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Sustained Ocean Observations represent the key to understanding the origins of ocean climate variability and its impact on atmospheric climate (Fridtjof Nansen Medal Lecture)

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Sustained ocean observing programmes with open access to the observations offer remarkable opportunities for understanding the origin of interannual ocean climate variability and its impact on atmospheric climate. Traditionally ocean observations have been exploratory or experimental, usually of short duration and/or limited spatial extent so that we lack long time series of basin-scale ocean conditions except perhaps for SST, which here is considered to be an atmospheric variable that is responding to (rather than causing) ocean variability. An exception in the ocean is the sustained TOGA monitoring of El Nino-Southern Oscillation climate variability in the Pacific over the last 25 years. Now with satellite records of sea surface height and wind stress for the past 20 years, with Argo records of ocean heat and salt content variability down to 2000 m depth for the past 10 years and with basin-scale current monitoring programmes like Rapid (that includes the Florida Straits transport monitoring done since 1980) for the past 9 years, we can begin to examine events in ocean circulation, their effects on upper ocean heat content including sea surface temperature and then their effects on the atmosphere. With a proper observational basis, we can identify the origin of the ocean variability and its subsequent impact on the climate.

We illustrate the opportunities by examining an event in the Atlantic meridional overturning circulation in 2009-10 when the overturning was 30% lower than normal. The principal proximate cause of the reduced overturning circulation was an increase in southward mid-ocean thermocline flow accompanied by a reduction in the deep southward flow of Lower North Atlantic Deep Water thereby increasing the gyre circulation at the expense of the overturning circulation. Because the overturning circulation transports a sizeable amount of heat and salt northwards, the reduction in overturning circulation affects upper ocean heat and salinity content, notably north of 26N where colder upper ocean temperatures coincide with cold sea surface temperatures in December 2010 that possibly affected the North Atlantic Oscillation and hence European wintertime conditions.

Once the record of ocean variability encompasses several interannual variability events, we can develop a framework for predicting the effects of ocean variability on the atmospheric climate that can be tested against new events. A cautionary note is that long time series are needed: even 25 years of sustained El Nino monitoring does not seem long enough to understand the diversity of initiation, evolution and decay of individual El Nino events. Sustained ocean observations will be needed for a long time.