“Introduction to Real-time Networks”

Dr. Roy K. Dokka

Louisiana State University
(rdokka1@lsu.edu)

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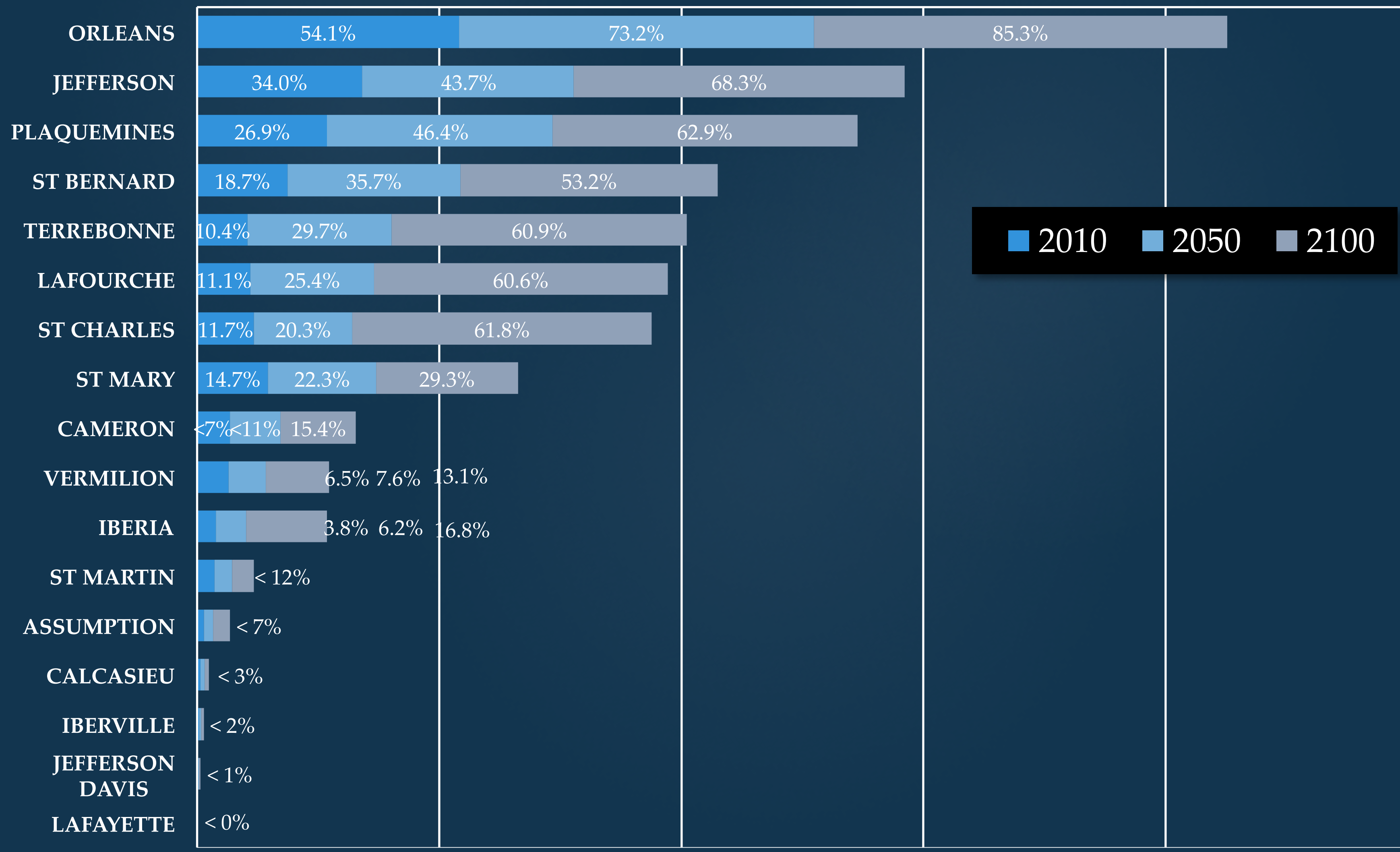
Along the Gulf Coast, your enemy is subsidence and sea-level rise.

- Subsidence moves BMs away from the datum. Thus, subsidence affects your ability to access the National Spatial Reference System (NSRS). The benchmark you are using to base a design, to prepare a flood certificate, or establish the height of a levee, may no longer be valid.
- Subsidence over time changes the spatial relationship between terrestrial and water datums.
- Bad vertical control means unrealistic flood models, inadequate hurricane protection design, unreliable flood maps, and and failed coastal restoration projects.

And it is not going to get any better!

Percent Land Below Sea Level by Parish Through 2100

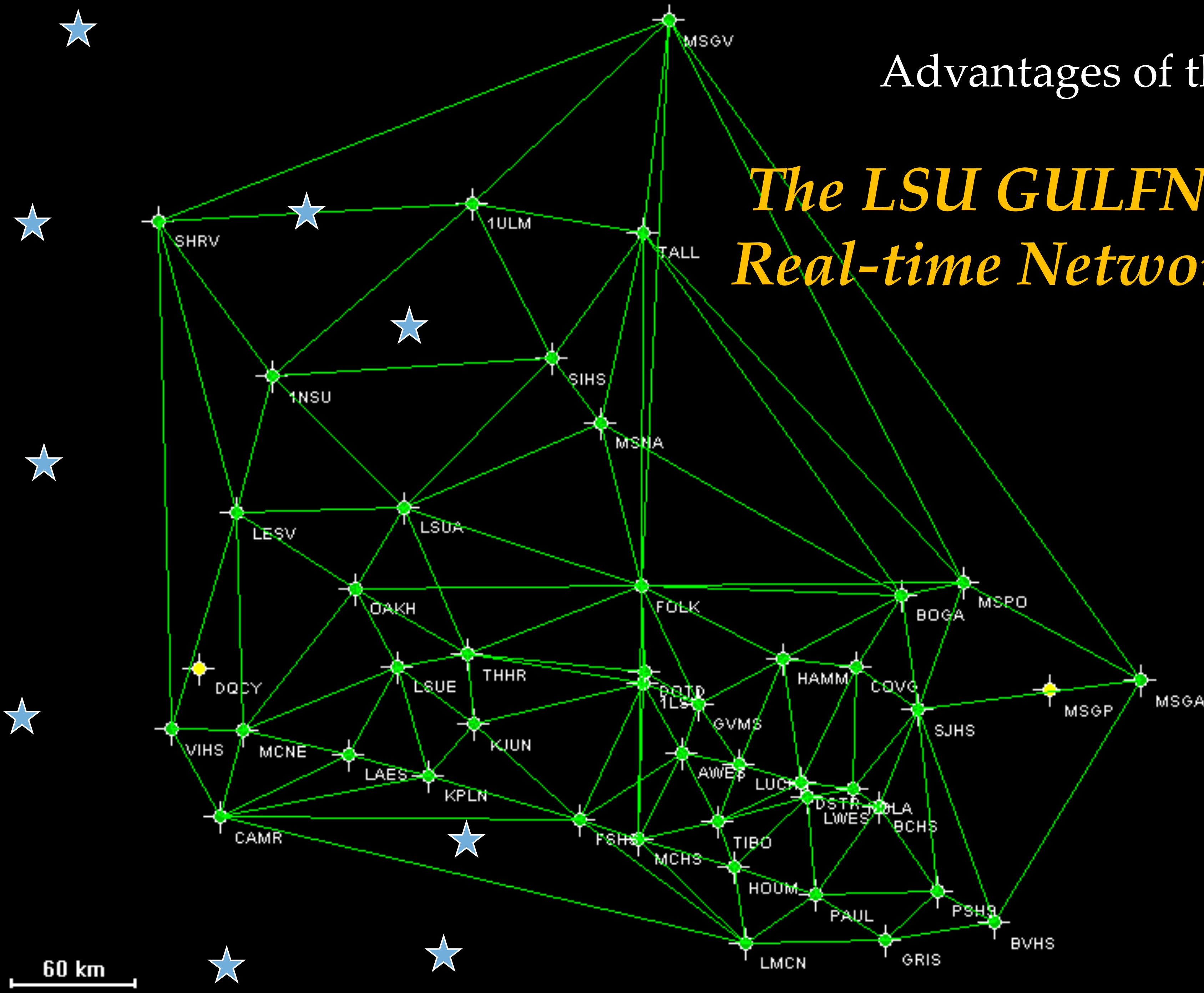


And imagine if Al Gore is right!!

