NC STATE UNIVERSITY

Coastal Models of Oil Transport in the Northern Gulf of Mexico

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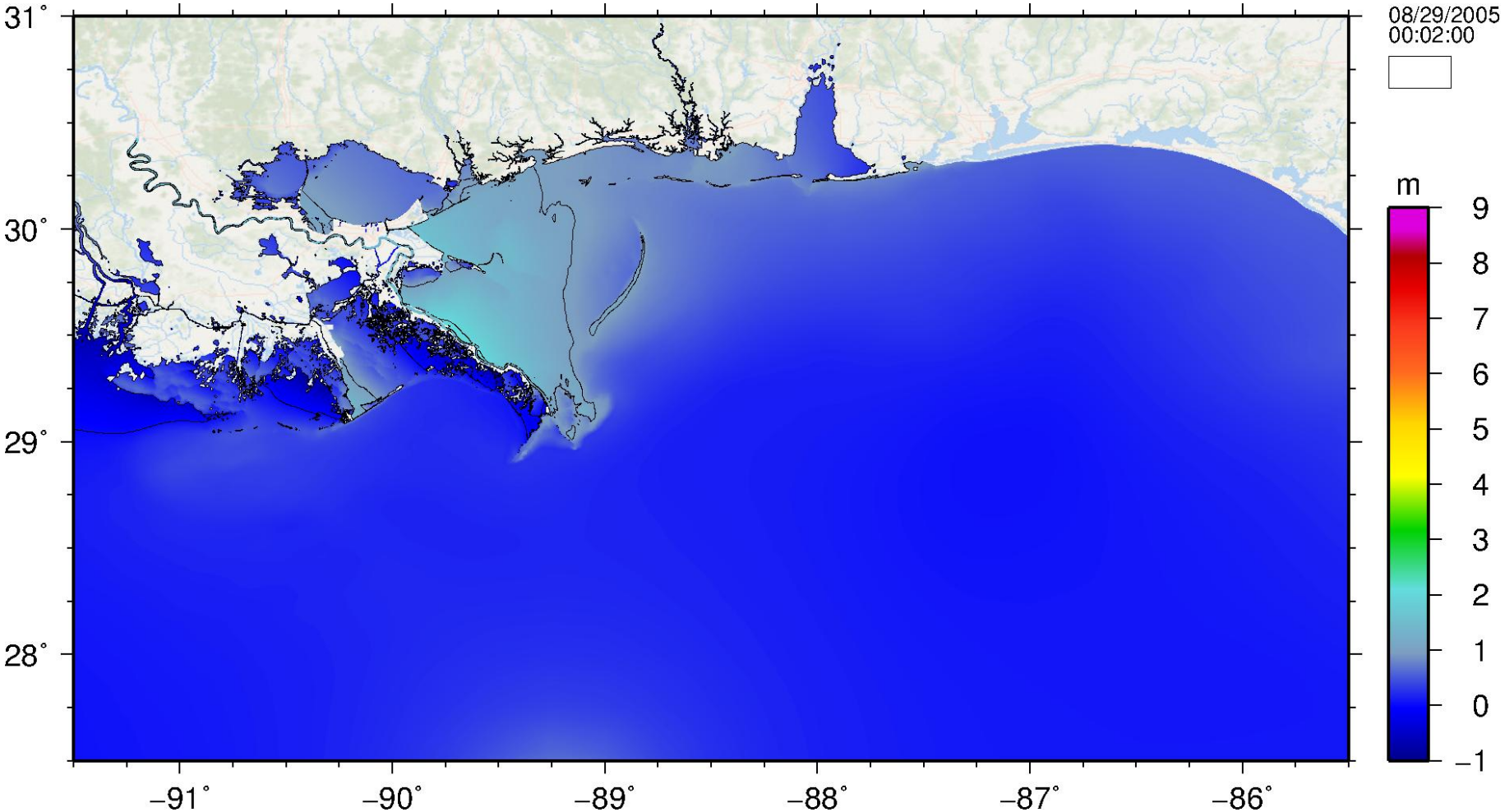
Houston TX, 19 February 2015

Coastal Flooding with ADCIRC

– ADCIRC 2D Simulation of Storm Surge during Katrina (2005)



S Bunya, JC Dietrich, *et al.* (2010). A High-Resolution Coupled Riverine Flow, Tide, Wind, Wind Wave and Storm Surge Model for Southern Louisiana and Mississippi: Part I Model Development and Validation. *Monthly Weather Review*, 138(2), 345-377.

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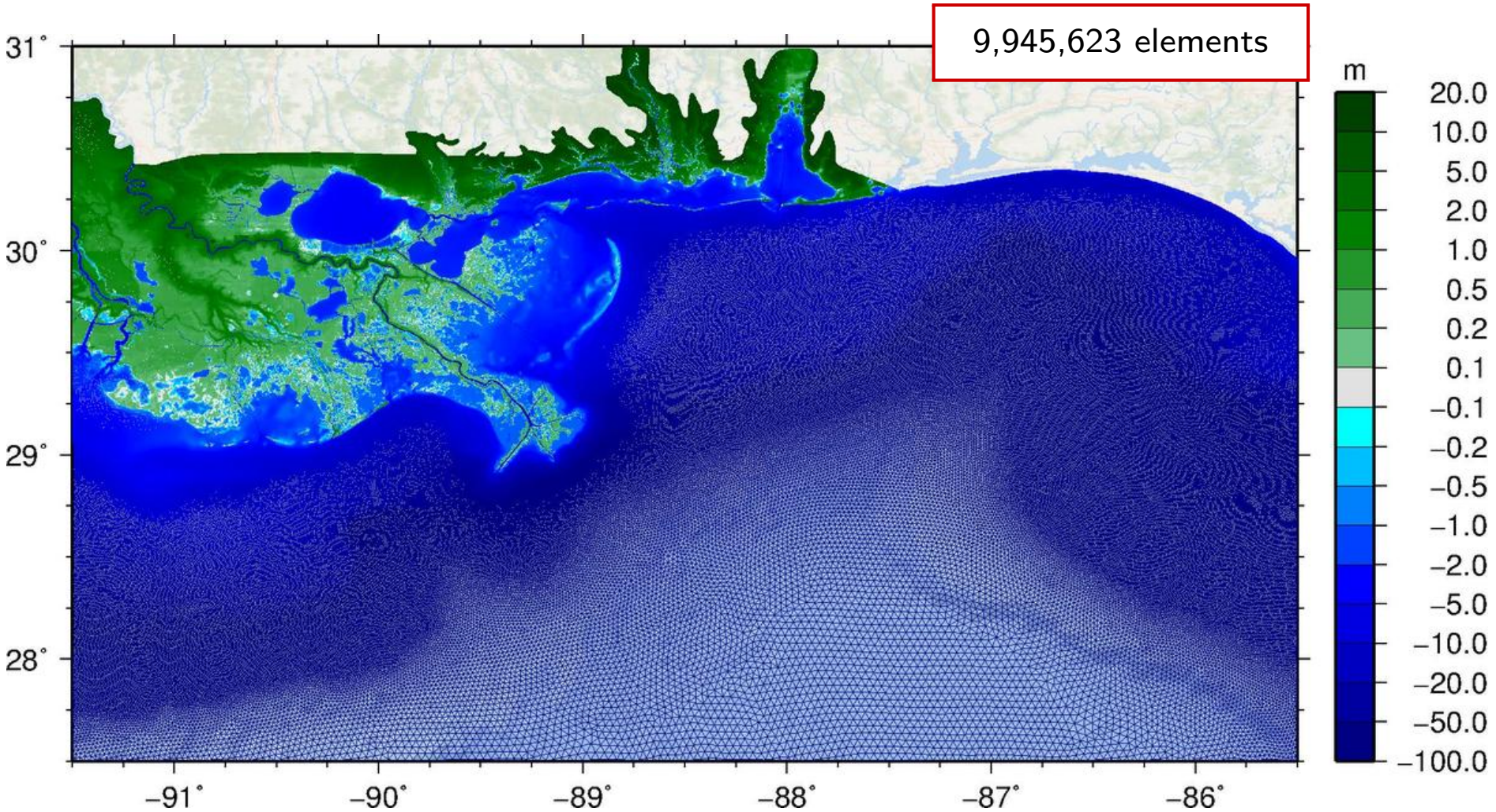
Coastal Flooding with ADCIRC

– SL16 Finite Element Mesh for Southeastern Louisiana



Response during the Deepwater Horizon Event

– Daily Predictions of Oil Spill Transport as Lagrangian Particles

Initial response was built into the ADCIRC Surge Guidance System

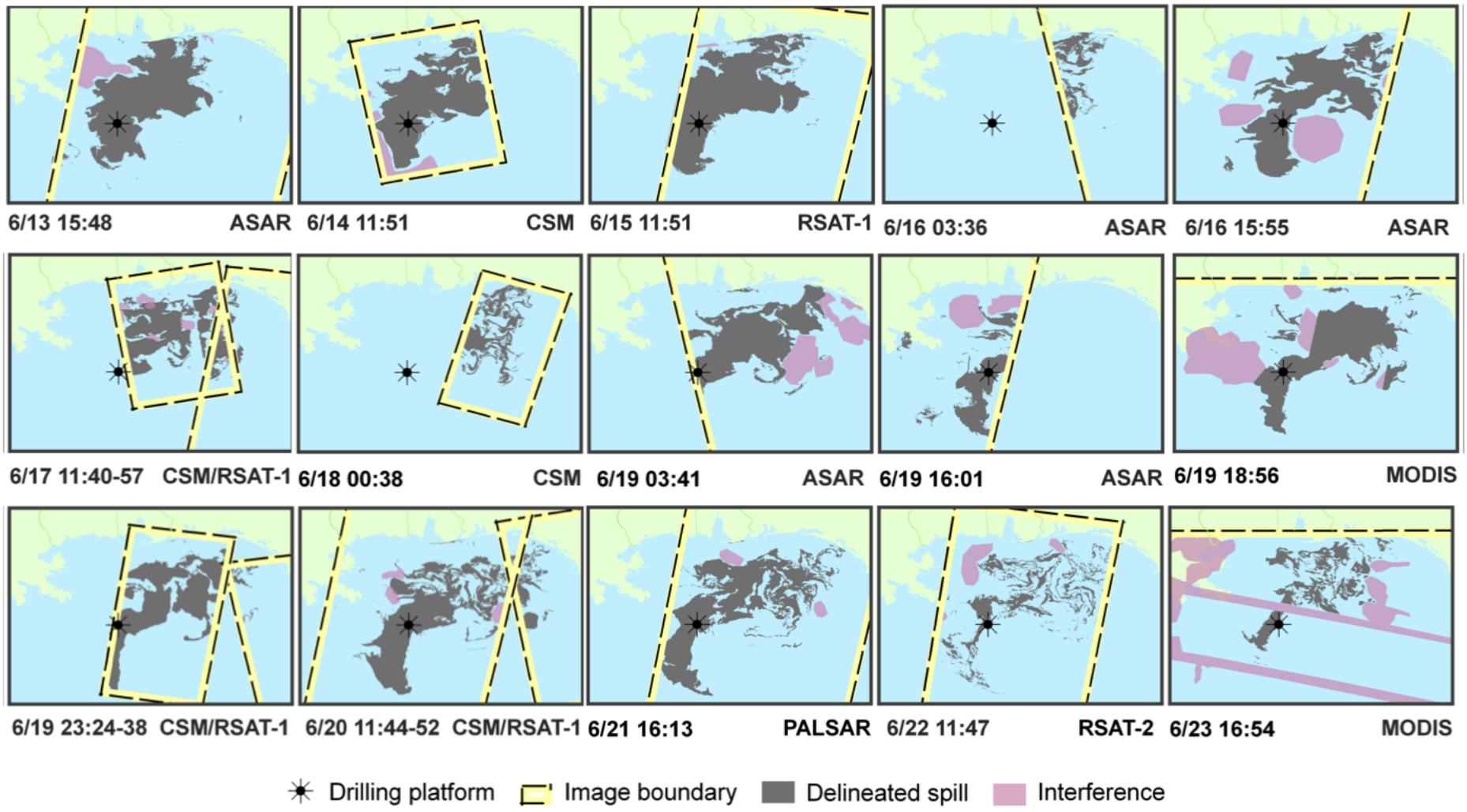
- Used operational, 2D, barotropic version of ADCIRC
- Considered surface transport of oil as Lagrangian particles:
  - Random-walk dispersion from Proctor *et al.* (1994)
  - Ability to combine the current velocities with some percentage (0-3%) of the wind velocities
- Wind fields from WRF-NAM (`nomads.ncdc.noaa.gov`)
- Initialize locations of the oil from NESDIS (`www.nesdis.noaa.gov`) as daily slick extents

Parallelized with hybrid OpenMP/MPI

- 11M particles were tracked on a 10M-element mesh using 256 cores on TACC Ranger in about **5.5 min/day**

