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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

A 0-4h warning system prototype at DWD:
Using machine learning to classify severe summer convective storms based on a multi-data approach

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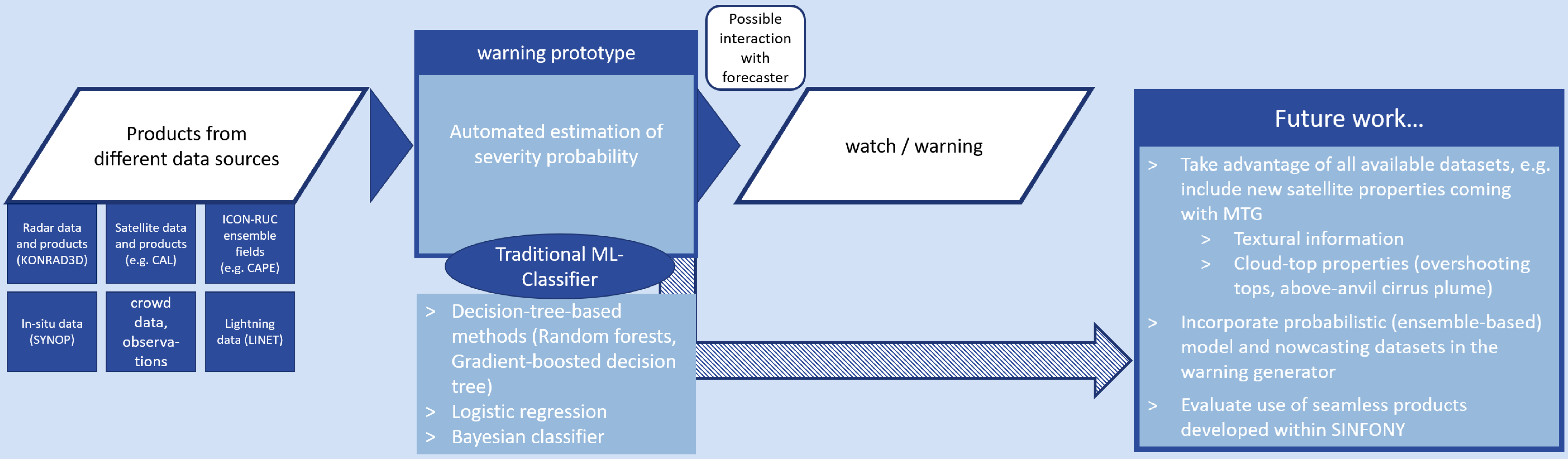

Nowcasting and Seamless prediction at DWD

(Pre-)operational nowcasting and warning products

- NowCastSat-Aviation: aviation nowcasting (detection, severity classification, forecast) based on storm objects derived from GEO-IR/WV-channels and ground-based lightning, enhanced by an NWP filter
- KONRAD3D: nowcasting (detection, severity classification, tracking, forecast) based on storm objects derived from radar volume scans, incorporating addition info from lightning and radar-based hydrometeor classification
- NowCastMIX: warning generator on communal level using a fuzzy logic approach to fold information from radar storm products (detection, postprocessing), ground-based lightning, regional NWP, ground stations and satellite-based cloud top height

Seamless prediction products (0-12h) in SINFONY

The SINFONY products include an object-based convection product, based on a nowcasting ensemble (KONRAD3D-EPS), for which objects are derived from simulated radar data coming from DWD rapid-update NWP ICON-RUC-Ensemble.

In addition, SINFONY develops pixel-based precipitation ensemble forecasts, derived from measured and simulated radar data.

SINFONY POLARA Polarimetric Radar Algorithms

References:

[1] Kuhn, H. W. „The Hungarian Method for the Assignment Problem". *Naval Research Logistics Quarterly* 2, Nr. 1–2 (1955): 83–97. https://doi.org/10.1002/nav.3800020109.

[2] Rathmann, Nils, und Michael Mott. „Effective Radar Algorithm Software Development at the DWD", 2012, 6.

We develop a prototype for a data-driven, early (0-4h in advance) warning system for severe summer convective storms over Germany based on a multitude of input datasets (satellite and radar products, lightning data, rapid-update NWP). We are planning to use traditional machine learning techniques (random forests, Bayesian classifier, etc.) to estimate the probability that existing storms produce severe weather in the near future (0-2h) and that new storms emerge over a larger period of time (2-4h).

Lifecycle analysis for training labels using tracking of different storm objects

To prepare the labelled training data for the machine learning classifier, we currently develop a lifecycle-spanning tracking considering cell detection in different datasets over time (SINFONY forecast products > satellite > radar). The difficulty of relating storm detection from different data is apparent in this effort. Some details on the problem of relating satellite and radar is shown in the box below ("Relation of radar- and satellite-based storm objects"). The tracking associates detected objects from consecutive data snapshots using the Hungarian method [1] and allows easy provision of deviating similarity metrics to relate different object types (e.g. radar-with-radar or radar-with-satellite). The software is developed as part of the DWD-owned POLARA framework [2].

Detection of storms in VIS006-based cloud albedo

As a current work package, we are evaluating an "Effective cloud albedo (CAL)"-based storm detection as basis for the satellite objects. CAL can be derived from the VIS006-channel (wavelength=0.6µm) of MSG/MTG, for which MTG will provide 500m spatial resolution at the sub-satellite point. This resolution advantage compared to e.g. infrared channels could provide a more precise identification of the convective centres.

