Shanghai Ocean University

Oil spill trajectory prediction using the GNOME model and satellite images

Yongliang Wei, Zeyan Tang and Jianqiang Liu

2015.10.15

College of Marine Sciences

Contents

1. Introduction
2. Oil spill modeling
3. Impacts of data resolution
4. Summary

1. Introduction

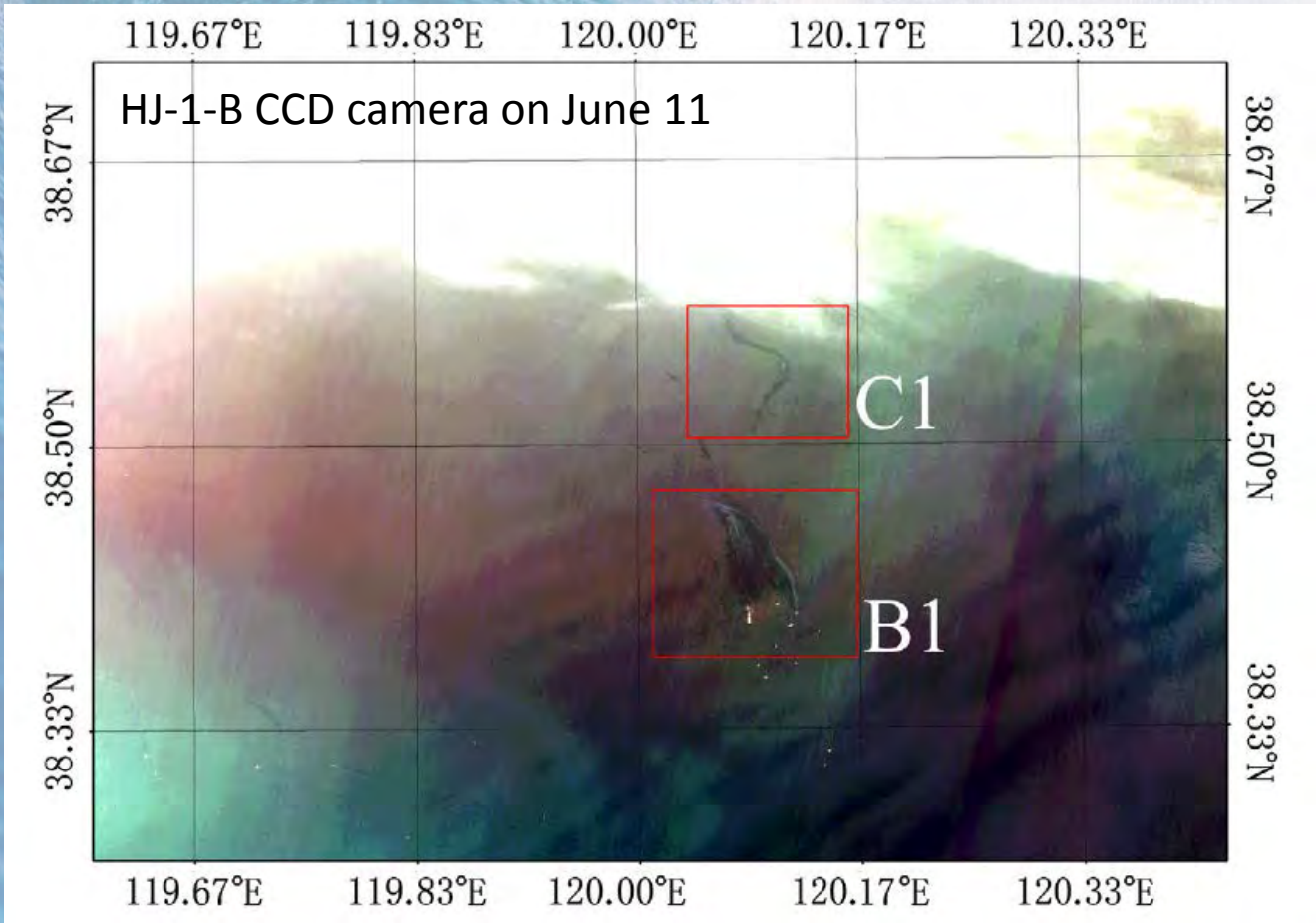
➢ Marine oil spill

- Serious threat to marine environment and ecosystem
- Numerous costs to cleanup
- 2010: Deepwater Horizon (Mexico Bay, USA)
- 2011: Penglai 19-3 (Bohai Sea, China)

➢ Marine oil spill by remote sensing

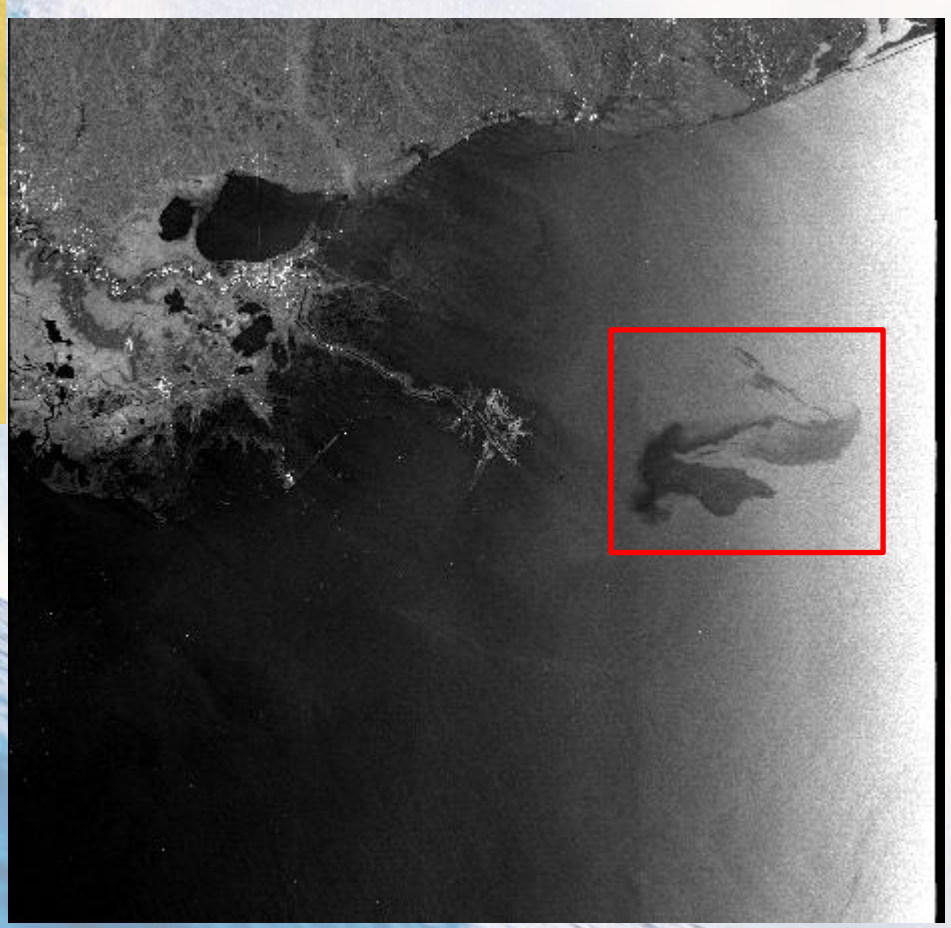
1. Optical remote sensing

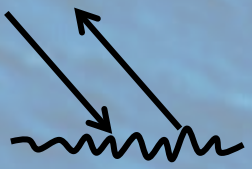
Available in daytime



2. Microwave remote sensing

- Synthetic Aperture Radar (SAR)
- Side-look, active, imaging radar
- Day/night, all weather condition
- Backscattered radar cross section through Specular & Bragg resonant mechanism



