An IDL-based weather forecast system for aviation using real-time data from remote sensing instruments, nowcasting tools and numerical models

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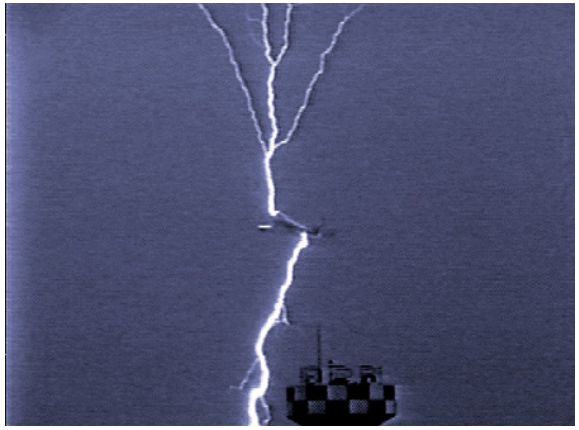
Innovative weather forecast system for aviation – why?

Example thunderstorms

icing



lightning

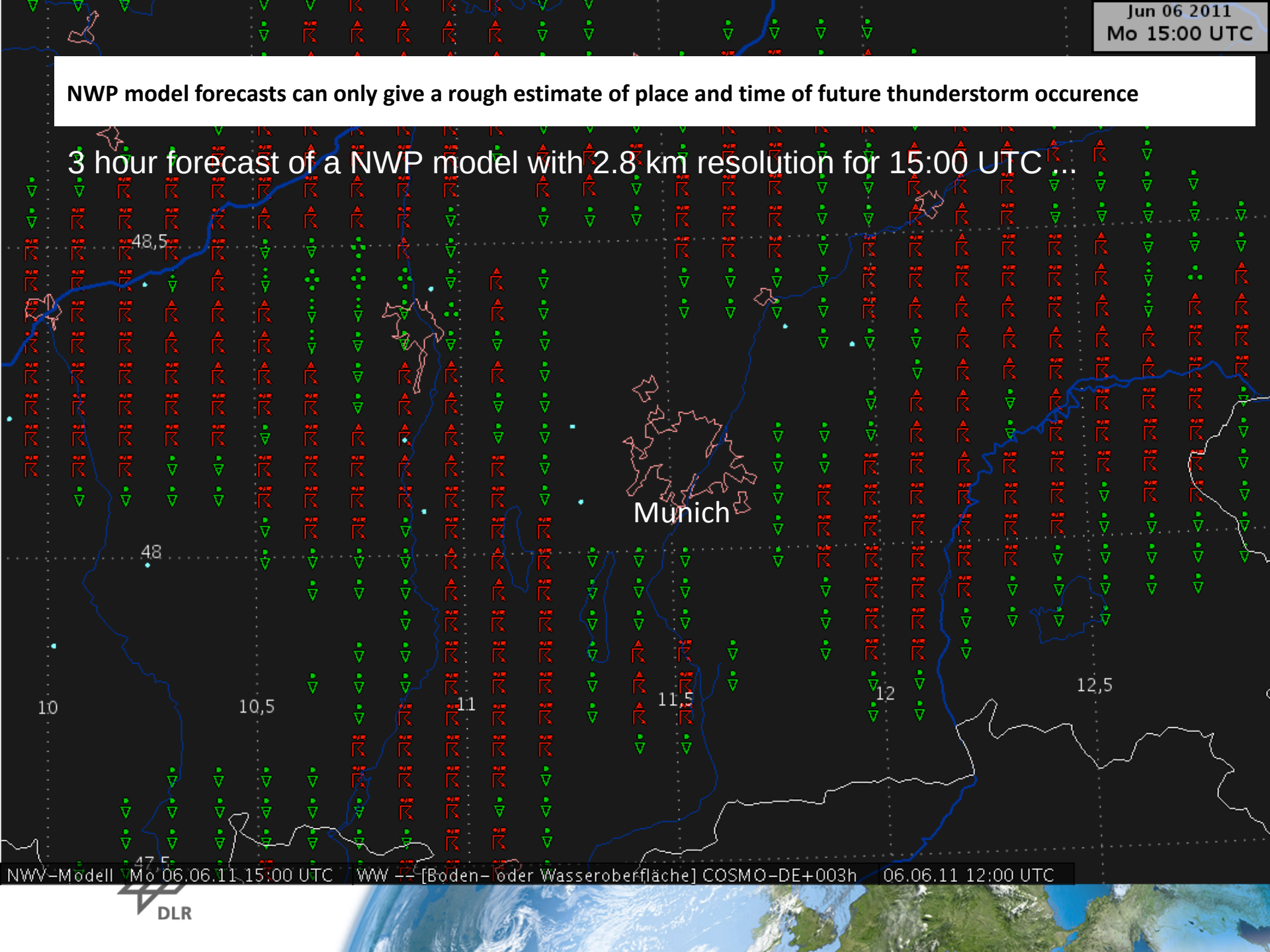
hail

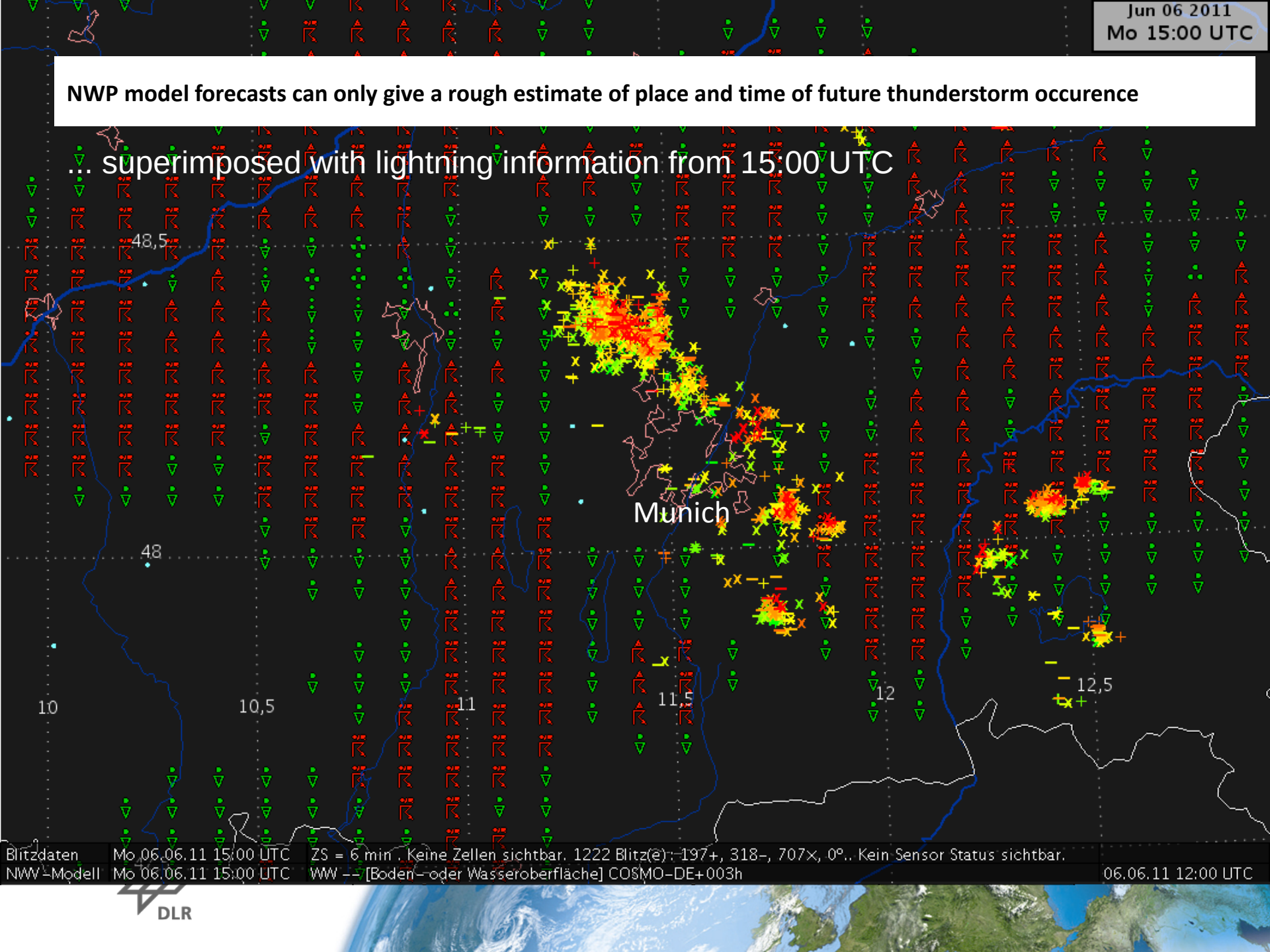
- Adverse weather is responsible for 40-50% of all delays in Europe
- Thunderstorm activity is the reason for up to 90 % of all delays in the airspace over the USA during the summer months.
- Thunderstorms are the most dangerous weather phenomenon for aviation (survey with pilots)

Thunderstrom information for aviation is still rudimentary these days!

