Impact of Satellite-Derived Cloud Cover on Road Weather Forecast in the Czech Republic

Vojtěch Bližňák[1], Petr Pešice[1], Pavel Sedlák[1], Zbyněk Sokol[1], Jindřich Šťástka[2], Martin Tomáš[2], Petr Zacharov[1]

(1) Institute of Atmospheric Physics CAS, Department of Meteorology, Prague, Czech Republic

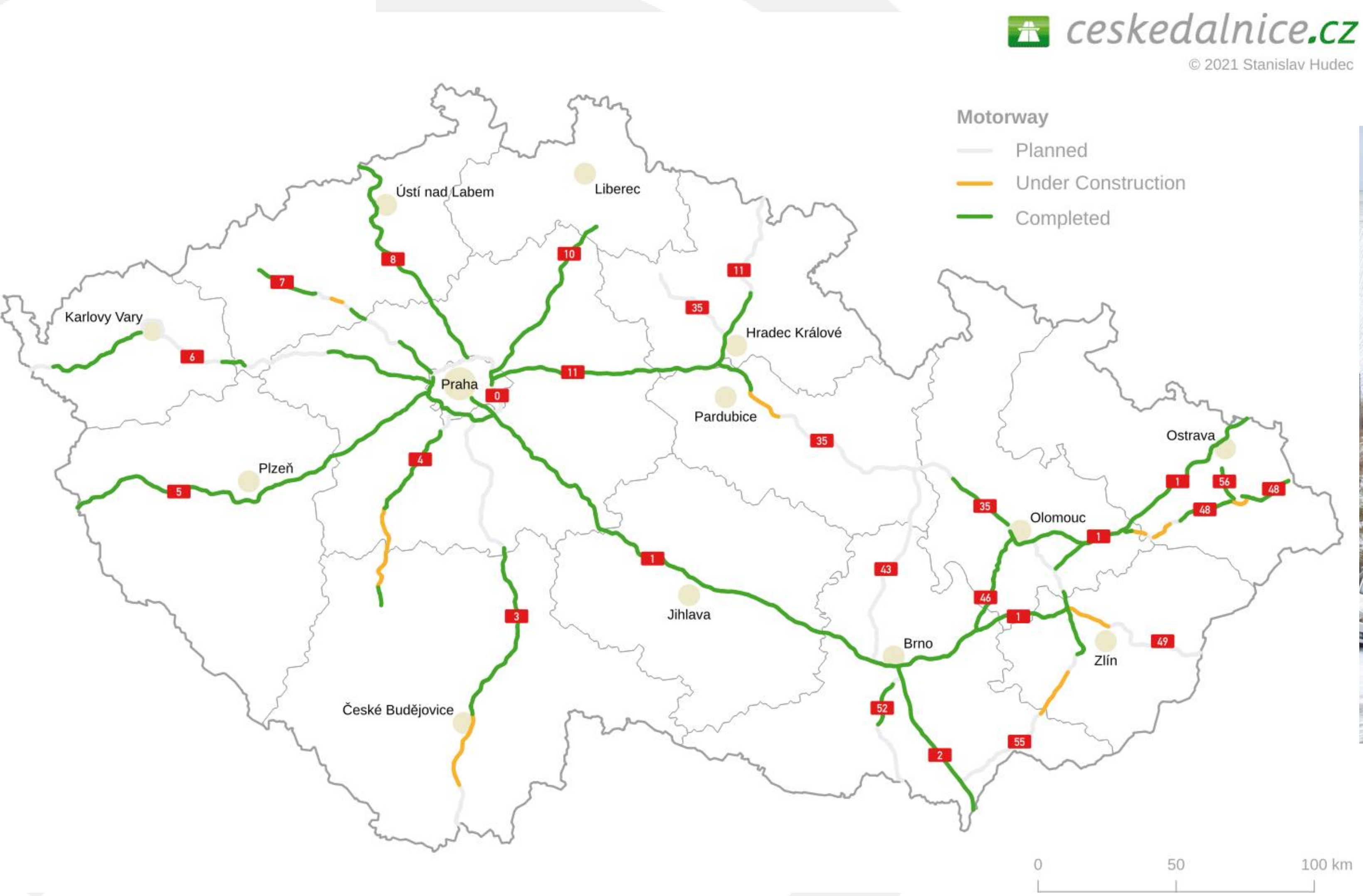
(2) Czech Hydrometeorological Institute, Prague, Czech Republic

Email: bliznak@ufa.cas.cz

„High-latitude weather week“, January 30 – February 2, 2023

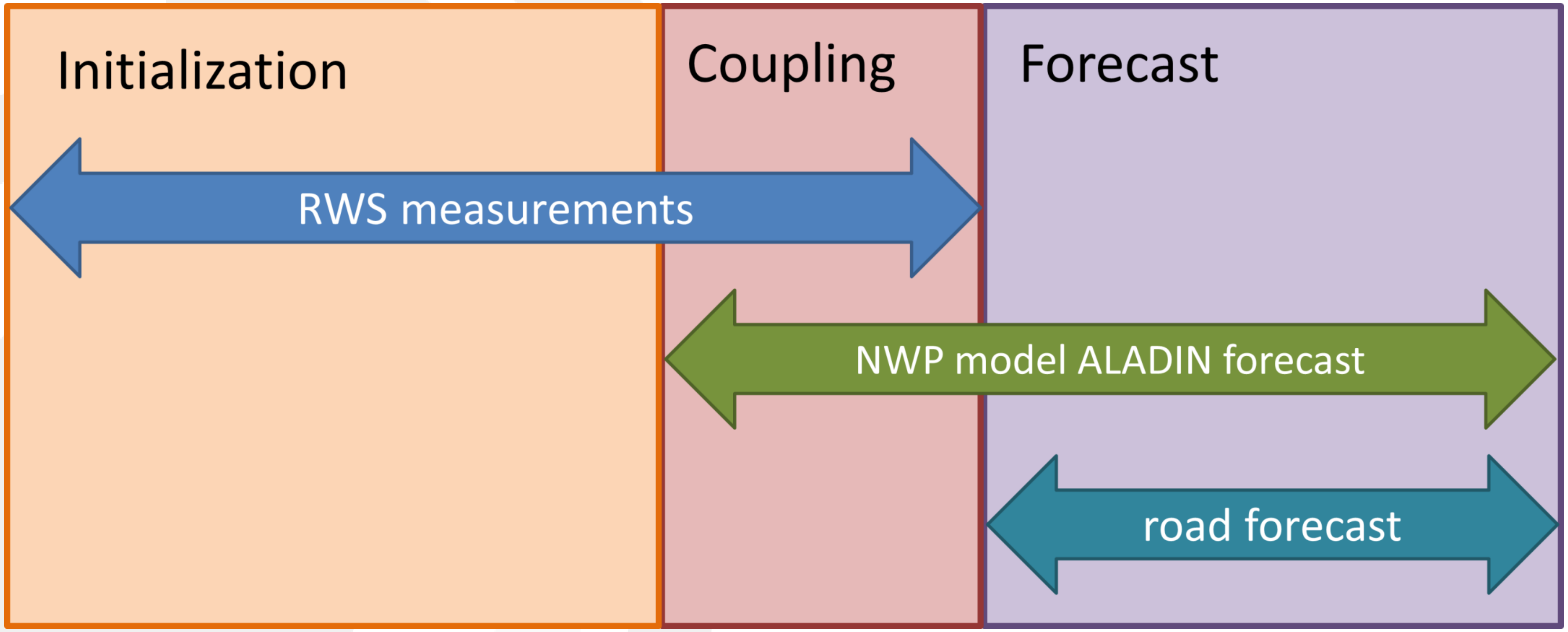
Motivation and goals

- **Improve** short-term (0 - 3 h) road weather forecast by using satellite-derived products that provide information about cloud cover
- **Implement** this methodology into the road weather forecast model **FORTE** (**FO**recast of **R**oad **TE**mperature and condition) within the ongoing research project FROST (2020-2024)
- **Operatively run** the forecasting system on the Czech motorway network since 2023
- **Reducing** the number of traffic accidents and possible loss of human life during winter season



Model FORTE

- **1D physical model of heat transfer and energy balance** calculating linearly continuous forecast (i.e., road surface temperature (RST) and road surface condition (RSC))
- It originally stems from the **METRo model** (Crevier and Delage, 2001)
- The model uses measured data from **road weather stations** (RWS) and prognostic data obtained by integration of the **ALADIN NWP model** as inputs to prepare initial and boundary conditions



