Graupel mixing ratio forecast from a cloud resolving NWP model as a tool for lightning activity prediction

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- NWP model used – AROME-BG

- Lightning data – ATDnet

- Evaluation metrics – POD, F, PC, FBI

- Results for the summer 2021

AROME-BG

- AROME is a non-hydrostatic limited area cloud-resolving model, commonly used in ACCORD

- It was developed by Météo-France in close collaboration with national and international institutes so as to benefit from the latest research in atmospheric modelling

- It uses mostly the physical parameterizations from Méso-NH model and the dynamic core of ALADIN model

- The microphysics scheme used in the present study uses three-class ice parameterization ICE3 scheme

- It runs operationally 4 times daily (00, 06, 12, 18 UTC) with a forecast range 36 h (48 h)
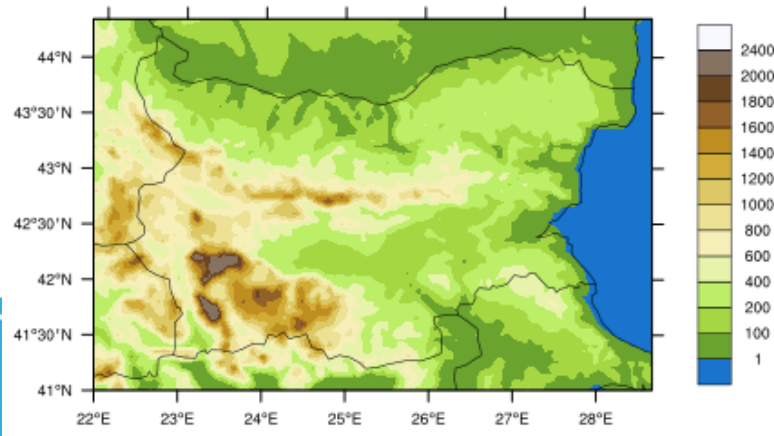
AROME-BG configuration:

horizontal resolution - 2.5 km
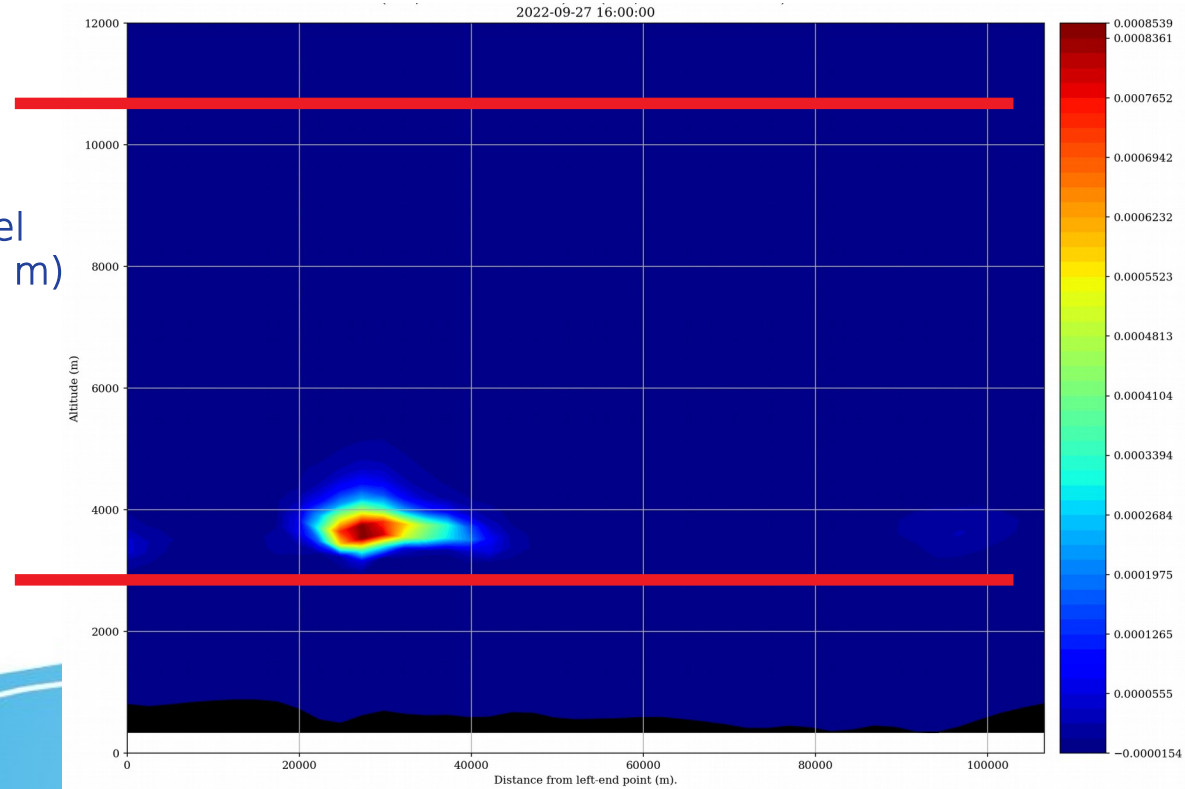vertical levels – 60 (90)
time step – 60 s
LBC – from ALADIN-BG