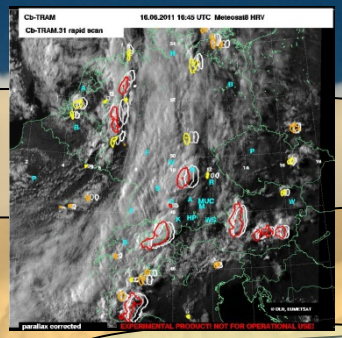
Goal: Help to increase safety and efficiency for air traffic during adverse weather situations

DLR

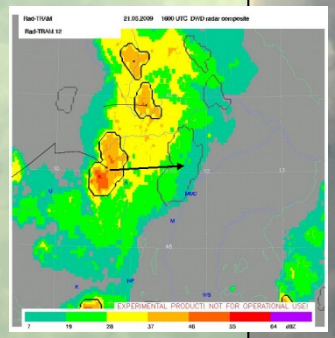

Jun 06 2011
Mo 15:00 UTC
NWP model forecasts can only give a rough estimate of place and time of future thunderstorm occurence
3 hour forecast of a NWP model with 2.8 km resolution for 15:00 UTC ...
48,5
Munich
48
10
10,5
11
11,5
12
12,5
NWV-Modell Mo 06.06.11 15:00 UTC WW -- [Boden- oder Wasseroberfläche] COSMO-DE+003h 06.06.11 12:00 UTC
DLR


Jun 06 2011
Mo 15:00 UTC
NWP model forecasts can only give a rough estimate of place and time of future thunderstorm occurence
... superimposed with lightning information from 15:00 UTC
48,5
48
10
10,5
11
11,5
12
12,5
Munich
Blitzdaten Mo 06.06.11 15:00 UTC ZS = 6 min . Keine Zellen sichtbar. 1222 Blitz(e): 197+, 318-, 707×, 0°.. Kein Sensor Status sichtbar.
NWV-Modell Mo 06.06.11 15:00 UTC WW -- [Boden- oder Wasseroberfläche] COSMO-DE+003h
06.06.11 12:00 UTC
DLR

Thunderstorms as weatherobjects with multiple object attributes



Cb top:
conv. turbulence,
lightning activity, etc.
detected by satellite
(Cb-TRAM)

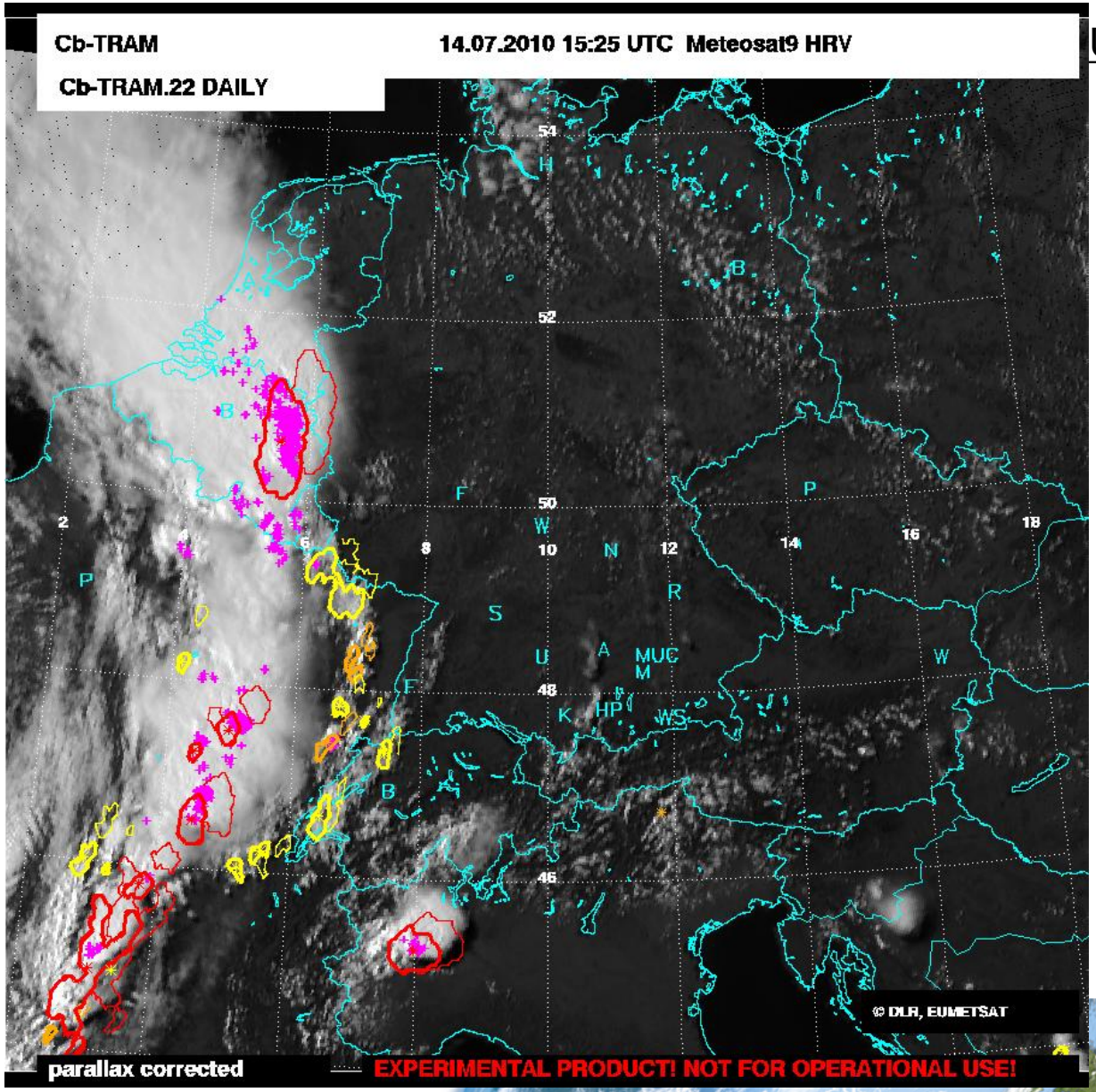


Cb bottom:
hail, icing, lightning, heavy rain,
turbulence, etc.
detected by radar
(Rad-TRAM)

Picture by Martin Köhler, DLR

Cb-TRAM - Cumulonimbus TRacking And Monitoring

satellite data analysis
→en-route



Used MSG (rapidscan) data:

WV 6.2	IR 10.8
IR 12.0	HRV

Detection stages:

1: Convection Initiation (CI)
- development in HRV
- IR 10.8 cooling

2: Rapid development
- WV 6.2 rapid cooling (> 1K/15min)

3: Mature storms
- T 6.2 - T 10.8
- HRV texture

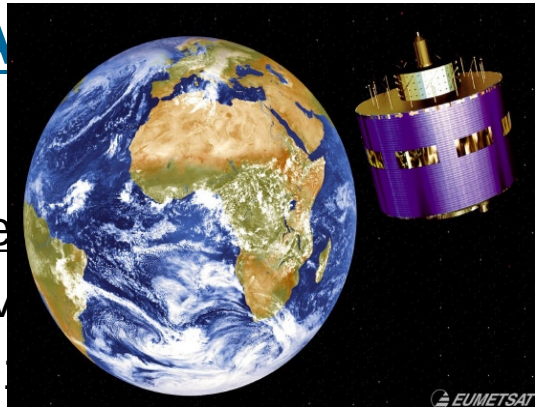
Lightning (LINET)

Extrapolation up to 60 min
(here 30 minute nowcast plotted)

