

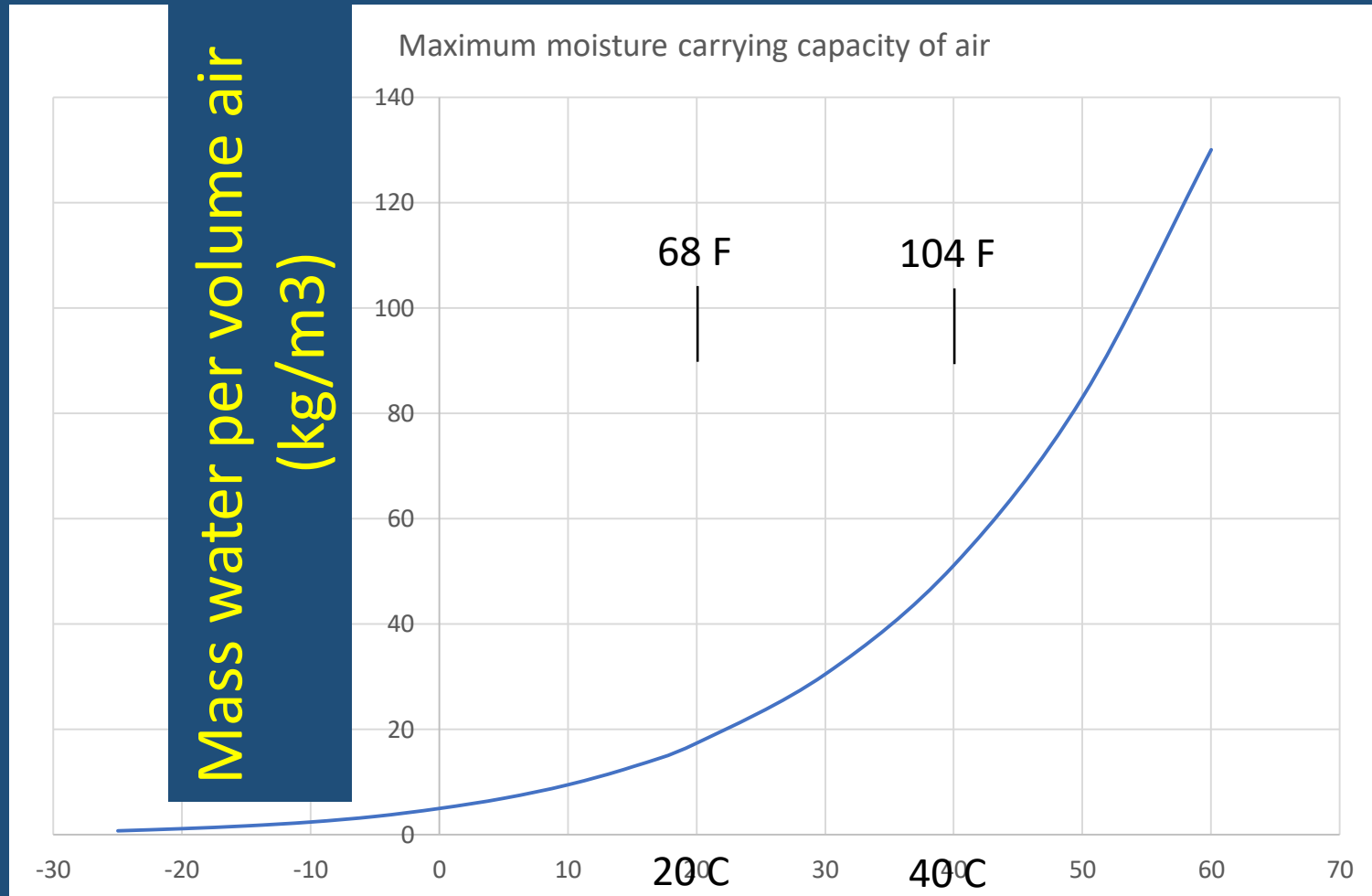
Too Much Water

Compiled by Phil Nelson,
2017



Maximum moisture carrying capacity of air

The Engineering Toolbox Jan 2017



Temperature (deg C)



Downdraft of precipitation from
a young Cumulonimbus



Tower cumulus building
into a thunderstorm.

Floods aka “Extreme Rainfall”

Attribution confidence for extreme rainfall: medium

Pakistan 2010

worst flooding in
Pakistan's history

National
Geographic



Grocery shopping in Thailand 2011

worst floods in 50 years

National Geographic



Nigeria 2012

worst floods in a
half century

National
Geographic



The Ganges River overflows, 2016



Joydeep Mukherjee, 2016

Lifting houses to escape Chennai floods

India Climate Dialogue, Gopikrishna Warner 2 Nov 2016

In November-December 2015, the city received the highest rainfall in 100 years. This – combined with the reduction of the wetlands and waterways system in the city – led to floods of the kind that left their mark on the walls of buildings and also the minds of people



A building being lifted in Chennai, India. Memories of the ruinous floods in Chennai last year, partially blamed on climate change, have prompted many residents to raise the height of their houses to avoid getting inundated *Photo by G. Warner*

Southern England 2014

wettest Dec-Jan
since 1876

National
Geographic



A Christmas letter from my old friend Alan in northern England, 2015

“Last Saturday night Storm Desmond dumped 8 inches rain on the Lake District causing widespread floods and landslides. Here Ullswater rose 6 feet and washed away our lovely, 250 years old, stone bridge. Downstream another old bridge was damaged and closed.

So access to Penrith is hard, particularly for Katy and family who commute there for work and school. Some villages are cut off completely and have no electricity, telephone and internet connection. Not very Christmassy I'm afraid. Still we have most of the family here for Christmas. “

UK's Storm Desmond, December 2015 A fierce Atlantic storm, Desmond, struck parts of northern England, southern Scotland and Ireland, with 13.44 inches of rain falling in Cumbria – a new national record for rainfall accumulation in 24-hours.

Three analyses: 1, statistical analyses of the historical temperature record, 2, the trend in a global coupled climate model, and 3, the results of thousands of simulations of possible weather with a regional climate model.

