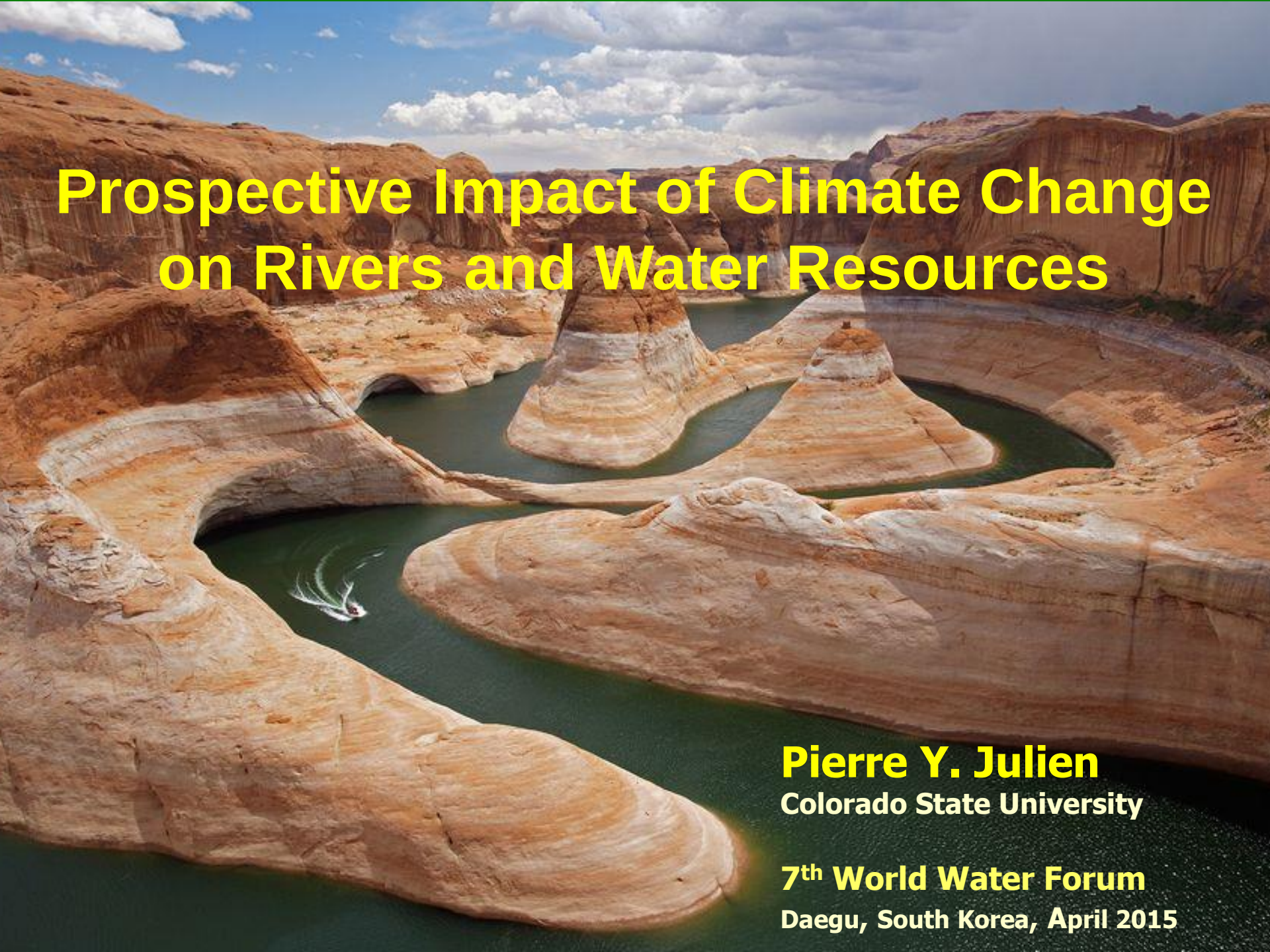
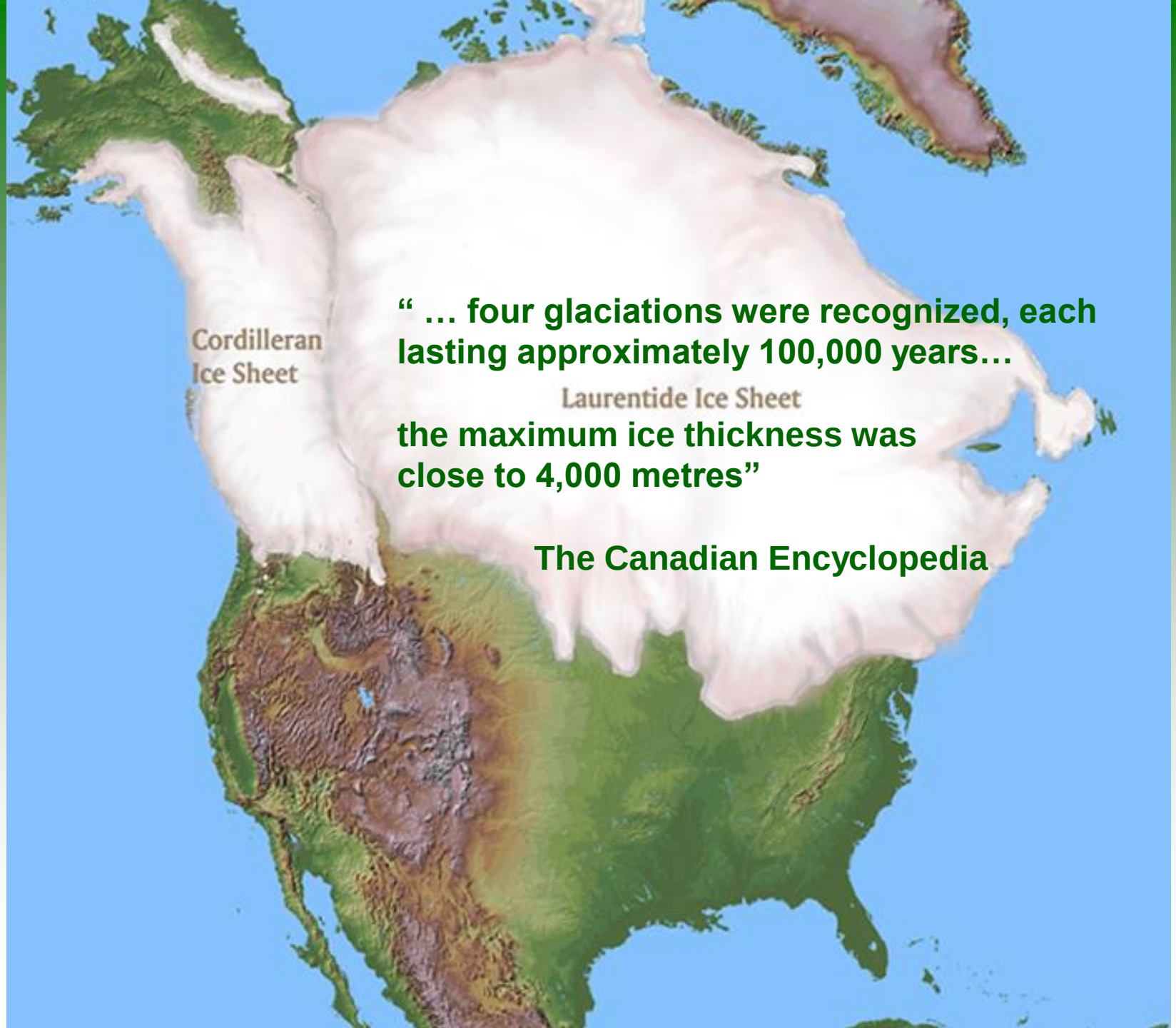


