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Tropical Highlights - December 2007

A moderate-strength La Niña continued during December 2007. This is reflected by a continuation since October of below-average equatorial sea surface temperatures (SSTs) from west of the Date Line to the South American coast (Figs. T9, T18). The equatorial SSTs were more than 1.5°C below average east of 170°W during December (Figs. T9, T18), which is consistent with the negative values of the latest monthly Niño-3.4 index (-1.5°C) and the monthly Niño-1+2 index (-2.0°C) (Table T2). The sub-surface temperature departures remained negative across the eastern equatorial Pacific, where temperatures at thermocline depth ranged from -2°C to -4°C below average (Fig. T17).

During December 2007, strong low-level easterly anomalies (more than 3.0 m s⁻¹) spanned the western and central equatorial Pacific – in fact, the 850 mb wind index in the western Pacific (+3.7) is the largest value observed in the historical record back to 1979 (Fig. T20, Table T1). This pattern is consistent with a continued shallower-than-average thermocline in the central and eastern equatorial Pacific (Figs. T15, T16). These conditions were associated with enhanced convection (above-average rainfall amounts) across the eastern tropical Indian Ocean and Indonesia and a continuation of suppressed convection (below-average rainfall amounts) across the central and eastern equatorial Pacific (Figs. T25, T26, E3). Consistent with these anomalies, the Tahiti – Darwin SOI was +1.8 during December (Table T1, Fig. T1).

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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* Preliminary
** Revised

**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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* Preliminary
** Revised

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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Outgoing Longwave Radiation Anomaly (W/m²)

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FIGURE T16. Mean (top) and anomalous (bottom) depth of the 20°C isotherm for DEC 2007. Contour interval is 40 m (top) and 10 m (bottom). Dashed contours in bottom panel indicate negative anomalies. Data are derived from the NCEP’s global ocean data assimilation system version 2 which assimilates oceanic observations into an oceanic GCM (Xue, Y. and Behringer, D.W., 2006: Operational global ocean data assimilation system at NCEP, to be submitted to BAMS). Anomalies are departures from the 1982–2004 base period means.
FIGURE T17. Equatorial depth-longitude section of ocean temperature (top) and ocean temperature anomalies (bottom) for DEC 2007. Contour interval is 1°C. Dashed contours in bottom panel indicate negative anomalies. Data are derived from the NCEP’s global ocean data assimilation system version 2 which assimilates oceanic observations into an oceanic GCM (Xue, Y. and Behringer, D.W., 2006: Operational global ocean data assimilation system at NCEP, to be submitted to BAMS). Anomalies are departures from the 1982–2004 base period means.
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FIGURE T22. Mean (top) and anomalous (bottom) 200-hPa streamfunction (CDAS/Reanalysis). Contour interval is 20 x 10^6 m^2 s^{-1} (top) and 5 x 10^6 m^2 s^{-1} (bottom). Negative (positive) values are indicated by dashed (solid) lines. The non-divergent component of the flow is directed along the contours with speed proportional to the gradient. Thus, high (low) stream function corresponds to high (low) geopotential height in the Northern Hemisphere and to low (high) geopotential height in the Southern Hemisphere. Anomalies are departures from the 1979-1995 base period monthly means.
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FIGURE T26. Estimated total (top) and anomalous (bottom) rainfall (mm) based on the Special Sensor Microwave/Imager (SSM/I) precipitation index (Ferraro 1997, *J. Geophys. Res.*, **102**, 16715-16735). Anomalies are computed from the 1987-2006 base period monthly means. Anomalies have been smoothed for display purposes.
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.
FIGURE T30. Pressure-longitude section (80W-100E) of the mean (top) and anomalous (bottom) divergence (contour interval is $1 \times 10^{-6} \, \text{s}^{-1}$) 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 December 2007, 310 satellite-tracked surface drifting buoys, 80% with subsurface drogues attached for measuring mixed layer currents, were reporting from the tropical Pacific. Strong current anomalies were associated with well-developed instability waves, particularly at 5N, 130-140W. Elsewhere, currents exhibited uniformly westward anomalies (stronger NEC, SEC; weaker NECC). These anomalies were ~10 cm/s across the basin. Cold anomalies of -0.5 to -1.5 C were measured by most drifters east of 130W and south of the equator, a persistent anomaly for the last three months, with larger anomalies of -1.5C to -3.0C common east of 100W. Comparable cold anomalies were seen in the northern TIW train, associated with advection of upwelled equatorial water. Also seen since October, warm anomalies were common west of the dateline.