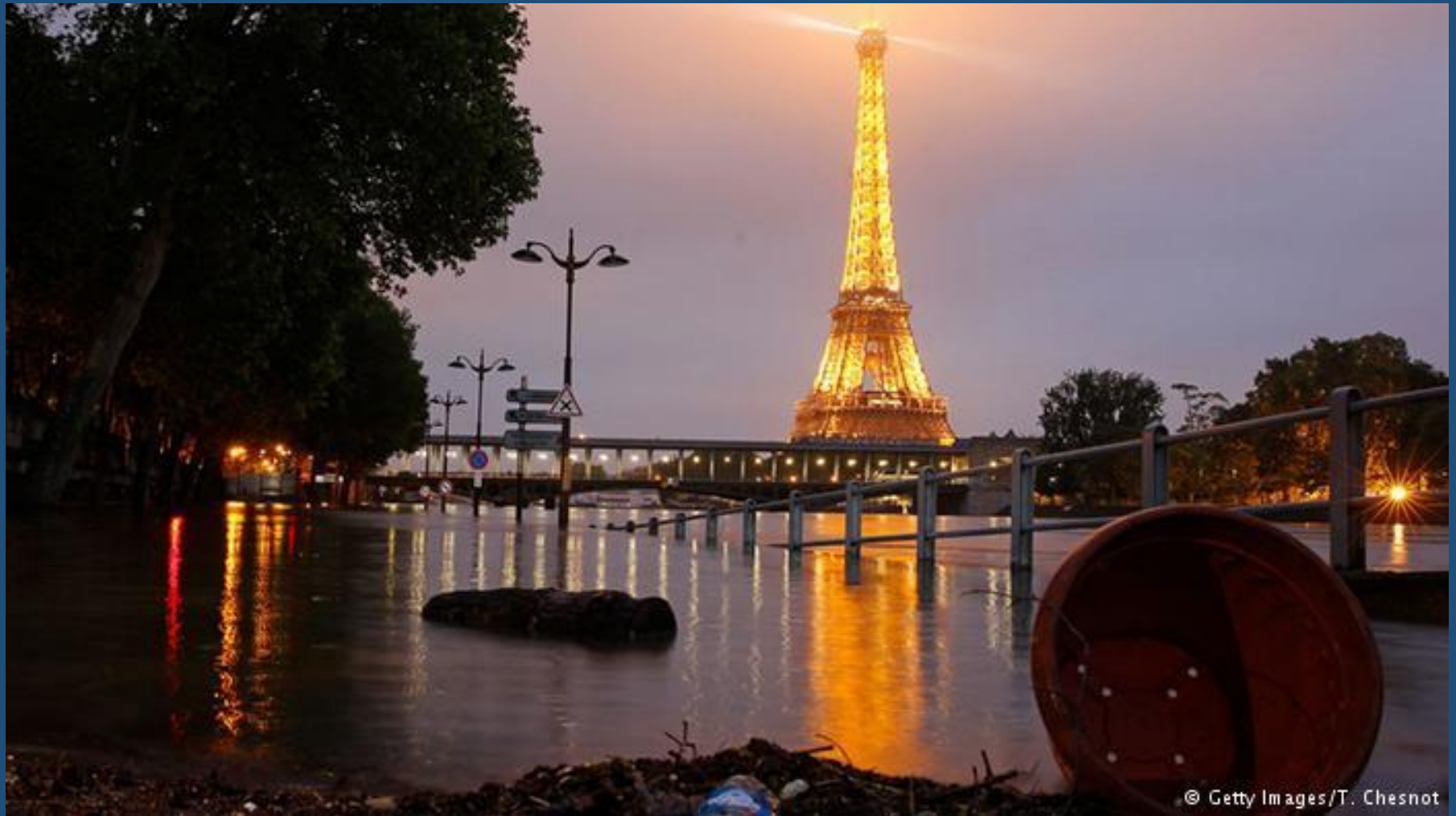
The team found that an event like this is now roughly 40% more likely due to climate change than it was in the past, with an uncertainty range of 5% to 80%



Paris, France, Seine River, 1 June 2016



Paris, France, Seine River, 1 June 2016



Calculations found that global warming increased the chances for the Loire river basin flooding by 90 percent and the Seine river basin by 80 percent. That's compared to a world with no man-made climate change. (Climate Central, Claims Journal)

Bavaria, Germany, 1 June 2016

Getty Images

Attribution results for Germany were inconclusive



Somewhere in central Europe, 1 June 2016



© picture-alliance/dpa/F. Kraufmann

CLAIMS JOURNAL

Man Made Climate Change Likely Contributed to French Flood

By SETH BORENSTEIN | June 14, 2016

A senior climate researcher at the Royal Netherlands Meteorological Institute, Geert Jan van Oldenborgh , says the team's calculations found that global warming increased the chances for the Loire river basin flooding by 90 percent and the Seine river basin by 80 percent. That's compared to a world with no man-made climate change.

Parts of France got three months of rain in just one month, much of it in just three days. The Seine, which runs through Paris, rose to 20 feet (6.1 meters) above its normal height.

"It was very weird weather," van Oldenborgh said. "It was made more likely due to climate change."

The researchers couldn't find a link with the German rain..

Wintertime flooding, Missouri, December 2015

“wintertime floods among costliest ever”
USA Today, January 9, 2016
(damage will exceed \$1 billion)



Pacific, Missouri, Jeff Roberson, AP



Robert Cohen, St. Louis Post-Dispatch



Robert Cohen, St. Louis Post-Dispatch via AP

Seeking higher ground, Houston, Texas, April 2016



Walking the dog, Houston, Texas, April 2016

Texas Monthly



Haughton Louisiana, March 2016
After 20 inches of rainfall in 4-day period



Louisiana Flood of August 2016 resulted from '1,000-year' rain in 2 days

Ted Jackson/Nola.com | The Times-Picayune via AP



40,000 homes damaged.

20,000 rescued; 10,000 in shelters.

Largest Red Cross response since Superstorm Sandy

Travis Spradling/The Advocate via AP

Over 20 inches of rain in 72 hours
Governor's family evacuated in Baton Rouge.



Flooding in the South Looks a Lot Like Climate Change

By Jonah Engel Bromwich, New York Times AUG. 16, 2016

Max Becherer/FR 171354AP, via Associated Press



“Climate change is never going to announce itself by name. But this is what we should expect it to look like.”

David Grunfeld/The Times-Picayune, via Associated Press

“The flooding in Louisiana is the eighth event since May of last year in which the amount of rainfall in an area in a specified window of time matches or exceeds the NOAA predictions for an amount of precipitation that will occur once every five hundred years, or has a 0.2 percent chance of occurring in any given year.”



