Drift of buoyant objects in the Baltic sea – model data analysis

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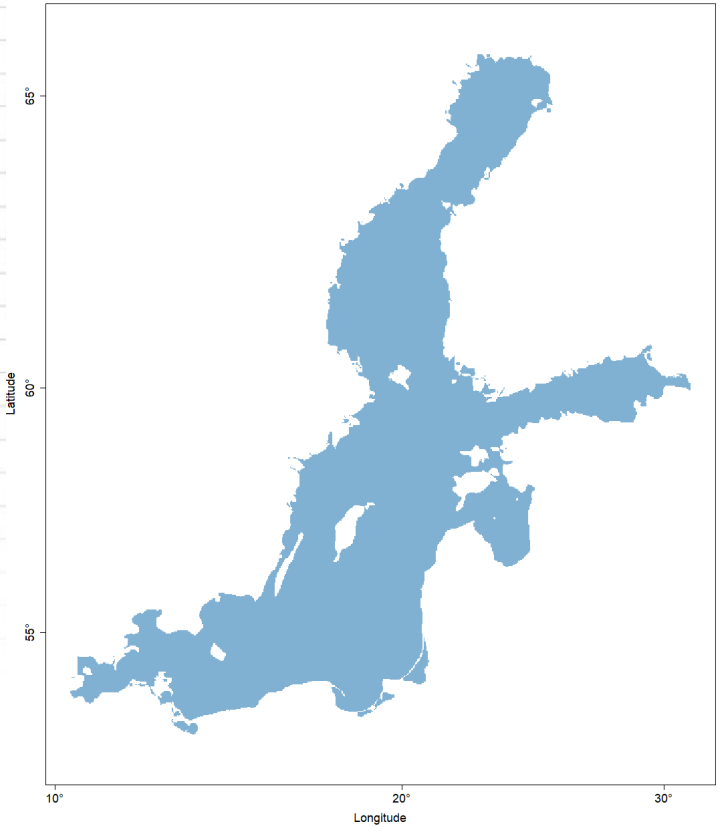
EGU General Assembly 2020
04.05.2020

Model data description

- Small particles on the surface of the sea are simulated;
- Regular 2x2 km grid – 95 700 particles released daily for 10 years;
- Motion of the particle governed by the wind velocity and the surface current; Ice interrupts movement;
- Oceanographic data – Copernicus Marine Environment Monitoring service; Marine meteorology data – DMI HARMONIE model;
- Particle washed ashore when it reaches coastal mesh element; Islands are included in the simulation



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Aims of statistical analysis

1. Which coastal regions are most at risk – in which regions landed the most particles?

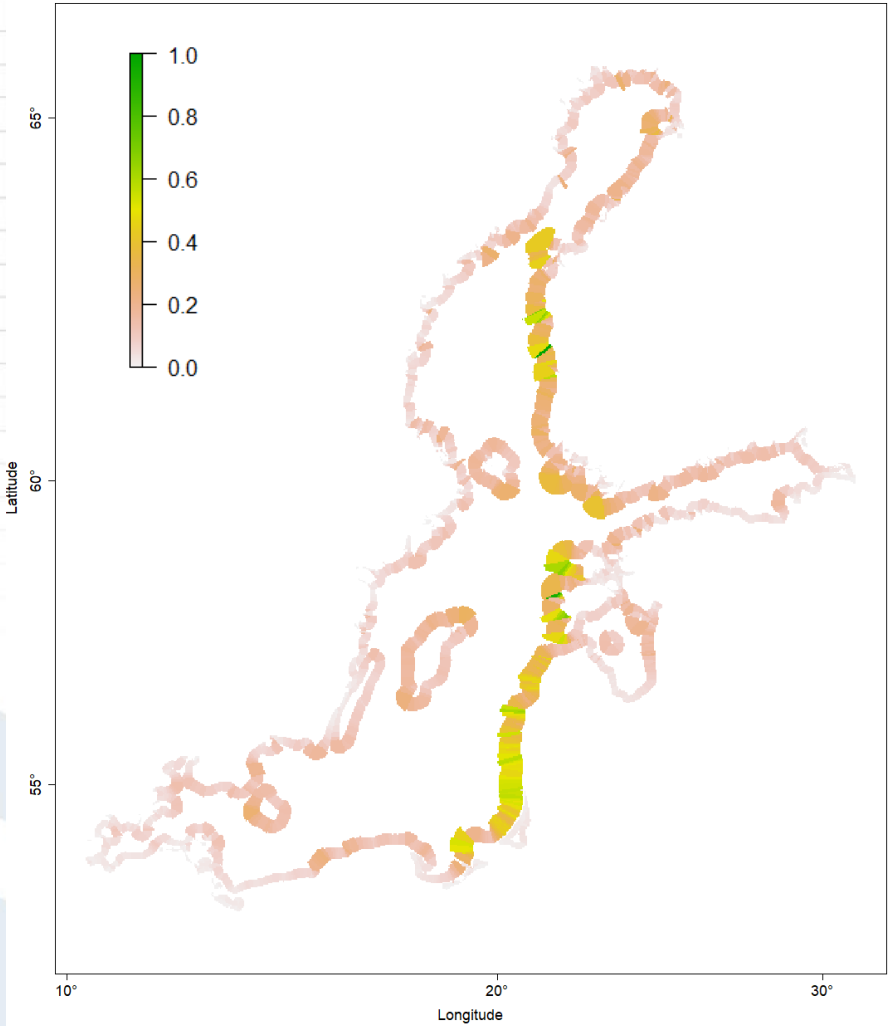
2. How many days does it take from different regions of the Sea to reach the coast?

