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WELCOME REMARKS

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Executive Director | **SESAR 3 JU**

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FAA KEYNOTE

Steve Bradford

Chief Scientist | **FAA**

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PLENARY 2: ENVIRONMENT/MET ER PROJECT SHOWCASE

Olivia Nunez

ATM Expert| **SESAR 3 JU**

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ENV/MET PROJECT SHOWCASE

Tobias Bauer
DLR
DYNCAT

Angelo Riccio
University of Naples
CREATE

Hughes Brenot
BIRA
ALARM

Riccardo Biondi
UNIPD
SINOPTICA

Antonio Franco
Universidad de Sevilla
FMPMet

Moderated by:

Olivia Nunez
SESAR 3 JU)

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Research Scientist | **DLR**

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Dynamic Aircraft Energy and Configuration Management with DYNCAT

Tobias BAUER &
Fethi ABDELMOULA
DLR

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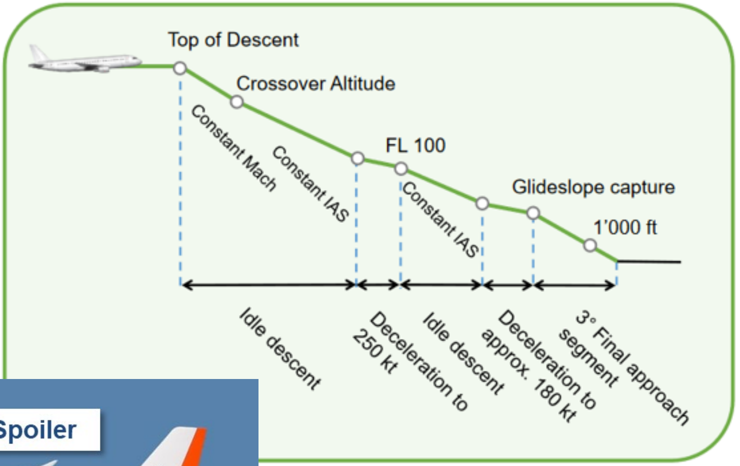
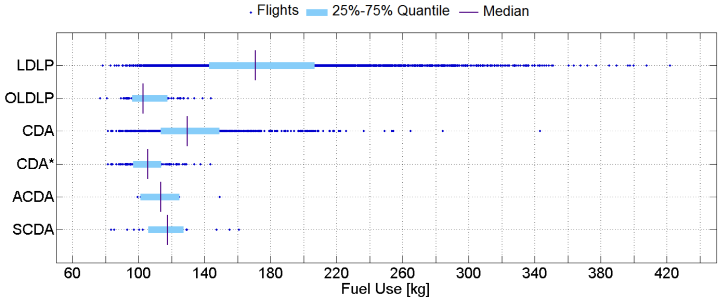
The challenge of aircraft energy management

- descent and landing approach:
  reduce potential and kinetic energy from cruise (high and fast) to touchdown (low and slow)
- *configure* flaps and landing gear
- the theory: Continuous Descent Operation (CDO) in idle from top of descent to stabilisation altitude (typically 1000 ft above threshold)
- the practice: wide variation of fuel consumption and noise for nominally identical transitions

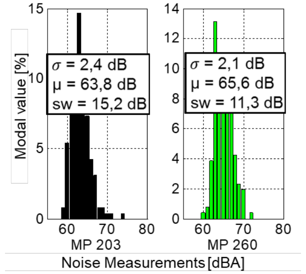
what are the reasons for these differences?



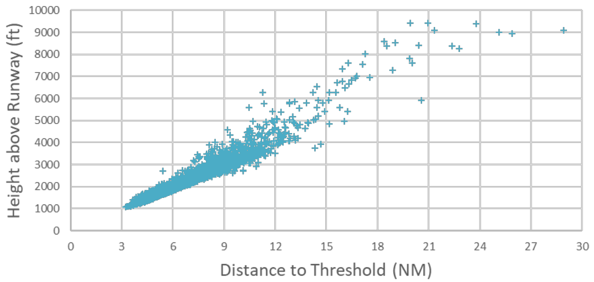
example: fuel use for different approach types



example: noise monitoring data for nominally identical trajectories

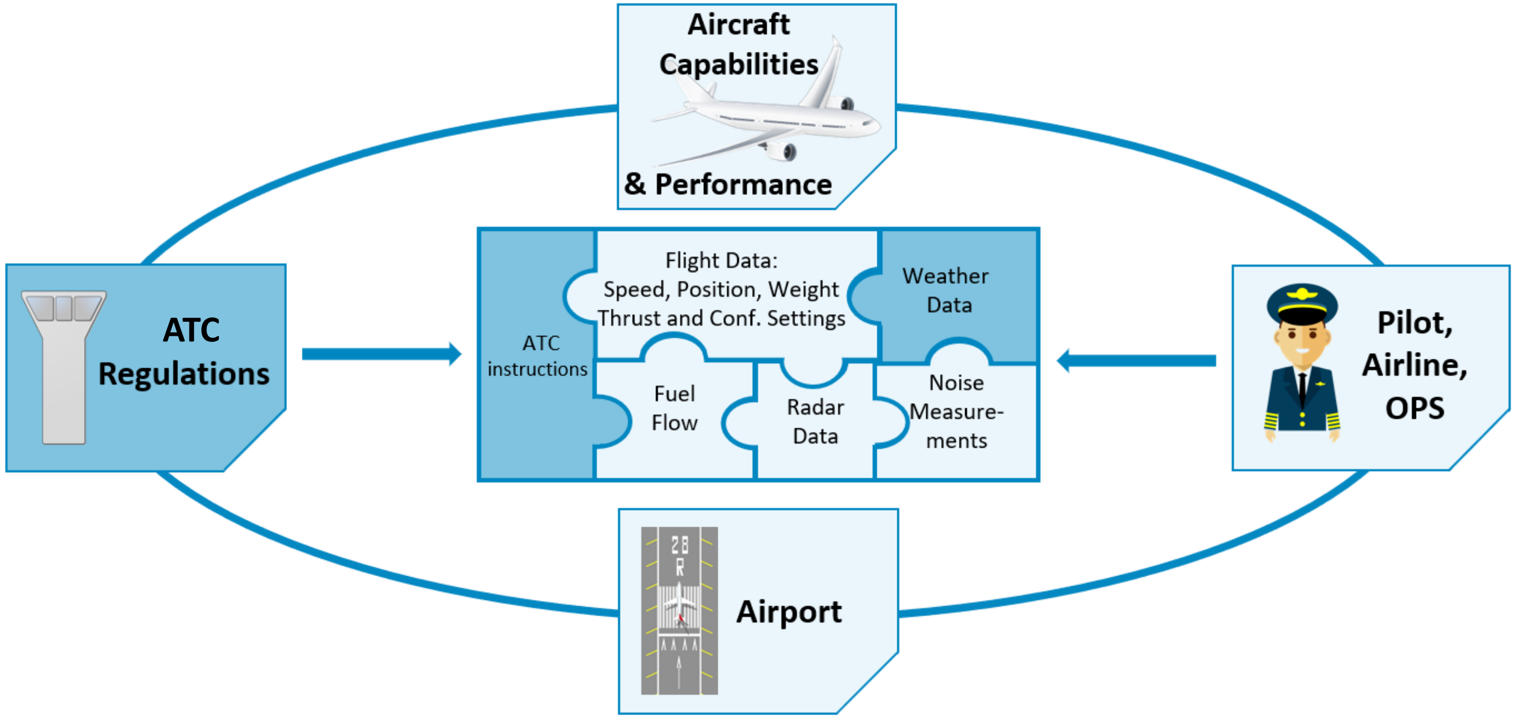


example: height/airspeed of landing gear extension



DYNCAT project approach

exemplary approach: LSZH (ZRH) runway 14, A320-214



with input from practitioners (pilots, ATCos) and authorities throughout the project

Analysis of combined real-world data from all relevant sources

↓

Definition of **operational concept**

↓

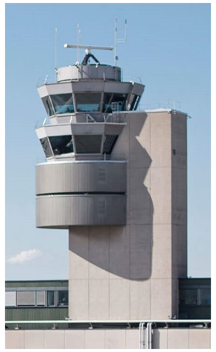
Prototyping of DYNCAT algorithms into FMS and CDS demonstrator on an industrial test bench

