Improved Safety for Air Traffic through Ground and Satellite Based Observing Systems

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- FLYSAFE Project: CB WIMS
  thunderstorm weather information and management system

- Aircraft thunderstorm encounters as seen by ground and satellite based observing systems

- Conclusions

- Mitigation measures

FLYSAFE - An Integrated Project of the 6th Framework Programme of the European Commission (2005 - 2009)

Problem addressed by FLYSAFE:

"How can pilots and air traffic control be provided with the right information at the right time in order to reduce or even avoid risks"

- ACARE (Advisory Council for Aeronautics Research in Europe): Vision 2020

FLYSAFE task:

Design, develop, implement, test and validate a complete Next Generation Integrated Surveillance System (NG ISS)

Three threats were addressed:

- **Weather**
- **Traffic**
- **Terrain**

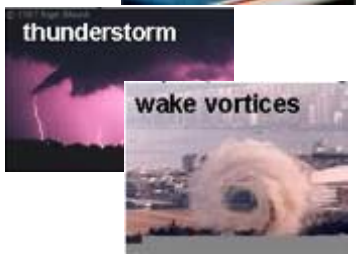
Information flow between ground and A/C

raw data / grid data

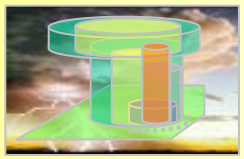
object data

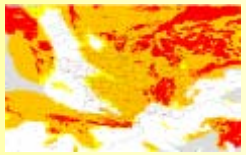
objects in a weather corridor

Data sources:
- PIREP,
- radar,
- satellites,
- aircraft,
- weather observations & predictions



WIMS
- WV
- CAT
- ICE
- CB

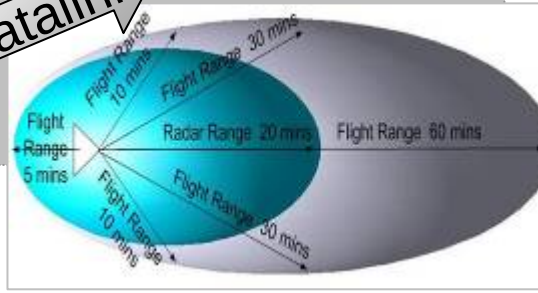




Ground based weather processor (GWP)

Requests

datalink



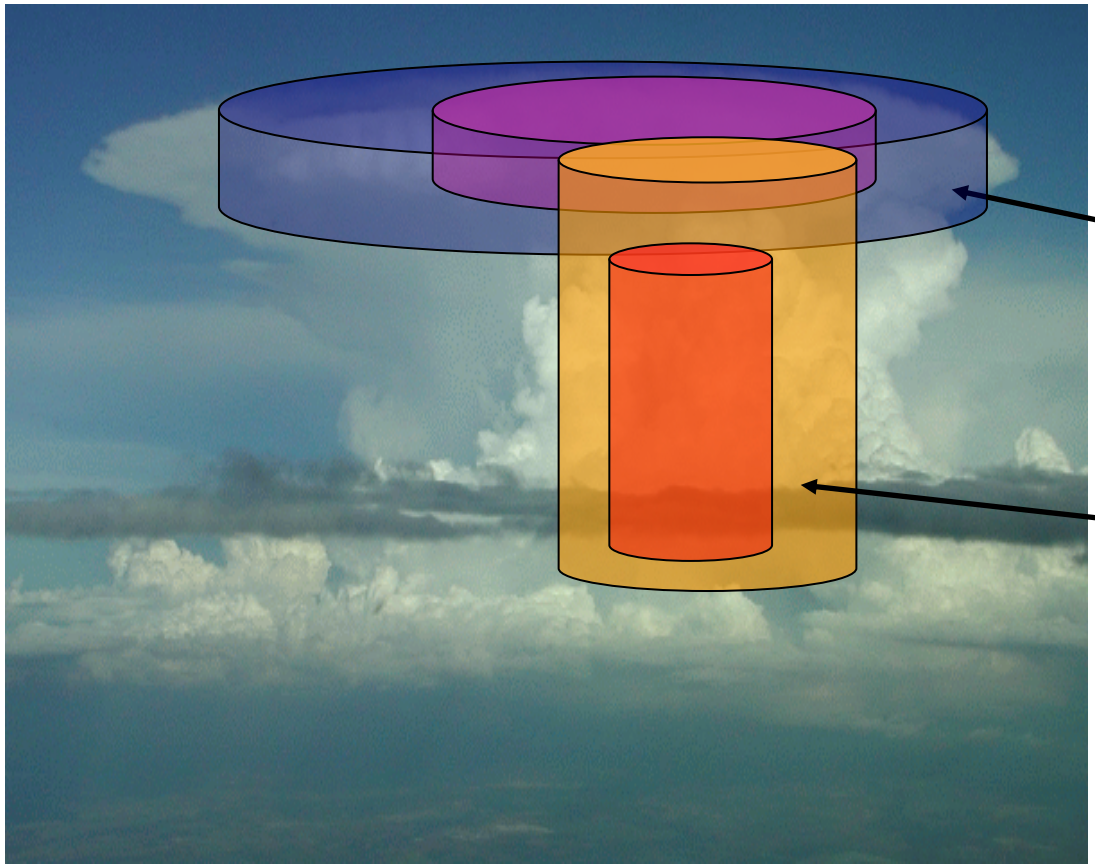
also possible

CB WIMS
Thunderstorm weather information and management system

Thunderstorms are a Safety Issue for more than one reason

- wind shear & turbulence
- lightning stroke
- hail
- icing
- heavy ra
- visibility

CB WIMS (DLR, MeteoFrance, UKMetOffice, UniHannover, ONERA)

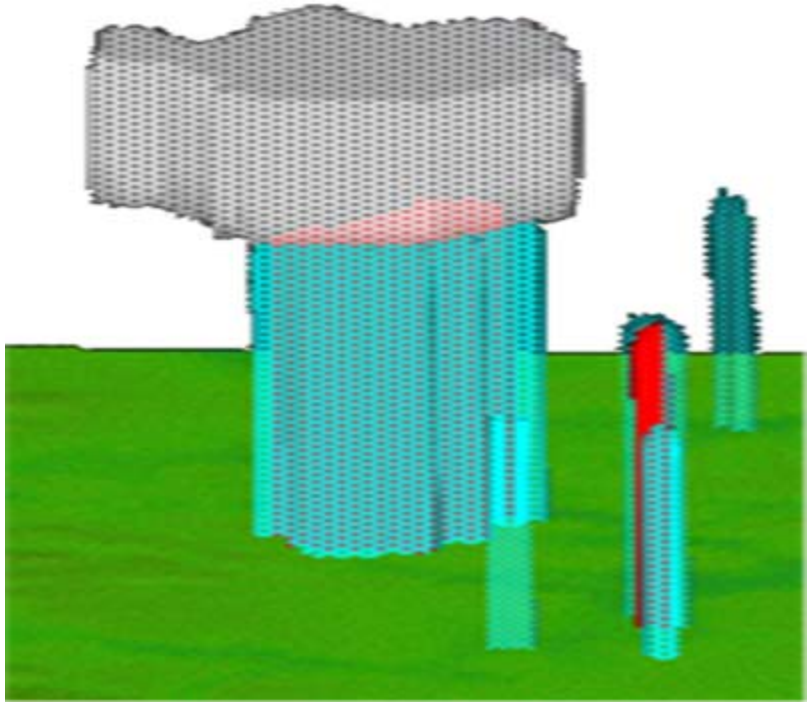


Representation of a thunderstorm by hazard volumes

Cb top volumes: convective turbulence, lightning

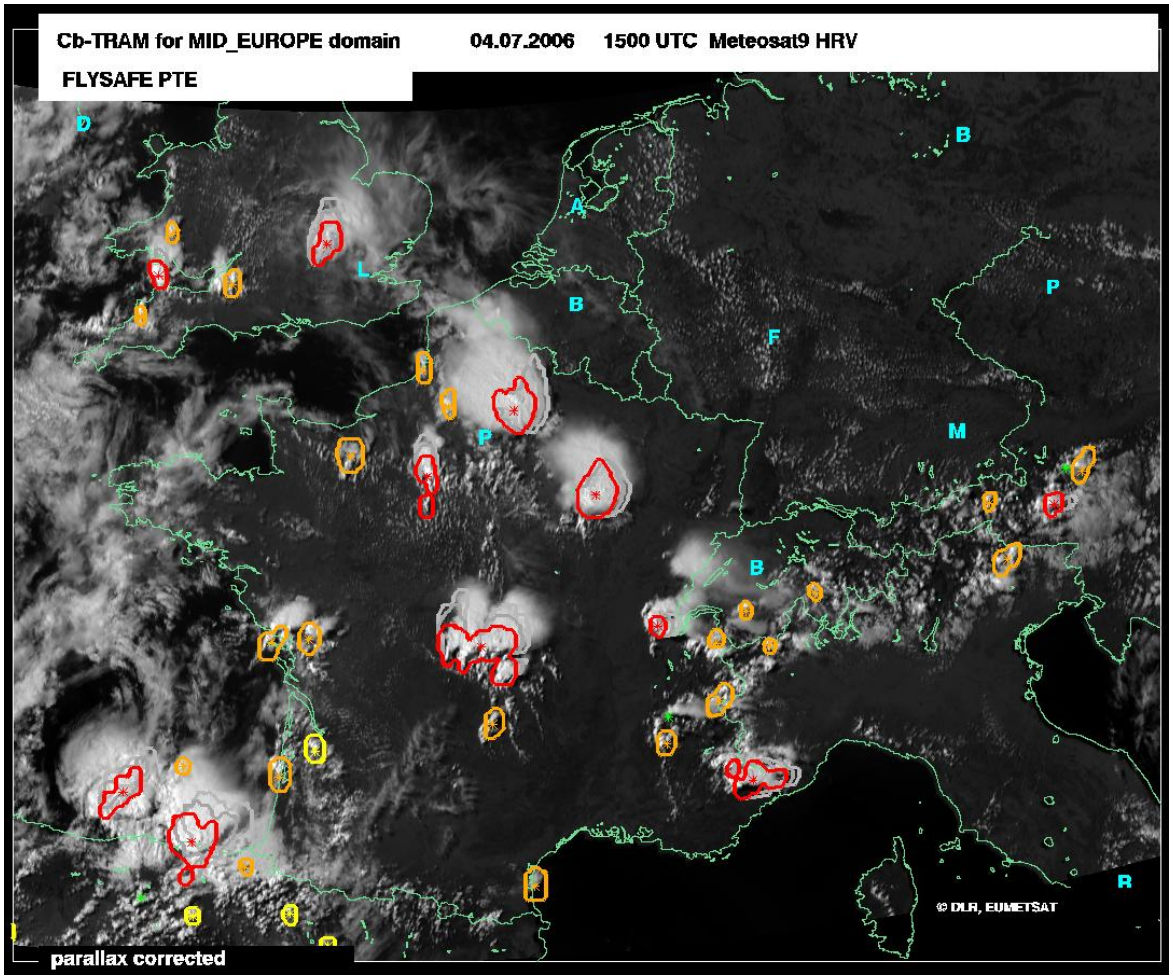
Cb bottom volumes: hail, icing, lightning, heavy rain, wind shear, turbulence

CB WIMS object attributes delievered in GML/XML files



- Area covered, as a polygon
- Layer (top or bottom)
- Upper boundary
- Lower boundary
- Moving direction
- Moving speed
- Gravity centre location
- Severity level (moderate, severe)
- Trend on area
- Trend on vertical development
- Hail occurrence flag
- Confidence level
- Nowcasts every 5 minutes up to 30 minutes, + 45 and 60 minutes

CB top volumes provided by Cb-TRAM
Thunderstorm Tracking and Monitoring (DLR)