Louisiana flood price tag could hit \$15 billion

CBS News, 8 Sept 2016

The devastating floods that hit Louisiana and other parts of the Gulf Coast last month likely caused total economic losses of between \$10 billion and \$15 billion, according to reinsurer AON Benfield. That would make it one the costliest natural disasters in U.S. history.

AON Benfield also expects insured losses to be in the low single-digit billions because more than 80 percent of the homes in the affected region lacked flood insurance. At least 13 people were killed in the floods that left parts of Baton Rouge underwater, destroyed 150,000 homes and left thousands homeless.

Hurricane Katrina: \$49 billion in 2015 dollars.

Sept 11, 2001: \$24.6 billion.

Superstorm Sandy: \$65 billion.

“The global warming signal is present in these numbers,” study lead Karin van der Wiel of NOAA and Princeton University recently told the Associated Press. “For a precipitation event of this size to occur on the central Gulf Coast, the odds have increased by at least 40 percent and most likely doubled.”

Louisiana floods of August 2016 – comments

"Yet people were cooking huge pots of jambalaya and passing out servings. Local residents from Baton Rouge and Zachary cooked large batches of red beans to feed sheriffs in Ascension Parish. Restaurant owners from New Orleans drove more than 50 miles to flooded areas to serve chicken fricassee, cornbread and bread pudding.

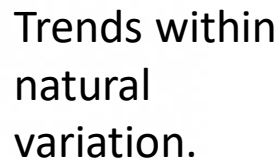
"Even through disaster, God has shown us how strong love truly is," Richardson said. "There is no end to the kindness that our people have right now. Our community is saving each other."

As the scope of the devastation sunk in, many Louisiana residents took to social media to rail against news outlets for what they believed was their lack of coverage. Why, some wondered, was the displacement of thousands of people less deserving of attention than the Olympics or Donald Trump?

"Why isn't national media covering the floods in Louisiana?" tweeted Amy Crowe Duhe, a Baton Rouge nursing student. "This is like nothing we've ever seen before."

<http://www.latimes.com/nation/>

The map shows the percent increase in very heavy events (heaviest 1% of all daily events) from 1958 to 2012



Floods – “Event Attribution”

“Extreme precipitation events of 2013 were found to have been much less influenced by human-induced climate change than extreme temperature events.”

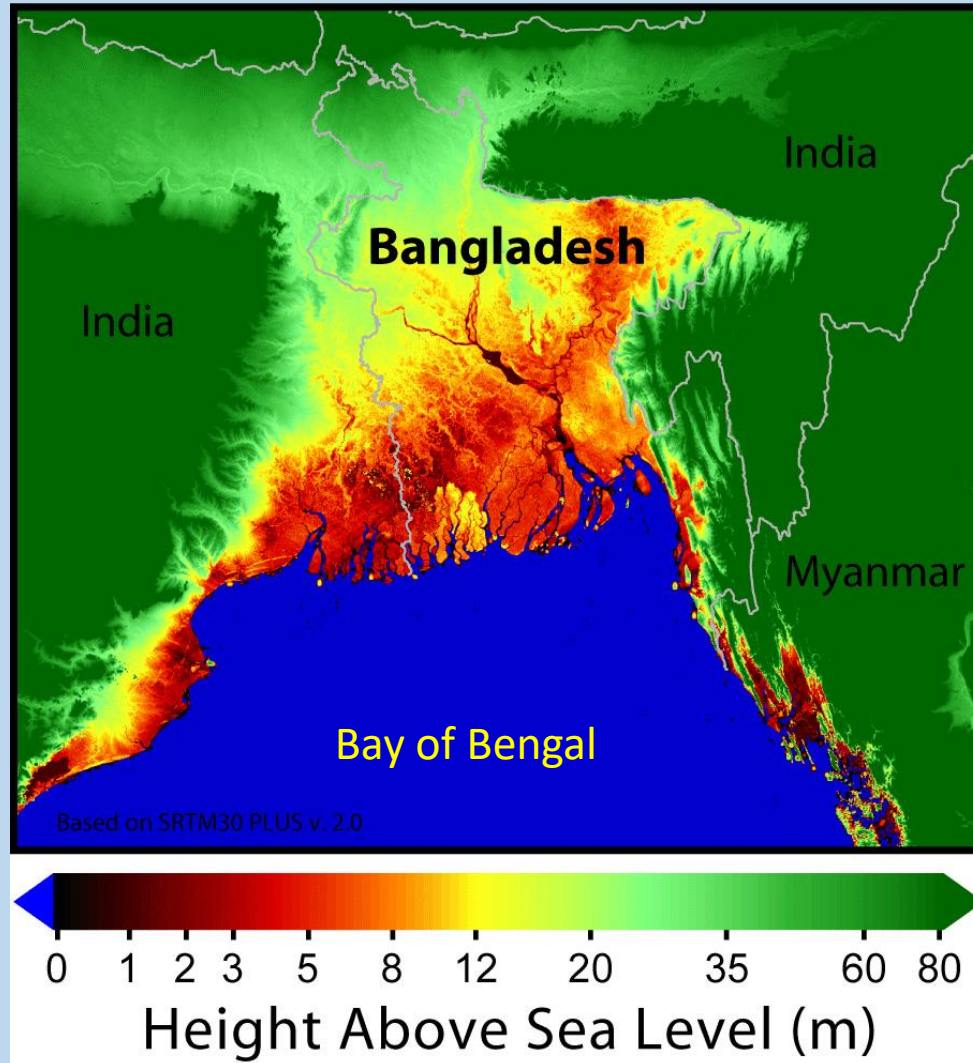
Of the five flood events in 2013 that were studied,
Anthropogenic influence increased the likelihood: two
Anthropogenic influence not found or uncertain: two
Anthropogenic influence decreased the likelihood: one
(this last event was the September 2013 rainfall centered around Boulder, Colorado)

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.*

Sea Level Rise and Coastal Subsidence

Global Impacts

The world's poorest people are most vulnerable



Borrowed Time on Disappearing Land

Facing Rising Seas, Bangladesh Confronts the Consequences of Climate Change

By GARDINER HARRIS, New York Times. March 28, 2014

A woman stands where her house was before Cyclone Aila destroyed it in 2009.

Scientists expect rising sea levels to submerge 17 percent of Bangladesh's land and displace 18 million people in the next 40 years.



