



Estimation of polluted area in case of potential leakage of the chemical munitions

Jaromir Jakacki

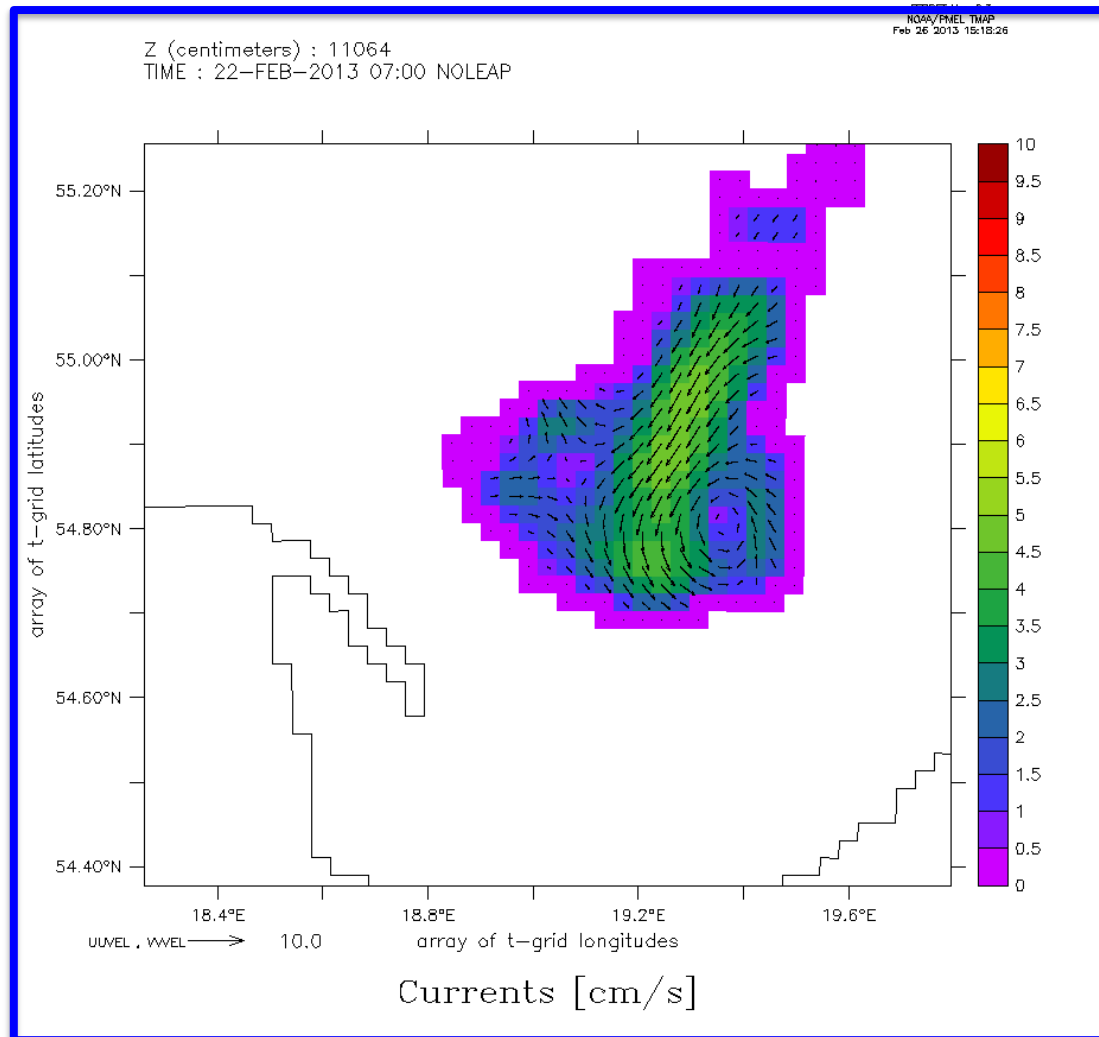
Institute of Oceanology PAS, Sopot, Poland



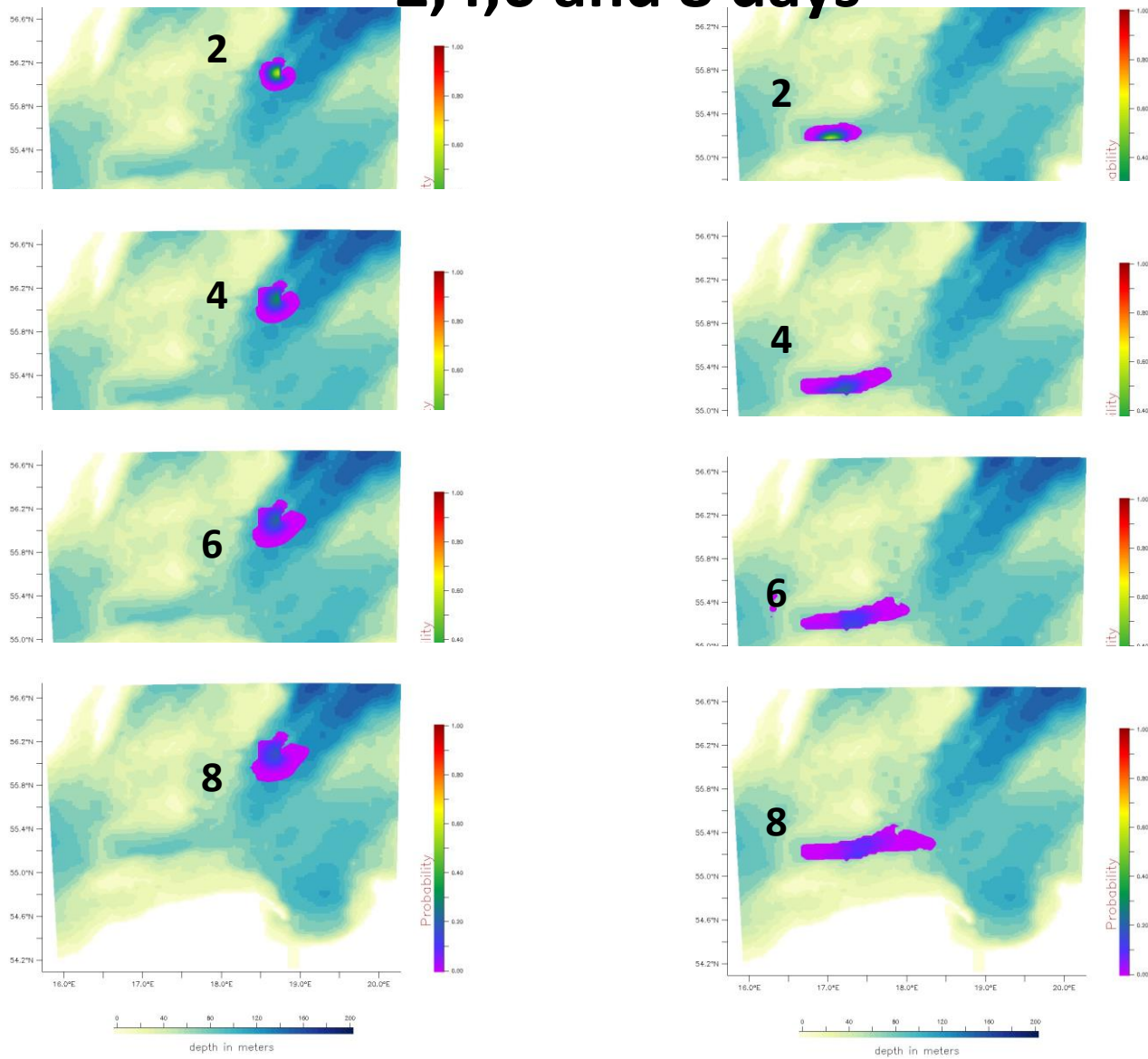
Outline:

- **Introduction**
- **Description of the method**
- **Few words about the model and validation**
- **Implementation of the method into selected
dumpsite locations**
- **Results for the selected stations**
- **Summary and future work**

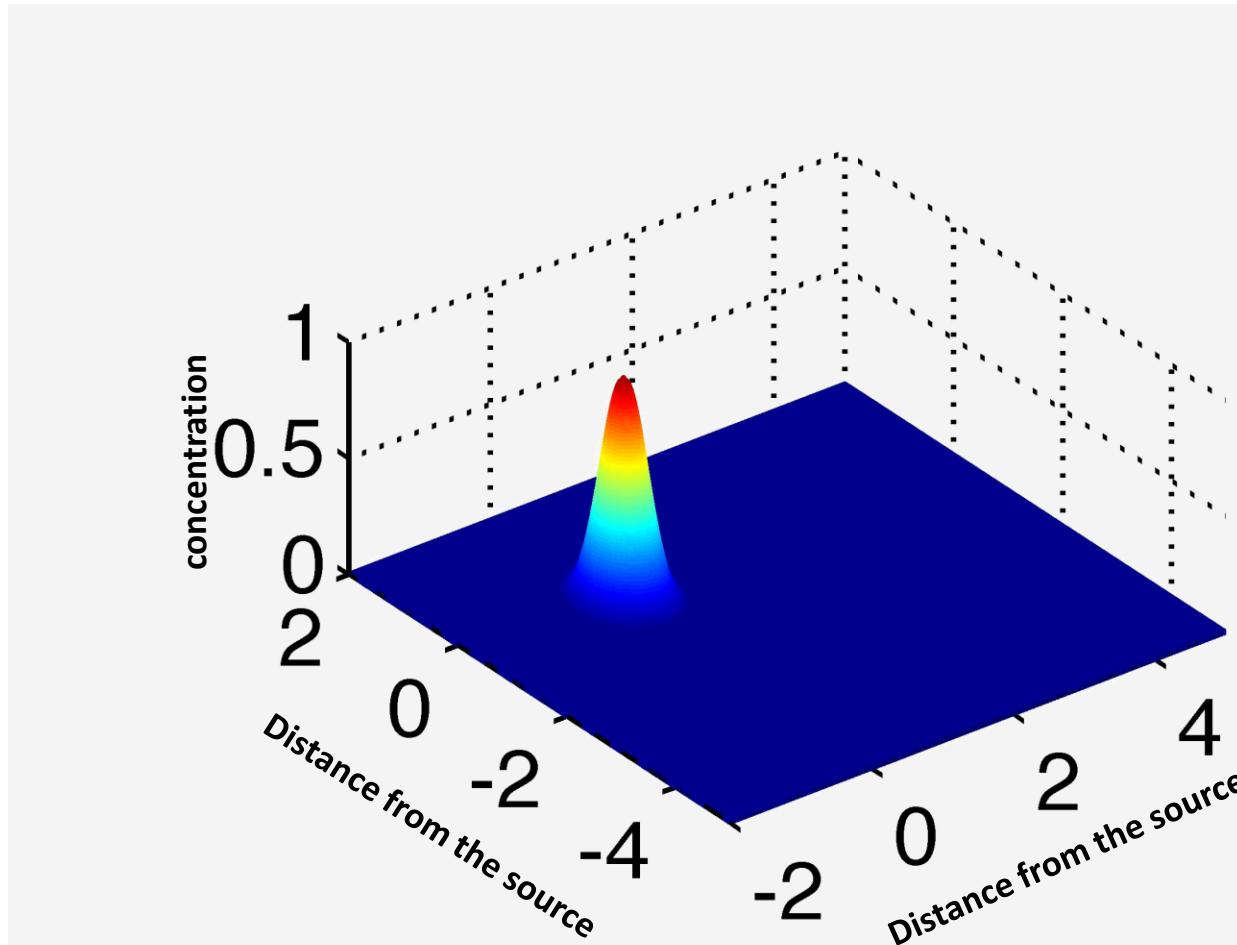
Example of the modeled bottom currents (48 hours animation)