Response during the Deepwater Horizon Event

– Oil Spill Extents in Satellite Imagery during 13-23 June 2010



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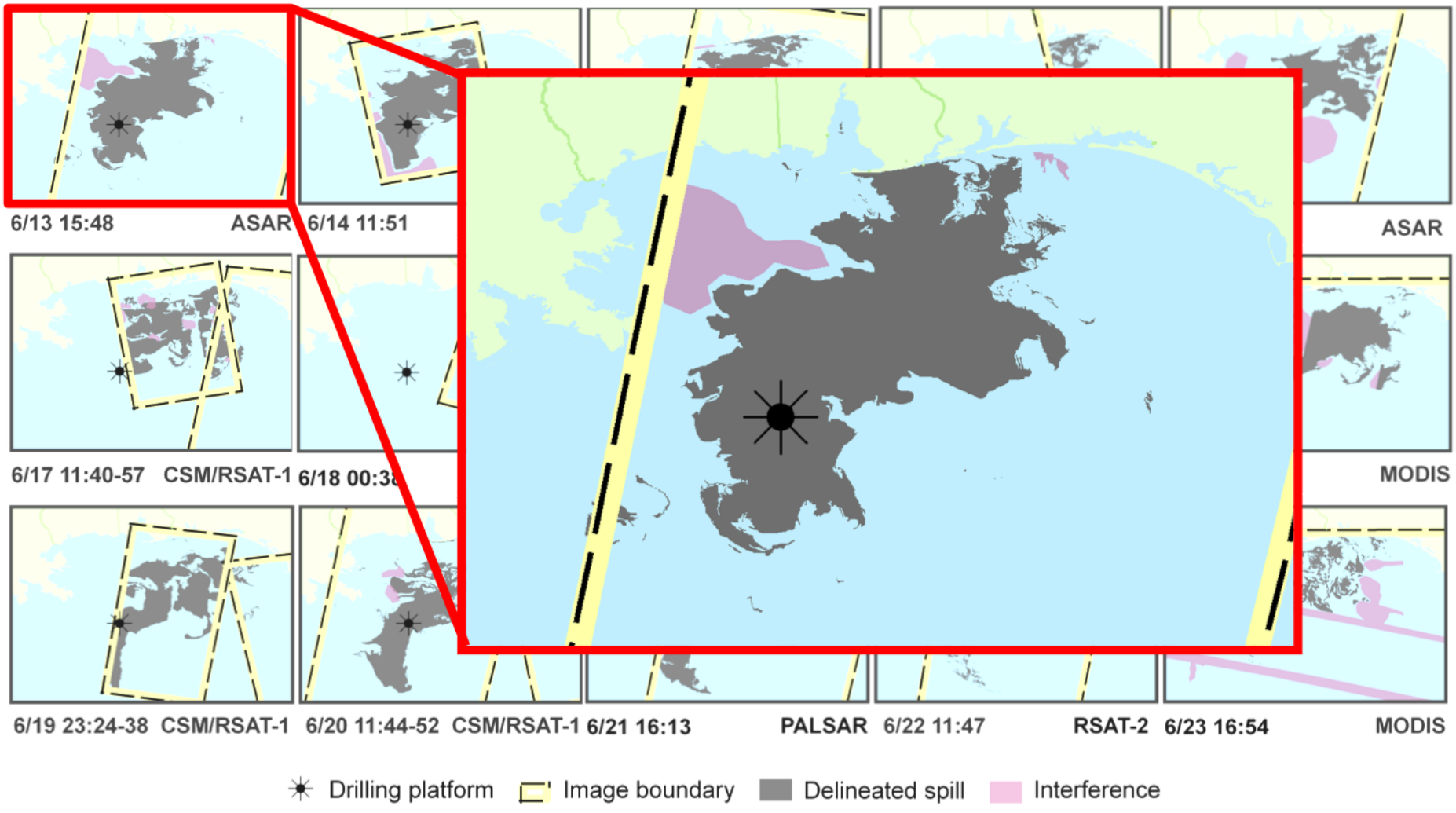

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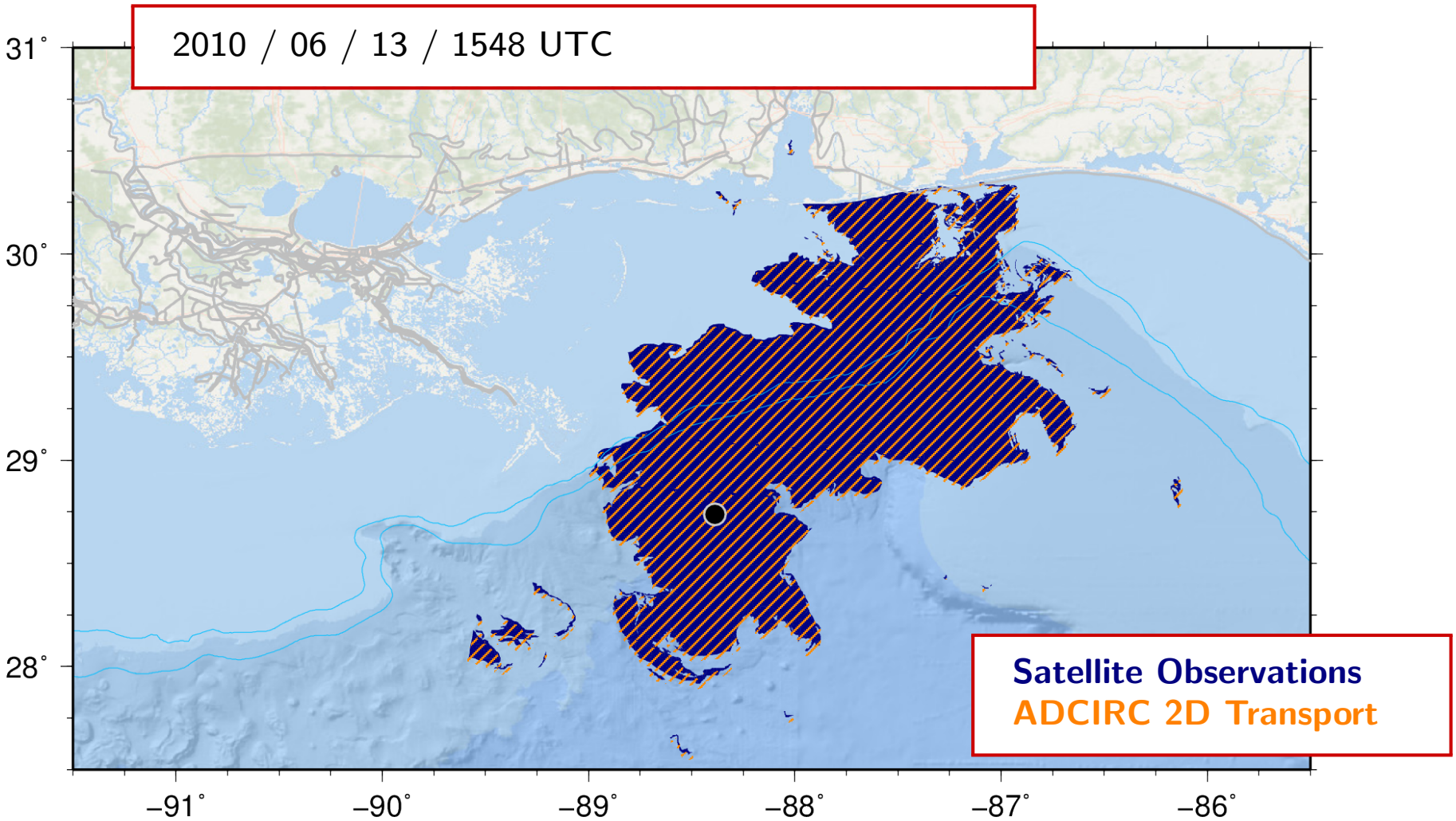

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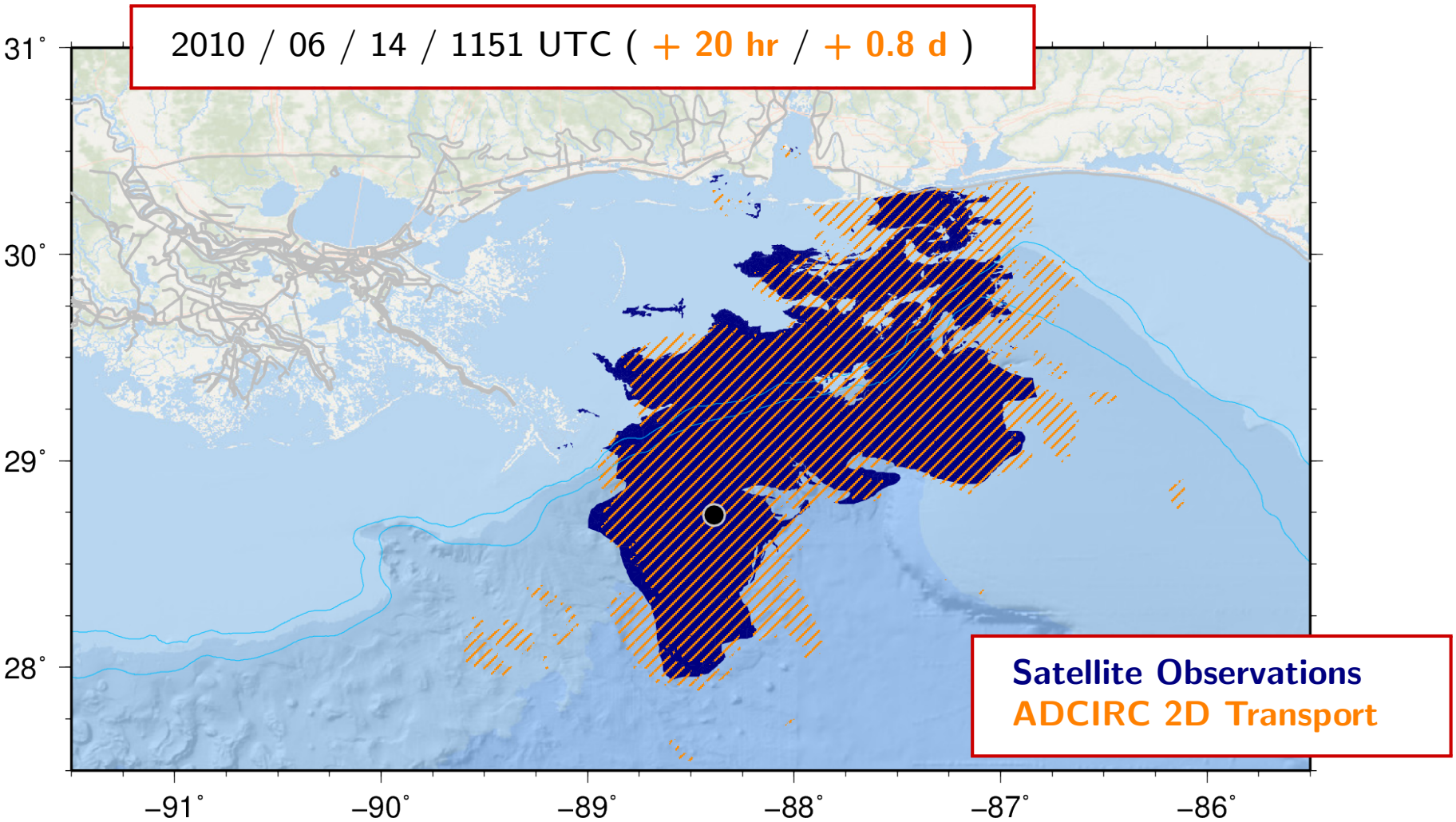

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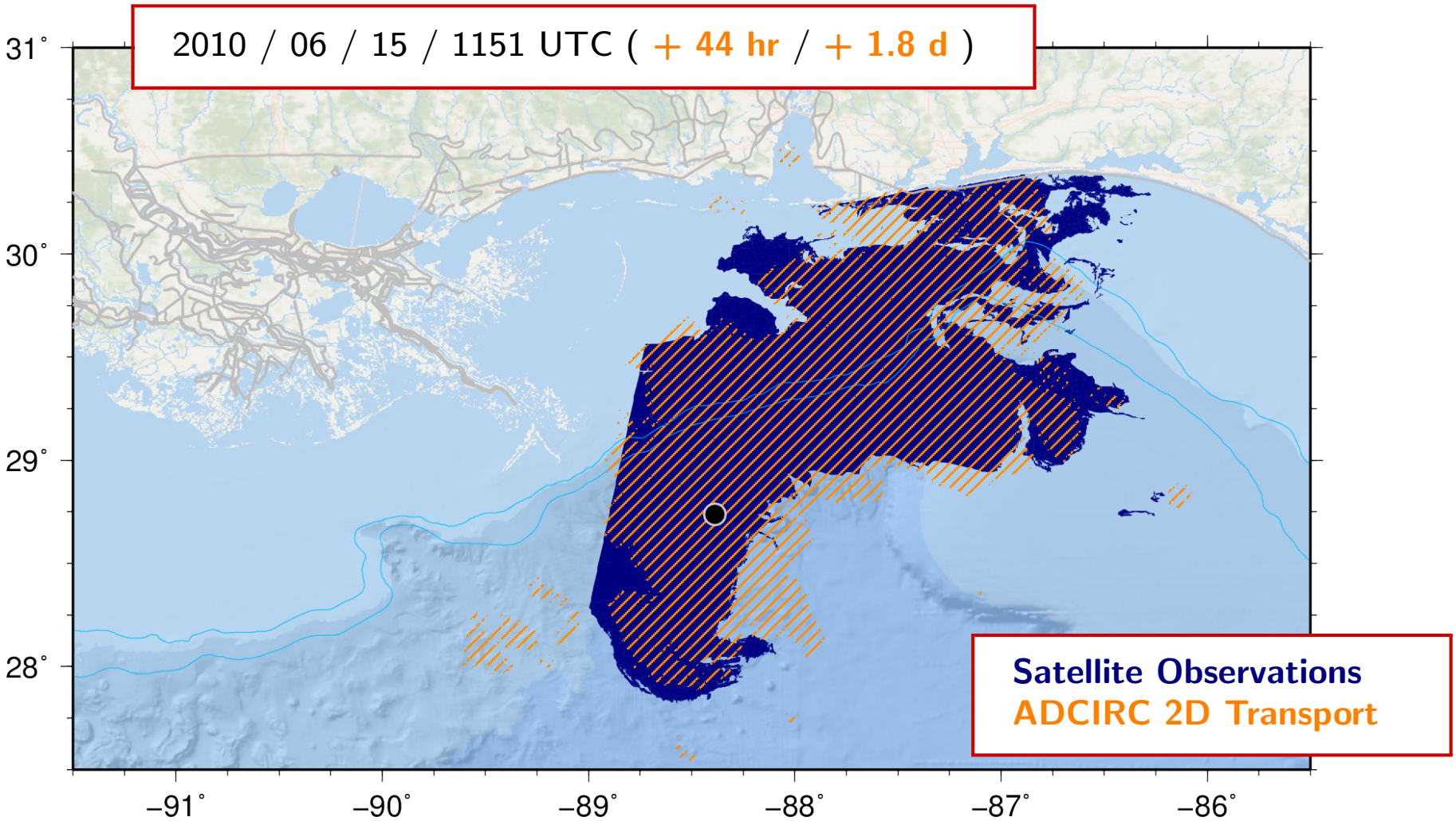