Kadir van Lohuizen for The New York Times

South Florida Company Uses Data to Predict Whether Your House Will Be Underwater in 30 Years

For \$99, a person can look up any address in four counties in south Florida and determine its risk of flooding from sea-level rise over the next 30 years. Broward-Palm Beach New Times, Jan 18, 2016



Photo by Dave vis Flickr Creative Commons

IN TIDE'S WAY: SOUTHEAST FLORIDA'S SEPTEMBER 2015 SUNNY-DAY FLOOD

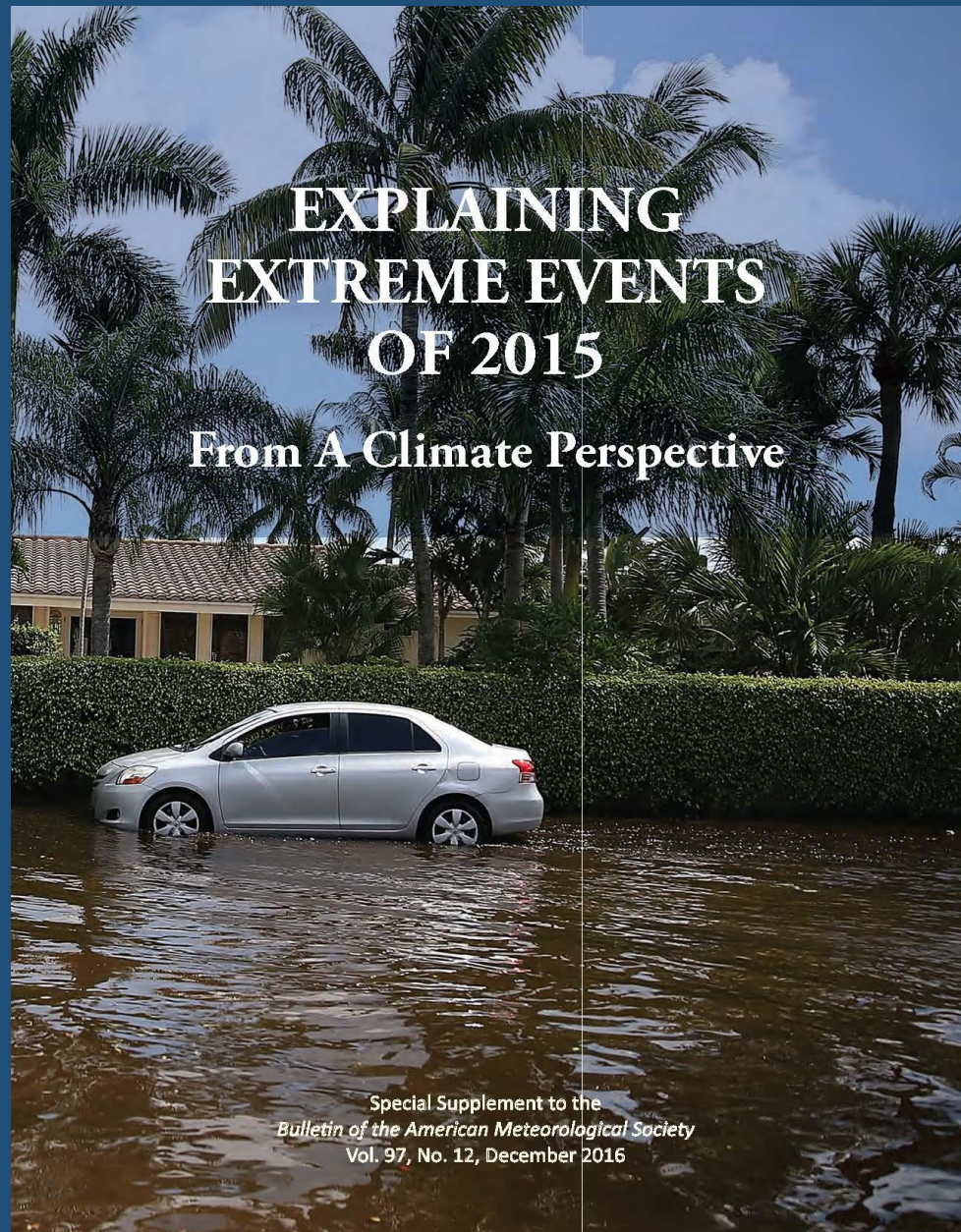
...flooding on 27 September inundated 0.57 m of normally dry land (~2 feet) and capped a weeklong event in which daily high tides exceeded the local nuisance flood threshold. Tidal floods of this magnitude occur only every few years now but will become commonplace in the coming decades.

The probability of a 0.57-m tidal flood within the Miami region has increased by >500% since 1994 from a 10.9-cm sea level rise (SLR)-related trend in monthly highest tides.

Special Supplement to the Bulletin of
the American Meteorological Society
Vol 97, no. 12, December 2016

EXPLAINING EXTREME EVENTS OF 2015

From A Climate Perspective



Special Supplement to the
Bulletin of the American Meteorological Society
Vol. 97, No. 12, December 2016

©Photo by Joe Raedle/Getty Images—Sept 30,
2015, Fort Lauderdale, FL.

Octopus in a Miami Beach parking garage during “supermoon” of 15 Nov 2016



South Florida continues prep for sea level rise

Brittany Wallard, Broward Sun Sentinel 27 Feb 2017

Fort Lauderdale raised the required height of sea walls & home site elevations.

Delray Beach added valves to keep salt water out of city drainage system.

Broward County ordered new flood maps to be drawn.



Flooding from seasonal king tides has worsened in Fort Lauderdale as a result of sea-level rise.

Joe Cavaretta/SunSentinal

First US climate refugees get \$48 million to move

Federal grant aims to move the entire community of the sinking Isle de Jean Charles, La., to a drier place. Christian Science Monitor, May 3, 2016



Lake Bistineau, Louisiana, March 14, 2016, Therese Apel/Reuters

Isle de Jean Charles. Since 1955, the island has lost 98 percent of its land.
Island Road, pictured, frequently washes out.
National Geographic, May 25, 2016



The island...is located deep in the southern bayous of Louisiana, about 75 miles (120 kilometers) south of New Orleans and 15 miles (24 kilometers) from the Gulf of Mexico.

Isle de Jean Charles, Louisiana. National Geographic, May 25, 2016



“We don’t have time,” tribal chief Albert Naquin, who spent the last 15 years advocating to relocate his people, said. “The longer we wait, the more hurricane season we have to go through. We hate to let the island go, but we have to. It is like losing a family member. We know we are going to lose it. We just don’t know when.”



