Skolkovo Institute of Science and Technology
High Performance Python Lab

# Final Project

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# Climate risks assessment

**The goal** is to develop a software for calculating the probability map of the occurrence of extreme natural events

**The motivation** is to reduce the economic risks associated with extreme weather events:

- Credit and investment risks
- Calculation of insurance reserves
- Corporate insurance risks

Meteorological

Hydrocreological

Climatic

# Extreme wind

High wind speed bears a physical risk to companies' assets:

- risk for buildings and structures
- risk for staff

## Weather Takes Out Key Oil Terminal on Russia's Black Sea Coast

## BEAUFORT WIND SCALE

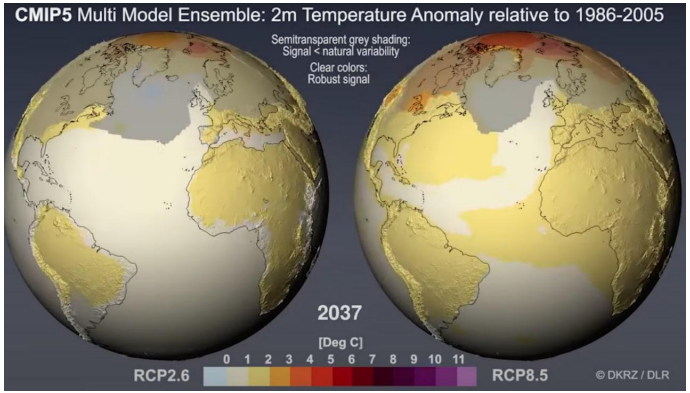
| Beaufort Number | Description | Wind speed | Wave height | Sea conditions | Land conditions |
|---|---|---|---|---|---|
| 0 | Calm | < 1 knot<br>< 1 mph<br>< 2 km/h | 0 ft<br>0 m | Sea like a mirror | Smoke rises vertically |
| 1 | Light air | 1–3 knots<br>1–3 mph<br>2–5 km/h | 0–1 ft<br>0–0.3 m | Ripples | Direction shown by smoke drift |
| 2 | Light breeze | 4–6 knots<br>4–7 mph<br>6–11 km/h | 1–2 ft<br>0.3–0.6 m | Small wavelets | Wind felt on face |
| 3 | Gentle breeze | 7–10 knots<br>8–12 mph<br>12–19 km/h | 2–4 ft<br>0.6–1.2 m | Large wavelets | Leaves and small twigs in constant motion |
| 4 | Moderate breeze | 11–16 knots<br>13–18 mph<br>20–28 km/h | 3.5–6 ft<br>1–2 m | Small waves | Raises dust and loose paper |
| 5 | Fresh breeze | 17–21 knots<br>19–24 mph<br>29–38 km/h | 6–10 ft<br>2–3 m | Moderate waves | Small trees and leafs begin to sway |
| 6 | Strong breeze | 22–27 knots<br>25–31 mph<br>39–49 km/h | 9–13 ft<br>3–4 m | Large waves | Large branches in motion |
| 7 | High wind, moderate gale, near gale | 28–33 knots<br>32–38 mph<br>50–61 km/h | 13–19 ft<br>4–5.5 m | Sea heaps up | Whole trees in motion |
| 8 | Gale, fresh gale | 34–40 knots<br>39–46 mph<br>62–74 km/h | 18–25 ft<br>5.5–7.5 m | Moderately high waves | Twigs break off trees |
| 9 | Strong/severe gale | 41–47 knots<br>47–54 mph<br>75–88 km/h | 23–32 ft<br>7–10 m | High waves | Slight structural damage |
| 10 | Storm, whole gale | 48–55 knots<br>55–63 mph<br>89–102 km/h | 29–41 ft<br>9–12.5 m | Very high waves | Trees uprooted, considerable structural damage |
| 11 | Violent storm | 56–63 knots<br>64–72 mph<br>103–117 km/h | 37–52 ft<br>11.5–16 m | Exceptionally high waves | Widespread damage |
| 12 | Hurricane force | ≥ 64 knots<br>≥ 73 mph<br>≥ 118 km/h | ≥ 46 ft<br>≥ 14 m | Exceptionally high waves, sea is completely white | Devastation |