Relation of radar- and satellite-based storm objects

We have conducted a case study relating storm objects derived from the existing DWD-(pre-)operational nowcasting products, KONRAD3D and NowCastSat-Aviation. The goal was to evaluate how these products could be combined in the lifecycle-spanning tracking. Therefore we have been looking into the detections of eight days in July and August 2021[1]. Both products detected about 10 000 storm objects within this time frame.

Figure 1 shows the ratios of satellite- and radar-based storm objects that intersect with the respective other kind. The overview shows that a simple collocation is not very reliable, especially for storm in the early development phase.

Figure 2 shows an example of why even intersecting objects can be difficult to relate. NowCastSat-Aviation objects often mark a large part of the cloud anvil, while KONRAD3D highlights areas of high radar reflectivity. This results in very different views on the storm and complicates property assignment.

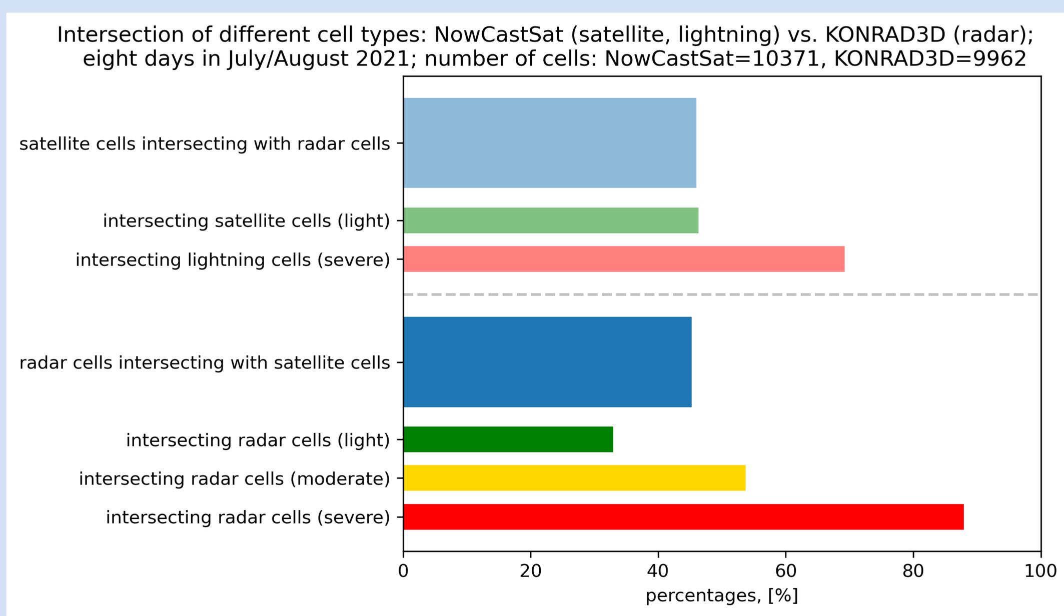

Figure 2: Ratios of intersecting storm cells detected from NowCastSat-Aviation and KONRAD3D.

[1] *in particular: 25, 26, 31 July and 2 – 6 August 2021.*

Outlook

In the future we want to investigate…

- a broad palette of satellite products for the storm objects: Next to new candidates for storm detection, we want to evaluate textural pat-tern approaches to identify convective centres.
- the use of e.g. the ICON-RUC-ensemble pseudo-member as indicator for developing storms: This could be used to mark areas of medium-range (2-4h) convective development and relate these to storms observed in consecutive time steps.
- different machine learning methods to fold the information of the different data sources.

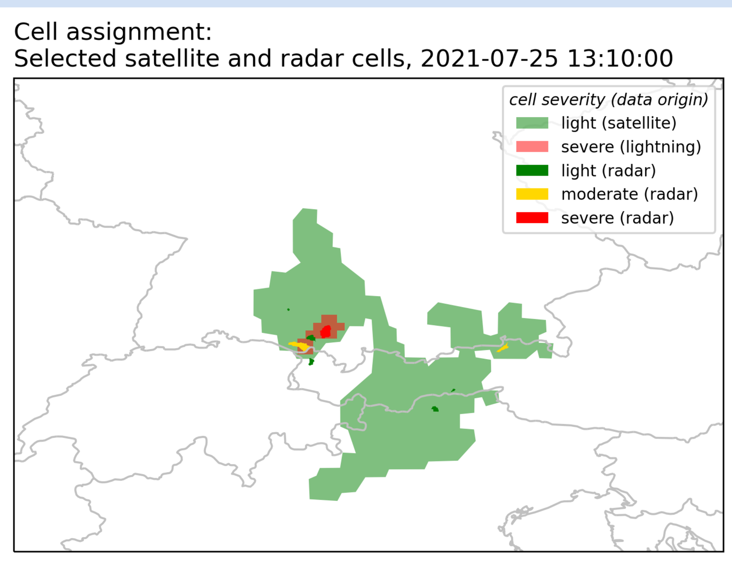

Figure1: Different views onto a mesoscale convective system on 25 July 2021. From satellite, the full extent of the cloud top is mark as the storm while radar methods highlight reflectivity hotspots.

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