CLIMATE DIAGNOSTICS BULLETIN

MAY 2010

NEAR REAL-TIME OCEAN / ATMOSPHERE Monitoring, Assessments, and Prediction

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Weather Service
National Centers for Environmental Prediction
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- NOAA-NESDIS-STAR, Center for Satellite Applications and Research
- NOAA-NDBC, National Data Buoy Center
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Software: Most of the bulletin figures generated at CPC are created using the Grid Analysis and Display System (GrADS).
- Climate Diagnostics Bulletin available on the World Wide Web

The CDB is available on the World Wide Web. The address of the online version of the CDB is:

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Positive sea surface temperature (SST) anomalies continued to decrease across most of the equatorial Pacific Ocean during May 2010 (Fig. T18). The latest monthly SST indices were 0.0°C for both the Niño-3.4 and the Niño-3 regions. (Table T2, Fig. T5). Consistent with this evolution, the oceanic thermocline (measured by the depth of the 20°C isotherm) was shallower than average across the central and eastern equatorial Pacific (Figs. T15, T16), with sub-surface temperatures reaching 1°C to 3°C below average in the region (Fig. T17).

Also during May, equatorial low-level easterly winds remained stronger than average over the western and central Pacific, while the upper-level westerly wind anomalies persisted across the central and eastern Pacific (Table T1, Figs. T20 and T21). This wind pattern was associated with enhanced convection over Indonesia and suppressed convection across the central equatorial Pacific (Figs. T25, T26 and E3). Collectively, these oceanic and atmospheric anomalies reflect the demise of El Niño.

For the latest status of the ENSO cycle see the ENSO Diagnostic Discussion at: http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/enso_advisory/index.html
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**TABLE T1** - Atmospheric index values for the most recent 12 months. Indices are standardized by the mean annual standard deviation, except for the Tahiti and Darwin SLP anomalies which are in units of hPa. Positive (negative) values of 200-hPa zonal wind index imply westerly (easterly) anomalies. Positive (negative) values of 850-hPa zonal wind indices imply easterly (westerly) anomalies.
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<thead>
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<td>NIÑO 3 5°N-5°S 150°W-90°W</td>
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<td>0.6 24.9</td>
<td>0.4 27.4</td>
<td>0.3 28.0</td>
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TABLE T2. Mean and anomalous sea surface temperature (°C) for the most recent 12 months. Anomalies are departures from the 1971–2000 adjusted OI climatology (Smith and Reynolds 1998, *J. Climate*, 11, 3320-3323).
FIGURE T1. Five-month running mean of the Southern Oscillation Index (SOI) (top), sea-level pressure anomaly (hPa) at Darwin and Tahiti (middle), and outgoing longwave radiation anomaly (OLR) averaged over the area 5N-5S, 160E-160W (bottom). Anomalies in the top and middle panels are departures from the 1951-1980 base period means and are normalized by the mean annual standard deviation. Anomalies in the bottom panel are departures from the 1979-1995 base period means. Individual monthly values are indicated by “x”s in the top and bottom panels. The x-axis labels are centered on July.
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FIGURE T27. Mean (top) and anomalous (bottom) cloud liquid water (g m$^{-2}$) based on the Special Sensor Microwave/Imager (SSM/I) (Weng et al 1997: J. Climate, 10, 1086-1098). Anomalies are calculated from the 1987-2006 base period means.
FIGURE T28. Mean (top) and anomalous (bottom) vertically integrated water vapor or precipitable water (kg m$^{-2}$) based on the Special Sensor Microwave/Imager (SSM/I) (Ferraro et al., 1996: *Bull. Amer. Meteor. Soc.*, 77, 891-905). Anomalies are calculated from the 1987-2006 base period means.
FIGURE T29. Pressure-longitude section (100E-80W) of the mean (top) and anomalous (bottom) divergence (contour interval is $1 \times 10^6$ s$^{-1}$) and divergent circulation averaged between 5N-5S. The divergent circulation is represented by vectors of combined pressure vertical velocity and the divergent component of the zonal wind. Red shading and solid contours denote divergence (top) and anomalous divergence (bottom). Blue shading and dashed contours denote convergence (top) and anomalous convergence (bottom). Anomalies are departures from the 1979-1995 base period monthly means.
May 2010
Divergence and West–East Divergent Circulation

