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COURSE ON "OCEAN-ATMOSPHERE INTERACTIONS IN THE TROPICS"
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"Variability of ENSO"

presented by

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Please note: These are preliminary notes intended for internal distribution only.

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6) Variability of ENSO

When does pure delayed oscillator breakdown?

- **The onset of ENSO**

  Clarke and Li, 1995; Mantua and Battisti, 1995.

How and Why does the cyclic nature of ENSO (DOT) breakdown? The cause(s) of the irregularity of ENSO.

What causes ENSO events to occur irregularly? Don't know, but there are several possibilities.

- **Noise (Weather; the Intraseasonal Oscillation, etc.)**

  Suarez and Schopf 1988; Battisti 1989, 1990; Goswami and Shukla 1991; Penland and Sardesmukh 1996

- **Competition between two or more coupled modes**

  In Cane and Zebiak model, interactions between the ENSO mode and the mobile mode (Mantua 1994; but c.f. Goswami and Shukla 1990 and Munnich et al. 1991).

- **Nonlinear modifications to delayed oscillator physics**

  Munnich et al. 1991.

- **Interactions between ENSO and the annual cycle**

  Chang et al. 1994; Tziperman et al 1994; Jin et al. 1994.

- **Interactions between ENSO and the monsoons (land)**

  Webster and Yang 1992

6A) Atmospheric Noise External to the Coupled Atmosphere/Ocean Climate System in the Tropical Pacific

- **Weather; the Intraseasonal Oscillation, etc. in an unstable coupled system**

  Suarez and Schopf 1988; Battisti 1989, 1990; Goswami and Shukla 1991;

- **External Noise and Seasonality in seasonal cycle in the stability of the coupled sysytem**

  (e.g., Kirtman and Schopf, 1997)

- **A stable coupled system, in which noise MUST be fundmental to ENSO**

  Penland and Sardeshmukh 1995

- **Stochasitically Driven Transient Growth of ENSO**

  Singular Vector Analyses; Ensemble forecast skill evaluation. [Blumenthal 1991; Chen et al. 1996; Xue et al. 1996; Moore and Kleeman 1996; Thompson 1997]

  What the pattern of noise drives the opimal growth in the coupled system?

  What is the pattern that this noise grows to?

  Applicable to the onset of some ENSOs?

