Corresponding Editor:

Stephanie C. Herring, PhD
NOAA National Climatic Data Center
325 Broadway, E/CC23, Rm 1B-131
Boulder, CO, 80305-3328
E-mail: stephanie.herring@noaa.gov

Cover credits:

Front: The final wave of rain storms make their way through Boulder, Colorado, bringing another day of flooding to the already rain swollen area, 15 September 2013. Image by ©Ed Endicott/Demotix/Corbis.

Back: The city of Boulder, Colorado, experienced substantial flooding for four days that have lasting effects, 18 September 2013. Image by ©Anna M Weaver/Demotix/Corbis.

HOW TO CITE THIS DOCUMENT

Citing the complete report:

Herring, S. C., M. P. Hoerling, T. C. Peterson, and P. A. Stott, Eds., 2014: Explaining Extreme Events of 2013 from a Climate Perspective. *Bull. Amer. Meteor. Soc.*, **95** (9), S1–S96.

Citing a section (example):

Hoerling, M., and Coauthors, 2014: Northeast Colorado extreme rains interpreted in a climate change context [in "Explaining Extremes of 2013 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **95** (9), S15–S18.

EDITORIAL AND PRODUCTION TEAM

Riddle, Deborah B., Lead Graphics Production, NOAA/NESDIS National Climatic Data Center, Asheville, NC
Veasey, Sara W., Graphics Team Lead, NOAA/NESDIS National Climatic Data Center, Asheville, NC
Griffin, Jessica, Graphics Support, CICS-NC, Asheville, NC
Love-Brotak, S. Elizabeth, Graphics Support, NOAA/NESDIS National Climatic Data Center, Asheville, NC
Misch, Deborah J., Graphics Support, JPS, Inc., NOAA/NESDIS National Climatic Data Center, Asheville, NC
Osborne, Susan, Copy Editor, JPS, Inc., NOAA/NESDIS National Climatic Data Center, Asheville, NC
Sprain, Mara, Editorial Support, LAC Group, NOAA/NESDIS National Climatic Data Center, Asheville, NC
Young, Teresa, Graphics Support, ERT/STG, Inc., NOAA/NESDIS National Climatic Data Center, Asheville, NC

6. SEASONAL AND ANNUAL MEAN PRECIPITATION EXTREMES OCCURRING DURING 2013: A U.S. FOCUSED ANALYSIS

Thomas R. Knutson, Fanrong Zeng, and Andrew T. Wittenberg

The Coupled Model Intercomparison Project phase 5 model analyses suggest that seasonal and annual mean precipitation extremes occurring during 2013 in north-central and eastern U.S. regions, while primarily attributable to intrinsic variability, were also partly attributable to anthropogenic and natural forcings combined.

Introduction. We analyze several U.S. regions with seasonal and annual mean precipitation anomalies in 2013 that we classify as "extreme" (i.e., ranked first, second, or third highest or lowest). Our analysis uses the Global Historical Climatology Network (GHCN) monthly precipitation dataset (Vose et al. 1992), covering 1900–2013, on a 5° × 5° grid effectively limited to land regions. The extremes are analyzed in the context of long-term climate change, using trend analysis of historical and control run experiments from 23 Coupled Model Intercomparison Project phase 5 (CMIP5) models (Supplemental Material; Taylor et al. 2012).

Where did seasonal and annual mean precipitation extremes occur in 2013? Figure 6.1a–e identifies several regions of the continental United States that experienced record or near-record seasonal or annual mean precipitation anomalies during 2013. Global maps of seasonal and annual anomalies, and their associated extreme occurrences for 2013 (Supplementary Fig. S6.1), show that record or near-record wet and dry anomalies for 2013 were well dispersed around the globe. Supplementary Fig. S6.2 shows that in recent decades, annual mean rainfall has shown greater areal coverage for record or near-record annual mean wet extremes than dry extremes. In contrast, recent seasonal and annual mean surface temperatures are much more strongly skewed toward warm extremes (e.g., Knutson et al. 2013a).

We focus on six U.S. regions in this study (Fig. 6.1; Supplementary Fig. S6.1) including: the "northern tier—ANN (annual);" "upper Midwest—MAM (March–May);" "Southern Plains—MAM;" "eastern United States—JJA (June–August);" "Northern Plains—SON (September–November);" and "California—ANN." Each region we analyzed contains multiple grid boxes and stations, which reduces the risk of instrumental or reporting errors at a single station controlling results for a given "extreme event." The California region—which in these data did not have annual precipitation anomalies ranked within the lowest three on record during 2013—nonetheless experienced widely publicized drought conditions during 2013, and so is analyzed here.

What is the climate change context for the regional precipitation extremes? Annual or seasonal mean precipitation time series for the focus regions (Fig. 6.1) show some moderate trend-like behavior. For each series, a least squares linear trend (1900–2013) was initially assessed by a standard *t* test (two-sided; $p = 0.10$), assuming that the residual anomalies, after trend removal, were temporally independent. (This assumption is later relaxed for our model-based assessments.) Three of the regions had significant positive trends (1900–2013): northern tier—ANN; upper Midwest—MAM; and Northern Plains—SON. The eastern United States—JJA had a nonsignificant trend over 1900–2013 but had a significant trend over 1950–2013 (discussed later). The significant trends mentioned above remained significant according to the above preliminary tests even if 2013 was excluded. None of the regions had significant negative trends. Previous studies have noted significant annual mean precipitation increases over much of the central and northern United States (Hartmann et al. 2014), and some increases in flood magnitudes over the north-central United States (Hirsch and Ryberg 2012), although these regional changes were not specifically attributed to anthropogenic forcing.

Observed trends for our selected regions were compared to CMIP5 historical and control runs using a "sliding trend" analysis (Fig. 6.2; Supplementary Fig. S6.3), for a range of start years (all trends ending in 2013), following Knutson et al. (2013a). Sensitivity tests were also performed for trends excluding the

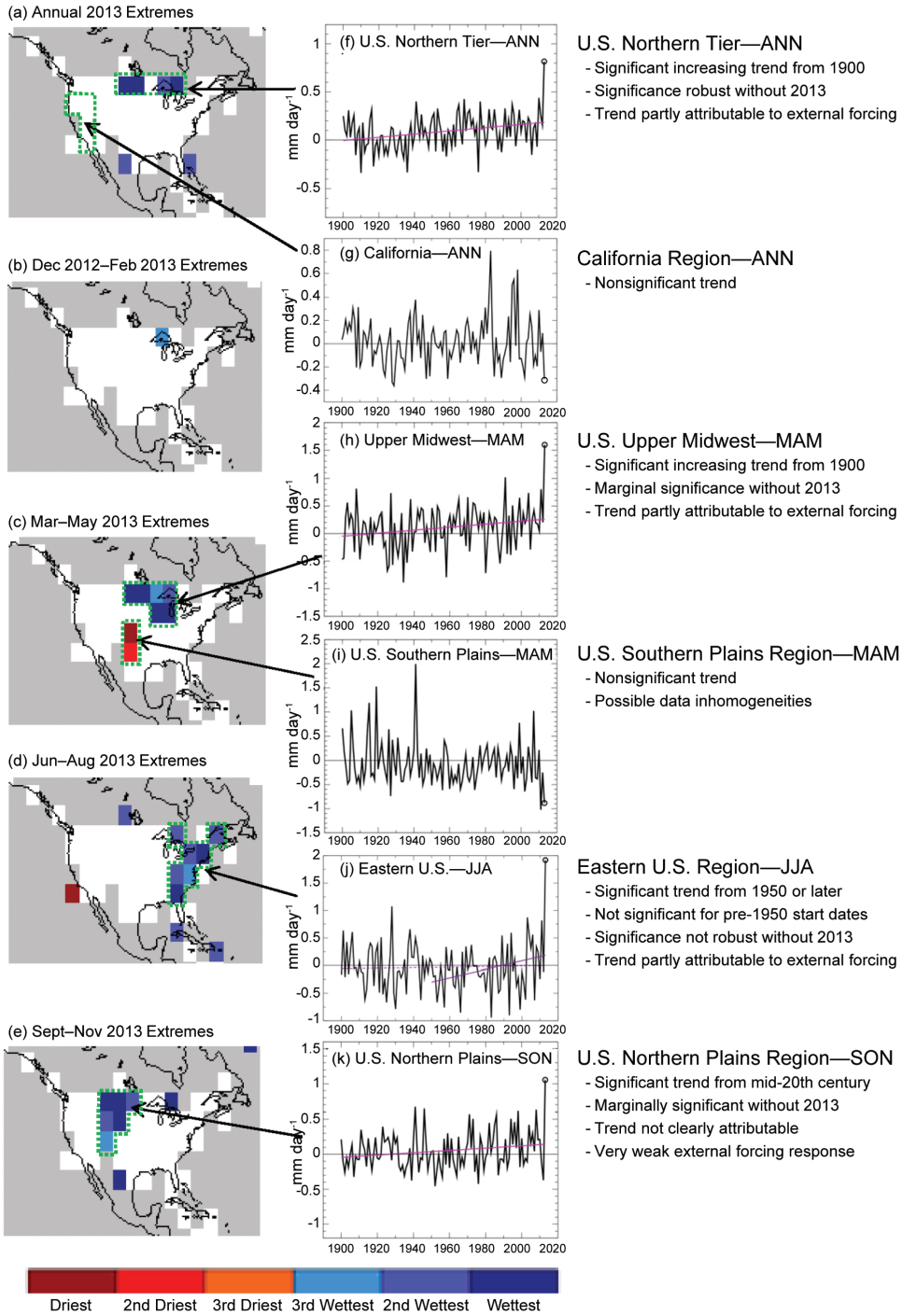

Fig. 6.1. Left column (a–e): Colors identify grid boxes where the annual or seasonal precipitation anomalies for 2013 rank first (dark red), second (red), or third (orange) driest or first (dark blue), second (medium blue) or third (light blue) wettest in the available observed record (see map legend). The seasons are DJF (December 2012–February 2013); MAM (March–May 2013); JJA (June–August 2013); and SON (September–November 2013). The various averaging regions used in the study are shown by the green dashed outlines in (a–e). Gray areas did not have sufficiently long records, defined here as containing at least 100 available annual or seasonal means, with an annual mean requiring at least three of four seasons to be available, and a seasonal mean requiring at least one of three months to be available. Center column (f–k): Time series of precipitation from the extremes regions shown by arrows/green outlines (see also Fig. S6.1 for region definitions). Black: observed anomalies in mm day^{-1}; purple sloping line: significant linear trends (1900–2013, except 1950–2013 for eastern U.S. region—see text for explanation). The observed anomalies for 2013 are circled for emphasis in (f–k). The overall analysis results of the paper are summarized for each region in the right column.

highly anomalous 2013 observed values (Supplementary Fig. S6.3). Briefly, if observed trends were outside of the 5th–95th percentiles of the control run distribution, they were designated as "detectable" compared to internal variability. Detectable positive trends that lie either within or above the 5th–95th percentile range of the All-Forcing (anthropogenic and natural forcing) distribution are interpreted as at least "partly attributable to external forcing." For example, the northern tier—ANN plot (Fig. 6.2b) shows that the positive observed trends in this region are detectable compared to internal variability (black curve outside the purple shading) and at least partly attributable to external forcing (inside the pink shading) for start dates from 1900 to about 1940, but are generally not detectable for trend start dates more recent than 1940.

