Monitoring Ocean - Atmosphere Interactions in Western Boundary Current Extensions

an OceanObs'09 Community White Paper

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Western boundary currents as they extend eastward into the ocean basin (referred to as WBCEs) are regions of intense air-sea interaction, where the ocean loses heat and moisture to the atmosphere and absorbs carbon dioxide. Air-sea interactions in WBCEs affect weather and climate both locally and remotely and thus significant societal benefit can be achieved by improving their representation in numerical models of the atmosphere and ocean.

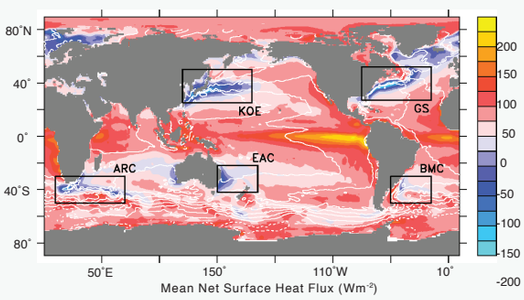

Figure 1*. Climatological mean net surface heat flux into the ocean from the OAFLUX product (Yu and Weller, 2007). White contours indicate mean dynamic sea level (Rio, 2004).*

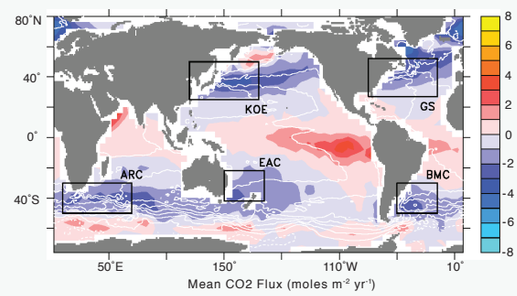

Figure 2. *Climatological mean annual sea-air CO_2 flux (moles m^{-2} yr^{-1}) Adapted from Takahashi et al. (2009). White contours indicate mean dynamic sea level (Rio, 2004).*

WBCE Systems

KOE *Kuroshio Oyashio Extension*
GS *Gulf Stream*
ARC *Agulhas Return Current*
EAC *East Australian Current*
BMC *Brazil-Malvinas Confluence*

The open-ocean strong currents, sharp fronts, and energetic synoptic variability make WBCEs challenging regions to observe.

Stakeholders for the WBCE Observing System include:

- Operational meteorological and oceanographic centers
- International research programs
- Model assessments
- State of the climate assessments
- Carbon markets
- Ecosystem and fisheries managers

Major Recommendations
(for full set see CWP):

- Satellite records for SST, wind speed and direction, and sea level must be maintained uninterrupted. These and other remote measurements, should resolve the synoptic and frontal variability in the WBCEs under all weather conditions.
- Atmospheric pressure measurements from Volunteer Observing Ships and surface drifters in WBCE regions are critical for assimilation in NWP models, and for their validation in real-time.
- Argo enhanced sampling is needed for WBCEs. A subset of these should have 5-day profiling rates and carry oxygen sensors for ventilation studies.
- Each WBCE system should have an OceanSITES reference station or an array of reference stations that includes both physical and biogeochemical measurements. Establishing a Southern Hemisphere site is of highest priority.
- Each WBCE system should have a repeat section of underway physical and biogeochemical measurements that cross the jet and, ideally, its recirculation gyres.
- The biogeochemical and physical observing systems should be coordinated to serve the broad community.

Existing & Proposed WBCE Observing Systems
will provide data for assimilation into numerical models, for assessment of model realism, and for analyses of climate processes

Squares indicate flux reference sites, diamonds indicate biogeochemical stations, stars indicate NSF global nodes. Black indicates existing stations; grey indicates proposed sites.

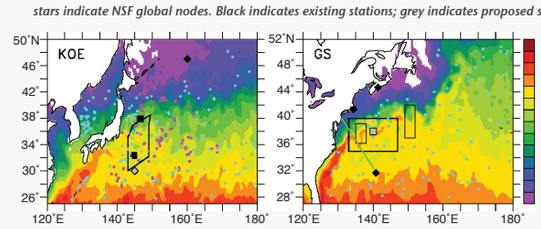

Figure 3. *Coordinated observing system in the Kuroshio-Oyashio Extension (left) and the Gulf Stream (right), superimposed on SST for March 15, 2006. Dots indicate location of Argo floats during March 10-20, 2006. Magenta dots indicate Argo floats deployed during the KESS. The KESS study region is indicated by the box in the left panel. The CLIMODE study region (thick box) and SYNOP study regions (thin boxes) are indicated in the right panel. The Oleander repeat section is indicated by a green line.*

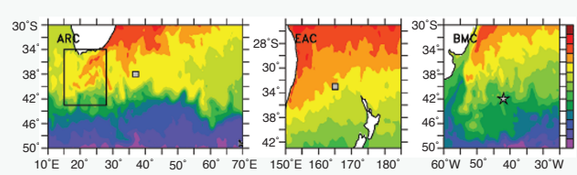

Figure 4. *Coordinated observing system for the Agulhas Return Current (left), the East Australian Current system (middle) and the Brazil-Malvinas Confluence (right), superimposed on SST for September 15, 2006. The KAPEX study region is indicated by the box in the left panel. The entire EAC region will be within SPICE study domain.*

WBCE Data will Lead to Improved Model Realism

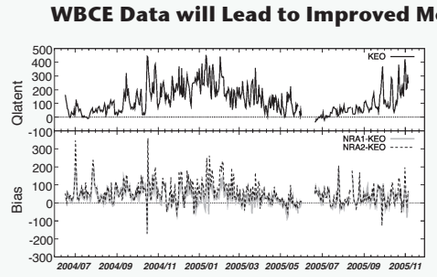

Figure 5. *Latent heat flux estimated from the Kuroshio Extension Observatory (KEO) reference data (top) and the latent heat flux differences between NCEP reanalyses and KEO (bottom). From Kubota et al. (2008).*

This reference data shows that the NRA model could be improved by using a better flux algorithm, microwave SST, and having improved moisture physics.