Real-time networks offer a viable alternative to expensive geodetic leveling to maintain local geodetic control.

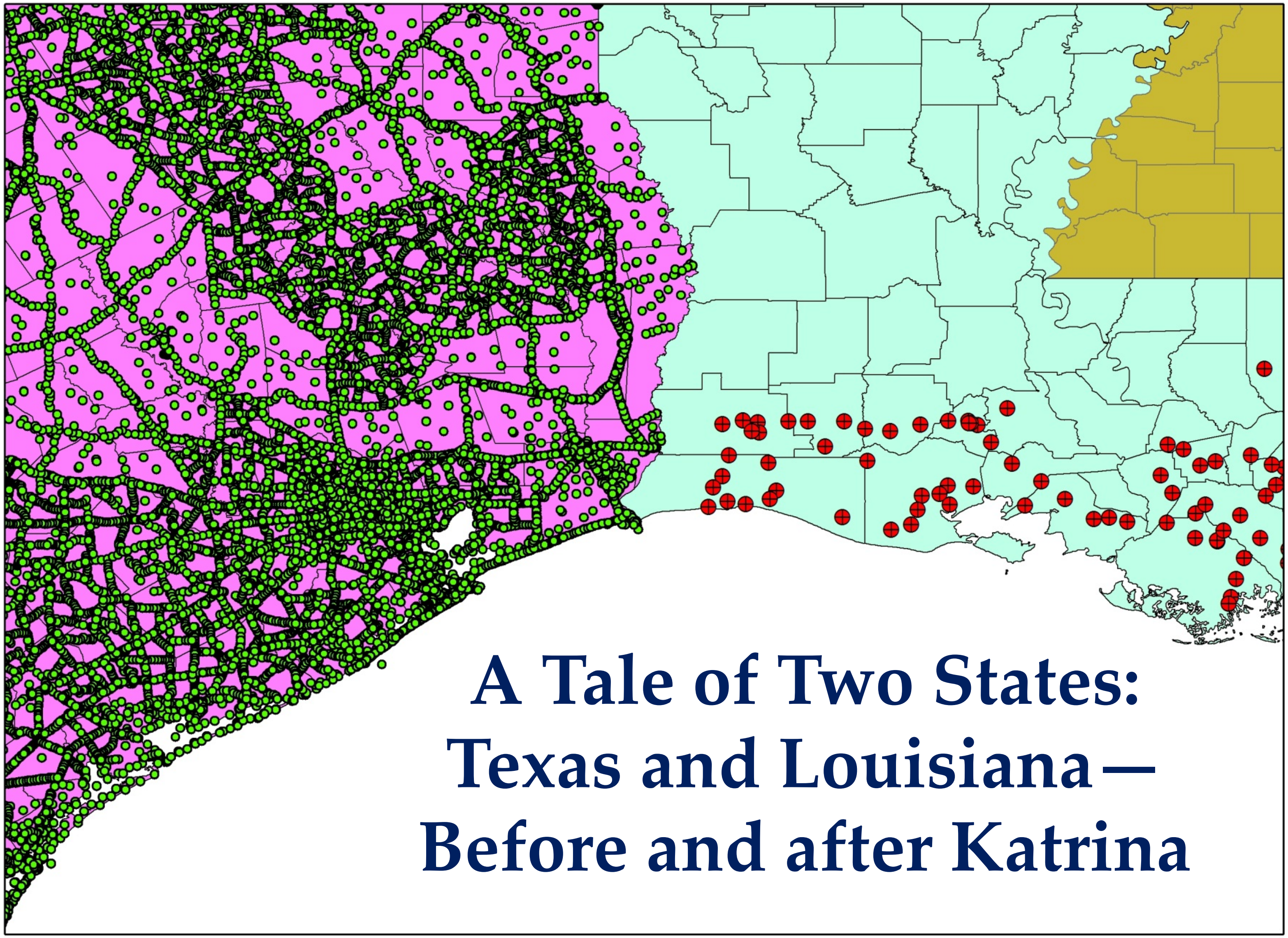
Advantages of the :

The LSU GULFNet Real-time Network



Today's Talk

- Review realities of maintaining control.
- Review challenges.
- Discuss solutions.
- Describe GULFNet RTN.
- Discuss uses.



A Tale of Two States: Texas and Louisiana— Before and after Katrina

Realities of Establishment of Vertical Control

How is vertical control established and maintained nationally?

- Long-line continental geodetic leveling.
  - Very expensive.
  - No appetite at federal level to return to “the good old days.”
- GNSS
  - CORS
  - Benchmark recalibration using GNSS combined with high accuracy Geoid models.

Realities of Establishment of Vertical Control (cont.)

How is vertical control established and maintained locally?

- Local decision and responsibility.
- Use NSRS as POB to establish local networks:
  - Benchmark networks established by:
    - geodetic leveling.
    - GNSS.
  - Local dense networks of CORS to support conventional RTK.
  - Real-time networks.

Realities of Establishment of Vertical Control (cont.)

Big Questions:

- What will be done?
- Who will do what?
- Who will manage for it?
- Who will pay for it?

Who will ultimately decide what path will be taken?

My guess is that this man will decide.

Count de Monet

Global Challenges for NGS/NOAA

- *To provide all of the USA with an accurate and up-to-date NSRS that meets national needs.*
- *Providing guidance to users of the use of technology to effectively access the NSRS.*
- *CORS, geoid models, etc. accomplishes this on a national level.*
- *OPUS products seek to accomplish recalibration at local level with user help.*
- *New NGS RTN guidelines seeks to do this on a local level.*

Universal Challenges in Maintaining Control

- *Cost*
- *Time*
- *Loss of Monumentation*
- *Leadership at local and state level.*

Special Challenges in Louisiana and the Gulf Coast

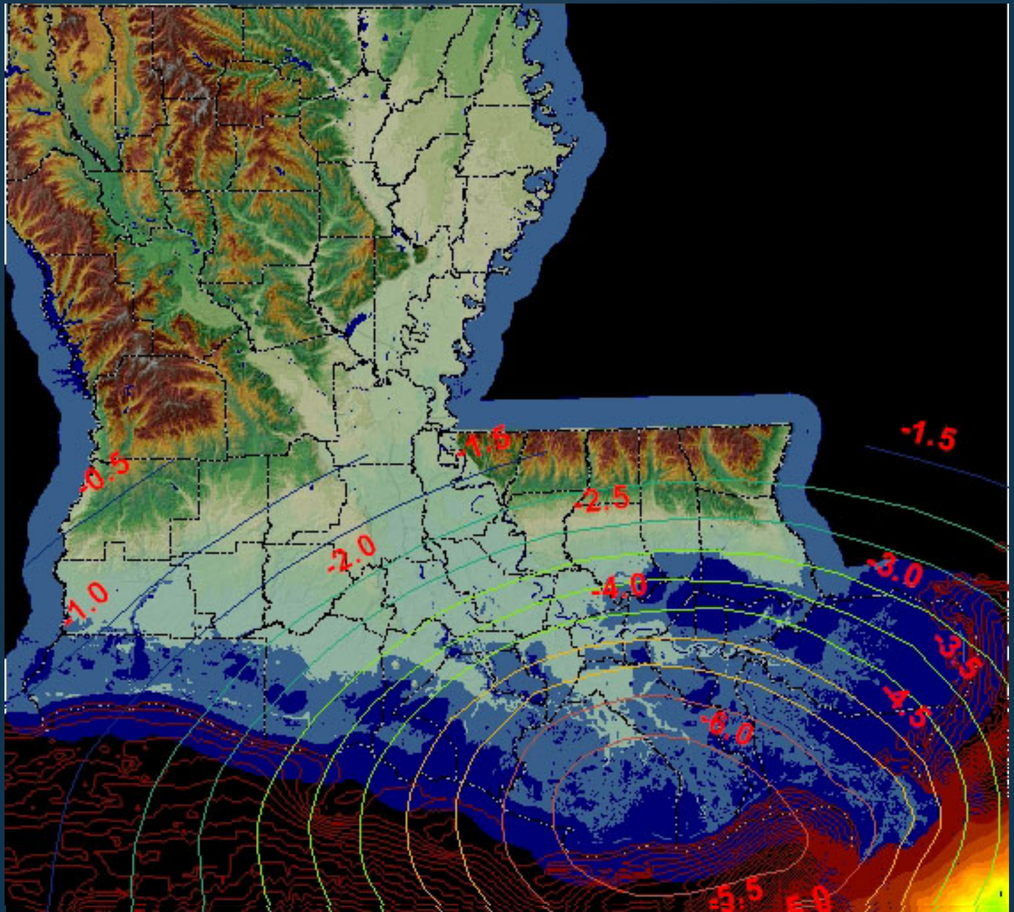
- *Climate*
- *Geology*
- *Monumentation*
- *Dealing with the NSRS*
- *The Culture*
- *$$$*

Climate Challenges

- Louisiana is humid. Signals slow in atmosphere due to moisture. Variable atmosphere leads to measurement variability.
- Much of what we know about GNSS was learned in arid to semi-arid climates.
- Being a coastal state, we also need to know where sea level is.