- **What are the implications for the limits and structure of forecast skill**

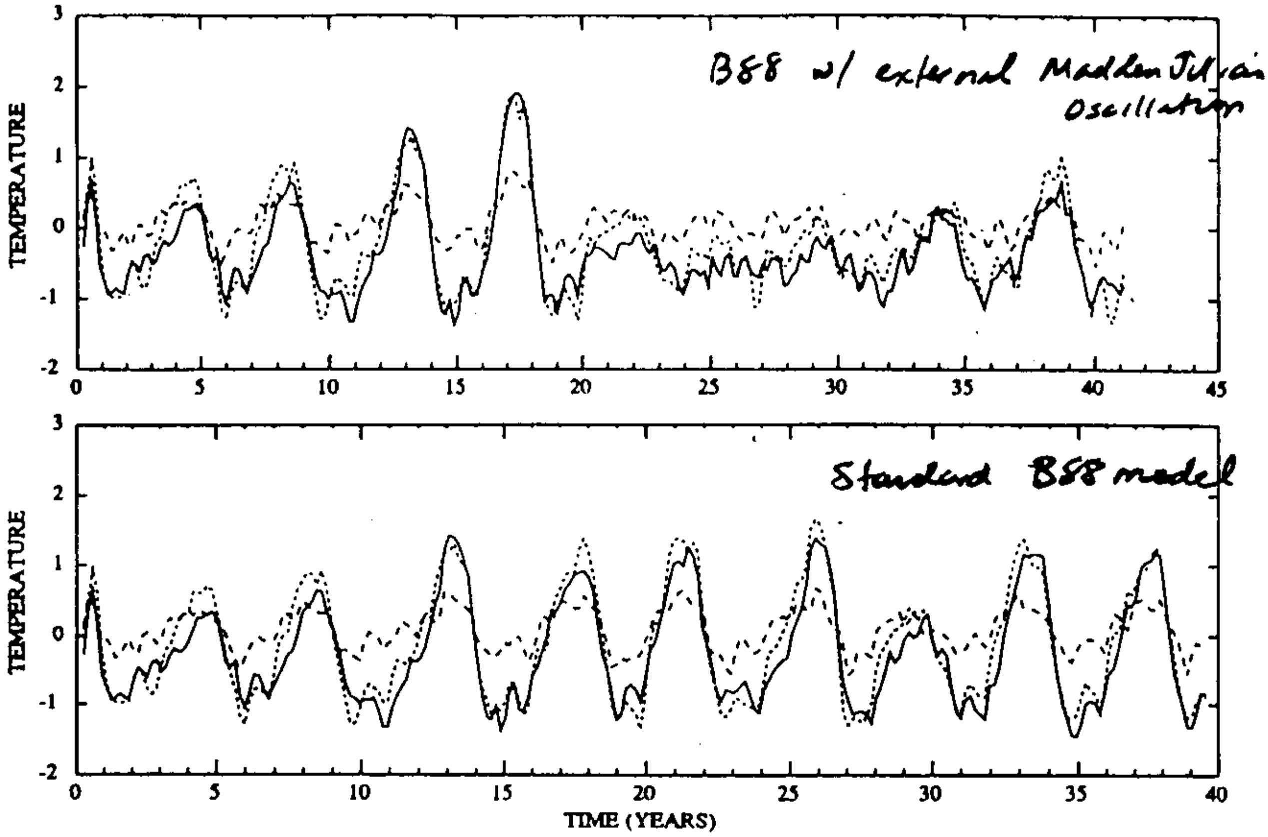
