



# Atmospheric science research for numerical weather prediction and climate modeling in Slovenia: contribution of the PECS program



Matic Šavli, Žiga Zaplotnik, Veronika Hladnik, Gregor Skok and  
Nedjeljka Žagar, *University of Ljubljana, Slovenia*

# Atmospheric science research at UL-FMF

- UL-FMF is offering the only meteorology education in Slovenia at both undergraduate and graduate levels.
- Meteorology group at UL-FMF is carrying out research ranging from global dynamics, data assimilation, numerical weather prediction and air quality modelling to the precipitation verification.
- The group has strong ties with the national weather service ARSO and an active collaboration with a number of leading institutes across Europe and USA (e.g. ECMWF, NCAR).
- PECS projects contributed to the growth of the group, in addition to the European funds (the first Slovenia ERC project, MODES) and bilateral funds.

# PECS Slovenia program at UL-FMF: atmospheric sciences

**1. “Mesoscale wind profiles and data assimilation for numerical weather prediction”, Contract no. 4000103953**

**Period:** 2012-2016

**Staff:** Matic Šavli and Nedjeljka Žagar

**2. “Multivariate Relationships between the Aerosols, Moisture and Winds in Four-Dimensional Data Assimilation for the Global Monitoring for Environment and Security”, Contract no. 4000106730**

**Period:** 2014-2016

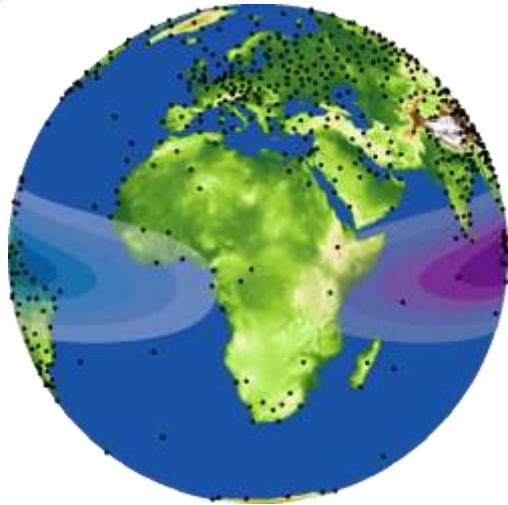
**Staff:** Žiga Zaplotnik and Nedjeljka Žagar

**3. “Analysis and verification of mid-latitude cyclonic system prediction in ERA-Interim reanalysis using satellite-derived precipitation measurements”, Contract no. 4000106865**

