OCCI Final Report

An Orographic Conduit for Atlantic Forcing of Pacific Decadal Climate Variability

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What were the primary questions you were trying to address with this research? (Or, if more appropriate, was there a hypothesis or theory that you were trying to prove or disprove?)

This project was based on the hypothesis that decadal climate variability in the Atlantic region might influence decadal variability in the tropical Pacific Ocean through a unique pathway. The Sierra Madre mountains connecting North and South America have distinct gaps through which gale-force winds blow during wintertime when atmospheric pressure builds up in the Gulf of Mexico. These so-called "gap winds," which previous work by the PI had been shown to be related to large-scale climate variability in the North Atlantic, offer a potential conduit linking the Atlantic and tropical Pacific.

What have you discovered or learned that you didn't know before you started this work?

I was surprised to find a global climate model with relatively high resolution to accurately simulate the gap winds blowing seasonally through Chivela Pass and producing a realistic response of the ocean in the Gulf of Tehuantepec, eastern Pacific Ocean. This offered a unique opportunity to study this problem from end to end in a single climate model simulation. I discovered that the simulated gap winds exhibit significant decadal variability, the cause of which can be traced back to decadal atmospheric variability in the mid- and high-latitude North Atlantic region. Furthermore, since the model simulation includes the coupling to the global ocean, the response of the tropical Pacific to the decadal cycle in the gap winds could be investigated. I confirmed the hypothesis that the Atlantic Ocean can influence the Pacific Ocean with the linkage being a relatively small but important feature in the orography of a mountain range.

What is the significance of your findings for others working in this field of inquiry and for the broader scientific community?

Tropical oceans exhibit natural variability on a wide range of time scales. However, the causes of climate variability on the decadal time scale in the tropical Pacific Ocean have remained elusive. The dynamics of the processes uncovered in this project will require further investigation with more models and eventually long-term observations. In addition, the regional-scale processes associated with the gap winds can be used as benchmarks in future assessments of model fidelity.

What is the significance of this research for society?

There are two aspects of this research that bear significance for society. First, predicting the strong gap winds themselves can contribute to weather and maritime prediction in Mexico, Central America, and the eastern Pacific Ocean. The second aspect is due to the remarkable influence of the tropical Pacific Ocean on global weather and climate variability. One of the outcomes of this research is a better understanding of the remote processes controlling tropical Pacific decadal variability and may therefore lend predictive capacity for rainfall and other climate regimes that are controlled by the tropical Pacific.

What were the most unusual or unexpected results and opportunities in this investigation?

Perhaps the most unexpected result was the realism with which a global climate model was able to simulate such a complex dynamical feature at a regional scale. This is what truly enabled an end-to-end diagnostic study within a single model simulation of the causes, effects, and implications of a process that was hypothesized to be important.

What were the greatest challenges and difficulties?

When working with global models, especially those with relatively high spatial resolution, a challenge is always working with large volumes of data.

When and where was this investigation conducted? (For instance, did you conduct new field research, or was this a new analysis of existing data?)

No field work was involved in this project. The research relied entirely on modeling and data analysis.

What were the key tools or instruments you used to conduct this research?

The primary tool used to conduct this research was a coupled climate model called MIROC3.2-hires, developed at the University of Tokyo. This climate model is global in scale and includes the atmosphere, ocean, sea ice, land surface, as well as the dynamic interactions between each of these components.

Is this research part of a larger project or program?

This research was largely built on previous research I had begun while working on my Ph.D. thesis at the University of Maryland.

What are your next steps?

Next, I would like to use the decadal signal of the gap winds as simulated in the global model and apply that to a circulation model of the tropical Pacific Ocean with much higher resolution. This will allow a more comprehensive investigation of the ocean response to the

gap winds and further illuminate the patterns and propagation of ocean variability that is forced by atmospheric processes originating far away in the North Atlantic.

Have you published findings or web pages related to this research? Please provide a citation, reprint, and web link (when available).

My next step is to wrap up the manuscript describing the simulated decadal variability of the gap winds and the mechanism linking them to atmospheric variability in the North Atlantic region. A follow-up publication will be prepared after the high-resolution ocean model simulations are conducted and analyzed. To build on the results already achieved under this award, appropriate funding sources for the latter are currently being pursued.

Please provide photographs, illustrations, tables/charts, and web links that can help illustrate your research.

Highlight figures are provided on the following pages.

