

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

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Knowledge for Tomorrow



## 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**

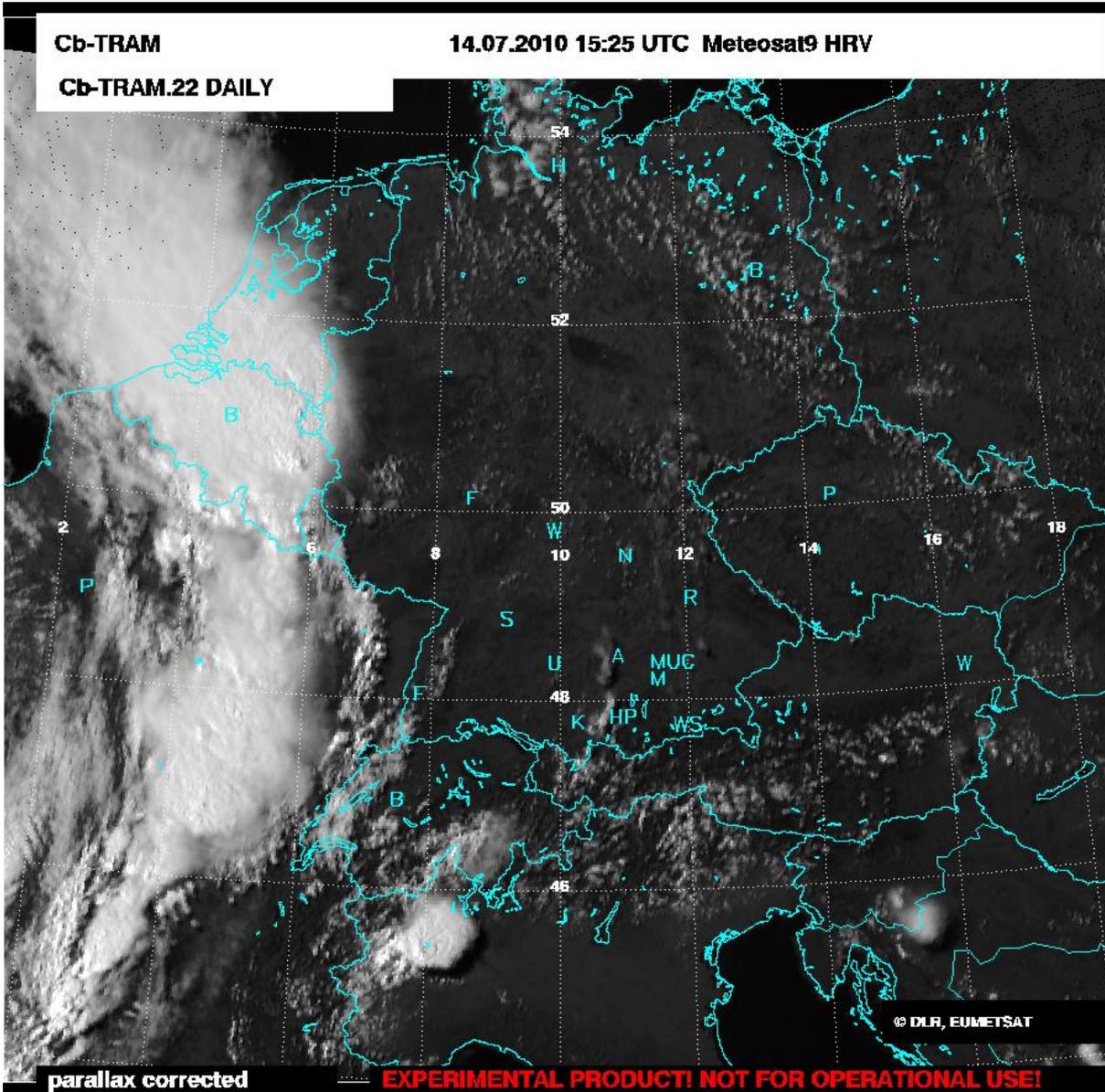


# Cb-TRAM - Cumulonimbus TRacking And Monitoring

Cb-TRAM

14.07.2010 15:25 UTC Meteosat9 HRV

Cb-TRAM.22 DAILY



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parallax corrected

EXPERIMENTAL PRODUCT! NOT FOR OPERATIONAL USE!

