

# Enhance object-based thunderstorm nowcasting with the use of next-generation satellite data at DWD

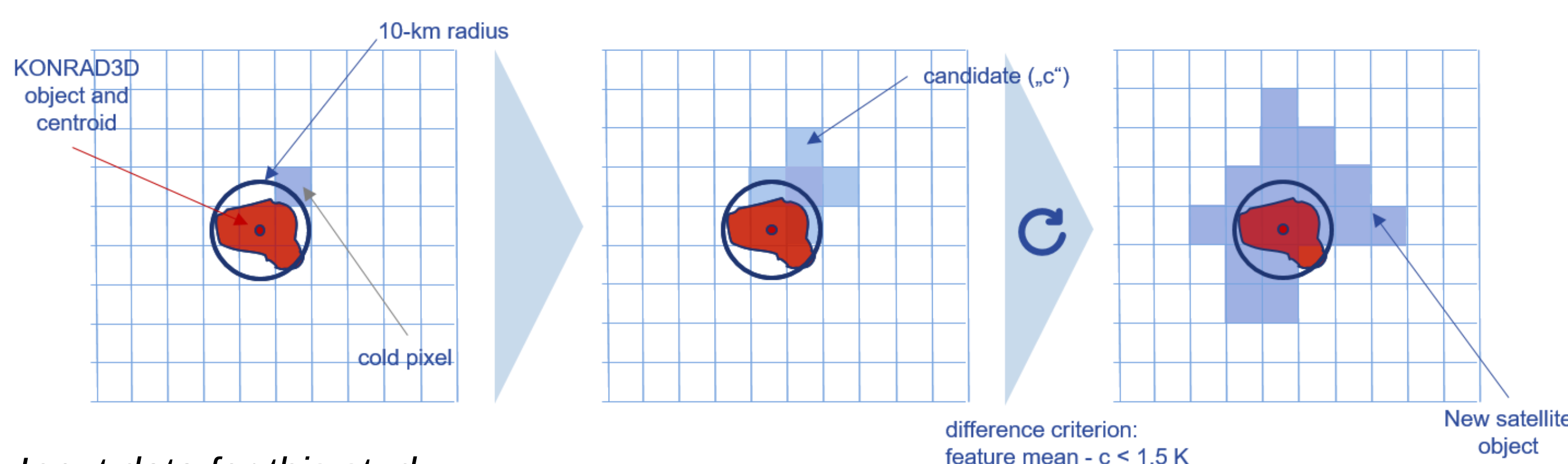
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The new Flexible Combined Imager (FCI) instrument on Meteosat Third Generation will provide an image repeat rate of 10 minutes and a spatial resolution of the up to 500m. This higher resolution compared to its predecessor, new channels and instruments on board will offer improvements for the thunderstorm nowcasting over Europe and Africa.

At Deutscher Wetterdienst, we work to incorporate satellite-based storm features to enhance the radar-based nowcasting tool KONRAD3D. We define satellite features using a region-growing algorithm seeded on the KONRAD3D centroids and calculate relevant satellite proxies for convection within these features, like cloud-top temperatures and heights.

## Region-growing algorithm

- adapted from Han et al. (2019)
- Idea: identify cold cloud area seeded on radar-based storm features (here: KONRAD3D centroids)
- for details on KONRAD3D, please visit Manuel Werner's poster (Sess. 5, P37)<sup>+</sup>



## Input data for this study

- time range: 6 - 31 August 2021 → 12 575 single detections in KONRAD3D
- satellite field: brightness temperature (10.8μm) from Meteosat Second Generation SEVIRI instrument, Meteosat Third Generation FCI not available yet

## What information are available from the satellite?

Example: cloud-top heights

93 % of the satellite-based cloud-top heights are higher than the corresponding radar-echo-top heights.

The higher cloud tops are especially common in developing lifecycle stages.