↓

Evaluation / quantification

↓

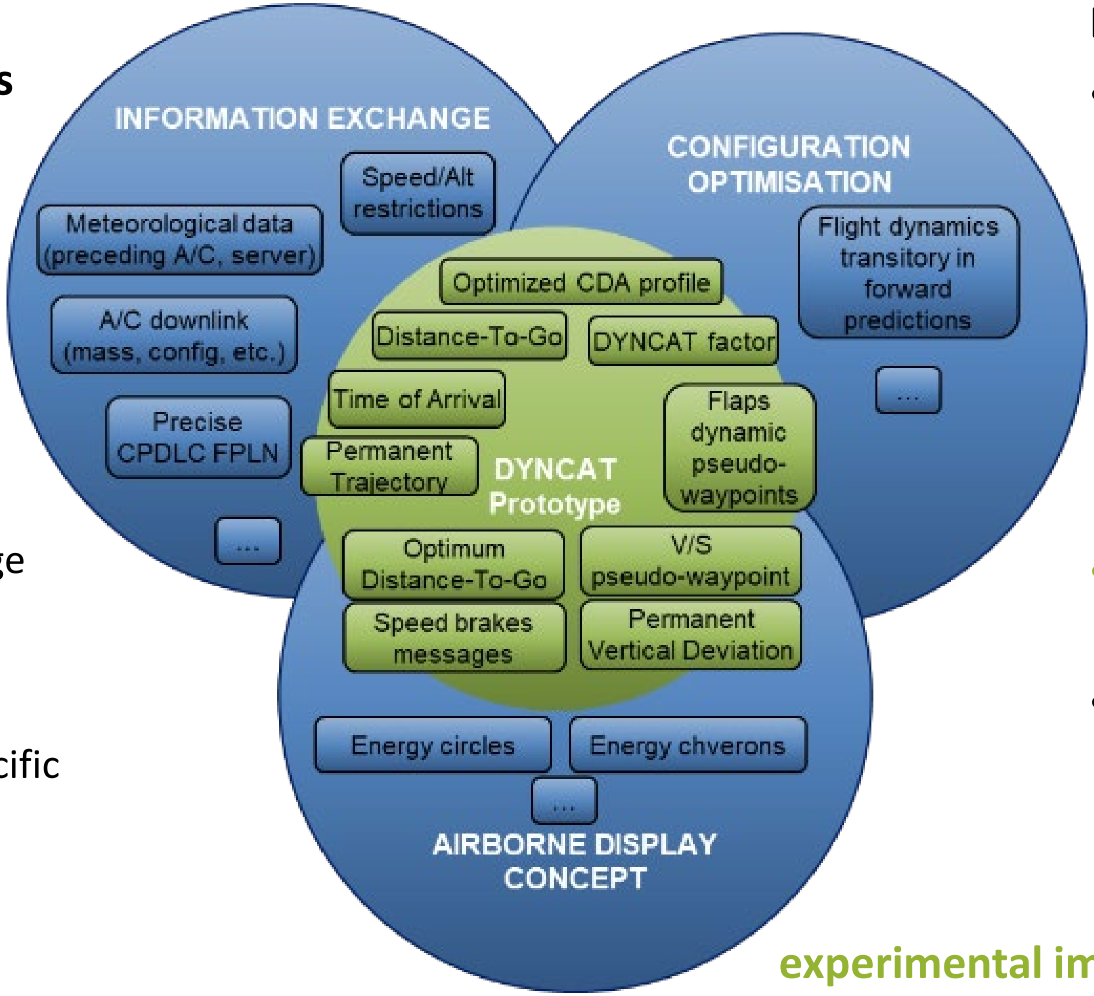
Recommendations



Data analysis and operational concept

identified points for improvements

- missing information about the expected route to the runway
- missing information about the expectable speed / altitude instructions
- changing / unknown wind conditions
- compromise of efficiency vs. reserves
- experience / skills and pilot knowledge about the approaching airport
- unnecessarily rigid instructions from ATC
- ATC lack of knowledge about the specific aircraft performance characteristics

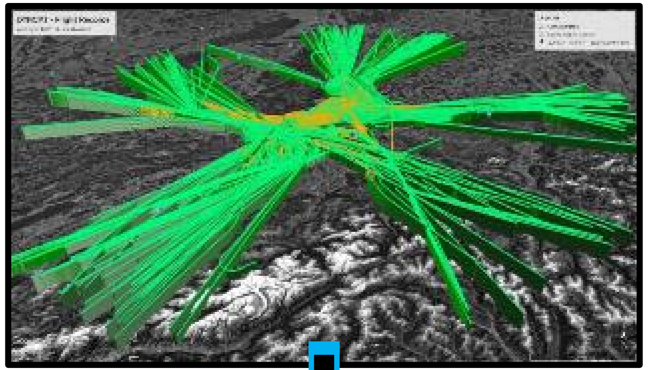


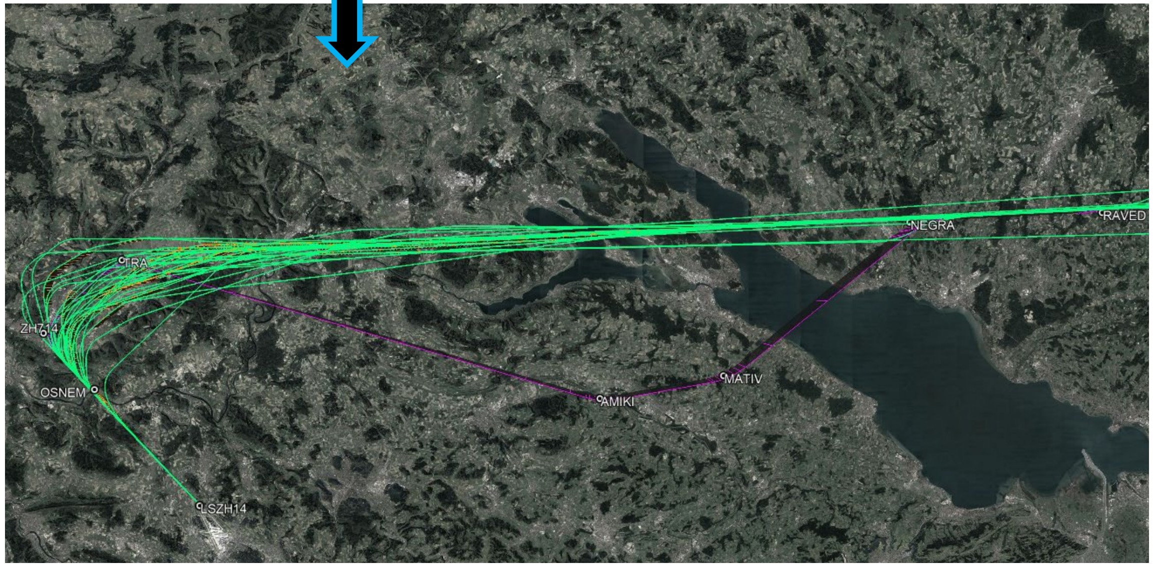
DYNCAT operational concept

- *improved communication / information exchange:*
  - meteo data
  - ATC restrictions
  - aircraft capabilities and precise flight plan downlink
  - distance-to-go / time of arrival
- *aircraft configuration and speed schedule optimisation*
- *improved display concept*
  - energy awareness
  - pseudo waypoints for optimal changes

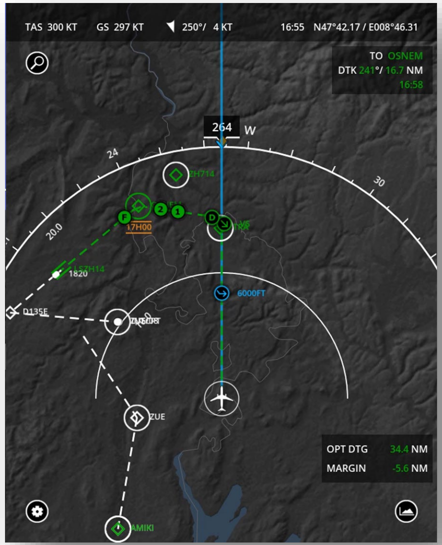
experimental implementation of selected components

FMS prototype testing in RTS on test bench

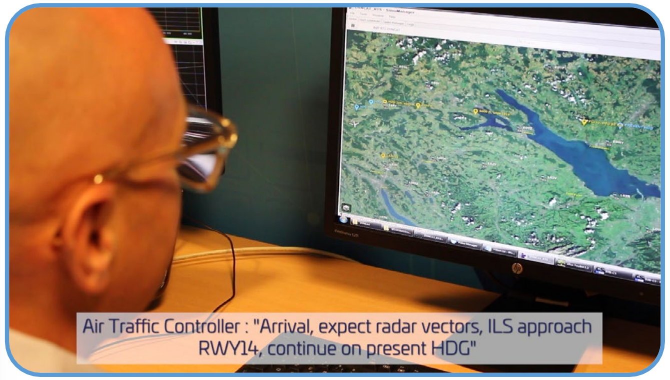




- scenario: typical over-energy situation caused by shortcut



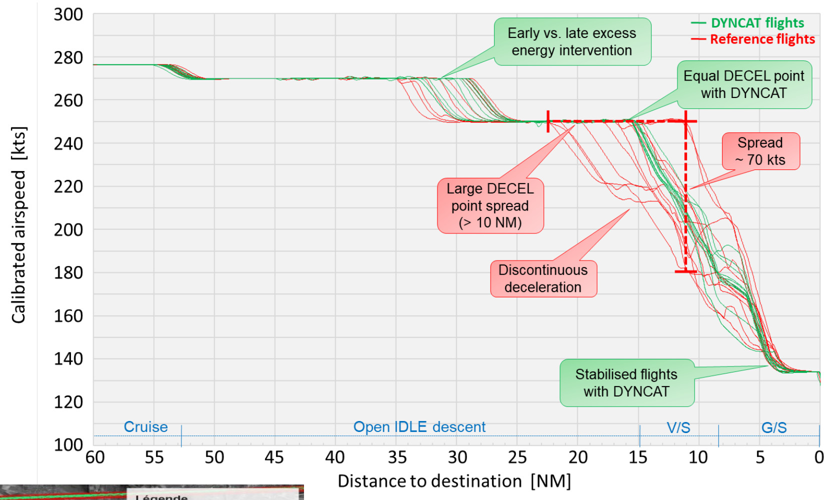
- experimental cockpit display system

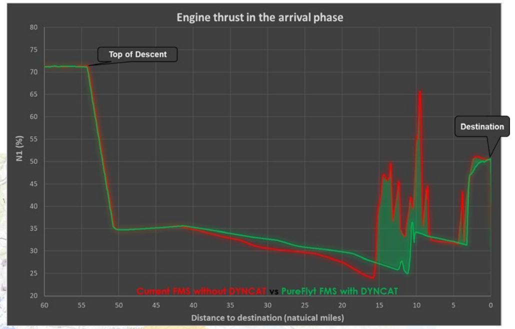


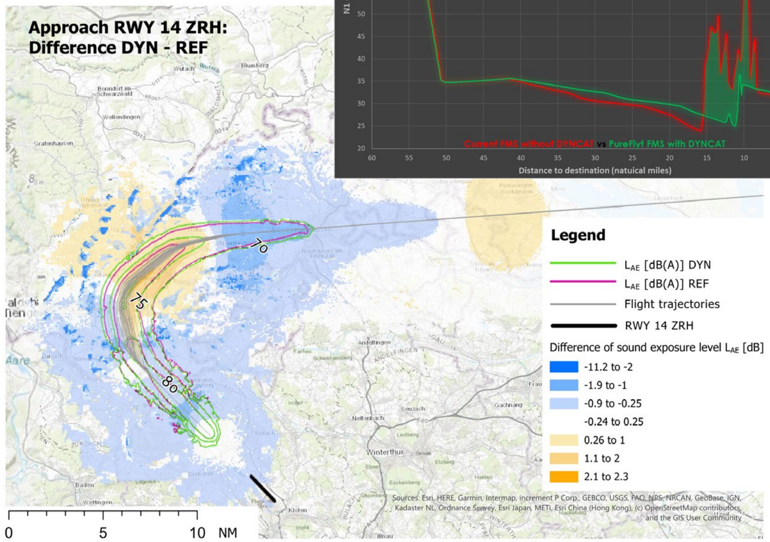
- piloted simulation trials, 1 ATCo + 10 airline pilots

