our ability to collect temperature and salinity profiles from the open ocean has developed starting with the early voyages of HMS Challenger and SMS Gazelle in the1870s, through the 1920s and 30s (Discovery Investigations and Meteor Expedition) to the 1940s and the invention of the bathythermograph.

Post-WWII the development of the CTD was initially a mixed blessing with improvements in data quality not evident until the 1980s. The expendable bathythermograph developed in the 1960s and used extensively from naval and commercial vessels greatly increased the number of shallow temperature profiles. The advent of altimeter satellites, notably Topex-Poseidon, and the conduct of the World Ocean Circulation Experiment in the 1990s enabled a global and truly international approach to observations. WOCE also led to the development of robotic profilers and ultimately to the Argo array that for the first time freed data collection from the constraint of being ship-based.

The progress towards today's capability has been marked by technological innovation (and failure), by behind-the-scenes work to establish and maintain standards and by growing international collaboration.

Biography | John Gould has had a long career first exploring the circulation of the North Atlantic working alongside John Swallow and colleagues at the UK National Institute of Oceanography and Institute of Oceanographic Sciences. Later he was international project director for the WCRP's World Ocean Circulation Experiment and CLIVAR project and more recently as the Director of the Argo profiling float project during its formative phase. He is an Emeritus Fellow at the National Oceanography Centre in Southampton documenting the history of UK marine science during the 20th century.

Argo - How it came about, how it works and what it delivers
Br Brian King, National Oceanography Centre

Abstract | Argo came into existence because of the timely coincidence of a simple but fundamental scientific question – how fast is the ocean warming ? - key technological advances, and an approach to wide international cooperation among oceanographers fostered through the 1990s by the World Ocean Circulation Experiment. Argo partners maintain a fleet of freely-drifting 'floats'. Each float is an aluminium tube, about 1.5 metres long, with a small bladder that can be inflated or deflated to change buoyancy and move up or down through the water. Once every 10 days, a cycle is completed between the ocean surface and 2000 metres depth. A profile of ocean temperature and salinity is measured and sent to a shore station by satellite. Argo currently has around 4000 active floats, each of which has a lifetime of about 5 years before its batteries are exhausted. International cooperation means that any ocean region only needs to be measured by one national group – all data are immediately and freely shared, so any research agency, or indeed any member of the public, can inspect and analyse the data. In each five years of Argo's existence, it makes as many measurements of ocean temperature as the entire history of ocean observing prior to Argo. This has enabled us to describe global warming with unprecedented reliability. Over 90% of all global warming energy (measured by Joules of heat uptake rather than degrees of temperature change) is in the oceans, and Argo is the program that is measuring it. Argo measurements have become fundamental to the Assessment Reports by the Intergovernmental Panel on Climate Change. Until now, Argo has mainly measured the physical changes in the ocean – temperature and salinity. A new age

is dawning in which Argo will measure changes in biogeochemical properties such as dissolved oxygen and carbon dioxide inventory.

Biography | After degrees in applied mathematics and fluid mechanics, Brian King's early career involved making ocean measurements from research ships. In 1998 he had the opportunity to join a small working group to consider how the concept of a global network of freely-drifting autonomous instruments measuring ocean temperature, to be known as 'Argo', might be turned into reality. Twenty years and two million ocean profiles later, Brian is still a member of the International Argo Steering Team, helping to redefine Argo to take advantage of the next generation of technological advances.

How good are past and present ocean profile data?
Viktor Gouretski, Institute of Atmospheric Physics, Beijing

Abstract | The voyage of H.M.S. Challenger marks the beginning of the almost 150 year long history of the observational oceanography. Since then the instrumentation and methods for the determination of temperature, salinity, and other parameters of the sea water undergone a significant evolution. Respectively, the historical archive of the hydrographic profiles is rather inhomogeneous, being a blend of several data subsets obtained by means of thermometers, mechanical (MBT) and expendable (XBT) bathythermographs, ship-based CTDs, anchored buoys, profiling floats, and CTDs attached to marine animals. Along with the instrumentation, the temperature and salinity reference scales have also undergone changes. As the general thermohaline structure of the global ocean was established the further accumulation of the data put the identification of the ocean climate change in the focus of the oceanographic research. The importance of the proper quality control of the data was recognized, as systematic biases were revealed in the expendable bathythermograph data, the most abundant data set between 1970s and 1990s. The depth and temperature XBT biases resulted in the artificial decadal scale variability in the earlier estimates of the ocean heat content - the most important metric to diagnose the ocean climate change. Since then the correction schemes for the bathythermograph data were developed allowing to use these types of data in climate applications. The analysis of the outliers in temperature and salinity data as identified by the quality control procedure shows a significant improvement in the observational accuracy over time. We demonstrate however that selected oldest temperature and salinity profile data are accurate enough for the assessment of the ocean climate change.