Mean

Anomaly

FIGURE T30. Pressure-longitude section (80W-100E) of the mean (top) and anomalous (bottom) divergence (contour interval is $1 \times 10^{-6}$ s$^{-1}$) and divergent circulation averaged between 5N-5S. The divergent circulation is represented by vectors of combined pressure vertical velocity and the divergent component of the zonal wind. Red shading and solid contours denote divergence (top) and anomalous divergence (bottom). Blue shading and dashed contours denote convergence (top) and anomalous convergence (bottom). Anomalies are departures from the 1979-1995 base period monthly means.
FIGURE T31. Pressure-latitude section of the mean (top) and anomalous (bottom) zonal wind (m s⁻¹) and divergent circulation averaged over the west Pacific sector (120E–170E). The divergent circulation is represented by vectors of combined pressure vertical velocity and the divergent component of the meridional wind. Red shading and solid contours denote a westerly (top) or anomalous westerly (bottom) zonal wind. Blue shading and dashed contours denote an easterly (top) or anomalous easterly (bottom) zonal wind. Anomalies are departures from the 1979-1995 base period monthly means.
FIGURE T32. Pressure-latitude section of the mean (top) and anomalous (bottom) zonal wind (m s\(^{-1}\)) and divergent circulation averaged over the central Pacific sector (130W-180W). The divergent circulation is represented by vectors of combined pressure vertical velocity and the divergent component of the meridional wind. Red shading and solid contours denote a westerly (top) or anomalous westerly (bottom) zonal wind. Blue shading and dashed contours denote an easterly (top) or anomalous easterly (bottom) zonal wind. Anomalies are departures from the 1979-1995 base period monthly means.
During May 2010, 487 satellite-tracked surface drifting buoys, 75% with subsurface drogues attached for measuring mixed layer currents, were reporting from the tropical Pacific. Dramatic 50 cm/s westward anomalies were measured by many near-equatorial drifters at longitudes from the dateline to 100W, a broader extent than seen in the last two months. A narrower band of strong eastward anomalies at 4-5N, centered on 120W, persisted from last month. Warm anomalies of +0.5C to +1.5C were common south of the equator, while cold anomalies of -0.5C to -1.5C were measured by several drifters north of 10N and west of 140W.

**Figure A1.1**
- **Top:** Movements of drifting buoys in the tropical Pacific Ocean during April 2005. The linear segments of each trajectory represent a one week displacement. Trajectories of buoys which have lost their subsurface drogues are gray; those with drogues are black.
- **Middle:** Monthly mean currents calculated from all buoys 1993-2002 (gray), and currents measured by the drogued buoys this month (black) smoothed by an optimal filter.
- **Bottom:** Anomalies from the climatological monthly mean currents for this month.
FIGURE A1.2. Wind Vectors and sea surface temperature (SSTs) from the TAO/TRITON mooring array. Top panel shows monthly means; bottom panel shows monthly anomalies from the COADS wind climatology and Reynolds SST climatology (1971-2000). The TAO/TRITON array is presently supported by the United States (NOAA), Japan (STA), and France (IRD). Further information is available from Richard L. Crout (NOAA/NDBC).
FIGURE A1.3. Time-longitude sections of surface zonal winds (m s$^{-1}$), sea surface temperature (C) and 20°C isotherm depth (m) for the past 24 months. Analysis is based on 5-day averages of moored time series data from the TAO/TRITON array. Positive winds are westerly. Squares on the abscissas indicate longitude where data were available at the start of the time series (top) and end of the time series (bottom). The TAO/TRITON array is presently supported by the United States (NOAA), Japan (STA), and France (IRD). Further information is available from Richard L. Crout (NOAA/NDBC).
FIGURE A1.4. Time-longitude sections of surface zonal winds (m s⁻¹), sea surface temperature (°C) and 20°C isotherm depth (m) for the past 24 months. Analysis is based on 5-day averages of moored time series data from the TAO/TRITON array. Anomalies are relative to monthly climatological cubic spline fitted to 5-day intervals (COADS winds, Reynolds SST, CTD/XBT 20°C depth). Positive winds are westerly. Squares on the abscissas indicate longitude where data were available at the start of the time series (top) and end of the time series (bottom). The TAO/TRITON array is presently supported by the United States (NOAA), Japan (STA), and France (IRD). Further information is available from Richard L. Crout (NOAA/...
In cooperation with institutions in Peru and Ecuador, NOAA-AOML maintained a network coastal stations reporting SST and sea level in real time (via satellite downlink) during the TOGA program, from 1985 to 1995. The South American partners took over full operational responsibility thereafter while NOAA-AOML assumed a data management role, continuing publication of these monthly reports along with their partners. The five-day averages (pentads) at critical stations give us an effective means of monitoring coastal conditions with good time resolution and compact data volume. SSTs and sea level continue to oscillate about normal values, although with a tendency toward seasonally lower sea level farther south (Callao). The amplitude of intraseasonal oscillations compared with the first half of previous years, appears weaker. We will want to be alert for signs of persistent and growing negative anomalies in both variables, which could possibly confirm other indications (e.g., along the equator) of a developing La Nina condition over the rest of 2010.