Figure 6.2e, for the upper Midwest—MAM, indicates detectable trends compared to internal variability, except for mid-20th century start dates. For the eastern United States—JJA (Fig. 6.2h), positive trends are detectable for start years of ~1940 and later but not from the early 20th century. The cases of detectable trends for the three regions discussed above are also generally cases where the observed trends are at least partly attributable to external forcing according to the models (i.e., within or above the pink regions on the "sliding trend" graphs). The robustness of these assessments to exclusion of the highly anomalous 2013 value is examined in Supplementary Fig. S6.3. This analysis indicates that the most robust findings are for the northern tier—ANN region, while the detection result for the recent (late 20th century) trends in the eastern United States—JJA region is not very robust to exclusion of 2013. Intermediate robustness results are indicated for the upper Midwest—MAM region. As discussed in the Discussion section and Supplemental Material, insufficient ensemble sizes for the available CMIP5 Natural Forcing experiments have precluded us from robust trend detection compared to the Natural Forcing-only trend distributions, and so our results do not specifically distinguish a detectable *anthropogenic-only* influence on seasonal/annual precipitation trends for any of the focus regions. Some further discussion of trend results for three additional regions: the Southern Plains—MAM, Northern Plains—SON, and California—ANN is contained in the Supplemental Material.

Are the 2013 regional extremes attributable to anthropogenic and natural forcing? We next examine the 2013 anomalies in particular (relative to 1900–40 baseline values) in the three U.S. regions that had both extreme 2013 anomalies *and* long-term increasing trends that were assessed as partly attributable to anthropogenic and natural forcing: northern tier—ANN, upper Midwest—MAM, and eastern United States—JJA. For each of these regions, the CMIP5 multimodel ensemble-mean of the All-Forcing simulations shows a trend toward increasing rainfall but at a rate much smaller than the observed trend (Fig. 6.2a,d,g; Supplementary Fig. S6.4). Because the modeled response series are noisy for estimating a single-year value (even after ensemble-averaging), we apply temporal smoothing to estimate the 2013 All-Forcing anomaly (Supplementary Fig. S6.4; Supplemental Material). Using this estimated 2013 "All-Forcing" anomaly, we then estimate the 2013 All-Forcing distribution via a "rightward displacement" of the CMIP5 multimodel control run variability distribution (Fig. 6.2c,f,i). Using these forced and unforced anomaly distributions for each region, we estimate the influence of "anthropogenic + natural" forcings on the occurrence rate of extreme anomalies, using the "second-ranked year" anomalies (2010, 1991, or 1928) as the threshold values for fraction of attributable risk (FAR) calculations. We tested using the record 2013 values as the thresholds for FAR calculations but found that those values were either extremely rare or unprecedented in the modeled distributions so that the FAR results were very sensitive to our methodology. Therefore, we report here only the calculations based on the second-ranked years.

Note that the ensemble-mean All-Forcing response (shift between red and blue distributions in Fig. 6.2c,f,i) explains just a small fraction of the observed anomalies for 2013, implying a likely dominant role for internal variability in the 2013 rainfall extremes. For northern tier—ANN, the FAR of threshold-exceeding extremes due to anthropogenic and natural forcing combined is estimated as 0.60, based on estimates using the 2010 observed values as the threshold, with an occurrence ratio (All-Forcing vs. Control runs) of 2.5. In other words, the fraction of current risk of events exceeding the threshold that is attributable to external forcing is about 0.6. For the upper Midwest—MAM region, FAR is estimated as 0.49, with an occurrence ratio of 2.0. For the eastern United States—JJA, the FAR is estimated as 0.36 with an occurrence ratio of 1.6. The FAR estimates discussed here are based on the multimodel ensemble-mean All-Forcing response. However, considerable uncertainty remains in the FAR estimates; for example, FAR estimates based on individual models rather than the multimodel ensemble (not shown) can fall below zero or substantially exceed the multimodel estimates.

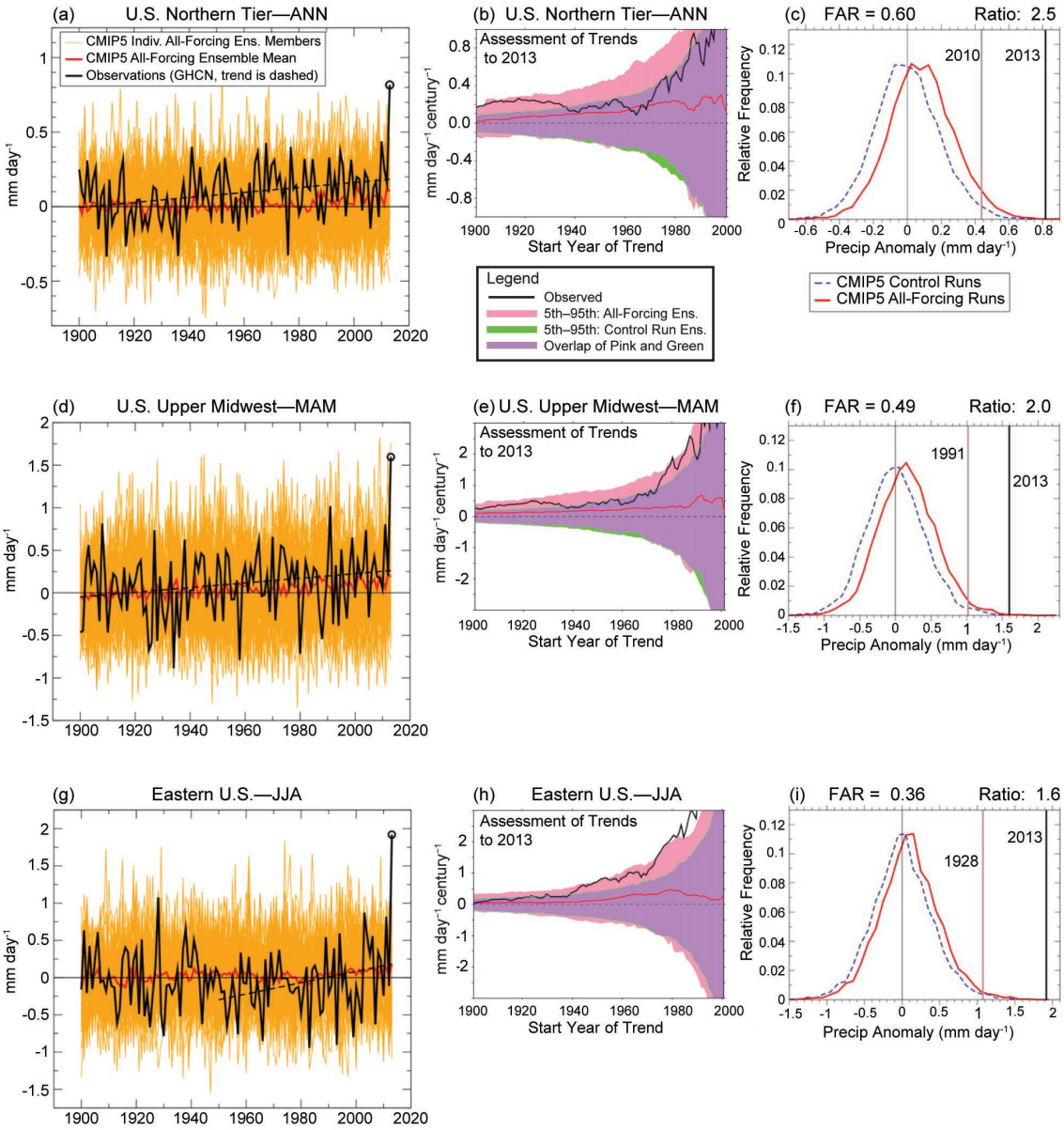

Fig. 6.2. (a,d,g) Rainfall time series averaged over the (a) U.S. northern tier–ANN, (d) U.S. upper Midwest—MAM and (g) eastern U.S.—JJA regions relative to 1900–40 baseline values. Black curves are observations, red curves are CMIP5 ensemble-mean All-Forcing responses, orange curves are individual model ensemble members, and sloping black dashed lines depict significant linear trends for observations. (b,e,h) Sliding trend analysis of precipitation trends for the series in (a,d,g) but for various start years (x-axis) with all trends ending in 2013. Black curves: observed trends; red curves: CMIP5 All-Forcing multimodel ensemble-mean trends; pink shading: 5th–95th percentile range of trends from the CMIP5 All Forcing (anthropogenic + natural forcing) runs, extended to 2013 with RCP4.5 scenarios; green shading: 5th–95th percentile range of internally generated trends from CMIP5 control runs; purple shading: overlap of pink and green regions. (c,f,i) Analysis comparing extreme observed anomalies (relative to 1900–40 baseline) for 2013 or for the next-most extreme year (2010, 1991, 1928) with CMIP5 model-simulated anomaly distributions. Blue histogram: CMIP5 multimodel control run distribution showing model-estimated internal climate variability. Red histogram: All-Forcing distribution obtained by shifting the control run distribution to the right by the estimated All-Forcing ensemble mean response (relative to the 1900–40 baseline) for 2013 (see also Supplemental Material). The black and gray vertical lines in (c,f,i) depict extreme observed anomalies, including the record observed values for 2013 (black) and the second-ranked year (gray), for comparison to the modeled distributions of anomalies. Denoting p_f and p_c as the occurrence rates within the All-Forcing and Control run distributions, respectively, of anomalies exceeding the defined second-ranked-year thresholds shown in the plots, then FAR = $1-p_c/p_f$, and the occurrence ratio is p_f/p_c.

Another important potential source of uncertainty is the adequacy of the control run variability, which is compared to "residual" observed variability in the Supplemental Material (Supplementary Figs. S6.5–7). Our basic findings appear robust to this uncertainty, although the simulation or estimate of internal climate variability remains an important topic for further research.

Discussion and conclusions. Three of the focus regions, northern tier—ANN, upper Midwest—MAM, and eastern United States—JJA, had record or near-record seasonal or annual precipitation anomalies during 2013 as well as detectable positive trends that were at least partly attributable to external forcing (anthropogenic and natural forcing combined). However, detection was marginal for the eastern United States. According to the models, external forcing increased the likelihood of rainfall events as extreme as the observed second-ranked year thresholds by factors of 1.6 to 2.5. The climate change detection here is only with respect to control run (intrinsic) climate variability. We have not attempted detection relative to natural forcing and intrinsic variability combined, since (a) the simulated ensemble-mean response to external forcings is generally much smaller than the observed long-term trends, interannual variability, and 2013 anomalies; and (b) too few simulations with only natural forcing were performed to sufficiently delineate the response to that forcing. Thus, while there is some suggestion of increased risk attributable to anthropogenic forcing in our findings (Supplementary Fig. S6.4), this is not emphasized here due to the lack of a sufficiently detectable long-term anthropogenic trend contribution. Extensions of the CMIP5 Natural Forcing runs through 2013, and larger ensembles of Natural Forcing experiments by various modeling centers, would be particularly useful for further investigations.

Important caveats are that we have not yet systematically analyzed regional precipitation trends globally (which would clarify the large-scale context of our findings), nor have we assessed possible data homogeneity issues, alternative datasets (e.g., Becker et al. 2013), or effects of radiative forcings on precipitation variance. Clearly, it would be much more difficult to detect anthropogenic influences on regional precipitation extremes than on surface temperatures (e.g., Knutson et al. 2013a). This is already evident in other recent analyses of regional precipitation trends (van Oldenborgh et al. 2013; Bhend and Whetton 2013). Nonetheless, some studies have reported detectable anthropogenic influence for zonal-mean precipitation (e.g., Zhang et al. 2007; Marvel and Bonfils 2013), precipitation extremes over large land regions of the Northern Hemisphere (Min et al. 2011), or precipitation changes in the extratropical Southern Hemisphere (Fyfe et al. 2012) or Mediterranean region (Hoerling et al. 2012). We conclude that the 2013 extreme precipitation "events" for three U.S. regions/seasons (northern tier—ANN, upper Midwest—MAM, and eastern United States—JJA) are tentatively attributable in part to external (anthropogenic and natural) forcing, with a likely much larger additional contribution from unforced intrinsic variability. We suggest that these regions be monitored for possible future emergence of anthropogenically forced precipitation increases, including more extreme seasonal or annual mean rainfall.