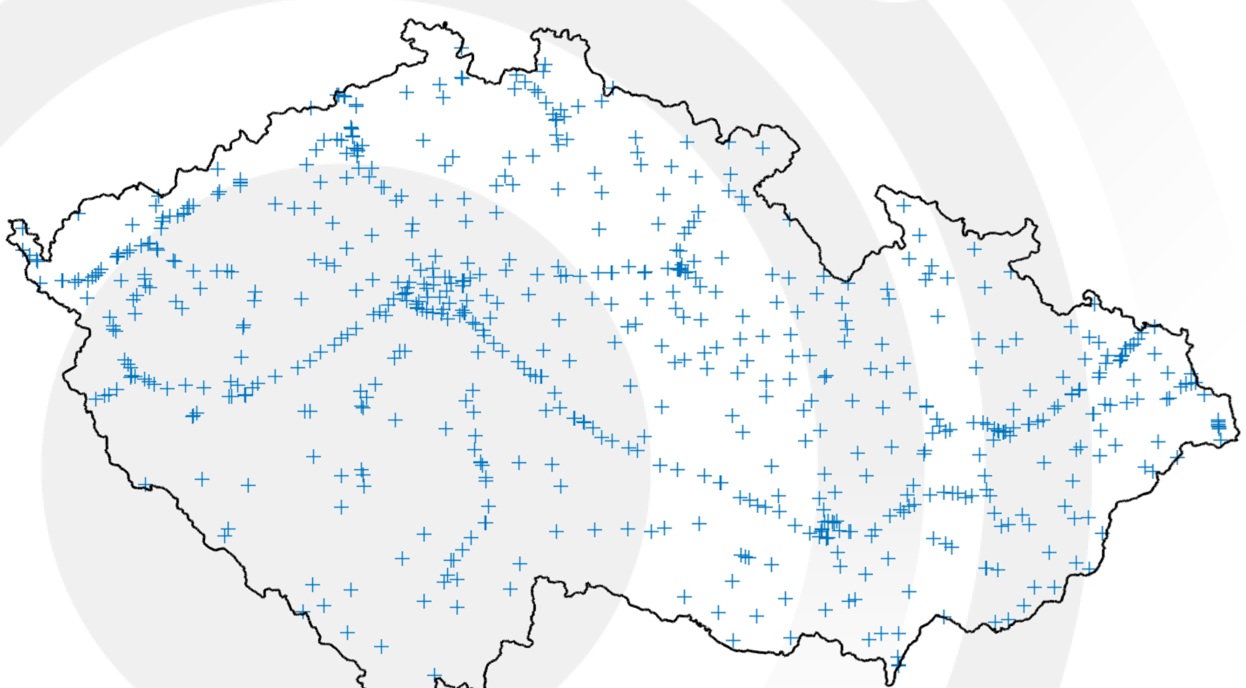
Model FORTE

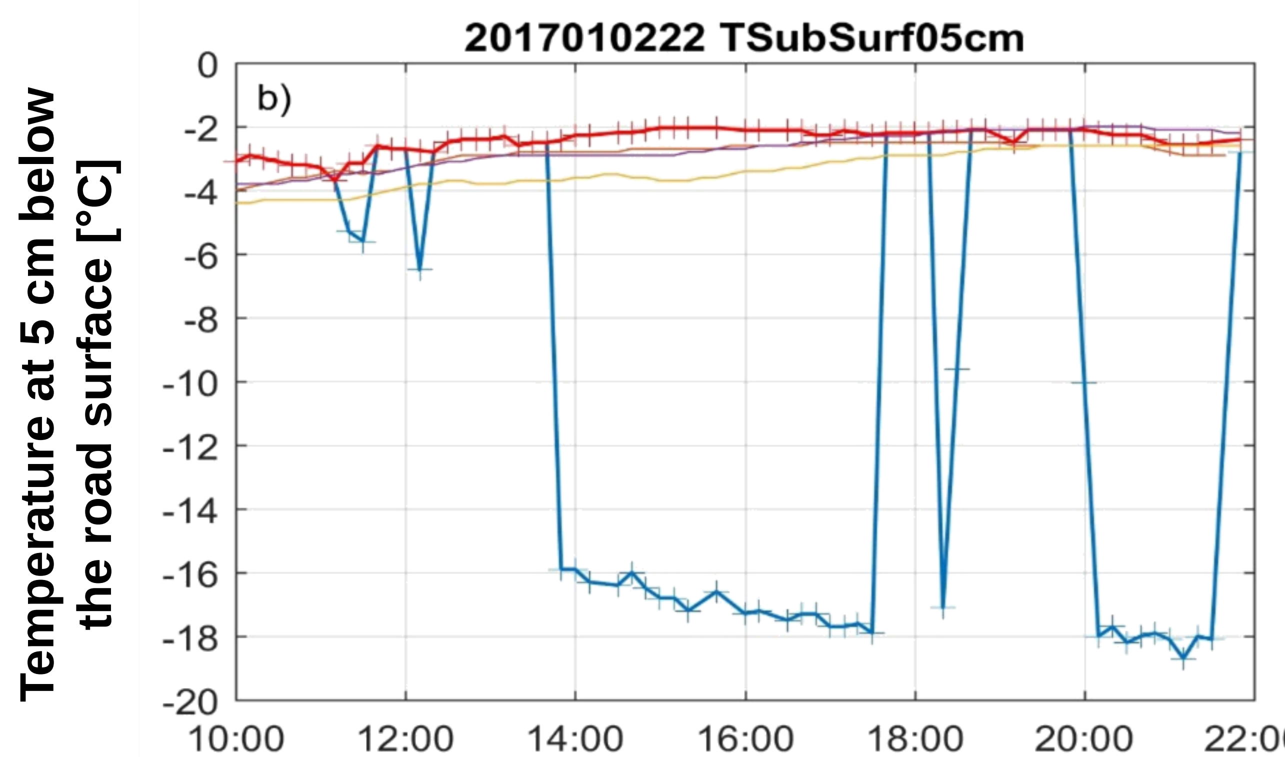
- **1D physical model of heat transfer and energy balance** calculating linearly continuous forecast (i.e., road surface temperature (RST) and road surface condition (RSC))
- It originally stems from the **METRo model** (Crevier and Delage, 2001)
- The model uses measured data from **road weather stations** (RWS) and prognostic data obtained by integration of the **ALADIN NWP model** as inputs to prepare initial and boundary conditions
- Shadowing effect taking into account the topography of the road surroundings and the **sky-view factor** were included in the FORTE model

RWS measurements

- Air temperature and humidity at 2 m
- Wind speed at 10 m
- Road surface condition (RSC)
- Road surface temperature (RST)
- Temperature at 5 cm below the road surface
- Temperature at 30 cm below the road surface

RWS network (726)