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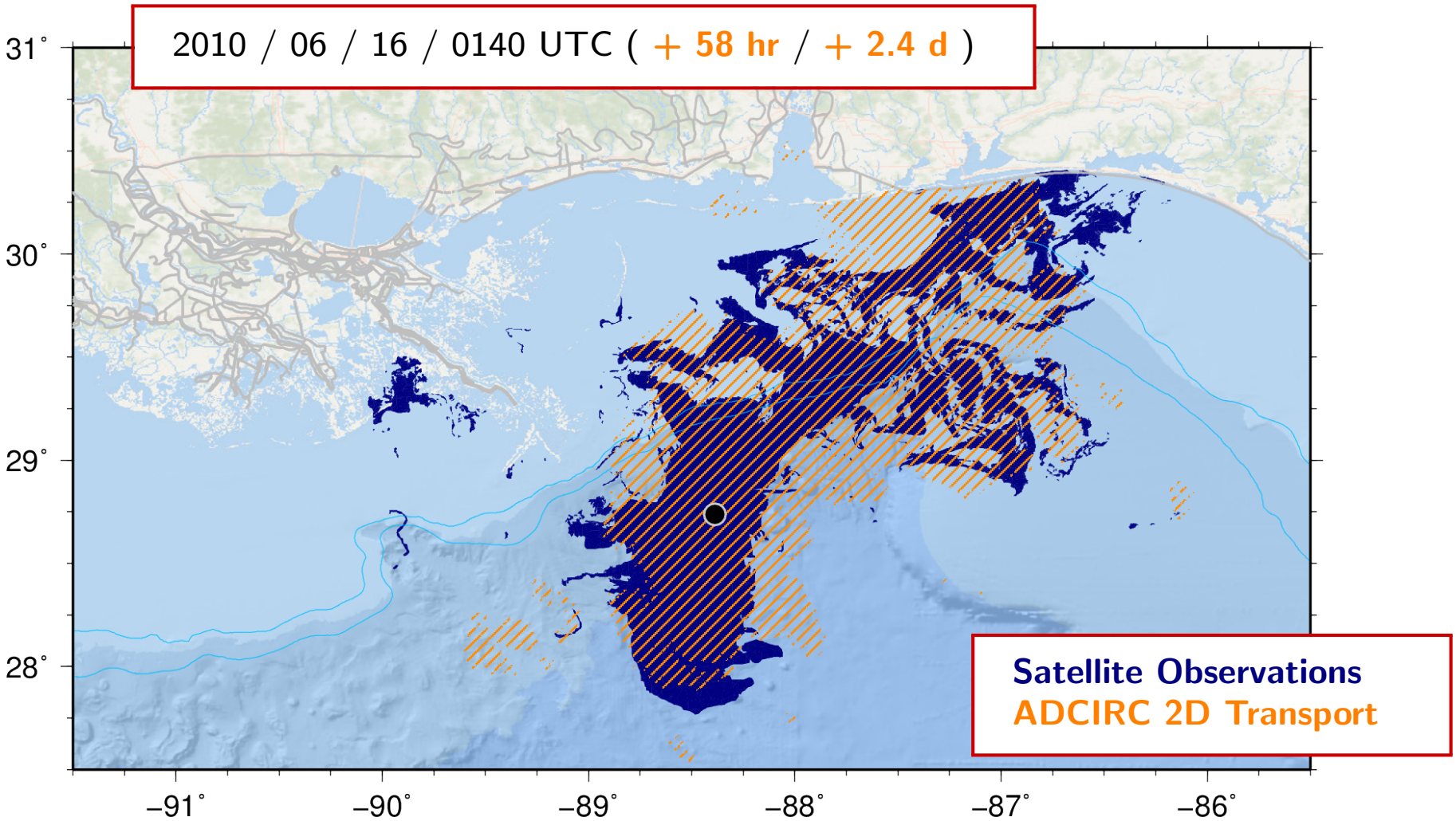

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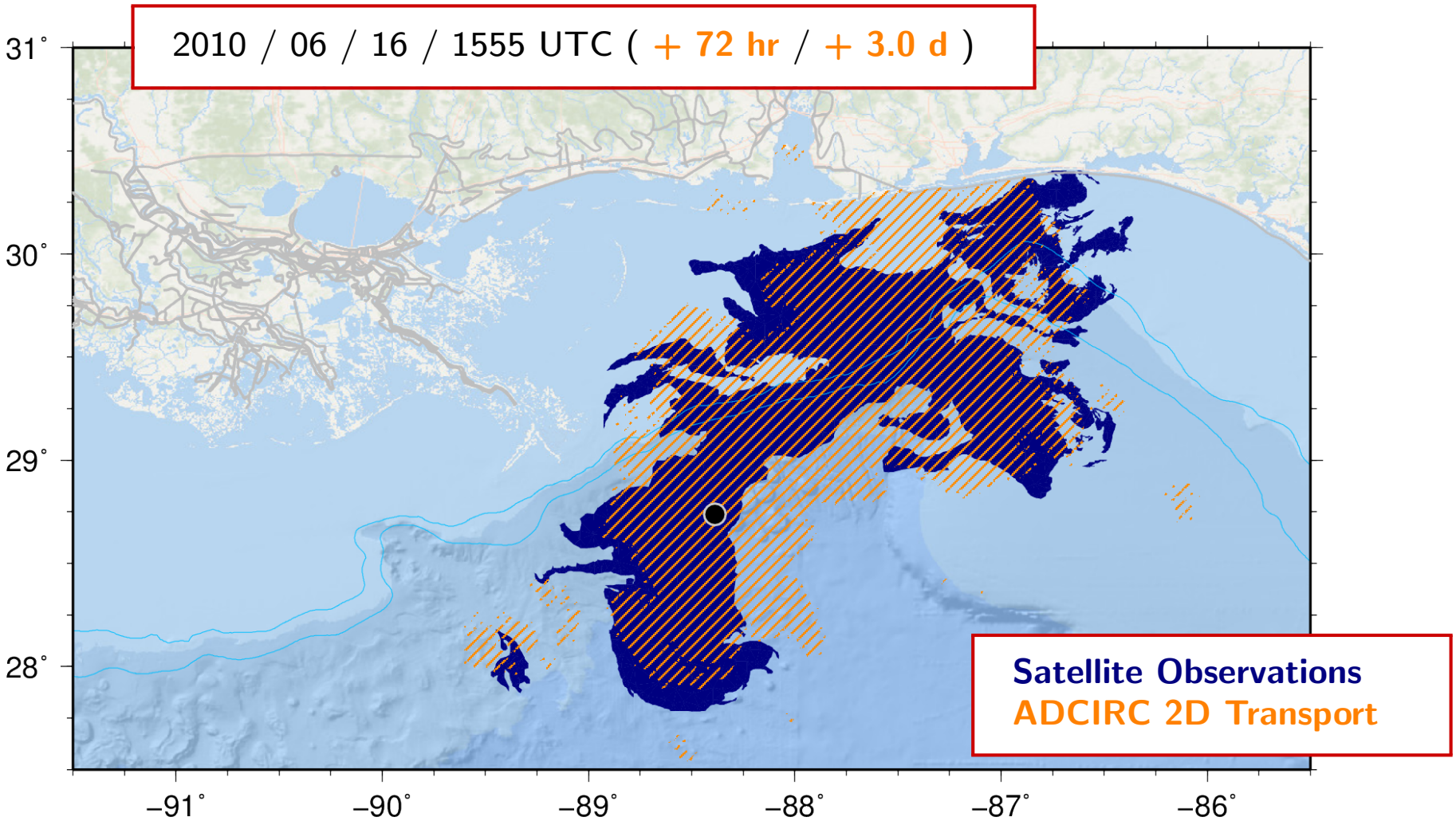

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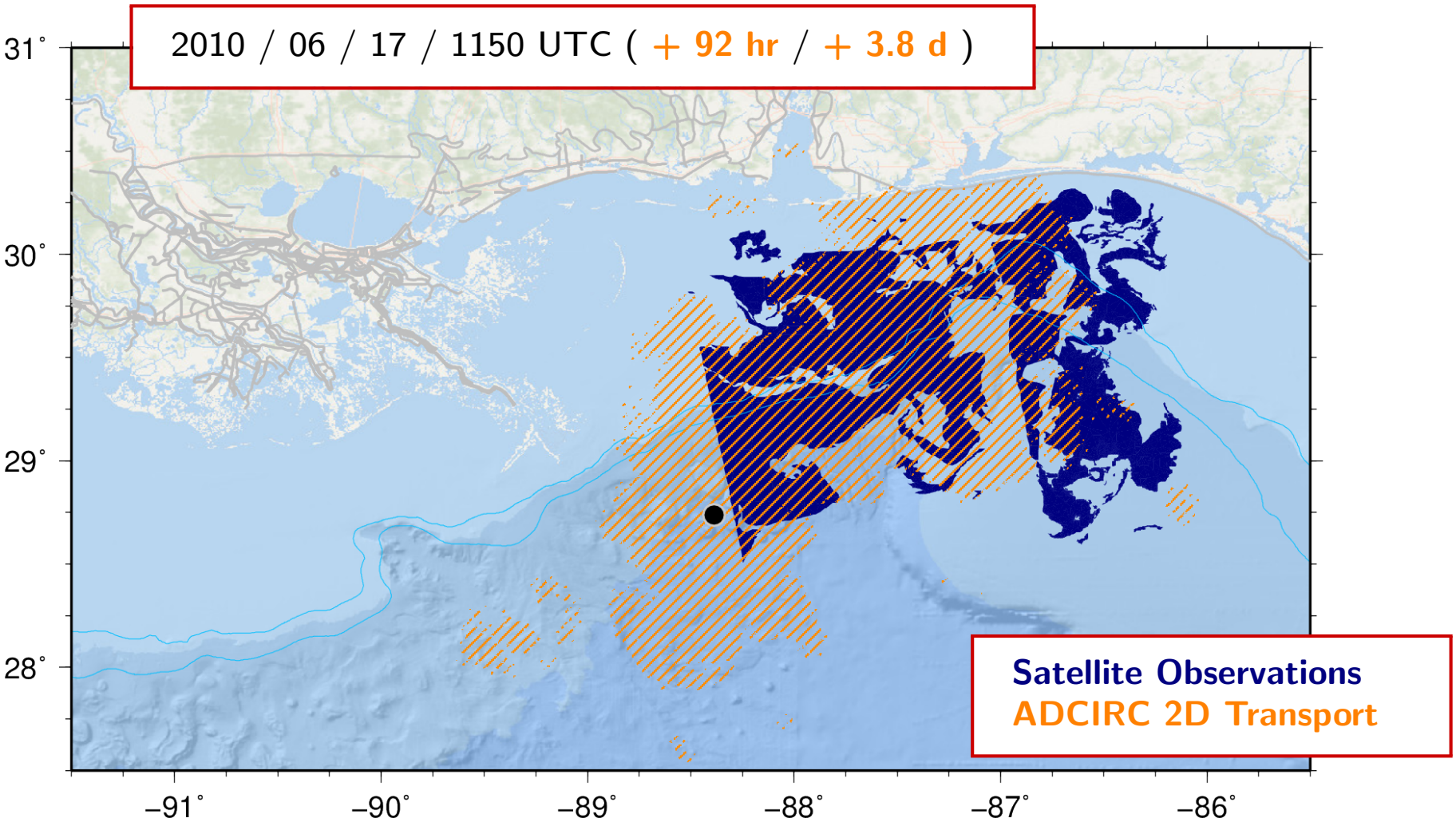