Prospective Impact of Climate Change on Rivers and Water Resources

Pierre Y. Julien
Colorado State University

7th World Water Forum
Daegu, South Korea, April 2015



“ … four glaciations were recognized, each lasting approximately 100,000 years…

the maximum ice thickness was close to 4,000 metres”

The Canadian Encyclopedia

Rainfall vs Snowmelt

Upper Elevation: flooding from snowmelt

Lower Elevation: flooding from thunderstorms

Pine beetle and the Colorado Forest


Waldo Fire
Colorado June 2012


Waldo Fire
Colorado June 2012


Impact on water quality

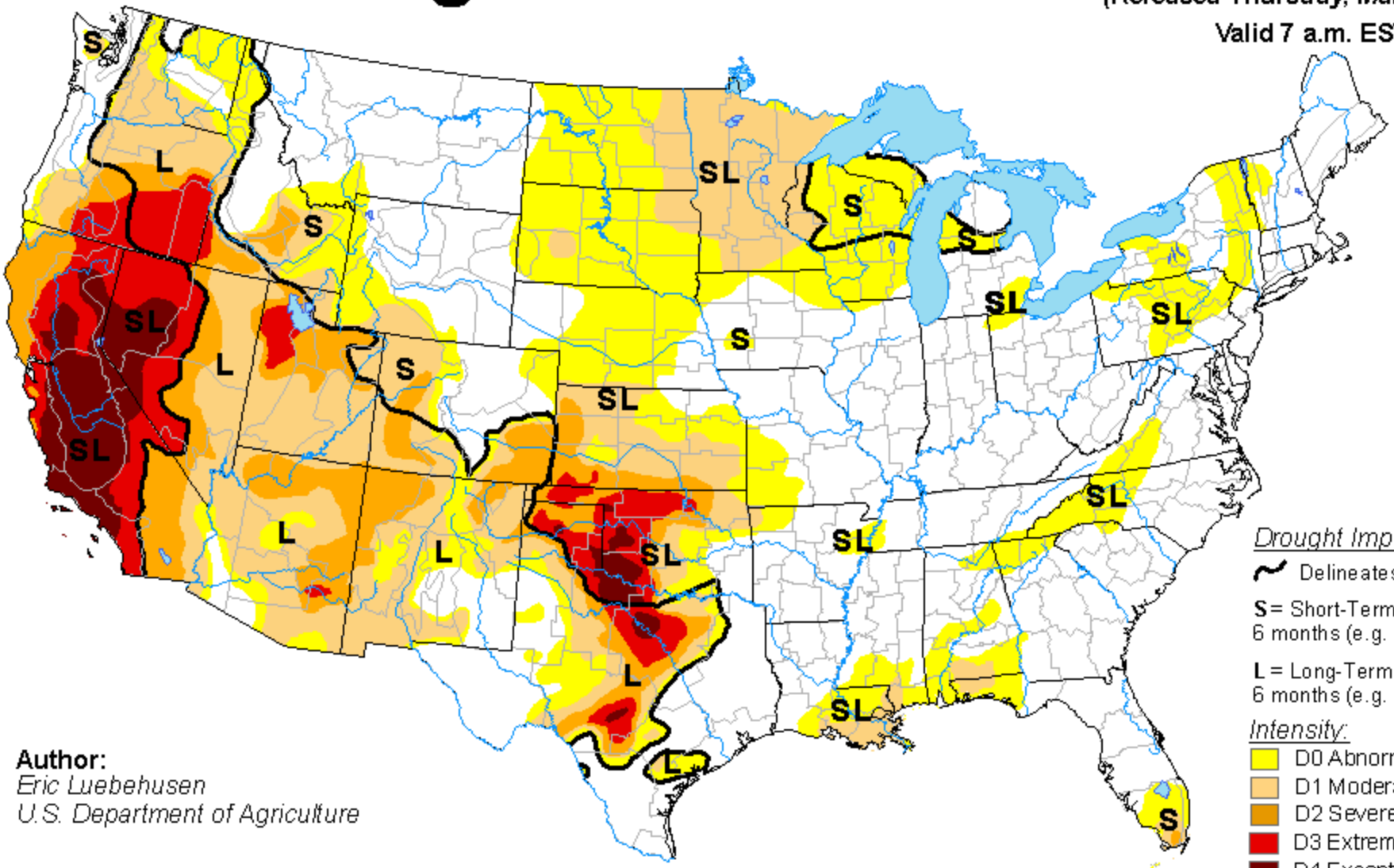
Sediment Plugs on the Rio Grande

U.S. Drought Monitor

March 24, 2015

(Released Thursday, Mar. 26, 201

Valid 7 a.m. EST



Author:
Eric Luebehusen
U.S. Department of Agriculture

Drought Impact Type

Delineates dominant

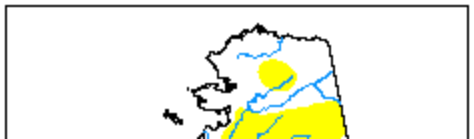