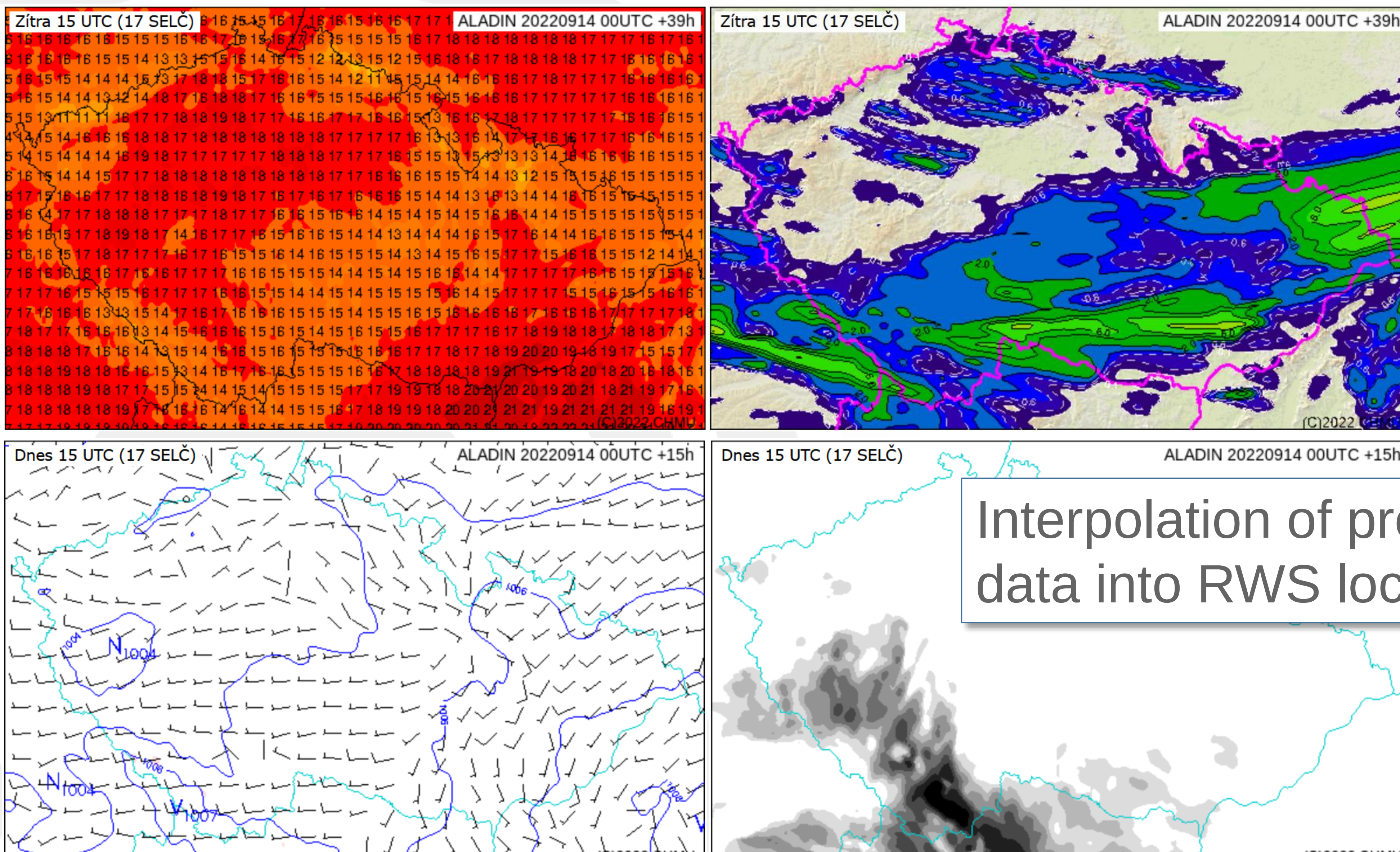


Original TSubSurf05cm
Corrected Tsubsurf05cm

IAP

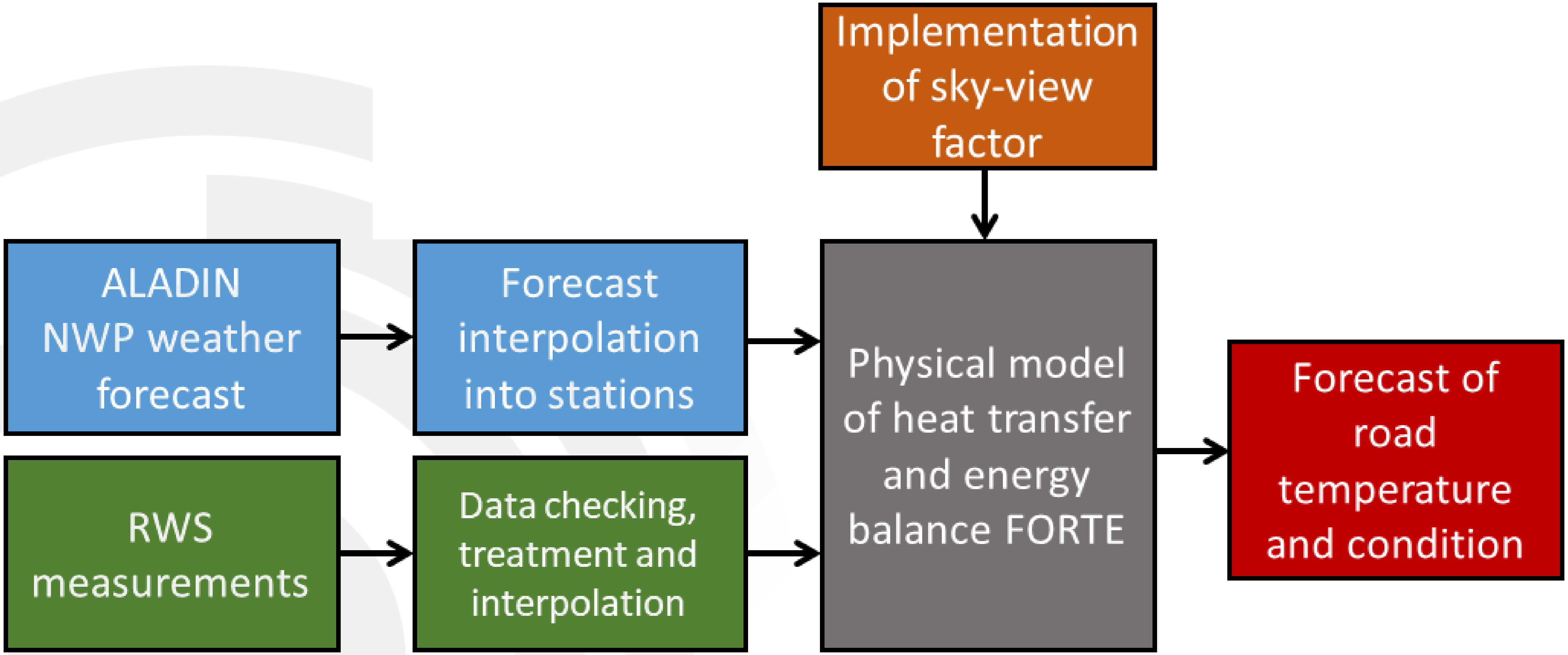
NWP model ALADIN forecast

- Air temperature and humidity at 2 m
- Wind speed at 10 m
- Model pressure at the model orography
- Cloud cover N
- Accumulated precipitation and type (rain/snow)