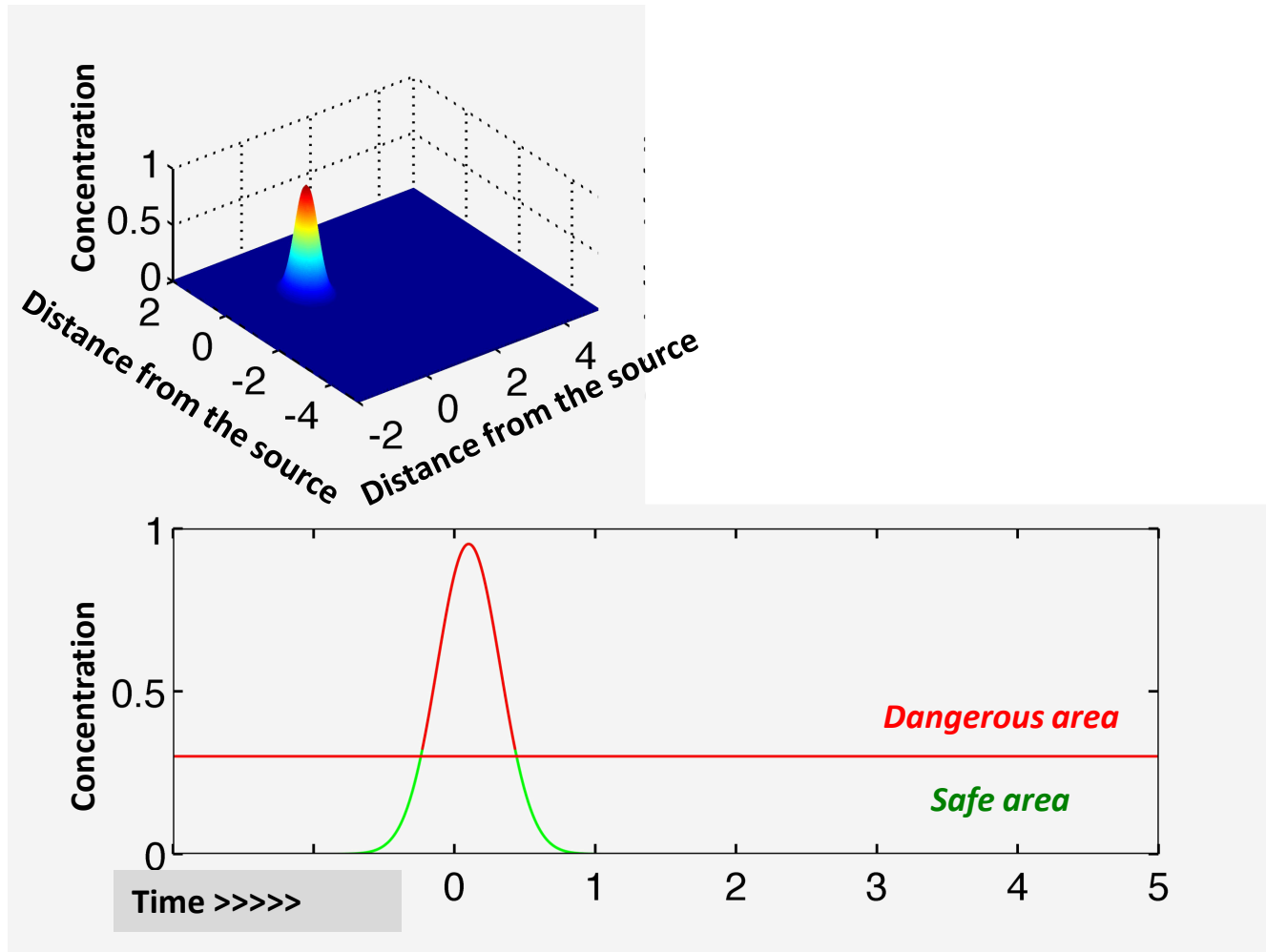
Example of the probability of finding passive tracer concentration Gotland Basin (left) and Slupsk Furrow after 2,4,6 and 8 days



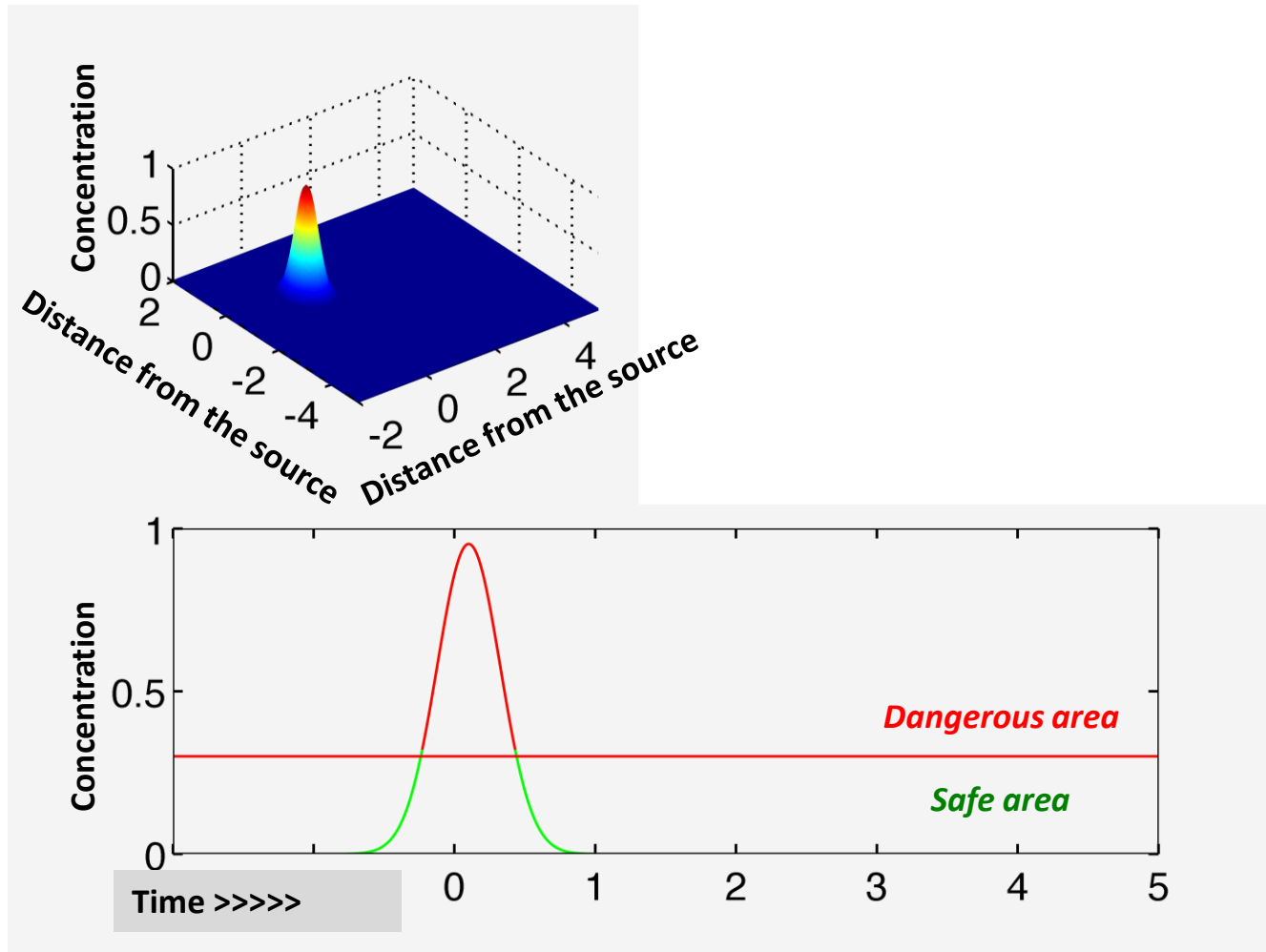
Tracer concentration – treatment o of the results (1)



