ISOBAR

ISOBAR

Artificial intelligence solutions to meteo-based air traffic imbalances for network operations planning

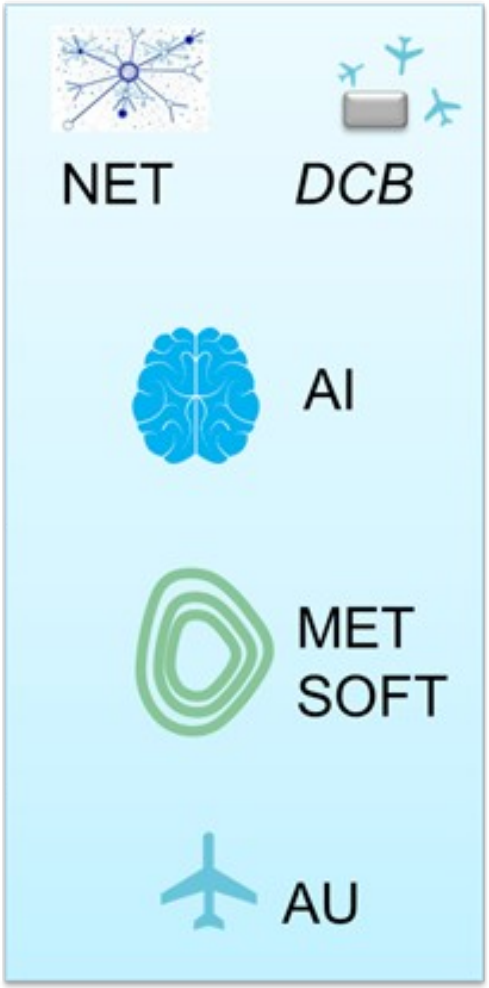


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Laure Raynaud, Marta Sánchez Cidoncha, Gilles Gawinowski, Manuel Fernando Soler Arnedo, Aniel Jardines, Juan Simarro, Danlin Zheng, Yan Xu, Elodie Bastie, Berangère Arnould, Florenci Rey, Ahmed Khassiba, Aurelie Peuaud and Marie Carré

SESAR JOINT UNDERTAKING

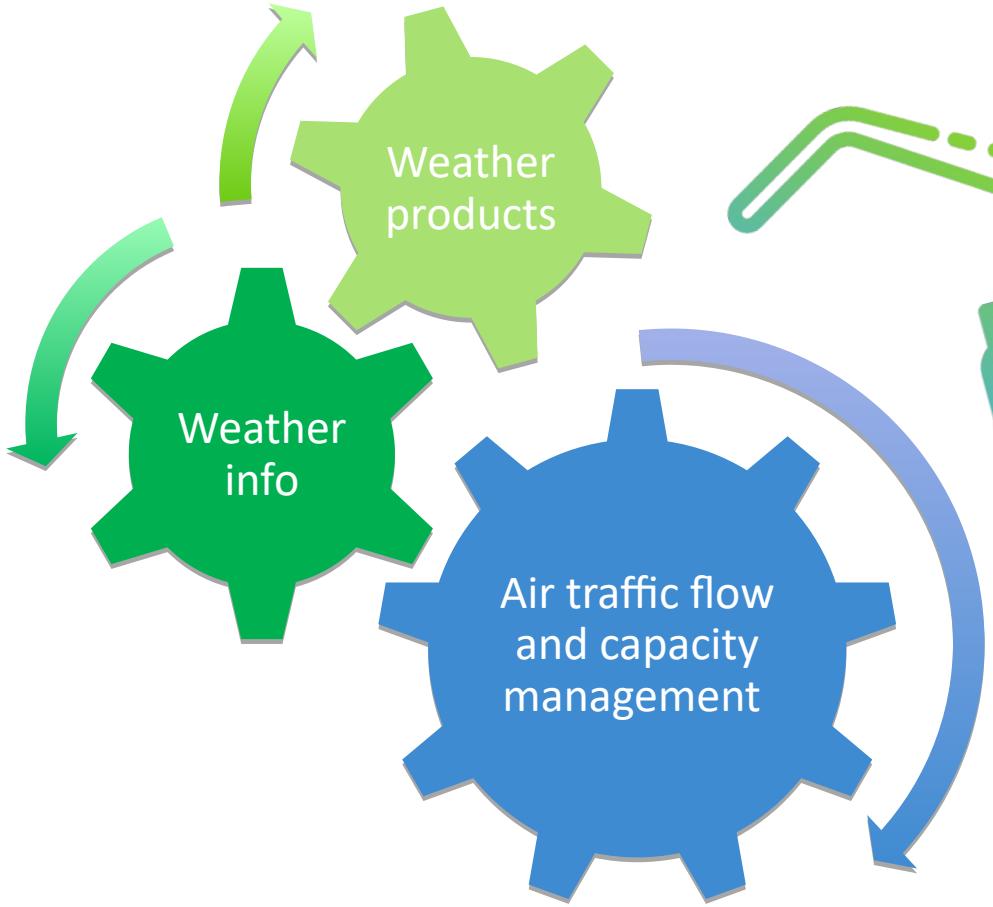
Founding Members
EUROPEAN UNION EUROCONTROL