S = Short-Term, typically
6 months (e.g. agriculture

L = Long-Term, typically g
6 months (e.g. hydrology,

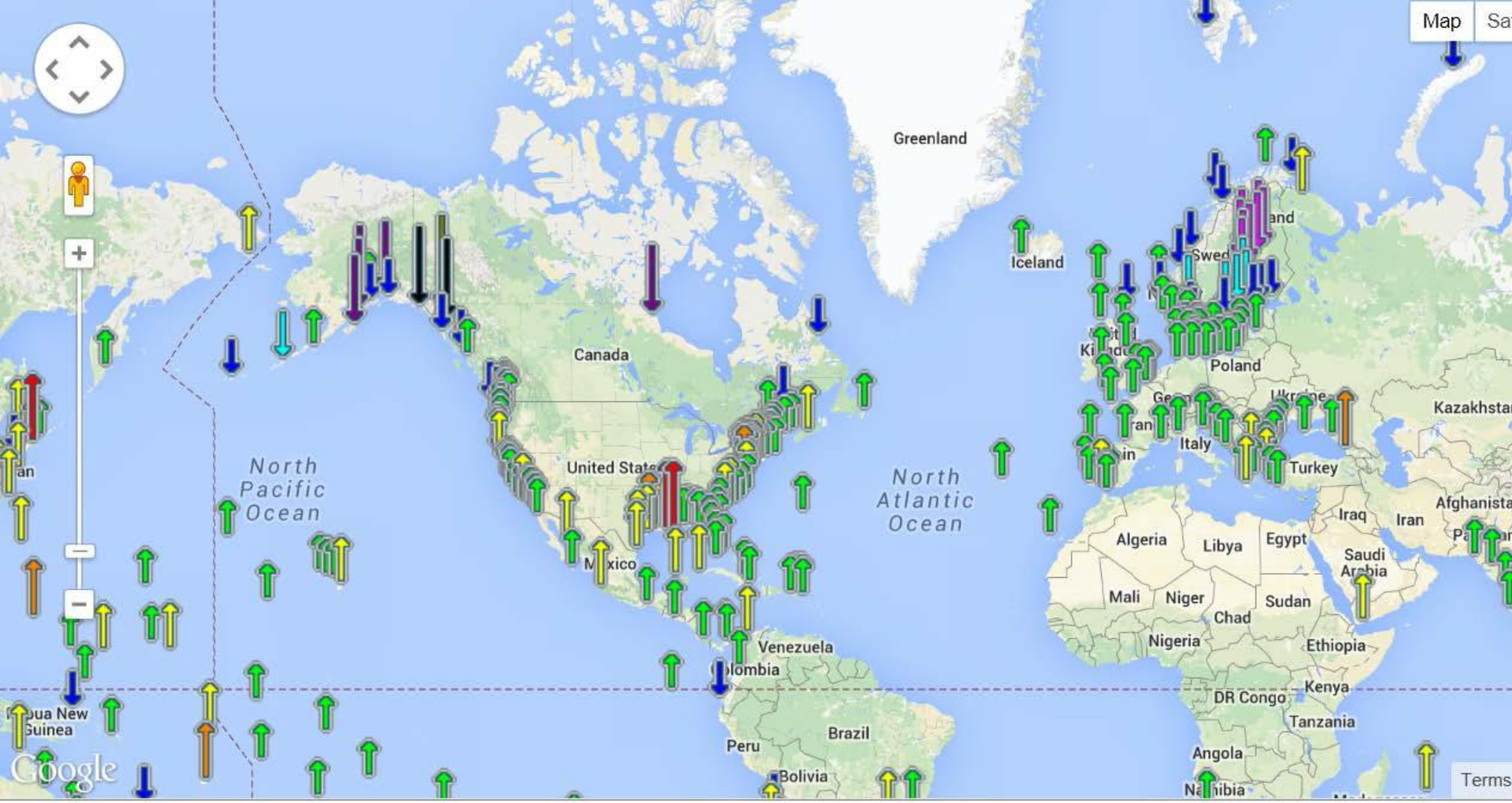
Intensity:

- D0 Abnormally Dry
- D1 Moderate Droug
- D2 Severe Drought
- D3 Extreme Drought
- D4 Exceptional Drou

The Drought Monitor focuses
scale conditions. Local condi
vary. See accompanying text
forecast statements.




California Imposes First Mandatory Water Restrictions to Deal With Drought
PHILLIPS, Calif. — Gov. Jerry Brown on Wednesday ordered mandatory water use reductions for the first time in California's history, saying the state's four-year drought had reached near-crisis proportions after a winter of record-low snowfalls.
Oroville Lake, April 2015



The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to access additional information about that station.