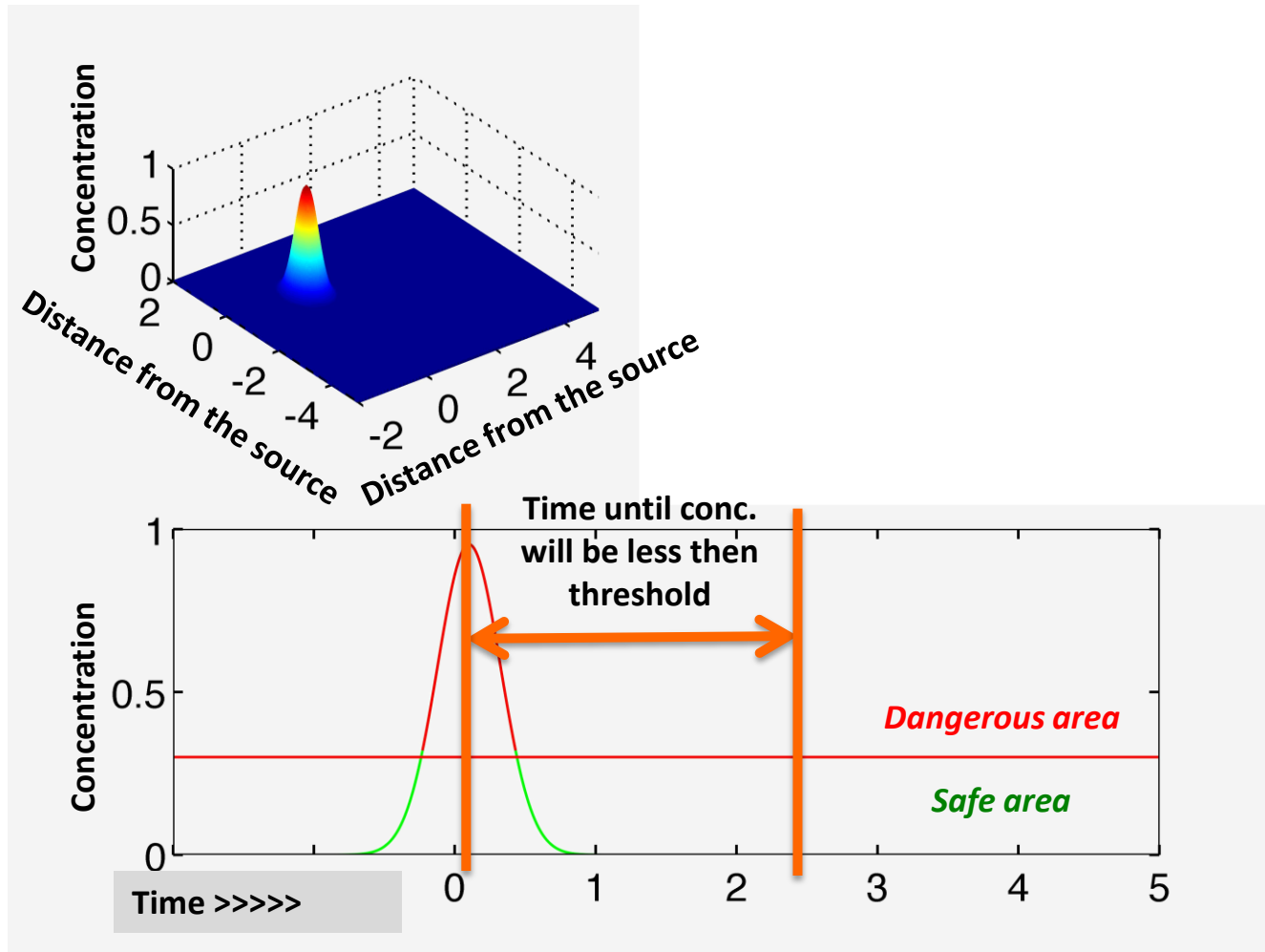
Tracer concentration – treatment o of the results (2)



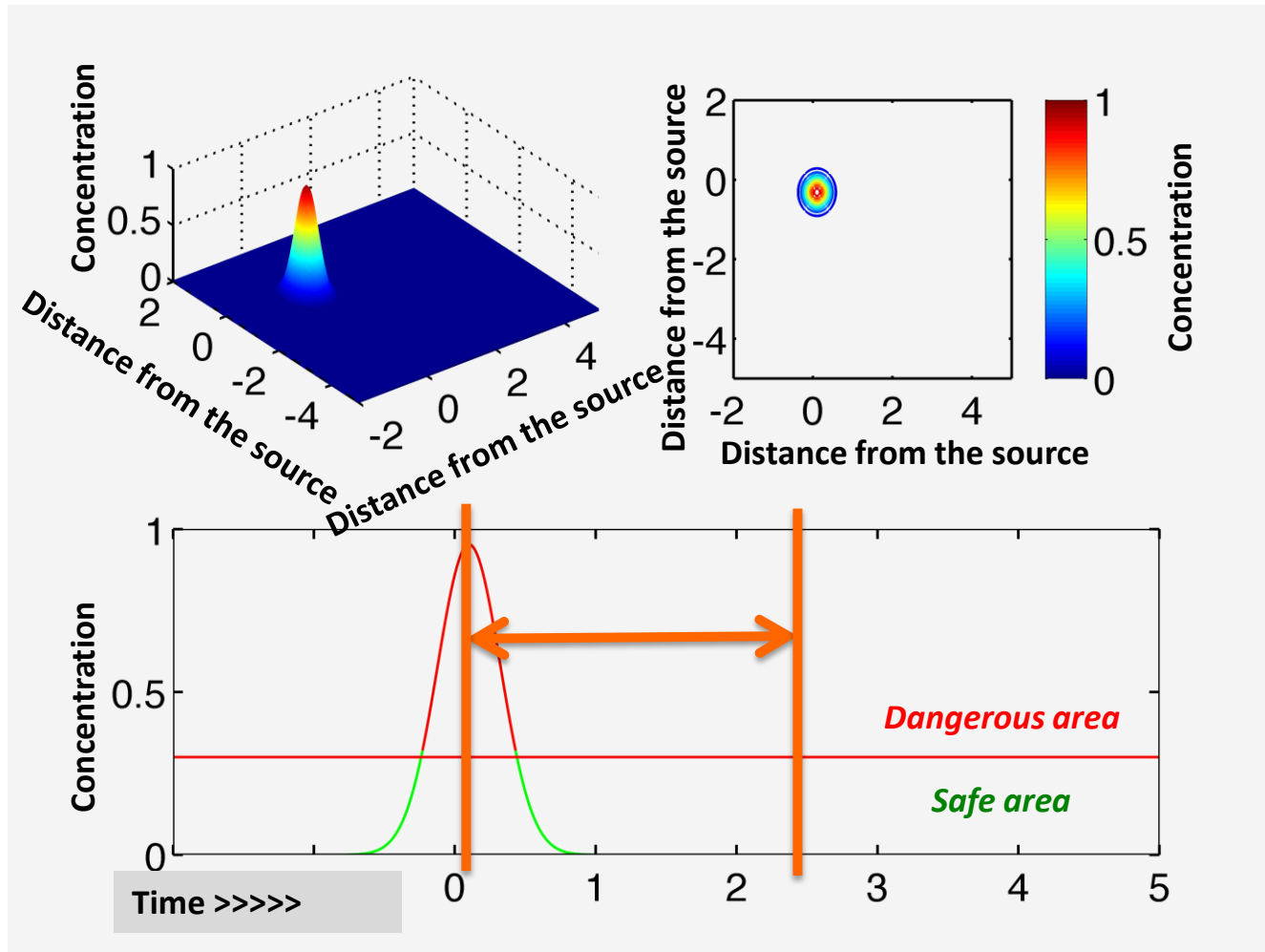
Tracer concentration – treatment o of the results (3)



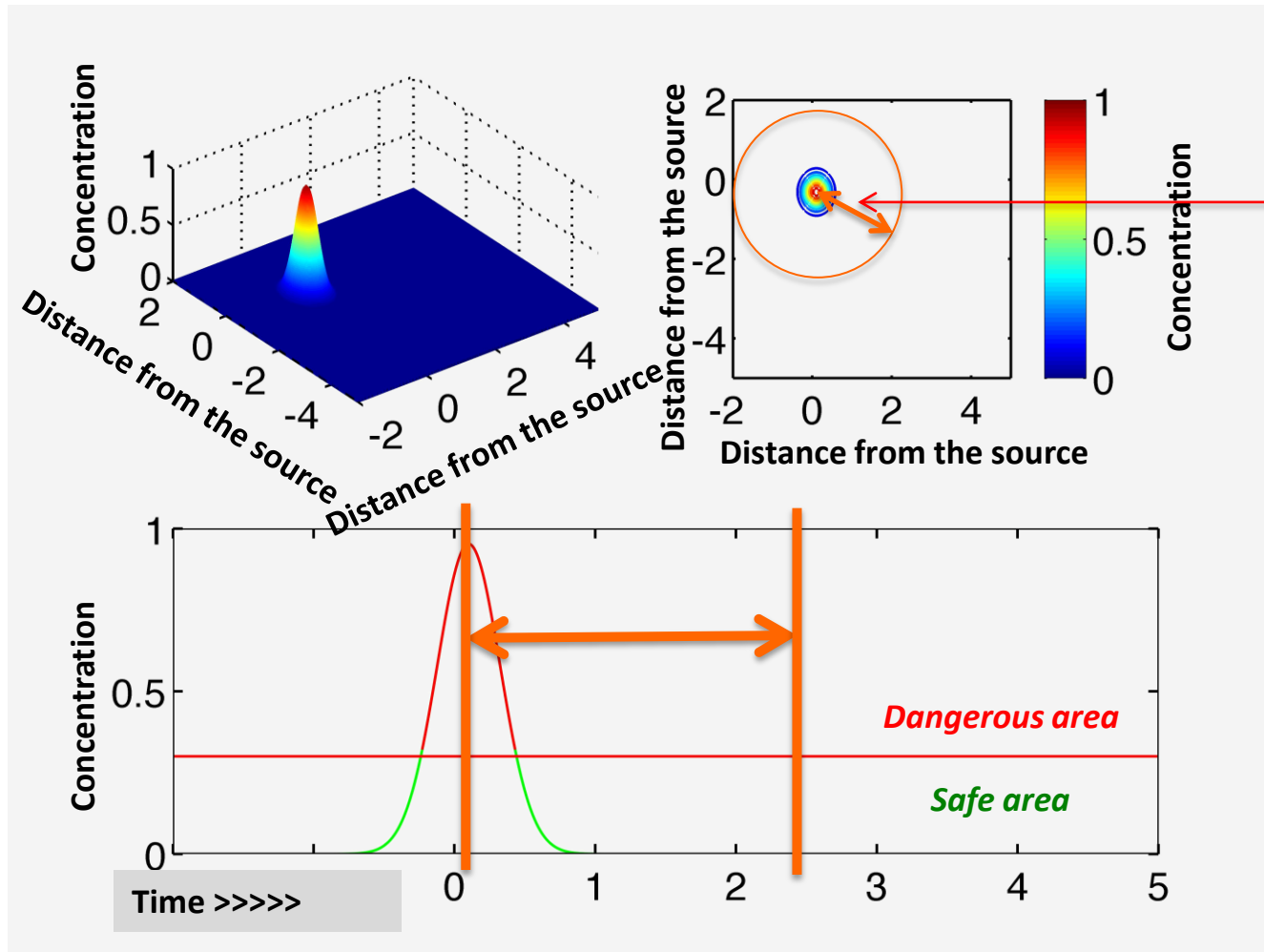
Tracer concentration – treatment o of the results (3)



