Meteosat-based Characterization of the Initiation and Growth of Severe Convective Storms over Central Europe

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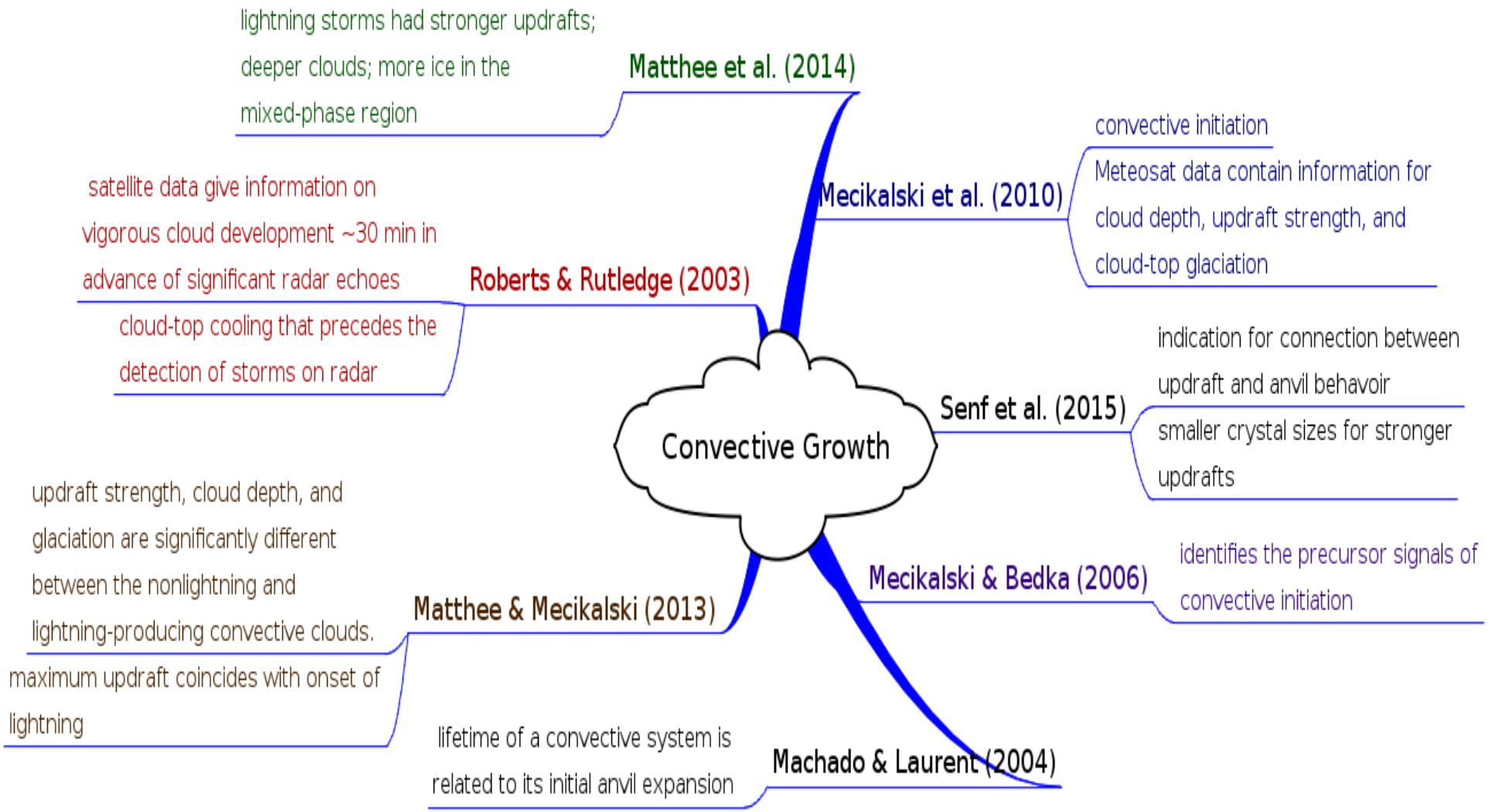
Outline

State-of-the-Art



Research Questions

Process Understanding

- What are typical characteristics of growing convective storms in Central Europe?

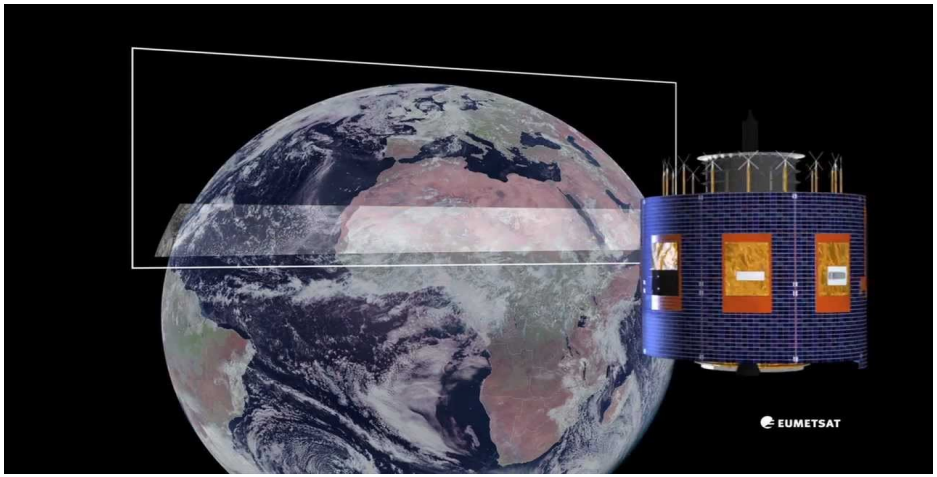
Predictability

- How are different satellite- and radar-based growth properties interrelated?
- And how much information give these observation-based growth properties on possible later storm severity?

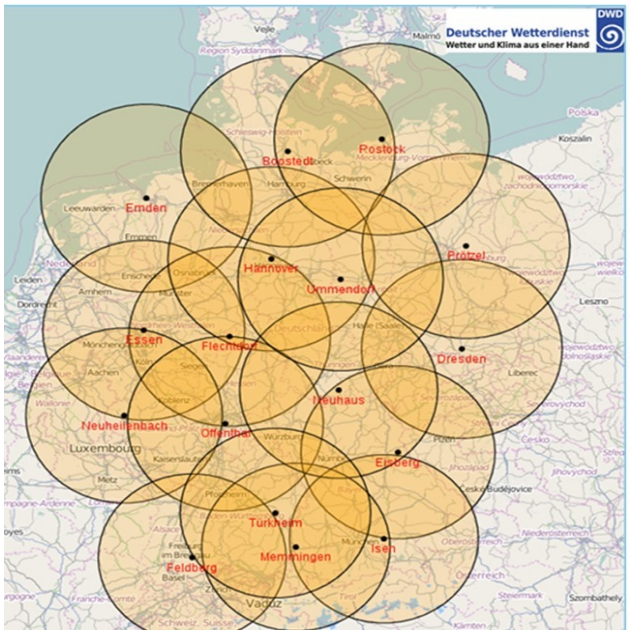
Outline

Data

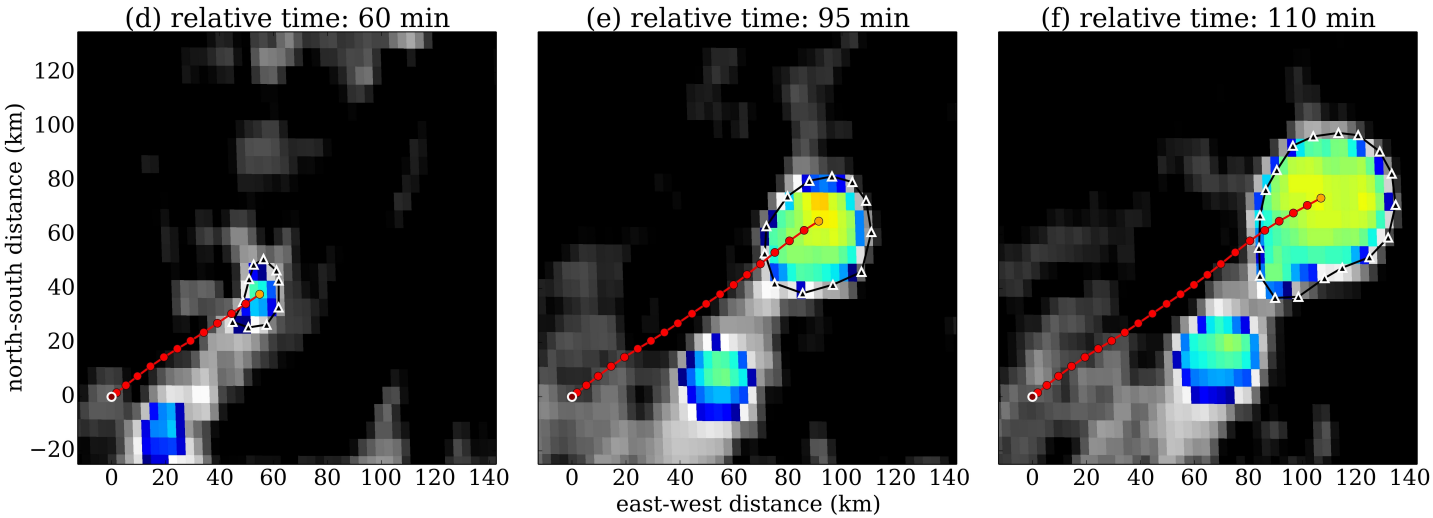
- **Cloud observations (Meteosat)**
  - visible and infrared radiances,
  - cloud products, e.g. effective particle radius
  - temporal resolution: 5 min,
  - spatial resolution: 3 x 6 km^2



