Quantifying Climate Risks (and Risk Management options) in Deltas

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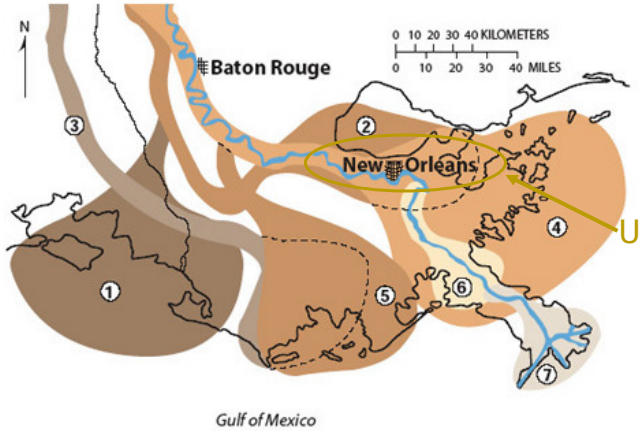
Katrina & New Orleans – A cautionary tale

The foundations of a Catastrophe - Development of the Mississippi Delta - last 5000 years

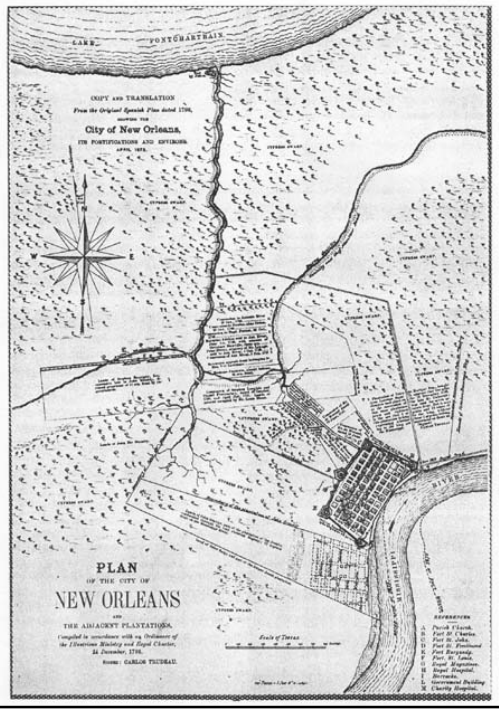


Underlain by 3 recent delta sequences

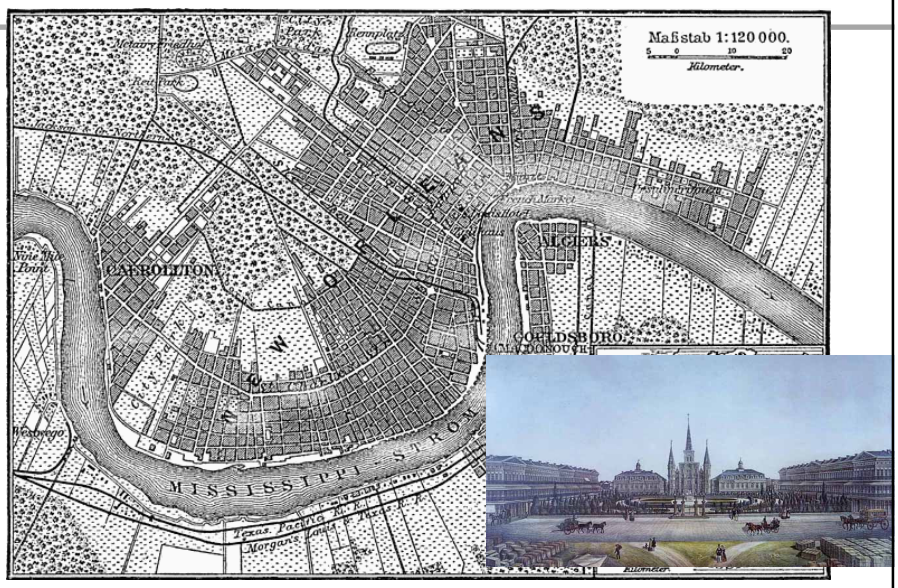
1. Sale Cypremont >4800 yrs BP
2. Cocodre ca 4600-3500 yrs BP
3. Teche ca 3500-2800 yrs BP
4. St Bernard ca 2800-1000yrs BP
5. S Lafourche ca1000-300yrs BP
6. Plaquemine ca 750-500yrs BP
7. Balize <550yrs BP