Tracer concentration – treatment o of the results (4)



Tracer concentration – treatment o of the results (4)

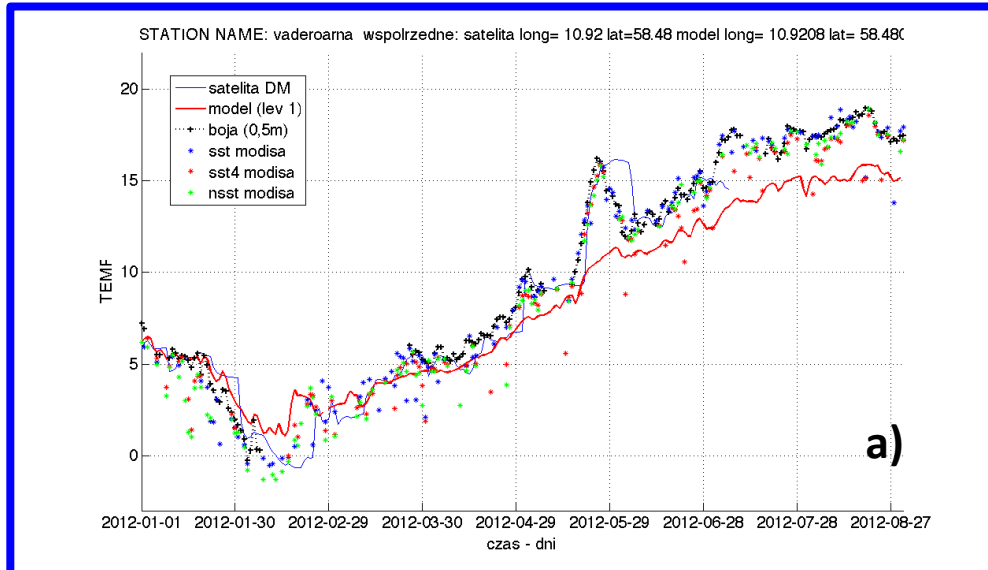
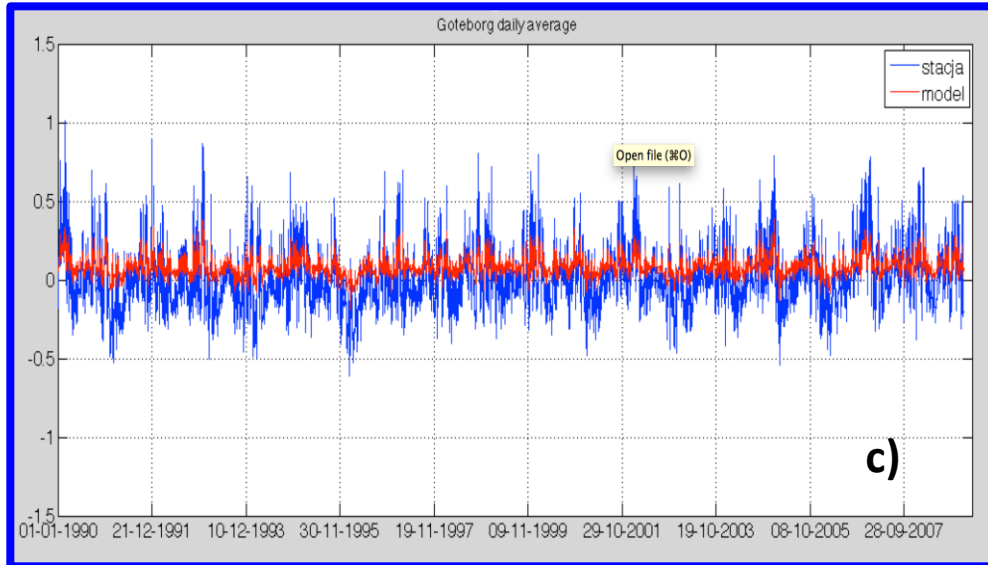


Distance from the source to the concentration bigger then threshold (and take into account the circle)

Few words about the tool

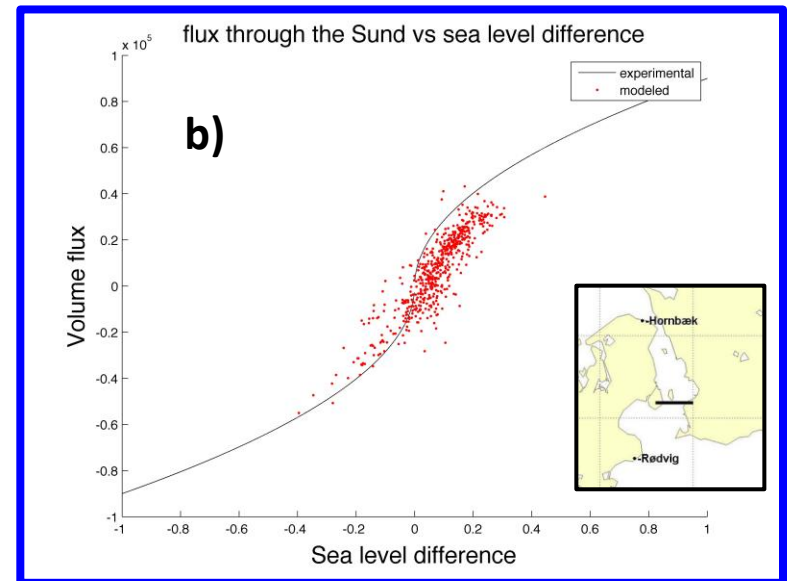
- Modified (modification especially for the Baltic Sea) Parallel Ocean Program – z-coordinate hydrodynamic model
- Biharmonic horizontal mixing
- Modified kpp parameterization
- Modified BBL for better representation of the bottom flow (bottom drag depends on bottom cell thickness).
- Orlanski conditions and assimilation sea level at the Goteborg area (modified barotropic equation for fitting assimilation sea level at the Goteborg area)
- Model covers the whole Baltic, horizontal resolution is about 2.3 km (1/48 degrees) and thickness of vertical levels is equal to 5 meters
- Passive tracer were added for analyzing polluted area

Validation of the barotropic flow through the Sund (b), temperature (c) and sea level (a) at the boundary



$$\Delta\eta = K_f \cdot Q \cdot |Q|$$

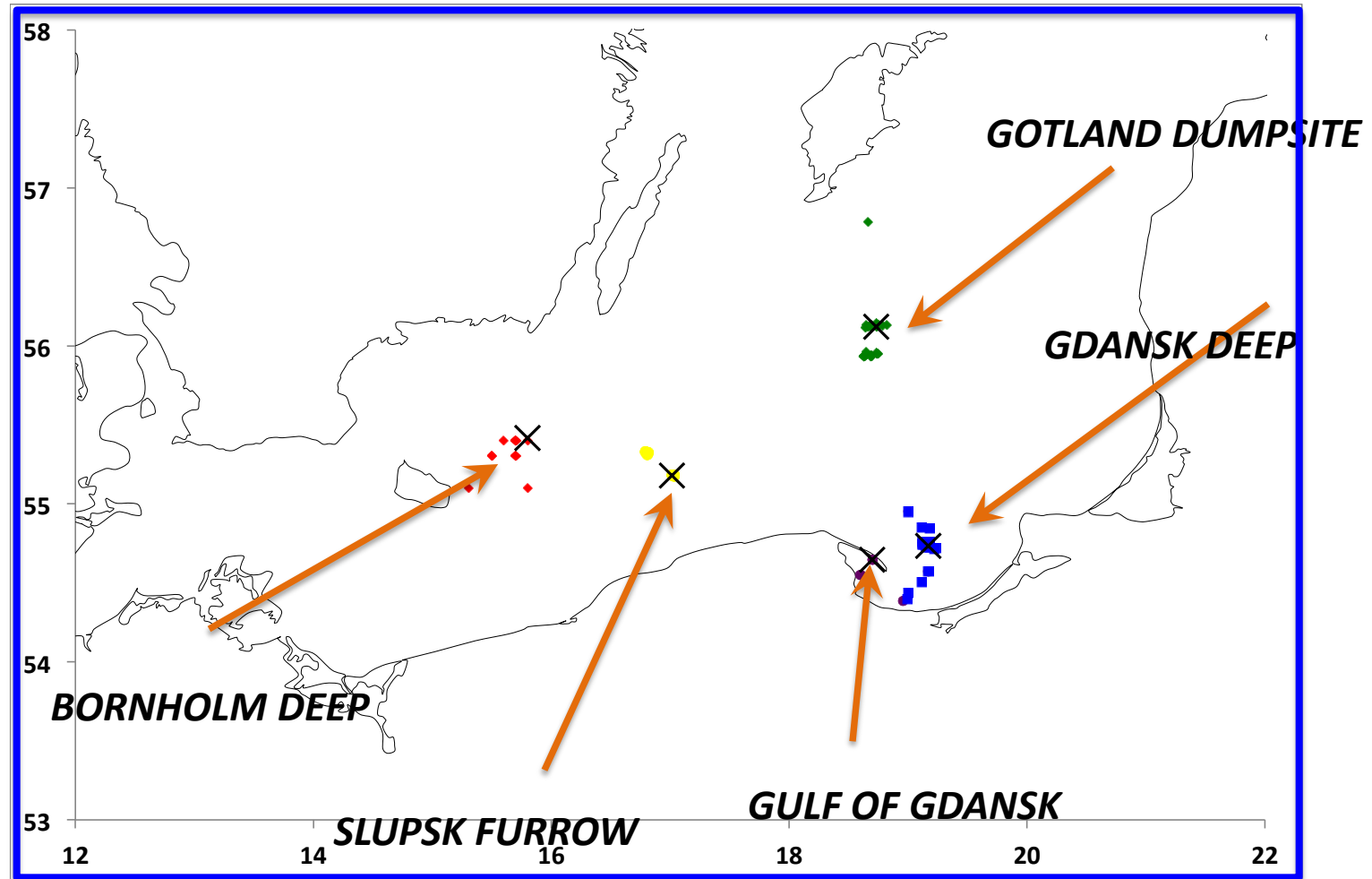
(Mattsson 1995, Grode 2004)



