Three dimensional reconstruction of the atmospheric El Niño-Southern Oscillation signal

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The El Niño-Southern Oscillation (ENSO) signal in the troposphere and lower stratosphere up to 20 km altitude is detected by means of radio occultation (RO) temperature data from CHAMP, GRACE-A, and Formosat-3/COSMIC from August 2006 to December 2010. Two El Niño and three La Niña events occurred in this rather short time period: El Niño events were observed in 2006/2007 and 2009/2010; La Niña events occurred in 2007/2008, 2008/2009, and 2010/2011.

We find that the atmospheric ENSO response is composed of distinctive zonal mean patterns and eddies (deviations from the zonal mean) whose evolutions are not simultaneous. In general, positive sea-surface temperature anomalies come along with warm tropospheric and cold stratospheric zonal mean temperatures. The node of these positive and negative correlations occurs around the tropopause. At low latitudes equatorwards of 30°, the eddy ENSO temperature signal shows an east-west dipole centered slightly westward to the date line. During the warm ENSO phase, positive anomalies are observed in the tropospheric central and eastern Pacific area. Negative anomalies are observed in the troposphere over the western Pacific and the maritime continent. For these eddy fields we find the node of positive and negative correlations to sea-surface temperature at approximately 15 km at low latitudes, which is well below the tropopause. Furthermore, we find that the atmospheric zonal mean ENSO signal lags sea-surface temperature anomalies by three months but there is no lag for the eddy ENSO signal. These coherent signals are evidence that atmospheric zonal mean and eddy ENSO responses are modulated through different physical mechanisms.