Chief Editor: Gerald D. Bell
Editors: Wei Shi, Michelle L’Heureux, and Michael Halpert
Bulletin Production: Wei Shi

External Collaborators:
- Center for Ocean-Atmospheric Prediction Studies (COAPS)
- Cooperative Institute for Research in the Atmosphere (CIRA)
- Earth & Space Research
- International Research Institute for Climate and Society (IRI)
- Joint Institute for the Study of the Atmosphere and Ocean (JISAO)
- Lamont-Doherty Earth Observatory (LDEO)
- NOAA-CIRES, Climate Diagnostics Center
- NOAA-AOML, Atlantic Oceanographic and Meteorological Laboratory
- NOAA-NESDIS-STAR, Center for Satellite Applications and Research
- NOAA-NDBC, National Data Buoy Center
- Scripps Institution of Oceanography

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:

http://www.cpc.ncep.noaa.gov/products/CDB

If you have any problems accessing the bulletin, contact Dr. Wei Shi by E-mail:

Wei.Shi@noaa.gov
Table of Contents

TROPICS

Highlights .............. page 6
Table of Atmospheric Indices ........... page 7
Table of Oceanic Indices ............ page 8

FIGURE

Time Series
Southern Oscillation Index (SOI) T1
Tahiti and Darwin SLP Anomalies T1
OLR Anomalies T1
CDAS/Reanalysis SOI & Equatorial SOI T2
200-hPa Zonal Wind Anomalies T3
500-hPa Temperature Anomalies T3
30-hPa and 50-hPa Zonal Wind Anomalies T3
850-hPa Zonal Wind Anomalies T4
Equatorial Pacific SST Anomalies T5

Time-Longitude Sections
Mean and Anomalous Sea Level Pressure T6
Mean and Anomalous 850-hPa Zonal Wind T7
Mean and Anomalous OLR T8
Mean and Anomalous SST T9
Pentad SLP Anomalies T10
Pentad OLR Anomalies T11
Pentad 200-hPa Velocity Potential Anomalies T12
Pentad 850-hPa Zonal Wind Anomalies T13
Anomalous Equatorial Zonal Wind T14
Mean and Anomalous Depth of the 20°C Isotherm T15

Mean & Anomaly Fields
Depth of the 20°C Isotherm T16
Subsurface Equatorial Pacific Temperatures T17
SST T18
SLP T19
850-hPa Vector Wind T20
200-hPa Vector Wind T21
200-hPa Streamfunction T22
200-hPa Divergence T23
200-hPa Velocity Potential and Divergent Wind T24
OLR T25
SSM/I Tropical Precipitation Estimates T26
Cloud Liquid Water T27
Precipitable Water T28
Divergence & E-W Divergent Circulation T29 - T30
Pacific Zonal Wind & N-S Divergent Circulation T31 - T32

Appendix 1: Outside Contributions
Tropical Drifting Buoys A1.1
FIGURE

Pacific Wind Stress and Anomalies A1.2
Satellite-Derived Surface Currents A1.3 - A1.4

FORECAST FORUM
Discussion ........ page 49
Canonical Correlation Analysis Forecasts F1 - F2
NCEP Coupled Model Forecasts F3 - F4
NCEP Markov Model Forecasts F5 - F6
LDEO Model Forecasts F7 - F8
Linear Inverse Modeling Forecasts F9 - F10
ENSO-CLIPER Model Forecast F11
Model Forecasts of Niño 3.4 F12

EXTRATROPICS
Highlights ........ page 64
Table of Teleconnection Indices ........ page 66
Global Surface Temperature E1
Temperature Anomalies (Land Only) E2
Global Precipitation E3
Regional Precipitation Estimates E4 - E5
U. S. Precipitation E6
Northern Hemisphere
Teleconnection Indices E7
Mean and Anomalous SLP E8
Mean and Anomalous 500-hPa heights E9
Mean and Anomalous 300-hPa Wind Vectors E10
500-hPa Persistence E11
Time-Longitude Sections of 500-hPa Height Anomalies E12
700-hPa Storm Track E13
Southern Hemisphere
Mean and Anomalous SLP E14
Mean and Anomalous 500-hPa heights E15
Mean and Anomalous 300-hPa Wind Vectors E16
500-hPa Persistence E17
Time-Longitude Sections of 500-hPa Height Anomalies E18
Stratosphere
Height Anomalies S1 - S2
Temperatures S3 - S4
Ozone S5 - S6
Vertical Component of EP Flux S7
Ozone Hole S8
Appendix 2: Additional Figures
Arctic Oscillation and 500-hPa Anomalies A2.1
Snow Cover A2.2
Tropical Highlights - January 2019

