Object-based fuzzy logic fusion of multiple data sources for nowcasting of CI

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DLR

Aims are to…

…improve the detection of CI for a detection of storms earlier in their lifecycle

…reduce the amount of „false alarms“ substantially

…derive a probability estimate of further development for each cell

Basic Idea

Satellite-based early detection of newly developing CI objects

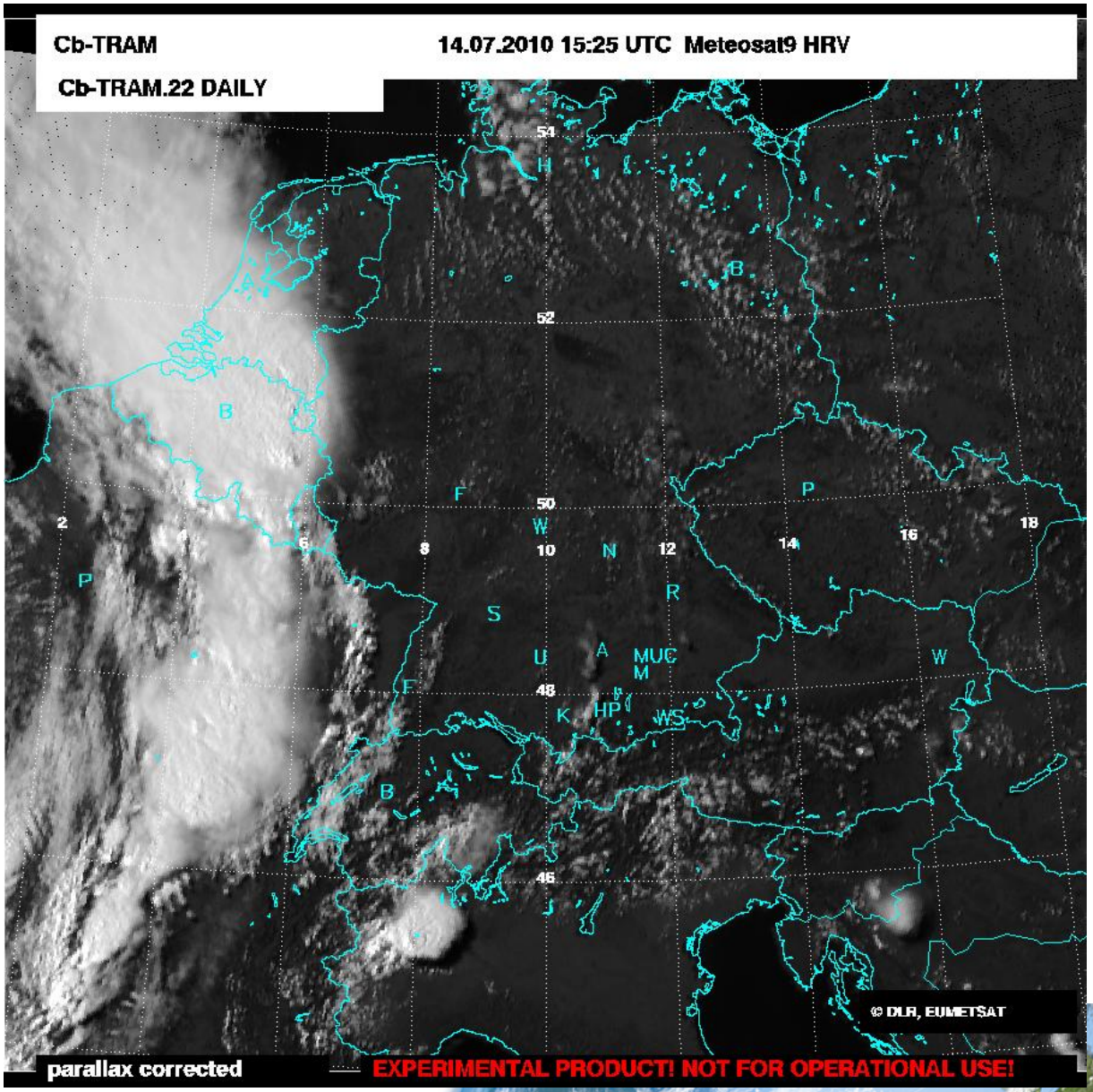
…combined with…

ingredients for further development to a thunderstorm

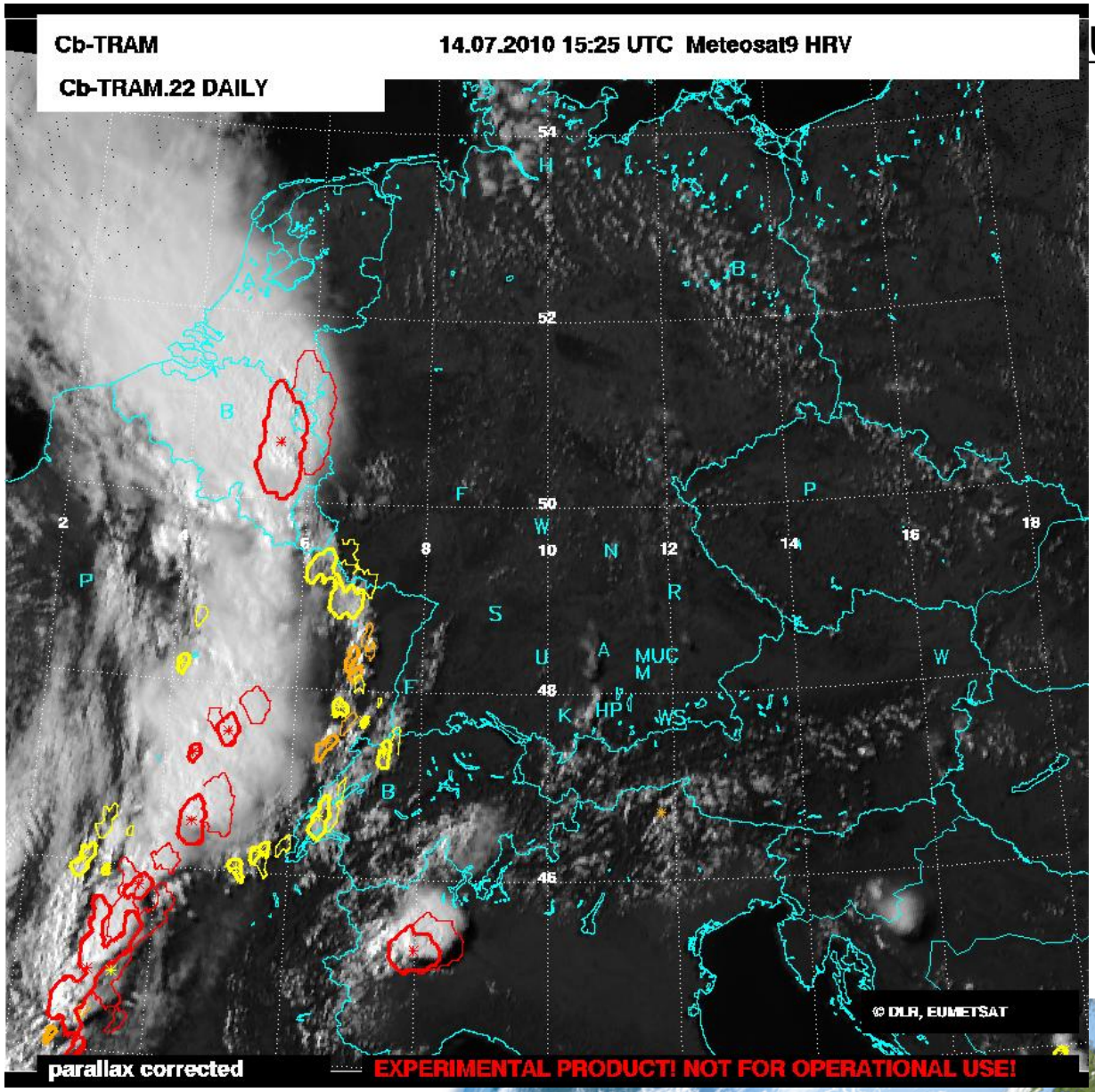
Ingredients are:

Moisture
Instability
Lift

Cb-TRAM - Cumulonimbus TRacking And Monitoring



Cb-TRAM - Cumulonimbus TRacking And Monitoring



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

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

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

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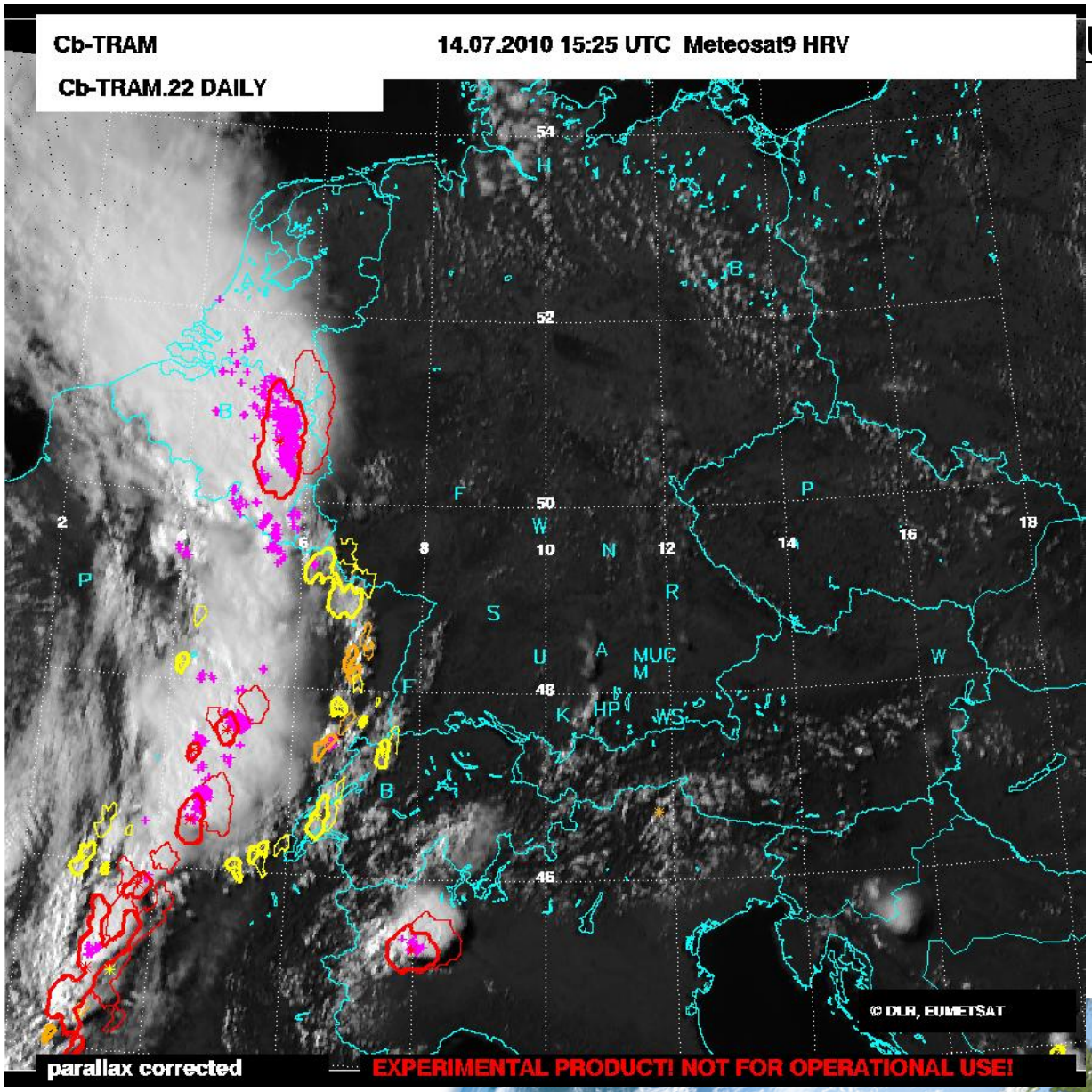

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Lightning (LINET)

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

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CI-Verification

Specific characteristics of CI verification

→ object based approach
→ statistical reasonable analysis
(summer 2009, Central Europe)

oPOD for next 60 minutes around 0.25

oFAR too high (around 0.8)