New Orleans

- Founded in 1718
- Closest 'dry' land (on the natural levee) to the sea
- Portage between the Mississippi River and Lake Pontchartrain

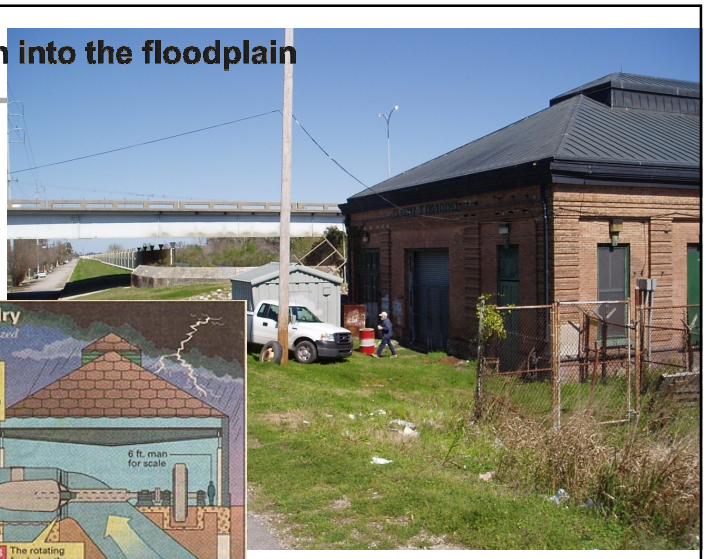


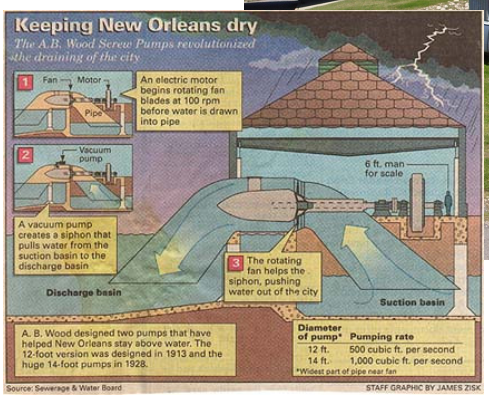
New Orleans before the pumps (1888)



