Subsidence and Elevation in New Orleans

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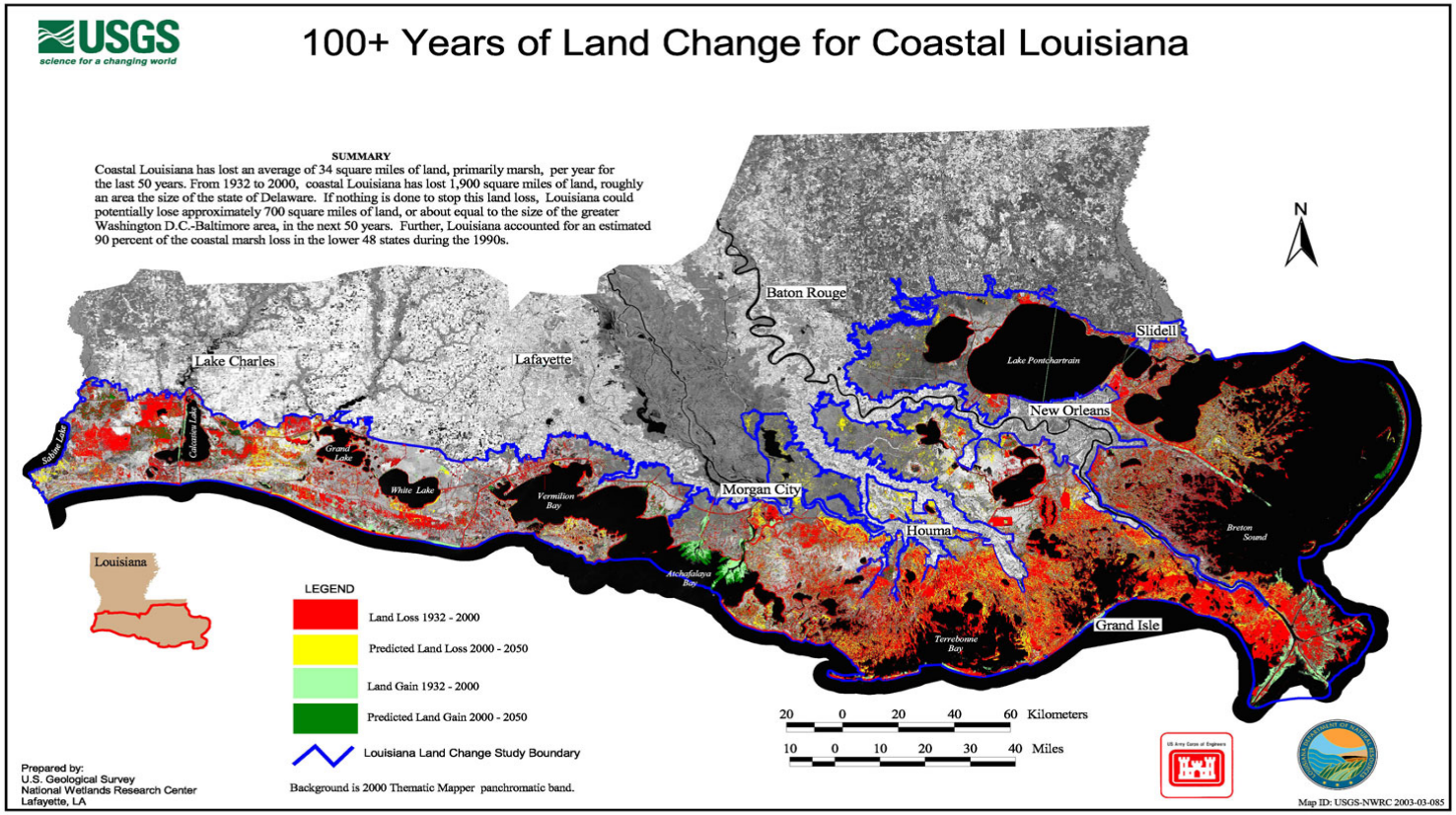
Land loss in Louisiana

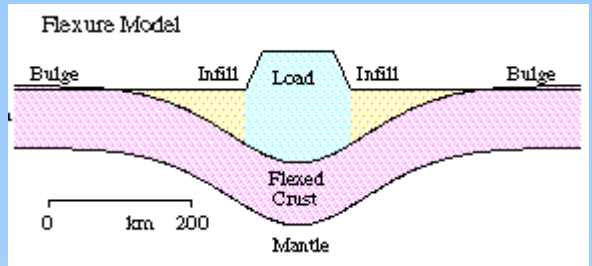


http://www.nwrc.usgs.gov/upload/landloss11X17.pdf

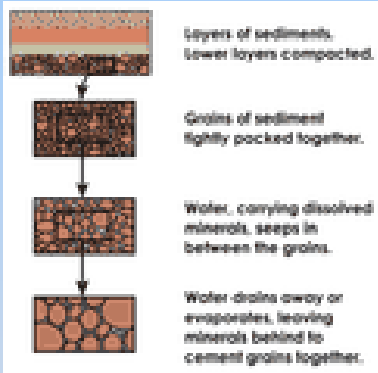
Land loss is mainly due to subsidence and sea level rise

Why Subsidence?

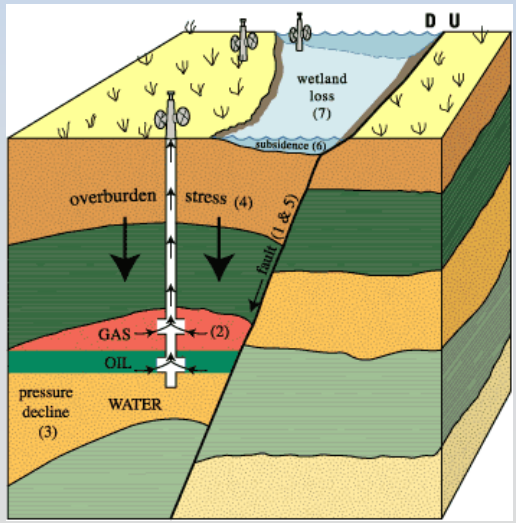
- Sediment load



- Sediment compaction

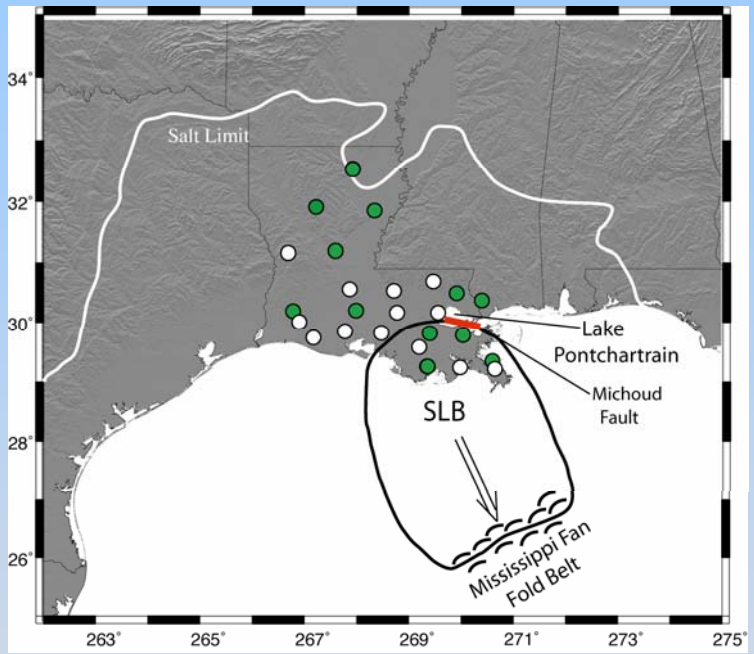


- Fluid withdrawal (water and oil production)