Climate Change Is A 'Matter Of Life And Death' For The Marshall Islands

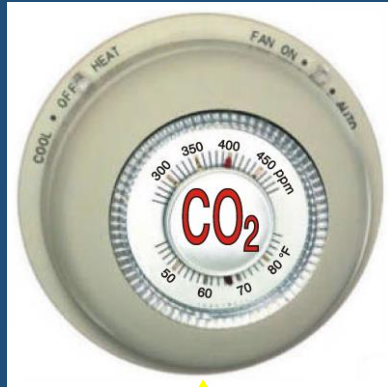
By Jon Letman, Civil Beat, Honolulu. Nov 4, 2016

“Marshallese people, culture and land have a symbiotic relationship — one can’t exist without the other. That’s why moving from our islands is not a viable option. As a nation facing cultural extinction due to climate change, we plead to stronger and major polluting countries to spare us the imminent fate of being climate refugees.”

Hilde Heine, President of the Republic of the Marshall Islands.



Rising tides are taking their toll on this Majuro graveyard. Tombstones and markers are slipping into the sea as the ocean claims the land.



More Water Vapor
and Clouds

Warmer Air,
Warmer Water
(Global Warming)

Atmosphere
Biosphere
Cryosphere
(Climate Change)

WHAT YOU CAN DO

Personal
Family, Friends, Neighbors
Town and City

State

National
International

Why climate change divides us

Christian Science Monitor, Oct 12, 2016

Fort Collins, Larimer County



The community solar farm in Fort Collins is just one example of the way that city in Northern Colorado is taking a lead on climate change solutions. The city has reduced per capita greenhouse gas emissions by 18 percent since 2005, and has a plan to be carbon neutral by 2050.

Amanda Paulson/The Christian Science Monitor

Weld County, Colorado



Roni Sylvester stands in front of several of the gas wells drilled on the 200-acre farm where she and her husband live in LaSalle, Colo. The farm has been in her husband's family for four generations. Ms. Sylvester is a property-rights advocate who believes that climate change is a hoax, and is bothered by the many inroads into property rights that she says are caused by environmental legislation and activists.

Amanda Paulson/The Christian Science Monitor

STATE: Many organizations, here is one....

In the absence of federal leadership, the states must lead. For too long, Congress has refused to take even the smallest steps to address climate change

Colorado cannot wait. As the governor himself put it, it would be “government malpractice” to not pursue cost-effective strategies to clean up air pollution.

Conservation Colorado web site.



STATE: Many organizations, here is another....



Welcome to the Sierra Club Colorado Chapter

With more than 73,000 members and supporters here in Colorado, we work together to protect our communities and the planet.

The Sierra Club Colorado Chapter works state-wide to focus our work at the municipal and county levels. We're involved in everything from hiking, to environmental education, to conservation.

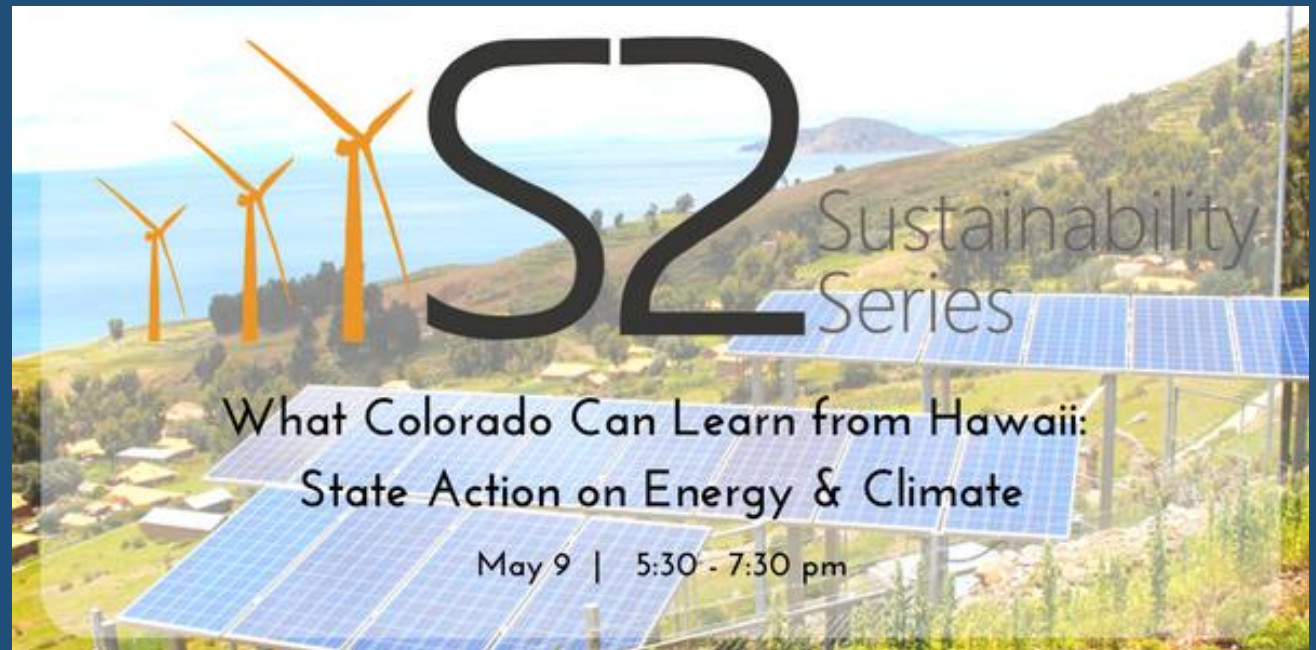
Sierra Club web site, extracted 9 April 2017

The Alliance Center



**Sign up on their mailing list
and pick what you want to
receive (free)**

**On Wynkoop St,
one block from
Union Station.**



Colorado's Renewable Energy Standard

In 2004, Colorado passed the first voter-led Renewable Energy Standard (RES) in the nation, requiring electricity providers to obtain a minimum percentage of their power from renewable energy sources. The legislature has increased the amount of renewable energy required three times since 2004, including HB10-1001 which required investor-owned utilities to generate 30% of their electricity from renewable energy by 2020, of which 3% must come from distributed energy resources.

The most recent update, SB 13-252, requires cooperative utilities to generate 20% of their electricity from renewables. The RES has sparked the development of hundreds of new renewable energy projects across the state, generating thousands of jobs and helping to reduce the state's greenhouse gas emissions.

Colorado's Public Utility Commission

The Colorado PUC has full economic and quality of service regulatory authority over investor-owned electric and gas utilities, as well as partial regulatory control over municipal utilities and cooperative electric associations.