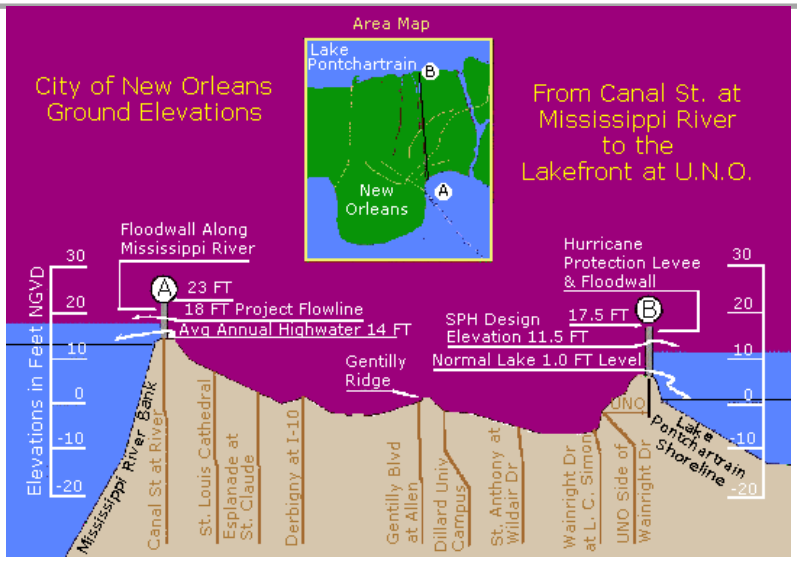
The expansion into the floodplain

- Pumps
  1913-1928

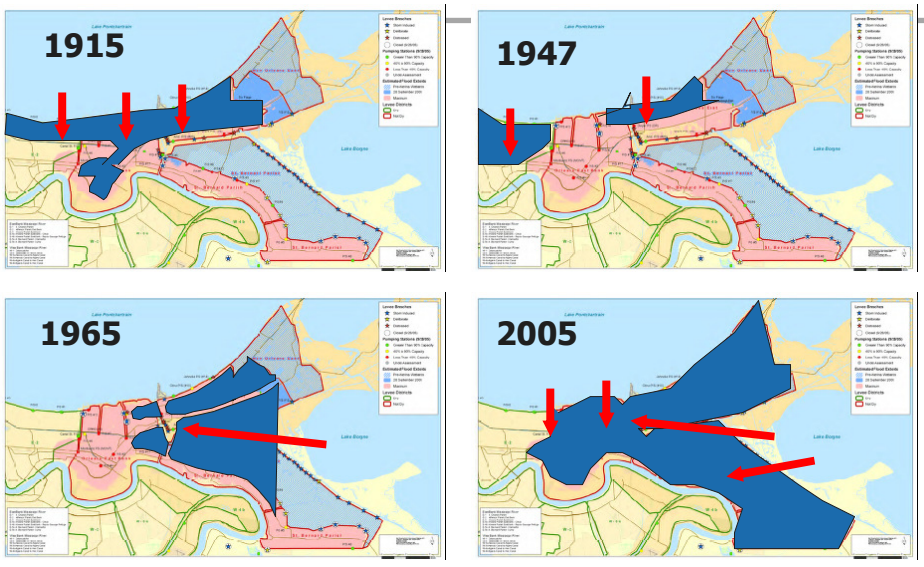




A cross section through New Orleans



100 years of storm surge flooding



From 1965 Betsy to 2005 Katrina

Death toll in S. Louisiana = 81

Death toll in S. Louisiana = 1292

No vertical evacuation routes in the city: water levels in Katrina 1.3-1.6m higher than in Betsy

Catastrophe Models are used to quantify the impact of extremes

....because we never know which particular extreme will happen next

therefore we need to look at the full range of possibilities

Framework for modeling an individual Tropical Cyclone

Cat models are built out of modules that mimic the process of loss generation.

- **A stochastic event component which simulates physical parameters, location, and frequency for each storm in a set of stochastic storms covering the full range of potential hurricanes**
- **A hazard model determines the relevant variables, for example the peak-gust windspeed for each stochastic storm and analyzed location**
- **A vulnerability module that links hazard and damage**
- **A financial model that estimates the loss given the damage**

Storm surge catastrophe loss modelling

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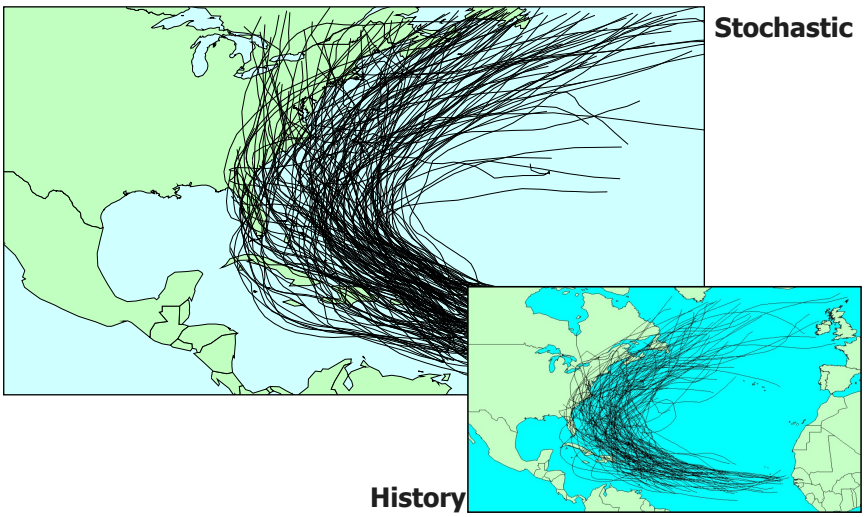
Type 1 Stochastic Tracks