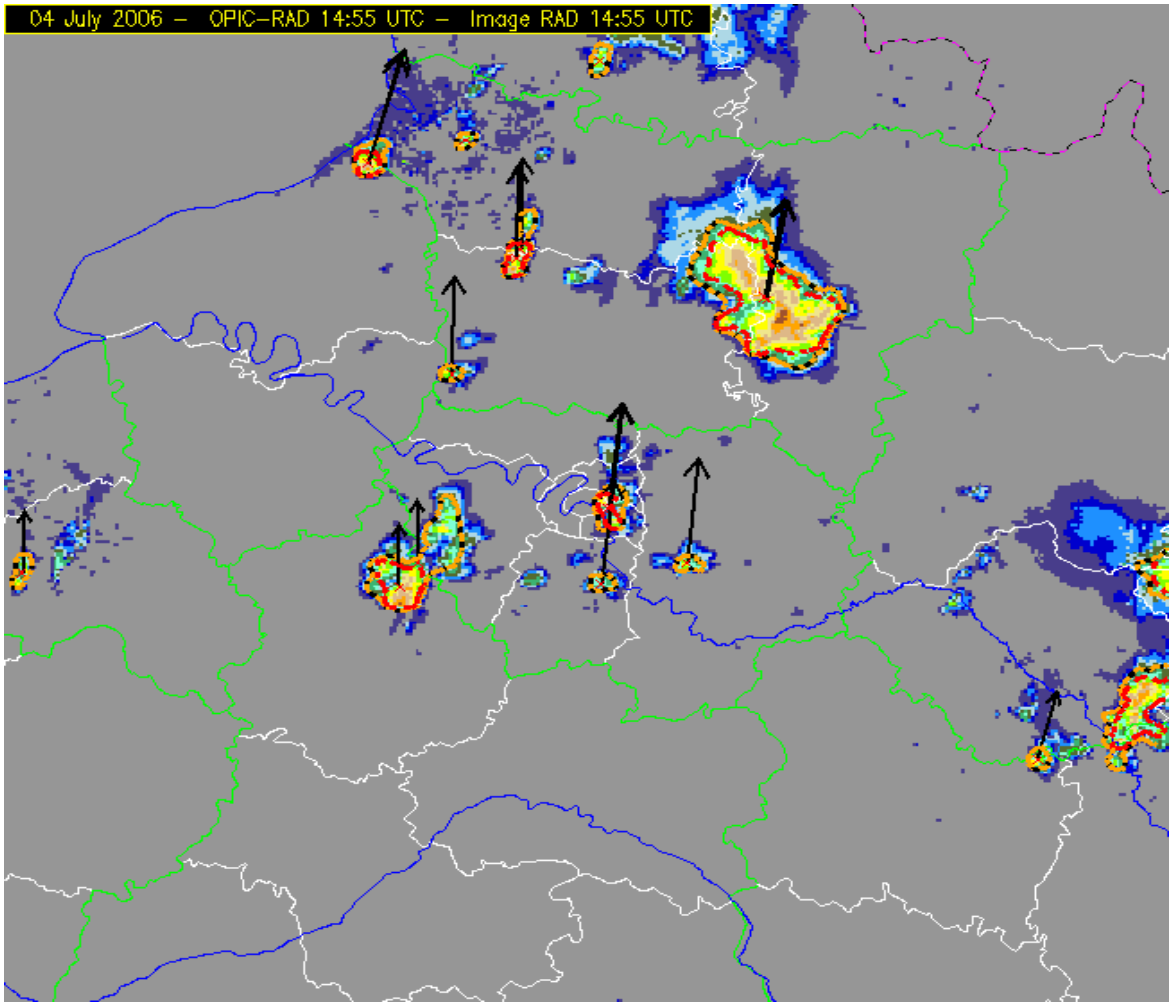


Detection of convection by combination of Meteosat 9 Channels HRV, IR 10.8, IR 12.0, WV 6.2 μm

3 development stages:
- initiation (yellow)
- rapid growth (orange)
- mature (red contours
- 15/30 min nowcast (white)

Meteosat HRV image with CB-TRAM cells for 4 July 2006 1500 UTC

Cb bottom volumes provided by Météo France' CONO algorithm



CONO algorithm uses

- 3-D radar data (TMA Paris)
- 2 severity levels:
  33 dBZ und 41 dBZ
- hail information

Detected bottom volumes in 2 severities (orange and red) for 04.07.2006 1500 UTC, TMA Paris

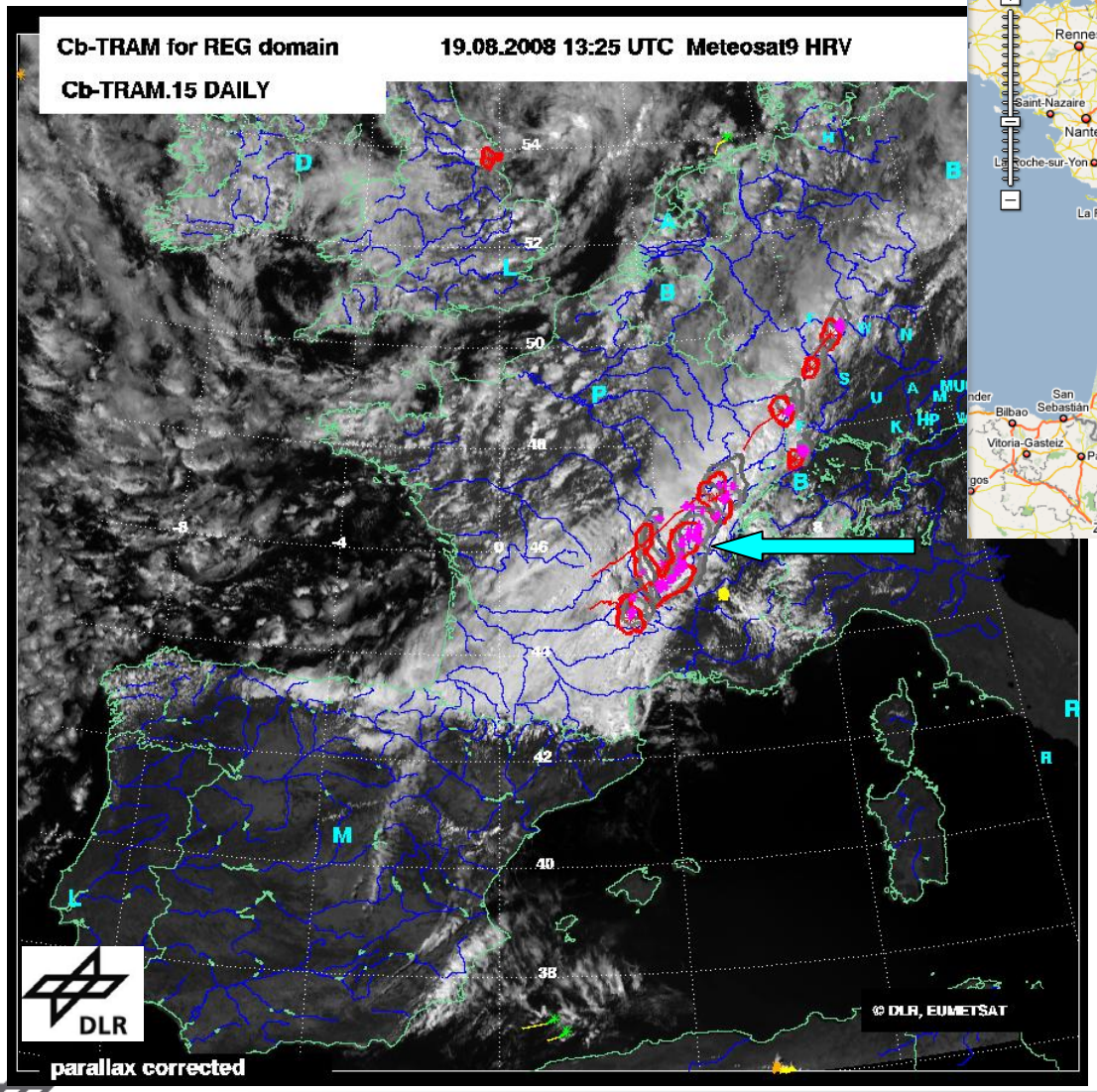
Evaluation in Flight Tests

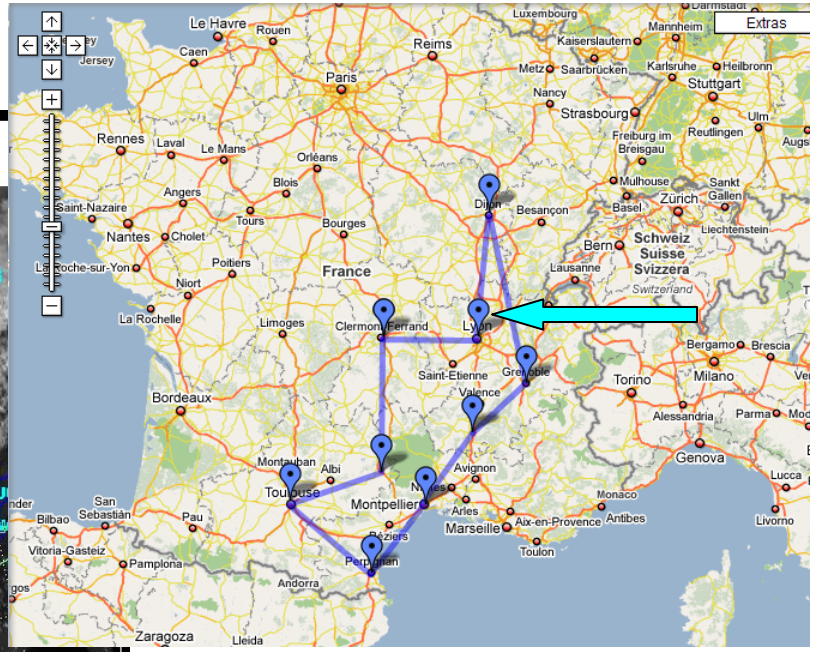
SAFIRE (ATR - 42): off-line evaluation

NLR Metro Swearingen II: on-line evaluation

- SAFIRE: 6 most successful flights (out of 11) during summer campaign

Flight Test with Saphire on 9 August 2008



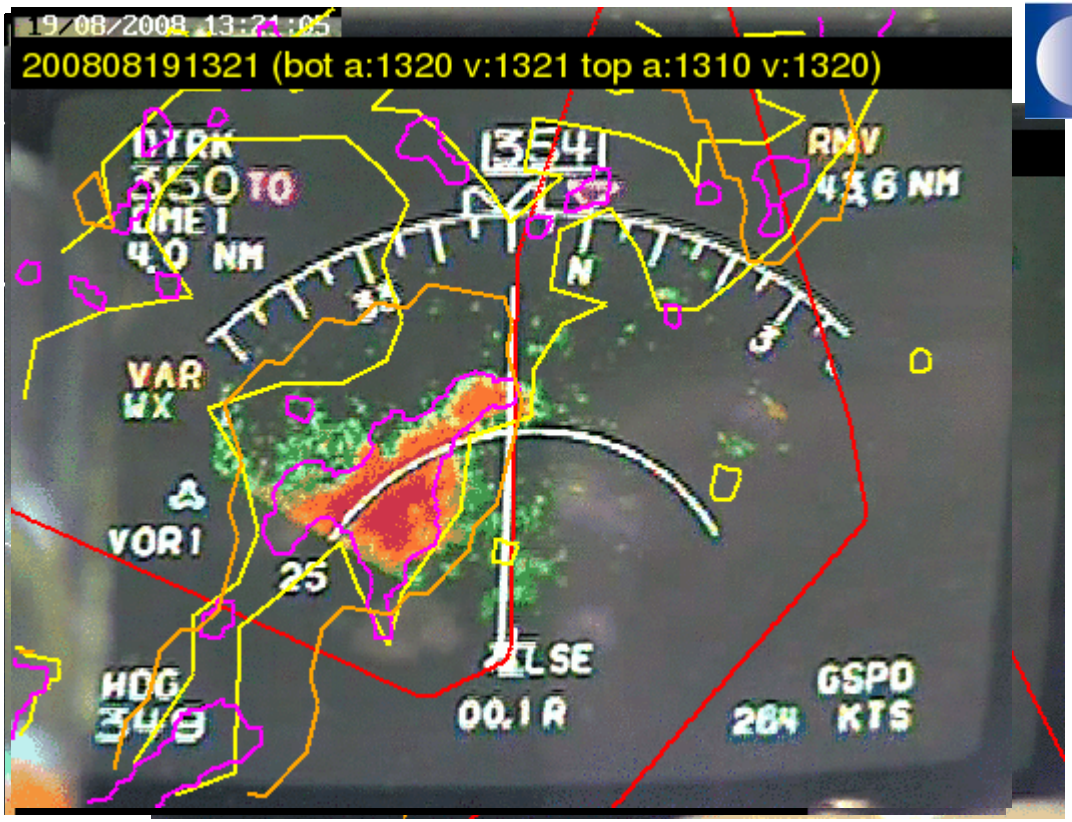


Left: Meteosat HRV with
Cb cells in red (with tracks),
LINET lightning obs in purple
At 1325 UTC.
Right: flight track

On board observations
near Lyon (arrow)

CB WIMS provides wider coverage during turns

19 August 2008 1319 - 1321 UTC



Onboard radar video (from SAFIRE) with DLR Cb top objects in yellow. Last snapshot also with bottom volumes in orange and purple.

