# Identifying mechanisms of low-level jets near coast of Kurzeme using Principal Component Analysis

**M. Pogumirskis**, **T. Sīle, U. Bethers.** University of Latvia. Email: maksims.pogumirskis@lu.lv

## Low-level jets

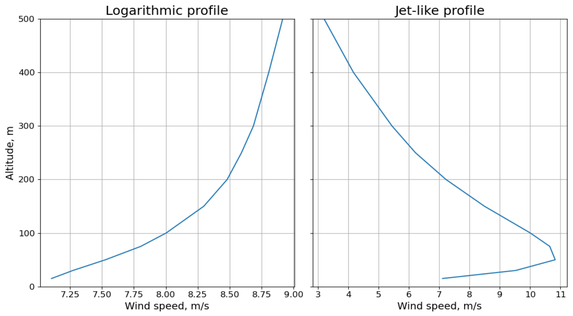
Normal wind speed vertical profile can be described using logarithmic relation. In case of low-level jets there is a local maxima in the vertical wind speed profile. Maxima of low-level jets near coast of Kurzeme (western region of Latvia) is tipically within the lowest 100 metres of the atmosphere. Low-level jets can cause uneven load on wind turbine rotors that could lead to their damage.

## Motivation

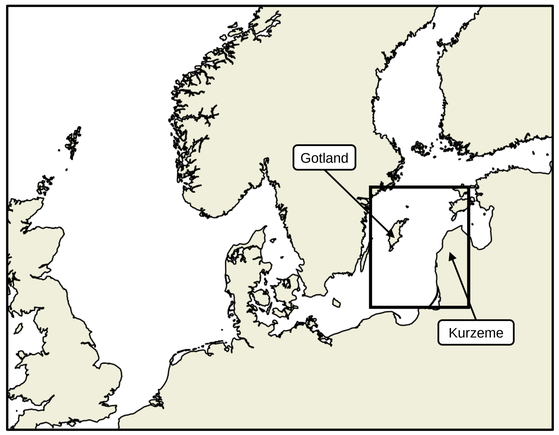
Baltic sea is a semi-enclosed sea which is a favourable location for low-level jets to form. Studies have estimated that over the Baltic Sea low-level jets are present up to 50% of the time during the spring. This work focuses on part of the Baltic Sea near the coast of Kurzeme. Recent studies have identified presence of low-level jets in the region. Aim of this study is to gain better understanding about climatology and mechanisms of low-level jets in the region.

## Data

- UERRA reanalysis
- 11x11 km spatial resolution, 6h temporal resolution
- Study period between 1977 and 2017
- 12 vertical levels between 10m and 500m



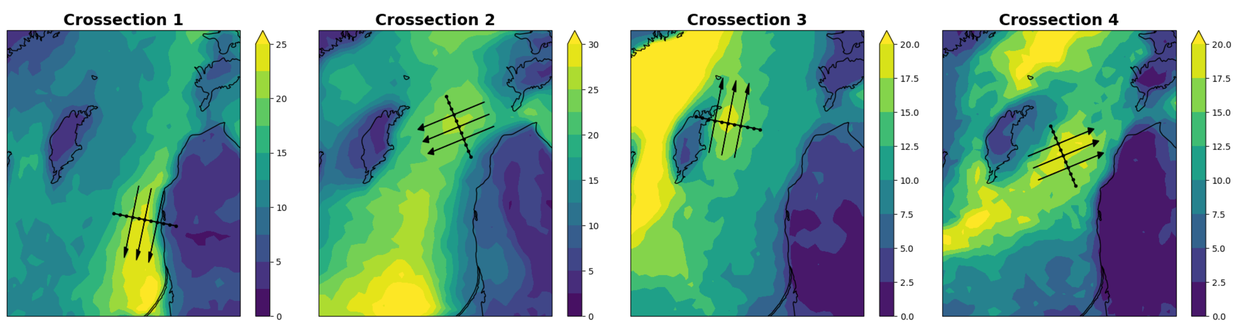

Examples of logarithmic (left) and jet-like (right) vertical wind speed profiles




Region of study

## Locations of low-level jets

Low-level jet events can be identified automatically by searching for a maxima in the vertical wind speed profile. Such approach was used to estimate frequency of low-level jets in the region. Additionally, low-level jet events were grouped by the wind direction to identify main trajectories of low-level jets. However, low-level jets can be caused by a number of different mechanisms, which can not be identified by inspecting the wind speed profile alone. To identify these mechanisms, several vertical crossections of atmosphere, that low-level jets frequently flow through, and additional meteorological parameters were chosen for further analysis.




