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Vulnerability of Coastal Infrastructure to the Extreme Storm Surges (the Case of Varandey Area – Russian Arctic, Pechora Sea)



**Russian Science
Foundation**

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Varandey marine shipping terminal - Russia, Nenets Autonomous Okrug



A stationary offshore ice-resistant loading berth 22 km from the shore at a depth of 17 m for pumping oil onto tankers



Catastrophic storm surge flood of 2010 and its consequences



Sea level data

Source: direct sea level observation at Varandey station

Provided by:

Russian Hydrometeorological Service

(Northern division, based in Archangelsk)

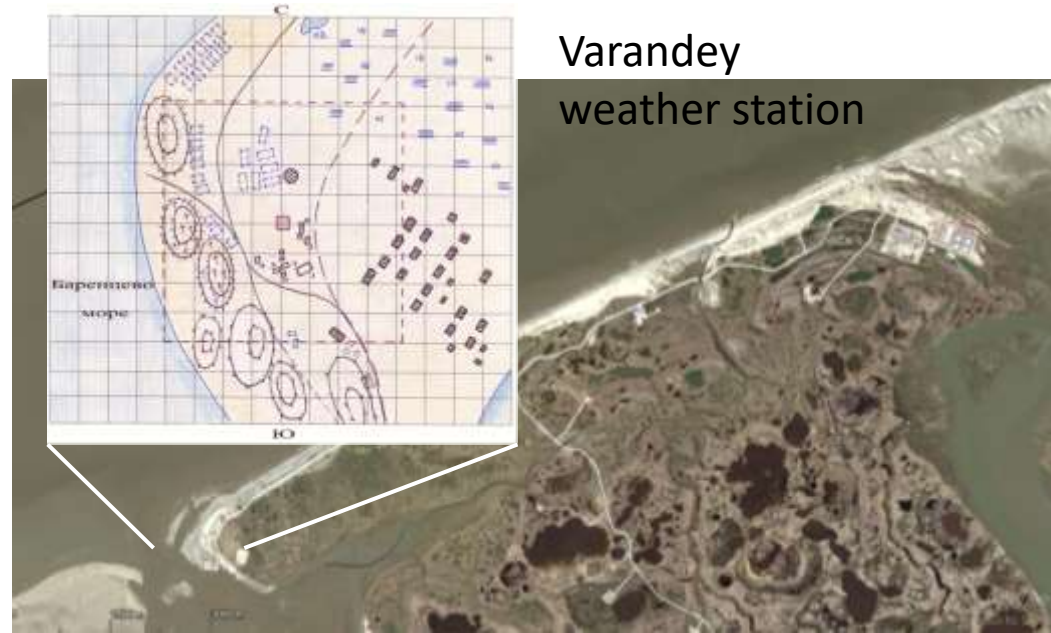
via special agreement on Arctic coast monitoring

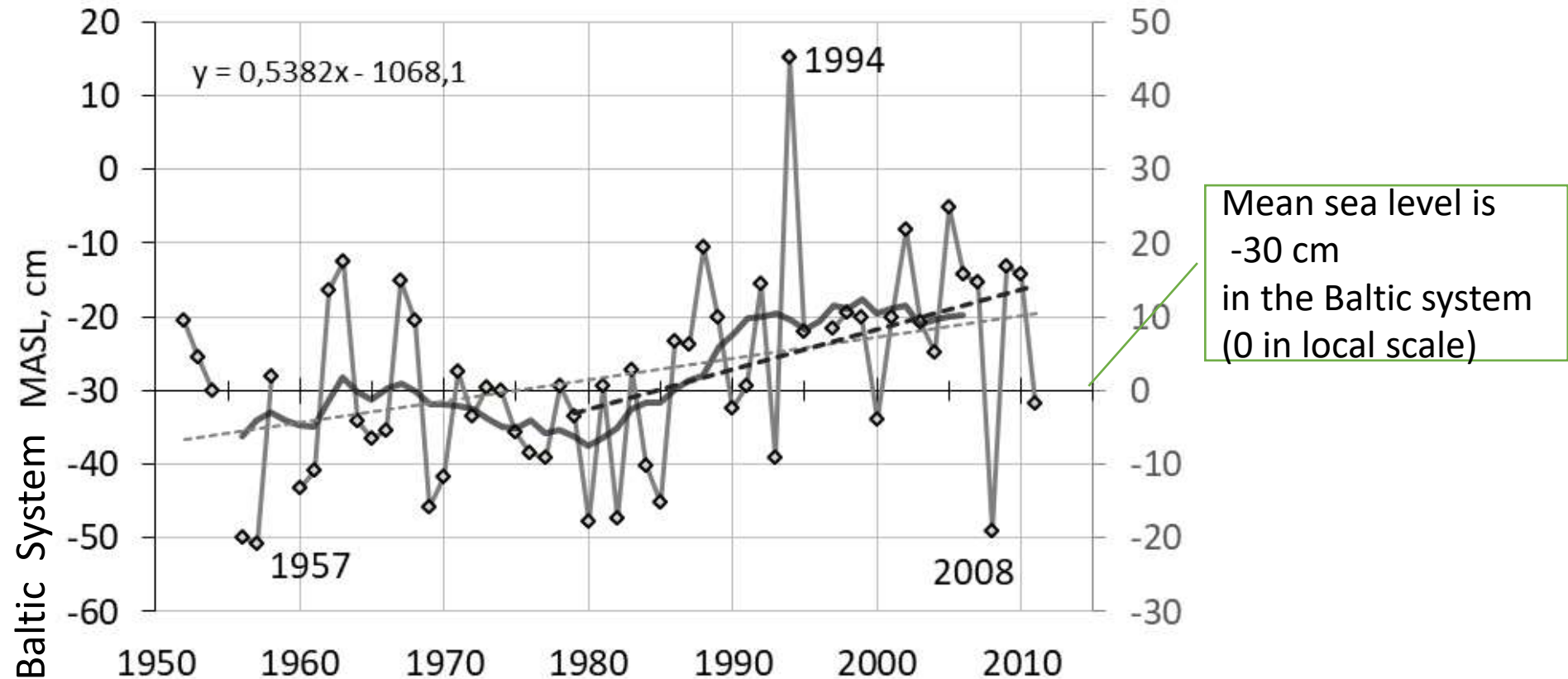
Period: 1951 – 2011 (2011 - the final year of the agreement

