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Final Report

IMPACTS OF INTERANNUAL CLIMATE VARIABILITY ON AGRICULTURAL AND MARINE ECOSYSTEMS
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Background. The El Nino – Southern Oscillation (ENSO) is the dominant mode of global interannual climate variability, and seems to be the only mode for which current prediction methods are more skillful than climatology or persistence. The *Zebiak and Cane* [1987] intermediate coupled ocean-atmosphere model has been in use for ENSO prediction for more than a decade [*Cane et al 1986*], with notable success. However, the sole dependence of its original initialization scheme and the improved *Chen et al.* [1995] initialization on wind fields derived from merchant ship observations proved to be a liability during 1997/1998 El Nino event: the deficiencies of wind observations prevented the oceanic component of the model from reaching the realistic state during the year prior to the event, and the forecast failed.

Our work on the project was concentrated on the use of satellite data for improving various stages of ENSO prediction technology: model initialization, bias correction, and data assimilation. Close collaboration with other teams of the IDS project was maintained throughout.

Model initialization. *Chen et al.* [1999] showed that the better wind fields obtained from the NSCAT scatterometer would have yielded good forecasts. Unfortunately, the satellite failed in June of 1997, so its data was available for only 9 months. Other data can compensate for poor winds. *Chen et al.* [1998] achieved a high level of forecast skill, including excellent forecasts for the 97/98 event, by "nudging" sea level height assimilated fields [*Cane et al.* 1996] into the initialization run of the model. Assimilation of sea level heights effectively influences the representation of subsurface behavior and corrects the model initial states as successfully as subsurface temperature assimilation does that to the NCEP ocean GCM with the similar forecast results.

Bias correction. The only sea level data used by *Chen et al.* [1998] were from 34 tropical Pacific IGOSS tide gauge stations. The much better coverage of

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Topex/Poseidon (T/P) altimetry data yields only moderate improvement in the forecasts. While assimilation of T/P altimetry certainly brings the solution closer to the true state of the ocean, the large part of the improvement over a purely wind-driven solution is captured by the assimilation of the data from the sparse tide gauge network. The major features of these differences (zonally elongated maxima in the NW and SW corners of the domain as well as the one near 10N and eastern boundary) are present in the comparison of sea level fields of NCEP ocean GCM with T/P altimetry as well. Note that the NCEP fields assimilate both the T/P altimetry and subsurface temperature profiles. Similar differences from the T/P altimetry are evident in the POMC_4C run of the Semtner and Chervin high-resolution ocean model and point towards deficiencies in the wind fields as a probable culprit [*Kaplan et al.* 2001). In the long term, we expect the problems in the wind forcing to be fixed (i.e. by the Quickscat mission) or alleviated by better ocean models and data assimilation. A shorter-term goal, developing better models for the error in the data assimilation procedures will allow us to exploit the T/P altimetry data more completely. In addition, tuning the data assimilation parameters against the high-resolution T/P altimetry data will extend benefits to the assimilation of in situ data in the pre-Topex era. The resulting improved hindcasts of the tropical Pacific sea level will be extremely helpful for the development and improvement of reliable procedures of ENSO prediction.

Data assimilation. The utility of a formal data assimilation approach for initialization of El Nino predictions with the Zebiak-Cane model was studied with an approximation of the non-linear coupled model by a system of seasonally dependent linear models (Markov models). The low dimensional nature of such an approximation allows to determine a sequence of "perfect" initial states, which define trajectory segments best fitting the observed data. Declaring these perfect initial conditions to be the "true" states of the model, we computed a priori parameters for data assimilation and test the ability of its solutions (optimal interpolation, Kalman filter, and optimal smoother) to produce an estimate of the "truth" superior to the less theoretically sound estimates. We found no discernible improvements and identified the violation of standard data assimilation "textbook" assumptions on temporal whiteness of observational errors and system noise as the reason for this failure [*Cañizares et al.* 2001]. We work on a variety of possible ways to overcome these difficulties [*Cañizares et al.* 2000].

PUBLICATIONS

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