Biography | Viktor Gouretski is a visiting scholar in the Institute of Atmospheric Physics, Beijing.

His research focuses on the general thermohaline structure of the ocean, ocean climate change, quality assessment, improvement and analysis of the global hydrographic archive.

He received a PhD in physics and mathematics from the Arctic and Antarctic Research Institute in St. Petersburg, Russia, in 1982.

He moved to Germany in 1990 to prepare the Southern Ocean Hydrographic atlas with the co-workers from the Alfred-Wegener-Institute. Later, in the WOCE special analysis center, he analyzed the consistency of the WOCE hydrographic data and compiled the WOCE atlas of the Atlantik Ocean and the WOCE Global Hydrographic Climatology. In the following years he worked on the development of the XBT bias correction schemes and the assessment of the ocean heat content change.

Gouretski has spent many months on research ships collecting oceanographic data.

Making a data product from ocean profiles – the EN4 experience
Dr Rachel Killick, Met Office

Abstract | This presentation will give an overview of EN4, the UK Met Office's subsurface temperature and salinity dataset, freely available for research purposes from http://www.metoffice.gov.uk/hadobs/en4/. It will cover what EN4 is, how it's created using Argo and other sources, and why it's useful. There will also be sneak previews of HadIOD, the, soon to be released, integrated surface and subsurface Met Office dataset and also some upcoming plans for EN4. We'll also tell you how you can get involved in the near future in providing your input to EN4 - shaping the next major update of this dataset to be released in 2020.

Biography | I joined the Met Office to be an Ocean Observation Scientist in October 2015. Prior to this, I undertook a BSc in Mathematics followed by a PhD in homogenisation of daily surface air temperature at the University of Exeter, UK. My role at the Met Office consists largely of maintaining and updating EN4, our subsurface ocean temperature and salinity product. I am also involved in collaborative in situ ocean work with the Copernicus Marine Environmental Monitoring Service In Situ Thematic Assembly Centre.

How ocean profile products are used – climate change applications
Dr Matt Palmer, Met Office

Abstract | The ocean plays a pivotal role Earth's climate system through its ability to store and re-distribute large quantities of heat and freshwater. The vast majority of the human-induced climate change is manifested in warming of the global oceans. This ocean warming acts to reduce the rate of surface temperature rise, but also leads to global sea level rise through the effect of thermal expansion. Regional sea level change is also influenced by local changes in ocean circulation and heat and freshwater content. In addition, changes in ocean salinity provide important insights into the response of rainfall patterns under climate change. In this talk, I will review some of the key aspects of the ocean's role in climate change, including Earth's energy budget and sea level rise. The presentation will highlight the importance of ocean profile observations and the new insights that have been made possible by the Argo array of autonomous profiling floats. I will discuss our current understanding of future climate change and how further expansion of the ocean observing system is vital to improved climate monitoring and providing robust projections of future climate change.

Biography | Dr Matt Palmer is the lead scientist for sea level research at the Met Office Hadley Centre. His work includes refinement of ocean profile databases, understanding the ocean's role in the climate system and developing global and regional sea level projections. He recently led the marine projections work for the current round of UK climate change projections and is a lead author on the forthcoming Intergovernmental Panel on Climate Change 6th Assessment Report (IPCC AR6). Matt is co-chair of the International Quality controlled Ocean Database (www.iquod.org) initiative and a member of the Ocean Observations Panel for Climate (http://www.goosocean.org/physicsclimate)

The use and impact of Argo products in seasonal - to - decadal prediction
Dr Leon Hermanson

Abstract | Prediction further ahead than a few months is dependent on processes that vary on time scales longer than the weather in the atmosphere. The primary source of predictability is the ocean. The science of seasonal - to - decadal prediction has seen many advances in recent years to the point where the skill is now sufficient for climate services based on these predictions. This talk will focus on multi-annual predictions, where the importance of accurate initial conditions below the ocean surface are most important. It will describe how Argo products are used to create a starting point for the predictions and what would happen if we did not have these. The Met Office has in the last year developed a new strategy for creating an ocean analysis that tries to account for the uncertainty in covariance between observations and other locations in the ocean (such as the deep ocean), which is used to create a data set with complete coverage of temperature and salinity in the ocean. The introduction of Argo in the analysis and the global coverage it provides means that anomalies can be estimated at more locations in the ocean. This results in ensemble members of a prediction potentially being able to better encompass uncertainty arising from unobserved ocean locations.