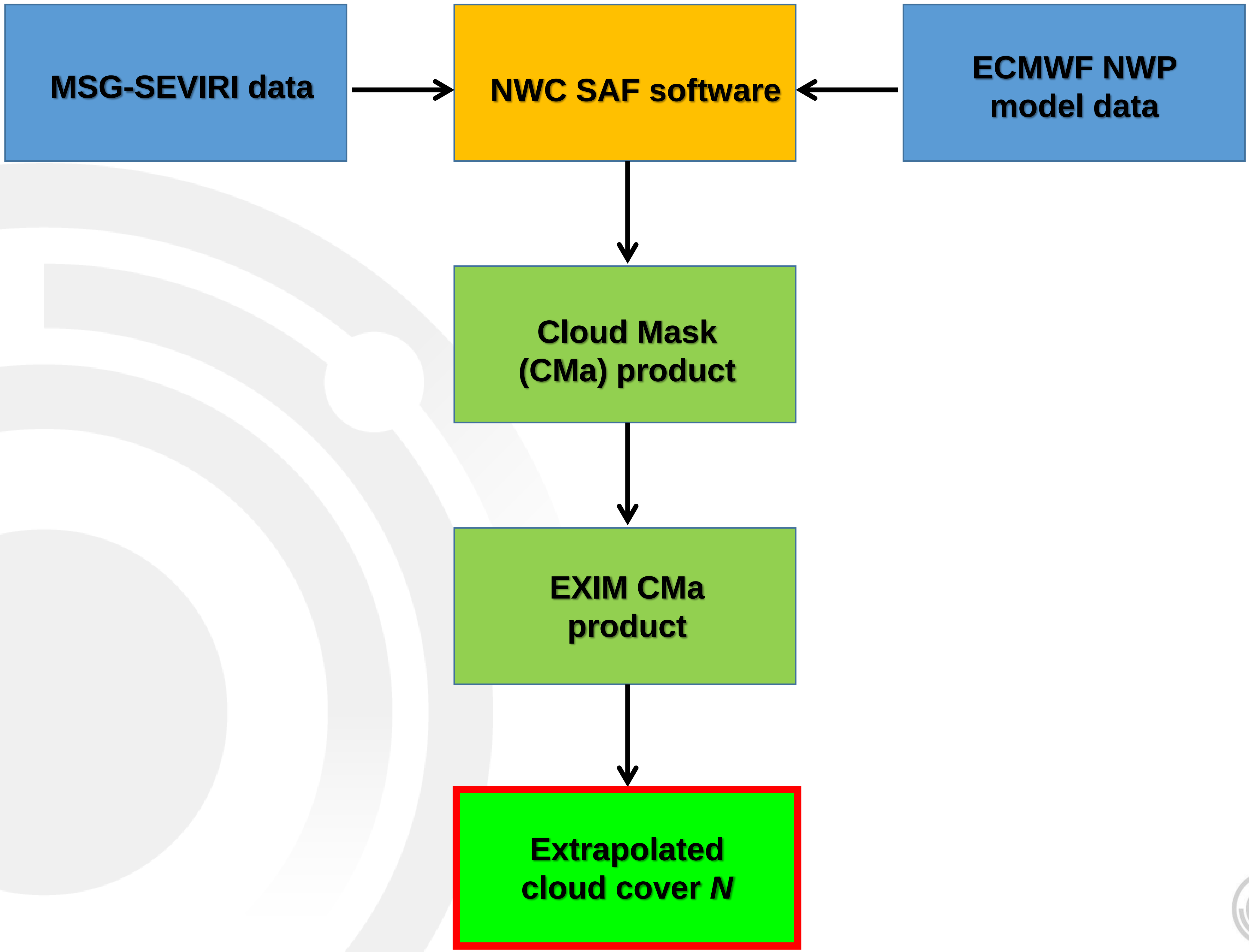


Interpolation of prognostic data into RWS locations

Forecasting system FROST

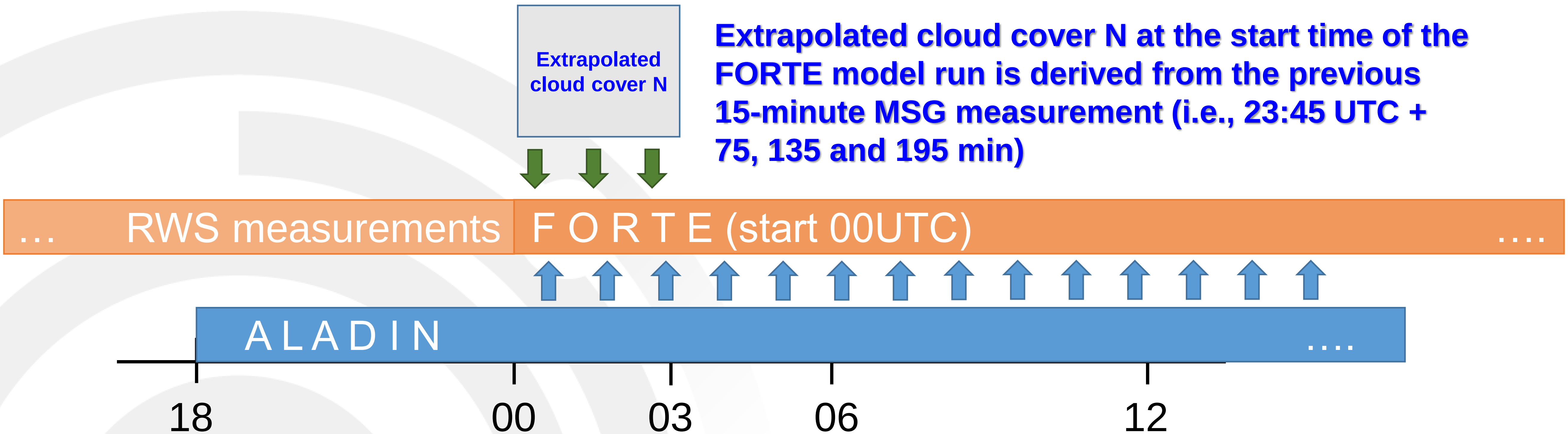


Extrapolation of cloud cover



Data flow timeline

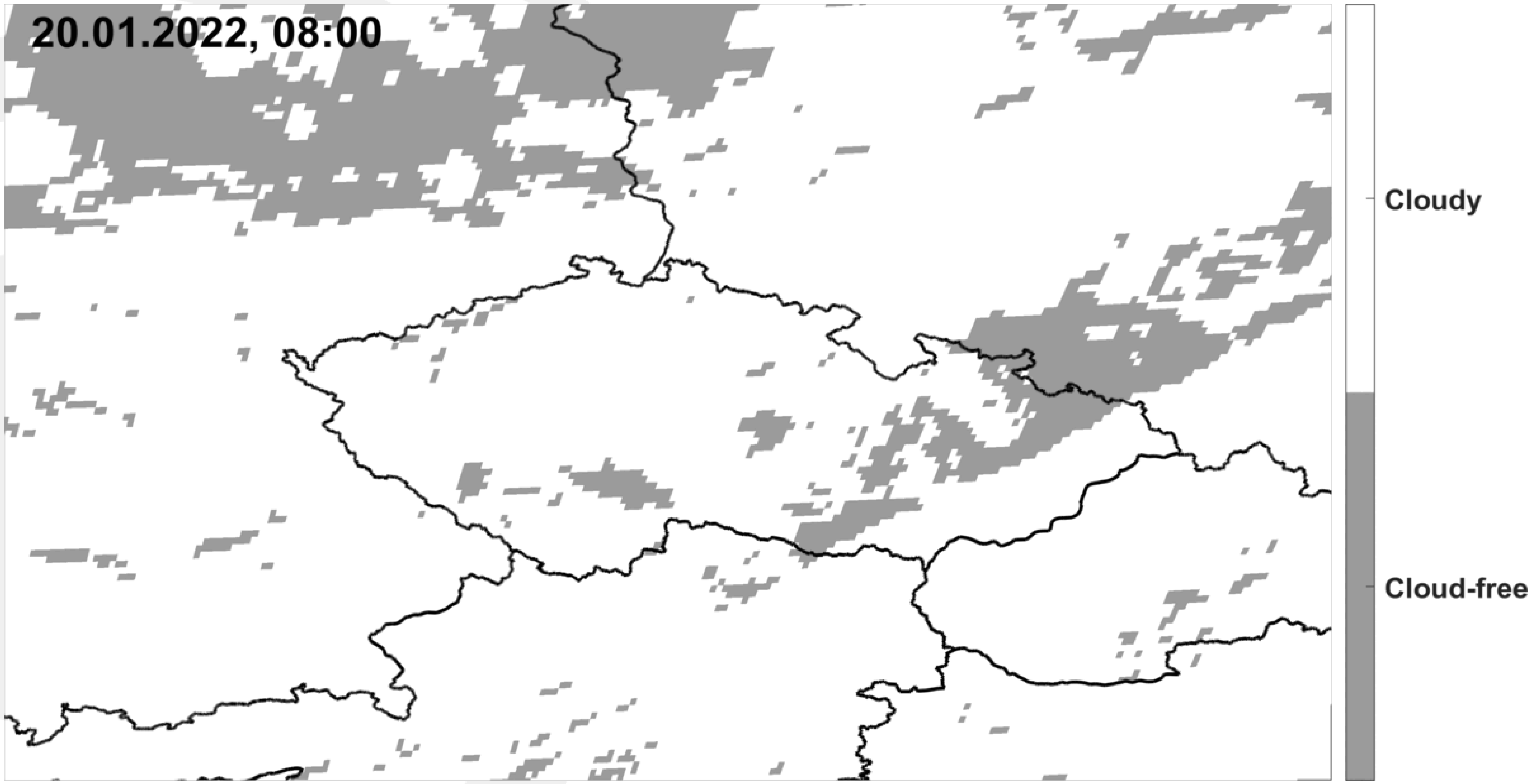
Extrapolated cloud cover N at the start time of the FORTE model run is derived from the previous 15-minute MSG measurement (i.e., 23:45 UTC + 75, 135 and 195 min)



Prognostic cloud cover at the start time of the FORTE model run is derived from the previous ALADIN run (6-h delayed, i.e. 18:00 UTC + 07, 08 and 09 h)

EXIM CMa

- Kinematic extrapolation of Cloud Mask (CMa) NWC/GEO product based on atmospheric motion vectors (AMVs) with a defined period of lead time
- The AMVs are generated by the NWC/GEO High Resolution Wind Package PGE09-HrW and are interpolated onto the SEVIRI pixel grid using an inverse distance weighted interpolation scheme
- Extrapolation is performed using a 2-layer scheme – trajectories are calculated separately for low layers (900 – 501 hPa) and high layers (500 - 100 hPa)
- The prerequisite for a correct estimate is to maintain the wind speed and its direction

