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TROPOS
Leibniz Institute for Tropospheric Research

Hans-Ertel-Zentrum für Wetterforschung
Deutscher Wetterdienst

DWD

The OASE project within the Hans Ertel Centre for Weather Research

Data Composite and Selected Results

Fabian Senf

and the HErZ-OASE research group

Outline

(1) Data Composite

Observational Studies

(2) Characterization of early development of Severe Storms

(3) Relationships of multi-sensor parameters of Severe Storms in mature phase

Model – Observation Combination

(4) Uncertainties in synthetic Satellite images and derived products

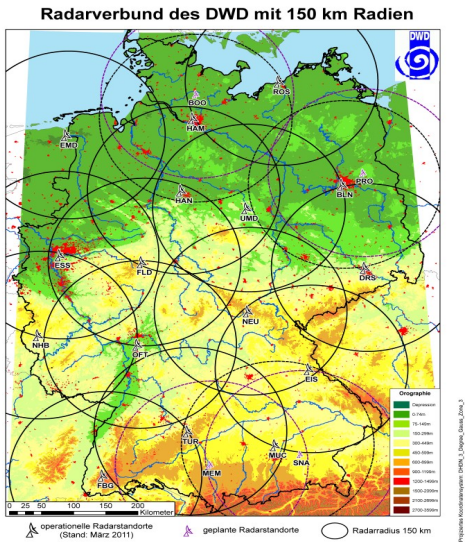
(5) Object-based forecast verification

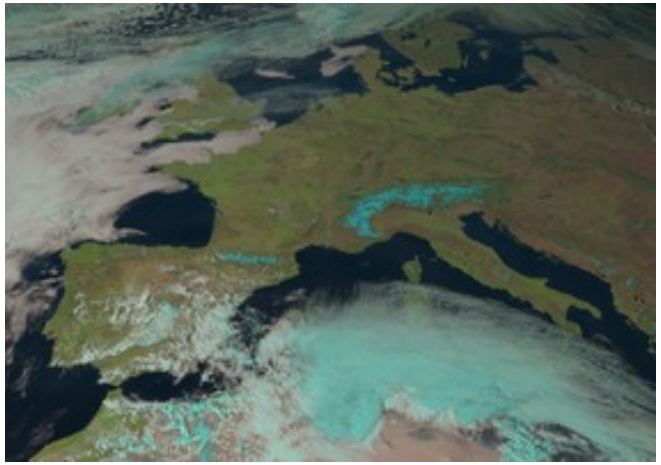
(1) Data Composite

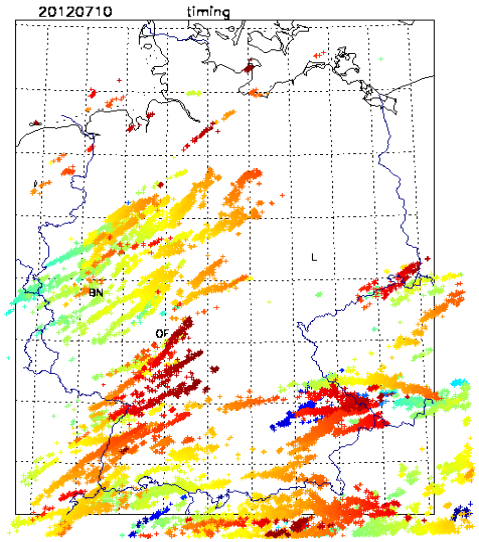
(1) Data Composite

Observations:

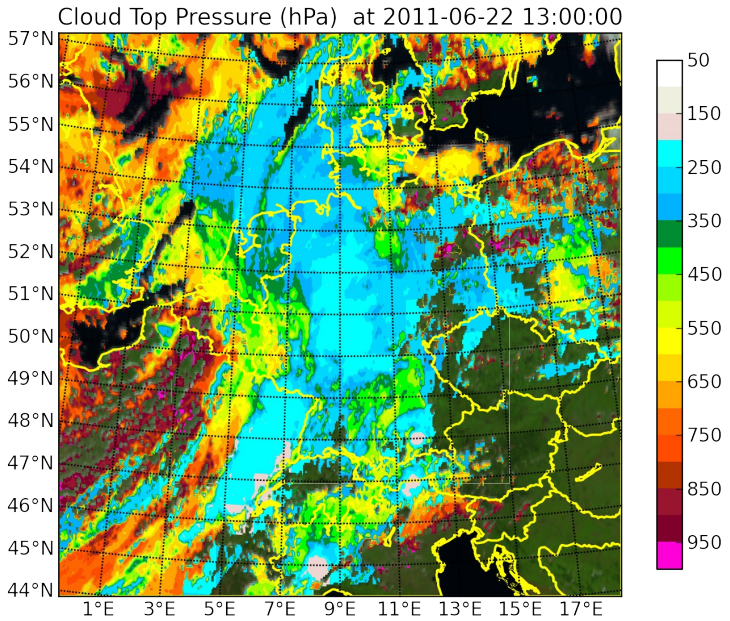
- MSG-SEVIRI 5 min rapid scan, ~ 3 x 6 km² spatial resolution
- RADOLAN - RX: 5 min precipitation radar scans
- 3d scanning, polarimetric research radars (Jülich, Bonn)
- LINET: lightning detection from antenna network: total, *(type, polarity)*







(1) Data Composite



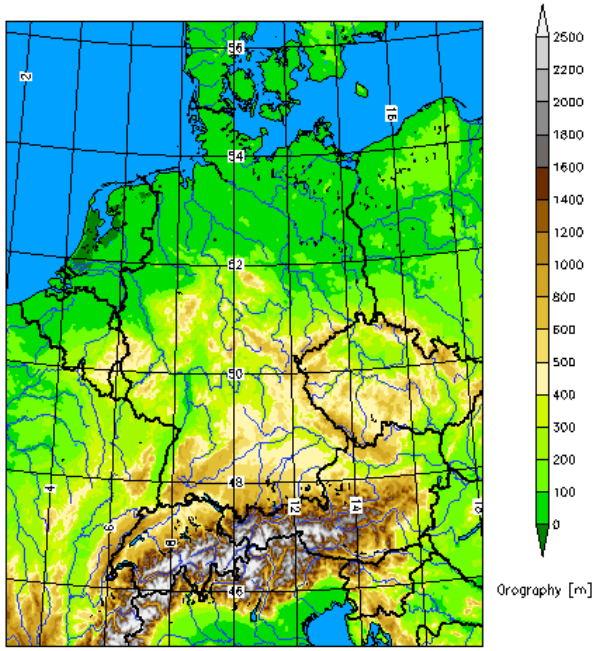
Products:

- NWCSAF retrievals for cloud mask, cloud type, cloud top height
- KNMI CPP retrievals for cloud optical thickness, effective radius, cloud phases, cloud water content
- radar-based hydro-meteor classification

(1) Data in Addition

Model forecast as additional data:

- COSMO-DE: regional, convection-permitting NWP model covering Central Europe
- spatial resolution: 2.8 x 2.8 km², available at 15 min time resolution