For the aim of the study, the integrated graupel mixing ratio r_g between model levels 35 (2756 m) and 15 (10306 m) was considered:
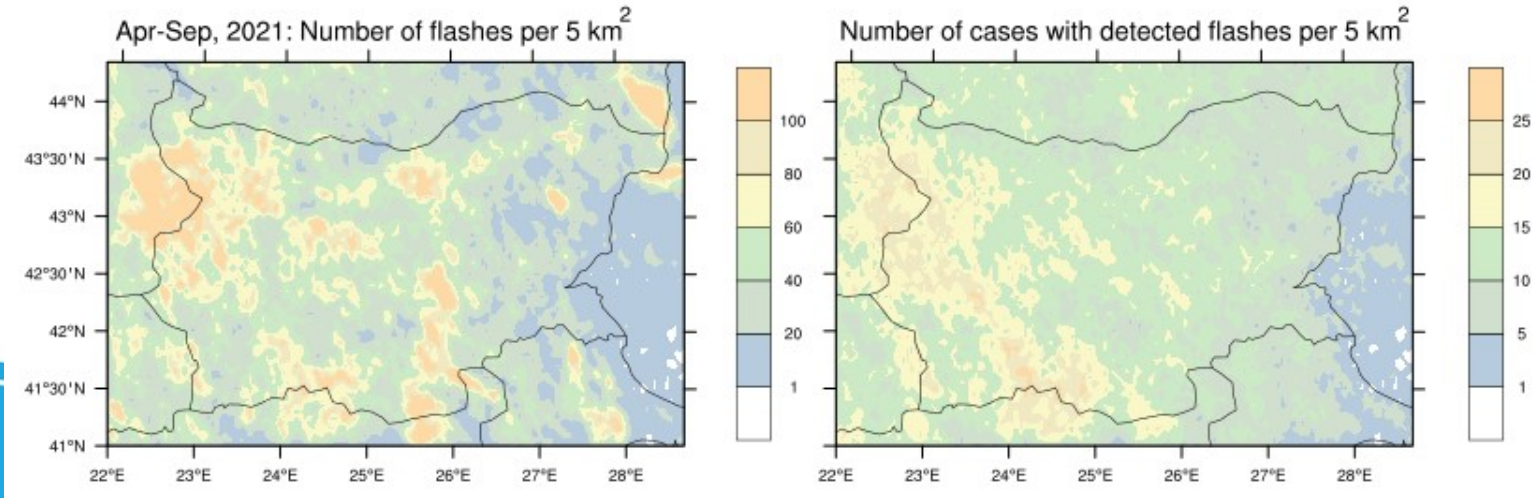
$r_g > 0 \rightarrow$ lightning
$r_g < 0 \rightarrow$ no lightning

ATDnet

- ATDnet (Arrival Time Differencing NETwork) is the most recent version of the VLF (very low frequency) lightning location network of the Met Office that operates since 1987;

- It takes advantage of the long propagation paths of the VLF spherics emitted by lightning discharges, which propagate over the horizon via interactions with the ionosphere;

- Data are collected every minute, BUFR encoded and sent by the UK Met Office on behalf of the World meteorological organization to member states through its Global telecommunication system;

- Due to the uncertainty of ATDnet accuracy over the studied region, in the present study lightning data and forecasted graupel mixing ratios were considered on resolutions of 5x5 km and 10x10 km with flash rate for one and three hours, as well on a daily base using upscalling neighborhood method;

- Cases with lightning were considered as bins from the corresponding mesh with at least one detected flash

