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Deutscher Wetterdienst
Wetter und Klima aus einer Hand

Convection detection for automatic METAR reports using radar, satellite and lightning data

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The goal: *The 24/7 operational automatic detection of deep convection using a multi sensor approach.*

Why? *Convective weather conditions are part of aviation weather observations done by human observers. Those METARs are subject to full automation till 2021 at all international airports in Germany.*

The plan: *Analyzing the data in two steps: 1) Detection methods separately for radar and satellite data. 2) Data fusion to combine the pre-analyzed data with lightning information using NWP analyses as background information to detect the convective present weather and clouds.*

What kind of data will be used?

To detect the convective cloud types **Towering Cumulus (TCU)** and **Cumulonimbus (CB)** and the convective present weather conditions **Shower (SH)** and **Thunderstorm (TS)** automatically, the following data types will be used:

Radar
- 17 C-band radar systems (16 dual polarimetric)
- 10 fixed elevations (1° x 1 km) + terrain following "precipitation" scan (1° x 250 m); 5 min resolution
- 2 X-band radar systems (Frankfurt, Munich)
- 3D reflectivity composite, QPE, hydrometeor type

Lightning
- LINET lightning system
- "Real time" availability
- Accuracy of lightning stroke location: ~100 m

Satellite
- Meteosat Second Generation (MSG, geostationary)
- Infrared, Visible (3 x 4 km) and High Resolution Visible (HRV, 1 x 2 km) channels, 5 min resolution
- Cloud top cooling rate, brightness temp., albedo etc.

NWP analyses
- COSMO-DE (2,8 km resolution, 3 hourly)
- 0°C height, thermal stratification

Case study 12th of May 2015
Radar: Reflectivity values >60 dBZ indicate deep convection and possibly hail. **Lightning data**: The history shows a cell splitting and three active cores. **Satellite**: Highest (brightest) albedo mark cores of the cumulonimbus, anvil reaches out to the NE. **NWP Analyses**: High instability and humidity enable deep convection.