Sea surface temperatures (SSTs) remained above-average across the equatorial Pacific during January 2019 (Fig. T18, Table T2). The latest monthly Niño indices were +0.5°C for the Niño 1+2 region, +0.5°C for the Niño 3.4 region and +0.7°C for the Niño 4 region (Table T2, Fig. T5). The depth of the oceanic thermocline (measured by the depth of the 20°C isotherm) was above-average across the central and much of the eastern equatorial Pacific (Figs. T15, T16), and the corresponding sub-surface temperatures were 1-3°C above average (Fig. T17).

Also during January, the lower-level easterly winds were weaker-than-average (indicated by westerly anomalies) across the equatorial Pacific (Table T1, Fig. T20), while the upper-level westerly winds anomalies were above-average over the eastern equatorial Pacific (Fig. T21). Meanwhile, tropical convection was near-average over Indonesia and enhanced over the central equatorial Pacific (Figs. T25, E3). Collectively, these oceanic and atmospheric anomalies reflect a transition to weak El Niño conditions.

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
<table>
<thead>
<tr>
<th>Month</th>
<th>SLP Anomalies</th>
<th>Tahiti minus Darwin SOI</th>
<th>850-hPa Zonal Wind Index</th>
<th>200-hPa Wind Index</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Tahiti</td>
<td>Darwin S0I</td>
<td>5N-5S</td>
<td>5N-5S</td>
</tr>
<tr>
<td></td>
<td>5N-135S</td>
<td>135E-180</td>
<td>135W-120W</td>
<td>160E-160W</td>
</tr>
<tr>
<td></td>
<td>5N-135S</td>
<td>135E-180</td>
<td>135W-120W</td>
<td>160E-160W</td>
</tr>
<tr>
<td></td>
<td>OL R Index</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jan 19</td>
<td>0.1</td>
<td>0.0</td>
<td>-1.0</td>
<td>-0.4</td>
</tr>
<tr>
<td>Dec 18</td>
<td>0.7</td>
<td>0.2</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Nov 18</td>
<td>0.4</td>
<td>-0.2</td>
<td>-0.2</td>
<td>-0.2</td>
</tr>
<tr>
<td>Oct 18</td>
<td>0.9</td>
<td>0.2</td>
<td>0.4</td>
<td>0.4</td>
</tr>
<tr>
<td>Sep 18</td>
<td>-1.6</td>
<td>-0.9</td>
<td>-1.1</td>
<td>-0.7</td>
</tr>
<tr>
<td>Aug 18</td>
<td>-0.9</td>
<td>-0.3</td>
<td>-0.4</td>
<td>-0.6</td>
</tr>
<tr>
<td>Jul 18</td>
<td>0.5</td>
<td>-0.9</td>
<td>-0.1</td>
<td>-0.9</td>
</tr>
<tr>
<td>Jun 18</td>
<td>-0.2</td>
<td>0.2</td>
<td>0.4</td>
<td>0.1</td>
</tr>
<tr>
<td>May 18</td>
<td>1.4</td>
<td>0.4</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>Apr 18</td>
<td>0.6</td>
<td>0.4</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>Mar 18</td>
<td>0.4</td>
<td>-0.4</td>
<td>-0.3</td>
<td>-0.3</td>
</tr>
<tr>
<td>Feb 18</td>
<td>-0.8</td>
<td>-0.5</td>
<td>-1.2</td>
<td>-0.3</td>
</tr>
<tr>
<td>Jan 18</td>
<td>0.1</td>
<td>0.1</td>
<td>0.8</td>
<td>0.1</td>
</tr>
</tbody>
</table>

