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A MULTIMODEL APPROACH FOR FORECASTING OF CONVECTIVE WEATHER IN SUPPORT OF BULATSA AIR TRAFFIC MANAGEMENT

BULATSA
BULGARIAN AIR TRAFFIC SERVICES AUTHORITY

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Motivation

The impact of adverse weather condition on European ATM Network have increased significantly in recent years, which led to a significant increase in delays in summer 2024. In an attempt to mitigate the impact of weather, Bulgarian Air Navigation Service Provider BULATSA has introduced a special weather procedure that requires weather forecasters to provide more accurate and spatially detailed predictions of severe weather areas within the Bulgarian airspace. The proposed methodology attempts to provide a tool for forecasting convective zones that may affect the trajectory of aircrafts and influence the the organization of air trafic control. It uses available data from NWP models, which are appropriately combined within the operational meteorological system used in BUATSA to offer forecasters a useful assessment of the location of affected areas and the probability of events.

Background

BULATSA MET department provide a dedicated convective forecast with validity from to hours up to the end of the next day. Represented methodology is relevant for two forecasts with validity more than 24 hours:

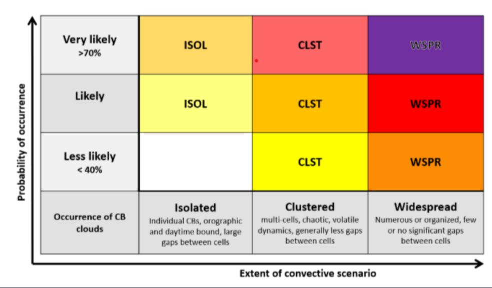
- Forecast of hazardous phenomena for the purpose of planning the capacity of the controlled airspace FIR-SIGWX. The forecast is provided to ATC center and Flight management posiotin
- The Cross Border Convective Forecast (CBCF) for area of BULATSA responsibility. CBCF is a collaborative forecast that provides Network Manager (NM) at EUROCONTROL, and participating ANSPs, with information about convective weather across European Airspace.

Risk Matrix

All of the convective forecasts consist: polygons and an assessment of the risk, based on the spatial coverage or severity and probability of occurrence.

Prob.\ Cover	ISOL	OCNL	FRQ
HIGH			
MED			
LOW			

Matix used in Forecast of hazardous phenomena for the purpose of planning the capacity of the controlled airspace FIR-SIGWX



Matrix used in Cross Border Convective Forecast

Conception

The proposed method integrates two products. First determines the location (CB Cond) and the second one the probability of events (4 CBmodels). Both products are using carefully selected parameters from weather prediction models.