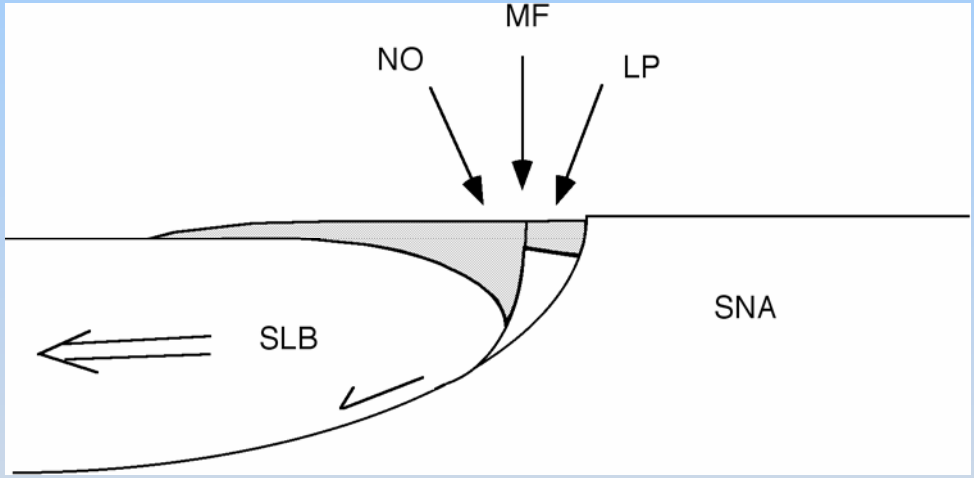


- Tectonics

Why Subsidence? - Tectonics



Southern Louisiana Block is sliding on a weak salt layer toward the Gulf of Mexico



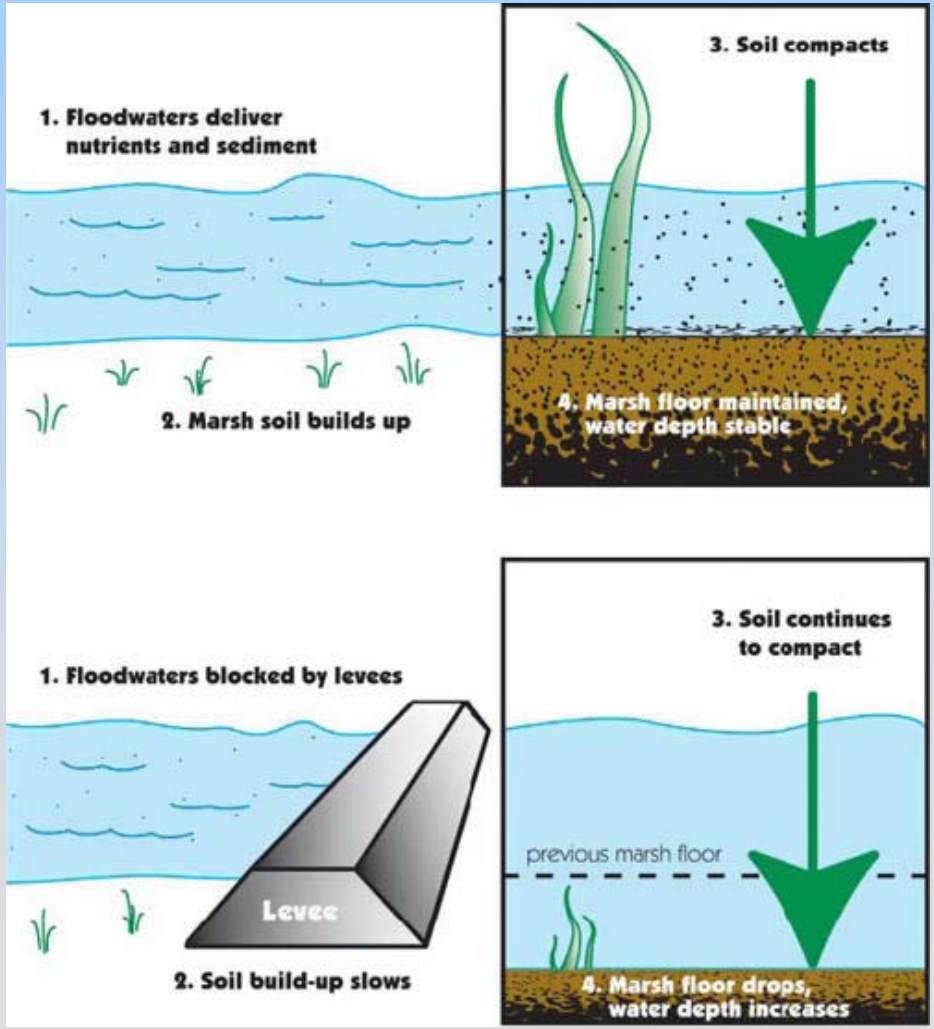
Dixon et al. (2006)

Surface Subsidence

The primary cause of this massive land loss is the alteration of natural processes that are essential to sustaining wetlands.