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**Sea Sfc Temperature**

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**Anomalies**

** - Data missing due to hardware failure

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Email: David.Enfield@noaa.gov; Phone: (305) 361-4351; Fax: (305) 361-4392

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FIGURE A1.5. Five-day averages of sea surface temperature (SST, °C) and sea level height (SLH, cm) from GOES receiving stations in Ecuador & Peru. Dashed line and shading show climatology, departures.
FIGURE A1.6. FSU SURFACE PSEUDO-STRESS VECTORS AND ANOMALIES: May 2010. Pseudo-stress vectors (top) are objectively analyzed from ship and buoy winds on a 2° grid. Ship and buoy data are independently weighted and the background field is created from the data. Contour interval of the vector magnitudes is 20 M/S^2. Anomalies (bottom) are departures from 1978–2001 mean. The contour interval is 15 M/S^2. For more information, please visit our web site at http://www.coaps.fsu.edu/RVSMDC/html/winds.shtml. Produced by Jeremy Rolph, Mark A. Bourassa, and Shawn R. Smith, Center for Ocean-Atmospheric Prediction Studies, Florida State University, Tallahassee, FL 32306–2040, USA.
Forecast Forum

The canonical correlation analysis (CCA) forecast of SST in the central Pacific (Barnett et al. 1988, *Science*, 241, 192196; Barnston and Ropelewski 1992, *J. Climate*, 5, 13161345), is shown in Figs. F1 and F2. This forecast is produced routinely by the Prediction Branch of the Climate Prediction Center. The predictions from the National Centers for Environmental Prediction (NCEP) Coupled Forecast System Model (CFS03) are presented in Figs. F3 and F4a, F4b. Predictions from the Markov model (Xue, et al. 2000: *J. Climate*, 13, 849871) are shown in Figs. F5 and F6. Predictions from the latest version of the LDEO model (Chen et al. 2000: *Geophys. Res. Let.*, 27, 25852587) are shown in Figs. F7 and F8. Predictions using linear inverse modeling (Penland and Magorian 1993: *J. Climate*, 6, 10671076) are shown in Figs. F9 and F10. Predictions from the Scripps / Max Planck Institute (MPI) hybrid coupled model (Barnett et al. 1993: *J. Climate*, 6, 15451566) are shown in Fig. F11. Predictions from the ENSOCLIPER statistical model (Knaff and Landsea 1997, *Wea. Forecasting*, 12, 633652) are shown in Fig. F12. Niño 3.4 predictions are summarized in Fig. F13, provided by the Forecasting and Prediction Research Group of the IRI.

The CPC and the contributors to the Forecast Forum caution potential users of this predictive information that they can expect only modest skill.

ENSO Alert System Status

La Niña Watch / Final El Niño Advisory

Outlook

Conditions are favorable for a transition to La Niña conditions during June – August 2010.
Discussion

El Niño dissipated during May 2010 as positive surface temperature (SST) anomalies decreased rapidly across the equatorial Pacific Ocean and negative SST anomalies emerged across the eastern half of the Pacific (Fig. T18). All of the Niño indices decreased between 0.5°C to 1.0°C during the month (Table T2). Since the end of February, subsurface heat content anomalies (average temperatures in the upper 300m of the ocean) have decreased steadily. Below-average temperatures have strengthened at depth and currently extend to the surface in parts of the eastern Pacific (Fig. T17). Also during May, enhanced convection persisted over Indonesia, while the area of suppressed convection strengthened and expanded over the tropical central Pacific (Fig. T25). The low-level easterly trade winds strengthened over the western and central equatorial Pacific, and anomalous upper-level westerly winds prevailed over the east-central Pacific (Figs. T20, T21). Collectively, these oceanic and atmospheric anomalies reflect the demise of El Niño and return of ENSO-neutral conditions.

The majority of models predict ENSO-neutral conditions (between -0.5°C to +0.5°C in the Niño-3.4 region) through early 2011 (Figs. F1-F13). However, over the last several months, a growing number of models, including the NCEP Climate Forecast System (CFS), indicate the onset of La Niña conditions during June-August 2010. There is an increasing confidence in these colder model forecasts, which is supported by recent observations that show cooling trends in the Pacific Ocean and signs of coupling with the atmospheric circulation. Therefore, conditions are favorable for a transition to La Niña conditions during June-August 2010.

