

An oil spill at the Arctic Centre

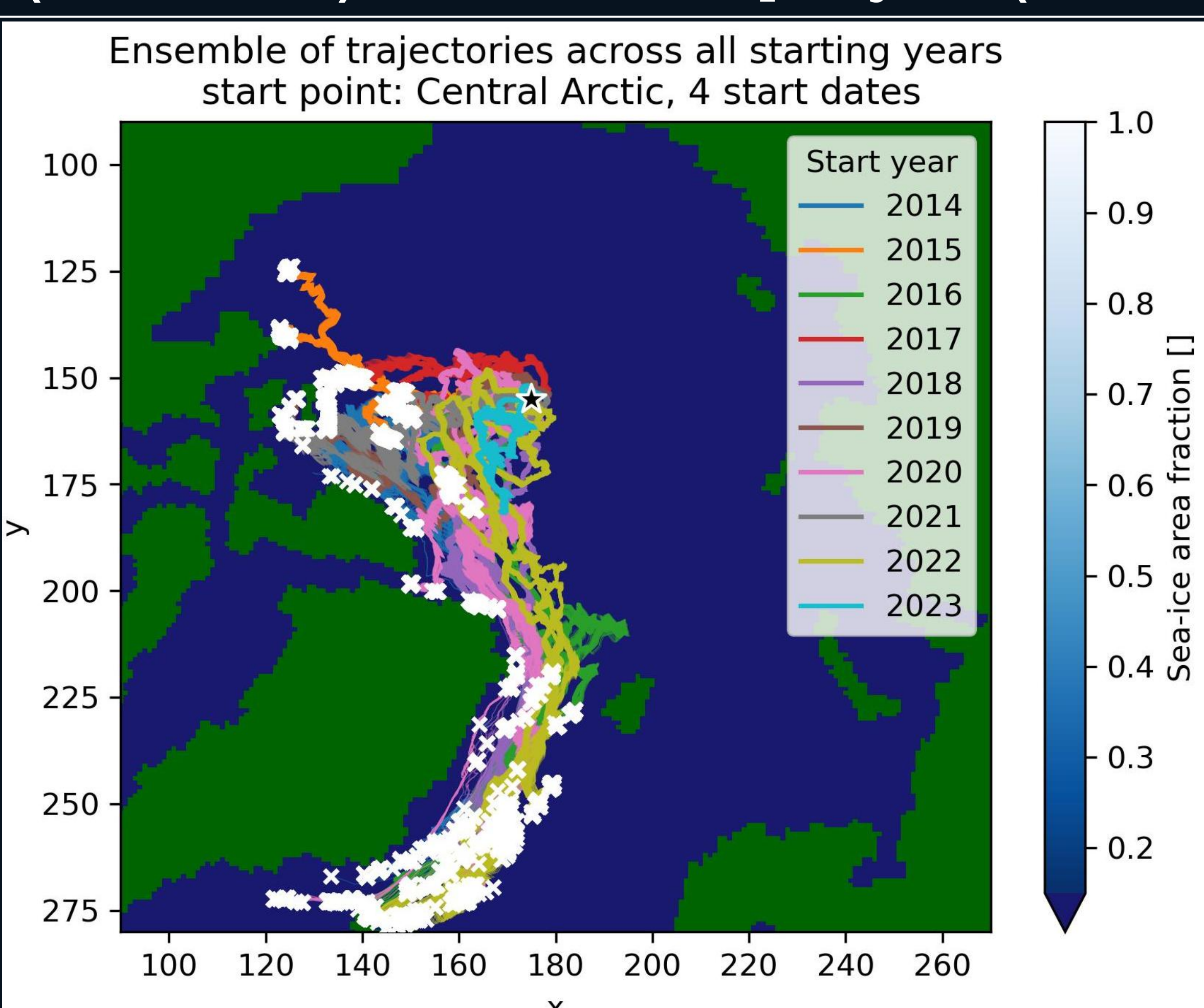
Policy brief - A disaster waiting to happen.



Relevant plots and explanation on next page

Annual sea ice concentrations in the Arctic are declining and by 2050 we could see ice free Arctic summers. The reduction in sea ice will lead to increased shipping and access to natural resources. These two factors significantly increase the likelihood of an oil spill in the Arctic. An oil spill in the Arctic would be devastating to the local wildlife and communities within the region. The Arctic conditions and distances required to travel would make an oil spill incredibly difficult to manage.