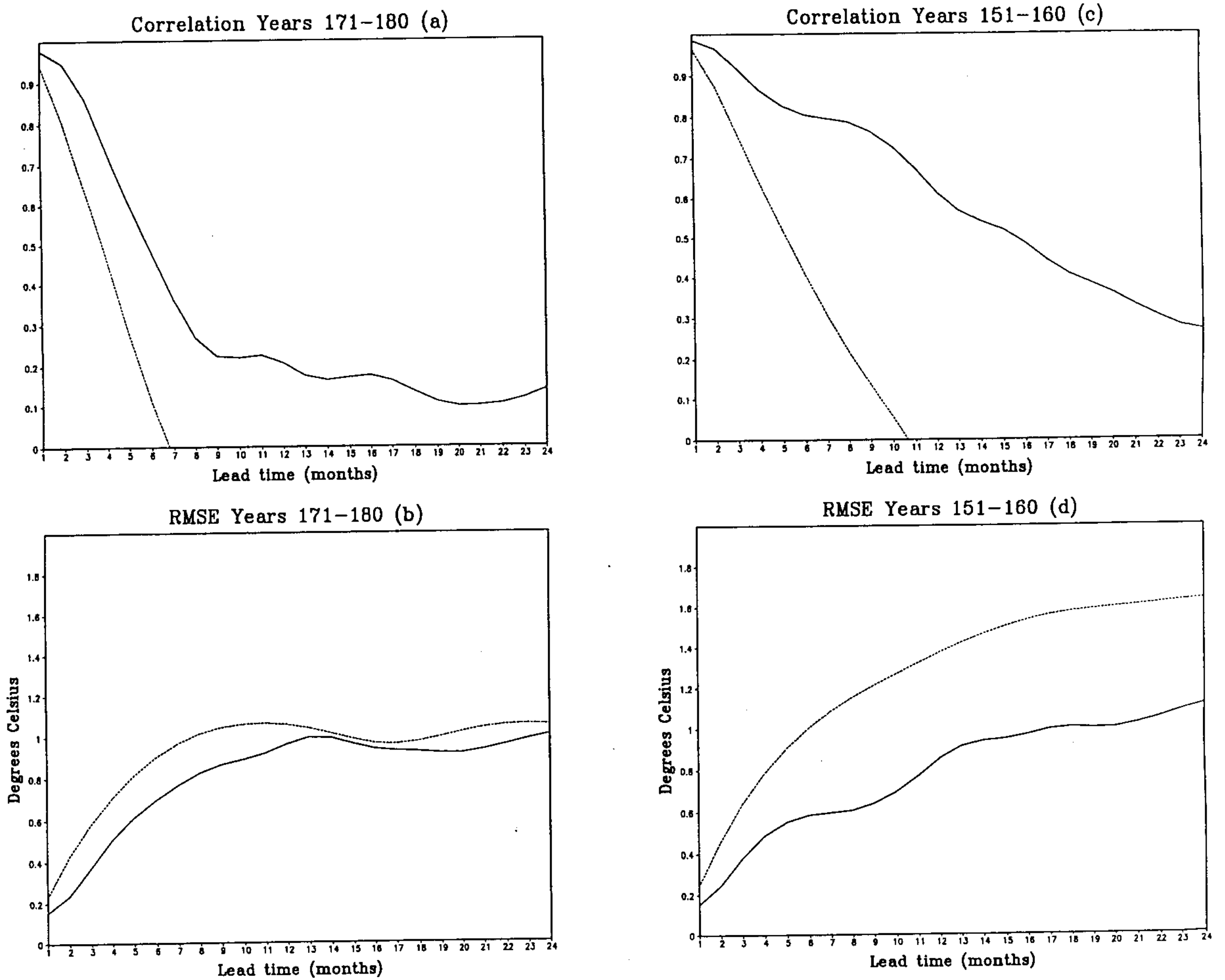
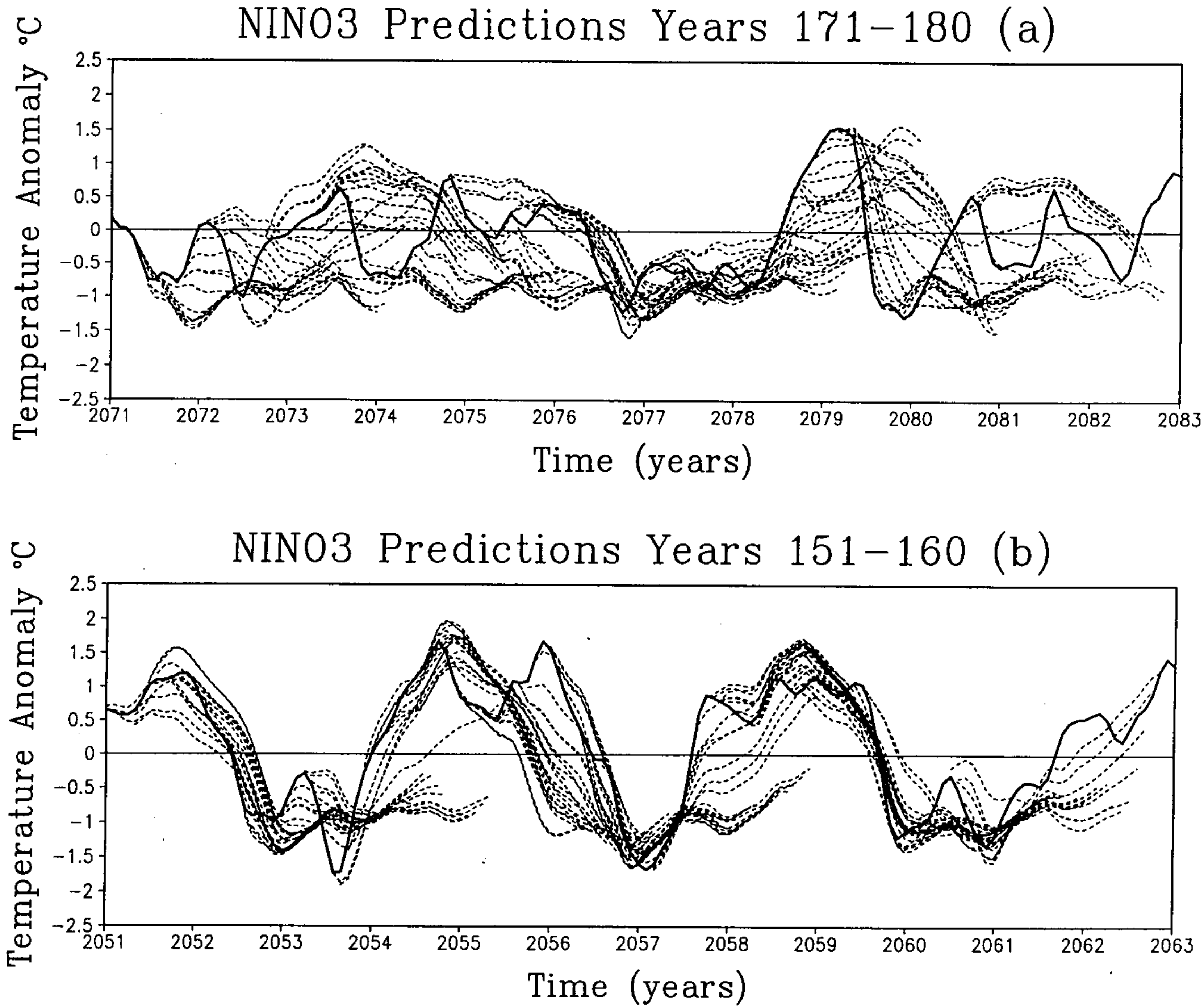