7. OCTOBER 2013 BLIZZARD IN WESTERN SOUTH DAKOTA

Laura M. Edwards, Matthew J. Bunkers, John T. Abatzoglou, Dennis P. Todey, and Lauren E. Parker

An early October blizzard in South Dakota is determined to be climatologically anomalous. Climate models suggest that early autumn extreme snowfall events in western South Dakota are less likely due to anthropogenic climate change.

Introduction. An early season blizzard on 4–5 October 2013 in western South Dakota (SD) and neighboring areas of Wyoming, Nebraska, and North Dakota caused severe infrastructure damage and economic losses to businesses and agricultural communities. Estimated losses total $38 million in SD alone.

The blizzard produced 50.8–99.6 cm of snow across the plains and 139.7 cm of snow in the northern

REFERENCES

Adler, R. F., and Coauthors, 2003: The Version 2 Global Precipitation Climatology Project (GPCP) monthly precipitation analysis (1979-Present). *J. Hydrometeor.*, **4**, 1147–1167.

Alexandersson, H., T. Schmith, K. Iden, and H. Tuomenvirta, 1998: Long-term variations of the storm climate over NW Europe. *Global Atmos. Ocean Sys.*, **6**, 97–120.

——, H. Tuomenvirta, T. Schmith, and K. Iden, 2000: Trends of storms in NW Europe derived from an updated pressure data set. *Climate Res.*, **14**, 71–73.

Allan, R., and C. K. Folland, 2012: [Global climate] Atmospheric circulation: Mean sea level pressure [in "State of the Climate 2011"]. *Bull. Amer. Meteor. Soc.*, **93** (7), S35–S36.

——, and B. J. Soden, 2008: Atmospheric warming and the amplification of precipitation extremes. *Science*, **321**, 1484.

Allen, M., 1999: Do-it-yourself climate prediction. *Nature*, **401**, 642.

——, 2003: Liability for climate change. *Nature*, **421**, 891–892.

Andermann, C., L. Longuevergne, S. Bonnet, A. Crave, P. Davy, and R. Gloaguen, 2012: Impact of transient groundwater storage on the discharge of Himalayan rivers. *Nature Geosci.*, **5**, 127–132.

Arblaster, J. M., and L. V. Alexander, 2012: The impact of the El Niño-Southern Oscillation on maximum temperature extremes. *Geophys. Res. Lett.*, **39**, L20702, doi:10.1029/2012GL053409.

Ashfaq, M., Y. Shi, W.-W. Tung, R. J. Trapp, X. Gao, J. S. Pal, and N. S. Diffenbaugh, 2009: Suppression of south Asian summer monsoon precipitation in the 21st century. *Geophys. Res. Lett.*, **36**, L01704, doi:10.1029/2008GL036500.

BAAQMD, 2014: Challenging "Winter Spare the Air" season comes to a close. Bay Area Air Quality Management District, press release, 4 March 2014. [Available online at http://www.baaqmd.gov/~/media/Files/Communications%20and%20Outreach/Publications/News%20Releases/2014/2014-019-WSTA-SEASON-ENDS-030414.ashx?la=en.]

Bacmeister, J. T., M. J. Suarez, and F. R. Robertson, 2006: Rain reevaporation, boundary layer–convection interactions, and Pacific rainfall patterns in an AGCM. *J. Atmos. Sci.*, **63**, 3383–3403.

——, M. F. Wehner, R. B. Neale, A. Gettelman, C. Hannay, P. H. Lauritzen, J. M. Caron, and J. E. Truesdale, 2014: Exploratory high-resolution climate simulations using the Community Atmosphere Model (CAM). *J. Climate*, **27**, 3073–3099.

Balmaseda, M. A., L. Ferranti, F. Molteni, and T. N. Palmer, 2010: Impact of 2007 and 2008 Arctic ice anomalies on the atmospheric circulation: Implications for long-range predictions. *Quart. J. Roy. Meteor. Soc.*, **136**, 1655–1664.

Barnett, T. P., and Coauthors, 2008: Human-induced changes in the hydrology of the western United States. *Science*, **319**, 1080–1083.

Barriopedro, D., E. M. Fischer, J. Lutenbacher, R. M. Trigo, and R. Garcia-Herrera, 2011: The hot summer of 2010: redrawing the temperature record map of Europe. *Science*, **332**, 220–224.

Becker, A., P. Finger, A. Meyer-Christoffer, B. Rudolf, K. Schamm, U. Schneider, and M. Ziese, 2013: A description of the global land-surface precipitation data products of the Global Precipitation Climatology Centre with sample applications including centennial (trend) analysis from 1901 to present. *Earth Syst. Sci. Data*, **5**, 71–99.

Berg, P., J. O. Haerter, P. Thejll, C. Piani, S. Hagemann, and J. H. Christensen, 2009: Seasonal characteristics of the relationship between daily precipitation intensity and surface temperature. *J. Geophys. Res.*, **114**, D18102, doi:10.1029/2009JD012008.

BfG-DWD, 2013: Länderübergreifende Analyse des Juni-Hochwassers 2013. Bundesanstalt für Gewässerkunde, 69 pp. [Available online at http://www.vhw.de/fileadmin/user_upload/Themenfelder/Umweltrecht/2013_09_04_pm_bfg-bericht.pdf.]

Bhend, J., and P. Whetton, 2013: Consistency of simulated and observed regional changes in temperature, sea level pressure and precipitation. *Climatic Change*, **118**, 799–810, doi:10.1007/s10584-012-0691-2.

Bindoff, N. L., and Coauthors, 2014: Detection and attribution of climate change: From global to regional. *Climate Change 2013: The Physical Science Basis*, T. F. Stocker et al., Eds., Cambridge University Press, 867–952.

Blackham, M., 2013: Dust bowled. *Water Atmos.*, **8**, 12–21.

Bladé, I., B. Liebmann, D. Fortuny, and G. J. Oldenborgh, 2012: Observed and simulated impacts of the summer NAO in Europe: Implications for projected drying in the Mediterranean region. *Climate Dyn.*, **39**, 709–727, doi:10.1007/s00382-011-1195-x.

Blunden, J., and D. S. Arndt, Eds., 2014: State of the Climate in 2013. *Bull. Amer. Meteor. Soc.*, **95** (7), S1–S257.

Boé, J., L. Terray, C. Cassou, and J. Najac, 2009: Uncertainties in European summer precipitation changes: Role of large scale circulation. *Climate Dyn.*, **33**, 265–276, doi:10.1007/s00382-008-0474-7.

Borah, N., A. K. Sahai, R. Chattopadhyay, S. Joseph, S. Abhilash, and B. N. Goswami, 2013: A self-organizing map–based ensemble forecast system for extended range prediction of active/break cycles of Indian summer monsoon. *J. Geophys. Res. Atmos.*, **118**, 9022–9034, doi:10.1002/jgrd.50688.

Buisán, S. T., M. A. Sanz, and J. I. López-Moreno, 2014: Spatial and temporal variability of winter snow and precipitation days in the western and central Spanish Pyrenees. *Int. J. Climatol.*, in press, doi:10.1002/joc.3978.

Bureau of Meteorology, 2012: State of the Climate 2012. [Available online at http://www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2012.aspx.]

——, 2013a: Extreme heat in January 2013. Bureau of Meteorology Special Climate Statement 43, 19 pp. [Available online at http://www.bom.gov.au/climate/current/statements/scs43e.pdf.]

——, 2013b: Australia's warmest September on record. Bureau of Meteorology Special Climate Statement 46, 26 pp. [Available online at http://www.bom.gov.au/climate/current/statements/scs46.pdf.]

——, 2014: Annual Climate Report 2013. Bureau of Meteorology (Australia), 31 pp. [Available online at http://www.bom.gov.au/climate/annual_sum/2013/index.shtml.]

CAL FIRE, 2014: Drought prompts CAL FIRE to increase statewide staffing: Expected prolonged, elevated threat of wildfire due to dry conditions. CAL FIRE, news release, 28 January 2014. [Available online at http://www.fire.ca.gov/communications/downloads/newsreleases/2014/2014_Drought_Staffing.pdf.]

Carrera, M., R. Higgins, and V. Kousky, 2004: Downstream weather impacts associated with atmospheric blocking over the northeast Pacific. *J. Climate*, **17**, 4823–4840.

Cassou, C., 2008: Intraseasonal interaction between the Madden–Julian Oscillation and the North Atlantic Oscillation. *Nature*, **455**, 523–527.

Cattiaux, J., and P. Yiou, 2012: Contribution of atmospheric circulation to remarkable European temperatures of 2011. *Bull. Amer. Meteor. Soc.*, **93**, 1054–1057.

——, R. Vautard, C. Cassou, P. Yiou, V. Masson-Delmotte, and F. Codron, 2010: Winter 2010 in Europe: A cold extreme in a warming climate. *Geophys. Res. Lett.*, **37**, L20704, doi:10.1029/2010gl044613.

Cayan, D., and J. Roads, 1984: Local relationships between United States West Coast precipitation and monthly mean circulation parameters. *Mon. Wea. Rev.*, **112**, 1276–1282.

CDFW, 2014: CDFW puts closures in effect on some rivers, recommends further changes to the Fish and Game Commission. *California Department of Fish and Wildlife News*, 29 January 2014. [Available online at http://cdfgnews.wordpress.com/2014/01/29/cdfw-puts-closures-in-effect-on-some-rivers-recommends-further-changes-to-the-fish-and-game-commission.]

Chattopadhyay, R., A. K. Sahai, and B. N. Goswami, 2008: Objective identification of nonlinear convectively coupled phases of monsoon intraseasonal oscillation: Implications for prediction. *J. Atmos. Sci.*, **65**, 1549–1569.

Chen, S., and D. Cayan, 1994: Low-frequency aspects of the large-scale circulation and West Coast United States temperature/precipitation fluctuations in a simplifed general circulation model. *J. Climate*, **7**, 1668–1683.

Christidis, N., and P. A. Stott, 2014: Change in the odds of warm years and seasons due to anthropogenic influence on the climate. *J. Climate*, **27**, 2607–2621.

——, ——, and S. J. Brown, 2011: The role of human activity in the recent warming of extremely warm daytime temperatures. *J. Climate*, **24**, 1922–1930.

——, ——, G. S. Jones, H. Shiogama, T. Nozawa, and J. Luterbacher, 2012: Human activity and warm seasons in Europe. *Int. J. Climatol.*, **32**, 225–239.

——, ——, A. A. Scaife, A. Arribas, G. S. Jones, D. Copsey, J. R. Knight, and W. J. Tennant, 2013: A new HadGEM3-A-based system for attribution of weather- and climate-related extreme events. *J. Climate*, **26**, 2756–2783.

CIB, cited 2013: Central European flooding 2013. EURO4M Climate Indicator Bulletin. [Available online at http://cib.knmi.nl/mediawiki/index.php/Central_European_flooding_2013.]

Clark, A., B. Mullan, and A. Porteous, 2011: Scenarios of regional drought under climate change. National Institute of Water & Atmospheric Research, 135 pp. [Available online at http://www.niwa.co.nz/sites/niwa.co.nz/files/slmacc_drought_sldr093_june2011.pdf.]