# Cb-TRAM - Cumulonimbus TRacking And Monitoring

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14.07.2010 15:25 UTC Meteosat9 HRV

Cb-TRAM.22 DAILY

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**

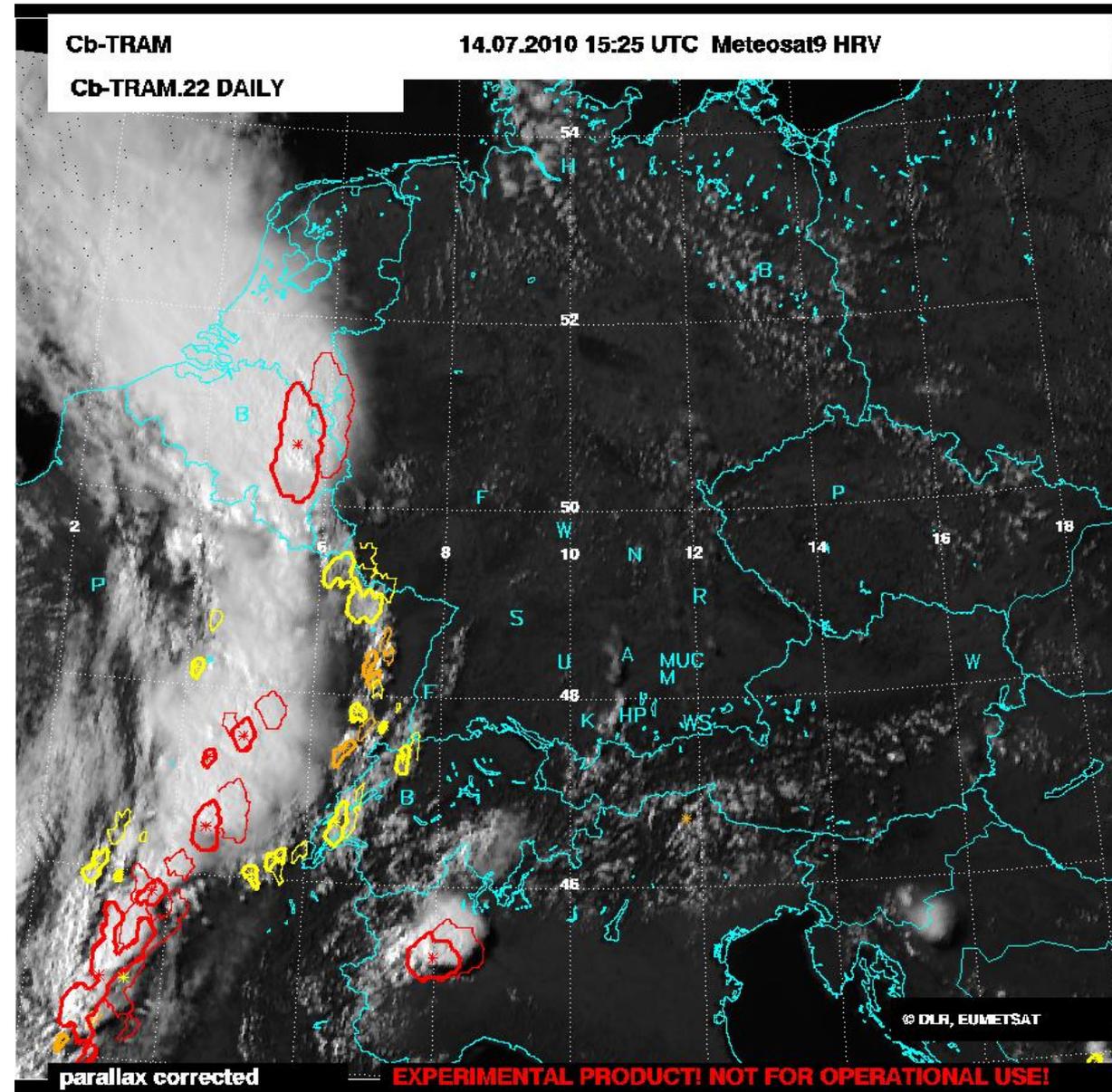
WV 6.2 rapid cooling  
(> 1K/15min)