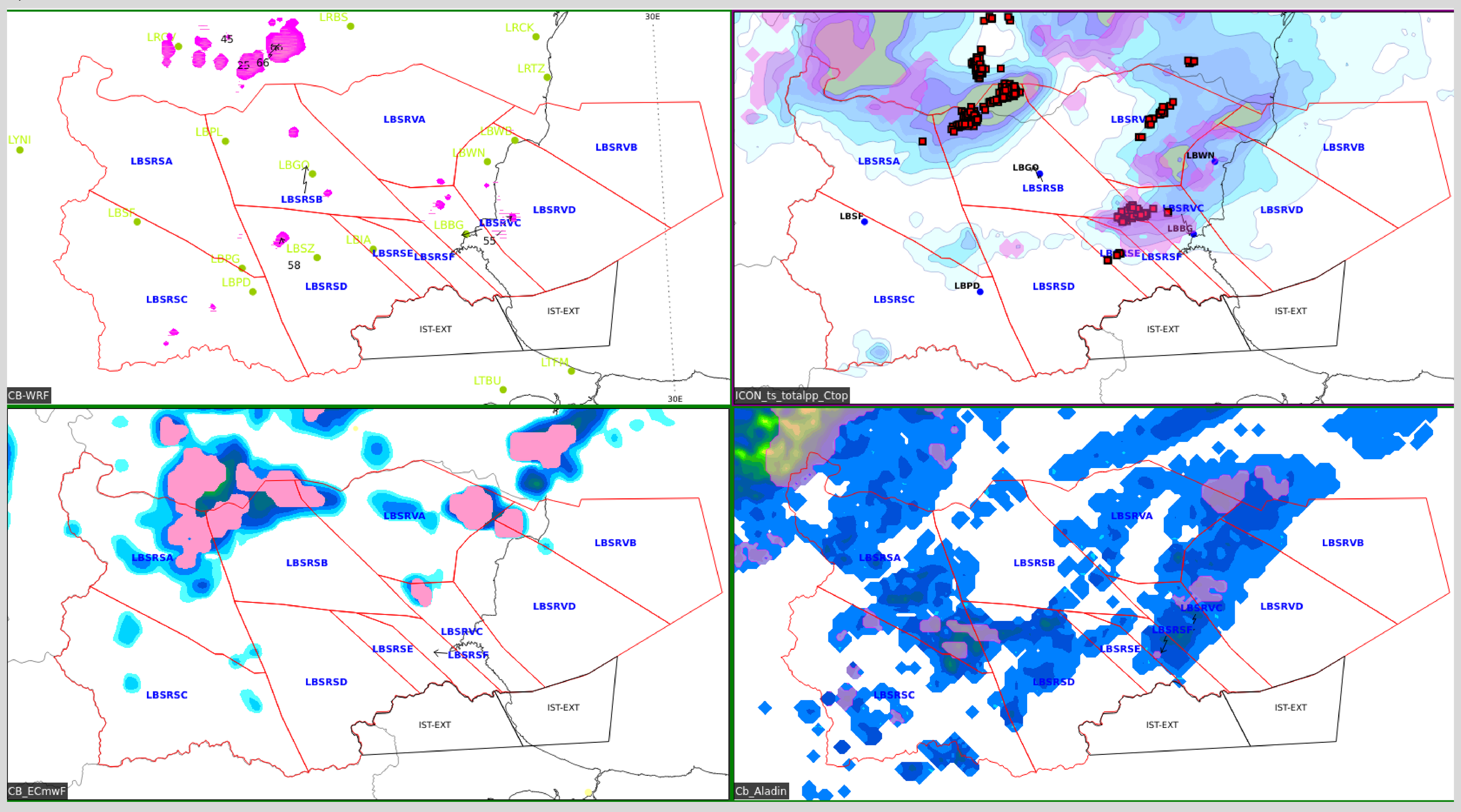
- **4 CBmodels**: Each model contributes with two parameters, for which empirical threshold values have been defined. When, at the same location and time, these parameters exceed their respective thresholds, their intersection identifies areas with potential for significant convective activity. An expert-based assessment is used to assign weights to each model in the decision-making process. The sum of the weighting coefficients from models whose parameters meet the predefined criteria determines the probability level that forecasters can rely on. .
- **Cb Cond**: The location, extent of the polygons, and severity of the convective events are determined by the intersection of the Lightning Potential Index from the **ICON EU** model and the simulated radar reflectivity at 10 cm wavelength from the regional NWP model **BULATSA WRF**.

NWP models and parameters

	ICONE-EU	ECMWF IFS	ALADIN NIMH	BULATSA WRF
First Parameter	Lightning potential index maximum for last 1h >30 J.kg^{-1}	Convective precipitation >0.5mm	Convective rain >1mm	Radar reflectivity at 10cm: 20 hybrid level
Second Parameter	Height of convective cloud top >FL300	Height of convective top >FL280	Vertical velocity at 700hPa <-0.6 hPa.m^{-1}	Radar reflectivity at 10cm: 25 hybrid level
Combination	Intersection	Intersection	Intersection	Maximum from both level