CMA, 2014: *China Climate Bulletin for 2013.* China Meteorological Administration, 50 pp.

Compo, G. P., and P. D. Sardeshmukh, 2010: Removing ENSO-related variations from the climate record. *J. Climate*, **23**, 1597–1978.

Coumou, D., and S. Rahmstorf, 2012: A decade of weather extremes. *Nature Climate Change*, **2**, 491–496, doi:10.1038/NCLIMATE1452.

Dai, A., 2008: Temperature and pressure dependence of the rain-snow phase transition over land and ocean. *Geophys. Res. Lett.*, **35**, L12802, doi:10.1029/2008GL033295.

——, 2011: Drought under global warming: a review. *Wiley Interdiscip. Rev.: Climate Change*, **2**, 45–65.

——, 2013: The influence of the Inter-decadal Pacific Oscillation on US precipitation during 1923-2010. *Climate Dyn.*, **41**, 633–646.

Daithi, S., 2013: Boundary conditions for the C20C Detection and Attribution project: The ALL-Hist/est1 and NAT-Hist/CMIP5-est1 scenarios. International CLIVAR C20C+ Detection and Attribution Project, 18 pp. [Available online at http://portal.nersc.gov/c20c/input_data/C20C-DandA_dSSTs_All-Hist-est1_Nat-Hist-CMIP5-est1.pdf.]

Dangendorf, S., S. Müller-Navarra, J. Jensen, F. Schenk, T. Wahl, and R. Weisse, 2014: North Sea storminess from a novel storm surge record since AD 1843. *J. Climate*, **27**, 3582–3595.

Dee, D. P., and Coauthors, 2011: The ERA-Interim reanalysis: Configuration and performance of the data assimilation system. *Quart. J. Roy. Meteor. Soc.*, **137**, 553–597, doi:10.1002/qj.828.

DEFRA, 2013: Defra to meet the cost of removing sheep killed in snow, Department for Environment, Food & Rural Affairs, press release, 15 May 2013. [Available online at https://www.gov.uk/government/news/defra-to-meet-the-cost-of-removing-sheep-killed-in-snow.]

Deser, C., A. S. Phillips, and M. A. Alexander, 2010: Twentieth century tropical sea surface temperature trends revisited. *Geophys. Res. Lett.*, **37**, L10701, doi:10.1029/2010GL043321.

Deutschländer, T., K. Friedrich, S. Haeseler, and C. Lefebvre, 2013: Severe storm XAVER across northern Europe from 5 to 7 December 2013. Deutscher Wetterdienst, 19 pp. [Available online at http://www.dwd.de/bvbw/generator/DWDWWW/Content/Oeffentlichkeit/KU/KU2/KU24/besondere__ereignisse__global/stuerme/englischeberichte/201312__XAVER__europe,templateId=raw,property=publicationFile.pdf/201312_XAVER_europe.pdf.]

Dobhal, D. P., A. K. Gupta, M. Mehta, and D. D. Khandelwal, 2013: Kedarnath disaster: Facts and plausible causes. *Current Sci.*, **105**, 171–174.

Dole, R., J. Perlwitz, J. Eischeid, P. Pegion, T. Zhang, X. W. Quan, T. Xu, and D. Murray, 2011: Was there a basis for anticipating the 2010 Russian heat wave? *Geophys. Res. Lett.*, **38**, L06702, doi:10.1029/2010GL046582.

Donat, M. G., and Coauthors, 2013: Updated analyses of temperature and precipitation extreme indices since the beginning of the twentieth century: The HadEX2 dataset. *J. Geophys. Res. Atmos.*, **118**, 2098–2118, doi:10.1002/jgrd.50150.

Dong, B.-W., R. T. Sutton, and T. Woollings, 2013a: The extreme European summer 2012 (in "Explaining Extreme Events of 2012 from a Climate Perspective"). *Bull. Amer. Meteor. Soc.*, **94** (9), S28–S32.

——, ——, ——, and K. Hodges, 2013b: Variability of the North Atlantic summer stormtrack: Mechanisms and impacts. *Environ. Res. Lett.*, **8**, 034037, doi:10.1088/1748-9326/8/3/034037.

Douville, H., S. Bielli, C. Cassou, M. Dequé, N. M. J. Hall, S. Tyteca, and A. Voldoire, 2011: Tropical influence on boreal summer mid-latitude stationary waves. *Climate Dyn.*, **38**, 1783–1798.

Dube, A., R. Ashrit, A. Ashish, K. Sharma, G. R. Iyengar, E. N. Rajagopal, and S. Basu, 2013: Performance of NCMRWF forecast models in predicting the Uttarakhand heavy rainfall event during 17–18 June 2013. [India] National Centre for Medium Range Weather Forecasting Research Report NMRF/RR/08/2013, 35 pp. [Available online at http://www.ncmrwf.gov.in/ncmrwf/KEDARNATH_REPORT_FINAL.pdf.]

——, ——, ——, ——, ——, ——, and ——, 2014: Forecasting the heavy rainfall during Himalayan flooding - June 2013. *Wea. Climate Extremes*, **4**, 22–34, doi:10.1016/j.wace.2014.03.004.

Dubey, C. S., D. P. Shukla, A. S. Ningreichon, and A. L. Usham, 2013: Orographic control of the Kedarnath disaster. *Current Sci.*, **105**, 1474–1476.

Durga Rao, K. H. V., V. Venkateshwar Rao, V. K. Dadhwal, and P. G. Diwakar, 2014: Kedarnath flash floods: A hydrological and hydraulic simulation study. *Current Sci.*, **106**, 598–603.

DWR, 2013: DWR experimental winter outlook for water year 2014: Sees mostly dry conditions for California. California Department of Water Resources, news release, 27 November 2013. [Available online at http://www.water.ca.gov/news/newsreleases/2013/112513.pdf.]

——, 2014: DWR drops state water project allocation to zero, seeks to preserve remaining supplies. California Department of Water Resources, news release, 31 January 2014. [Available online at http://www.water.ca.gov/news/newsreleases/2014/013114pressrelease.pdf.]

El Kenawy, A., J. I. López-Moreno, and S. M. Vicente-Serrano, 2012: Trend and variability of surface air temperature in northeastern Spain (1920-2006): Linkage to atmospheric circulation. *Atmos. Res.*, **106**, 159–180.

Favre, A., and A. Gershunov, 2009: North Pacific cyclonic and anticyclonic transients in a global warming context: Possible consequences for Western North American daily precipitation and temperature extremes. *Climate Dyn.*, **32**, 969–987.

Feser, F., R. Weisse, and H. von Storch, 2001: Multi-decadal atmospheric modeling for Europe yields multi-purpose data. *Eos, Trans. Amer. Geophys. Union*, **82**, 305–310.

——, M. Barcikowska, O. Krueger, F. Schenk, R. Weisse, and L. Xia, 2014: Storminess over the North Atlantic and northwestern Europe - A review. *Quart. J. Roy. Meteor. Soc.*, in press, doi:10.1002/qj.2364.

Field, C. B., and Coauthors, Eds., 2012: *Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation*. Cambridge University Press, 582 pp.

Fischer, E. M., U. Beyerle, and R. Knutti, 2013: Spatial aggregation reveals robust projections in climate extremes. *Nature Climate Change*, **3,** 1033–1038, doi:10.1038/NCLIMATE2051.

Folland, C. K., J. Knight, H. W. Linderholm, D. Fereday, S. Ineson, and J. W. Hurrell, 2009: The summer North Atlantic oscillation: Past, present, and future. *J. Climate*, **22**, 1082–1103.

Francis, J. A., and S. J. Vavrus, 2012: Evidence linking Arctic amplification to extreme weather in mid-latitudes. *Geophys. Res. Lett.*, **39**, L06801, doi:10.1029/2012GL051000.

Franke, R., 2009: Die nordatlantischen Orkantiefs seit 1956. *Naturwiss. Rundsch.*, **62**, 349–356, updated.

Fyfe, J. C., N. P. Gillett, and G. J. Marshall, 2012: Human influence on extratropical southern hemisphere summer precipitation. *Geophys. Res. Lett.*, **39**, L23711, doi:10.1029/2012GL054199.

——, ——, and F. W. Zwiers, 2013: Overestimated global warming over the past 20 years. *Nature Climate Change*, **3**, 767–769.

Gershunov, A., and D. Cayan, 2003: Heavy daily precipitation frequency over the contiguous United States: Sources of climatic variability and seasonal predictability. *J. Climate*, **16**, 2752–2765.

Geyer, B., 2014: High-resolution atmospheric reconstruction for Europe 1948–2012: coastDat2. *Earth Sys. Sci. Data*, **6**, 147–164, doi:10.5194/essd-6-147-2014.

Ghosh, S., D. Das, S.-C. Kao, and A. R. Ganguly, 2012: Lack of uniform trends but increasing spatial variability in observed Indian rainfall extremes. *Nature Climate Change*, **2**, 86–91.

Goswami, B. N., V. Venugopal, D. Sengupta, M. S. Madhusoodanan, and P. K. Xavier, 2006: Increasing trend of extreme rain events over India in a warming environment. *Science*, **314**, 1442–1445.

Graham, R. A., and R. H. Grumm, 2010: Utilizing normalized anomalies to assess synoptic-scale weather events in the western United States. *Wea. Forecasting*, **25**, 428–445.

Grams, C. M., H. Binder, S. Pfahl, N. Piaget, and H. Wernli, 2014: Atmospheric processes triggering the central European floods in June 2013. *Nat. Hazards Earth Syst. Sci.*, **14**, 1691–1702, doi:10.5194/nhess-14-1691-2014.

Graves, C. E., J. T. Moore, M. J. Singer, and S. Ng, 2003: Band on the run - Chasing the physical processes associated with heavy snowfall. *Bull. Amer. Meteor. Soc.*, **84**, 990–994.

Grumm, R. H., and R. Hart, 2001: Standardized anomalies applied to significant cold season weather events: Preliminary findings. *Wea. Forecasting*, **16**, 736–754.

Haeseler, S., and Coauthors, 2013: Heavy storm CHRISTIAN on 28 October 2013. Deutscher Wetterdienst, 20 pp. [Available online at http://www.dwd.de/bvbw/generator/DWDWWW/Content/Oeffentlichkeit/KU/KU2/KU24/besondere__ereignisse__global/stuerme/englischeberichte/20131028__CHRISTIAN__europe,templateId=raw,property=publicationFile.pdf/20131028_CHRISTIAN_europe.pdf.]

Hamill, T., 2014: Performance of operational model precipitation forecast guidance during the 2013 Colorado Front-Range floods. *Mon. Wea. Rev.*, **142**, 2609–2618.

Hansen, W. R., B. J. Chronic, and J. Matelock, 1978: Climatography of the Front Range urban corridor and vicinity, Colorado. USGS Professional Paper 1019, 59 pp. [Available online at http://pubs.usgs.gov/pp/1019/report.pdf.]

Hart, R. E., and R. H. Grumm, 2001: Using normalized climatological anomalies to rank synoptic-scale events objectively. *Mon. Wea. Rev.*, **129**, 2426–2442.

Hartmann, D. L., and Coauthors, 2014: Observations: Atmosphere and surface. *Climate Change 2013: The Physical Science Basis,* T. F. Stocker et al., Eds., Cambridge University Press, 159–254.

Hasselmann, K., 1979: On the signal-to-noise problem in atmospheric response studies. *Meteorology over the Tropical Oceans*, B. D. Shaw, Ed., Royal Meteorological Society, 251–259.

Haylock, M. R., N. Hofstra, A. M. G. Klein Tank, E. J. Klok, P. D. Jones, and M. New, 2008: A European daily high-resolution gridded dataset of surface temperature and precipitation for 1950–2006. *J. Geophys. Res.*, **113**, D20119, doi:10.1029/2008JD010201.