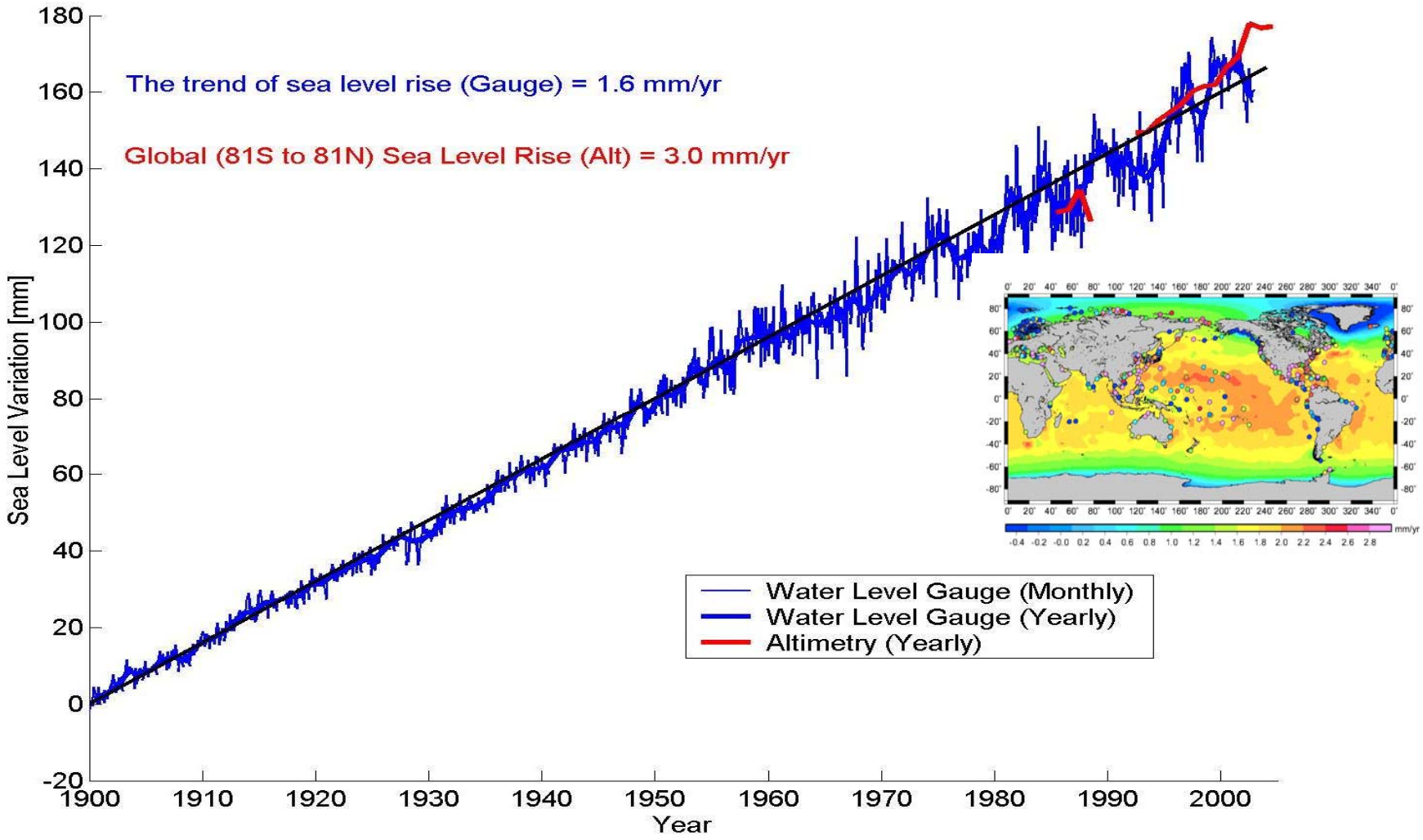
- **Levee construction for flood protection**
- **Creation of navigation channels, and canals for oil and gas exploration and production.**

With Floodwaters Blocked, Nutrients, Sediment No Longer Offset Subsidence



http://www.lacoast.gov/watermarks/2005-08/1wetlandsDisappear/

Sea Level from Multiple Atlimetry & Tide Gauge (1900-2002)

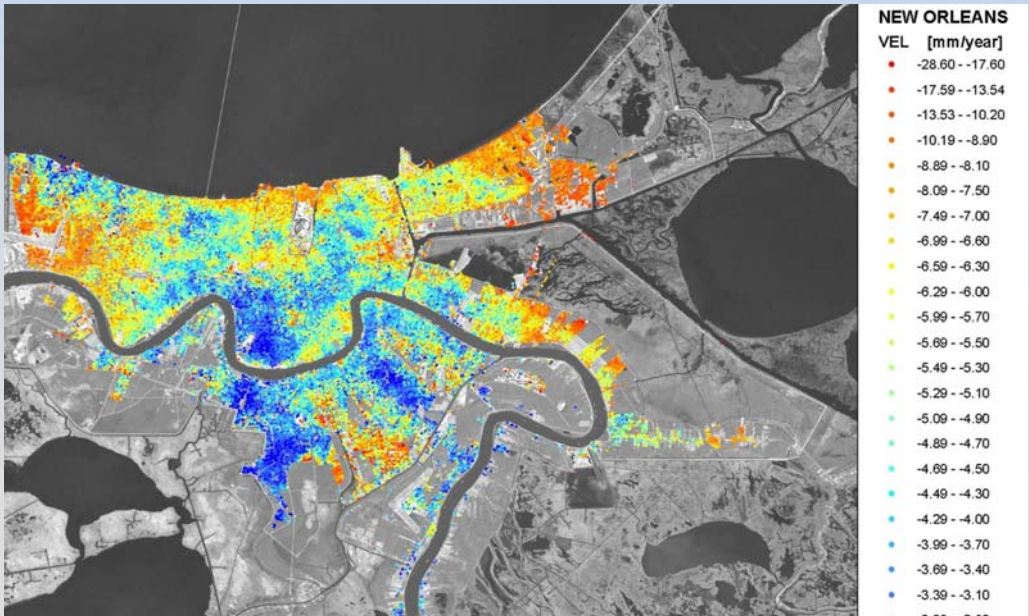


(C.K. Shum, 2006)

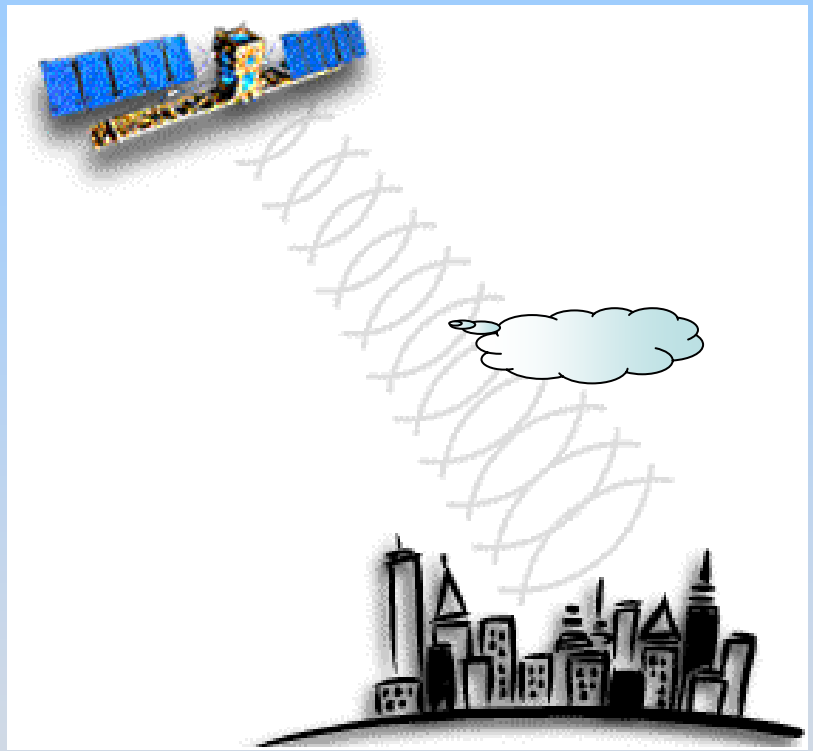
Space-based monitoring of surface movements