Weekly updates of oceanic and atmospheric conditions are available on the Climate Prediction Center homepage (El Niño/La Niña Current Conditions and Expert Discussions).
FIGURE F1. Canonical correlation analysis (CCA) sea surface temperature (SST) anomaly prediction for the central Pacific (5°N to 5°S, 120°W to 170°W (Barnston and Ropelewski, 1992, *J. Climate*, 5, 1316-1345). The three plots on the left hand side are, from top to bottom, the 1-season, 2-season, and 3-season lead forecasts. The solid line in each forecast represents the observed SST standardized anomaly through the latest month. The small squares at the mid-points of the forecast bars represent the real-time CCA predictions based on the anomalies of quasi-global sea level pressure and on the anomalies of tropical Pacific SST, depth of the 20°C isotherm and sea level height over the prior four seasons. The vertical lines represent the one standard deviation error bars for the predictions based on past performance. The three plots on the right side are skills, corresponding to the predicted and observed SST. The skills are derived from cross-correlation tests from 1956 to present. These skills show a clear annual cycle and are inversely proportional to the length of the error bars depicted in the forecast time series.
FIGURE F2. Canonical Correlation Analysis (CCA) forecasts of sea-surface temperature anomalies for the Nino 3.4 region (5N-5S, 120W-170W) for the upcoming five consecutive 3-month periods. Forecasts are expressed as standardized SST anomalies. The CCA predictions are based on anomaly patterns of SST, depth of the 20C isotherm, sea level height, and sea level pressure. Small squares at the midpoints of the vertical forecast bars represent the CCA predictions, and the bars show the one (thick) and two (thin) standard deviation errors. The solid continuous line represents the observed standardized three-month mean SST anomaly in the Nino 3.4 region up to the most recently available data.
FIGURE F3. Predicted 3-month average sea surface temperature (left) and anomalies (right) from the NCEP Coupled Forecast System Model (CFS03). The forecasts consist of 40 forecast members. Contour interval is 1°C, with additional contours for 0.5°C and -0.5°C. Negative anomalies are indicated by dashed contours.
FIGURE F4. Predicted and observed sea surface temperature (SST) anomalies for the Nino 3 (top) and Nino 3.4 (bottom) regions from the NCEP Coupled Forecast System Model (CFS03). The forecasts consist of 40 forecast members. The ensemble mean of all 40 forecast members is shown by the blue line, individual members are shown by thin lines, and the observation is indicated by the black line. The Nino-3 region spans the eastern equatorial Pacific between 5N-5S, 150W-90W. The Nino 3.4 region spans the east-central equatorial Pacific between 5N-5S, 170W-120W.
FIGURE F5. Predicted 3-month average sea surface temperature anomalies from the NCEP/CPC Markov model (Xue et al. 2000, *J. Climate*, 13, 849-871). The forecast is initiated in MAY 2010. Contour interval is 0.3°C and negative anomalies are indicated by dashed contours. Anomalies are calculated relative to the 1971-2000 climatology.
FIGURE F6. Time evolution of observed and predicted SST anomalies in the Nino 3.4 region (up to 12 lead months) by the NCEP/CPC Markov model (Xue et al. 2000, J. Climate, 13, 849-871). Anomalies are calculated relative to the 1971-2000 climatology. Shown in each panel are the forecasts grouped by three consecutive starting months: (a) is for December, January, and February, (b) is for March, April, and May, (c) is for June, July, and August, and (d) is for September, October, and November. The observed Nino 3.4 SST anomalies are indicated by the black dashed lines. The Nino 3.4 region spans the east-central equatorial Pacific between 5N-5S, 170W-120W.
FIGURE F7. Forecasts of the tropical Pacific Predicted SST (shading) and vector wind anomalies for the next 3 seasons based on the LDEO model. Each forecast represents an ensemble average of 3 sets of predictions initialized during the last three consecutive months (see Figure F8).
FIGURE F8. LDEO forecasts of SST anomalies for the Nino 3 region using wind stresses obtained from (top) QuikSCAT, (middle) NCEP, and (bottom) Florida State Univ. (FSU), along with SSTs (obtained from NCEP), and sea surface height data (obtained from TOPEX/POSEIDON) data. Each thin blue line represents a 12-month forecast, initialized one month apart for the past 24 months. Observed SST anomalies are indicated by the thick red line. The Nino-3 region spans the eastern equatorial Pacific between 5N-5S, 150W-90W.
FIGURE F9. Forecast of tropical SST anomalies from the Linear Inverse Modeling technique of Penland and Magorian (1993: *J. Climate*, 6, 1067-1076). The contour interval is 0.3°C. Anomalies are calculated relative to the 1951-2000 climatology and are projected onto 20 leading EOFs.
FIGURE F10. Predictions of SST anomalies in the Nino3.4 region (blue line) for leads of three months (top) to 12 months (bottom), from the Linear Inverse Modeling technique of Penland and Magorian (1993: J. Climate, 6, 1067-1076). Observed SST anomalies are indicated by the red line. Anomalies are calculated relative to the 1951-2000 climatology and are projected onto 20 leading EOFs. The Nino 3.4 region spans the east-central equatorial Pacific between 5N-5S, 170W-120W.
FIGURE F11. SST anomaly forecast for the equatorial Pacific from the Hybrid Coupled Model (HCM) developed by the Scripps Institution of Oceanography and the Max-Plank Institut fuer Meteorologie.
FIGURE F12. ENSO-CLIPER statistical model forecasts of three-month average sea surface temperature anomalies (green lines, deg. C) in (top panel) the Nino 4 region (5N-5S, 160E-150W), (second panel) the Nino 3.4 region (5N-5S, 170W-120W), (third panel) the Nino 3 region (5N-5S, 150W-90W), and (fourth panel) the Nino 1+2 region (0-10S, 90W-80W) (Knaff and Landsea 1997, Wea. Forecasting, 12, 633-652). Bottom panel shows predictions of the three-month standardized Southern Oscillation Index (SOI, green line). Horizontal bars on green line indicate the adjusted root mean square error (RMSE). The Observed three-month average values are indicated by the thick blue line. SST anomalies are departures from the 1971-2000 base period means, and the SOI is calculated from the 1951-1980 base period means.
FIGURE F13. Time series of predicted sea surface temperature anomalies for the Nino 3.4 region (deg. C) from various dynamical and statistical models for nine overlapping 3-month periods. The Nino 3.4 region spans the east-central equatorial Pacific between 5N-5S, 170W-120W. Figure provided by the International Research Institute (IRI).
1. Northern Hemisphere