1955 – the start of Varandey observation)

4 times per day during the ice-free period

In Total: 58652 measurements
from -185cm up to 358cm
in Baltic System



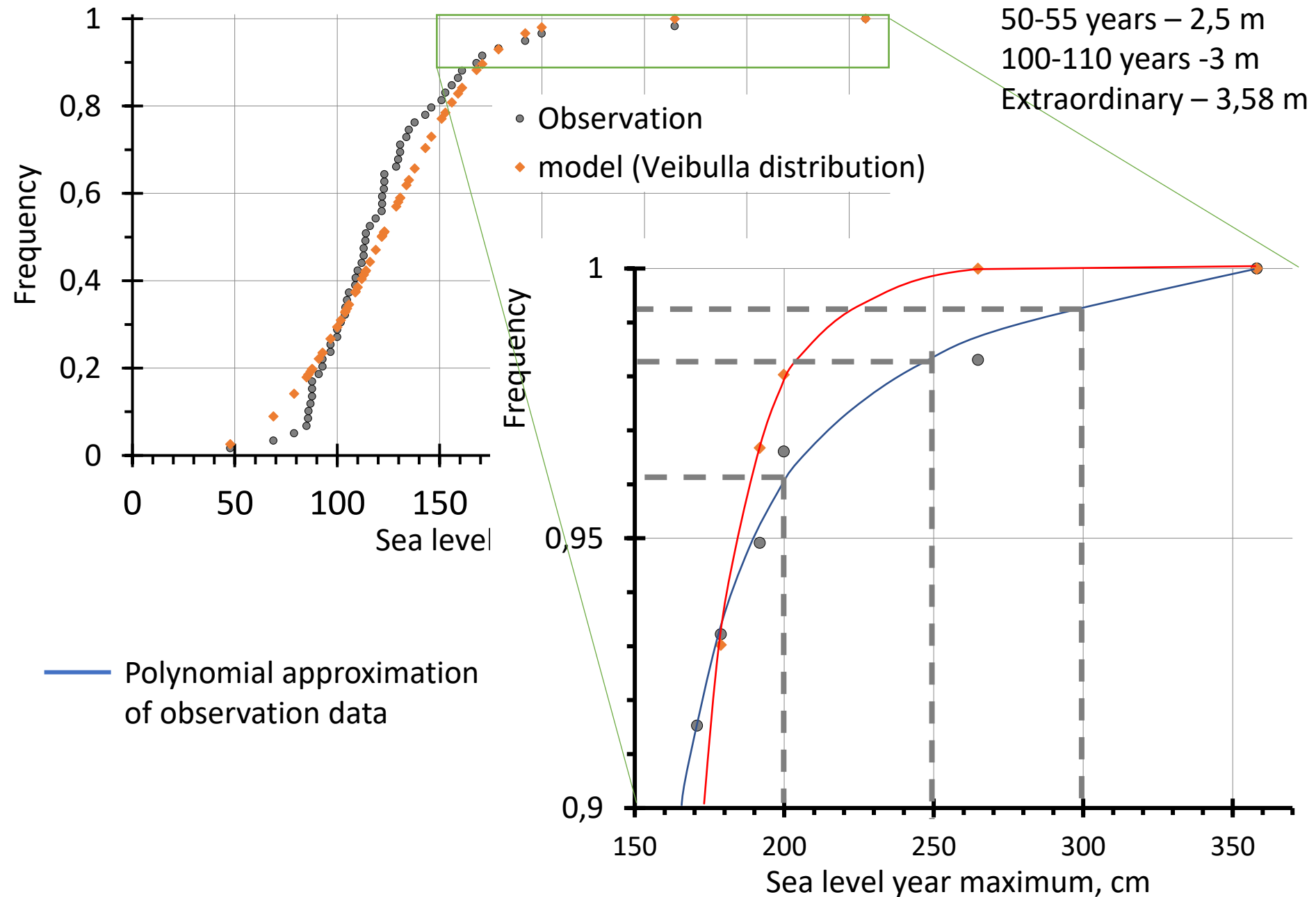


Sea level rise is about **0.5 cm per year**, which means that it has risen by about 15 cm since the minimum of 1980s