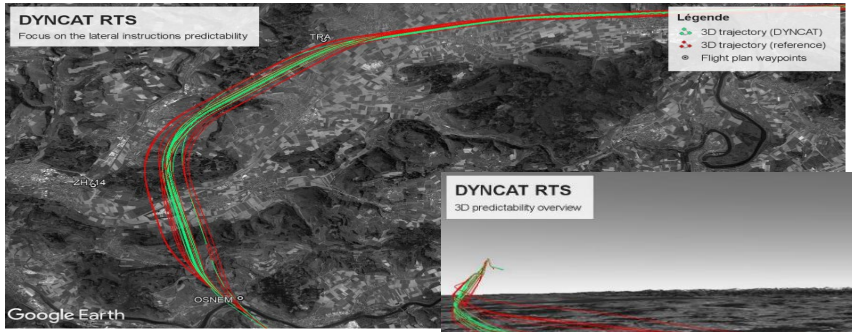
Quantified benefits of DYNCAT FMS function

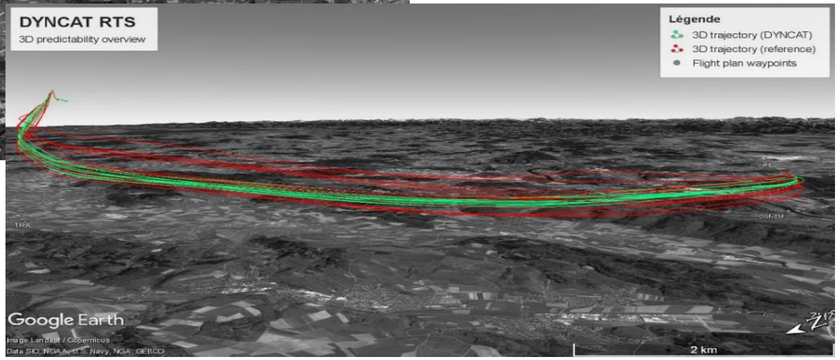
- better stabilisation
- higher predictability of trajectory (in 4D)

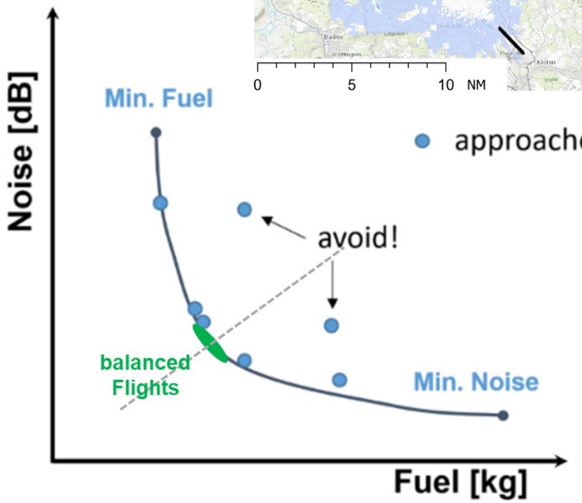












- fuel use & noise reduction
- optimal trade-off

Thank you

Empa
Materials Science and Technology

SKY LAB

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THALES
Building a future we can all trust

SWISS

all deliverables available at
https://www.dyncat.eu/

please visit poster #31

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PLENARY 2: ENVIRONMENT/MET ER PROJECT SHOWCASE

Angelo Riccio

Associate Professor | **University of Naples**

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CREATE

innovative operations and **C**limate and weathe**R** mod**E**ls to improve **AT**m resilienc**E** and reduce impacts

5-8 December 2022, Budapest

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EUROPEAN PARTNERSHIP

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Project objectives

- Achieve innovative procedures in ATM to *reduce climate and environmental impacts*, taking advantage of high-resolution CTMs (Chemical Transport Models)
- *Improve traffic flows and ATM resilience*, taking benefit of weather information, especially in a climate change scenario, when weather extremes are expected to be more frequent in the future

Case studies

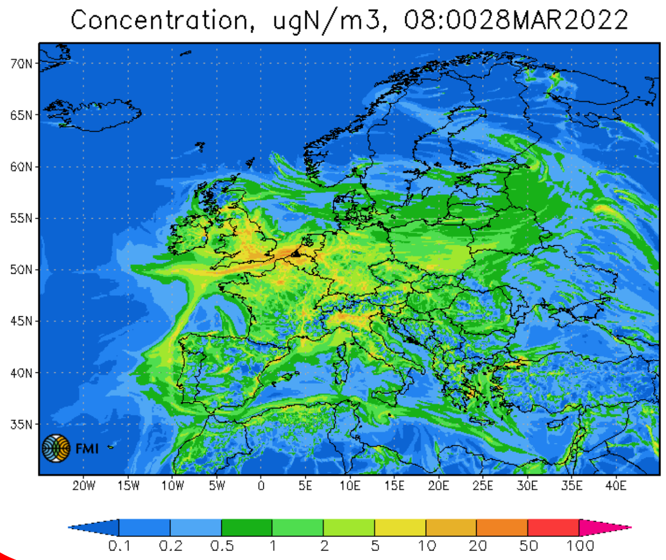
- TMA use case: Naples Capodichino, a mid-size European airport close to an urban area
- En-route use case: North-Atlantic domain, extending on the ECAC area

Project SOLUTIONS

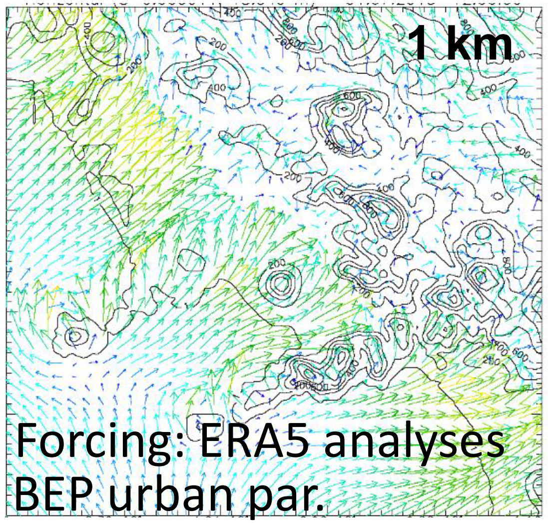
- CREATE-SOL-1: Multi-scale multi-pollutant air quality system (AQS)
  - This solution enables the evaluation of the impact that the air traffic regulation policy options can have on the environment and climate, estimating the extent of the environmental impacts that current and future air traffic movements might have
- CREATE-SOL-2: Multi-aircraft environmentally-scored weather-resilient optimized 4D-trajectories (WAAP, Weather Avoidance for ATC Planning)
  - This solution aims to support the update and revision process of the reference business trajectory (RBT) in highly disrupted scenarios due to weather hazards or climate-sensitive zones, tackling (near) real-time aspects and the network and safety constraints arising in a multi-aircraft environment
- CREATE-SOL-3: CO_2 and non-CO_2 balanced Environmental Scores Module
  - The solution points to the "greenness" of aircraft trajectories related to flight and ATC sector environmental performance. Candidate trajectories are evaluated with respect to CO_2, NO_x and contrail probability formation

Multi-scale multi-pollutant air quality system (AQS) solution

Regional scale air quality (SILAM)

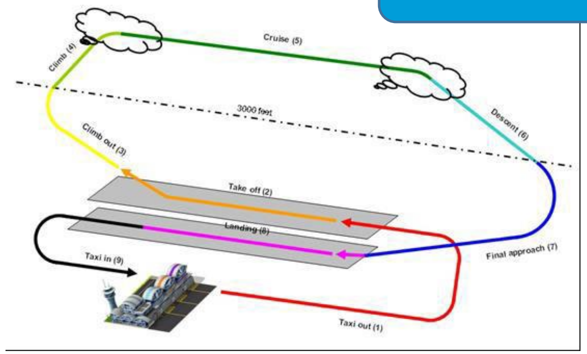


Urban scale meteorology (WRF)



Italian emission inventory

+ AEM Kernel

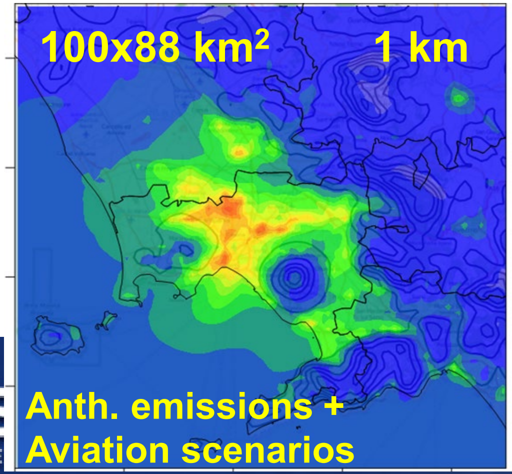


Aircraft+airport emissions

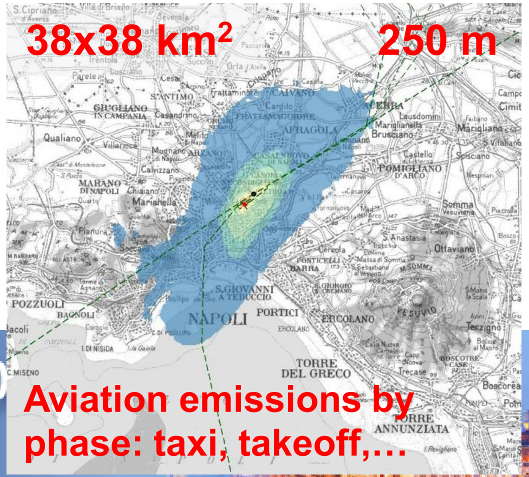
air quality

air quality

Urban scale CTM (FARM)



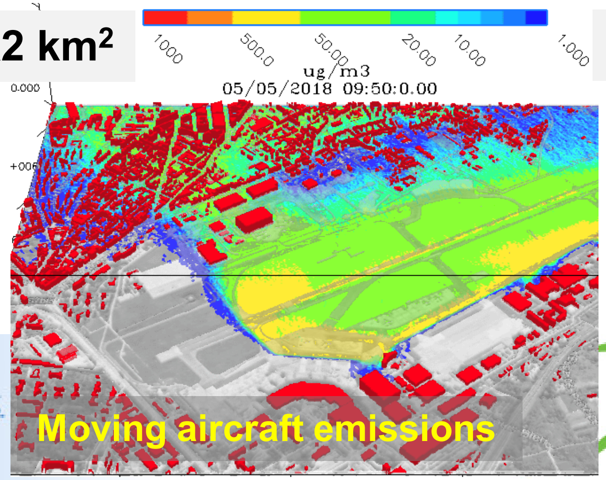
Local scale LPM (SPRAY)