Apr-Sep, 2021: Number of flashes per 5 km^2

Number of cases with detected flashes per 5 km^2

2021: Cases with Lightning
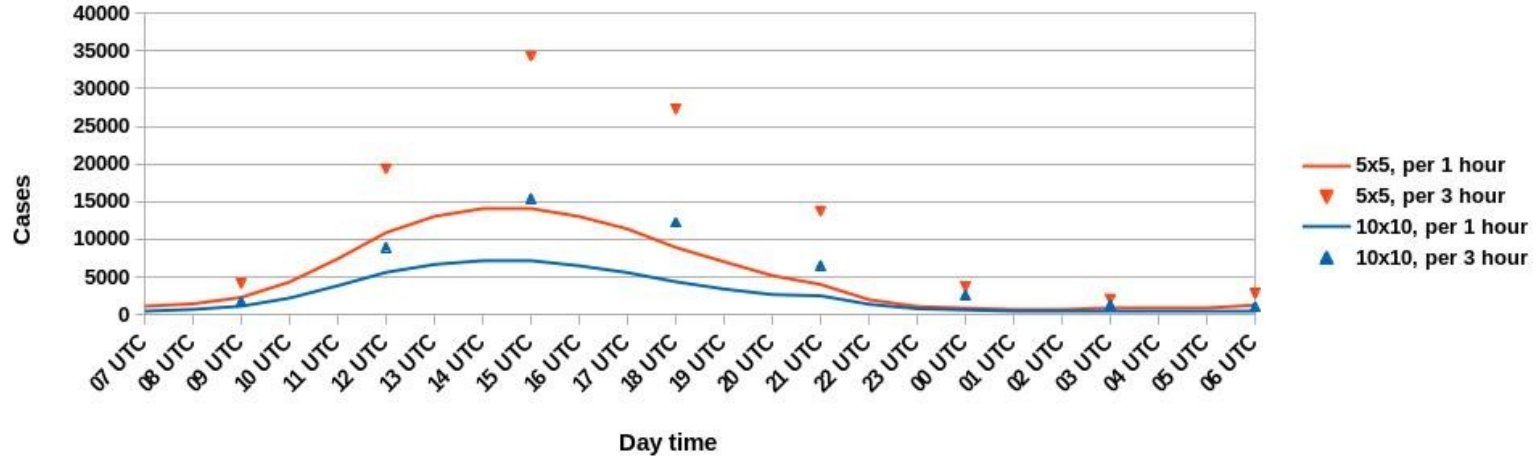
2021: Cases with Lightning
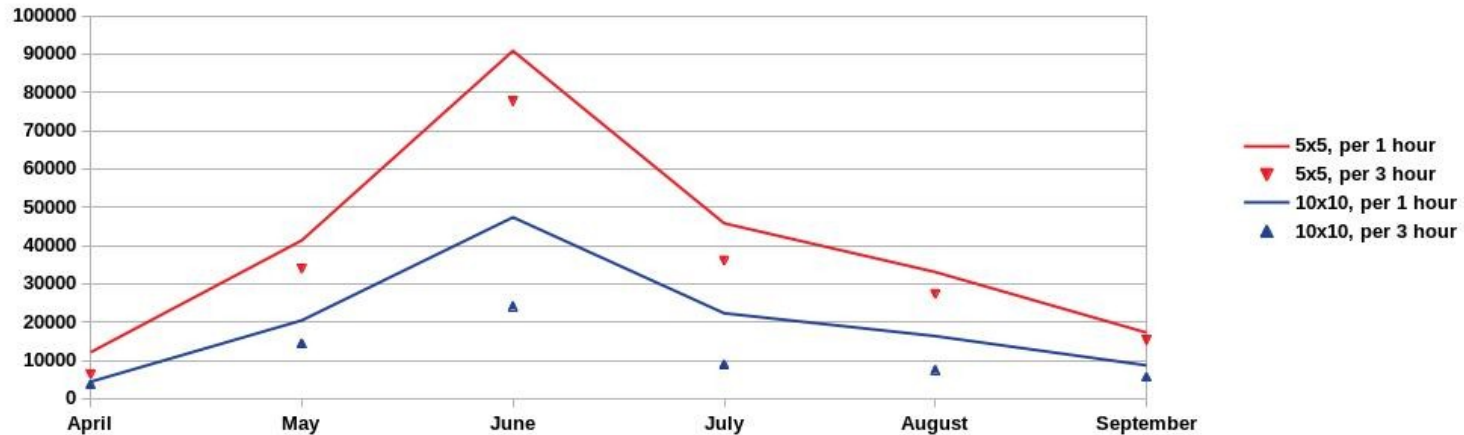
Evaluation metrics

	Event observed	
	Yes	No
Event forecast Yes	a	b
No	c	d

Frequency bias index: $FBI = \frac{a+b}{a+c}$

$0 < FBI < \infty$,
FBI = 1 – perfect score,
FBI < 1 - under forecasting,
FBI > 1 - over forecasting