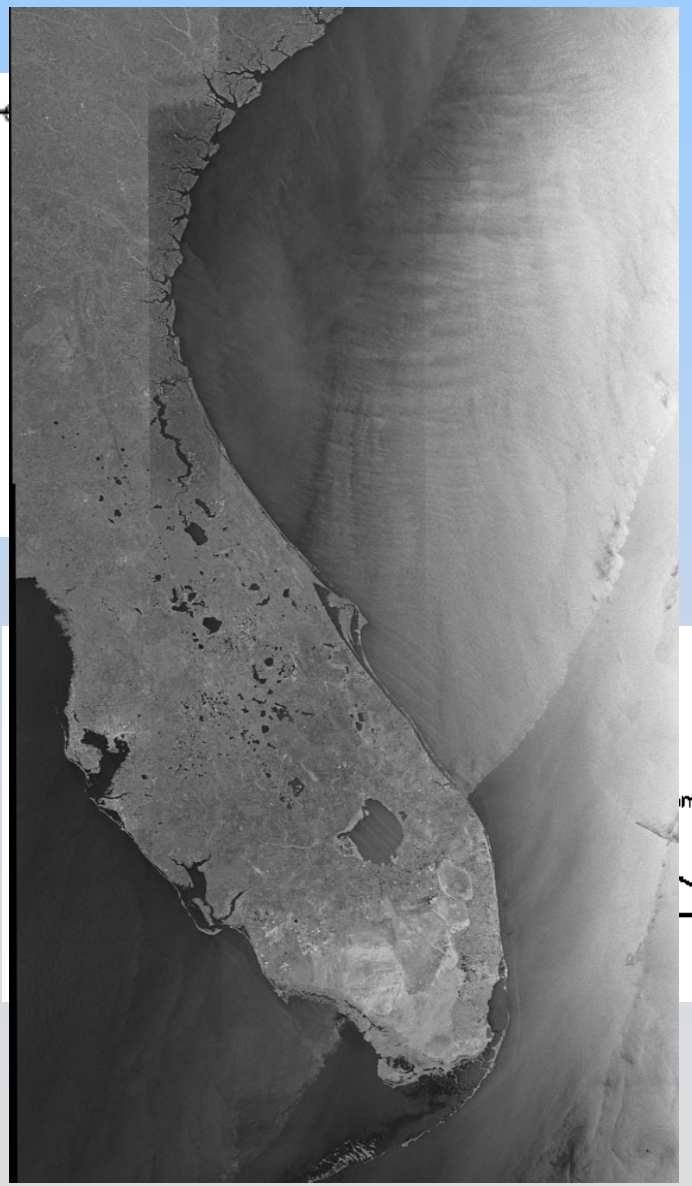
The techniques: PSInSAR

Permanent Scatterers
Interferometric **(InSAR)**
Synthetic Aperture Radar (SAR)



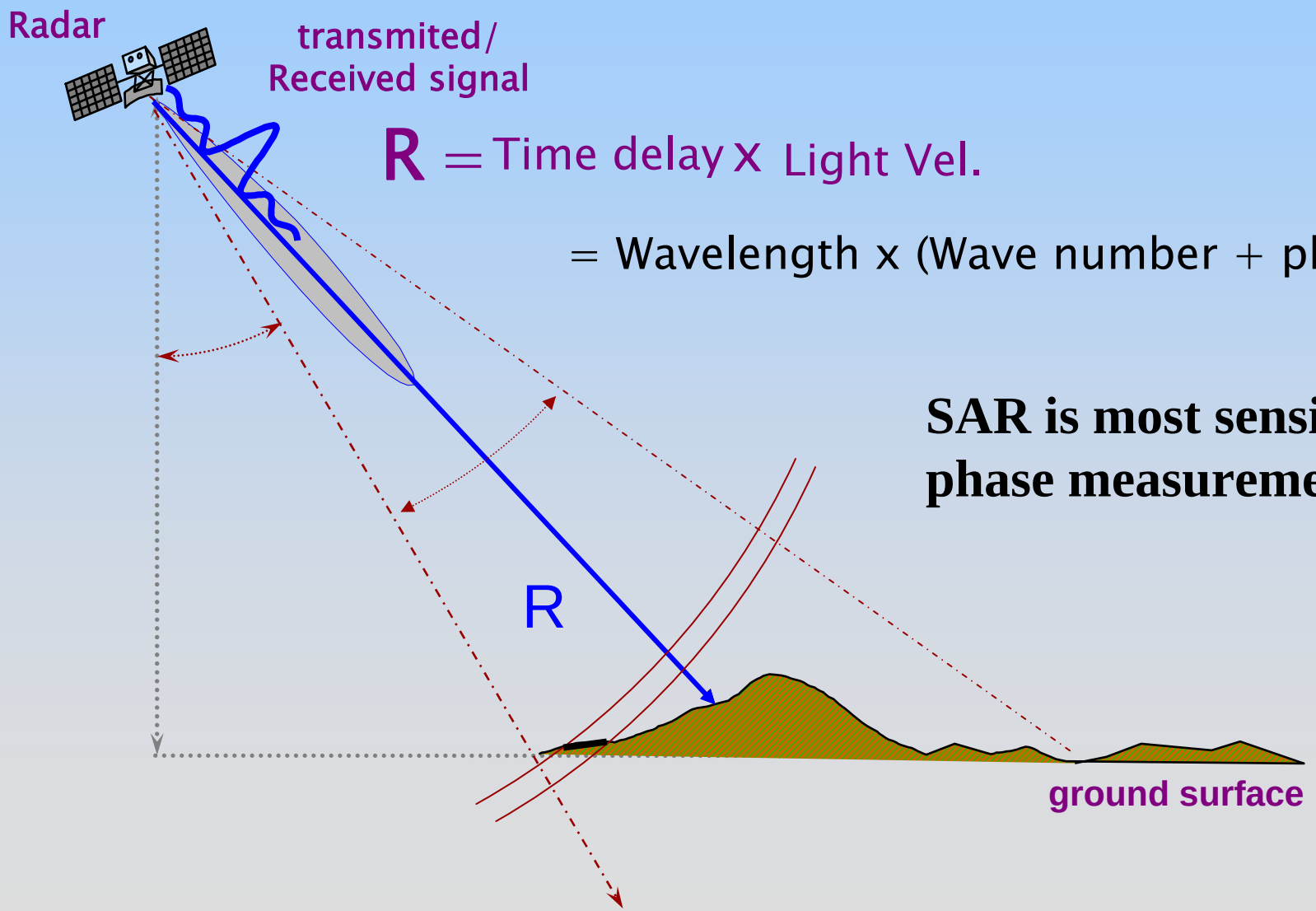
Synthetic Aperture Radar (SAR)





