Computation of Aquarius-derived Sea Surface Density (SSD)

Julian J Schanze, Earth & Space Research, Seattle, WA (jschanze@esr.org)

Density is a highly non-linear derived variable which depends on temperature, salinity, and pressure. With the introduction of the Thermodynamic Equation Of State in 2010 (TEOS-10), a new thermodynamically consistent formulation of temperature, salinity and density (amongst other variables) was introduced (IOC *et al.*, 2010). TEOS-10 has been accepted by the Intergovernmental Oceanographic Commission and UNESCO to replace the previously used UNESCO Equation of State 1980 (EOS-80) (UNESCO, 1981). TEOS-10 introduces a number of new variables that are required for the computation of density from *in-situ* measurements. The two relevant variables for the purposes of computing surface density from Aquarius Sea Surface Salinity (SSS) and the ancillary Sea Surface Temperature (SST) fields are Absolute Salinity (S_A) and Conservative Temperature (Θ).

Thus, to determine surface density from Aquarius-derived and ancillary data fields, S_A and Θ have to be computed prior to calculating the density. It should be noted that while S_A should be used in all scientific publications involving salinity, it is not recommended for archival purposes. For this reason, Aquarius data will continue to be distributed as practical salinity (S_P) as defined by the Practical Salinity Scale (PSS-78) (UNESCO, 1981).

Conservative Temperature (Θ) is similar to potential temperature in EOS-80, but is designed to be conserved both under adiabatic mixing and changes in depth (IOC, 2010), which is fulfilled neither by potential or *in-situ* temperature. Absolute Salinity (S_A) is a true mass fraction, and defined as the mass fraction of the solute in standard seawater with a density that is identical to the sample. Consequently, S_A has units of g kg^{-1}. These definitions are explained in more detail in IOC (2010) as well as Pawlowicz (2010).

All computations are performed using the Gibbs-SeaWater (GSW) Oceanographic Toolbox (McDougall & Barker, 2011) V3.03 for C. In the first step, S_A is computed from S_P using the subroutine **gsw_sa_from_sp**, which requires four inputs, S_P, pressure, longitude and latitude. In the next step, Θ is computed from sea surface temperature (ITS-90, Preston-Thomas (1990)) using the subroutine **gsw_ct_from_t**, which requires S_A, pressure, and temperature as inputs. Having computed all required input variables, density is then determined using the subroutine **gsw_rho**, which requires S_A, Θ, and pressure as input variables. In all these computations, pressure is fixed to a value of 0, as pressure is defined relative to atmospheric pressure.

IOC, SCOR and IAPSO, 2010: The international thermodynamic equation of seawater – 2010: Calculation and use of thermodynamic properties. *Intergovernmental Oceanographic Commission, Manuals and Guides No. 56*, UNESCO (English), 196 pp.

McDougall, T.J. and P.M. Barker, 2011: Getting started with TEOS-10 and the Gibbs Seawater (GSW) Oceanographic Toolbox, *SCOR/IAPSO WG127*, ISBN 978-0-646-55621-5, 28pp.

Pawlowicz, R., 2010: What every oceanographer needs to know about TEOS-10 (The TEOS-10 Primer, Web document, http://www.teos-10.org/pubs/TEOS-10_Primer.pdf, 10pp.

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UNESCO, 1981: The Practical Salinity Scale 1978 and the International Equation of State of Seawater 1980. *UNESCO technical papers in marine science 36*, 25pp.