TABLE 7.1 - 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. Anomalies are departures from the 1981-2010 base period means.
<table>
<thead>
<tr>
<th>Month</th>
<th>PACIFIC SST</th>
<th>ATLANICT SST</th>
<th>GLOBAL</th>
</tr>
</thead>
<tbody>
<tr>
<td>JAN 19</td>
<td>0.5 25.1</td>
<td>0.5 26.2</td>
<td>0.5 27.1</td>
</tr>
<tr>
<td>DEC 18</td>
<td>0.8 23.6</td>
<td>1.0 26.1</td>
<td>1.0 27.5</td>
</tr>
<tr>
<td>NOV 18</td>
<td>0.7 22.8</td>
<td>1.0 26.0</td>
<td>1.0 27.6</td>
</tr>
<tr>
<td>OCT 18</td>
<td>0.4 21.2</td>
<td>0.9 25.8</td>
<td>0.9 27.6</td>
</tr>
<tr>
<td>SEP 18</td>
<td>-0.1 20.3</td>
<td>0.3 25.2</td>
<td>0.3 27.1</td>
</tr>
<tr>
<td>AUG 18</td>
<td>0.1 20.7</td>
<td>0.2 25.2</td>
<td>0.3 27.1</td>
</tr>
<tr>
<td>JUL 18</td>
<td>-0.2 21.4</td>
<td>0.4 26.1</td>
<td>0.3 27.5</td>
</tr>
<tr>
<td>JUN 18</td>
<td>-0.6 22.2</td>
<td>0.3 26.7</td>
<td>0.2 27.9</td>
</tr>
<tr>
<td>MAY 18</td>
<td>-0.5 23.7</td>
<td>-0.2 26.9</td>
<td>-0.1 27.7</td>
</tr>
<tr>
<td>APR 18</td>
<td>-1.0 24.6</td>
<td>-0.4 27.1</td>
<td>-0.4 27.4</td>
</tr>
<tr>
<td>MAR 18</td>
<td>-0.8 25.8</td>
<td>-0.8 26.4</td>
<td>-0.7 26.5</td>
</tr>
<tr>
<td>FEB 18</td>
<td>-0.6 25.6</td>
<td>-1.0 25.4</td>
<td>-0.9 25.8</td>
</tr>
<tr>
<td>JAN 18</td>
<td>-0.8 23.7</td>
<td>-1.1 24.5</td>
<td>-0.8 25.8</td>
</tr>
</tbody>
</table>