Proportion correct index: $PC = \frac{a+d}{a+b+c+d}$

$0 < PC < 1$,
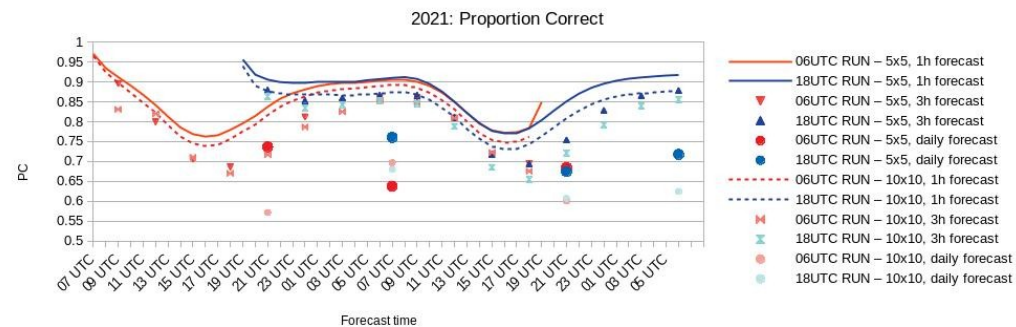PC = 1 – perfect score, yes and no forecasts are rewarded equally
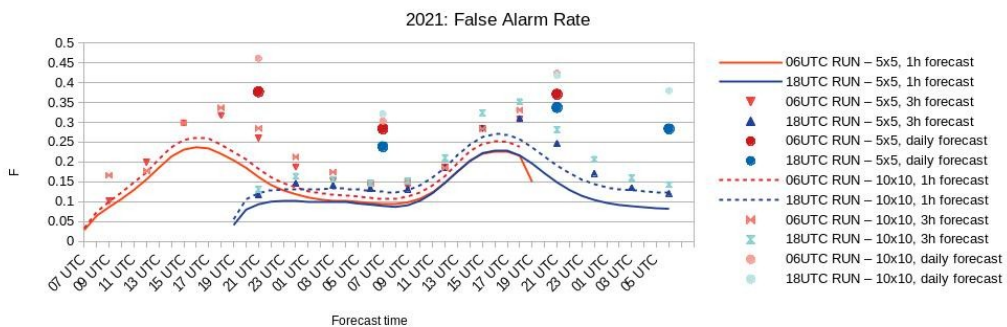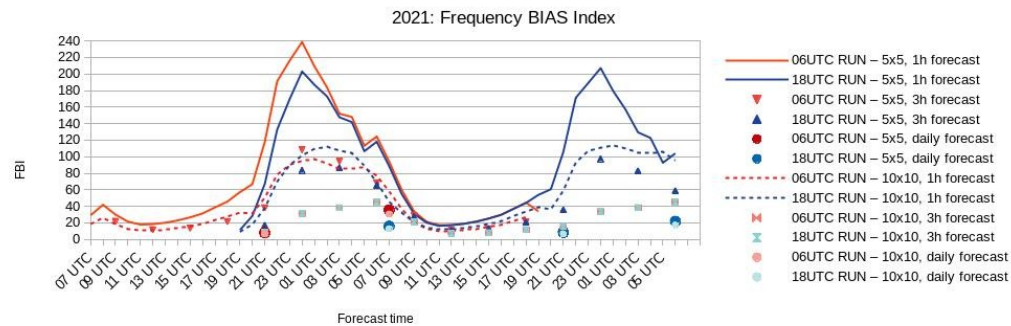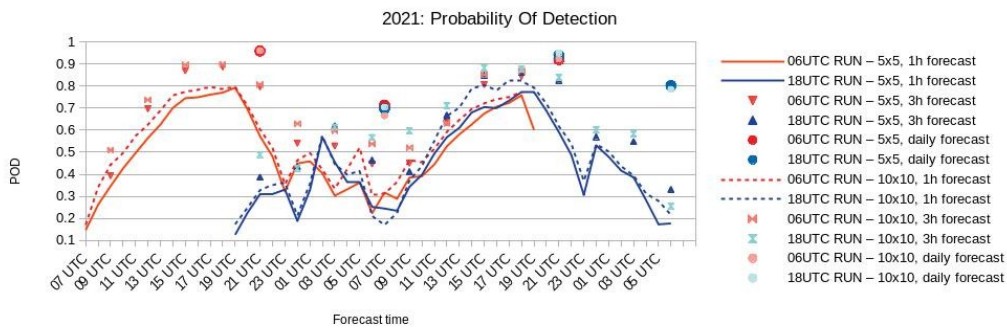
Probability of detection: $POD = \frac{a}{a+c}$