Obstacle resolving LPM (PMSS)

2.5x2 km²

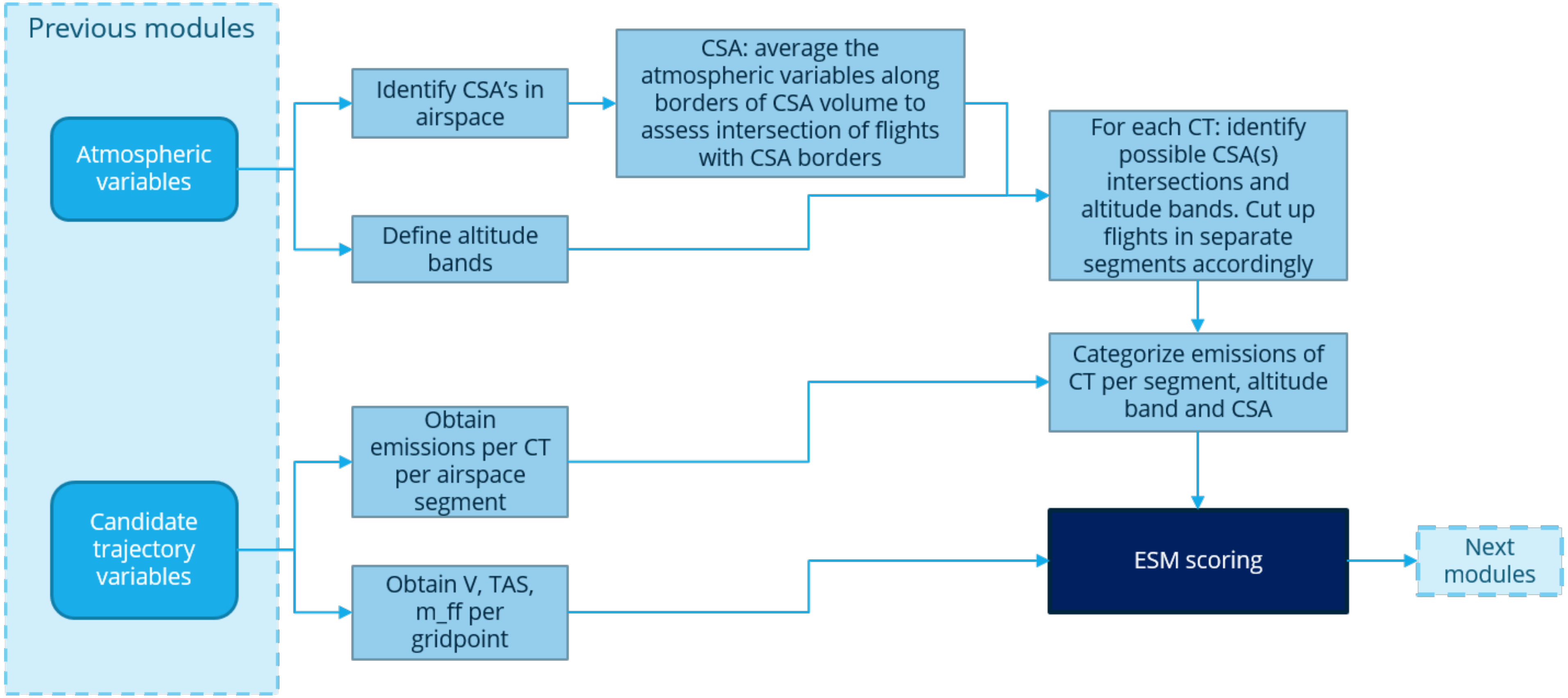
5 m



Environmental Scores Module **(ESM) solution**

The Environmental Scoring Module (ESM) assigns scores to each candidate trajectory:

- ✓ CO_2 emission is linearly related to the fuel burnt
- ✓ NO_x and H_2O emissions impact are related to altitude
- ✓ Contrail formation probability and impact are related to Climate Sensitive Areas and interference with other Candidate Trajectories



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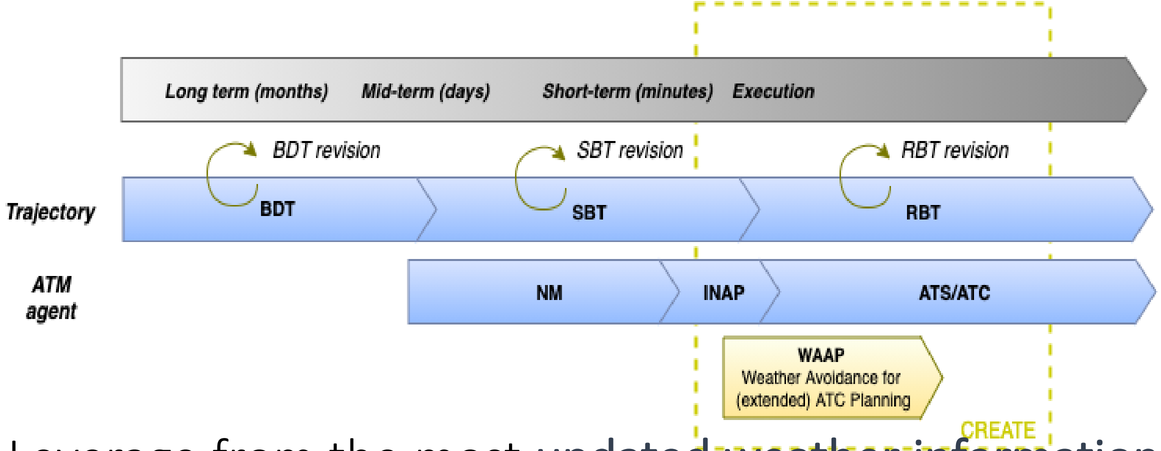
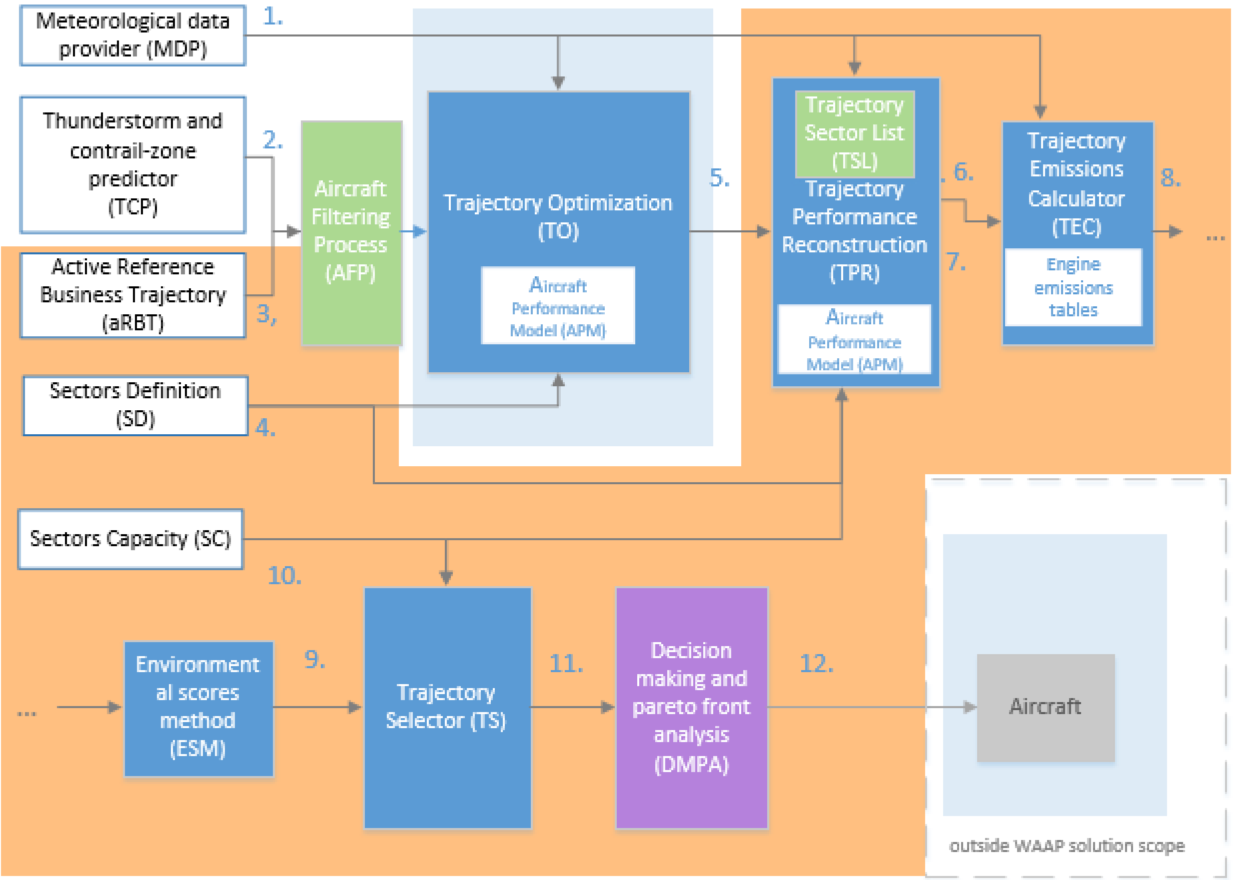
Weather avoidance for ATC planning (WAAP) solution

Proposal for an ATC decision support tool (and associated ConOps), to support the RBT revision process in highly disrupted scenarios due to weather hazards or climate-sensitive zones





- Leverage from the most updated weather information to re-plan trajectories in the execution phase of the flight in heavily disrupted scenarios:
  - Bridging the gap between planning and execution
  - Increasing capacity (mitigate capacity loss) and maintain/increase safety
  - Increasing flight efficiency and improve the environmental impact

Main RESULTS

- Development and application of high-resolution CTMs (Chemical-Transport Models) for air quality assessment studies to test the advantages in terms of environmental impact in TMAs (Terminal Manoeuvring Areas) and on the regional and global scales
- New ATM concepts, i.e. 4D multi-aircraft trajectory optimisation and replanning algorithm, based on CTMs and weather forecasting models to estimate the impact on air quality and climate
    - The multi-aircraft optimization framework integrates short-range high-resolution meteorological information, so as to quickly respond to newly available meteorological information and improve the ATM system resilience to local weather
    - Also, air quality information is used to minimize the impact during descent/climbing phases in TMA areas
    - The first "nuclei" of an ATC decision support tool, in line with the SESAR "extended ATC planning" concept, has been designed, to find a system-wide global solution
- New environmental scoring methods to estimate the impact of non-CO_2 emissions in TMA areas, and the impact of CO_2 and non-CO_2 emissions in climate-sensitive zones

VALIDATION activities

- The multi-aircraft optimization framework allows to generate a set of alternative trajectories per flight in the execution phase with the trajectory optimisation module, avoiding weather related no-fly areas and contrail-sensitive areas located across the original trajectory
- It is fast enough to be used (and re-used) for real-time applications, given the background information on weather and air quality
- It can achieve an improvement in air quality, providing alternative trajectories as short as possible thus reducing the additional fuel consumption and delay associated to the modified trajectory to the minimum possible one

All validation activities and results have been presented to a wide audience of stakeholders, including climate/air quality modelers, ANSPs, experts in air traffic services and air space management, and international conferences

Climate and weatheR modEls to improve
ATM resiliencE and reduce its impacts

For more details, all deliverables are available from the CREATE web site:

https://create-project.eu/

Thank you for your attention!