Description: Zinner et al., 2008,09 & 13

Cb-TRAM - Cumulonimbus TRacking A

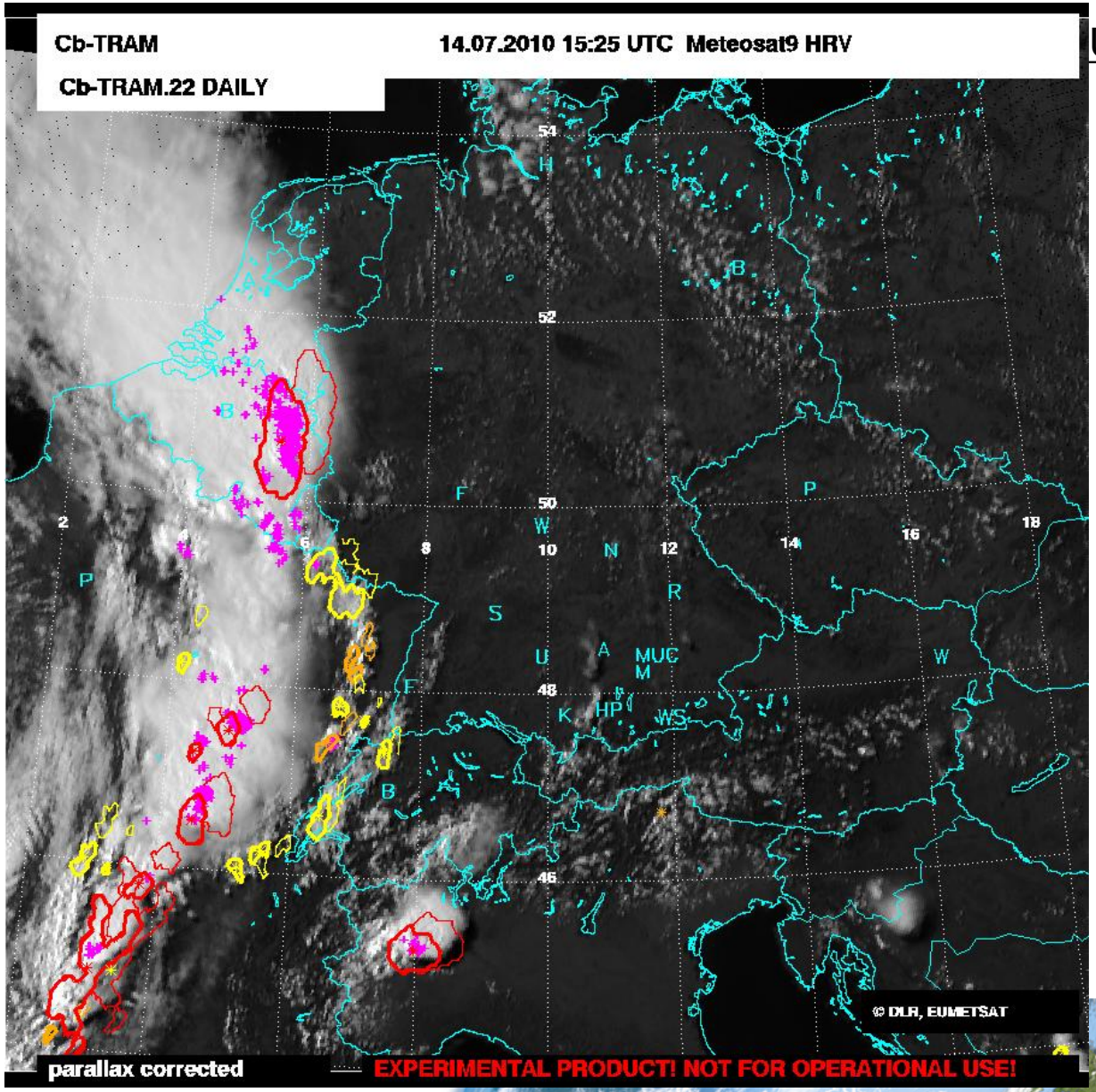
satellite data analysis
→en-route



Use

WV

IR



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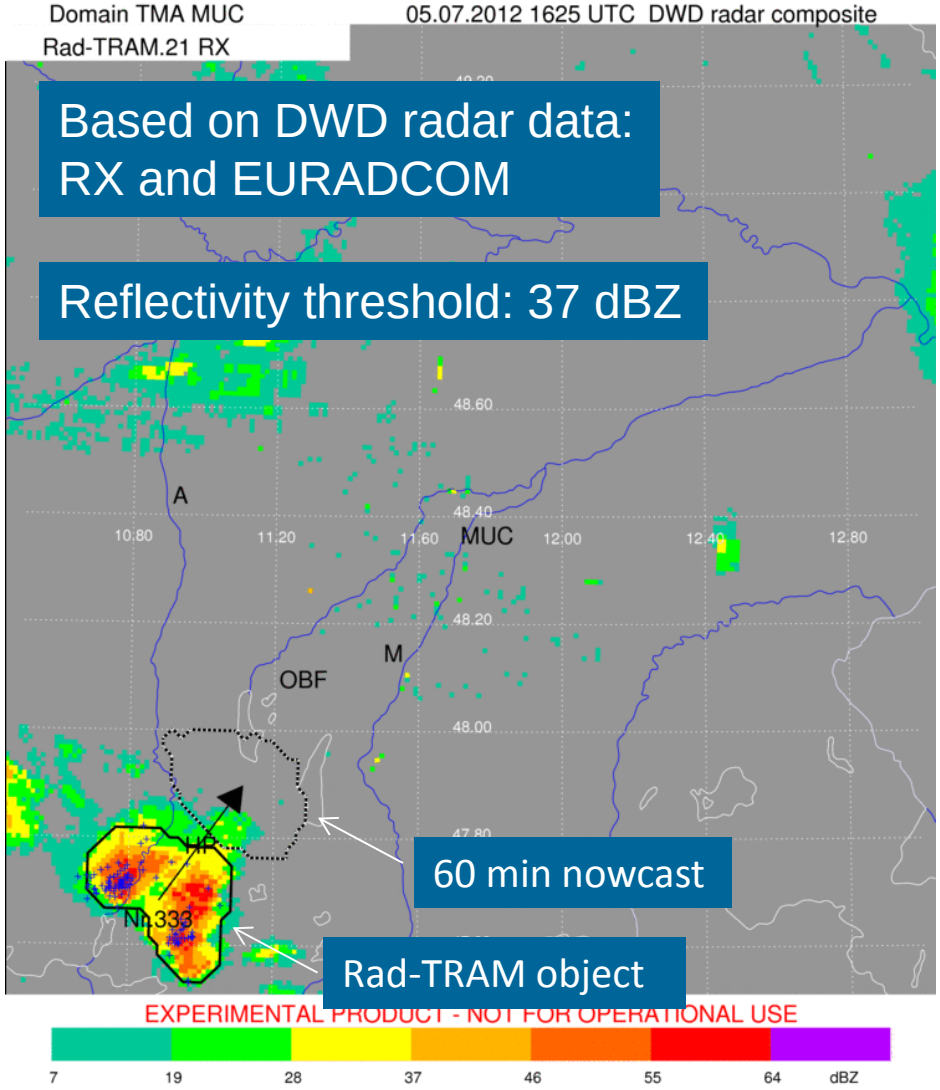
Lightning (LINET)

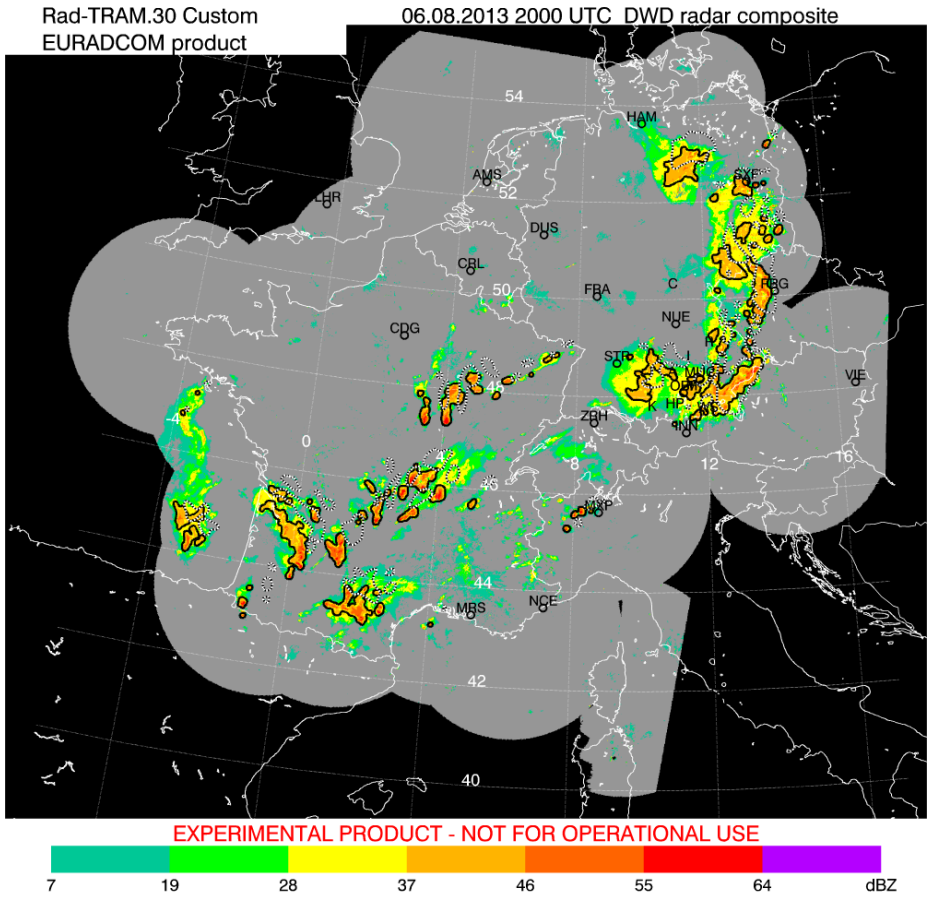
Extrapolation up to 60 min
(here 30 minute nowcast plotted)