ISOBAR Consortium



Motivation

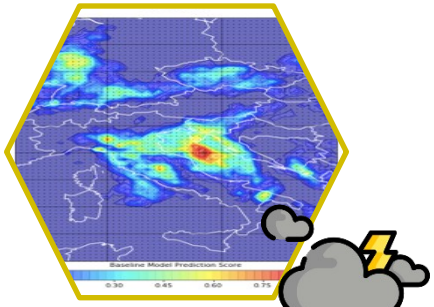
Artificial Intelligence Solutions to Meteo-Based Imbalances for Network Operations Planning



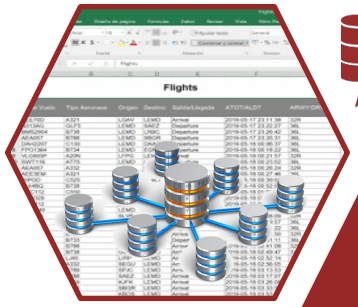


Learning from historical data and operational feedback

ISOBAR Solution

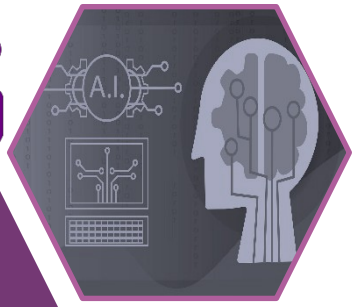


Meteo Engine for prediction of convective storms



Data integration

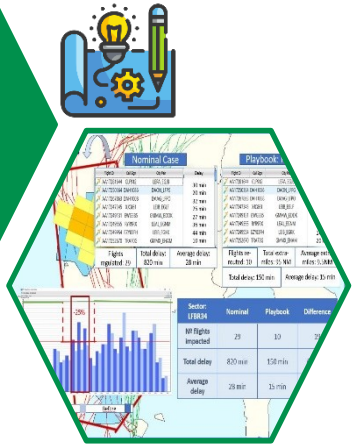
Mitigation strategies prescription



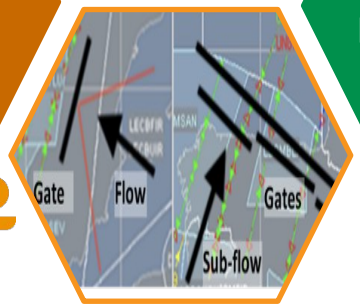


Demand and capacity prediction

ISOBAR solution **protoype** and **evaluation**



ATM **operational framework**



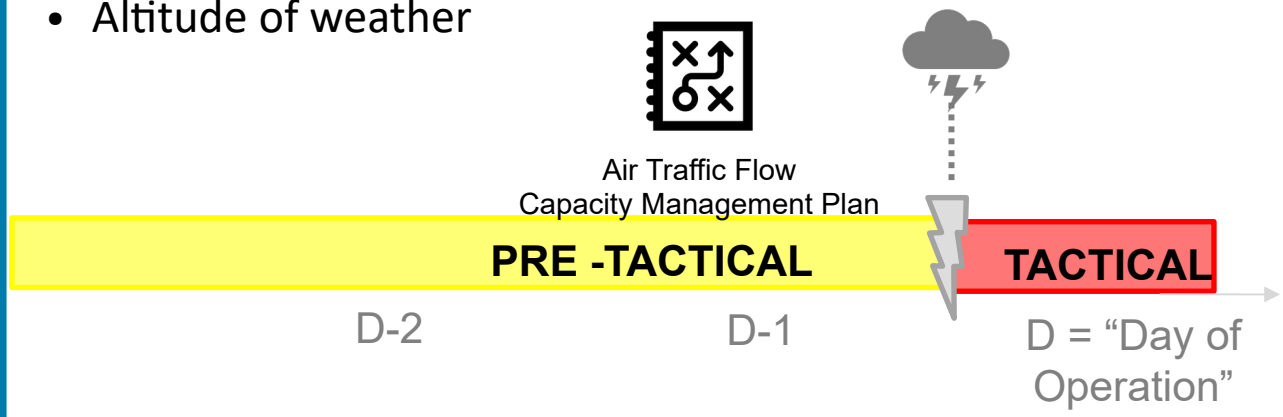
ATM Operational Framework

ATM **operational framework**

