Amended writing to account for version 2.0 upgrade.

(Unchanged text in blue, amended text in black)

2.1.1

- Location: The light green tab's data template was developed to process vertical casts located at a given location. Longitude and latitude must be input in cells 'B1:B2' in decimal format (degrees). Longitude can either be within the domain (-180º to 180º) or (0º to 360º) i.e., 10º 30' W can be input as -10.5º or 349.5º. The latitude domain is (-90º to 90º) i.e., 30º S would be -30º. The input of the cast coordinates is essential, as Absolute Salinity is dependent of location (Sect 3.6). If either the longitude or the latitude cells are left empty, the Salinity Anomaly is set to zero and Absolute Salinity becomes equal to Reference Salinity.

- Pressure: pressure (p) units are dbar. For seawater properties, pressure is always the pressure of the water column, i.e., absolute pressure subtracted by atmospheric pressure. Therefore, at the surface, $p = 0$. For the upper ocean, 10 dbar ≈ 10 m.

- Salinity: the user can toggle the input between Practical Salinity (the salinity quantity which continues to be the recommended quantity to be archived (IOC, SCOR and IAPSO, 2010)), conductivity (mS cm^{-1}) (i.e., measured by an *in situ* transducer), or the conductivity ratio (i.e., ratio between the conductivities of the sample and of Standard Sea Water, measured by a salinometer). Column 'D' of the spreadsheet ('Practical Salinity (S_P)') either copies the S_P value if this was the salinity input or calculates S_P from conductivity using function {*SP_from_C(C, t, p)*} or from the conductivity ratio using function {*SP_from_R(R, t, p)*}, depending on the radio button selected.

- Temperature: temperature (ºC) may be selected to be either ITS-90 or IPTS-68 (data sets before 1990 are in the IPTS-68 standard, but recent data may still be applying this standard instead of the newer ITS-90 – checking the instrument specifications and/or the metadata associated with the data is advisable). Column 'J' of the spreadsheet ('Temperature ITS-90') either copies the temperature input if ITS-90 is selected or converts the IPTS-68 values to ITS-90 (ITS-90 = IPTS-68 / 1.00024). All functions use temperature ITS-90 as input.

2.2

- Whenever the location is in the Baltic (which is checked by the {*is_Baltic(lon, lat)*} function), the Salinity Anomaly cells display 'Baltic'. This spreadsheet also includes a line with data from line one of the 'TEOS-10 Test Data' tab (surface data from the NW Pacific) as well as a line of data without location coordinates (e.g., a sample from an estuary). In this case, Salinity Anomaly is set to zero and Absolute Salinity becomes equal to Reference Salinity.

2.6 Info tab (green)

This tab lists all released versions of TEOS-10 EXCEL, providing detailed information on the updates included in each version.

3.VBA (Visual Basic for Applications) modules

Table 1. List of all VBA Modules and formulas included in v.2.0 of TEOS-10 Excel. Direct translations from GSW are marked with 'YES' and original or modified functions marked with 'NO'.

