

Gibbs SeaWater (GSW) Oceanographic Toolbox of TEOS – 10

Practical Salinity (SP), PSS-78

gsw_SP_from_C	Practical Salinity from conductivity, C (incl. for SP < 2)
gsw_C_from_SP	conductivity, C, from Practical Salinity (incl. for SP < 2)
gsw_SP_from_R	Practical Salinity from conductivity ratio, R (incl. for SP < 2)
gsw_R_from_SP	conductivity ratio, R, from Practical Salinity (incl. for SP < 2)
gsw_SP_salinometer	Practical Salinity from a laboratory salinometer (incl. for SP < 2)
gsw_SP_from_SK	Practical Salinity from Knudsen Salinity

Absolute Salinity (SA), Preformed Salinity (Sstar) and Conservative Temperature (CT)

gsw_SA_from_SP	Absolute Salinity from Practical Salinity
gsw_Sstar_from_SP	Preformed Salinity from Practical Salinity
gsw_CT_from_t	Conservative Temperature from in-situ temperature

Absolute Salinity – Conservative Temperature plotting function

gsw_SA_CT_plot	function to plot Absolute Salinity – Conservative Temperature profiles on the SA-CT diagram, including the freezing line and selected potential density contours
----------------	--

other conversions between temperatures, salinities, entropy, pressure and height

gsw_deltaSA_from_SP	Absolute Salinity Anomaly from Practical Salinity
gsw_SA_Sstar_from_SP	Absolute Salinity & Preformed Salinity from Practical Salinity
gsw_SR_from_SP	Reference Salinity from Practical Salinity
gsw_SP_from_SR	Practical Salinity from Reference Salinity
gsw_SP_from_SA	Practical Salinity from Absolute Salinity
gsw_Sstar_from_SA	Preformed Salinity from Absolute Salinity
gsw_SA_from_Sstar	Absolute Salinity from Preformed Salinity
gsw_SP_from_Sstar	Practical Salinity from Preformed Salinity
gsw_pt_from_CT	potential temperature from Conservative Temperature
gsw_t_from_CT	in-situ temperature from Conservative Temperature
gsw_CT_from_pt	Conservative Temperature from potential temperature
gsw_pot_enthalpy_from_pt	potential enthalpy from potential temperature
gsw_pt_from_t	potential temperature
gsw_pt0_from_t	potential temperature with reference pressure of 0 dbar
gsw_t_from_pt0	in-situ temperature from potential temperature with p_ref of 0 dbar
gsw_t90_from_t48	ITS-90 temperature from IPTS-48 temperature
gsw_t90_from_t68	ITS-90 temperature from IPTS-68 temperature
gsw_z_from_p	height from pressure
gsw_p_from_z	pressure from height
gsw_z_from_depth	height from depth
gsw_depth_from_z	depth from height
gsw_Abs_Pressure_from_p	Absolute Pressure, P, from sea pressure, p
gsw_p_from_Abs_Pressure	sea pressure, p, from Absolute Pressure, P
gsw_entropy_from_CT	entropy from Conservative Temperature
gsw_CT_from_entropy	Conservative Temperature from entropy
gsw_entropy_from_pt	entropy from potential temperature
gsw_pt_from_entropy	potential temperature from entropy
gsw_entropy_from_t	entropy from in-situ temperature
gsw_t_from_entropy	in-situ temperature from entropy
gsw_adiabatic_lapse_rate_from_CT	adiabatic lapse rate from Conservative Temperature
gsw_adiabatic_lapse_rate_from_t	adiabatic lapse rate from in-situ temperature
gsw_molality_from_SA	molality of seawater
gsw_ionic_strength_from_SA	ionic strength of seawater