3. What are the main pathways for the particles – where do particles from different sea regions land?

1. Coastal zones at risk

Which coastal regions are most at risk – in which regions landed the most particles?

Illustration of which coastal regions get more particles washed out on average



More particles landed at Eastern part of the Baltic sea than on the Western part.

2. Travel time

How many days does it take from different regions of the Sea to reach the coast?

Illustrations of the set of symbolic data used in cluster analysis

Example of location where in some simulations in November particles landed right away and in some – were frozen for some time

Each starting grid point is described by twelwe histograms, each describing how much time in days it took to land on the coast for particles released in the corresponding month

Y_1

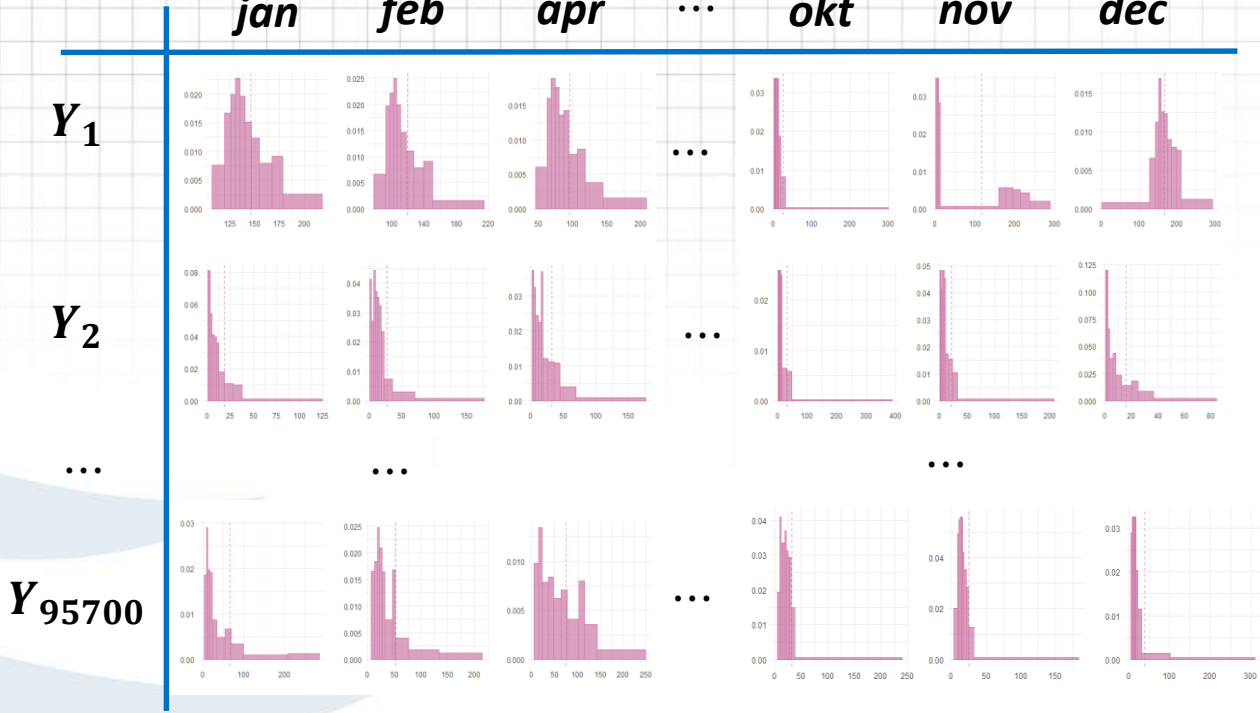
Y_2

…

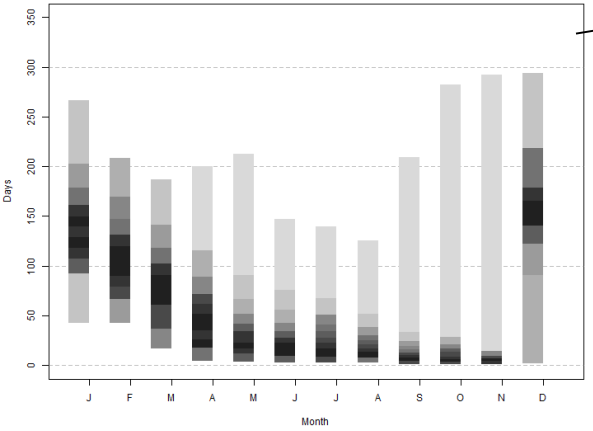
Y_{95700}

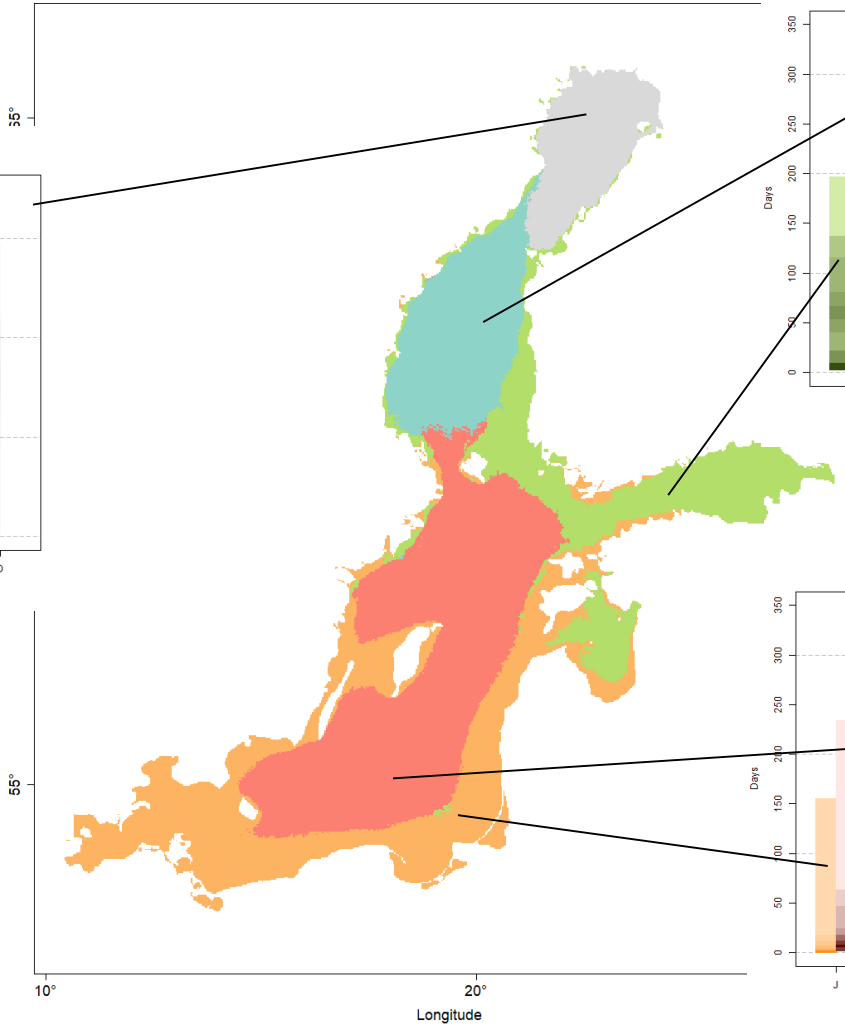
Description of clustering analysis performed:

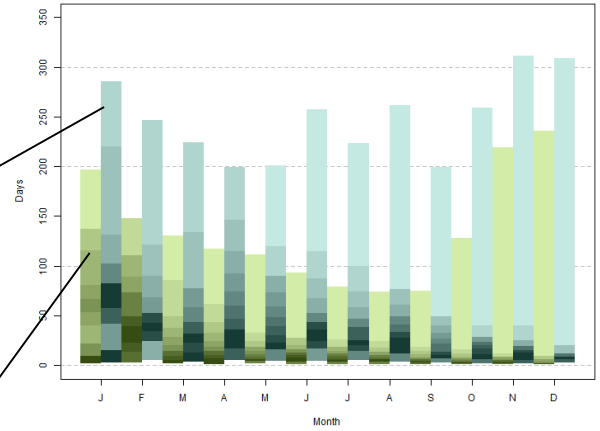
- We have 12-dimensional symbolic data set;
- Same method, distance metric and algorithm as before;
- No weights;
- Solution with 5 clusters was chosen.

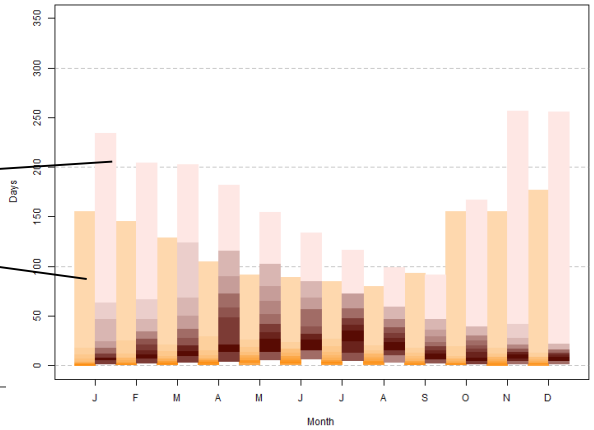


Clusters in regard of travel time



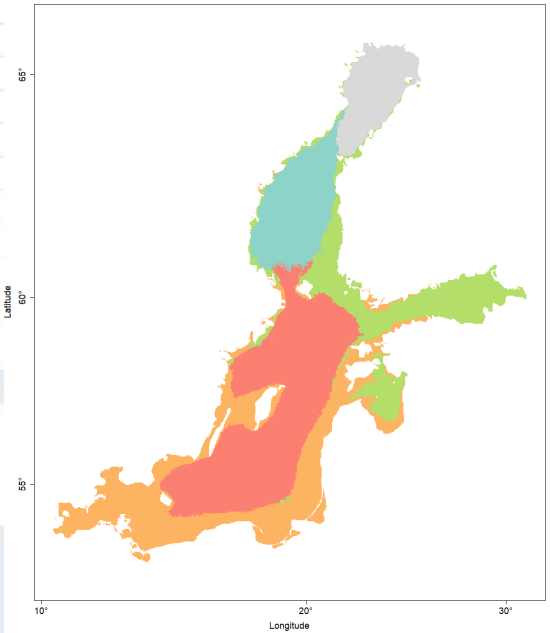






Graphs illustrate **cluster centers - histograms**, darker color means higher probability