**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

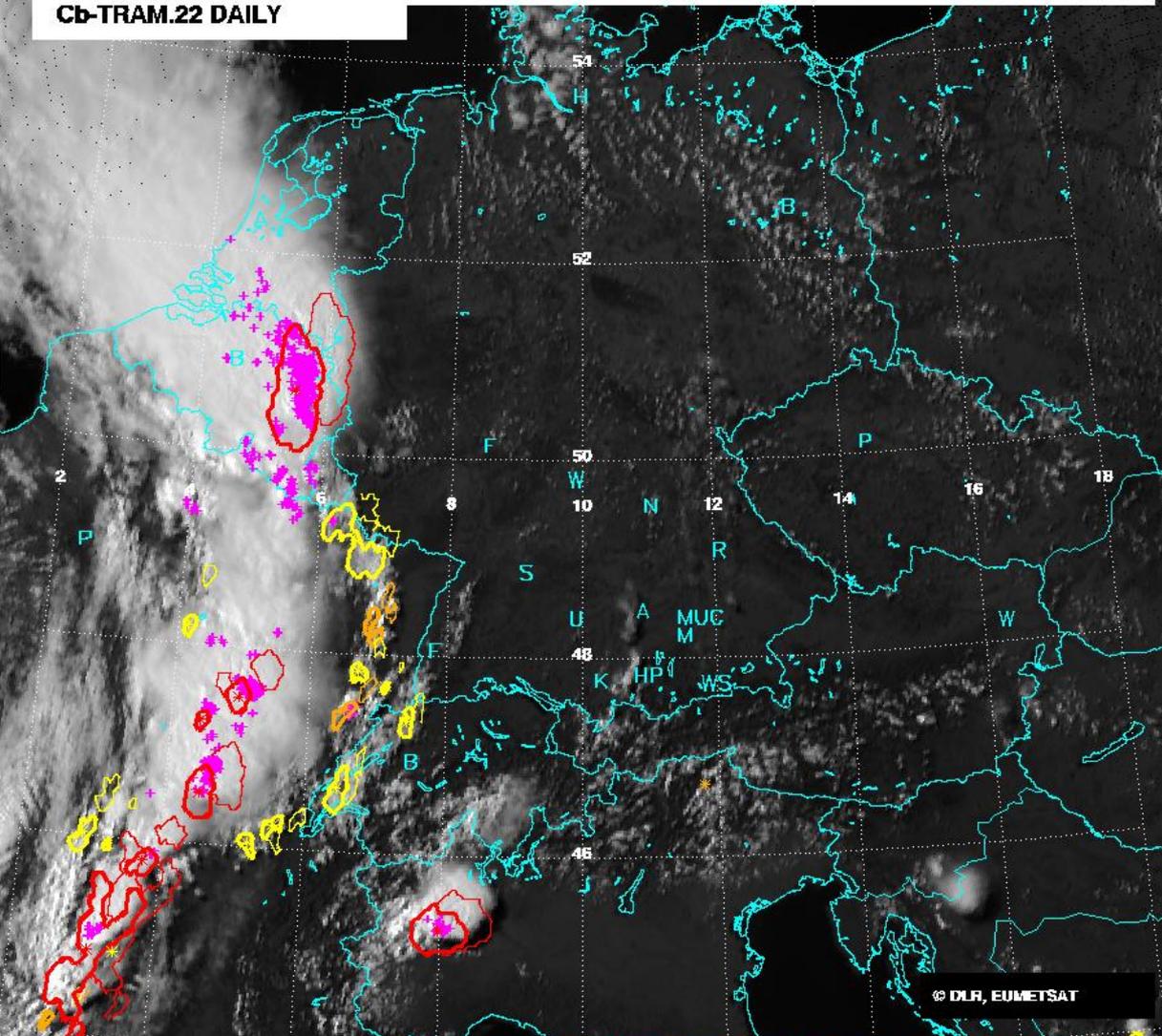


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**Lightning (LINET)**

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

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

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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:

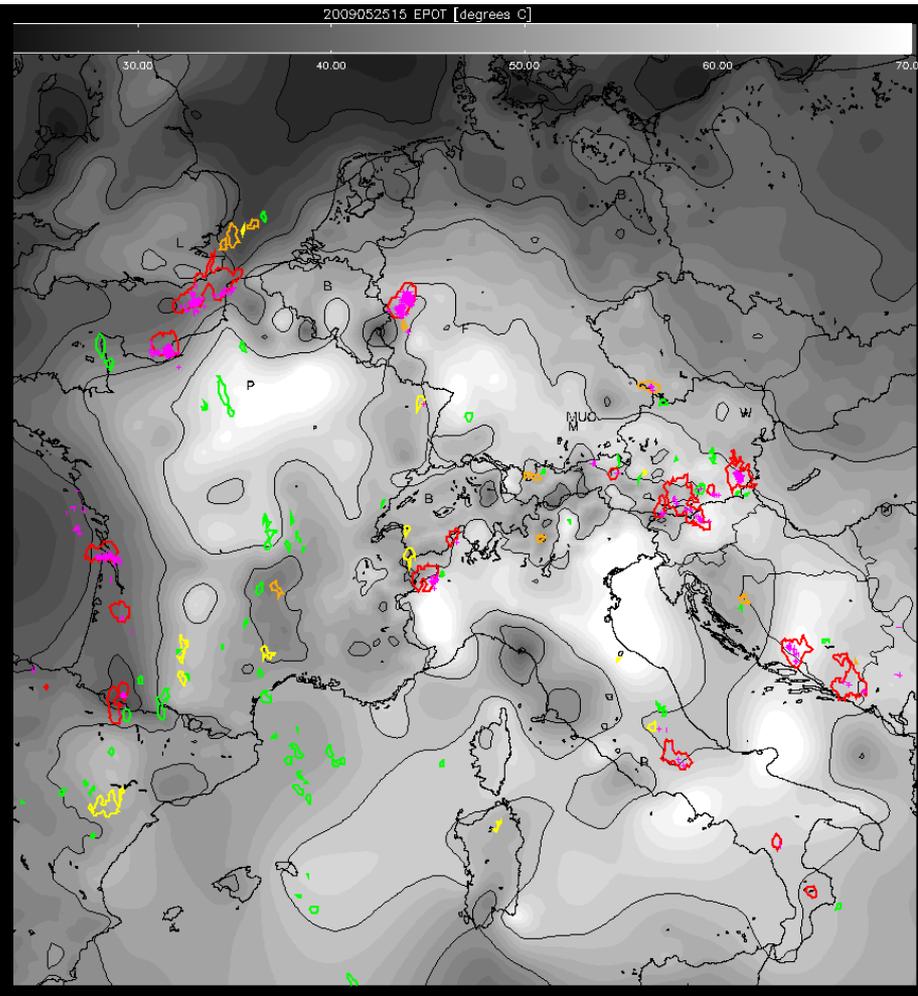
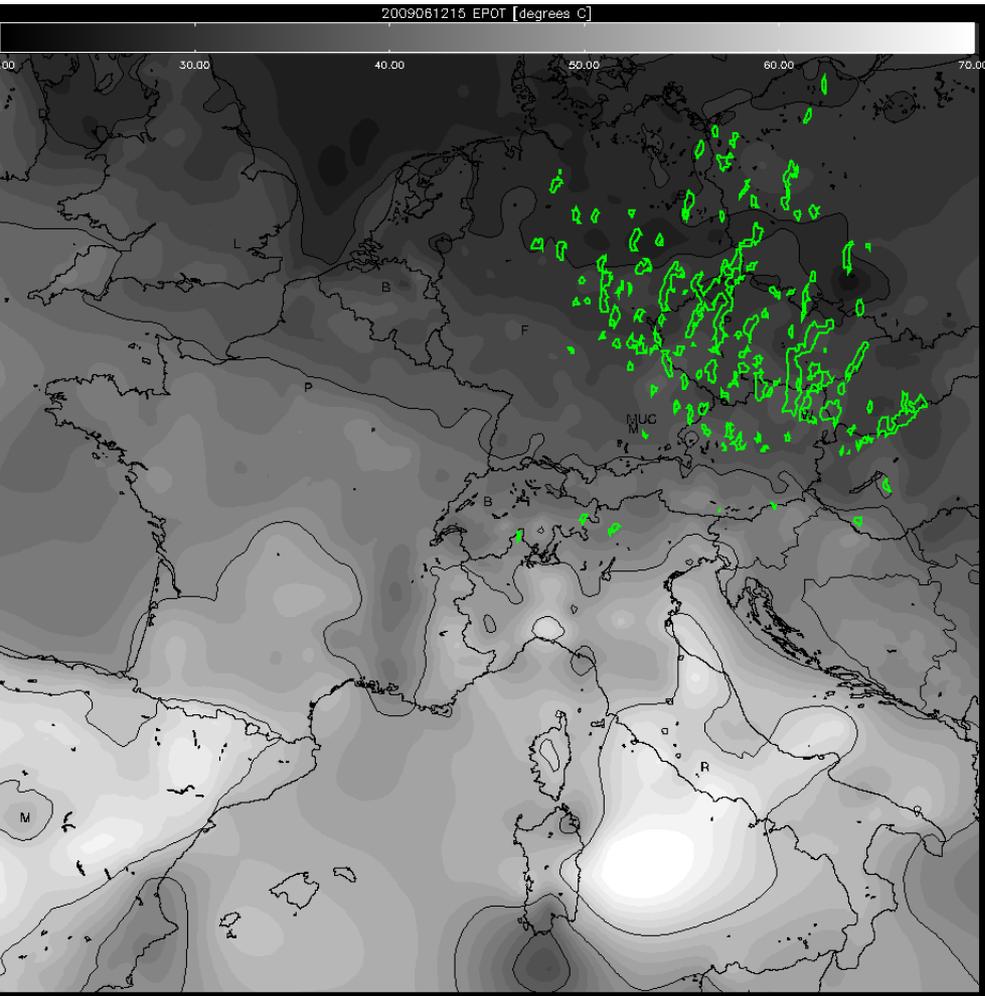
- Moisture:  
equivalent potential temperature  $\theta_e$  (Synop/VERA)
- Instability:  
KO-Index (VERA  $\theta_e$  on lowest level, COSMO-EU  $\theta_e$  above)  
$$KO = 0.5(\theta_{e_{500\text{hPa}}} + \theta_{e_{700\text{hPa}}}) - 0.5(\theta_{e_{850\text{hPa}}} + \theta_{e_{1000\text{hPa}}_{\text{VERA}}})$$