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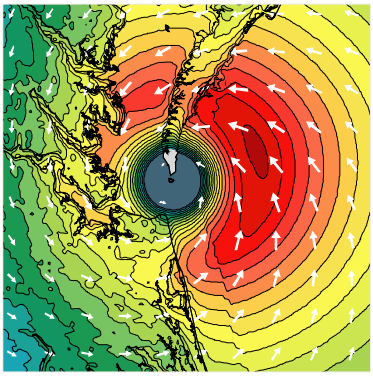
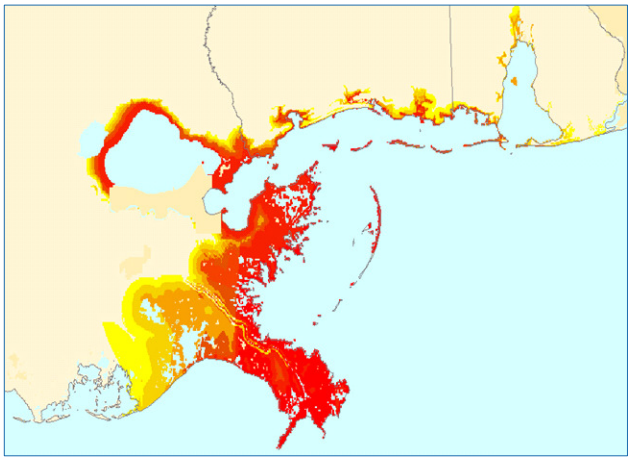
Modeling windfields and windspeed at a Location

- For specific locations, consider:
  - Direction of approaching winds
  - Terrain/roughness upwind
  - During the entire passage of each modeled storm
- Solution: time-stepping directional windfield
  - Upwind roughness sampled 80 km in eight directions
  - Each hurricane windfield modeled at 15-minute intervals
  - Highest windspeed stored at each location over the passage of a storm



Storm Surge Footprint

- Generated with full 3D coupled ocean-atmosphere storm surge and wave model
- Inundation zone benchmarked against high-resolution elevation data



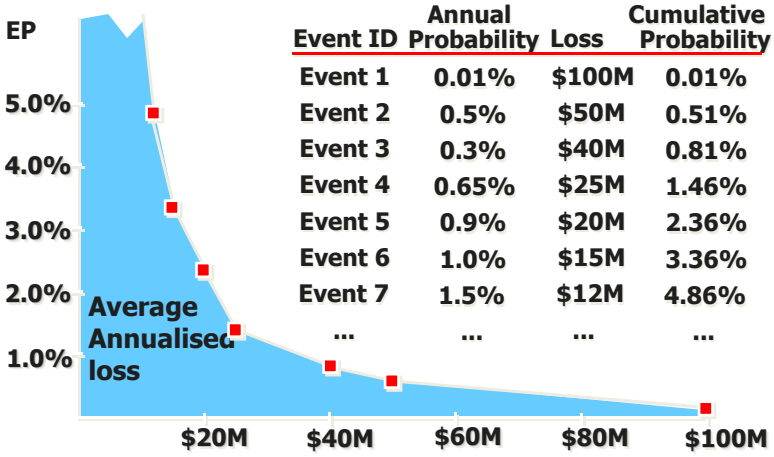
Overtopping of flood defences in Katrina (5m surge and 4.7m levees)

Breaching of flood defences in Katrina

- Defences failed when water level 1.5m below crest elevation
- Breach scoured to more then 10m below ground level

Storm Surge vulnerability

Building the Exceedance Probability (EP) Curve



Event ID	Annual Probability	Loss	Cumulative Probability
Event 1	0.01%	$100M	0.01%
Event 2	0.5%	$50M	0.51%
Event 3	0.3%	$40M	0.81%
Event 4	0.65%	$25M	1.46%
Event 5	0.9%	$20M	2.36%
Event 6	1.0%	$15M	3.36%
Event 7	1.5%	$12M	4.86%
...	...	...	...