Quick and strong turn typical of TMA tracks

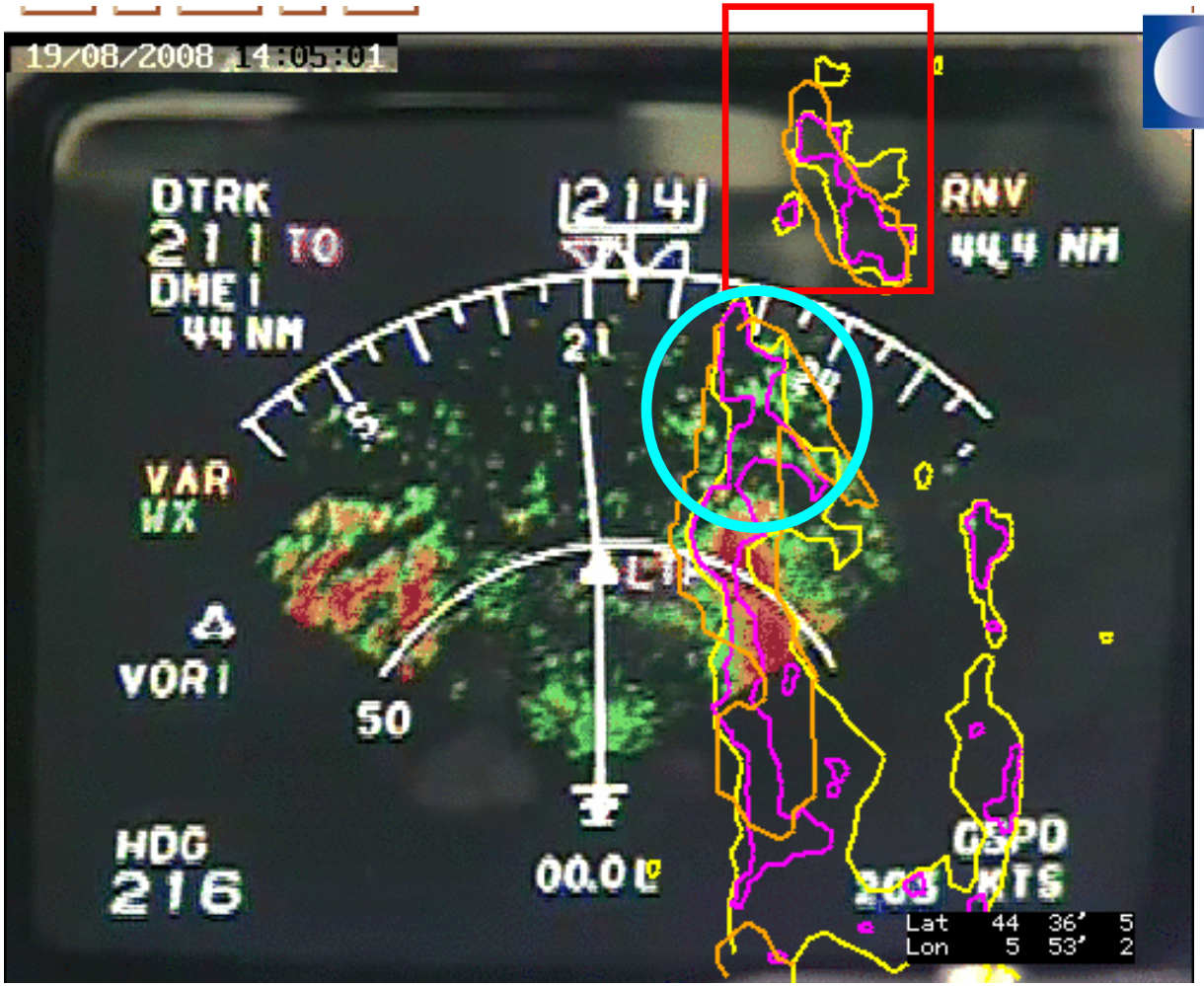
The Cb top objects here are 10 minutes forecasts, which is representative of the processing and telecom delay for on-ground data to the GWP.

CB WIMS added value in CB crowded cases

19.08.2008
14:05 UTC

Cb top
(orange)

Cb bottom
(yellow, pink)



METEO FRANCE

CB WIMS added value in CB crowded cases

19.08.2008
14:15 UTC

Cb top
(orange)

Cb bottom
(yellow, pink)

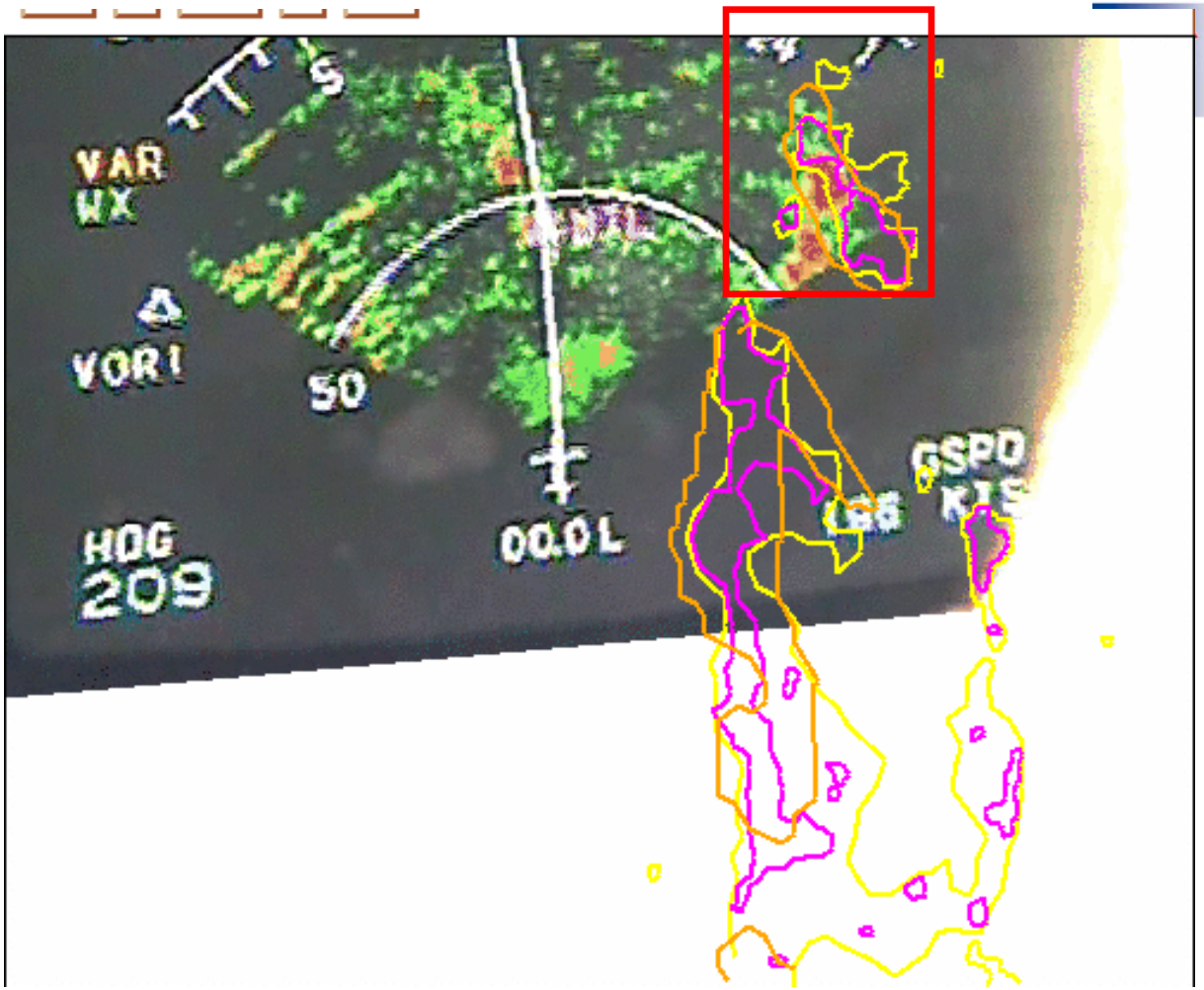
METEO FRANCE

CB WIMS added value in CB crowded cases

19.08.2008
14:25 UTC

Cb top
(orange)

Cb bottom
(yellow, pink)



METEO FRANCE

Aircraft thunderstorm encounters as seen by ground and satellite based observing systems