FIG. 6. SST indices for the first 45 and 40 years of two runs of the standard physics model including a parameterized 30–60 atmospheric signal and some additional noise in the zonal wind. In the model, Niño 1 (solid line) extends from 10° to 5°S, and 6° offshore (equivalent of 87°W), Niño 3 (dotted line) covers the area (5°S to 5°N, 90° to 150°W), and Niño 4 (dashed line) spans (5°S to 5°N, 150°W to 160°E).

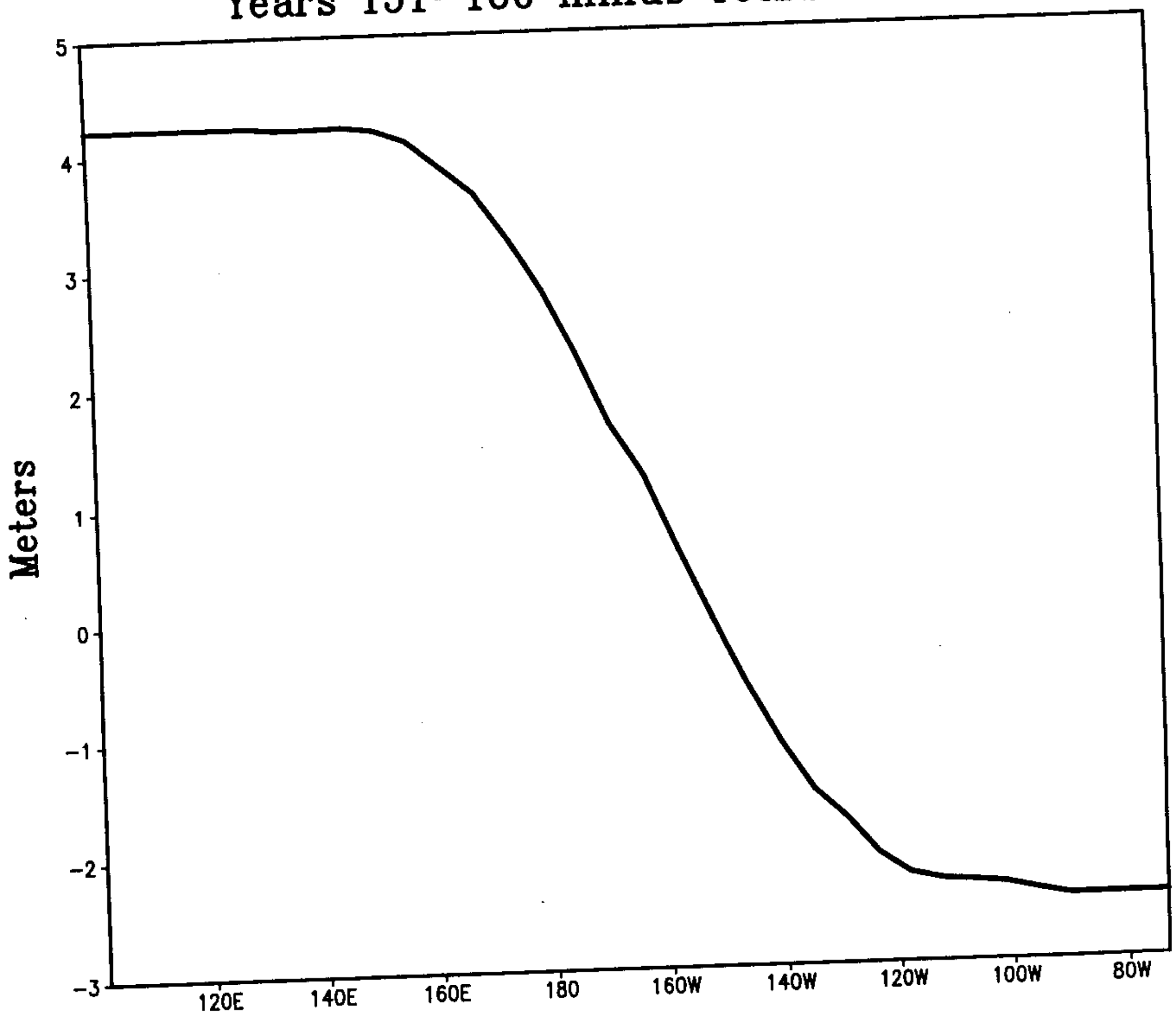
(from Battisti 1989)



Correlation Years 171–180 (a)
Lead time (months)
Correlation Years 151–160 (c)
Lead time (months)
RMSE Years 171–180 (b)
Degrees Celsius
Lead time (months)
RMSE Years 151–160 (d)
Degrees Celsius
Lead time (months)