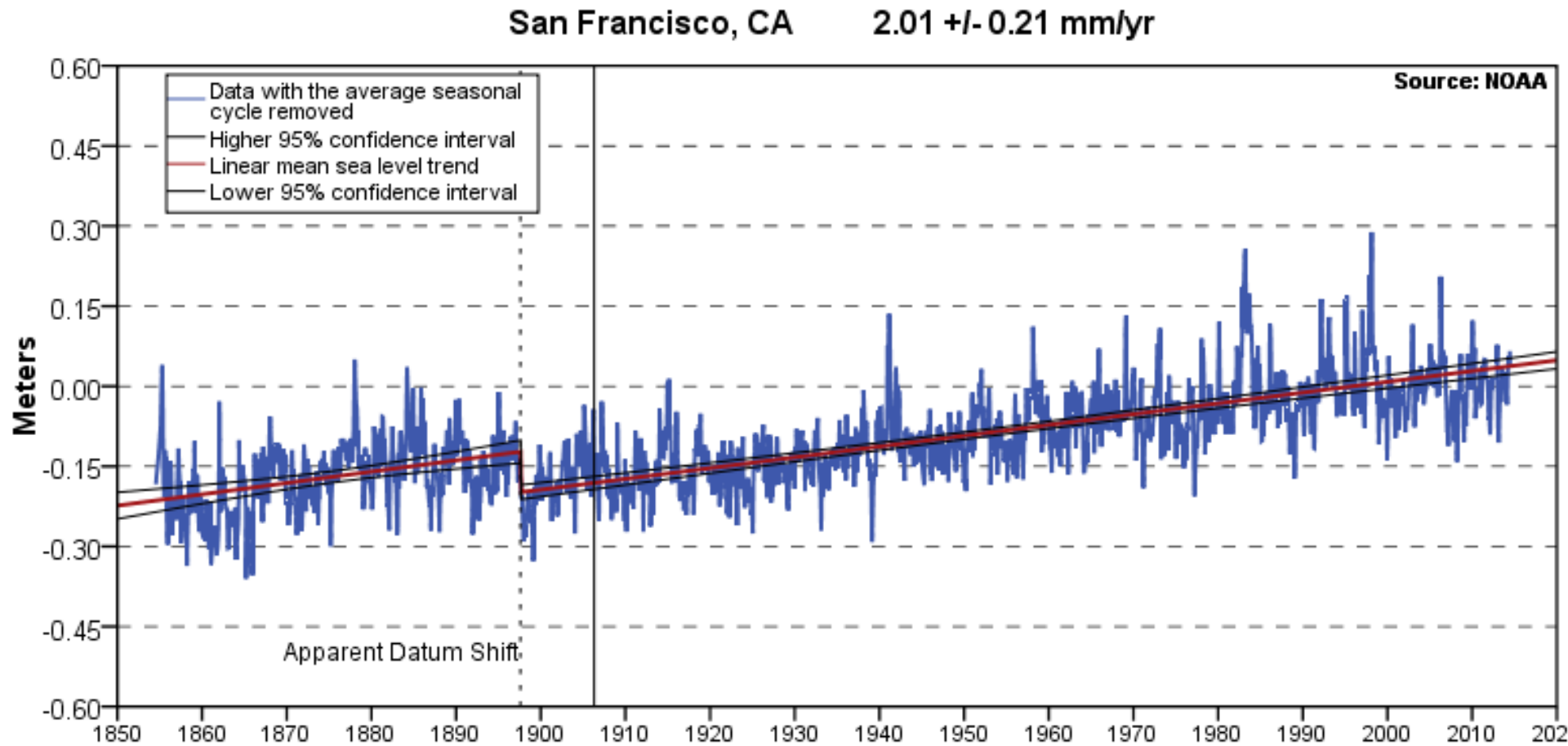
Sea Level Trends

mm/yr (feet/century)

15 to 21 (5 to 7)	6 to 9 (2 to 3)	-3 to 0 (-1 to 0)	-12 to -9 (-4 to -3)
12 to 15 (4 to 5)	3 to 6 (1 to 2)	-6 to -3 (-2 to -1)	-15 to -12 (-5 to -4)
9 to 12 (3 to 4)	0 to 3 (0 to 1)	-9 to -6 (-3 to -2)	-18 to -15 (-6 to -5)