specific volume, density and enthalpy

gsw_specvol	specific volume
gsw_alpha	thermal expansion coefficient with respect to CT
gsw_beta	saline contraction coefficient at constant CT
gsw_alpha_on_beta	alpha divided by beta
gsw_specvol_alpha_beta	specific volume, thermal expansion and saline contraction coefficients
gsw_specvol_first_derivatives	first derivatives of specific volume
gsw_specvol_second_derivatives	second derivatives of specific volume
gsw_specvol_first_derivatives_wrt_enthalpy	first derivatives of specific volume with respect to enthalpy
gsw_specvol_second_derivatives_wrt_enthalpy	second derivatives of specific volume with respect to enthalpy
gsw_specvol_anom	specific volume anomaly
gsw_specvol_anom_standard	specific volume anomaly relative to SSO & 0°C
gsw_rho	in-situ density and potential density
gsw_rho_alpha_beta	in-situ density, thermal expansion and saline contraction coefficients
gsw_rho_first_derivatives	first derivatives of density
gsw_rho_second_derivatives	second derivatives of density
gsw_rho_first_derivatives_wrt_enthalpy	first derivatives of density with respect to enthalpy
gsw_rho_second_derivatives_wrt_enthalpy	second derivatives of density with respect to enthalpy
gsw_sigma0	sigma0 with reference pressure of 0 dbar
gsw_sigma1	sigma1 with reference pressure of 1000 dbar
gsw_sigma2	sigma2 with reference pressure of 2000 dbar
gsw_sigma3	sigma3 with reference pressure of 3000 dbar
gsw_sigma4	sigma4 with reference pressure of 4000 dbar
gsw_cabbeling	cabbeling coefficient
gsw_thermobaric	thermobaric coefficient
gsw_enthalpy	enthalpy
gsw_enthalpy_diff	difference of enthalpy between two pressures
gsw_dynamic_enthalpy	dynamic enthalpy
gsw_enthalpy_first_derivatives	first derivatives of enthalpy
gsw_enthalpy_second_derivatives	second derivatives of enthalpy
gsw_sound_speed	sound speed
gsw_kappa	isentropic compressibility
gsw_internal_energy	internal energy
gsw_internal_energy_first_derivatives	first derivatives of internal energy
gsw_internal_energy_second_derivatives	second derivatives of internal energy
gsw_CT_from_enthalpy	Conservative Temperature from enthalpy
gsw_SA_from_rho	Absolute Salinity from density
gsw_CT_from_rho	Conservative Temperature from density
gsw_CT_maxdensity	Conservative Temperature of maximum density of seawater

Gibbs SeaWater (GSW) Oceanographic Toolbox of TEOS – 10

vertical stability

gsw_Nsquared
gsw_Turner_Rsubrho
gsw_IPV_vs_fNsqared_ratio

buoyancy (Brunt-Väisälä) frequency squared (N^2)
Turner angle & Rsubrho
ratio of the of isopycnal potential density to N^2

geostrophic streamfunctions, acoustic travel time and geostrophic velocity

gsw_geo_strf_dyn_height
gsw_geo_strf_dyn_height_pc
gsw_geo_strf_isopycnal
gsw_geo_strf_isopycnal_pc

dynamic height anomaly
dynamic height anomaly for piecewise constant profiles
approximate isopycnal geostrophic streamfunction
approximate isopycnal geostrophic streamfunction for piecewise constant profiles
Cunningham geostrophic streamfunction
Montgomery geostrophic streamfunction
dynamic height anomaly divided by 9.7963 m s^{-2}
pressure integrated steric height
acoustic travel time
geostrophic velocity

gsw_geo_strf_Cunningham
gsw_geo_strf_Montgomery
gsw_geo_strf_steric_height
gsw_geo_strf_PISH
gsw_travel_time
gsw_geostrophic_velocity

neutral versus isopycnal slopes and ratios

gsw_isopycnal_slope_ratio

gsw_isopycnal_vs_ntp_CT_ratio

gsw_ntp_pt_vs_CT_ratio

ratio of the slopes of isopycnals on the SA-CT diagram for p & p_{ref}
ratio of the gradient of CT in a potential density surface to that in the neutral tangent plane
ratio of gradients of pt & CT in a neutral tangent plane

derivatives of entropy, CT and pt

gsw_CT_first_derivatives
gsw_CT_second_derivatives
gsw_entropy_first_derivatives
gsw_entropy_second_derivatives
gsw_pt_first_derivatives
gsw_pt_second_derivatives

first derivatives of Conservative Temperature
second derivatives of Conservative Temperature
first derivatives of entropy
second derivatives of entropy
first derivatives of potential temperature
second derivatives of potential temperature