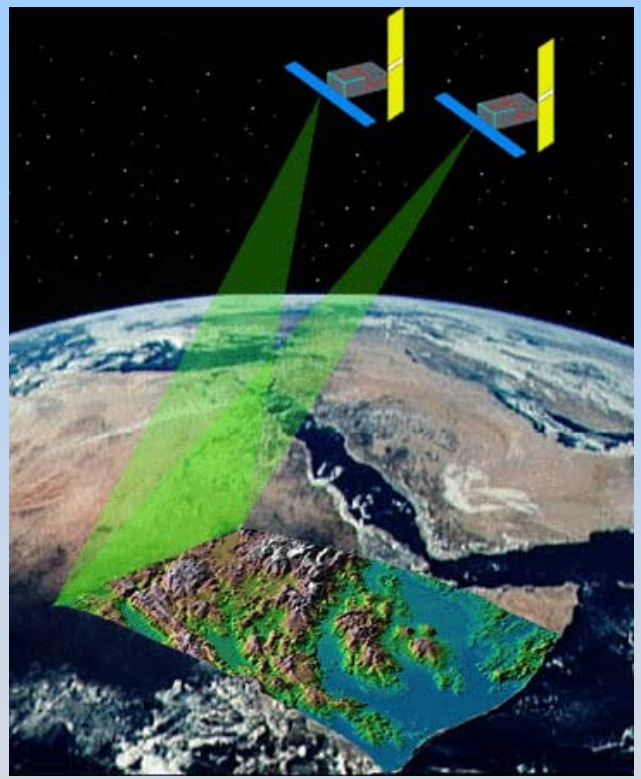
RADAR remote sensing is an `active` imaging technique that utilises the microwave region (~1-100 cm) of the EM spectrum

SAR – phase observable

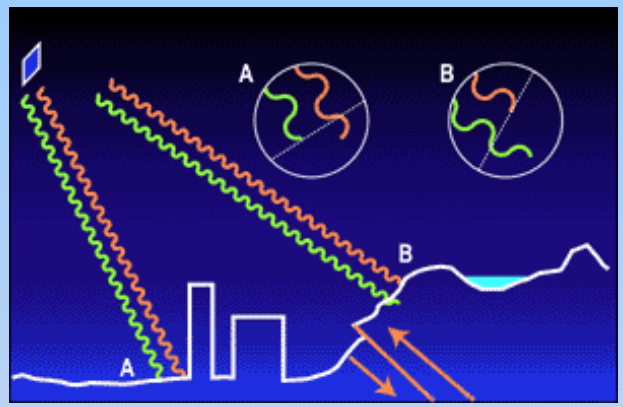


SAR is most sensitive to phase measurements

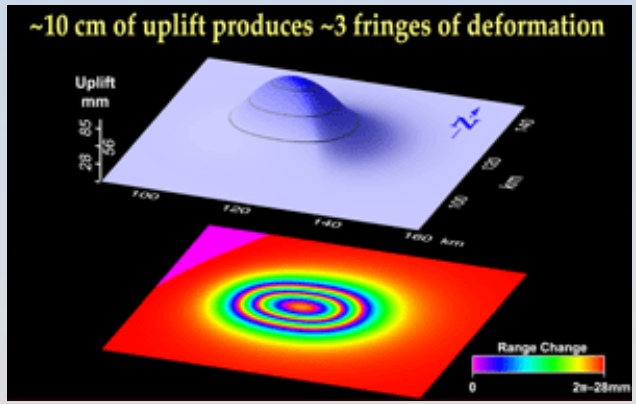
Interferometric SAR - InSAR



Two or more data acquisition of the same area from nearby location (< 1000 m)