# Data

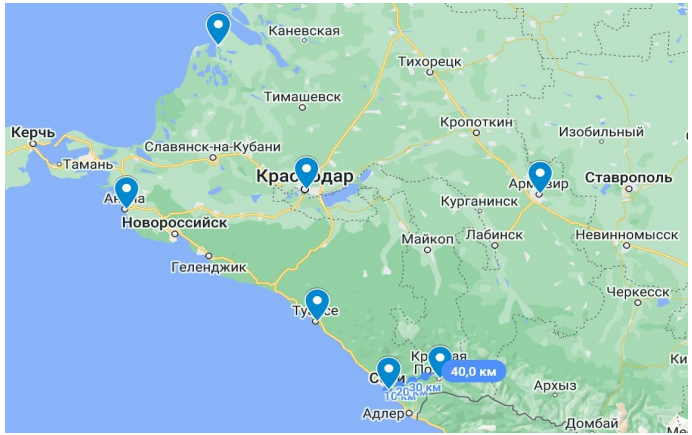
- CMIP
  - Climate model
  - Daily temperature, precipitation, wind speed
  - Boxes 0.25° x 0.25° - **pixel**

- RusHydroMet
  - 521 weather stations
  - Average wind speed, gusts, temperature, precipitation, soil moisture, etc
  - 8 measurements per day
  - Measurements since ~1965