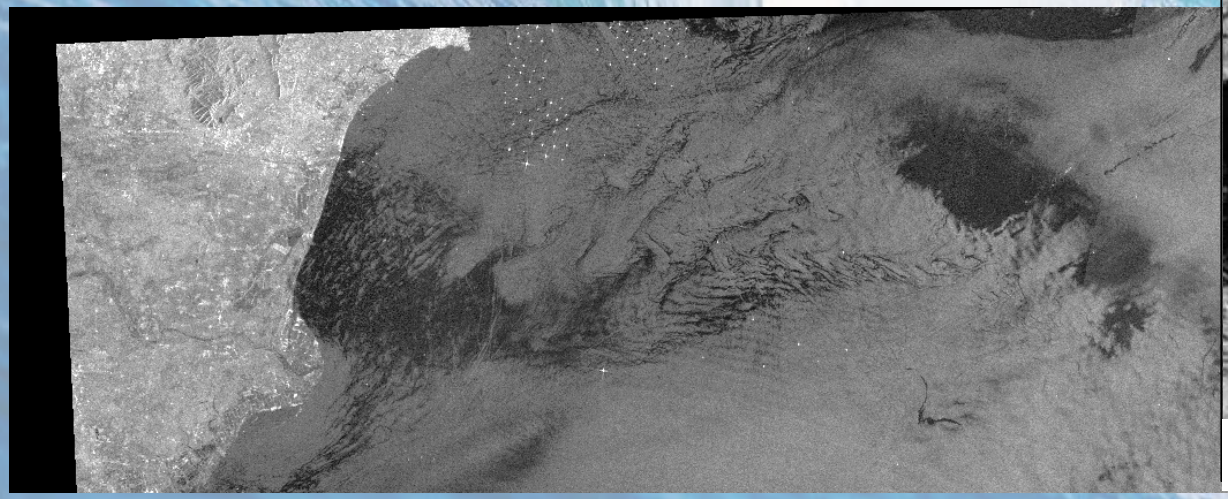


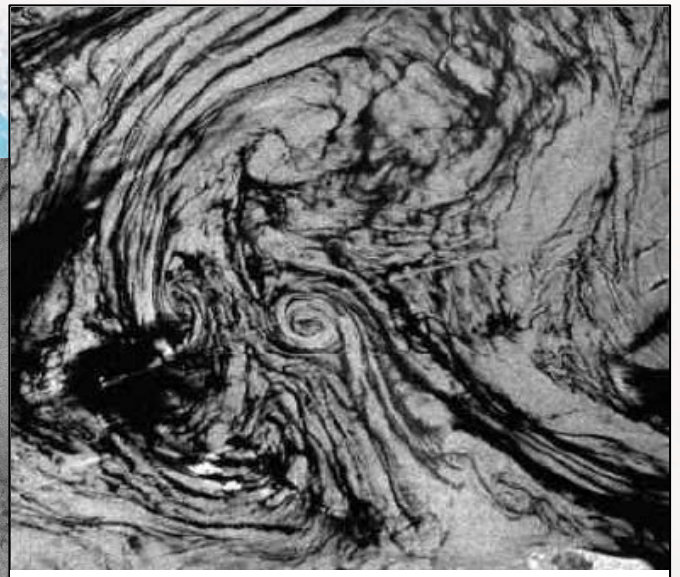
Bragg resonant

Specular

Oil spill look-alikes in SAR image

- Low wind speed
- Organic films
- Sea ice, …





SAR Marine User manual, 2004

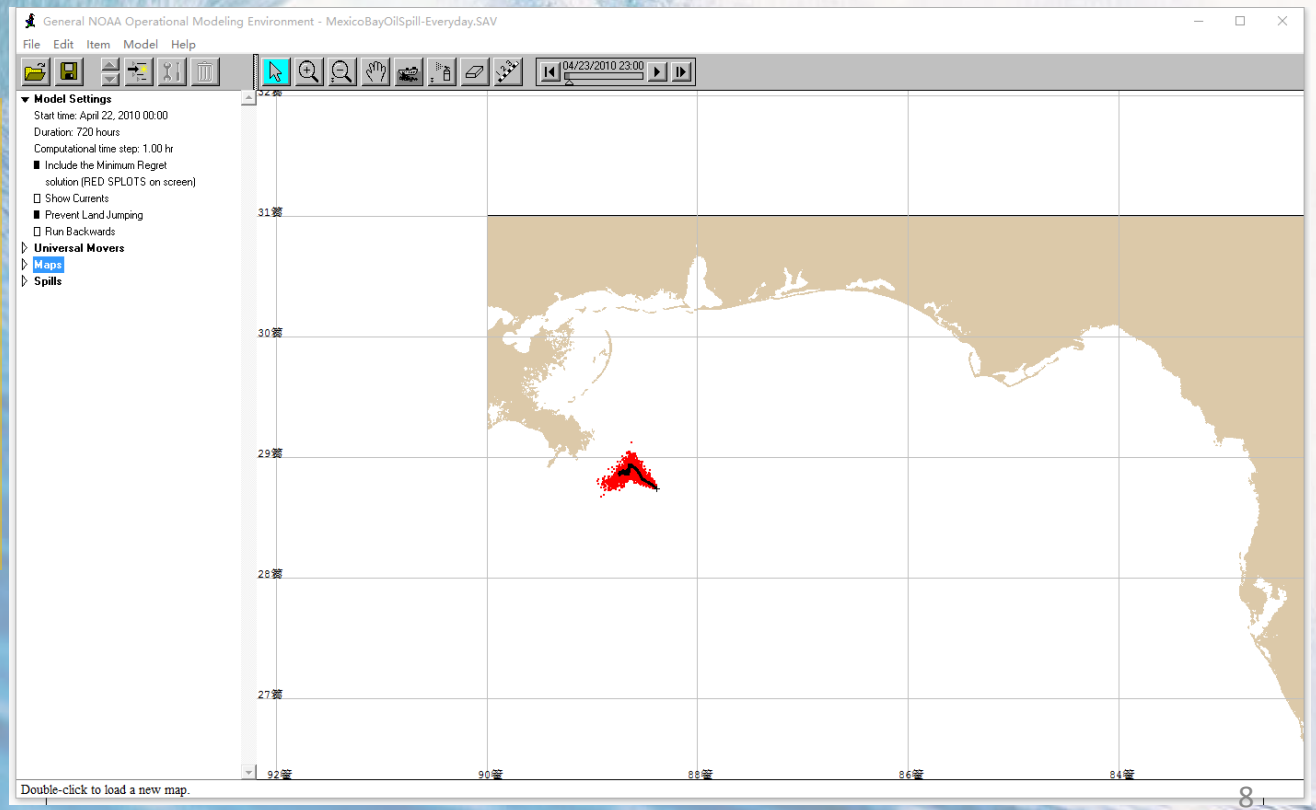
Two questions related to oil spill remote sensing

1. Oil spill detection
2. Trajectory prediction

➢ GNOME model

- General NOAA Operational Modeling Environment
- By NOAA/Emergency Response Division
- Free software

- Gasoline
- Kerosene/jet fuels
- Diesel
- Fuel oil #4
- Medium crude
- Fuel oil #4
- Non-weathering



- **'Splot': a volume of spilled oil**
- **Track oil using Lagrangian method**

$$\vec{L} = \vec{L}_0 + \int_{t_0}^{t_0+\Delta t} V_t\left(x(t_0), y(t_0), t_0\right) dt$$

- **Driving forces:**
  surface winds and currents

- **Output:**
  - ✓ **Best Guess Solution**
  - ✓ **Minimum Regret Solution**

2. Oil spill modeling

Satellite images and GNOME: Penglai19-3

- **ENVISAT-ASAR**
- **HJ-1 CCD**

GNOME settings:

Current: NCOM (Navy Coastal Ocean Model), 0.125˚×0.125˚, 3-hour

Wind: ASCAT (Advanced Scatterometer), 0.25˚×0.25˚, 1-day

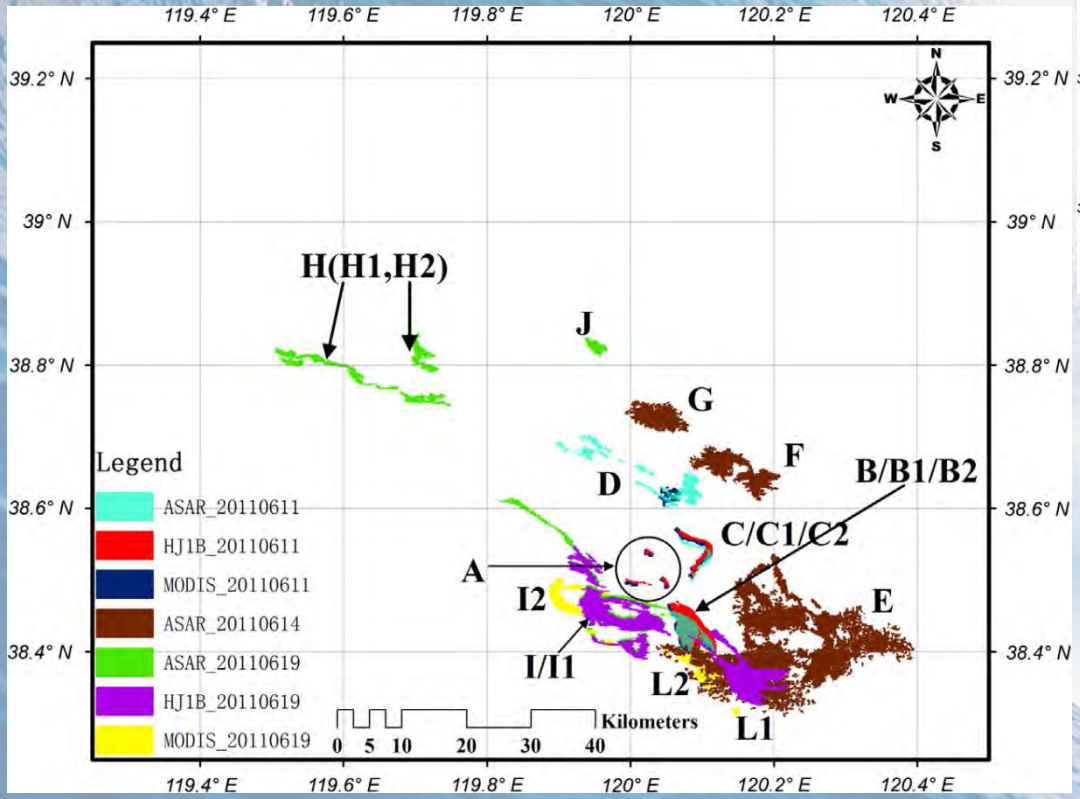
Start time: 2011/06/11 02:00 UTC

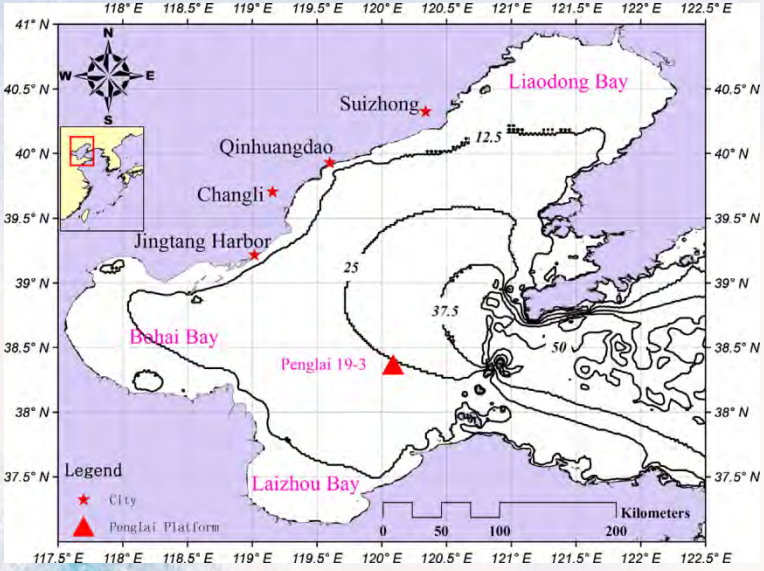
Model time interval: 1 hour

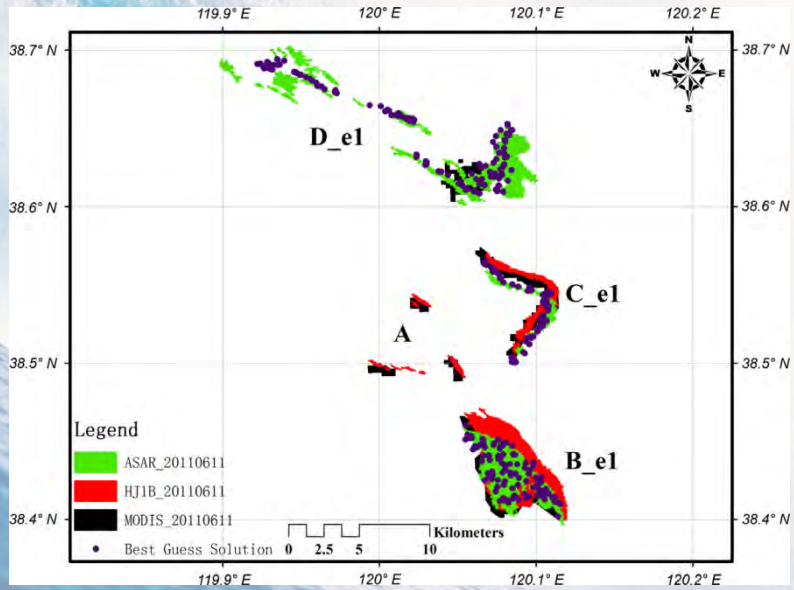
Oil type: Medium crude

Xu, Q., et al., 2013

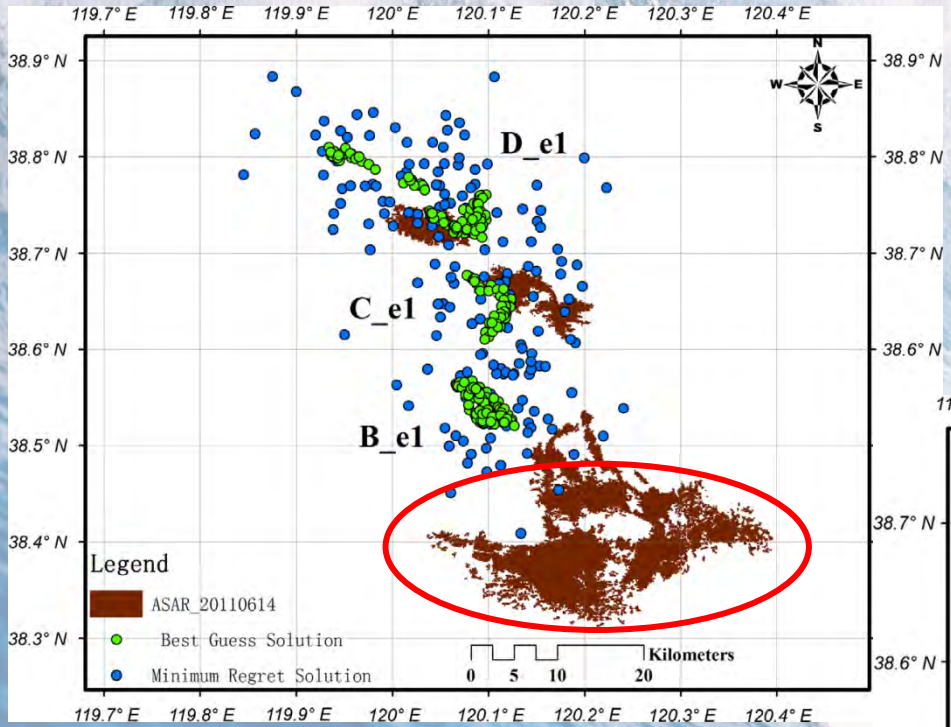
Oil spills extracted from satellite images

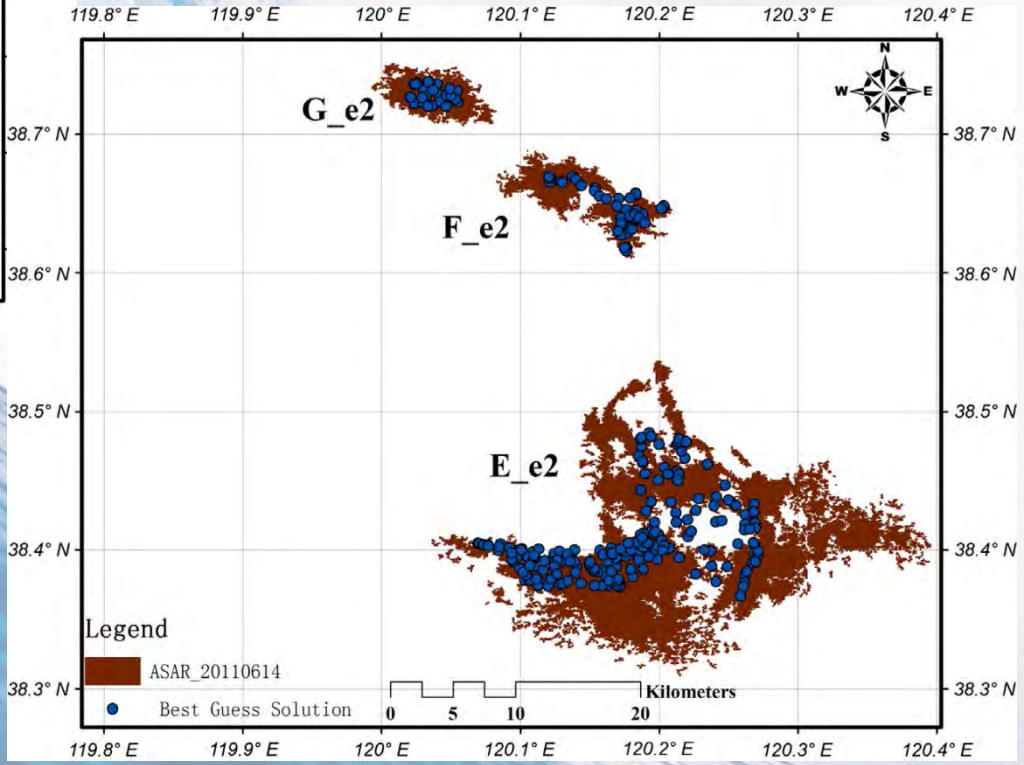






Xu, Q., et al., 2013





Newly released

3. Impacts of data resolution

- Data with different resolutions from varies sources
- Remote sensing dataset increase rapidly
- Remote sensed current and wind data usually have low resolutions

Satellite images and GNOME: Deepwater Horizon

- **ENVISAT-ASAR**

GNOME settings:

Current: NCOM (Navy Coastal Ocean Model)

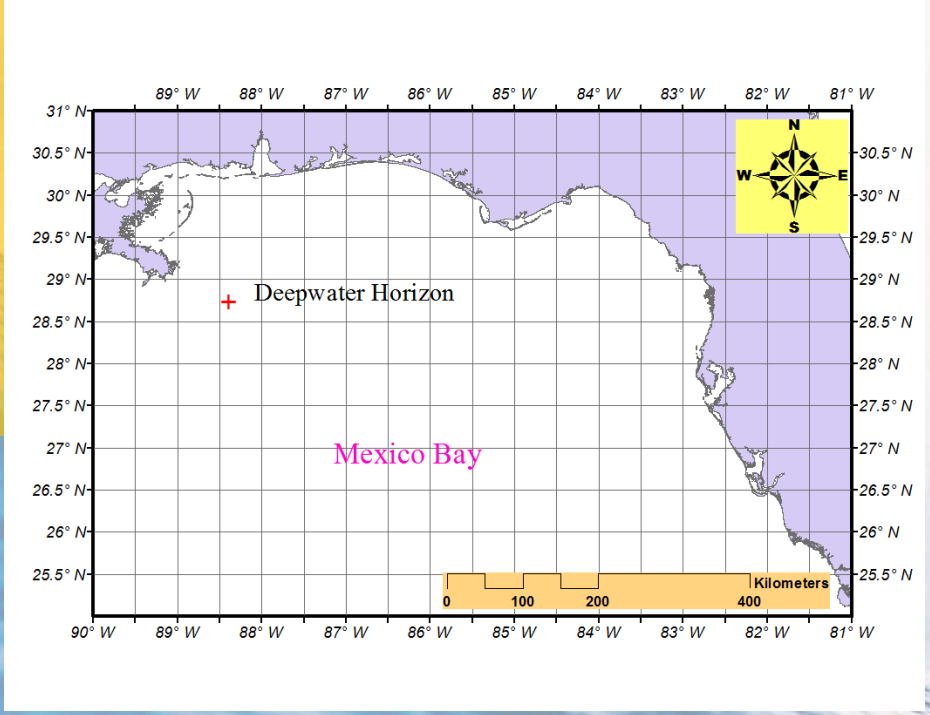
Wind: ECMWF (European Center for Medium-Range Weather Forecasts)