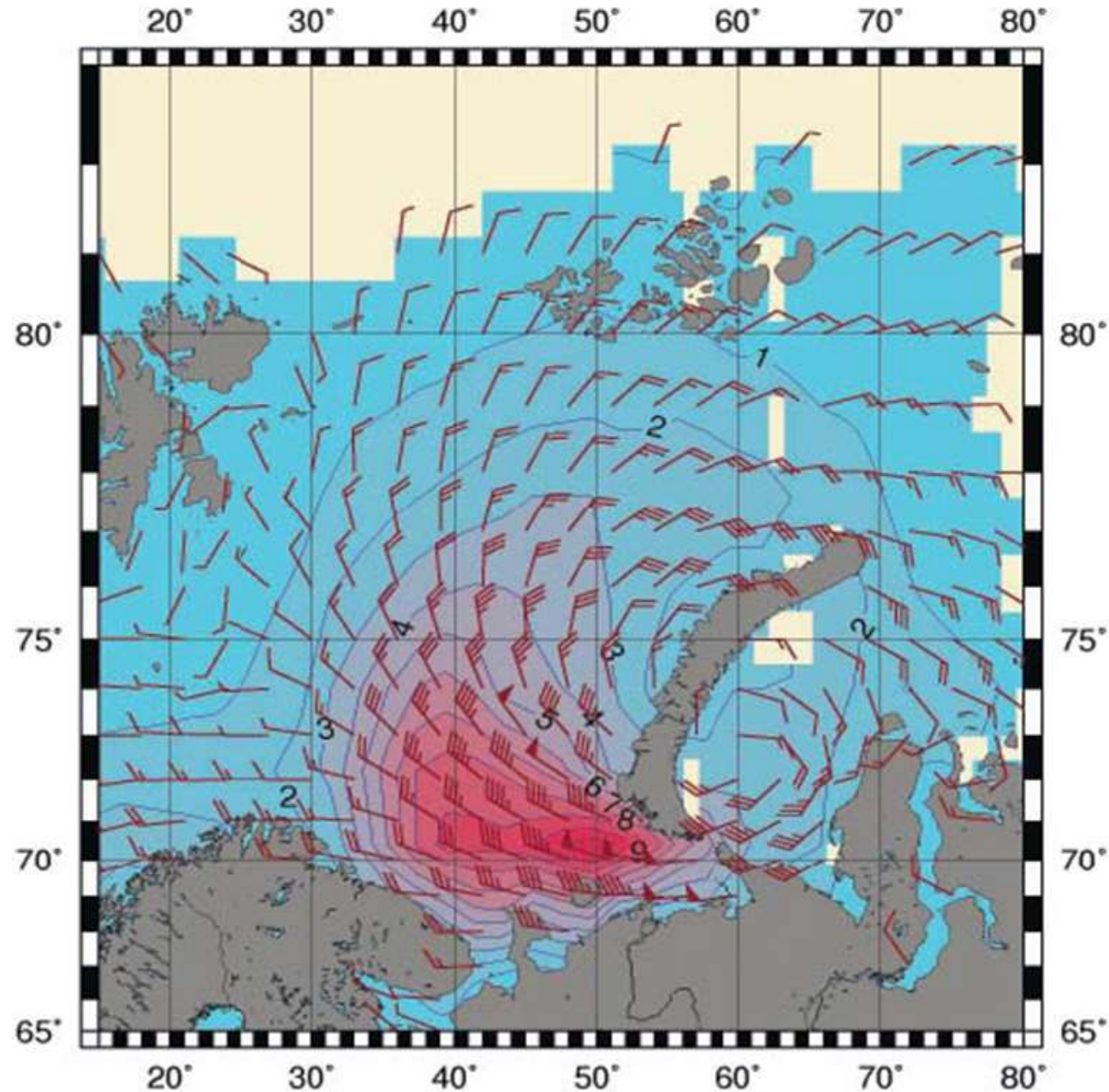
If the rate is still the same, then it is about **22cm up to 2024**

***MASL** – mean annual sea level

Sea level Year maximums distribution



Wind and wave heights of 13% sufficiency on June 24, 2010 (Review of hydrometeorological conditions ..., 2010, Arctic and Antarctic Research Institute)

