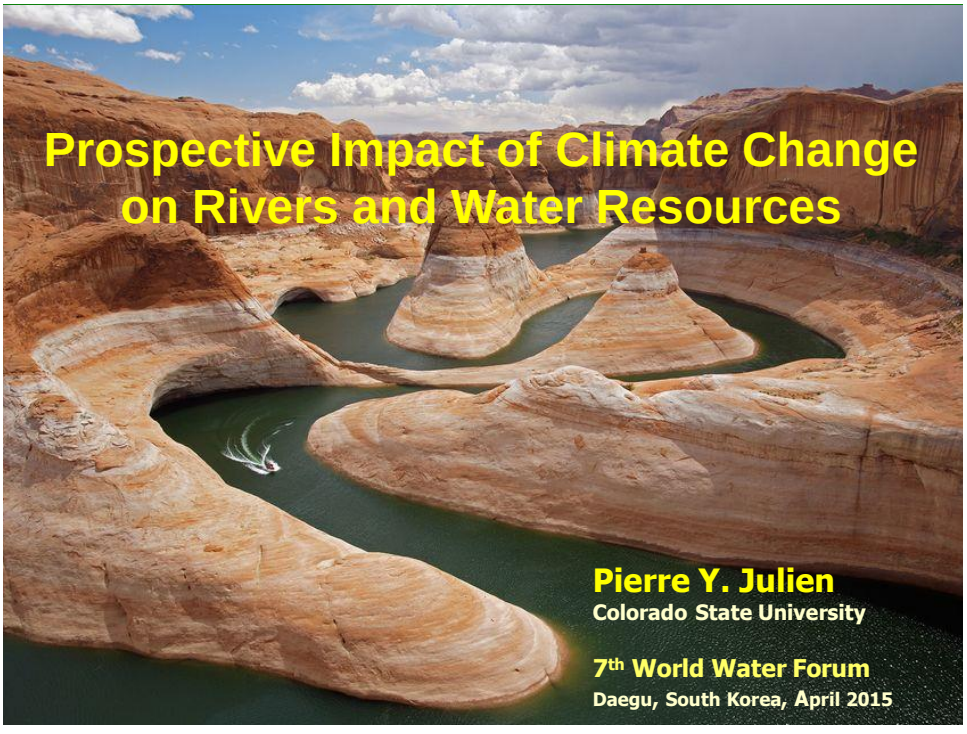
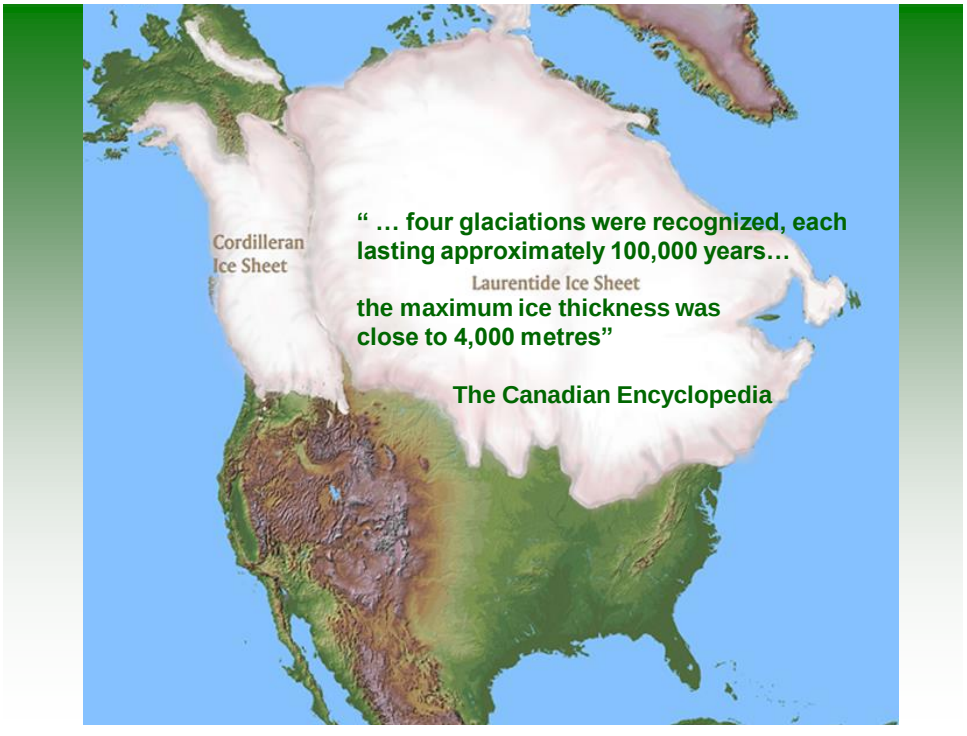