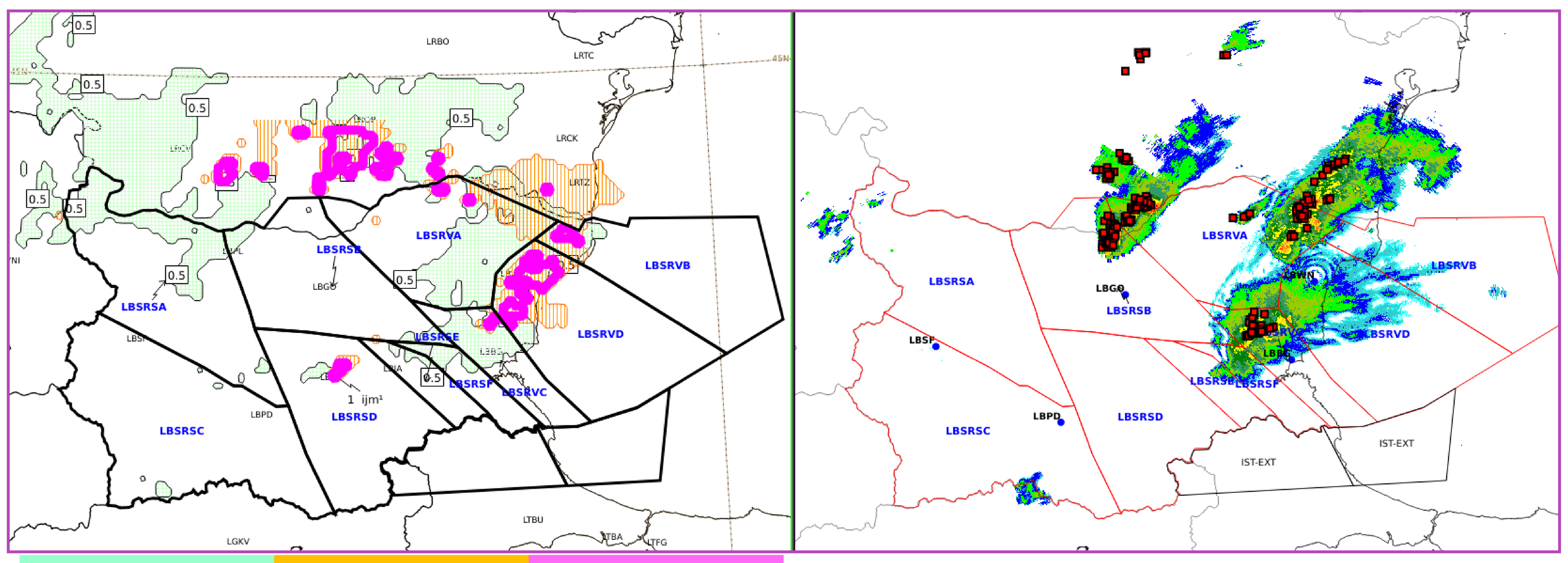
4 CBmodels product

- To determine the weights, 27 convective situations were analyzed.
- For verification were used LINET lightning data, BULATSA radar data
- In each situation, the model forecasts were ranked by forecasters from 1st to 4th place. The total points for each model were divided by the overall number of points, which determined the weight of the respective model.
- The calculated model weights are: WRF 0.32; ICON-EU: 0.28 ECMWF: 0.22; ALADIN: 0.18



Vizualization of 4 CBmodels together with lightning data in BULATSA IBL VW system

CB Cond product



ISOL	OCNL	FRQ
WRF Rad Refl at 25 hybrid level	WRF Rad Refl at 4000m> 15dBz LPI>4 J/kg	WRF Rad Refl at 7000m> 35dBz LPI>10J/kg

Varna radar Zmax product
Lightnings detected by Linet network (5 min)

Conversion Table

Probability	Model Weights
Very unlikely	<0.22
Less likely	0.22-0.40
Likely	0.41-0.70
Very likely	>0.70

Tool validation

- The evaluation and verification were carried out independently by 10 operational forecasters.
- The CB-Conditions forecast was assessed in three categories:

1 – Good forecast;
2 – Useful but insufficient forecast
3 – Poor forecast.

CONCLUSION

- A multi-model methodology for forecasting hazardous convection has been developed.
- The approach is simple and intuitive, providing an "all-in-one view" and delivering reliable forecasts.
- Initial user feedback is positive, even though full implementation is still pending.
- It is operationally efficient, adaptable for improvements, and quickly applicable in operational environments.