

GOSUD recommendations for good practices in thermosalinometer measurements : Delayed mode quality control

Delayed mode quality control

Definition of TSG variables

Thermo-salinometers (TSG) installed on board research, commercial or other opportunity ships, aim at measuring the ocean surface temperature and salinity properties (*SST* and *SSS*). However, the values that are reported by the devices do not correspond to the exact Sea-Surface conditions. Water is pumped into the measuring device through a water intake, positioned at a specific depth below surface and distance from the ship bow. Whenever possible, a temperature sensor is set near the water intake to give the **SSTP** measurement. The water has to travel some distance in the water circuit before it reaches the conductivity cell. To deduce salinity (**SSPS**) from the conductivity measurement, the temperature of the water volume inside the conductivity cell (**SSJT**) must be known accurately.

The variables measured with the thermosalinometer (TSG) system are summarised in the following table.

| Temperature variable | Salinity variable | Location | Flow |
|----------------------|-------------------|---------------------------|--------|
| <i>SST</i> | <i>SSS</i> | Ocean | ↓ ↓ |
| SSTP | | Ship Intake near the hull | |
| SSJT | SSPS | TSG, inside the ship | |

Variables measured with the thermo-salinometer (in bold), in order to approach the Ocean Sea Surface Temperature (*SST*) and Salinity (*SSS*).

- Sea Surface Temperature (**SSTP**) is the temperature of the seawater at the water intake, located at a depth between 2 and 10 m depending on the ship and its load. When the water is pumped inside the ship, it represents the temperature of the oceanic surface layer that is mixed by the ship displacement. When the seacock is closed, or the pump stopped, it gives the temperature of the water volume trapped close to the temperature sensor.
- Sea Surface Jacket Temperature (**SSJT**) is the temperature of the water volume inside the TSG. **SSJT** is used to deduce salinity from the conductivity measurement. It may differ from **SSTP** because of heat exchange on the way to the TSG and in the TSG room. The temperature change on the way depends on the flow rate, on the pipe characteristics and on the temperature difference between the seawater and the ambient temperature.
- Sea Surface Practical Salinity (**SSPS**) is the salinity of the water inside the TSG deduced from the conductivity measurement, and **SSJT**. When the flow rate is sufficient, **SSPS** represents the salinity of the oceanic surface layer that is mixed by the ship displacement. When the seacock is closed, or the pump stopped, it is the salinity of the water volume trapped in the TSG.

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Applying quality control flags

Attribution of QC-flags is done using dedicated softwares that allow visual inspection of ship trajectory, measurement time series and their comparison with SSS and SST climatologies. Potential problems of the acquisition system observed on board or experienced and diagnosed in the past are also taken into account.

Unqualified data have a quality control flag (QC-flag) value set to 0.

Data considered of good quality, consistent with regional climatological ranges, even though they may need adjustment, have a QC-flag value set to 1.

Several identified cases may lead to data outside of climatological ranges. Other values of the QC-flag are then applied:

Problems on the water flow: When the flow on the conductivity cell is insufficient, due to seacock/valve closure, , the corresponding **SSPS QC-flag values are set to 4 (bad data)**. These events are characterized by an increasingly large difference (up to several °C) between SSTP and SSJT, and values of SSPS that remain nearly constant. The standard criterion used to detect an anomaly is a SSTP-SSJT difference over 0.2 °C, but it may vary with the ship and the area. In rare cases generally due to pipe clogging, the flow might be detected as slightly insufficient and the QC-flag value is set to 3. Installing flow-meters on the ships allows to obtain a direct measure of the flow rate and to define an objective criterion based on a threshold value.

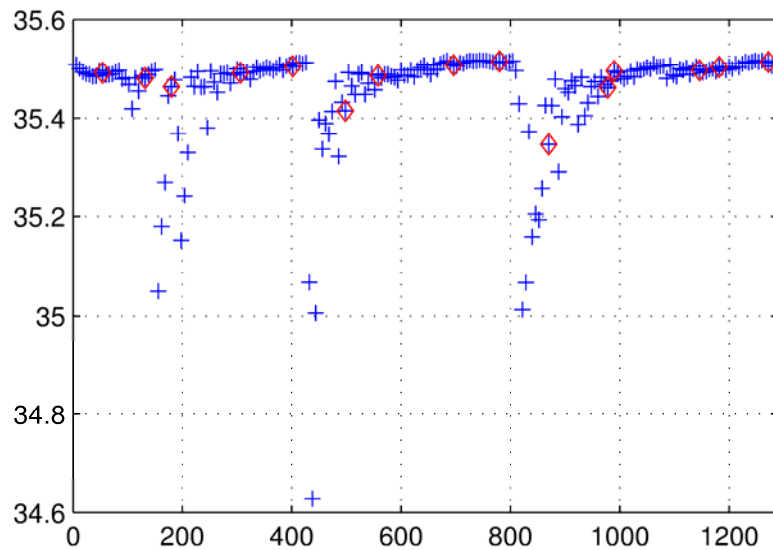
Air bubbles: During severe sea state conditions, air bubbles reach the conductivity cell, inducing a drop of the measured conductivity. The SSPS reported by the TSG decreases accordingly, to a slightly underestimated value (of the order of 0.1) when only small bubbles are present or to several PSS, in the case of stronger waves. The normal SSPS value is recovered within a few minutes, the frequency of these events depends on the sea state. In that case, **SSPS QC-flag values are set to 2, 3 or 4**, depending on the magnitude of the salinity decrease. The effect of air bubbles on the full resolution data is illustrated in Figure 2.

Shells in the conductivity cell: It may happen that shells or other solid matter get trapped inside the conductivity cell, inducing erroneous conductivity measurement with salinity drops by several PSS or tenths of PSS, a step-like recovery occurs as the debris change position within the conductivity cell or are flushed out. In that case, **SSPS QC-flag values are set to 4**.

Electronic failure: It may happen that the TSG has an electronic failure, inducing very noisy data and/or unrealistic SSPS values. The TSG is then as soon as possible dismantled and tested in the laboratory, which can confirm the problem. In that case, **SSPS QC-flag values are set to 4**.

Harbour: Measurements taken in the harbour or estuaries are difficult to qualify because of the high variability due to tides and river runoffs. Those data should be looked at by experts with knowledge of the local conditions. The corresponding **SSTP and SSPS QC-flag values are set to 6**.

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Example of the effect of air bubbles due to waves on the salinity measurement.

| QC value | QC definition | Cases when it is applied |
|----------|---------------------|--|
| 0 | No QC was performed | |
| 1 | Good data | Data consistent with regional climatological ranges |
| 2 | Probably good data | Small amounts of air bubble may lead to slightly under estimate the salinity |
| 3 | Probably bad data | Flow on the conductivity cell lower than required or Numerous air bubble reduce significantly the salinity |
| 4 | Bad data | seacock closed or insufficient flow in the conductivity cell or shell or large debris inside the conductivity shell or electronic failure |
| 5 | Value changed | |
| 6 | Harbour | The ship has entered a bay or harbour. |
| 7 | Not used | |
| 8 | Interpolated value | Applies to position only |
| 9 | Missing value | |

Definition of the quality control flags and how they are applied in delayed mode

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References

Software used to perform quality control of thermosalinometer data:

TSG-QC (<http://www.ird.fr/us191/spip.php?article63>).

Published article on the method

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