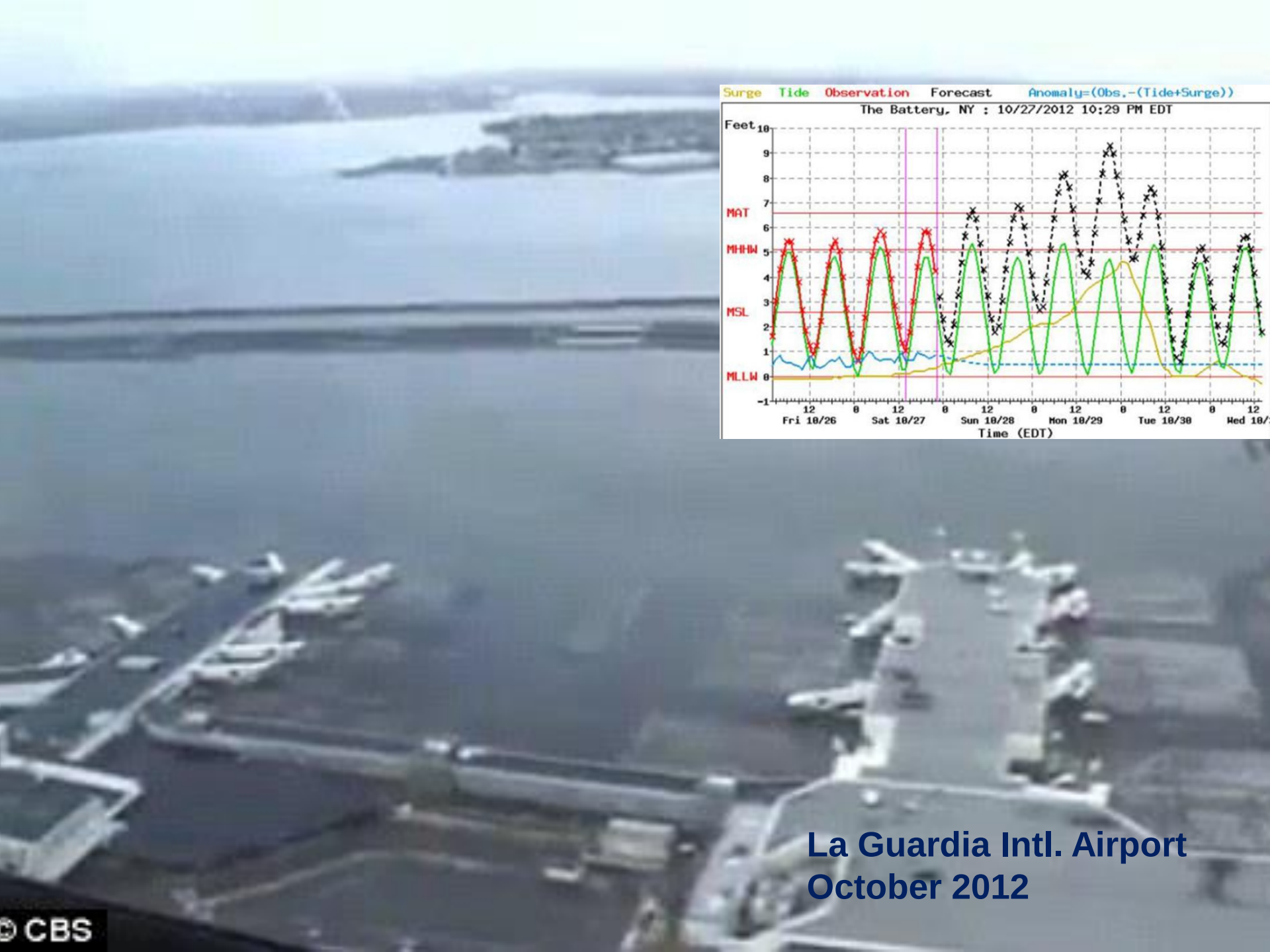
Mean Sea Level Trend

9414290 San Francisco, California



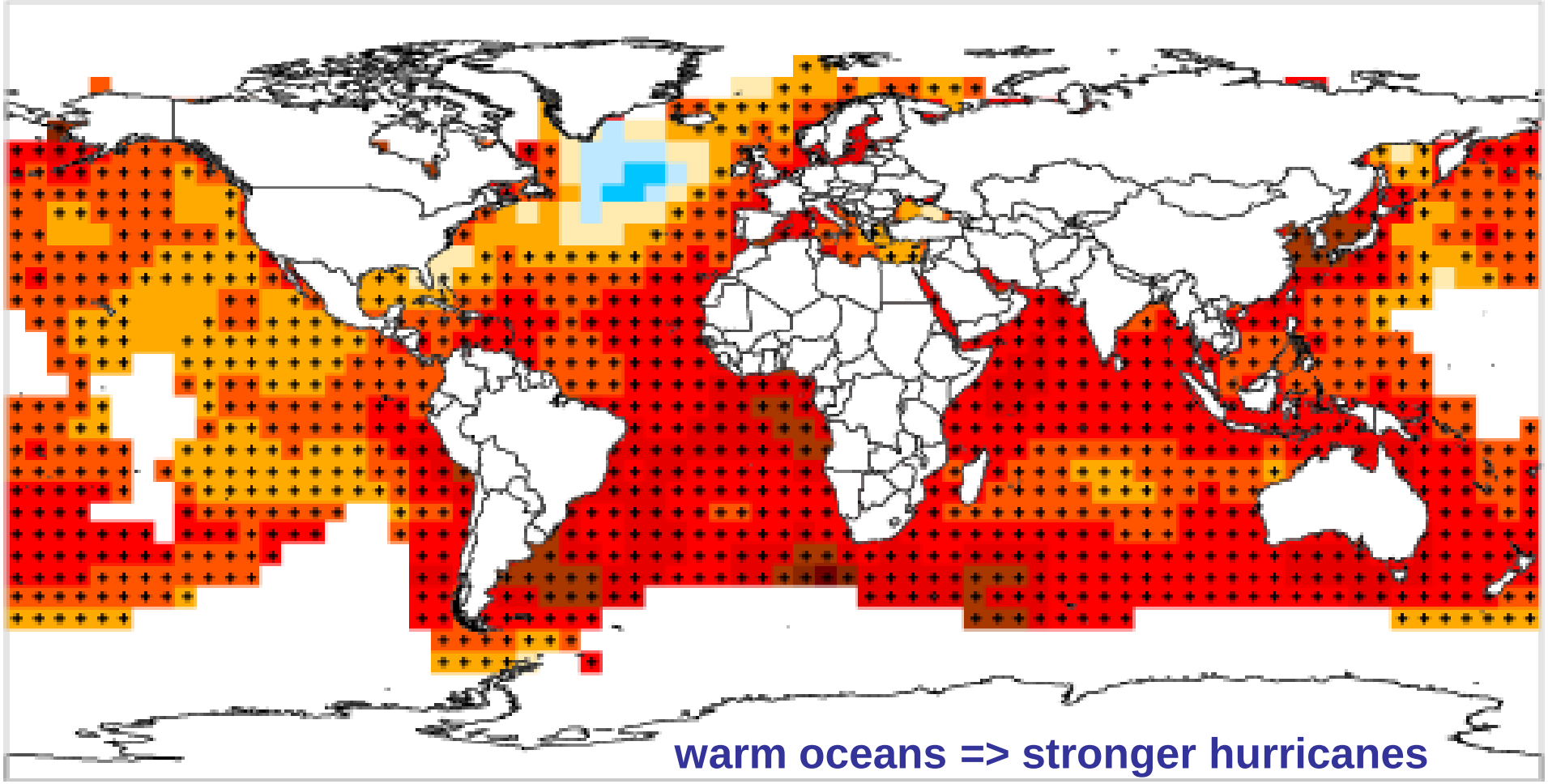
rs/year with a 95% confidence interval of +/- 0.21 mm/yr based on monthly mean sea level data from 1897 to 2006 whic
100 years.