- **Precip. Observations (Radolan)**
  - radar reflectivities
  - temporal resolution: 5 min
  - spatial resolution: 1 x 1 km^2



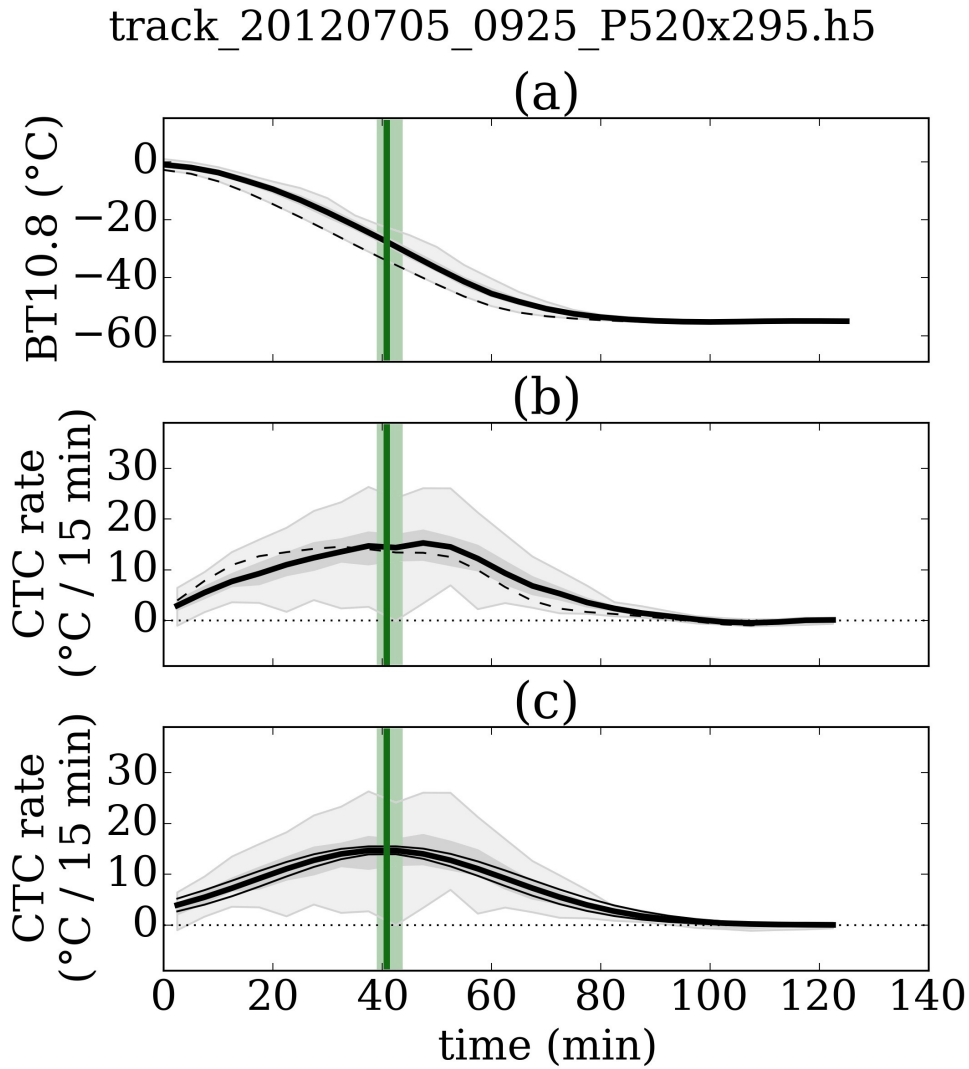
Method



- single cells automtically identified using threshold-based clustering techniques
- manually determined backward satellite-based tracks
- along-track properties collected, random-track bootstrapping
- anvil defined as connected area with BT10.8 < 240 K

Defintion: Time of Max. Cloud-top Cooling

- 5 min time difference of Meteosat 10.8 μm Brightness Temperature (window channel)
- generate random tracks in 3x3 region
- determine t_{cool} from a Gaussian fit



(following Senf et al. (2015))

Domain

Randomly selected cell tracks for the years 2012, 2013 and 2014

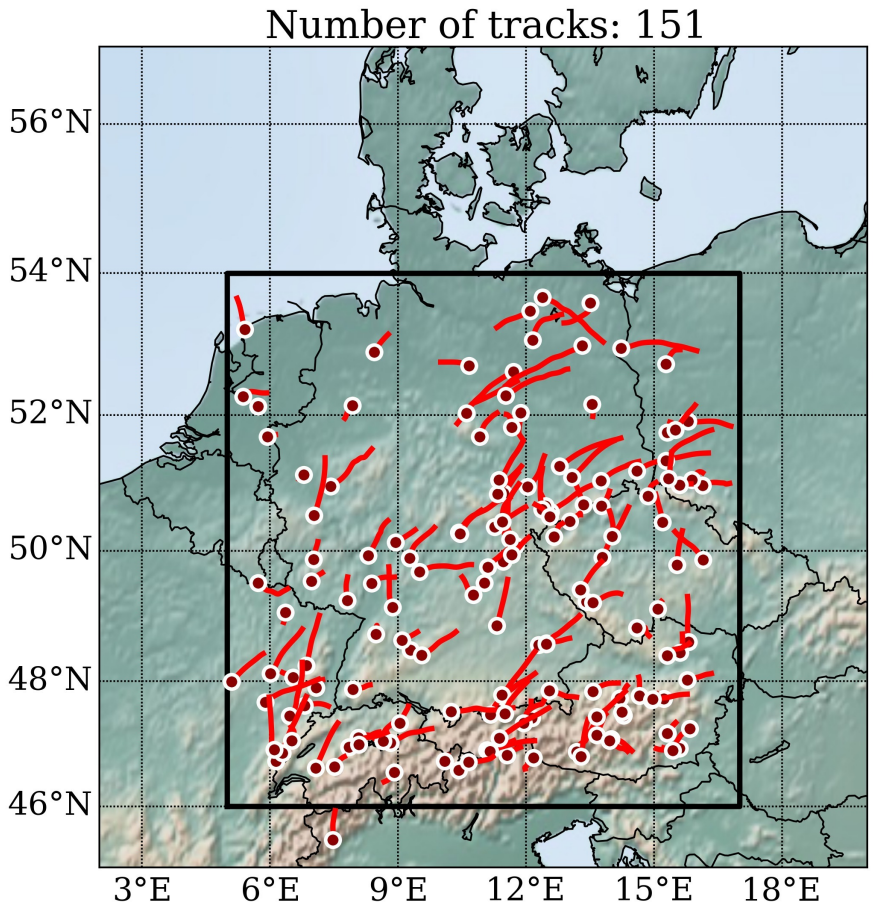
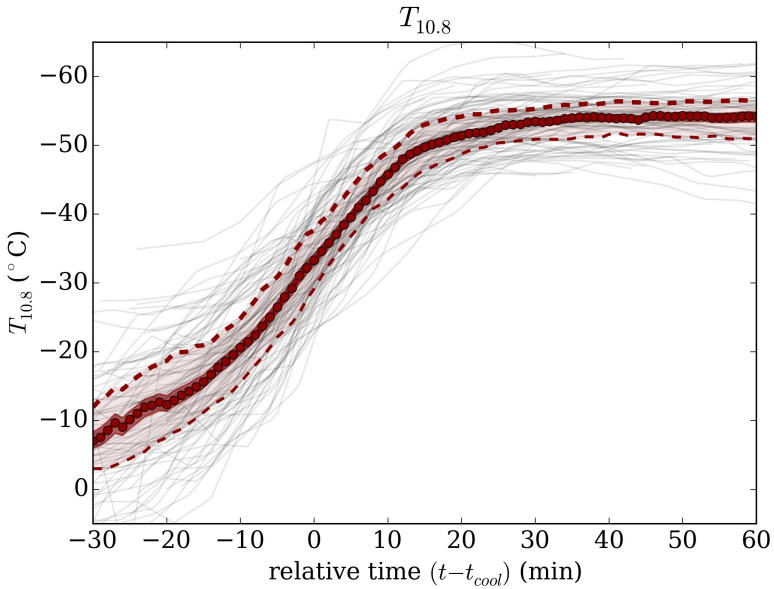
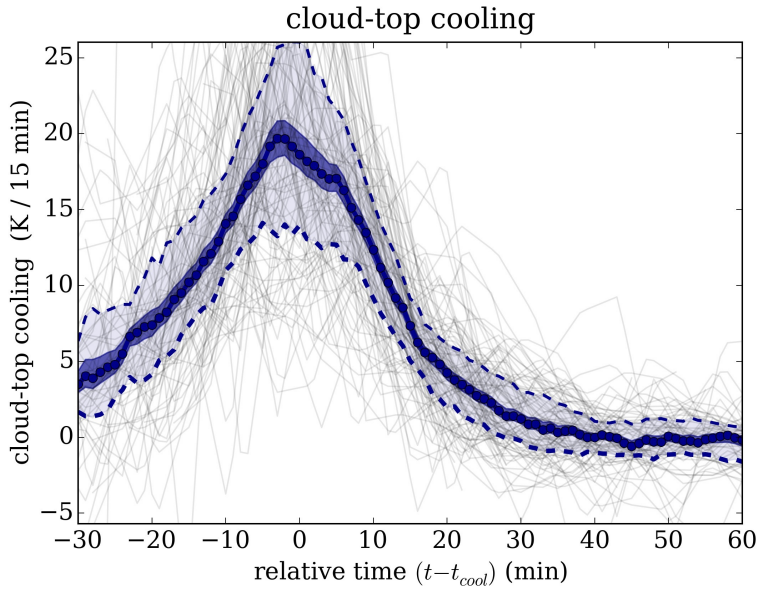