VBA Module	GSW	Description
CT_from_pt(SA, pt)	YES	Calculates Conservative Temperature of seawater from potential temperature (whose reference sea pressure is zero dbar)
Entropy_part (SA, t, p)	YES	This function calculates entropy, except that it does not evaluate any terms that are functions of Absolute Salinity alone. This function is called by {pt0_from_t}
Entropy_part_zerop (SA, pt0)	YES	This function calculates entropy at a sea pressure of zero, except that it does not evaluate any terms that are functions of Absolute Salinity alone. This function is called by {pt0_from_t}
Gibbs_pt0_pt0 (SA, pt0)	YES	This function calculates the second derivative of the specific Gibbs function with respect to temperature at zero sea pressure. This function is called by {pt0_from_t}
Hill_ratio_at_SP2(t)	YES	Calculates the Hill ratio, which is the adjustment needed to apply for Practical Salinities smaller than 2. This function is called by {SP_from_C(C,t,p)} and {SP_from_R(R,t,p)}
is_Baltic(lon, lat)	NO	Checks if a location is in the Baltic Sea. This function is original and different from the GSW counterpart. Baltic limits are taken from Figure 2 of Feistel et al. (2019: 6)
LookUp_atlas(table_name, p, lon, lat)	NO	This function builds and interrogates the Atlas database and was developed specifically for the EXCEL implementation of TEOS-10. 'table_name' can be one of the two look-up tables [deltaSA_ref] or [SAAR_ref]. Results are a 3D interpolation of the 8 vertices of the cube around the (lon, lat, p) location in the ocean
pt0_from_t(SA, t, p)	YES	Calculates potential temperature with reference pressure, p_ref = 0 dbar.
rho(SA, CT, p)	YES	Calculates in-situ density from Absolute Salinity, Conservative Temperature, and pressure
SA_Baltic(SP)	YES	Calculates Absolute Salinity in the Baltic from Practical Salinity
sigma_CT_line(SA, sigma, min_temp, max_temp)	NO	Calculates Conservative Temperature (CT) from SA at a constant sigma value (e.g., 25) between min_temp and max_temp. Function used to build potential density (sigma) lines to be plotted in the Absolute Salinity - Conservative Temperature Diagram. It calls the {sigma0(SA,CT)} function
sigma0(SA, CT)	YES	Calculates potential density anomaly with reference pressure of 0 dbar
Sound_Speed(SA, CT, p)	YES	Calculates the speed of sound in seawater from Absolute Salinity, Conservative Temperature, and pressure
SP_from_C(C,t,p)	YES	Calculates Practical Salinity from Conductivity, temperature, and pressure
SP_from_R(R,t,p)	YES	Calculates Practical Salinity from the conductivity Ratio, temperature, and pressure
Formulas used outside VBA Modules		
t = t68 / 1.00024	YES	Calculates temperature ITS-90 from temperature IPTS-68
$S_R = S_P * 35.16504 / 35$	YES	Calculates Reference Salinity (S_R) from Practical Salinity (S_P)
$\delta S_A = S_R *$ [SAAR_Atlas]	YES	Absolute Salinity Anomaly equals the product of Reference Salinity by the interpolated Absolute Salinity Anomaly Ratio
$S_A = S_R + \delta S_A$	YES	Absolute Salinity equals Reference Salinity plus Absolute Salinity Anomaly

Table 1 lists all functions (VBA modules) and formulas included in version 2.0 of TEOS-10 EXCEL. Most modules are a direct translation…

As referred before, access to the VBA project environment can be obtained by pressing [Alt + F11] (Windows) or [Fn + Alt + F11] (Mac). All functions (alphabetically listed in table 1) are described next, following the spreadsheet's column sequence.

3.1. Practical Salinity (S_P)

S_P is computed from conductivity using function {*SP_from_C(C, t, p)*} or from the conductivity Ratio using function {*SP_from_R(R, t, p)*}, depending on the radio button selected. Practical Salinity is a dimensionless quantity, although PSU (Practical Salinity Units) is commonly used. For reference, the calculation algorithm is designed so that the conductivity of Reference Composition Seawater at $S_P = 35$, $t_{68} = 15$, $p = 0$ is 42.9140 mS cm^{-1}, which can be used to validate the conductivity function. For the conductivity Ratio function, a ratio = 1 and $t_{68} = 15$, will result in $S_P = 35$. If $S_P < 2$ both functions call the {*Hill_ratio_at_SP2(t)*} function which corrects the SP value based on the Hill et al. (1986) algorithm. This algorithm is adjusted so that it is exactly equal to the PSS-78 algorithm at SP = 2.

The following figures were updated:

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O
1	Longitude	162.5	degrees	Longitude and Latitude are needed for estimating the Absolute Salinity Anomaly. If either is left blank, Absolute Salinity Anomaly is set to zero.											
2	Latitude	33	degrees	User data should be input in white cells only. All coloured colums will update automatically. DATA CAN BE DELETED BUT **NOT MOVED prior to deletion** OR THE FORMULAS WILL LOOSE THEIR REFERENCE.											
3	Pressure (dbar)	Salinity: Practical Salinity / Conductivity (mS/cm) / Conductivity Ratio	Temperature (°C): ITS-90 / IPTS-68	Practical Salinity (S_P)	Reference Salinity (S_R) (g kg^{-1})	delta S_A Atlas (g kg^{-1})	SAAR Atlas (g kg^{-1})	Absolute Salinity Anomaly (δS_A) (g kg^{-1})	Absolute Salinity (S_A) (g kg^{-1})	Temperature ITS-90 (°C)	Potential temperature (θ) (°C)	Conservative Temperature (Θ) (°C)	Potential Density (σ_Θ) (kg m^{-3} - 1000)	In situ Density ($\rho_{SA,\Theta,p}$) (kg m^{-3})	Sound Speed (c) (m s^{-1})
4															
5	0	34.57586	19.507610	34.5759	34.7389	0.000327101505	0.000009410247	0.000326901616	34.7392	19.5076	19.5076	19.5130	24.5709	1024.5709	1519.5537
6	10	34.74774	20.008300	34.7477	34.9116	0.000339231758	0.000009773386	0.000341204433	34.9119	20.0083	20.0065	20.0072	24.5716	1024.6148	1521.2985
7	20	34.67881	19.133780	34.6788	34.8423	0.000333521900	0.000009747636	0.000339630409	34.8427	19.1338	19.1302	19.1319	24.7466	1024.8333	1518.9494
8	30	34.68279	18.834320	34.6828	34.8463	0.000375042687	0.000010581871	0.000368739417	34.8467	18.8343	18.8290	18.8302	24.8264	1024.9566	1518.2704
9	40	34.68397	18.288160	34.6840	34.8475	0.000389800378	0.000011376763	0.000396451974	34.8479	18.2882	18.2813	18.2817	24.9648	1025.1387	1516.8712
10	50	34.68861	17.893830	34.6886	34.8522	0.000430311850	0.000012931657	0.000450696471	34.8526	17.8938	17.8853	17.8852	25.0661	1025.2838	1515.8962
11	76	34.69963	17.056150	34.6996	34.8633	0.000569195077	0.000016219010	0.000565447460	34.8638	17.0561	17.0436	17.0423	25.2778	1025.6097	1513.8627
12	101	34.69791	16.492310	34.6979	34.8615	0.000696512528	0.000019779266	0.000689535385	34.8622	16.4923	16.4761	16.4742	25.4100	1025.8520	1512.5741
13	126	34.71489	16.128460	34.7149	34.8786	0.000843341842	0.000023960698	0.000835715273	34.8794	16.1285	16.1085	16.1059	25.5080	1026.0600	1511.8947
14	151	34.68967	15.684310	34.6897	34.8532	0.001001694449	0.000028396145	0.000989697859	34.8542	15.6843	15.6608	15.6585	25.5905	1026.2530	1510.9066
15	176	34.65537	15.247770	34.6554	34.8188	0.001146533554	0.000032958859	0.001147587425	34.8199	15.2478	15.2209	15.2191	25.6623	1026.4358	1509.9149
16	202	34.63723	15.028760	34.6372	34.8006	0.001306176088	0.000038329968	0.001333904319	34.8019	15.0288	14.9982	14.9967	25.6975	1026.5858	1509.6304
17	252	34.58649	14.440070	34.5865	34.7496	0.001555687022	0.000045929491	0.001596030542	34.7512	14.4401	14.4029	14.4022	25.7872	1026.8977	1508.5164
18	303	34.53391	13.762160	34.5339	34.6968	0.001918317195	0.000056693585	0.001967083277	34.6987	13.7622	13.7189	13.7189	25.8905	1027.2291	1507.0947