Usage of additional data sources

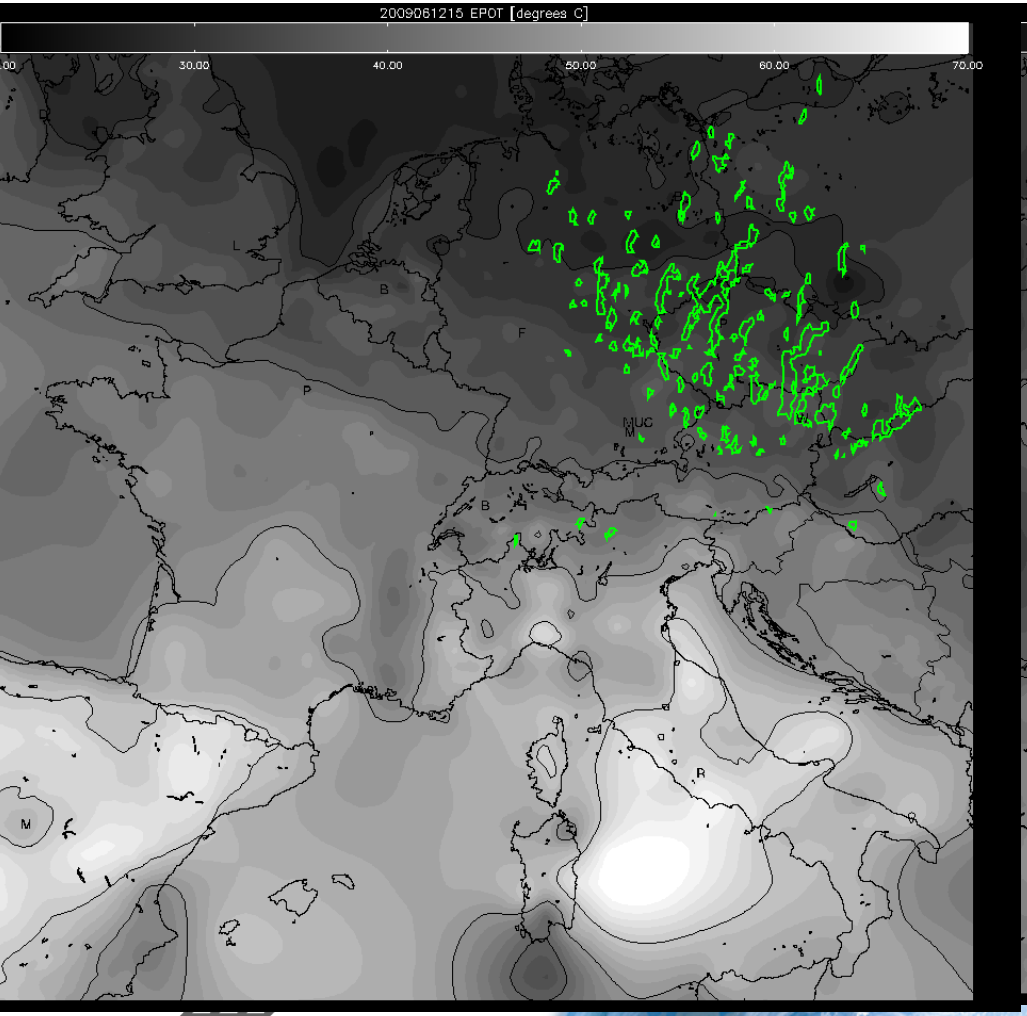
1. step: LINET data

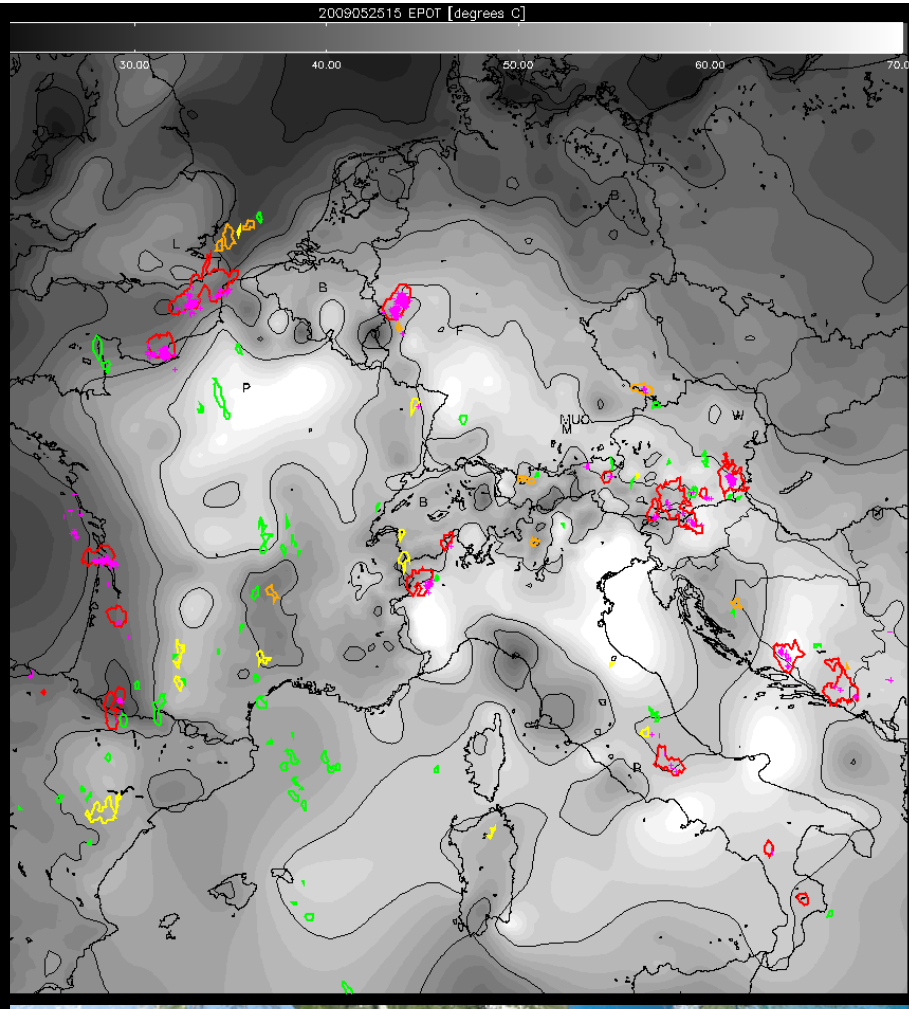
2. step: Ingredients - moisture, instability, and lift:

- Moisture:
  equivalent potential temperature θ_e (Synop/VERA)
- Instability:
  KO-Index (VERA θ_e on lowest level, COSMO-EU θ_e above)
  $KO=0.5(\theta_{e\_500hPa} + \theta_{e\_700hPA}) - 0.5(\theta_{e\_850hPA} + \theta_{e\_1000hPA\_VERA})$
- Lift:
  vertical motion in 500 hPA (smoothed omega from COSMO-EU)

More information and references:
www.univie.ac.at/amk/vera/

V ienna E nhanced R esolution A nalysis θ_e

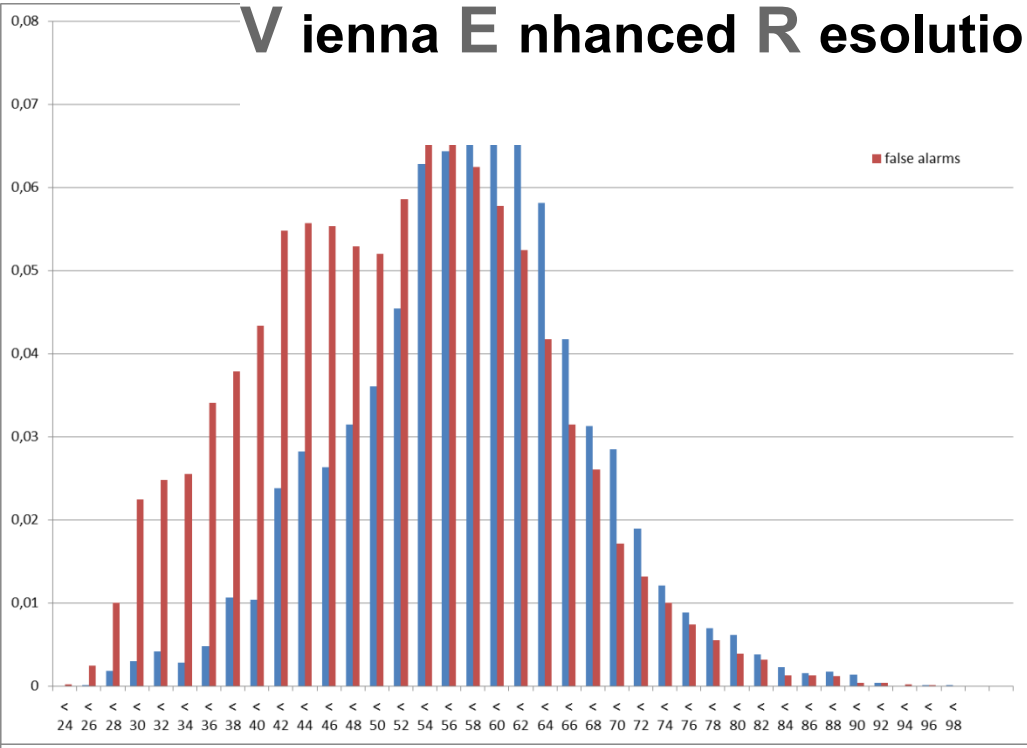


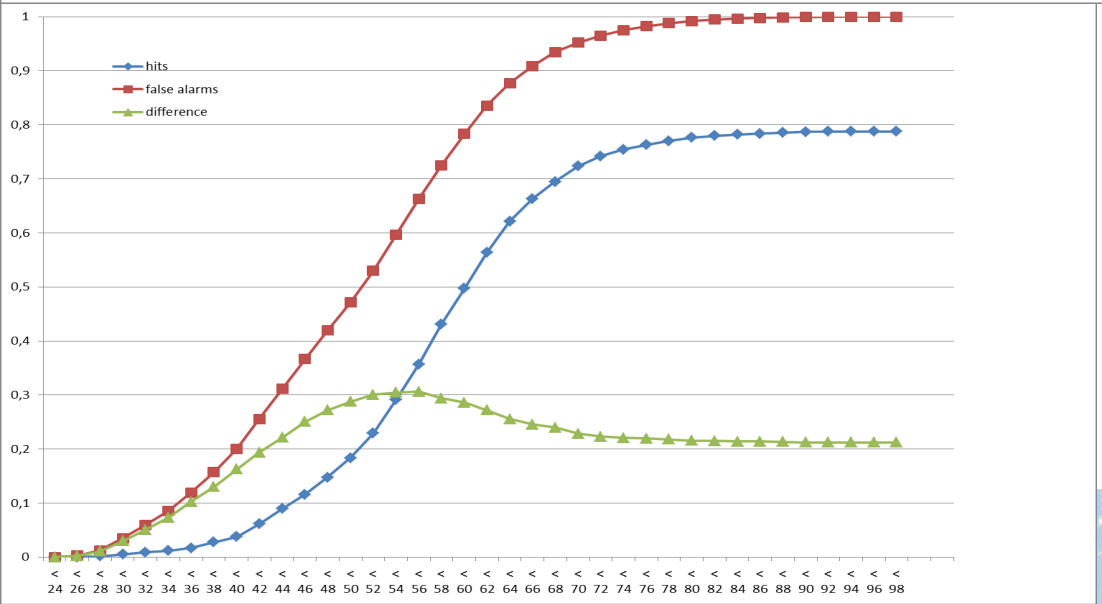


θe June 12 2009 15 UTC

θe May 25 2009 15 UTC

V ienna E nhanced R esolution A nalysis θ_e



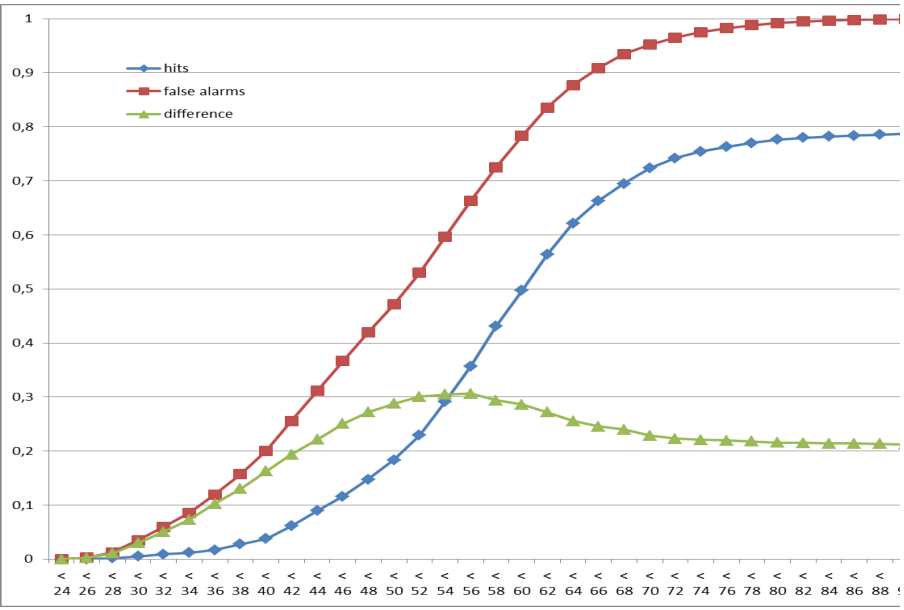


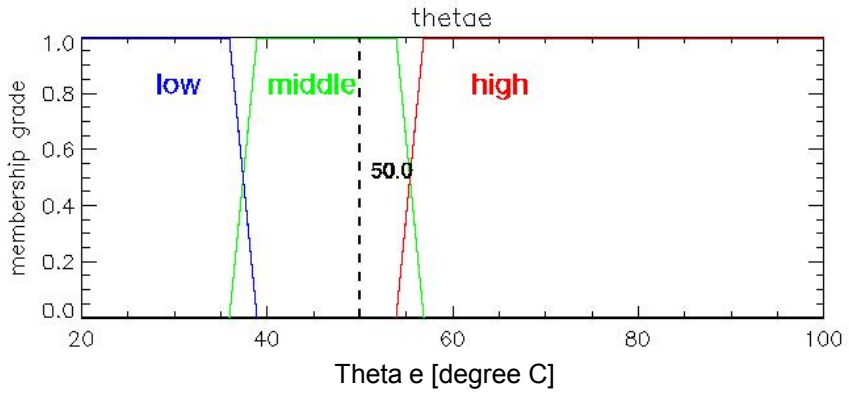
Statistics calculated for ~ 35.000 CI cells over 87 days in summer 2009 (May 15 - August 31)

