



Understanding our oceans

Oceans play a key role in regulating the global climate system. The interaction of oceans with the Earth's atmosphere is strongly linked to seawater properties such as salinity and pH, which must be accurately monitored to identify long-term climate trends. However, measurements of these properties are challenging without a traceability chain to link them to units defined in the SI, which would ensure they are comparable regardless of where and when they are made.

Europe's National Measurement Institutes working together

The European Metrology Research Programme (EMRP) brings together National Measurement Institutes in 23 countries to address key measurement challenges at a European level. It supports collaborative research to ensure that measurement science meets the future needs of industry and wider society.

Challenge

The oceanography community most commonly measures ocean salinity using the 'Practical Salinity Scale', which is based on comparing seawater electrical conductivity with the conductivity of a commercially available standard solution made from North Atlantic seawater. This salinity is then used to calculate other properties, like density and sound speed. However, small chemical changes in the standard solution, and in the ocean itself due to climate change, make relationships between Practical Salinity and these other properties uncertain. One such change arises from increases in dissolved carbon dioxide. This means small changes in ocean properties cannot be reliably identified.

The equation of state for seawater, from which the thermodynamic properties of seawater can be derived, is another key component of global climate models. The inclusion of density and speed of sound data in the equation of state will assist in the determination of other properties, including salinity and temperature, especially for deep-sea regions where precise measurements are difficult to make, and further improve the reliability of the climate models they feed into.

Ocean going vessels equipped with acoustic sensors could provide a cost-effective, extensive seawater temperature measurement network, via speed of sound, to supplement satellite data for climate models. However, improved SI traceability for the probes used to measure the speed of sound in seawater is needed before this type of monitoring system can be implemented.

Solution

The EMRP project *Metrology for ocean salinity and acidity* has provided a reference method for ocean salinity, which makes Practical Salinity measurements traceable to the SI units through density measurements. This means that possible long-term drifts in the chemical composition of the standard seawater solution can now be accounted for and eliminated.

In addition, probes used to measure the speed of sound in seawater can now be traceably calibrated under typical operating conditions at newly-developed facilities at project partners PTB and INRIM – the National Measurement Institutes of Germany and Italy. Measurements at sea have confirmed the performance of a prototype transfer standard developed at INRIM, bringing easily achievable traceability to ship-based probes, and have assisted in the generation of in-situ measurement best practice.

Impact

As a result of the EMRP project, NMI members have for the first time been invited to sit on the prestigious Joint Committee for the Properties of Seawater, the organisation responsible for maintaining and improving seawater standards (including the Thermodynamic Equation of Seawater – 2010: TEOS-10). The committee is keen to promote measurement traceability and ensure data compatibility in the years to come.

Ocean Scientific International Ltd (OSIL) is going to incorporate density measurements into the preparation of its standard seawater, which is the only internationally-recognised calibration standard for the measurement of practical salinity. This will provide SI traceability to ocean salinity measurements across the globe and allow the oceanography community to reliably identify even small changes.

The project outputs will make a substantial contribution towards improving the accuracy of ocean salinity and density measurements which provide key input into global climate models.

Ocean metrology

The EMRP project *Metrology for ocean salinity and acidity* developed measurement methods, standards and tools to improve the measured ocean data used for climate monitoring and modelling. Focussing on both thermodynamic quantities – salinity, density, speed of sound and temperature – and chemical quantities – pH, oxygen content and composition – the project's outputs enable the traceable calibration of sensor networks and satellite systems. This will allow scientists to reliably identify small changes in long-term oceanographic data series.



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