- 1) Model resolution is about 2.3 km**
- 2) For each location the points were “inserted” into model cells and places with maximum number of points has been chosen.**
- 3) It is assumed that one point gives concentration equal to $10 \mu\text{g}/\text{cm}^3$ – it means if in one cell is 3 points, initial concentration is $30 \mu\text{g}/\text{cm}^3$**

Station		long	lat	Initial conc	depth
BM	BORNHOLM	15.80	55.42	30	88
SF	SLUPSK_FURROW	17.02	55.18	50	73
GT	GOTLAND_DEEP	18.73	56.12	100	103
GD	GDANSK_DEEP	19.17	54.73	130	98
GB	GULF_OF_GDANSK	18.70	54.65	20	33

Points taken into account for analysis



Dangerous concentration is equal to part per thousand of the one point concentration ($=0.1 \mu\text{g}/\text{cm}^3$) – I call it threshold. It means:

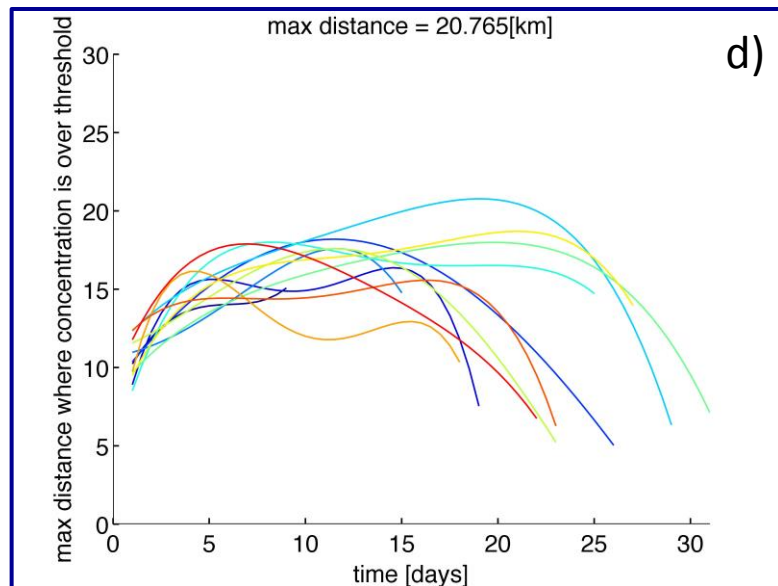
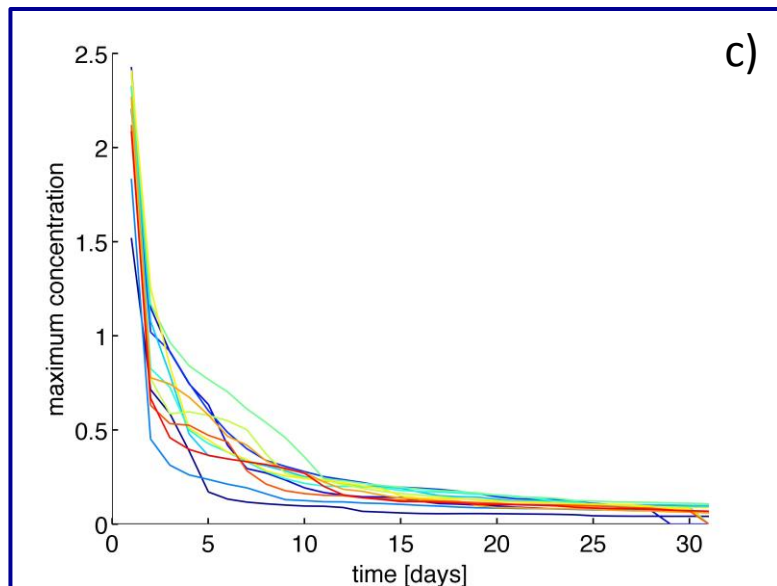
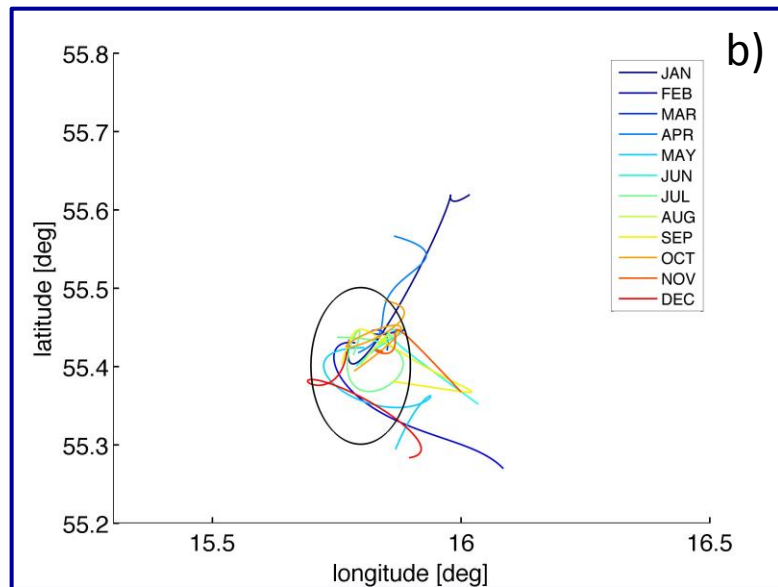
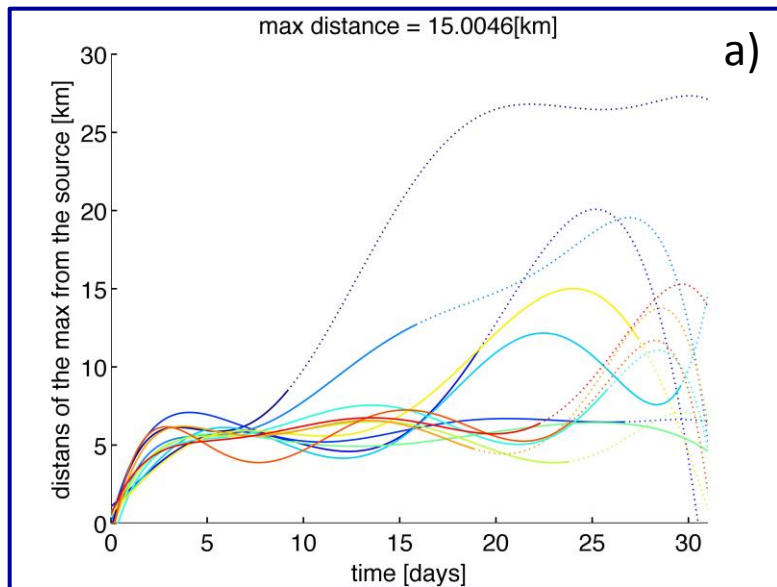
- 1) it is important how big will be area where threshold is bigger then assumed – it will be represented by the maximum distance from the source to the place where concentration is bigger then assumed threshold**
- 2) Also time dependence of the maximum concentration will be shown**
- 3) Trajectory of the maximum concentration**
Distance of the maximum concentration from the source.

For each of the selected station 12 simulation were done. All integrations started from the beginning of each month and from normal model state (after spinup) and with assumed concentration. It means: $12 * 5 = 60$ simulations

