"Course on Ocean-Atmosphere Interaction in the Tropics"
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"Prediction"

(Supplement to SMR/596-1: "Forecasting El Niño with a Geophysical Model")

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Please note: These notes are intended for internal distribution only
FORECASTING CONSIDERATIONS

ENSO is generated in the Tropical Pacific
   Data from the Tropical Pacific alone may be sufficient (though not optimal)

ENSO is a coupled cycle
   A deterministic process, not a stochastic one; hence possibly predictable
   Large-scale, Low frequency

ENSO is aperiodic
   Predictability is limited in principle

Data is sparse, Model is highly simplified
   Prediction may be impossible in practice

Data assimilation_INITIALIZATION is primitive
   The only data used is the FSU surface wind

The ocean has the inertia
   Heat content (thermocline depth) is an essential precondition
Fig. 1. Location of tropical Pacific 2° lat by 5° long boxes with five to nine surface marine observations (lightly stippled) and ten or more observations (heavily stippled) for the month of March 1987. Buoy locations are also indicated.

From Reynolds et al. J. Climate 1987. Errors of 2-3 m/s

Heavily stippled: > 10 observations/month
Fig. 3. Sea surface temperature anomalies (°C) for selected periods averaged over the NINO3 region. The light curves in each panel are from forecasts initiated in the 6 successive months from August through the following January. The dashed curve is the average of the 6 (the consensus forecast) and the heavy curves are the observed values.
Correlation of Individual Forecasts with Observed NINO3 1970 - 1985

Correlation of Latest 6 Forecasts Averaged with Observed NINO3 1970 - 1985
Figure Caption:
Cane, Zebiak, you model
Statistical model: Forecast skill using the upper ocean temperatures at 5°N (from an OGCM forced by observed winds) as predictor (see Lueders manuscript 'WIT and Graham')

Latif, Flugel: OGCM coupled to empirical forecast (see Lueders manuscript)

Constant wind: If the winds are held constant at their initial values (O'Brien method, but applied to our OGCM)
Some conclusions from this model's forecasts

ASPECTS OF ENSO ARE PREDICTABLE AT LEAD TIMES OF 3, 6, 9, 12, ... MONTHS
  Model shows statistically significant skill in predicting
  ENSO indices; events have been predicted in advance
  Skill is modest
  Skill is for low frequencies (events) only

ENSO IS A LARGE SCALE, LOW FREQUENCY, ROBUST CYCLE
  Allows prediction with models and data which do not capture
  smaller scale higher frequency "details"

EQUATORIAL PACIFIC COUPLED OCEAN-ATMOSPHERE
INTERACTIONS ARE ESSENTIAL
  but events in other regions are of interest and influence

PREDICTION SKILL VARIES IN TIME
  seasonally, and with the situation
  and some features are less predictable than others

VERIFICATION STATISTICS ARE LIMITED
  there are only 4 events in the "data rich" period 1970-1989
  There is a need for more events to practice on. It should be
  possible to collect and analyze an adequate data set back to the
  mid-1950s

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Results here are from an "intermediate" model using only surface
winds of poor quality and a minimal data assimilation procedure:
there are obvious avenues for improvement

Improved MODELS
work up from intermediate models or over from GCMs? cf the
history of NWP
atmosphere models for climate and coupling are in their
infancy
surface flux parameterizations and ocean models for SST

Improved DATA
relation of prediction to observing network
how should it be enhanced to support prediction?

Improved DATA ASSIMILATION / INITIALIZATION
only winds were used; not SST, XBTs, sea level,
different climatologies for reality, coupled model, forced
component models

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Breakthroughs are welcome, but much progress can be made
with what is known now. The application of present knowledge
and data would be facilitated by an organized, focused effort,
especially for data aspects

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Much remains to do:
Skill is modest
What features can be predicted?
ENSO indices are of some use in the tropics, but what of
mid-latitudes and tropical features such as drought in Northeast
Brasil, monsoon rainfall in India?

How should forecast information be disseminated?
How should prediction efforts be organized?
Forecasts of NINO3 SST Anomalies

Forecasts are made using the model and procedures outlined in Cane, Zebiak and Dolan 1986 (Nature 231, 827-832) and Barnett et al. 1988 (Science 241, 192-196).

Results are presented for six different lead times ranging from 0 months to 15 months. Each forecast is actually the mean of forecasts from six consecutive months, adjusted to have the same mean and standard deviation as the observed. Note that 0 month lead can differ from the observed because SST data is not used in initialization. For each lead time, forecast values are indicated by x’s and observed values by a solid line (for 9, 12 and 15 month lead times, observed values are 3 month averages; otherwise they are monthly averages). Error bars represent ±1 root-mean-square error, based on the years 1972-1987.

The latest forecast included in these results (from December initial conditions) is provisional. The results generally indicate no significant anomalies over the next several seasons.
June 91 forecast.
Adjusted for atmospheric pressure

Anomaly of sea level from the 1976 to 1986 mean May sea level

May 1991
Anomaly in cm
Pressure Center
Sea Level
CACSSTF Y=1° S Z=0.0 D=stt
point mean: 27.047 ± 2.2675 range [20.3 to 31.0]
28°C contour
This is the observed sea surface temperature, which could be appended monthly, from CAC.

26.0 28.0 30.0
CACSSTF Y=1°S Z=0.0 D=sst
point mean: 27.297 ± 2.0667 range [21.4 to 30.85]
26°C contour. 1979-80
This is the observed sea surface temperature, which could be appended monthly. from CA

26.0

28.0

30.0
CACSSTF Y=1°S Z=0.0 D=ssst
point mean: 27.498 ± 2.1176 range [21.05 to 30.35]
28°C contour. 1990-91
This is the observed sea surface temperature, which could be appended monthly, from CAC

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26.0
28.0
30.0