Figure: Investigated domain with tracks (solid lines) and starting positions (points).

Outline

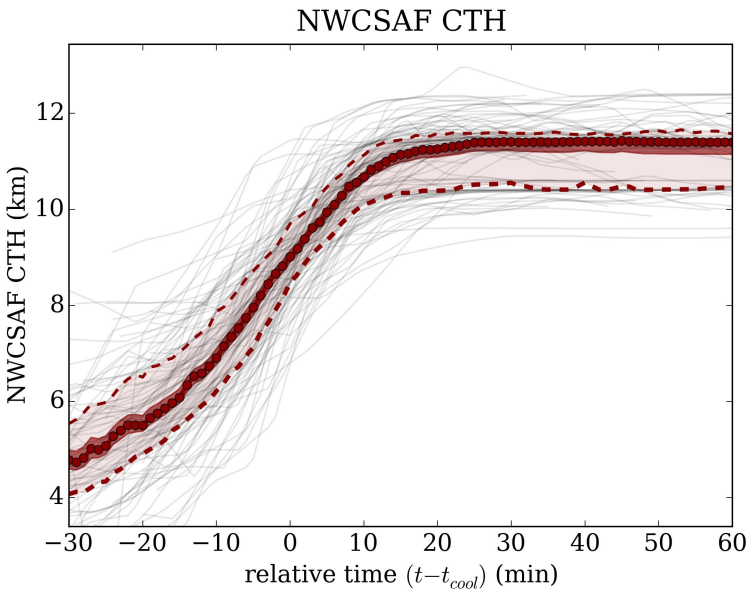
Cloud-top Temperature and Cooling Rate

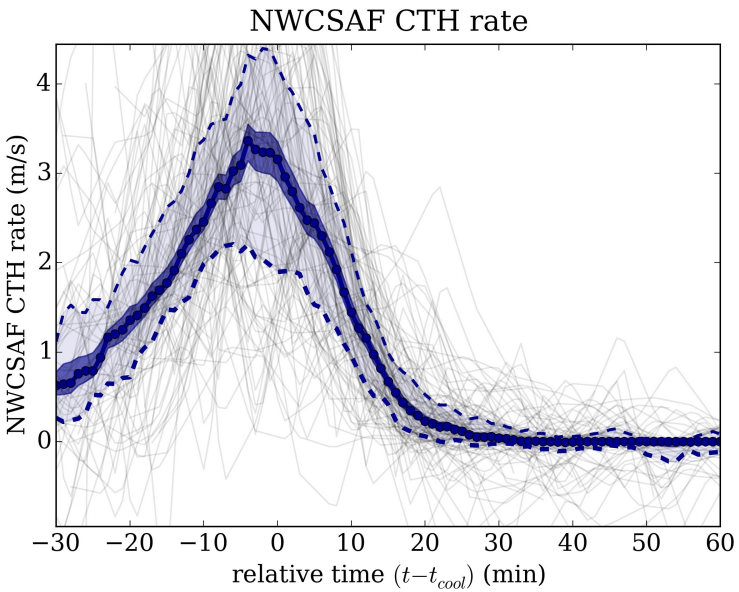




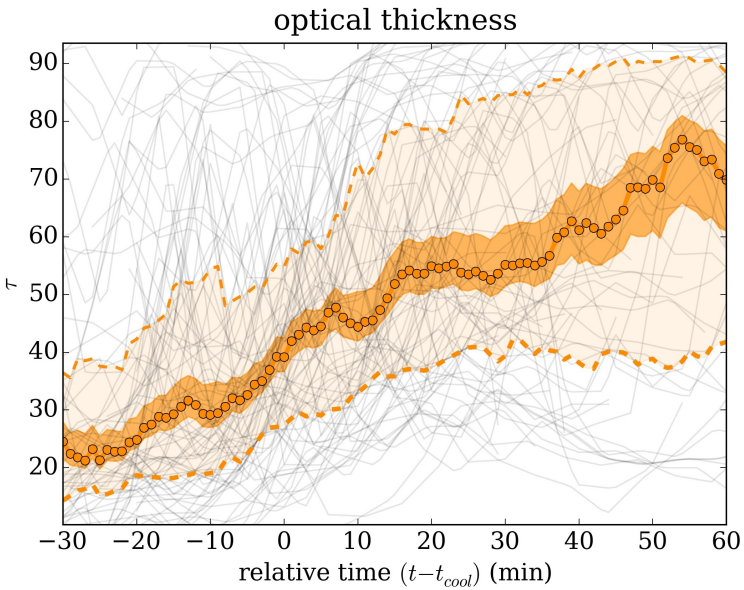
- max. cooling rate $\approx$ 20 K per 15 min
- typical cooling during $\approx$ 30 min

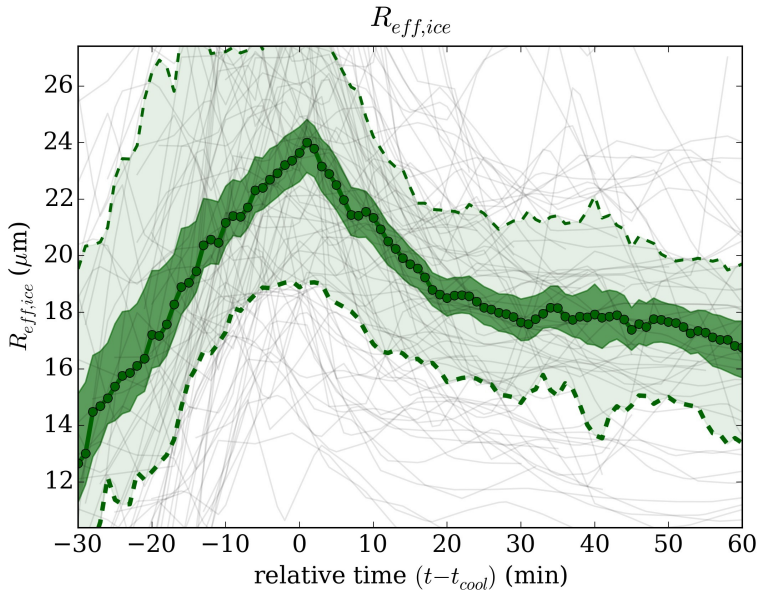
NWCSAF Cloud-top Height and Ascend Rate





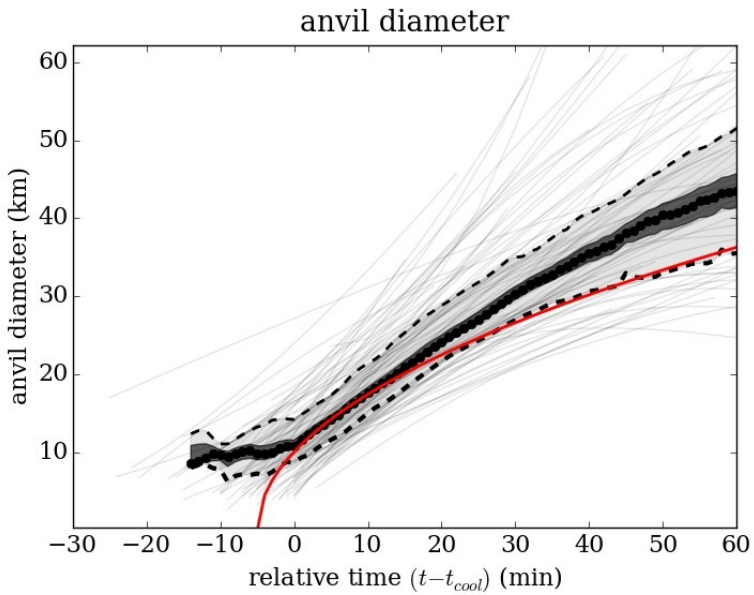
CPP Optical Thickness and Ice Effective Radius