TABLE T2. Mean and anomalous sea surface temperature (°C) for the most recent 12 months. Anomalies are departures from the 1981–2010 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 5S-5N, 160E-160W (bottom). Anomalies in the top and middle panels are departures from the 1981-2010 base period means and are normalized by the mean annual standard deviation. Anomalies in the bottom panel are departures from the 1981-2010 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.
FIGURE 12. Three-month running mean of a CDAS/Reanalysis-derived (a) Southern Oscillation Index (RSOI), (b) standardized pressure anomalies near Tahiti (solid) and Darwin (dashed), (c) an equatorial SOI ([EPAC] - [INDO]), and (d) standardized equatorial pressure anomalies for (EPAC) (solid) and (INDO) (dashed). Anomalies are departures from the 1981-2010 base period means and are normalized by the mean annual standard deviation. The equatorial SOI is calculated as the normalized difference between the standardized anomalies averaged between 5°N–5°S, 80°W–130°W (EPAC) and 5°N–5°S, 90°E–140°E (INDO).
FIGURE T3. Five-month running mean (solid lines) and individual monthly mean (dots) of the 200-hPa zonal wind anomalies averaged over the area 5N-5S, 165W-110W (top), the 500-hPa virtual temperature anomalies averaged over the latitude band 20N-20S (middle), and the equatorial zonally-averaged zonal wind anomalies at 30-hPa (red) and 50-hPa (blue) (bottom). In the top panel, anomalies are normalized by the mean annual standard deviation. Anomalies are departures from the 1981-2010 base period means. The x-axis labels are centered on January.
FIGURE T4. Five-month running mean (solid line) and individual monthly mean (dots) of the standardized 850-hPa zonal wind anomaly index in the latitude belt 5N-5S for 135E-180 (top), 175W-140W (middle) and 135W-120W (bottom). Anomalies are departures from the 1981-2010 base period means and are normalized by the mean annual standard deviation. The x-axis labels are centered on January. Positive (negative) values indicate easterly (westerly) anomalies.
FIGURE T5. Nino region indices, calculated as the area-averaged sea surface temperature anomalies (C) for the specified region. The Nino 1+2 region (top) covers the extreme eastern equatorial Pacific between 0-10S, 90W-80W. The Nino-3 region (2nd from top) spans the eastern equatorial Pacific between 5N-5S, 150W-90W. The Nino 3.4 region (3rd from top) spans the east-central equatorial Pacific between 5N-5S, 170W-120W. The Nino 4 region (bottom) spans the date line and covers the area 5N-5S, 160E-150W. Anomalies are departures from the 1981-2010 base period monthly means (Smith and Reynolds 1998, J. Climate, 11, 3320-3323). Monthly values of each index are also displayed in Table 2.
FIGURE T6. Time-longitude section of mean (top) and anomalous (bottom) sea level pressure (SLP) averaged between 5N-5S (CDAS/Reanalysis). Contour interval is 1.0 hPa (top) and 0.5 hPa (bottom). Dashed contours in bottom panel indicate negative anomalies. Anomalies are departures from the 1981-2010 base period monthly means. The data are smoothed temporally using a 3-month running average.
FIGURE T7. Time-longitude section of mean (top) and anomalous (bottom) 850-hPa zonal wind averaged between 5N-5S (CDAS/Reanalysis). Contour interval is 2 ms$.^1$. Blue shading and dashed contours indicate easterlies (top) and easterly anomalies (bottom). Anomalies are departures from the 1981-2010 base period monthly means. The data are smoothed temporally using a 3-month running average.
FIGURE T8. Time-longitude section of mean (top) and anomalous (bottom) outgoing longwave radiation (OLR) averaged between 5N-5S. Contour interval is 10 Wm$^{-2}$. Dashed contours in bottom panel indicate negative OLR anomalies. Anomalies are departures from the 1981-2010 base period monthly means. The data are smoothed temporally using a 3-month running average.
FIGURE T9. Time-longitude section of monthly mean (top) and anomalous (bottom) sea surface temperature (SST) averaged between 5N-5S. Contour interval is 1°C (top) and 0.5°C (bottom). Dashed contours in bottom panel indicate negative anomalies. Anomalies are departures from the 1981-2010 base period means (Smith and Reynolds 1998, *J. Climate*, 11, 3320-3323).
FIGURE T10. Time-longitude section of anomalous sea level pressure (hPa) averaged between 5N-5S (CDAS/Re-analysis). Contour interval is 1 hPa. Dashed contours indicate negative anomalies. Anomalies are departures from the 1981-2010 base period pentad means. The data are smoothed temporally using a 3-point running average.
FIGURE T11. Time-longitude section of anomalous outgoing longwave radiation averaged between 5N-5S. Contour interval is 15 Wm$^{-2}$. Dashed contours indicate negative anomalies. Anomalies are departures from the 1981-2010 base period pentad means. The data are smoothed temporally using a 3-point running average.
