Oil spill trajectory prediction using the GNOME model and satellite images

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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

HJ-1-B CCD camera on June 11

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

\[ \bar{L} = \bar{L}_0 + \int_{t_0}^{t_0+\Delta t} V_i \{x(t_0), y(t_0), t_0\} dt \]

• 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 various 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
<table>
<thead>
<tr>
<th>Data Resolution</th>
<th>Current</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial</td>
<td>0.125° × 0.125°</td>
<td>0.5° × 0.5°</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.25° × 0.25°</td>
</tr>
<tr>
<td>Temporal</td>
<td>3-hour</td>
<td>6-hour</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12-hour</td>
</tr>
<tr>
<td>Date</td>
<td>Time</td>
<td>Date</td>
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<tr>
<td>--------------</td>
<td>---------------</td>
<td>--------------</td>
</tr>
<tr>
<td>20100426</td>
<td>155843 UTC</td>
<td>20100429</td>
</tr>
</tbody>
</table>

**Legend**

- 20100426
- 20100429
- 20100502
Wind: 6-hour, 0.125° vs 0.25°

 GNOME output: 20100426 1600 UTC
Wind: 6-hour, 0.125° vs 0.5°

Finer resolution shows more details
Wind: 6-hour vs 12-hour, 0.125°

Difference: 20 km
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

 GNOME output: 20100429 0400 UTC
Wind: 6-hour, 0.125°, BGS vs MRS

GNOME output: 20100502 0400 UTC
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

Legend
- 20100429
- from0426-20100429-6hr0.125-BGS
- from0426-20100429-6hr0.125-MRS
Wind: 6-hour, 0.125°, BGS vs MRS

 GNOME output: 20100502 0400 UTC
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!