The 500-hPa circulation during May featured above-average heights across the polar region, and generally below average heights in the middle latitudes (Fig. E9). This pattern reflected the negative phase of the Arctic Oscillation (AO). Regional circulation features during the month included above average heights over eastern North America, Greenland, northwestern Russia, and eastern Siberia, and below average heights across the central North Pacific, western U.S., high latitudes of the western North Atlantic, and central Europe. Over the North Atlantic, the anomalies projected strongly (-1.5) onto the negative phase of the North Atlantic Oscillation (NAO) (Table E1, Fig. E7). The negative NAO signal has been exceptionally persistent since July 2009. The circulation during May 2010 also reflected a strong negative phase (-3.1) of the West Pacific (WP) pattern, which contrasts with the positive phase of the WP pattern that had previously persisted from January through April.

The main surface temperature signals during May were consistent with the upper-level circulation, and included above average temperatures in eastern North America and northwestern Russia, and below average temperatures in the western U.S. (Fig. E1). The main precipitation signals included above-average totals in the northern Plains states, southwestern Canada, eastern Europe/ western Russia, and portions of China (Fig. E3). Below average totals were observed in the northeastern U.S., eastern Canada, and southern Alaska.

a. North Pacific/ North America

Over the Pacific sector, the circulation during May featured a north-south dipole pattern of 500-hPa height anomalies, with above average heights at high latitudes and below average heights in the middle latitudes (Fig. E9). This pattern reflected a strong negative phase of the WP teleconnection pattern (Fig. E7), and is opposite to that which persisted from January-April. This phase change of the WP pattern occurred coincident with the demise of El Niño, and with a corresponding shift back to Indonesia of the area of enhanced equatorial convection (Fig. T25).

Over the United States, the circulation during May featured a strong trough in the west and a ridge in the east. This pattern resulted in an east-west dipole pattern of surface temperature anomalies, with well below average temperatures in the west and above average temperatures in the east (Fig. E1). For much of the western U.S., temperatures were 2°-4°C below average, with departures generally in the lowest 10th percentile of occurrences.