FIGURE T12. Time-longitude section of anomalous 200-hPa velocity potential averaged between 5N-5S (CDAS/Re-analysis). Contour interval is $3 \times 10^6$ m$^2$s$^{-1}$. Dashed contours indicate negative anomalies. Anomalies are departures from the 1981-2010 base period pentad means. The data are smoothed temporally using a 3-point running average.
FIGURE T13. Time-longitude section of anomalous 850-hPa zonal wind averaged between 5N-5S (CDAS/Reanalysis). Contour interval is 2 ms\(^{-1}\). Dashed contours indicate negative anomalies. Anomalies are departures from the 1981-2010 base period pentad means. The data are smoothed temporally by using a 3-point running average.
FIGURE T14. Equatorial time-height section of anomalous zonally-averaged zonal wind (m s⁻¹) (CDAS/Reanalysis). Contour interval is 10 ms⁻¹. Anomalies are departures from the 1981-2010 base period monthly means.
FIGURE T15. Mean (top) and anomalous (bottom) depth of the 20C isotherm averaged between 5N-5S in the Pacific Ocean. Data are derived from the NCEP’s global ocean data assimilation system which assimilates oceanic observations into an oceanic GCM (Behringer, D. W., and Y. Xue, 2004: Evaluation of the global ocean data assimilation system at NCEP: The Pacific Ocean. AMS 84th Annual Meeting, Seattle, Washington, 11-15). The contour interval is 10 m. Dashed contours in bottom panel indicate negative anomalies. Anomalies are departures from the 1981-2010 base period means.
FIGURE T16. Mean (top) and anomalous (bottom) depth of the 20°C isotherm for JAN 2019. 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 1981–2010 base period means.
FIGURE T17. Equatorial depth-longitude section of ocean temperature (top) and ocean temperature anomalies (bottom) for JAN 2019. 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 1981–2010 base period means.
FIGURE T18. Mean (top) and anomalous (bottom) sea surface temperature (SST). Anomalies are departures from the 1981-2010 base period monthly means (Smith and Reynolds 1998, J. Climate, 11, 3320-3323).
FIGURE T19. Mean (top) and anomalous (bottom) sea level pressure (SLP) (CDAS/Reanalysis). In top panel, 1000 hPa has been subtracted from contour labels, contour interval is 2 hPa, and values below 1000 hPa are indicated by dashed contours. In bottom panel, anomaly contour interval is 1 hPa and negative anomalies are indicated by dashed contours. Anomalies are departures from the 1981-2010 base period monthly means.
FIGURE T20. Mean (top) and anomalous (bottom) 850-hPa vector wind (CDAS/Reanalysis) for JAN 2019. Contour interval for isotachs is 4 ms$^{-1}$ (top) and 2 ms$^{-1}$ (bottom). Anomalies are departures from the 1981-2010 base period monthly means.
FIGURE T21. Mean (top) and anomalous (bottom) 200-hPa vector wind (CDAS/Reanalysis) for JAN 2019. Contour interval for isotachs is 15 ms\(^{-1}\) (top) and 5 ms\(^{-1}\) (bottom). Anomalies are departures from 1981-2010 base period monthly means.
FIGURE T22. Mean (top) and anomalous (bottom) 200-hPa streamfunction (CDAS/Reanalysis). Contour interval is $20 \times 10^6 \text{ m}^2\text{s}^{-1}$ (top) and $5 \times 10^6 \text{ m}^2\text{s}^{-1}$ (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 1981-2010 base period monthly means.
FIGURE T23. Mean (top) and anomalous (bottom) 200-hPa divergence (CDAS/Reanalysis). Divergence and anomalous divergence are shaded blue. Convergence and anomalous convergence are shaded orange. Anomalies are departures from the 1981-2010 base period monthly means.
FIGURE T24. Mean (top) and anomalous (bottom) 200-hPa velocity potential (10^6 m^2 s^-1) and divergent wind (CDAS/Reanalysis). Anomalies are departures from the 1981-2010 base period monthly means.
FIGURE T25. Mean (top) and anomalous (bottom) outgoing longwave radiation for JAN 2019 (NOAA 18 AVHRR IR window channel measurements by NESDIS/ORA). OLR contour interval is 20 Wm\(^{-2}\) with values greater than 280 Wm\(^{-2}\) indicated by dashed contours. Anomaly contour interval is 15 Wm\(^{-2}\) with positive values indicated by dashed contours and light shading. Anomalies are departures from the 1981-2010 base period monthly means.
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 SSM/I 1987-2010 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 1987-2010 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 1987-2010 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 1981-2010 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 1981-2010 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 1981-2010 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 1981-2010 base period monthly means.
Tropical Pacific Drifting Buoys  R. Lumpkin/M. Pazos, AOML, Miami

