Diagrama T/S e Análise de Massas de Água

• Conceito de Massas de água
• O diagrama TS e seus usos
Plots of salinity as a function of temperature, called T-S plots, are used to:

- delineate water masses and their geographical distribution;
- to describe mixing among water masses;
- and to infer motion of water in the deep ocean.

Here's why the plots are so useful: water properties, such as temperature and salinity, are formed only when the water is at the surface or in the mixed layer. Heating, cooling, rain, and evaporation all contribute. Once the water sinks below the mixed layer, temperature and salinity can change only by mixing with adjacent water masses. Thus water from a particular region has a particular temperature associated with a particular salinity, and the relationship changes little as the water moves through the deep ocean.
Características básicas de um T/S

Exemplo de um T/S típico

A T-S diagram contoured in $\sigma_t$ values.

T-S diagram contouring is shown for various $\sigma_t$ values.

Características básicas de um T/S

Exemplo de um T/S típico

T-S diagram (After Stowe, 1996)
I, II, III – águas tipo

Linhas – massas de água
Temperature and salinity are not independent variables. For example, the temperature and salinity of the water at different depths below the Gulf Stream are uniquely related (figure right), indicating they came from the same source region, even though they do not appear related if temperature and salinity are plotted independently as a function of depth.

http://oceanworld.tamu.edu/resources/ocng_textbook/chapter13/chapter13_03.htm
An example of a T-S diagram for observations at depths from 150 m to 5,000 m at 9oS latitude in the Atlantic Ocean. Dots represent individual seawater samples; numbers indicate depths in hundreds of meters. Red boxes represent the major subsurface Atlantic water masses. AABW = Antarctic Bottom Water; NADW = North Atlantic Deep Water; AAIW = Antarctic Intermediate Water.

Temperature and salinity of 99% (75%) of the ocean water are represented by points within the blue (red) area. (After Gross, 1993).
Fig. 5.34. Variations with latitude of the salinity minimum characterizing the Antarctic intermediate water between 17°S and 9°N in the Atlantic.
Figure 13.9 T-S plot of data collected at various latitudes in the western basins of the south Atlantic. Lines drawn through data from 5°N, showing possible mixing between water masses: NADW ? North Atlantic Deep Water, AIW ? Antarctic Intermediate Water, AAB - Antarctic Bottom Water, U - Subtropical Lower Water.
Fig. 24. The straight line of mixing of two water masses.

the mixture will then be determined by the formulae of mixing:

\[ T = T_1 m_1 + T_2 m_2 \]

\[ S = S_1 m_1 + S_2 m_2 \]

Fig. 25. Triangle of mixing (nomogram for the determination of the percentage content of water masses).
Möller et al. (2008)
TS Diagrams REVIZEE - project
Prof. > 100 m
TS-Diagrams with nutrients for winter

Aseff (2009)
3.3. Density variations as a function of temperature for constant salinities. T on the abscissa, d and e, on the ordinate.
O diagrama TS-time

Medidas brutas. Cores indicam a variação temporal

Medidas mensais e seus desvios
<table>
<thead>
<tr>
<th>Water Mass</th>
<th>Winter</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Termohaline Interval</td>
<td>% of Total Volume (14.285 km³)</td>
</tr>
<tr>
<td>CW/PPW</td>
<td>T &gt; 11°C &amp; S ≤ 33.5</td>
<td>23</td>
</tr>
<tr>
<td>TW</td>
<td>T ≥ 18.5°C &amp; S ≥ 36</td>
<td>8</td>
</tr>
<tr>
<td>STSW</td>
<td>T &gt; 15°C &amp; 33.5 &lt; S &lt; 35.5  T &gt; 18°C &amp; 35.5 &lt; S &lt; 36</td>
<td>25</td>
</tr>
<tr>
<td>SASW</td>
<td>T ≤ 14°C &amp; 33.5 &lt; S ≤ 34.5</td>
<td>31</td>
</tr>
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Figure 2.2 Simulated three-dimensional $T$-$S$ diagram of the water masses of the world ocean. Apparent elevation is proportional to volume. Elevation of highest peak corresponds to $26.0 \times 10^6$ km$^3$ per bivariate class $0.1^\circ C \times 0.01\%_o$.
Other Tracers
I have illustrated the core method using salinity as a tracer, but many other tracers are used. An ideal tracer is easy to measure even when its concentration is very small; it is conserved, which means that only mixing changes its concentration; it does not influence the density of the water; it exists in the water mass we wish to trace, but not in other adjacent water masses; and it does not influence marine organisms (we don't want to release toxic tracers).
Various tracers meet these criteria to a greater or lesser extent, and they are used to follow the deep and intermediate water in the ocean. Here are some of the most widely used tracers.
Salinity is conserved, and it influences density much less than temperature.
Oxygen is only partly conserved. Its concentration is reduced by the respiration by marine plants and animals and by oxidation of organic carbon.
Silicates are used by some marine organisms. They are conserved at depths below the sunlit zone.
Phosphates are used by all organisms, but they can provide additional information.
$^3$He is conserved, but there are few sources, mostly at deep-sea volcanic areas and hot springs.
$^3$H (tritium) was produced by atomic bomb tests in the atmosphere in the 1950s. It enters the ocean through the mixed layer, and it is useful for tracing the formation of deep water. It decays with a half life of 12.3 yrs and it is slowly disappearing from the ocean. Figure 10.15 shows the slow advection or perhaps mixing of the tracer into the deep north Atlantic. Note that after 25 years little tritium is found south of 30°N. This implies a mean velocity of less than a mm/s.
Fluorocarbons (Freon used in air conditioning) have been recently injected into atmosphere. They can be measured with very great sensitivity, and they are being used for tracing the sources of deep water. Sulphur hexafluoride SF$_6$ can be injected into sea water, and the concentration can be measured with great sensitivity for many months.
Each tracer has its usefulness, and each provides additional information about the flow.
Outros diagramas de propriedades

Fonte: Johannes Karstensen
Water mass definitions (TS-time diagrams) for the southern, central and northern regions of the Great Barrier Reef lagoon. The regions are defined as north = 10 - 15°S, centre = 15 - 20°S, south = 20 - 25°S. Standard deviations are not given for every month but for the ensemble of TS-data in each region. Adapted from Pickard (1977).

Mean freshwater input from land in the Great Barrier Reef lagoon. Adapted from Pickard (1977).
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  – É o processo pelo qual as massas de água são injetadas em profundidades maiores seguindo as mesmas isopicnais da região da sua formação.

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PREOCUPADO COM A LOUVADEUSA, OVERMAN?

NÃO...

...DIGA-ME, ESQUILO: EM NÓSSE HEMISFERIO, A ÁGUA ESCONDE PELO RALO GIRANDO NO SENTIDO HORA'RIO OU ANTI-HORA' RIO?

PRA MIM, TANTO FAZ, MEU RELOGIO É DIGITAL.

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| Water Mass | Winter | | | | Summer |
|-----------|--------|--------|--------|
|           | Termohaline Interval | % of Total Volume (14.285 km³) | Termohaline Interval | % of Total Volume (14.338 km³) |
| CW/PPW    | T>11°C & S≤33.5 | 23 | T>11°C & S≤33.5 | 15 |
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