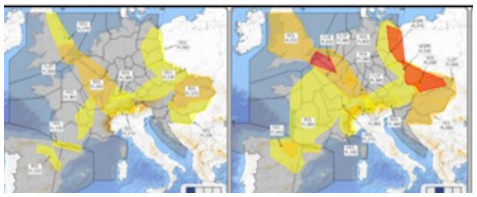
- EUROCONTROL creates an Air Traffic Flow Capacity Management Plan for tomorrow's traffic operations
- It establishes sectors, sector configurations, and routes to be utilized
- Improve convective weather information to improve decision making during pre-tatictial planning phase.

Application Requierements

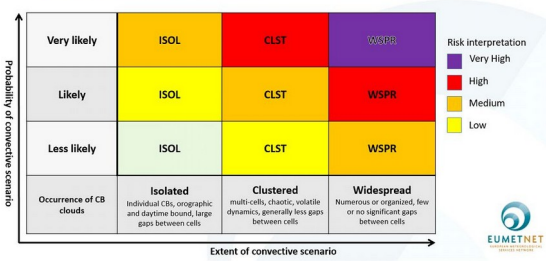
- Lead time greater 24hrs
- Probabilility of weather
- Severity of weather
- Altitude of weather



Cross-boarder forecasts



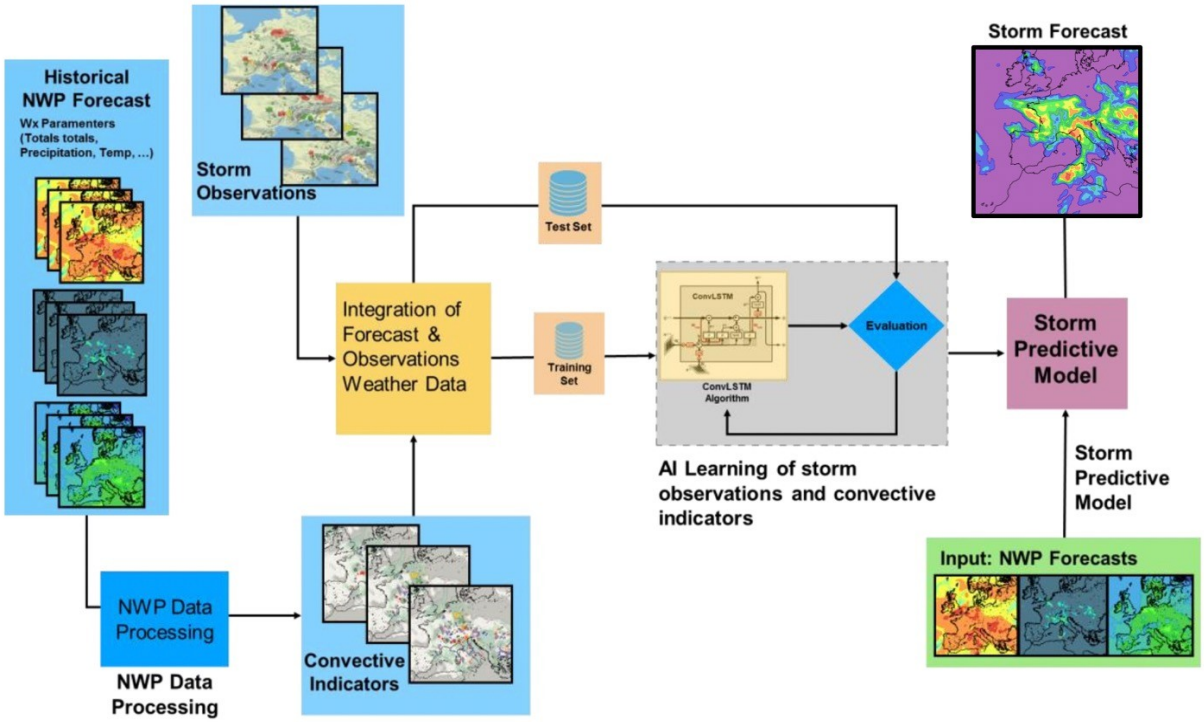
D-1
Unified Risk Matrix for forecasters and users



Meteo Engine

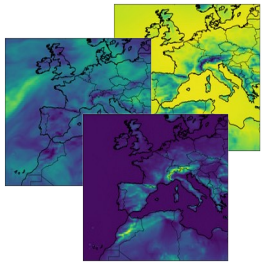
Meteo Engine for prediction of convective storms