Biography | Leon is a Senior Scientist at the Met Office in the Predictability Research group, which he joined in 2011. He is primarily concerned with understanding and exploiting the predictability on seasonal to decadal time scales that arises from slow climate processes. He is particularly interested in decadal prediction and the role of the North Atlantic in decadal variability. Previously, he worked at the University of Reading with Prof. Rowan Sutton on the initialisation of the Atlantic Meridional Overturning Circulation (AMOC) for decadal prediction. Leon completed a PhD in Meteorology in 2006 at the University of Reading.

Global Coordination of Ocean Observations: Progress, Challenges and Opportunities
Katherine (Katy) Hill, World Meteorological Organisation

Abstract | The basis of the Ocean observing System today, was developed through major global experiments in the 1980s and 1990s, TOGA, WOCE and JCOFS, culminating in a plan agreed at OceanObs'99, which has largely been implemented. The sustained ocean observing system for climate is hence a significant community achievement; but we now face new challenges, as the Global Ocean Observing System (GOOS) expands to meet a broader range of applications, and the Global Climate Observing System is expected to inform adaptation, mitigation strategies. I will outline the international and intergovernmental oversight of global scale observations, progress to date, then discuss some of the challenges and opportunities for the coming decade;

- How do we evolve the observing system to meet a broader range of applications, from hurricane forecasting, to supporting ecosystem services?
- How do we maintain the interest and momentum for sustaining observations, when funding is on short term funding cycles?
- How do we continually evaluate and innovate the observing system to meet evolving needs?
- How do we foster the next generation of leaders for the next charge forward for sustained observing?
- How do we evolve our coordination activities to meet future needs?

I will try and answer some of these questions, and perhaps pose a few more!

Biography | Katy is based at the World Meteorological Organisation in Geneva. Working with Global Climate Observing System (GCOS) and the Global Ocean Observing System (GOOS) , Katy leads on managing the Ocean Observations Physics and Climate panel. She previously worked for the WCRP's CLIVAR International Project, and Australia's Integrated Marine Observing System where she oversaw the scientific design of the observing system, and ensured the data was t used for optimum impact. After completing a B.Sc in Marine Sciences at the Oceanography Centre, Katy completed an M.Sc at the University of Victoria, Canada and a PhD at CSIRO in Hobart, Australia.

Beyond Argo: Ocean Gliders and Sensors on seals
Prof Karen Heywood, University of East Anglia

Abstract | Argo is providing unprecedented temporal and spatial coverage of monitoring of ocean properties on a global scale, as this meeting demonstrates. However there are some key regions where Argo floats struggle to maintain an observing network. One of these is the polar regions. This talk will discuss alternative strategies and platforms for obtaining Argo-like profiles in areas affected by sea ice coverage. Small sensors on the heads of seals now provide the largest number of profiles in high latitudes. The advantages and disadvantages of this approach will be discussed together with some examples from recent Antarctic campaigns. Profiling ocean gliders also provide hydrographic profiles in key regions where Argo floats may struggle, such as shelf break currents. Although they share the same buoyancy-driven mechanisms as floats, their location can be directed rather than drifting with the current. Thus gliders can provide repeat occupations of sections, and their frequent, closely-spaced profiles yield measurements of the submesoscale. The float, glider and seal tag communities are working together to drive innovation in small, frugal sensors for these platforms, particularly for biology and biogeochemistry. These complementary platforms provide the tools we need for the future ocean observing system.

Biography | Karen Heywood is a physical oceanographer at the University of East Anglia. In 1995 she became the UK's first (and still the only?) female professor of physical oceanography. She leads research into marine physics, ocean circulation, and ocean processes that are important for understanding climate, marine ecosystems and biogeochemical cycling. She focuses on ocean observations, with a particular interest in Antarctic processes and the interactions between ocean and ice. She is an enthusiastic early adopter of new technologies. Since 2009 she has led UEA's ocean glider research group, owning and operating a fleet now numbering 10 gliders, with campaigns worldwide.