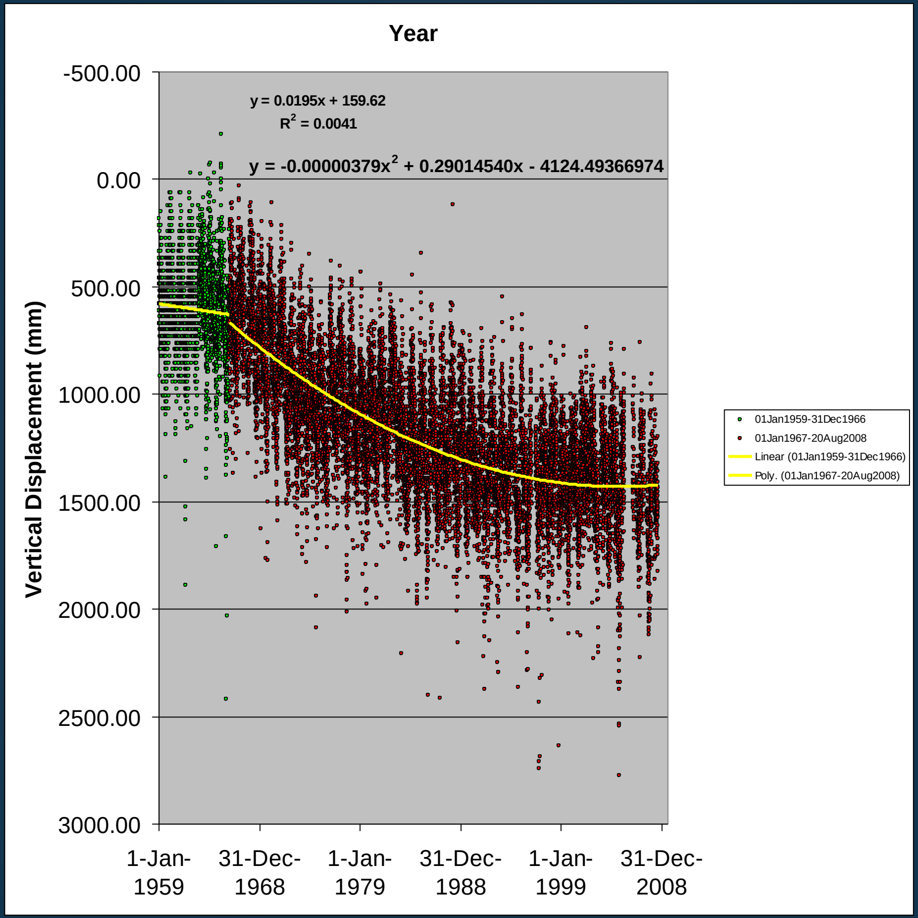
Geology Challenges

- Louisiana landscape is dynamic.
- Subsidence!
- Access to the NSRS is a moving target.
- Concepts such as HTDP and VTDP don't work well here.



Monumentation Challenges

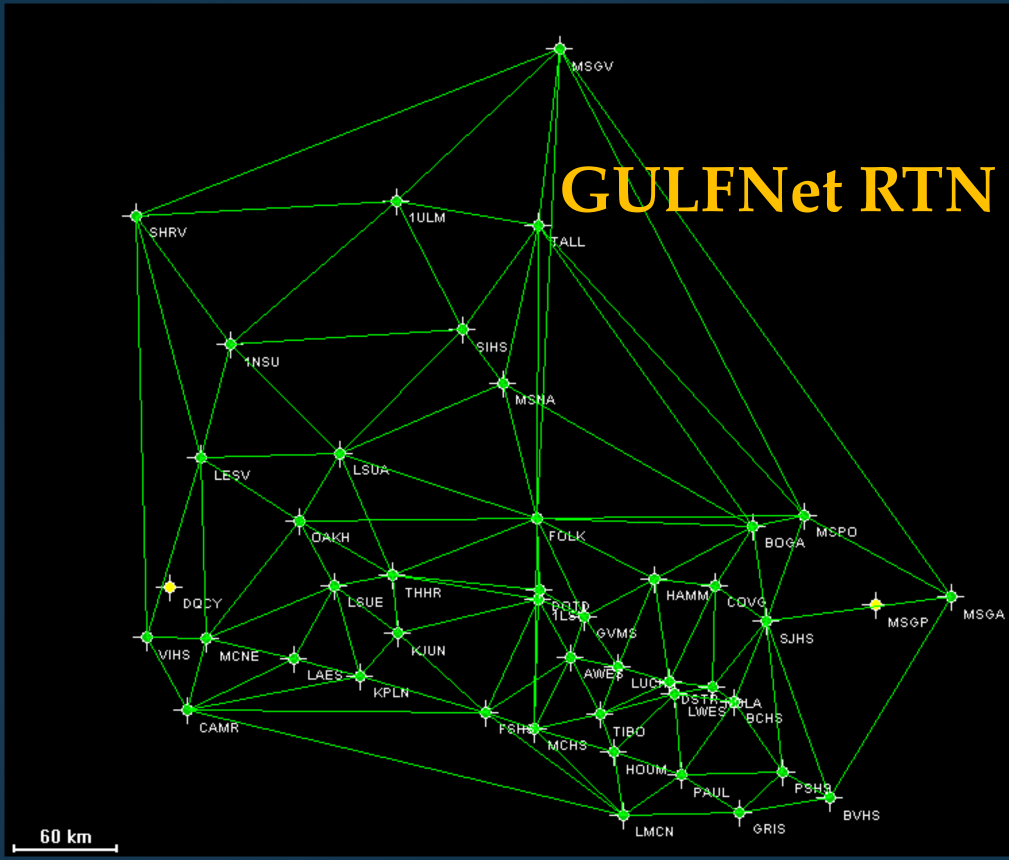
- Monument stability is a myth everywhere. Everything moves!
- South Louisiana is mud and muck.
- Masonry buildings founded on deep piles work best.
- Integrity monitoring is critical.



Paris Road Bridge on Interstate 510

Dealing with the NSRS

- State-wide system of National CORS.
- Geoid models
- Small number of coastal zone BMs.
- GULFNet RTN. ½ National CORS. VRS solutions will equal OPUS solutions. We also have today's coordinates.



The Culture

- The economic realities:
  - Long-line geodetic leveling will be rare because of cost.
  - GNSS, coupled high accuracy geoid models, is the alterative. RTNs are means to maintain accurate and up-to-date control given rising costs and shrinking budgets.
- The cultural realities are:
  - People don’t like change.
  - People will use products that work and help them make $ $. Time is money.
  - Carrots (making more $) and sticks (watching competitors make more $$ or lawsuits) will facilitate change.
- Changing the culture means:
  - More education is needed.

$$$

- Our Economic reality:
  - The CORS network in Louisiana was funded by federal earmark $$ and $$ derived from the RTN. It cost ~$2M and a lot of sweat!
  - Federal funding for geodetic control has not and is not a priority within the federal government or within NOAA. Do you see more $$ coming from Washington D.C. soon?
  - The state is cutting the budget and shows no interest in creating more bureaucracy.
  - An RTN paid for by users who value it is the key to maintaining local control.
- Our bottom line:
  - No money, no RTN, no CORS.

LSU Center for Geoinformatics Gulfnet Real-time GNSS Network

- Meets or exceeds all NGS guidelines for real-time networks.
- GPS and GLONASS
- Provides VRS technology
  - ✓ True network solutions
  - ✓ "Instant" positioning—3 min. control pt.
  - ✓ No ppm error
  - ✓ Post-processing w/ 1 second data.