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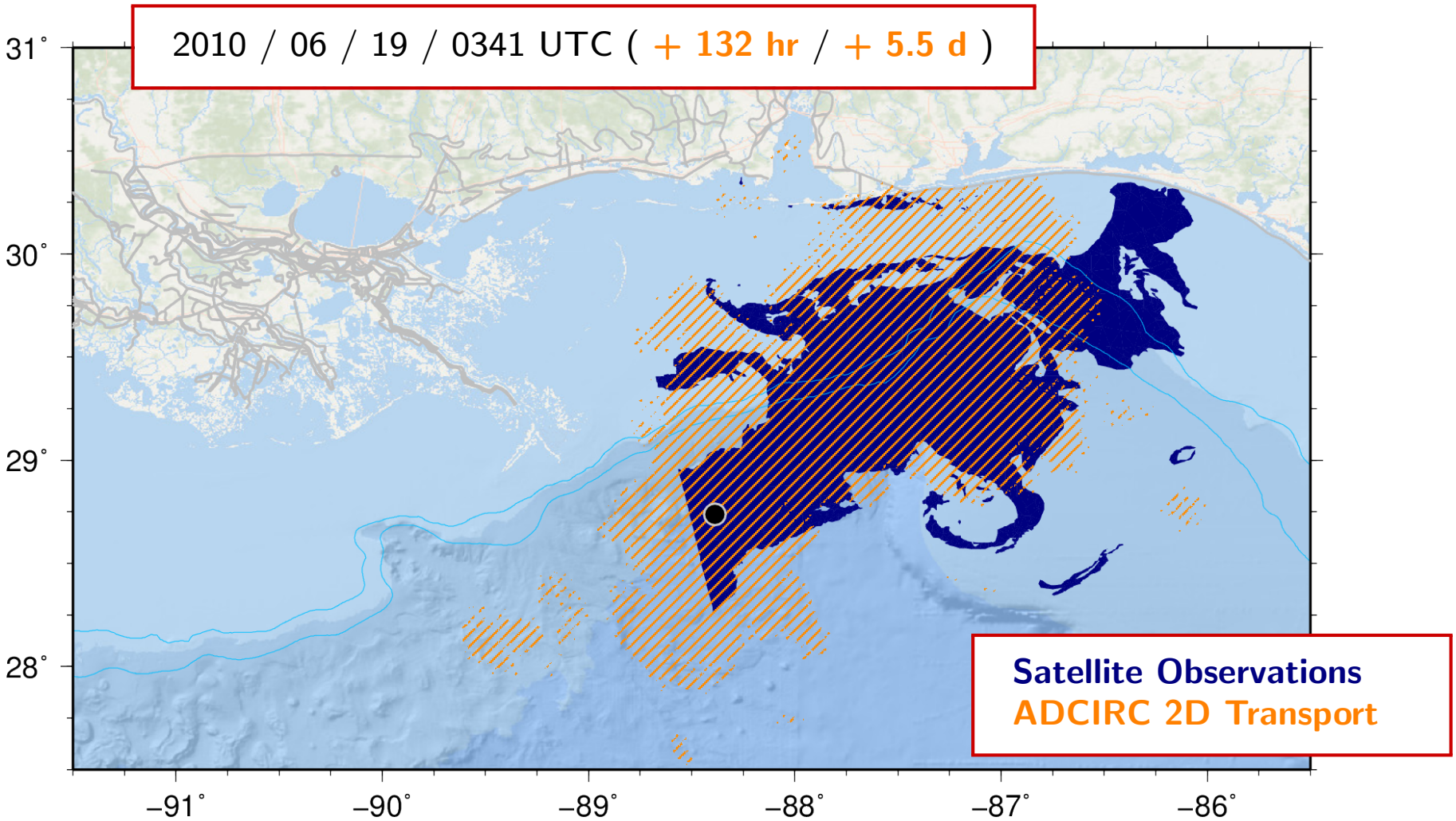

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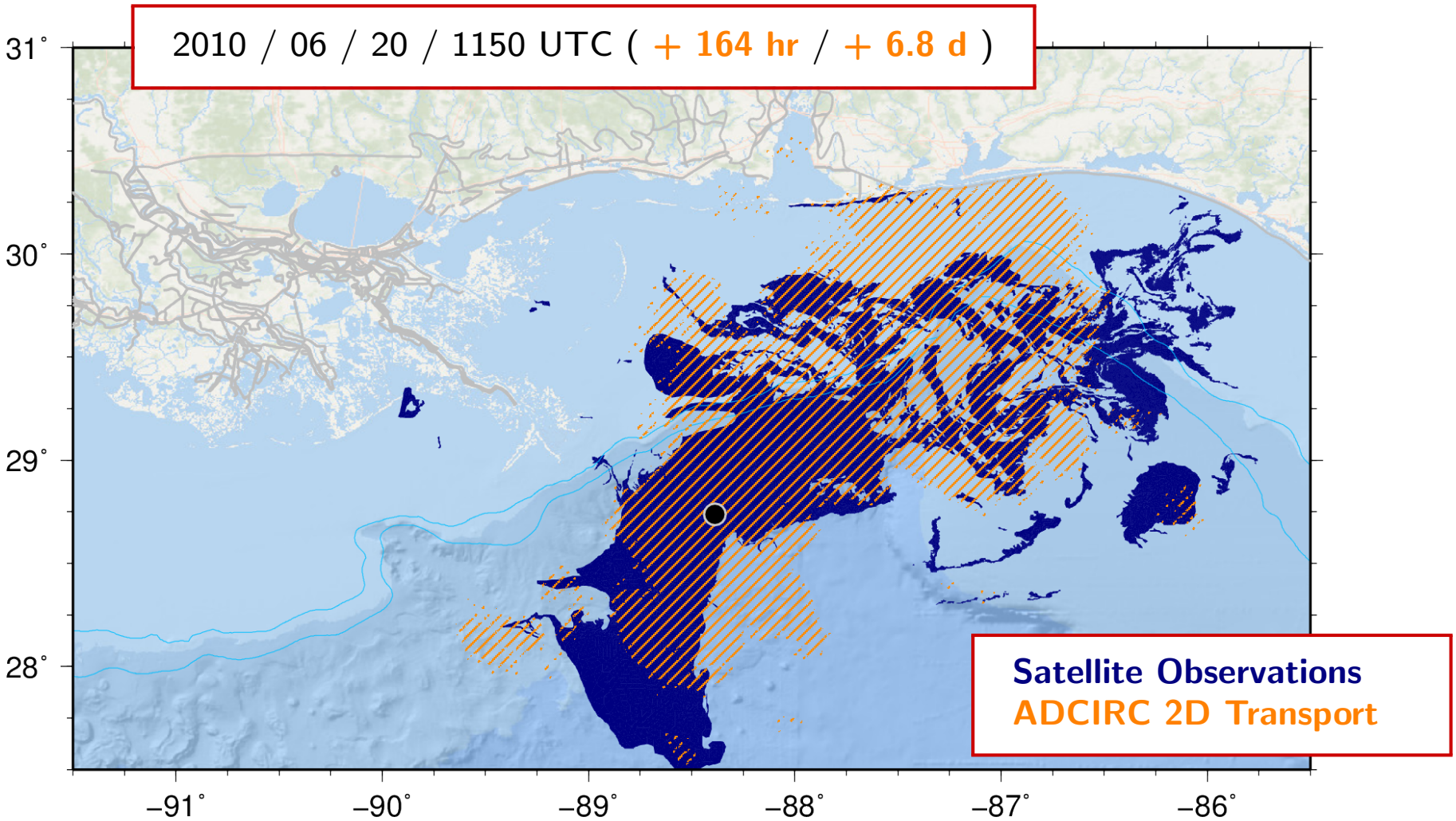

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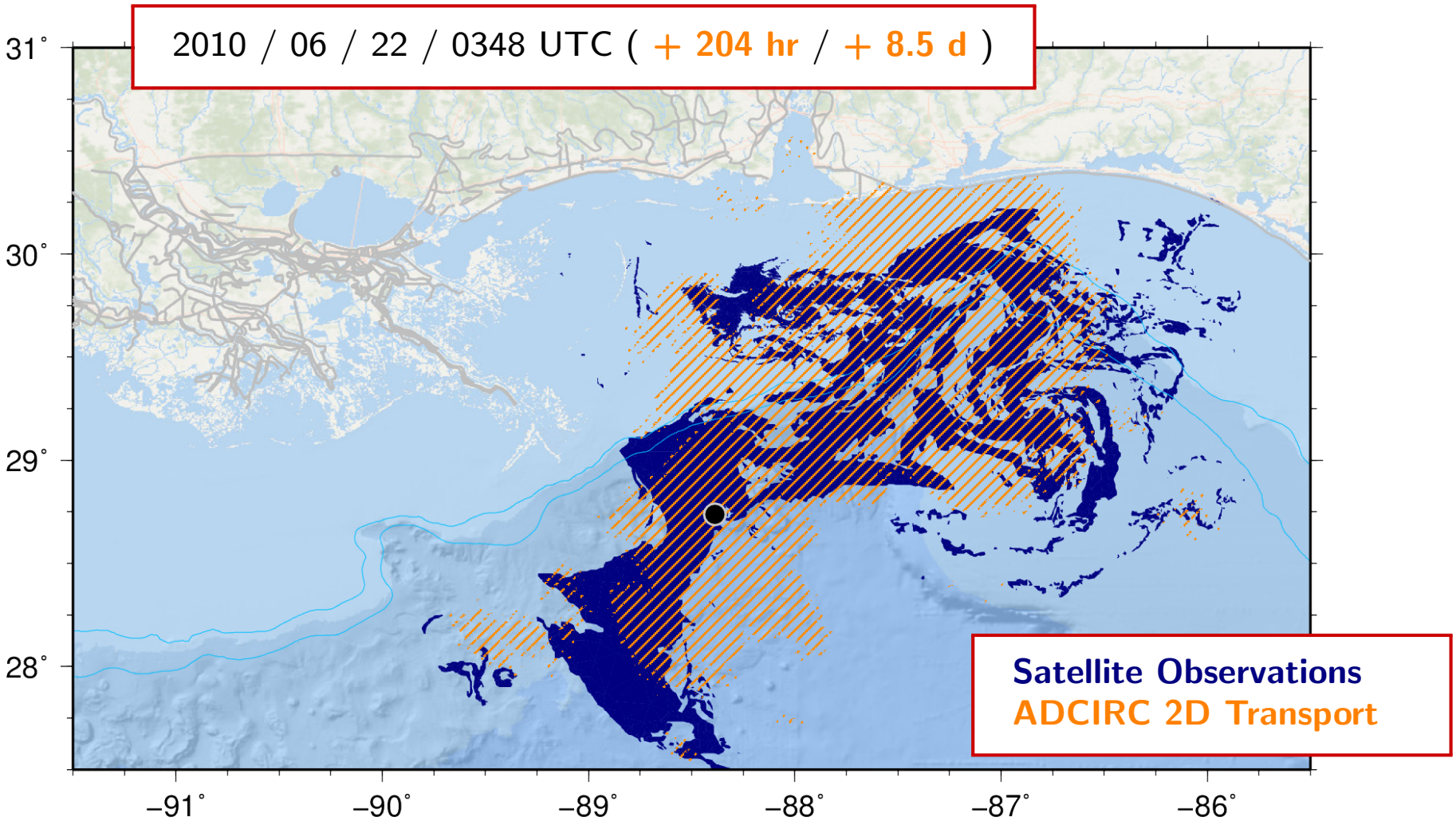

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Model Development during CARTHE

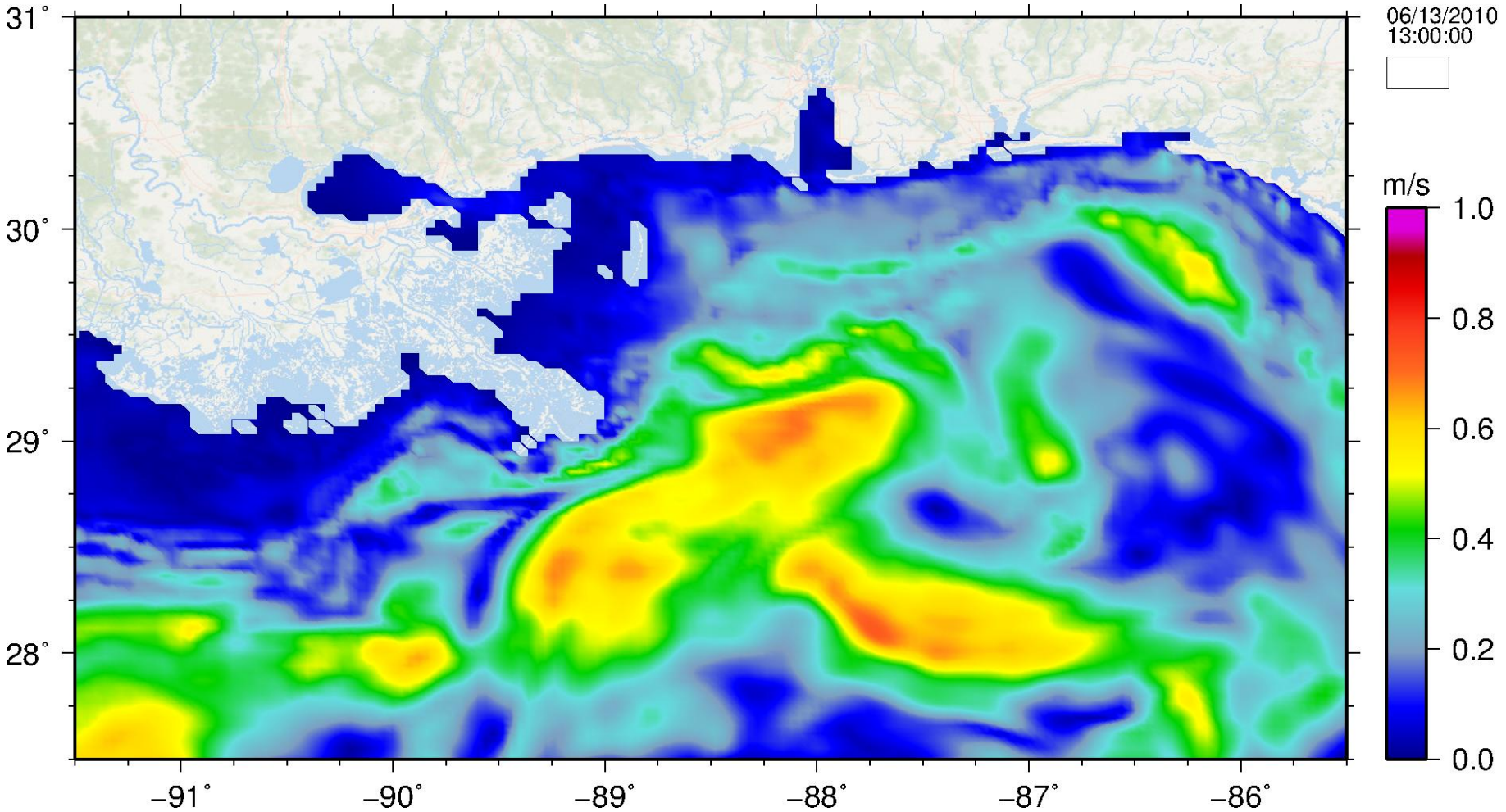
– Transition from 2D Barotropic to 3D Baroclinic Simulations