seawater and ice properties at freezing temperatures

gsw_CT_freezing
gsw_CT_freezing_poly
gsw_t_freezing
gsw_t_freezing_poly
gsw_pot_enthalpy_ice_freezing
gsw_pot_enthalpy_ice_freezing_poly
gsw_SA_freezing_from_CT
gsw_SA_freezing_from_CT_poly
gsw_SA_freezing_from_t
gsw_SA_freezing_from_t_poly
gsw_pressure_freezing_CT
gsw_CT_freezing_first_derivatives
gsw_CT_freezing_first_derivatives_poly
gsw_t_freezing_first_derivatives
gsw_t_freezing_first_derivatives_poly
gsw_pot_enthalpy_ice_freezing_first_derivatives
gsw_pot_enthalpy_ice_freezing_first_derivatives_poly
gsw_latentheat_melting

Conservative Temperature freezing temp of seawater
Conservative Temperature freezing temp of seawater (poly)
in-situ freezing temperature of seawater
in-situ freezing temperature of seawater (poly)
potential enthalpy of ice at which seawater freezes
potential enthalpy of ice at which seawater freezes (poly)
SA of seawater at the freezing temp (for given CT)
SA of seawater at the freezing temp (for given CT) (poly)
SA of seawater at the freezing temp (for given t)
SA of seawater at the freezing temp (for given t) (poly)
pressure of seawater at the freezing temp (for given CT)
first derivatives of CT freezing temp of seawater
first derivatives of CT freezing temp of seawater (poly)
first derivatives of in-situ freezing temp of seawater
first derivatives of in-situ freezing temp of seawater (poly)
first derivatives of potential enthalpy of ice at freezing
first derivatives of potential enthalpy of ice at freezing (poly)
latent heat of melting of ice into seawater

thermodynamic interaction between ice and seawater

gsw_melting_ice_SA_CT_ratio
gsw_melting_ice_SA_CT_ratio_poly
gsw_melting_ice_equilibrium_SA_CT_ratio
gsw_melting_ice_equilibrium_SA_CT_ratio_poly
gsw_ice_fraction_to_freeze_seawater
gsw_melting_ice_into_seawater
gsw_frazil_ratios_adiabatic
gsw_frazil_ratios_adiabatic_poly
gsw_frazil_properties
gsw_frazil_properties_potential
gsw_frazil_properties_potential_poly

SA to CT ratio when ice melts into seawater
SA to CT ratio when ice melts into seawater (poly)
SA to CT ratio when ice melts, near equilibrium
SA to CT ratio when ice melts, near equilibrium (poly)
ice mass fraction to freeze seawater
SA and CT when ice melts in seawater
ratios of SA, CT and P changes during frazil ice formation
ratios of SA, CT and P changes during frazil ice formation (poly)
SA, CT & ice mass fraction from bulk SA & bulk enthalpy
SA, CT & ice fraction from bulk SA & bulk potential enthalpy
SA, CT & ice fraction from bulk SA & bulk potential enthalpy (poly)

thermodynamic interaction between sea ice and seawater

gsw_melting_seaice_SA_CT_ratio
gsw_melting_seaice_SA_CT_ratio_poly
gsw_melting_seaice_equilibrium_SA_CT_ratio
gsw_melting_seaice_equilibrium_SA_CT_ratio_poly
gsw_seaice_fraction_to_freeze_seawater
gsw_melting_seaice_into_seawater

SA to CT ratio when sea ice melts into seawater
SA to CT ratio when sea ice melts into seawater (poly)
SA to CT ratio when sea ice melts, near equilibrium
SA to CT ratio when sea ice melts, near equilibrium (poly)
sea ice mass fraction to freeze seawater
SA and CT when sea ice melts into seawater

thermodynamic properties of ice Ih

gsw_specvol_ice
gsw_alpha_wrt_t_ice
gsw_rho_ice
gsw_pressure_coefficient_ice
gsw_sound_speed_ice
gsw_kappa_ice
gsw_kappa_const_t_ice
gsw_internal_energy_ice
gsw_enthalpy_ice
gsw_entropy_ice
gsw_cp_ice
gsw_chem_potential_water_ice
gsw_Helmholtz_energy_ice
gsw_adiabatic_lapse_rate_ice
gsw_pt0_from_t_ice
gsw_pt_from_t_ice
gsw_t_from_pt0_ice
gsw_t_from_rho_ice
gsw_pot_enthalpy_from_pt_ice
gsw_pt_from_pot_enthalpy_ice
gsw_pot_enthalpy_from_pt_ice_poly
gsw_pt_from_pot_enthalpy_ice_poly
gsw_pot_enthalpy_from_specvol_ice
gsw_specvol_from_pot_enthalpy_ice
gsw_pot_enthalpy_from_specvol_ice_poly
gsw_specvol_from_pot_enthalpy_ice_poly