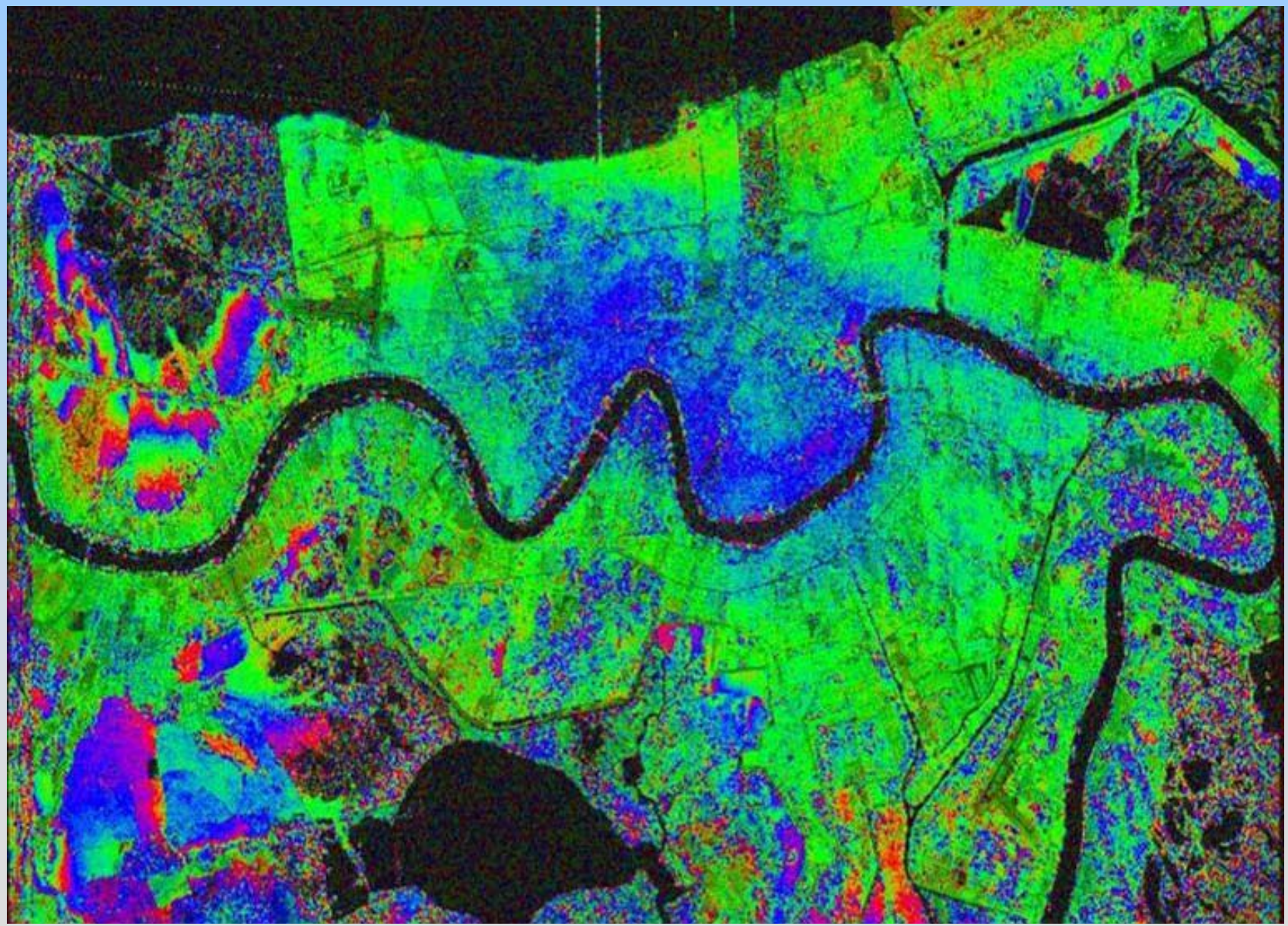


Changes in surface location result in detectable phase changes



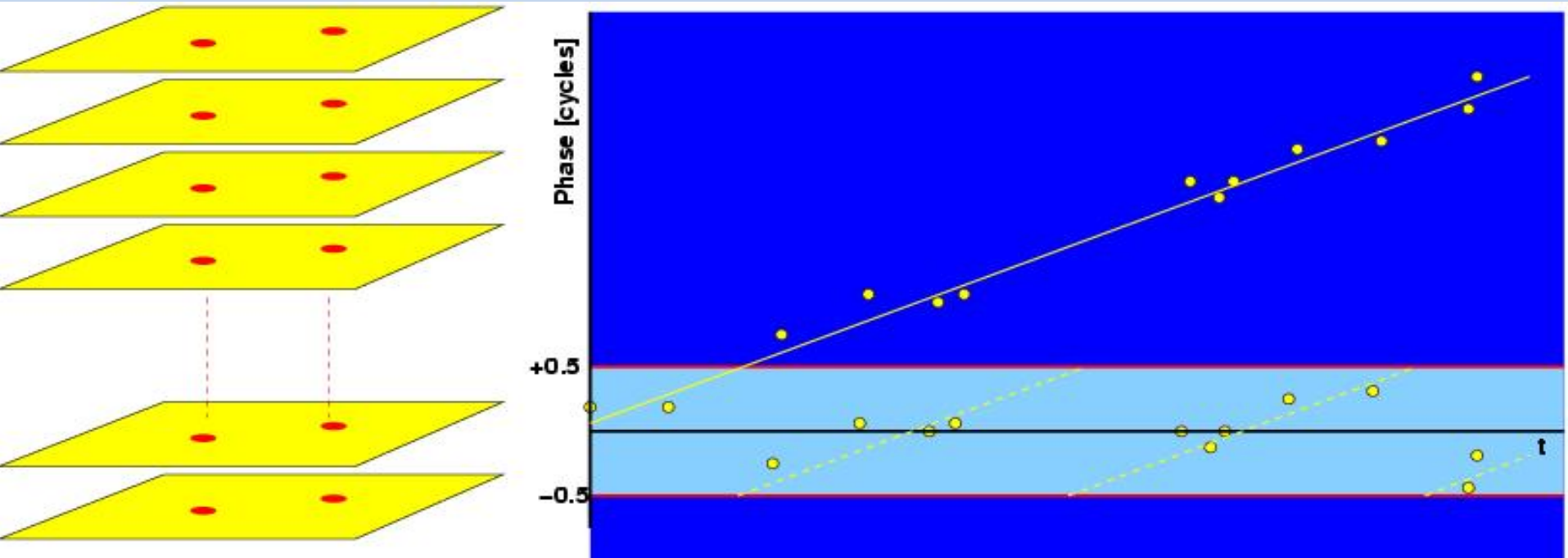
Fringes – 1 cycle (2π) = ½ λ

Surface or Atmospheric changes in Louisiana Over 48 days (2005/02/03-2005/03/01)