Above average precipitation occurred across the north-central U.S. and south-central Canada during May, with monthly totals in the upper 90th percentile of occurrences (Fig. E3). This enhanced precipitation occurred in association with large-scale ascending motion and upper-level divergence immediately downstream of the mean trough axis. Conversely, below average precipitation occurred immediately downstream of the mean ridge axis, with totals in portions of eastern Canada in the lowest 10th percentile of occurrences.
b. Europe

The 500-hPa circulation during May featured a north-south dipole pattern of height anomalies, with above average heights over Greenland and below average heights over the high latitudes of the western North Atlantic (Fig. E9). This pattern reflected the ongoing negative phase of the NAO, which has persisted since July 2009 (Fig. E7).

Also during May 2010, the circulation featured a trough over central Europe and a ridge over northwestern Russia. This pattern contributed to above average precipitation over eastern Europe and western Russia, with some areas recording totals in the upper 90th percentile of occurrences (Fig. E3). It also contributed to well above average temperatures in western Russia, with some areas recording departures exceeding +4°C (Fig. E1).

2. Southern Hemisphere

The 500-hPa circulation during May featured above average heights over the central ocean basins, and below average heights across the high latitudes of the eastern South Pacific and over eastern Australia (Fig. E15). At 200-hPa, the South Pacific jet stream was retracted westward and the jet exit region was located well west of the date line (Fig. T21). This jet stream configuration is consistent enhanced convection over Indonesia (Fig. T25).
### TELECONNECTION INDICES

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<td>-0.1</td>
<td>0.2</td>
</tr>
<tr>
<td>MAY 09</td>
<td>1.7</td>
<td>1.5</td>
<td>-1.2</td>
<td>1.6</td>
<td>-0.6</td>
<td>---</td>
<td>0.2</td>
<td>0.2</td>
<td>-0.8</td>
</tr>
</tbody>
</table>

**TABLE E1-Standardized amplitudes of selected Northern Hemisphere teleconnection patterns for the most recent thirteen months (computational procedures are described in Fig. E7).** Pattern names and abbreviations are: North Atlantic Oscillation (NAO); East Atlantic pattern (EA); West Pacific pattern (WP); East Pacific - North Pacific pattern (EP-NP); Pacific/North American pattern (PNA); Tropical/Northern Hemisphere pattern (TNH); East Atlantic/Western Russia pattern (EATL/WRUS-called Eurasia-2 pattern by Barnston and Livezey, 1987, *Mon. Wea. Rev.*, 115, 1083-1126); Scandanavia pattern (SCAND-called Eurasia-1 pattern by Barnston and Livezey 1987); and Polar Eurasia pattern (POLEUR). No value is plotted for calendar months in which the pattern does not appear as a leading mode.
FIGURE E1. Surface temperature anomalies (°C, top) and surface temperature expressed as percentiles of the normal (Gaussian) distribution fit to the 1971–2000 base period data (bottom) for MAY 2010. Analysis is based on station data over land and on SST data over the oceans (top). Anomalies for station data are departures from the 1971–2000 base period means, while SST anomalies are departures from the 1971–2000 adjusted OI climatology. (Smith and Reynolds 1998, *J. Climate*, 11, 3320-3323). Regions with insufficient data for analysis in both figures are indicated by shading in the top figure only.
FIGURE E2. Monthly global (top), Northern Hemisphere (middle), and Southern Hemisphere (bottom) surface temperature anomalies (land only, °C) from January 1990 - present, computed as departures from the 1971–2000 base period means.
FIGURE E3. Anomalous precipitation (mm, top) and precipitation percentiles based on a Gamma distribution fit to the 1979–2000 base period data (bottom) for MAY 2010. Data are obtained from a merge of raingauge observations and satellite-derived precipitation estimates (Janowiak and Xie 1999, *J. Climate*, 12, 3335–3342). Contours are drawn at 200, 100, 50, -25, -50, -100, and -200 mm in top panel. Percentiles are not plotted in regions where mean monthly precipitation is <5mm/month.
FIGURE E4. Areal estimates of monthly mean precipitation amounts (mm, solid lines) and precipitation percentiles (%, bars) for the most recent 13 months obtained from a merge of raingauge observations and satellite-derived precipitation estimates (Janowiak and Xie 1999, *J. Climate*, 12, 3335–3342). The monthly precipitation climatology (mm, dashed lines) is from the 1979–2000 base period monthly means. Monthly percentiles are not shown if the monthly mean is less than 5 mm.
FIGURE E5. Areal estimates of monthly mean precipitation amounts (mm, solid lines) and precipitation percentiles (%, bars) for the most recent 13 months obtained from a merge of raingauge observations and satellite-derived precipitation estimates (Janowiak and Xie 1999, *J. Climate*, 12, 3335–3342). The monthly precipitation climatology (mm, dashed lines) is from the 1979–2000 base period monthly means. Monthly percentiles are not shown if the monthly mean is less than 5 mm.
FIGURE E6. Observed precipitation (upper left), departure from average (upper right), percent of average (lower left), and average precipitation (lower right) for MAY 2010. The units are given on each panel. Base period for averages is 1971–2000. Results are based on CPC’s U. S. daily precipitation analysis, which is available at http://www.cpc.ncep.noaa.gov/prodcuts/precip/realtime.
FIGURE E7. Standardized monthly Northern Hemisphere teleconnection indices. The teleconnection patterns are calculated from a Rotated Principal Component Analysis (RPCA) applied to monthly standardized 500-hPa height anomalies during January 1950 – December 2000. To obtain these patterns, ten leading un-rotated modes are first calculated for each calendar month by using the monthly height anomaly fields for the three-month period centered on that month: [i.e., The July modes are calculated from the June, July, and August standardized monthly anomalies]. A Varimax spatial rotation of the ten leading un-rotated modes for each calendar month results in 120 rotated modes (12 months x 10 modes per month) that yield ten primary teleconnection patterns. The teleconnection indices are calculated by first projecting the standardized monthly anomalies onto the teleconnection patterns corresponding to that month (eight or nine teleconnection patterns are seen in each calendar month). The indices are then solved for simultaneously using a Least-Squares approach. In this approach, the indices are the solution to the Least-Squares system of equations which explains the maximum spatial structure of the observed height anomaly field during the month. The indices are then standardized for each pattern and calendar month independently. No index value exists when the teleconnection pattern does not appear as one of the ten leading rotated EOF’s valid for that month.