The PUC's mission is to serve the public interest by effectively regulating utilities and facilities so that the people of Colorado receive safe, reliable, and reasonably-priced services consistent with the economic, environmental and social values of the state.

Along with the Colorado General Assembly, the PUC plays a central role in determining the details of electric and gas policy in Colorado.

<https://www.colorado.gov/pacific/energyoffice/regulatory-information> accessed Nov 2016



CRES Jefferson County (JCRES) is a regional chapter of the Colorado Renewable Energy Society (CRES), a statewide, non-partisan, non-profit, 501(c)3 membership organization. JCRES is dedicated to the advancement of all forms of renewable energy (RE), energy efficiency (EE), and their synergy with sustainability and economic development in all of JeffCo's cities and towns, including Golden, Lakewood, and Wheat Ridge. Our goal is to raise awareness and provide educational activities to increase the adoption of existing and emerging EE/RE technologies, techniques, and policies.

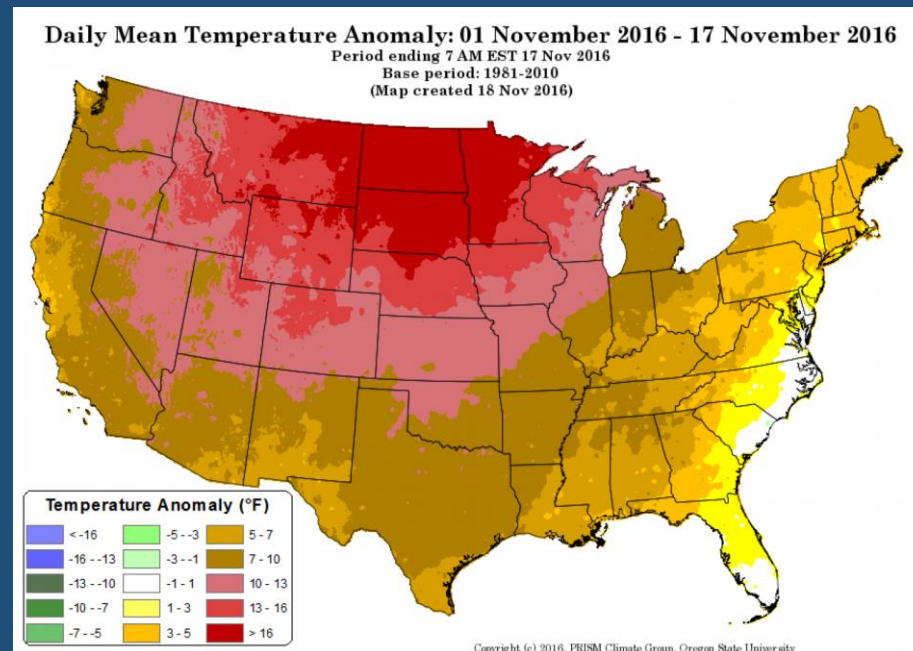
<https://www.cres-energy.org/jefferson-county-jcres/>

America's TV meteorologists: Symptoms of climate change are rampant, undeniable

By Paul Douglas, The Washington Post, 18 Nov 2016

I interviewed 11 of America's premiere broadcast TV meteorologists, to hear their thoughts and stories of how a rapidly changing climate is affecting local weather patterns:

Chief meteorologist Mike Nelson at Denver's KMGH-TV: "With a gradual warming of the planet our regional climate is likely to become drier on average over the next 100 years. The result will be more wildfires, lower water levels in our reservoirs and more frequent droughts."



Hurricanes and Typhoons

(Skip this if short of time)

Attribution confidence for tropical cyclones: low

Climate Change Is Knocking on the Door of Our Urban Fortresses

How should cities respond?

By Nexus Media, with Sabrina McCormick, 9/8/2016



Few cities are ready for the challenges they already face, and planning is wildly inconsistent from city to city.

New Orleans after Hurricane Katrina in 2005.
Source: U.S. Navy

'Scary' climate change may force zoning changes: planning chief

New York Post, 8 Sept 2016

Photo: Chad Bachman



Homes in Staten Island are flooded after Superstorm Sandy in 2012.

City Planning chief Carl Weisbrod said the changes his office are considering include new requirements to “help raise new buildings and existing buildings in flood prone areas.”

“We are further along than any other place in the country, but it’s a scary proposition,” Weisbrod told an Association for a Better New York breakfast in midtown.

“Sea levels are rising, and we are going to have to deal with that.”

Photos: R Train Resumes Full Service Between Manhattan And Brooklyn

Jen Chung in News, Sep 15, 2014



MTA Photo / Gothamist

The Montague Tube was shut down Aug. 3, 2013.... Construction crews had to enter the 4,000-foot section under the East River from entry points in Manhattan and Brooklyn, removing all debris and bringing in all equipment and tools through the tunnels themselves. Crews replaced 11,000 feet of track, 30,000 feet of concrete and terra cotta duct banks, 75,000 feet of power cable and 200,000 feet of communications cable.

After an extensive 13-month rehabilitation project that involved replacing "two miles of track, 37 miles of communication cable and 14 miles of power cable," the R train resumed full service between Manhattan and Brooklyn this morning. At a press conference yesterday, Governor Andrew Cuomo said, "Superstorm Sandy brought incredible destruction down on the New York City subway system - but today we're taking another huge step forward to repair the damage and strengthen the system to withstand the next major storm."

De Blasio Admits More Than 1,000 Sandy-Ravaged Homes Won't Be Rebuilt On Schedule

By Emma Whitford in News, Oct 20, 2016



*Staten Island's Midland Beach a few days after Sandy
(Jessica Lehrman / Gothamist)*

Late Wednesday night, days before the four year anniversary of Hurricane Sandy, members of the City Council received Mayor de Blasio's formal admission that his office will not finish construction on hurricane-damaged homes in the Build It Back program by the end of 2016, as promised.

Build it Back leaders detailed snags the project has hit since its June 2013 inception. For one, the sandy terrain underneath many damaged buildings proved difficult to build on. "The original model assumed that over 90% of these houses could be lifted and set back down," said Build It Back Director Amy Peterson. "Certainly what we found with the architects, is that this is not what it takes." John Grathwol, budget director for the Office of Management and Budget, added that, in the midst of a construction boom, the program has "struggled to get enough architects."