Use of Cb-TRAM for detection of severe convection over oceans

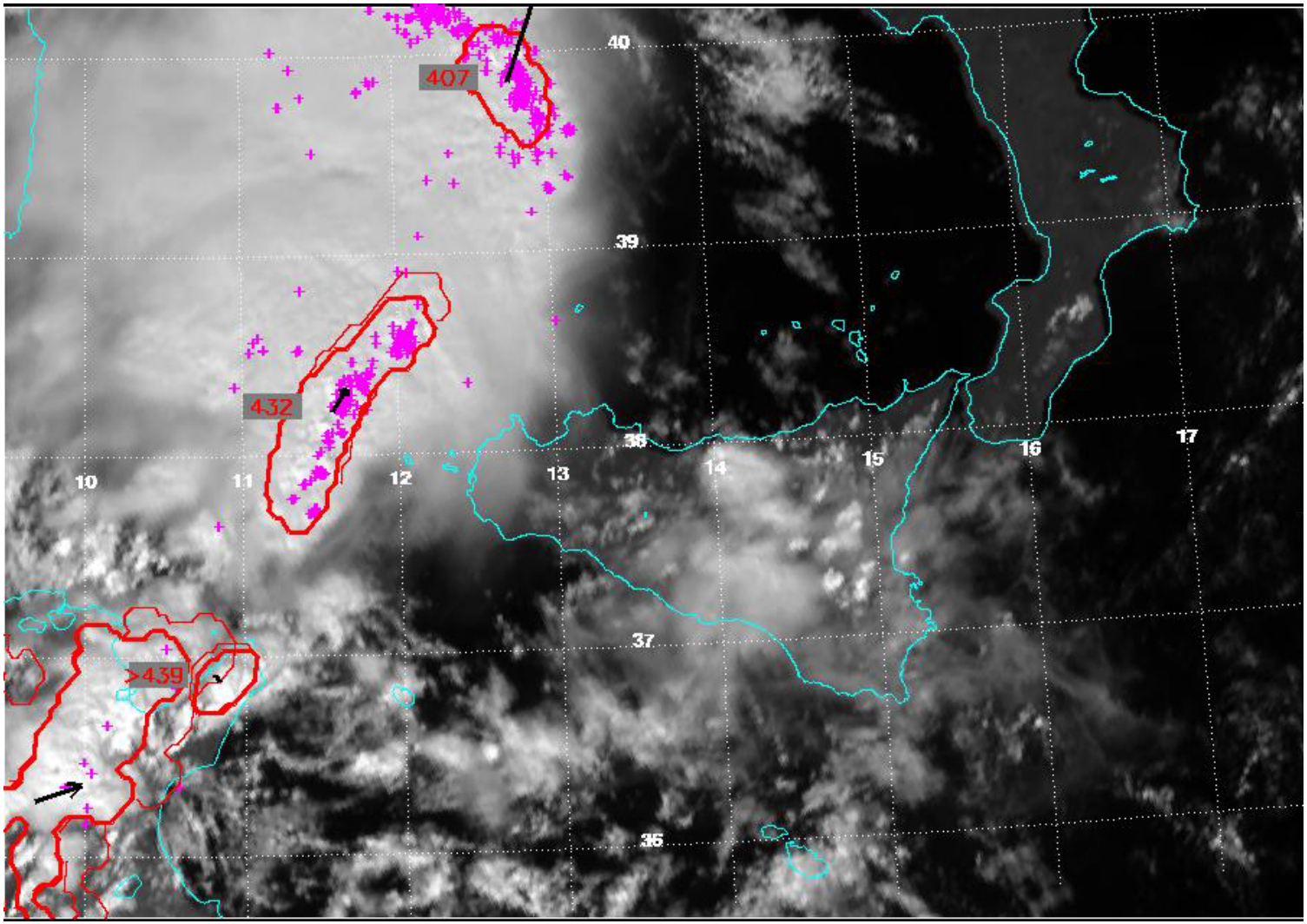
The slides shown in the following shall demonstrate the met capablities we have today and the usefulness these systems could have to better inform pilots and ATM.

Challenge for the future: make these systems operational bring the met hazard information into the cockpit (data link) and fuse it with onboard met information.

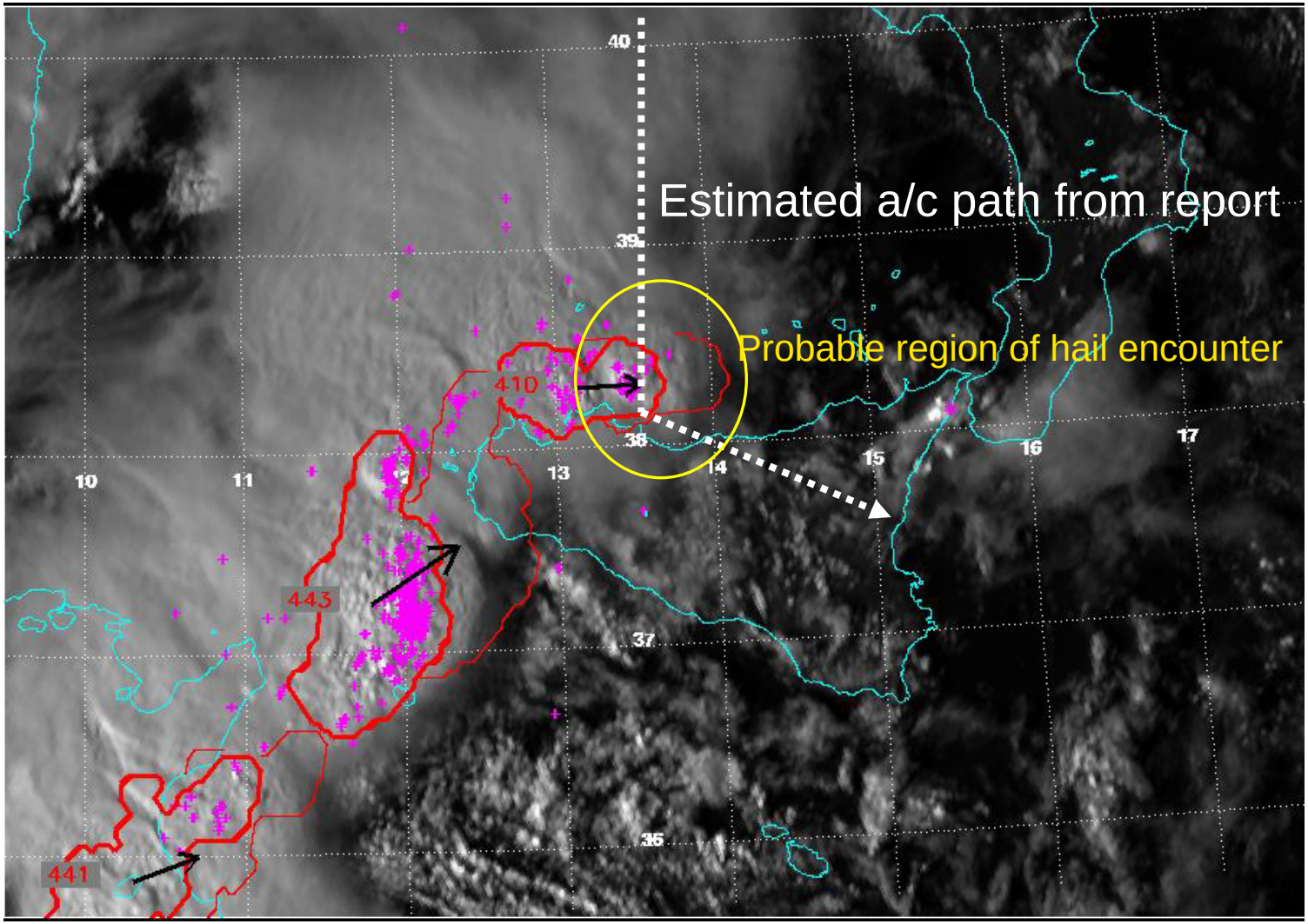
A319 near Catania on Oct 1st 2009: Encounter of severe turbulence and hail

http://avherald.com/h?article=420d4cbd&opt=0

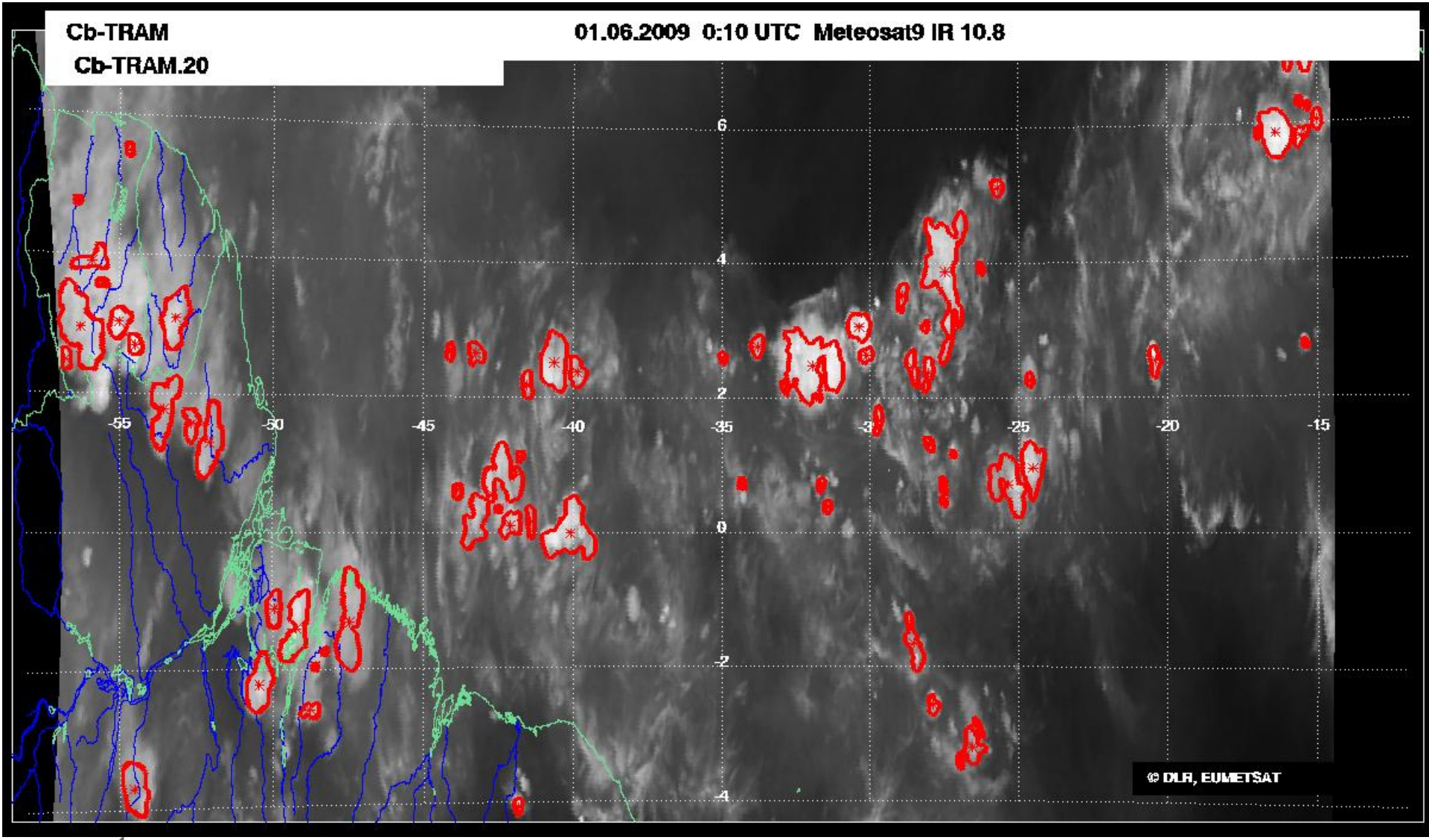
Nose Damage (Photo: ATRDRIVER)

