Stochastic Forecasting of Drifting Ships and Smaller Objects

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Objective

• To generate search areas for the Norwegian Search and Rescue Service based on the best available wind and current information

Challenge

• Make search areas as small as possible, but not smaller
Other uses

• Containers
• Mine-like objects
• Objects at large (buoys, ROVs)
The Uncertainties Involved

• Where and when did the accident take place?
• Which object should we look for (life raft, person in water, …)?
• What are the wind conditions like in the area?
• What are the surface currents in the area?
Search Maths

\[ POS = POD \times POC \]

- **POS**: Probability of success (do we find what we are looking for?)
- **POD**: Probability of detection (the keen eyes of the rescuers)
- **POC**: Probability of containment (are we searching in the right place?), our business
Forces on a Drifting Object

- Wind (leeway)
- Surface current
- Wave motion (damping and excitation)

The motion of an object of arbitrary shape is difficult to model, approximations are needed.
Leeway divergence

- Leeway divergence sends objects at an angle relative to downwind.
- Symmetry allows stable drift left and right of downwind (little jibing is observed).

? Diverging search areas with time
Wind speed and object drift is approximately linearly related. Different objects drift differently.

- Undrogued life raft
- Life raft with drogue

\( \sigma_d \) experimental error
Maritime Life Rafts with Deep Ballast System and Canopy
(4–6 person capacity)

Crosswind

Wind Speed to 10–m height (m/s)
Crosswind Component of Leeway (cm/s)

RIGHT of Downwind
LEFT of Downwind

σ_e
experimental error
Empirical leeway model

Perturbed wind (random walk)

$W = W_{10} + w'$

Constant leeway perturbations

$\varepsilon \in N(0, \sigma)$

$a' = a + \varepsilon / 10$, slope

$b' = b + \varepsilon / 2$, offset

Downwind leeway [cm/s]

$L_d = a_d' \|W\| + b_d'$

Crosswind leeway [cm/s]

$L_c = \pm a_c' \|W\| \pm b_c'$
Archive and prognoses

7 day archive combined with 60 h prognoses of
- Wind from 20 km res. atmospheric model (HIRLAM 20)
- Surface currents from 4 km res. ocean model with tides and wind forcing (POM)
Wind and current close up

**Longitude**

- 30° 15' E
- 30° 16' E
- 30° 17' E
- 30° 18' E

**Latitude**

- 55°
- 72° N
- 72° N
- 56° N

**Ensemble mean trajectory**

**Observed trajectory**

- Drift start 2002–03–13T11 UTC
- Pickup +104 h

- 13T12
- 15T06
- 16T04
- 16T09
- 17T01
Iceland–Faroe exercise 2003–02–06T11 UTC to 2003–02–07T11 UTC

Convex hull of ensemble +24 h (search area)

Ensemble mean trajectory

Observed raft trajectory

Liferaft pickup +24 h

Liferaft release position 2003–02–06T11 UTC
Iceland–Faroe exercise 2004–05–03T22 UTC to 2004–05–04T14 UTC

- Longitude: 12°W
- Latitude: 62°N

Liferaft release position 2004–05–03T22 UTC
Liferaft pickup +16h

Convex hull of ensemble (search area)
Manual search areas
Operational use of LeeWay model

- Service operational from 2002
- Simulation started by web order form
- Result transferred by e-mail
- Result presented in JRCC decision support system SARA
System architecture

Wind and Current

Web order

Drift Simulator

Result Presentation

E-mail Transport

GRIB format
Web order, old

Leeway order form

If necessary, contact meteorologist on duty at +47 55 23 66 00.
High resolution leeway model, operational since 2004-01-05. See also the [old leeway model](#) (coarse resolution ocean model).