From P. O'Brien, USACE



La Guardia Intl. Airport
October 2012

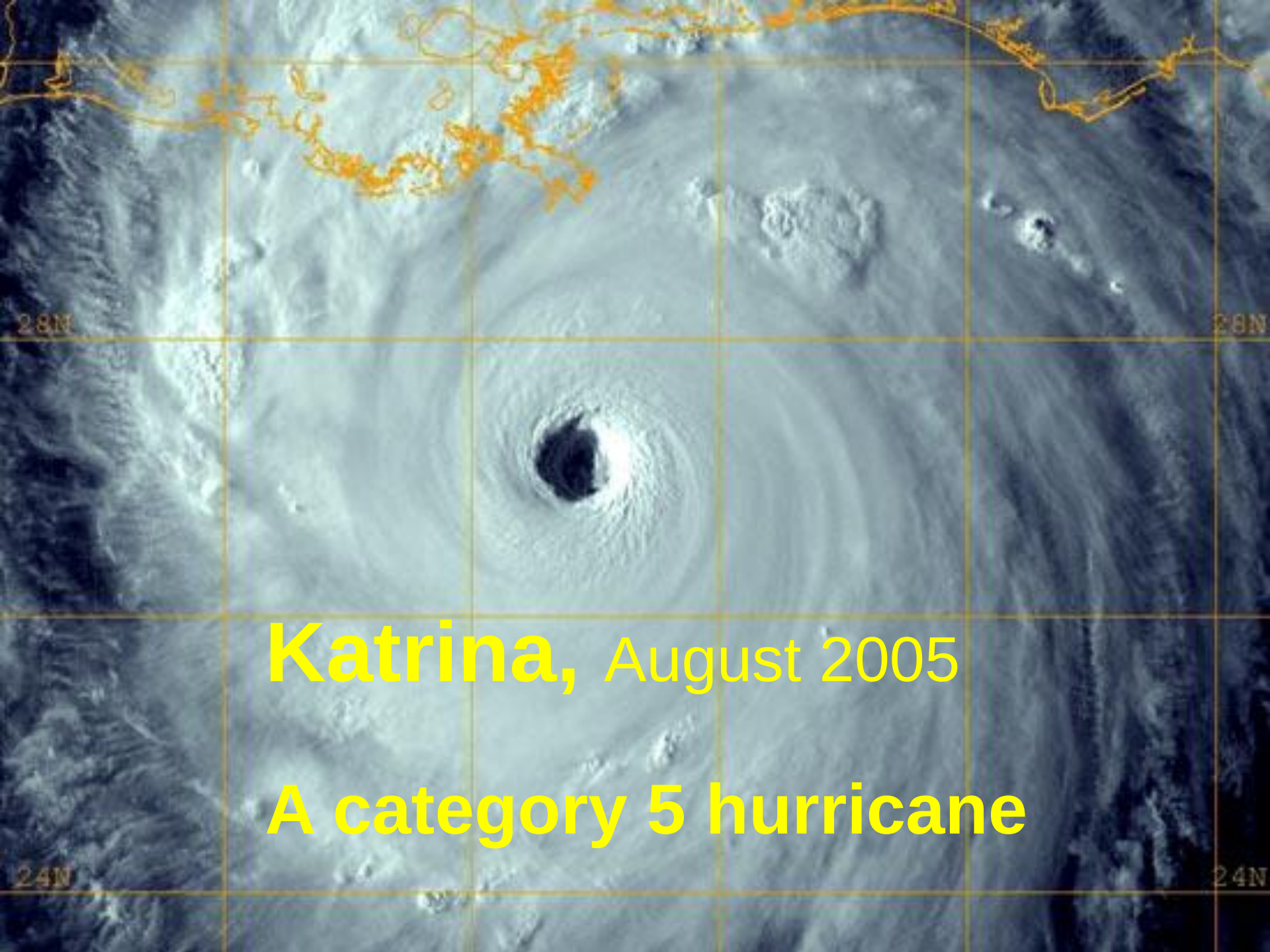
Figure 2. Change in Sea Surface Temperature, 1901–2012



Change in sea surface temperature (°F):