- Machine learning (LSTM), multi-parameter approach
- Maximisation of the area of ROC curves (reference = **RDT** product)
- Positive results using different ensemble prediction systems : ECMWF IFS, AROME-EPS, γ-SREPS



Meteo Engine

Meteo Engine for prediction of convective storms

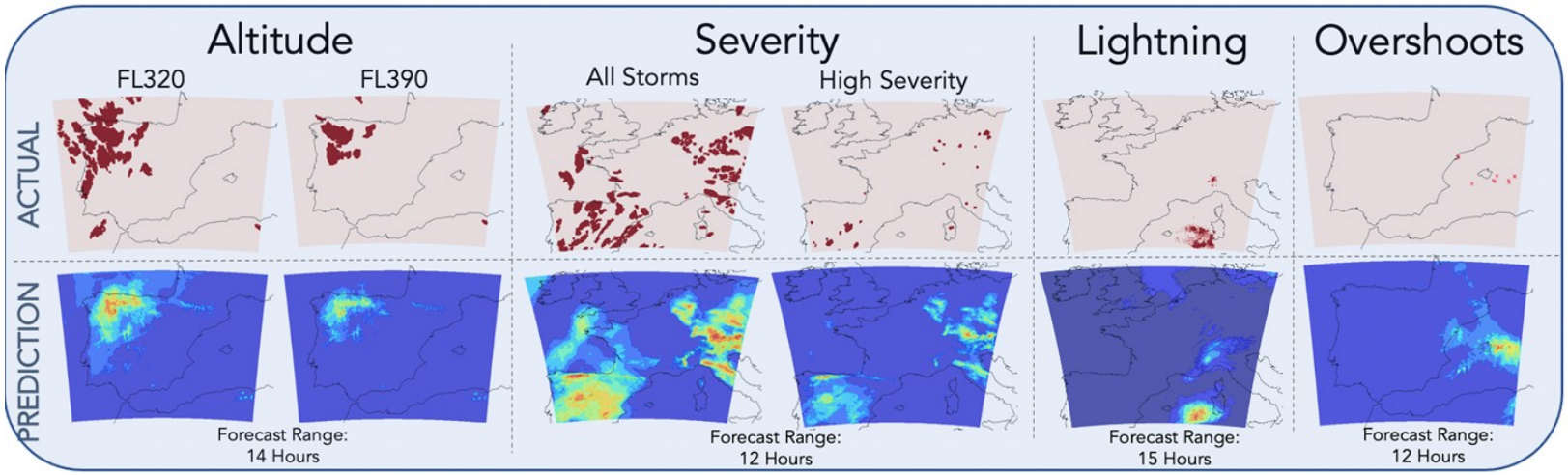


Numerical Weather Products

ML Model

Severity
Altitude
Lightning
Overshoot

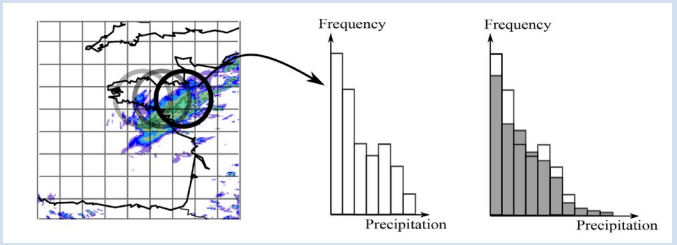
Severity	1
	1
	1
	0
	0
Altitude	1
	1
	0
	0
Lightning	0
Overshoot	0



