Subsurface Salinity

Preamble/Introduction

The global sub-surface salinity observing system is vital for closure of the global hydrological cycle, estimates of oceanic evaporation and precipitation, and halosteric component of sea level change. Sub-surface salinity, along with coincident subsurface temperature and velocity observations, are required to calculate in-situ density and ocean mass and freshwater transports. Salinity observations are an important in-situ validation for satellite observations of sea surface salinity (SSS). In addition, subsurface salinity, together with temperature and pressure and satellite surface observations of SST, SSS and SSH are used to derive large-scale gridded climate products including ocean velocity, mixed-layer depth, density stratification, sea level and indirect interior ocean mixing used in many weather and climate applications.

Subsurface salinity observing systems acquire data over a large range of spatial and temporal scales. Moorings offer very high temporal resolution at specific locations, but with spatial resolution limited by density of the array. Gliders and other autonomous platforms achieve much higher spatial resolution depending on endurance and other instrument characteristics. The global network of profiling floats (Argo) delivers salinity profiles (nominally 0-2000 m) from which monthly to annual scale global maps of temperature distribution are derived. Cable-based observations are now being used at select sites. Ship-based Conductivity-Temperature-Depth (CTD) observations provide full depth salinity observations from boundary current scale to basin scale depending on horizontal resolutions and tracks of research voyages.

Ocean salinity observations are an important input for data assimilation ocean models that are being used to provide gridded global and regional estimates of ocean circulation at varying spatial and temporal scales. On-going salinity observations are required to further our understanding of the ocean’s role in the global water cycle, and to further quantify ocean changes in response to climate change.

Version 5.2 Updated January 2017 by OOPC.
## Variable Information

<table>
<thead>
<tr>
<th>Name of Variable (ECV and/or EOV)</th>
<th>Subsurface Salinity</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Sub-Variables</strong>&lt;sup&gt;1&lt;/sup&gt;</td>
<td>Foundation and bulk SSS</td>
</tr>
<tr>
<td><strong>Derived Variables</strong>&lt;sup&gt;2&lt;/sup&gt;</td>
<td>Ocean freshwater content, ocean freshwater transport, subsurface density, mixed layer depth, geostrophic currents/velocities, water mass identities, steric and halosteric sea level</td>
</tr>
<tr>
<td><strong>Supporting Variables</strong>&lt;sup&gt;3&lt;/sup&gt;</td>
<td></td>
</tr>
<tr>
<td><strong>Contact/Lead Expert(s)</strong>&lt;sup&gt;4&lt;/sup&gt;</td>
<td>OOPC</td>
</tr>
</tbody>
</table>

1. **Sub-variables** are components of the EOV/ECV that may be measured, derived variables of other EOV/ECVs, or inferred from other elements of the observing system.
2. **Derived Variables** are quantities or indicators calculated from the EOV or ECV.
3. **Supporting variables** are other EOV/ECVs, or other measurements from the observing system, that may be needed to deliver the EOV.
4. **Contact experts** should include experts or teams for requirements setting, product development.

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<table>
<thead>
<tr>
<th>Requirements Settings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Responsible</strong></td>
</tr>
<tr>
<td><strong>GCOS/GOOS Panel</strong></td>
</tr>
<tr>
<td><strong>Implementation Plan</strong></td>
</tr>
<tr>
<td><strong>JCOMM Observations Coordination Group</strong></td>
</tr>
<tr>
<td><strong>WCRP</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Readiness Levels</th>
<th>Mature to concept</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Phenomena to capture</th>
<th>Water masses</th>
<th>Sea Level</th>
<th>Fresh water storage with depth</th>
<th>Circulation</th>
<th>Stratification</th>
<th>Upwelling</th>
<th>Mixed layer</th>
<th>Coastal shelf exchange process</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>monthly</td>
<td>monthly</td>
<td>monthly</td>
<td>weekly</td>
<td>weekly</td>
<td>weekly</td>
<td>hourly</td>
<td>hourly</td>
</tr>
<tr>
<td>Temporal Scales of phenomena</td>
<td>monthly</td>
<td>monthly</td>
<td>monthly</td>
<td>weekly</td>
<td>weekly</td>
<td>weekly</td>
<td>hourly</td>
<td>hourly</td>
</tr>
<tr>
<td>Spatial scales of phenomena (horizontal and vertical - order)</td>
<td>H100km V10 m</td>
<td>H 100km V integrated quantity</td>
<td>H 10km V 10m</td>
<td>H 50 km V 10m</td>
<td>H 10 km V 10m</td>
<td>H 10 km V 1 m</td>
<td>H10km V 1 m</td>
<td>H1 km V1 m</td>
</tr>
<tr>
<td>Magnitudes/ range of the signal, thresholds to capture</td>
<td>0.01</td>
<td>0.001</td>
<td>0.101</td>
<td>0.001</td>
<td>0.001</td>
<td>0.01</td>
<td>0.01</td>
<td>0.1</td>
</tr>
</tbody>
</table>