-1 -0.5 0 0.5 1 1.5 2 2.5 3 3.5 4

Insufficient data

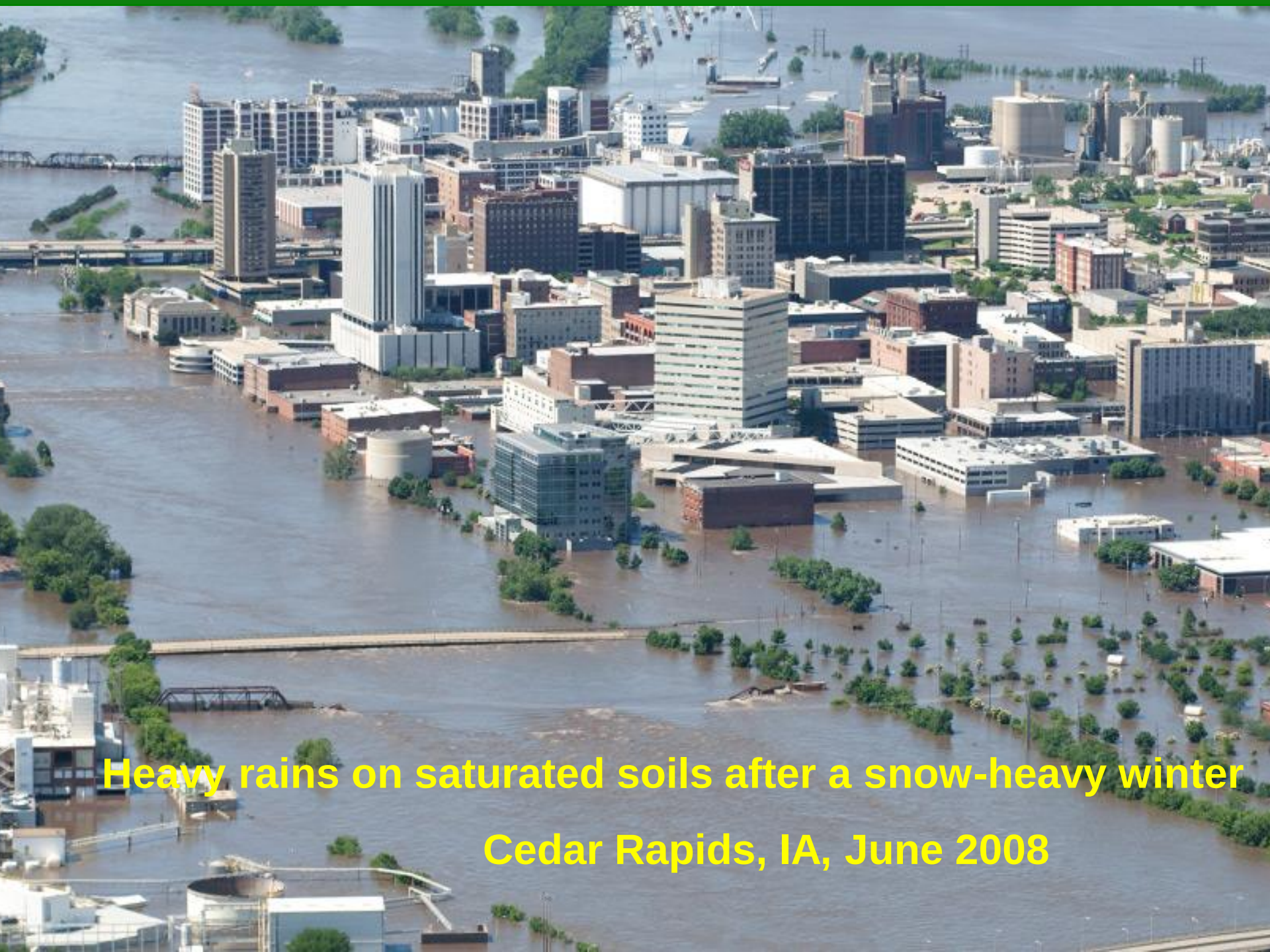


Katrina, August 2005

A category 5 hurricane

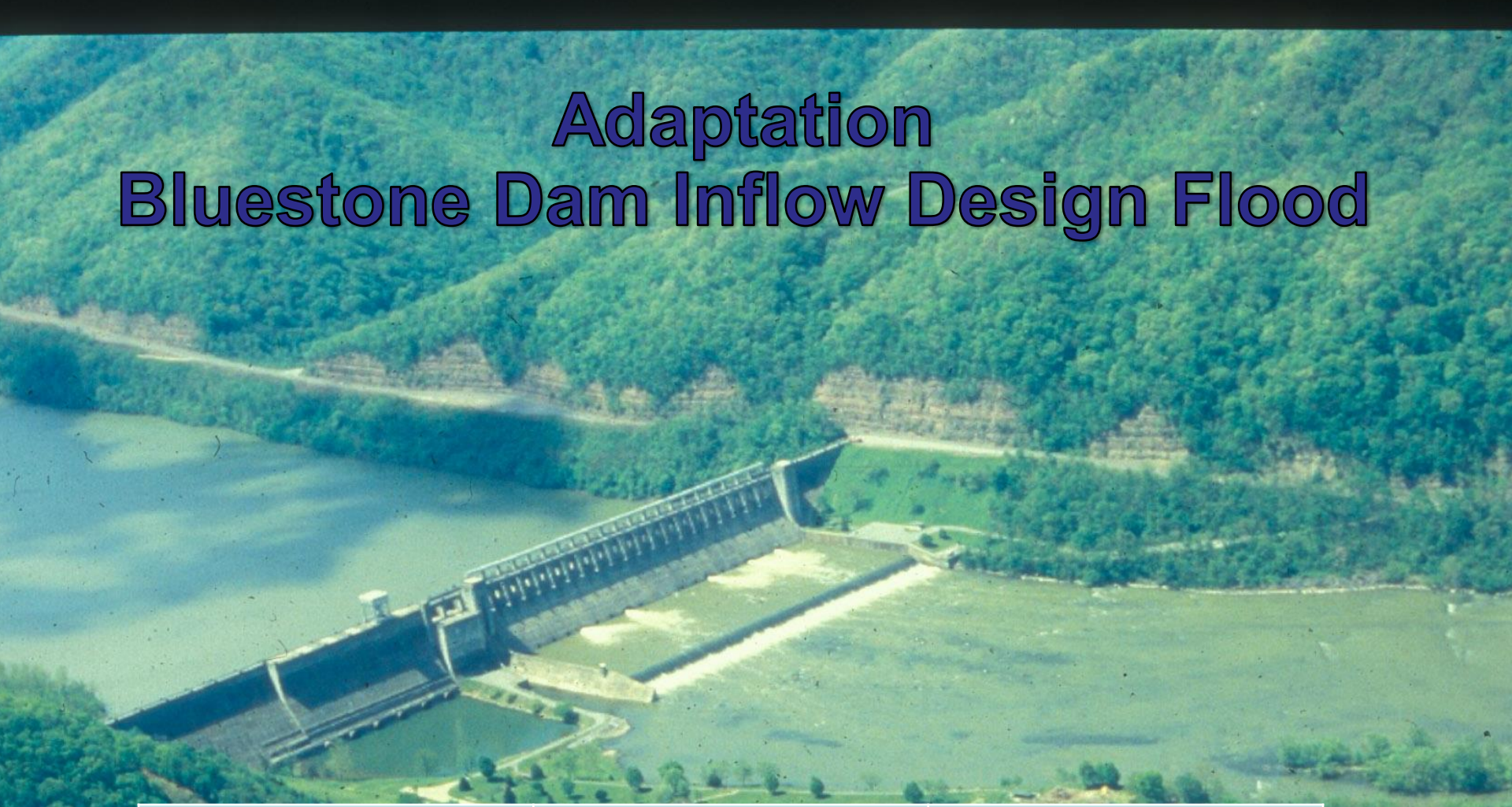

New Orleans in August 2005
after Hurricane Katrina
Damage $108 billions


Cincinnati
New Orleans
Miami
Katrina
August 2005
Saffir-Simpson Hurricane Scale
Tropical
Hurricane Category
Depr
Storm
1
2
3
4
5


Heavy rains on saturated soils after a snow-heavy winter
Cedar Rapids, IA, June 2008


Cedar Rapids, IA, June 2008

Adaptation
Bluestone Dam Inflow Design Flood



	Precipitation	Peak Inflow
1938 Design – Original	13 inches	430,000 cfs
1982 Update	20 inches	1,086,000 cfs
2014 Update	18 inches	**1,564,000 cfs**

From N. Koutsunis, USACE

Structural Measures at a Glance

GENERAL COASTAL RISK REDUCTION PERFORMANCE FACTORS:
STORM SURGE AND WAVE HEIGHT/PERIOD, WATER LEVEL

Levees

Benefits/Processes

Surge and Wave attenuation and/or dissipation

Reduce Flooding

Risk Reduction for vulnerable areas

Performance Factors

Levee height, crest width, and slope

Wave height and period

Water level