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PLENARY 2: ENVIRONMENT/MET ER PROJECT SHOWCASE

Hughes Brenot

Research scientist | **BRIA**

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ALERT PROJECT

https://alarm-project.eu

Aviation safety can be jeopardized by multiple hazards.
The overall objective of ALARM is to develop a prototype global multi-hazard monitoring and Early Warning System for these risks.

Project information

- **Horizon 2020**
- ID: **891467**
- Call: **H2020-SESAR-2019-2** (SESAR 2020 EXPLORATORY RESEARCH)
- **1st Nov. 2020 – 31st Dec. 2022**

uc3m · BIRA-IASB · SATAVIA MAKING AVIATION SMARTER · Università degli Studi di Padova · DLR · symopt

ALERT SOLUTIONS

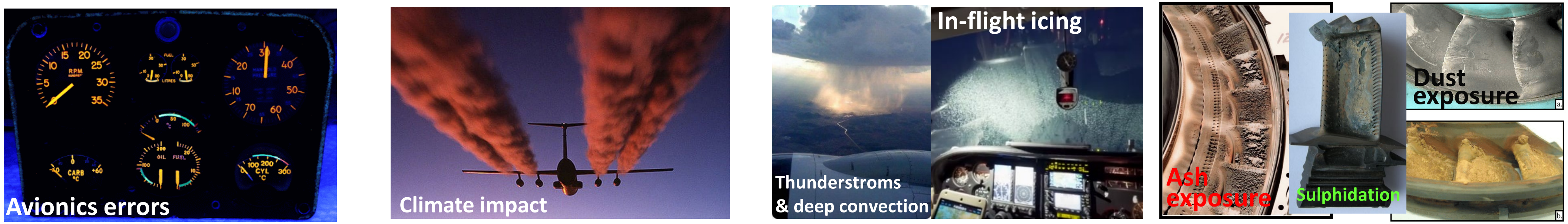
Space Weather
- Radiation exposure
- HF radio wave disturb.
- Navigation errors
- Avionics errors

Environmental Hotspots
- Area where aviation emissions have a very large climate impact

Severe Weather
- Thunderstroms
- Deep convection
  - In-flight icing
  - Turbulence
  - Wind shear

Smoke Dust Ash & SO_2

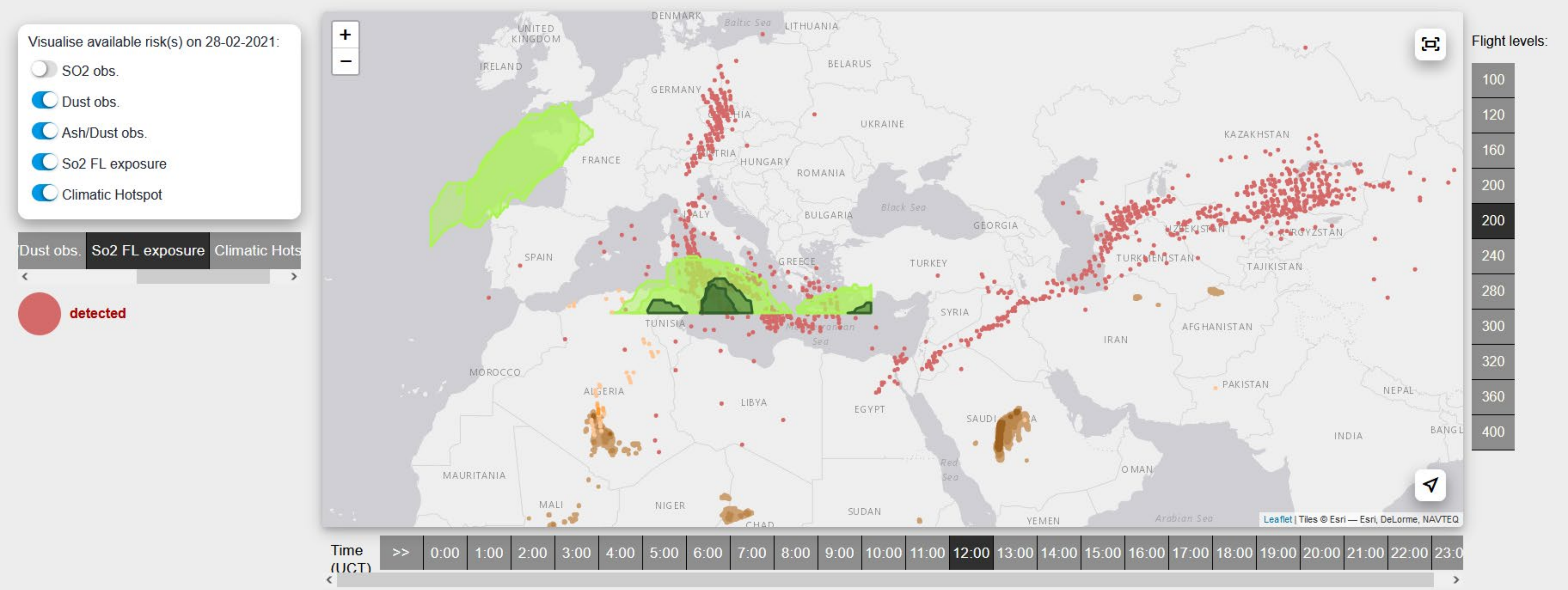
Natural Airborne Hazard
- Detection of hazardous clouds
- FL contaminations
- Alert and forecasts contamination airport



ALERT SOLUTIONS

demo available → https://alarm.aeronomie.be

ALERT SOLUTIONS



demo available → https://alarm.aeronomie.be

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Riccardo Biondi

Principal Researcher| UNIPD

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SINOPTICA

Satellite-borne and IN-situ Observations to Predict The Initiation of Convection for ATM

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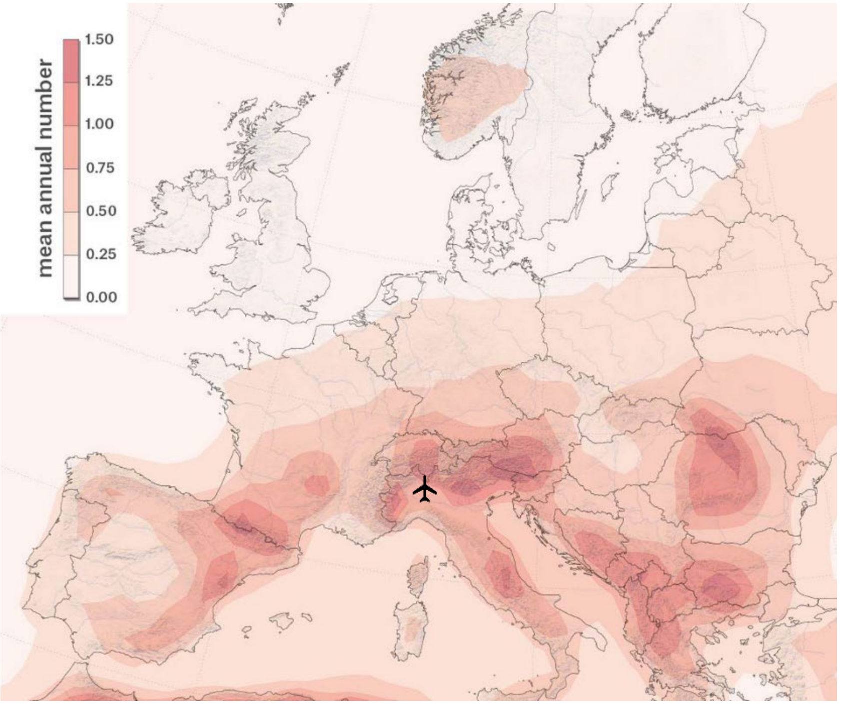
GReD

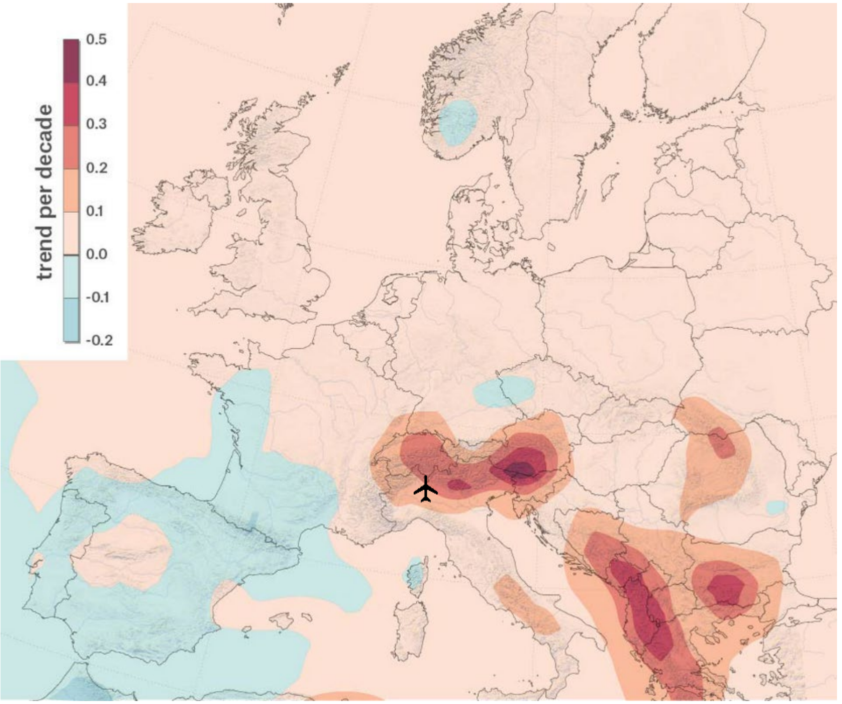
Objectives

- Development of a near real-time data assimilation system into a high-resolution Numerical Weather Prediction (NWP) Model
- Investigation of the usefulness of the augmented NWP Model nowcasting for Air Traffic Management (ATM) activities
- Integration of the NWP nowcasting into ATM procedures and decision-support systems