Frequency (in %) of low-level jet events when wind is blowing from the particular direction in May.
Analysed cross sections and directions of low-level jet flow are also shown.

## Principal Component Analysis (PCA)

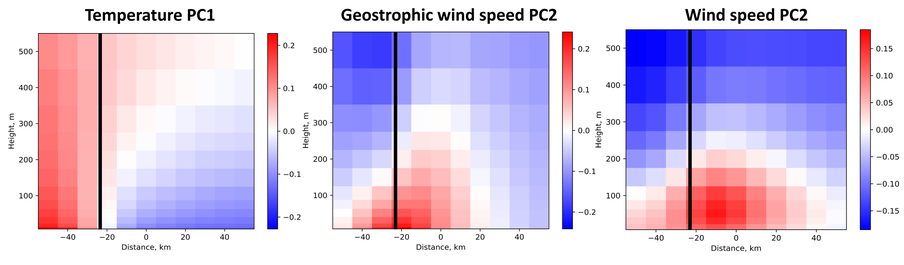
Typically, humans are necessary to analyse the meteorological situation and determine the mechanisms causing low-level jets. In this work a machine-learning based approach is used to automatically identify mechanisms of low-level jets during the entire period of study. PCA was applied to time series of vertical cross section data of air temperature, wind speed and geostrophic wind speed. Principal Components (PC) describing main spatial patterns of these meteorological variables were identified. By combining PCs from multiple meteorological variables mechanisms of low-level jets can be described.

**PC of temperature:**
Red – higher temperature
Blue – lower temperature

**PC of (geostrophic) wind speed:**
Red – higher wind speed
Blue – lower wind speed

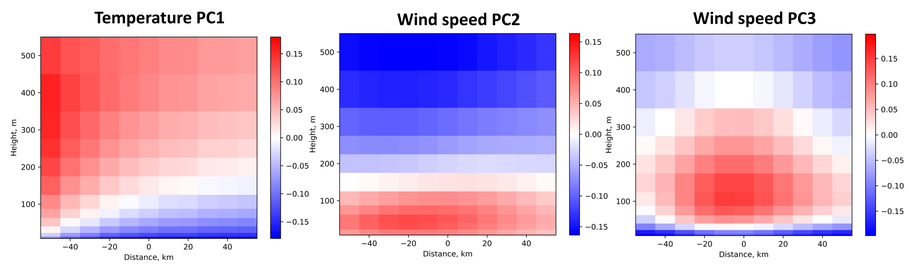
## Coastal low-level jets (Crossection 1)

(land is located left of the black vertical line)




PC1 for temperature indicates higher temperature over the land and lower temperature over the sea. From thermal wind relation that leads to higher geostrophic wind speed near the surface at the coastline, which is indicated by PC2 of geostrophic wind speed. However, due to friction force highest wind speed is a little higher, which is indicated by PC2 of wind speed.

## Low-level jets due to temperature inversion (Crossection 2)




PC1 for temperature indicates lower temperature near the surface of sea and higher temperature in the higher levels of atmosphere or so called temperature inversion. When air flow with temperature inversion faces a change in the surface roughness, a jet forms.
For wind speed PC2 indicates higher wind speed in the lowest 100m and PC3 indicates higher wind speed between 100m and 200m. By combining these two Principal Components, low-level jets at different heights can be described.

## Conclusions

- Presence of coastal low-level jets was identified near western coast of Kurzeme (Crossection 1) and near eastern coast of Gotland (Crossection 3).
- Presence of low-level jets caused by the temperature inversion was identified both near coast of Kurzeme (Crossection 2) and near Gotland (Crossection 4).
- Presence of low-level jets caused by the advection of warm air masses both from coast of Kurzeme (Crossection 2) and from Gotland (Crossection 4) was identified in the Baltic proper.
- Results of this work can help to identify events of low-level jets, which can be further analysed using satelite scatterometry data and mesoscale numerical modelling.