specific volume of ice
thermal expansion coefficient of ice with respect to in-situ temp
in-situ density of ice
pressure coefficient of ice
sound speed of ice (compression waves)
isentropic compressibility of ice
isothermal compressibility of ice
internal energy of ice
enthalpy of ice
entropy of ice
isobaric heat capacity of ice
chemical potential of water in ice
Helmholtz energy of ice
adiabatic lapse rate of ice
potential temperature of ice with reference pressure of 0 dbar
potential temperature of ice
in-situ temp from potential temp of ice with p_{ref} of 0 dbar
in-situ temp from density of ice
potential enthalpy from potential temperature of ice
potential temperature from potential enthalpy of ice
potential enthalpy from potential temperature of ice (poly)
potential temperature from potential enthalpy of ice (poly)
potential enthalpy from specific volume of ice
specific volume from potential enthalpy of ice
potential enthalpy from specific volume of ice (poly)
specific volume from potential enthalpy of ice (poly)

Gibbs SeaWater (GSW) Oceanographic Toolbox of TEOS – 10

isobaric evaporation enthalpy

gsw_latentheat_evap_CT	latent heat of evaporation of water from seawater (isobaric evaporation enthalpy) with CT as input temperature
gsw_latentheat_evap_t	latent heat of evaporation of water from seawater (isobaric evaporation enthalpy) with in-situ temperature, t, as input

spiciness

gsw_spiciness0	spiciness with reference pressure of 0 dbar
gsw_spiciness1	spiciness with reference pressure of 1000 dbar
gsw_spiciness2	spiciness with reference pressure of 2000 dbar

planet Earth properties

gsw_f	Coriolis parameter
gsw_grav	gravitational acceleration
gsw_distance	spherical earth distance between points in the ocean

TEOS–10 constants

gsw_T0	Celsius zero point; 273.15 K
gsw_P0	one standard atmosphere; 101 325 Pa
gsw_S0	Standard Ocean Reference Salinity; 35.165 04 g/kg
gsw_uPS	unit conversion factor for salinities; (35.165 04/35) g/kg
gsw_cp0	the “specific heat” for use with CT; 3991.867 957 119 63 (J/kg)/K
gsw_C3515	conductivity of SSW at SP=35, t ₆₈ =15, p=0; 42.9140 mS/cm
gsw_SonCl	ratio of SP to Chlorinity; 1.80655 (g/kg) ⁻¹
gsw_valence_factor	valence factor of sea salt; 1.2452898
gsw_atomic_weight	mole-weighted atomic weight of sea salt; 31.4038218... g/mol

dissolved gasses

gsw_Arsol	argon solubility from SA and CT
gsw_Arsol_SP_pt	argon solubility from SP and pt
gsw_Hesol	helium solubility from SA and CT
gsw_Hesol_SP_pt	helium solubility from SP and pt
gsw_Krsol	krypton solubility from SA and CT
gsw_Krsol_SP_pt	krypton solubility from SP and pt
gsw_N2sol	nitrogen solubility from SA and CT
gsw_N2sol_SP_pt	nitrogen solubility from SP and pt
gsw_Nesol	neon solubility from SA and CT
gsw_Nesol_SP_pt	neon solubility from SP and pt
gsw_O2sol	oxygen solubility from SA and CT
gsw_O2sol_SP_pt	oxygen solubility from SP and pt

specific volume, density and enthalpy in terms of CT, based on the exact Gibbs function