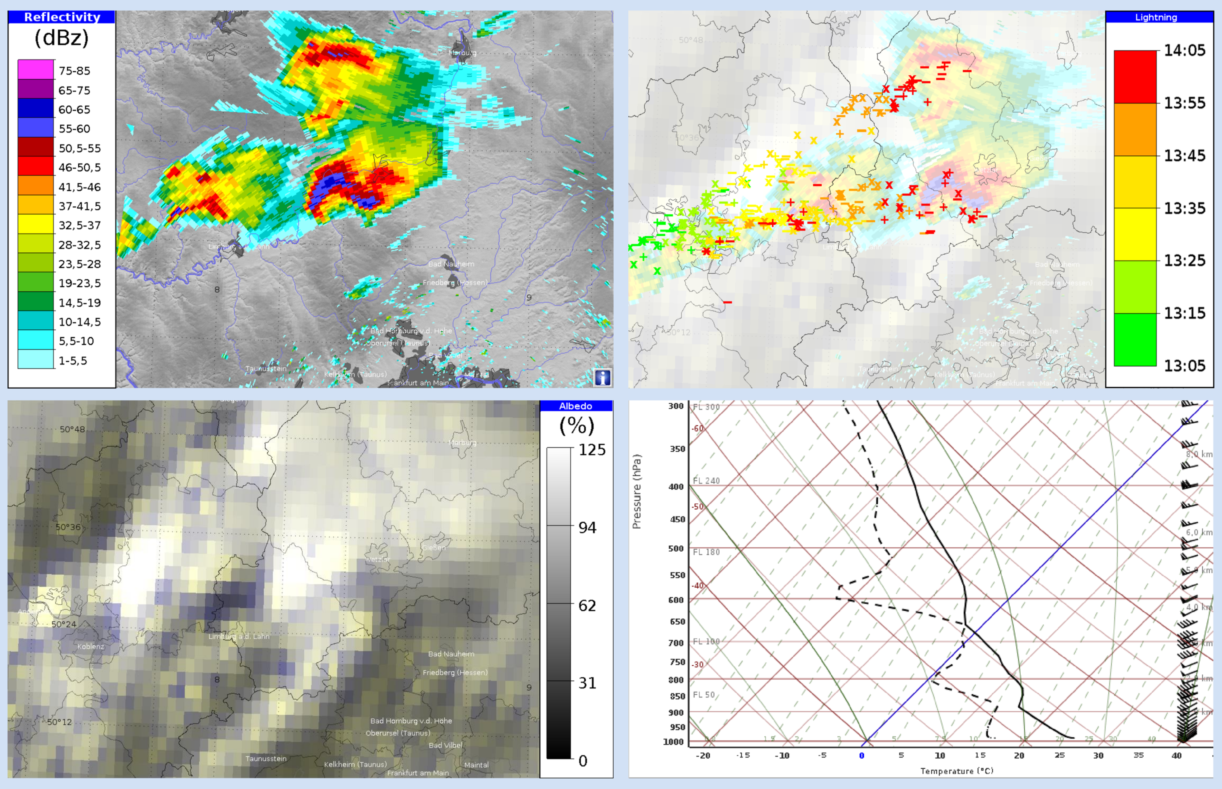


Fig. 1: Case study of a thunderstorm north of Frankfurt am Main moving ENE observed on 12th of May 2015 14:05 UTC. From upper left to lower right: C-band radar reflectivity (dBZ) of LINET lightning strokes of past 60 minutes (radar and sat image shaded), High resolution visible MSG satellite image, COSMO-DE proximity sounding analyses (12 UTC). Geo data: © GeoBasis-DE / BKG 2015

How to detect and combine?

Convective and stratiform
At first, detection methods for convection are applied separately to radar and satellite data. By using 3D radar data, the vertically oriented deep convective cores can be separated from horizontally oriented stratiform areas. Light showers with a low reflectivity will be more difficult to detect. Satellite data enables non-precipitating cloud detection.

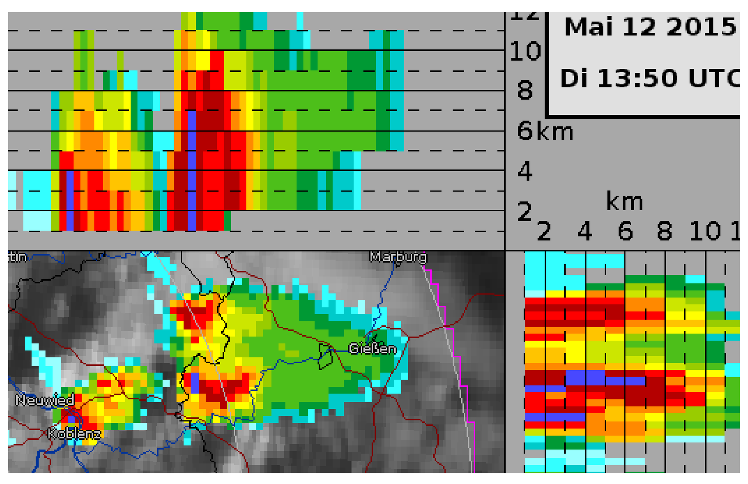


Fig. 2: Case study of Fig. 1 but 13:50 UTC, radar reflectivity max display with side view shows the high reflectivity convective cores besides stratiform regions in the eastern part of the Cb anvil.

Possible detection methods

Satellite
- SATCASTv2[1]: Detection of convective initiation of developing TCU
- RDT[2], Cb-Tram[3]: Detection and tracking of CB
- SDLAC[4]: Cluster-based cloud classification