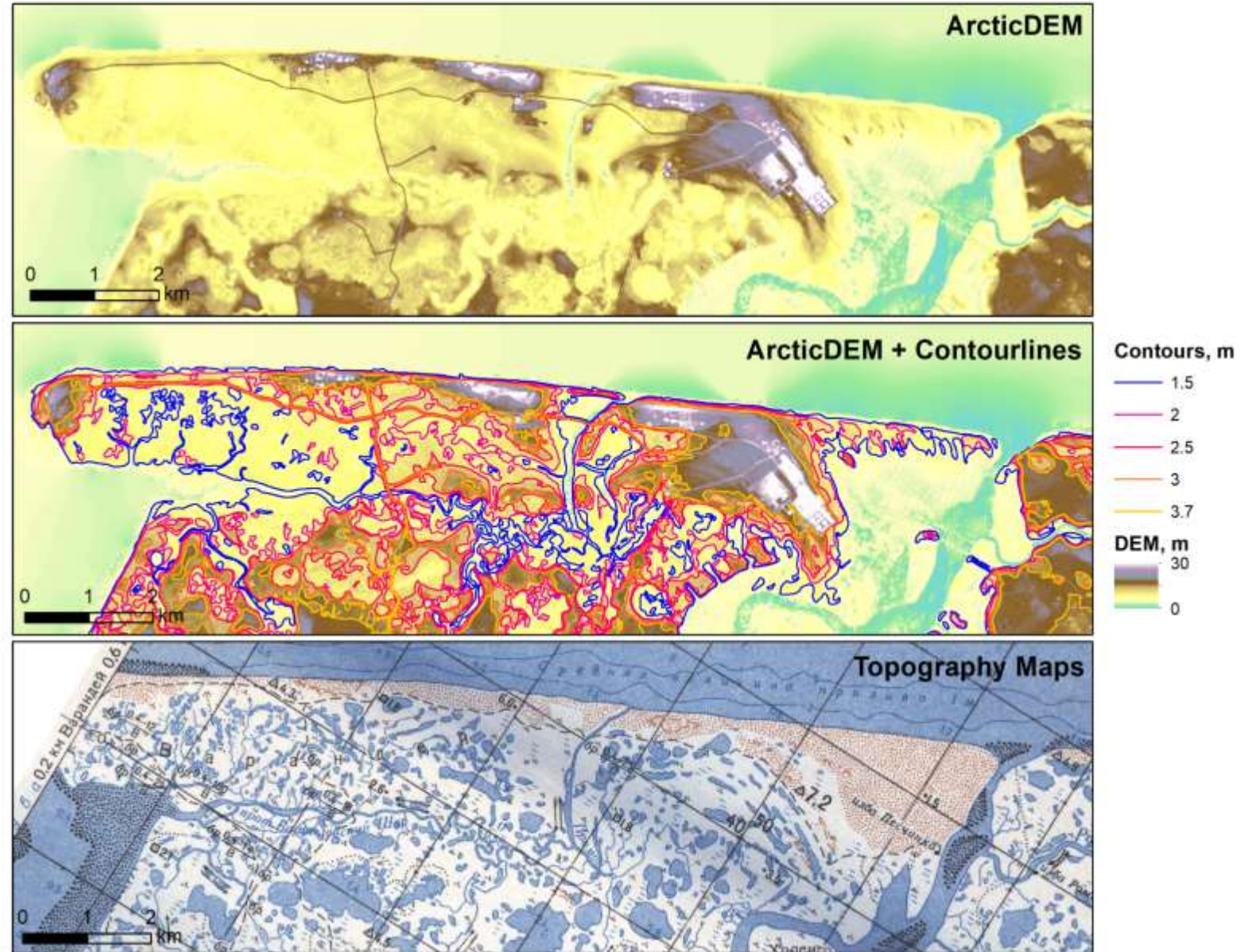


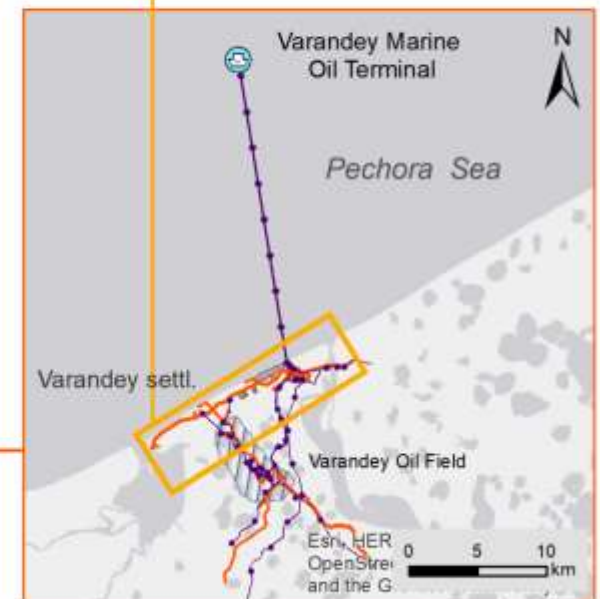
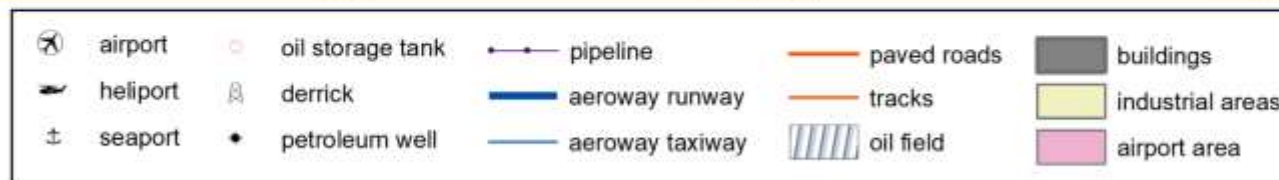
WNW and W winds
up to 28 m/s