19	353	34.44696	12.587460	34.4470	34.6094	0.002406799849	0.000074277399	0.002570695638	34.6120	12.5875	12.5399	12.5411	26.0606	1027.6275	1503.9112
20	404	34.37410	11.610510	34.3741	34.5362	0.003092026444	0.000101116678	0.003492184663	34.5397	11.6105	11.5588	11.5609	26.1915	1027.9920	1501.3222
21	505	34.17681	8.998112	34.1768	34.3380	0.004943227283	0.000152354201	0.005231533736	34.3432	8.9981	8.9428	8.9471	26.4886	1028.7658	1493.3821
22	606	34.04839	6.567234	34.0484	34.2089	0.007328918773	0.000217880674	0.007453467487	34.2164	6.5672	6.5115	6.5167	26.7417	1029.5063	1485.5902
23	707	34.05378	5.180429	34.0538	34.2144	0.010134516840	0.000293431730	0.010039578297	34.2244	5.1804	5.1224	5.1270	26.9196	1030.1657	1481.6929
24	808	34.13533	4.453866	34.1353	34.2963	0.012801564089	0.000365710401	0.012542510966	34.3088	4.4539	4.3914	4.3949	27.0677	1030.7880	1480.4628
25	909	34.21526	4.010992	34.2153	34.3766	0.014899810655	0.000425738110	0.014635428541	34.3912	4.0110	3.9430	3.9457	27.1798	1031.3704	1480.3736
26	1010	34.28701	3.630195	34.2870	34.4487	0.016512321555	0.000473242399	0.016302579738	34.4650	3.6302	3.5568	3.5588	27.2768	1031.9375	1480.5196
27	1111	34.33858	3.351287	34.3386	34.5005	0.017685037469	0.000508934903	0.017558509209	34.5181	3.3513	3.2720	3.2736	27.3463	1032.4752	1481.0620
28	1213	34.38449	3.102174	34.3845	34.5466	0.018687486637	0.000538076023	0.018588711984	34.5652	3.1022	3.0169	3.0181	27.4074	1033.0086	1481.7362
29	1314	34.42426	2.876307	34.4243	34.5866	0.019494191089	0.000561454629	0.019418798328	34.6060	2.8763	2.7851	2.7861	27.4607	1033.5292	1482.4828
30	1416	34.45672	2.694073	34.4567	34.6192	0.020176311159	0.000582091514	0.020151541483	34.6393	2.6941	2.5966	2.5974	27.5037	1034.0426	1483.4231
31	1517	34.48842	2.506860	34.4884	34.6510	0.020753899596	0.000599223978	0.020763738622	34.6718	2.5069	2.4034	2.4040	27.5459	1034.5510	1484.3241
32	1771	34.54501	2.196994	34.5450	34.7079	0.021602210963	0.000617441618	0.021430104714	34.7293	2.1970	2.0767	2.0772	27.6186	1035.7882	1487.2625
33	2025	34.58881	1.953304	34.5888	34.7519	0.021906208811	0.000625378399	0.021733094502	34.7736	1.9533	1.8154	1.8157	27.6744	1037.0030	1490.4856
34	2279	34.61341	1.825799	34.6134	34.7766	0.021834954336	0.000625665801	0.021758546231	34.7984	1.8258	1.6682	1.6684	27.7053	1038.1828	1494.2095
35	2534	34.63526	1.709283	34.6353	34.7986	0.021631273849	0.000621030221	0.021610969888	34.8202	1.7093	1.5312	1.5314	27.7329	1039.3583	1498.0128
36	2789	34.64812	1.626311	34.6481	34.8115	0.021385378943	0.000614436829	0.021389468131	34.8329	1.6263	1.4264	1.4267	27.7507	1040.5169	1501.9703
37	3045	34.65890	1.566066	34.6589	34.8223	0.021139155635	0.000607589802	0.021157693528	34.8435	1.5661	1.3432	1.3434	27.7651	1041.6695	1506.0602
38	3300	34.66710	1.527974	34.6671	34.8306	0.020918230176	0.000601218243	0.020940774256	34.8515	1.5280	1.2809	1.2811	27.7759	1042.8067	1510.2450
39	3556	34.67315	1.503932	34.6732	34.8366	0.020701479725	0.000595069372	0.020730222690	34.8574	1.5039	1.2314	1.2317	27.7841	1043.9387	1514.5230
40	3812	34.67689	1.489079	34.6769	34.8404	0.020516621253	0.000589541645	0.020539870502	34.8609	1.4891	1.1901	1.1903	27.7898	1045.0614	1518.8548