(2) Characterization of early development of Severe Storms

with contributions from Felix Dietzsch

(2) Characterization of early development of Severe Storms

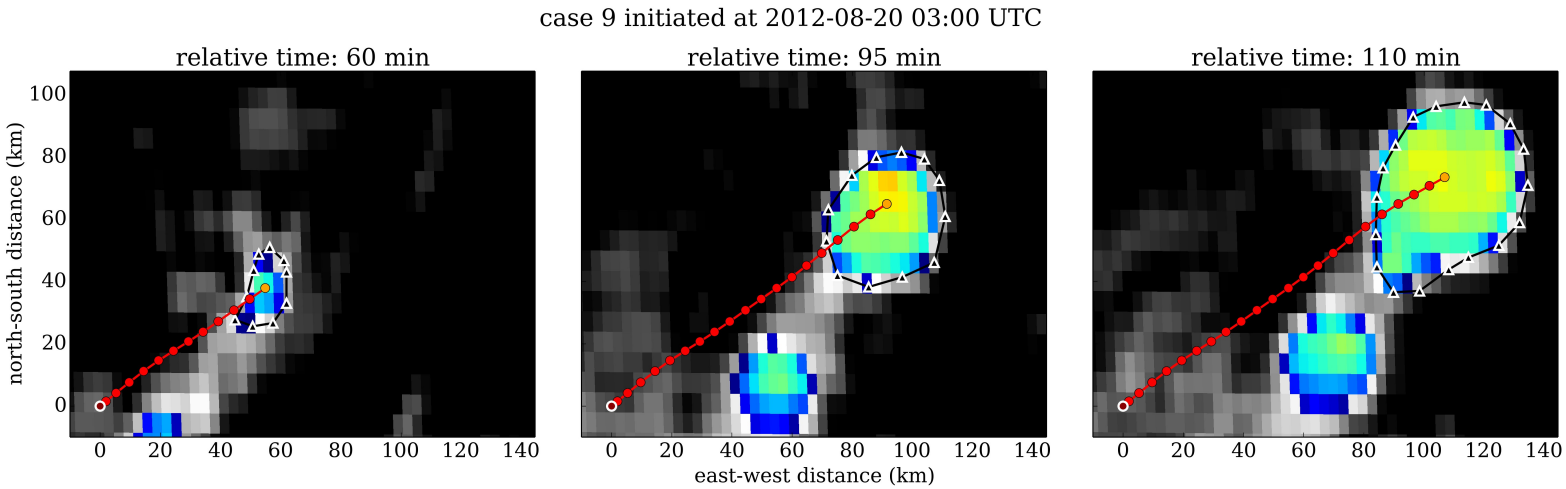
Objectives:

- *in general:* a physically consistent picture of severe storms in the early growth phase over Central Europe
- *in detail:* connection between dynamical and micro-physical properties at different times in storm development

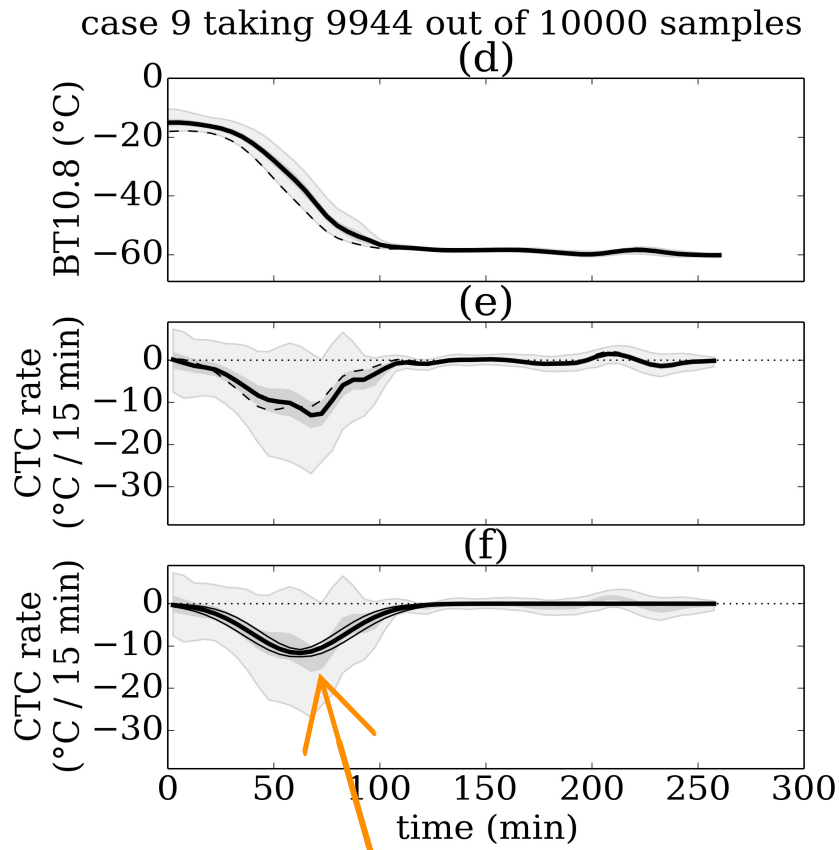
Method:

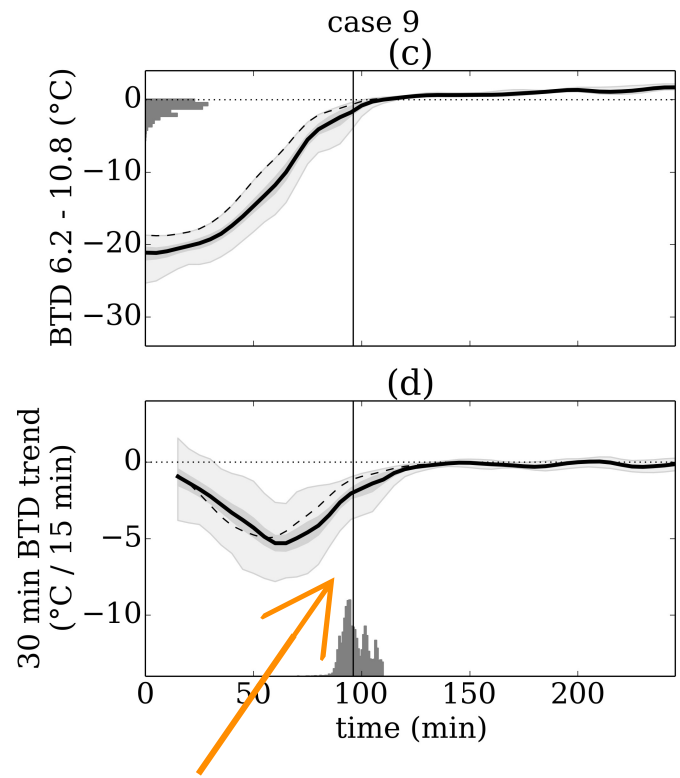
- subjective case selection for severe storm events in 2012
- manual tracking and anvil determination from MSG-SEVIRI images
- life cycle of satellite-based along-track storm and uncertainty estimates from close neighbourhood
- synchronization with respect to time of minimum cloud-top cooling rate