Significant wave height
up to 10 m

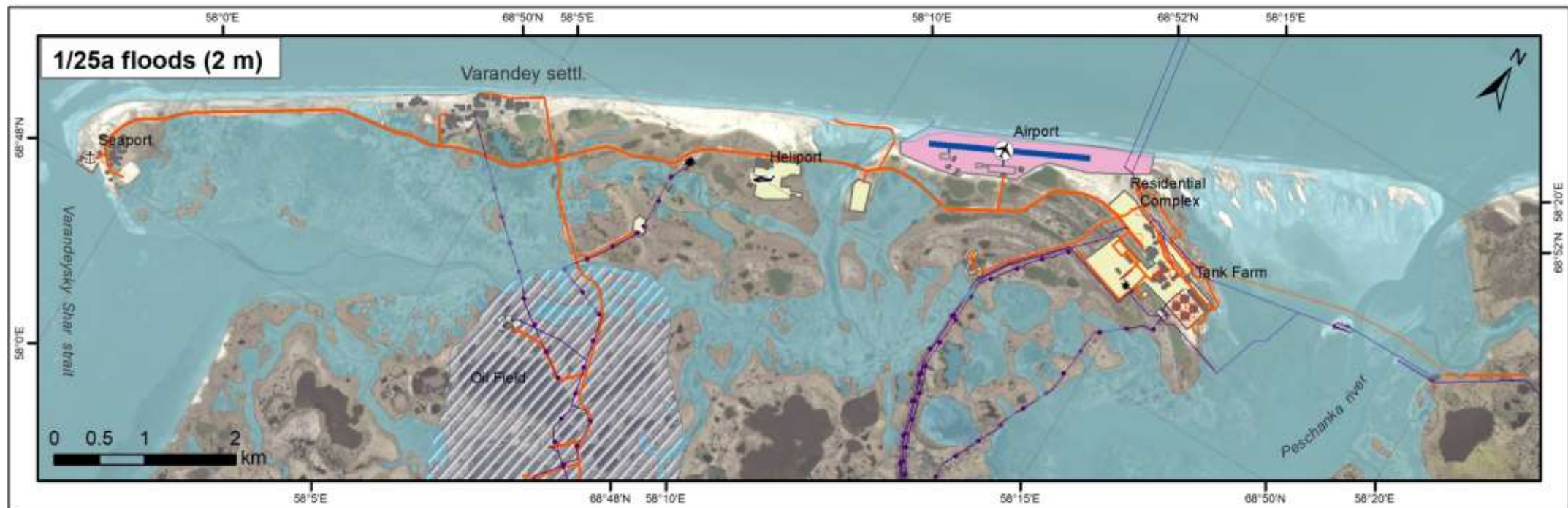
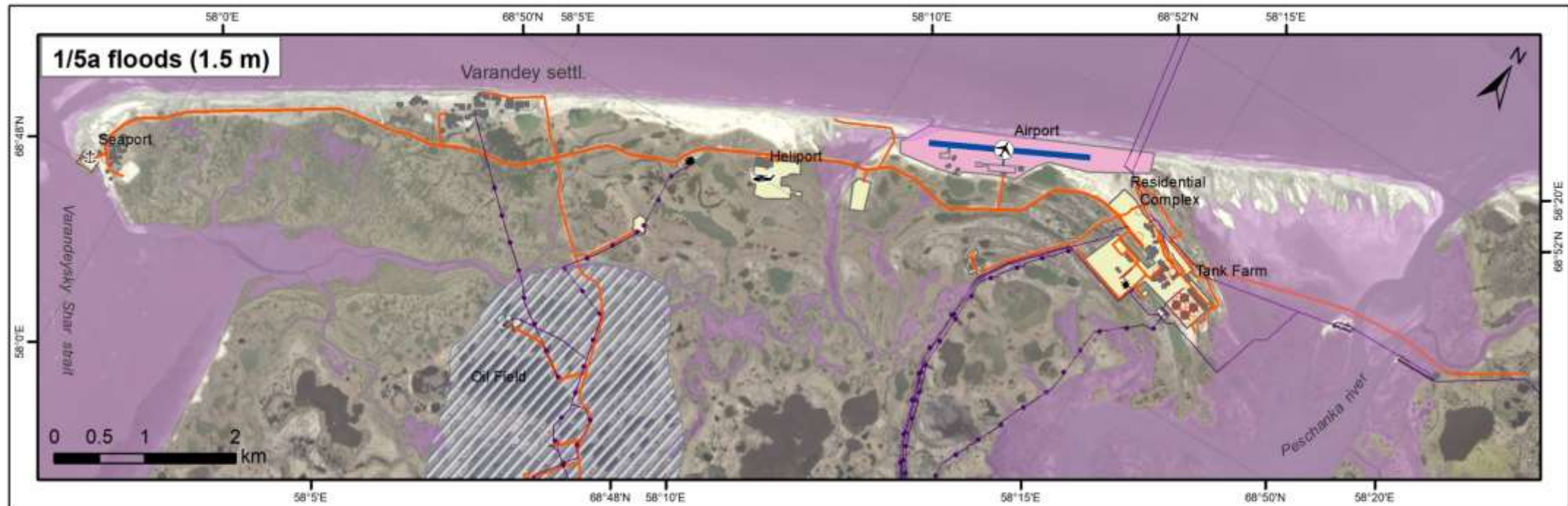
Materials & Methods