Start time: 2010/04/22 00:00 UTC

Model time interval: 1 hour

Release amount: 5000 barrels/day

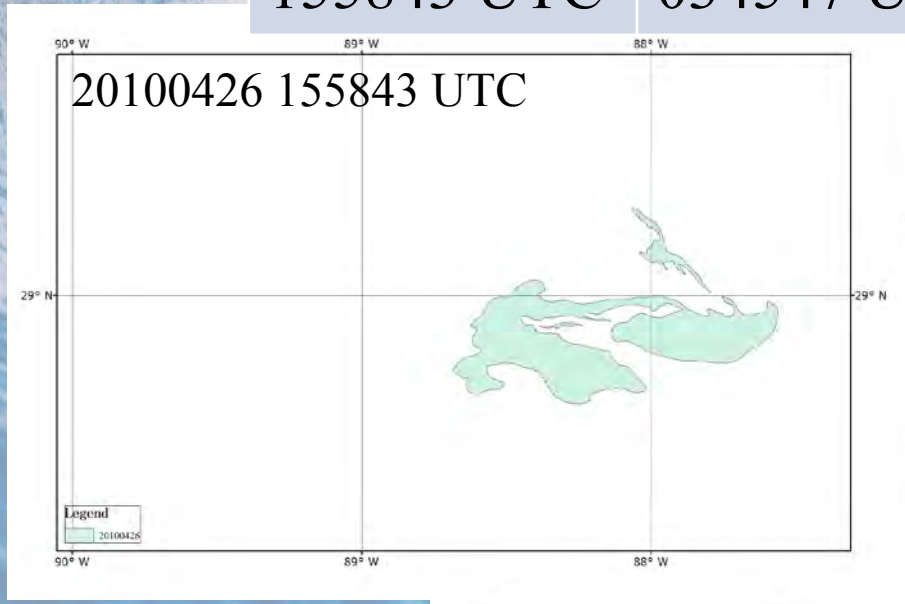
Oil type: Non-weathering

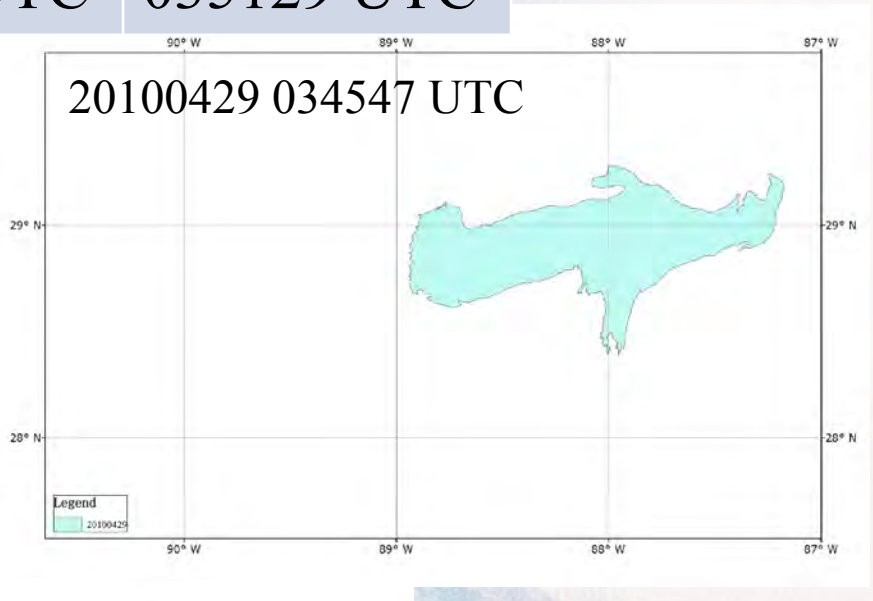


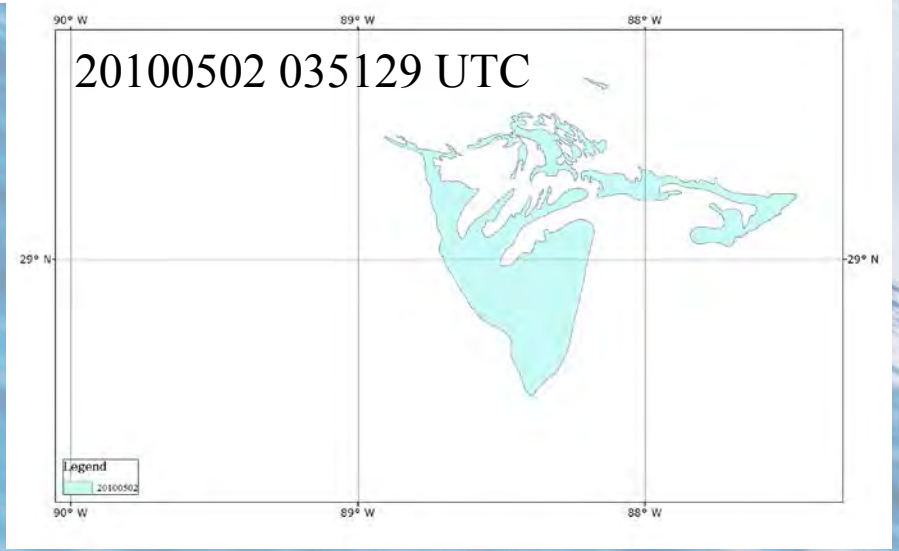
Data / Resolution	Current	Wind
Spatial	0.125°×0.125°	0.5°×0.5° 0.25°×0.25° 0.125°×0.125°
Temporal	3-hour	6-hour 12-hour

ENVISAT-ASAR

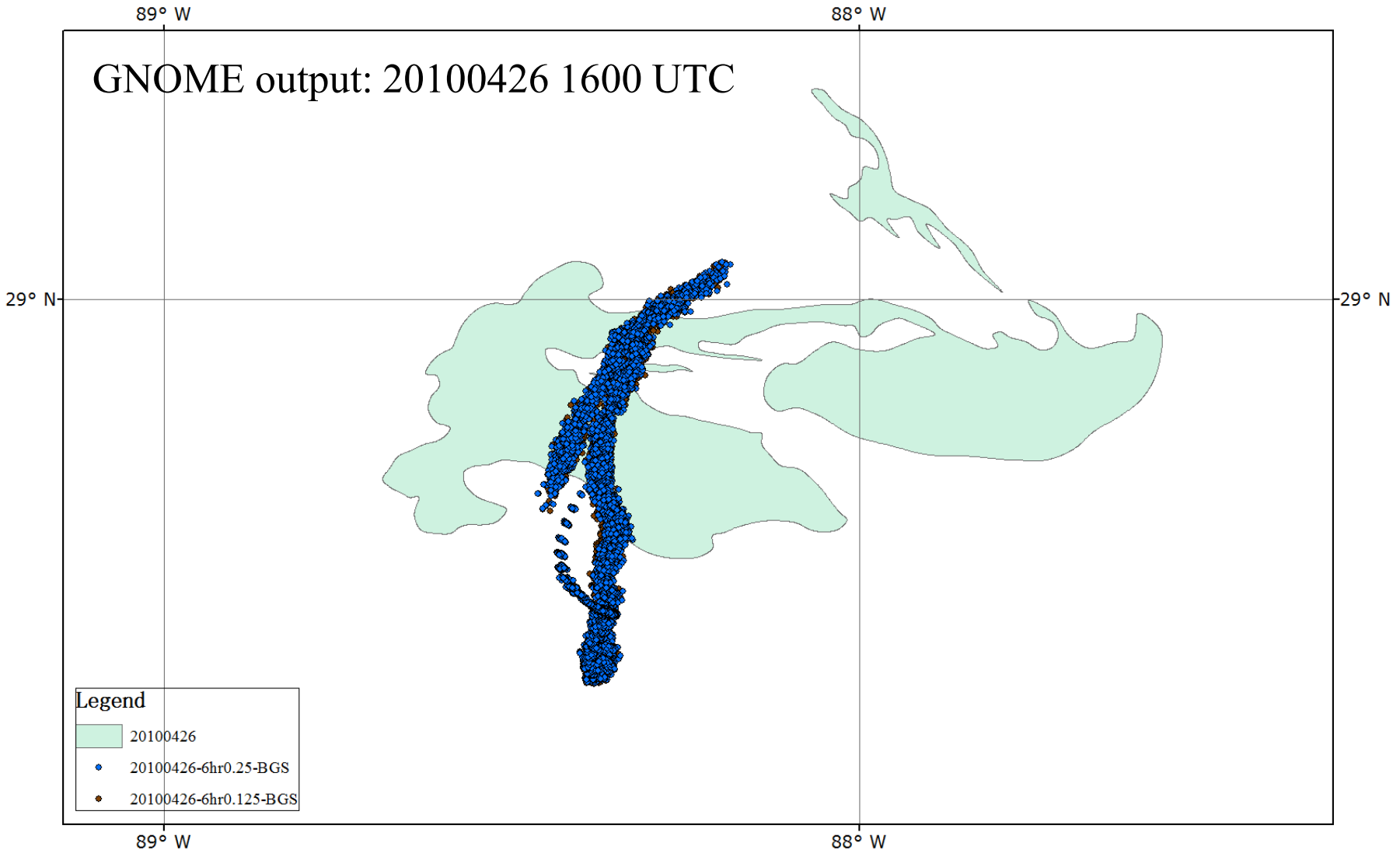
20100426 155843 UTC	20100429 034547 UTC	20100502 035129 UTC