During January 2019, 261 satellite-tracked surface drifting buoys were reporting from the tropical Pacific. Several drifters indicated very strong (~50 cm/s) eastward anomalies near the equator at 160E-180. Elsewhere, the drifter array indicated that large-scale currents were close to their climatological January strengths across the basin.

Figure A1.1 Top: Movements of drifting buoys in the tropical Pacific Ocean during January 2019. 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.
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: El Niño Advisory

Outlook

Weak El Niño conditions are present and are expected to continue through the Northern Hemisphere spring 2019 (~55% chance).

Discussion

El Niño conditions formed during January 2019, based on the presence of above-average sea surface temperatures (SSTs) across most of the equatorial Pacific Ocean (Fig. T18) and corresponding changes in the overlying atmospheric circulation. The monthly Niño indices remained above average, although decreasing in all regions relative to January (Table T2). The Niño-4 region was the warmest, with a value of +0.7°C for January. Positive subsurface temperature anomalies (averaged across 180°-100°W) increased in the last couple weeks, in association with a downwelling Kelvin wave that contributed to above-average temperatures in the central Pacific (Fig. T17). Compared to last month, the region of enhanced equatorial convection expanded near the Date Line, while anomalies remained weak over Indonesia (Fig. T25). Low-level wind anomalies became westerly across the western Pacific Ocean, while upper-level wind anomalies were mostly westerly over the eastern Pacific (Figs. T20 and T21). The equatorial Southern Oscillation index was negative (-0.6
standard deviations; Fig. T2). Overall, these features are consistent with borderline, weak El Niño conditions.

The majority of models in the IRI/CPC plume predict a Niño 3.4 index of +0.5°C or greater through at least the Northern Hemisphere spring 2019 (Figs. F1-F13). Given the recent downwelling Kelvin wave and the forecast of westerly wind anomalies, most forecasters expect SST anomalies in the east-central Pacific to increase slightly in the upcoming month or so. Because forecasts through the spring tend to be more uncertain and/or less accurate, the predicted chance that El Niño will persist beyond the spring is 50% or less. In summary, weak El Niño conditions are present and are expected to continue through the Northern Hemisphere spring 2019 (~55% chance).

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 JAN 2019. 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) QuickSCAT, (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 1981-2010 climatology and are projected onto 20 leading EOFs.
FIGURE F10. Predictions of Niño 3.4 SSTA (blue solid line) and verification (solid red line). The Niño 3.4 Index was calculated in the area 6N-6S, 170W-120W. The 1980-2010 climatology was subtracted from ERSST data between 1950 and 2010, after which they were projected onto 20 EOFs containing 90% of the variance. Significant 1950-2010 trends were subtracted from the corresponding PCs, the forecast was made on the detrended anomalies, after which the trend was added to the forecast. The dotted lines indicate the one standard deviation confidence interval for the forecasts based on a perfect adherence to assumption.
FIGURE F11. 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 1981-2010 base period means, and the SOI is calculated from the 1951-1980 base period means.
FIGURE F12. 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 – January 2019

1. Northern Hemisphere

The 500-hPa circulation during January featured above-average heights over western Canada, the high latitudes of the North Atlantic, and eastern Asia, and below-average heights over the western North Pacific and much of Europe (Fig. E9). At 200-hPa, the circulation featured anticyclonic streamfunction anomalies over the central subtropical North and South Pacific, in association with an eastward extension of the mean subtropical ridge in both hemispheres (Fig. T22). This pattern is consistent with an anomalous eastward extension of deep tropical convection to the International Date Line (Fig. T25).

The main land-surface temperature signals during January included above-average temperatures across most of Alaska, western Canada, the western U.S., and eastern Asia (Fig. E1). The main precipitation signals included above-average totals in the central and northeastern U.S., the mountainous western U.S., and eastern Europe, and below-average totals in Great Britain (Fig. E3).

a. North Pacific and America

The 500-hPa circulation during January featured above-average heights over western Canada (Fig. E9), which contributed to above-average surface temperatures across southern Alaska and western Canada (Fig. E1). At 200-hPa, anticyclonic streamfunction anomalies were present over the central subtropical North Pacific, in association with an eastward extension of the mean subtropical ridge (Fig. T22). This pattern was accompanied by an eastward extension of the East Asian jet stream and its jet exit region to well east of the date line (Fig. T21). These conditions contributed to increased storminess and above-average precipitation in portions of the mountainous West (Fig. E3).