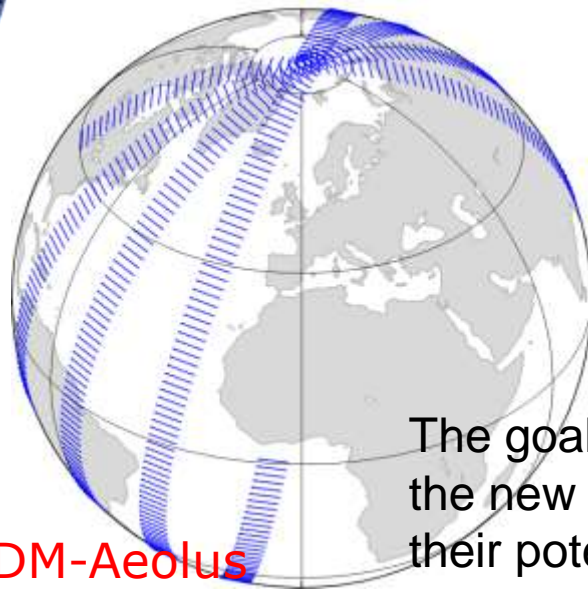
**Period:** 2014-mid 2016

**Staff:** Veronika Hladnik and Gregor Skok

# Wind observations are needed to improve weather forecast everywhere



12-hr radiosondes measurements



6-hr ADM-Aeolus measurements

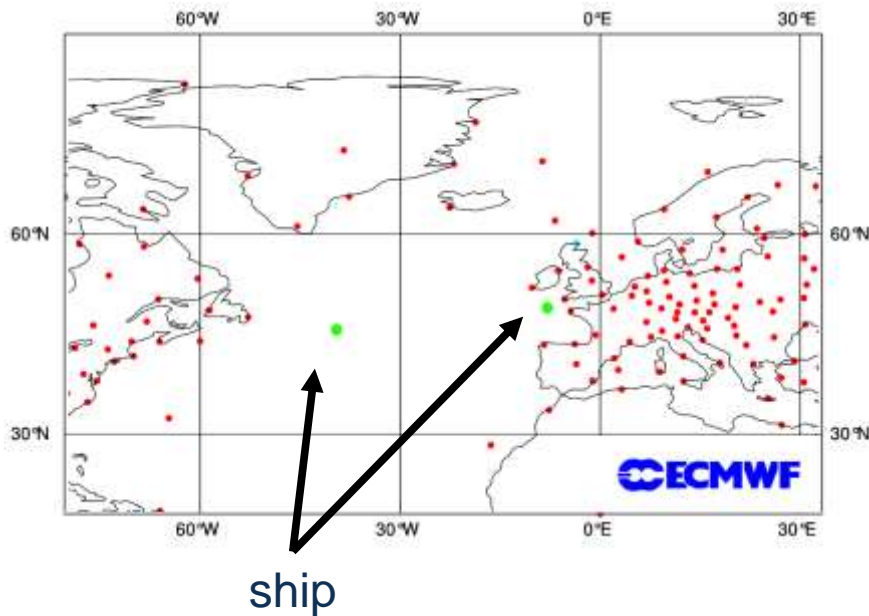
<http://www.esa.int/esaLP/LPadmaeolus.html>



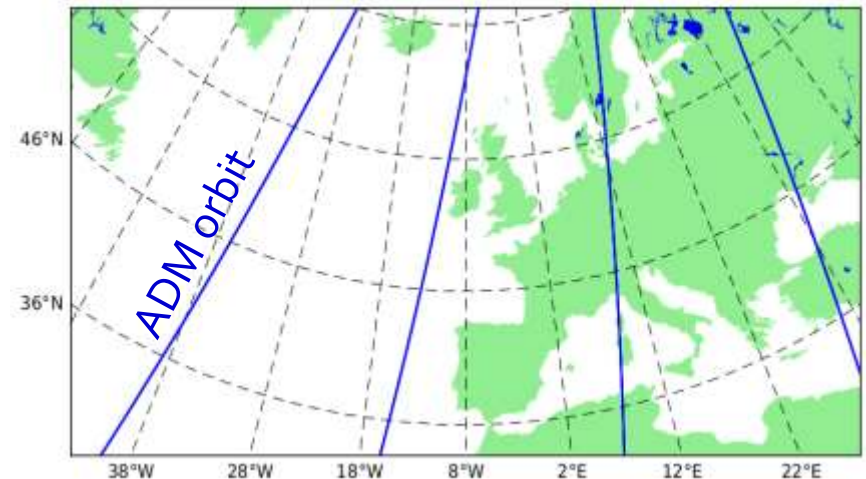
The goal of our work is to implement the new wind profiles and estimate their potential impact in a mesoscale weather forecast model over Europe