(2) Characterization of early development of Severe Storms



(2) Characterization of early development of Severe Storms

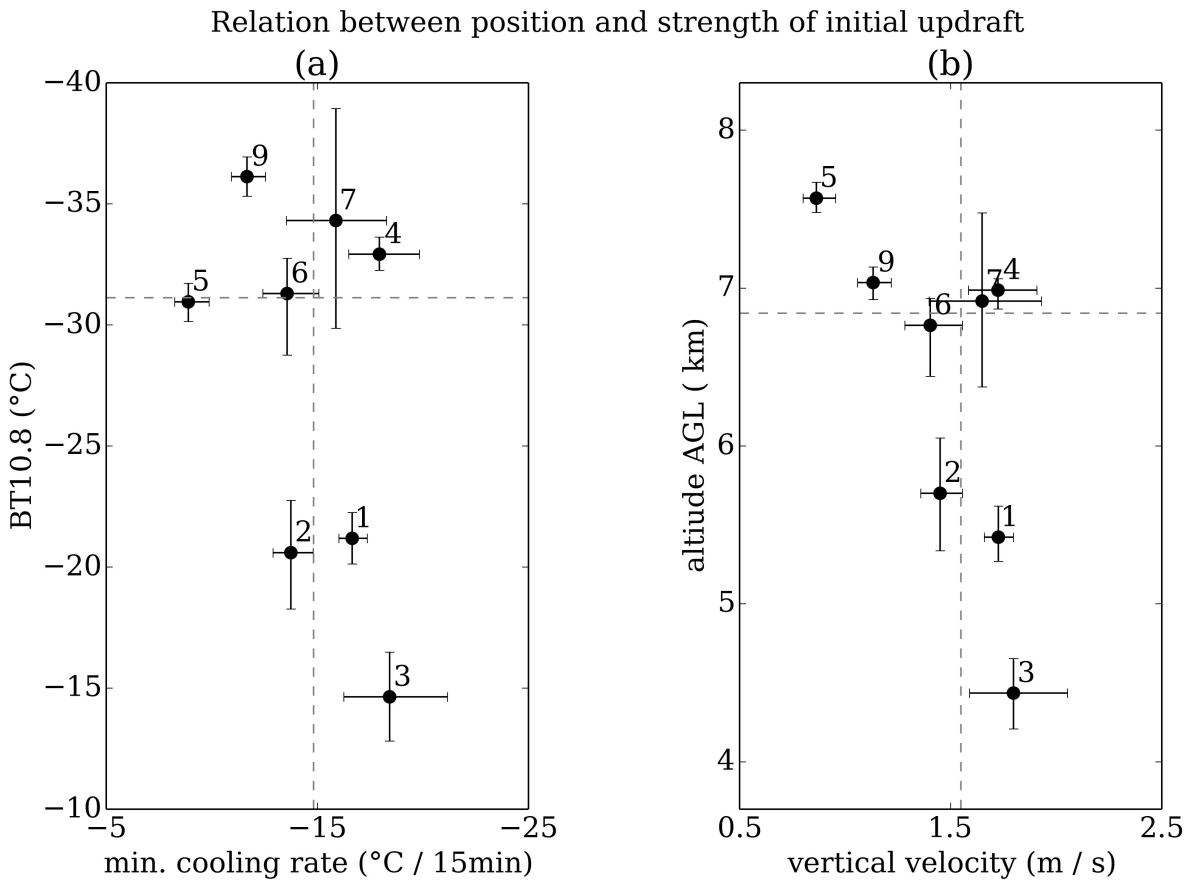




time of max. cooling

time of maturity:
- end of vertical growth

(2) Characterization of early development of Severe Storms



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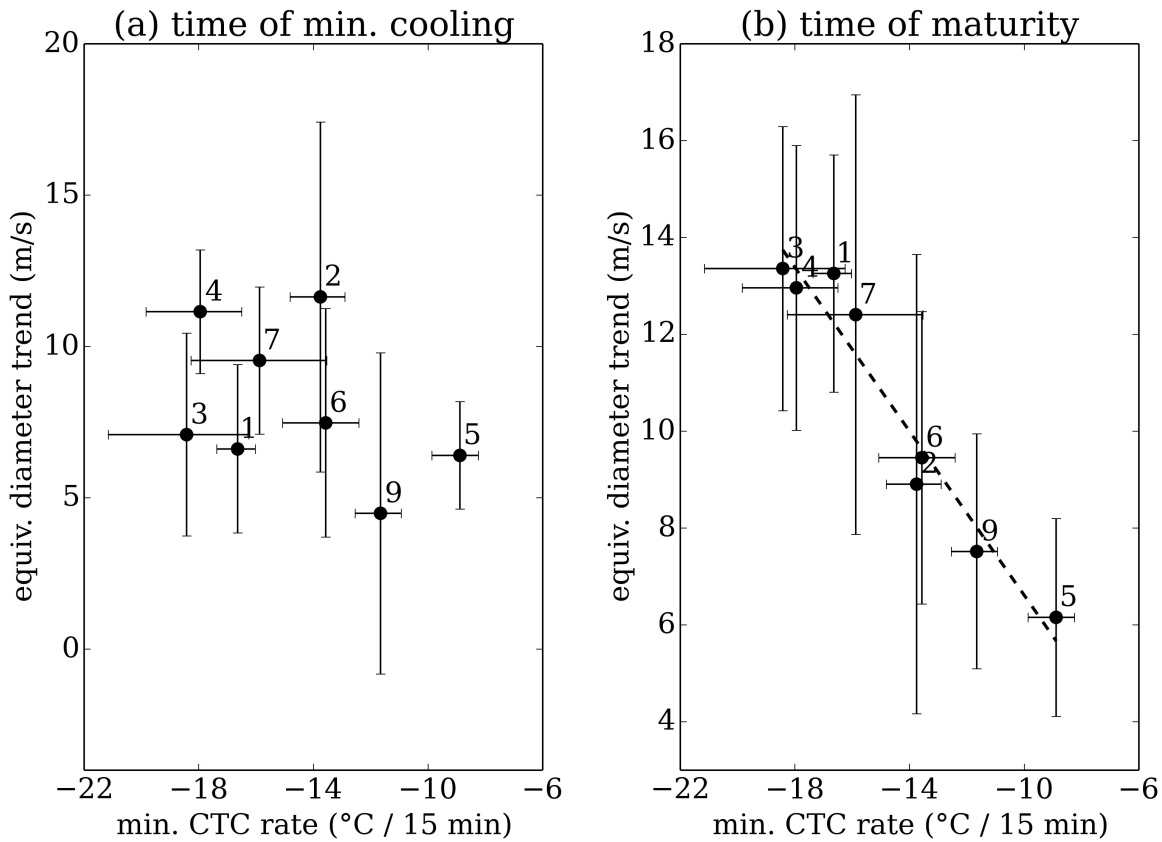

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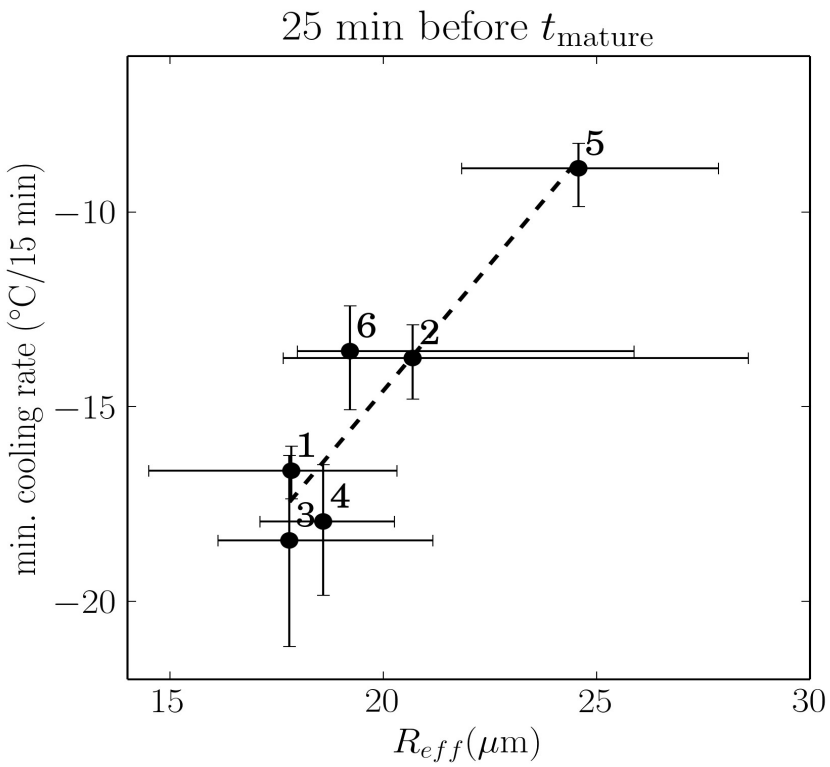