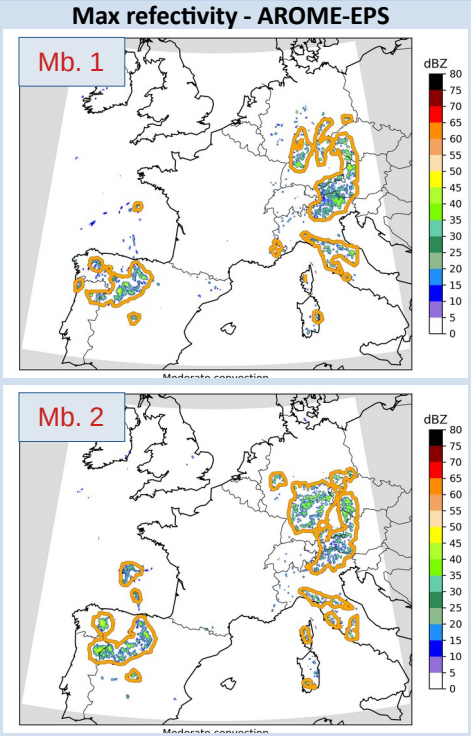
Meteo Engine – benchmark

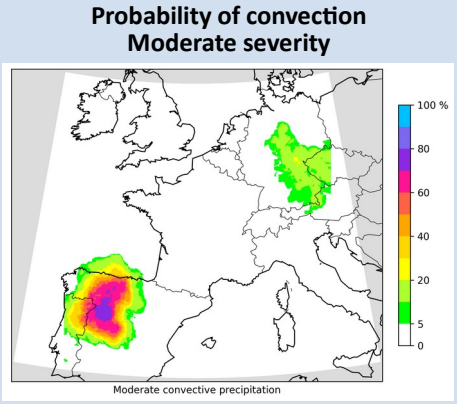
Meteo Engine for prediction of convective storms

- Similarity-based method using maximum reflectivity fields from AROME-EPS
- Additional predictor : ICA (Indice of Convection AROME)
- Use of this product as **benchmark** to test the effectiveness of Meteo Engine for <u>total and moderate severity</u>



Raynaud et al. (2019), Rottner et al. (2019)

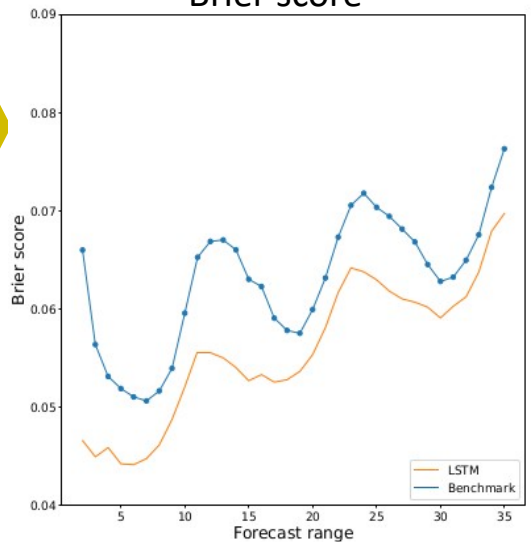




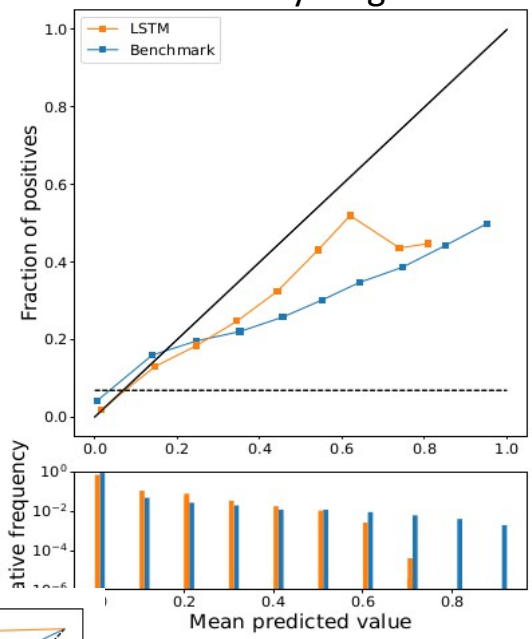
Meteo Engine – probabilistic scores

Meteo Engine for prediction of convective storms

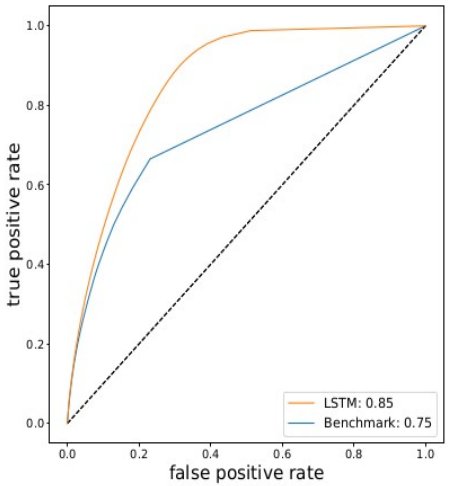
Brier score



Reliability diagram



ROC curve



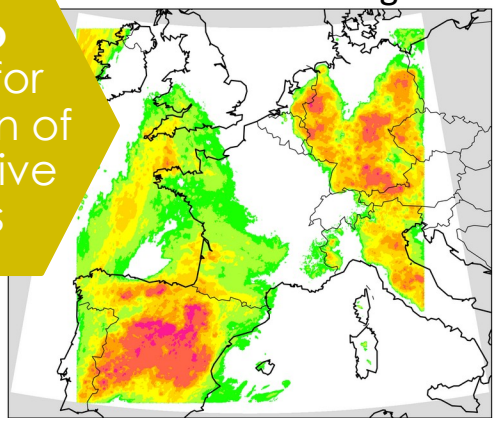
Results for **total convection** (any severity level)