gsw_specvol_CT_exact	specific volume
gsw_alpha_CT_exact	thermal expansion coefficient with respect to CT
gsw_beta_CT_exact	saline contraction coefficient at constant CT
gsw_alpha_on_beta_CT_exact	alpha divided by beta
gsw_specvol_alpha_beta_CT_exact	specific volume, thermal expansion and saline contraction coefficients
gsw_specvol_first_derivatives_CT_exact	first derivatives of specific volume
gsw_specvol_second_derivatives_CT_exact	second derivatives of specific volume
gsw_specvol_first_derivatives_wrt_enthalpy_CT_exact	first derivatives of specific volume with respect to enthalpy
gsw_specvol_second_derivatives_wrt_enthalpy_CT_exact	second derivatives of specific volume with respect to enthalpy
gsw_specvol_anom_CT_exact	specific volume anomaly
gsw_specvol_anom_standard_CT_exact	specific volume anomaly relative to SSO & 0°C
gsw_rho_CT_exact	in-situ density and potential density
gsw_rho_alpha_beta_CT_exact	in-situ density, thermal expansion and saline contraction coefficients
gsw_rho_first_derivatives_CT_exact	first derivatives of density
gsw_rho_second_derivatives_CT_exact	second derivatives of density
gsw_rho_first_derivatives_wrt_enthalpy_CT_exact	first derivatives of density with respect to enthalpy
gsw_rho_second_derivatives_wrt_enthalpy_CT_exact	second derivatives of density with respect to enthalpy
gsw_sigma0_CT_exact	sigma0 with reference pressure of 0 dbar
gsw_sigma1_CT_exact	sigma1 with reference pressure of 1000 dbar
gsw_sigma2_CT_exact	sigma2 with reference pressure of 2000 dbar
gsw_sigma3_CT_exact	sigma3 with reference pressure of 3000 dbar
gsw_sigma4_CT_exact	sigma4 with reference pressure of 4000 dbar
gsw_cabbeling_CT_exact	cabbeling coefficient
gsw_thermobaric_CT_exact	thermobaric coefficient
gsw_enthalpy_CT_exact	enthalpy
gsw_enthalpy_diff_CT_exact	difference of enthalpy between two pressures
gsw_dynamic_enthalpy_CT_exact	dynamic enthalpy
gsw_enthalpy_first_derivatives_CT_exact	first derivatives of enthalpy
gsw_enthalpy_second_derivatives_CT_exact	second derivatives of enthalpy
gsw_sound_speed_CT_exact	sound speed
gsw_kappa_CT_exact	isentropic compressibility
gsw_internal_energy_CT_exact	internal energy
gsw_internal_energy_first_derivatives_CT_exact	first derivatives of internal energy
gsw_internal_energy_second_derivatives_CT_exact	second derivatives of internal energy
gsw_CT_from_enthalpy_exact	Conservative Temperature from enthalpy
gsw_SA_from_rho_CT_exact	Absolute Salinity from density
gsw_CT_from_rho_exact	Conservative Temperature from density
gsw_CT_maxdensity_exact	Conservative Temperature of maximum density of seawater

laboratory functions, for use with densimeter measurements

gsw_SA_from_rho_t_exact	Absolute Salinity from density
gsw_deltaSA_from_rho_t_exact	Absolute Salinity Anomaly from density
gsw_rho_t_exact	in-situ density

Gibbs SeaWater (GSW) Oceanographic Toolbox of TEOS – 10

basic thermodynamic properties in terms of in-situ t , based on the exact Gibbs function