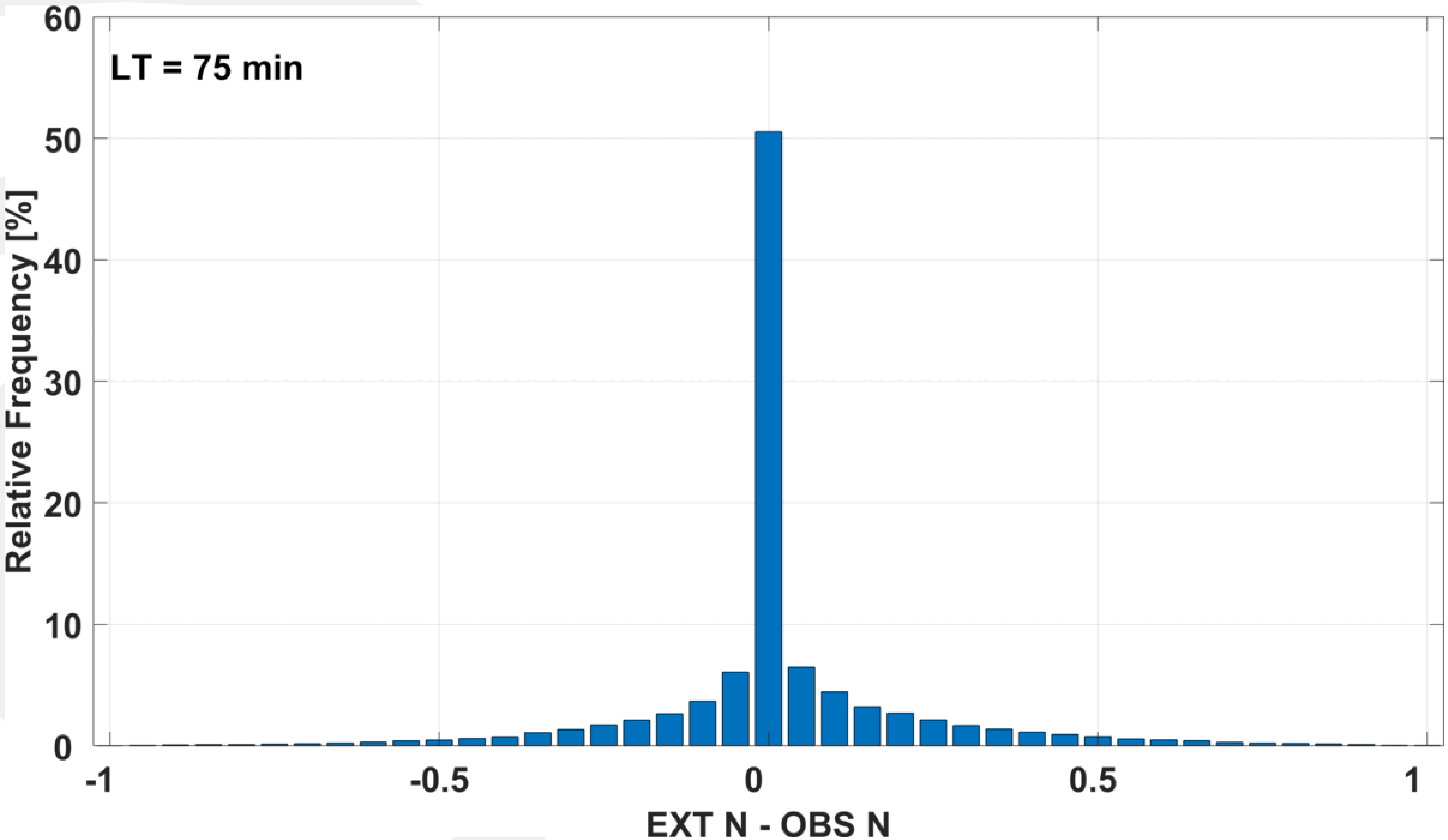


IAP

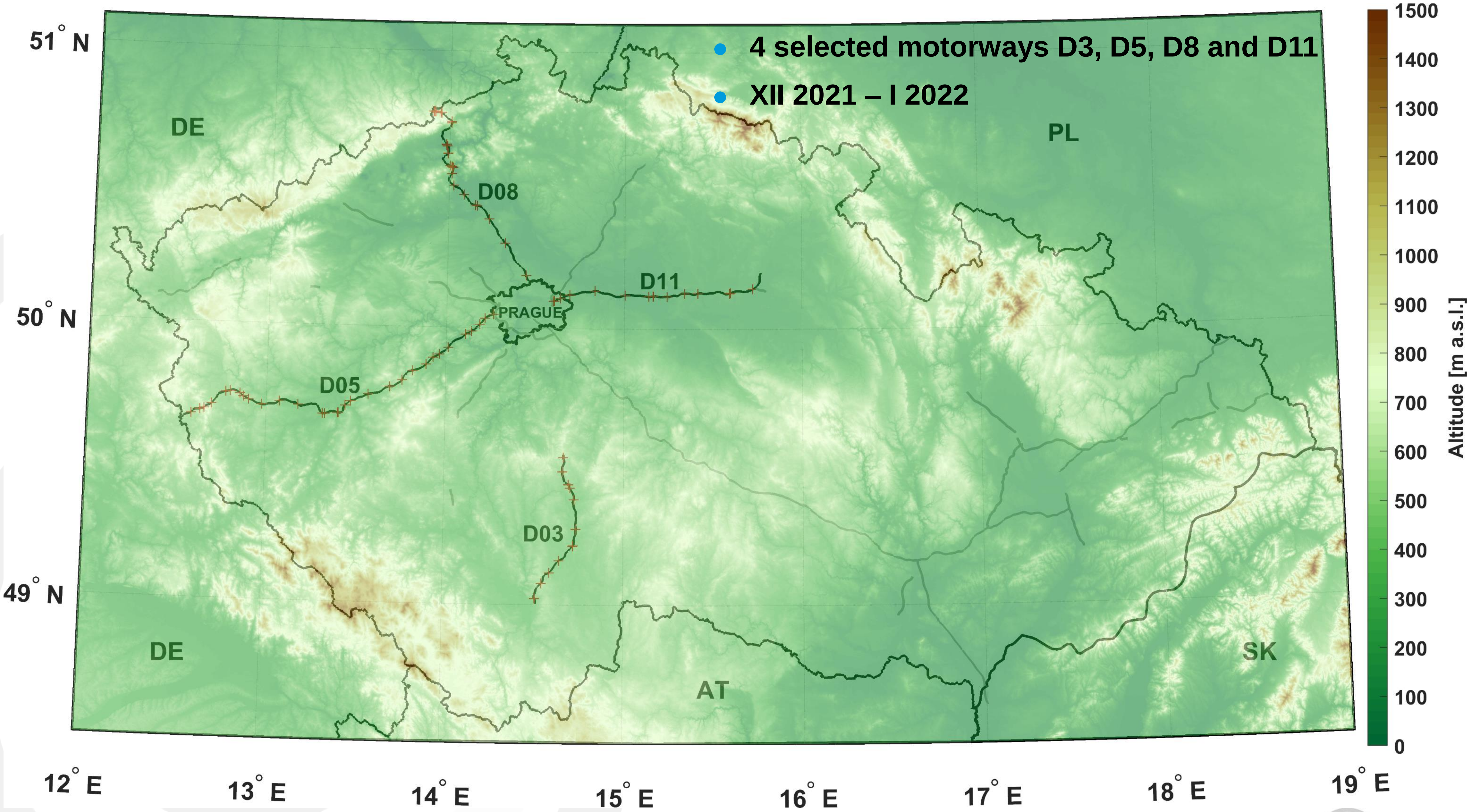
EXIM CMa accuracy

Lead time	Better than persistence
15 min	91,1 %
30 min	74,3 %
45 min	62,6 %
60 min	60,8 %