We simulated an oil spill of 100 beads over 25 km × 25 km grid at the Arctic Centre (Lat: 84.25, Lon: -168.69). Using the sea ice movement and concentration from 10 consecutive years we tracked how the oil beads would progress day by day. We considered the oil beads to be free from sea ice (dropped out) when the ice concentration hit 15% or the bead struck land. We found the movement to not depend significantly on start location (tested over 5,625 km² grid), however, the trajectory and dropout was dependent on start date. Therefore, our simulation was: 100 oil beads centred at the Arctic Centre (25 km × 25 km), 10 starting years (2014-2023), 4 start dates per year (1st Oct, 1st Nov, 1st Dec, 31st Dec), totalling 4,000 ensemble runs.



3 Scenarios for oil bead dropout

Scenario 1 (most likely): Oil beads remain in ice in the high latitudes of the Arctic until summer comes and the beads melt out. Dropouts centred around early August north of Greenland and Northern Canadian islands.

Scenario 2: Oil beads travel far enough south through the Greenland Sea that they melt out at lower latitudes to the east of Greenland. Dropouts centred around late February.

Scenario 3: Oil beads survive one full year and then drop out the following summer at high latitudes. Dropouts centred around early July

In all three scenarios the beads may hit land on the Northern islands of Canada or the North coast of Greenland. These areas should always be considered at risk.

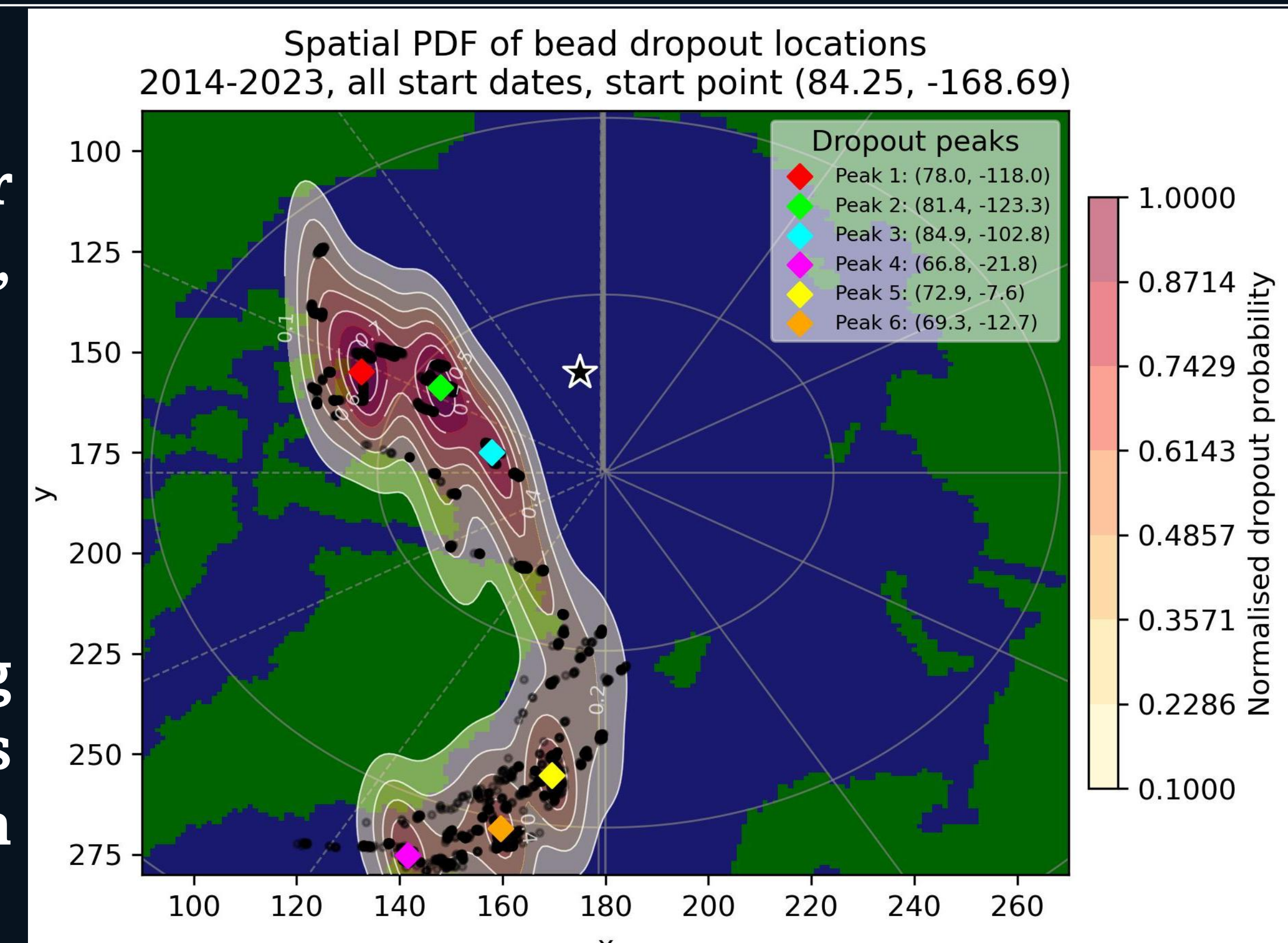
Where & When

When: The first oil beads started to drop out of the ice by day 200 after the event of the oil spill. From then beads dropout rapidly, on average, 50% of beads had dropped out by day 425 after the event.