(2) Characterization of early development of Severe Storms

Summary:

- systematic relationship between maximum of vertical cloud-top motion and its altitude above ground: larger updraft at lower altitudes
- systematic relationship between minimum cloud-top cooling rate and anvil expansion rate: high correlation after around 40 min
- also relation between effective radius and min. cooling rate after 20 min (not shown)

Outlook:

- to be published soon
- extension to more cases and use of multi-sensor dataset

(3) Relationships of multi-sensor parameters of Severe Storms in mature phase

study from Akos Horvath

(3) Relationships of multi-sensor parameters of Severe Storms in mature phase

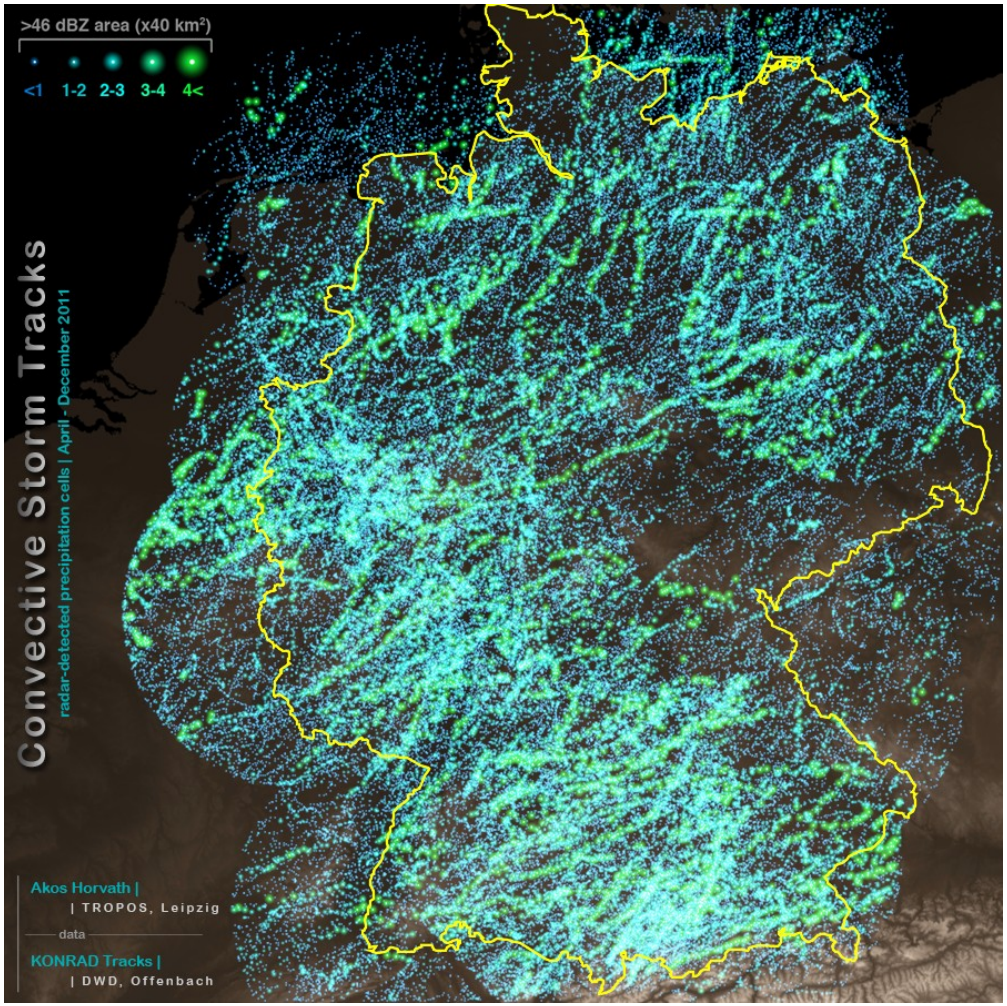
Objectives:

- *in general:* storm properties in the mature phase and its relation to severe weather
- *in detail:* relation between satellite-based estimates of micro-physical storm properties and timing and intensity of lightning

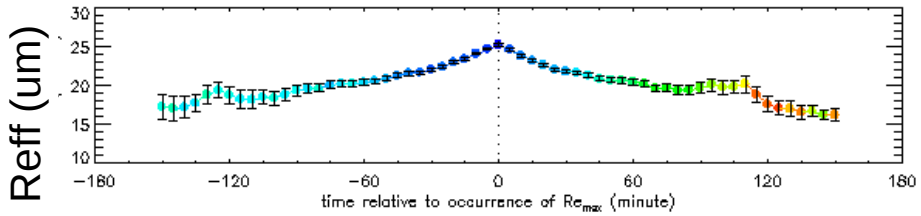
Method:

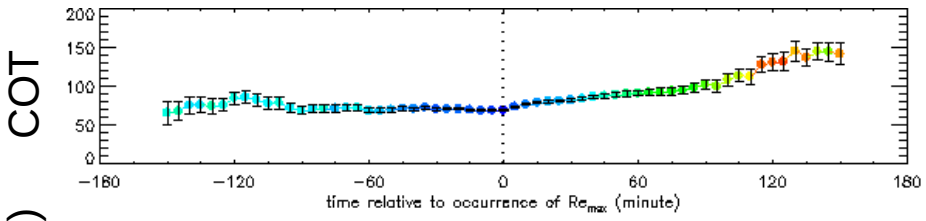
- whole summer season 2011
- tracking with DWD KONRAD – radar threshold-based tracking scheme
- satellite products (Reff, COT, CWP, CTH) along the track (mean values in a 5 x 5 box) and lightning (within 15 km radius)
- synchronization with respect to time of maximum of effective radius

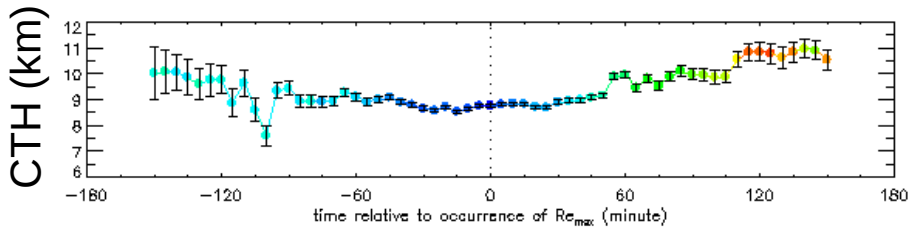
(3) Relationships of multi-sensor parameters of Severe Storms in mature phase

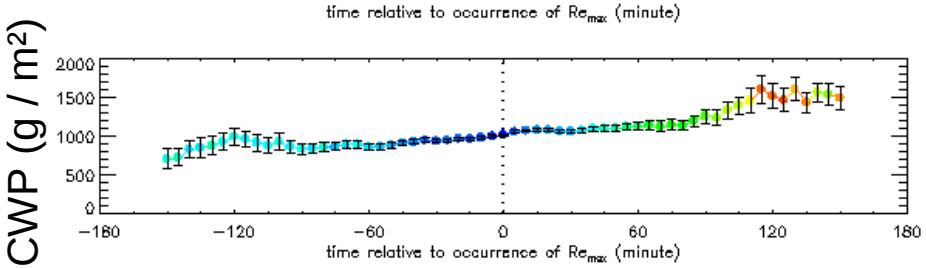


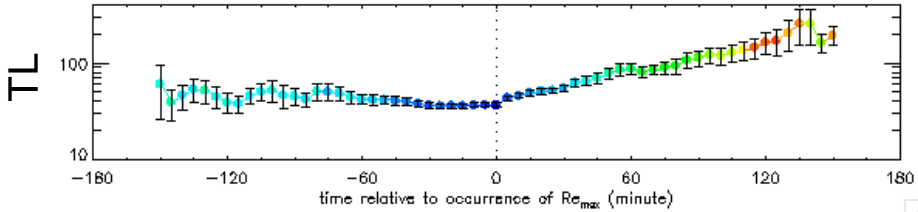
(3) Relationships of multi-sensor parameters of Severe Storms in mature phase