Hegerl, G., and F. Zwiers, 2011: Use of models in detection and attribution of climate change. *Wiley Interdiscip. Rev.: Climate Change*, **2**, 570–591.

——, O. Hoegh-Guldberg, G. Casassa, M. P. Hoerling, R. S. Kovats, C. Parmesan, D. W. Pierce, and P. A. Stott, 2009: Good practice guidance paper on detection and attribution related to anthropogenic climate change. IPCC Expert Meeting on Detection and Attribution Related to Anthropogenic Climate Change, T. F. Stocker et al., Eds., University of Bern, Switzerland, 1–8. [Available online at https://www.ipcc-wg1.unibe.ch/guidancepaper/IPCC_D&A_GoodPracticeGuidancePaper.pdf.]

Hendon, H. H., D. W. J. Thompson, and M. C. Wheeler, 2007: Australian rainfall and surface temperature variations associated with the Southern Hemisphere annular mode. *J. Climate*, **20**, 2452–2467.

——, E.-P. Lim, J. M. Arblaster, and D. T. L. Anderson 2014: Causes and predictability of the record wet spring over Australia in 2010. *Climate Dyn.*, **42**, 1155–1174.

Hewitson, B. C., and R. G. Crane, 2002: Self-organizing maps: Applications to synoptic climatology. *Climate Res.*, **22**, 13–26.

Hewitt, H. T., D. Copsey, I. D. Culverwell, C. M. Harris, R. S. R. Hill, A. B. Keen, A. J. McLaren, and E. C. Hunke, 2011: Design and implementation of the infrastructure of HadGEM3: The next-generation Met Office climate modelling system. *Geosci. Model Dev.*, **4**, 223–253.

Hirabayashi, Y., R. Mahendran, S. Koirala, L. Konoshima, D. Yamazaki, S. Watanabe, H. Kim, and S. Kanaes, 2013: Global flood risk under climate change. *Nature Climate Change*, **3**, 816–821.

Hirsch, R. M., and K. R. Ryberg, 2012: Has the magnitude of floods across the USA changed with global CO2 levels? *Hydrolog. Sci. J.*, **57**, 1–9, doi:10.1080/02626667.2011.621895.

Hoerling, M., J. Eischeid, J. Perlwitz, X. Quan, T. Zhang, and P. Pegion, 2012: On the increased frequency of Mediterranean drought. *J. Climate*, **25**, 2146–2161.

——, and Coauthors, 2013: Anatomy of an extreme event. *J. Climate*, **26**, 2811–2832.

Hong, C.-C., H.-H. Hsu, N.-H. Lin, and H. Chiu, 2011: Roles of European blocking and tropical-extratropical interaction in the 2010 Pakistan flooding. *Geophys. Res. Lett.*, **38**, L13806, doi:10.1029/2011GL047583.

Hoskins, B. J., and K. I. Hodges, 2002: New perspectives on the Northern Hemisphere winter storm tracks. *J. Atmos. Sci.*, **59**, 1041–1061.

Houze, R. A., K. L. Rasmussen, S. Medina, S. R. Brodzik, and U. Romatschke, 2011: Anomalous atmospheric events Leading to the summer 2010 floods in Pakistan. *Bull. Amer. Meteor. Soc.*, **92**, 291–298.

HPRC, cited 2014: High Plains Regional Center - Current climate summary maps. [Available online at http://www.hprcc.unl.edu/.]

Hudson, D., A. G. Marshall, Y. Yin, O. Alves, and H. H. Hendon, 2013: Improving intraseasonal prediction with a new ensemble generation strategy. *Mon. Wea. Rev.*, **141**, 4429–4449.

Huffington Post, 2014: The costs of California's bellwether drought: What can we expect? [Available online at http://www.huffingtonpost.com/peter-h-gleick/the-costs-of-californias_b_4747043.html.]

Hurrell, J. W., and C. Deser, 2009: North Atlantic climate variability: The role of the North Atlantic Oscillation. *J. Marine Sys.*, **79**, 231–244.

——, and Coauthors, 2013: The Community Earth System Model: A framework for collaborative research. *Bull. Amer. Meteor. Soc.*, **94**, 1339–1360.

Johnson, N. C., 2013: How many ENSO flavors can we distinguish? *J. Climate*, **26**, 4816–4827.

Jones, D. A., W. Wang, and R. Fawcett, 2009: High-quality spatial climate data-sets for Australia. *Aust. Meteor. Oceanogr. J.*, **58**, 233–248.

Jones, P. D., D. H. Lister, T. J. Osborn, C. Harpham, M. Salmon, and C. P. Morice, 2012: Hemispheric and large-scale land surface air temperature variations: An extensive revision and an update to 2010. *J. Geophys. Res.*, **117**, D05127, doi:10.1029/2011JD017139.

Joseph, S., and Coauthors, 2014: North Indian heavy rainfall event during June 2013: Diagnostics and extended range prediction. *Climate Dyn.*, in press, doi:10.1007/s00382-014-2291-5.

Junker, N. W., R. H. Grumm, R. Hart, L. F. Bosart, K. M. Bell, and F. J. Pereira, 2008: Use of normalized anomaly fields to anticipate extreme rainfall in the mountains of northern California. *Wea. Forecasting*, **23**, 336–356.

Jurewicz, M. L., and M. S. Evans, 2004: A comparison of two banded, heavy snowstorms with very different synoptic settings. *Wea. Forecasting*, **19**, 1011–1028.

Kalnay, E., and Coauthors, 1996: The NCEP/NCAR 40-Year Reanalysis Project. *Bull. Amer. Meteor. Soc.*, **77**, 437–471.

Karoly, D. J., 2009: The recent bushfires and extreme heat wave in southeast Australia. *Bull. Aust. Meteor. Oceanogr. Soc.*, **22**, 10–13.

——, and K. Braganza, 2005: A new approach to detection of anthropogenic temperature changes in the Australian region. *Meteor. Atmos. Phys.,* **89**, 57–67.

——, and Coauthors, 2012: Science underpinning the prediction and attribution of extreme events. WCRP Grand Challenge white paper, 5 pp. [Available online at http://www.wcrp-climate.org/documents/GC_Extremes.pdf.]

Kerr, R., 2013: In the hot seat. *Science*, **342**, 688–689.

Kim, Y. H., M.-K. Kim, and W.-S. Lee, 2008: An investigation of large-scale climate indices with the influence of temperature and precipitation variation in Korea. *Atmosphere*, **18**, 83–95. (In Korean with English abstract.)

Kistler, R., and Coauthors, 2001: The NCEP-NCAR 50-year reanalysis: Monthly means CD-ROM and documentation. *Bull. Amer. Meteor. Soc.*, **82**, 247–267.

Klein-Tank, A. M. G., and Coauthors, 2002: Daily dataset of 20th-century surface air temperature and precipitation series for the European Climate Assessment. *Int. J. Climatol.*, **22**, 1441–1453.

Knutson, T. R., F. Zeng, and A. T. Wittenberg, 2013a: Multimodel assessment of regional surface temperature trends: CMIP3 and CMIP5 Twentieth Century simulations. *J. Climate*, **26**, 8709–8743.

——, ——, and ——, 2013b: The extreme March 2012 warm anomaly over the eastern United States: Global context and multimodel trend analysis [in "Explaining Extreme Events of 2012 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **94** (9), S13–S17.

Knutti, R., and J. Sedláček, 2013: Robustness and uncertainties in the new CMIP5 climate model projections. *Nature Climate Change*, **3**, 369–373.

Kohonen, T., 2001: *Self-Organizing Maps.* 3rd ed. Springer Series in Information Sciences, Vol. 30, Springer, 501 pp.

Krishnamurthy, C. K. B., U. Lall, and H.-H. Kwon, 2009: Changing frequency and intensity of rainfall extremes over India from 1951 to 2003. *J. Climate*, **22**, 4737–4746.

Kumar, A., H. Wang, W. Wang, Y. Xue, and Z.-Z. Hu, 2013: Does knowing the oceanic PDO phase help predict the atmospheric anomalies in subsequent months? *J. Climate*, **26**, 1268–1285.

Kunkel, K. E., and Coauthors, 2013: Monitoring and understanding trends in extreme storms: State of knowledge. *Bull. Amer. Meteor. Soc.*, **94**, 499–514.

Lamarque, J.-F., and Coauthors, 2010: Historical (1850–2000) gridded anthropogenic and biomass burning emissions of reactive gases and aerosols: Methodology and application. *Atmos. Chem. Phys.*, **10**, 7017–7039, doi:10.5194/acp-10-7017-2010.

Langford, S., S. Stevenson, and D. Noone, 2014: Analysis of low-frequency precipitation variability in CMIP5 historical simulations for southwestern North America. *J. Climate*, **27**, 2735–2756.

Lau, W. K. M., and K.-M. Kim, 2011: The 2010 Pakistan flood and Russian heat wave: Teleconnection of hydrometeorological extremes. *J. Hydrometeor.*, **13**, 392–403.

Lewis, S. C., and D. J. Karoly, 2013: Anthropogenic contributions to Australia's record summer temperatures of 2013. *Geophys. Res. Lett.*, **40**, 3705–3709, doi:10.1002/grl.50673.

Li, C., and M. Yanai, 1996: The onset and interannual variability of the Asian summer monsoon in relation to land–sea thermal contrast. *J. Climate*, **9**, 358–375.

Li, H., J. Sheffield, and E. F. Wood, 2010a: Bias correction of monthly precipitation and temperature fields from Intergovernmental Panel on Climate Change AR4 models using equidistant quantile matching. *J. Geophys. Res.*, **115**, D10101, doi:10.1029/2009JD012882.

——, A. Dai, T. Zhou, and J. Lu, 2010b: Responses of East Asian summer monsoon to historical SST and atmospheric forcing during 1950–2000. *Climate Dyn.*, **34**, 501–514.

Lindenberg, J., H.-T. Mengelkamp, and G. Rosenhagen, 2012: Representativity of near surface wind measurements from coastal stations at the German Bight. *Meteor. Z.*, **21**, 99–106.

López-Moreno, J. I., 2005: Recent variations of snowpack depth in the Central Spanish Pyrenees. *Arct. Antarct. Alp. Res.*, **37**, 253–260.

——, and S. M. Serrano-Vicente, 2007: Atmospheric circulation influence on the interannual variability of snowpack in the Spanish Pyrenees during the second half of the twentieth century. *Nordic Hydrol.*, **38**, 38–44.

——, ——, and S. Lanjeri, 2007: Mapping of snowpack distribution over large areas using GIS and interpolation techniques. *Climate Res.*, **33**, 257–270.

——, ——, S. Beguería, A. M. El Kenawy, and M. Angulo, 2010: Trends in daily precipitation on the north-eastern Iberian Peninsula, 1955-2006. *Int. J. Climatol.*, **120**, 248–257.

Lorenz, R., E. B. Jaeger, and S. I. Seneviratne, 2010: Persistence of heat waves and its link to soil moisture memory. *Geophys. Res. Lett.*, **37**, L09703, doi:10.1029/2010GL042764.

Lott, F. C., N. Christidis, and P. A. Stott, 2013: Can the 2011 East African drought be attributed to human-induced climate change? *Geophys. Res. Lett.*, **40**, 1177–1181.

Mantua, N. J., S. R. Hare, Y. Zhang, J. M. Wallace, and R. C. Francis, 1997: A Pacific interdecadal climate oscillation with impacts on salmon production. *Bull. Amer. Meteor. Soc.*, **78**, 1069–1079.