How Cat models can be used to show

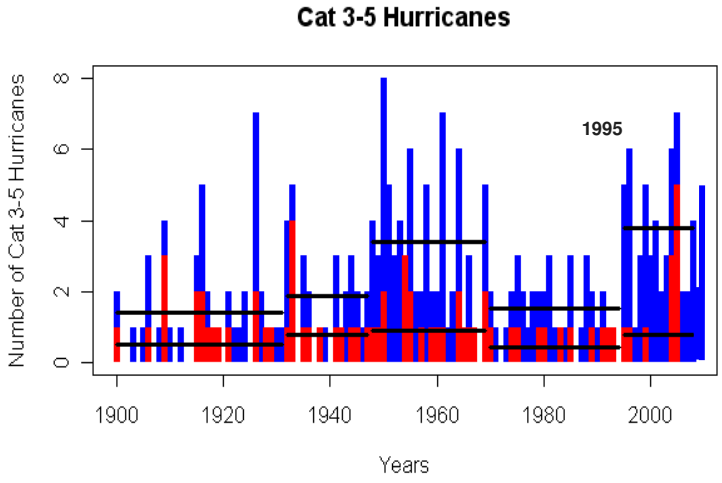
- future expected risk costs around climate change

- impact of changes in hazard assessment

- best value in adaptation strategies

-

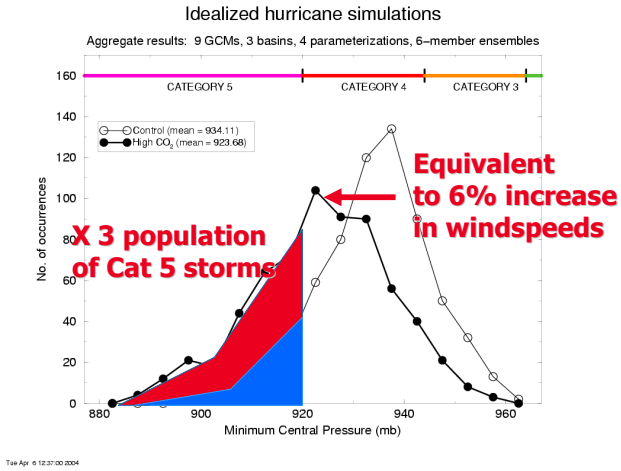
Annual activity of Cat3-5 hurricanes



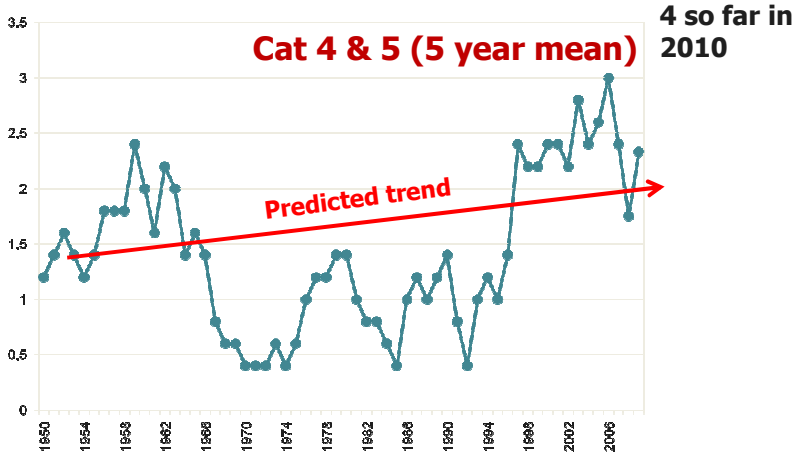
Basin Numbers
Landfall Numbers

Change points from *Jewson and Penzer, 2005*

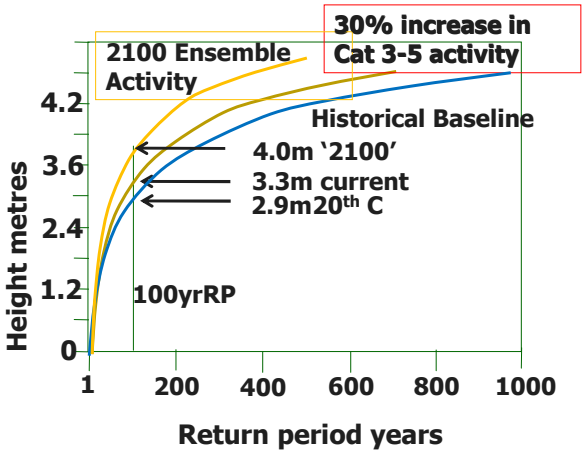
Shift in mean of simulated Hurricane Intensities under 2 x CO2 (Knutson and others)