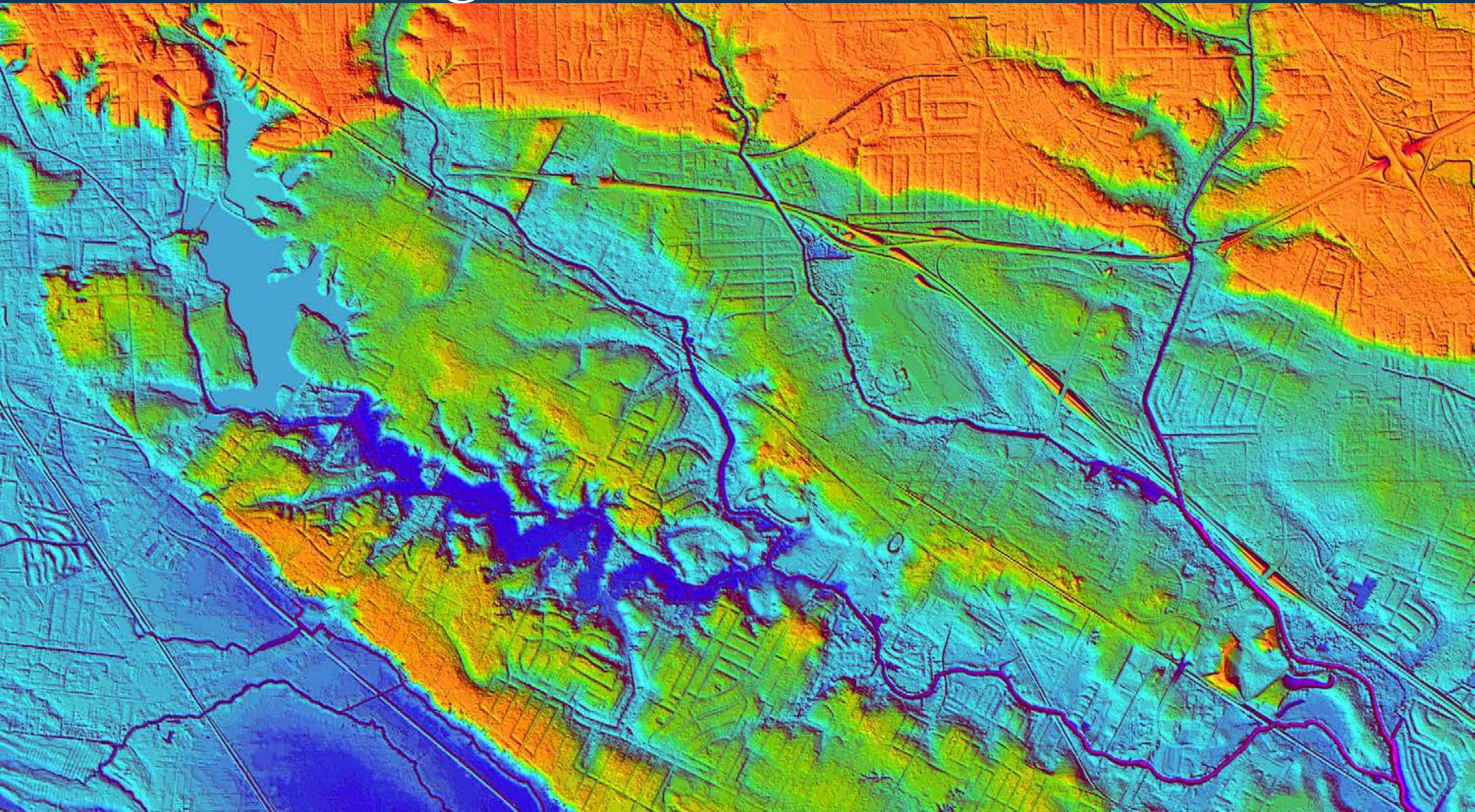
GULFNet RTN Users

- Geodetic control surveys.
- Construction stake-out.
- Hydro-surveying.
- Precision agriculture.
- Machine guidance for construction.
- Dredging.
- GIS.
- Strain monitoring of dams, bridges, and offshore platforms.
- Topography mapping.

Surveying With Gulfnet Real-time GNSS Network

- Control surveying
  - RTN speeds acquisition of observations:
    - ✓ minutes rather than hours.
  - Still requires use NGS 58 and 59 principles for best results.
- Stakeout—load the “blueprints” and navigate to the staking points.
- Topo surveying

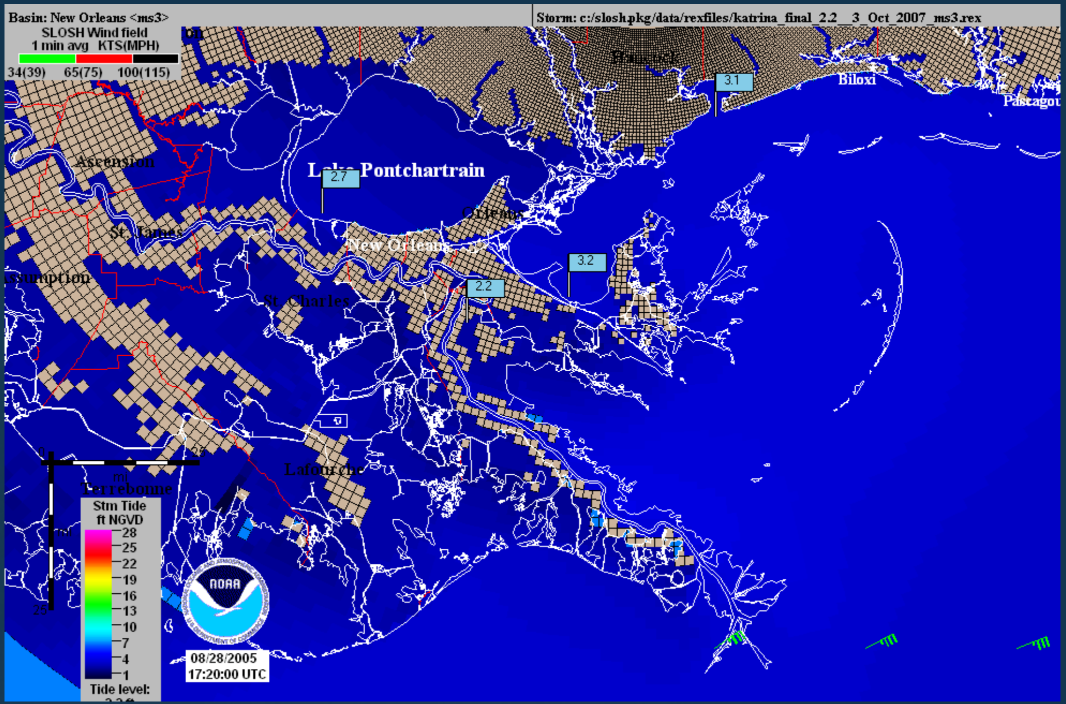
Application Example: Accuracy Assessment of a Regional LiDAR DEM

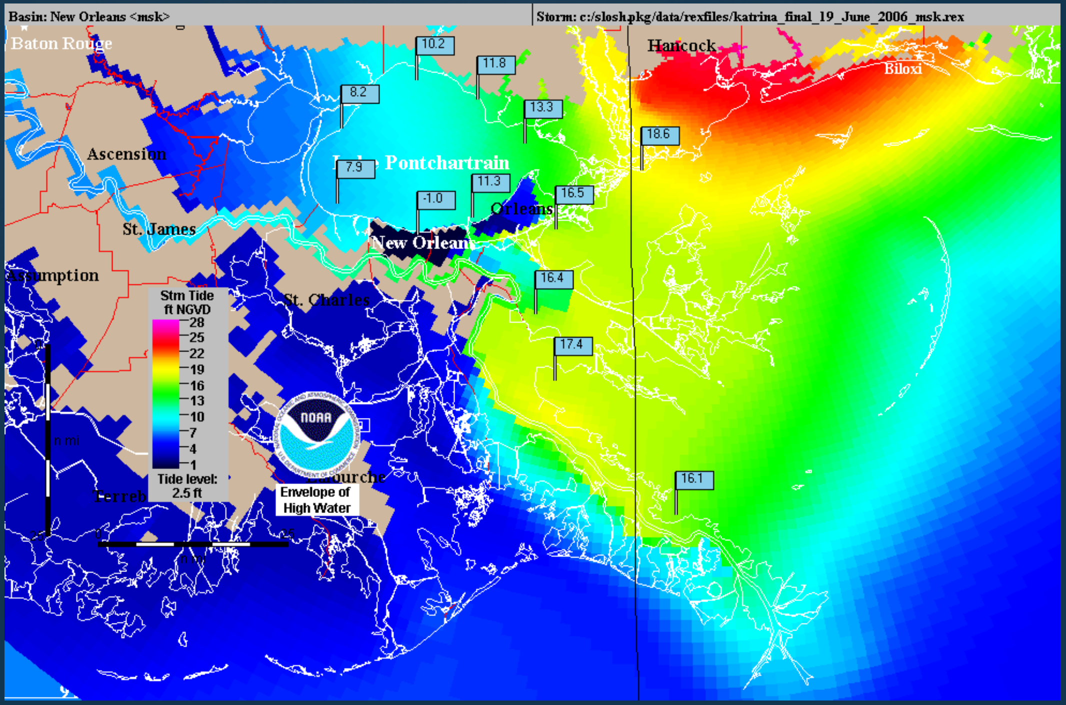


Digital Elevation Models

- DEMs are arguably the most important geospatial product in today's world.
- Serve as sources of topography for models that simulate river flooding, storm surges, forest fires, and airborne transport.
- New technologies like LiDAR are resulting in more precise and topologically more realistic DEMs.
- Precision, of course, is not accuracy. Accuracy assessment is an "after-the-fact" exercise that is essential for geospatial activities.