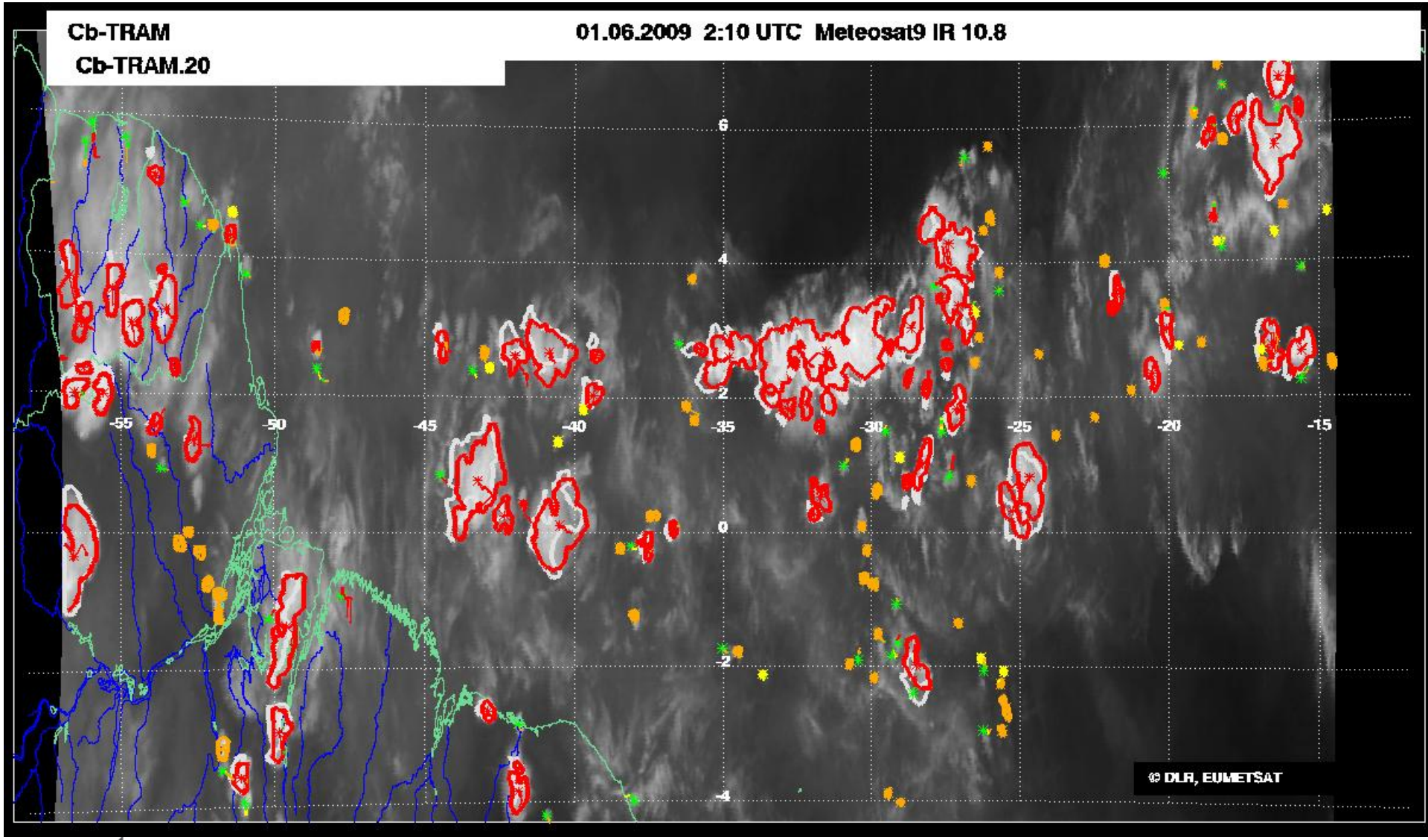


1155 Z

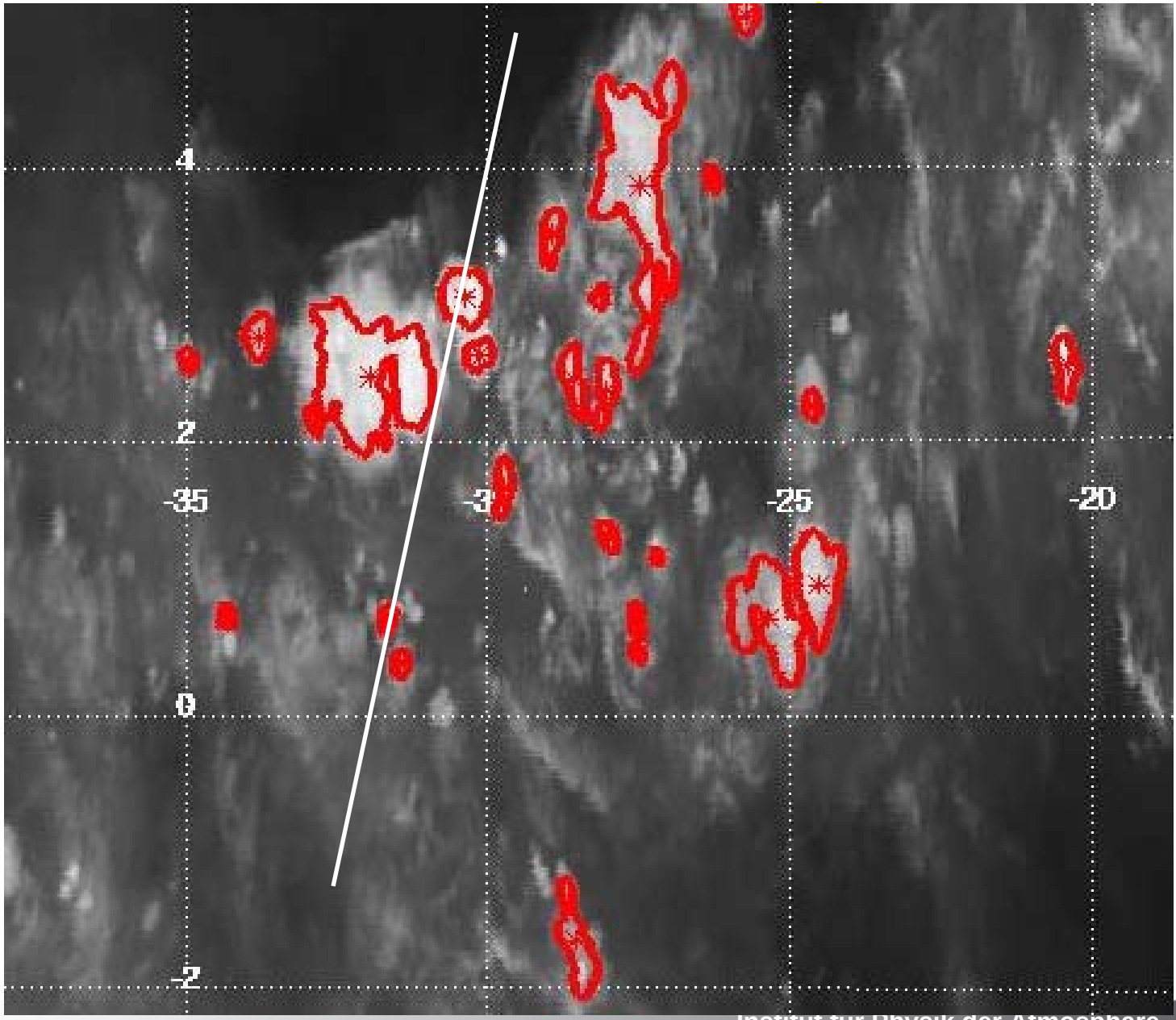

Estimated a/c path from report
Probable region of hail encounter
410
443
441
40
39
38
37
35
10
11
13
14
15
16
17

1455 Z

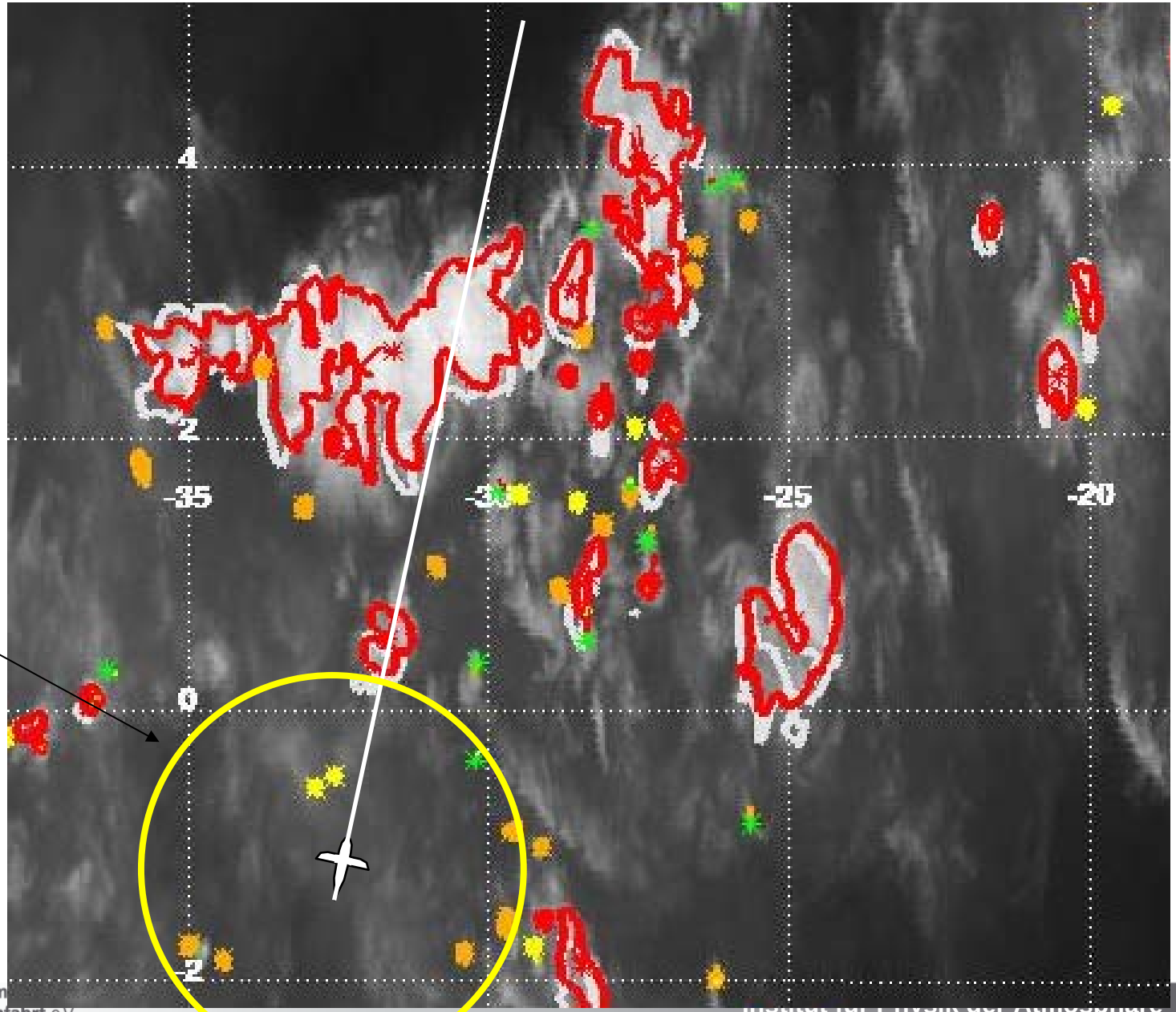

Cb-TRAM
Cb-TRAM.20
01.06.2009 0:10 UTC Meteosat9 IR 10.8
6
4
2
0
-2
-4
-55
-50
-45
-40
-35
-30
-25
-20
-15
© DLR, EUMETSAT


Cb-TRAM
Cb-TRAM.20
01.06.2009 2:10 UTC Meteosat9 IR 10.8
6
4
2
0
-2
-4
-55
-50
-45
-40
-35
-30
-25
-20
-15
© DLR, EUMETSAT