# ADM-Aeolus wind profiles for better short-range weather forecasts in Europe

Data coverage (radiosonds)  
8 May 2016 00 UTC

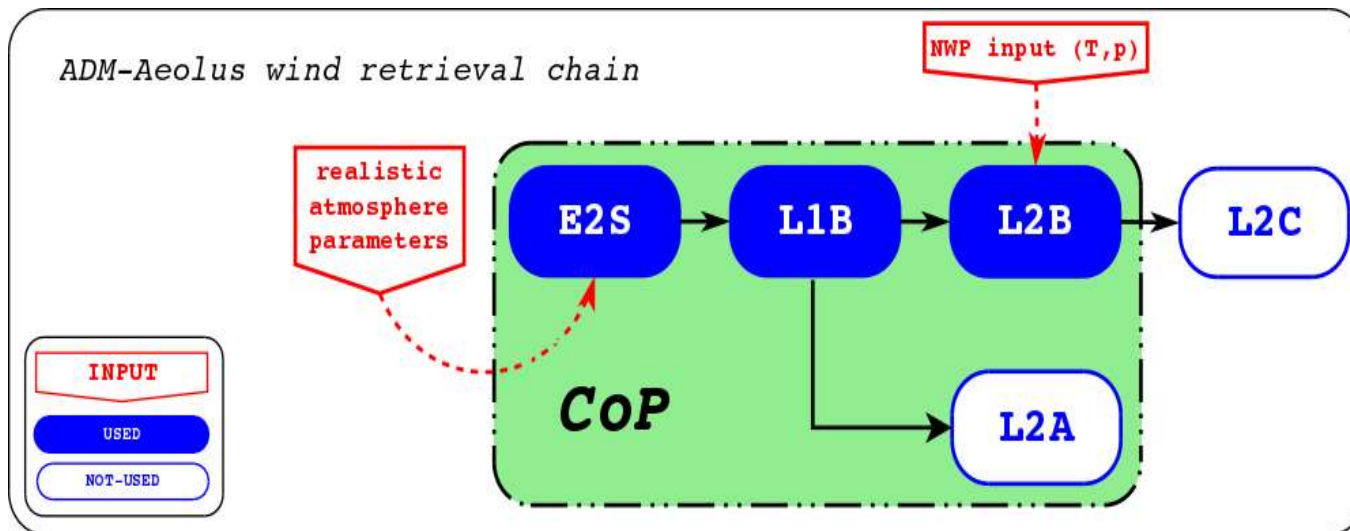


LAM domain of interest



ADM wind profiles over North Atlantic are expected to improve weather over Europe.

# Development of a new forecasting system at UL-FMF using the ADM-Aeolus observations



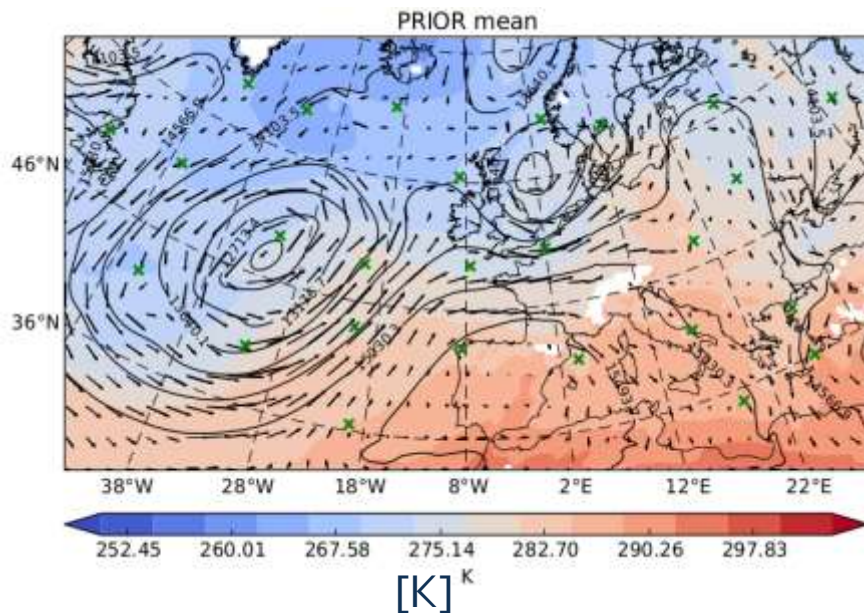
A complete chain-of-software (CoP) E2S-L1bP-L2B to process the observations

We are currently the only group in Europe that has been working with a Aeolus CoP and a mesoscale forecast system