Where: Two main areas where the beads will dropout.

- First (most likely): North of Canada and Greenland
- Second: Off the east coast of Greenland

Oil beads quickly disperse and dispersion rate is dependent on starting date with early December having the largest total dispersion. Oil beads can reach a dispersed area of 245,000 km² with greatest dispersion occurring in scenario 2.



Clean-up Methods / recommendations

- Mechanical Containment & Recovery: Physically removing the oil using skimming, requiring open water with the oil resting at the surface. Difficult in areas with large icebergs.
- Dispersants: Enhance natural dispersion of oil droplets to below toxicity concentration, requiring calm seas and rapid application before the oil weathers or emulsifies. Cold water extends the time window.
- In-situ burning: Igniting the oil slick to burn off the surface oil, requiring sufficient oil thickness and relatively calm conditions.

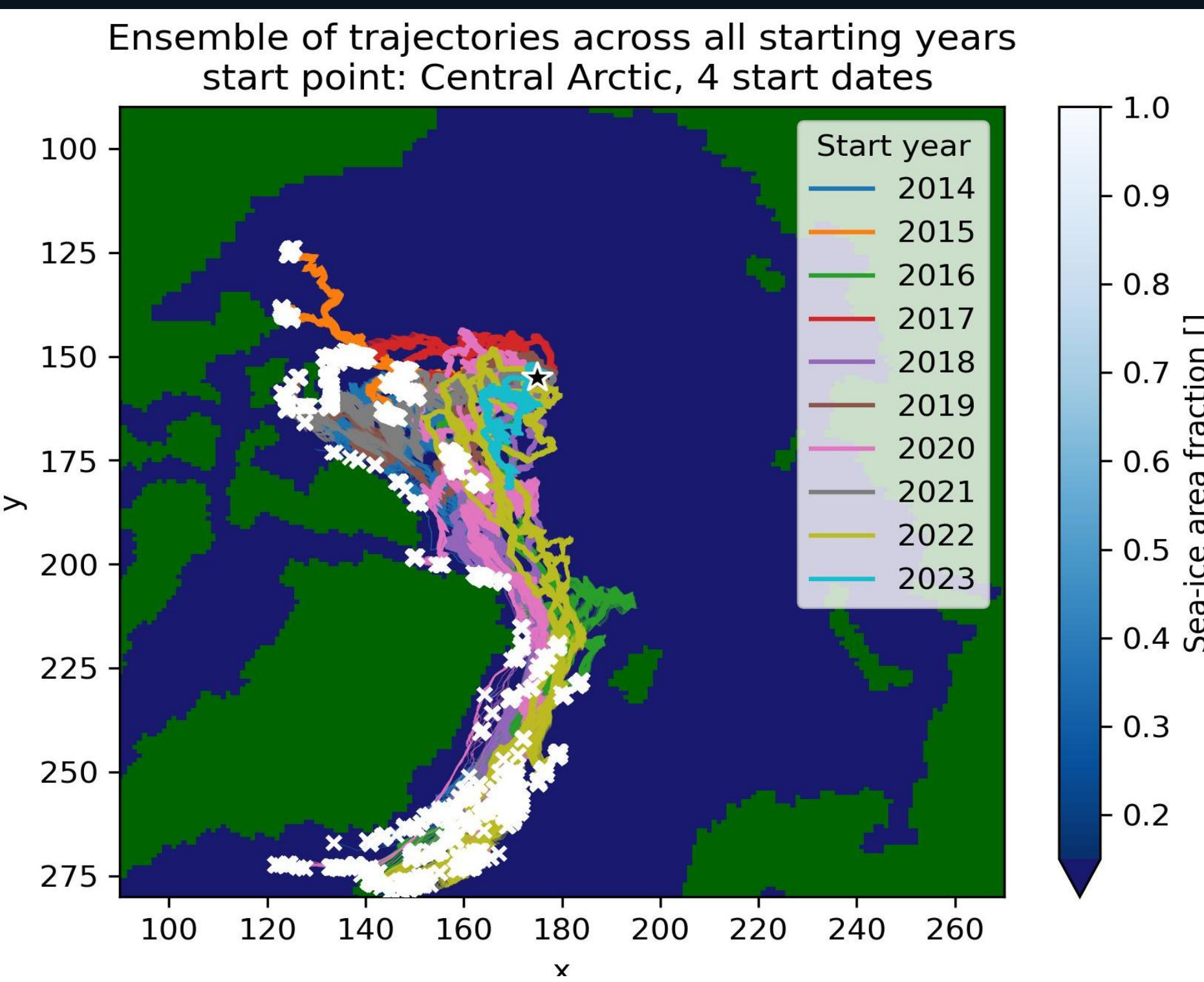
Recommendations:

- Recommendation 1: Strengthen regulatory frameworks governing Arctic drilling and shipping to minimise spill risk.
- Recommendation 2: Create/Support organisations that are able to develop a streamlined process to assess, track and respond to each unique oil spill condition.
- Recommendation 3: Without 1 or 2, our suggested response plan is as follows:
 - Oil in the Arctic Circle North of Greenland and Canada. Use in-situ burning and dispersants. Estimated timing based on the simulation: 6 months to move and deploy teams to the site to manage the spill.
 - Oil escapes to Greenland sea. Use mechanical containment and recovery to manage. Estimated timing based on the simulation: 1 year to move and deploy teams to the site to manage the spill. However, the longer you wait, the larger the occupied area becomes and the containment becomes untenable.

Detailed description of figures and scientific backing for policy brief.

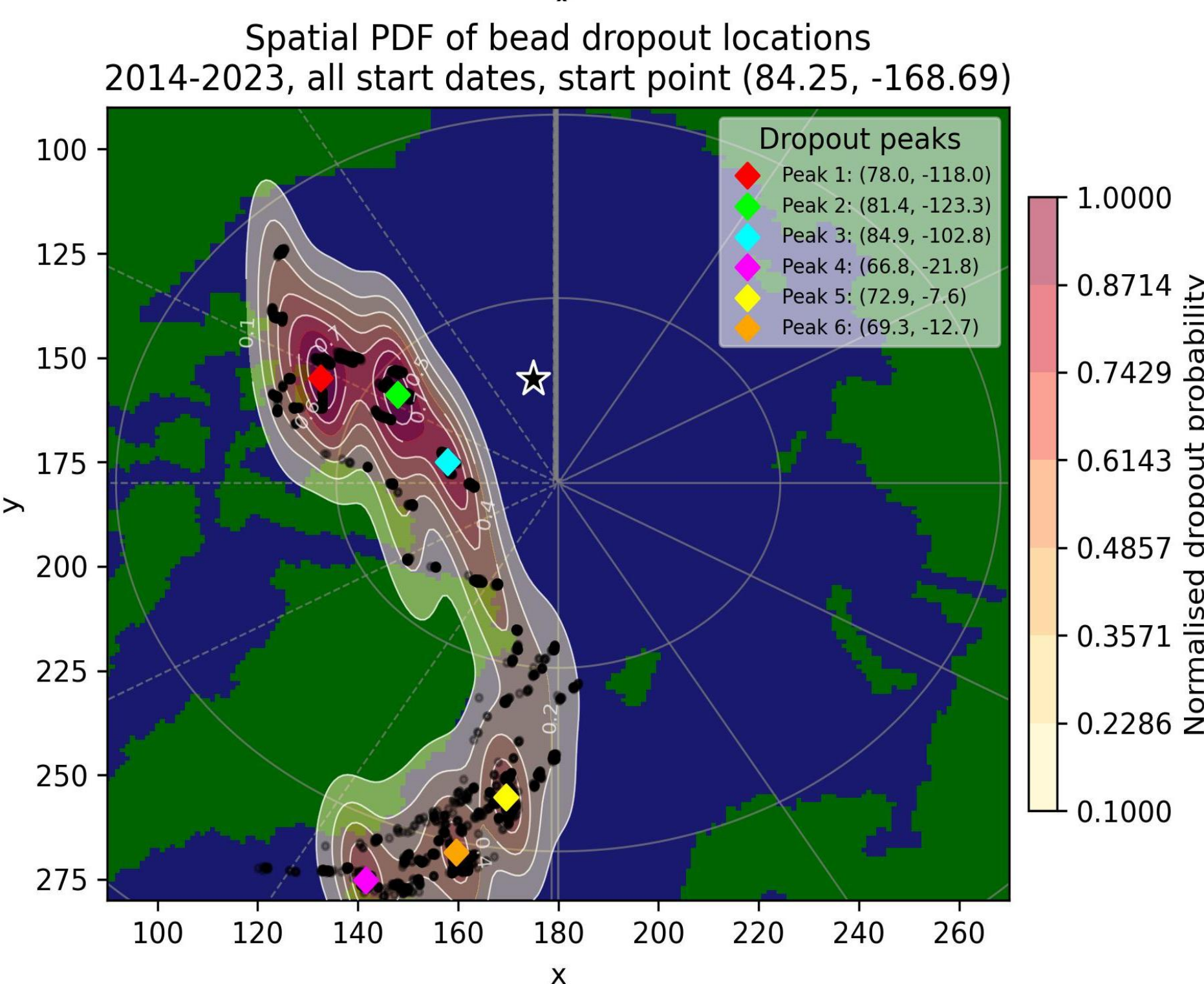
Code and figures can be found here: <https://github.com/CTaylor991/LPHYS2268-An-oil-spill-in-the-Arctic>