1 June 2009 00 UTC: Cb-TRAM analysis of mature convection

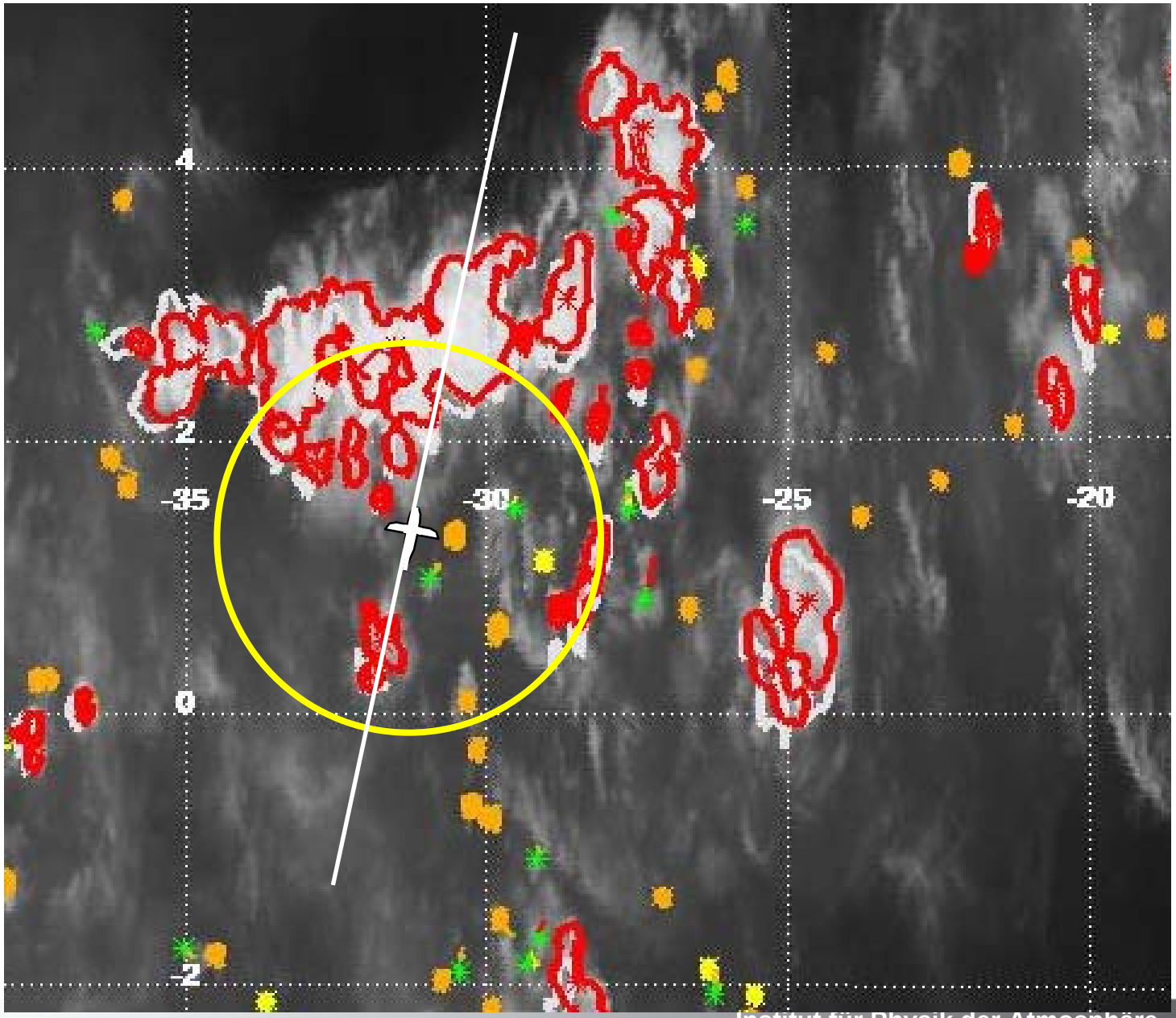


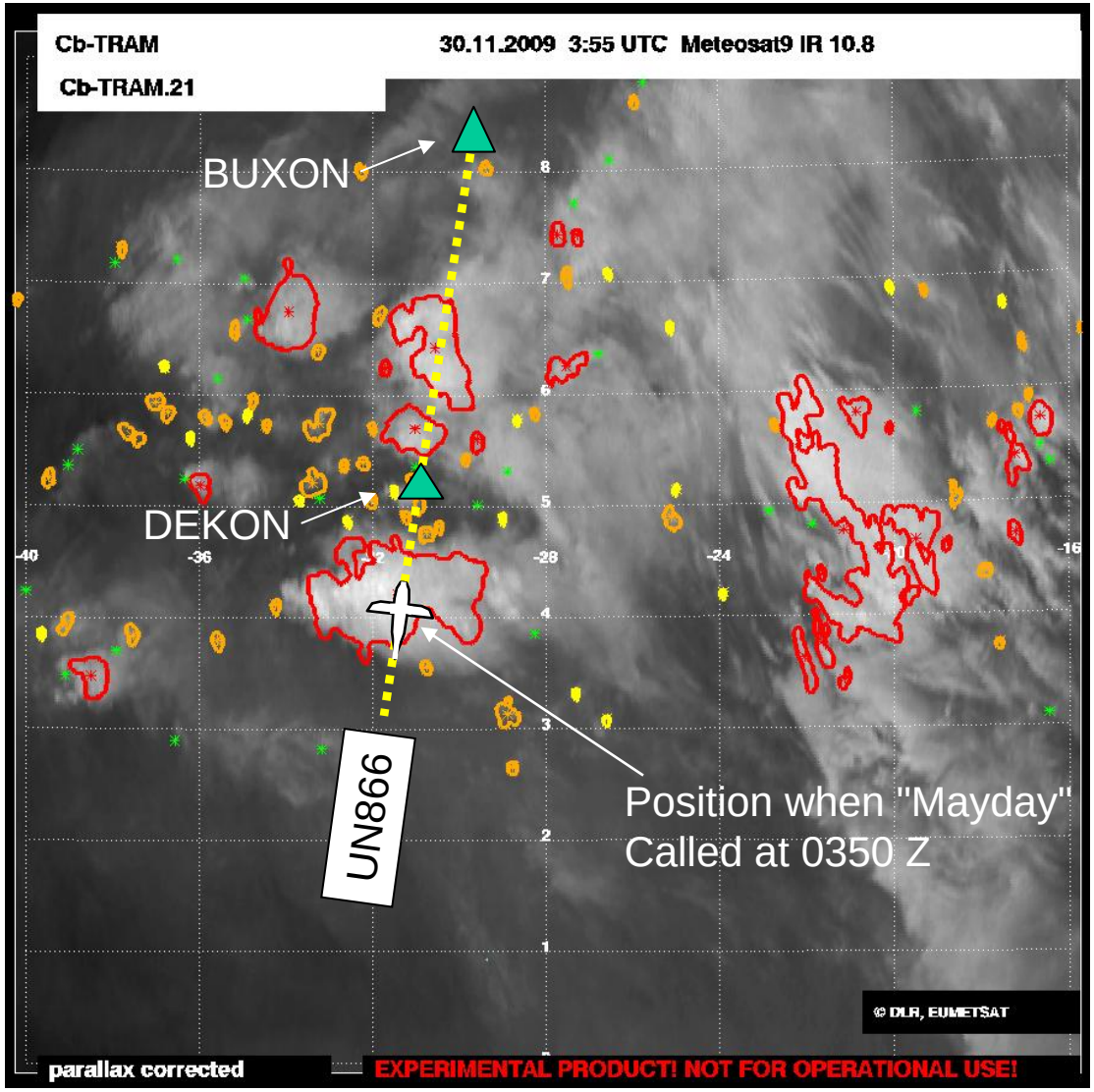
0130 UT: Cb-TRAM analysis



80 nm radar range;
Pilot cannot see what he is heading towards

0200 UT



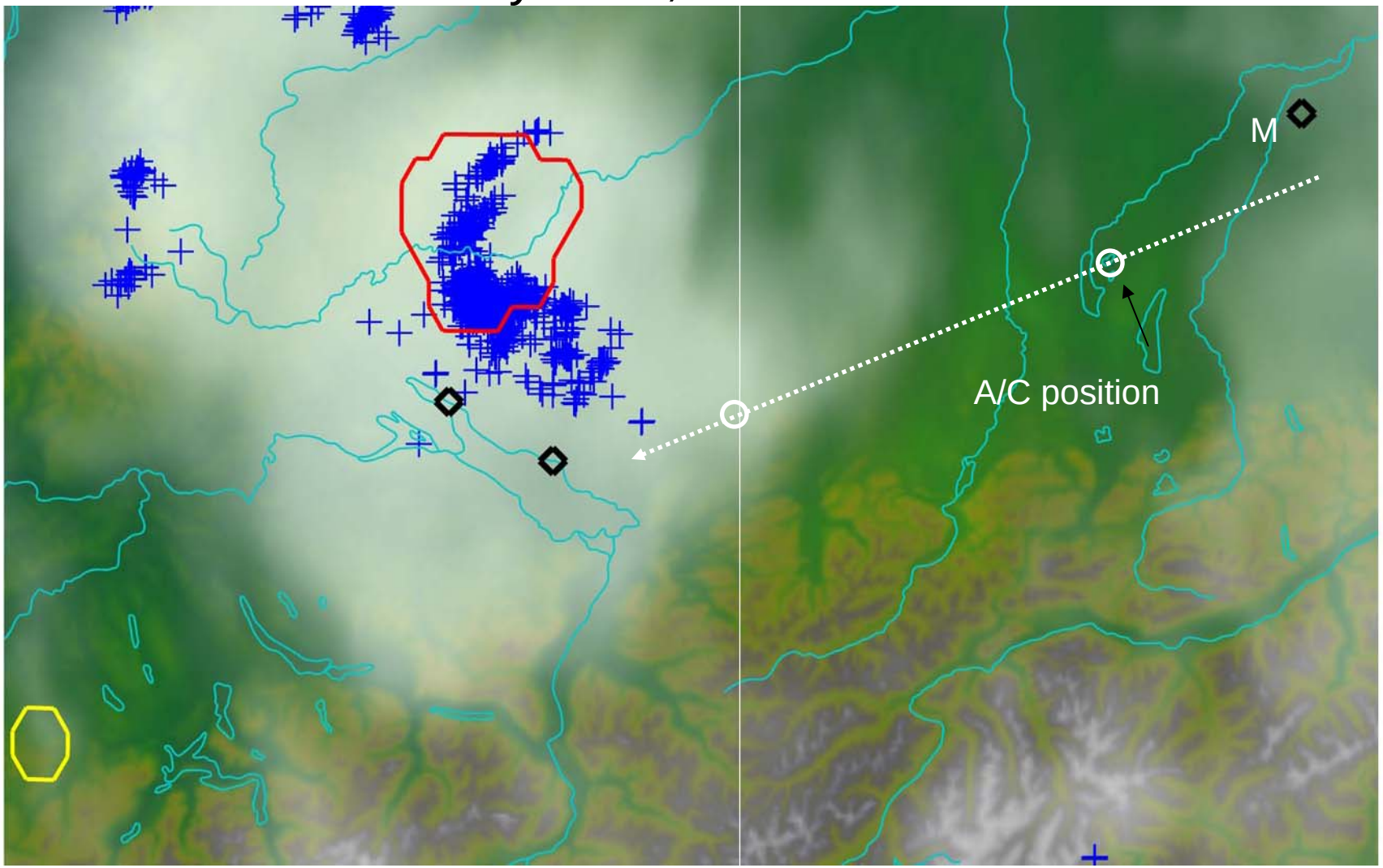


IR Meteosat 9 image at 0350 Z on 30 Nov 09 with mature convective cells (red) from CbTRAM analysis.