SAF validation report
2-layer scheme
18 April – 8 May 2018

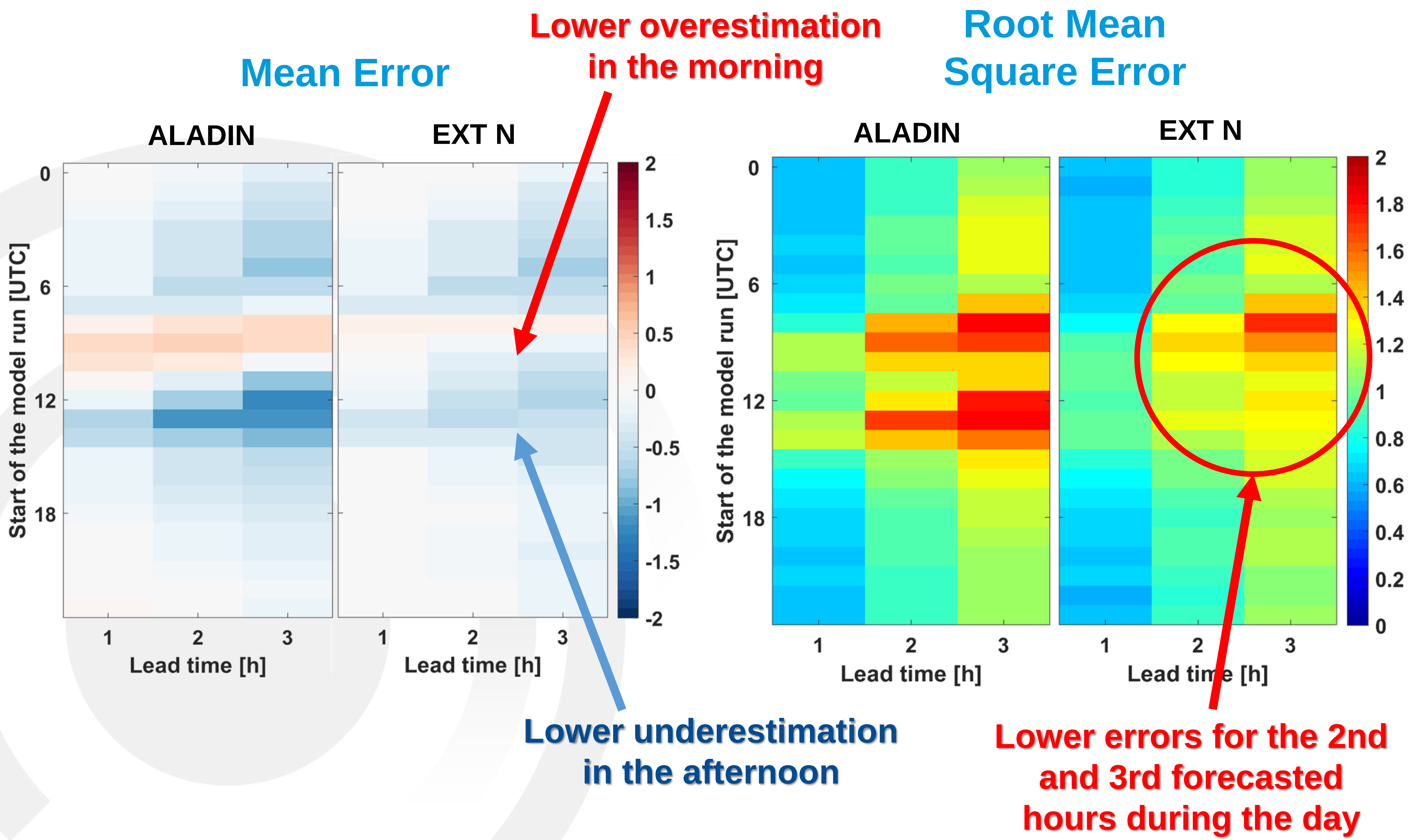


Selection of locations and period for verification

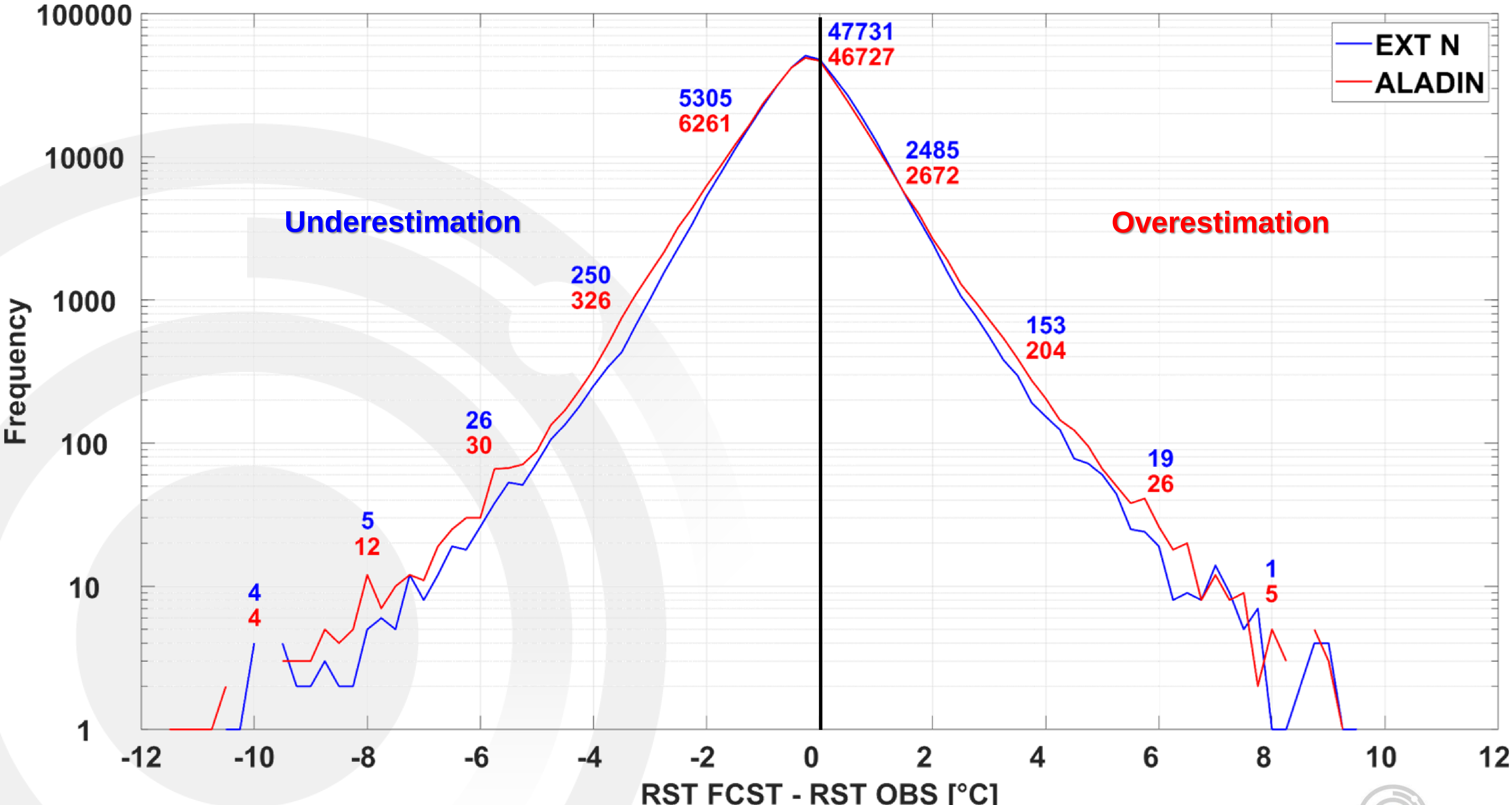


IAP

Verification of forecasted RST

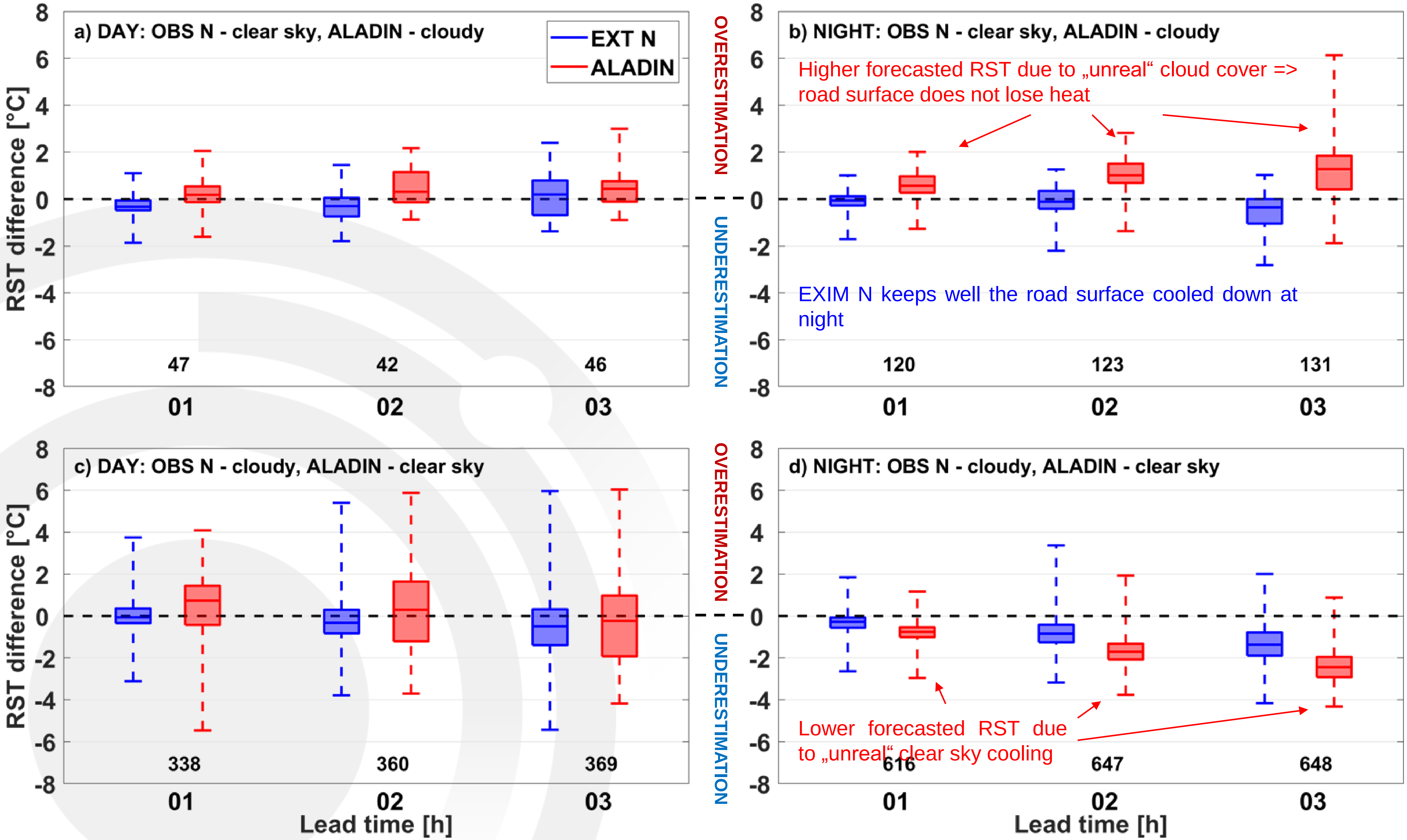


Frequency distribution of forecasted RST differences



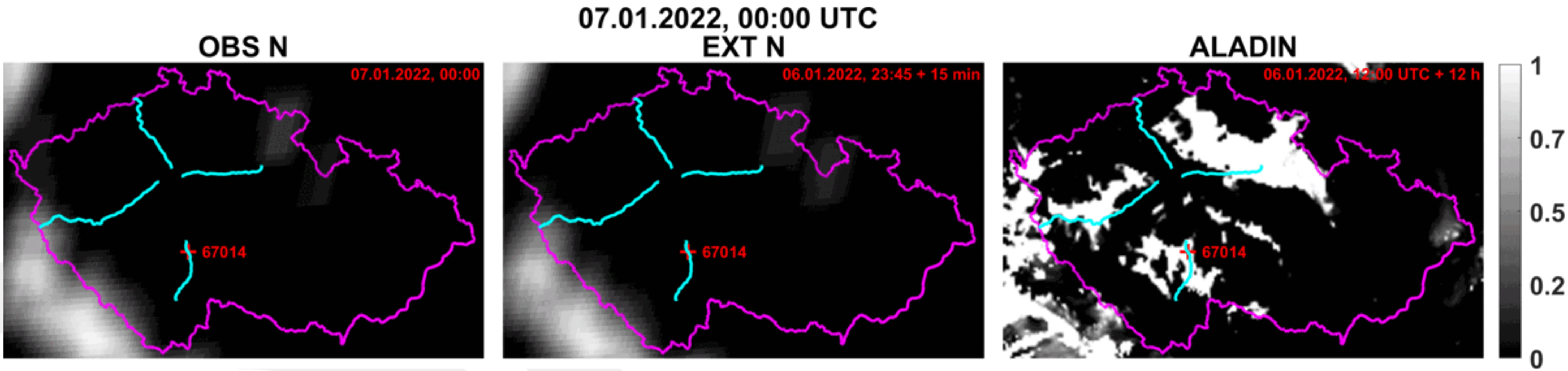
IAP

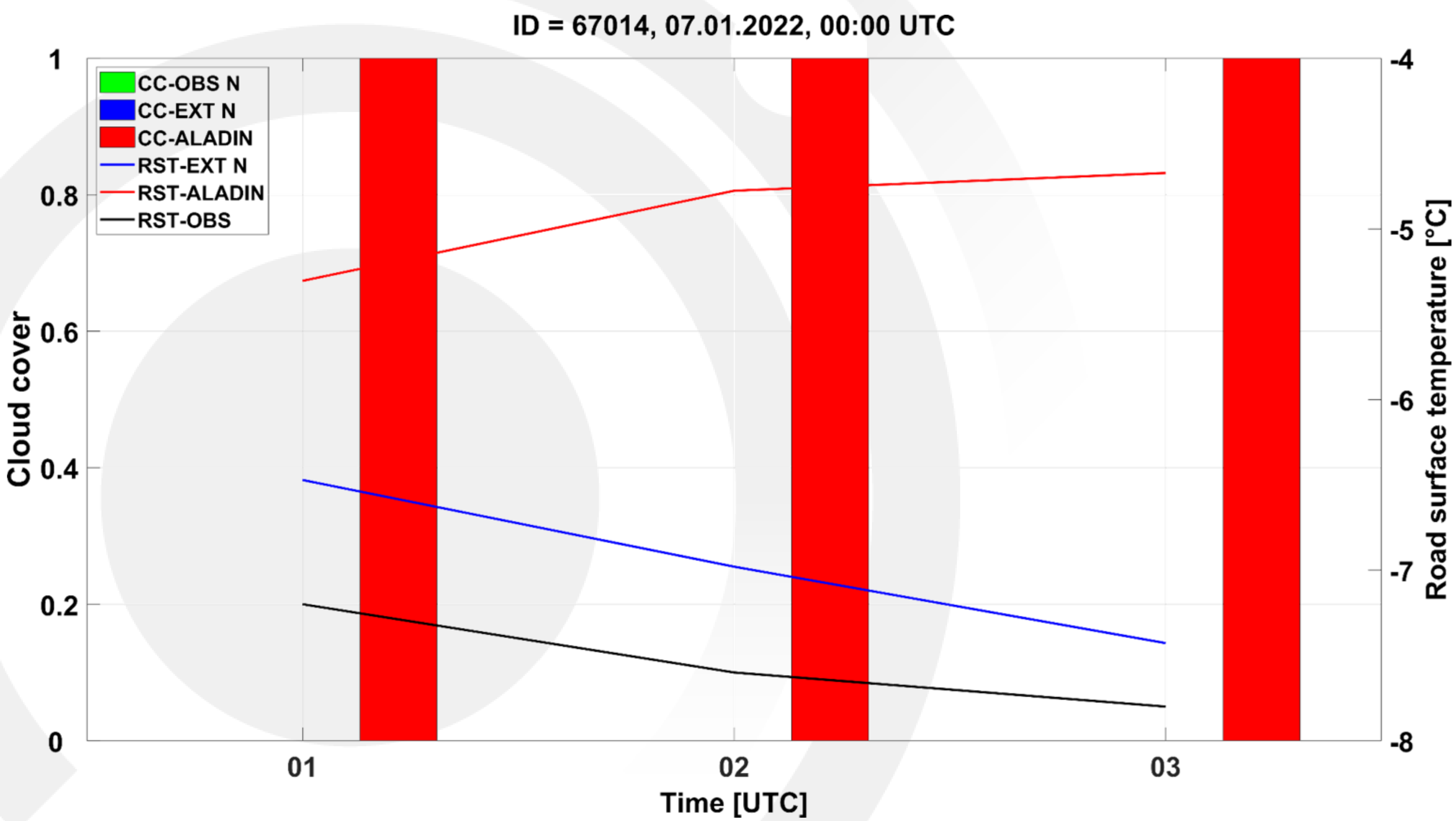
