Schmitt/Carton
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CLIVAR Salinity Working Group Status Report

The CLIVAR Salinity Working Group was charged last summer with the task of developing a whitepaper covering current and pending developments in salinity research of relevance to CLIVAR goals and objectives. Two meetings have been held this spring to provide source material for the CSWG. The first was comprised of a group of three sessions, *Role of Ocean Salinity in Climate I, II, III* at the Ocean Sciences Meeting in Honolulu, February, 2006. The two oral sessions, which attracted an overflowing audience, had overview talks led by Arnold Gordon and Ray Schmitt covering a diverse series of 12 talks. The poster session included an additional 18 presentations.

These sessions formed the basis for organization of the *US CLIVAR Salinity Workshop* held in Woods Hole, MA 8-10 May, which was followed immediately by the NASA *Aquarius Science Team Meeting.* The workshop, attended by approximately 80 scientists, was organized around 19 half-hour long overview talks to identify hot topics in salinity research with application to circulation, climate, and water cycle studies, to describe gaps in our knowledge. We anticipate that the whitepaper will follow the structure of the presentations. A very rough draft exists already. We expect a finished whitepaper in winter 2006. We hope it will be the basis of an article on the oceanic component of the hydrologic cycle for BAMS.

Fluxes, salinity, stratification. The seasonal cycle of freshwater for the ocean is analogous to, but greatly exceeds in intensity, the continental hydrologic cycle. For example, the discharge of the Mississippi River is only 1% of Atlantic rainfall. Our understanding of net freshwater flux is improving due primarily to improved satellite data sets. Thus we can document the mean and seasonal cycles which imply the existence of large divergences of freshwater within the ocean; in the Atlantic implied transports approach $1x10^6 m^3/s$. While salinities are generally higher in the evaporative zones of the subtropics the relationship between freshwater flux and salinity is complicated, as is its impact on stratification. For example, in the tropics barrier layers may develop within the mixed layer that can affect mixed layer temperature and entrainment rates. Papers were cited showing the impact of barrier layers on hurricane intensification and the development of ENSO. Salinity also affects the partial pressure of CO_2 and thus salinity becomes a factor in carbon sequestration discussions.

Salinity trends. Salinity trends are evident wherever enough quality data exist for multiple decades suggesting the presence of planetary-scale changes are occurring in the ocean component of the hydrologic cycle. We begin with a review of evidence that there has been a broad and deep decrease in salinities around the Atlantic Northern subpolar gyre over the past 5 decades with potentially serious consequences for deepwater formation rates. A number of causes have been put forward to explain these changes, including increases in continental melting, but changes in net surface flux remains a strong possibility, as these fluxes are so large. Trends toward decreasing salinity have also been observed in the Ross Sea and the bottom waters of the Australian-Antarctic Basin. Here also, decreases in deep salinity reflect decreases in surface fluxes. Incidentally, the change in surface fluxes over the Southern Ocean since the 1960s may be related to a shift positive phase of the Southern Hemisphere Annular Mode.

Observations and monitoring opportunities The Argo profiling floats have revolutionized subsurface salinity monitoring with the quantity of data and their spatial and temporal coverage. For example, prior to Argo, the year with the most salinity profiles was 1987. In that year 64,000 salinity profiles were collected. Argo surpassed this total in 2005, collecting 69,000 salinity profiles and increasing the number of profiles below 1500m from 11,000 in 1987 to 33,000 in 2005. Other key instruments include ship-borne thermosalinographs (TSGs), and increasingly, salinity measurements from moorings. New opportunities for expanding surface salinity coverage include deploying TSGs on the autonomous surface drifters and use of gliders for repetitive sampling of lines. Of course remotely sensed observations from Aquarius offers the potential to provide global monitoring of sea surface salinity at the 0.2PSU level. However, developing the potential of Aquarius will require an instrument suite in the water to provide calibration and validation.

Data assimilation The workshop briefly touched on the potential contribution of model simulation and data assimilation. Clearly data assimilation will be needed to connect together different oceanographic observation sets, meteorological flux estimates, and our understanding of ocean physics to provide the uniformly gridded global estimates required for many applications. And model simulations will be required to test hypotheses.

Recommendations: The whitepaper will outline needs for additional measurements to enhance the developing monitoring system (no prioritization):

- *In situ* SSS observations (all three)
  - SSS on Global Drifter Program
  - Expand Thermosalinographs on VOS
  - Surface ARGO Salinity measurements (extra sensor for upper 5m)
- Maintain/Expand Salinity sensors on moored arrays (climate prediction, climate research)
- Arctic/subarctic salinity obs; monitoring overflows and passages (climate change/research, climate prediction)
  - Glider lines
  - S sensors on all IOOS moorings, platforms and vehicles
- Expanded flux buoys
- Paleo-Salinity estimators (climate change/research)
- Consider plans for a "CAGE" type budget experiment to constrain surface flux estimates and oceanic heat and freshwater storage and advection. Float and glider technology, in combination with satellite remote sensing and modern mixing measurements, make this a viable approach to improving our understanding of air-sea fluxes.