2016 Hurricane season ends, busiest since 2010

By Doyle Rice, USA Today, 30 Nov 2016

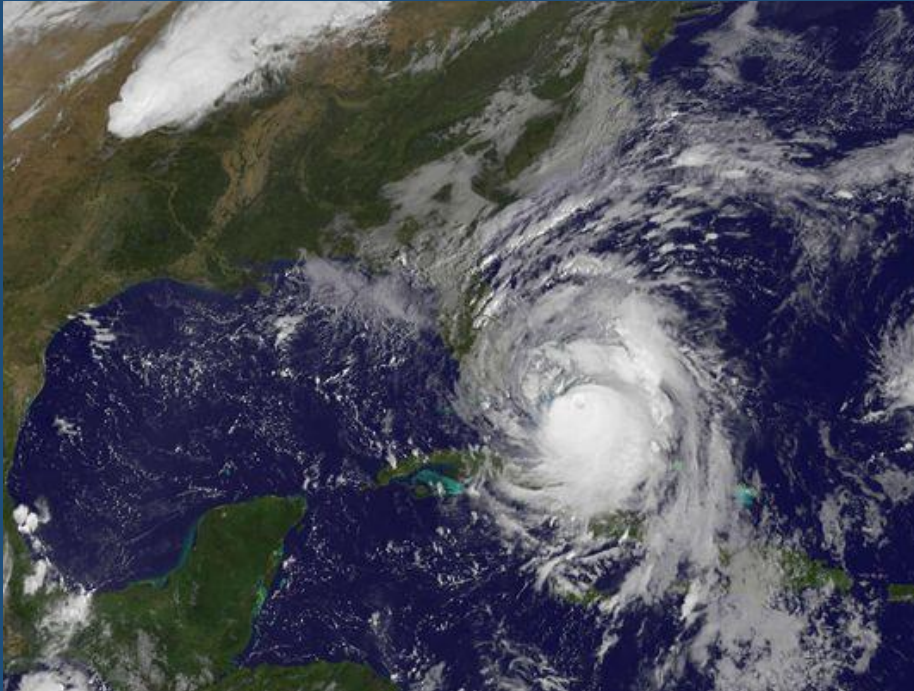


Photo: HO, AFP/Getty Images

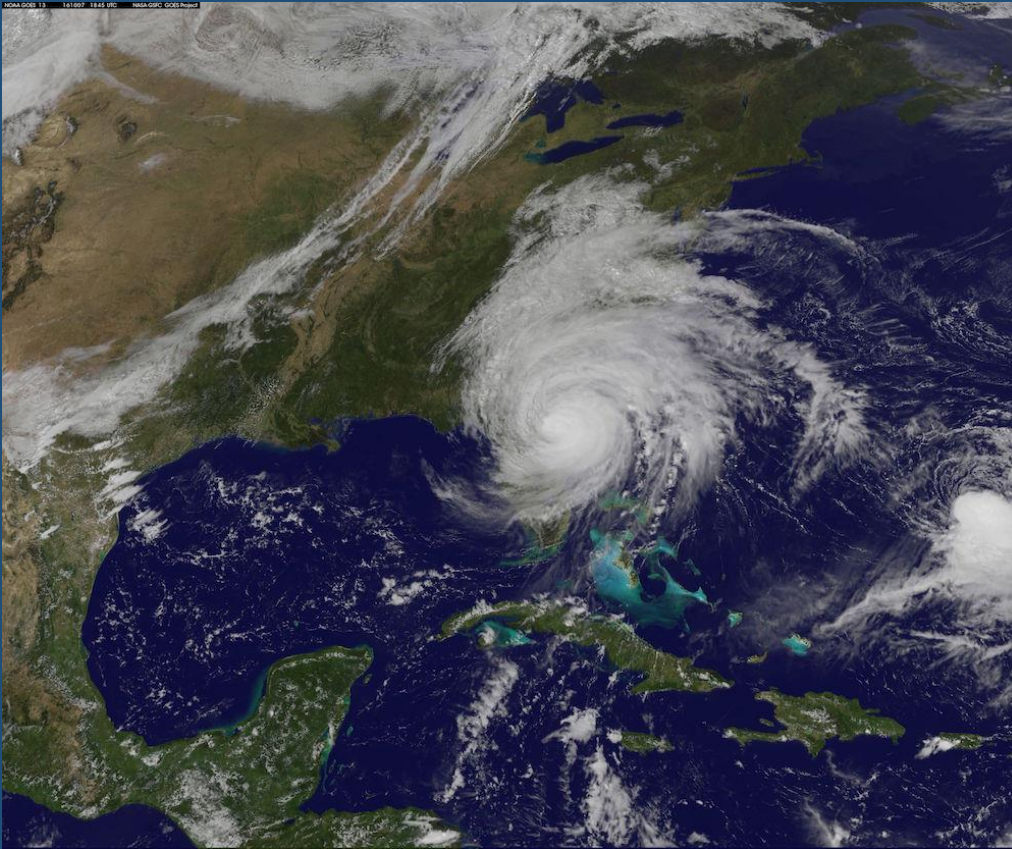
In all, a total of 15 named tropical storms formed during 2016, seven of which turned into hurricanes (Alex, Earl, Gaston, Hermine, Matthew, Nicole and Otto), according to the National Oceanic and Atmospheric Administration.

The strongest and longest-lived storm of the season was Matthew, which had winds of 160 mph and lasted as a major hurricane for eight days from Sept. 30 to Oct. 7. Matthew was the first category 5 hurricane in the Atlantic since Felix in 2007.

- Matthew killed at least 500 people and perhaps as many as 1,000 in Haiti.
- Matthew killed 49 people in the U.S.

From Caribbean to Carolinas, Hurricane Matthew Left Devastation in Wake

By Andrea Thompson, Wxshift, Oct 11, 2016



Hurricane Matthew as it skirted the coast of Florida on Oct. 7. Credit: NASA/NOAA GOES Project

A few miles made the difference between a storm that could have been so much worse and one that was already bad enough.

With at least 30 people killed in the U.S., and more than 1,000 killed in Haiti, Hurricane Matthew was one of the worst Atlantic hurricanes since Sandy. It tied as the fifth longest-lived major hurricane in the Atlantic since satellite records began in the late 1960s, and was the longest-lived major hurricane to form after Sept. 25...

Hurricane Matthew, one of the biggest extreme weather events in 2016, devastated Haiti. Hurricane Matthew was the first category 4 storm to make landfall since 1963.