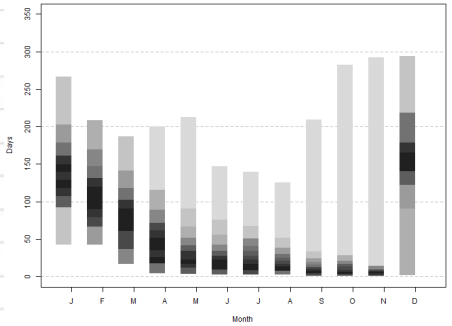
Interpretation of clusters

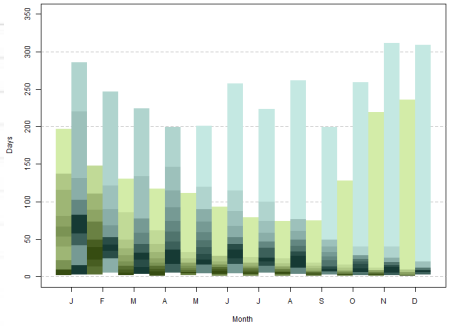


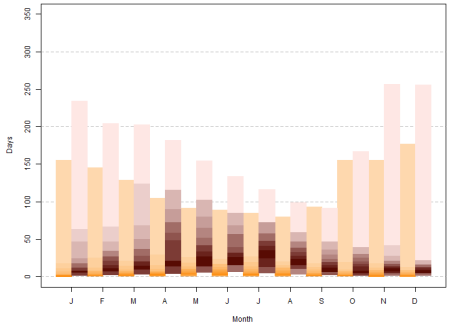
Always ice – particles released in winter months take long time for landing on the coast

Regular ice – two peaks in the histogram in January imply that in some simulations particles land on the coast right away and in some are frozen for some time. Cluster corresponding to the Gulf of Bothnia shows more pronounced second peak in January and longer swim time in all seasons.

No ice – Average histograms of released particle time to coast do not show impact of ice. Coastal and non-coastal zones are distinguished.





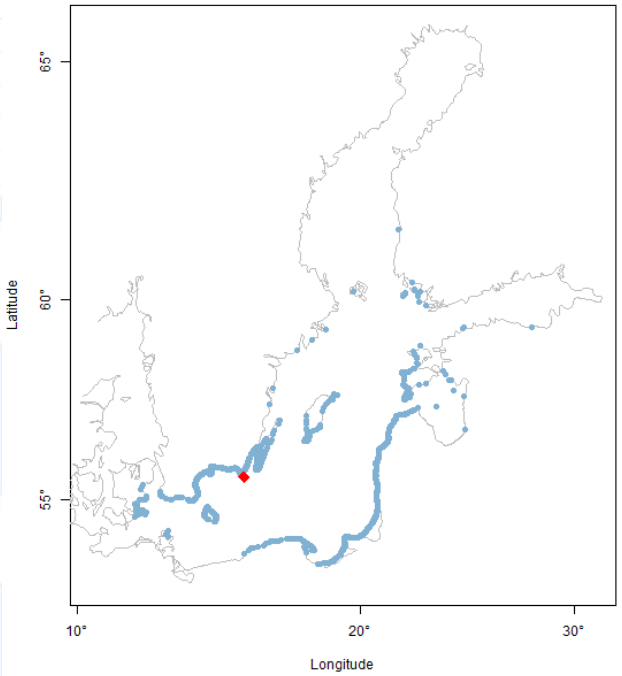


3. Main pathways

What are the main pathways for the particles – where do particles from different sea regions land?

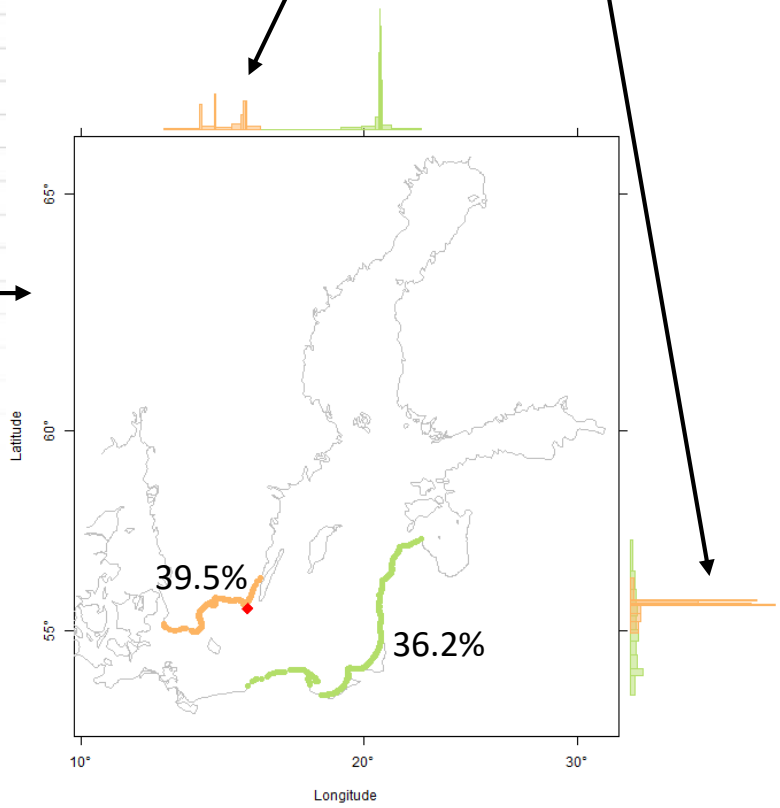
What are end locations from particles that start at the same grid point at the sea?