Coupling with the HYbrid Coordinate Ocean Model (HYCOM)

- Connect with existing expertise in CARTHE
- NRL operates a high-resolution forecast system for the Gulf
  - Horizontal resolution of $1/25^\circ$ (about 3.5km) with 20 vertical surfaces
  - Navy Coupled Ocean Data Assimilation (NCODA)
    - Satellite altimeter observations
    - Satellite and in situ sea surface temperatures
    - In situ vertical temperature and salinity profiles
  - Model results are available for download from hycom.org
    - Hourly output containing temperature, salinity, 3D currents, etc.
    - Output at standard Levitus depths (so fixed vertical layers in output)
- How are we coupling with HYCOM?
  - Initial conditions – Salinities, temperatures
  - Surface boundary conditions – Heat fluxes
  - Open ocean boundary conditions – Sea surface heights, salinities temperatures

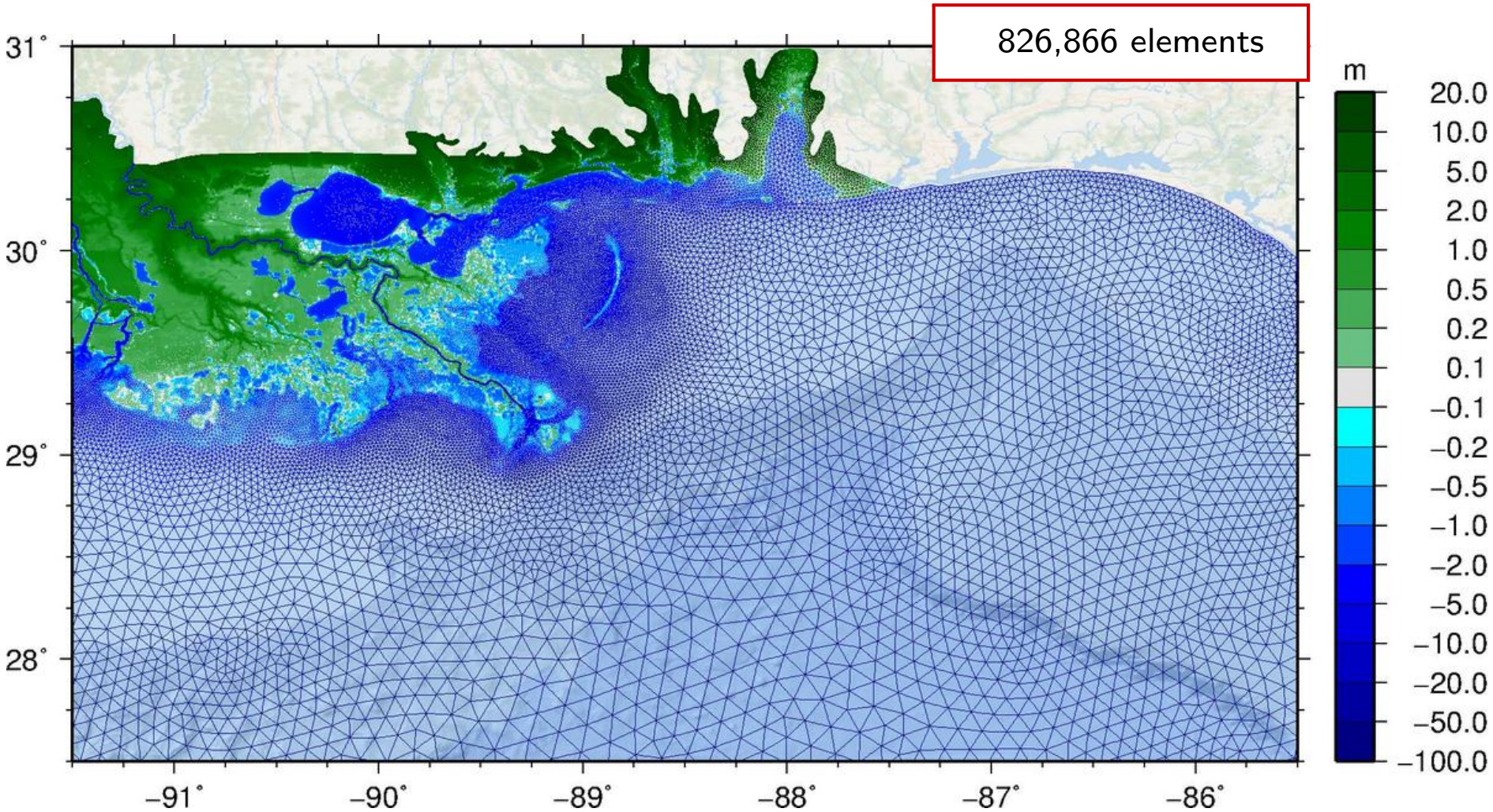
Model Development during CARTHE

– HYCOM Surface Currents during 13-16 June 2010



Model Development during CARTHE

– SURA-UL Finite-Element Mesh for Southeastern Louisiana



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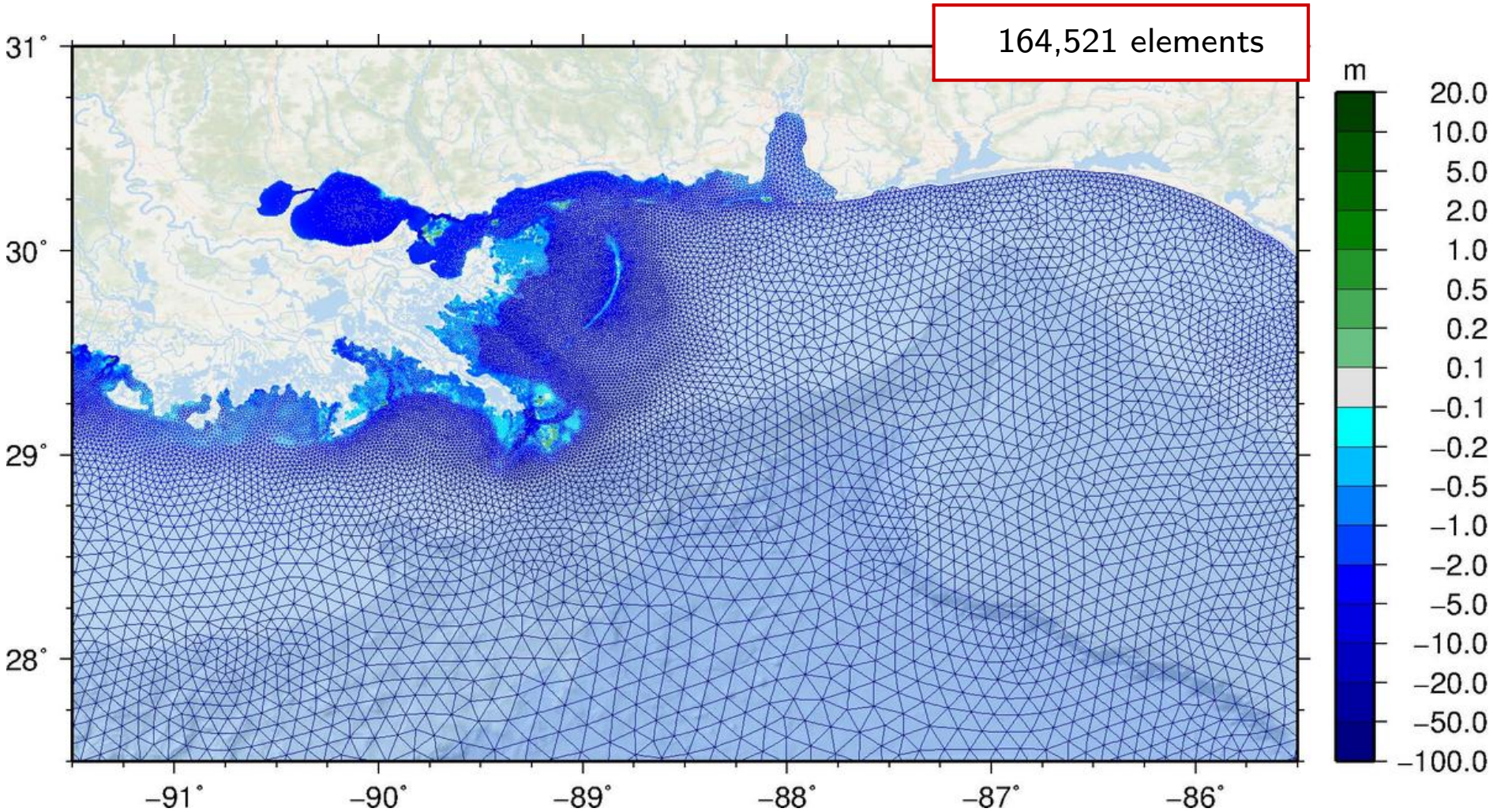