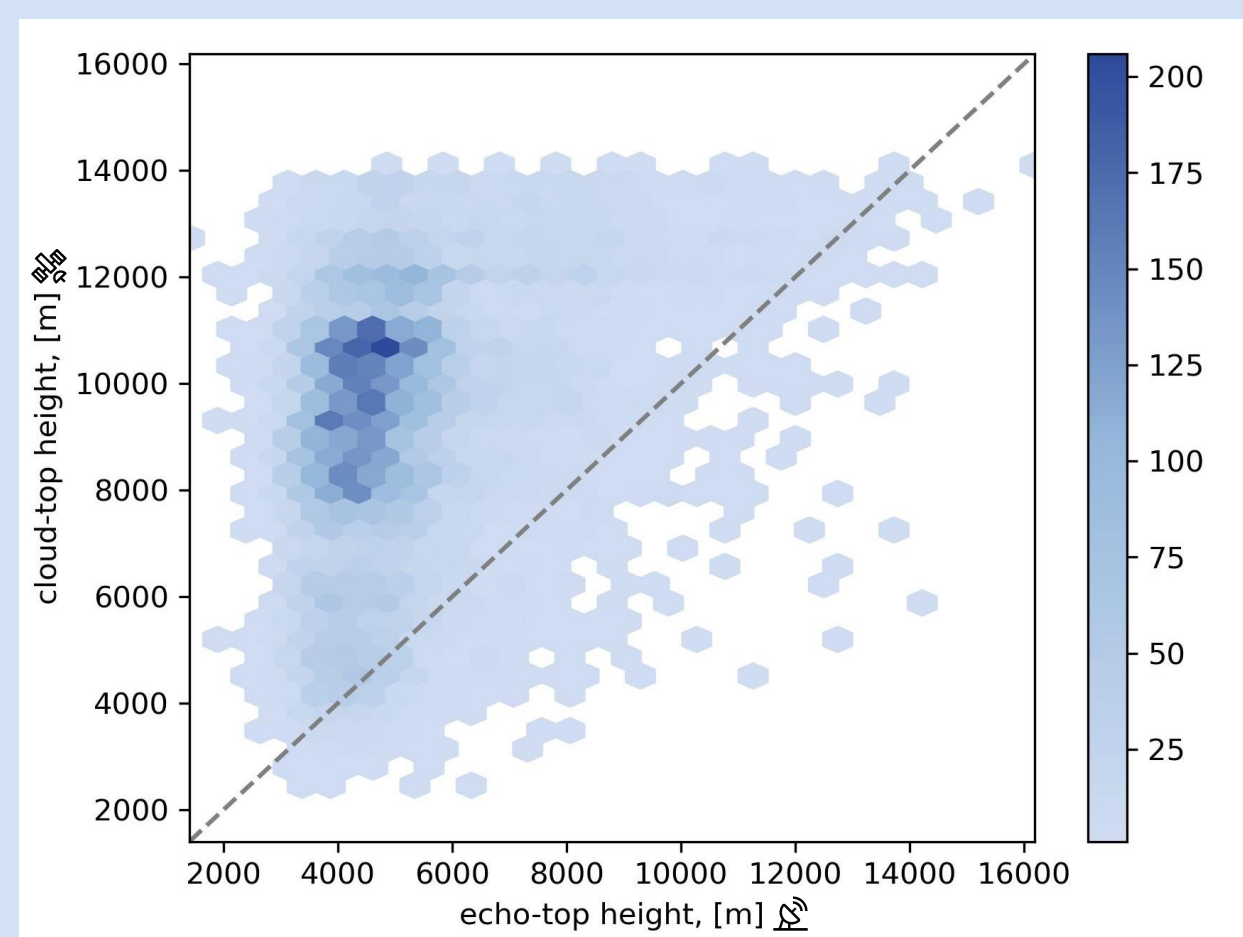


Figure: Distribution of outlier-corrected (90-th percentile) cloud-top heights from satellite calculated with the region-growing algorithm against maximum feature-based echo-top heights from radar (KONRAD3D). The counts of features within each bin are shown in color (blues).