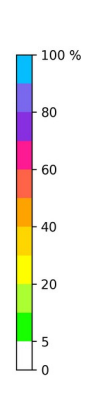
Meteo Engine

Meteo Engine for prediction of convective storms

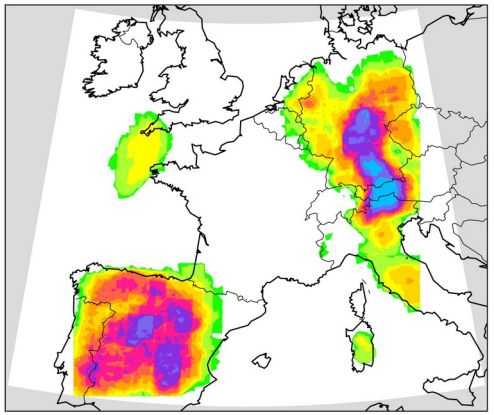
A case study for total severity :

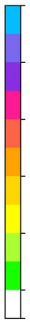
Machine learning



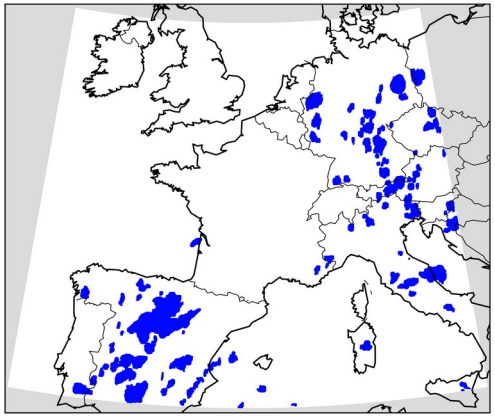


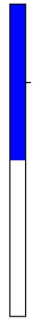
Object-oriented



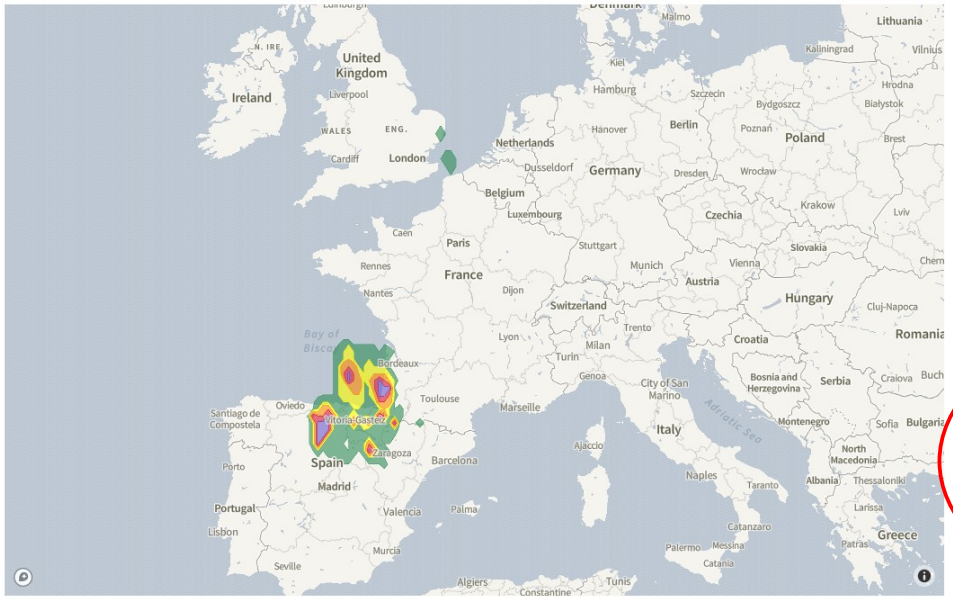


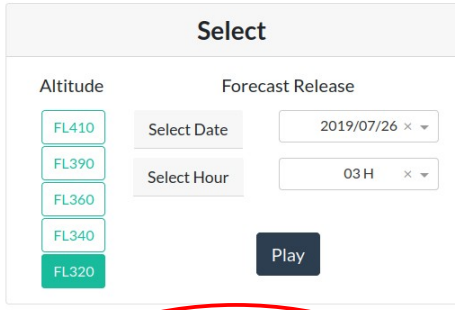
Actual

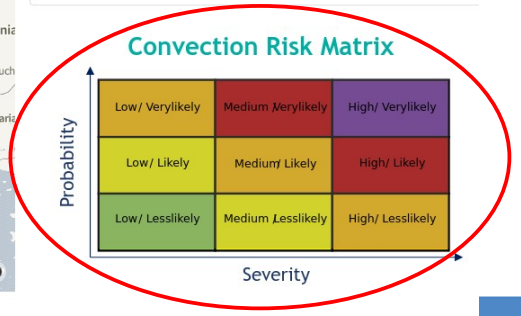




Met dashboard is available following this link : https://isobar-project.eu/dashboard/