- Lift:  
vertical motion in 500 hPA (smoothed omega from COSMO-EU)



# Vienna Enhanced Resolution Analysis $\theta_e$

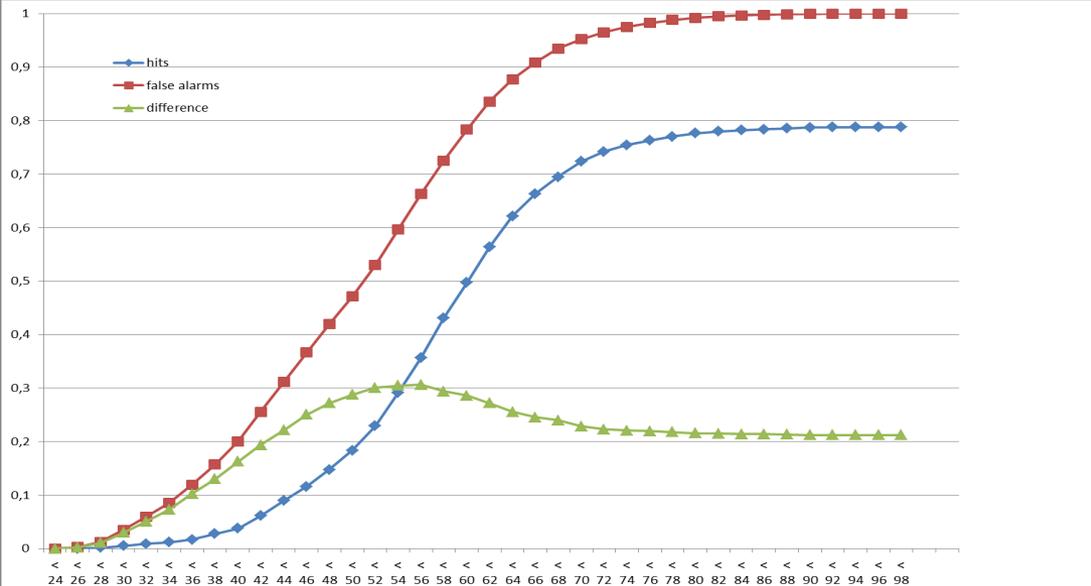
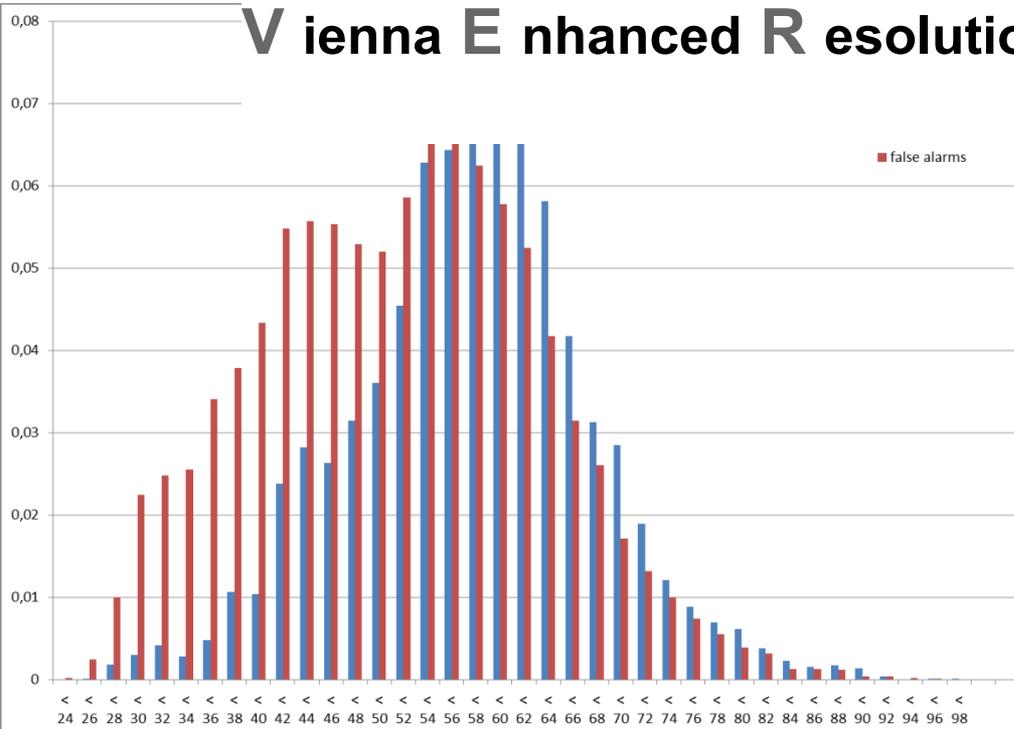


$\theta_e$  June 12 2009 15 UTC



$\theta_e$  May 25 2009 15 UTC