**Figure A1.1** Top: Movements of drifting buoys in the tropical Pacific Ocean during December 2007. 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 climatologic 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.

In December, negative east Pacific anomalies of SST and sea level continued to strengthen. SST anomalies have now reached between -2°C and -3°C and sea levels are now routinely lower than -10 cm. Sea levels at Callao have been punctuated by intraseasonal fluctuations of large amplitude over the last half year.

|          | Dec 4 | Baltra | Talara | Callao | Dec 9 | Baltra | Talara | Callao | Dec 14 | Baltra | Talara | Callao | Dec 19 | Baltra | Talara | Callao | Dec 24 | Baltra | Talara | Callao | Dec 29 | Baltra | Talara | Callao |
|----------|-------|--------|--------|--------|-------|--------|--------|--------|--------|-------|--------|--------|--------|--------|--------|--------|-------|--------|--------|-------|--------|--------|--------|-------|--------|--------|
| SST      |       |        |        |        |       |        |        |        |       |        |        |        |       |        |        |       |       |        |        |       |        |        |       |       |        |        |
| SLH      |       |        |        |        |       |        |        |        |       |        |        |        |       |       |        |        |       |        |        |       |       |        |        |       |        |        |       |       |        |        |
| Anomalies|       |        |        |        |       |        |        |        |       |        |        |        |       |       |        |        |       |        |        |       |       |        |        |       |        |        |       |       |        |        |

** - Data missing due to hardware failure
FIGURE A1.6.

FSU SURFACE PSEUDO-STRESS VECTORS AND ANOMALIES: December 2007. 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 10 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.

Outlook

La Niña is expected to continue into the Northern Hemisphere spring 2008.

Discussion

La Niña remained at moderate strength during December 2007, with below-average sea surface temperatures (SSTs) extending from 160ºE to the South American coast (Fig. T18). All of the Niño region indices remained cooler than “0.9°C (Table T2), with the Niño-3.4 and Niño-3 indices persisting near “1.5°C. The upper-ocean heat content (average temperatures in the upper 300 m of the ocean) in the central and east-central equatorial Pacific remained below average, with temperatures ranging from 2°C to 5°C below average at thermocline depth (Fig. T17). Consistent with these oceanic conditions, stronger-than-average low-level easterly winds and upper-level westerly winds continued across the central equatorial Pacific (Figs. T20 and T21), convection remained suppressed throughout the central equatorial Pacific, and slightly enhanced convection covered the far western Pacific (Fig. T25). Collectively,
these oceanic and atmospheric conditions reflect a mature La Niña.

The recent SST forecasts (dynamical and statistical models) for the Niño 3.4 region indicate a continuation of La Niña conditions into Northern Hemisphere spring 2008 (Figs. F1-F13). Over half of the models predict a moderate strength La Niña to continue through February-April, followed by weaker La Niña conditions. Current atmospheric and oceanic conditions and recent trends are consistent with a likely continuation of La Niña into the Northern Hemisphere spring 2008.

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 20°C 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 (CFSv3). 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 DEC 2007. 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 Meteorlogie.
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).
Extratropical Highlights – December 2007

1. Northern Hemisphere

The 500-hPa heights during December 2007 featured positive anomalies over the central and eastern North Pacific, the eastern US, and Scandinavia, and negative anomalies over western Canada and the high latitudes of the North Atlantic Ocean (Fig. E9). The anomaly pattern from the central extratropical Pacific Ocean to eastern North America is consistent with La Niña. At 200-hPa the subtropical circulation across Australasia and the Pacific Ocean was also consistent with La Niña, with anticyclonic streamfunction anomalies flanking the region of enhanced convection over Indonesia and cyclonic streamfunction anomalies flanking the region of suppressed convection over the central equatorial Pacific (Fig. T22).

The main surface temperature departures during December reflected warmer than average conditions in Alaska, the eastern US, Scandinavia, and much of northern Asia, and isolated areas of below-average temperatures over the western US and central Russia (Fig. E1). The main precipitation anomalies included above average totals across the northwestern and northeastern US, and below-average totals over large portions of Europe and western Russia (Fig. E3).

a. North Pacific/North America

The La Niña signal was prominent across the Pacific and North America during December. La Niña is associated with a westward retraction of deep tropical convection toward Indonesia and the eastern Indian Ocean, and a complete disappearance of tropical convection from the central equatorial Pacific (Fig. T25). These conditions result in a westward retraction of deep tropospheric heating, and hence a westward retraction of the subtropical ridge toward Indonesia (Fig. T22). Over the central equatorial Pacific, the reduction in convective heating contributes to an increased strength of the mid-Pacific trough.