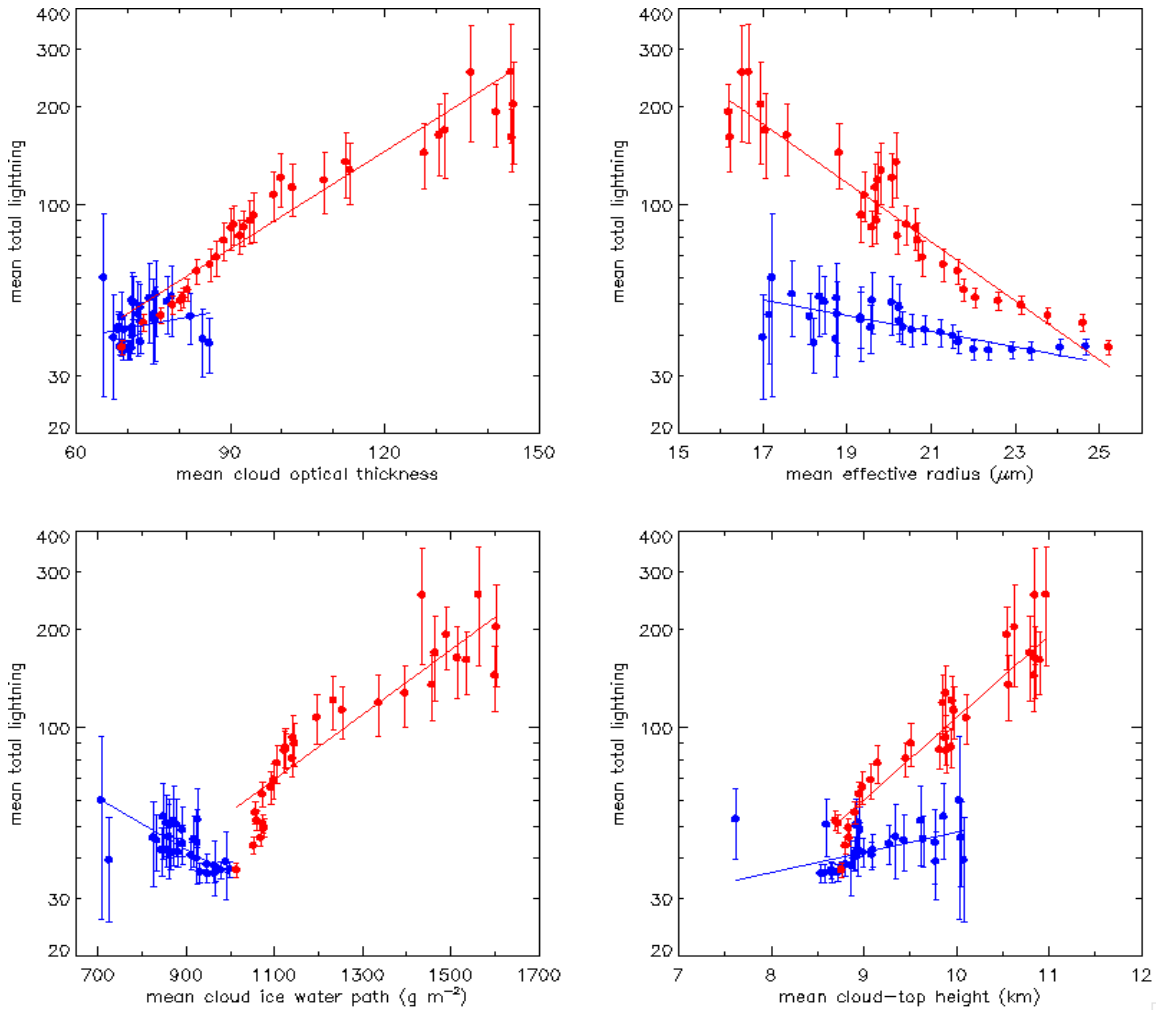








(3) Relationships of multi-sensor parameters of Severe Storms in mature phase



before max(R_{eff})

after max(R_{eff})

(3) Relationships of multi-sensor parameters of Severe Storms in mature phase

Summary:

- more lightning after the max. of effective radius
- after the max. of effective radius, clouds are optically thicker, have higher tops, and contain more water/ice
- lightning jumps are related to hail warnings derived from radar data (not shown)

Outlook:

- to be published soon
- extension to 2012

(4) Uncertainties in synthetic Satellite images and derived products

(4) Uncertainties in synthetic satellite images and derived products

Objectives:

- use the wealth of information in satellite images and derived products for model verification in a consistent way
- perfect model experiments for evaluation of strength and weaknesses of derived products under controlled, but realistic conditions

Method:

- synthetic MSG-SEVIRI images from COSMO-DE forecasts with radiative transfer model RTTOV
- embed synthetic images in HRIT files and use them in NWCSAF software to generate

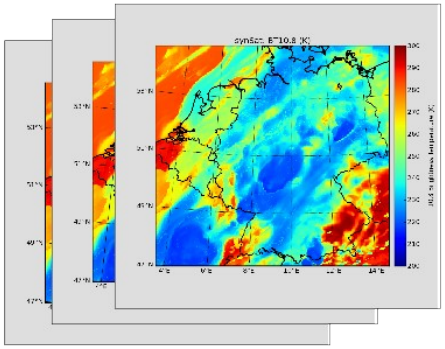
  ➔ synthetic cloud mask, cloud type and cloud top height
  ➔ synthetic motion vectors, and RDT cloud objects