Climate evolution according to the CMIP




Weather station locations in Krasnodarskiy Kray

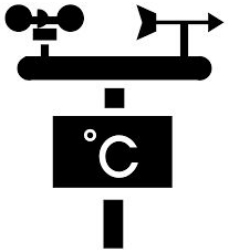


# Forecasting the probability of a strong wind

Training on pairs:
weather station neighbourhood
+
existence of strong wind

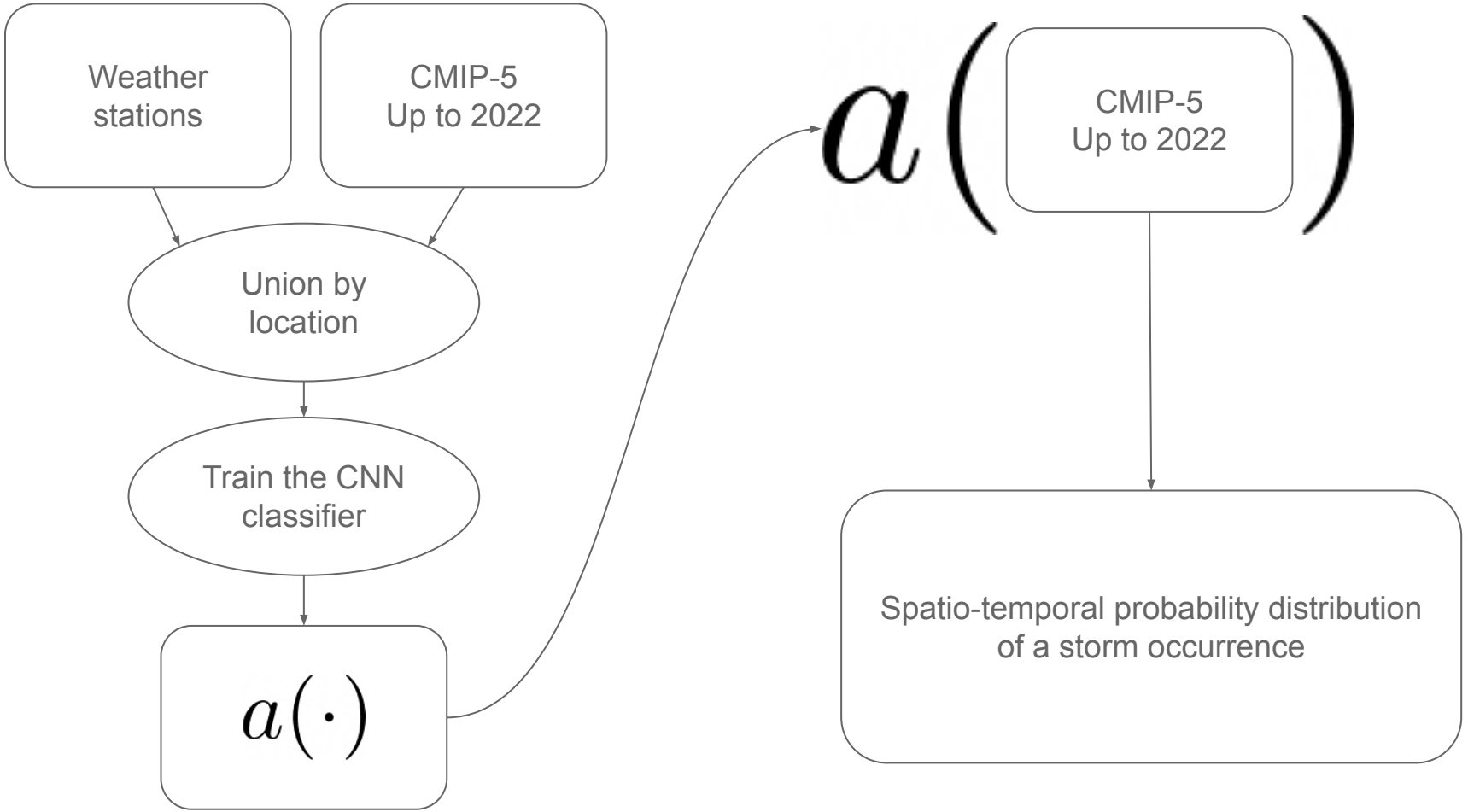
→

Retrieve the probability of
wind speed > 20, 30, … m/s




- Weather station neighbourhood – geographically close **pixels**
- Pixels contain model climate data from CMIP
- Data from weather stations contain existence of strong wind
- Model returns the probability of strong wind by location

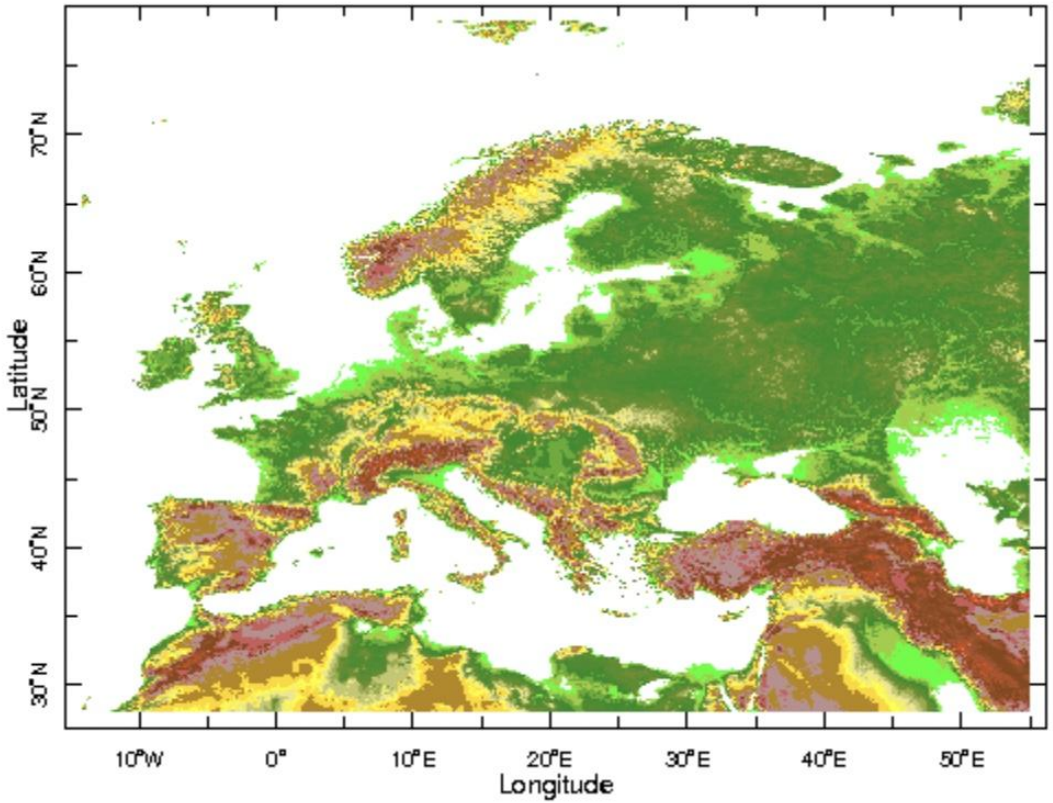
Weather station coverage of Russia


Weather stations
CMIP-5 Up to 2022
Union by location
Train the CNN classifier
$a(\cdot)$
$a($
CMIP-5 Up to 2022
$)$
Spatio-temporal probability distribution of a storm occurrence