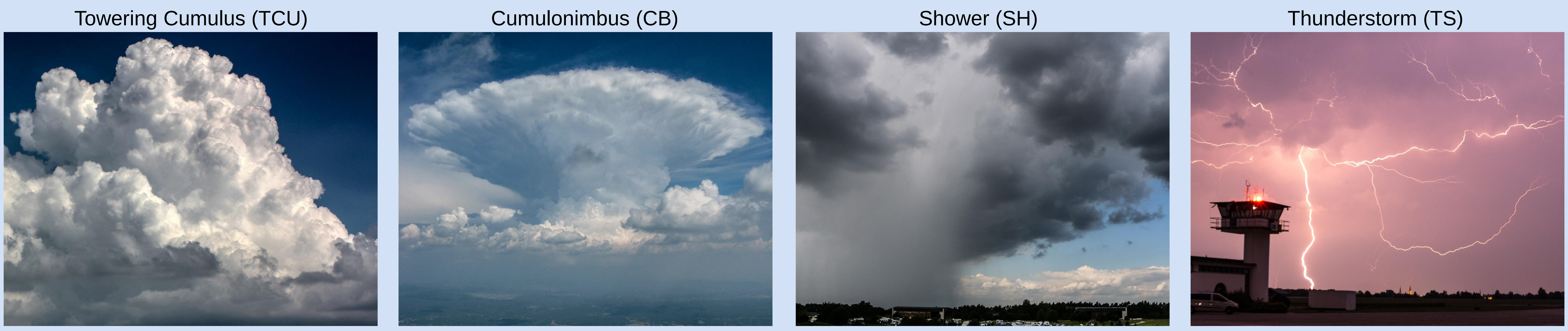
Radar
- KONRAD3D: 3D convective cell detection and tracking under current development at DWD

[1]: Walker et al. 2012, JAMC; [2]: Morel et al. 2002, Eumetsat; [3]: Zinner et al. 2008, MetAtmPhys; [4]: Berendes et al. 2008, JGeophysRes

The data combination
After analyzing radar and satellite data, the results will be combined with lightning data and NWP analyses.
If inconsistencies occur (e.g. lightning strokes and no clouds) data quality information (uncertainties, data availability) will be used to prioritize the data types and generate consistent output.

What output will be generated?

Fig. 3: Pictures of the four main output weather and cloud types. © Thomas Schubert



- Data fields (50 x 50 km) for 15 international airports with 250 m resolution:
  - Present weather (TS, SH)
  - Cloud type (CB, TCU)
- Detection algorithms run every minute.
- Subsequent steps:
  - Combining data sets with in-situ and ceilometer measurements.
  - Providing information needed to generate the automatic METAR (every half hour or in between if special criteria are fulfilled).

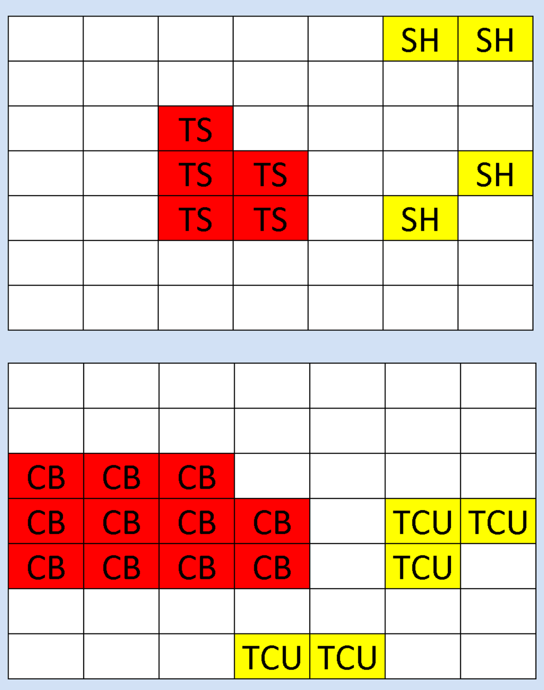


Fig. 4: Schematic examples of possible present weather (TS, SH) and cloud type (CB, TCU) data fields.

METAR FAQ

What is it? Half hourly observed **MET**eorological **A**erodrome **R**eports.
For whom? Dedicated to airline pilots, but used by most pilots and forecasters.
Where is it valid? It describes weather and clouds within 8 km around the airport and, if that's cloud free, the vicinity (radius 8-16 km).
How does a report look like and what is the content?

	airport	time	wind (direction, speed, variation)	visibility
METAR	LPPR	151330Z	23004KT 190V280	9000
weather	clouds (amount, height, type)		temperature/dewpoint	QNH
-SHRA	FEW020**CB** SCT040		15/13	Q1015=

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