$0 < POD < 1$,
POD = 1 – perfect score,
sensitive to misses events and hits only

False alarm rate: $F = \frac{b}{b+d}$

$0 < F < 1$,
POD = 0 – perfect score,
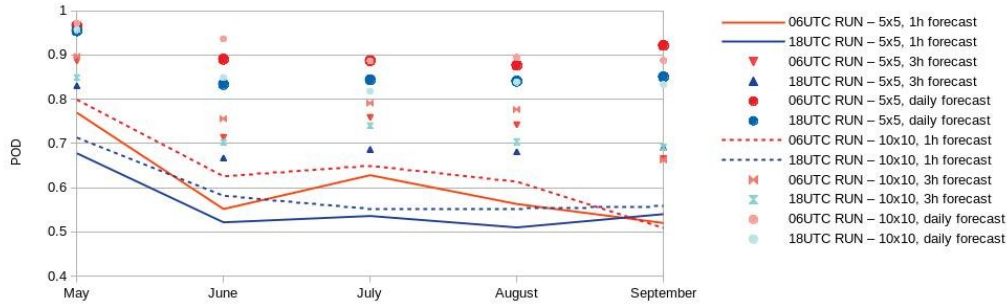sensitive to false alarms and correct negatives

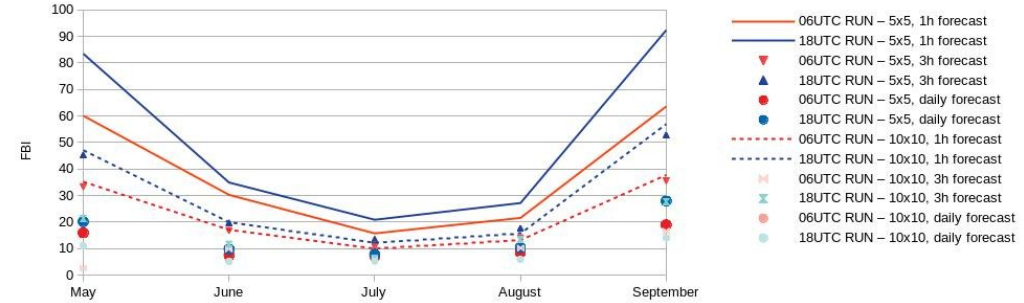# Results: 1. Diurnal distribution of forecast skill-scores

→ Decreases of forecast spatial resolution and time frequency → POD and F↑ while FBI and PC↓

→ POD and FBI give considerably better scores of the forecast during the day hours → lightning activity is better forecasted and with less over estimations during the day;

→ F and PC give slightly better scores of the forecast during night hours (due to higher number of "no lightning cases"?)

→ No significant difference between POD, F and PC for the two model runs (06 and 18 UTC), while FBI for 18 UTC is slightly better than this for 06 UTC

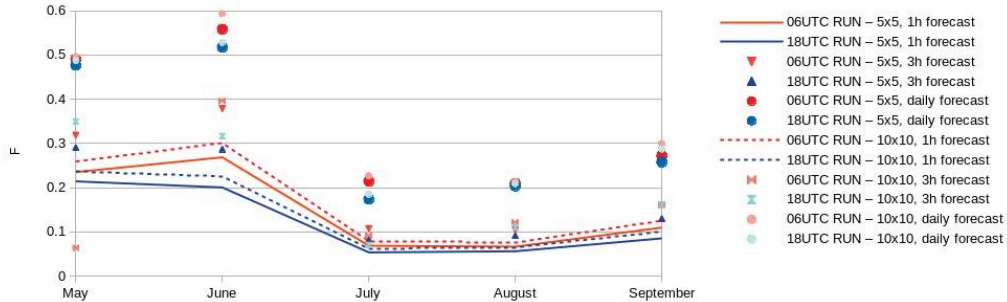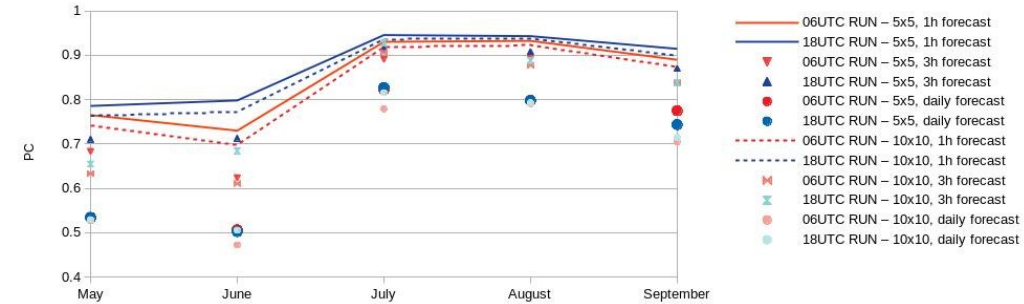# Results: 2. Monthly distribution of forecast skill-scores


→ POD is higher for the first part of the warm half-year of 2021, while the other considered skill-scores give better results July, August and September; the month with highest number of lightning cases June is with lowest skill-scores;

→ Regarding POD and FBI, there are differences in monthly scores of the two model runs and the 06 UTC run give better results;