Credit: Getty Images



Hurricane Matthew Took A Big Bite Out Of Southeastern States' Beaches

Greg Allen, NPR Morning Edition, Nov 1, 2016

September 6, 2014



October 14, 2016



Photos taken before Hurricane Matthew (Sept. 6, 2014) and after (Oct. 14, 2016) show that the storm washed away a 16-foot sand dune, destroying boardwalks and decks and exposing a seawall at Vilano Beach, Fla. USGS photo

Poor, Displaced and Anxious in North Carolina as Floods Climb After Hurricane Matthew

By Jess Bidgood, New

York Times Oct 13, 2016



“The poorest of the poor in North Carolina are the ones who are being hurt the most by these floods,” Gov. Pat McCrory said at an otherwise upbeat news conference on Thursday. “These people have nothing,” he added, urging people to donate to a state disaster fund.

Ryan Christian and Delores Miller canoed down a street Tuesday in Lumberton, N.C., where a third of residents live in poverty. Credit Travis Long/The News & Observer, via Associated Press

Super typhoon Nepartak hits Taiwan, July 2016

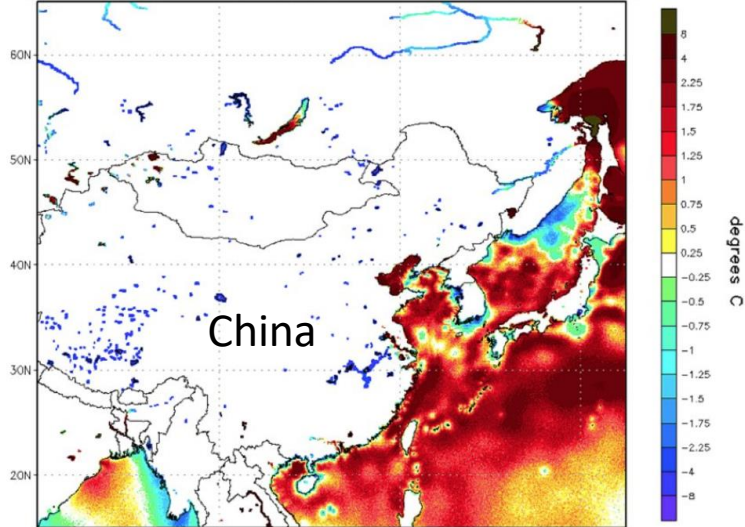
For Nepartak, conditions were ideal. Waters in the Philippine Sea surpassed 86° F, ramping up the spin cycle to produce a near-perfect storm of terrifying force.

Map: SST Anomaly During Nepartak

by NOAA/ NWS/ NCEP/ EMC Marine Modeling and Analysis Branch

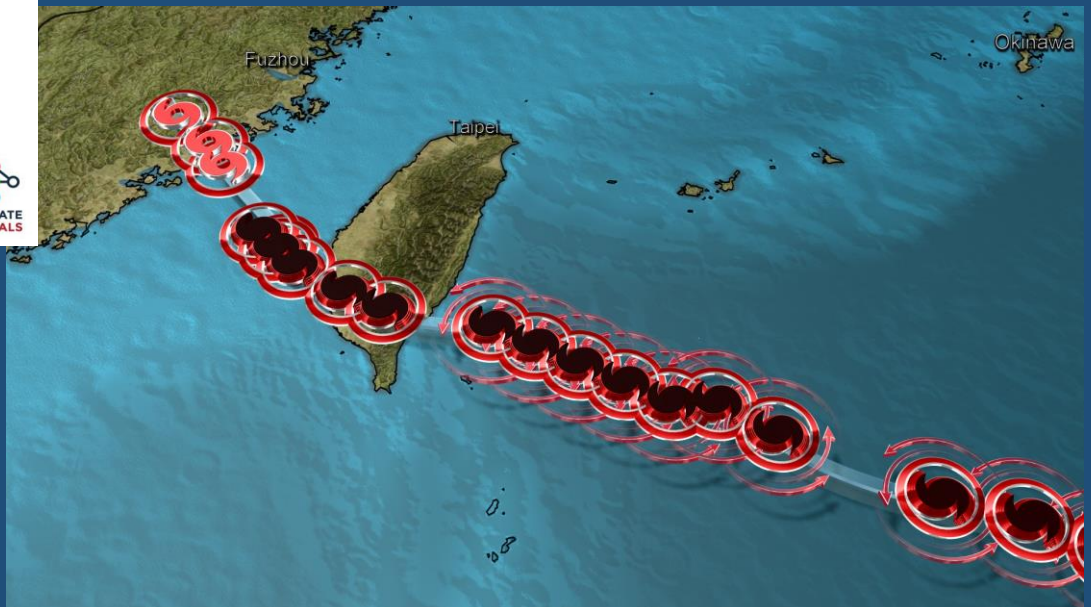
NOAA/NWS/NCEP/EMC Marine Modeling and Analysis Branch Oper H.R.

RTG_SST_HR Anomaly (0.083 deg X 0.083 deg) for 05 Jul 2016



Sea temperature as much as 4 deg C above average

Category 5, wind speeds of 150 mph



Agency-France Press
Getty Images,
New York Times

Super Typhoon Wipes Out Nearly Every Home In This Philippine City, Oct 2016

Five of the 10 deadliest typhoons to ever hit the archipelago nation came in the last decade.



The Philippines suffered its second major storm in a week as Super Typhoon Haima made landfall Wednesday, reportedly destroying or damaging nearly every home in Tuguegarao City, a northeastern city of about 153,000 people.

Nearly 100,000 were evacuated ahead of the storm, which had sustained winds of 140 mph, according to the BBC. At least four people were killed.

A man takes cover as strong winds and rain topple trees while Typhoon Haima lashes Narvacan, Ilocos Sur, northern Philippines on Thursday Oct. 20, 2016

Research Highlight: Typhoons in China, Japan, and Philippines Have Gotten Stronger Since 1970s --Trend especially pronounced among landfalling typhoons because of warming coastal waters

Wei Mei, a former Scripps postdoctoral scholar, and Shang-Ping Xie, the Roger Revelle Chair in Environmental Science at Scripps, said ...that the strongest intensification has occurred in typhoons that make landfall, which is about half of all typhoons. It is a consequence of strong ocean warming near the coasts of East and Southeast Asia.

“The intensification of landfalling typhoons coincided with rapid economic development in coastal China,” said Mei. “The effects were strongly felt there.”

The paper, “Intensification of landfalling typhoons over the northwest Pacific since the late 1970s,” appeared in the Sept. 5 advance online publication of the journal *Nature Geoscience*.