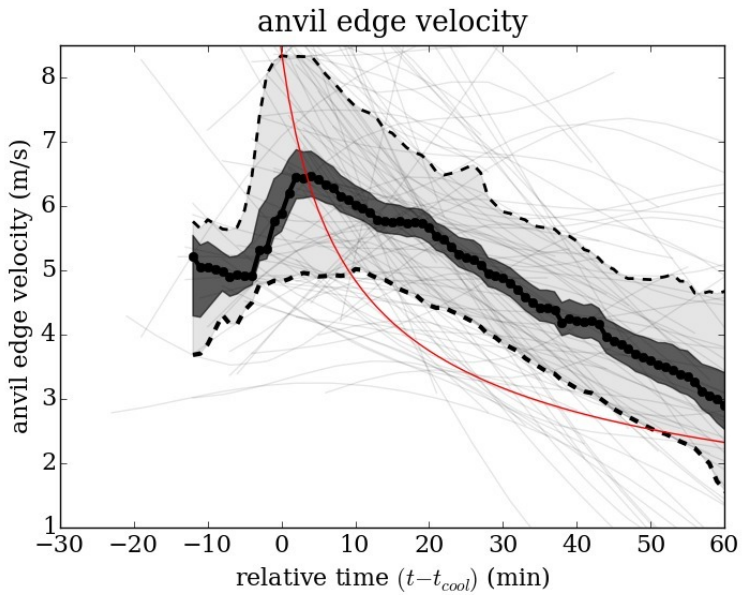




- optical thickness monotonically increasing
- ice effective radius with pronounced peak after t_{cool}: real physics or retrieval artifact?
- crystal size decrease: effect of size separation by different fall velocities?

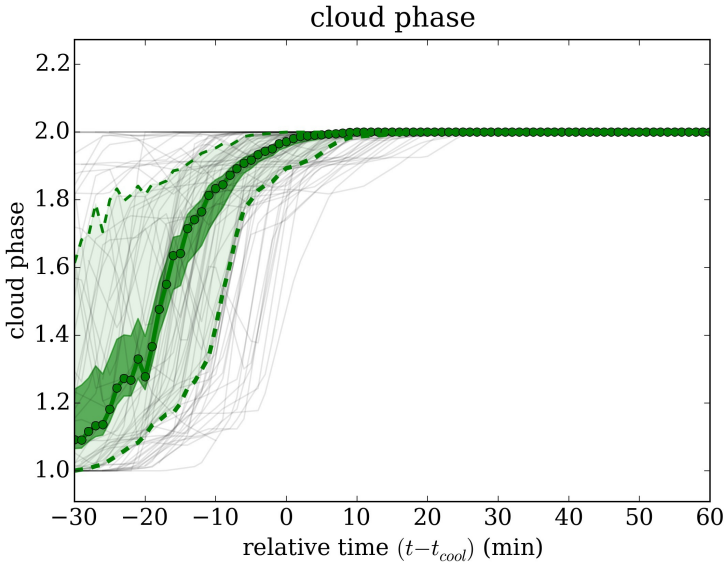
Anvil Size and Edge Speed





- anvil is expanding with 3 to 6 m/s
- increasing mass flux divergence (non-stationary)

Glaciation Indicators



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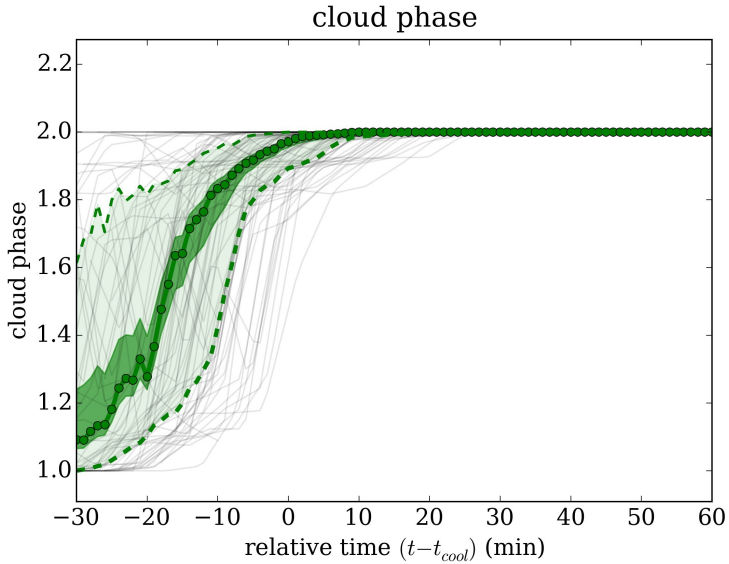
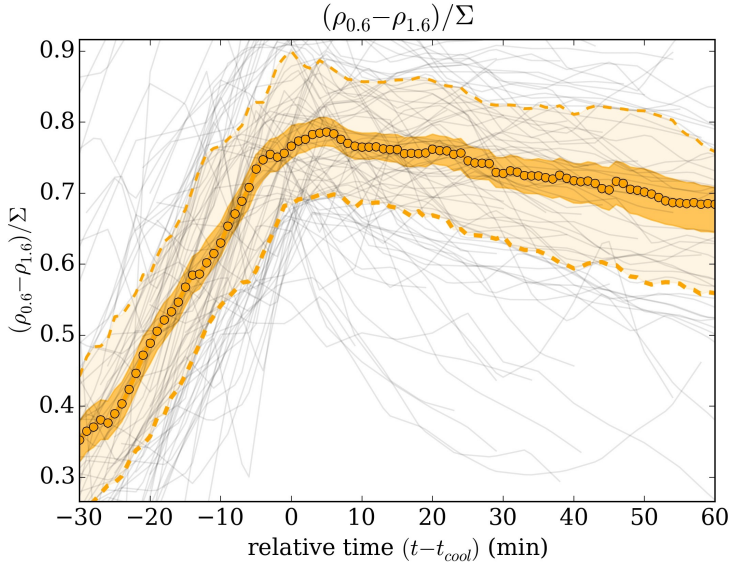
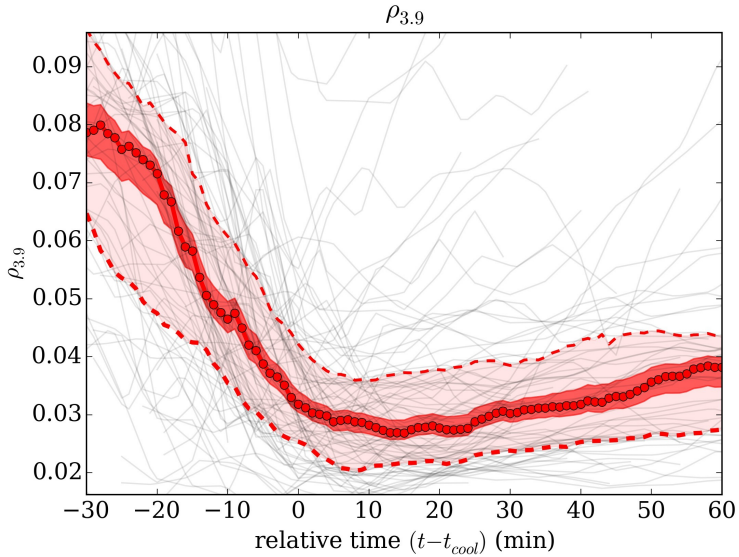
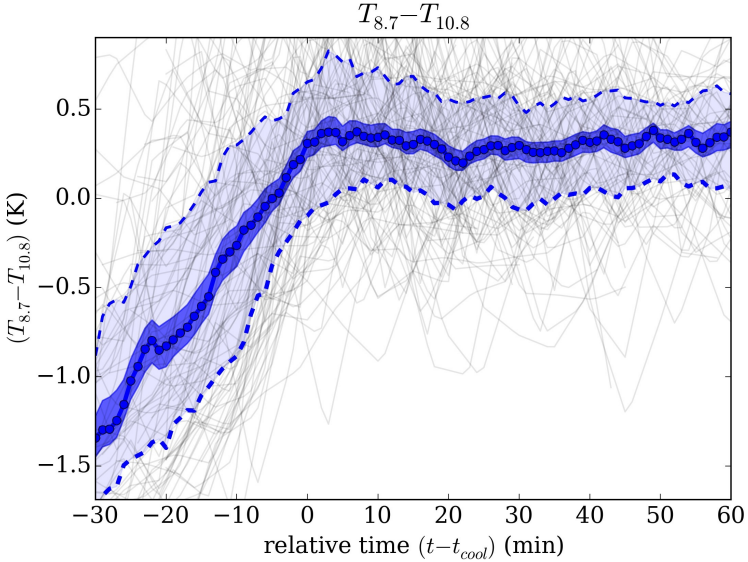
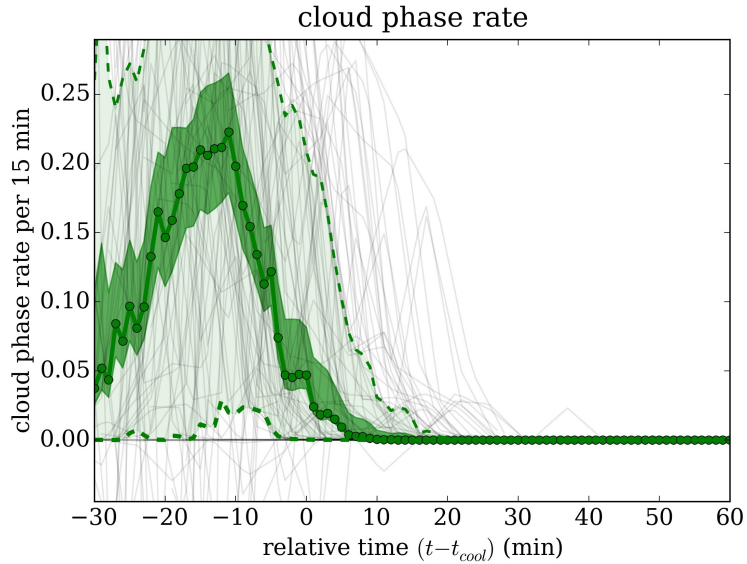