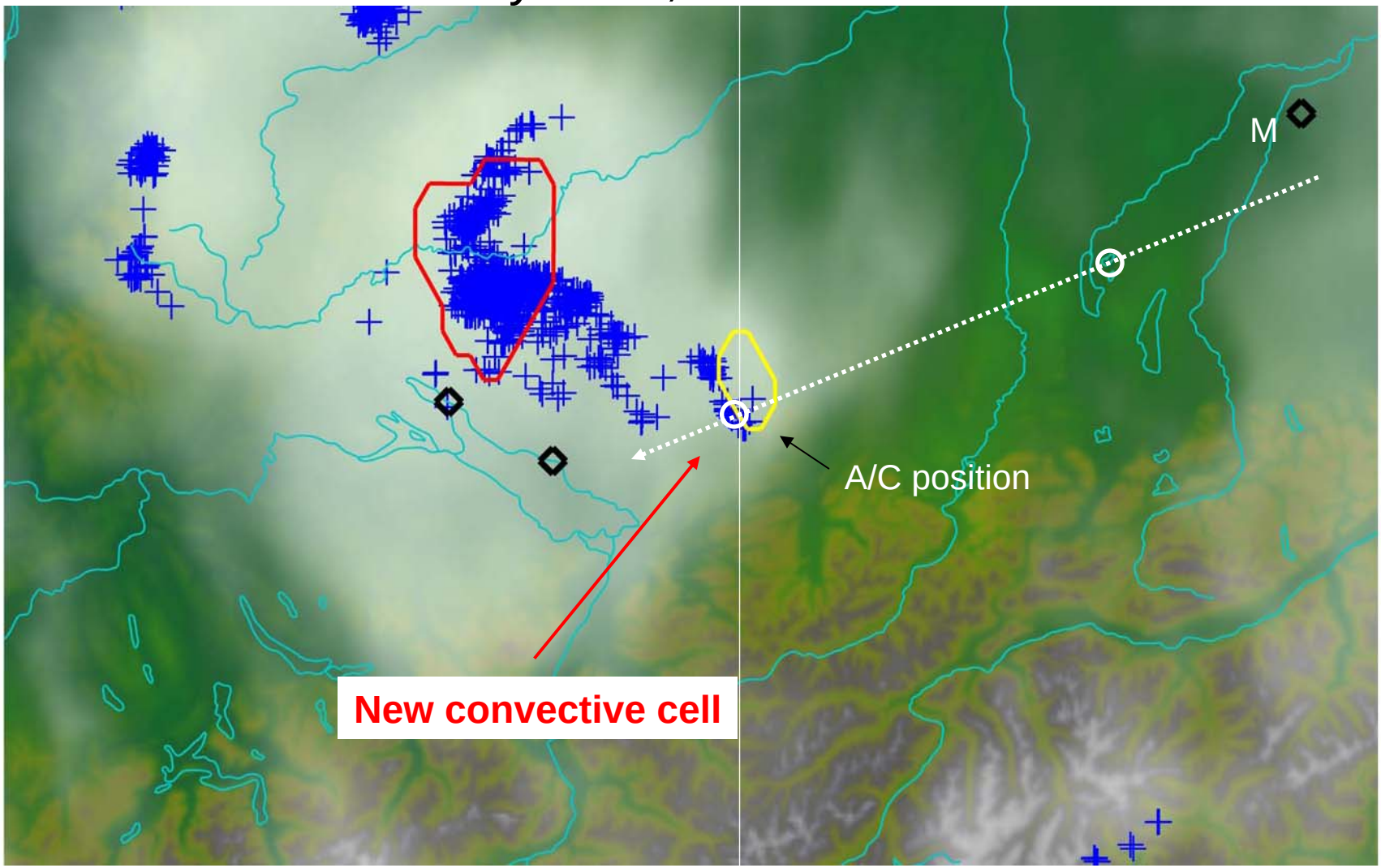
Cloud top temperature = 203 K
Flight level 380

Severe turbulence was encountered for about 30 minutes

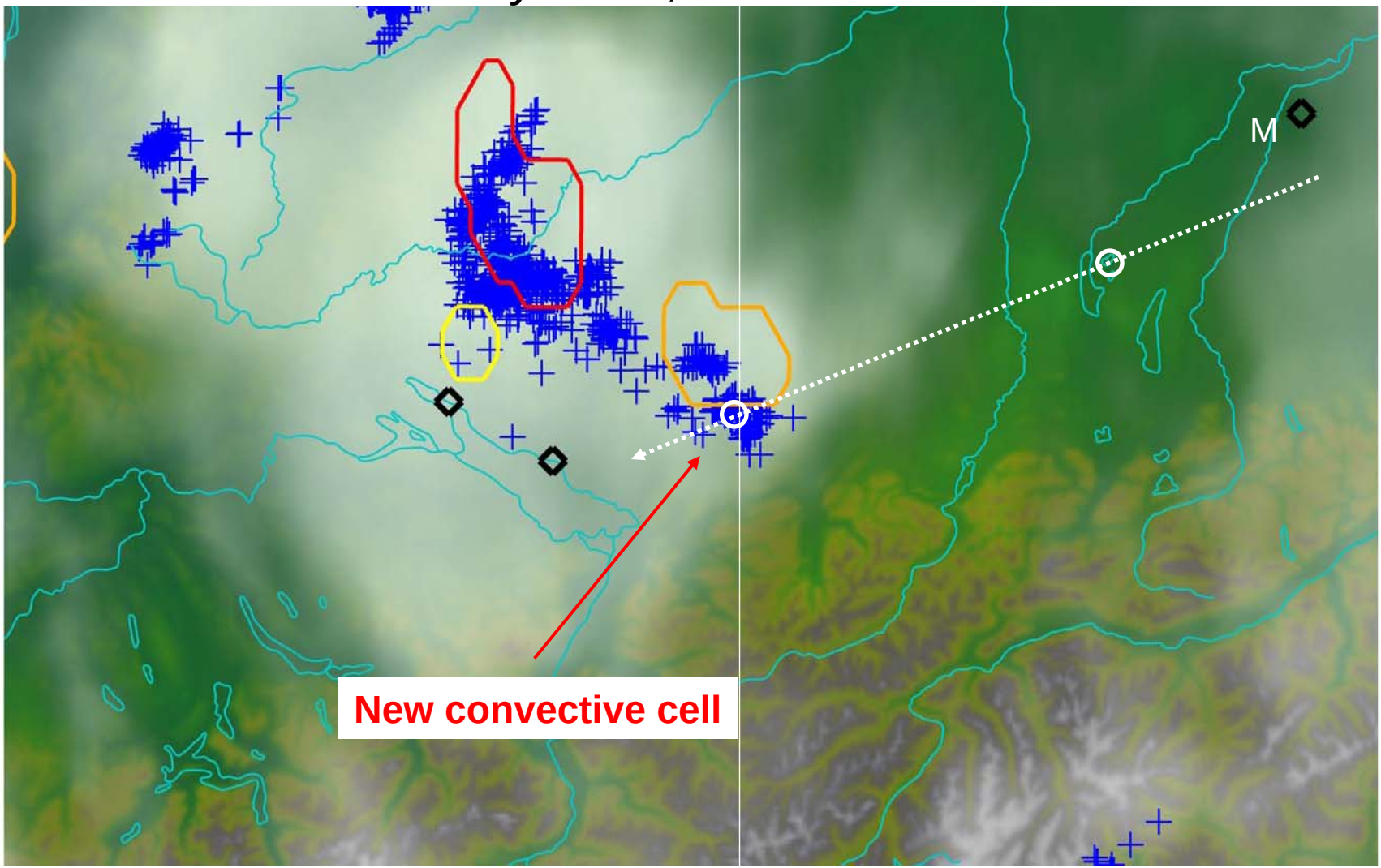
9 May 2009, 1755 UT

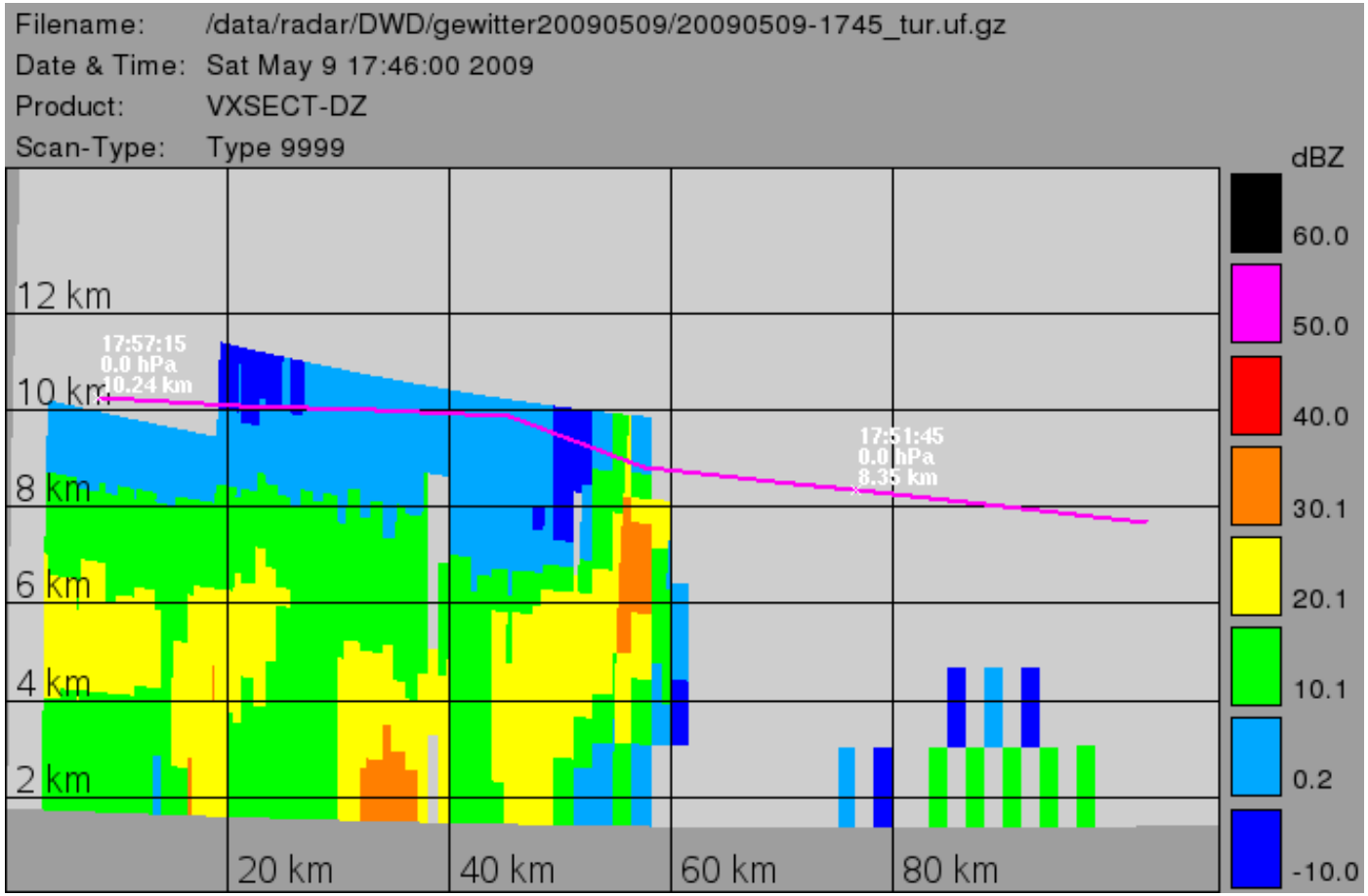


9 May 2009, 1800 UT



9 May 2009, 1805 UT

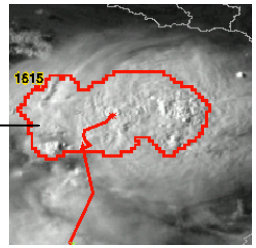




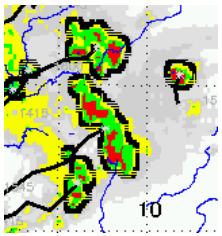
Vertical section through the radar reflectivity field as gained from the Türkheim radar at about 1748 UT along the flight path (pink line). Aircraft positions marked for 1751 and 1757 UTC

WxFUSION

Weather **F**orecast **U**ser-oriented **S**ystem **I**ncluding **O**bject **N**owcasting