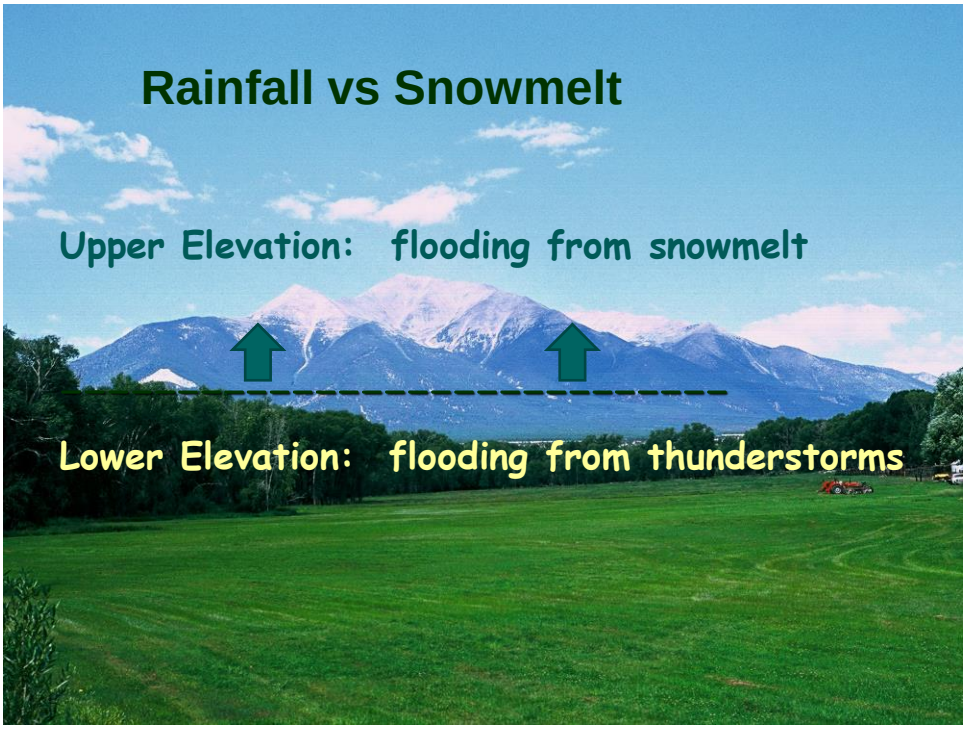

