

## GLOBALLY, CLIMATE CHANGE HAD A DIRECT HAND IN

IMPACT	STUDIES
<b>WARMING</b>	
Long-term temperature change	(Ribe et al., 2017; Lott et al., 2013; Jones et al., 2013; Zhou and Tung, 2013; Wigley and Santer, 2012; Santer et al., 2013b; Kemp and Horton, 2013; Christidis et al., 2010; Allen et al., 2006; Zhang et al., 2006; Gillett et al., 2003; Stott, 2003; Jones et al., 2003; Zwiers and Zhang, 2003; Tett et al., 2002; Stott et al., 2001; Tett et al., 1999; North and Stevens, 1998; Hegerl et al., 1997; Hegerl et al., 1996; Santer et al., 1996; Santer et al., 1995)
Hot and cold extremes	(Van Oldenborgh, 2018; Dittus and Karoly, 2016; Christidis and Stott, 2016; Kim et al., 2015; Fischer and Knutti, 2014; Min et al., 2013; Morak et al., 2013; Zwiers et al., 2011; Christidis et al., 2005)
Seasonal changes	(Knutson and Ploshay, 2016; Kamae et al., 2014; Christidis and Stott, 2014; Stott et al., 2011; Jones et al., 2008)
Record hot years	(Knutson et al., 2018; King, 2017; Mann et al., 2017a; Kam et al., 2017; King et al., 2016; Record Hot Year, 2015; Rahmstorf and Coumou, 2011)
Daily temperature extremes	(Wehner et al., 2018; Van Oldenborgh, 2018; Li et al., 2018; Christidis et al., 2011a)
<b>AVERAGE PRECIPITATION</b>	
Average precipitation change	(Wan et al., 2014; Polson and Hegerl, 2013; Min et al., 2008a; Zhang et al., 2007)
<b>ATMOSPHERIC MOISTURE CONTENT</b>	
Atmospheric moisture content increase	(Sarojini et al., 2012; Santer et al., 2009; Willett et al., 2007; Santer et al., 2007)
<b>EXTREME PRECIPITATION</b>	
Record-breaking precipitation	(Lehner et al., 2018; Abatzoglou et al., 2014; Morak et al., 2011; Bonfils et al., 2007)
Moderate precipitation extremes	(Huang et al., 2018)
Heavy precipitation extremes	(Van Der Wiel et al., 2016; Wang et al., 2016)
<b>SEA SURFACE TEMPERATURE</b>	
Marine heatwave increase	(Frölicher et al., 2018)
Global oceans and sea surface temperature increase	(Newman et al., 2018; Kam et al., 2016; Weller et al., 2016b; Ting et al., 2009; Gillett et al., 2008b; Santer et al., 2006; Weller et al., 2016c)

Upper ocean warming	(Gleckler et al., 2012)
<b>CORAL BLEACHING</b>	
Great Barrier Reef coral bleaching in March 2016	(King, 2016)
<b>OCEAN HEAT CONTENT</b>	
Global ocean heat content increase	(Balmaseda et al., 2013; Pierce and Barnett, 2006; Barnett et al., 2005; Reichert et al., 2002; Levitus et al., 2001; Barnett et al., 2001)
Arctic ocean heat content increase	(Lind et al., 2018)
Southern Ocean heat content increase	(Fyfe, 2006; Banks et al., 2000)
Indo-Pacific warm pool expansion	(Weller et al., 2016a)
<b>SEA LEVEL RISE</b>	
Global long-term sea level rise	(Marcos et al., 2017; Slangen et al., 2016; Dangendorf et al., 2015; Slangen et al., 2014; Marcos and Amores, 2014; Jevrejeva et al., 2009)
<b>ARCTIC WARMING</b>	
Arctic warmth in 2016	(Kam et al., 2018; Sun et al., 2017; Van Oldenborgh et al., 2016)
Arctic long-term temperature change	(Najafi et al., 2015; Chylek et al., 2014; Fyfe et al., 2013; Gillett et al., 2008a)
<b>ARCTIC SEA ICE</b>	
Arctic sea ice loss	(Notz and Stroeve, 2016; Notz and Marotzke, 2012; Min et al., 2008b)
Sea of Okhotsk record low minimum sea ice extent in 2015	(Paik et al., 2017)
Northern hemisphere record low winter sea ice maximum in 2015	(Fučkar et al., 2017)
Northern Hemisphere record low summer sea ice minimum in 2012	(Kirchmeier-Young, 2016; Zhang and Knutson, 2013; Guemas et al., 2013)
Arctic sea ice loss and the “warm Arctic, cold Siberia” pattern	(Zhang et al., 2018)
<b>SNOW COVER EXTENT</b>	
Northern hemisphere spring snow cover extent	(Najafi et al., 2016; Rupp and Mote, 2013)
<b>GLACIER MELT</b>	
Glacier mass loss	(Marzeion et al., 2014)

<b>DRYING</b>	
Warmer and drier land areas	(Chan and Wu, 2015)
<b>ATMOSPHERIC STRUCTURE</b>	
Tropospheric warming and expansion	(Christidis and Stott, 2015; Santer et al., 2013a; Santer et al., 2003)
Sea level pressure change	(Gillett et al., 2013; Gillett and Stott, 2009; Gillett et al., 2003)
<b>LARGE-SCALE CIRCULATION</b>	
Planetary wave stalling	(Mann et al., 2017b)
Hadley cell widening	(Kim et al., 2017)
Atmospheric storminess	(Wang et al., 2008)
<b>TROPICAL CYCLONE ACTIVITY</b>	
Tropical cyclone activity	(Zhang et al., 2017; Holland and Bruyère, 2014; Mann and Emanuel, 2011)
<b>OCEAN CHEMISTRY</b>	
Acidification increase	(Sutton et al., 2016; Friedrich et al., 2012)
Oxygen content decrease	(Andrews et al., 2013)
Salinity changes	(Pierce et al., 2012; Terray and Corre, 2012; Stott et al., 2008; Banks et al., 2000)
<b>BIOLOGICAL SYSTEMS</b>	
Biological systems change	(Mao et al., 2016; Rosenzweig et al., 2008; Christidis et al., 2007)
<b>FLOOD RISK</b>	
Major flood frequency increase	(Milly et al., 2002)

*Climate change detection and attribution studies are broken down into two broad groups: US and global. Within the two groups, the studies are categorized by the subject of each study's detection or attribution finding. Finally, studies within each category are grouped together by impact. Impacts are trends or events affected by climate change.*