NINO3 Predictions Years 171−180 (a)
Temperature Anomaly °C
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
2071
2072
2073
2074
2075
2076
2077
2078
2079
2080
2081
2082
2083
Time (years)
NINO3 Predictions Years 151−160 (b)
Temperature Anomaly °C
2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
2051
2052
2053
2054
2055
2056
2057
2058
2059
2060
2061
2062
2063
Time (years)

Mean Thermocline Depth Anomaly
Years 151-160 minus Years 171-180



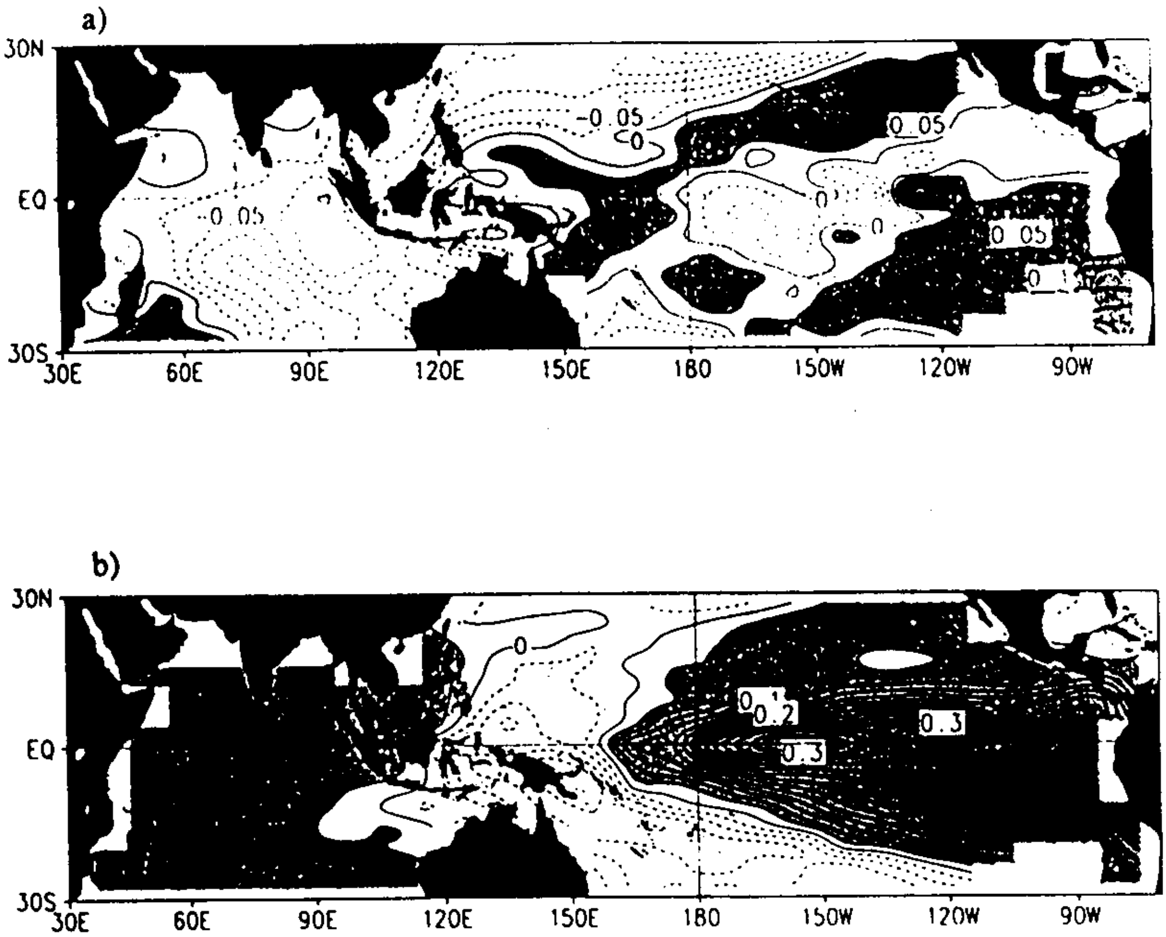


FIG. 6. (a) Top: Optimal initial SST perturbation $\underline{\phi}_1(7)$ optimized to give maximum amplification of SST anomalies at seven months. When this is specified as the initial condition in (6) [or (10)], the SST anomaly pattern evolves into the pattern shown in the bottom panel (b). The contour interval is arbitrary (0.025) but the same in both panels. Negative values are indicated by dashed contours.