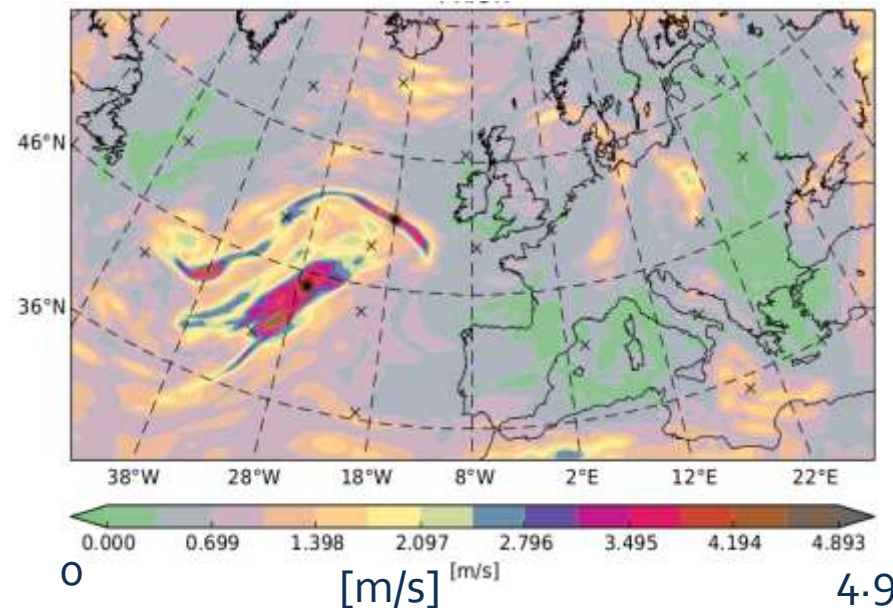


# A modern method for the spatial spread of the impact of new wind observations

Observations are still not dense enough. Their impact needs to be spread in space according to the properties of the errors in the last forecast that has to be improved.



Forecast of circulation



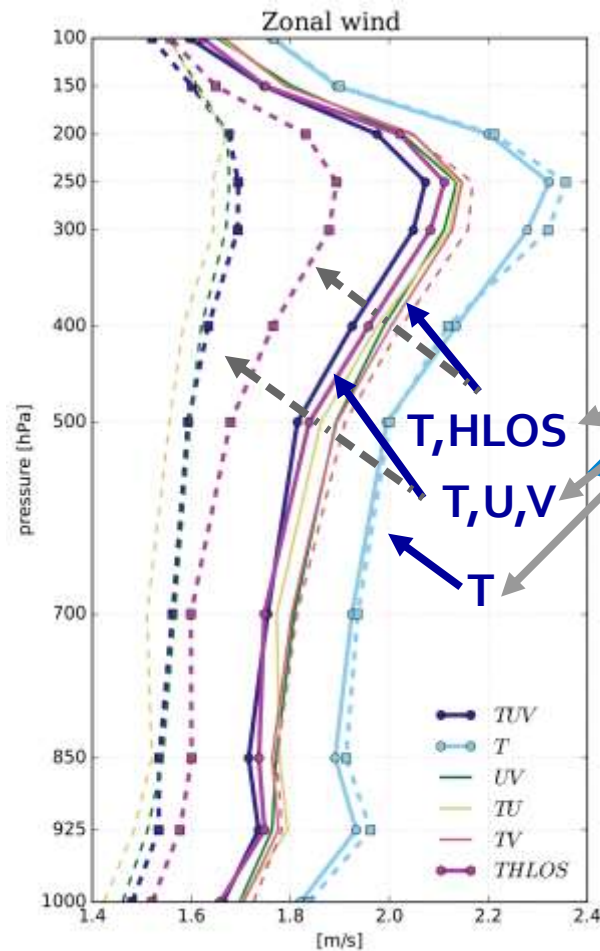
Estimate of forecast errors

# Potential impact of ADM winds

## RMSE

- 6h forecast (solid)
- analysis (dashed)

Forecasts that took into account ADM-Aeolus in their initial conditions profiles are significantly better



Experiments assimilating different types of obs.