Cloud tracker



Radar tracker

Lightning

Surface Analysis

POLDIRAD

User-specified **T**arget **W**eather **O**bject **TWO**

in

Fusion

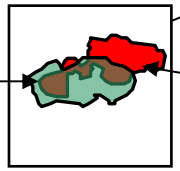
out

TWO

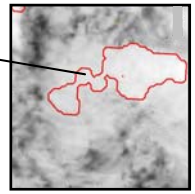
Initiation
Track
Nowcast
Forecast

forecast validation

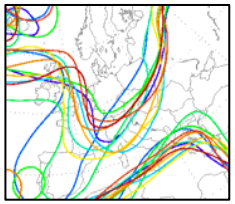
forecast validation



Object Comparison

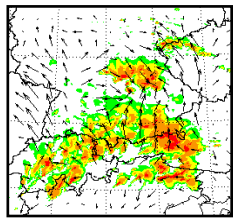


SYNSAT

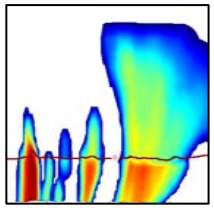


COSMO-DE & Ensemble Forecasts

Local forecasting

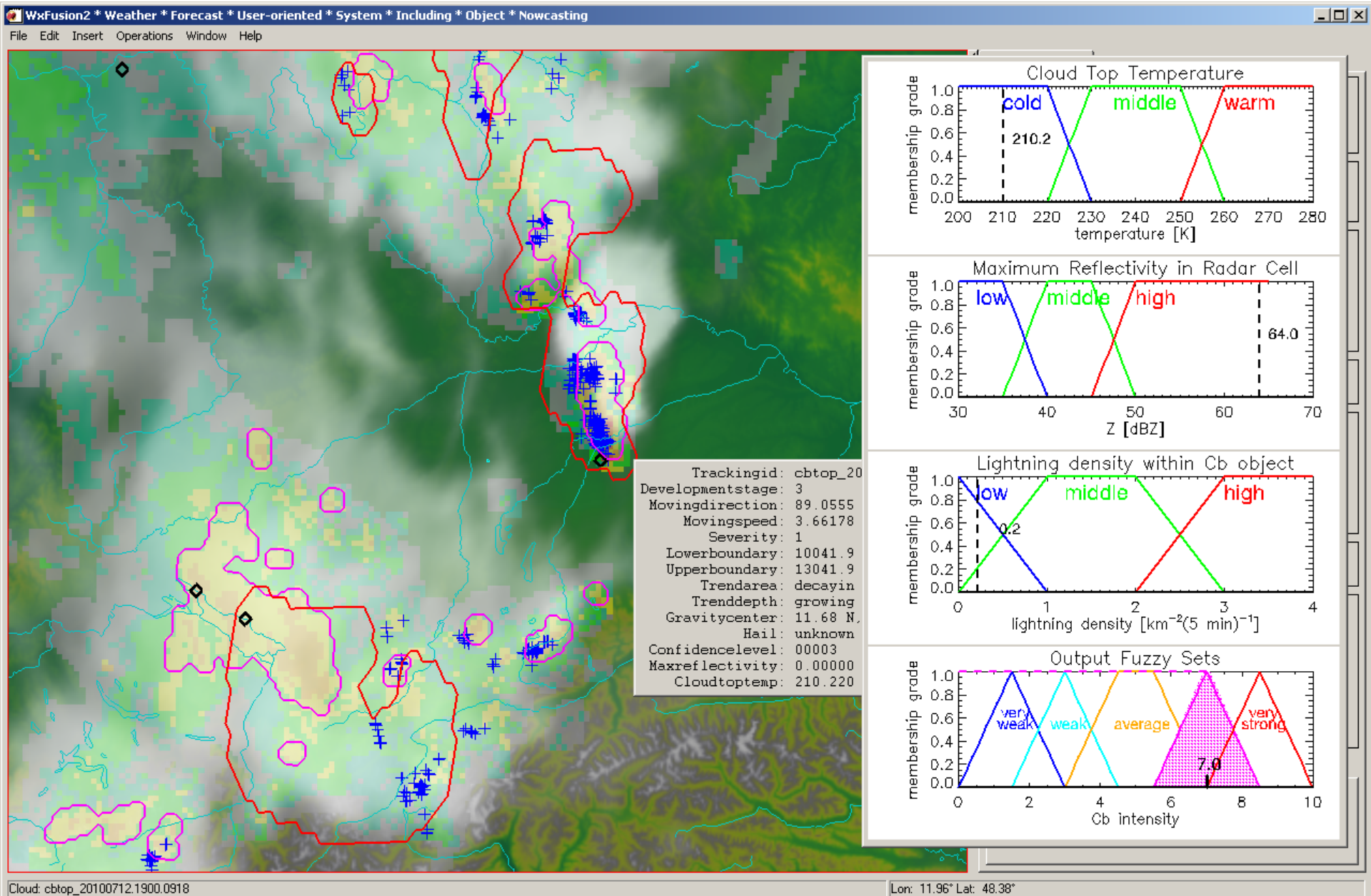


SYNRAD



SYNPOLRAD

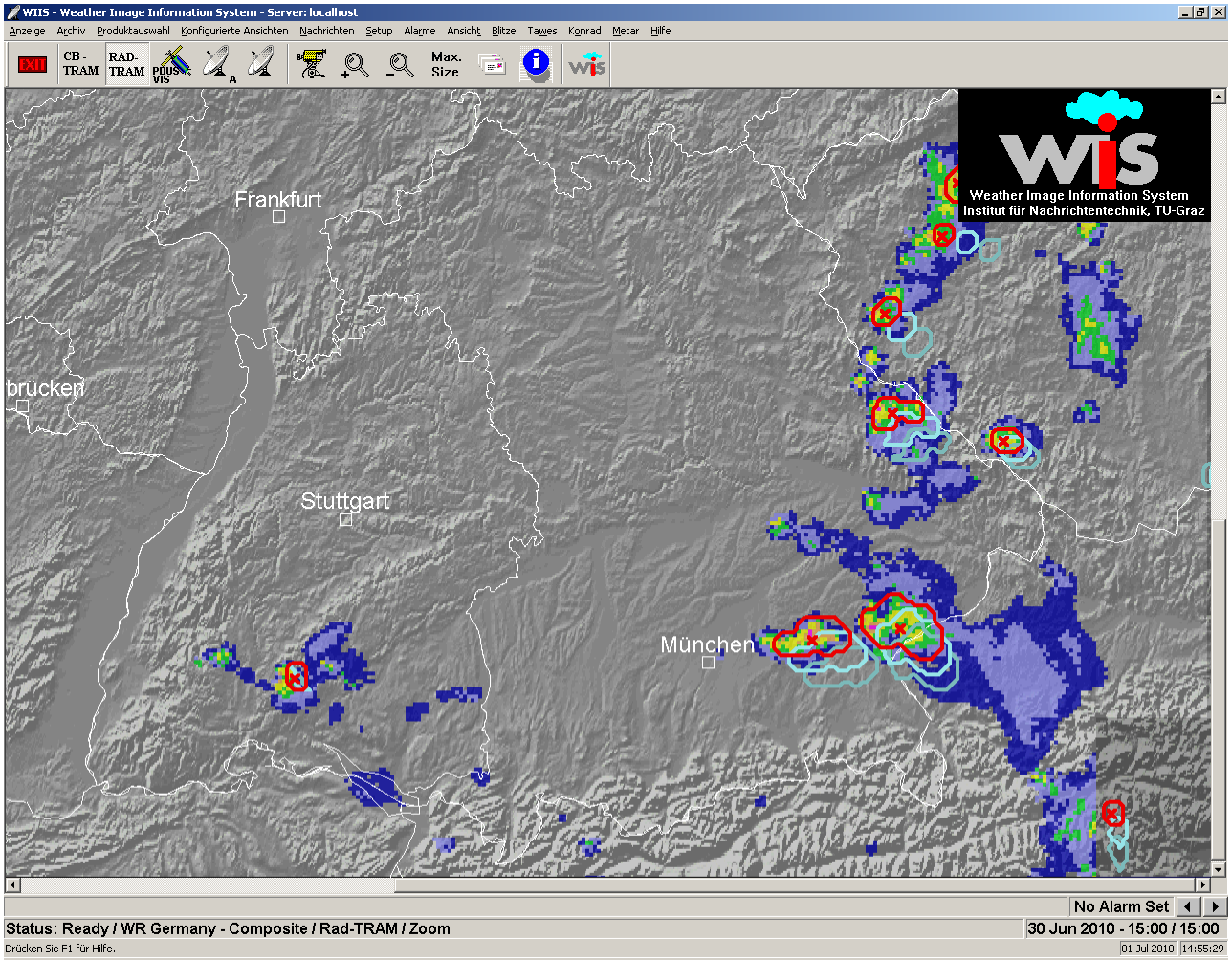
WxFUSION GUI: using fuzzy logic to determine Cb intensity



Summer Campaign 2010

- Operational testing of nowcasting systems at Munich Airport
- Active involvement of users of the system:
    - Lufthansa Hub Control Centre Munich
    - DFS (German Air Traffic Control)
    - FMG (Airport Operations)
    - DWD (German Weather Service)
- Evaluation through realtime acces to WxFUSION products and nowcasting performance

Weather information system for air traffic control, airlines, airport operations during MUC summer campaign 2010



rot:
Starkniederschlag > 37dBz

blau:
30 und 60 Min. nowcast

Conclusions

FLYSAFE results

- CB WIMS: Thunderstorms can be represented by relatively simple bottom and top volumes in a meaningful way for aviation (pilots and controllers)
  - Reduction of complex weather processes to the relevant information for users for helping in decision making
  - Object data formatetd in GML/XML files: small data size, easy to read, short transmission time, extendable
- CB WIMS data could be especially useful at the strategic time scale, namely beyond 10 minutes and in combination with Strategic Data Consolidation and Conflict Detection & Solution functions on-board an aircraft
- There is a real potential of the CB WIMS concept for safety in aviation since it surveys a much larger area than a single radar on-board the aircraft it fuses data from lightning, satellite, radar and atmospheric analyses from ground with on-board information and hence it provides a "complete" picture
- Uplink of weather information to the flight deck has been tested in one research a/c using industry standard internet technologies and current satellite data links (Intelsat) (Mirza et al, 2008, 2009a, Verbeck et al, 2009).

Mitigating measures

- **New weather information systems** are being developed or are already in place for all kind of atmospheric hazards to aviation, e.g. thunderstorms, icing, turbulence, volcanic ash, etc. see e.g. NCAR/RAL (http://www.rap.ucar.edu/projects/)
- Still need to **improve forecasting** capabilities, especially for closing the gap between nowacsting and forecasting
- Need to make available and **dissiminate this new weather information** in a standardized way and format to all avation stack holders from a unique single authorative source. Programmes in USA and Europe: NextGEN and SESAR (4-D weather cube)
- **Technological development**
  - Data link: e.g. SANDRA Project of DLR-IKN (Air-air and air-ground datalink). Next Talk by Michael Schnell
  - Radar technology: detection of atmosperic disturbances, e.g. turbulence within tropical convective clouds active cells might not be detected (different level of reflectivity)

Mitigating measures

Climate change

- New aircraft, with new technology, which are designed and certified with respect to safety today, may stay in operation for several decades. Hence, it is reasonable to ask what climate changes have to be taken into account in the next 50 years.
- Climate change might raise the risk for aviation to encounter hazardous weather due to:
  - More severe thunderstorms (e.g. J. Sander, DLR 2010; yesterday's talk by U. Ulbrich, Uni Berlin and U. Wienert, DWD)

    -> impact on turbulence, hail, lightning, icing conditions
  - More frequent thunderstorms?
  - Possible warming of upper troposhere in tropical regions might increase icing risk for fligths at cruise level. Icing of the Pitot-Tubes is possible even at temperatures down to -40° C (DLR observations with Do-228 a/c)
  - Possible changes in other meteorological parameters

Literature

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Mirza, A, Lunnon, B., Gill, P., 2009 European Initiatives For The Integration Of Meteorological Data With ATM, American Meteorological Society, 89th Meeting, Phoenix.

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Tafferner, A., C. Forster, M. Hagen, T. Hauf , B. Lunnon, A. Mirza, Y. Guillou, T. Zinner, 2010: Improved thunderstorm weather information for pilots through ground and satellite based observing systems. 14th conference on ARAM, 90th AMS Annual Meeting, Atlanta 2010

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