Prospective Impact of Climate Change
on Rivers and Water Resources
Pierre Y. Julien
Colorado State University
7th World Water Forum
Daegu, South Korea, April 2015


Cordilleran
Ice Sheet
Laurentide Ice Sheet
" … 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

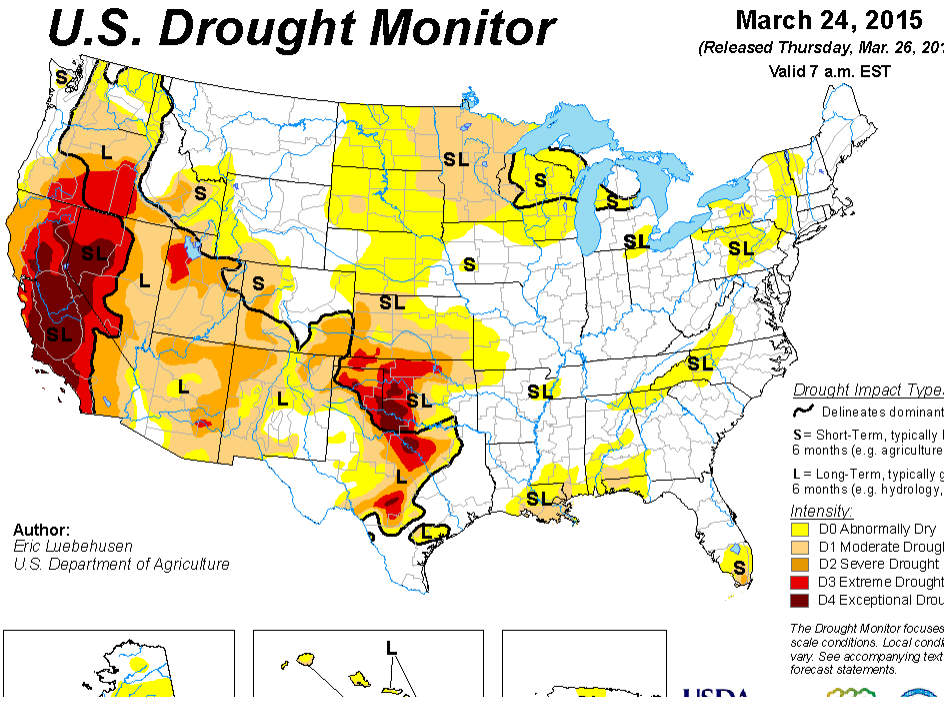

Pine beetle and the Colorado Forest


Waldo Fire
Colorado June 2012

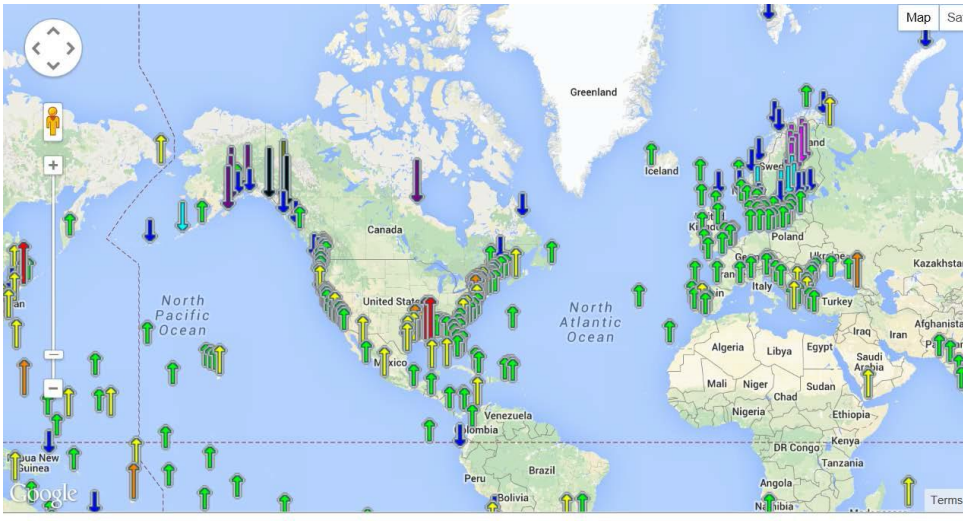

Waldo Fire
Colorado June 2012


Impact on water quality


Sediment Plugs on the Rio Grande
Where did the water go?
From D. Baird, USBR


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
6 months (e.g. hydrology,
Intensity:
D0 Abnormally Dry
D1 Moderate Drough
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