# Coupling of the aerosols, moisture and winds in 4D-Var

There is a large amount of observations of atmospheric compositions, primarily from satellites

Currently, there is no feedback from these observations to the analyzed winds. In other words, atmospheric aerosols are primarily treated as passive tracers (unless there is a moisture involved)

**We investigate if and how we can extract wind field information from the spatio-temporal distribution of aerosols**

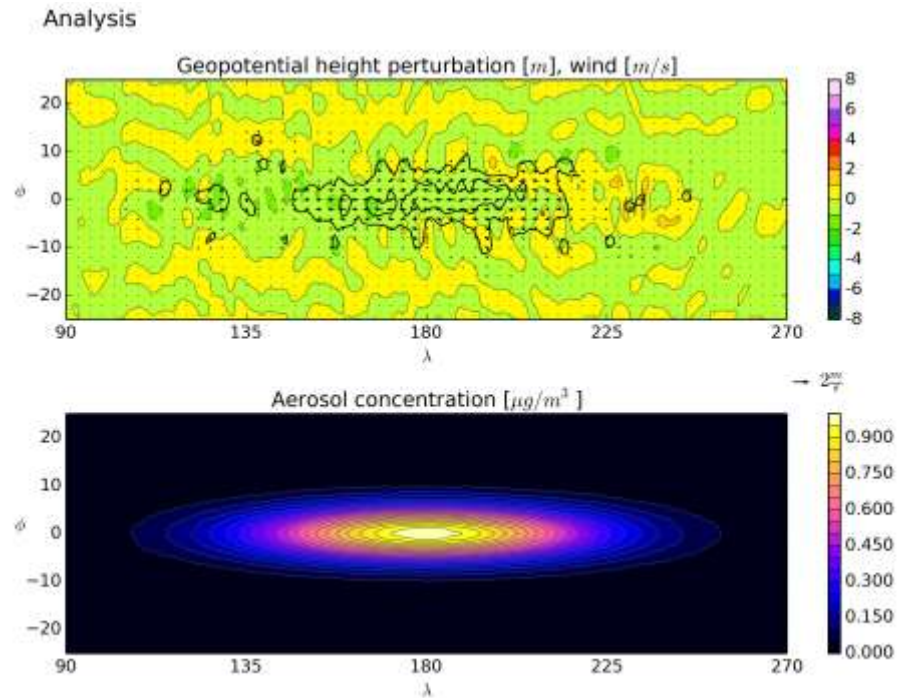


# Coupling of the aerosols, moisture and winds in 4D-Var

**How to estimate winds from the time series of aerosol observations?**

**Challenges:**

- Dynamics that governs the transport is non-linear
- There are large impacts of moisture, e.g. wet deposition of aerosols by precipitation
- We must take Aerosol sources and permanent sinks, e.g. dry sedimentation



Example of results: Extraction of winds from simulated aerosol observations.

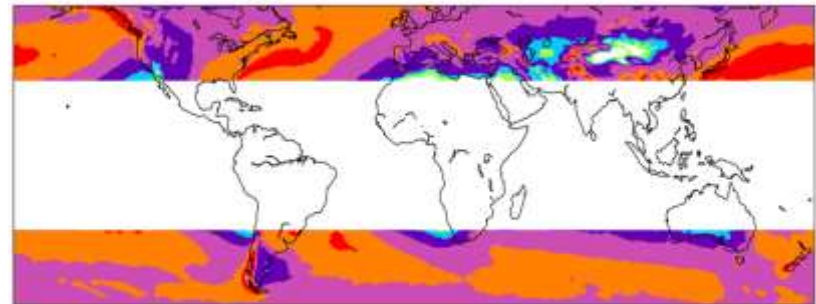
# Quantification of precipitation associated with mid-latitude cyclones

Cyclonic systems and the associated precipitations are extremely important for the day-to-day weather in the mid-latitudes and all weather-related planning (e.g. agriculture, energy sector)

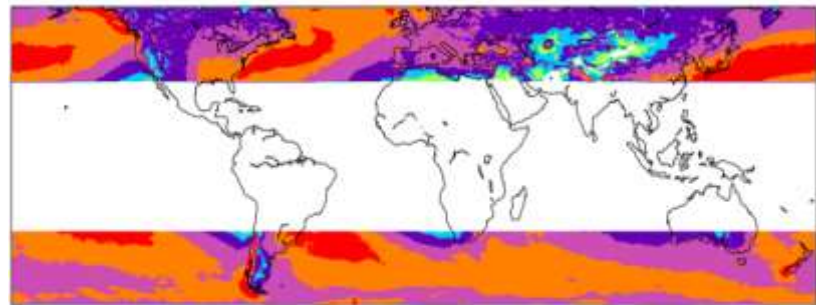
**Project goal:** Quantitative comparison of satellite derived precipitation (CMORPH dataset) and ERA-Interim reanalysis precipitation related to the mid-latitude cyclones.