Effect of cloud cover on RST



Case study: 07.01.2022 00:00 UTC

OBS N/EXT N – clear sky, ALADIN – cloudy





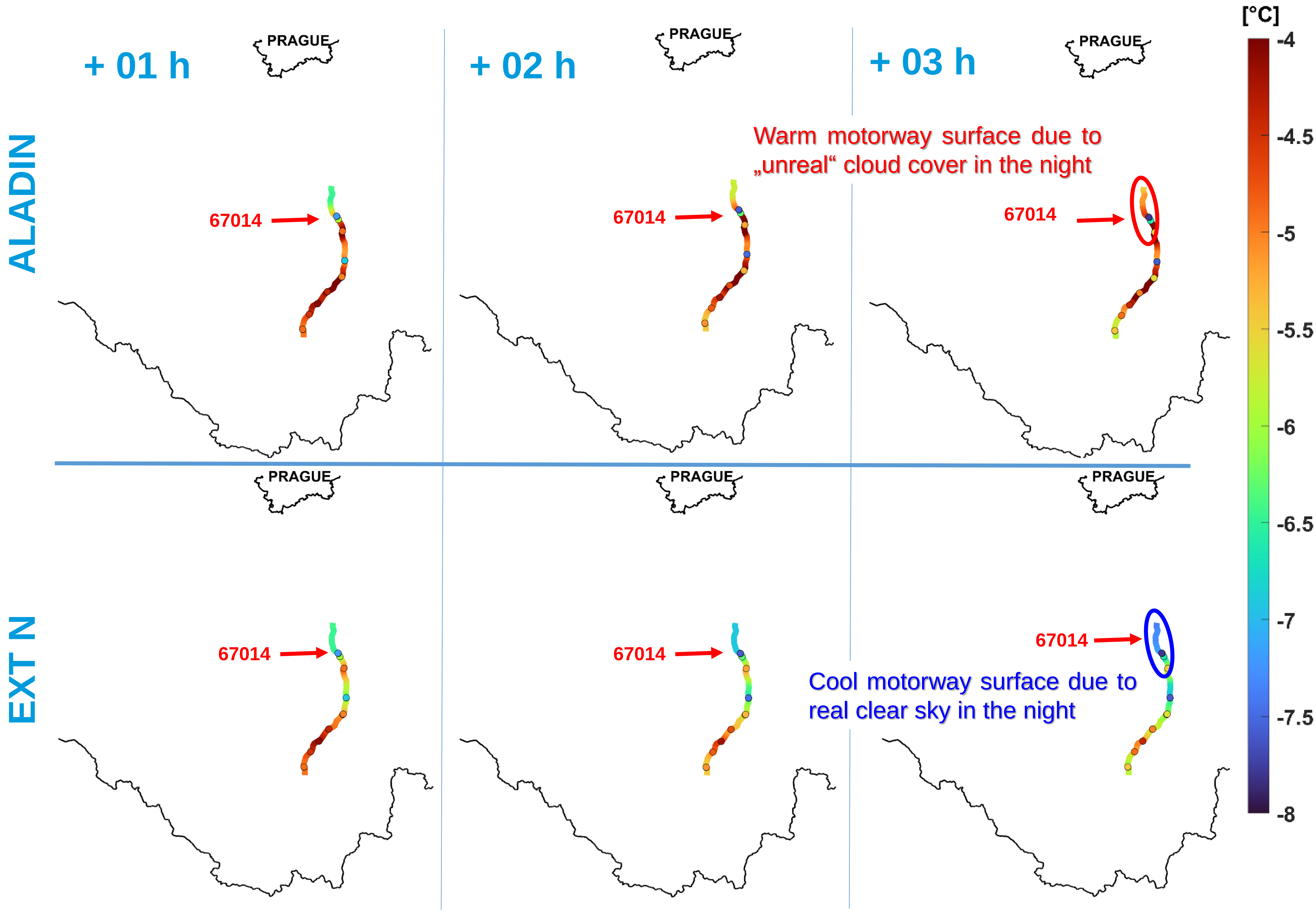
- **ALADIN**

„unreal“ clouds during the night => surface does not lose heat => **increase of forecasted RST**

- **OBS N/EXT N**

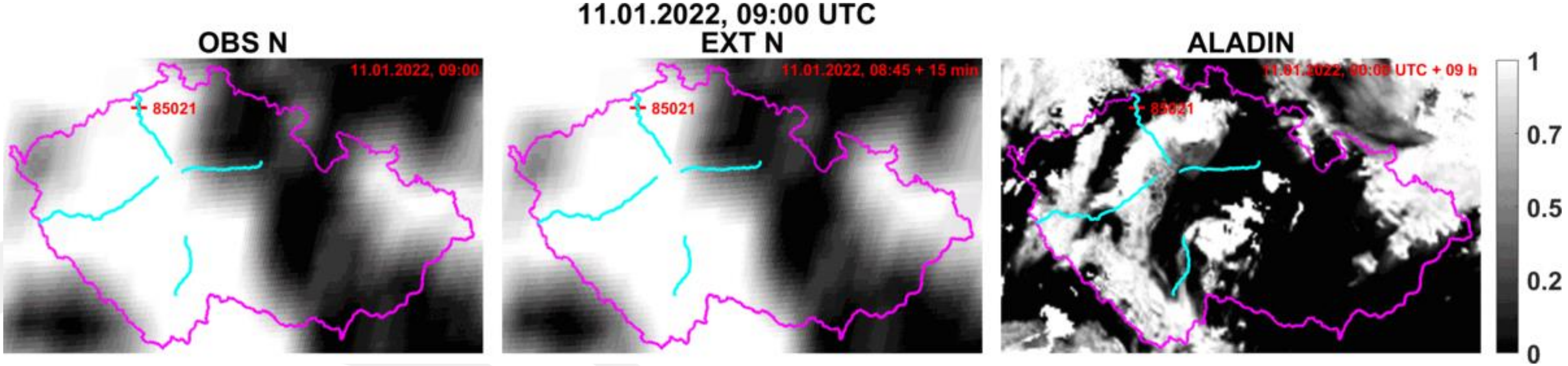
real clear sky during the night => cooling of the surface => **decrease of forecasted RST**