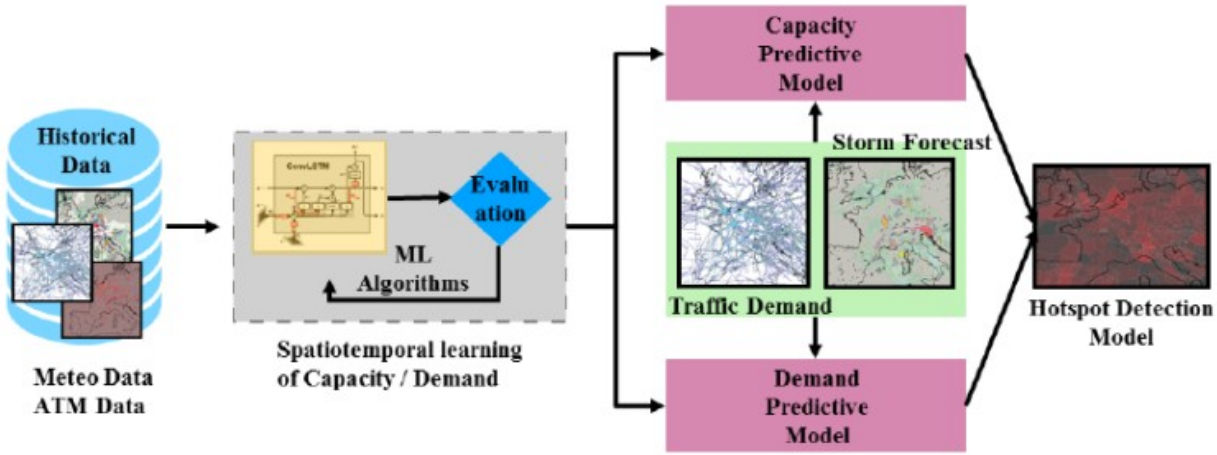
Demand and capacity prediction

Demand and capacity prediction

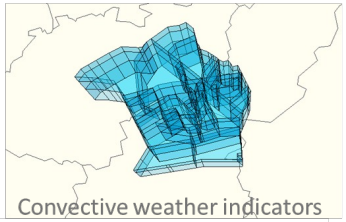
- Neural Network Model to predict entry count for sectors in Spain and France
- Prediction based on weather regulation rate reduction from the past

Results:

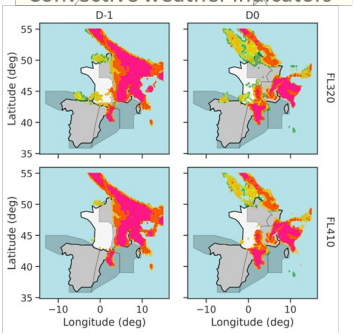
- Entry count prediction for over 350 sector/sector configurations
- Hotspot detection
- **Hotspot** : A sector-period that is unsustainably overloaded