# Vienna Enhanced Resolution Analysis $\theta_e$



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

$\theta_e < 36^\circ$ :

1.7 % of all hits

12.0 % of all false alarms

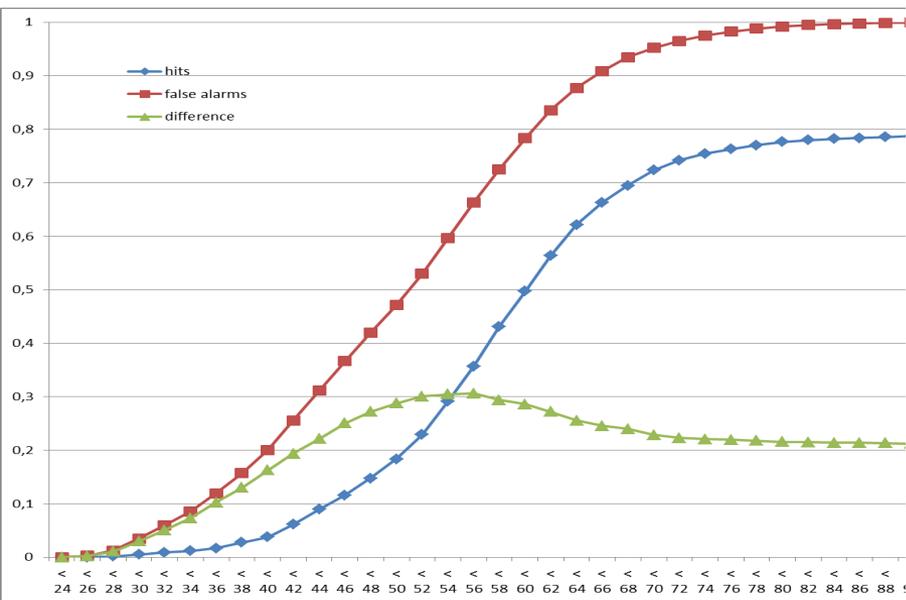
$\theta_e < 41^\circ$ :