The strength, structure, and position of the East Asian jet stream are strongly linked to conditions in the tropics and subtropics. For example, the jet core coincides with the strongest north-south height gradient at 200-hPa, which is heavily influenced by the height anomalies in the subtropics. The jet exit region coincides with the area of strong diffluence between the subtropical ridge and trough axes. Therefore, during La Nina the core of the East Asian jet stream is often retracted well westward toward Asia, as was seen during December (Fig. T21) and the heart of the jet exit region is shifted westward to well west of the date line.

The downstream circulation features are retracted westward as well. This includes a shift of the mean ridge from western North America to the central/eastern North Pacific, and a shift of the mean Hudson Bay trough to central or even western North America (Fig. E9). During December, these conditions were associated with above-average precipitation over much of the northern tier of the US (Fig. E6), and above-average temperatures in the southeast (Fig. E1).

b. North Atlantic and Europe

The circulation during December featured a north-south dipole pattern of 500-hPa height anomalies over the North Atlantic Ocean, with below-average heights centered over Greenland and above-average
heights extending across the middle latitudes (Fig. E9). A strong blocking ridge was also evident over Scandinavia. This pattern was associated with a northward shift of the East Atlantic jet entrance region over eastern North America, which contributed to the above average temperatures in that region. It was also associated with a split-flow pattern over the eastern North Atlantic, with the northern branch of the jet stream affecting Scandinavia, and the southern branch affecting central and southern Europe.

The enhanced poleward heat transport associated with the northern branch of the jet stream led to well above-average temperatures over Scandinavia and western Russia (Fig. E1). In western Europe, areas of below-average precipitation generally resulted from a northward shift in the mean storm track, and from strong anticyclonic curvature within the southern branch of the flow. In eastern Europe and western Russia, well below-average precipitation resulted from anomalous upper-level convergence and descending motion downstream of the blocking ridge.

2. Southern Hemisphere

The 500-hPa height field during December featured negative anomalies centered over Antarctica and positive anomalies spanning the middle latitudes (Fig. E15). In the subtropics, the pattern of negative (anticyclonic) 200-hPa streamfunction anomalies over the central Indian Ocean and positive (cyclonic) streamfunction anomalies over the central Pacific was consistent with La Niña.

The South African rainy season extends from October to April, and is often stronger than average during La Niña. During December, well above-average totals covered much of the monsoon region (Fig. E3), and departures in many areas exceeded the 90th percentile of occurrences. Area-averaged totals for the entire monsoon region were the largest since 1979, and were above average for the third straight month (Fig. E4).
### 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); Scandinavian 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.

<table>
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<th>MONTH</th>
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<th>EA</th>
<th>WP</th>
<th>EP-NP</th>
<th>PNA</th>
<th>TNH</th>
<th>EATL/WRUS</th>
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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 DEC 2007. 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 DEC 2007. 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, -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 DEC 2007. 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.
FIGURE E8. Northern Hemisphere mean and anomalous sea level pressure (CDAS/Reanalysis) for DEC 2007. 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 DEC 2007. Mean heights are denoted by solid contours drawn at an interval of 8 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 DEC 2007. 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 DEC 2007 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 DEC 2007 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: 700-hPa heights for DEC 2007 overlaid with standard deviation of high-pass filtered height (left) and normalized anomalous variance of high-pass filtered height (right). Heights are indicated by thick solid contours in both panels (interval is 60 m). High-pass filtered fields reflect fluctuations having periods less than 10 days, and are indicated by thin contours and shading. Contour interval for standard deviation is 15 m with values > 45 m shaded. Contour interval for normalized variance is 1 standard deviation, with positive values shown by solid contours and dark shading and negative values shown by dashed contours and light shading. Anomalies are departures from the 1964-93 base period monthly means.
FIGURE E14. Southern Hemisphere mean and anomalous sea level pressure (CDAS/Reanalysis) for DEC 2007. 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 DEC 2007. Mean heights are denoted by solid contours drawn at an interval of 8 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 DEC 2007. 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 DEC 2007 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 DEC 2007 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 DEC 2007. 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 DEC 2007 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. Bar graph of total ozone monthly mean percent anomaly (difference of each monthly value from the average for that month for the entire record since 1979), for latitude zones 50°N-30°N, 30°N-30°S, 30°S-50°S.
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 DEC 2007. 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 NH polar vortex (representing the area enclosed by the 32 PVU contour on the 450K isentropic surface), and the areal coverage of temperatures < -78C 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 DEC 2007 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 DEC 2007 based on 1987–2006 baseline 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.