Description: Zinner et al., 2008,09 & 13

Rad-TRAM - Radar Tracking and Monitoring

weather radar data analysis
→take-off and landing

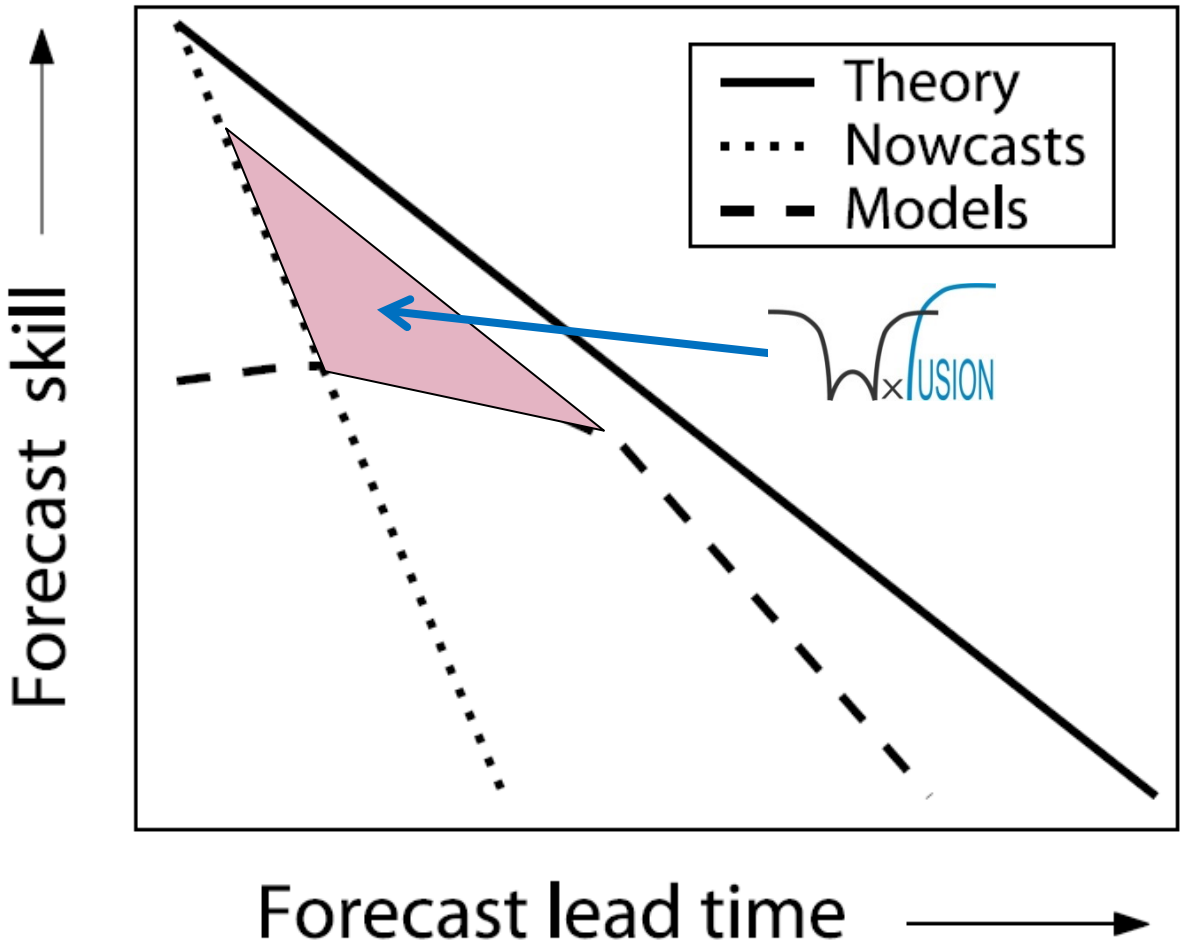




Available every 5th minute

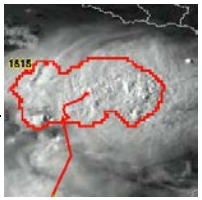
Tracking and nowcasting based on pyramidal image matching like in Cb-TRAM

Forecast skill for convective precipitation



after Lin et al. , 2005, Golding, 1998

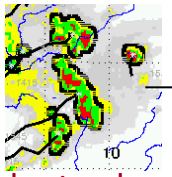
Weather Forecast User-oriented System Including Object Nowcasting


Cloud tracker


POLDIRAD


Lightning

Surface Analysis


Radar tracker

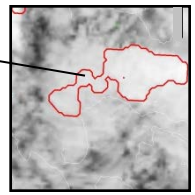
weather object specification oriented at user requirements

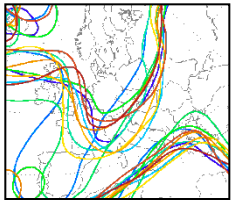
Initiation
Track
Nowcast
Forecast

forecast validation

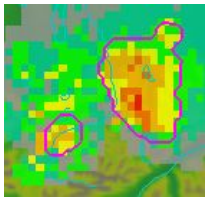
forecast validation

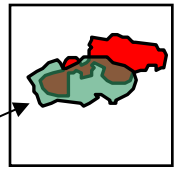

Object Comparison


SYNSAT


COSMO-DE & Ensemble

Local forecasting


SYNRAD


Object Comparison

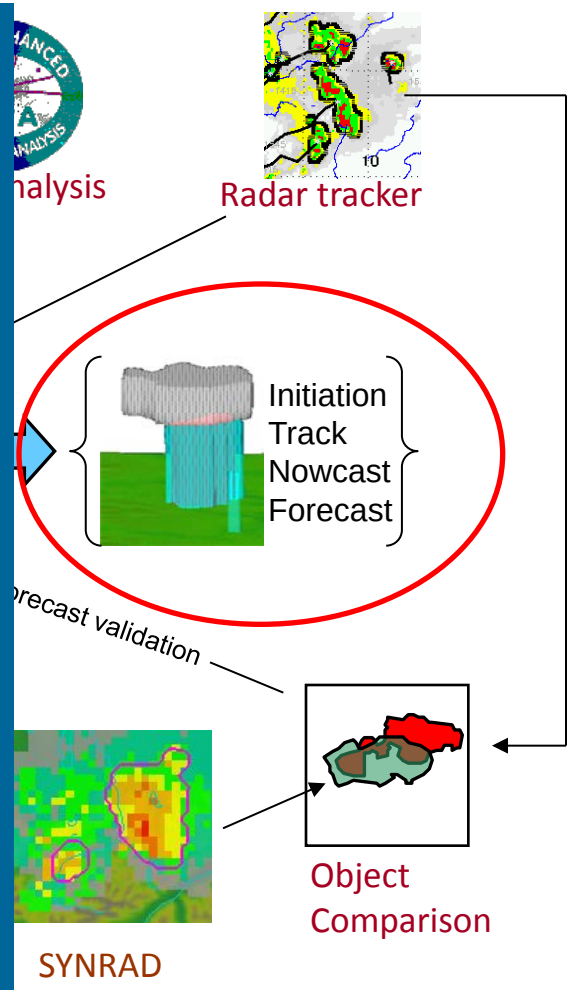
Predicting the future state of a weather object through:

Nowcast based on extrapolation methods

Forecast based on NWP models
(ensemble model and high resolution forecasts)