NOAA Slosh models depend on accurate and up-to-date topography

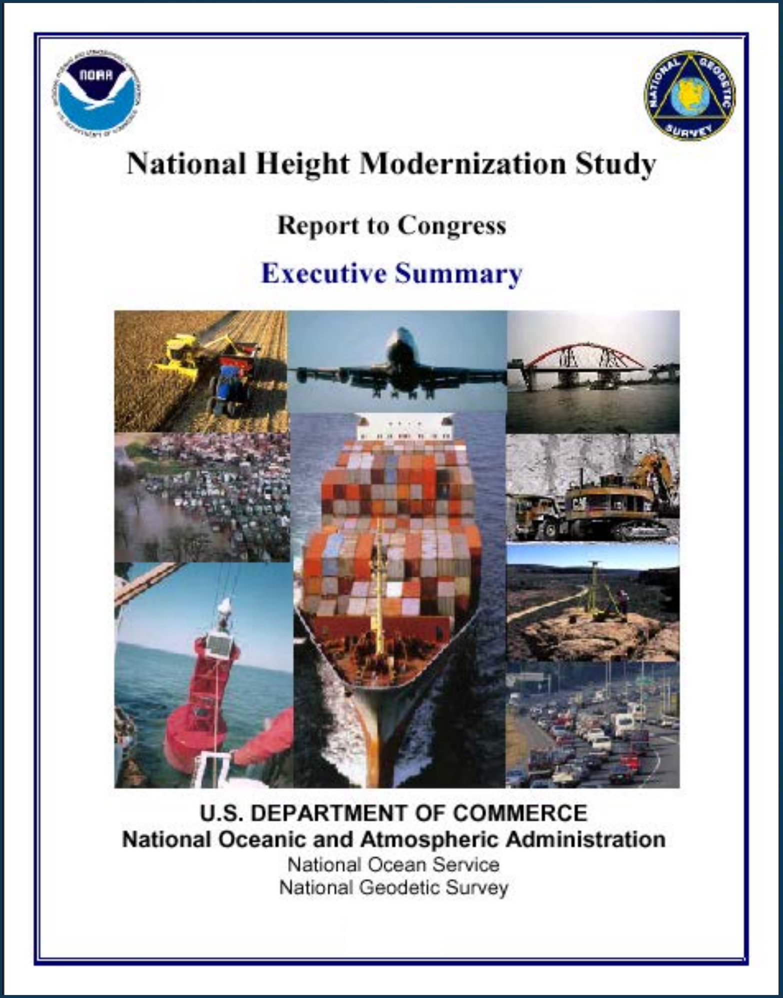




DEMs for New Orleans

- Three DEMs are considered:
  - NGDC 10m topobathy
  - NED
  - LOSCO state-wide 2002-2008
- LOSCO 5 m is the basis for the NGDC and NED topo
- These data are the topographic basis for New Orleans flood maps and hurricane storm surge modeling.

NOAA told the U.S. Congress in 2001 that the system used to measure elevations in LA was,



"inaccurate and obsolete and unable to support public safety."

Accurate elevations were not restored until late 2005. Any elevations obtained between 2001 and 2006 are highly suspect.

How accurate is the LOSCO DEM in the New Orleans area?

- *"It's in the metadata."* Metadata is mute.
- QA/QC reports say it is excellent and passes FEMA requirements.
- This seems strange given that NGS/NOAA told the Congress that vertical control was non-existent between 2001 and 2005.
- Closer examination shows that the QA/QC process is flawed.
- Conclusion: The LiDAR and the DEMs should have never been accepted by FEMA and the State of Louisiana.

Even though QA/QC Reports say The Lidar products are “excellent”,

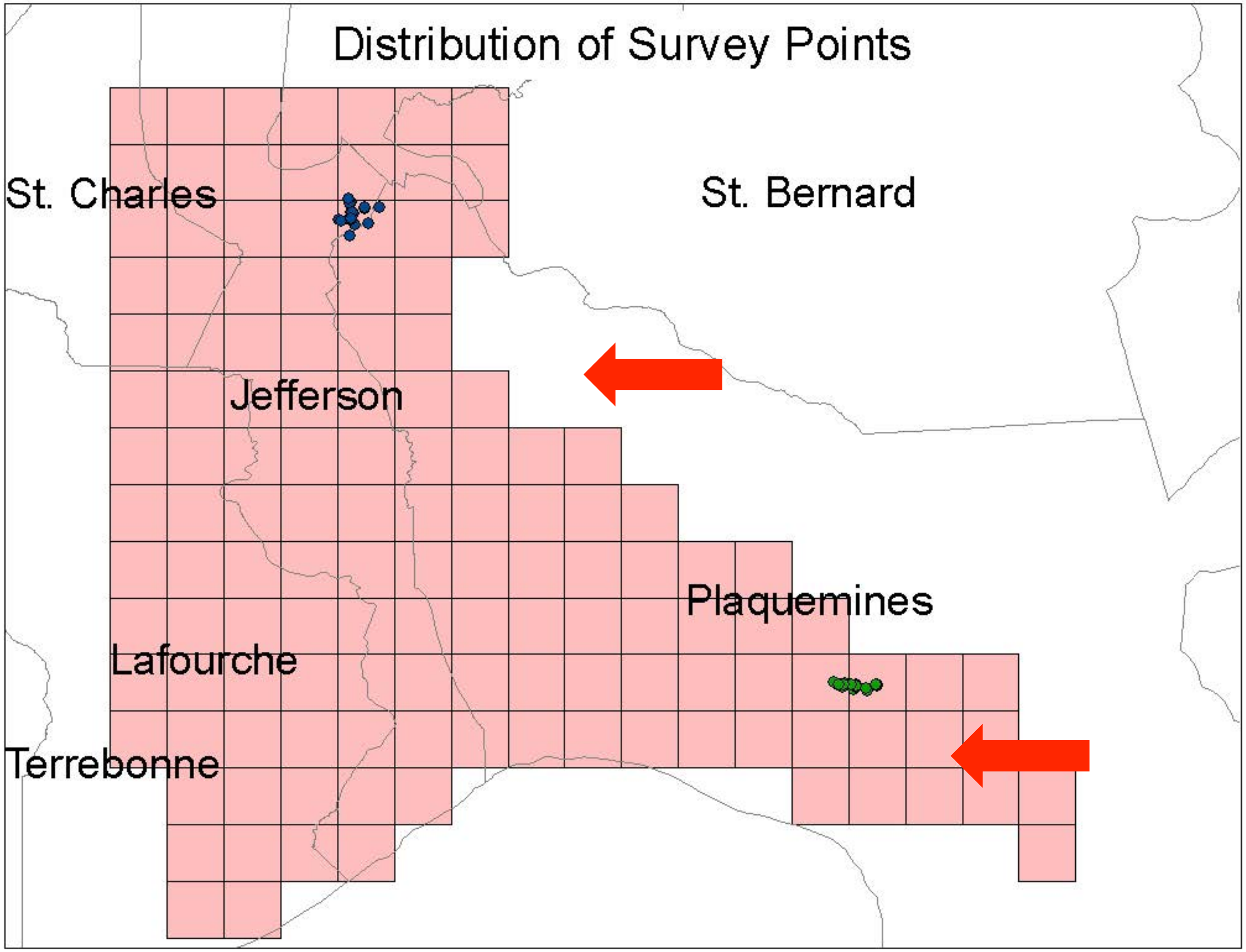
- FEMA Accuracy Assessment was not carried out according to the FEMA guidelines.
- The products can’t be “excellent” because sampling strategy violates assumptions that unpin the statistics used.