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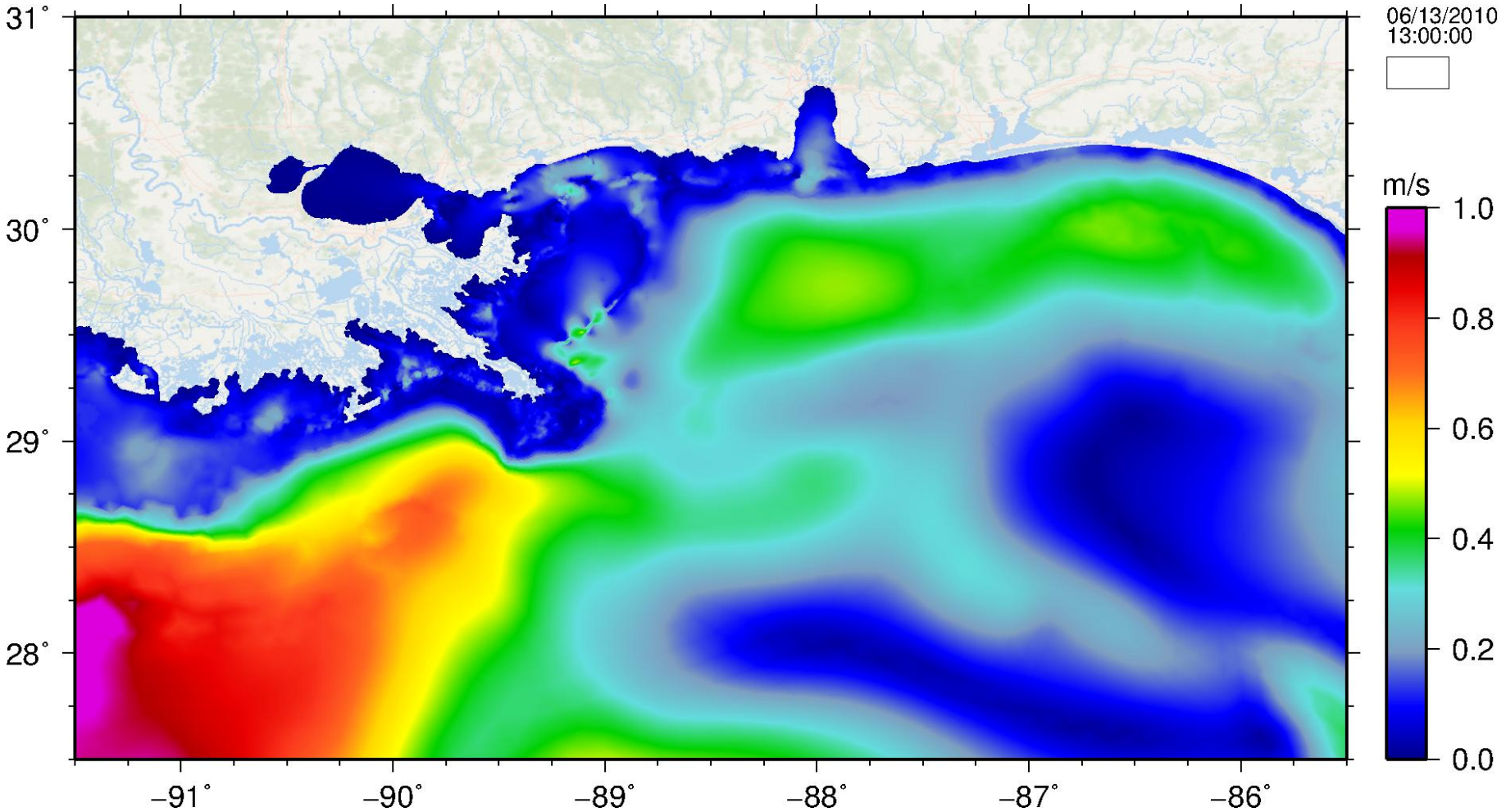
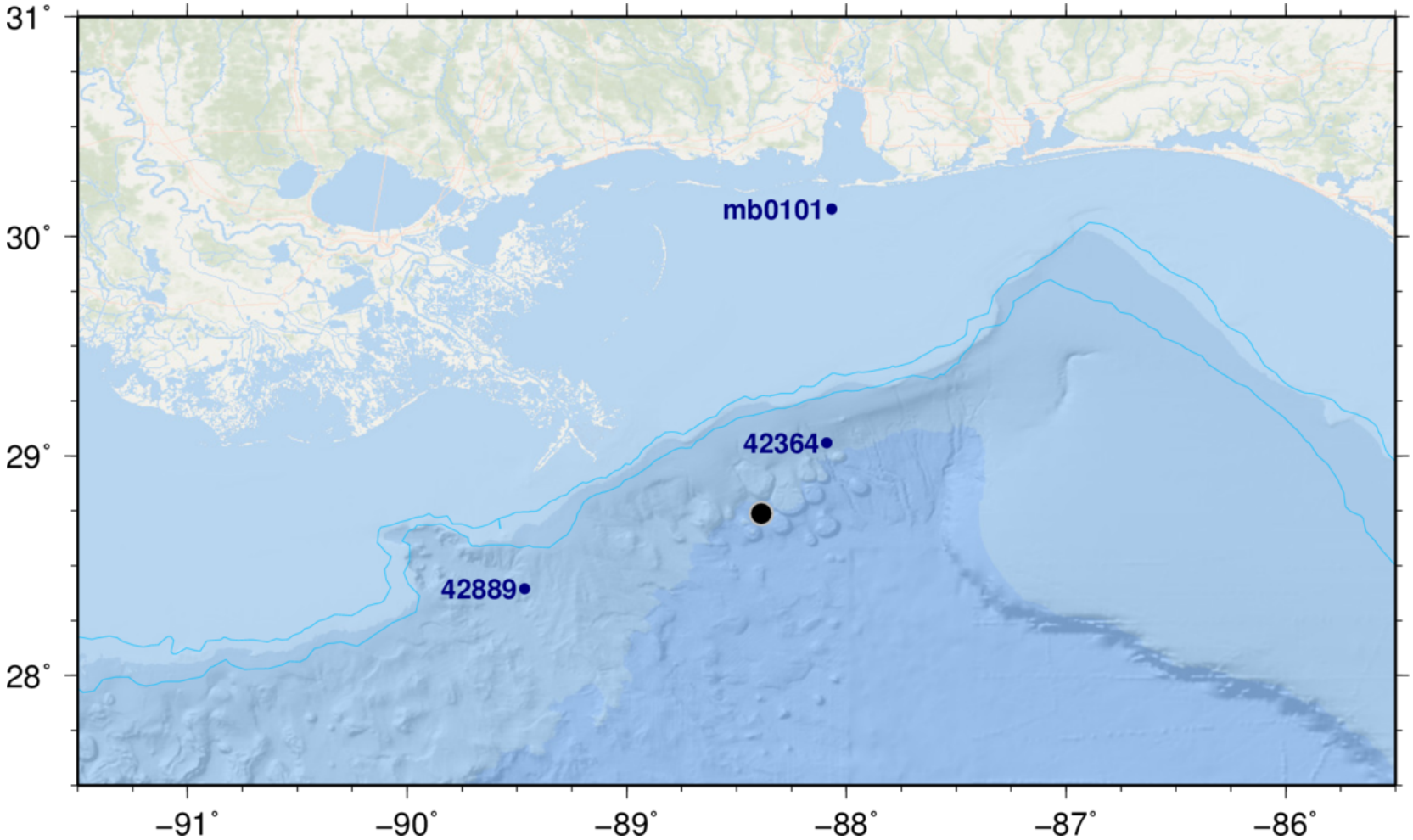


Model Development during CARTHE

– Comparison of Surface Currents to Observations



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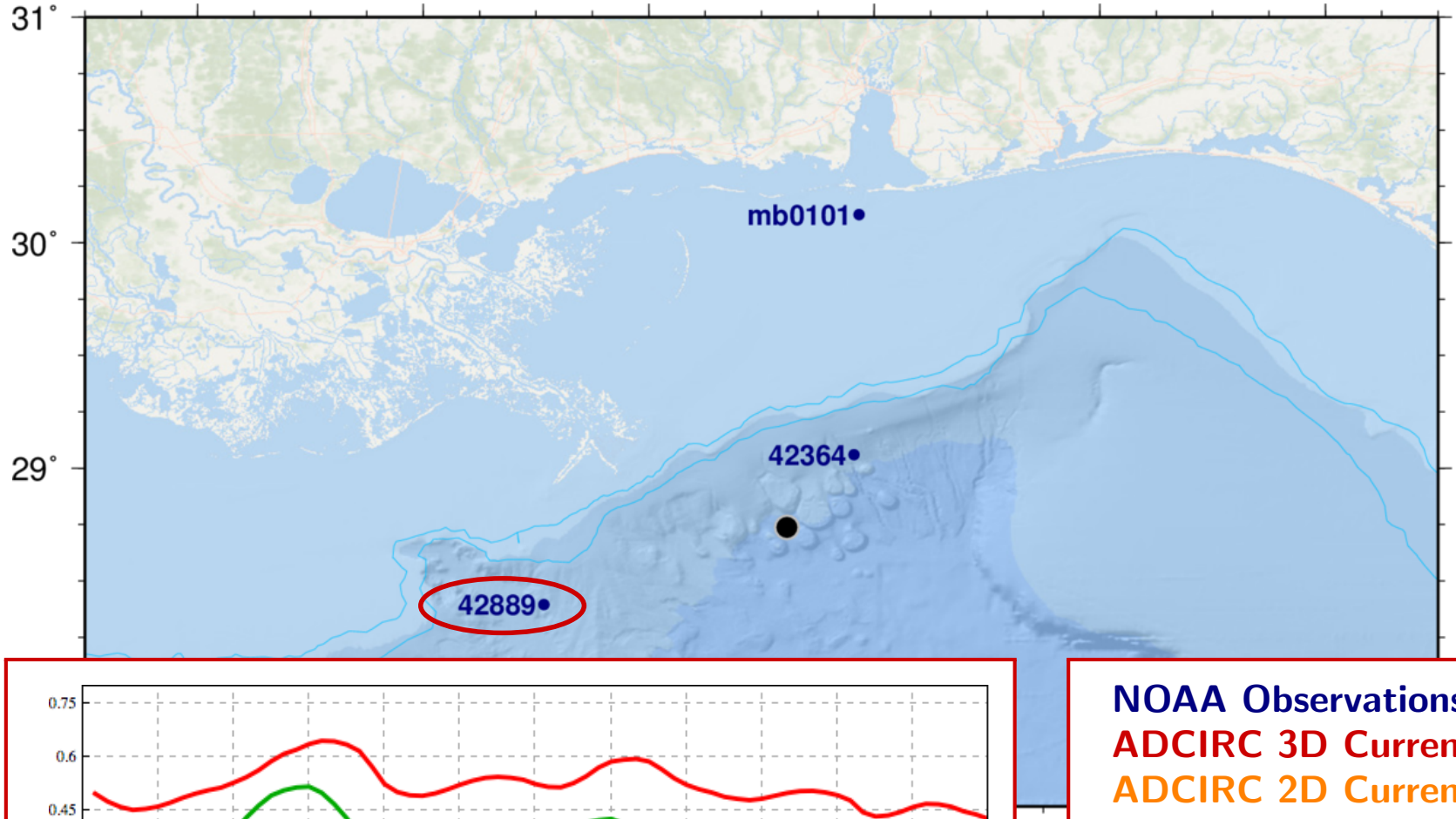

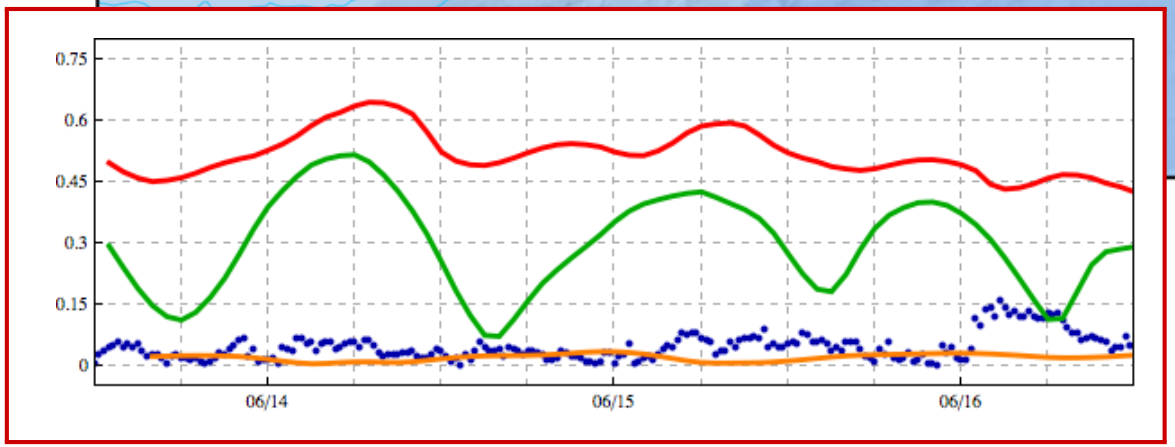

NOAA Observations
ADCIRC 3D Currents
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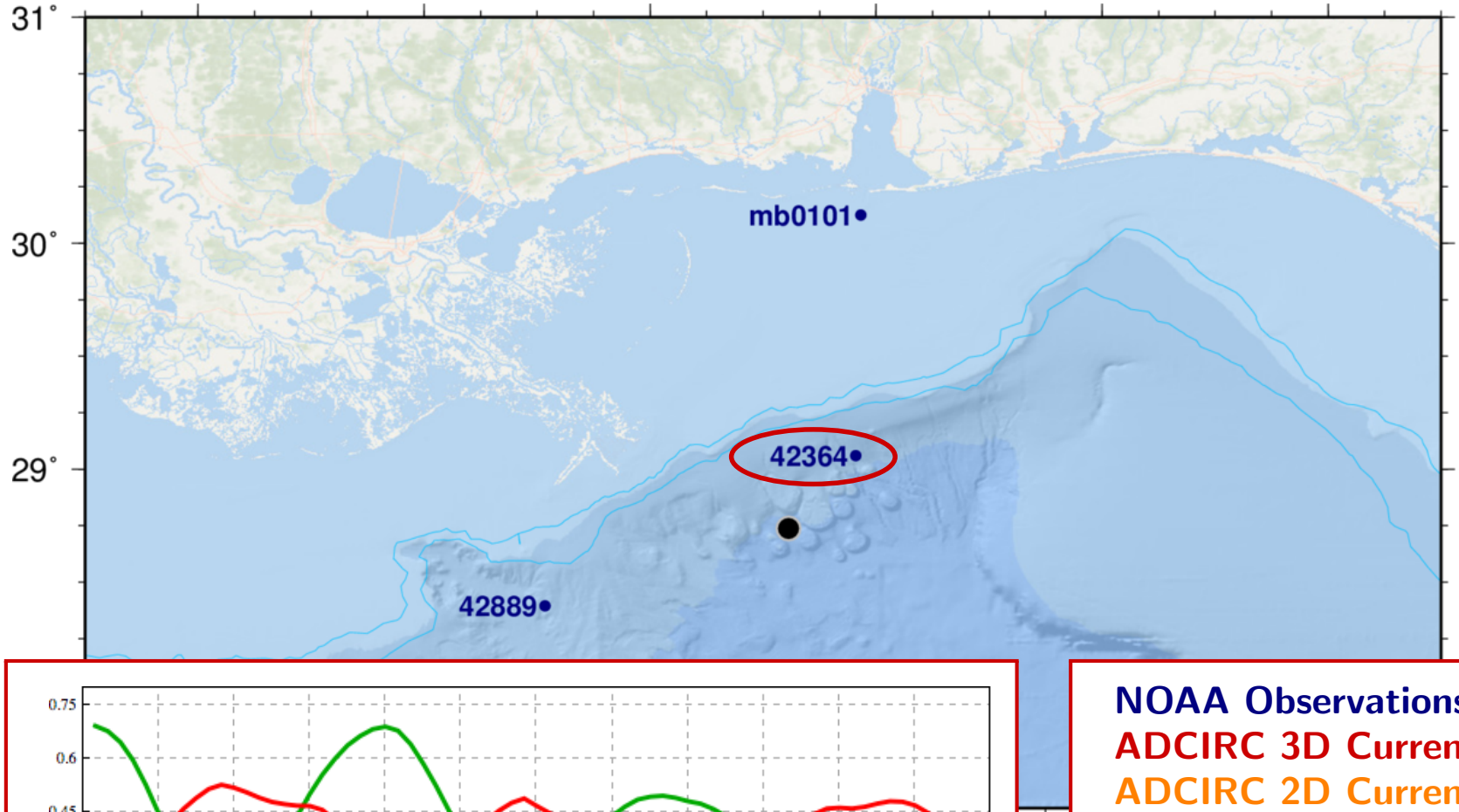