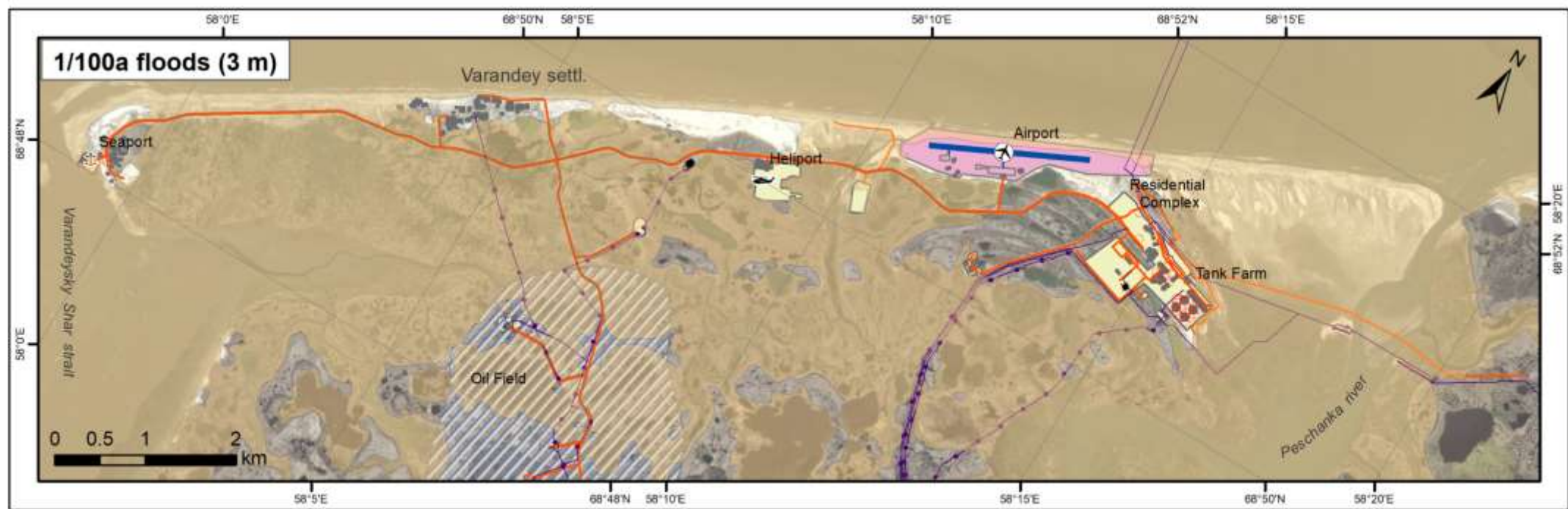
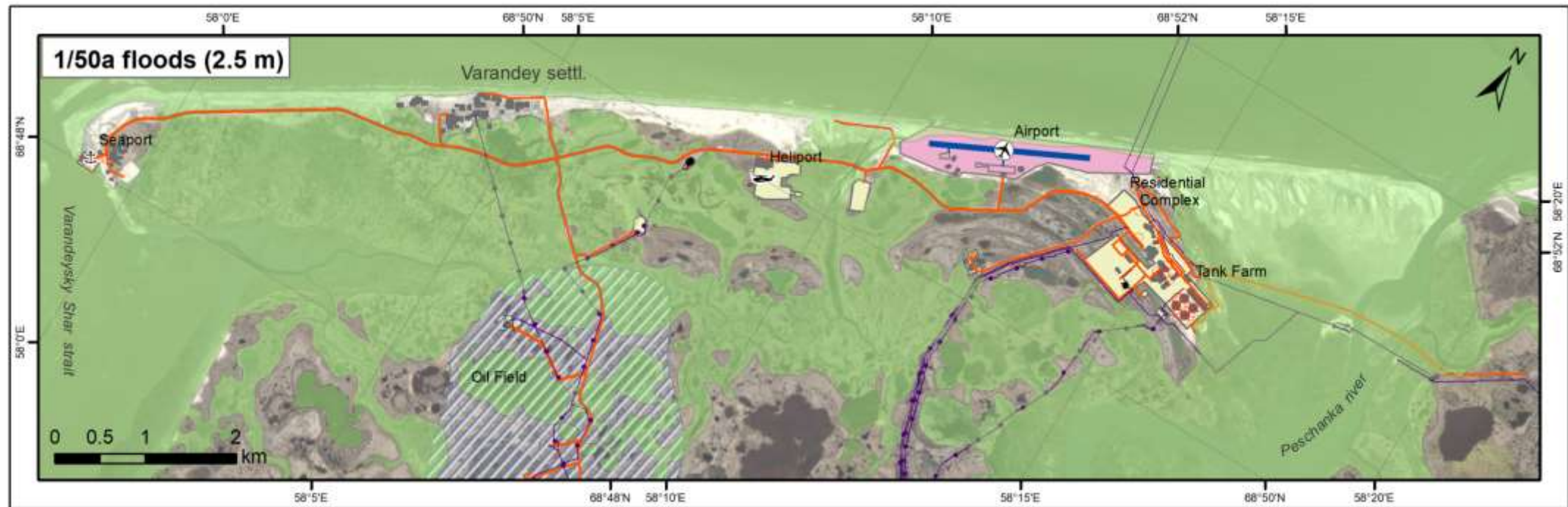
- Elevation model was extracted from ArcticDEM [Polar Geospatial Center],
- corrected with topography maps 100k
- Infrastructure data – from OpenStreetMaps
- Satellite image – from YandexMaps
- Spatial analysis performed in ESRI ArcGIS