(4) Uncertainties in synthetic satellite images and derived products

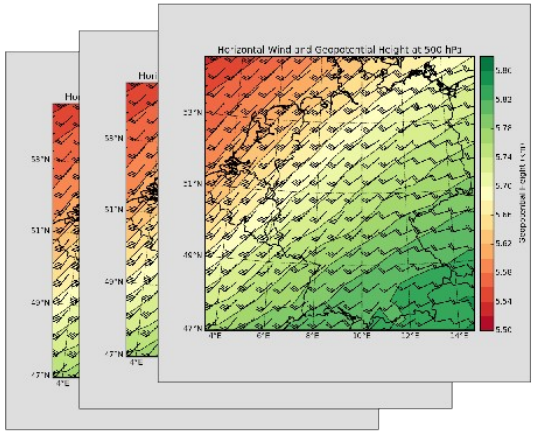
synthetic MSG – SEVIRI images

RTTOV

EUMETSAT Nowcasting–SAF

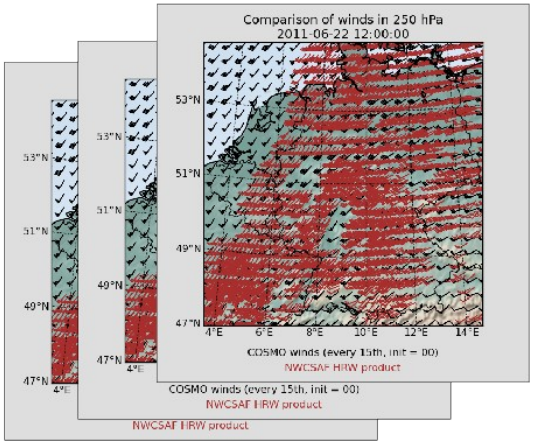


COSMO–DE forecast

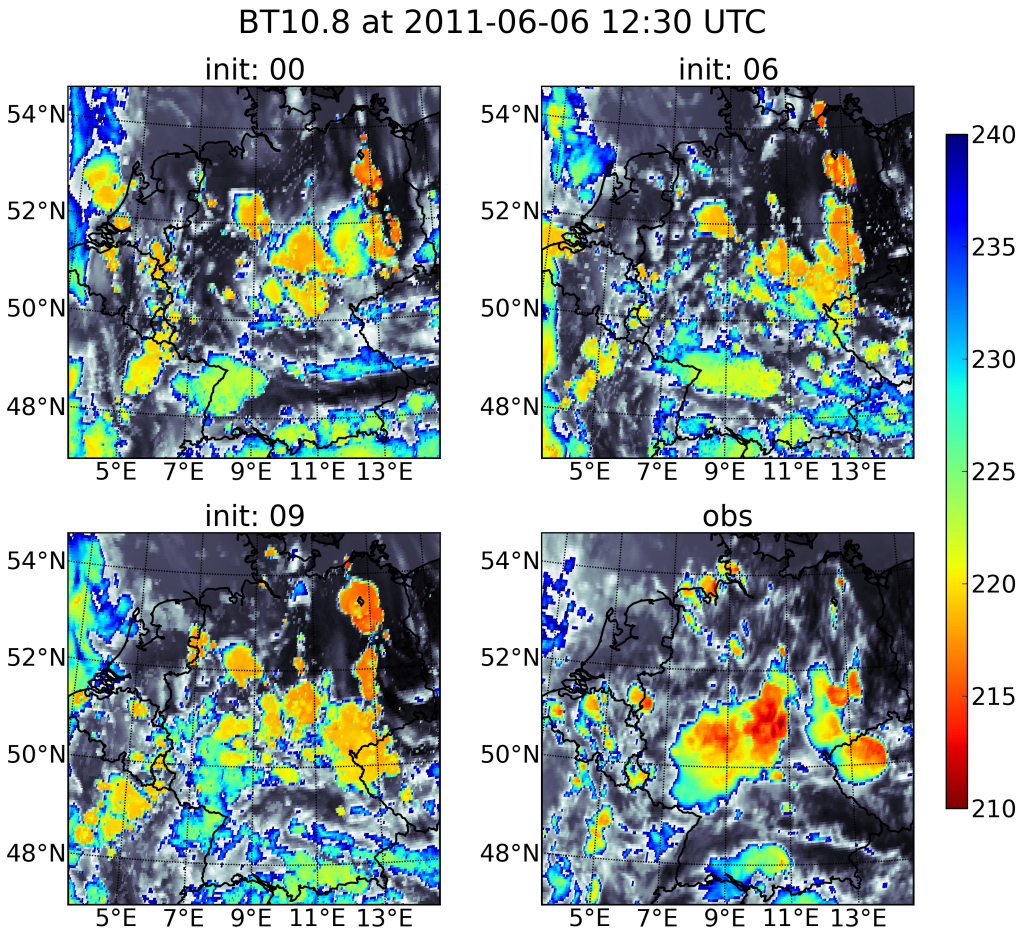


Closure

synthetic cloud winds

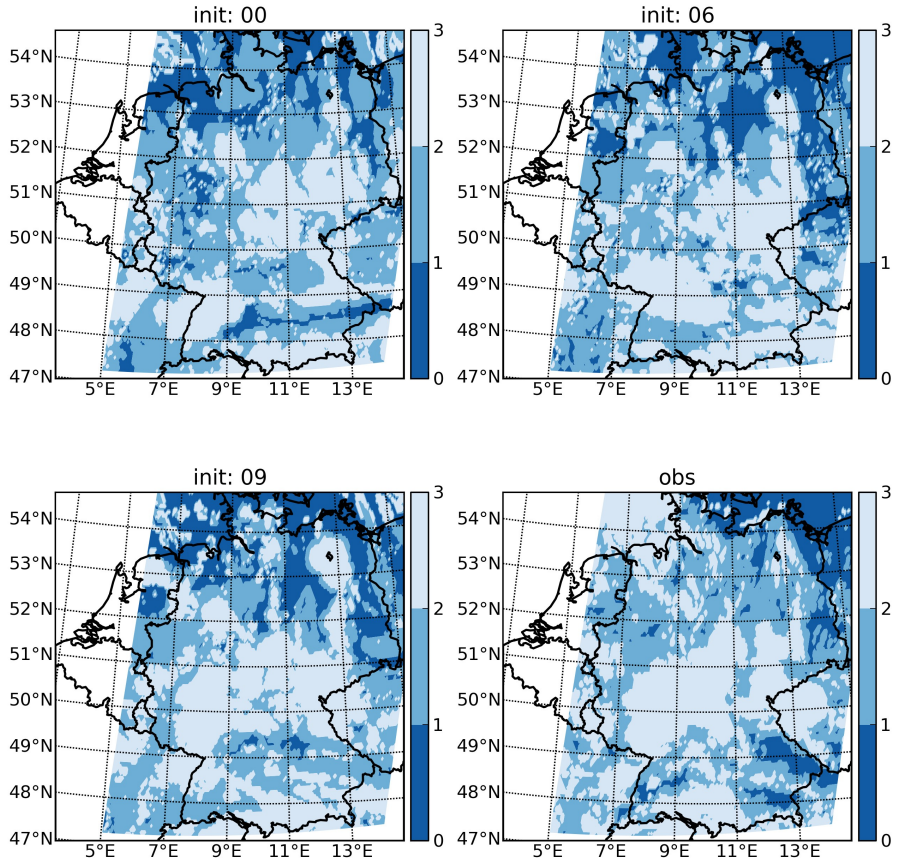


(4) Uncertainties in synthetic satellite images and derived products



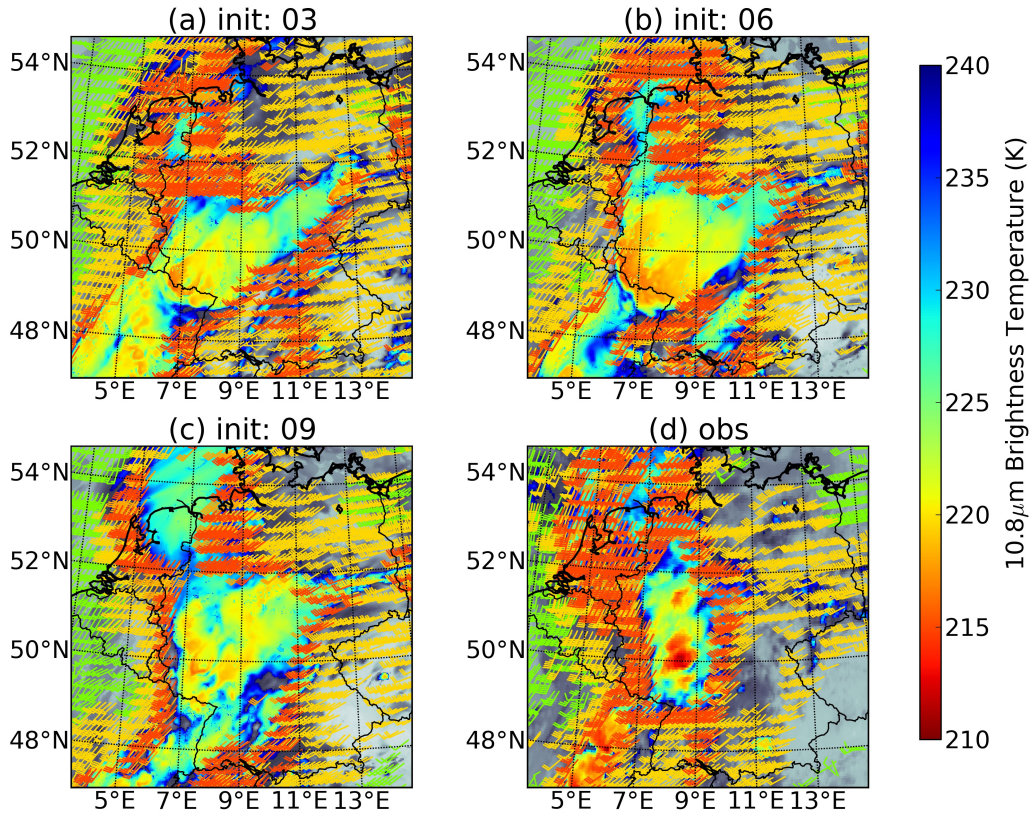
(4) Uncertainties in synthetic satellite images and derived products