Selection of the *forecast* that agrees *best* with the *observation*

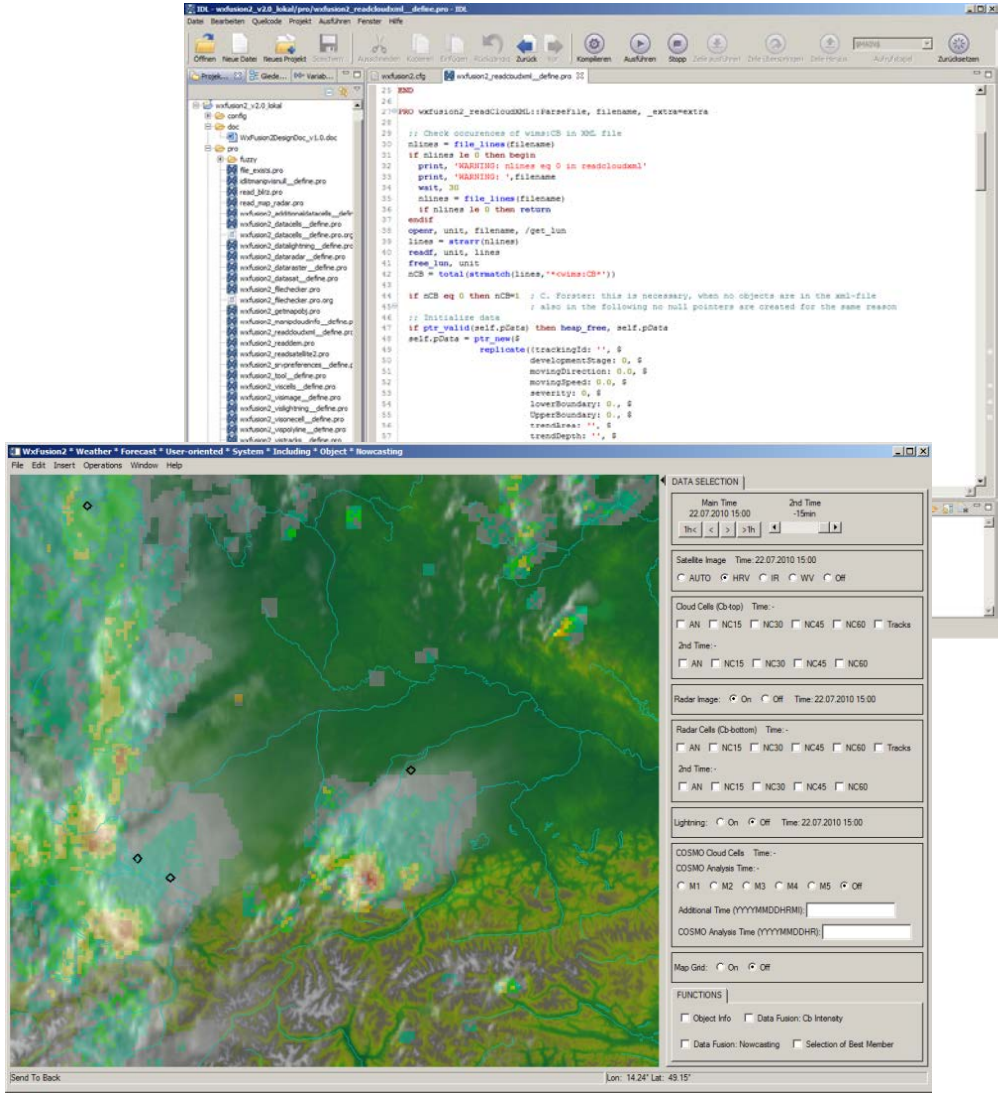
Combination of nowcast and forecast by applying *fuzzy logic*



IDL: the platform to realize the WxFUSION concept

IDL …

- is a platform for data analysis and visualization
- provides a means to easily describe weather objects as well as their attributes
- provides an effective platform to integrate and overlay different data sources
- enables a quick analysis of the changes made in a WxFUSION algorithm
- is highly specialized for the processing and display of geospatial imagery



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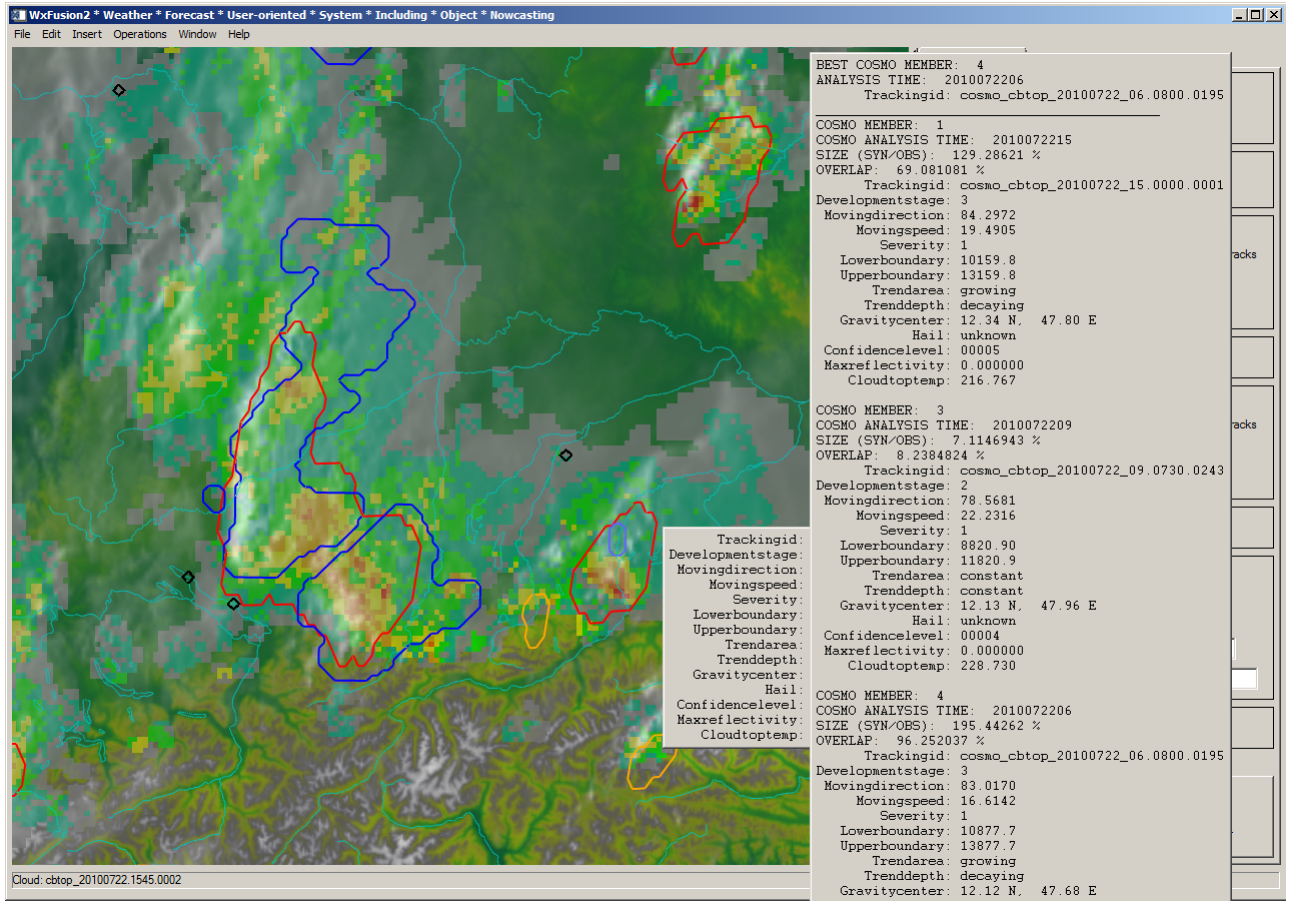
EXELIS

Visual Information Solutions

EXELIS exhibition stand Nr.8

WxFUSION GUI with selection of best member



red: observed Cb-TRAM objects on 22. July 2010 17:00 UTC.
blue: synthetic objects of COSMO-DE member 4 (analysis 22. July 2010 06 UTC)

Shown is a list of COSMO-DE Members that have an overlap with the current observation
The member having the best overlap with the observation is listed on top (here No.4)