SINOPTICA

Hotspot selection





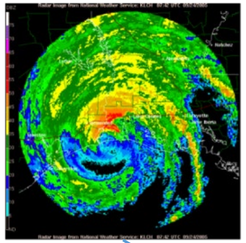
11/05/2019

14/07/2021

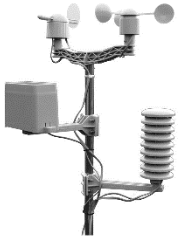
Milano Malpensa - MXP

Datasets and experiments

Radar

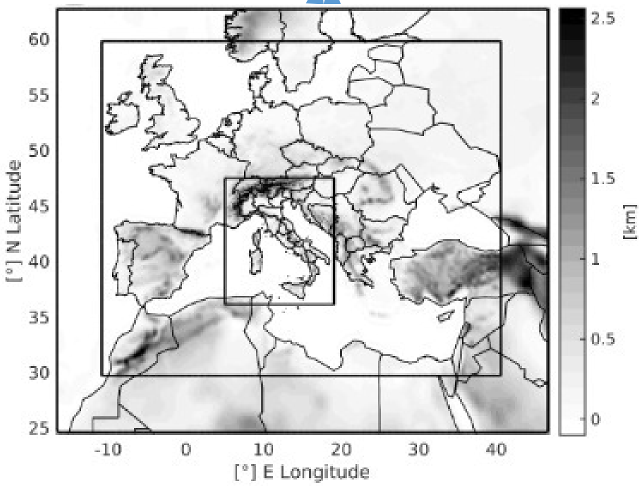


Weather station



Lightning

GNSS



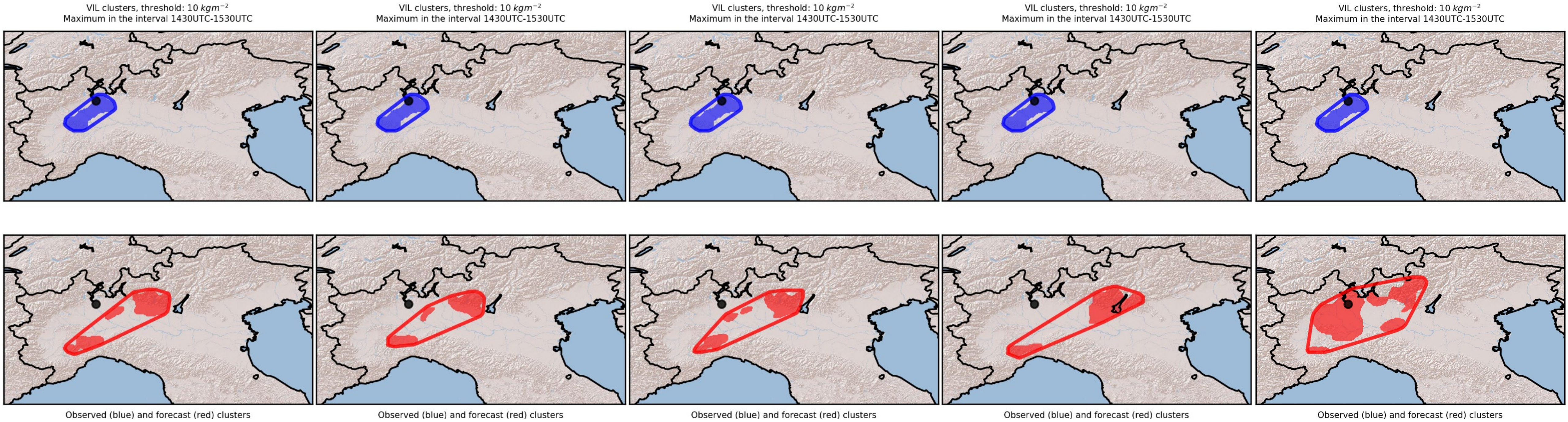
Experiment	Description
CTL	No assimilation
Radar	Radar data have been assimilated
Radar + GNSS	Radar and GNSS data have been assimilated
Radar + WS	Radar data and temperature measured by Civil Protection weather stations have been assimilated
Radar + Lightning	Radar and lightning data have been assimilated

Domain	Horizontal grid dimensions	Horizontal grid spacing	Vertical levels
D01	216x191	22.5 km	50
D02	523x448	7.5 km	50
D03	430x469	2.5 km	50