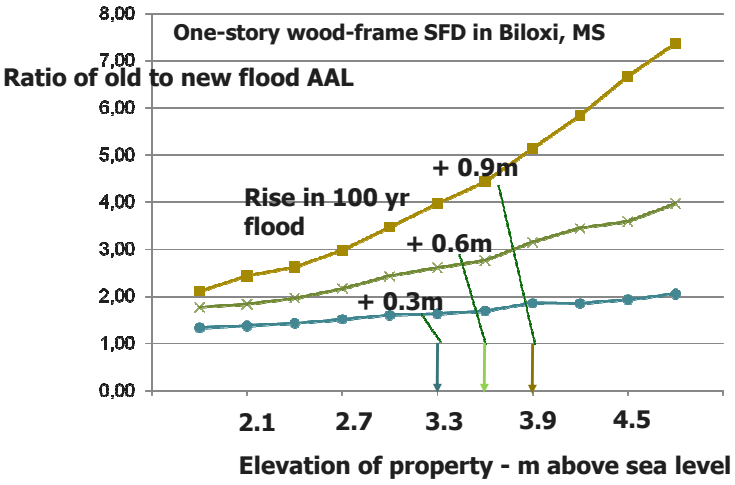
Is there evidence the population of intense Cat 4 and 5 hurricanes is shifting?



Implications of changes in activity of intense Hurricanes on extreme sea levels

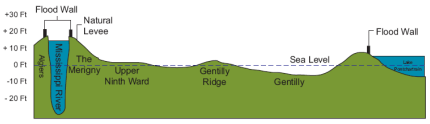


Ratio of new to old storm surge flood AAL with rise in 100 year flood elevation

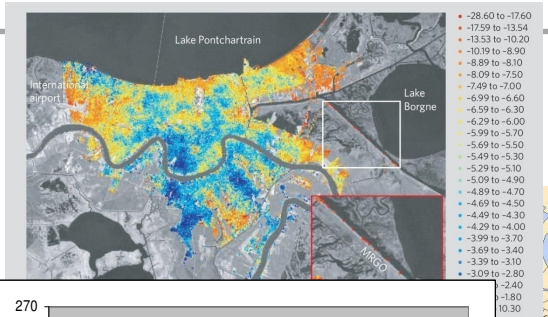


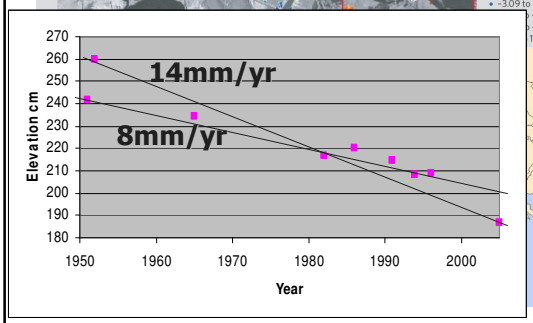
The future of New Orleans

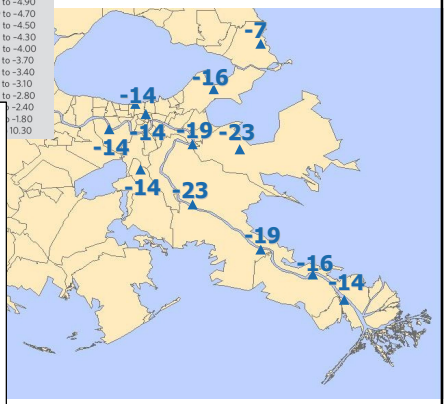
- What is the level of flood risk in New Orleans? And how will it change over time?
- The long term future of the city depends on the risk remaining below an acceptable level for those living and running businesses in the city.
- Exploration of flood risk through modeling (comprehensive stochastic hurricane tracks, high resolution windfields, storm surges, and fragility of levee systems)



Annual subsidence mm/yr (as discovered since 2005!)