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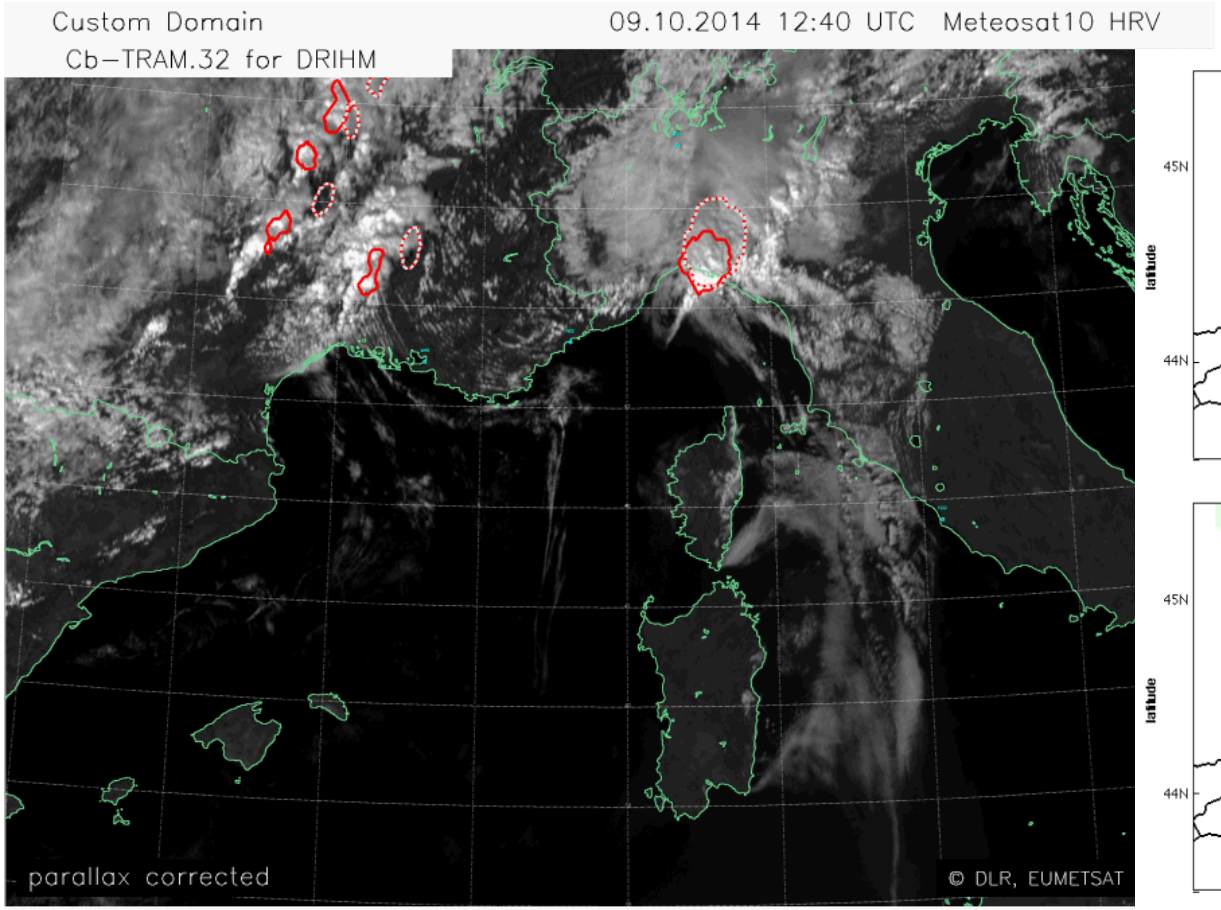
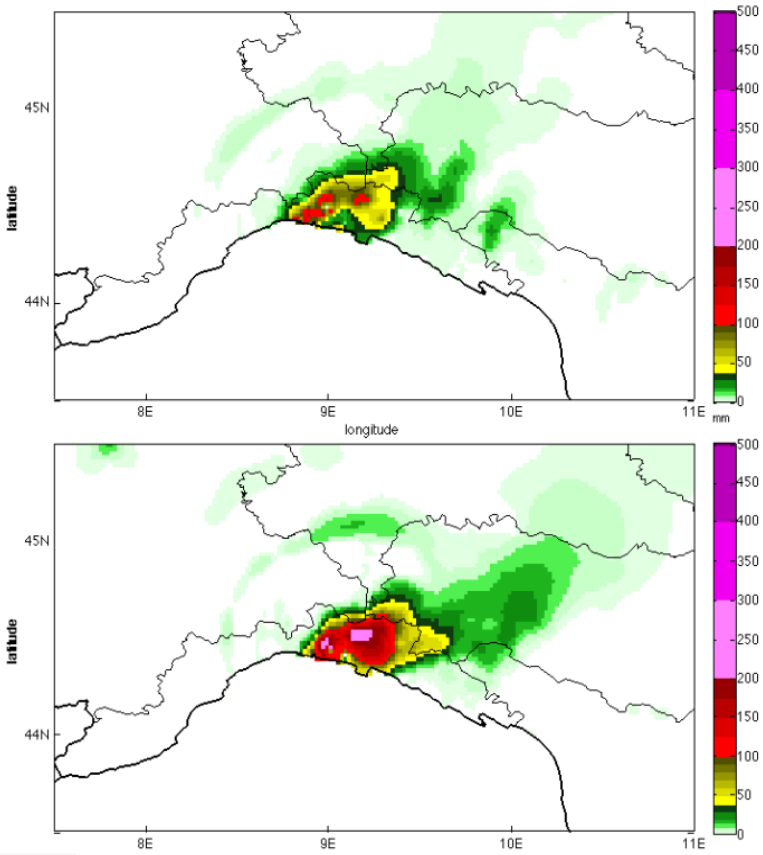
Best member selection example case

flooding in the city of Genoa on 9 October 2014





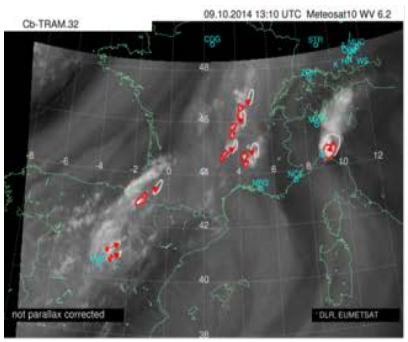
EXPERIMENTAL PRODUCT – NOT FOR OPERATIONAL USE

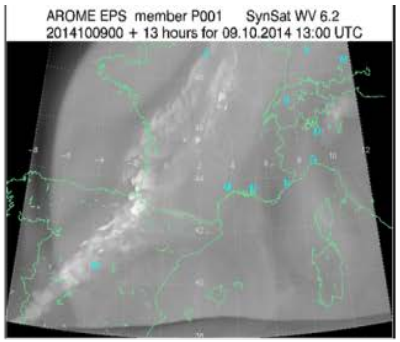
Cb-TRAM detects a storm cell which persists in that location for about 6 hours

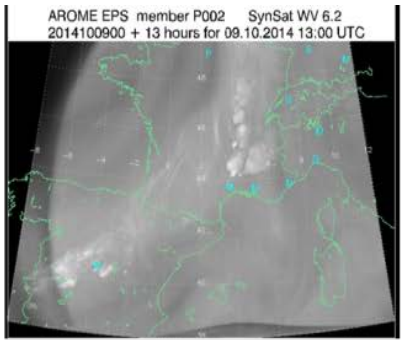
observed rainfall as given by the 12 hour precipitations sums from 00 to 12 UTC (top) and from 12 to 24 UTC (bottom)

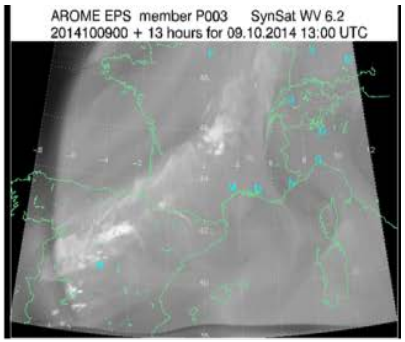
Best member selection example case

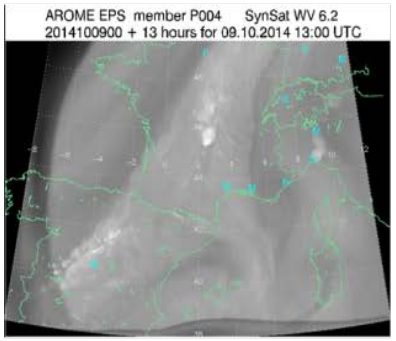
flooding in the city of Genoa on 9 October 2014