TEOS-10 Test Data | TS-55 | CTD-020 | Surface Data | Vertical Profiles | SA - Θ Diagram | longs_ref | lats_ref | ndepth_ref | p_ref | deltaSA_ref | SAAR_ref | info

Figure 1: TEOS-10 EXCEL workbook light green data tab. Seawater properties in coloured columns are computed on the fly from user data pasted into white cells.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	Longitude and Latitude are needed for estimating the Absolute Salinity Anomaly. If either is left blank, Absolute Salinity Anomaly is set to zero.																
2	User data should be input in white cells only. All colour colums will update automatically. DATA CAN BE DELETED BUT **NOT MOVED prior to deletion** OR THE FORMULAS WILL LOOSE THEIR REFERENCE.																
3	Long (degrees)	Lat (degrees)	Pressure (dbar)	Salinity: Practical Salinity / Conductivity (mS/cm) / Conductivity Ratio; Temperature (°C): ITS-90 / IPTS-68		Practical Salinity (S_P)	Reference Salinity (S_R) (g kg^{-1})	delta S_A Atlas (g kg^{-1})	SAAR Atlas (g kg^{-1})	Absolute Salinity Anomaly (δS_A) (g kg^{-1})	Absolute Salinity (S_A) (g kg^{-1})	Temperature ITS-90 (°C)	Potential temperature (θ) (°C)	Conservative Temperature (Θ) (°C)	Potential Density (σ_Θ) (kg m^{-3} - 1000)	In situ Density ($\rho_{SA,\Theta,p}$) (kg m^{-3})	Sound Speed (c) (m s^{-1})
4																	
5	20.05	59.02	0	5.39	12.3	5.3900	5.4154	Baltic	Baltic	Baltic	5.4890	12.3000	12.3000	12.8682	3.7047	1003.7047	1462.7763
6	20.1	59.02	0	5.39	12.2	5.3900	5.4154	Baltic	Baltic	Baltic	5.4890	12.2000	12.2000	12.7641	3.7177	1003.7177	1462.4072
7	20.15	59.02	0	5.38	12.1	5.3800	5.4054	Baltic	Baltic	Baltic	5.4790	12.1000	12.1000	12.6601	3.7228	1003.7228	1462.0253
8	20.2	59.02	0	5.41	12.1	5.4100	5.4355	Baltic	Baltic	Baltic	5.5091	12.1000	12.1000	12.6596	3.7460	1003.7460	1462.0613
9																	
10	162.5	33	0	34.57586	19.50761	34.5759	34.7389	0.000327101505	0.000009410247	0.000326901616	34.7392	19.5076	19.5076	19.5130	24.5709	1024.5709	1519.5537
11																	
12			0	0.52	12.4	0.5200	0.5225	0.000000000000	0.000000000000	0.000000000000	0.5225	12.4000	12.4000	13.0624	-0.1400	999.8600	1457.1626
13																	
14																	
15																	

TEOS-10 Test Data | TS-55 | CTD-020 | Surface Data | Vertical Profiles | SA - Θ Diagram | longs_ref | lats_ref | ndepth_ref | p_ref | deltaSA_ref | SAAR_ref | info

Figure 2: TEOS-10 EXCEL workbook 'Surface data' tab. Surface data from different locations (location coordinates for each line). Four samples are from the Baltic Sea, one from the NW Pacific and the last sample (without long/lat coordinates) is from an estuary.