# Elevation data

The worldwide elevation data at a lower resolution of 0.001 degrees is integrated into the model

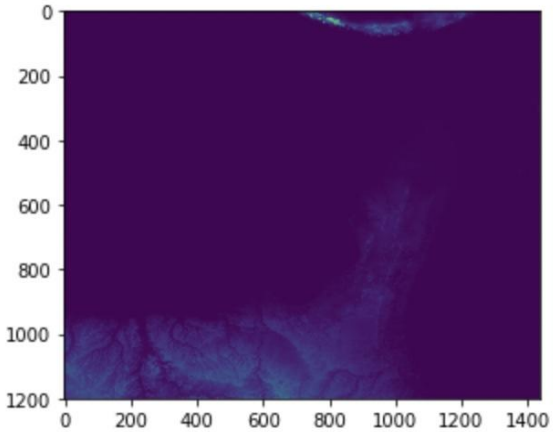
The lower resolution data is more informative

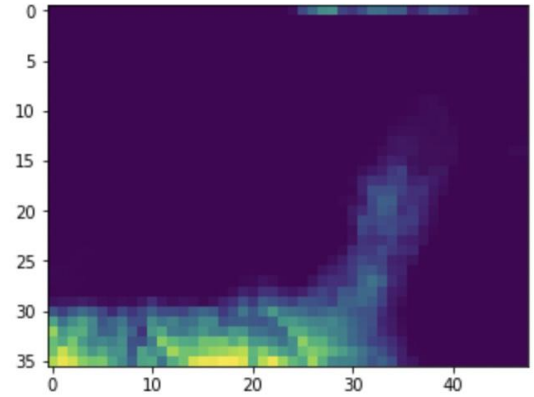


# Resolution increase

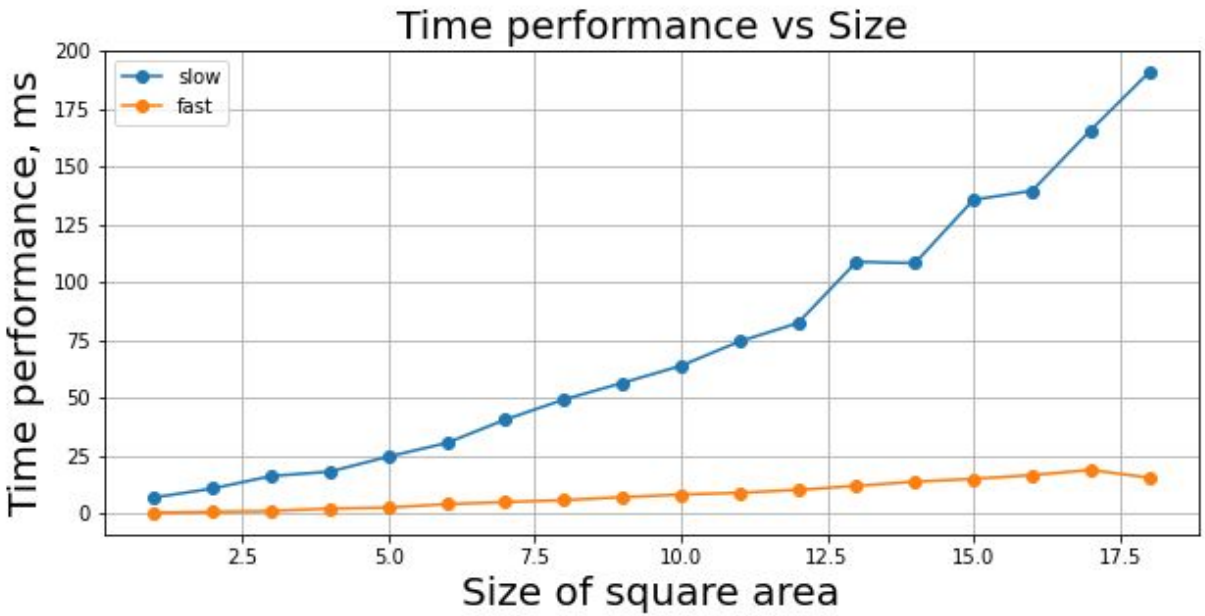
Elevation data requires increasing of resolution

Example of data processing for Florida for the case of aggregation by mean value is shown



# Speedup with Numba



# We welcome you to the discussion