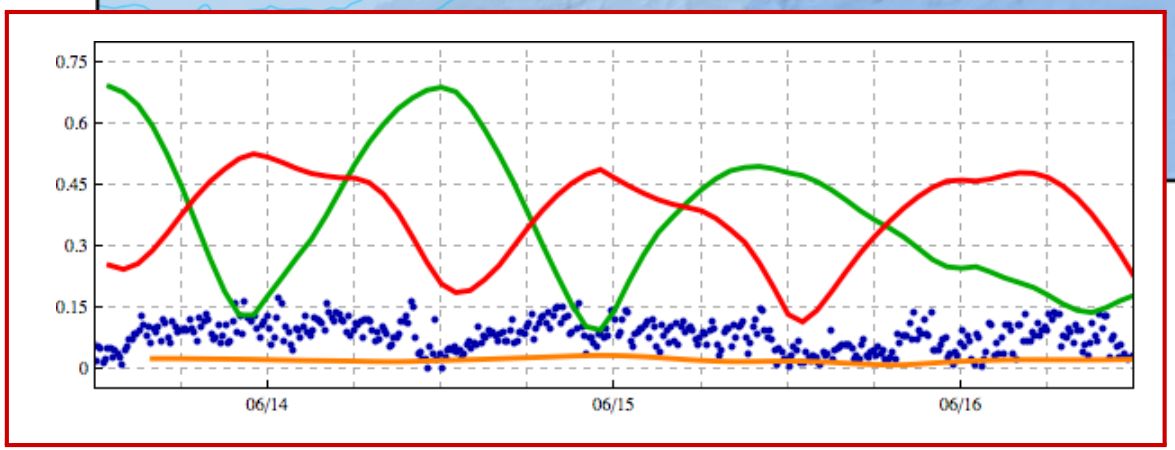

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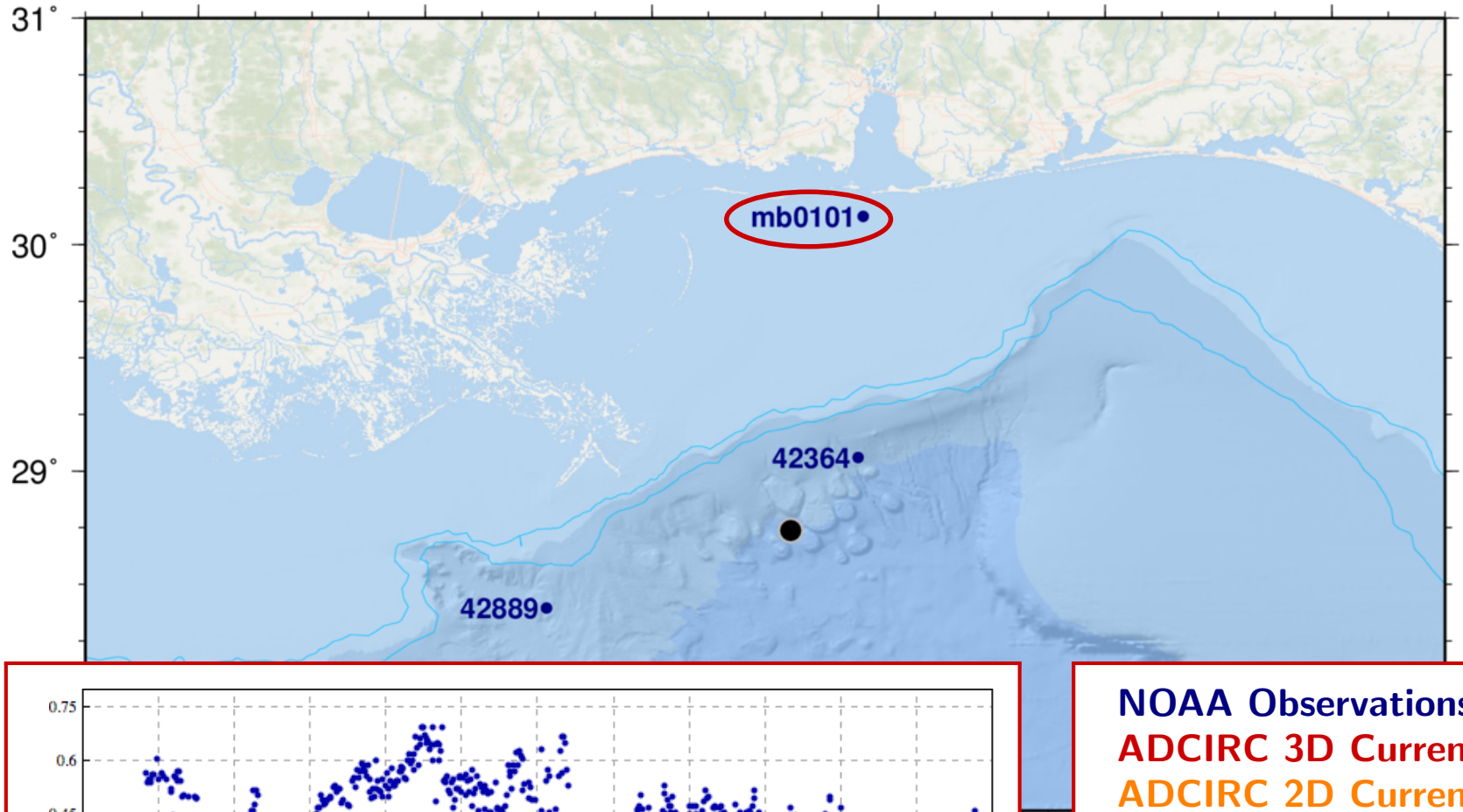

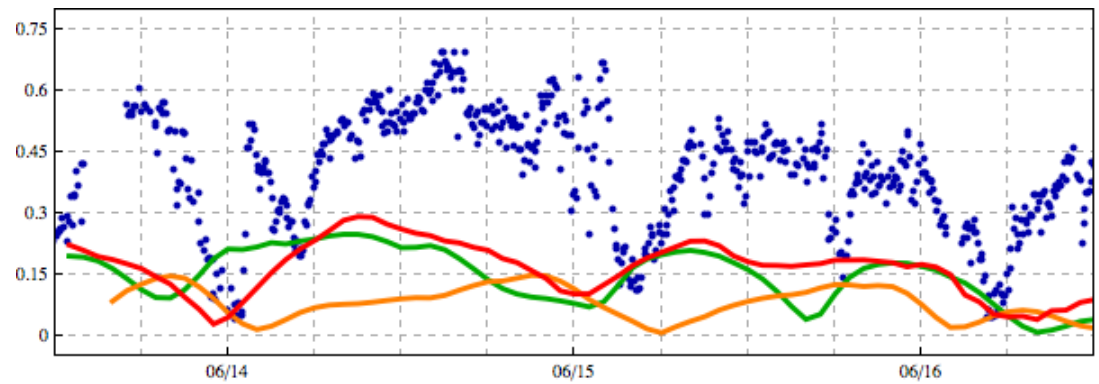

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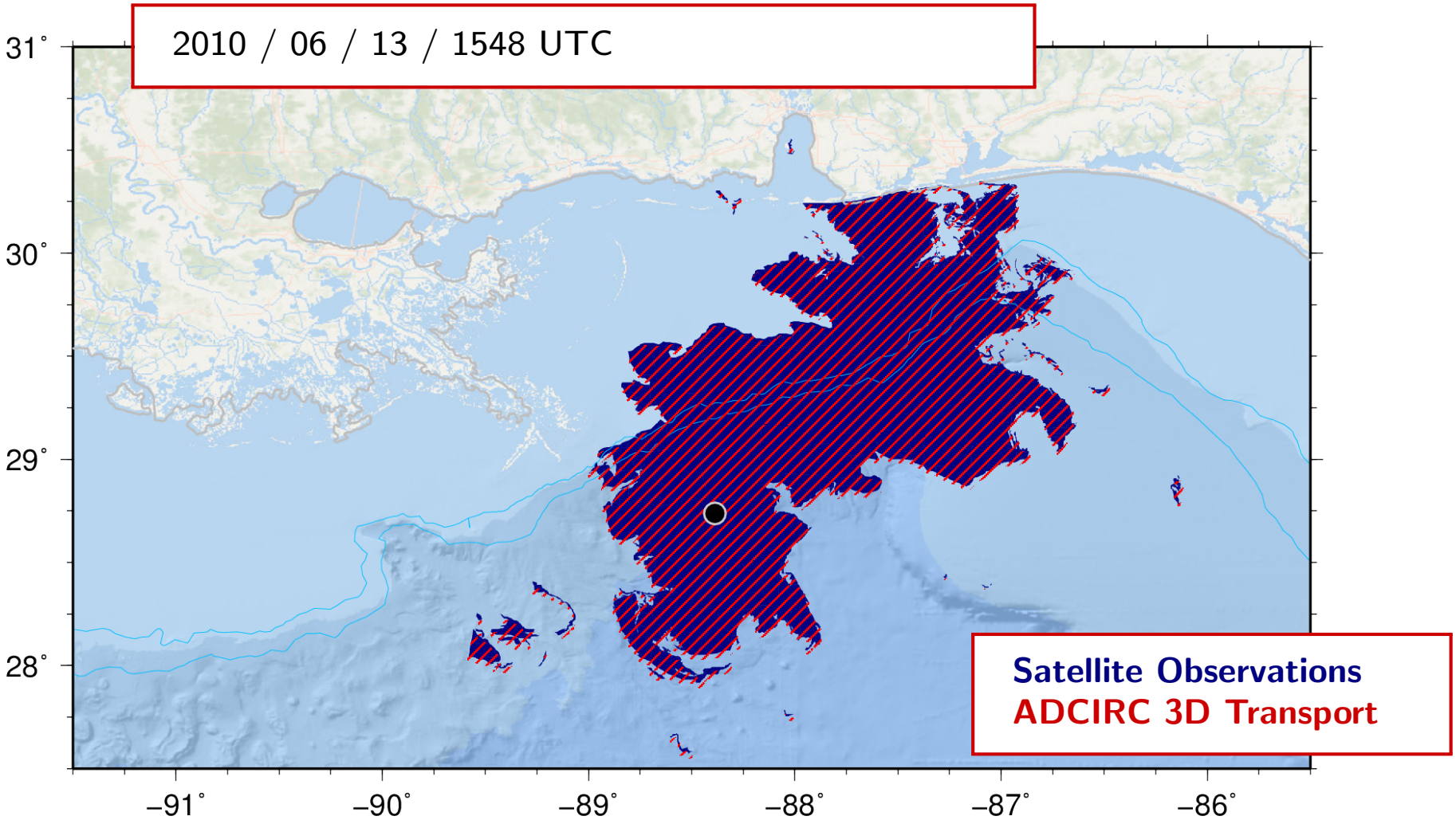

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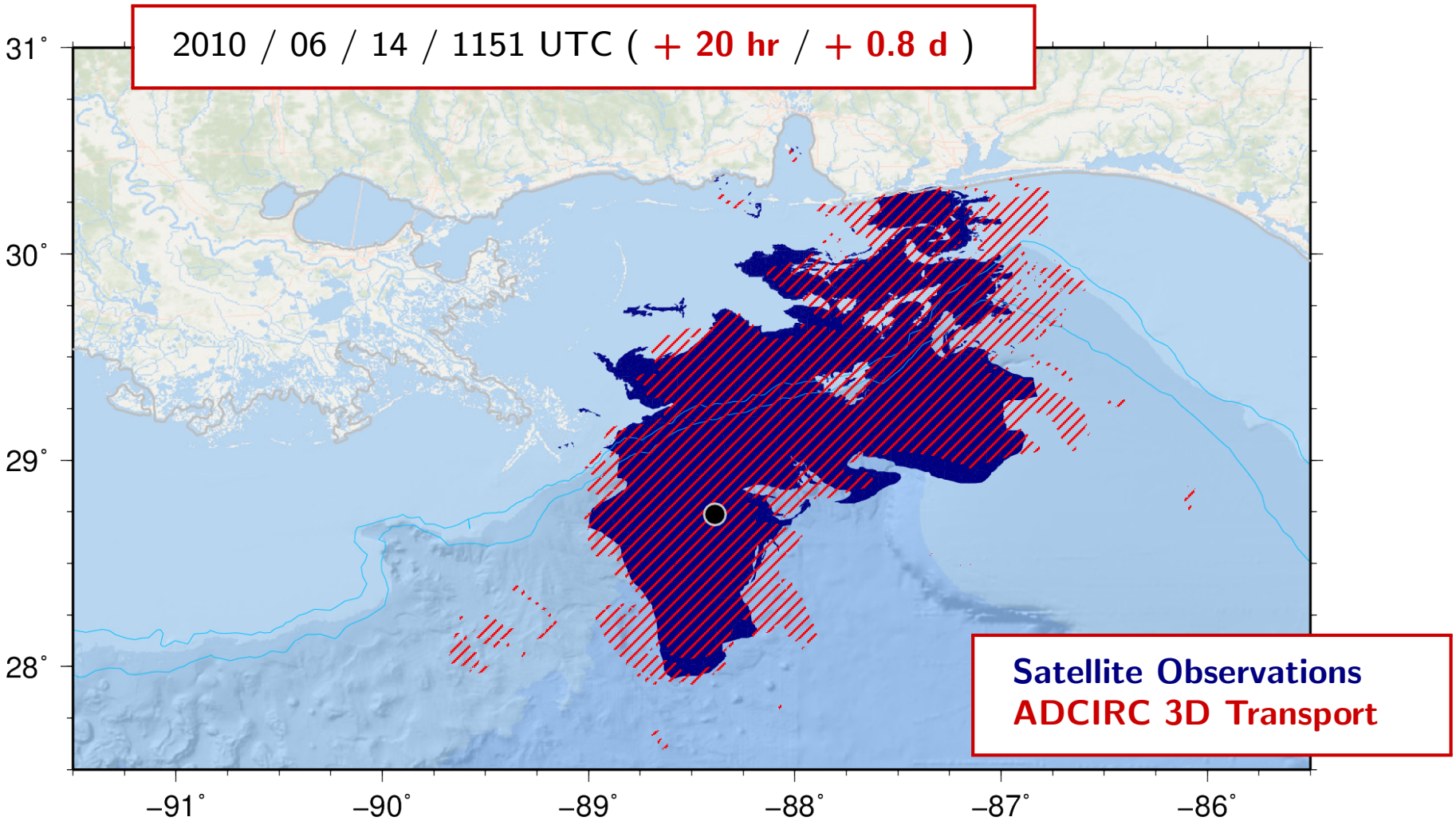