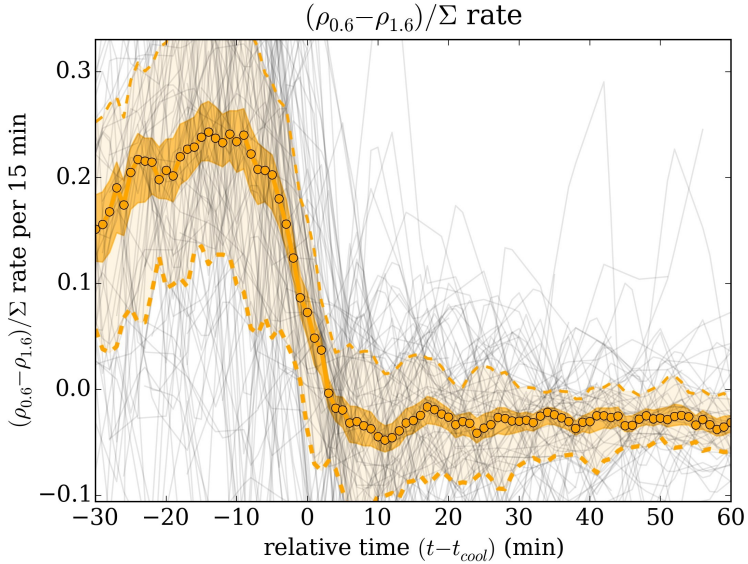


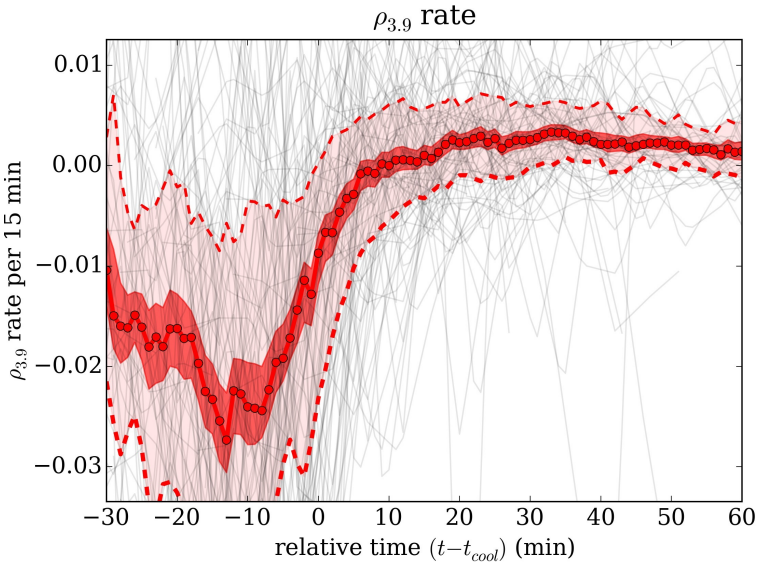


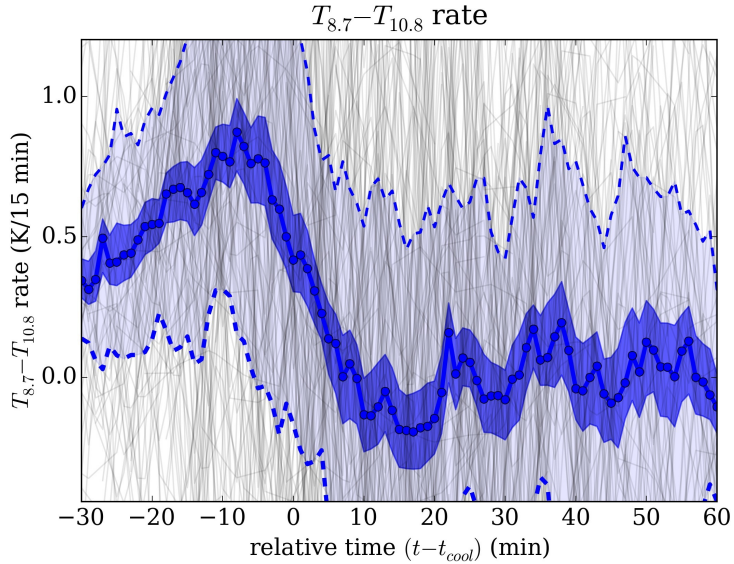


Glaciation Rates

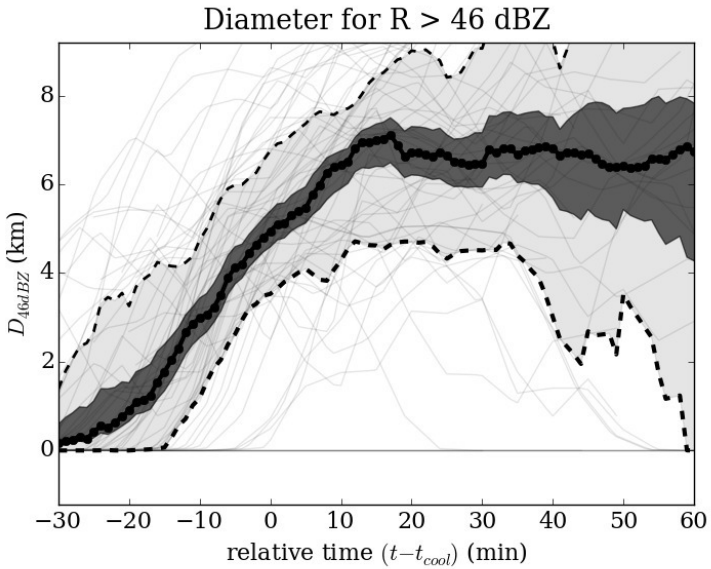


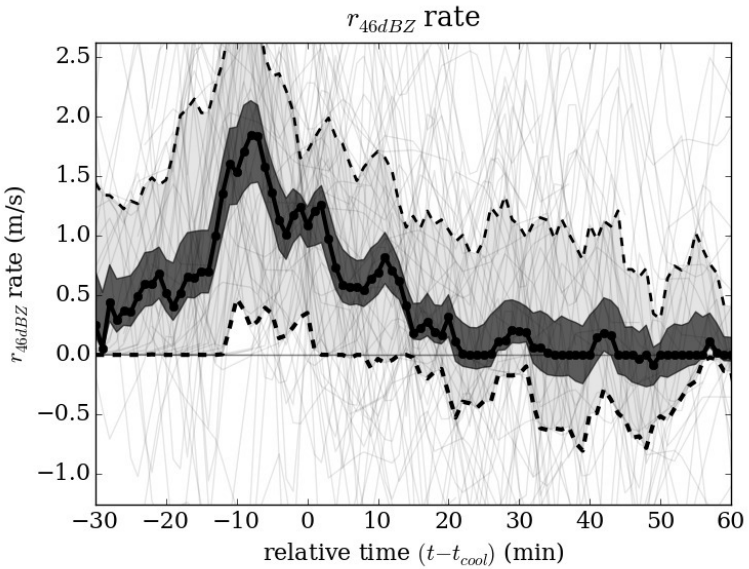




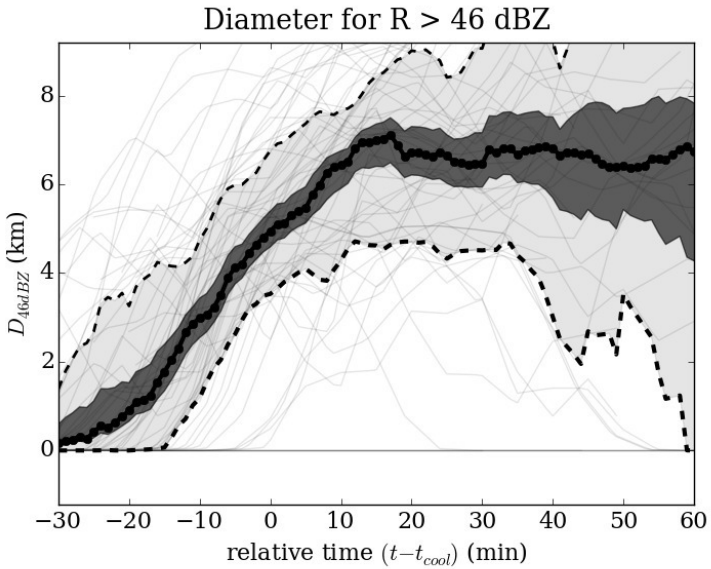


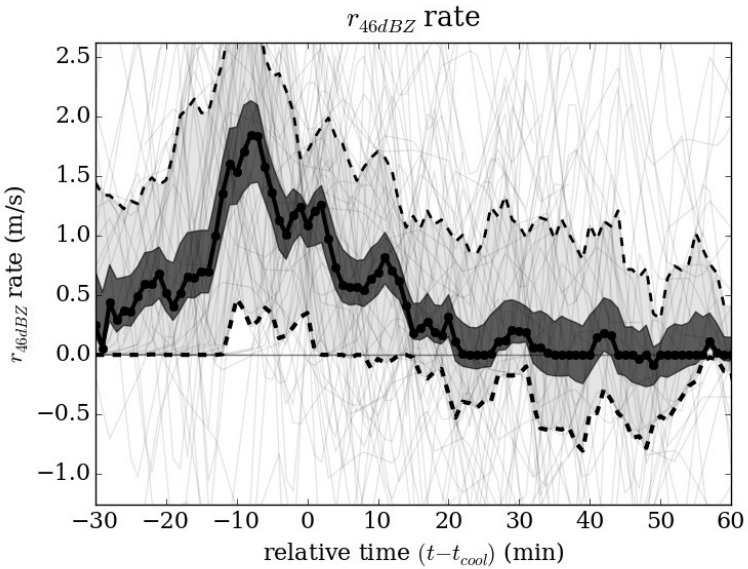
Precipitation

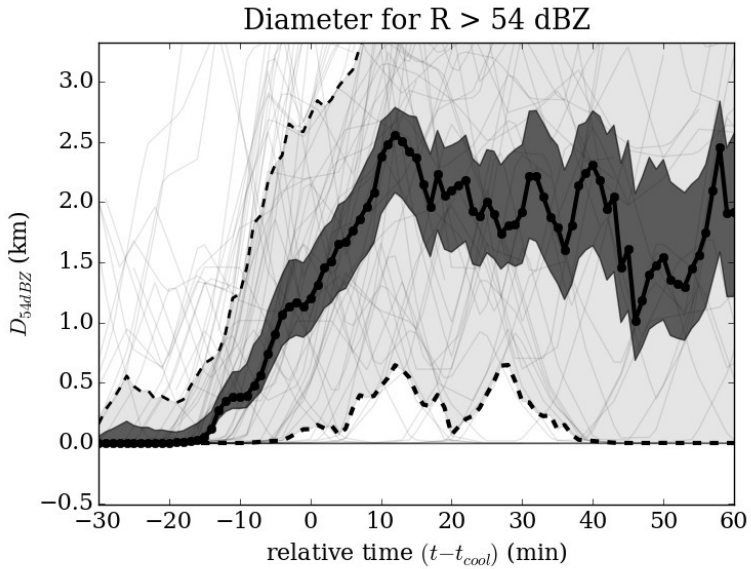