Gifs to visualise the 3 scenarios can be found at the above link



Trajectories of each ensemble run. Different colours correlate to each year of the ensemble. White crosses mark where the beads dropped out when reaching 15% sea ice concentration or less or when striking land. The star shows the starting point for all beads.

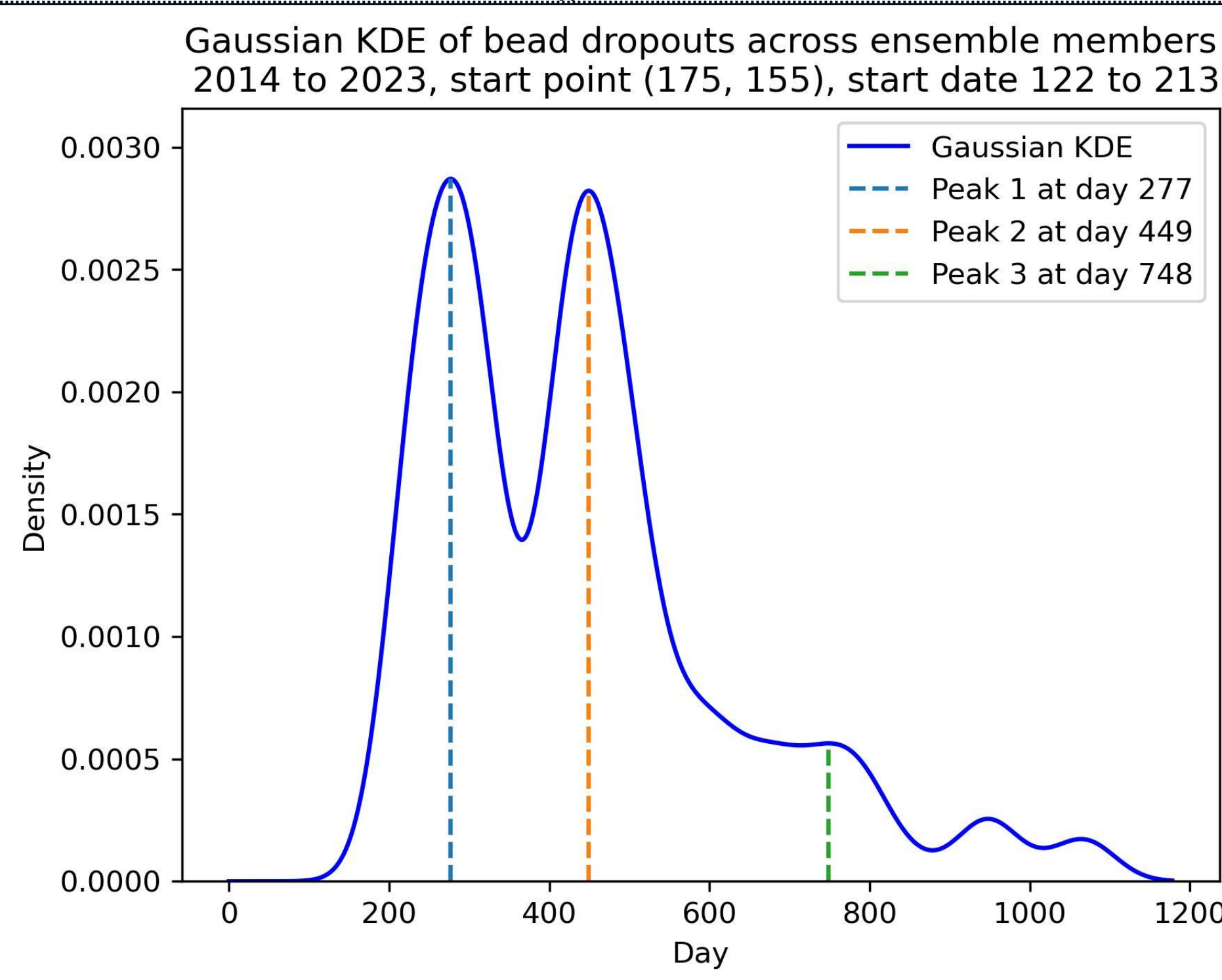
This plot shows the variety of different trajectories that the beads took in our simulation. It shows that the oil beads tend to move towards the same hemisphere but can still disperse between Northern Canada / Greenland and East of Greenland in the Greenland sea.



