H2020 SINOPTICA (Satellite-borne and IN-situ Observations to Predict The Initiation of Convection for ATM) project: initial results

SUPPORTED BY SESAR JOINT UNDERTAKING

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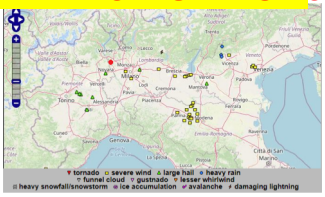
ABSTRACT

The H2020 SINOPTICA Project (2020-2022) aims at exploiting the untapped potential of assimilating remote sensing (EO-derived and ground-based radar) as well as GNSS-derived datasets (including radio occultation data) and in-situ weather stations data. Those data will be used for very high-resolution, very short-range numerical weather forecasts to improve the prediction of extreme weather events to the benefit of Air Traffic Management (ATM) operations. This will be done by setting up a continuously updated database of remote sensing-derived, GNSS-derived and in-situ weather stations variables, in combination with an automated assimilation system to feed an NWP model. SINOPTICA weather forecast results will be integrated into ATM decision-support tools, visualizing weather information on the controller's display, and generating new 4D trajectories to avoid severe weather areas. This contribution presents the initial results of the assimilation of aforementioned observations into the WRF model, operated at cloud-resolving grid spacing, for two case studies: a hailstorm event occurred on 11 May 2019 nearby Malpensa airport and a severe convection episode occurred near Punta Raisi airport (Palermo) on 15 July 2020.

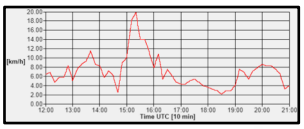
THE PROBLEM: SEVERE WEATHER AFFECTING AIRPORTS



The Malpensa airport after the hail event of 11 May 2019.



Severe weather registers for the 11 May 2019 (source: ESSL). The extent event affected most part of Northern Italy, including the Airport (red dot).



10-minute average wind speed measured in Cameri (11 May 2019). Image retrieved from DEWETRA platform (Italian Civil Protection Department). Maximum of 20 km/h was recorded coinciding with the passage of the squall line over the region (see the bottom of the poster).

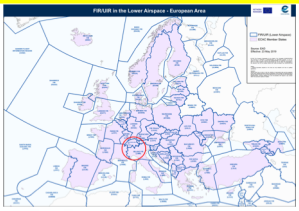
THREATS

- Regions of significant updrafts and downdrafts, especially in the Terminal Maneuvering Area around an airport
- Top and base of cumulus clouds for the final approach
- Lightning potential 5 nautical miles (nmi) around airports (this is an IATA recommendation for safety of ground operations)
- Wind fields at different levels for safe and efficient approach procedures
- Turbulence areas as an issue of passenger comfort
- Wind profile on final approach, typically 3°/25 nmi along the runway centerline and derived quantities like head- or tailwind and wind shear
- Wind at runway thresholds
- Aircraft icing potential
- Low visibility regarding Runway Visual Range (RVR) thresholds

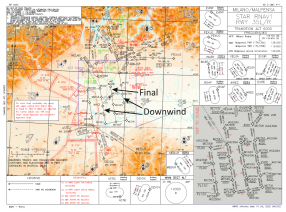
THE NECESSITY: IMPROVING AIR TRAFFIC MANAGEMENT DURING SEVERE WEATER EVENTS



Evaluate the impact of extreme weather events on air traffic. Example of a severe weather event on 11 May 2019, in the vicinity of Malpensa Airport Milano. The results are needed for the development of air traffic controller support systems for sequencing and guiding air traffic in adverse weather situations.

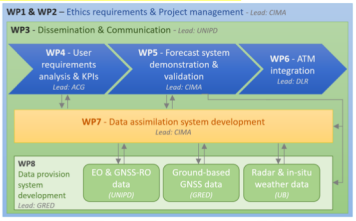


A circle with a radius of 150 nmi around Milano describes, as an example, the Extended Arrival Manager scheduling horizon in Europe where **meteorological information and forecasts for the flight guidance have to be available** (adapted from European Aeronautical Database (EAD), EUROCONTROL).



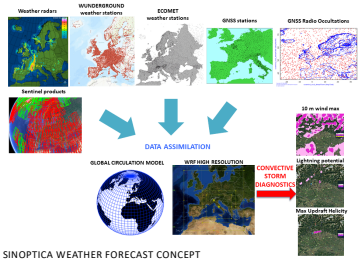
The downwind areas and the final for the runways 35R and 35L of Malpensa airport (adapted from [ENAV 2020]). In the last approach phase, **aircraft have no possibility to overfly or fly underneath convection cells**. As a result, pilots get around them autonomously. The Extended Arrival Manager will help both pilots and controllers to find a safe diversion and coordinating the surrounding traffic simultaneously.

