Sea Surface Salinity Variability from Simulations and Observations: Preparing for Aquarius

1. Introduction
Oceanic freshwater transport has been shown to play an important role in the global hydrological cycle. Sea surface salinity (SSS) is representative of the surface freshwater fluxes and the upcoming Aquarius mission scheduled to be launched in December 2010 will provide sufficient spatial and temporal SSS coverage to better estimate the net exchange. In most ocean general circulation models, SSS is relaxed to climatology to prevent model drift. While SSS remains a well observed variable, relaxing to SST reduces the range of SSS variability in the simulations (Fig. 1). The main objective of the present study is to simulate surface tracers using a primitive equation ocean model for multiple forcing data sets to identify and establish a baseline SSS variability. The simulated variability scales are compared to those from near-surface argo salinity measurements.

2. Background
Mechanisms controlling SSS
- E-P
- Vertical Mixing
- Advection/Diffusion

E and P Variability
- E-P standard deviation ~500 mm/syr
- Precipitation variability of over 250 mm/syr over Indian and Equatorial Pacific
- Evaporation in North Atlantic ~250 mm/syr

Upper Ocean Mixed Box
- Measured and simulated quantities based on different hypothesis are used to compute entrainment mixing.

3. Objectives
Investigate SSS and SSS Variability - Provide SSS and for use in Aquarius forward model and retrieval algorithm development

4. Model Configuration and Simulations
A fully coupled Hybrid Coordinate Ocean Model (HYCOM) is configured at 0.25° resolution at the equator. There are 26 layers: 5 in the vertical with a minimum spacing of 3 m and a maximum spacing of 5 m
- Initial conditions derived from Levitus climatology
- Monthly forcing fields from COADS, CORE and OMIP are used including precipitation.
- Evaporation is calculated using bulk formula from state variables.
- Monthly river runoff from the global river data set
- Model spin-up for 30 years for multiple boundary conditions with and without relaxation.
- Additional five year simulations with no relaxation for multiple boundary conditions.
- Simulations with NCEP forcing from 1994 to 2009 from a CORE forced 200 yr run.
- Restated to NCEP surface temperature
- KPP mixing scheme
- SSS and SST from 2004 to 2009 analyzed

5. Results: Forcing Experiments
Evolution of domain averaged temperature and salinity for different boundary conditions and forcing data sets indicate that the COADS forcing needs SSS to be relaxed for the drift to be small whereas the CORE and OMIP forcing data sets make the model drift less with relaxation.

For all the three forcing datasets, when SSS is relaxed, the amplitude of annual cycle in the SST increases. Significant freshening occurs in the model for COADS forcing when the SST is relaxed whereas no relaxation boundary condition recovers the SST annual cycle magnitude better. The drifts in SSS and SST are much smaller in both CORE and OMIP forced cases however, similar to Figure 1, when SST is relaxed the magnitude of SSS annual cycle is reduced.

A comparison of the mean SSS and evolution for the three forcing datasets is shown in Figure 2 when the surface is not relaxed. Results indicate that the CORE or OMIP forcing datasets lead to smaller drifts and therefore may be preferable to COADS. Spatial SSS and SST differences at the end of 30 year integration are shown in Figures 3 and 4.

6. Results: Sub-grid scale parameterizations

7. Results: 2004-2009 Comparison and Analysis
The spatial and temporal variability of simulated monthly mean SST and SSS from 2004-2009 are compared to those from near-surface temperature and salinity data from Argo profiling floats. While the argo spatial coverage has increased significantly in recent years, there are still regions where the coverage is not optimal. Fits of near-surface monthly mean temperature and salinity at 5° spatial resolution are constructed using a fully controlled argo measurements and the annual cycle and its spatial variability are analyzed to quantify the range of observed variability and realism of simulated SST and SSS.

8. Conclusions

9. Standard Deviations of the simulated and observed SSS. Although qualitatively the simulated spatial patterns match the observations in most of the domain, the model variability is much lower than Argo measurements.

10. Amplitudes of annual and semi-annual components of SSS decomposed using a harmonic analysis procedure. As mentioned earlier, simulated SSS fields have less spatial variability. Maximum variability occurs in the ITCC region which has a large amplitude of 0.4 PSU in the observations (top right panel) in the open ocean. Closer to the river discharge regions, the model also produces higher variability. The semi-annual component has maximum amplitudes near the coastal regions, with a clear signal along the ITCC region as well. The range of values of the annual and semi-annual components are higher than what was found from climatology (Royer and Levitus, 2002). Although, the model variability is less, a similar pattern is also seen in the simulated results.

Acknowledgments
This work was supported by NASA’s Ocean Margins Program and Aquarius mission.