1. For each starting grid point at the sea we have ~3650 simulations

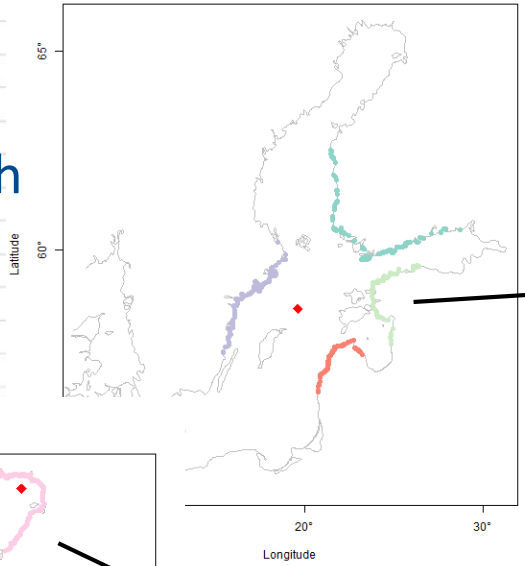


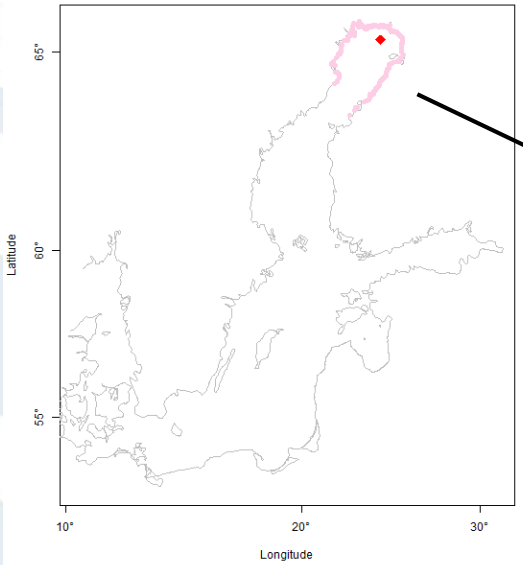
2. Main <u>non-island</u> landing locations are identified, as well as the percentage of simulations that landed there

3. Landing locations are described by their longitude and latitude histograms



The described process is repeated for each of the release grid points

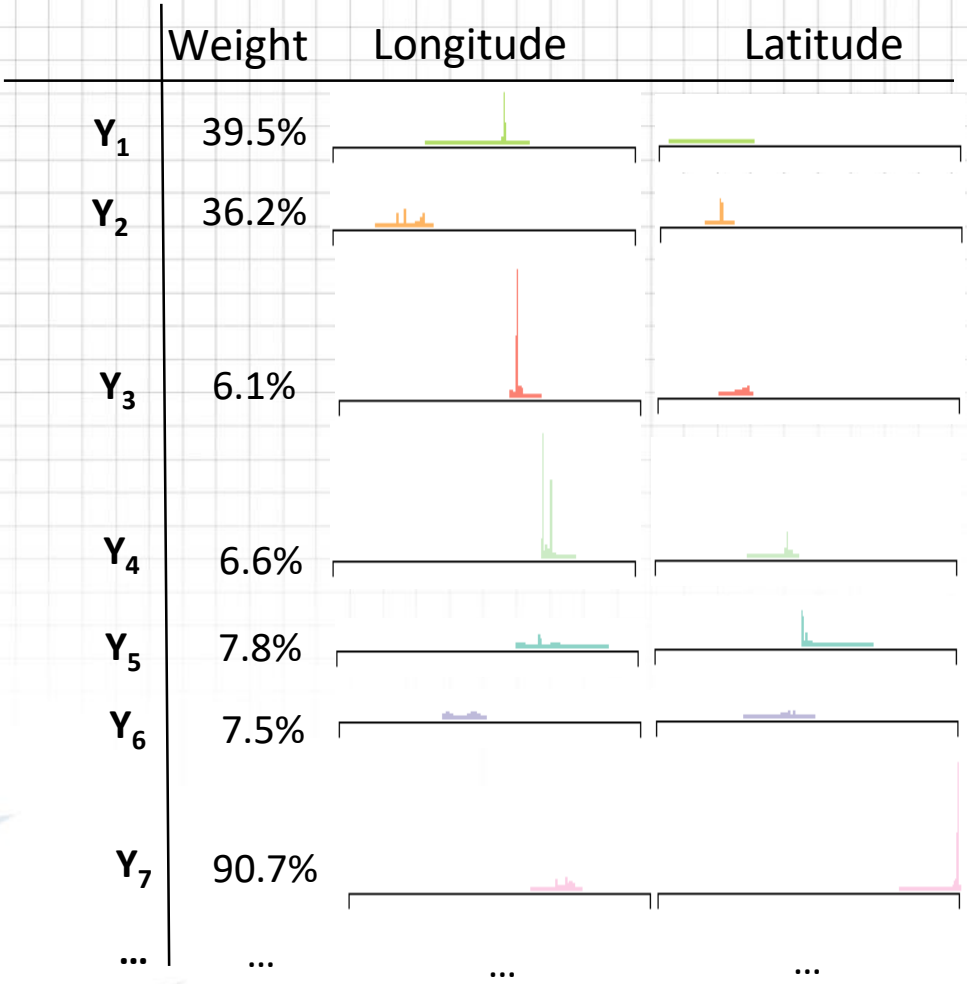




	Weight	Longitude	Latitude
Y_1	39.5%		
Y_2	36.2%		
Y_3	6.1%		
Y_4	6.6%		
Y_5	7.8%		
Y_6	7.5%		
Y_7	90.7%		
...	...	...	...