Sector geometries



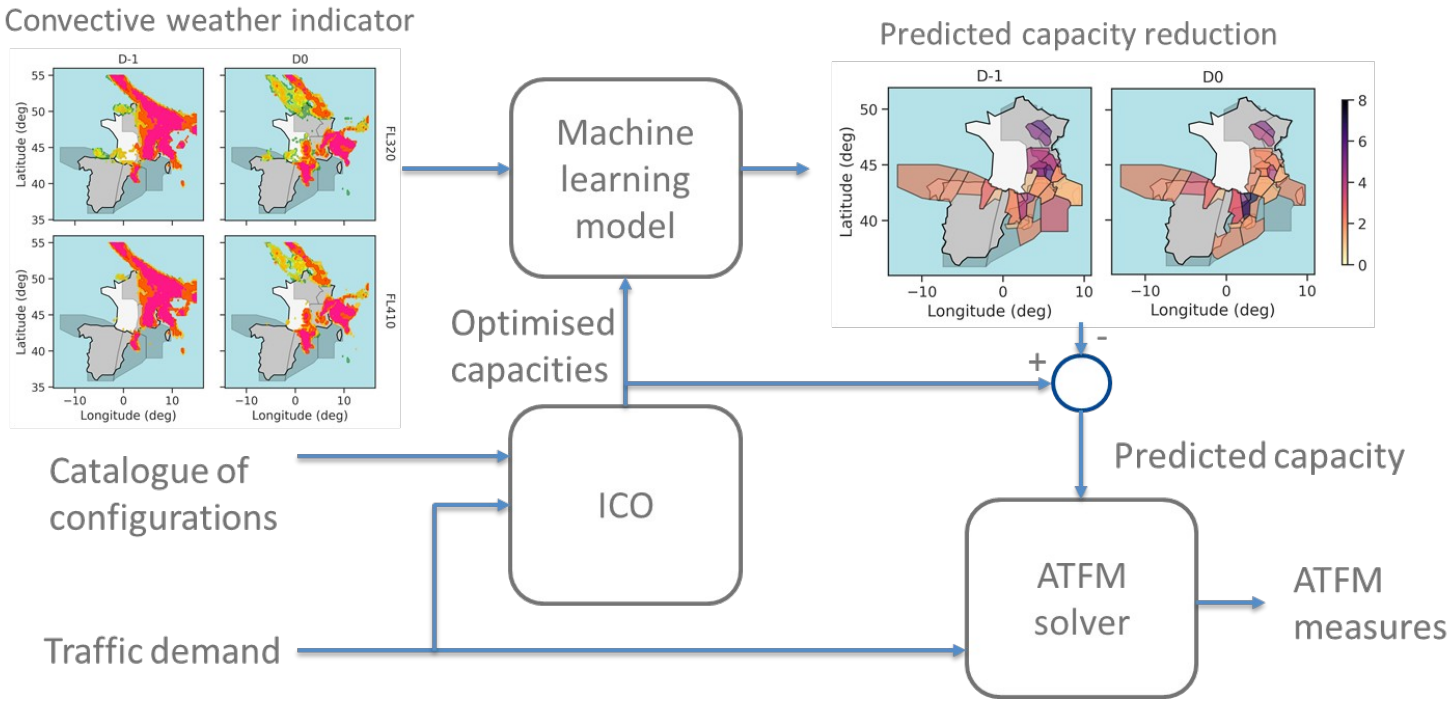
Convective weather indicators



Mitigation strategies – DCB solvers

Mitigation strategies prescription

- DCB Solver Suite provides efficient solutions at the network level
- Objective: minimisation of the air traffic delays over the whole network
- It is the last component of the value chain



ISOBAR Prototype

ISOBAR solution **prototype** and **evaluation**

The overall concept validation in ISOBAR has been addressed through a offline exercise to assess the **operational acceptability of ISOBAR Collaborative Framework**, with human interactions (air traffic controllers) with AI components to manage convective weather situations.

Main Conclusions:

- The **convective weather prediction** allows air traffic controllers to understand the weather situation, DCB impact, and imbalances propagation at the network level;
- Workflow **supports a collaborative process** to better manage in anticipated manner the weather-related problems and solutions.
- Very good **stability** of prediction and solution.



Conclusions

- The correct interpretation of NWP models/crossborder at the ATM level is often challenging → difficult to anticipate capacity and demand → **many delays**

- ISOBAR prototype is able to provide two valuable information:

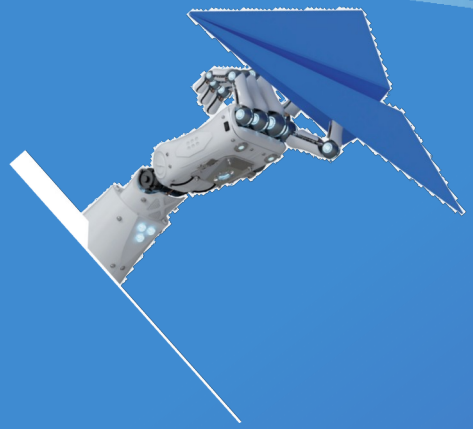
  1) **Convective risk matrix** to visualise areas where convection is forecasted by ensemble prediction systems

  2) **Solutions** at a network level in order to minimise air traffic delays

- **Artificial intelligence** applied separately to each component of the value chain highlighted its capability to provide efficient solutions for air traffic and flow management on the basis of raw forecast from NWM models

➢ Multi-model approach?

ISOBAR



Thank you very much for your attention!

SESAR JOINT UNDERTAKING

Founding Members

EUROPEAN UNION EUROCONTROL