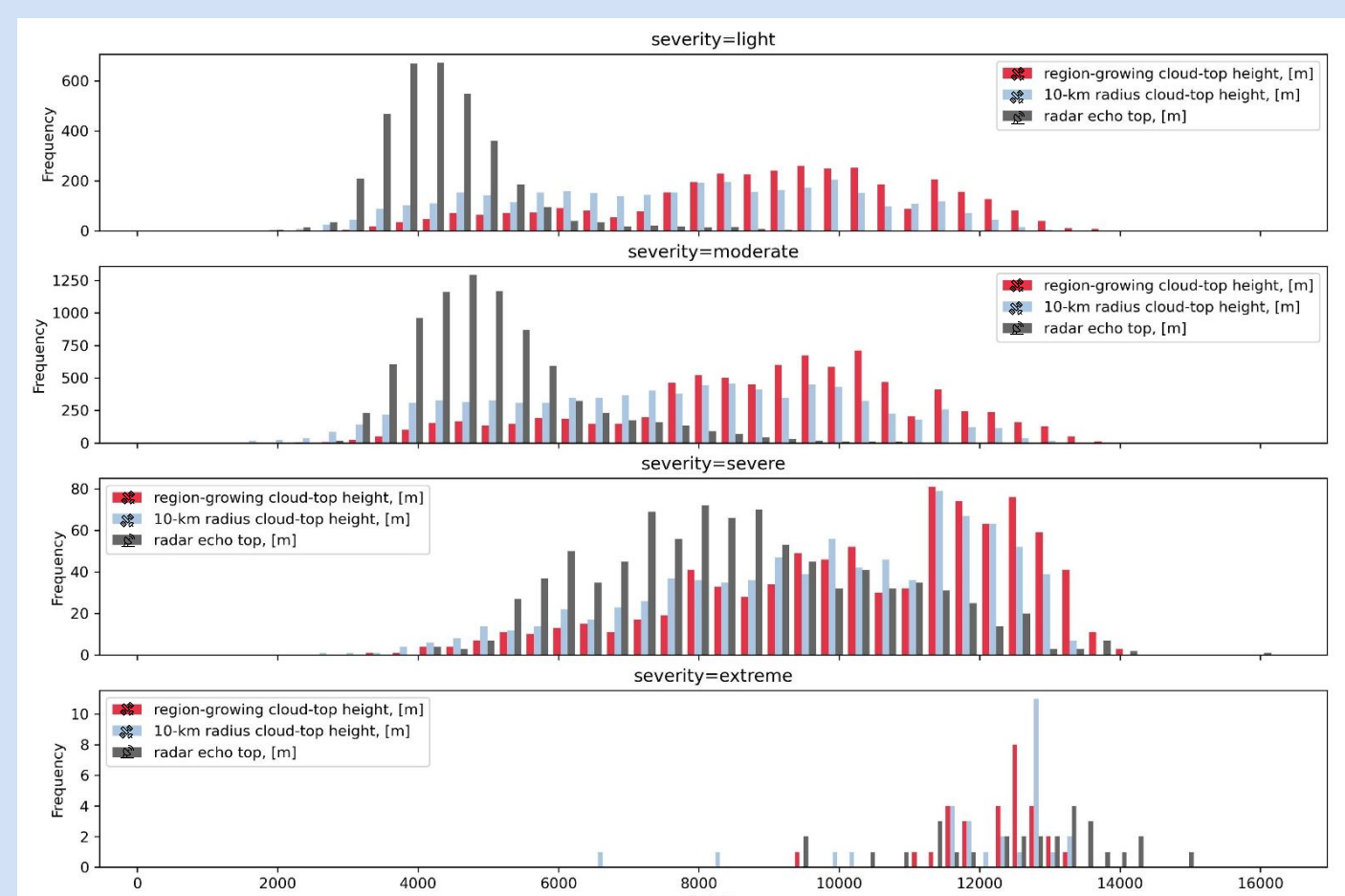