Marshall, A. G., D. Hudson, M. C. Wheeler, O. Alves, H. H. Hendon, M. J. Pook, and J. S. Risbey, 2013: Intra-seasonal drivers of extreme heat over Australia in observations and POAMA-2. *Climate Dyn.*, doi:10.1007/s00382-013-2016-1.

Martin, J. E., 1999: Quasigeostrophic forcing of ascent in the occluded sector of cyclones and the trowal airstream. *Mon. Wea. Rev.*, **127**, 70–88.

Marty, C., 2008: Regime shift of snow days in Switzerland. *Geophys. Res. Lett.*, **35**, L12501, doi:10.1029/2008GL033998.

Marvel, K., and C. Bonfils, 2013: Identifying external influences on global precipitation. *Proc. Natl. Acad. Sci. USA*, **110**, 19301–19306.

Massey, N., and Coauthors, 2014: weather@home – development and validation of a very large ensemble modelling system for probabilistic event attribution. *Quart. J. Roy. Meteor. Soc.*, in press, doi:10.1002/qj.2455.

Mastrandrea, M. D., K. J. Mach, G.-K. Plattner, O. Edenhofer, T. F. Stocker, C. B. Field, K. L. Ebi, and P. R. Matschoss, 2011: The IPCC AR5 guidance note on consistent treatment of uncertainties: a common approach across the working groups. *Climate Change*, **108**, 675–691.

Matulla, C., W. Schöner, H. Alexandersson, H. von Storch, and X. Wang, 2007: European storminess: Late nineteenth century to present. *Climate Dyn.*, **31**, 125–130.

Mayes, B. E., J. M. Boustead, M. O'Malley, S. M. Fortin, and R. H. Grumm, 2009: Utilizing standardized anomalies to assess synoptic scale weather events in the central United States. Preprints, *23rd Conf. on Weather Analysis and Forecasting*, Omaha, NE, Amer. Meteor. Soc., 16B.3. [Available online at http://ams.confex.com/ams/pdfpapers/154217.pdf.]

McCabe, G. J., and M. D. Dettinger, 1999: Decadal variations in the strength of ENSO teleconnections with precipitation in the western United States. *Int. J. Climatol.*, **19**, 1399–1410.

McKee, T. B., and N. J. Doesken, 1997: Colorado Extreme Storm Precipitation Data Study. Climatology Rep. 97-1, Colorado Climate Center, Colorado State University, 109 pp. [Available online at http://climate.colostate.edu/pdfs/Climo_97-1_Extreme_ppt.pdf.]

Menne, M., I. Durre, R. Vose, B. Gleason, and T. Houston, 2012: An overview of the Global Historical Climatology Network-Daily database. *J. Atmos. Oceanic Technol.*, **29**, 897–910.

Met Office, cited 2014: Hot dry spell July 2013. [Available online at http://www.metoffice.gov.uk/climate/uk/interesting/2013-heatwave.]

Michelangeli, P.-A., R. Vautard, and B. Legras, 1995: Weather regimes: Recurrence and quasi-stationarity. *J. Atmos. Sci.*, **52**, 1237–1256.

Min, S.-K., X. Zhang, F. W. Zwiers, and G. C. Hegerl, 2011: Human contribution to more-intense precipitation extremes. *Nature*, **470**, 378–381, doi:10.1038/nature09763.

——, ——, ——, H. Shiogama, Y.-S. Tung, and M. Wehner, 2013: Multi-model detection and attribution of extreme temperature changes. *J. Climate*, **26**, 7430–7451.

Mishra, A., and J. Srinivasan, 2013: Did a cloud burst occur in Kedarnath during 16 and 17 June 2013. *Current Sci.*, **105**, 1351–1352.

Mitchell, T., and W. Blier, 1997: The variability of wintertime precipitation in the region of California. *J. Climate*, **10,** 2261–2276.

Molod, A., L. Takacs, M. Suarez, J. Bacmeister, I.-S. Song, and A. Eichmann, 2012: The GEOS-5 Atmospheric General Circulation Model: Mean climate and development from MERRA to Fortuna**.** NASA Tech. Rep. Series on Global Modeling and Data Assimilation, NASA TM—2012-104606, Vol. 28, 117 pp.

Moore, J. T., C. E. Graves, S. Ng, and J. L. Smith, 2005: A process-oriented methodology toward understanding the organization of an extensive mesoscale snowband: A diagnostic case study of 4–5 December 1999. *Wea. Forecasting*, **20**, 35–50.

Morak, S., G. C. Hegerl, and J. Kenyon, 2011: Detectable regional changes in the number of warm nights. *Geophys. Res. Lett.*, **38**, L17703, doi:10.1029/2011GL048531.

——, ——, and N. Christidis, 2013: Detectable changes in the frequency of temperature extremes. *J. Climate*, **26**, 1561–1574.

Morice, C. P., J. J. Kennedy, N. A. Rayner, and P. D. Jones, 2012: Quantifying uncertainties in global and regional temperature change using an ensemble of observational estimates: The HadCRUT4 dataset. *J. Geophys. Res.*, **117**, D08101, doi:10.1029/2011JD017187.

Mudelsee, M., M. Börngen, G. Tetzlaff, and U. Grünewald, 2003: No upward trends in the occurrence of extreme floods in central Europe. *Nature*, **425**, 166–169.

Nairn, J., and R. Fawcett, 2013: Defining heatwaves: Heatwave defined as a heat impact event servicing all community and business sectors in Australia. CAWCR Technical Report No. 060, 84 pp. [Available online at http://www.cawcr.gov.au/publications/technicalreports/CTR_060.pdf.]

Namias, J., 1978a: Recent drought in California and western Europe. *Rev. Geophys.*, **16**, 435–458.

——, 1978b: Multiple causes of the North American abnormal winter 1976–1977. *Mon. Wea. Rev.*, **106**, 279–295.

NASA Earth Observatory, cited 2014: MODIS TERRA imagery. [Available online at http://earthobservatory.nasa.gov/IOTD/view.php?id=82910.]

NCDC, 2005: *Storm Data*. NOAA/NESDIS National Climatic Data Center, **47** (10), 132 pp. [Available online at http://www.ncdc.noaa.gov/IPS/sd/sd.html.]

NCLIMDIV, 2014: NOAA's gridded climate divisional dataset. National Climatic Data Center, Asheville, NC, digital media, retrieved 05 June 2014. [Available online at http://www.ncdc.noaa.gov/cag.]

Neelin, J. D., B. Langenbrunner, J. E. Meyerson, A. Hall, and N. Berg, 2013: California winter precipitation change under global warming in the Coupled Model Intercomparison Project Phase 5 ensemble. *J. Climate*, **26**, 6238–6256.

New Zealand Treasury, 2013: Budget economic and fiscal update 2013. New Zealand Treasury, 176 pp. [Available online at http://www.treasury.govt.nz/budget/forecasts/befu2013/befu13-whole.pdf.]

Nicholls, N., 2004: The changing nature of Australian droughts. *Climatic Change*, **63**, 323–336.

NIDIS, cited 2014: National Integrated Drought Information System drought portal. [Available online at http://www.drought.gov/drought/news/ca-governor-signs-687-million-drought-plan.]

Nitschke, M., G. R. Tucker, and P. Bi, 2007: Morbidity and mortality during heatwaves in metropolitan Adelaide. *Med. J. Aust.*, **187**, 662–665.

NOAA, 2013: State of the climate: Global analysis for May 2013. [Available online at http://www.ncdc.noaa.gov/sotc/global/2013/5.]

NOAA NCDC, 2014: National overview: February 2014. [Available online at https://www.ncdc.noaa.gov/sotc/national/2014/2.]

Novak, D. R., L. F. Bosart, D. Keyser, and J. S. Waldstreicher, 2004: An observational study of cold season–banded precipitation in northeast U.S. cyclones. *Wea. Forecasting*, **19**, 993–1010.

Ogawa, F., H. Nakamura, K. Nishii, T. Miyasaka, and A. Kuwano-Yoshida, 2012: Dependence of the climatological axial latitudes of the tropospheric westerlies and storm tracks on the latitude of an extratropical oceanic front. *Geophys. Res. Lett.*, **39**, L05804, doi:10.1029/2011GL049922.

O'Gorman, P. A., and T. Schneider, 2009: The physical basis for increases in precipitation extremes in simulations of 21st-century climate change. *Proc. Natl. Acad. Sci. USA*, **106**, 14773–14777.

Omrani, N.-E., N. S. Keenlyside, J. Bader, and E. Manzini, 2014: Stratosphere key for wintertime atmospheric response to warm Atlantic decadal conditions. *Climate Dyn.*, **42**, 649–663.

Onogi, K., and Coauthors, 2007: The JRA-25 reanalysis. *J. Meteor. Soc. Japan*, **85**, 369–432.

Otto, F. E. L., N. Massey, G. J. van Oldenborgh, R. G. Jones, and M. R. Allen, 2012: Reconciling two approaches to attribution of the 2010 Russian heat wave. *Geophys. Res. Lett.*, **39**, L04702, doi:10.1029/2011GL050422.

Pall, P., T. Aina, D. A. Stone, P. A. Stott, T. Nozawa, A. G. J. Hilberts, D. Lohmann, and M. R. Allen, 2011: Anthropogenic greenhouse gas contribution to flood risk in England and Wales in autumn 2000. *Nature*, **470**, 382–385, doi:10.1038/nature09762.

Pekárová, P., D. Halmová, V. B. Mitková, P. Miklánek, J. Pekár, and P. Škoda, 2013: Historic flood marks and flood frequency analysis of the Danube River at Bratislava, Slovakia. *J. Hydrol. Hydromech.*, **61**, 326–333.

Perkins, S. E., and L. V. Alexander, 2013: On the measurement of heat waves. *J. Climate*, **26**, 4500–4517.

——, and E. M. Fischer, 2013: The usefulness of different realizations from the model evaluation of regional trends in heat waves. *Geophys. Res. Lett.,* **40**, 5793–5797, doi:10.1002/2013GL057833.

Peters, G. P., and Coauthors, 2012: The challenge to keep global warming below 2°C. *Nature Climate Change*, **3**, 4–6, doi:10.1038/nclimate1783.

Peterson, T. C., and Coauthors, 2008: Why weather and climate extremes matter. *Weather and Climate Extremes in a Changing Climate. Regions of Focus: North America, Hawaii, Caribbean, and U.S. Pacific Islands*. T. R. Karl et al., Eds., U.S. Climate Change Science Program and the Subcommittee on Global Change Research, 11–33.

Petoukhov, V., and V. Semenov, 2010: A link between reduced Barents-Kara sea ice and cold winter extremes over northern continents. *J. Geophys. Res.*, **115**, D21111, doi:10.1029/2009JD013568.

——, S. Rahmstorf, S. Petri, and H. J. Schellnhuber, 2013: Quasiresonant amplification of planetary waves and recent Northern Hemisphere weather extremes. *Proc. Natl. Acad. Sci. USA*, **110**, 5336–5341.

Pierce, D. W., 2002: The role of sea surface temperatures in interactions between ENSO and the North Pacific oscillation. *J. Climate*, **15**, 1295–1308.

Pinto, J. G., N. Bellenbaum, M. K. Karremann, and P. M. Della-Marta, 2013: Serial clustering of extratropical cyclones over the North Atlantic and Europe under recent and future climate conditions. *J. Geophys. Res. Atmos.*, **118**, 12476–12485, doi:10.1002/2013JD020564.

Polade, S. D., A. Gershunov, D. R. Cayan, M. D. Dettinger, and D. W. Pierce, 2013: Natural climate variability and teleconnections to precipitation over the Pacific-North American region in CMIP3 and CMIP5 models. *Geophys. Res. Lett.*, **40**, 2296–2301.

