Chapter 2
Data

In this study, the monthly atmospheric variables are from the 40-year European Centre for Median-Range Weather Forecasts (ECWMF) Re-Analysis (ERA-40) (Uppala et al 2005). The SST data is from the Hadley Centre Sea Ice and Sea Surface Temperature data set (HadISST) (Rayner et al. 2003), and the sea surface height (SSH), which is utilized as a proxy of upper-ocean heat content and thermocline depth, the ocean currents and the ocean temperature are from Simple Ocean Data Assimilation (SODA) version 2.0.2 (Carton et al. 2005). The ocean data assimilation product from the German Estimating the Circulation and Climate of the Ocean project (GECCO) (Köhl et al. 2006) is used for the oceanic mixed-layer heat budget analysis in Chap. 4. The GECCO serves as an appropriate dataset for ocean temperature budget analyses since no artificial internal sources and sinks of properties was adding when calculating the estimated state.

Monthly anomalies were obtained as departures from monthly mean climatology for the period of 1958–2001, then the Kolmogorov–Zurbenko (KZ) filter (Eskridge et al. 1997) was applied to remove high frequency (less than 6 months) and longer-than-ENSO scale (8 years) variations. The KZ filter gives iterative moving average that removes high frequency variation relative to the window size; the method cleanly separates various time scales of meteorological variables and has the same accuracy as the wavelet method. Hence, the band-pass filter (3 month window, two-iteration KZ filter minus 43 month window, two-iteration KZ filter) in particular preserves the peaks within ENSO time scale yet alleviates the abruptness of 1976/1977 climate change. The filtered data were highly correlated ($r > 0.9$) with those using other commonly employed methods, e.g., a 6 year high-pass filter based on successive application of running means centered at 25 and 37 months (Zhang et al. 1997). As a result, our conclusions presented here do not depend on our choice of a specific filter, and only analyses of KZ-filtered data are discussed.

Regular El Niño events (excluding the three super El Niño cases) are defined as Niño-3 SST anomalies exceeding 0.5 standard deviation for at least 3 months. The time span covered by ERA-40 includes nine regular El Niño events (1963/1964, 1965/1966, 1968/1969, 1969/1970, 1976/1977, 1986/1987, 1987/1988, 1991/1992, and 1994/1995). An El Niño onset year is denoted by suffix (0), Y (0), and the year follows an El Niño event is denoted as Y (−1). Likewise, months in and before an El Niño onset year are also denoted by suffix (0), and (−1), respectively. For

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example, October–November in the year before an El Niño event is abbreviated as ON (−1) and October–November in an El Niño year is abbreviated as ON (0).

Since the number of super El Niño is limited in the observation, the output of a coupled model, GFDL-ESM2M, is also used to investigate super El Niño with much more (12) events. The GFDL-ESM2M model output was obtained from the Coupled Model Intercomparison Project phase 5 (CMIP5) (Taylor et al. 2011) data archive (http://cmip-pcmdi.llnl.gov/cmip5/index.html). Simulated super El Niño in the preindustrial experiment for a 500 year simulation period was analyzed and compared to regular super El Niño in the model.

References

Carton, J. A., B. S. Giese, and S. A. Grodsky, 2005: Sea level rise and the warming of the oceans in the Simple Ocean Data Assimilation (SODA) ocean reanalysis. *J. Geophys. Res.*, **110**.

Eskridge, R. E., J. Y. Ku, S. T. Rao, P. S. Porter, and I. G. Zurbenko, 1997: Separating Different Scales of Motion in Time Series of Meteorological Variables. *Bull. Amer. Meteor. Soc.*, **78,** 1473-1483.

Köhl, A., D. Dommenget, K. Ueyoshi, and D. Stammer, 2006: The global ECCO 1952 to 2001 ocean synthesis, ECCO Report No.40. http://www.ecco-group.org/report_series.htm.

Rayner, N. A., and Coauthors, 2003: Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. *J. Geophys. Res.*, **108,** 4407.

Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2011: An Overview of CMIP5 and the Experiment Design. *Bull. Amer. Meteor. Soc.*, **93,** 485-498.

Uppala, S. M., and Coauthors, 2005: The ERA-40 re-analysis. *Q. J. R. Meteorol. Soc.*, **131,** 2961-3012.

Zhang, Y., J. M. Wallace, and D. S. Battisti, 1997: ENSO-like interdecadal variability: 1900-93. *J. Clim.*, **10,** 1004-1020.

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