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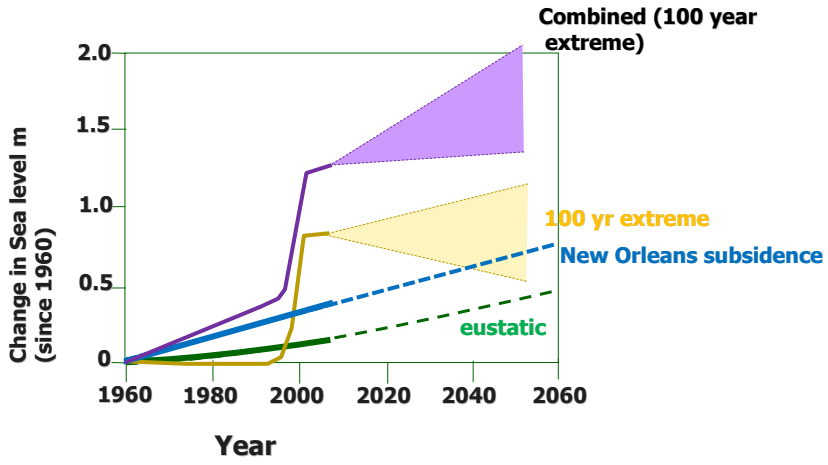
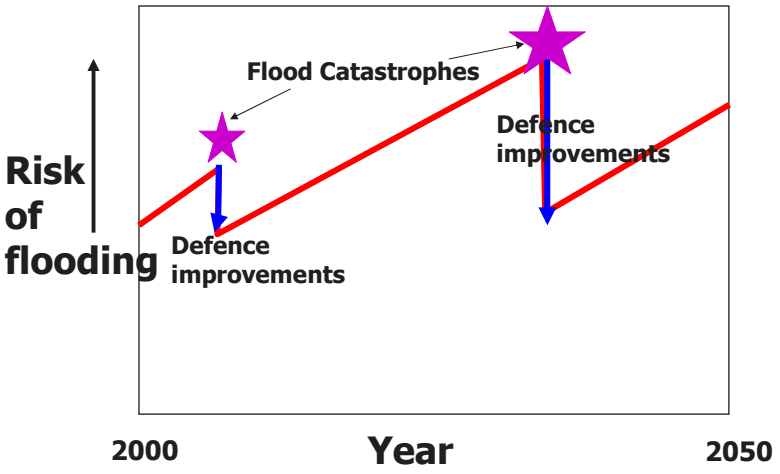
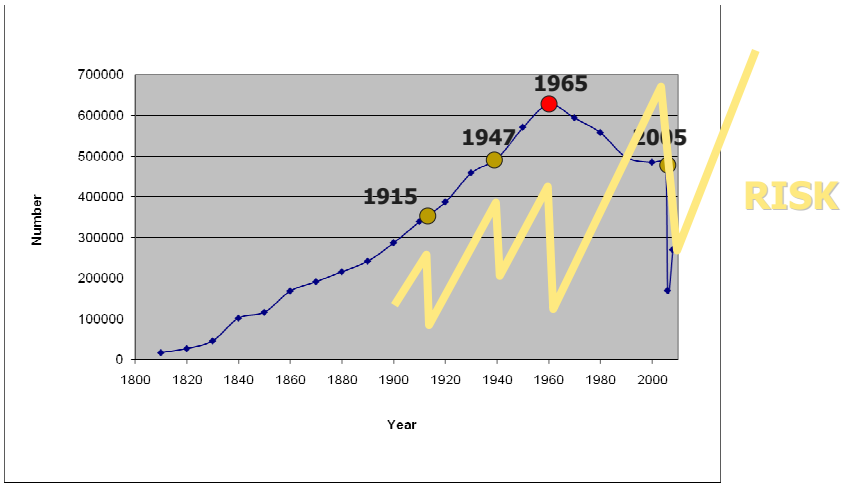
Rates of sea level rise (New Orleans)