Data updated through May 2010
FIGURE E8. Northern Hemisphere mean and anomalous sea level pressure (CDAS/Reanalysis) for MAY 2010. Mean values are denoted by solid contours drawn at an interval of 4 hPa. Anomaly contour interval is 2 hPa with values less (greater) than -2 hPa (2 hPa) indicated by dark (light) shading. Anomalies are calculated as departures from the 1979-95 base period monthly means.
FIGURE E9. Northern Hemisphere mean and anomalous 500-hPa geopotential height (CDAS/Reanalysis) for MAY 2010. Mean heights are denoted by solid contours drawn at an interval of 6 dam. Anomaly contour interval is 3 dam with values less (greater) than -3 dam (3 dam) indicated by dark (light) shading. Anomalies are calculated as departures from the 1979-95 base period monthly means.
FIGURE E10. Northern Hemisphere mean (left) and anomalous (right) 300-hPa vector wind (CDAS/Reanalysis) for MAY 2010. Mean (anomaly) isotach contour interval is 10 (5) ms⁻¹. Values greater than 30 ms⁻¹ (left) and 10 ms⁻¹ (right) are shaded. Anomalies are departures from the 1979-95 base period monthly means.
FIGURE E11. Northern Hemisphere percentage of days during MAY 2010 in which 500-hPa height anomalies greater than 15 m (red) and less than -15 m (blue) were observed. Values greater than 70% are shaded and contour interval is 20%.
FIGURE E12. Northern Hemisphere: Daily 500-hPa height anomalies for MAY 2010 averaged over the 5° latitude band centered on 40°N. Positive values are indicated by solid contours and dark shading. Negative values are indicated by dashed contours and light shading. Contour interval is 60 m. Anomalies are departures from the 1979-95 base period daily means.
FIGURE E13. Northern Hemisphere 500-hPa heights (thick contours, interval is 6 dam) overlaid with (Top) Standard deviation of 10-day high-pass (HP) filtered height anomalies and (Bottom) Normalized anomalous variance of 10-day HP filtered height anomalies. A Lanczos filter is used to calculate the HP filtered anomalies. Anomalies are departures from the 1979-2000 daily means.
FIGURE E14. Southern Hemisphere mean and anomalous sea level pressure (CDAS/Reanalysis) for MAY 2010. Mean values are denoted by solid contours drawn at an interval of 4 hPa. Anomaly contour interval is 2 hPa with values less (greater) than -2 hPa (2 hPa) indicated by dark (light) shading. Anomalies are calculated as departures from the 1979-95 base period monthly means.
FIGURE E15. Southern Hemisphere mean and anomalous 500-hPa geopotential height (CDAS/Reanalysis) for MAY 2010. Mean heights are denoted by solid contours drawn at an interval of 6 dam. Anomaly contour interval is 3 dam with values less (greater) than -3 dam (3 dam) indicated by dark (light) shading. Anomalies are calculated as departures from the 1979-95 base period monthly means.
FIGURE E16. Southern Hemisphere mean (left) and anomalous (right) 300-hPa vector wind (CDAS/Reanalysis) for MAY 2010. Mean (anomaly) isotach contour interval is 10 (5) ms$^{-1}$. Values greater than 30 ms$^{-1}$ (left) and 10 ms$^{-1}$ (rights) are shaded. Anomalies are departures from the 1979-95 base period monthly means.
FIGURE E17. Southern Hemisphere percentage of days during MAY 2010 in which 500-hPa height anomalies greater than 15 m (red) and less than -15 m (blue) were observed. Values greater than 70% are shaded and contour interval is 20%.
FIGURE E18. Southern Hemisphere: Daily 500-hPa height anomalies for MAY 2010 averaged over the 5° latitude band centered on 40°S. Positive values are indicated by solid contours and dark shading. Negative values are indicated by dashed contours and light shading. Contour interval is 60 m. Anomalies are departures from the 1979-95 base period daily means.