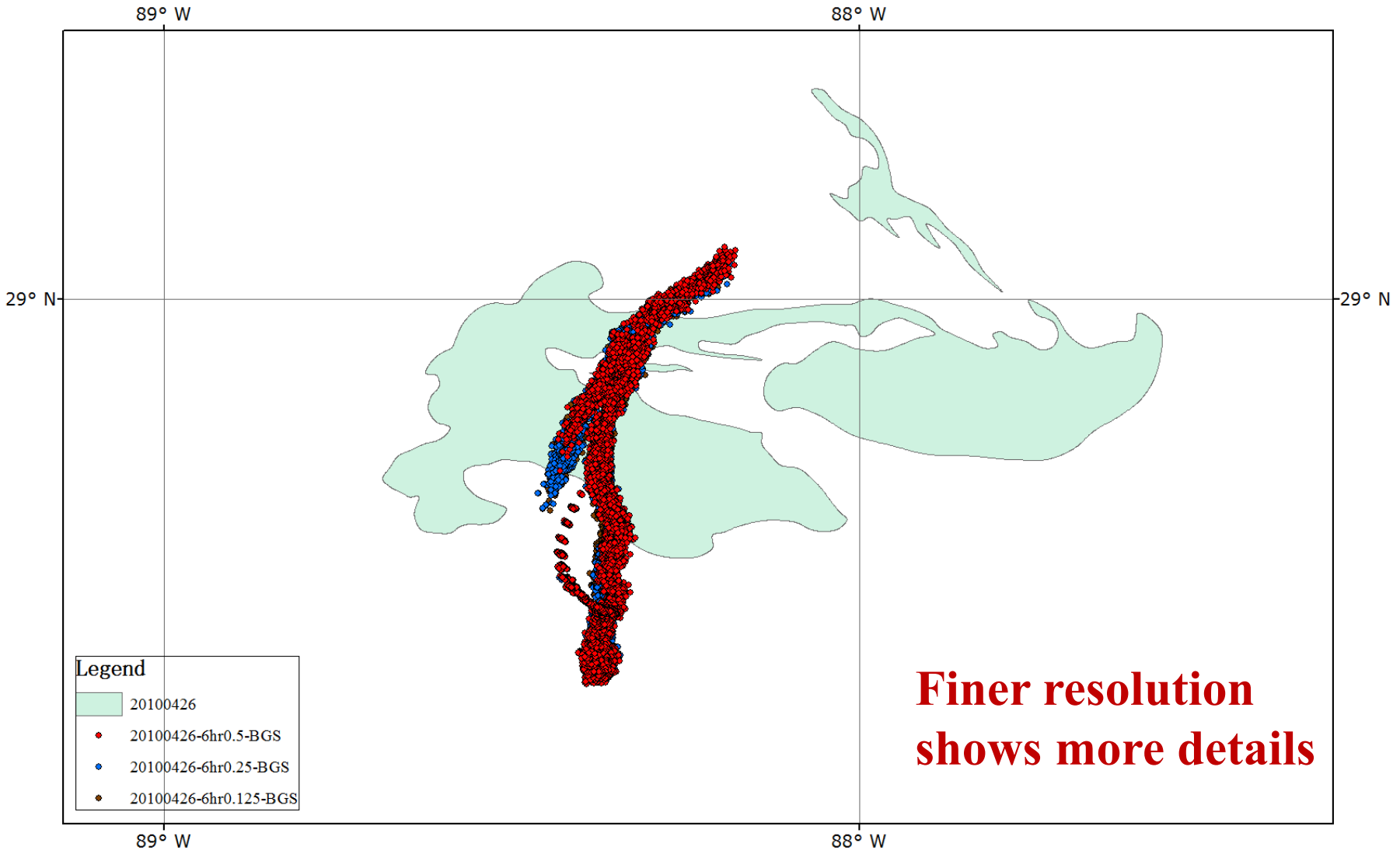




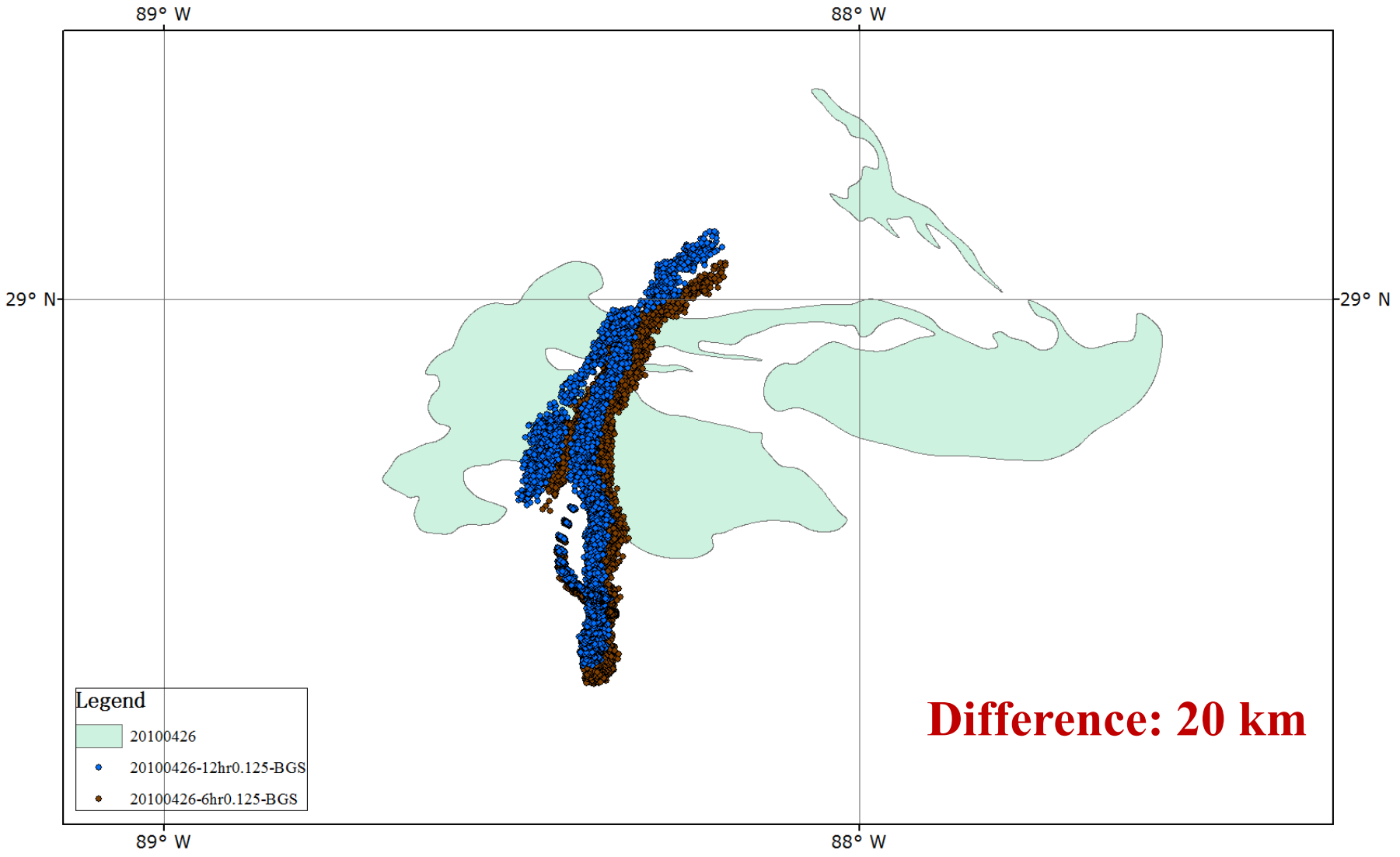
Wind: 6-hour, 0.125˚ vs 0.25˚



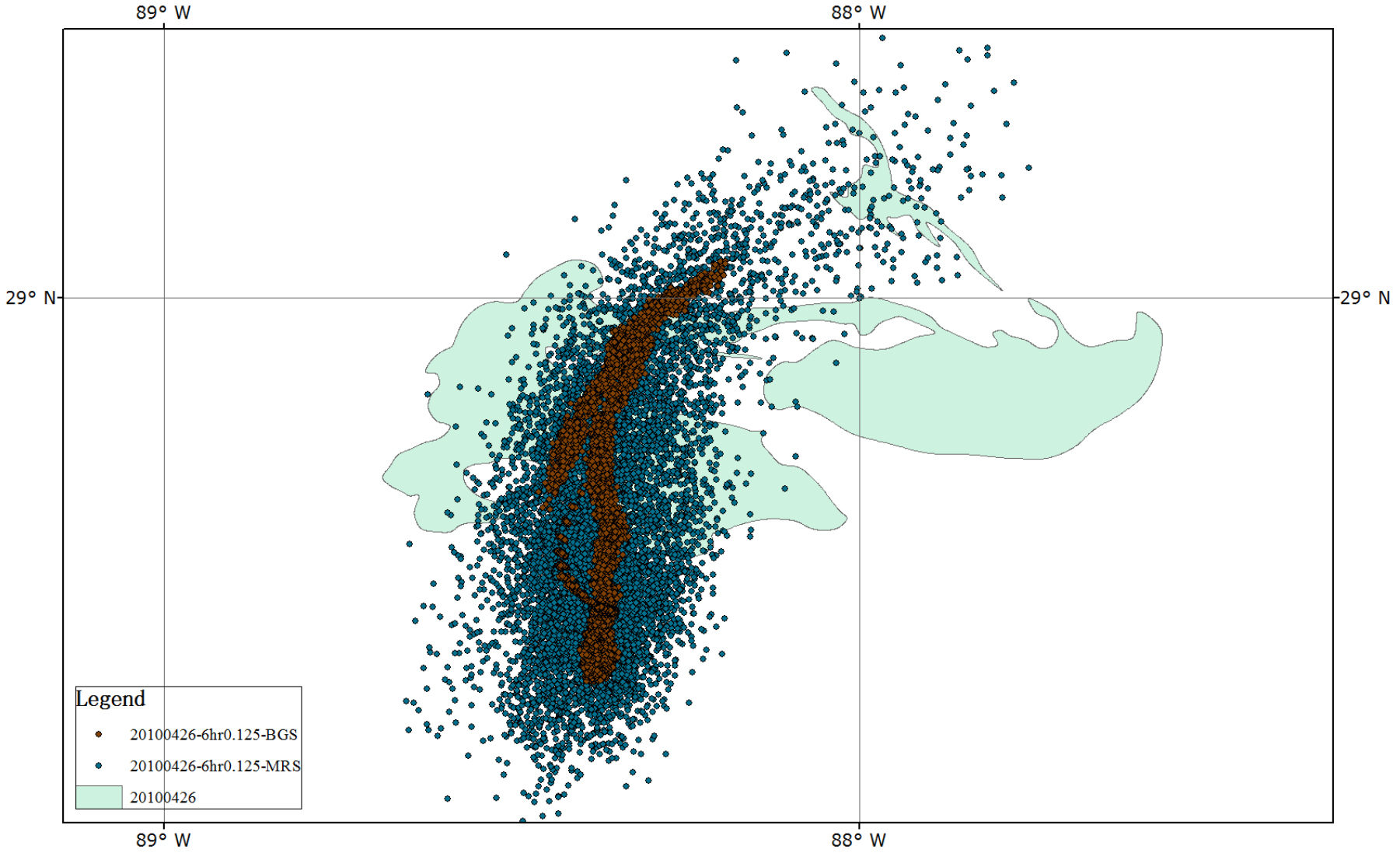
Wind: 6-hour, 0.125˚ vs 0.5˚



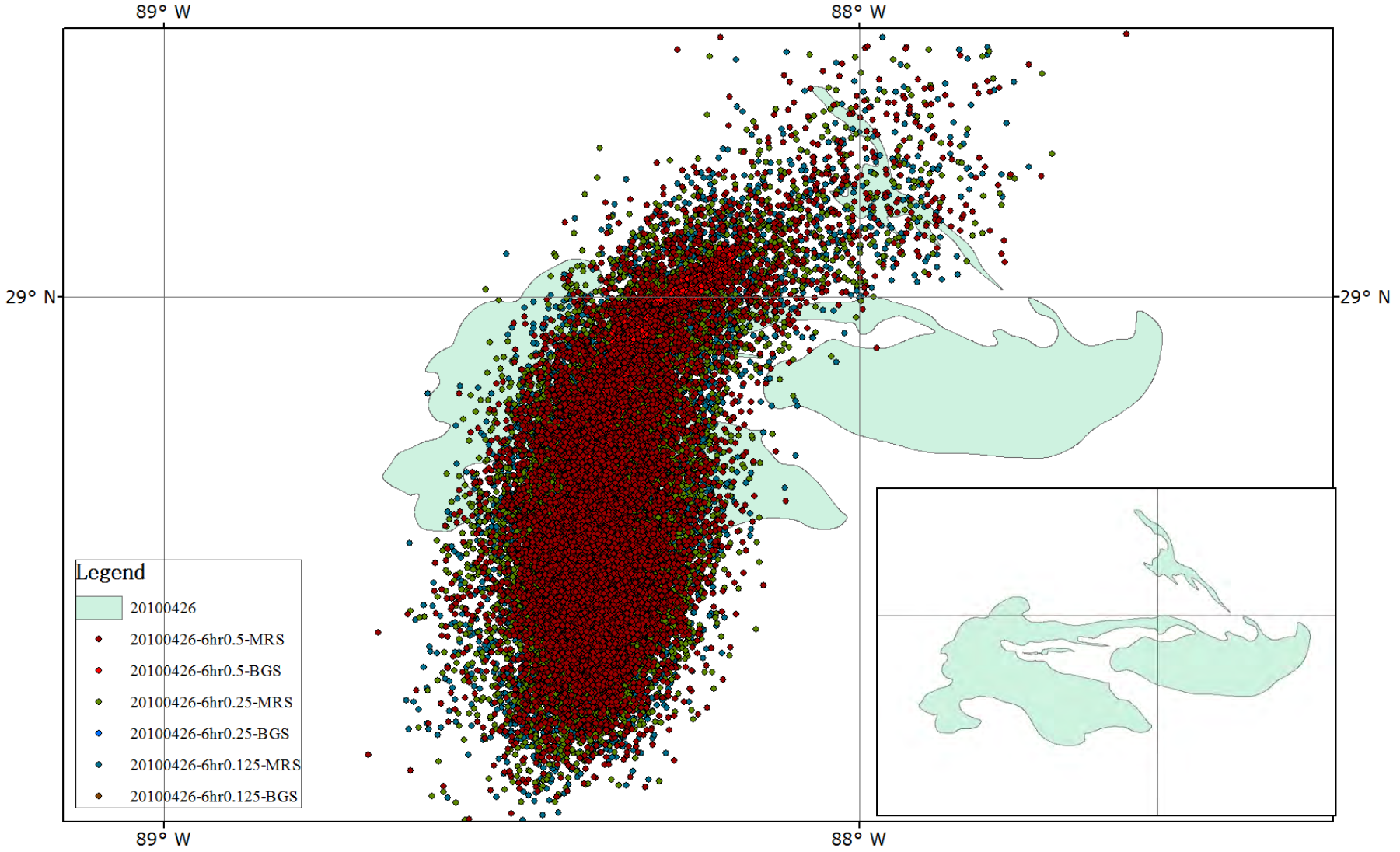
Wind: 6-hour vs 12-hour, 0.125˚