### Start position/time

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>Radius</th>
<th>Date (YYYY-MM-DD HH) [UTC]</th>
</tr>
</thead>
<tbody>
<tr>
<td>70° 25.00' N</td>
<td>31° 30.00' E</td>
<td>0.70 km</td>
<td>2006 04 17 06</td>
</tr>
</tbody>
</table>

### End position/time

<table>
<thead>
<tr>
<th>Latitude</th>
<th>Longitude</th>
<th>Radius</th>
<th>Date (YYYY-MM-DD HH) [UTC]</th>
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<tr>
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</tr>
</tbody>
</table>

### Object class

- [Choose object class](#)
- [Definitions](#)

### Email results

- [EHS Nord-Norge](#)
- [EHS Sør-Norge](#)
- Other

Password:

---

START

Save parameters to file and let the computation begin.

NEW

Empty parameters and use today's date.

COPY

Copy start position to end position.

RELOAD

Ignore changes and reread parameters from file.
Results, sailboat
Results, PIW and Life raft
Other simulators

- Oil drift
- Ship drift
Web order oil drift simulations

**Start simulation of oildrift**

**Oil Spill Details**

- **Date format** [YYYY-MM-DD HH]
- **Start date** 2006-4-17 13 UTC
- **End date**__
- **Latitude**__
- **Longitude**__
- **Spill depth** 0 m below sea level
- **Oil type** LIGHT (drauger)
- **Spill rate** 50.0 m³/h

**Simulation Options**

- **Simulation duration** 72 h

Note: the simulation will run until the number of hours above or until it runs out of input data.

**Send model results to:**
- [ ] http://metoc.met.no
- [ ] e-mail address: __________

**Description (max 100 chars):**

Oil drift simulation
Oil drift
Web order, ship drift simulations

Choose input method for defining ships
- Use automatic reader
- Manual input

Start position / time
- Date format: YYYY-MM-DD HH
- Date/time: 2006-04-17 13 UTC
- Latitude: °
- Longitude: °
- Radius: km

End position / time
- Date format: YYYY-MM-DD HH
- Date/time: 2006-04-17 13 UTC
- Latitude: °
- Longitude: °
- Radius: km

Ship's dimensions
- Beam: m
- Length: m
- Height: m
- Draft: m
- Orientation: unknown

Number of ships (ensemble size): 500

Simulation Options
- Simulation duration: 72 hours

Send model results to:
- e-mail address:

Description (max 100 chars):
- Ship drift simulation
### Ship drift, 1 simulation

<table>
<thead>
<tr>
<th>ID</th>
<th>shipdrift</th>
</tr>
</thead>
<tbody>
<tr>
<td>FILE</td>
<td>shipdrift_20050106111646.asc</td>
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<tr>
<td>SEQ</td>
<td>25</td>
</tr>
<tr>
<td>DATE</td>
<td>2005-01-06T20:00:00</td>
</tr>
<tr>
<td>LON</td>
<td>4.855</td>
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<tr>
<td>LAT</td>
<td>61.037</td>
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<tr>
<td>STATE</td>
<td>stranded(41)</td>
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<tr>
<td>LENGTH</td>
<td>125.0</td>
</tr>
<tr>
<td>BEAM</td>
<td>20.0</td>
</tr>
<tr>
<td>HEIGHT</td>
<td>23.0</td>
</tr>
<tr>
<td>DRAFT</td>
<td>6.0</td>
</tr>
<tr>
<td>ORIENTATION</td>
<td>unknown(-1)</td>
</tr>
</tbody>
</table>
Ship drift, ensemble model
Other services

- Weather forecasts overlay (MetOc)
- AIS/VMS
- Weather Observations
Weather forecast

Simulation Map

Date: 2003-10-27T06:00:00

Settings
After updating settings, press "Refresh"

Refresh

Variables
- Total precipitation, 6 hr
- Wind
- Magnitude Wind
- Temperature
- Pressure reduced to MSL
- Mean period of wind waves

Use simple background layers

Ascii Table
AIS

Legend

Graticule

Basestations

Ports
Weather Observations
Weather Observations

Station name: ICEXAIR 26916.1. WMO no: 63528. Programme: Barents Sea Network. Owner: Statoil