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5 See FOO readiness table on last page
6 Key physical, biological and/or ecological processes that need to be captured to address scientific applications
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Figure 1: Temporal and spatial scales of phenomena to be addressed.
### Observation Deployment & Maintenance

<table>
<thead>
<tr>
<th>Observing Elements</th>
<th>Profiling floats (Argo Array)</th>
<th>Repeat Hydrography (GO-SHIP)</th>
<th>Mooring Arrays (oceanSITES)</th>
<th>Ocean gliders</th>
<th>CTD Tagged Pinnipeds (MEOP)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relevant measured parameters</td>
<td>Conductivity</td>
<td>Conductivity, Salinity</td>
<td>Conductivity</td>
<td>Conductivity</td>
<td>Conductivity</td>
</tr>
<tr>
<td>Sensor(s)/ Technique</td>
<td>Conductivity, Temperature Depth (CTD)</td>
<td>CTD and bottle samples</td>
<td>CTD (fixed depths)</td>
<td>CTD</td>
<td>CTD</td>
</tr>
<tr>
<td>Readiness Level</td>
<td>Mature 8</td>
<td>Mature 8</td>
<td>Mature 8</td>
<td>Pilot 5 (implementation phase)</td>
<td>Pilot 5</td>
</tr>
<tr>
<td>Spatial sampling</td>
<td>Nominal Every 3° in ice-free ocean</td>
<td>Repeated transects over full-ocean depth, 50km station spacing.</td>
<td>Point-wise, fixed locations</td>
<td>Surface to 1000m, Coastal to regional (10-500 km).</td>
<td>Depth range 500-2000 m. Migration distance from 100 km to &gt;5000 km.</td>
</tr>
<tr>
<td>Temporal sampling</td>
<td>10 days (monthly resolved)</td>
<td>10-year global repeat survey. Each section completed in 2 month</td>
<td>Hourly averaged data. &gt;2 year timeseries if moorings maintained</td>
<td>Hourly</td>
<td>Average 2.5 profiles/day. Average 5-month CTD lifespan (1-10 months)</td>
</tr>
<tr>
<td>Special Characteristics/ Contributions</td>
<td>Near-global array design achieved and then maintained since late 2007. No seasonal and hemispheric sampling biases.</td>
<td>Highest quality, high spatial and vertical resolution full ocean depth, interdisciplinary measurements Calibration for other platforms.</td>
<td>Sparse global system of long-term, deepwater reference stations high temporal resolution measuring dozens of variables, from air-sea interactions down to 5,000 m. Sometimes arrays</td>
<td>Observations in coastal-open ocean transition zones. Can operate from several weeks to ~1 year.</td>
<td>Observations in remote high latitude locations, under sea-ice and during wintertime.</td>
</tr>
<tr>
<td>Random Uncertainty estimate (units, one standard dev).</td>
<td>The accuracy of salinity and pressure measurements Similar to modern CTDs (±0.005 PSS-78, 2.4 dbar).</td>
<td>±0.005 PSS-78 &lt; 0.015% m (modern accuracy, historical obs are uncertain)</td>
<td>±0.01 PSS-78</td>
<td>±0.05 PSS-78. Animal positions are determined using ARGOS telemetry information, with a typical accuracy of ±5 km.</td>
<td>±0.01 PSS-78</td>
</tr>
<tr>
<td>Uncertainty in the bias, one std dev</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figure 2. Well resolved observation scales of the component networks.
<table>
<thead>
<tr>
<th>Future observing Elements</th>
<th>Ice-Tethered Profilers</th>
<th>Deep Profiling floats (Argo)</th>
<th>Profiling floats in the sea-ice zone (Argo)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observing Elements</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Relevant measured parameters</td>
<td>Conductivity</td>
<td>Conductivity</td>
<td>Conductivity</td>
</tr>
<tr>
<td>Sensor(s)/Technique</td>
<td>Autonomous CTD</td>
<td>Autonomous CTD</td>
<td>Autonomous CTD</td>
</tr>
<tr>
<td>Phenomena addressed</td>
<td>Freshwater Storage Circulation Watermasses</td>
<td>Freshwater Storage Circulation Watermasses Sea Level</td>
<td>Freshwater Storage Circulation Watermasses Sea Level</td>
</tr>
<tr>
<td>Readiness Level</td>
<td>Pilot 5</td>
<td>Pilot 5</td>
<td>Pilot 5</td>
</tr>
<tr>
<td>Spatial sampling</td>
<td>&lt;1000m depth; point source</td>
<td>0- full depth ocean; 5o to global</td>
<td>2-2000db; &gt;100km to regional</td>
</tr>
<tr>
<td>Temporal sampling</td>
<td>Weekly</td>
<td>Unknown</td>
<td></td>
</tr>
<tr>
<td>Special Characteristics or Contribution</td>
<td>Ice covered ocean (seasonal and pack ice)</td>
<td>Ocean below 2000 m</td>
<td>Seasonal Sea ice zone</td>
</tr>
<tr>
<td>Estimated time when part of the observing system</td>
<td>&gt;10 years</td>
<td>&gt; 5-10 years</td>
<td>&gt;5-10 years</td>
</tr>
<tr>
<td>Supporting Variable(s)</td>
<td>T and P</td>
<td>T and P</td>
<td>T and P</td>
</tr>
<tr>
<td>Random Uncertainty estimate (units, 1 standard deviation)</td>
<td>Similar to modern CTDs (±0.005 PSS-78, 2.4 dbar)</td>
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### Data & Information Creation