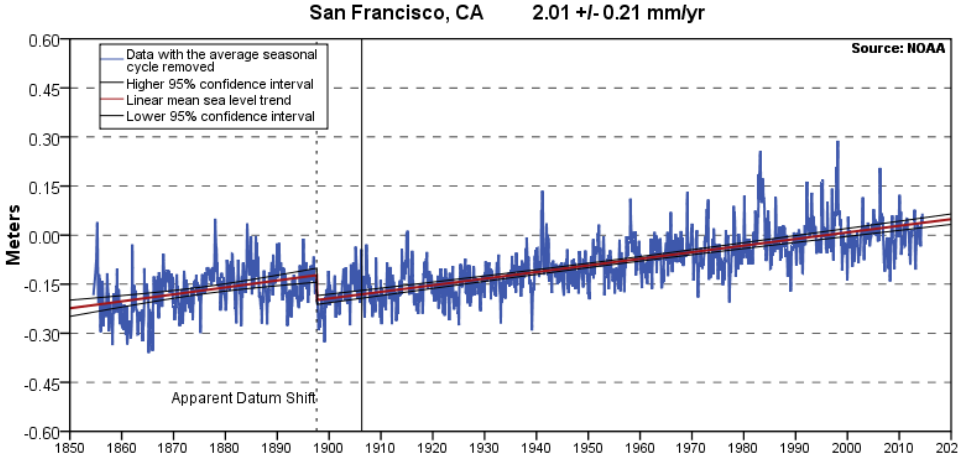


The map above illustrates regional trends in sea level, with arrows representing the direction and magnitude of change. Click on an arrow to acces additional information about that station.