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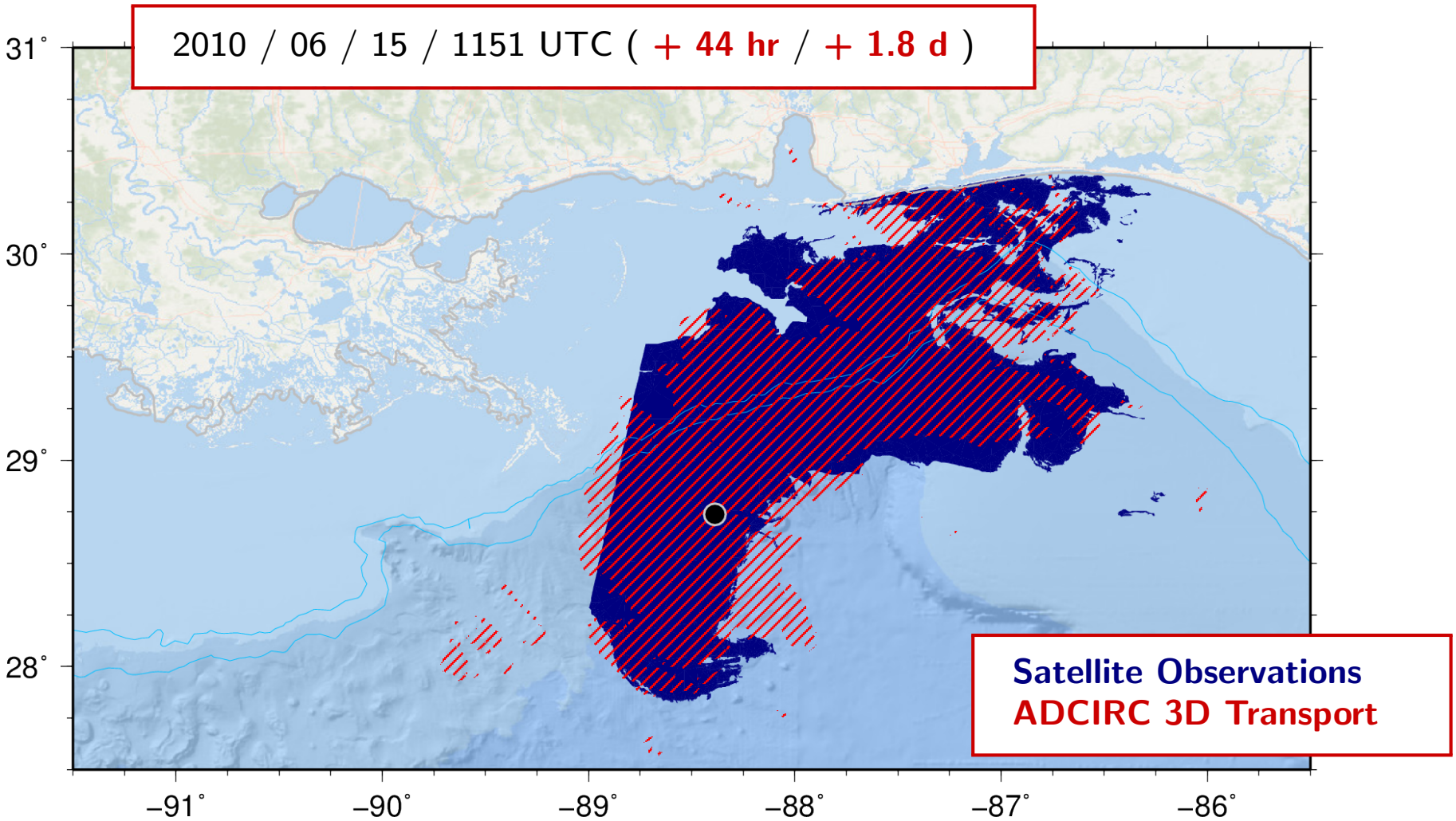

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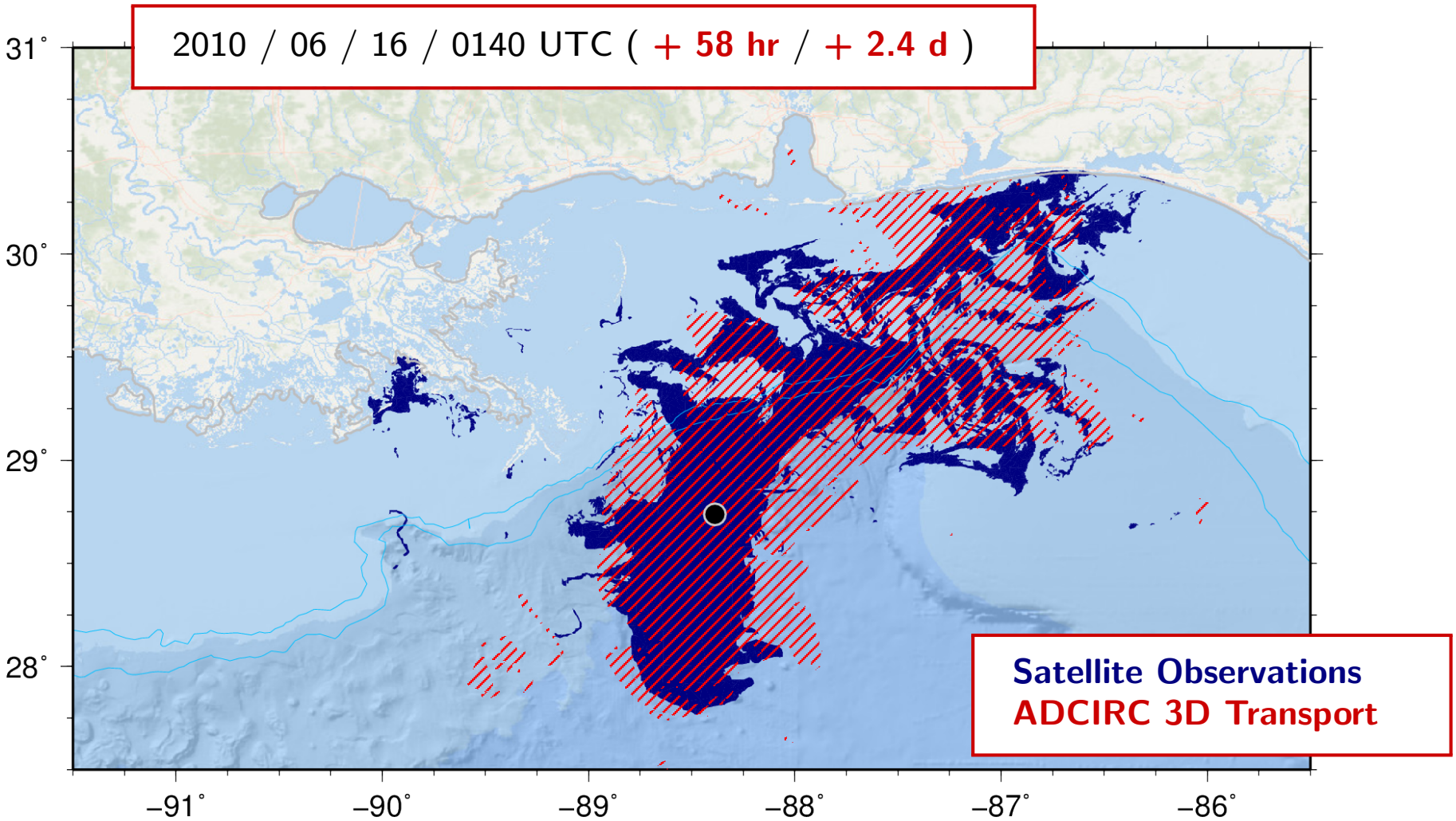

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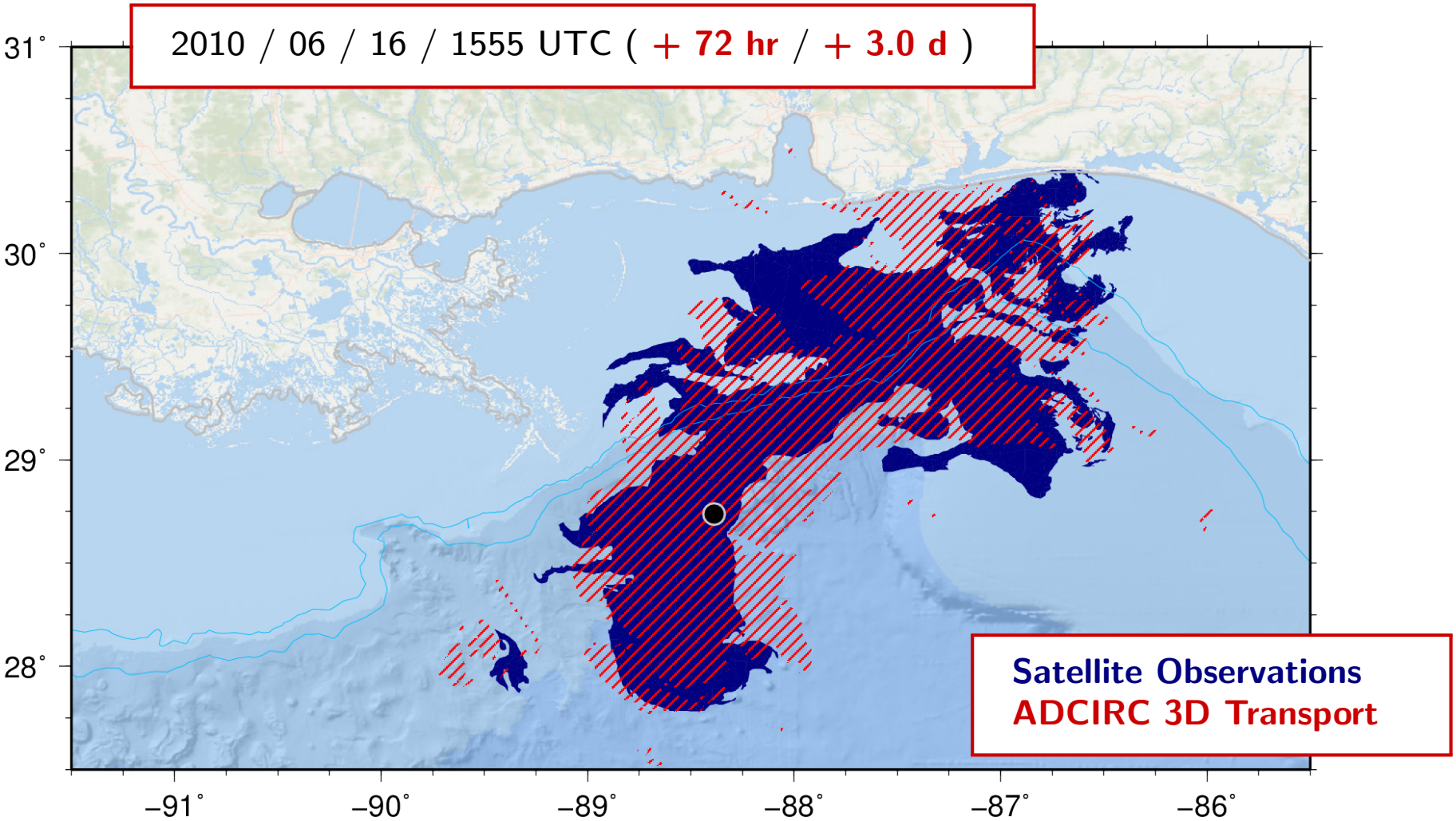

Summary and Future Work

Coupling of ADCIRC 3D with operational HYCOM:

- Interpolation of initial / boundary conditions to unstructured mesh
- Improvement in ADCIRC results:
  - Surface currents – Better match to NOAA measurements in nearshore
  - Transport – Better match to eastward oil motion in satellite imagery

Need to increase resolution in many aspects:

- Initial / boundary conditions via coupling with NCOM
- Wind forcing via coupling with meteorological model
- Upgrade to higher-res mesh:
  - Better representation of shelf break
  - Inclusion of coastline, floodplains, inlets and bays
- Ongoing validation to field observations during SCOPE