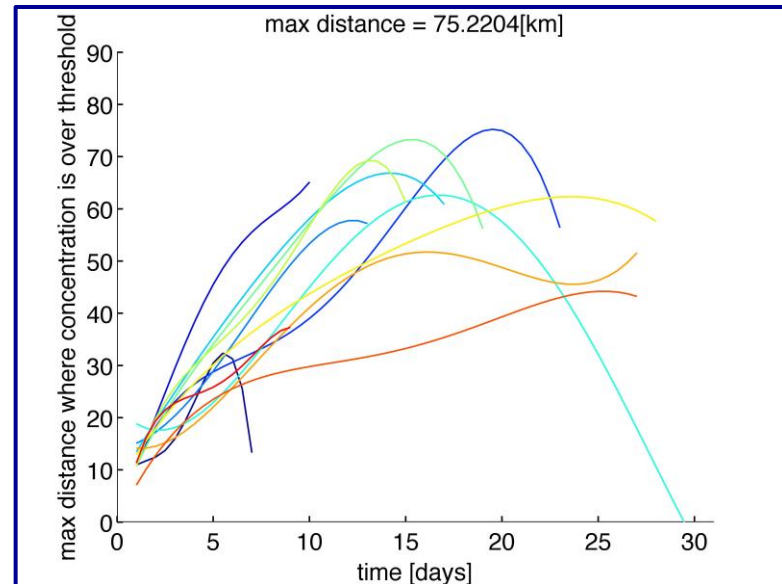
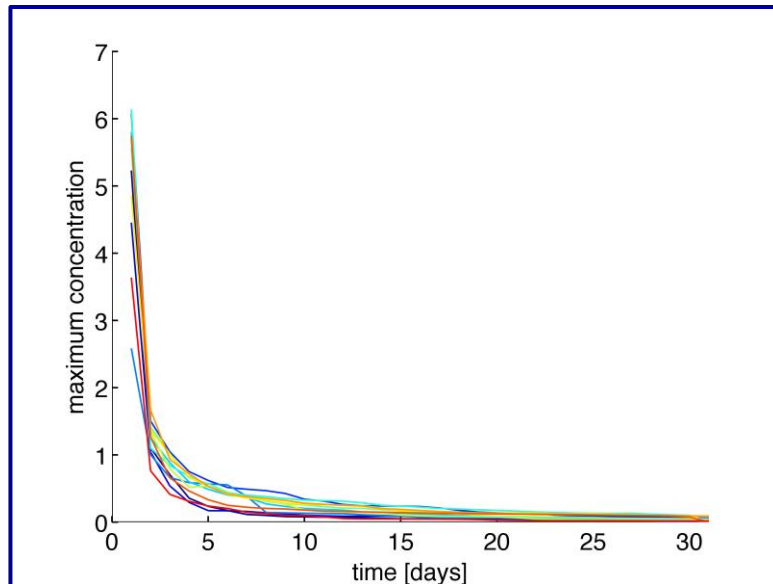
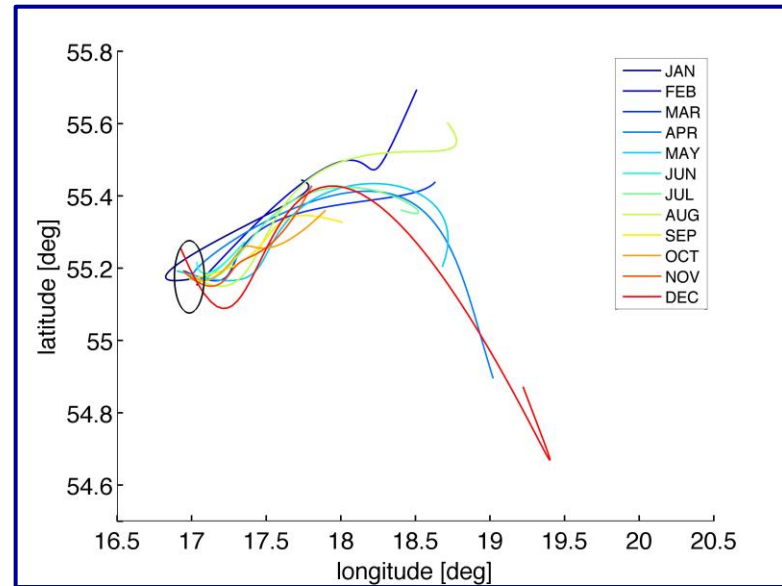
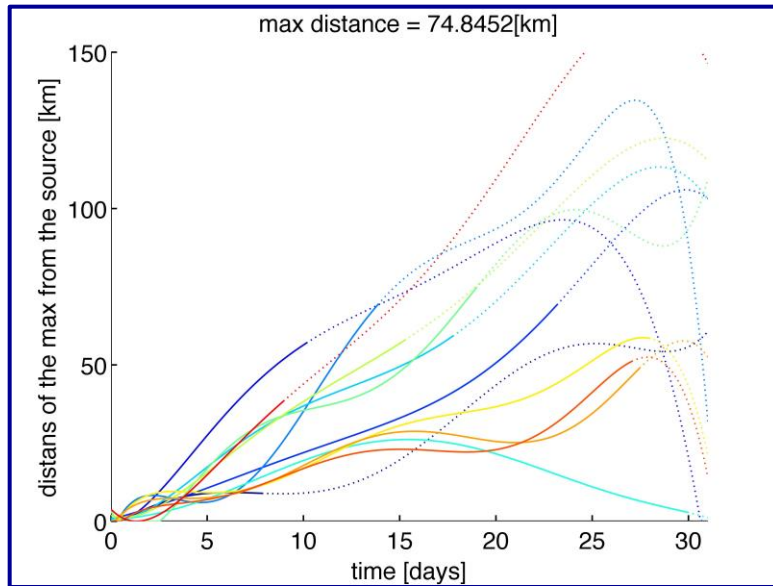
Next 5 slides will present the results:

- a. Distance from the source to maximum tracer concentration*
- b. Trajectories of the maximum concentration*
- c. Maximum concentration vs time*
- d. Maximal range to the place where concentration is bigger then assumed threshold level*

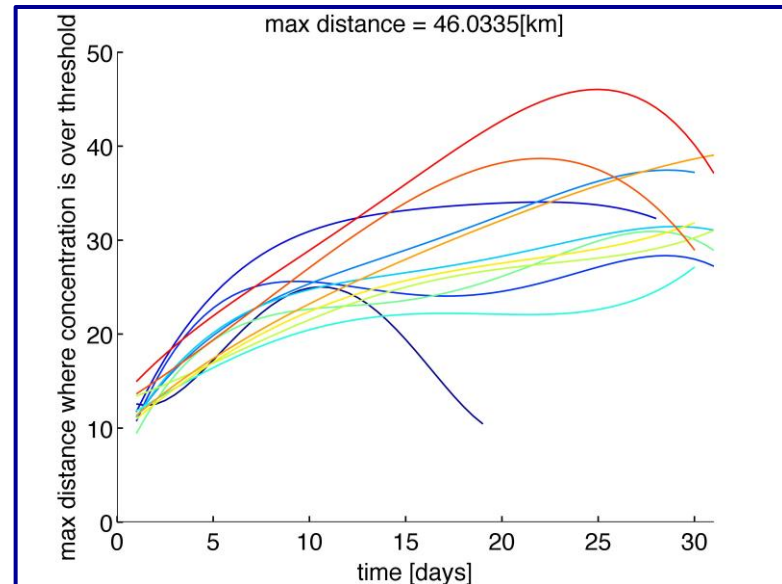
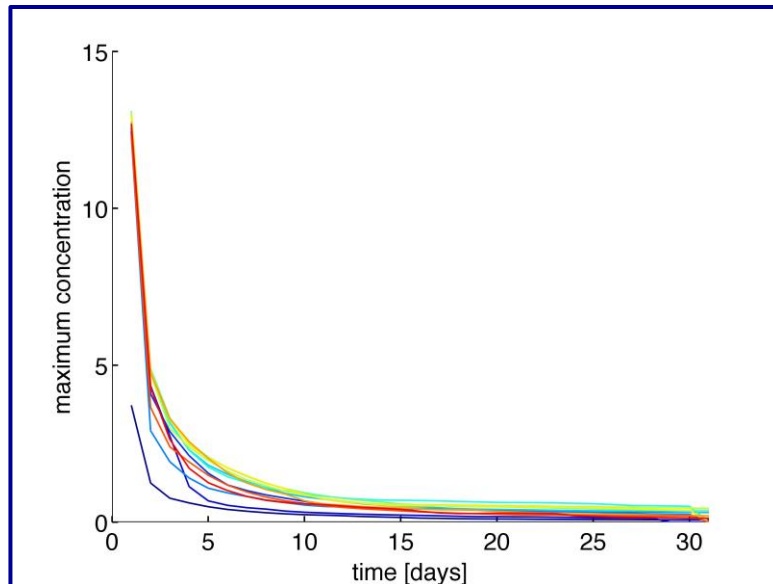
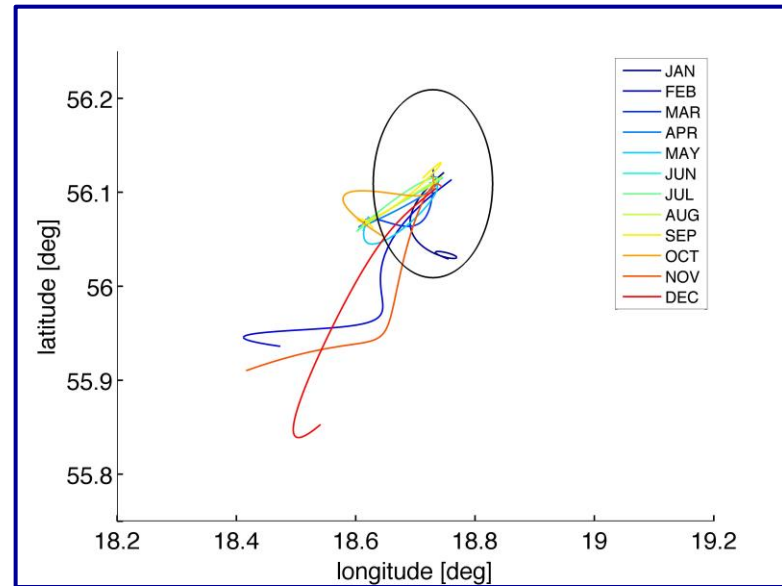
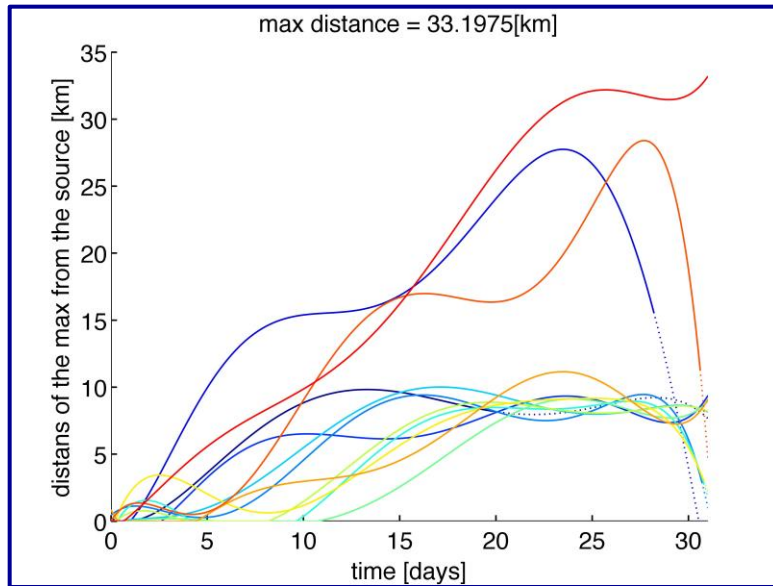
BORNHOLM DEEP