θe < 36 ° :
1.7 % of all hits
12.0 % of all false alarms

θe < 41 ° :
4.8 % of all hits
22.7 % of all false alarms

Fuzzy Logic





Fuzzy sets resembling…

contra CI (non-forcing):
filtering false alarms without losing hits

neutral:
filtering even more false alarms but start to lose hits too

pro CI (forcing):
no more filtering due to losing too many hits

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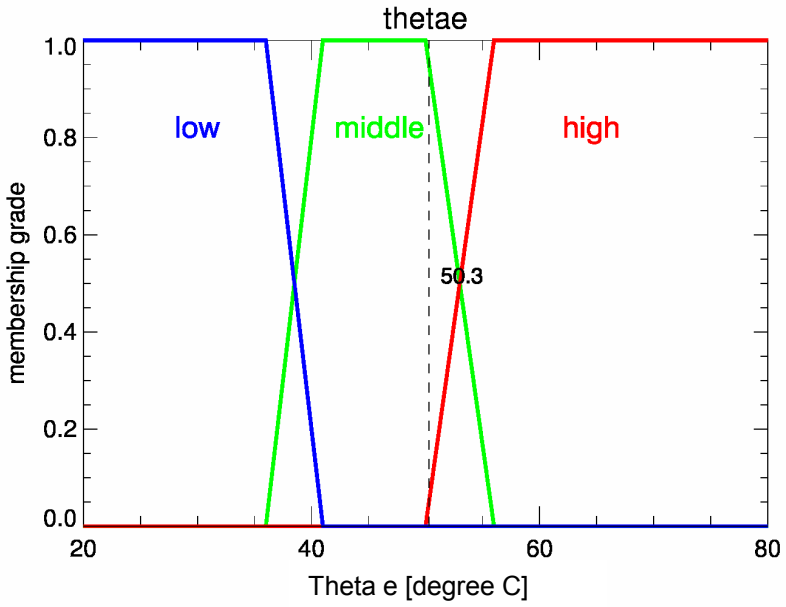
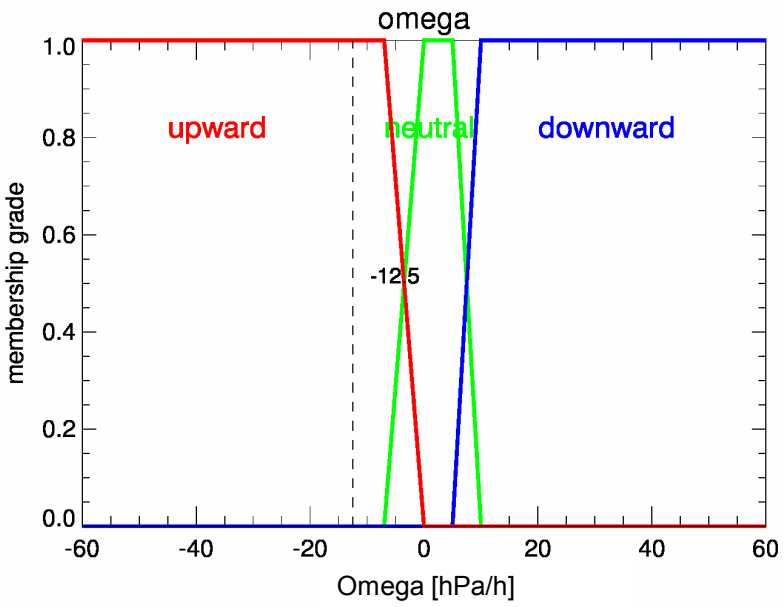
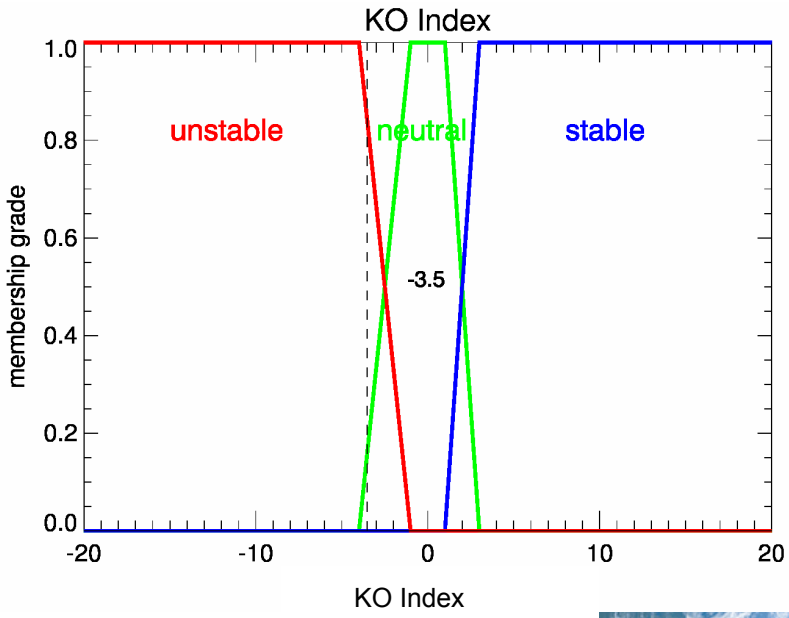
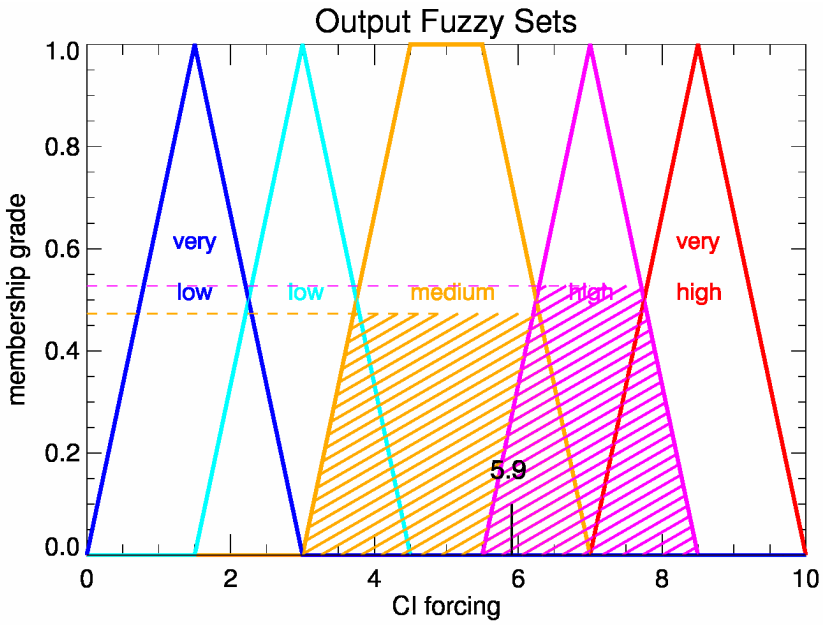
Fuzzy Logic