——, D. W. Pierce, D. R. Cayan, A. Gershunov, and M. D. Dettinger, 2014: The key role of dry days in changing regional climate and precipitation regimes. *Sci. Rep.*, **4**, 4364, doi:10.1038/srep04364.

Pope, V. D., M. L. Gallani, P. R. Rowntree, and R. A. Stratton, 2000: The impact of new physical parametrizations in the Hadley Centre climate model: HadAM3. *Climate Dyn.*, **16**, 123–146, doi:10.1007/s003820050009.

Porteous, A., and B. Mullan, 2013: The 2012-13 drought: An assessment and historical perspective. MPI Tech. Paper No. 2012/18. Ministry for Primary Industries/National Institute of Water & Atmospheric Research, 57 pp. [Available online at http://www.niwa.co.nz/sites/niwa.co.nz/files/2013-18-The%202012-13%20drought%20an%20assessment%20and%20historical%20perspective.pdf.]

Power, S., T. Casey, C. Folland, A. Colman, and V. Mehta, 1999: Inter-decadal modulation of the impact of ENSO on Australia. *Climate Dyn.*, **15**, 319–324.

——, M. Haylock, R. Colman, and X. Wang, 2006: The predictability of interdecadal changes in ENSO activity and ENSO teleconnections. *J. Climate*, **19**, 4755–4771.

Prakash, S., 2013: Brief Report on visit to Alaknanda Valley, Uttarakhand Himalaya during 22-24 June 2013. [India] National Institute of Disaster Management, [12 pp.] [Available online at http://www.nidm.gov.in/pdf/Uttarakhand%20Disaster.pdf.]

PRISM, 2014: PRISM climate data. PRISM Climate Group, Oregon State University, Corvallis, OR, digital media, retrieved 10 Feb 2014. [Available online at http://prism.oregonstate.edu.]

Qian, C., and T. Zhou, 2014: Multidecadal variability of North China aridity and its relationship to PDO during 1900-2010. *J. Climate*, **27**, 1210–1222.

Qian, Y., L. Leung, S. Ghan, and F. Giorgi, 2003: Regional climate effects of aerosols over China: Modeling and observation. *Tellus*, **55B**, 914–934.

——, D. Gong, J. Fan, L. Leung, R. Bennartz, D. Chen, and W. Wang, 2009: Heavy pollution suppresses light rain in China: Observations and modeling. *J. Geophys. Res.*, **114**, D00K02, doi:10.1029/2008JD011575.

Rajeevan, M., S. Gadgil, and J. Bhate, 2010: Active and break spells of the Indian summer monsoon. *J. Earth Sys. Sci.*, **119**, 229–247.

Rayner, N. A., D. E. Parker, E. B. Horton, C. K. Folland, L. V. Alexander, D. P. Rowell, E. C. Kent, and A. Kaplan, 2003: Global analyses of sea surface temperature, sea ice, and night marine air temperature since the late nineteenth century. J. *Geophys. Res.*, **108** (D14), 4407, doi:10.1029/2002JD002670.

Rienecker, M. M., and Coauthors, 2008: The GEOS-5 data assimilation system—Documentation of versions 5.0.1, 5.1.0, and 5.2.0. NASA Tech. Rep. Series on Global Modeling and Data Assimilation, NASA/TM-2007-104606, Vol. 27, 95 pp.

——, and Coauthors, 2011: MERRA: NASA's Modern-Era Retrospective Analysis for Research and Applications. *J. Climate*, **24**, 3624–3648.

Rupp, D. E., P. W. Mote, N. Massey, C. J. Rye, R. Jones, and M. R. Allen, 2012: Did human influence on climate make the 2011 Texas drought more probable? [in "Explaining Extreme Events of 2011 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **93**, 1052–1067.

——, ——, ——, F. E. L. Otto, and M. R. Allen, 2013: Human influence on the probability of low precipitation in the Central United States in 2012 [in "Explaining Extreme Events of 2012 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **94** (9), S2–S6.

Sampe, T., H. Nakamura, A. Goto, and W. Ohfuchi, 2010: Significance of a midlatitude SST frontal zone in the formation of a storm track and an eddy-driven westerly jet. *J. Climate*, **23**, 1793–1814.

Schaer, C., P. L. Vidale, D. Luethi, C. Frei, C. Haeberli, M. A. Liniger, and C. Appenzeller, 2004: The role of increasing temperature variability in European summer heatwaves. *Nature*, **427**, 332–336.

Schmidt, H., and H. von Storch, 1993: German Bight storms analysed. *Nature*, **365**, 791–791.

Schneider, U., A. Becker, P. Finger, A. Meyer-Christoffer, M. Ziese, and B. Rudolf, 2014: GPCC's new land surface precipitation climatology based on quality-controlled in situ data and its role in quantifying the global water cycle. *Theor. Appl. Climatol.*, **115**, 15–40, doi:10.1007/s00704-013-0860-x.

Schubert, S., and Coauthors, 2009: A U.S. CLIVAR project to assess and compare the responses of global climate models to drought-related SST forcing patterns: Overview and results. *J. Climate*, **22**, 5251–5272.

——, H. Wang, R. Koster, M. Suarez, and P. Groisman, 2014: Northern Eurasian heat waves and droughts. *J. Climate,* **27**, 3169–3207.

Schwartz, R. M., and T. W. Schmidlin, 2002: Climatology of blizzards in the conterminous United States, 1959-2000. *J. Climate*, **15**, 1765–1772.

Screen, J. A., I. Simmonds, C. Deser, and R. Tomas, 2013: The atmospheric response to three decades of observed Arctic sea ice loss. *J. Climate*, **26**, 1230–1248.

Seneviratne, S. I., 2012: Climate science: Historical drought trends revisited. *Nature*, **491**, 338–339.

——, T. Corti, E. L. Davin, M. Hirschi, E. B. Jaeger, I. Lehner, B. Orlowsky, and A. J. Teuling, 2010: Investigating soil moisture-climate interactions in a changing climate: A review. *Earth-Sci. Rev.*, **99**, 125–161.

——, M. G. Donat, B. Mueller, and L. V. Alexander, 2014: No pause in the increase of hot temperature extremes. *Nature Climate Change*, **4**, 161–163, doi:10.1038/nclimate2145.

Sewall, J. O., 2005: Precipitation shifts over western North America as a result of declining Arctic sea ice cover: The coupled system response. *Earth Interact.*, **9**, 1–23, doi:10.1175/EI171.1.

Sheffield, J., E. F. Wood, and M. L. Roderick, 2012: Little change in global drought over the past 60 years. *Nature*, **491**, 435–438.

——, and Coauthors, 2013: North American climate in CMIP5 experiments. Part I: Evaluation of historical simulations of continental and regional climatology. *J. Climate*, **26**, 9209–9245.

Sherwood, S., and Q. Fu, 2014: A drier future? *Science*, **343**, 737–738.

Shiogama, H., M. Watanabe, Y. Imada, M. Mori, M. Ishii, and M. Kimoto, 2013: An event attribution of the 2010 drought in the south Amazon region using the MIROC5 model. *Atmos. Sci. Lett.*, **14**, 170–175.

Siderius, C., and Coauthors, 2013: Snowmelt contributions to discharge of the Ganges. *Sci. Total Environ.*, **468–469** (Suppl.), S93–S101, doi:10.1016/j.scitotenv.2013.05.084.

Sillmann, J., V. V. Kaharin, F. W. Zwiers, X. Zhang, and D. Bronaugh, 2013: Climate extreme indicies in the CMIP5 multimodel ensemble: Part 2. Future climate projections. *J. Geophys. Res. Atmos.*, **118**, 2473–2493, doi:10.1002/jgrd.50188.

——, M. G. Donat, J. C. Fyfe, and F. W. Zwiers, 2014: Observed and simulated temperature extremes during the recent warming hiatus. *Environ. Res. Lett.*, **9**, 064023, doi:10.1088/1748-9326/9/6/064023.

Singh, D., M. Tsiang, B. Rajaratnam, and N. S. Diffenbaugh, 2014: Observed changes in extreme wet and dry spells during the South Asian summer monsoon season. *Nature Climate Change*, **4**, 456–461.

Slingo, J., 2013: Why was the start to spring 2013 so cold? Met Office briefing note, April 2013. [Available online at http://www.metoffice.gov.uk/research/news/cold-spring-2013.]

Smith, T. M., R. W. Reynolds, T. C. Peterson, and J. Lawrimore, 2008: Improvements to NOAA's historical merged land-ocean surface temperature analysis (1880-2006). *J. Climate*, **21**, 2283–2296.

Solomon, A., and M. Newman, 2012: Reconciling disparate twentieth-century Indo-Pacific Ocean temperature trends in the instrumental record. *Nature Climate Change*, **2**, 691–699.

Song, F., T. Zhou, and Y. Qian, 2014: Responses of East Asian summer monsoon to natural and anthropogenic forcings in the 17 latest CMIP5 models. *Geophys. Res. Lett.*, **41**, 596–603, doi:10.1002/2013GL058705.

Sperber, K. R., H. Annamalai, I.-S. Kang, A. Kitoh, A. Moise, A. Turner, B. Wang, and T. Zhou, 2013: The Asian summer monsoon: An intercomparison of CMIP5 vs. CMIP3 simulations of the late 20th century. *Climate Dyn.*, **41**, 2711–2744.

Stark, J. D., C. J. Donlon, M. J. Martin, and M. E. McCulloch, 2007: OSTIA: An operational, high resolution, real time, global sea surface temperature analysis system. *Oceans 2007 - Europe*, Aberdeen, Scotland, IEEE, Vols. 1–3, 331–334, doi:10.1109/OCEANSE.2007.4302251.

Stocker, T. F., and Coauthors, Eds., 2014: *Climate Change 2013: The Physical Science Basis*. Cambridge University Press, 1535 pp.

Stone, D. A., and M. R. Allen, 2005: Attribution of global surface warming without dynamical models. *Geophys. Res. Lett.*, **32**, L18711, doi:10.1029/2005GL023682.

——, ——, P. A. Stott, P. Pall, S.-K. Min, T. Nozawa, and S. Yukimoto, 2009: The detection and attribution of human influence on climate. *Ann. Rev. Environ. Res.*, **34**, 1–16.

Stott, P. A., D. A. Stone, and M. R. Allen, 2004: Human contribution to the European heatwave of 2003. *Nature*, **432**, 610–614, doi:10.1038/nature03089.

Sutton, R. T., and B.-W. Dong, 2012: Atlantic Ocean influence on a shift in European climate in the 1990s. *Nature Geosci.*, **5**, 788–792, doi:10.1038/ngeo1595.

——, and P. P. Mathieu, 2002: Response of the atmosphere–ocean mixed-layer system to anomalous ocean heat-flux convergence. *Quart. J. Roy. Meteor. Soc.*, **128**, 1259–1275.

Swart, N. C., and J. C. Fyfe, 2012: Observed and simulated changes in the Southern Hemisphere surface westerly wind-stress. *Geophys. Res. Lett.*, **39**, L16711, doi:10/1029/2012GL052810.

Tait, A., R. Henderson, R. Turner, and X. Zheng, 2006: Thin plate smoothing spline interpolation of daily rainfall for New Zealand using a climatological rainfall surface. *Int. J. Climatol.*, **26**, 2097–2115.

Taylor, K. E., R. J. Stouffer, and G. A. Meehl, 2012: An overview of CMIP5 and the experiment design. *Bull. Amer. Meteor. Soc.,* **93**, 485–498.