FIGURE S1. Stratospheric height anomalies (m) at selected levels for MAY 2010. Positive values are indicated by solid contours and dark shading. Negative values are indicated by dashed contours and light shading. Contour interval is 60 m. Anomalies are calculated from the 1979–95 base period means. Winter Hemisphere is shown.
FIGURE S2. Height-longitude sections during MAY 2010 for height anomalies (contour) and temperature anomalies (shaded). In both panels, positive values are indicated by solid contours and dark shading, while negative anomalies are indicated by dashed contours and light shading. Contour interval for height anomalies is 60 m and for temperature anomalies is 2°C. Anomalies are calculated from the 1979–95 base period monthly means. Winter Hemisphere is shown.
FIGURE S4. Daily mean temperatures at 10-hPa and 2-hPa (thick line) in the region 65°–90°N and 65°–90°S for the past two years. Dashed line depicts the 1979–99 base period daily mean. Thin solid lines depict the daily extreme maximum and minimum temperatures.
FIGURE S5. Monthly ozone anomalies (percent) from the long term monthly means for five zones: 50N-30N (NH mid-latitudes), 25N-10N (NH tropical surf zone), 10N-10S (Equatorial-QBO zone), 10S-25S (SH tropical surf zone), and 30S-50S (SH mid-latitudes). The long term monthly means are determined from the entire data set beginning in 1979.
FIGURE S6. Northern (top) and Southern (bottom) Hemisphere total ozone anomaly (percent difference from monthly mean for the period 1979–86). The region near the winter pole has no SBUV/2 data.
FIGURE S7. Daily vertical component of EP flux (which is proportional to the poleward transport of heat or upward transport of potential energy by planetary wave) at 100 hPa averaged over (top) 30°N–90°N and (bottom) 30°S–90°S for MAY 2010. The EP flux unit (kg m⁻¹ s⁻²) has been scaled by multiplying a factor of the Brunt Vaisala frequency divided by the Coriolis parameter and the radius of the earth. The letter 'M' indicates the current monthly mean value and the letter 'C' indicates the climatological mean value. Additionally, the normalized departures from the monthly climatological EP flux values are shown.
FIGURE S8. Daily time series showing the size of the SH polar vortex (representing the area enclosed by the 32 PVU contour on the 450K isentropic surface), and the areal coverage of temperatures < -78°C on the 450K isentropic surface.
FIGURE A2.1. (a) Daily amplitudes of the Arctic Oscillation (AO) the North Atlantic Oscillation (NAO), and the Pacific-North American (PNA) pattern. The pattern amplitudes for the AO, (NAO, PNA) are calculated by projecting the daily 1000-hPa (500-hPa) height anomaly field onto the leading EOF obtained from standardized time-series of daily 1000-hPa (500-hPa) height for all months of the year. The base period is 1979–2000.

(b-d) Northern Hemisphere mean and anomalous 500-hPa geopotential height (CDAS/Reanalysis) for selected periods during MAY 2010 are shown in the remaining 3 panels. Mean heights are denoted by solid contours drawn at an interval of 8 dam. Dark (light) shading corresponds to anomalies greater than 50 m (less than -50 m). Anomalies are calculated as departures from the 1979–95 base period daily means.
FIGURE A2.2. SSM/I derived snow cover frequency (%) (left) and snow cover anomaly (%) (right) for the month of MAY 2010 based on 1987 - 2006 base period for the Northern Hemisphere (top) and Southern Hemisphere (bottom). It is generated using the algorithm described by Ferraro et. al, 1996, Bull. Amer. Meteor. Soc., vol 77, 891-905.