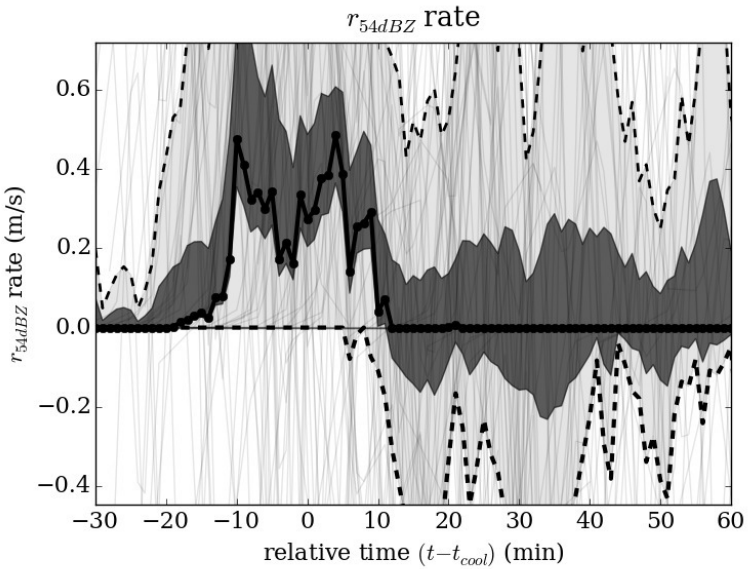


Precipitation

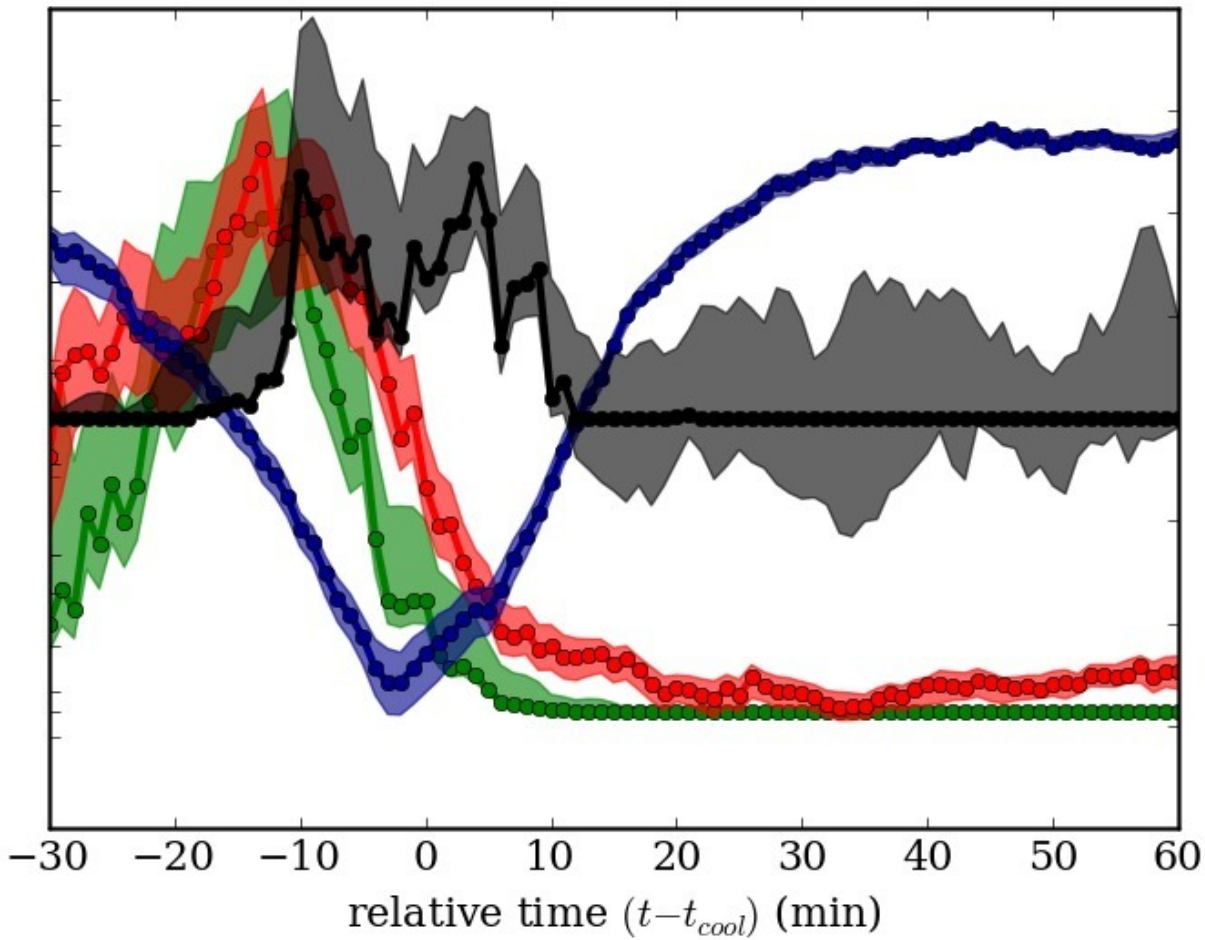








Growth Phase - Combined



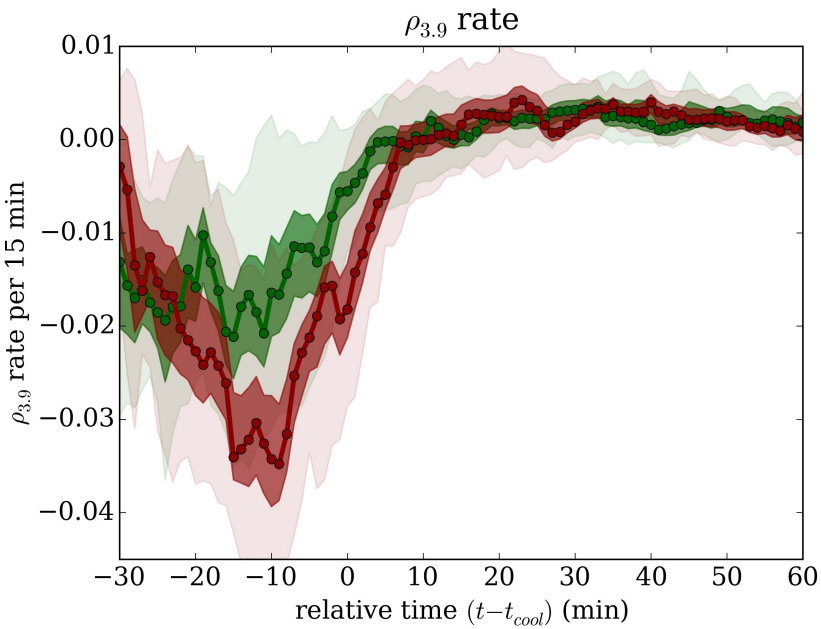
cloud phase rate

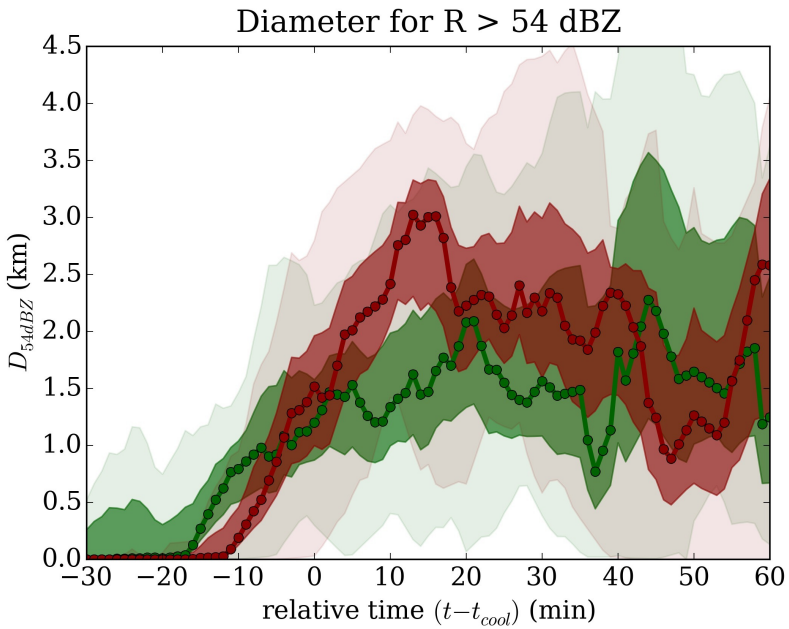
$\rho_{3.9}$ rate

r_{54dBZ} rate

$T_{10.8}$ rate

Glaciation vs. Precip.

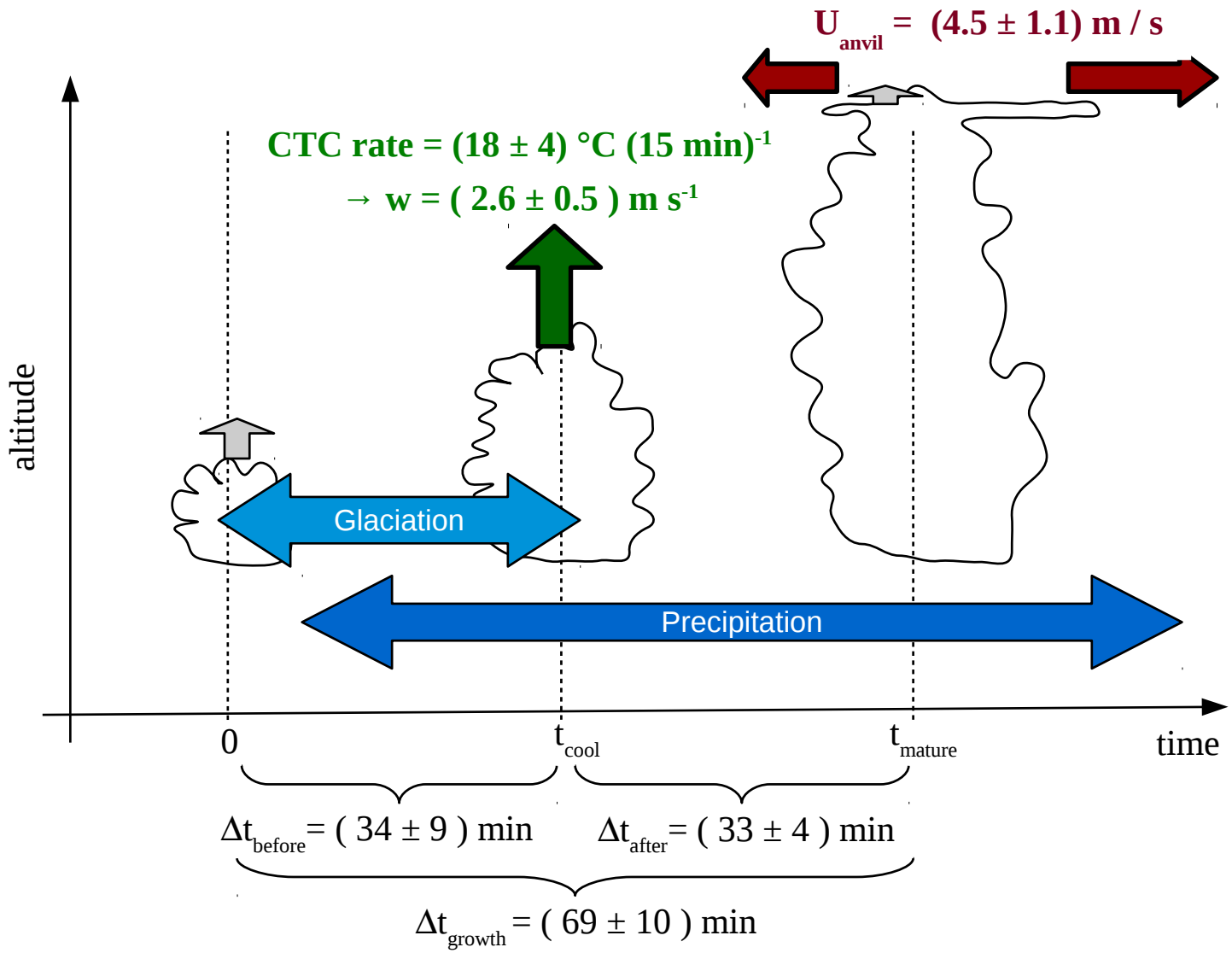




- stronger convective cores have larger freezing rates
- heavy precipitation sets in later and with maximum precip. areas 15 min after t_{cool}

Outline

Summary


U anvil = (4.5 ± 1.1) m / s
CTC rate = (18 ± 4) °C (15 min)-1
→ w = (2.6 ± 0.5) m s-1
altitude
Glaciation
Precipitation
0
t cool
t mature
time
Δt before = (34 ± 9) min
Δt after = (33 ± 4) min
Δt growth = (69 ± 10) min

What do we learn for nowcasting?