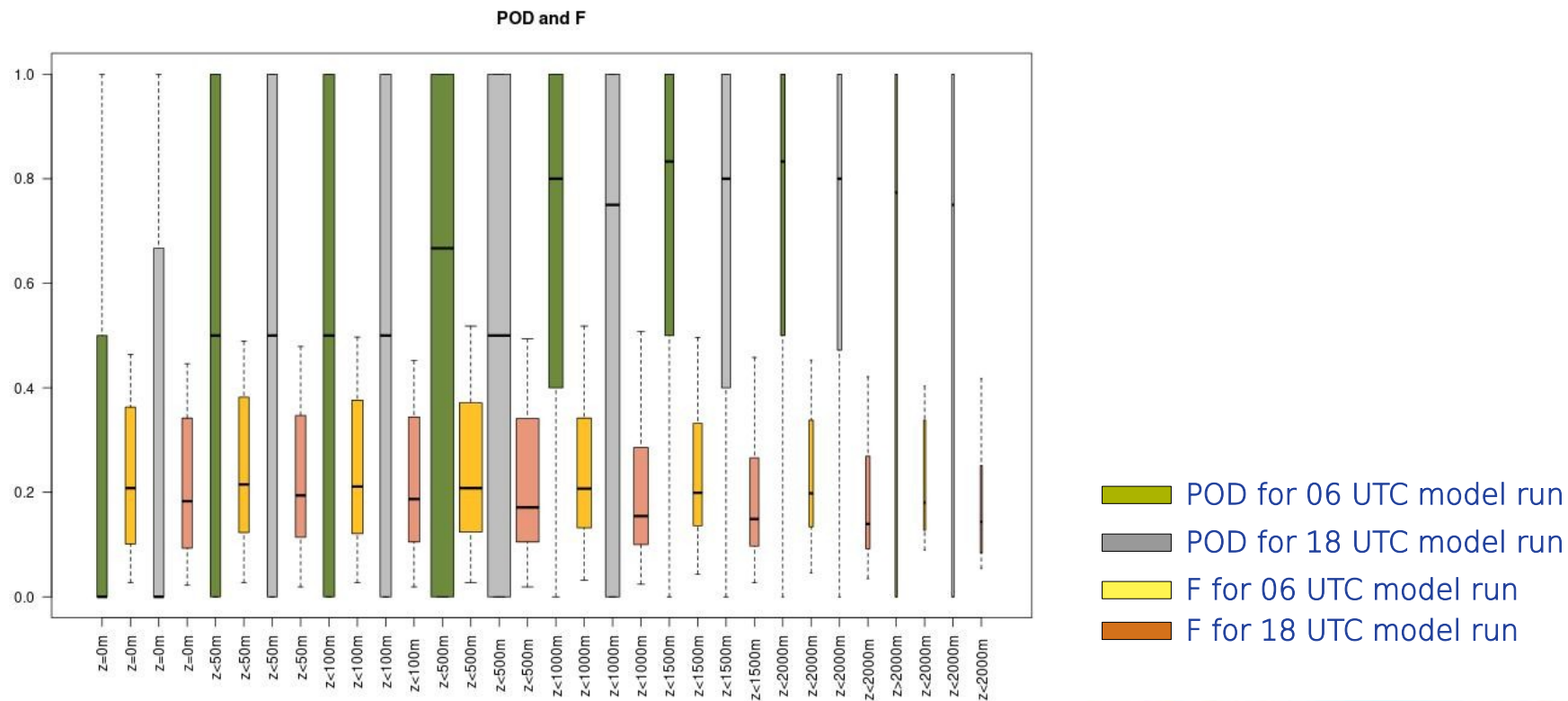# Results: 3. Spatial distribution of forecast skill-scores
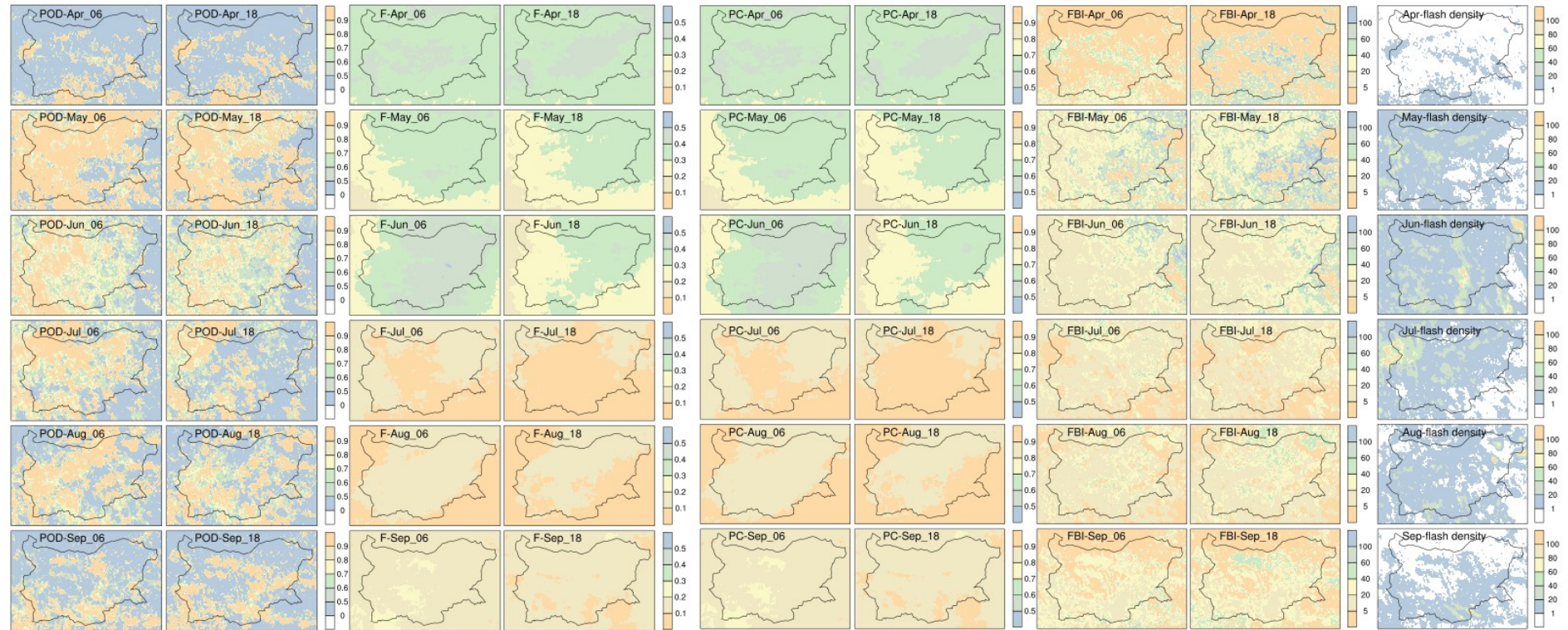
→ F and PC have similar spatial distribution of skill-scores for all months;

