WORKING GROUP PROSPECTUS:
Western Boundary Current Ocean-Atmosphere Interaction

December 2006

Motivation

A precipitous drop in the meridional transport of heat in the northern hemisphere ocean occurs where the mid-latitude western boundary currents separate from the coast and flow into the ocean interior. The drop in ocean heat transport is accompanied by correspondingly large transfers of heat to the atmosphere, thereby increasing the atmospheric meridional heat transport. The transfer of heat fuels intense cyclogenesis, resulting in storms that have recently been found to reach hurricane force. Variations in the heat fluxes are associated with changes in the amount of heat in the western boundary current regions, which are, in turn, caused by changes in the wind-forced ocean circulation through advection by the warm currents. Attempts to understand the midlatitude ocean-atmosphere interaction have been hampered by the dominance of tropical interactions in global models, by ocean and climate models that do not resolve the 100-km wide boundary currents, and by sparse observations of air-sea interaction near the currents. Midlatitude air-sea interaction is relatively unexplored compared to the tropics to and to the mid-latitude atmospheric bridge.

A combination of recent extensive field programs, high-resolution satellite observations, and improving models suggests the need for a re-examination of ocean-atmosphere interaction in the vicinity of midlatitude western boundary currents. The CLIVAR-endorsed field programs in the North Pacific (Kuroshio Extension System Study, KESS) and in the North Atlantic (CLIvar MOde water Dynamic Experiment, CLIMODE), are producing detailed observations of the intense air-sea fluxes over these current systems, as well as of the current systems and their dynamics and thermodynamics. Air-sea fluxes are now being monitored at the Kuroshio Extension Observatory (KEO) mooring, a long-term OceanSITES reference site at 32.3N, 144.5E, initiated during KESS. Despite the similarities in measurements of the KESS and CLIMODE field programs, no formal arrangement exists to compare and synthesize results. High resolution satellite observations of sea surface temperature, currents, vector winds and stratus clouds show persistent small-scale air-sea interactions that are not reproduced well in climate models, as well as interannual variations in the strength of the current systems. A recent analysis of the Community Climate System Model, Version 2 (CCSM2) has shown that interannual variations in air-sea fluxes in the Kuroshio Extension region are correlated with changes in the strength of the KE advection with a lag 1-2 years, suggesting predictability in the anomalous transfer of heat to the atmosphere.

This working group topic is timely because the KESS and CLIMODE groups are just beginning their analysis work, so the synthesis of those analyses could be shaped by encouraging joint group meetings. In addition, high-resolution satellite observations (with lengthening data records) and more accurate ocean and climate models are spurring increased interest in the midlatitude western boundary current regions.

Goals

A primary objective of the working group is to encourage better understanding of the climate implications of the western boundary current atmosphere-ocean interaction, which will in turn improve the decadal and longer timescale predictability of the climate system. Specific goals include:

- Bring together the KESS, CLIMODE and other western boundary current atmosphere-ocean interaction groups for a synthesis of results
- Identify shortcomings in atmosphere, ocean, and coupled models that need to be addressed to accurately model western boundary current atmosphere-ocean interaction
- Identify observational gaps and modeling experiments that would answer outstanding issues
- Frame big science issues, such as:

How does air-sea interaction compare in the western North Atlantic and North Pacific? What are the implications of the differences?

What is the nature of atmosphere-ocean interaction in western boundary current regions? On what temporal and spatial scales does this occur? Is there predictability in the system?

To what extent are coupled models getting the interaction right? Can we identify specific problems in ocean or atmosphere models? Is there a "coupled" interaction? What numerical experiments need to be done to test hypotheses?

To what extent does air-sea interaction extend beyond the boundary layer and influence broader climate variability in both the atmosphere and ocean? What role do stratiform and convective clouds play in the atmospheric response?

Specific tasks and timeline

Year 1: Convene a Joint KESS/CLIMODE working committee to cross-fertilize and coordinate work that is already underway and to define a set of synthesis analyses

Year 2: Convene a larger conference to frame science questions motivated by these regional measurements, to evaluate the ability of high-resolution atmospheric models to reproduce these effects, and to foster boundary layer and other atmospheric and climate model improvements.

Deliverables (Publications and Outreach)

Define a set of parallel analyses for KESS and CLIMODE to understand similarities and differences in air-sea interaction in the two basins

Product a white paper on outstanding issues in western boundary current air-sea interaction and model improvements needed with intended distribution through either US CLIVAR Variations or the Bulletin of the American Meteorological Society.

Reporting

Report to Process Study and Model Improvement (PSMI) Panel: This WG is directly responsive to several goals of PSMIP, notably, "use process studies to quantify climatically important processes," and "ensure that process studies lead to climate model improvements."

The U.S. CLIVAR sponsored Eddy Mixed-Layer IntEractions (EMILIE) Climate Process Team (CPT) is focused on understanding the effects of transient eddy motions on upper ocean properties and ocean-atmosphere interactions. In order to connect with this effort, we propose to work closely with EMILIE, some of whose members are active in CLIMODE.

Coordination with other groups and programs: Satellites observations from NASA sensors are critical to defining the atmosphere-ocean interactions, particularly at the interannual time scales. Feedback on the utility of QuikSCAT wind measurements, both for quantifying cyclogenesis and storm tracks, as well as for their contribution to air-sea fluxes will be important to NASA's Ocean Vector Wind Science Team.

Responsiveness to agency concerns:

This Working Group addresses key concerns of three supporting agencies, in particular:

NOAA: Describing and understanding the state of the climate system through integrated observations and analysis. Improving climate predictive capability from weeks to decades.

NASA: Understanding how climate variations induce changes in the global ocean circulation; improving predictions of climate variability and change [using satellite observations]; understanding the role of slowly varying components of the earth system (e.g. ocean and ice) in climate.

NSF: Advancing discovery, knowledge and understanding in climate science; understanding processes and exploiting new observing techniques; analyzing process studies to address known deficiencies in climate models. Identifying critically important questions and the facilities and research required to address them; providing feedback on long-range scientific priorities;

Suggested Leadership and Membership (in alphabetical order)
Suggested co-chairs include one person each from KESS and CLIMODE and one person affiliated with neither study.

Mike Alexander – air-sea interaction modeling [co-chair]
Nick Bond – modeling of KE region atmosphere
Meghan Cronin – KESS, KEO air-sea flux measurements
Claude Frankignoul – atmosphere/ocean interactions
Terry Joyce – CLIMODE, analyses of boundary currents and storm tracks
Kathie Kelly – CLIMODE, satellite observations of winds, currents, SST [co-chair]
Young-Oh Kwon – extratropical atmosphere/ocean interaction
Shiling Peng - – air-sea interaction modeling
Bo Qiu – KESS, ocean modeling and satellite observations [co-chair]
Roger Samelson – CLIMODE, air-sea interaction and modeling
Justin Small – KESS, air-sea interaction at ocean fronts and eddies
LuAnne Thompson – modeling of mid-latitude ocean circulation

Resources requested:
Travel funds for a KESS/CLIMODE joint meeting, funds for teleconferences, and support for a larger conference in year 2.