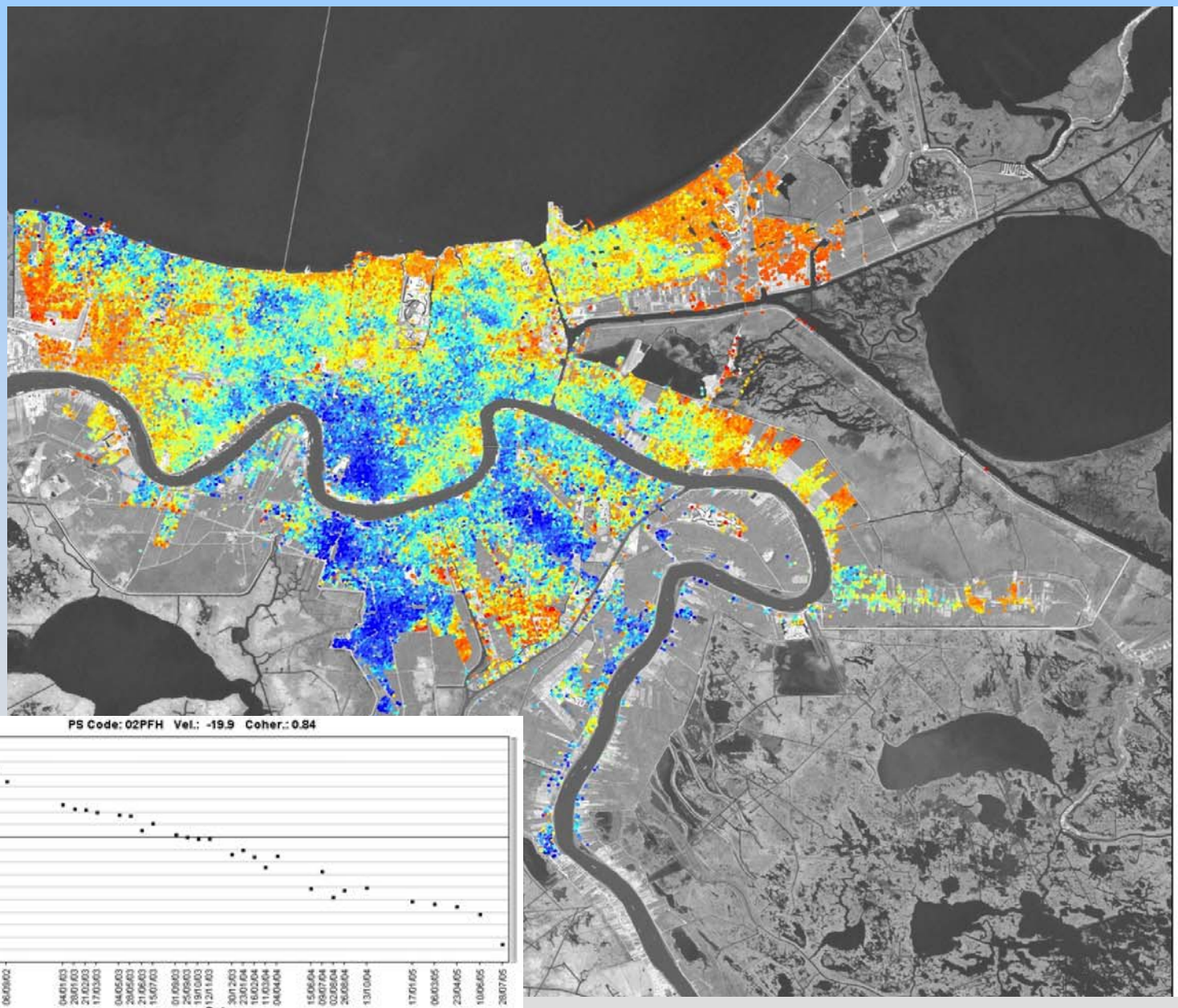


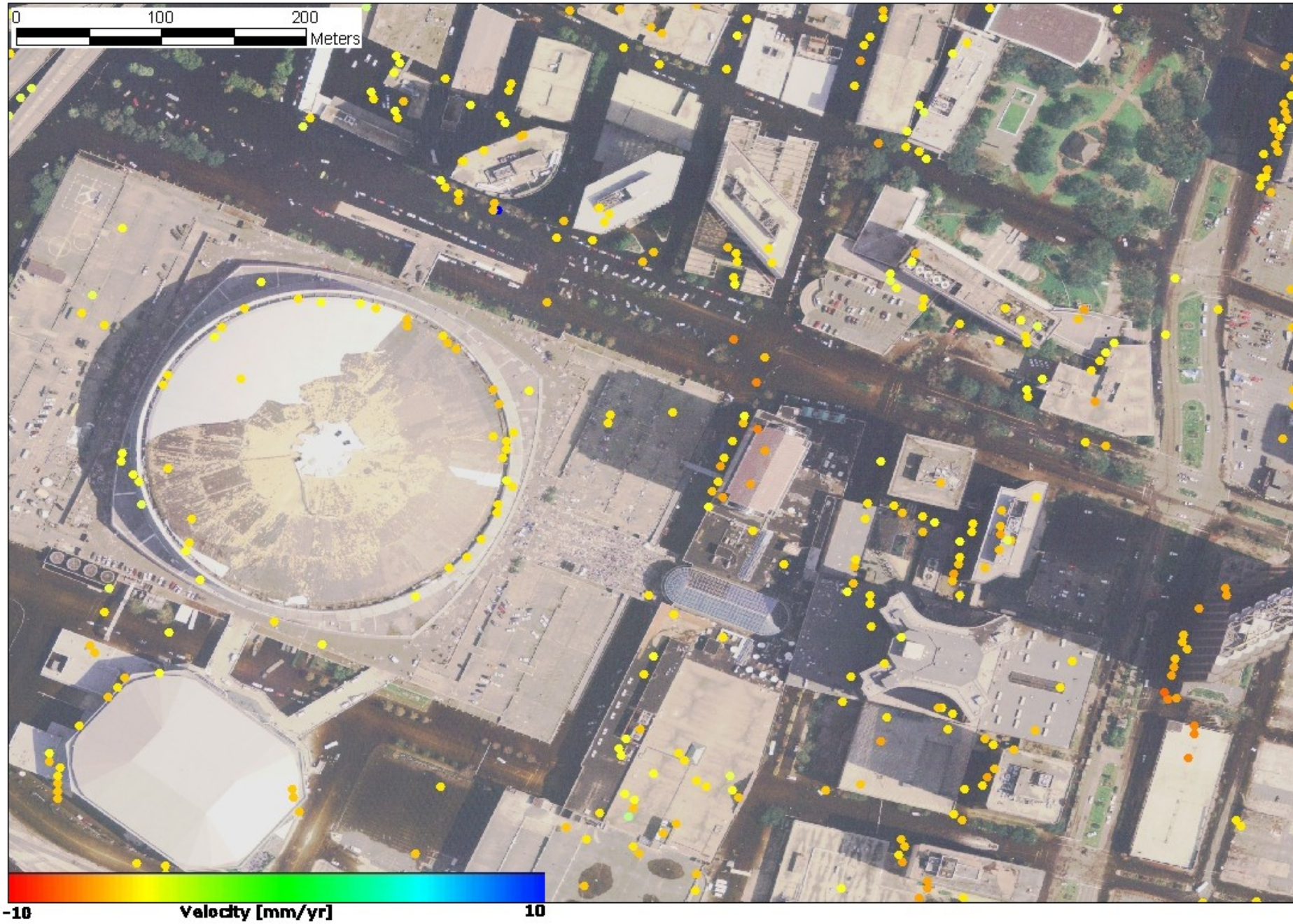
Permanent Scatterer InSAR: PS InSAR

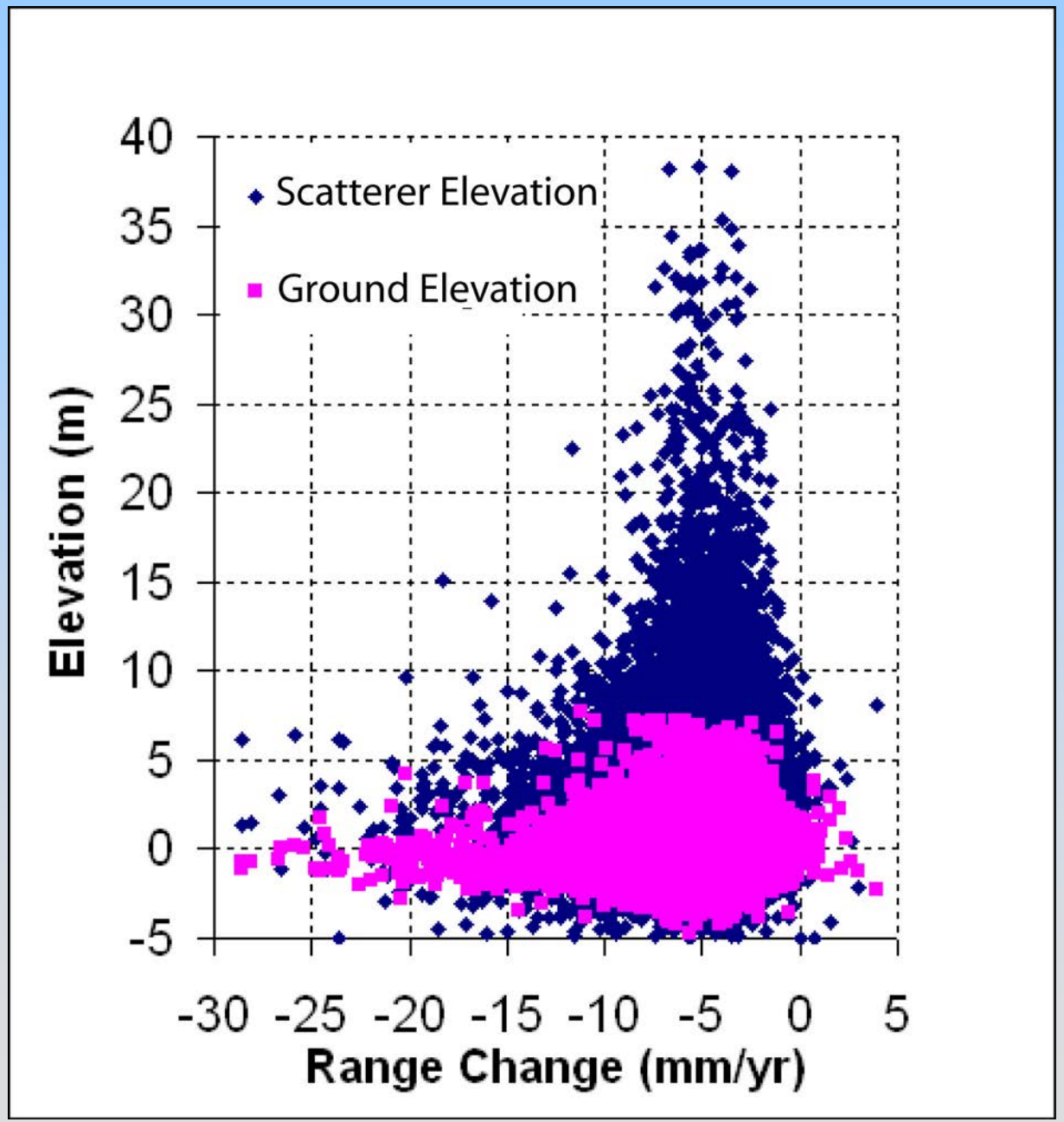
- **Analyzing large number of SAR scenes (> 20).**
- **Using a sub-set of the data – Only pixels with strong and consistent reflections in time.**
- **Multi-pass InSAR – time series necessary.**