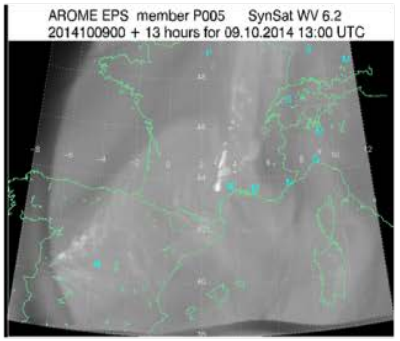


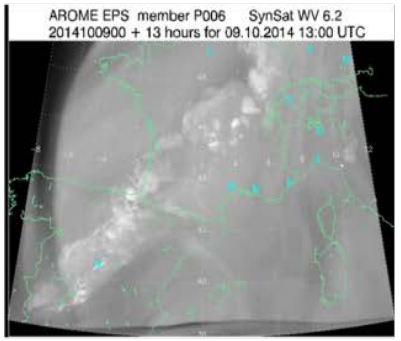


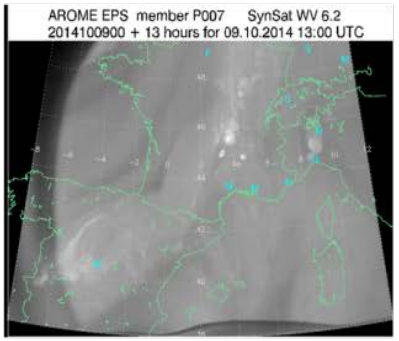


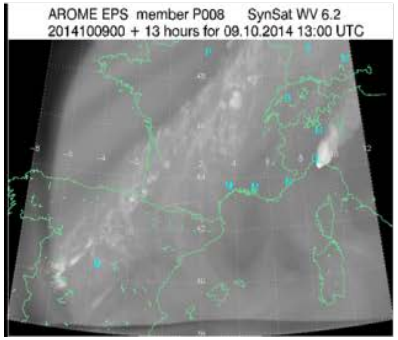


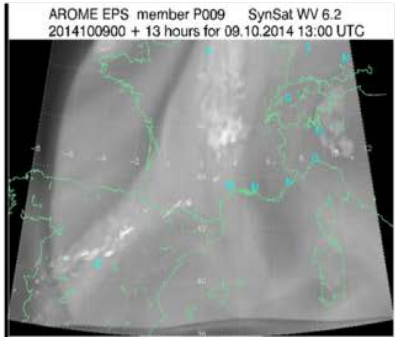


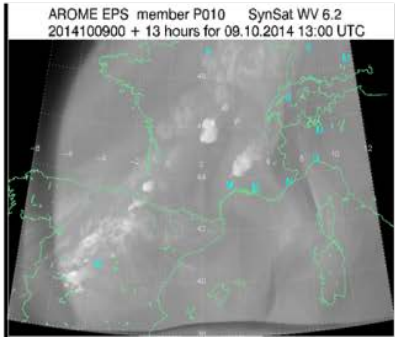


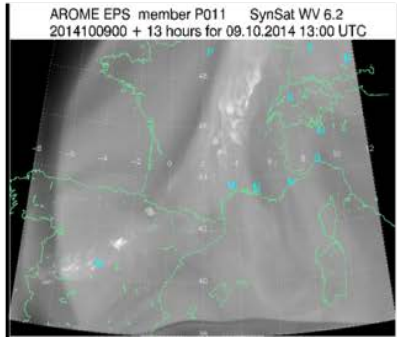












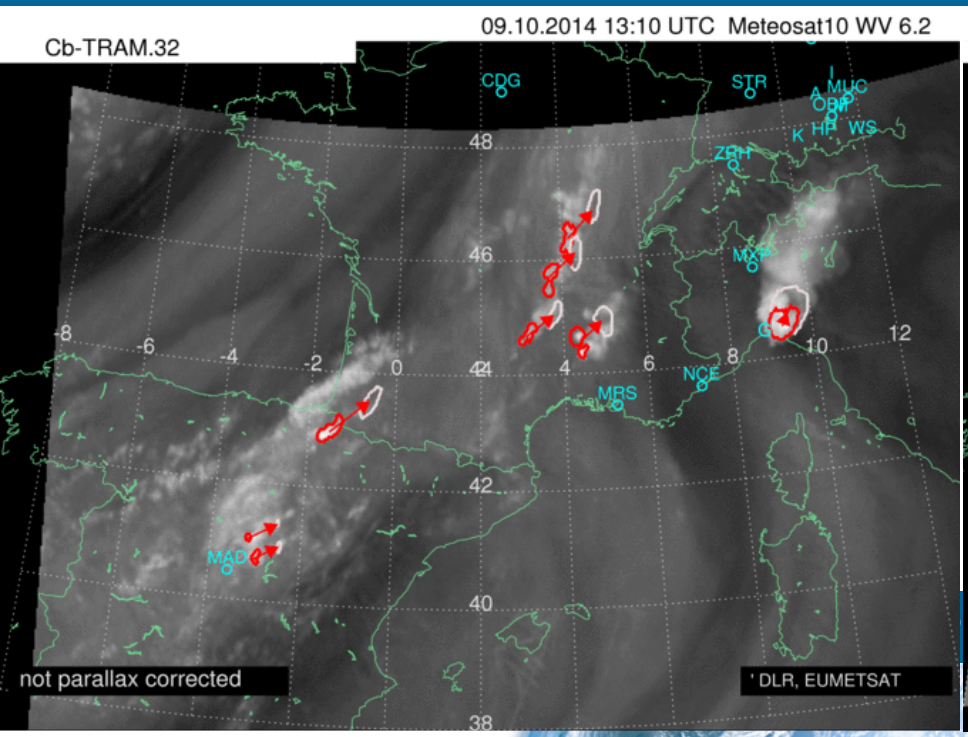
AROME EPS forecast provided by O. Nuissier, MeteoFrance

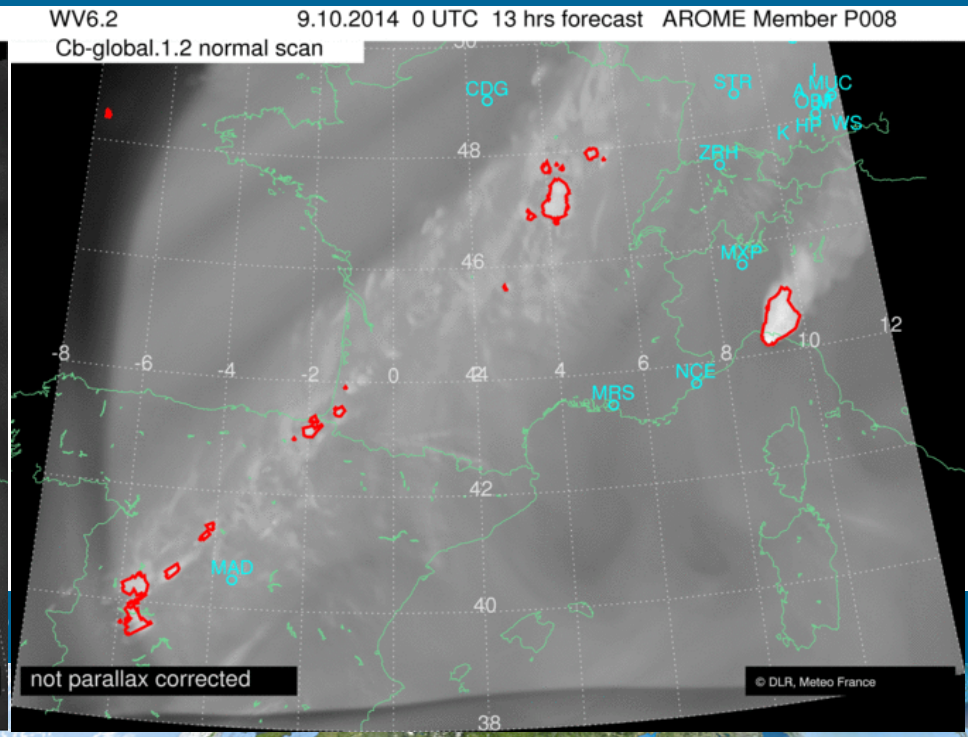
Best member selection example case

flooding in the city of Genoa on 9 October 2014

High potential for timely detection of flood hazard:

- Cb-TRAM detects thunderstorms in both, synthetic (member P008) and real satellite data near Genoa
- The thunderstorm near Genoa is not a transient feature in P008, but persists for about 5 hours
- The precipitation forecast of P008 shows large amounts of rainfall exceeding 200 mm over 24 hours