Spatial distribution of likelihood of location of bead dropout across all ensemble runs. Dropouts marked by black dots. The locations most likely for dropout are (Latitude, Longitude):

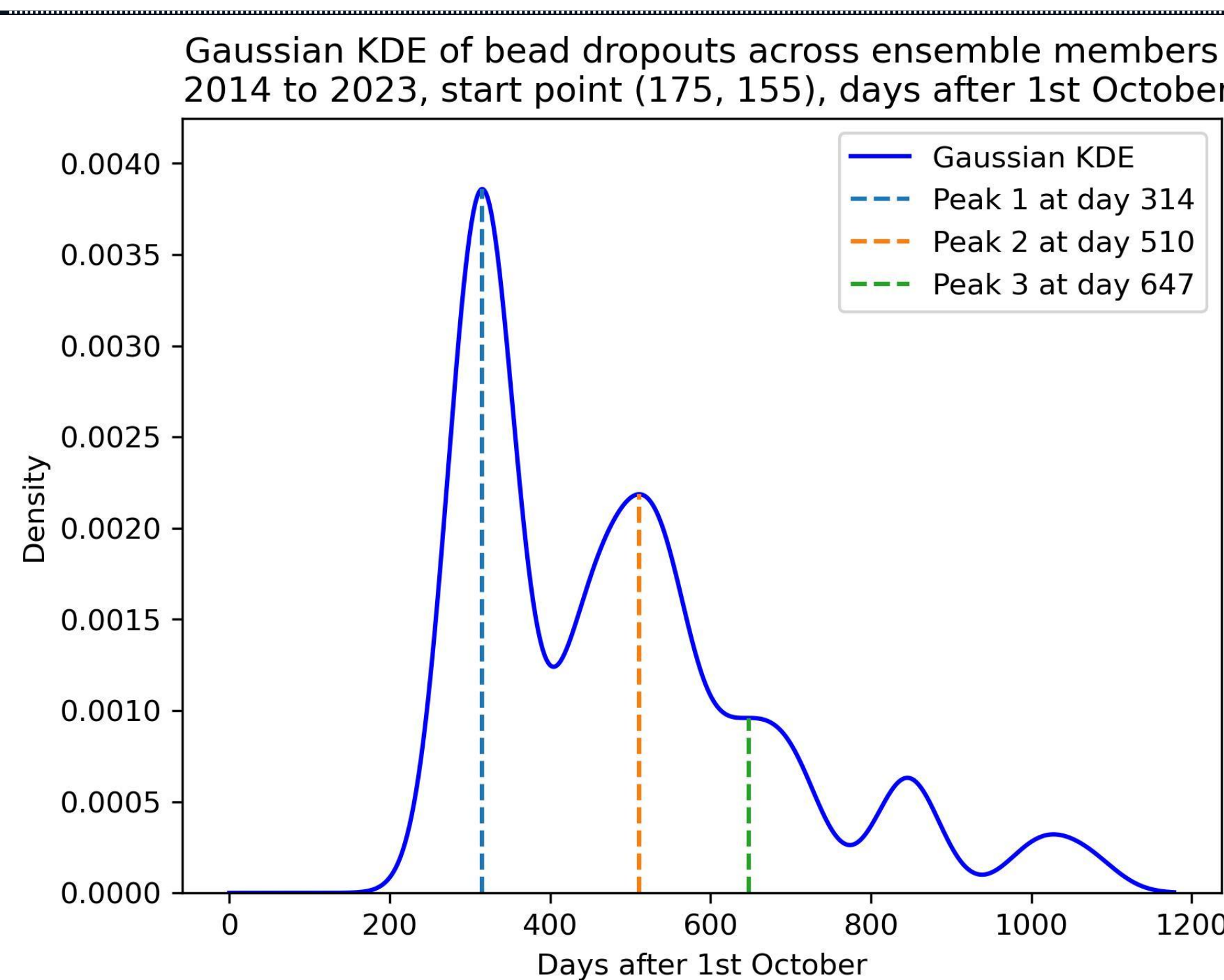
- | | | |
|-----------------|-----------------|-----------------|
| 1: 78.0, -118.0 | 2: 81.4, -123.3 | 3: 84.9, -102.8 |
| 4: 66.8, -21.8 | 5: 72.9, -7.6 | 6: 69.3, -12.7 |

Two main areas of dropout, North of Canada around the islands and North of Greenland or in the Greenland sea to the East of Greenland.