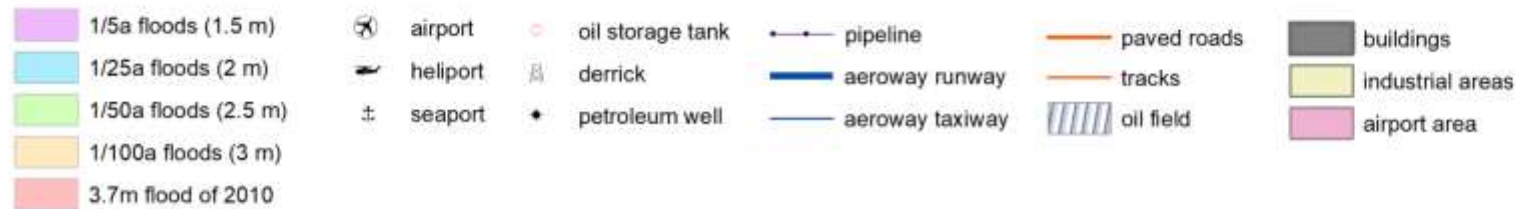
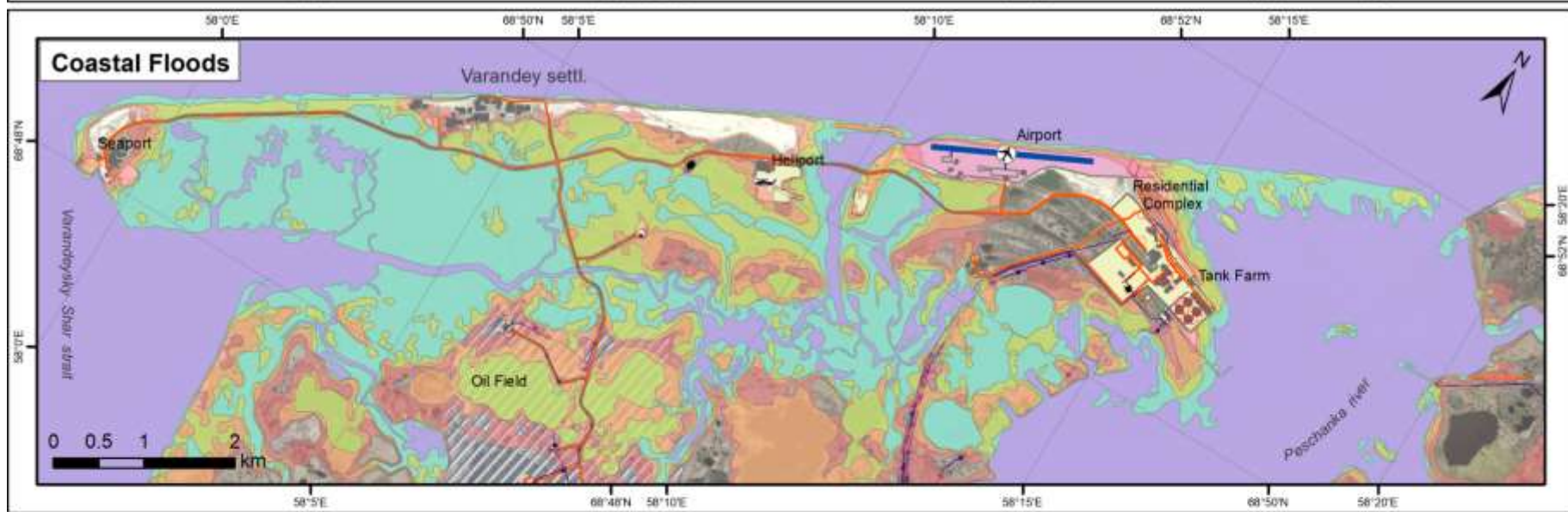
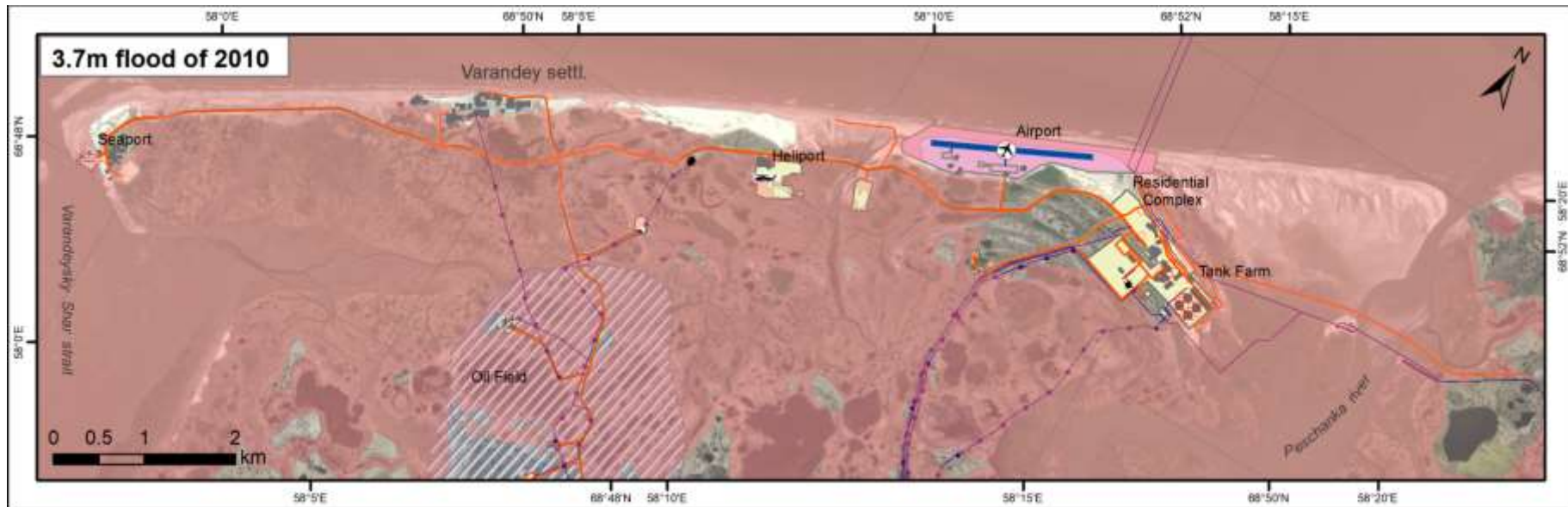