4.8 % of all hits

22.7 % of all false alarms



# Fuzzy Logic

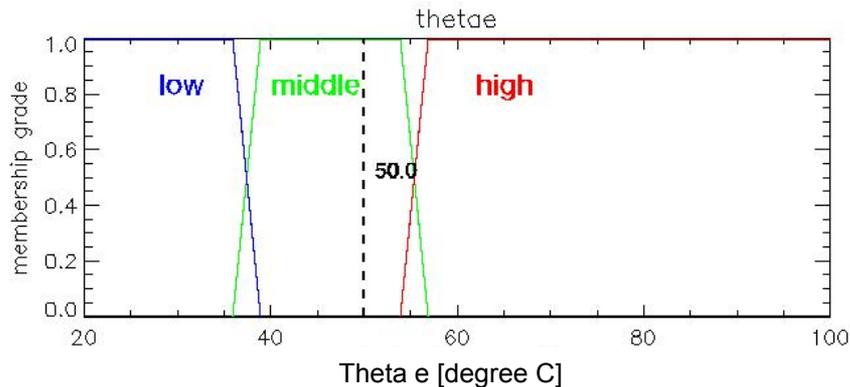


Fuzzy sets resembling...

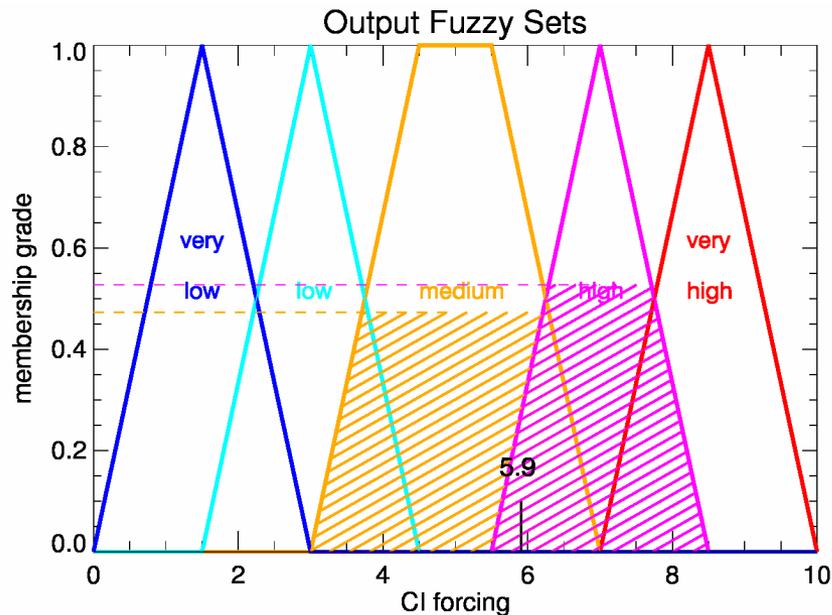
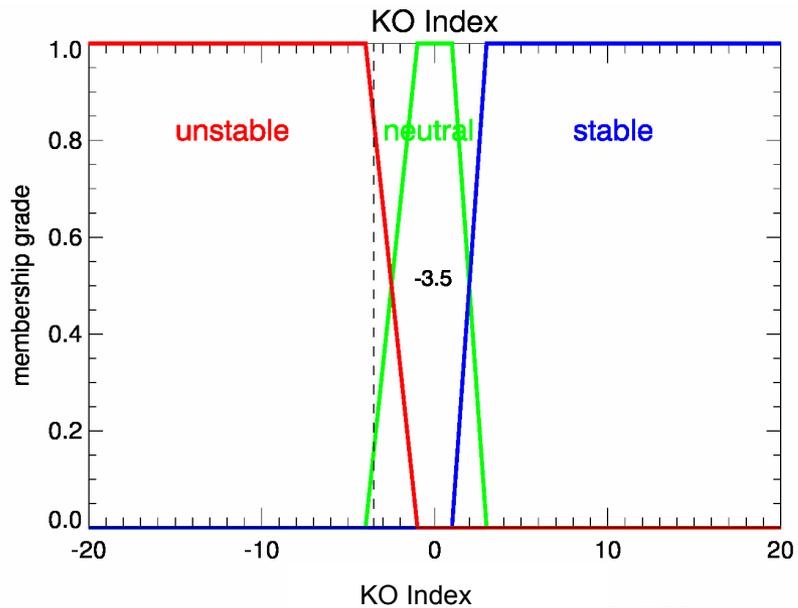
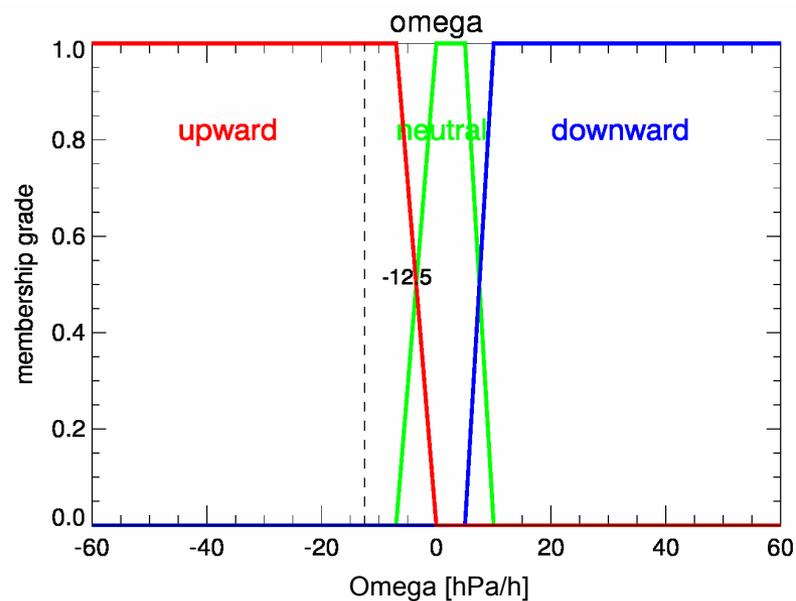
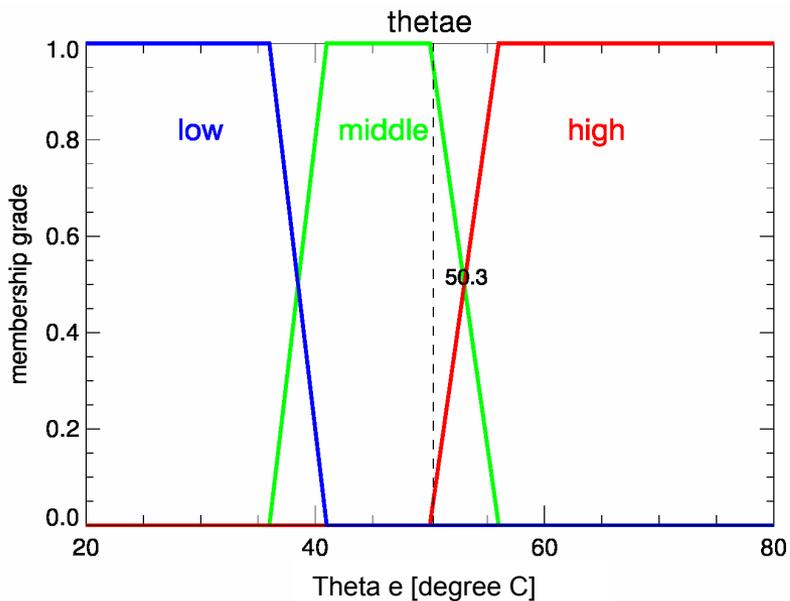
contra CI (non-forcing):  
filtering false alarms without losing hits

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

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



# Fuzzy Logic



# Thank you for your attention!

contact: [dennis.stich@dlr.de](mailto: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