<table>
<thead>
<tr>
<th>Data Centre/repository</th>
<th>World Ocean database National Oceanographic Data Center (NODC)</th>
<th>Coriolis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Readiness Level</td>
<td>Mature 9</td>
<td>Mature 9</td>
</tr>
<tr>
<td>Oversight &amp; Coordination</td>
<td>NODC and data contributors</td>
<td>Consortium of French Agencies</td>
</tr>
<tr>
<td>Data Stream delivery and QC...</td>
<td>Real time and delayed mode For operational oceanography and climate research</td>
<td>Real time and Delayed mode For operational oceanography and climate research.</td>
</tr>
<tr>
<td>Derived Products</td>
<td>Gridded salinity climatology.</td>
<td></td>
</tr>
</tbody>
</table>

*If there are too many products (i.e. SST), describe each type of product.*
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### Framework Processes and Readiness Levels (from the Framework for Ocean Observing [FOO])

<table>
<thead>
<tr>
<th>Readiness Levels</th>
<th>Requirements Processes</th>
<th>Coordination of Observational Elements</th>
<th>Data Management &amp; Information Products</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mature</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level 9 “Sustained”</td>
<td>Essential Ocean Variable:</td>
<td>System in Place:</td>
<td>Information Products Routinely Available:</td>
</tr>
<tr>
<td></td>
<td>Adequate sampling specifications</td>
<td>Globally</td>
<td>• Product generation standardized</td>
</tr>
<tr>
<td></td>
<td>Quality specifications</td>
<td>Sustainably indefinitely</td>
<td>• User groups routinely consulted</td>
</tr>
<tr>
<td>Level 8 “Mission qualified”</td>
<td>Requirements “Mission Qualified”:</td>
<td>System “Mission Qualified:”</td>
<td>Data Availability:</td>
</tr>
<tr>
<td></td>
<td>Longevity/stability</td>
<td>Regional implementation</td>
<td>• Globally available</td>
</tr>
<tr>
<td></td>
<td>Fully scalable</td>
<td>Fully scalable</td>
<td>• Evaluation of utility</td>
</tr>
<tr>
<td>Level 7 “Fitness for purpose”</td>
<td>Validation of Requirements:</td>
<td>Fitness-for-Purpose Observation:</td>
<td>Validation of Data Policy:</td>
</tr>
<tr>
<td></td>
<td>Consensus on observation impact</td>
<td>Full-range of operational environments</td>
<td>• Management</td>
</tr>
<tr>
<td></td>
<td>Satisfaction of multiple user needs</td>
<td>Meet quality specifications</td>
<td>• Distribution</td>
</tr>
<tr>
<td></td>
<td>Ongoing international community support</td>
<td>Peer review certified</td>
<td></td>
</tr>
</tbody>
</table>

**Figure 9. A Detailed View of Framework Processes for Varying Levels of Readiness.**