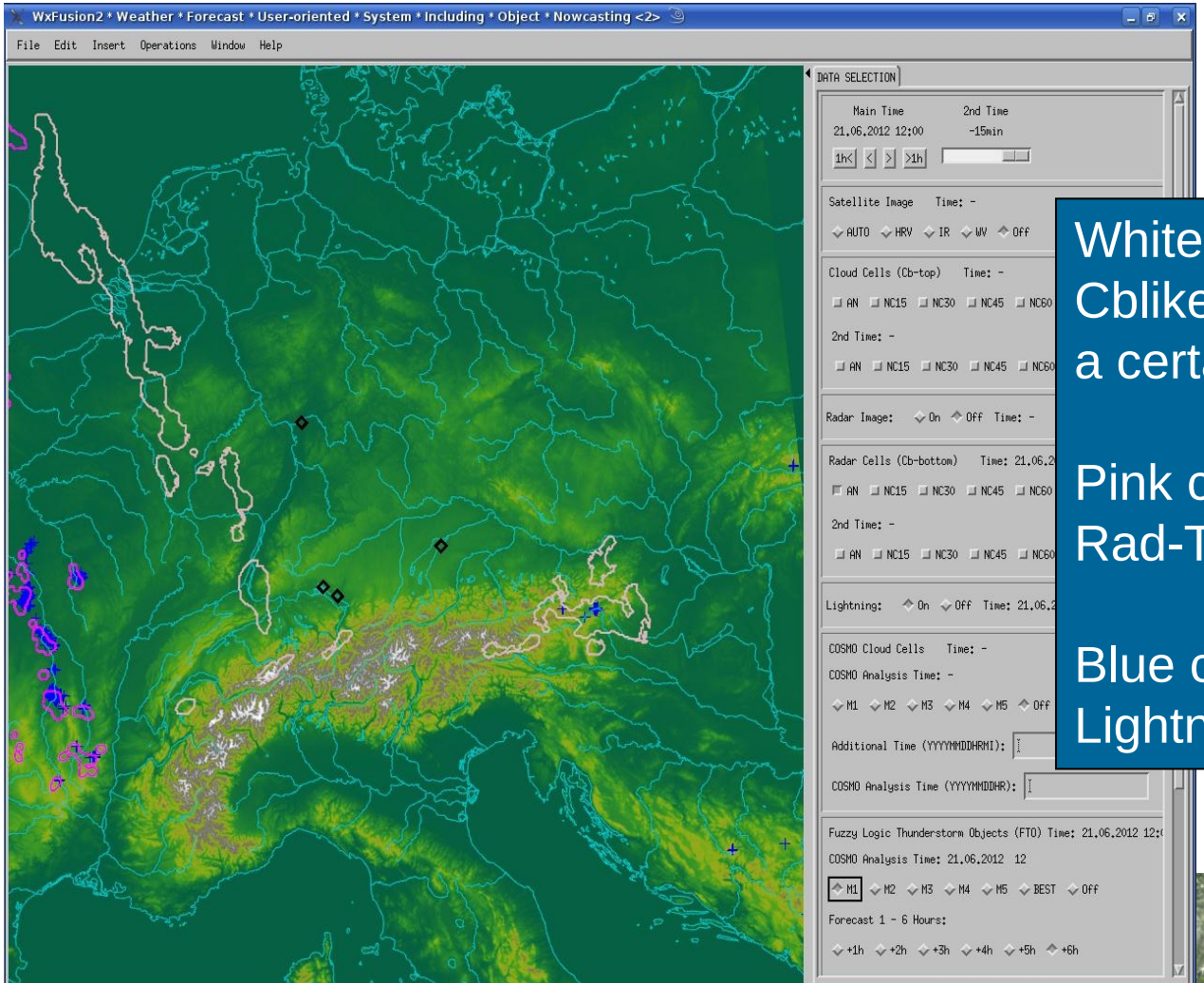




Cb indicator forecasts up to 6 hrs (Cblike)

Fuzzy logic combination of CAPE, 500 hPa vertical velocity, synthetic satellite and radar data from the DWD COSMO-DE model

Cblike 6 hrs forecast for 21 June 2012 18:00 UTC



White contours:
Cblike indicator exceeding a certain threshold

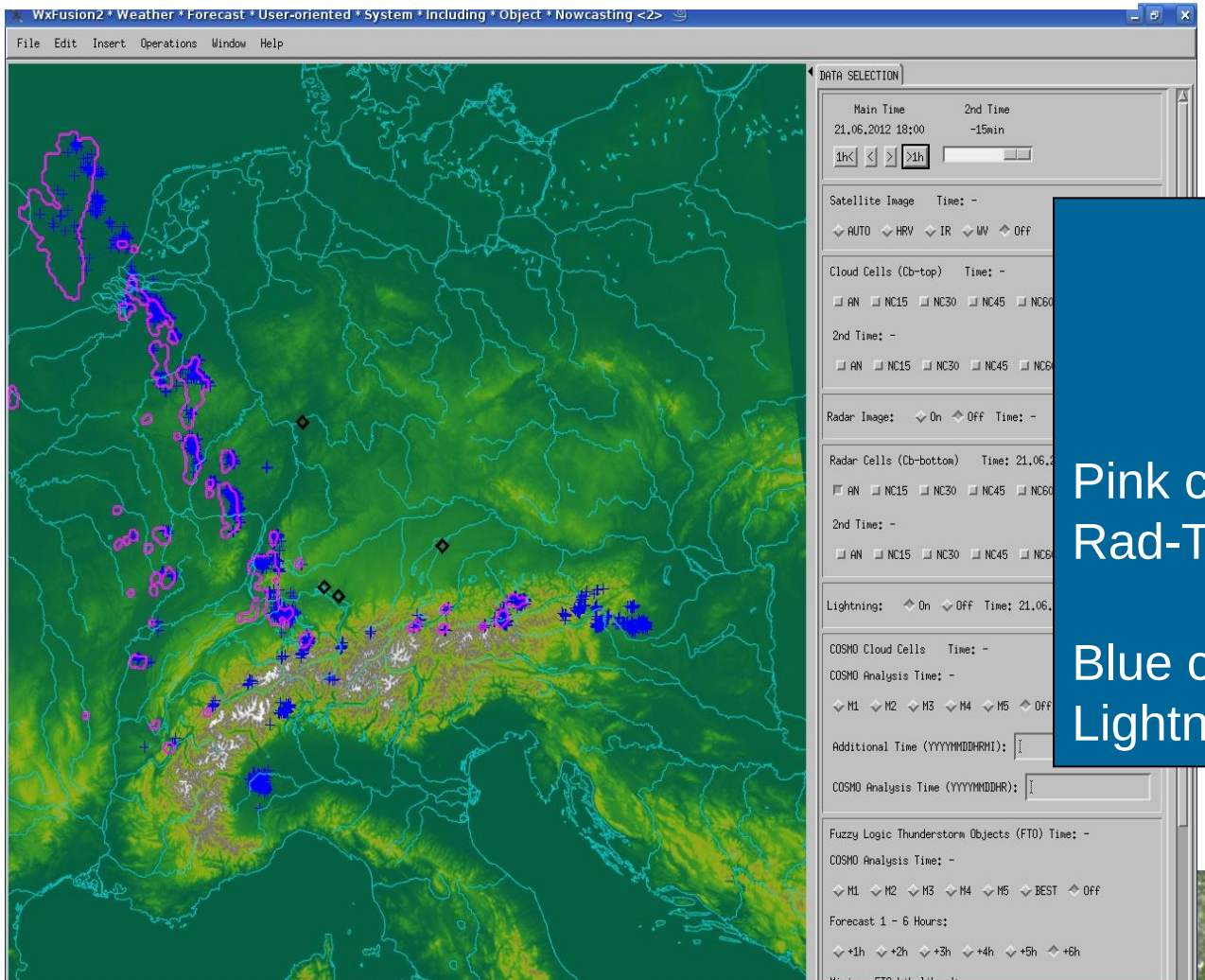
Pink contours:
Rad-TRAM cells

Blue crosses:
Lightning data (LINET)

Cb indicator forecasts up to 6 hrs (Cblike)

Fuzzy logic combination of CAPE, 500 hPa vertical velocity, synthetic satellite and radar data from the DWD COSMO-DE model

Cb observation 21 June 2012 18:00 UTC



Pink contours:
Rad-TRAM cells

Blue crosses:
Lightning data (LINET)

Summary

Thank you for your attention!

contact: dennis.stich@dlr.de

- WxFUSION
  - integrates and overlays data from different sources (observations, nowcasts, forecasts)
  - is based on IDL and uses an object-oriented approach
  - selects the best forecast out of an ensemble
  - combines data by using fuzzy logic and enables Cb likelihood forecasts up to 6 hrs
- modules of WxFUSION have successfully been tested in real time at Munich Airport