Description of clustering analysis performed:

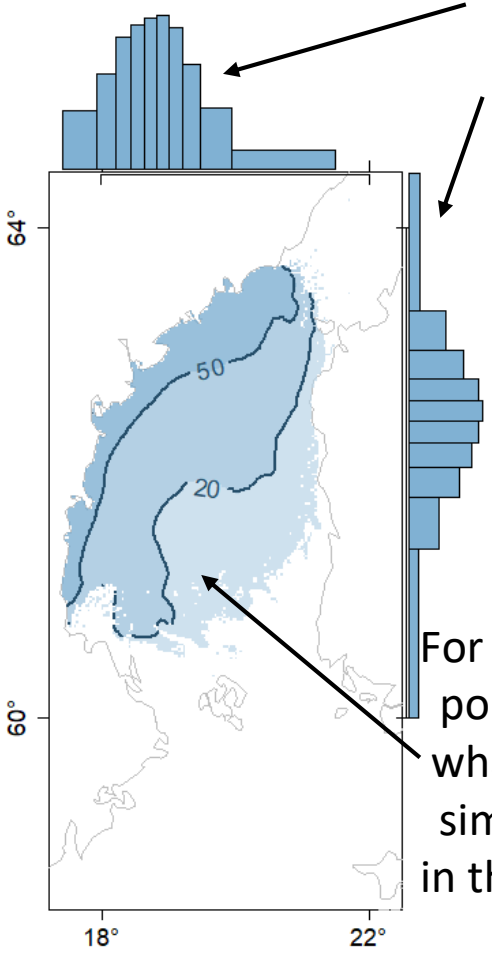
- We have 2-dimensional symbolic data set;
- Methods were based on [1] and R package HistDAWass;
- Wasserman distance metric;
- K-means clustering algorithm;
- Weights were taken into account when calculating cluster centers and distance to centers during clustering process;
- Solution with 11 clusters was chosen.

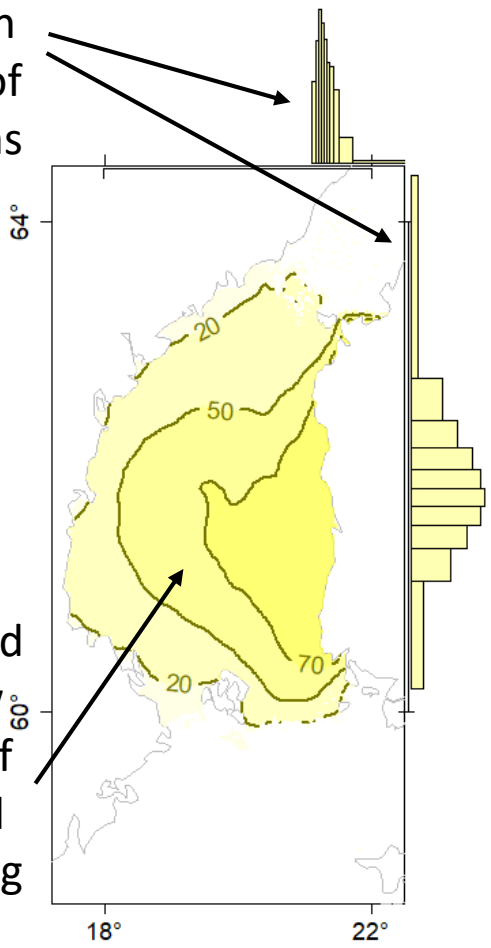


[1] Irpino, A. and Verde, R., 2015. Basic statistics for distributional symbolic variables: a new metric-based approach

