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

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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
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**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)

**Used MSG (rapidscan) data:**
- WV 6.2
- IR 10.8
- IR 12.0
- HRV

Description: Zinner et al., 2008,09 & 13
Cb-TRAM - Cumulonimbus TRacking And Monitoring

Detection stages:
1: Convection Initiation (CI) development in HRV IR 10.8 cooling
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Lightning (LINET)

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

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

Used MSG (rapidscan) data:
WV 6.2   IR 10.8
IR 12.0   HRV
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)
  \[ KO=0.5(\theta_e_{500hPA} + \theta_e_{700hPA}) - 0.5(\theta_e_{850hPA} + \theta_e_{1000hPA}_{VERA}) \]

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

Theta e [degree C]

low  middle  high

Omega [hPa/h]

upward  neutral  downward

KO Index

unstable  neutral  stable

Output Fuzzy Sets

very  low  medium  high
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
- **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.

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Thank you for your attention!

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