FEMA AA test samples are supposed to be representative of the population in terms of spatial distribution and ground cover type. Test results indicate that DEMs pass the FEMA test (RSME = 18.5 cm or less).

- Test samples are clustered. They are not randomly distributed.
- Errors are not normally distributed.
- The number of test samples do not meet FEMA requirements.
- FEMA guidelines allow producers to remove unfavorable test samples without cause.

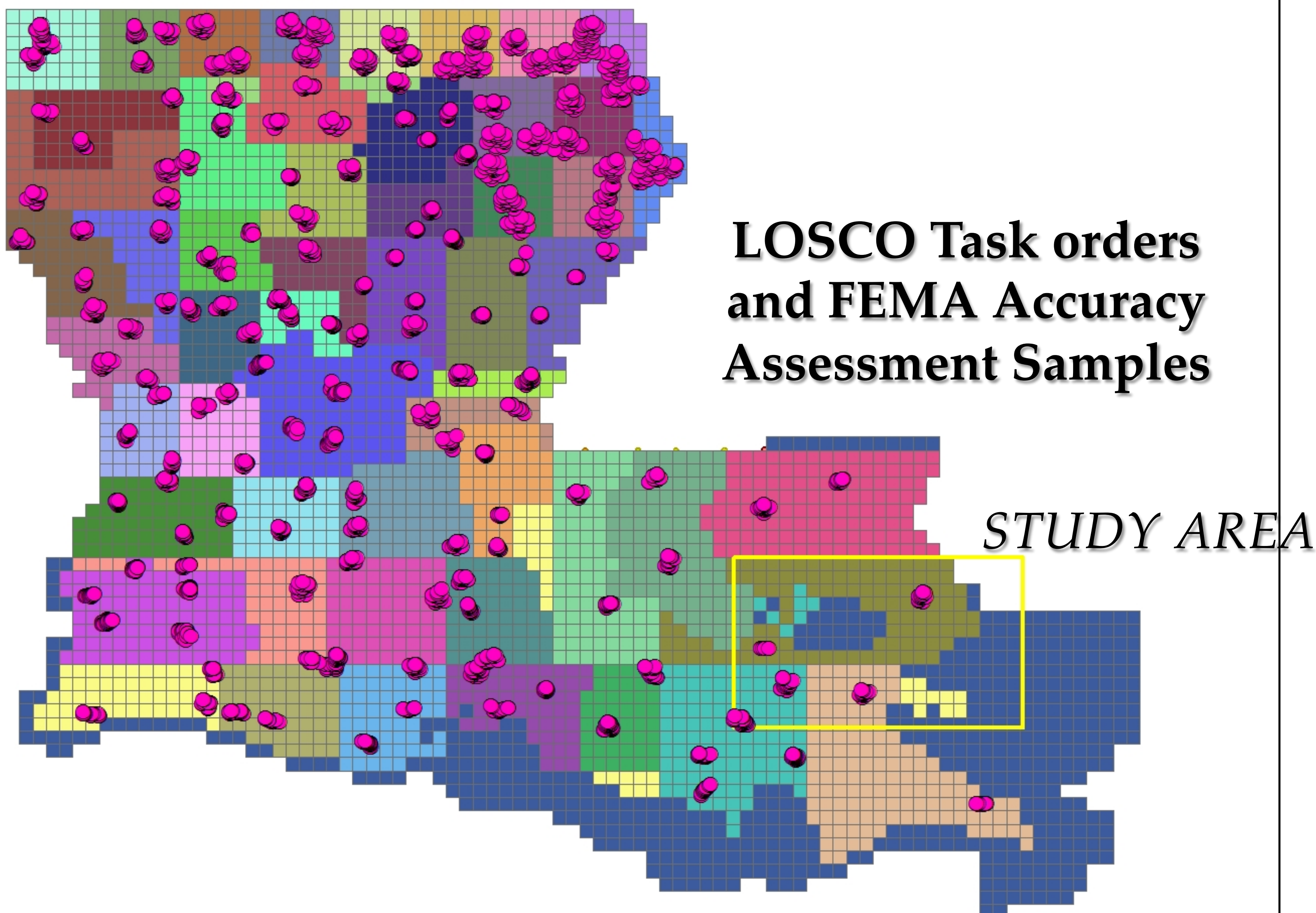
Surprisingly, all QA/QC reports show that all data pass with flying colors!

Highly Clustered Sampling !



QA/QC Sampling strategy violates assumptions that unpin the statistics used.

LOSCO Task orders and FEMA Accuracy Assessment Samples



FEMA requires that ground cover category must have >20 samples

Overall Statistics for Accuracy Assessment				
	Number Points	Average Error	RMSE Feet	RMSE CM
Open Terrain	11	0.12	0.35	10.58
High Grass	7	0.12	0.35	10.54
Brush	8	0.09	0.31	9.35
Forested	6	0.24	0.49	14.80
Urban	8	0.23	0.48	14.72

Outliers larger than the 95th percentile		
	Elevation Difference	Outliers are based on points larger than the 95th percentile. Using this method, 2 of the 40 points were removed from this dataset.
Forested	-1.02	
Urban	0.72	

One of the first Plaquemines, Jefferson, and Lafourche Parishes 2002-3

Unfortunately, QA/QC was not done properly in ANY parish in LA!

Overall Statistics for Accuracy Assessment				
	Number Points	Average Error	RMSE Feet	RMSE CM
Open Terrain	11	0.03	0.18	5.62
High Grass	10	0.06	0.24	7.32
Brush	10	0.27	0.52	15.90
Forested	12	0.25	0.50	15.25
Urban	12	0.02	0.13	4.11

Outliers larger than the 95th percentile		
	Elevation Difference	Outliers are based on points larger than the 95th percentile. Using this method, 3 of the 60 points were removed from this dataset.
Brush	1	
Brush	1.02	
Forested	0.86	

One of the last Claiborne Parish 2008

Conclusion:

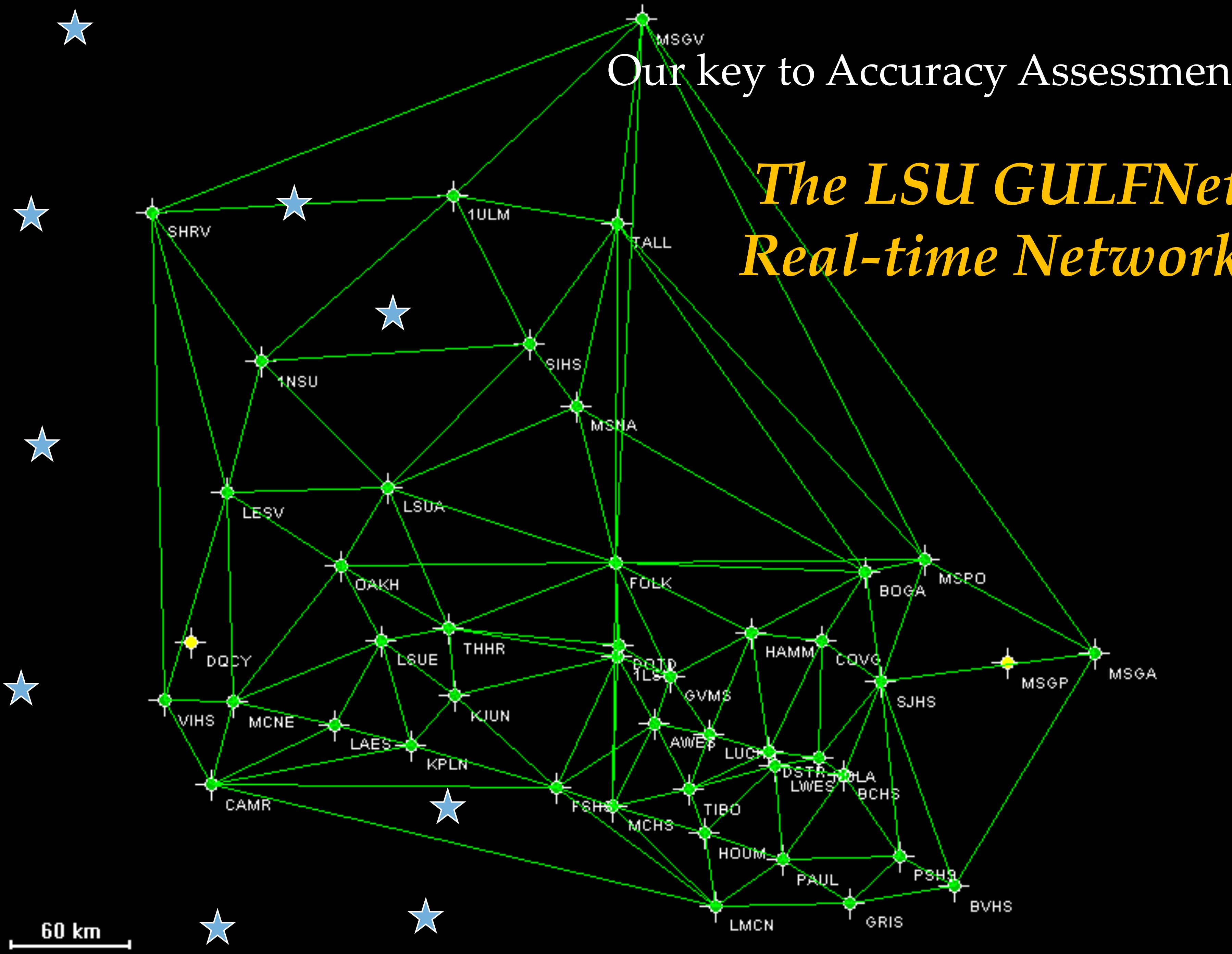
Although the test statistics indicate that the data pass FEMA requirements, violations of statistical assumptions invalidate the results of the tests.