Cloud-top vertical vs. horizontal anvil edge velocity

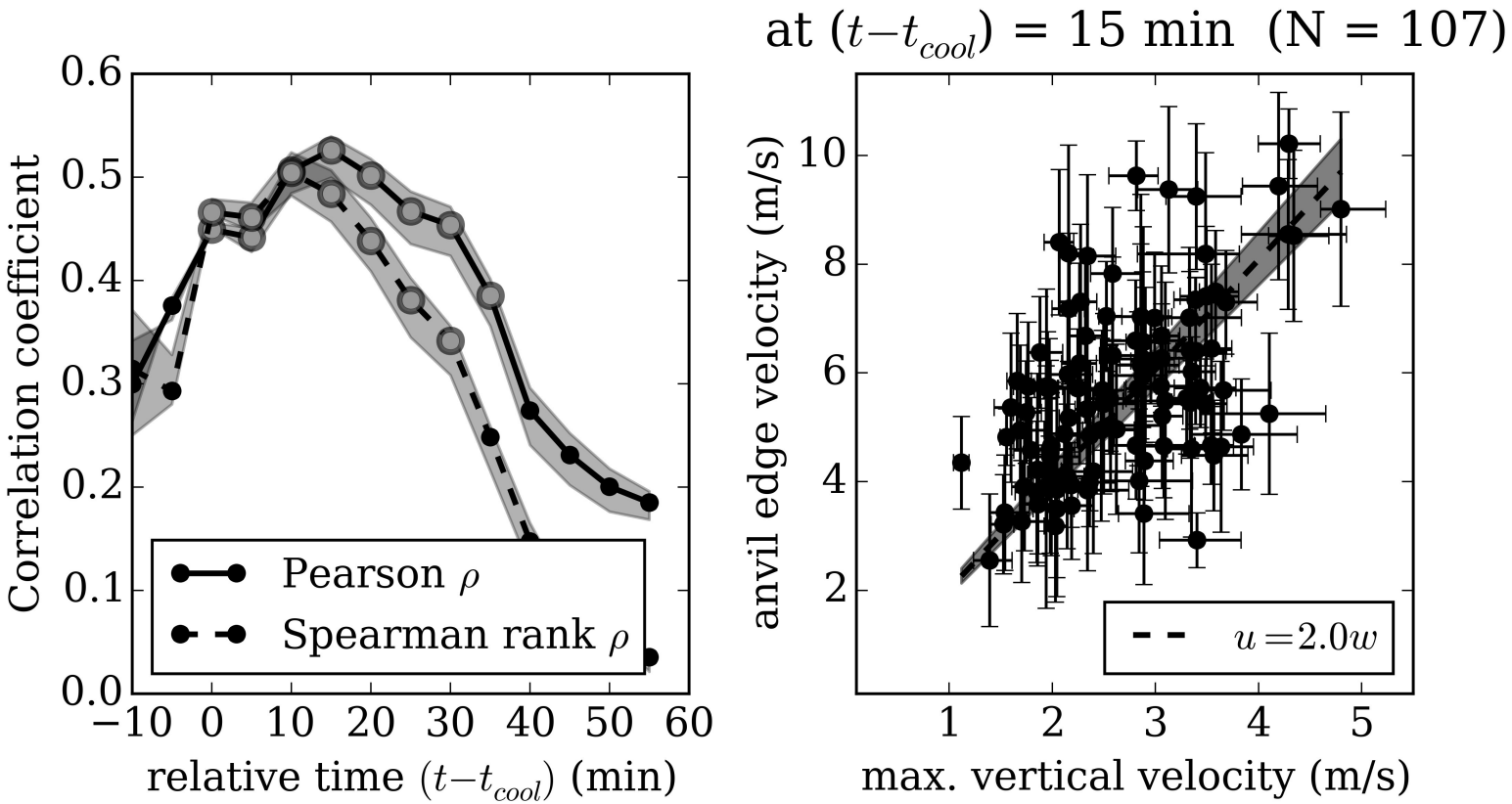


Figure: Right: Cross-correlation between max. cloud-top vertical velocity w_{max} and anvil edge velocity u_{anvil}. Left: w_{max} vs. u_{anvil} at $t - t_{cool} = 20$ min.

Cloud-top speed vs. effective particle radius

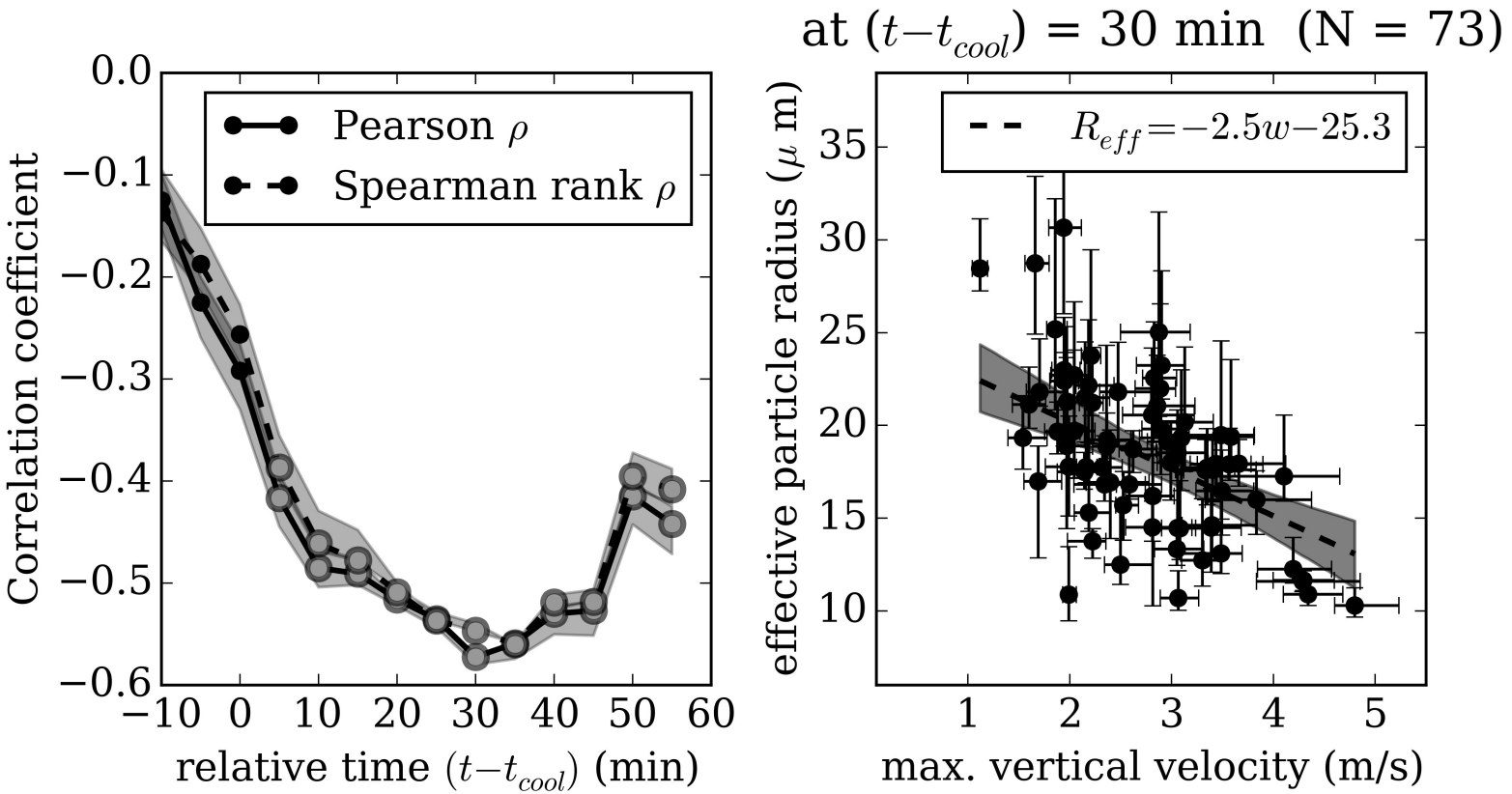


Figure: Right: Cross-correlation between max. cloud-top vertical velocity w_{max} and effective particle radius R_{eff}. Left: w_{max} vs. R_{eff} at $t - t_{cool} = 10$ min.