Study Area Location







flooded by	points	buildings	industrial areas
1.5m surge			1 near Peschanka river
2m surge		2 near Peschanka river	+ 1 at the Heliport + 1 at the Seaport
2.5m surge	1 crane in the Seaport	+ 2 near Peschanka river	+ 4 at the Residential Complex and near the Oil Field
3m surge	+ 2 oil storage tanks in the Seaport	+ 3 in Varandey settlement and at the Oil Field	+ 1 between the Airport and Varandey settlement
3.7m surge	+ 1 oil storage tank in the Seaport	+ 24 in Varandey settlement, at the Oil Field, Residential Complex, Heliport, Seaport	+ 2 at the Residential Complex and within the Oil Field

roads flooded by	length flooded, m	% flooded
1.5m surge	2939.197	4.4
2m surge	3072.2552	4.6
2.5m surge	4292.7261	6.4
3m surge	6200.7511	9.2
3.7m surge	13224.601	19.7
all roads	67256.9	100.0

Industrial areas flooded by	area flooded, sqm	% flooded
1.5 m surge	135.0956	0.01
2 m surge	447.73846	0.03
2.5 m surge	9715.8837	0.63
3 m surge	68793.91248	4.46
3.7 m surge	189218.4463	12.28
all area	1541183.72	100.00

In the event of a storm surge with a probability of 1/100, fixed assets with a replacement cost of approximately \$8 million (in 2024 prices) will be in the flood zone.

Conclusions

1. Sea level observation data for the period 1951-2013 from the Varandey weather station were processed, and the dates of extreme storm surges were identified.
2. Storm surge levels of varying probabilities were superimposed on a Digital Elevation Model. Flood zones under extreme scenarios and economic facilities located within their boundaries have been identified.
3. In the event of a storm surge with a probability of 1/100, fixed assets with a replacement cost of approximately \$8 million (in 2024 prices) will be in the flood zone. The amount of indirect losses is estimated at about \$ 140 million.

Contacts



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Thank you for your attention!