THE PROJECT: SINOPTICA



SINOPTICA WP structure

The **SINOPTICA project aims** at exploiting the untapped potential of assimilating remote sensing (EO-derived and ground-based radar) as well GNSS-derived datasets and in situ weather stations data into very high-resolution, very short-range numerical weather forecasts **to provide improved prediction of extreme weather events to the benefit of ATC (Air Traffic Control) operations**. This will be done by setting up a continuously updated database of remote sensing-derived, GNSS-derived and in situ weather stations variables, in combination with an automated assimilation system to feed an NWM. The usefulness of deploying dedicated networks of sensors to monitor atmospheric variables at high spatial resolution in the vicinity of ATM "hotspots" such as airports will be investigated as well. SINOPTICA weather forecast results will be integrated into ATC decision-support tools, visualizing weather information on the controller's display, and generating new 4D trajectories to avoid severe weather areas. The usefulness of the newly developed SINOPTICA tools will be monitored during the project and evaluated, thanks to the involvement of ATM stakeholders in the project consortium and advisory board.



SINOPTICA WEATHER FORECAST CONCEPT

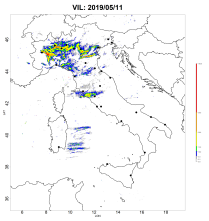
DATA AND SOME PRELIMINARY RESULTS: THE MALPENSA CASE OF 11 MAY 2019

RADAR

The Italian Civil Protection is responsible for the management of Italian Radar Mosaic and of the following products used in the framework of the SINOPTICA project:

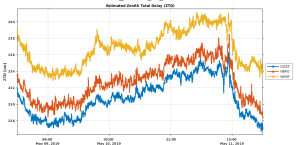
- ETM [m] - Echo tops maximum of 20 dBZ with 5-minute frequency.
- VIL [kg/m²] - Volume integrated liquid, with 5-minute frequency. VIL density is calculated as follows:

$$DVIL = \frac{VIL}{ETM}\left[\frac{g}{m^3}\right]$$



Max VIL for the Italian radar mosaic.

GNSS



GNSS raw data retrieved from continuously operating reference stations (CORS) are processed using the goGPS software to retrieve atmospheric parameters useful to get a better insight in the weather processes associated with high-impact events (i.e., zenith total delay, slant total delays, gradients). Ad-hoc cost-effective GNSS equipment is deployed near the Malpensa airport to demonstrate the feasibility to densify existing GNSS stations networks to get information about the water vapor distribution at higher spatial resolution.

RADAR-NOWCASTING UP TO 1H AHEAD

OBSERVED VIL 14:45 UTC

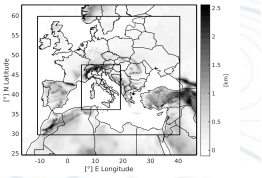


NOWCASTED VIL 14:45 UTC

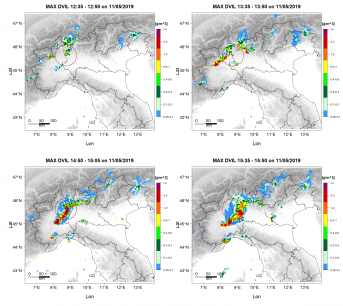


Example of observed VIL propagation with nowcasting technique PHAST (see Poletti et al., https://doi.org/10.5194/hess-23-3823-2019.)

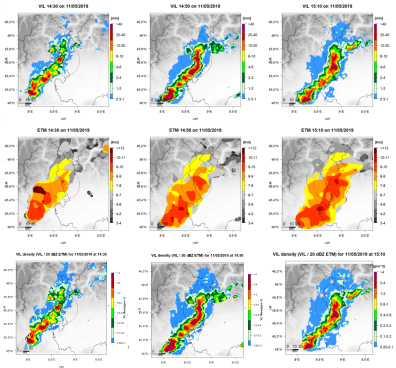
WRF-NOWCASTING 1-2 HOURS AHEAD



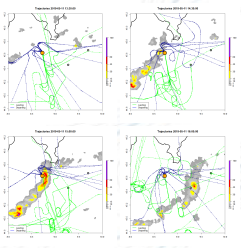
3 WRF domains respectively having spatial resolution 13.5, 4.5 and 1.5 km with 50 vertical levels. A cycling WRF 3D-VAR is used for the assimilation of weather radar reflectivity and GNSS-ZTD data. A qualitative comparison between RDR (radar data) and GNSS-ZTD simulations is performed in terms of VIL and cumulated rainfall.



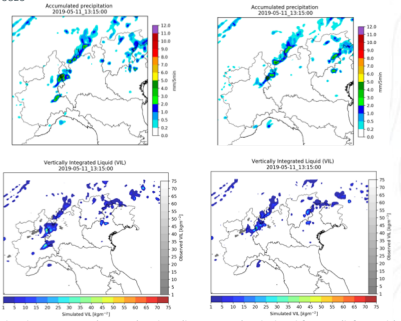
Maximum values of DVIL showing the development of the Mesoscale Convective System on Malpensa episode. Every image is showing the maximum DVIL value within fifteen minutes. Images go from 12:50 to 15:50 UTC.



Top panels: VIL images on 11 May when MCS is affecting the airport. Mid panels: ETM images. Bottom panels: DVIL images. Time evolution showed it is (from left to right) 14:30 UTC, 15:00 UTC and 15:10 UTC.



VIL images on 11 May before, during and after the MCS affected the Malpensa airport (orange dot). Green and blue lines indicate the flight trajectories during the 5 minutes associated to each image.



The 5 min cumulated precipitation (top row) and VIL (bottom row), calculated for RDR (left panels) and GNSS-ZTD (right panels) experiments, are presented. In both cases the squall line hits the Malpensa airport about 1h in advance, but both simulations correctly predict the intensity.

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