Thompson, D. W. J., S. Solomon, P. J. Kushner, M. H. England, K. M. Grise, and D. J. Karoly, 2011: Signatures of the Antarctic ozone hole in Southern Hemisphere surface climate change. *Nature Geosci.*, **4**, 741–749, doi:10.1038/ngeo1296.

Trenberth, K. E., 2011: Changes in precipitation with climate change. *Climate Res.*, **47**, 123–138.

——, G. Branstator, and P. Arkin, 1988: Origins of the 1988 American drought. *Science*, **242**, 1640–1645.

——, A. Dai, G. van der Schrier, P. D. Jones, J. Barichivich, K. R. Briffa, and J. Sheffield, 2014: Global warming and changes in drought. *Nature Climate Change*, **4**, 17–22.

Trewin, B., 2012: A daily homogenized temperature data set for Australia. *Int. J. Climatol.*, **33**, 1510–1529, doi:10.1002/joc.3530.

Trigo, R. M., and Coauthors, 2013: The record winter drought of 2011-12 in the Iberian Peninsula [in "Explaining Extreme Events of 2012 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **94** (9), S41–S45.

Uccellini, L. W., and P. J. Kocin, 1987: The interaction of jet streak circulations during heavy snow events along the East Coast of the United States. *Wea. Forecasting*, **2**, 289–308.

Ullah, K., and G. Shouting, 2013: A diagnostic study of convective environment leading to heavy rainfall during the summer monsoon 2010 over Pakistan. *Atmos. Res.*, **120–121**, 226–239.

USBR, 2014: Reclamation announces initial 2014 Central Valley Project water supply allocation. United States Bureau of Reclamation, news release, 21 February 2014. [Available online at http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=46045.]

USDA, 2014a: Obama Administration announces additional assistance to Californians impacted by drought. United States Department of Agriculture, news release, 0022.14. [Available online at http://www.usda.gov/wps/portal/usda/usdamediafb?contentid=2014/02/0022.xml&printable=true&contentidonly=true.]

——, 2014b: Secretarial Disaster Designations - 2014 Crop Year. All Crop - Total Counties by State (updated 9/3/2014). United States Department of Agriculture. [Available online at http://www.usda.gov/documents/2014-all-crop-list-counties.pdf.]

USGS, cited 2014: California Water Science Center. [Available online at http://ca.water.usgs.gov/data/drought/drought-impact.html.]

van Haren, R., G. J. van Oldenborgh, G. Lenderink, and W. Hazeleger, 2013a: Evaluation of modeled changes in extreme precipitation in Europe and the Rhine basin. *Environ. Res. Lett.*, **8**, 014053, doi:10.1088/1748-9326/8/1/014053.

——, ——, ——, M. Collins, and W. Hazeleger, 2013b: SST and circulation trend biases cause an underestimation of European precipitation trends. *Climate Dyn.*, **40**, 1–20.

van Oldenborgh, G. J., A. van Urk, and M. Allen, 2012: The absence of a role of climate change in the 2011 Thailand floods. *Bull. Amer. Meteor. Soc.*, **93**, 1047–1049.

——, F. J. Doublas Reyes, S. S. Dirjfhout, and E. Hawkins, 2013: Reliability of regional climate model trends. *Environ. Res. Lett.*, **8**, 014055, doi:10.1088/1748-9326/8/1/014055.

Vautard, R., and P. Yiou, 2009: Control of recent European surface climate change by atmospheric flow. *Geophys. Res. Lett.*, **36**, L22702, doi:10.1029/2009GL040480.

——, and Coauthors, 2007: Summertime European heat and drought waves induced by wintertime Mediterranean rainfall deficit. *Geophys. Res. Lett.*, **34**, L07711, doi:10.1029/2006GL028001.

VegDRI, cited 2014: Vegetation drought response index. [Available online at http://vegdri.unl.edu/.]

Vicente-Serrano, S. M., R. M. Trigo, J. I. López-Moreno, M. L. R. Liberato, J. Lorenzo-LaCruz, S. Beguería, E. Morán-Tejada, and A. El Kenawy, 2011: Extreme winter precipitation in the Iberian Peninsula in 2010: Anomalies, driving mechanisms and future projections. *Climate Res.*, **46**, 51–65.

Visbeck, M. H., J. W. Hurrell, L. Polvani, and H. M. Cullen, 2001: The North Atlantic Oscillation: Past, present, and future. *Proc. Natl. Acad. Sci. USA*, **98**, 12876–12877.

Vose, R. S., R. L. Schmoyer, P. M. Steurer, T. C. Peterson, R. Heim, T. R. Karl, and J. K. Eischeid, 1992: The Global Historical Climatology Network: Long-term monthly temperature, precipitation, sea level pressure, and station pressure data. ORNL/CDIAC-53, NCDP-041, 325 pp.

——, and Coauthors, 2014: Improved historical temperature and precipitation time series for U.S. climate divisions. *J. App. Meteor. Climatol.*, **53**, 1232–1251.

Wakabayashi, S., and R. Kawamura, 2004: Extraction of major teleconnection patterns possibly associated with the anomalous summer climate in Japan. *J. Meteor. Soc. Japan*, **82**, 1577–1588.

Wallace, J. M., I. M. Held, D. W. J. Thompson, K. E. Trenberth, and J. E. Walsh, 2014: Global warming and winter weather. *Science*, **343**, 729–730, doi:10.1126/science.343.6172.729.

Wang, B., B. Xiang, and J.-Y. Lee, 2013: Subtropical high predictability establishes a promising way for monsoon and tropical storm predictions. *Proc. Natl. Acad. Sci. USA*, **110**, 2718–2722.

Wang, S.-Y., R. E. Davies, W.-R. Huang, and R. R. Gillies, 2011: Pakistan's two-stage monsoon and links with the recent climate change. *J. Geophys. Res.*, **116**, D16114, doi:10.1029/2011JD015760.

——, L. Hipps, R. R. Gillies, and J.-H. Yoon, 2014: Probable causes of the abnormal ridge accompanying the 2013–2014 California drought: ENSO precursor and anthropogenic warming footprint. *Geophys. Res. Lett.*, **41**, 3220–3226, doi:10.1002/2014GL059748.

Watanabe, M., and Coauthors, 2010: Improved climate simulation by MIROC5: Mean states, variability, and climate sensitivity. *J. Climate*, **23**, 6312–6335.

Water CA, cited 2014: California Department of Water Resources. [Available online at http://www.water.ca.gov/waterconditions/.]

Webster, P. J., V. O. Magaña, T. N. Palmer, J. Shukla, R. A. Tomas, M. Yanai, and T. Yasunari, 1998: Monsoons: Processes, predictability, and the prospects for prediction. *J. Geophys. Res.*, **103** (C7), 14451–14510, doi:10.1029/97JC02719.

——, V. E. Toma, and H.-M. Kim, 2011: Were the 2010 Pakistan floods predictable? *Geophys. Res. Lett.*, **38**, L04806, doi:10.1029/2010GL046346.

Weisse, R., H. von Storch, and F. Feser, 2005: Northeast Atlantic and North Sea storminess as simulated by a regional climate model during 1958-2001 and comparison with observations. *J. Climate*, **18**, 465–479.

Wen, Q. H., X. Zhang, Y. Xu, and B. Wang, 2013: Detecting human influence on extreme temperatures in China. *Geophys. Res. Lett.*, **40**, 1171–1176, doi:10.1002/grl.50285.

Westra, S., L. V. Alexander, and F. W. Zwiers, 2013: Global increasing trends in annual maximum daily precipitation. *J. Climate*, **26**, 3904–3918.

Wheeler, M. C., and H. H. Hendon, 2004: An all season real-time multivariate MJO index: Development of an index for monitoring and prediction. *Mon. Wea. Rev.*, **132**, 1917–1932.

Wilks, D. S. 2006: *Statistical Methods in the Atmospheric Sciences*. International Geophysics Series, Vol. 91, Elsevier Academic Press, 627 pp.

WMO, 2010: Guide to meteorological instruments and methods of observation. WMO No. 8. World Meteorological Society, 437 pp. [Available online at http://www.wmo.int/pages/prog/www/IMOP/CIMO-Guide.html.]

——, 2013: The state of greenhouse gases in the atmosphere based on global observations through 2012. *WMO Greenhouse Gas Bulletin*, No. 9, 4 pp.

Wu, G., Y. Liu, B. He, Q. Bao, A. Duan, and F.-F. Jin, 2012: Thermal controls on the Asian summer monsoon. *Sci. Rep.*, **2**, Article 404, doi:10.1038/srep00404.

Wu, L., and Coauthors, 2012: Enhanced warming over the global subtropical western boundary currents. *Nature Climate Change*, **29**, 161–166.

Xavier, P. K., C. Marzin, and B. N. Goswami, 2007: An objective definition of the Indian summer monsoon season and a new perspective on the ENSO–monsoon relationship. *Quart. J. Roy. Meteor. Soc.,* **133**, 749–764.

Yiou, P., and J. Cattiaux, 2013: Contribution of atmospheric circulation to wet north European summer precipitation of 2012[in "Explaining Extreme Events of 2012 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **94** (9), S39–S41.

——, R. Vautard, P. Naveau, and C. Cassou, 2007: Inconsistency between atmospheric dynamics and temperatures during the exceptional 2006/2007 fall/winter and recent warming in Europe. *Geophys. Res. Lett.*, **34**, L21808, doi:10.1029/2007GL031981.

——, K. Goubanova, Z. X. Li, and M. Nogaj, 2008: Weather regime dependence of extreme value statistics for summer temperature and precipitation. *Nonlin. Processes Geophys.*, **15**, 365–378, doi:10.5194/npg-15-365-2008.

Yu, R., and T. Zhou, 2007: Seasonality and three-dimensional structure of the interdecadal change in East Asian monsoon. *J. Climate*, **20**, 5344–5355.

——, B. Wang, and T. Zhou, 2004: Tropospheric cooling and summer monsoon weakening trend over East Asia. *Geophys. Res. Lett.*, **31**, L22212, doi:10.1029/2004GL021270.

Zhang, X., F. W. Zwiers, G. C. Hegerl, F. H. Lambert, N. P. Gillett, S. Solomon, P. A. Stott, and T. Nozawa, 2007: Detection of human influence on twentieth-century precipitation trends. *Nature*, **448**, 461–465.

——, H. Wan, F. W. Zwiers, G. C. Hegerl, and S.-K. Min, 2013: Attributing intensification of precipitation extremes to human influence. *Geophys. Res. Lett.*, **40**, 5252–5257, doi:10.1002/grl.51010.

Zhou, T., D. Gong, J. Li, and B. Li, 2009: Detecting and understanding the multi-decadal variability of the East Asian Summer Monsoon - Recent progress and state of affairs. *Meteor. Z.*, **18**, 455–467.

——, F. Song, R. Lin, X. Chen, and X. Chen, 2013: The 2012 North China floods: Explaining an extreme rainfall event in the context of a long-term drying tendency [in "Explaining Extreme Events of 2012 from a Climate Perspective"]. *Bull. Amer. Meteor. Soc.*, **94** (9), S49–S51.

Zolina, O., C. Simmer, A. Kapala, P. Shabanov, P. Becker, H. Mächel, S. Gulev, and P. Groisman, 2013: New view on precipitation variability and extremes in Central Europe from a German high resolution daily precipitation dataset: Results from STAMMEX project *Bull. Amer. Meteor. Soc.*, **95**, 995–1002.

Zwiers, F. W., X. Zhang, and Y. Feng, 2011: Anthropogenic influence on long return period daily temperature extremes at regional scales. *J. Climate*, **24**, 881–892.