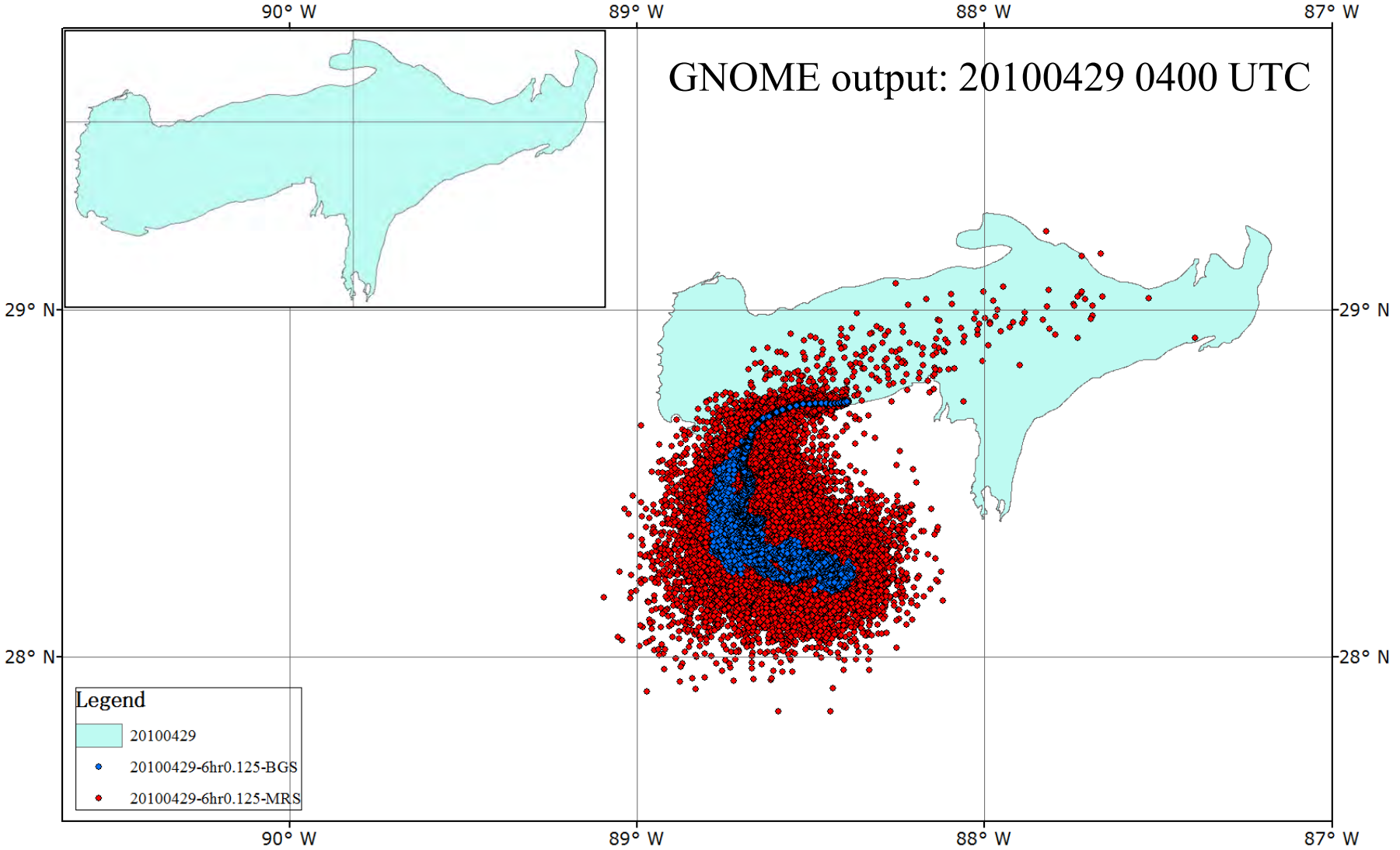
Wind: 6-hour, 0.125˚, BGS vs MRS



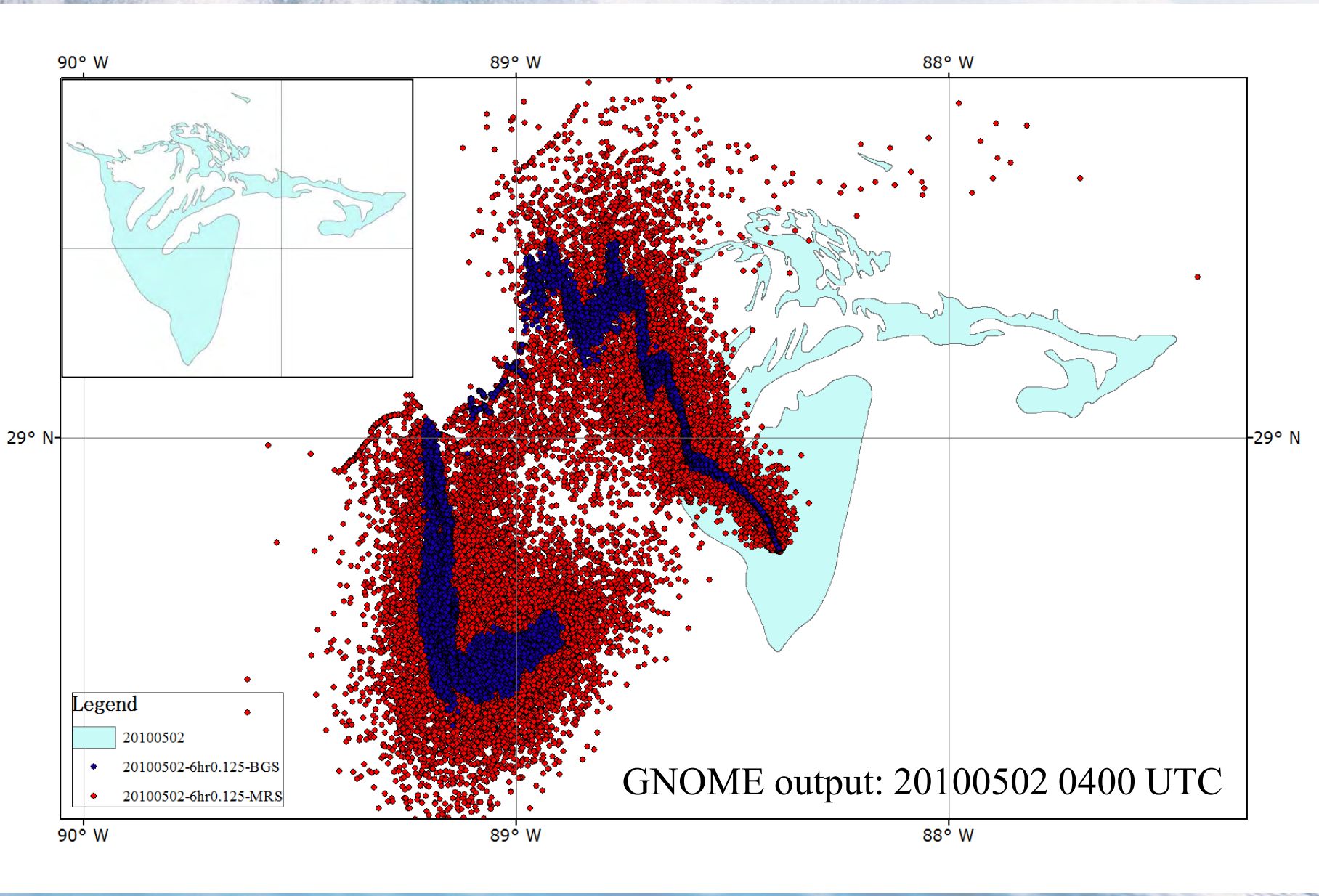
Wind: 6-hour, 0.125˚, 0.25˚, 0.5˚, MRS



Wind: 6-hour, 0.125˚, BGS vs MRS



Wind: 6-hour, 0.125˚, BGS vs MRS



A problem:

A significant difference between SAR imaged and GNOME predicted locations

Possible reasons:

1. **The initial oil spill location on 20100422 is not clear, as well as the surface distributions of oil spill on the following days;**
2. **Outside interferer;**
3. **Uncertainties of driving forces**

GNOME settings:

Current: NCOM, 0.125˚, 3-hour

Wind: ECMWF, 0.125˚, 6-hour

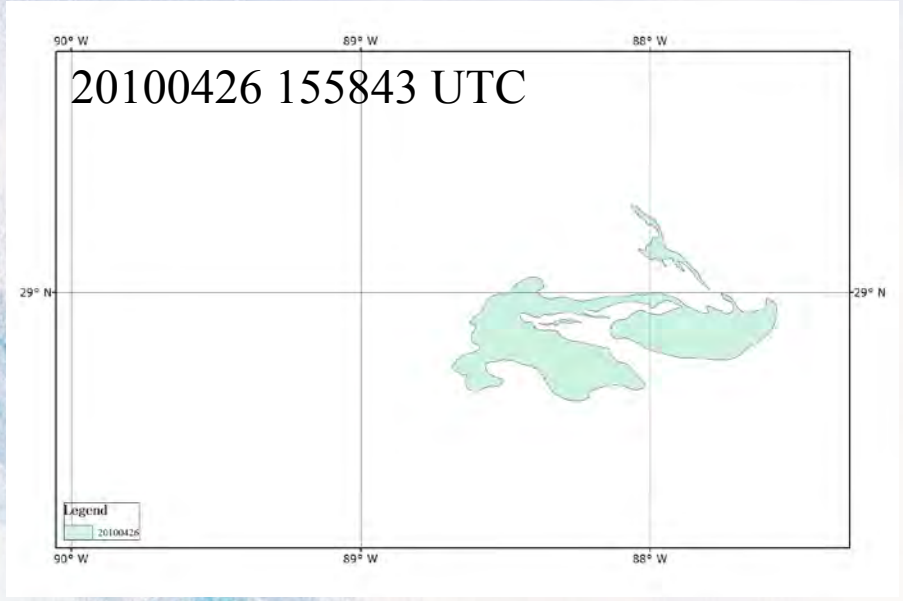
Start time: 2010/04/26 16:00 UTC

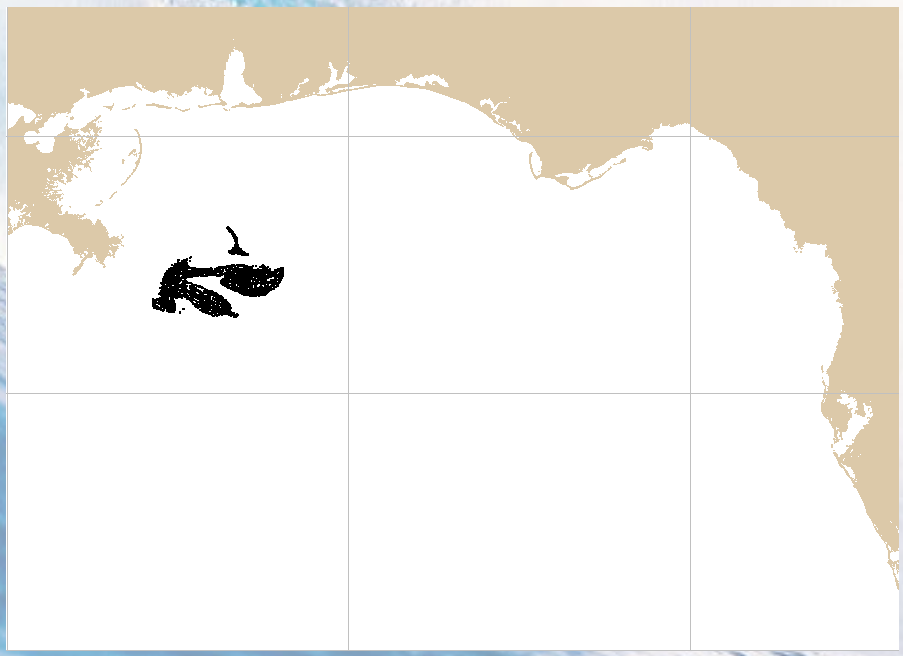
Model time interval: 1 hour

Amount already released: 15000 barrels

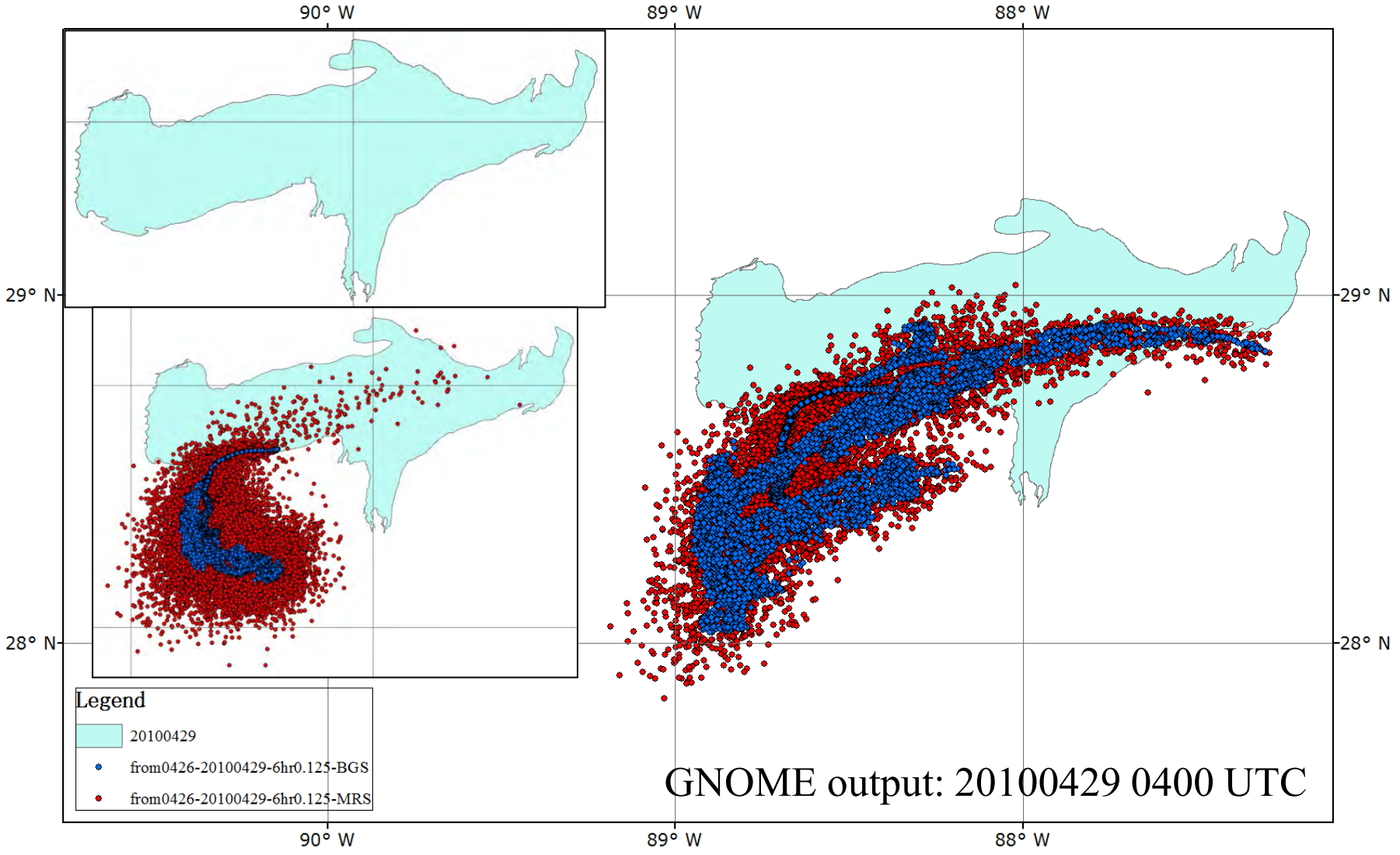
Release amount: 5000 barrels/day

Oil type: Non-weathering

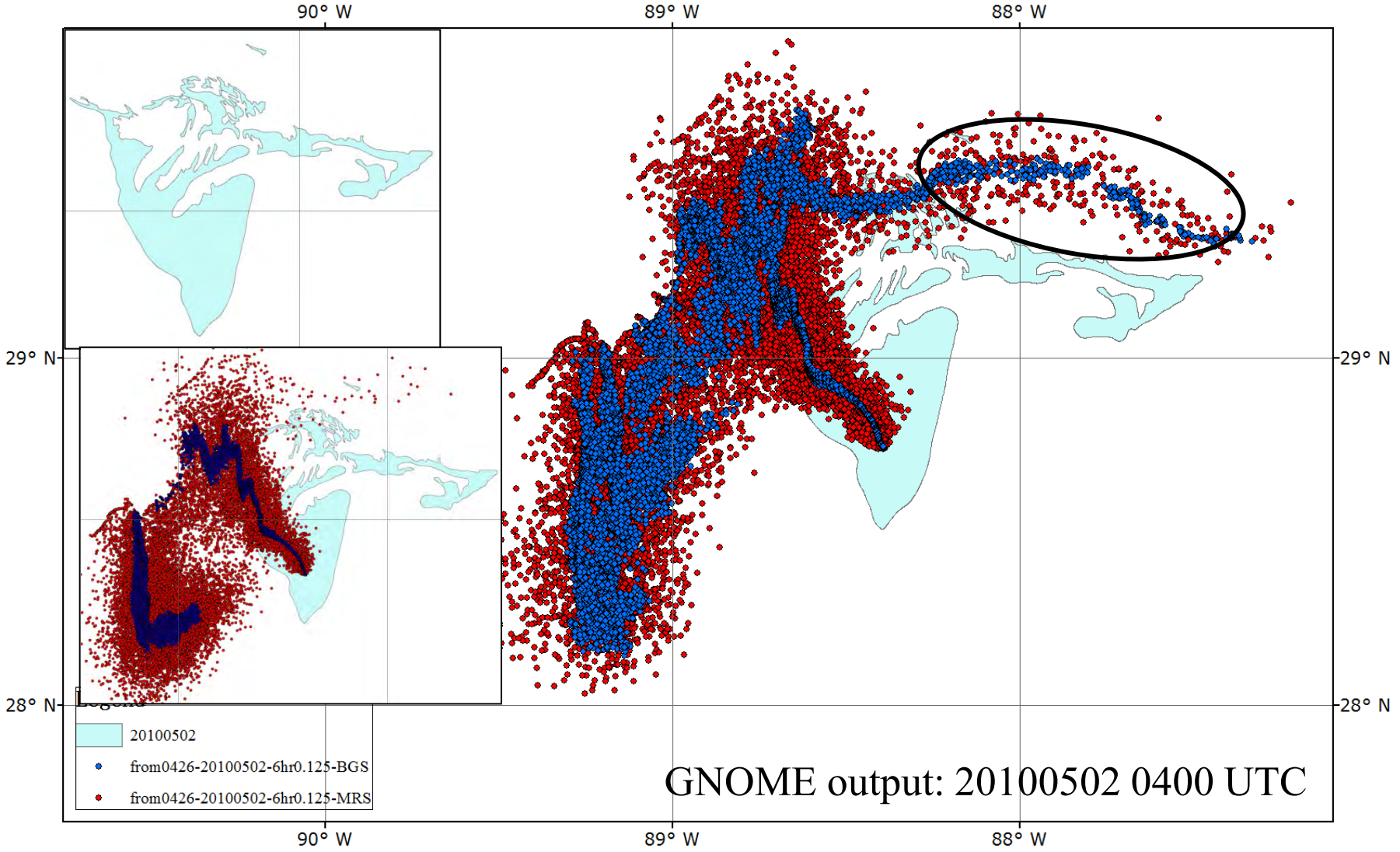




Wind: 6-hour, 0.125˚, BGS vs MRS



Wind: 6-hour, 0.125˚, BGS vs MRS



4. Summary

- GNOME can predict oil spill trajectory with reasonable accuracy;
- A finer spatial resolution can give more details on predicted trajectories;
- A finer temporal resolution can give more accurate predicted trajectories;
- The combination of oil spill location retrieved from satellite images and GNOME can produce more accurate results
- Current with different resolutions will be tested in future

Thank you very much!