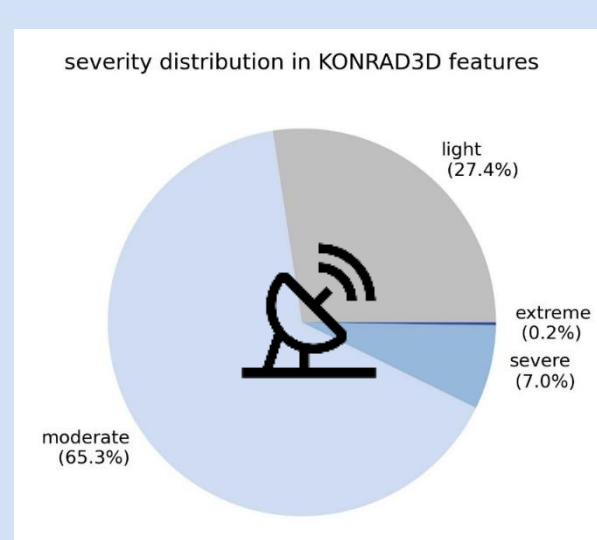
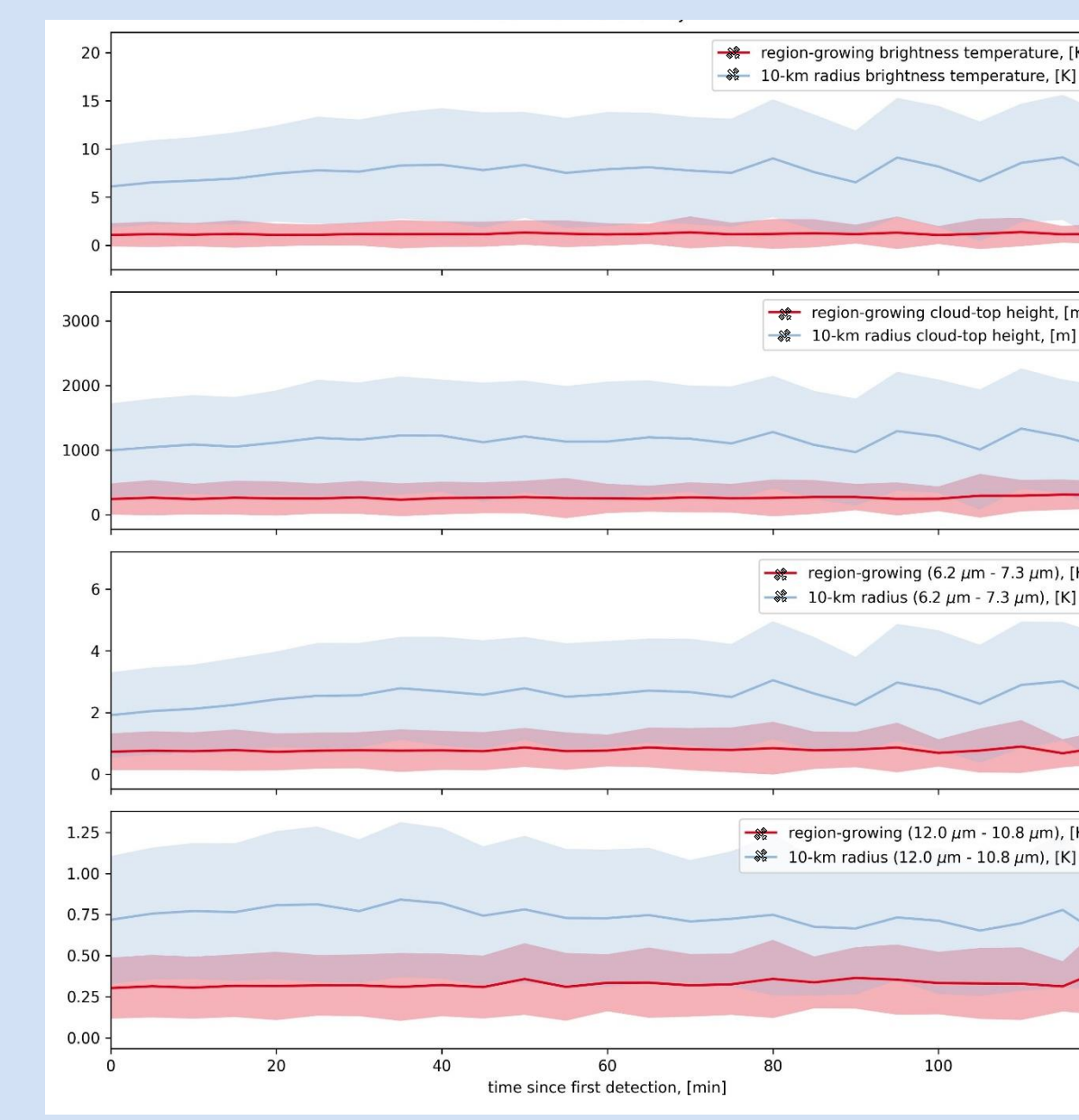