What then is the accuracy of the LOSCO DEM?

HOW IS THIS DONE?

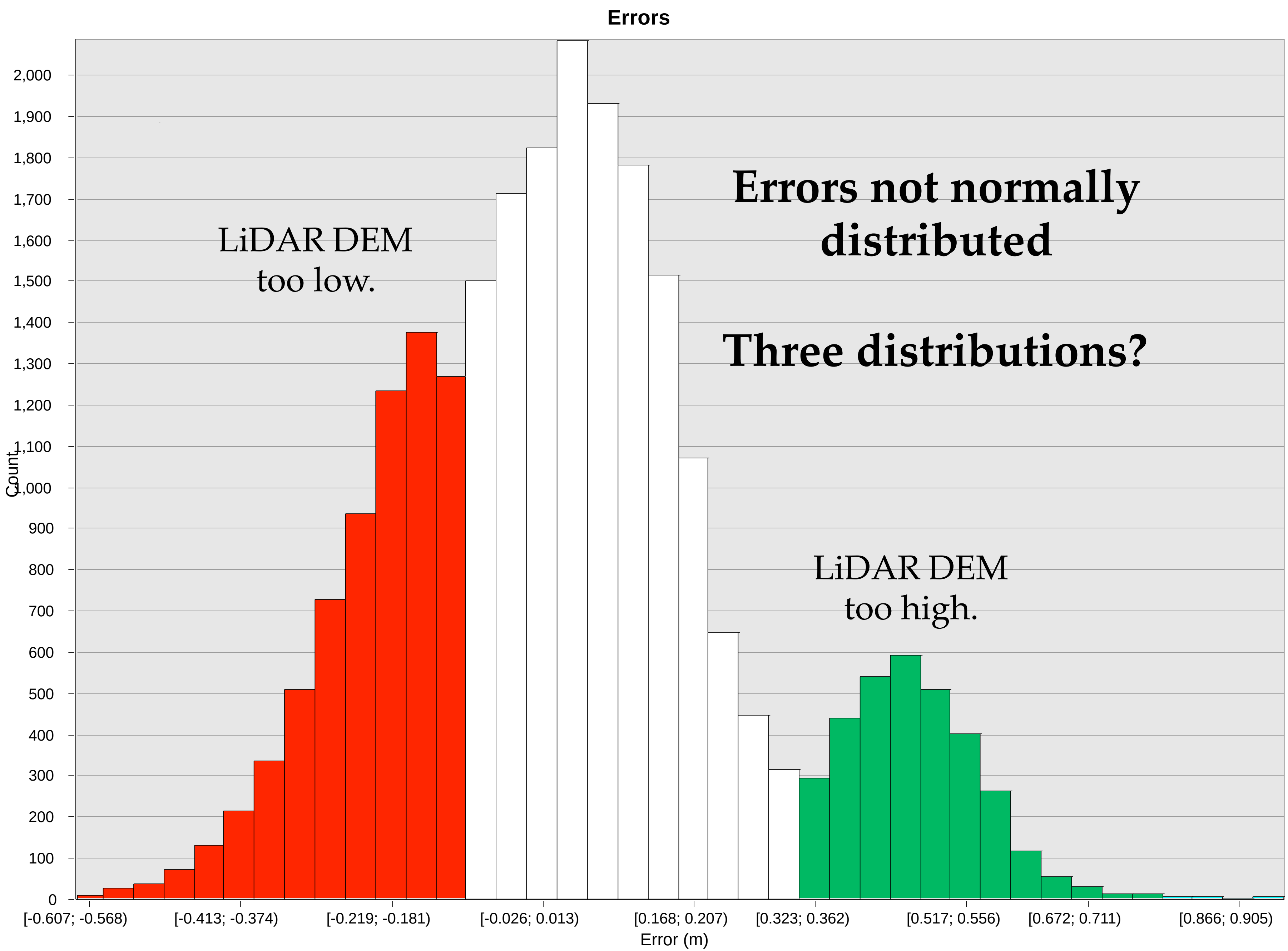
Our key to Accuracy Assessment:

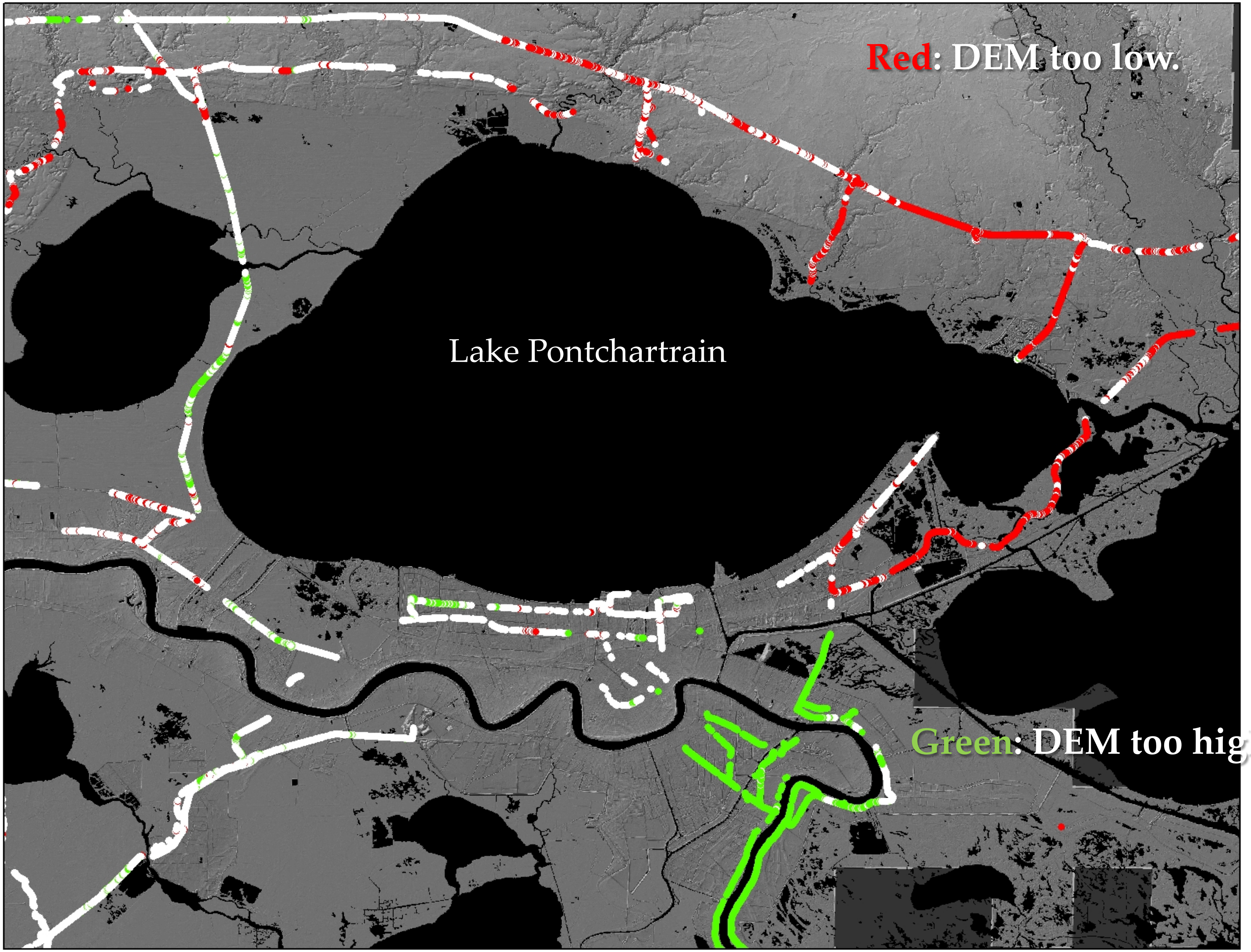
The LSU GULFNet Real-time Network



An Independent Accuracy Assessment

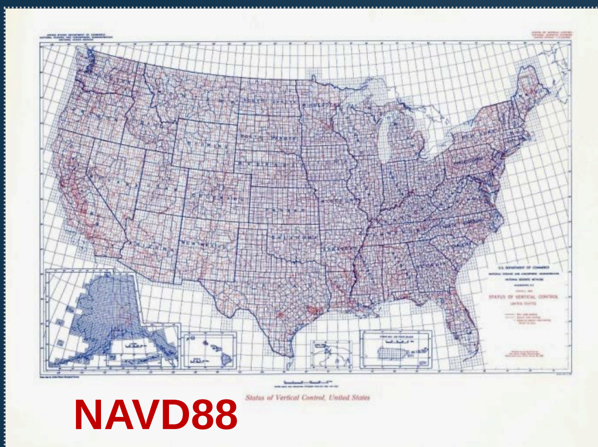
- AA tool: LSU GULFNET Real-time kinematic GNSS network
- Tied to National CORS network and modern geoid model.
- Vertical Accuracy (u95%)= 6 cm in vehicle traveling at highway speed. RTN error (u95%) = 1 cm; vehicle bounce = 6 cm; connection to NSRS (u95%)= 5 cm.
- Only roads and parking lots were sampled. Thus, comparison only considered areas of unequivocal LiDAR "bare-earth" returns.
- N=25,210 Mean error is 0.04 m. RSME = 0.245 m. Fails FEMA.
- NGDC: RSME=0.245 m. NED: RSME=0.257 m.
- Distribution of errors suggests geographic component.

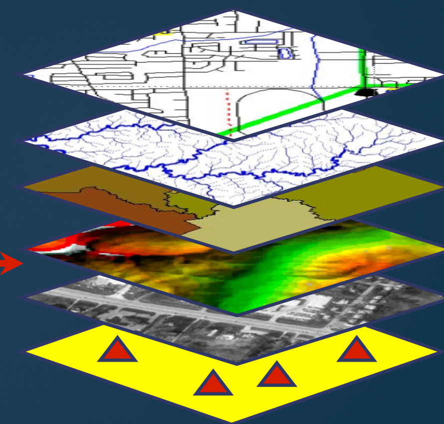

Errors
Errors not normally distributed
Three distributions?
LiDAR DEM too low.
LiDAR DEM too high.
Count
Error (m)
2,000
1,900
1,800
1,700
1,600
1,500
1,400
1,300
1,200
1,100
1,000
900
800
700
600
500
400
300
200
100
0
[-0.607; -0.568)
[-0.413; -0.374)
[-0.219; -0.181)
[-0.026; 0.013)
[0.168; 0.207)
[0.323; 0.362)
[0.517; 0.556)
[0.672; 0.711)
[0.866; 0.905)


Red: DEM too low.
Lake Pontchartrain
Green: DEM too high.

Local DEM accuracy was compromised because of flawed vertical control during 2001-2005

Subsidence moved BMs and
thus destroy the
linkage to the NSRS





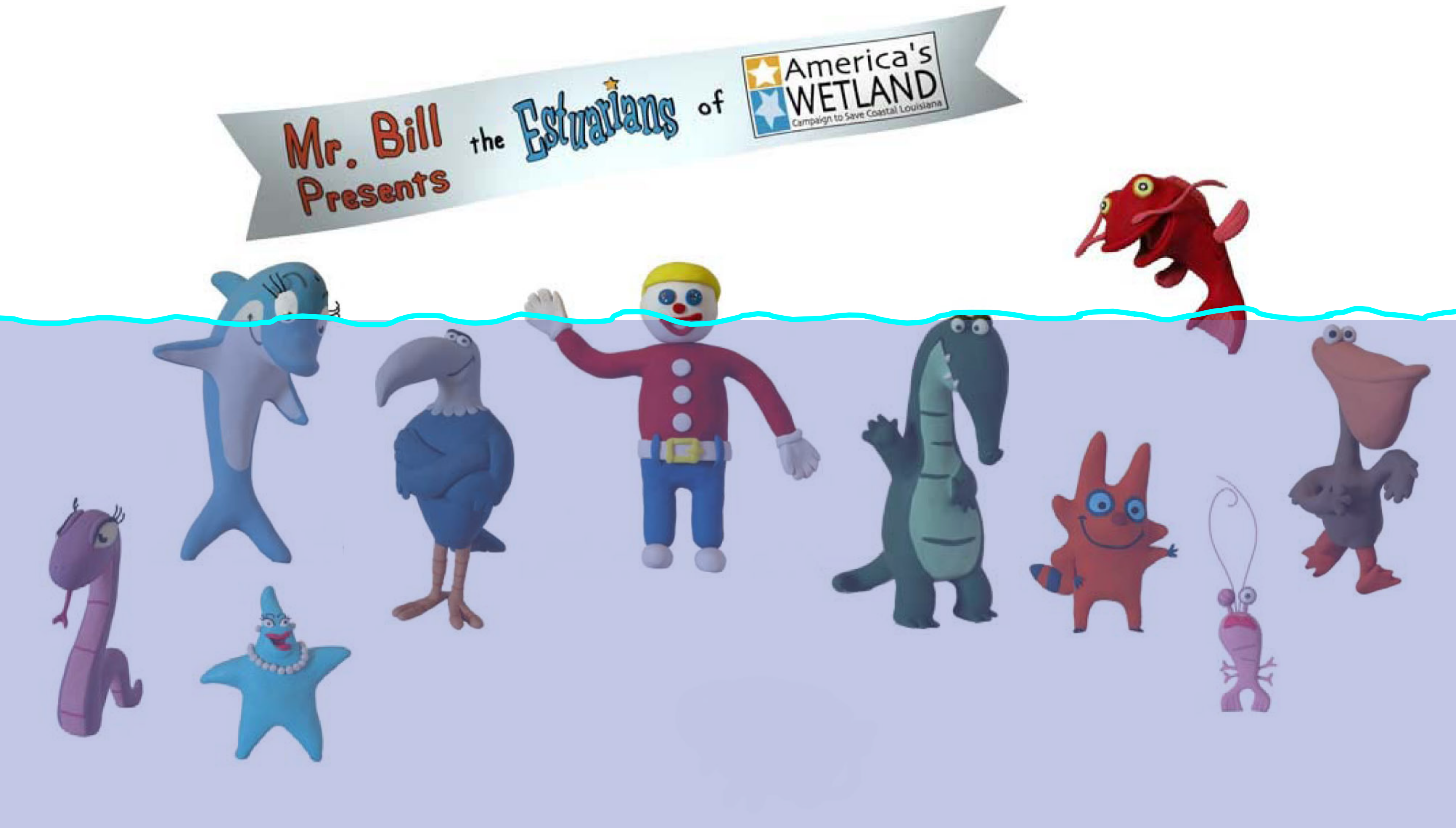
GEODETIC CONTROL

Conclusion: LiDAR was tied to <u>bad vertical control</u>

Summary

- DEMs are the basis for many geospatial activities.
- Accuracy assessment is a critical step in creation of reliable geospatial data but is often omitted.
- The LOSCO LiDAR-based DEM of Louisiana is an example. Great idea but unreliable results.
- Unreliability caused by the use of bad local vertical control during acquisition. Problem was not recognized because Accuracy Assessment was improperly done.
- FEMA requirements for AA of topo are too loose to assure accuracy. Guidelines for AA need to be revamped.
- This could not have been accomplished without GULFNet RTN.

Thank You!


Mr. Bill Presents
the Estuarians of
America's WETLAND
Campaign to Save Coastal Louisiana