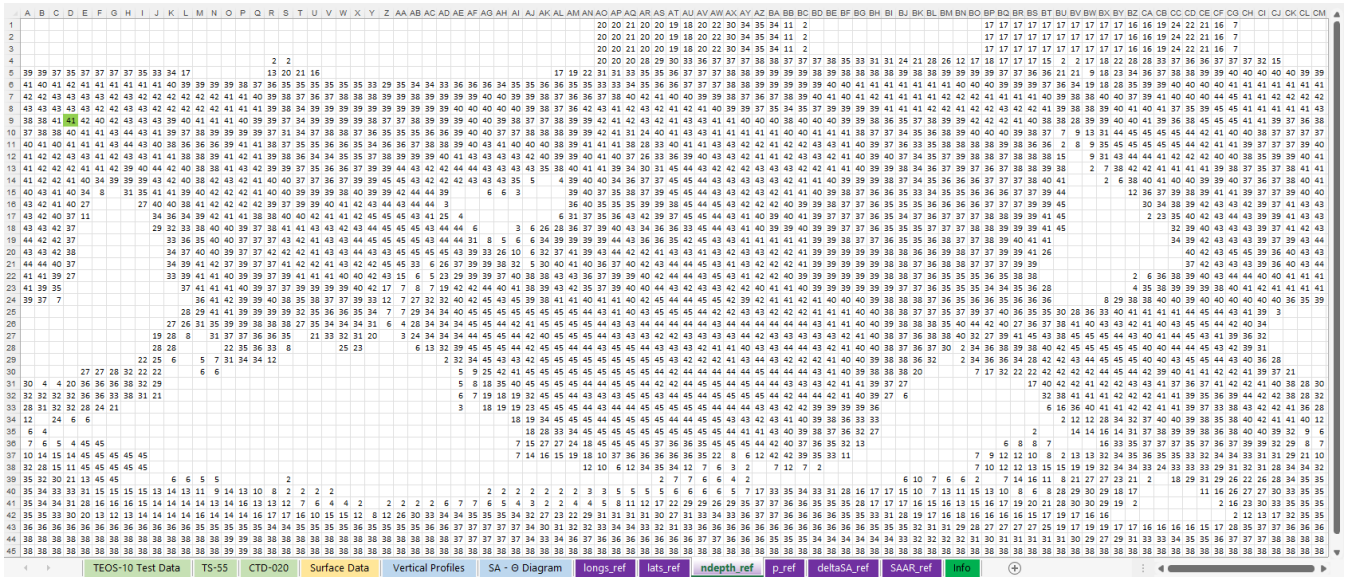

Figure 6: [ndepth_ref] look-up table. The table has 45 rows (latitude) by 91 columns (longitude). South is at the top (1st row is 86º S) and 1st column is 0º of longitude. The latitude x longitude grid is a 4º x 4º grid and each cell location is obtained from the [longs_ref] and [lats_ref] tables. Cell values are the number of pressure levels at the given location. The cell highlighted in green is used as a 'case study' in the text.

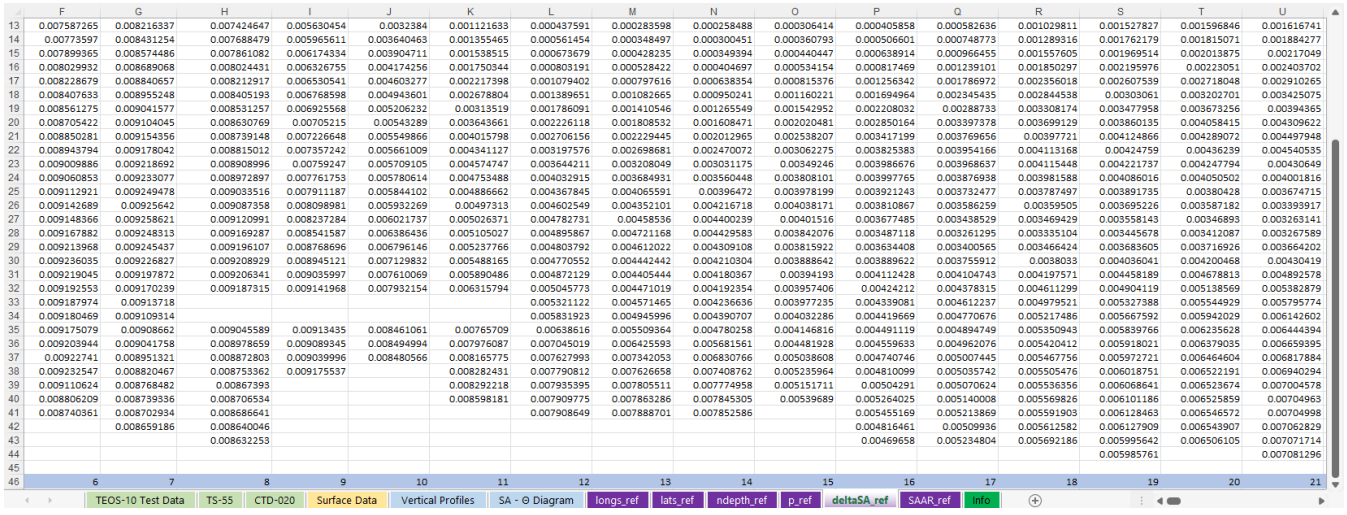

Figure 8: [deltaSA_ref] table: reference data missing for pressure levels 33 and 34 of columns 8, 9, 10 and 11.