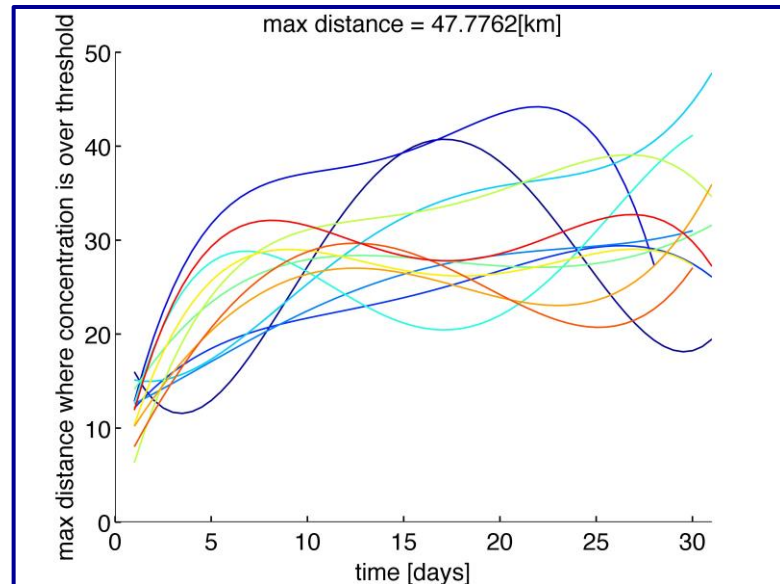
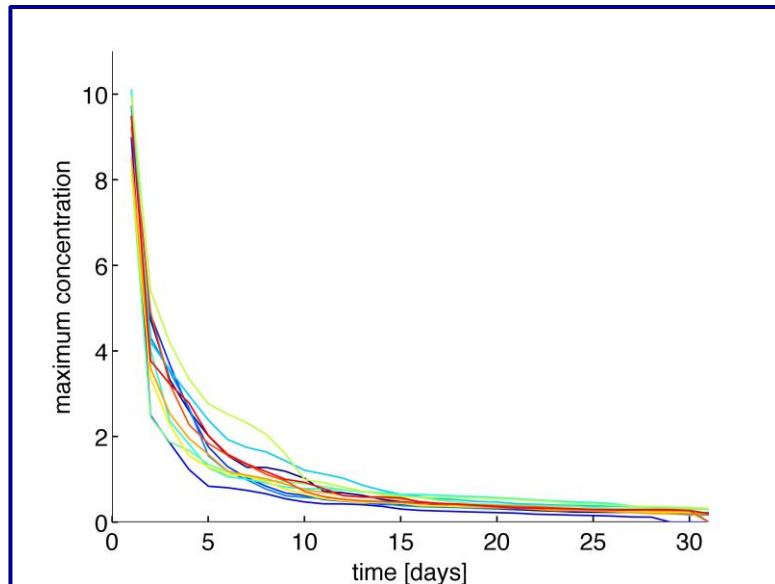
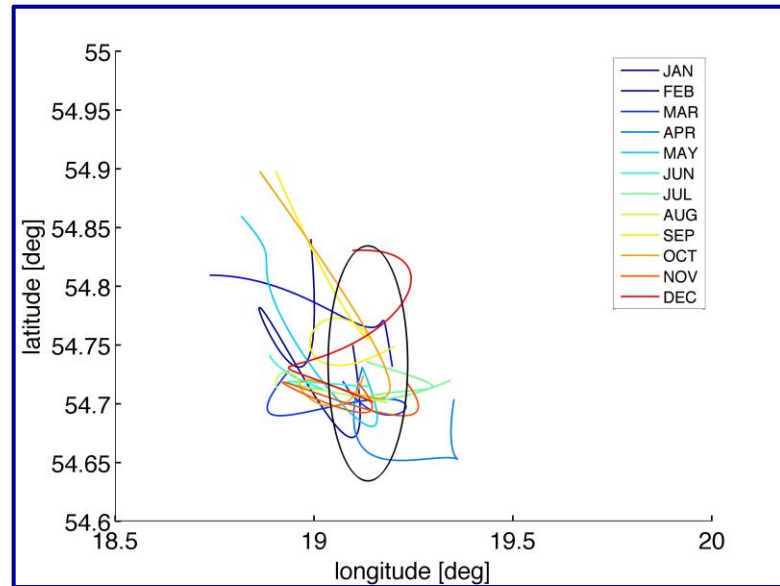
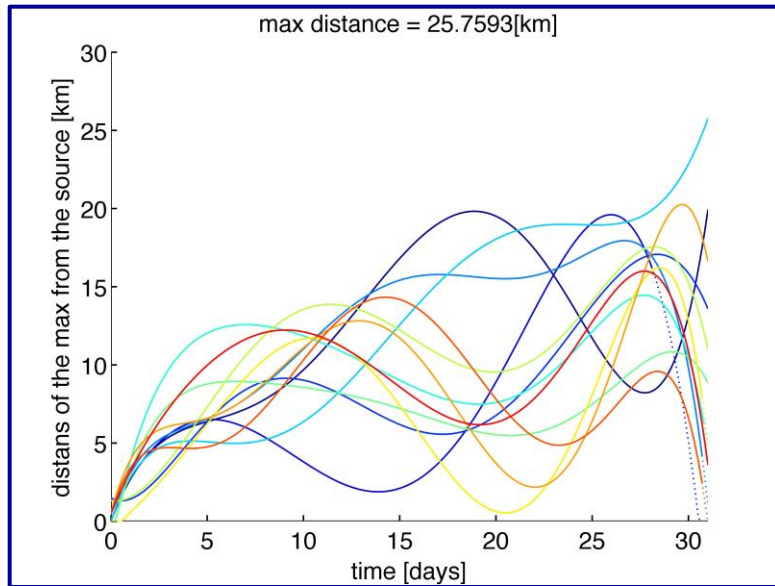
SLUPSK FURROW



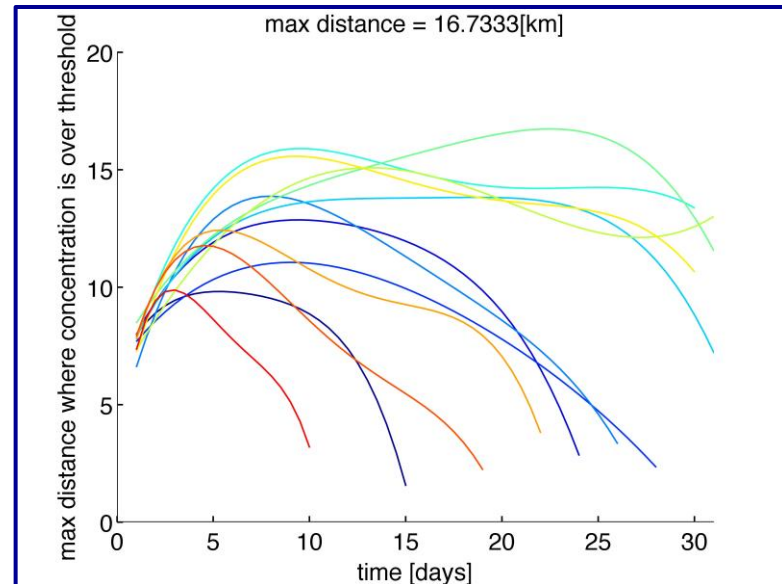
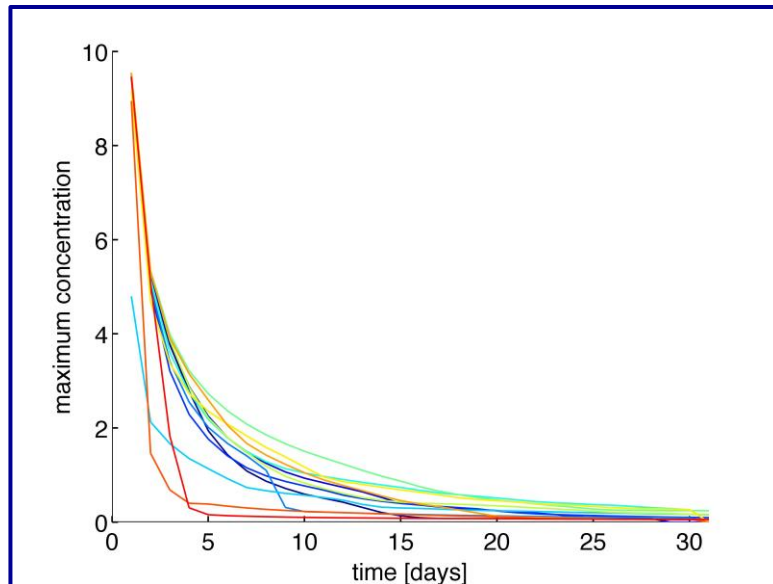
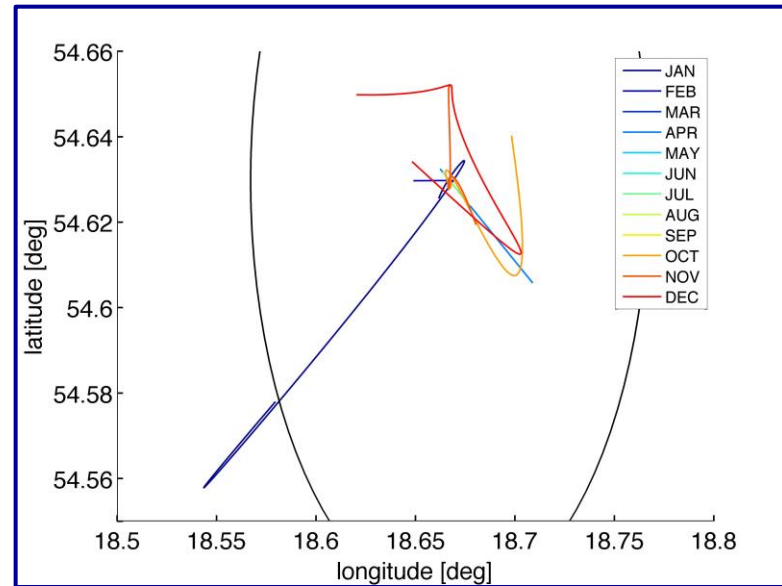
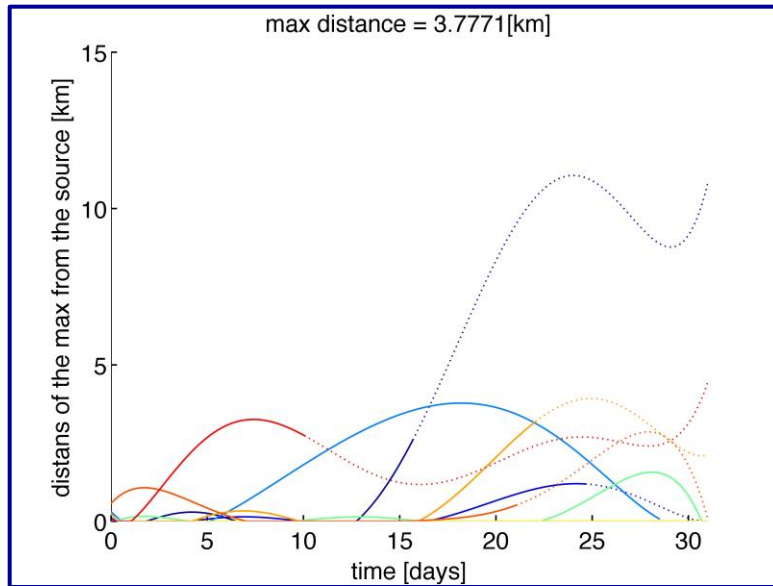
GOTLAND DUMPSITE