Example of 2 of the acquired clusters

West and East coasts of the Gulf of Bothnia



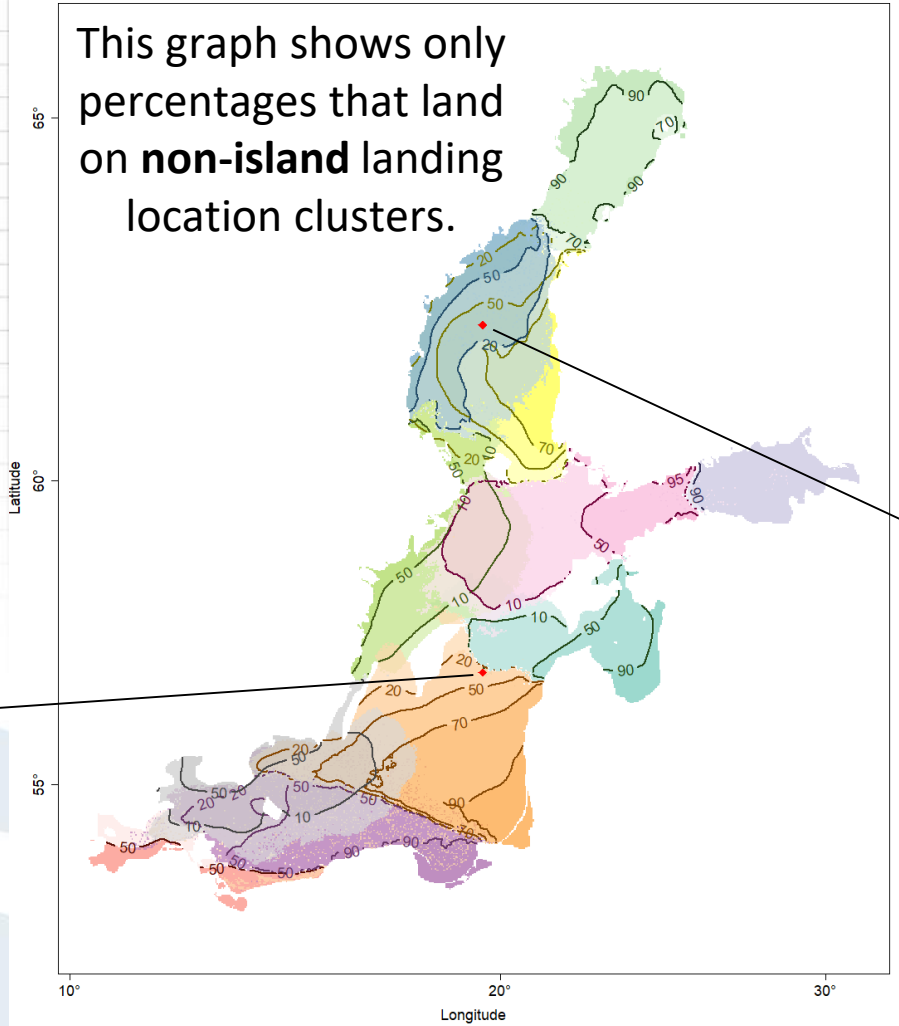


Histograms show centers for each of the clusters of landing locations

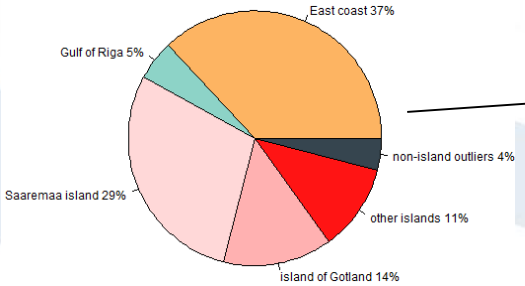
For each release grid point we can show what **percentage** of simulations landed in the corresponding cluster

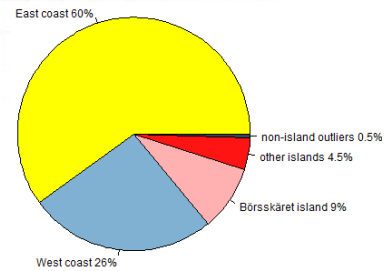
Illustration of all release grid points and in what landing location clusters they end in

This graph shows only percentages that land on **non-island** landing location clusters.



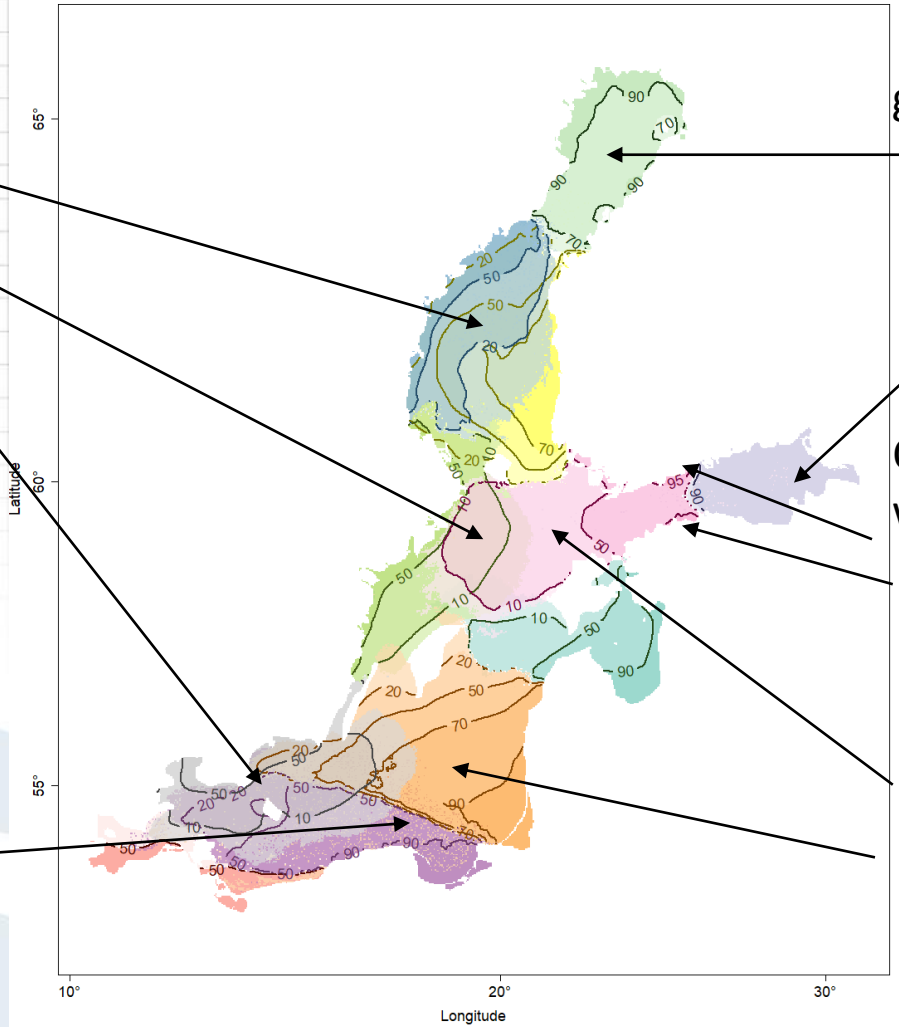
In pie-charts are some example release grid-points and percentages of simulations for landing location **clusters** or **islands**





Regions with overlapping colors and contour lines show release grid points with multiple dominant landing locations

This region problematic – dominant landing location for these release grid points stretches from coast of Poland to coast of Latvia, but clustering algorithm classifies it into one of the two clusters