→ In April, May and September, POD is high over the regions with detected lightning for the two model runs, but F have also high values; FBI differs for the two model runs during these months with higher values for 18 UTC run;

→ In June and July skill-scores give different results for the two model runs with POD and F higher for 06 UTC run; better scores are obtained in western part of Bulgaria, while the forecast for lightning activity over the Black sea is worse

Results: 4. Height distribution of forecast skill-scores

POD and F

Legend:
- POD for 06 UTC model run
- POD for 18 UTC model run
- F for 06 UTC model run
- F for 18 UTC model run

→ Lightning probability forecast performance is similar for the two model runs at all considered altitudes, with slightly lower performance of evening forecast;

→ POD is improving with the increase of the terrain height, while F is not affected significantly;

Results: 5. Case study - 01/07/2021
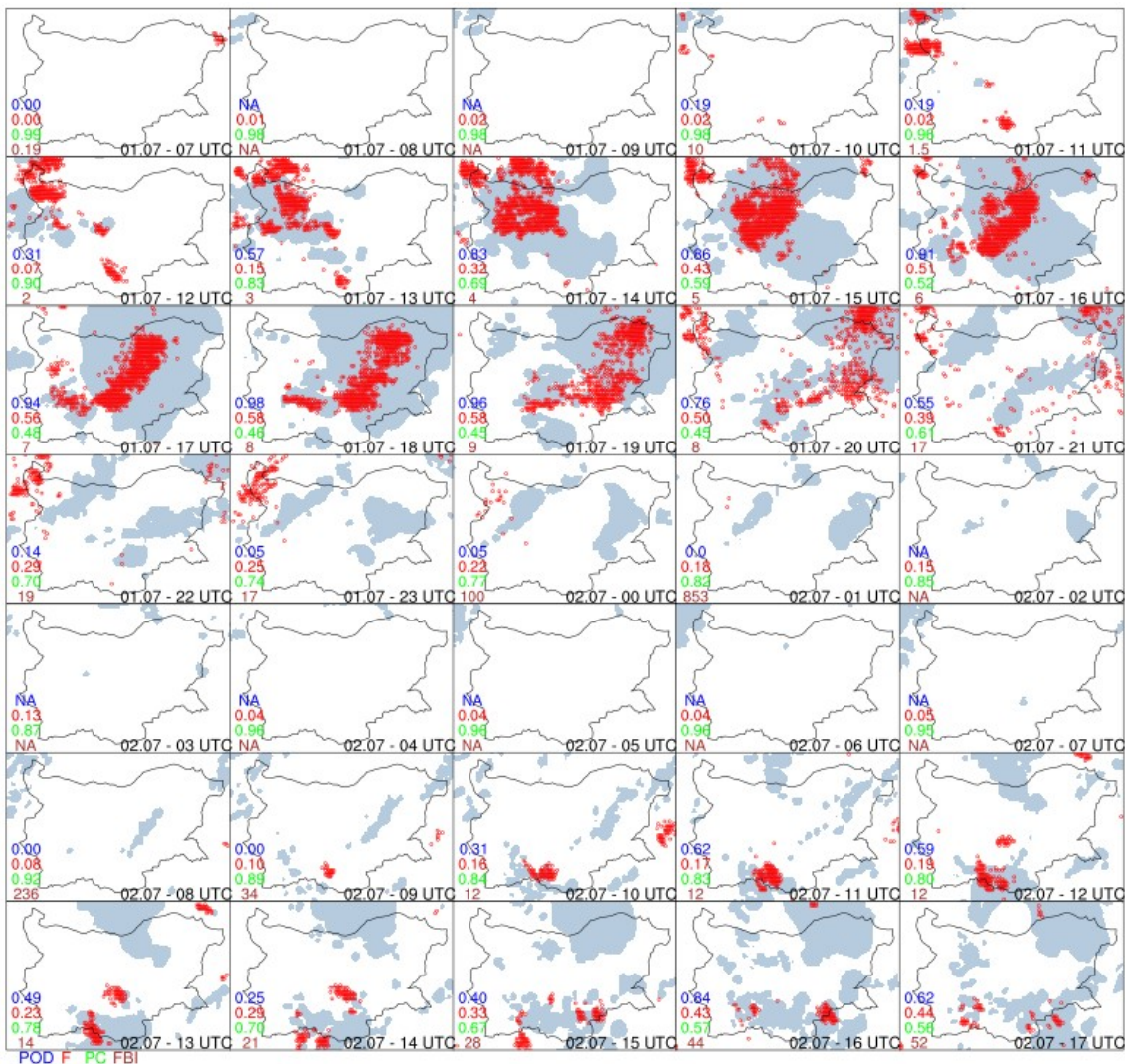
AROME-BG forecast (06 UTC run) for r$_g$>0 (grey) and corresponding cases with detected lightning (red)
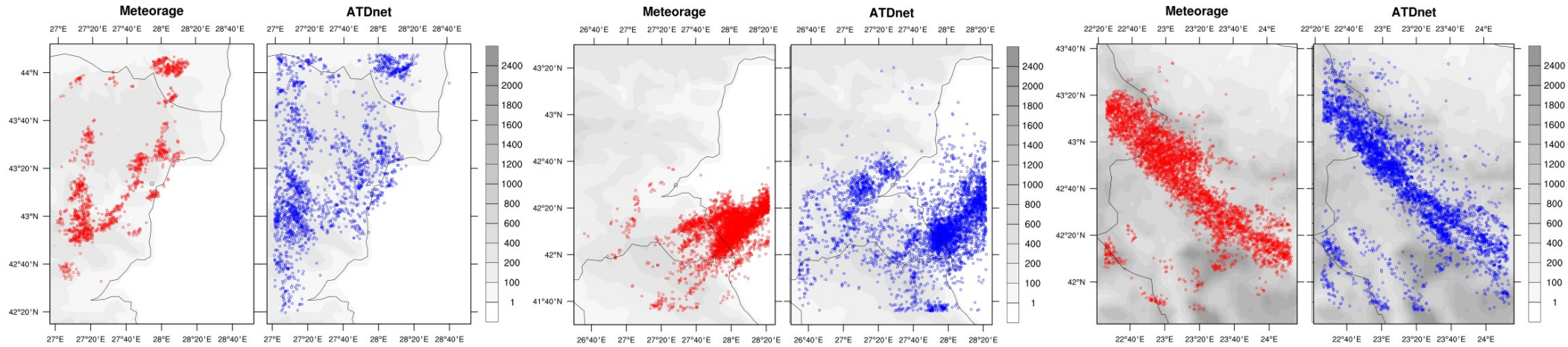
Conclusions

→ Graupel mixing ratio taken from AROME-BG could be used as a tool to forecast lightning probability

→ The relatively low performance over sea could be due to model performance or not most appropriate considered model levels over water pool

→ ATDnet accuracy?

Доц. Д-р Андрей Богачев

(1949 - 2022)

My most sincere feelings and thoughts go to the colleagues of the Bulgarian NWP/ACCORD team as well as to the family and friends of Andrey. He has been over the years an enthusiastic participant in the ALADIN and ACCORD activities, and a very welcome and much appreciated visitor in the French NWP Section GMAP. I will keep a lively memory of him as a regular and devoted "phaser" in Toulouse.

Claude Fischer, PM of ACCORD