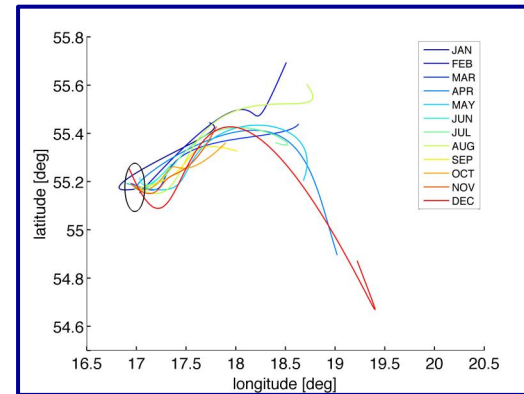
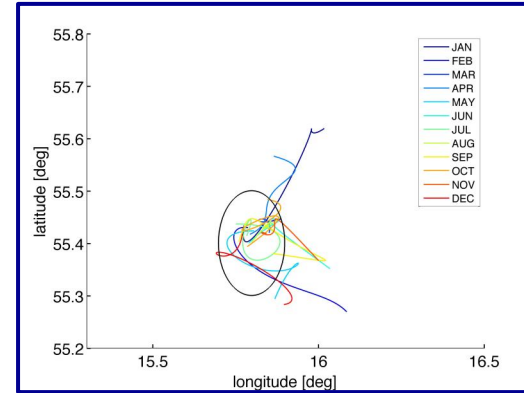
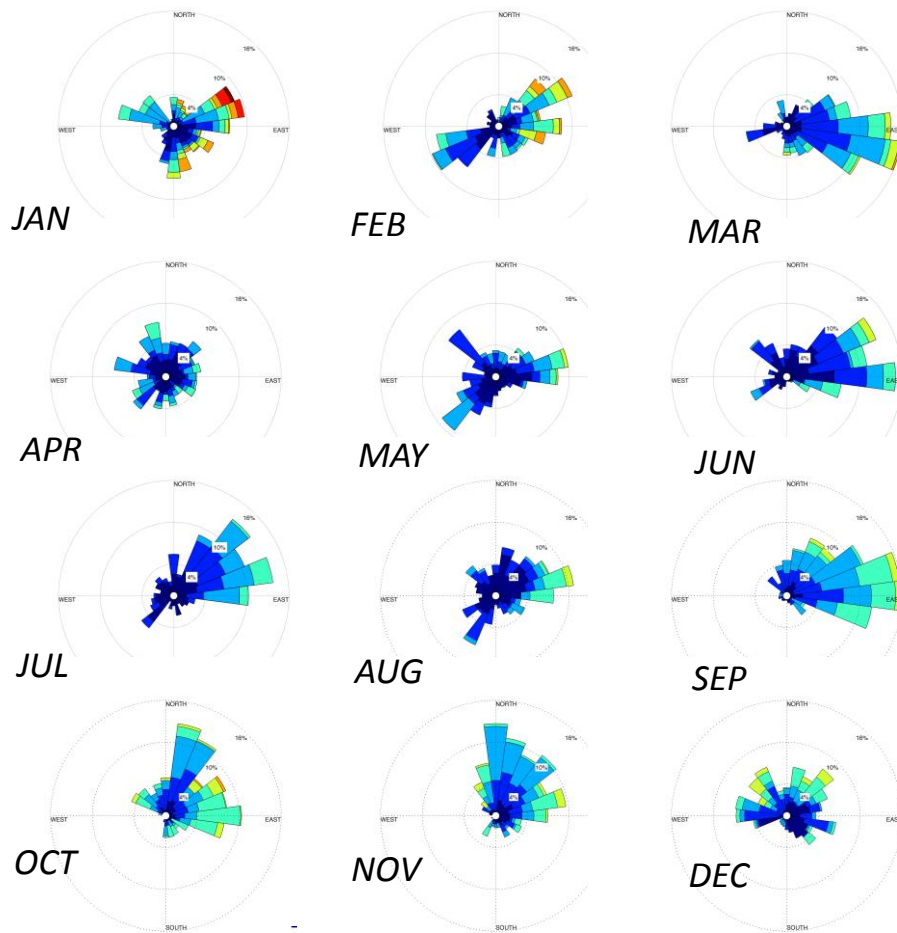
GDANSK DEEP



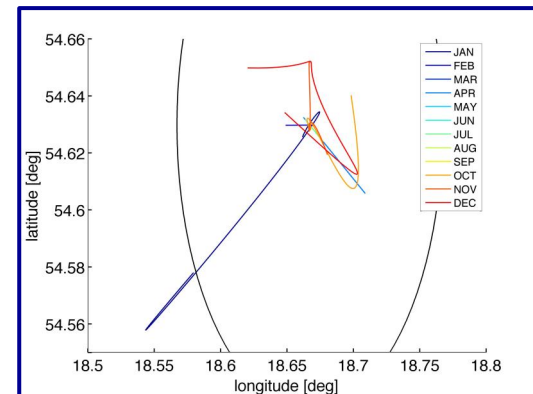
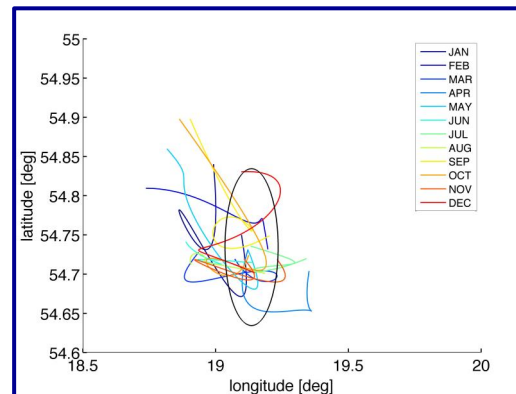
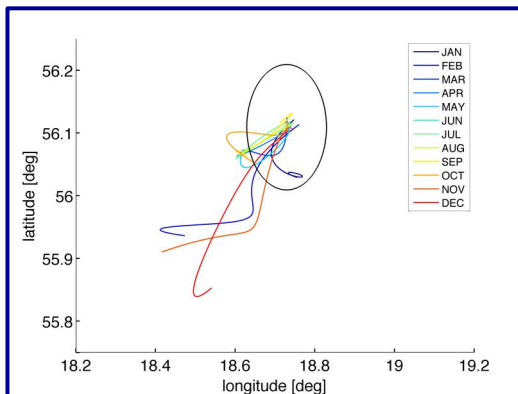
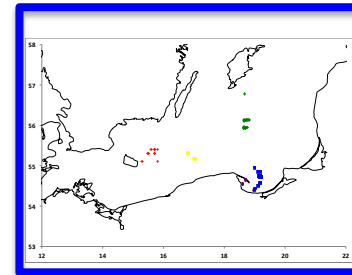
GULF OF GDANSK



Monthly mean wind roses and trajectories



wind averaging
area



Summary of the results

Station		long	lat	initial conc	max time [days]	max dist [km]
BM	BORNHOLM	15.80	55.42	30	30	20.0
SF	SLUPSK_FURROW	17.02	55.18	50	30	75.0
GT	GOTLAND_DEEP	18.73	56.12	100	30	46.0
GD	GDANSK_DEEP	19.17	54.73	130	30	47.0
GB	GULF_OF_GDANSK	18.70	54.65	20	30	16.0

Results for the same initial concentration (from one point)

BM	BORNHOLM	15.80	55.42	10	10	6.7
SF	SLUPSK_FURROW	17.02	55.18	10	6	15.0
GT	GOTLAND_DEEP	18.73	56.12	10	3	4.6
GD	GDANSK_DEEP	19.17	54.73	10	2	3.6
GB	GULF_OF_GDANSK	18.70	54.65	10	15	8.0

Summary and future plans

- The results strongly depend on the initial concentration, threshold level (0.1 currently) and time of initialization. Maximum time with concentration bigger than threshold varying between 3 and 31 days. Maximum distance could be from 3 km up 75.
- Of course real concentrations and threshold level will give more reliable results
- Shape of maximum concentration vs time (which looks like exponent, but it is not) suggest that it is possible to find function that will be represent this character.
- There is no simple dependence between wind speed and bottom currents at the selected stations.
- As a next step it is planned to apply real concentrations and real threshold level.

thank you for your attention