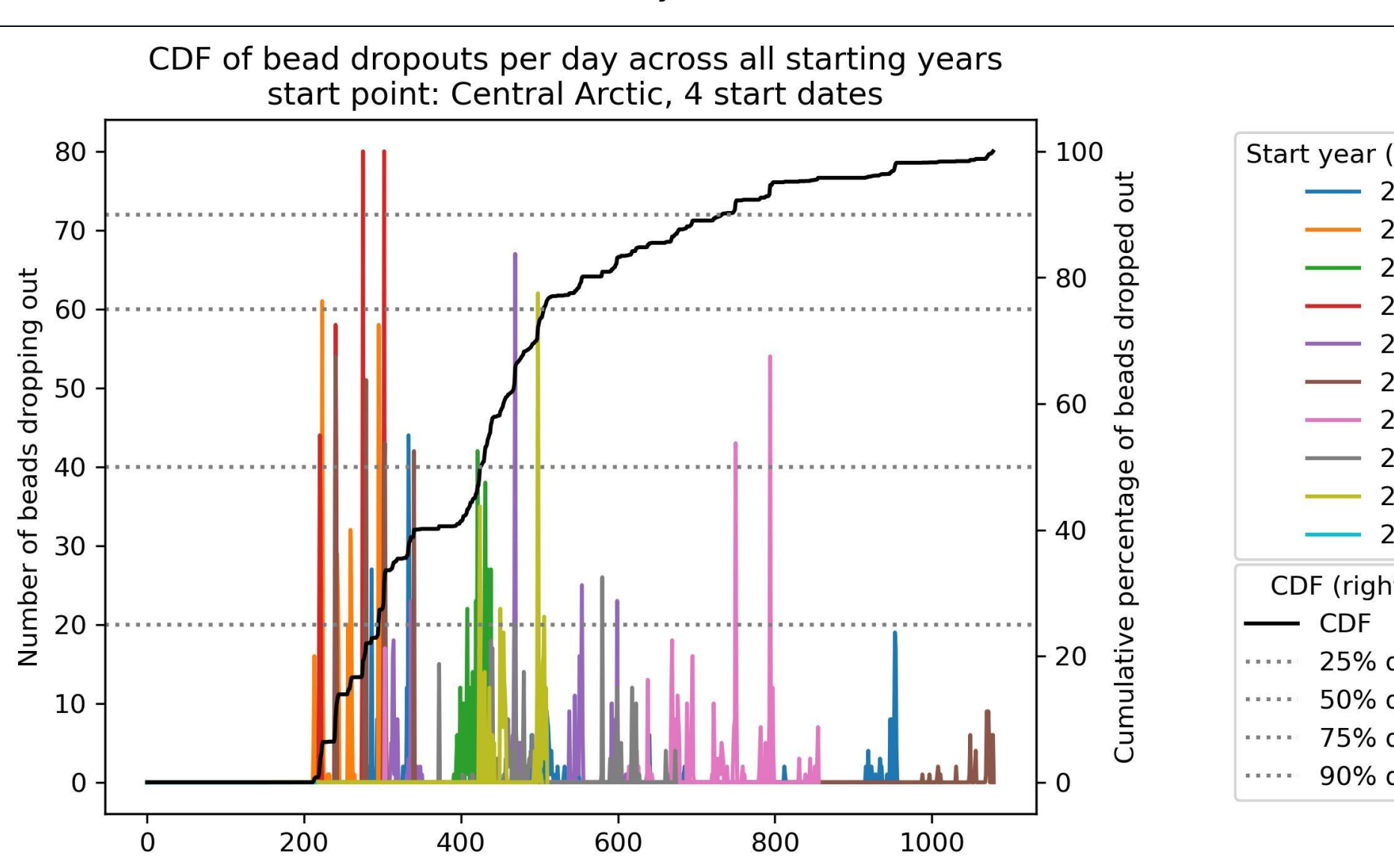
This graph shows the likelihood of an oil bead dropping out at a given number of days after the oil spill event occurs. This gives a representation of how long one has to act after the event before the oil beads start to drop out. The peaks represent the strongest dropout periods. It uses a Gaussian distribution based on the 4,000 ensemble members that we ran.