First Space-Based Image of Subsidence in New Orleans




0
100
200
Meters
-10
Velocity [mm/yr]
10


Scatterer Elevation
Ground Elevation
Elevation (m)
40
35
30
25
20
15
10
5
0
-5
-30
-25
-20
-15
-10
-5
0
5
Range Change (mm/yr)

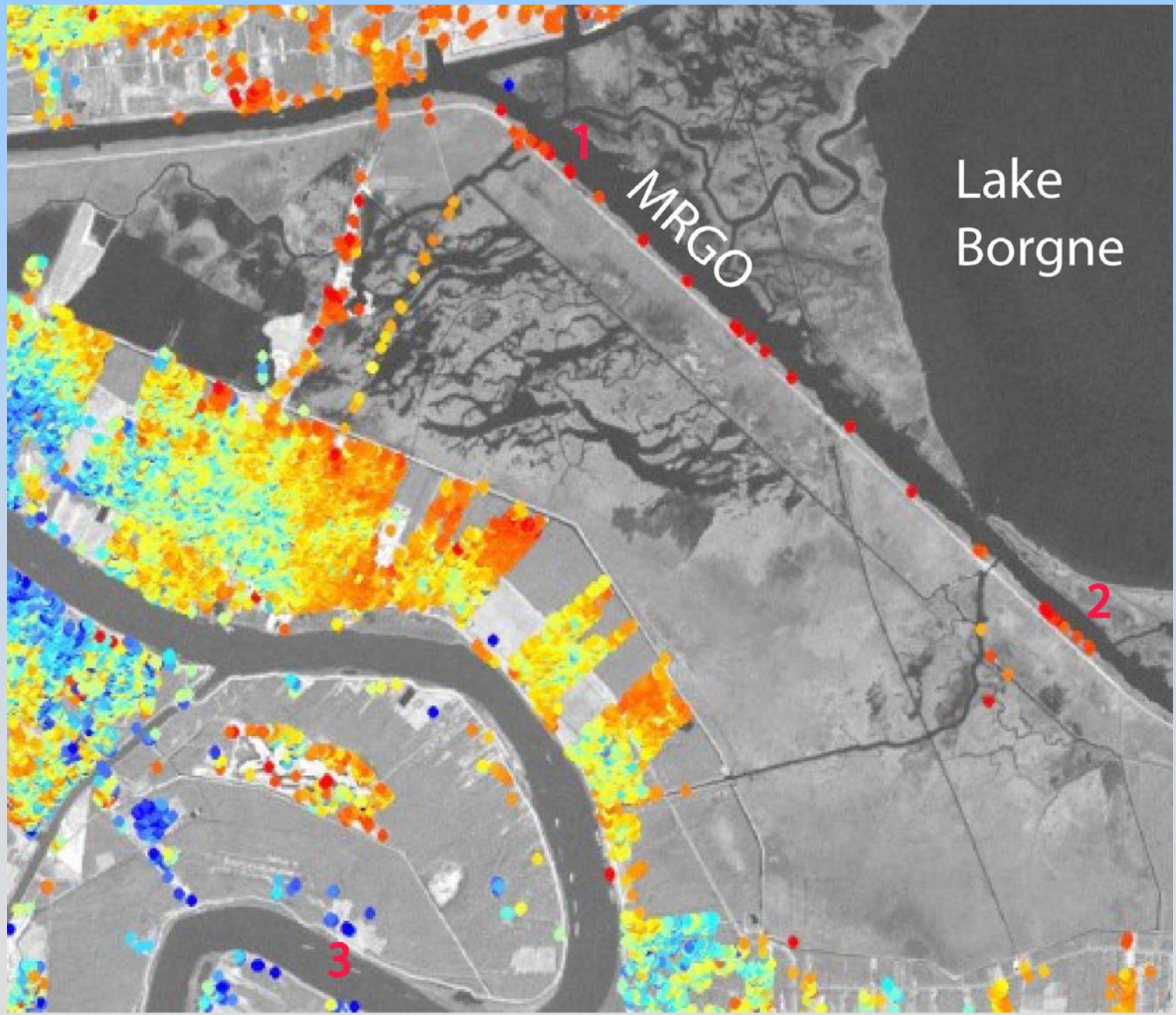
Distribution of Subsidence

- **Approximately 180,000 scatterers**
- **Mean subsidence rate is 6±2 mm/yr**
- **Large range of heights (10's of m above ground elevation) implies building tops are important radar reflectors**
- **High elevation scatterers subside at same rate as low elevations, implying building mass does not contribute to subsidence (importance of deep pilings; building codes work!)**
- **Tail of extremely high subsidence rates (20-30 mm/yr) in a few locations; these tend to be located in recently drained marshes (eg Kenner) or levees (large surface mass, no pilings)**

St. Bernards Parish:
Levee system post Katrina damage assessment

Source: http://www.freerepublic.com/focus/f-news/1489838/posts

St. Bernards Parish: PS on levees



Factors Contributing to Levee Failure; Implications for Rebuilding

- Levees adjacent to MRGO canal failed; these had high subsidence rates (>20 mm/yr)
- Levee failure may have been due height loss associated with subsidence (loading of weak marsh substrate by levee and consequent overtopping); or due to erosion of weak substrate by undercutting (in this case high subsidence rates were merely an indicator, not the cause, of failure)
- New levees will be built to withstand Cat 3 hurricanes; some levee failure is likely in case of Cat 5 due to storm surge
- Global warming is leading to ocean warming, and an increase in number and severity of tropical storms
- Cat 5 hurricanes are likely to hit New Orleans in the next few decades
- This implies that low lying areas will be flooded again in the future; rebuilding needs to take this into account

Conclusions

- Planned levees will not protect against Cat 5 storms; these are increasing in number as the ocean warms
- Rebuilding efforts should focus on areas that are higher than 2.5-3.0 meters below sea level; lower areas will flood again, and will have high death tolls due to drowning.
- As part of the rebuilding process, citizens/authorities need to find ways to raise the elevation of the low-lying areas, or elevate the buildings.
- Only a small fraction of New Orleans is lower than 3 m below sea level (severe danger zone); in the long run it will be cheaper to give housing credits to those displaced from these areas, allowing them to rebuild on higher ground, allowing low-lying areas to revert to wetlands.
- Planner should also take into consideration the continuous subsidence (6 mm/yr) and rising sea level (~2 mm/yr).

Other disaster-prone areas along the Gulf Coast

- Tremendous devastation occurred along the coast mainly to beach-front property. Most houses were destroyed by the hurricane winds and storm surge last year (Katrina), as well as, 36 years ago (Camille).

- Orrin Pilkey (Duke) suggested to not rebuild houses for the third time in three decades. Instead, he suggested to replace the first several rows of houses with a long, artificial dune going the length of the Gulf coast. The artificial dune would offer some protection, make the beachfront much more pleasant, and aid the tourist industry.