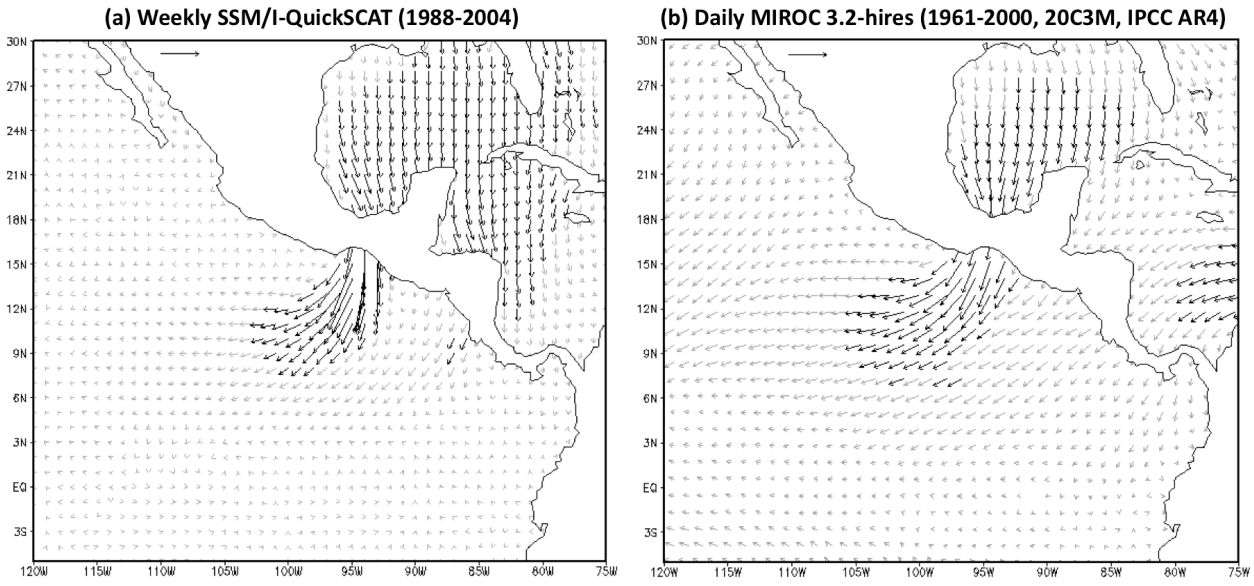

Figure 1. Observed (left) and simulated (right) gap winds flowing through Chivela Pass, Mexico and over the Gulf of Tehuantepec, eastern Pacific Ocean.

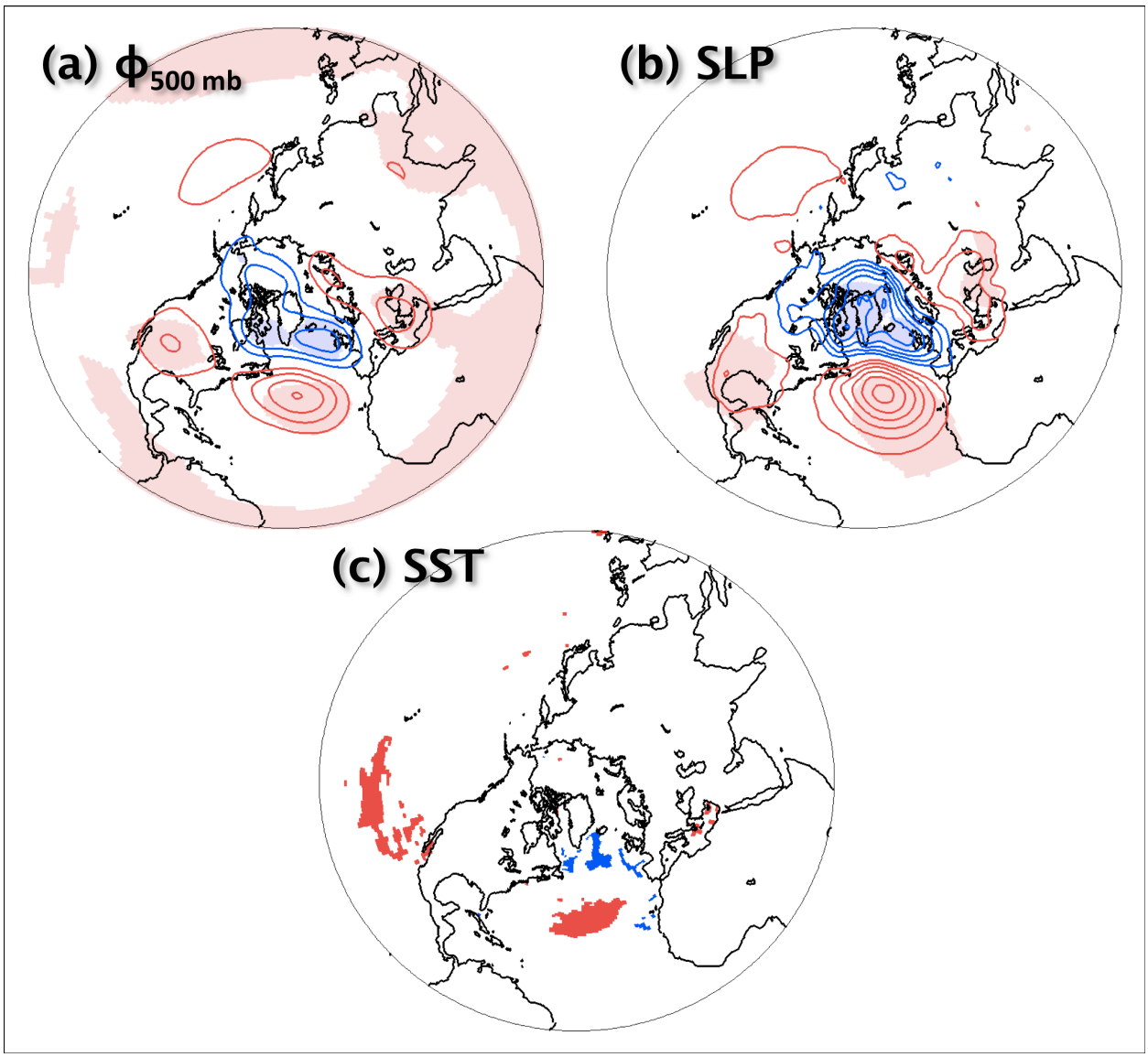

Figure 2. Large-scale features in the atmosphere (top) and ocean (bottom) associated with decades where the gap winds are strong.