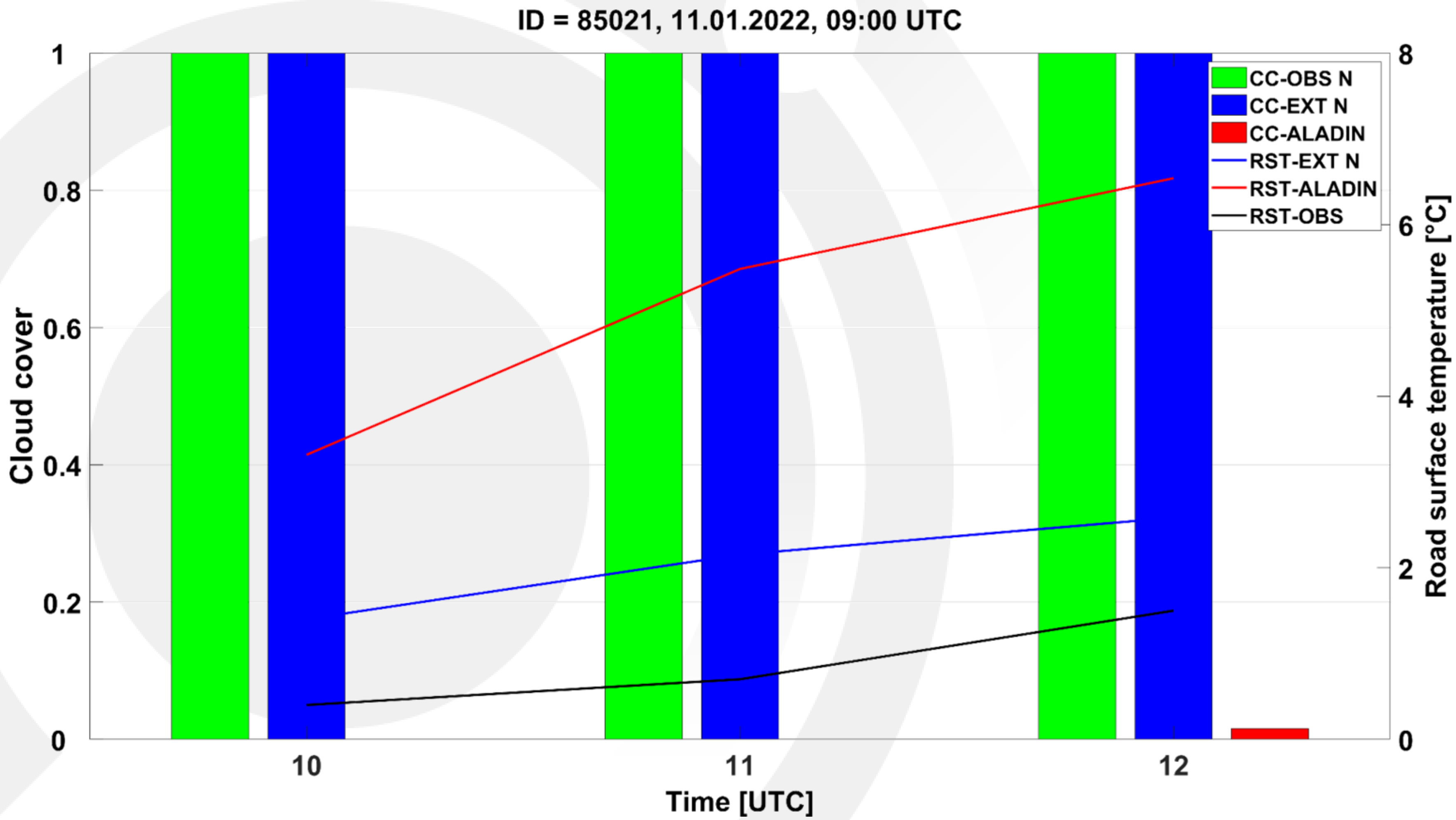
Linear forecast of RST – 07.01.2022, 00:00 UTC



Case study: 11.01.2022 09:00 UTC

OBS N/EXT N – cloudy, ALADIN – clear sky



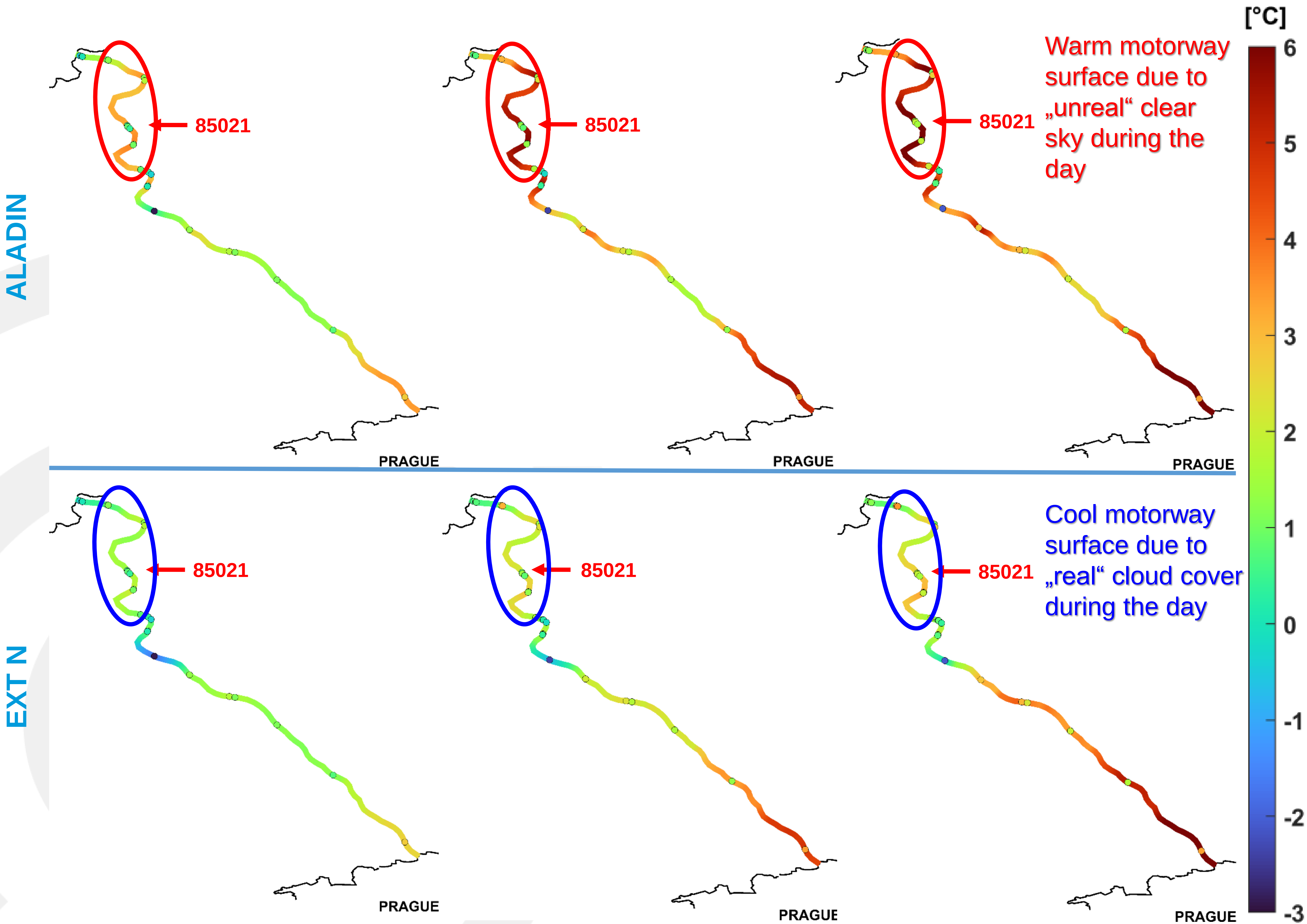


- **ALADIN**
  „unreal" clear sky during the day => fast warming of the surface => **increase of forecasted RST**

- **OBS N/EXT N**
  real cloud cover during the day => slow warming of the surface => **slow increase of forecasted RST**

IAP

Linear forecast of RST – 11.01.2022, 09:00 UTC



Summary and outlook

- The methodology of using **satellite-derived cloud cover information** to improve short-term road weather forecasting **has been successfully defined and applied** in the FORTE model

- Cloud cover extrapolated for the first 3 hours showed a **positive effect** on the radiative fluxes in the FORTE model resulting **in improved RST forecasts**, as the **extrapolation better describes the real cloud cover** compared to the NWP model forecast

- The forecasting system will be put **into operation** at the Czech hydrometeorological institute **during 2023**

- Next task - **blending the extrapolated cloud cover** with ALADIN NWP model data for the longer lead times (3 – 6 hours)

INSTITUTE OF ATMOSPHERIC PHYSICS CAS

Czech Academy of Sciences

Czech Hydrometeorological Institute

T A C R Technology Agency of the Czech Republic