According to the U.S. Drought Monitor, severe-to-exceptional drought continued in the four-corner states of Utah, Colorado, Arizona, and New Mexico. Farther north in Oregon, severe or extreme drought persisted across the central part of the state.

b. North Atlantic and Eurasia

The 500-hPa height pattern featured above-average heights over the high latitudes of the North Atlantic, and below-average heights over central and eastern Europe (Fig. E9). This pattern resulted in anomalous northerly flow and near-average surface temperatures throughout Europe (Fig. E1), and follows several months of above-average temperatures in that region. It also contributed to exceptionally dry conditions in Great Britain, and to above-average precipitation in eastern Europe (Fig. E3). These regions were situated downstream of the mean ridge and trough axes, respectively.

In eastern Asia, above-average heights at 500-hPa were accompanied by a more zonal wind pattern across central Russia (Fig. T21). These conditions contributed to well above-average surface
temperatures in eastern Asia, where departures of +3°C to +5°C were generally in the upper 70th or 90th percentile of occurrences (Fig. E1).

2. Southern Hemisphere

The mean 500-hPa circulation during January featured above-average heights over southeastern Australia, the high latitudes of the eastern South Pacific, and both the central South Atlantic and Indian Oceans (Fig. E15). Below-average heights were observed over the high latitudes of the western South Pacific and also over the high latitudes of the western South Atlantic. At 200-hPa, anticyclonic streamfunction anomalies over the central subtropical South Pacific were associated with an eastward extension of the mean subtropical ridge (Fig. T22). This pattern is consistent with an anomalous eastward extension of deep tropical convection to the International Date Line (Fig. T25).

In Australia, the amplified ridge in the southeast contributed to well above-average surface temperatures in the south-central and southeastern parts of the continent (Fig. E1), with many regions recording departures in the upper 90th percentile of occurrences. Much of the continent also recorded below-average precipitation during January (Fig. E3).

The South African monsoon season runs from October to April. During January, rainfall was below average in the western portion of the monsoon region, and above average in the eastern portion (Fig. E3). For the monsoon region as a whole, area-average totals in January were slightly above average (Fig. E4). This represents somewhat of an improvement in the monsoon rains from the past three months (October-January), when area-averaged totals were in the lowest 20th percentile of occurrences.
# TELECONNECTION INDICES