thetae
low
middle
high
50.3
membership grade
Theta e [degree C]


omega
upward
neutral
downward
-12.5
membership grade
Omega [hPa/h]


KO Index
unstable
neutral
stable
-3.5
membership grade
KO Index


Output Fuzzy Sets
very low
low
medium
high
very high
5.9
membership grade
CI forcing

Thank you for your attention!

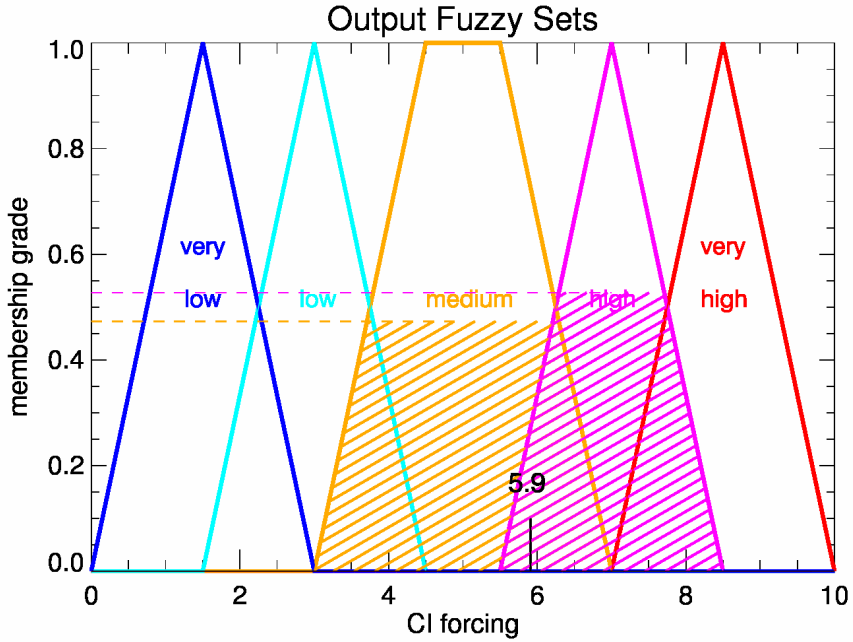
contact: dennis.stich@dlr.de

Results

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

Lowest probabilities can be filtered

5-65% less false alarms
while losing
0-25% hits
(user dependant)



The ***probability of further development*** is small for **„very low“** CI **forcing** values **(< 5%)** and rises to more than **55%** for the **highest CI forcing** value

The ***probability of further development*** is an additional information which can be treated as a kind of confidence level assigned to the CI detection