Storm Surge Barriers

Benefits/Processes

Surge and Wave attenuation

Reduced Salinity Intrusion

Performance Factors

Barrier height

Wave height

Wave period

Water level

Seawalls and Revetments

Benefits/Processes

Reduce flooding

Reduce wave overtopping

Shoreline stabilization behind structure

Performance Factors

Wave height

Wave period

Water level

Scour protection

Groins

Benefits/Processes

Shoreline stabilization

Performance Factors

Groin length, height, orientation, permeability and spacing

Depth at seaward end

Wave height

Water level

Longshore transportation rates and distribution

Detached Breakwaters

Benefits/Processes

Shoreline stabilization behind structure

Wave attenuation

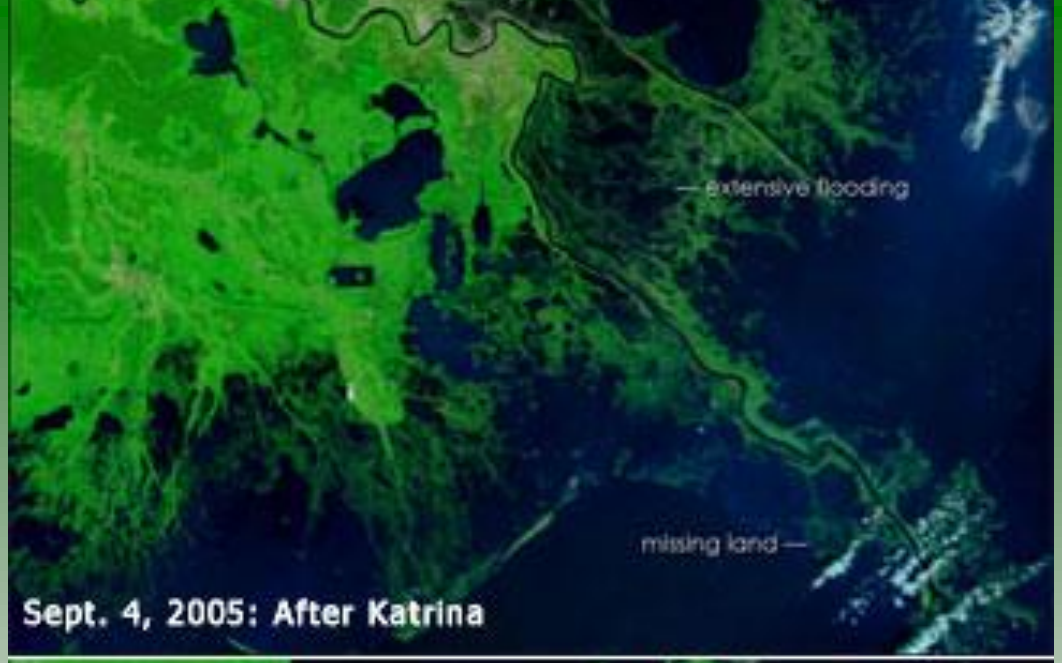
Performance Factors

Breakwater height and width.

Breakwater permeability, proximity to shoreline, orientation and spacing

From K. White, USACE, ETL 1100-2-1 https://corpsclimate.us

Impact of Katrina on wetlands




Lake Borgne Surge Barrier, New Orleans, LA
~ $10 billion … too much or not enough?


Thank You!
pierre@engr.colostate.edu