<table>
<thead>
<tr>
<th>Month</th>
<th>North Atlantic</th>
<th></th>
<th>North Pacific</th>
<th></th>
<th>EURASIA</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>NAO</td>
<td>EA</td>
<td>WP</td>
<td>EP-NP</td>
<td>PNA</td>
<td>TNH</td>
</tr>
<tr>
<td>JAN 19</td>
<td>0.2</td>
<td>-1.7</td>
<td>1.0</td>
<td>1.1</td>
<td>0.4</td>
<td>0.3</td>
</tr>
<tr>
<td>DEC 18</td>
<td>0.5</td>
<td>1.4</td>
<td>0.1</td>
<td>---</td>
<td>0.6</td>
<td>-0.6</td>
</tr>
<tr>
<td>NOV 18</td>
<td>-0.3</td>
<td>0.3</td>
<td>-0.6</td>
<td>1.4</td>
<td>0.2</td>
<td>---</td>
</tr>
<tr>
<td>OCT 18</td>
<td>1.5</td>
<td>-0.4</td>
<td>-1.1</td>
<td>1.2</td>
<td>0.4</td>
<td>---</td>
</tr>
<tr>
<td>SEP 18</td>
<td>1.8</td>
<td>0.1</td>
<td>-1.8</td>
<td>-0.8</td>
<td>1.2</td>
<td>---</td>
</tr>
<tr>
<td>AUG 18</td>
<td>2.4</td>
<td>1.8</td>
<td>-1.4</td>
<td>-0.8</td>
<td>1.2</td>
<td>---</td>
</tr>
<tr>
<td>JUL 18</td>
<td>1.4</td>
<td>2.4</td>
<td>-0.8</td>
<td>-0.2</td>
<td>-0.8</td>
<td>---</td>
</tr>
<tr>
<td>JUN 18</td>
<td>1.4</td>
<td>-0.5</td>
<td>-0.4</td>
<td>0.1</td>
<td>0.7</td>
<td>---</td>
</tr>
<tr>
<td>MAY 18</td>
<td>2.0</td>
<td>-0.1</td>
<td>-0.2</td>
<td>-1.0</td>
<td>-1.1</td>
<td>---</td>
</tr>
<tr>
<td>APR 18</td>
<td>1.2</td>
<td>1.1</td>
<td>-0.7</td>
<td>-0.2</td>
<td>-1.1</td>
<td>---</td>
</tr>
<tr>
<td>MAR 18</td>
<td>-1.4</td>
<td>-0.6</td>
<td>0.8</td>
<td>0.3</td>
<td>-1.2</td>
<td>---</td>
</tr>
<tr>
<td>FEB 18</td>
<td>1.3</td>
<td>-1.4</td>
<td>0.4</td>
<td>0.2</td>
<td>-1.7</td>
<td>2.2</td>
</tr>
<tr>
<td>JAN 18</td>
<td>1.2</td>
<td>0.5</td>
<td>0.4</td>
<td>0.7</td>
<td>-0.1</td>
<td>-0.3</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); Scandinavia 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 1981–2010 base period data (bottom) for JAN 2019. Analysis is based on station data over land and on SST data over the oceans (top). Anomalies for station data are departures from the 1981–2010 base period means, while SST anomalies are departures from the 1981–2010 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 1981–2010 base period means.
FIGURE E3. Anomalous precipitation (mm, top) and precipitation percentiles based on a Gamma distribution fit to the 1981–2010 base period data (bottom) for JAN 2019. 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 1981–2010 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 1981–2010 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 JAN 2019. The units are given on each panel. Base period for averages is 1981–2010. 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 the 1981-2010 base period. 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 JAN 2019. 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 1981-2010 base period monthly means.
FIGURE E9. Northern Hemisphere mean and anomalous 500-hPa geopotential height (CDAS/Reanalysis) for JAN 2019. 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 1981-2010 base period monthly means.
FIGURE E10. Northern Hemisphere mean (left) and anomalous (right) 300-hPa vector wind (CDAS/Reanalysis) for JAN 2019. Mean (anomaly) isotach contour interval is 10 (5) m s⁻¹. Values greater than 30 m s⁻¹ (left) and 10 m s⁻¹ (right) are shaded. Anomalies are departures from the 1981-2010 base period monthly means.
FIGURE E11. Northern Hemisphere percentage of days during JAN 2019 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 in-
FIGURE E12. Northern Hemisphere: Daily 500-hPa height anomalies for JAN 2019 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 1981-2010 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 1981-2010 daily means.
FIGURE E14. Southern Hemisphere mean and anomalous sea level pressure (CDAS/Reanalysis) for JAN 2019. 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 1981-2010 base period monthly means.
FIGURE E15. Southern Hemisphere mean and anomalous 500-hPa geopotential height (CDAS/Reanalysis) for JAN 2019. 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 1981-2010 base period monthly means.
FIGURE E16. Southern Hemisphere mean (left) and anomalous (right) 300-hPa vector wind (CDAS/Reanalysis) for JAN 2019. 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 1981-2010 base period monthly means.
FIGURE E17. Southern Hemisphere percentage of days during JAN 2019 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 in-
FIGURE E18. Southern Hemisphere: Daily 500-hPa height anomalies for JAN 2019 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 1981-2010 base period daily means.
FIGURE S1. Stratospheric height anomalies (m) at selected levels for JAN 2019. 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 1981-2010 base period means. Winter Hemisphere is shown.
FIGURE S2. Height-longitude sections during JAN 2019 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 1981-2010 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 1981-2010 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.
FIGURE S6. Northern (top) and Southern (bottom) Hemisphere total ozone anomaly (percent difference from monthly mean for the period 1979-1986). 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 JAN 2019. 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 1981–2010.

(b-d) Northern Hemisphere mean and anomalous 500-hPa geopotential height (CDAS/Reanalysis) for selected periods during JAN 2019 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 1981-2010 base period daily means.
FIGURE A2.2. SSM/I derived snow cover frequency (%) (left) and snow cover anomaly (%) (right) for the month of JAN 2019 based on 1987 - 2010 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.