SINOPTICA

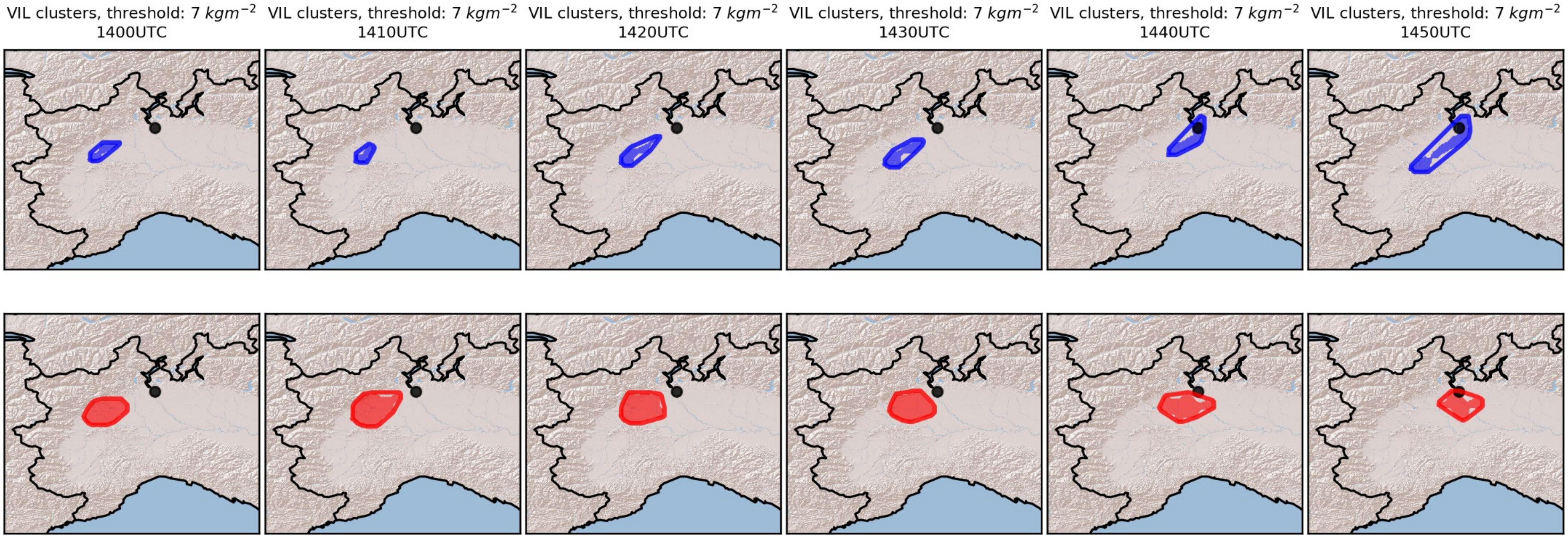
Nowcasting experiments

CTR | Radar | Radar + GNSS | Radar + WS | Radar + Lightning

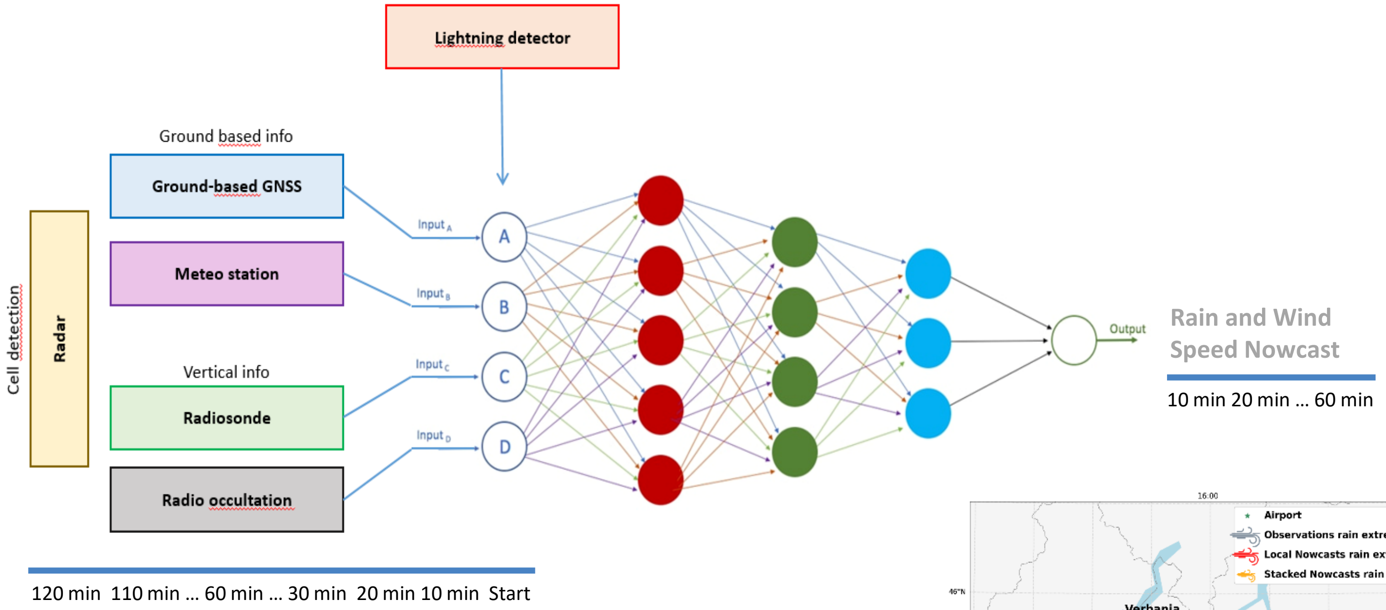


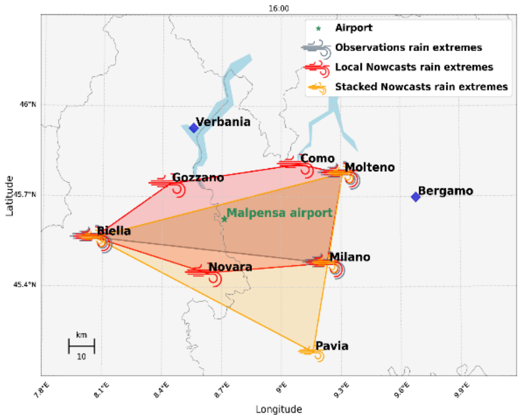
SINOPTICA

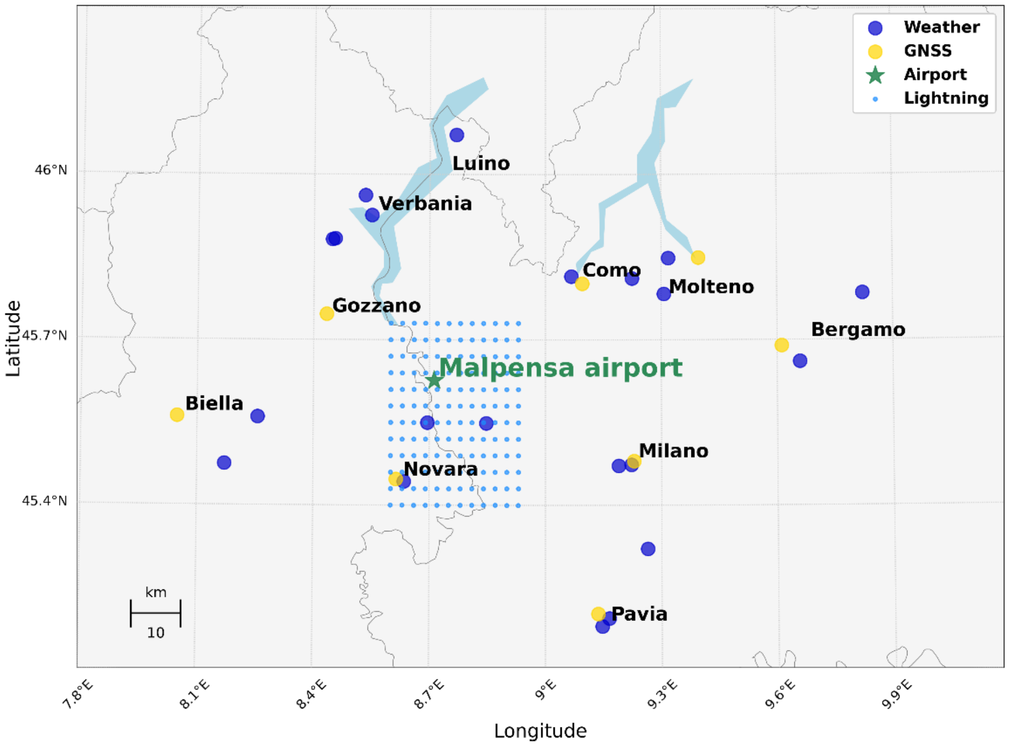
Nowcasting a case study



Nowcasting with Machine Learning







ML model performances

	WS+GNSS		WS+GNSS+LIGH		WS+GNSS+RADAR		WS+GNSS+RADAR+LIGH	
	POD	FAR	POD	FAR	POD	FAR	POD	FAR
10m	83.2	1.3	84.4	1.8	85.8	0.6	86.3	1.8
20m	92.1	1.7	89.6	1.1	90.5	1.7	91.1	1.7
30m	94.7	1.6	93.2	0.6	94.7	0.6	94.2	0.6
40m	95.3	1.1	93.8	0.6	95.3	0.5	95.3	0.5
50m	96.8	1.1	92.7	0.6	96.3	1.1	95.8	1.1
60m	94.7	1.6	93.2	1.1	95.8	2.2	94.2	0.6

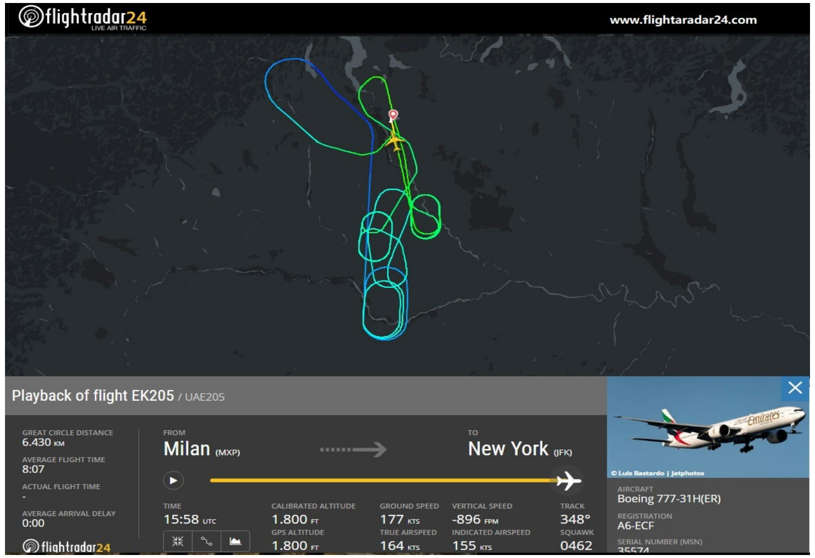
Extreme winds nowcasting performances

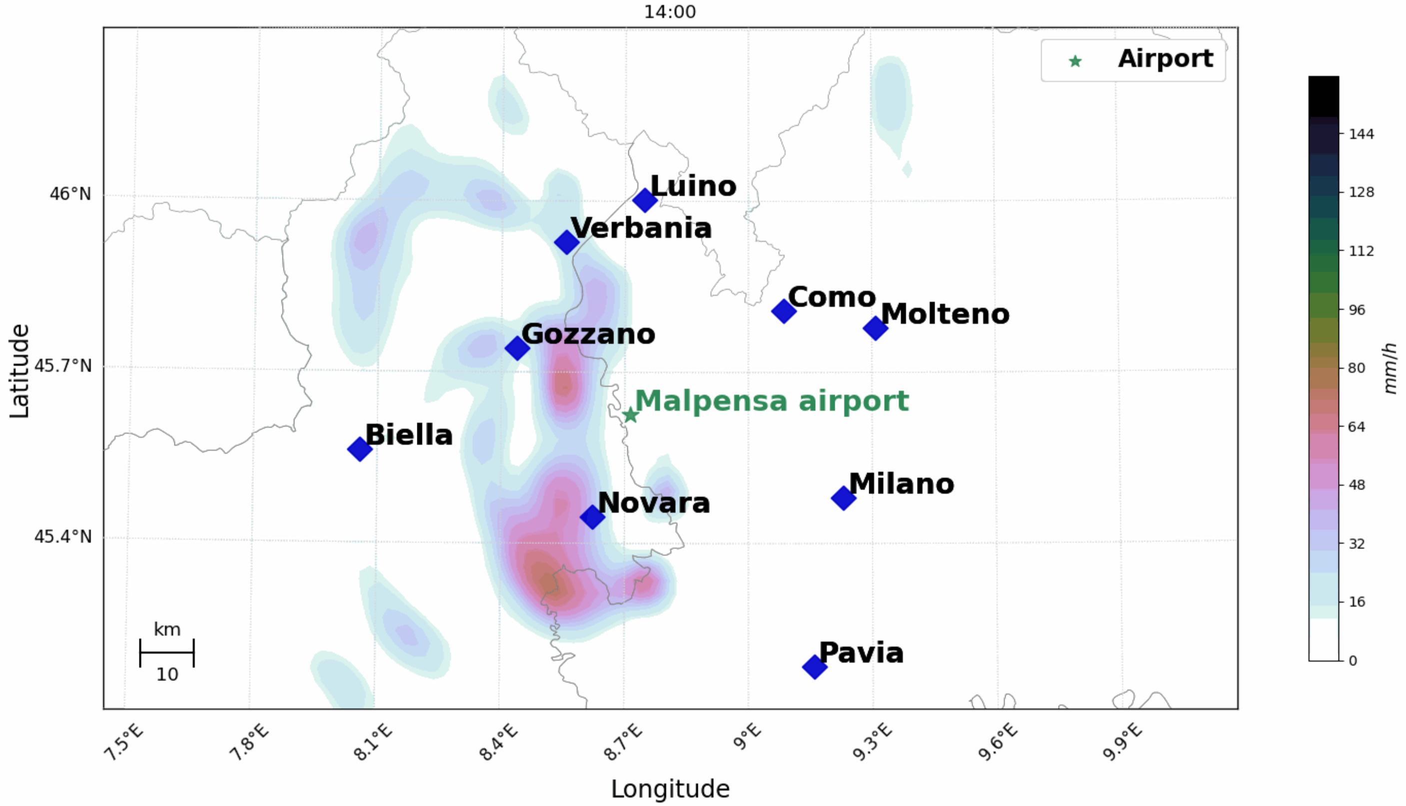
Extreme rain nowcasting performances

	WS+GNSS		WS+GNSS+LIGH		WS+GNSS+RADAR		WS+GNSS+RADAR+LIGH	
	POD	FAR	POD	FAR	POD	FAR	POD	FAR
10m	87.5	12.5	87.5	6.7	87.5	6.7	87.5	26.3
20m	81.3	7.1	75.0	25.0	93.8	21.1	81.3	35.0
30m	87.5	12.5	68.8	21.4	75.0	7.7	68.8	35.3
40m	87.5	50.0	50.0	20.0	81.3	7.1	62.5	37.5
50m	75.0	55.6	37.5	33.3	75.0	60.0	37.5	40.0
60m	75.0	36.8	6.3	50.0	62.5	63.0	25.0	50.0

POD - Probability Of Detection
FAR – False Alarm Rate

Combined use of NWP and ML





SESAR Innovation Days

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PLENARY 2: ENVIRONMENT/MET ER PROJECT SHOWCASE

Antonio Franco

Professor | University of Seville

5-8 December 2022, Budapest

sesar DIGITAL ACADEMY

Hosted by HungaroControl

EUROPEAN PARTNERSHIP

Co-funded by the European Union

Operational Context

- FMP-Met focusses on the **enhancement of ATM efficiency** under **adverse weather** by integrating **MET forecast uncertainty** information into the **decision-support tools** used by Flow Management Positions (**FMP**).