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



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

From P. O'Brien, USACE

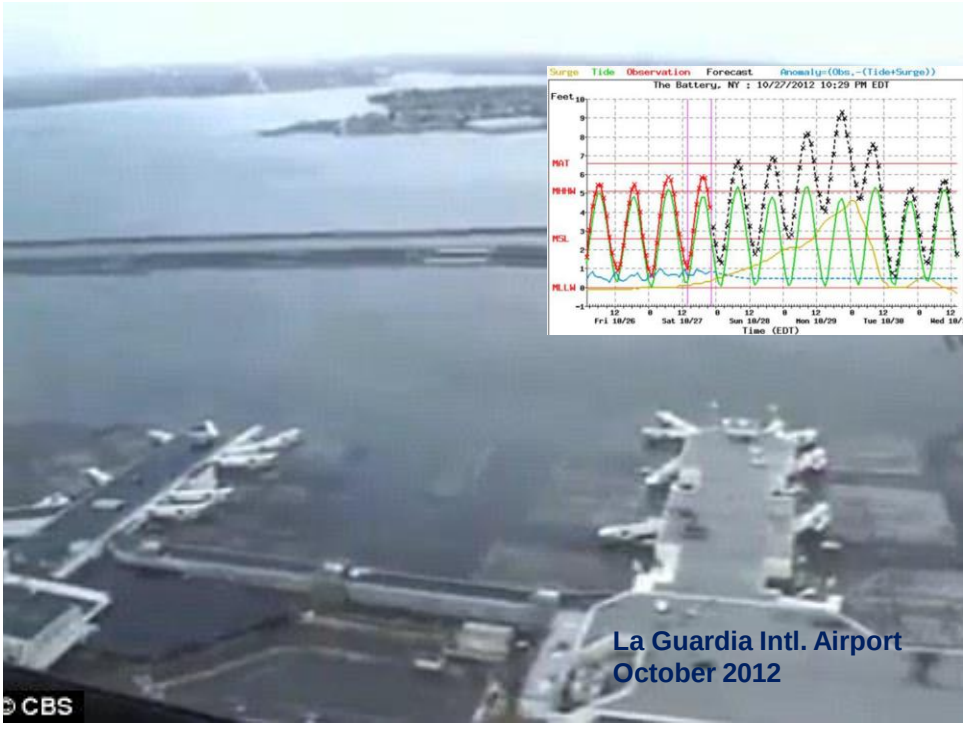
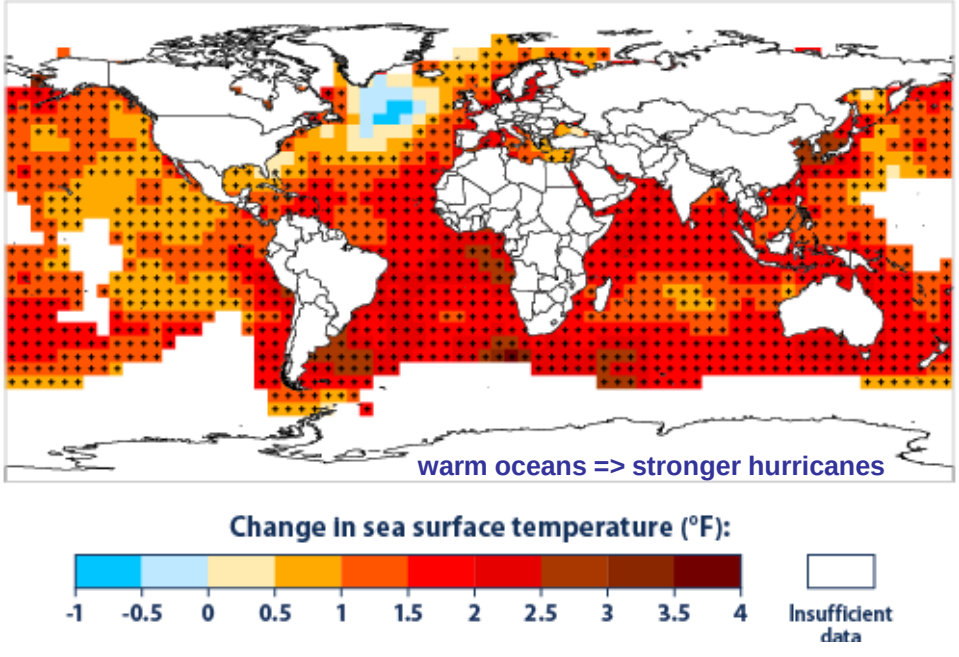
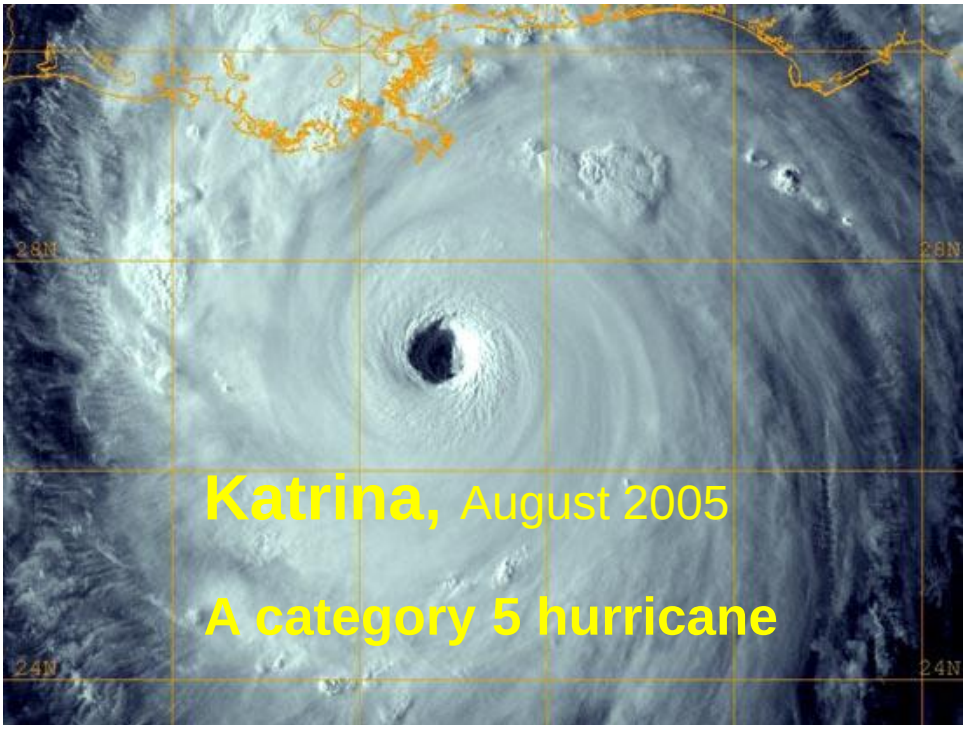