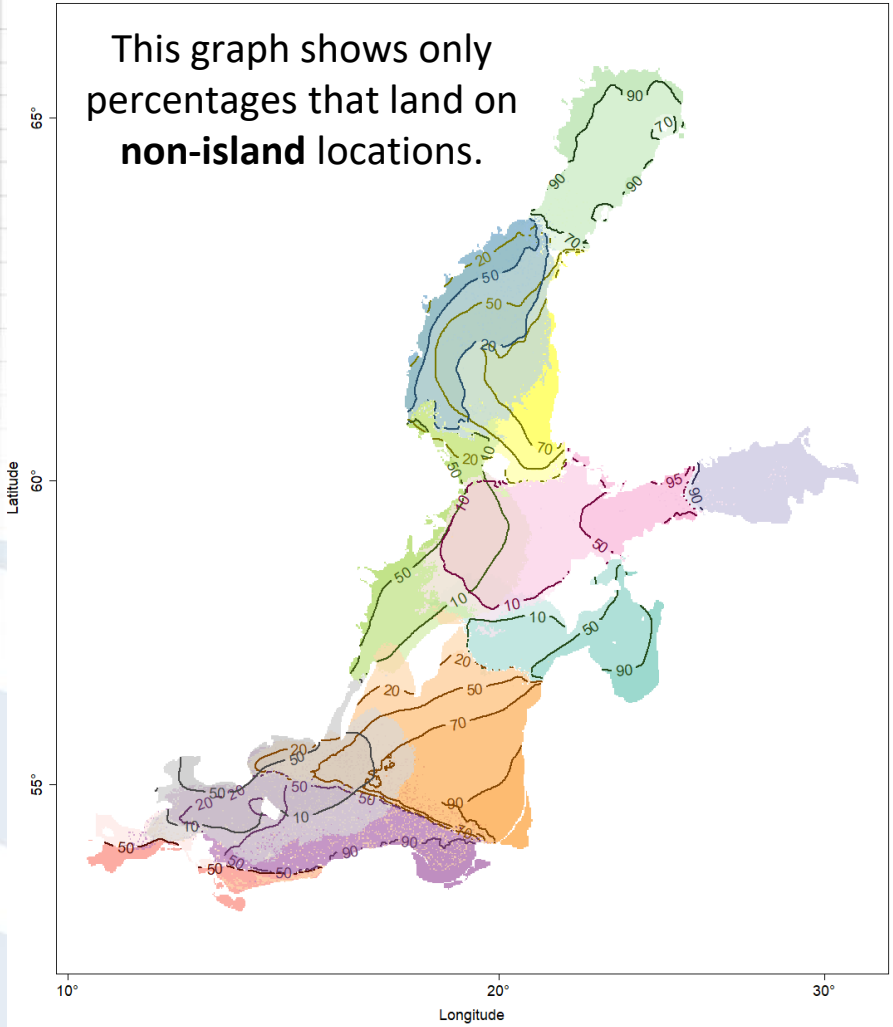


Particles with release grid locations at the tips of Gulfs of Bothnia and Finland also landed there

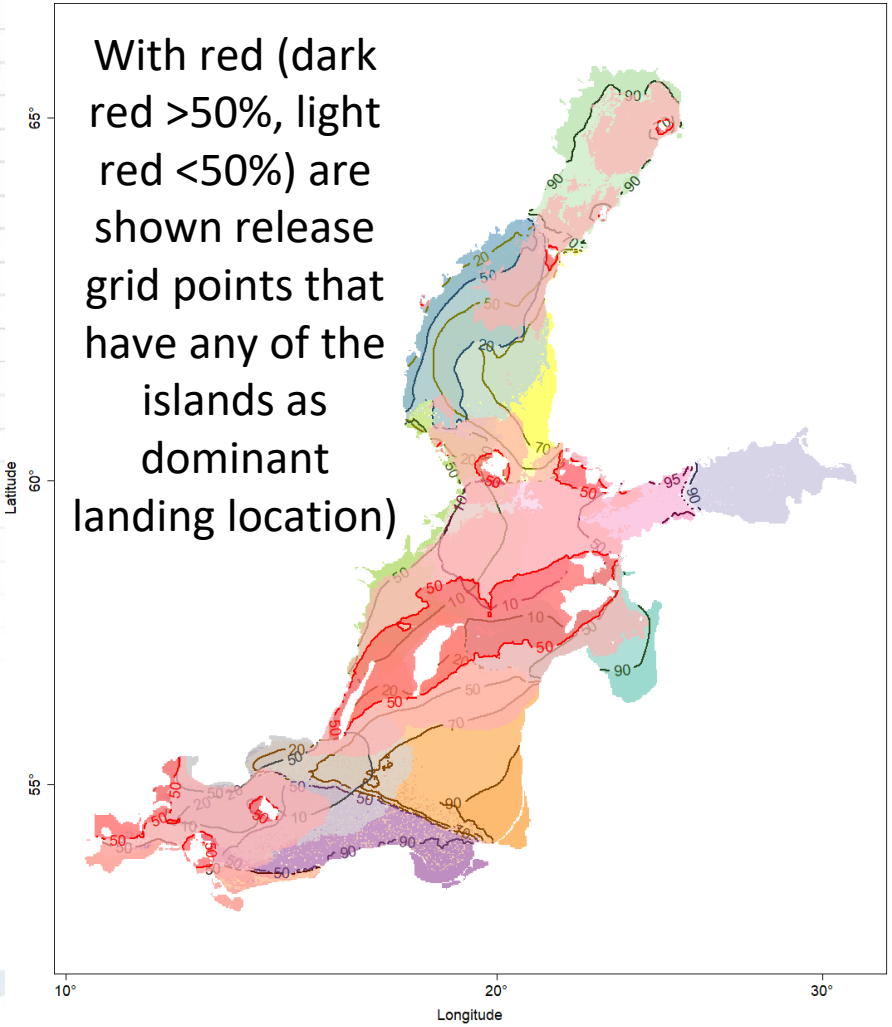
Coasts of bay of Finland where grouped into the same landing location cluster

From more release grid points particles are landing in the Eastern part of the Baltic sea than Westen part

This graph shows only percentages that land on **non-island** locations.



With red (dark red >50%, light red <50%) are shown release grid points that have any of the islands as dominant landing location)



Thank You for attention!

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Photo: Juris Sennikovs

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