CMa at 2011-06-06 12:30 UTC



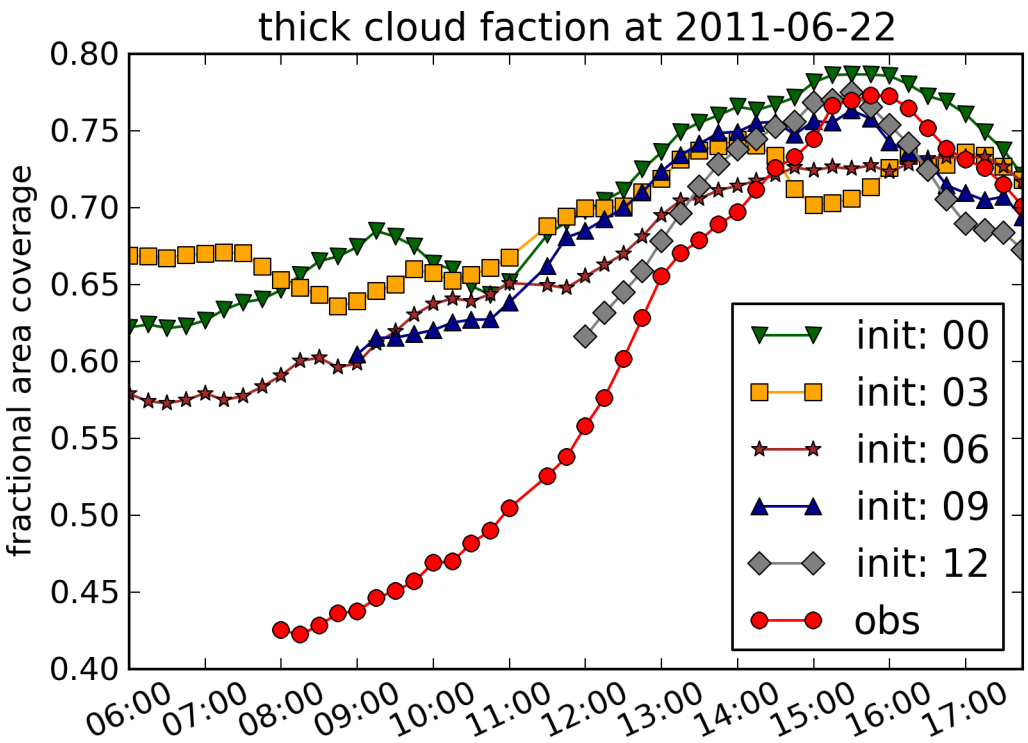
(4) Uncertainties in synthetic satellite images and derived products

HRW winds in 350 hPa for 2011-06-22 12:00 UTC



NWCSAF HRW product for WV6.2, WV7.3, IR10.8, IR12.0

(4) Uncertainties in synthetic satellite images and derived products



(4) Uncertainties in synthetic satellite images and derived products

Summary:

- synthetic data: good tool for the evaluation of model forecasts and product accuracy
- uncertainties depend on the formulation of the interaction between radiation and hydro-meteors (not shown)

Outlook:

- use it for systematic model verification

(5) Object-based verification of convection forecasts

with contributions from Martin Rempel

(5) Object-based forecast verification

Objectives:

- It is extremely hard to correctly forecast location and timing of convection initiation for models like COSMO-DE.
- However, can COSMO-DE forecasts reproduce at least the **statistics** of observed convective clouds?

Method:

i. subjective case selection for severe convection days in 2012

ii. object identification in observed and synthetic Meteosat images

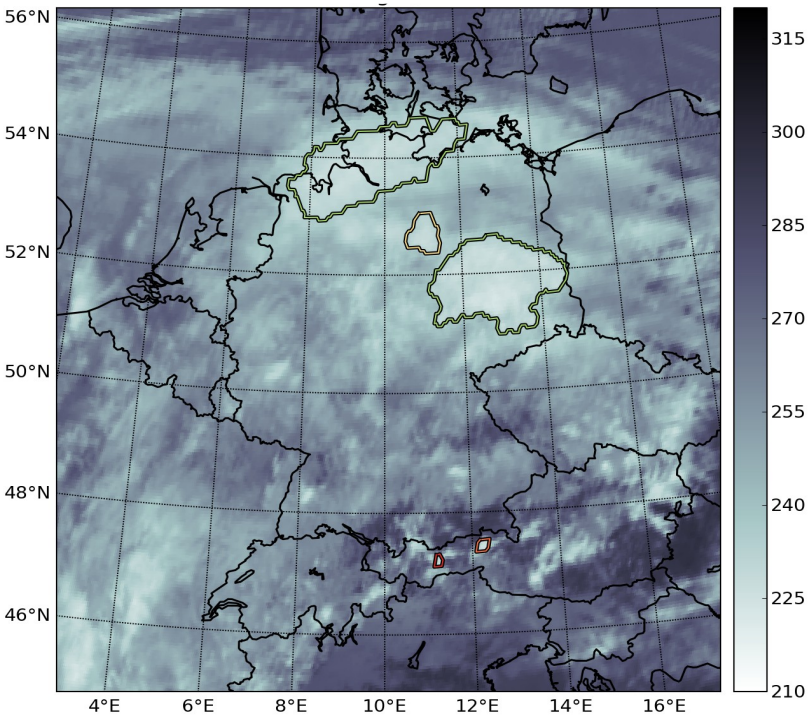
- ➔ threshold technique based on EUMETSAT NWCSAF-RDT product
- ➔ set of observed and synthetic convective cells

