New equation of state of seawater

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Seawater is a complex, dynamic mixture of dissolved minerals, salts, and organic materials that despite scientists best efforts, presents difficulties in measuring its potential to contain and disperse energy. Like the water itself, the calculations scientists employ to measure seawater are fluid, undergoing significant revisions and clarifications over the years as research techniques and instrumentation continues to evolve.

For 30 years, scientists have relied on a series of equations called International Equation of State of Seawater - or EOS-80, a collective term representing more than three decades of oceanographic best practice information from the early 1980's to present. Now, based on new oceanographic research, scientists have begun adopting a fresh approach to seawater thermodynamics, based in part by the work of University of Miami (UM) researcher, Dr. Frank Millero. Referred to collectively as the "Thermodynamic Equation Of Seawater - 2010," or "TEOS-10" for short, a new set of highly accurate and comprehensive formulas are beginning to provide much-needed adjustments and clarifications to the widely used EOS-80, that may be accepted internationally as early as 2010.

A member of the original committee that established the EOS-80, and a major contributor to and publisher of its latest revisions, UM Rosenstiel School of Marine and Atmospheric Science Professor Millero, is a leading force in oceanic chemistry research. His work alongside scientists from the across the United States, Canada, Europe, Great Britain, Australia and China is helping to guide the comprehensive reevaluation and construction of a set of equations that may well usher in

sweeping advancements in the fields of marine and atmospheric science.

The Practical Salinity Scale, or PSS-78, and the previous International Equation of State of Seawater, which expresses the density of seawater as a function of Practical Salinity, temperature and pressure, have served the oceanographic community well for three decades, along with a number of other equations formed to incorporate more accurate representations of seawater measurements and algorithms.

"With the advancements in high speed computer processing, and progress in other scientific disciplines, the need for a new equation of state was imminent," said Millero. "These developments, along with scientific demand for more accurate equations and the emphasis on the ocean as an integral part of the global heat engine, have lent weight to a series of recently published papers utilizing increasingly precise formulas that we are hoping will be adopted universally within the next year or so."

The new equation of state is a free energy function that can yield all the thermodynamic values of seawater of known temperature, salinity and pressure. This is more convenient than EOS-80 for modelers who examine the theoretical properties of seawater. Dr. Rainer Reistel, from the Leibniz Institute for Baltic Sea Research in Germany, is widely recognized as the pioneer in developing the new free energy function.

In 2005, the Scientific Committee on Oceanic Research (SCOR) and the International Association of Physical Sciences of the Ocean (IAPSO) established Working Group 127 on the "Thermodynamics and Equation of State of Seawater," or simply WG127. Since then this group has arrived at a series of algorithms that incorporate oceanography's best knowledge of seawater thermodynamics. The approach taken by WG127 has been to develop a Gibbs function from which all the thermodynamic properties of seawater can be derived by purely mathematical

manipulations. This method ensures that the various thermodynamic properties are self-consistent and complete. Named for physical chemist G. N. Gibbs, who developed free energy equations that can be used to study the thermodynamic properties of fluids. The new equation of state is based on a Gibbs function for seawater from which all the thermophysical properties of seawater can be derived in a physically consistent manner.

"The Gibbs function is a function of Absolute Salinity, temperature and pressure, which is a major departure from present practice (EOS-80). The reason for preferring Absolute Salinity over Practical Salinity is because the thermodynamic properties of seawater are directly influenced by the mass of dissolved constituents, or Absolute Salinity, whereas Practical Salinity depends of conductivity," said Millero. "If the new approach to defining the thermodynamic properties of seawater is well received by the scientific community, we would hope that TEOS-10 will become the new internationally accepted definition of seawater by 2010."

While Practical Salinity will still be the salinity variable that is stored in national databases (much as in situ temperature is stored in these databases), it is the new Absolute Salinity that will be used in journal publications, numerical ocean models and inverse models (as temperature is not used now, but rather, potential temperature for these purposes). The main reason for adopting the new salinity variable is to allow for the spatial differences in seawater composition; this variable composition affects conductivity differently to how it affects factors such as density, enthalpy, entropy and more.

Source: University of Miami Rosenstiel School of Marine & Atmospheric Science