- The FMP is an operational position in the ACC whose main role is to assist the ACC Supervisor to **choose the best ATC sector configuration** at the right time. The FMP:
  - monitors the level of traffic in airspace sectors
  - adjusts the value of capacity in view of adverse weather conditions or other contingencies, and
  - coordinates flow measures when an excess of demand over capacity is detected, that is, when the ROL (traffic to capacity ratio in %) is too large.

Motivation

- The presence of **convective cells** makes **sector demand irregular** and not easy to predict, **increases traffic complexity** and **reduces sector capacity**.

- In FMP's current practice:
  - MET conditions are obtained from **separate MET-briefing systems** (not CIFLO), and FMP must convert this information into impact on sector capacity and integrate it manually into the current CHMI.
  - To mitigate weather effects, **FMP actions are often reactionary and too late**, considered as the last option and applied when most flights are no longer subject to ATFCM measures.

There is clearly room for improvement!

Project scope and objective

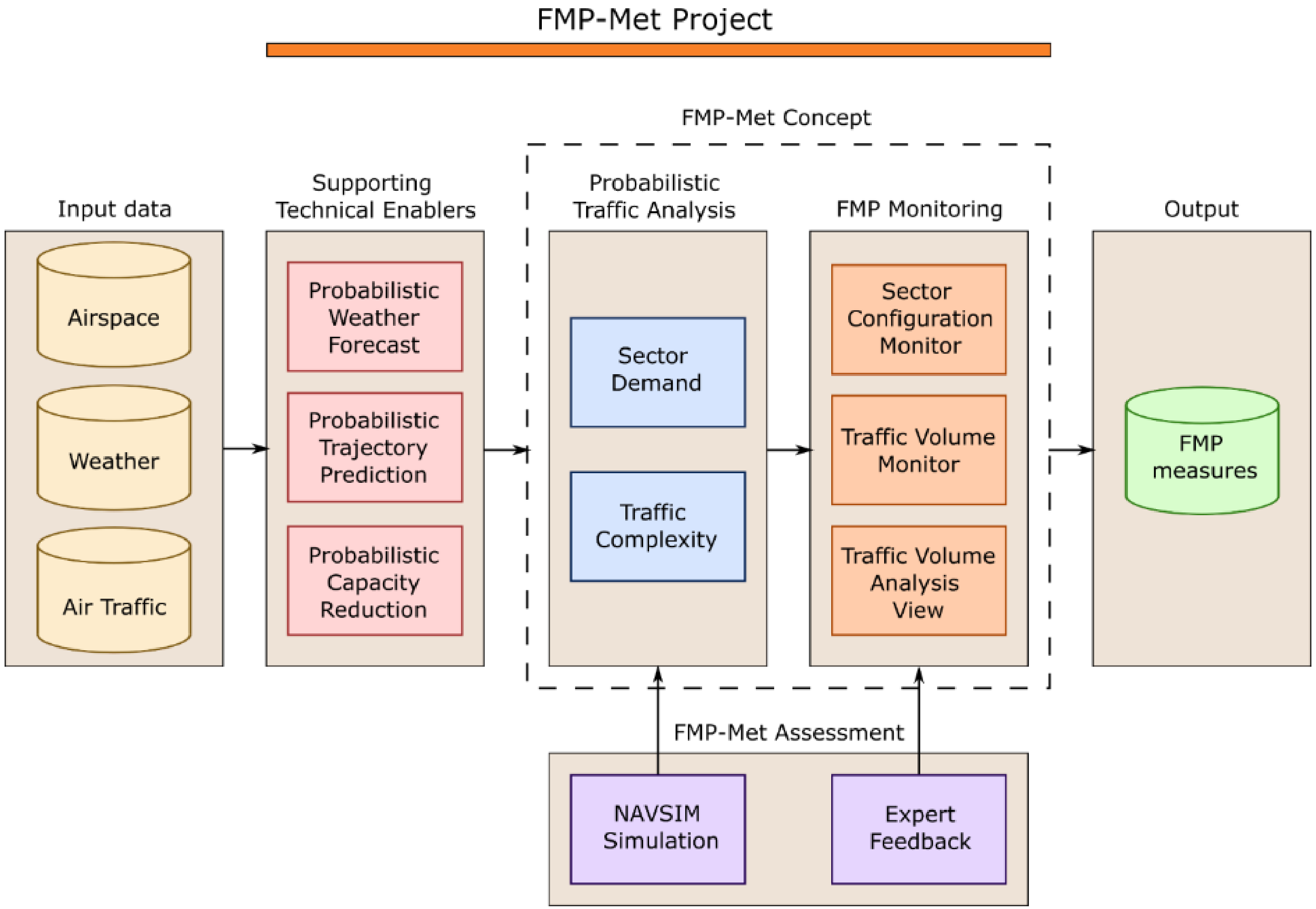
- **Overall objective**: Provide the FMP with an intuitive and interpretable **probabilistic assessment** of the impact of CW, with **8 hours in advance**. This assessment will consist of **probabilistic forecasts of demand, complexity, and capacity reduction**.

Such an enhanced product would **support the FMP in taking anticipated, appropriate, and timely flow measures** that contribute to increase the ATM efficiency and reduce delays.

- **Key research challenge**: Analysis of a traffic flow management problem with an extended time horizon.
  - Important levels of uncertainty → **Probabilistic approach**.
  - Integrating different probabilistic MET products is needed.

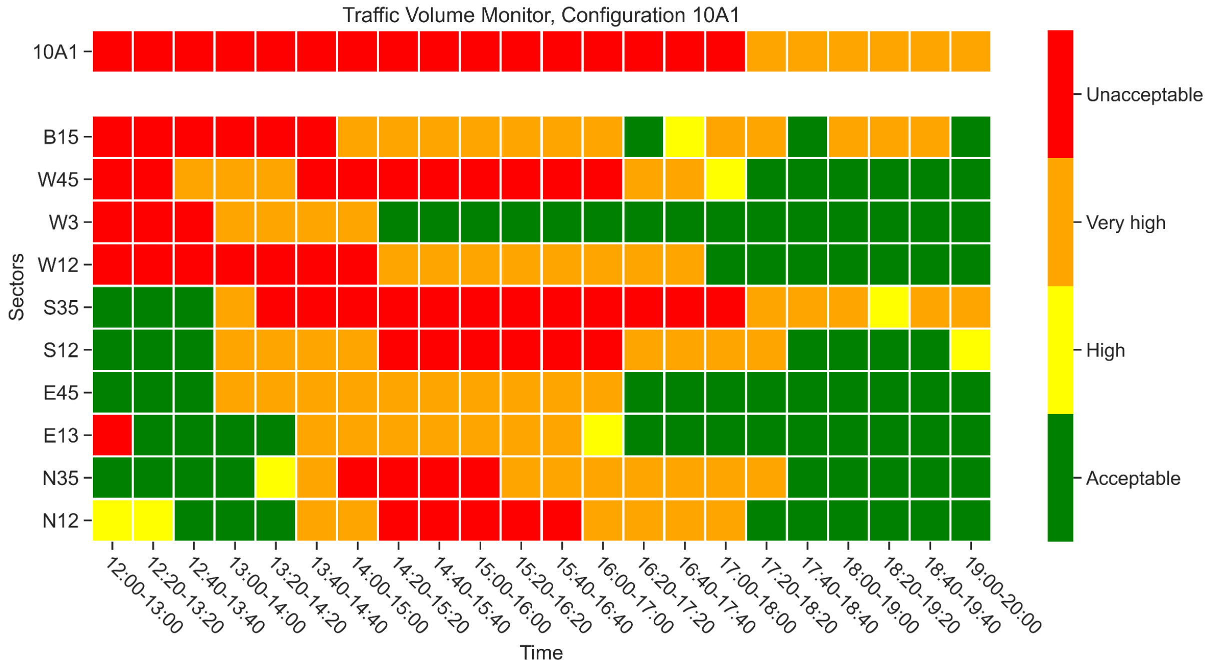
- In FMP-Met, **uncertainty management** is based on ensemble forecasting:
  - Several sources of MET uncertainty: **wind and air temperature, exposure to convection, and storm cell location**.
  - Other uncertainty sources: **operational uncertainty** (storm avoidance strategy) and **uncertainty in the TOT**.

Work Performed



Key Project Results (I)

Final FMP-Met Concept



Time evolution of the DCB for a specific sector configuration broken down into its constituting traffic volumes

$Z_{50} > 110$				
$100 < Z_{50} \leq 110$				
$90 < Z_{50} \leq 100$				
$Z_{50} \leq 90$				
	$Z_{95} \leq 90$	$90 < Z_{95} \leq 100$	$100 < Z_{95} \leq 110$	$Z_{95} > 110$

Probabilistic color code based on the 50th and 95th percentiles of the ROL distribution (Z_{50} and Z_{95}).

Key Project Results (II)

FMP Expert Feedback

- A **validation exercise** was conducted with **FMP experts** from ACG and CCL, intended to validate the probabilistic operational concept.
- Validation tool used: **Judgmental technique** (expert opinion) via questionnaires. **Results are qualitative**.
- **Main result**: The FMP-Met concept has been **assessed positively**.
  - The FMPs recognized that the FMP process in adverse weather can be operationally improved: **FMP-Met concept developed is a good first step**.
  - Good choice of the **graphical displays** selected for the tool concept developed: The experts consulted were **comfortable**.
  - FMPs **suggested improvements** for future development.

FMP-Met Project Consortium

ENV/MET PROJECT SHOWCASE

Tobias Bauer
DLR
DYNCAT

Angelo Riccio
University of Naples
CREATE

Hughes Brenot
BIRA
ALARM

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SINOPTICA

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FMPMet

Moderated by:

Olivia Nunez
SESAR 3 JU)

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