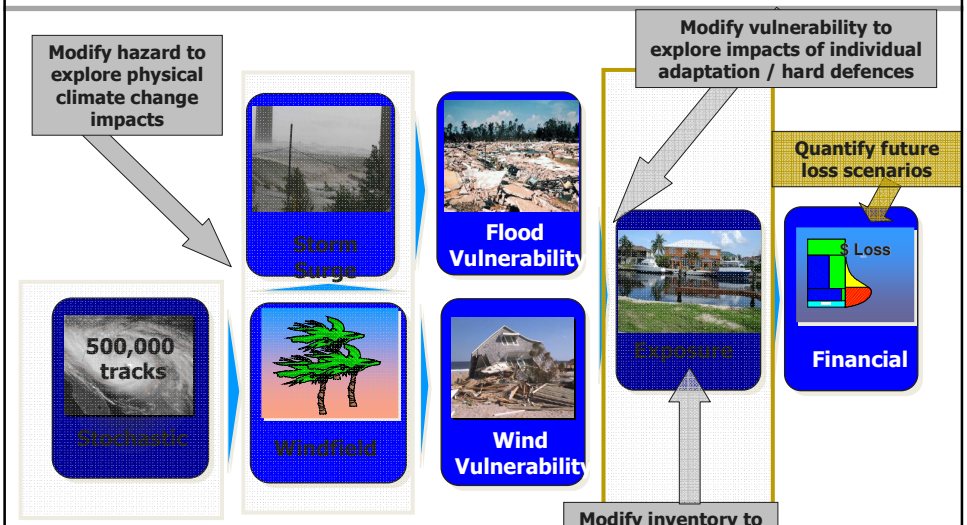
Reactive Investment Strategy where flood risk is rising - the example of New Orleans



'Voting with one's feet': New Orleans population and major floods



Cat models as tools to explore impacts and benefits of adaptation to extremes



e.g. future coastal flood risk

Modelling Benefits (£) of Adaptation to Climate Change

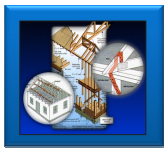
Model Changes to Hazard

Hazard

Changes to hazard climatology

Model Changes to the Vulnerability of Buildings

Vulnerability



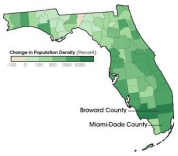
eg. Flood Resistance & Resilience Measures

(changes to primary and secondary modifiers)

Model Changes to Inventory

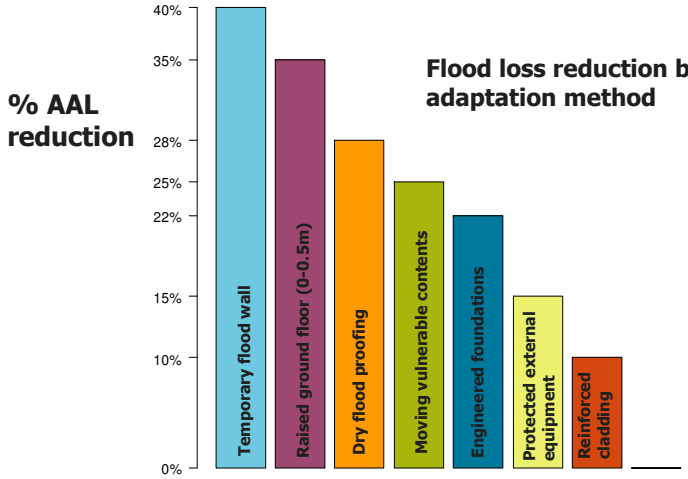
Inventory

e.g. Risk Averse Land Planning



Using Cat models to compare alternative adaptation measures

- Individual measures can substantially reduce losses (both in terms of average annual losses and losses from extreme events).



Delta Living - the Challenge

- Livelihoods can only be maintained long term on a sinking coastal delta by sustained (and accelerating) investment in flood protection to keep risk levels below defined targets
- Requires 'developed world' levels of investment – and even then this will probably not be enough to sustain second tier cities like New Orleans
- Identifying the benefit costs of alternative investments around extreme event risk reduction requires the application of probabilistic catastrophe loss modelling

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The beginning of the great retreat from the coasts

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