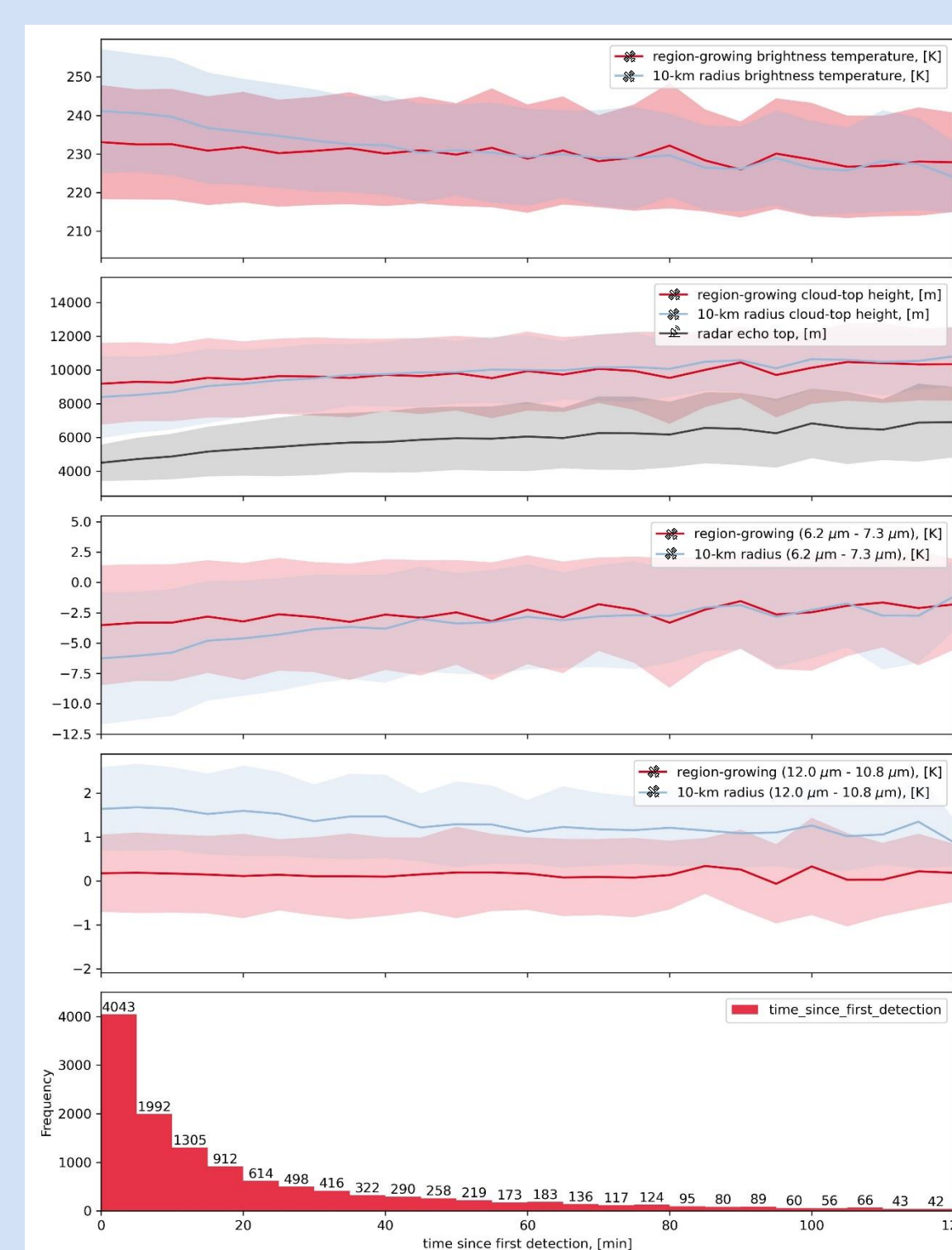