- Peak 1: Day 277
Peak 2: Day 449
Peak 3: Day 748



This graph represents the number of days after the 1st of October (despite the start date of the event) at which the oil beads dropout. This gives an estimation of the dates at which the oil spill will dropout. Dropout is dependent on sea ice coverage, which is dependent on climate conditions, which is heavily influenced by the date, therefore date of dropout is important.

- Peak 1: August 11th
Peak 2: February 23rd (+1 year)
Peak 3: July 9th (+1 year)

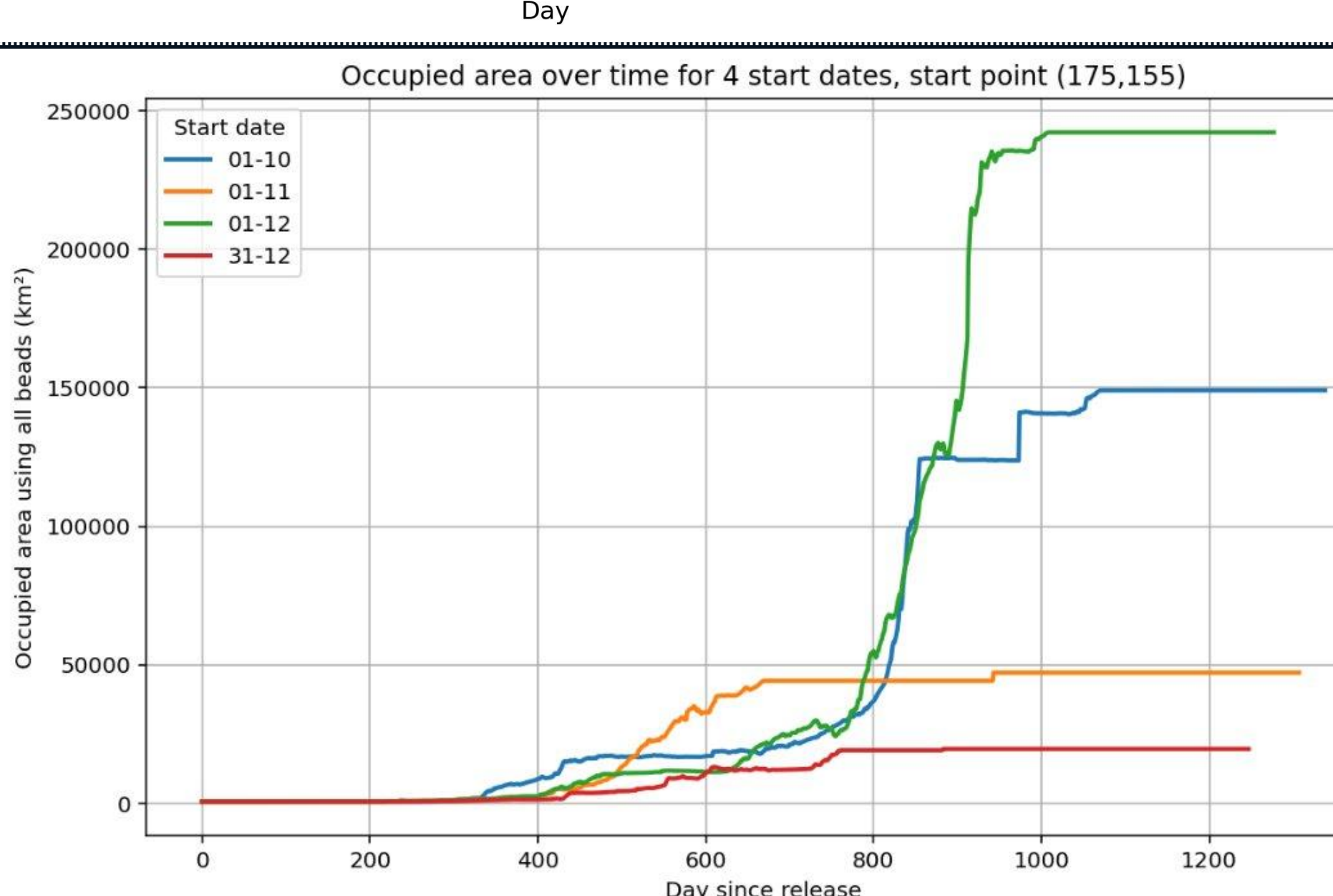


The grey line represent the total percent of dropped out beads with values on the right axis.

The colourful lines represent the absolute number of beads that dropped out per year of each start date.

25% = day 295, 50% = day 425, 75% = day 506, 90% = day 733

We see a rapid rise after 200 days but the total number of days that the oil remains trapped could extend for more than two years.



The occupied area remains relatively limited before entering a rapid expansion phase. Release timing strongly influences the final contaminated area, with early winter releases producing the largest affected regions.