## *Precipitation climatology: reanalysis*

a) ERAInt average annual precipitation



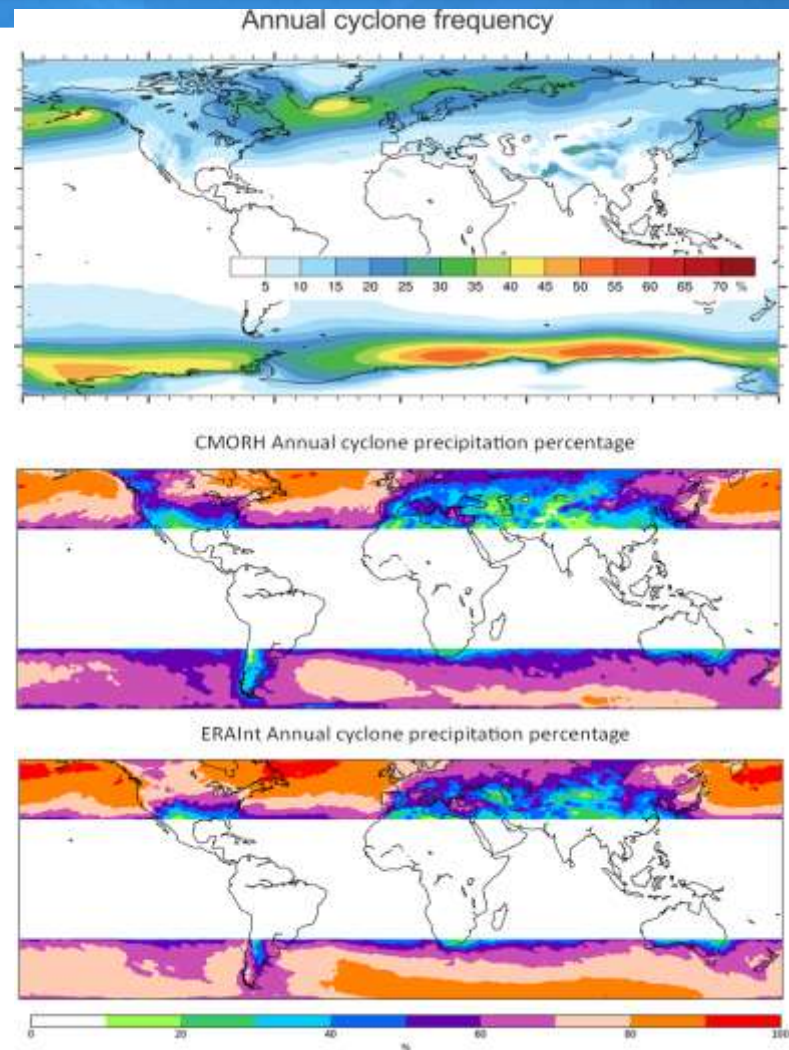
b) CMORPH average annual precipitation



## *Precipitation climatology: measurements*

# Precipitation associated with mid-latitude cyclones: results

- On average, about 50 % of precipitation can be attributed to cyclones
- In some regions this percentage exceeds 90%
- Over the oceans the satellite measurements and the reanalysis are similar
- Over the land the difference is generally larger with reanalysis having a higher percentage of cyclone precipitation





# Conclusions

UL-FMF atmospheric science group is capable of running projects with various levels of complexity, from data validation to basic research questions of importance for the selection of exploratory missions.

Recent outputs include a development of complex systems that handle the whole chain of steps from processing of raw measurements to the final products from the weather forecast models

A close collaboration exists with a number of weather and climate related institutes in Europe and wider to maintain and further develop the excellence