Figure: Height distribution grouped by the KONRAD3D feature severity (top to bottom: light, moderate, severe and extreme severity features). Colors define the feature detection methods: region-growing from satellite (red), 10-km radius around seed from satellite (blue) and 3D-detection from radar sweeps (KONRAD3D, grey).

## Why make it complicated when it can be easy?

Region-growing vs. 10-km radius

The split-window difference and „earlier“ detection show the biggest deviations.



Figures: left: satellite storm properties from region-growing (red), 10-km radius around the seed (blue) and 3D-detection from radar sweeps (KONRAD3D, grey) averaged in time bins of 5 minutes since first detection in radar data, shaded are spreads in the bins, the bottom panel shows bin counts; above: like on the left for the spreads within features.

## Looking at the same storm from radar and geostationary satellite?

The measurement methods (precipitation vs. radiance) and geometries of ground-based radar and geostationary satellite imager demand careful matching between features.

- › correct satellite fields for parallax-shift before detection
- › Region-growing features defined to match radar

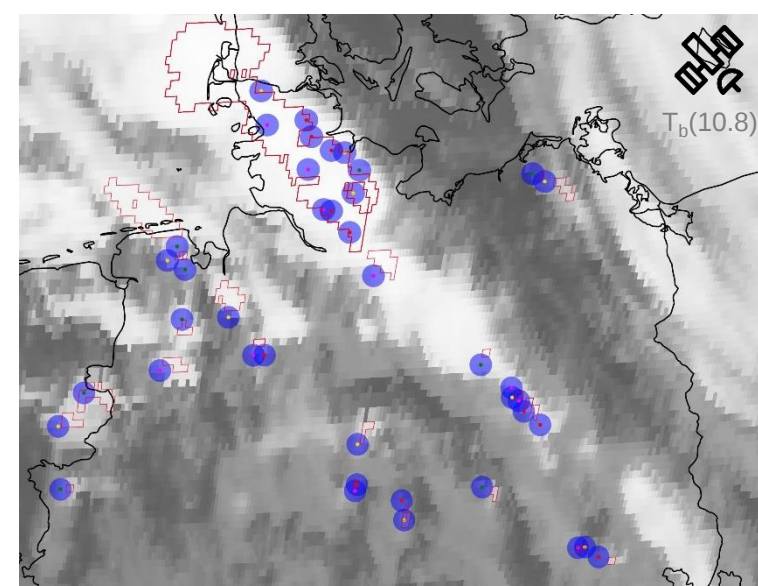


Figure: KONRAD3D centroids with 10-km radius (blue) and satellite features (red contours), 6 Aug 2021, 15:10.

## Satellite view on convection: Identify cold, high-reaching and thick clouds

The literature provides proxies to evaluate properties from geostationary satellites (see e.g. Walker et al., 2012).

| Storm property | Interest field, i.e. measured proxy ( $T_b$ = brightness temperature)                | References                                            |
|----------------|--------------------------------------------------------------------------------------|-------------------------------------------------------|
| cold           | Cloud-top temperature $T_b(10.8 \mu\text{m})$                                        | Walker et al. (2012)                                  |
| high-reaching  | Cloud-top height<br>water-vapour difference $T_b(6.2 \mu\text{m} - 7.3 \mu\text{m})$ | NWCSAF algorithm <sup>x</sup><br>Müller et al. (2018) |
| thick          | Split-window difference $T_b(12.0 \mu\text{m} - 10.8 \mu\text{m})$                   | Heidinger and Pavolonis (2008)                        |

## Conclusion

What additional information can we get from the satellite?

The cloud-top heights calculated from satellite gives significantly higher upper limits for the storms compared to the feature-based radar-echo-top height.

Do we need the complicated feature definition using region-growing?

Maybe. Differences in the statistics of satellite storm properties are small between region-growing and radius feature definition. The region-growing approach, however, delivers colder, higher and especially thicker features. In addition, the property spread within the satellite features is smaller with region-growing definition.

## Outlook

- Backtrack satellite features before radar detection into towering cumulus/convective initiation stage
- Collect additional proxies for early convection, e.g.
  - › Normalised Updraft Strength, Müller et al. (2019)
  - › trends of cloud-top properties, Jones et al. (2023)
  - › glaciation proxies, Walker et al. (2012)
- Define a data-driven model to connect properties of early convection with later radar-feature severity

## References

- <sup>+</sup> ECSS2023-150 | Posters | Session 5 Operational usage of KONRAD3D, DWD's scheme for detection, tracking, and nowcasting of convective cells Manuel Werner, Robert Feger, Lukas Josipovic, and Tim BöhmeThu, 11 May, 14:30–16:00 | Exhibition area | P37
- <sup>x</sup> Algorithm Theoretical Basis Document for the Convection Product Processors of the NWC/GEO, Nr. 1 (2022): 65. [https://www.nwcsaf.org/Downloads/GEO/2021/Documents/Scientific\\_Docs/NWC-CDOP3-GEO-MF-PI-SCI-ATBD-Convection\\_v1.0.1.pdf](https://www.nwcsaf.org/Downloads/GEO/2021/Documents/Scientific_Docs/NWC-CDOP3-GEO-MF-PI-SCI-ATBD-Convection_v1.0.1.pdf)
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