Figure 2. Change in Sea Surface Temperature, 1901–2012



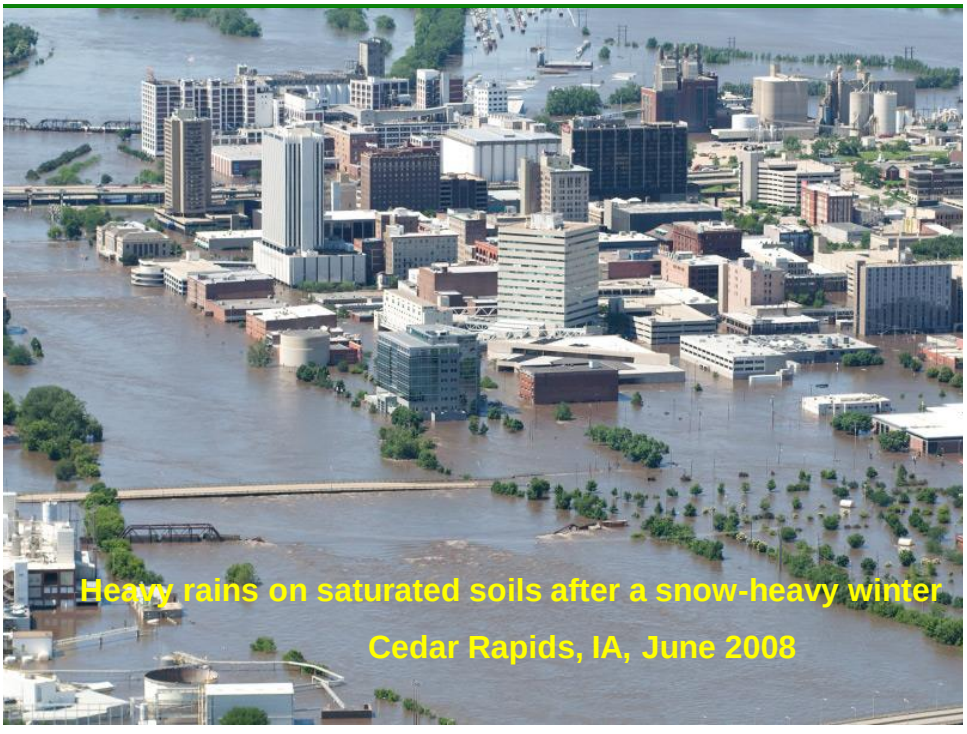


Katrina, August 2005

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
Depr
Storm
Hurricane Category
1
2
3
4
5


Heavy rains on saturated soils after a snow-heavy winter
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	Storm Surge Barriers	Seawalls and Revetments	Groins	Detached Breakwaters
Benefits/Processes	**Benefits/Processes**	**Benefits/Processes**	**Benefits/Processes**	**Benefits/Processes**
Surge and Wave attenuation and/or dissipation	Surge and Wave attenuation	Reduce flooding	Shoreline stabilization	Shoreline stabilization behind structure
Reduce Flooding	Reduced Salinity Intrusion	Reduce wave overtopping	**Performance Factors**	Wave attenuation
Risk Reduction for vulnerable areas	**Performance Factors**	Shoreline stabilization behind structure	Groin length, height, orientation, permeability and spacing	**Performance Factors**
Performance Factors	Barrier height	**Performance Factors**	Depth at seaward end	Breakwater height and width.
Levee height, crest width, and slope	Wave height	Wave height	Wave height	Breakwater permeability, proximity to shoreline, orientation and spacing
Wave height and period	Wave period	Wave period	Water level	
Water level	Water level	Water level	Longshore transportation rates and distribution	
		Scour protection		

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