Information on thunderstorm initiation, nowcast, and forecast for aviation safety and efficiency

by Dennis Stich, C. Forster, A. Tafferner, M. Köhler, I. Sölch, and T. Gerz

1st ECATS Conference (on Technical challenges for aviation in a changing environment)
Berlin, Germany, 18 - 21 November 2013
Thunderstorm information for air traffic - why?

- 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.
- Up to 96% of all delays at Munich Airport are due to adverse weather with thunderstorms and fog as the primary reasons.

Thunderstorm information for aviation is still rudimentary these days!
Thunderstorms as weather objects 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)
Cb-TRAM - **Cumulonimbus TRacking And Monitoring**

**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
CI postprocessing with additional data

LINET data & ingredients describing moisture, instability, and lift (equivalent potential temperature $\theta_e$, KO-Index, vertical motion $\omega$ in 500 hPA)

Generation of a **CI forcing** value for each CI detection with fuzzy logic

**CI forcing values** can be translated into a statistical probability of further development

Lowest probabilities can be filtered

The **probability of further development** is an additional information which can be treated as a kind of confidence level assigned to the CI detection
Cb-TRAM: area of application
first successful data link tests cooperation DLR - DLH

Lufthansa GADCom project (Ground Air Data Link Communication):

Real time link of Rad-TRAM and Cb-TRAM data in 5 EFBs (Electronic Flight Bags) of Lufthansa Cityline aircraft via mobile network on the ground and later in 5 EFBs of Lufthansa aircraft via FlyNet during cruise-flight
The Test Flight: Rio de Janeiro to Frankfurt, February 2013

According to the charts: Business as usual at the ITCZ
The Test Flight: Rio de Janeiro to Frankfurt, February 2013

But once we got there, the weather radar showed large red cells, embedded in amber.

Initially without the help of Cb-TRAM, the crew decided to deviate 90 degrees to the right.
Then, we uplinked the latest Cb-TRAMs to the eRM ... 

... planned the safest route with the eRM ... 

... and flew it tactically by looking at the weather radar
The result
If we would have uplinked the Cb-TRAM a few minutes earlier ....

... we would have seen the gap on the PUGSU DIKEB route

... or the gap on the ORARO-TASIL route

... and could have avoided a 300 NM deviation
Rad-TRAM - Radar Tracking and Monitoring

- Based on DWD radar data: RX and EURADCOM

- Black contours: areas > 37 dBZ

- Dotted contours: 60 min nowcast

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

- Available every 5th minute
Rad-TRAM: area of application

Rad-TRAM EURADCOM for TMA MUC

Rad-TRAM EURADCOM for TMA MUC

Rad-TRAM EURADCOM for TMA MUC

FOR OPERATIONAL USE

FOR OPERATIONAL USE

EXPERIMENTAL PRODUCT - NOT FOR OPERATIONAL USE

7  19  28  37  46  55  64  dBZ

www.DLR.de • Chart 14
Automated thunderstorm warnings (AutoAlert)

Aims:
Raise situational awareness

Presentation of the same information to describe the current situation to all stakeholders at an airport to support CDM

Weitere Gewitterzellen weniger als 100 km von MUC entfernt. Betroffene Bereiche: NW, SW, SE

Mittlere Zugrichtung aller Zellen: nord-oestlich

Zur Erläuterung:

Weitere Informationen:
Siehe Anhang, MetFROG und http://www.pa.op.dlr.de/nowcasting/ (User: nowcasting, Passwd: drizzle)

Mit freundlichen Grüßen,
das Gewitterteam des DLR Instituts für Physik der Atmosphäre

Feedback, Fragen und Anregungen bitte an cb-team@dlr.de  Tel.: 08153 28 3174 oder 01853 28 1218
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

White contours: Cblike indicator exceeding a certain threshold
Pink contours: Rad-TRAM cells
Blue crosses: Lightning data (LINET)
Short-range limited area NWP (COSMO-MUC)

For seamless prediction of airtraffic relevant phenomena

Forecast skill

Nowcasting  COSMO-MUC  COSMO-DE

(60 min)  (30 min - 4h)  (3h +)

Forecast lead time
Weather Forecast User-oriented System Including Object Nowcasting

Combination of data sources through fuzzy logic:

- Decision finding technique allowing for parameter ranges instead of fixed thresholds
- Takes into account the meteorological experience and concepts as well as local effects

Cloud tracker
POLDIRAD
Lightning
Surface Analysis
Radar tracker

Object Comparison
SYNSAT
COSMO-DE & Ensemble
Local forecasting
SYNRAD
Decrease of information detail over forecast time

1 Analysis
2 Nowcast < 30 min
3 Nowcast 30-60 min
4 Nowcast > 60 min

Thank you for your attention!
contact: dennis.stich@dlr.de