(5) Object-based forecast verification

RDT for COSMO - example case day

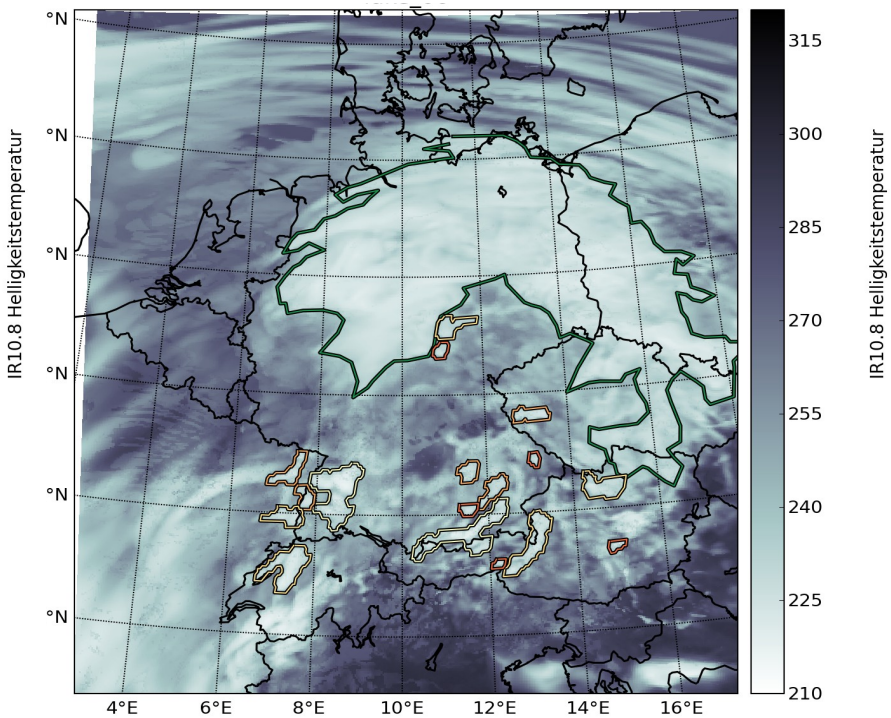
03-06-2012 12:00 UTC

observation



03-06-2012 12:00 UTC

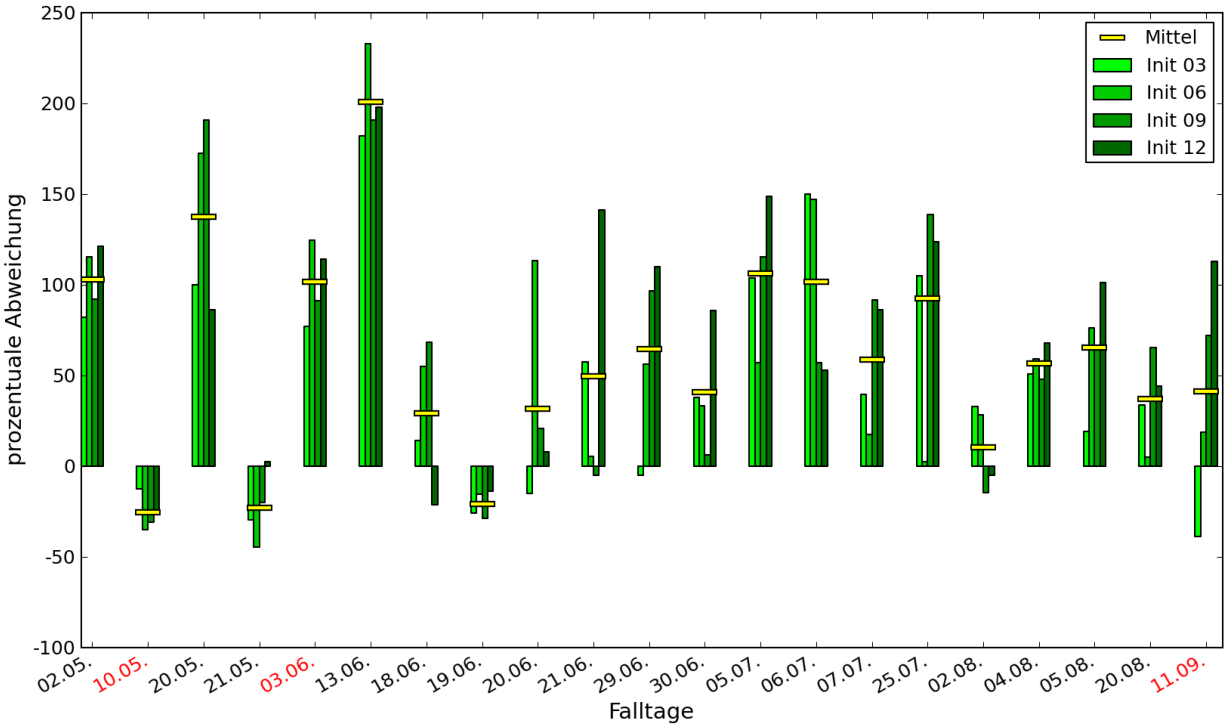
synthetic image from forecast



threshold: 240 K, cells coloured by cell size from small (red) to giant (green)

(5) Object-based forecast verification

relative deviation of forecasted cells smaller than 40 km

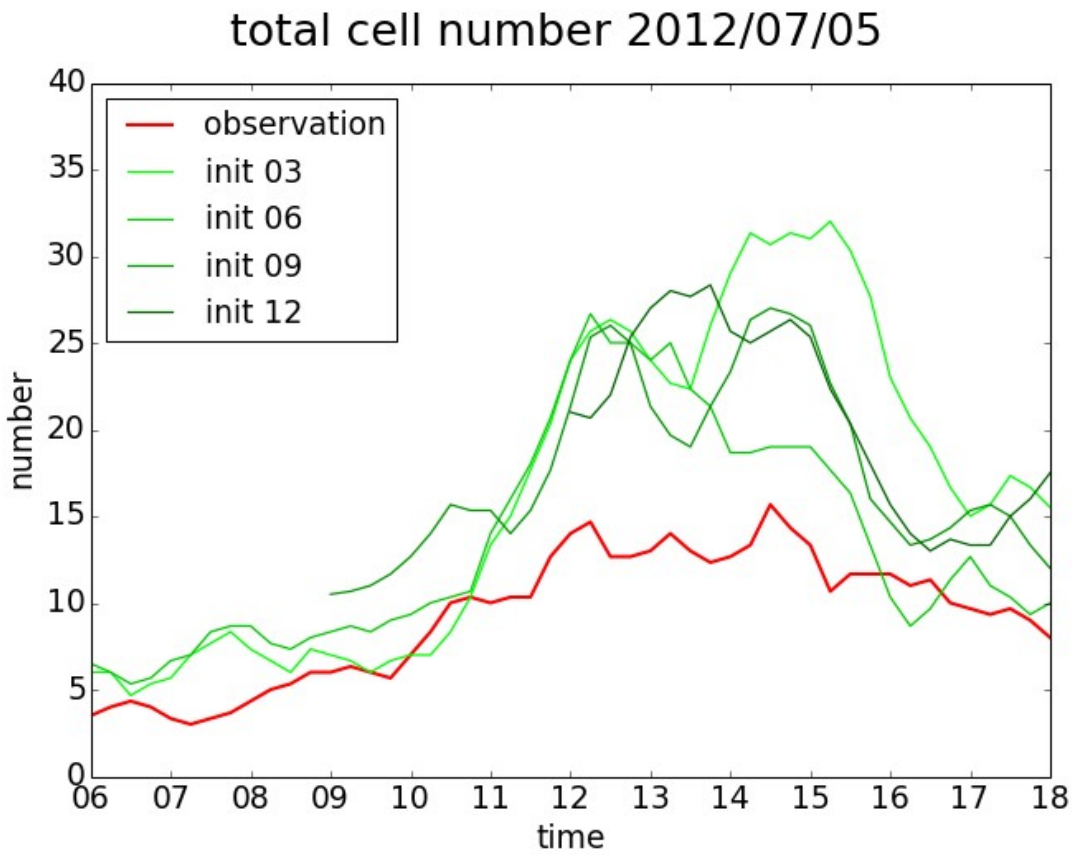


➔ COSMO forecasts overestimated the number of convective cells in 2012

(5) Object-based forecast verification

- the timing and duration of convective events is often misrepresented
- time-lagged ensemble mostly remains close together

diurnal cycle of convective cells



(5) Object-based forecast verification

Summary

- number of small cells is over-estimated in convection-permitting forecast model COSMO-DE
- diurnal cycle of convective cells is hardly captured

Outlook

- extend analysis to 2013
- improve convective cell selection (use additional information, e.g. lightning, vertical moisture fluxes)
- look closer at diurnal cycle of convective cell in combination with the preconvective environment
- evaluate cloud life cycles, cloud-top cooling rates and anvil expansion rates