gsw_specvol_t_exact	specific volume
gsw_alpha_wrt_CT_t_exact	thermal expansion coefficient with respect to Conservative Temperature
gsw_alpha_wrt_pt_t_exact	thermal expansion coefficient with respect to potential temperature
gsw_alpha_wrt_t_exact	thermal expansion coefficient with respect to in-situ temperature
gsw_beta_const_CT_t_exact	saline contraction coefficient at constant Conservative Temperature
gsw_beta_const_pt_t_exact	saline contraction coefficient at constant potential temperature
gsw_beta_const_t_exact	saline contraction coefficient at constant in-situ temperature
gsw_specvol_anom_standard_t_exact	specific volume anomaly relative to SSO & 0°C
gsw_rho_t_exact	in-situ density
gsw_pot_rho_t_exact	potential density
gsw_sigma0_pt0_exact	sigma0 from pt0 with reference pressure of 0 dbar
gsw_enthalpy_t_exact	enthalpy
gsw_dynamic_enthalpy_t_exact	dynamic enthalpy
gsw_CT_first_derivatives_wrt_t_exact	first derivatives of Conservative Temperature with respect to t
gsw_enthalpy_first_derivatives_wrt_t_exact	first derivatives of enthalpy with respect to t
gsw_sound_speed_t_exact	sound speed
gsw_kappa_t_exact	isentropic compressibility
gsw_kappa_const_t_exact	isothermal compressibility
gsw_internal_energy_t_exact	internal energy
gsw_SA_from_rho_t_exact	Absolute Salinity from density
gsw_t_from_rho_exact	in-situ temperature from density
gsw_t_maxdensity_exact	in-situ temperature of maximum density of seawater
gsw_cp_t_exact	isobaric heat capacity
gsw_isochoric_heat_cap_t_exact	isochoric heat capacity
gsw_chem_potential_relative_t_exact	relative chemical potential
gsw_chem_potential_water_t_exact	chemical potential of water in seawater
gsw_chem_potential_salt_t_exact	chemical potential of salt in seawater
gsw_t_deriv_chem_potential_water_t_exact	temperature derivative of chemical potential of water
gsw_dilution_coefficient_t_exact	dilution coefficient of seawater
gsw_Helmholtz_energy_t_exact	Helmholtz energy
gsw_osmotic_coefficient_t_exact	osmotic coefficient of seawater
gsw_osmotic_pressure_t_exact	osmotic pressure of seawater

Library functions of the GSW toolbox *(internal functions; not intended to be called by users)*

The GSW functions call the following library functions:

gsw_gibbs
 gsw_gibbs_ice
 gsw_SAAR
 gsw_Fdelta
 gsw_deltaSA_atlas
 gsw_SA_from_SP_Baltic
 gsw_SP_from_SA_Baltic
 gsw_infunnel
 gsw_entropy_part
 gsw_entropy_part_zerop
 gsw_interp_ref_cast
 gsw_linear_interp_SA_CT
 gsw_rr68_interp_SA_CT
 gsw_gibbs_pt0_pt0
 gsw_gibbs_ice_part_t
 gsw_gibbs_ice_pt0
 gsw_specvol_SSO_0
 gsw_enthalpy_SSO_0
 gsw_Hill_ratio_at_SP2

the TEOS-10 Gibbs function of seawater and its derivatives
 the TEOS-10 Gibbs function of ice and its derivatives
 Absolute Salinity Anomaly Ratio (excluding the Baltic Sea)
 ratio of Absolute to Preformed Salinity, minus 1
 Absolute Salinity Anomaly atlas value (excluding the Baltic Sea)
 Calculates Absolute Salinity in the Baltic Sea
 Calculates Practical Salinity in the Baltic Sea
 “oceanographic funnel” check for the 75-term equation
 entropy minus the terms that are a function of only SA
 entropy_part evaluated at 0 dbar
 linearly interpolates the reference cast
 linearly interpolates (SA,CT,p) to the desired p
 Reiniger & Ross (1968) interpolation of (SA,CT,p) to the desired p
 gibbs(0,2,0,SA,t,0)
 part of gibbs_ice(1,0,t,p)
 part of gibbs_ice(1,0,pt0,0)
 specvol(35.16504,0,p)
 enthalpy(35.16504,0,p)
 Hill ratio at a Practical Salinity of 2

The GSW data set:

gsw_data_v3_0

This file contains:

- (1) the global data set of Absolute Salinity Anomaly Ratio,
- (2) the global data set of Absolute Salinity Anomaly Ref.,
- (3) a reference cast (for the isopycnal streamfunction),
- (4) two reference casts that are used by gsw_demo
- (5) three vertical profiles of (SP, t , p) at known long & lat, plus the outputs of all the GSW functions for these 3 profiles, and the required accuracy of all these outputs.

documentation set

gsw_front_page
 gsw_check_functions
 gsw_demo
 gsw_ver
 gsw_licence

front page to the GSW Oceanographic Toolbox
 checks that all the GSW functions work correctly
 demonstrates many GSW functions and features
 displays the GSW version number
 creative commons licence for the GSW Oceanographic Toolbox

The GSW Toolbox is available from
www.TEOS-10.org

