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Lightning trends and what they tell us about the thunderstorm characteristics

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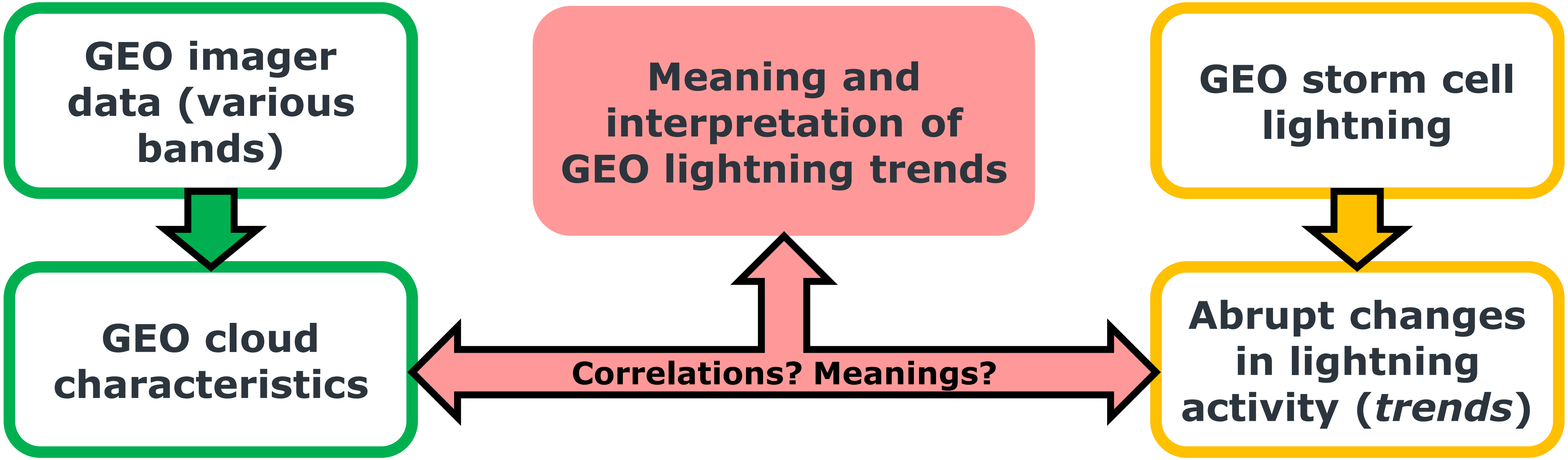
Introduction and Motivation

- **Meteosat Third Generation (MTG)** launched in December – Flexible Combined Imager (FCI) and Lightning Imager (LI)
- **Geostationary (GEO)** satellites (GOES-R series, Fengyun-4, MTG) for continuous **cloud characteristics** and **lightning locations**

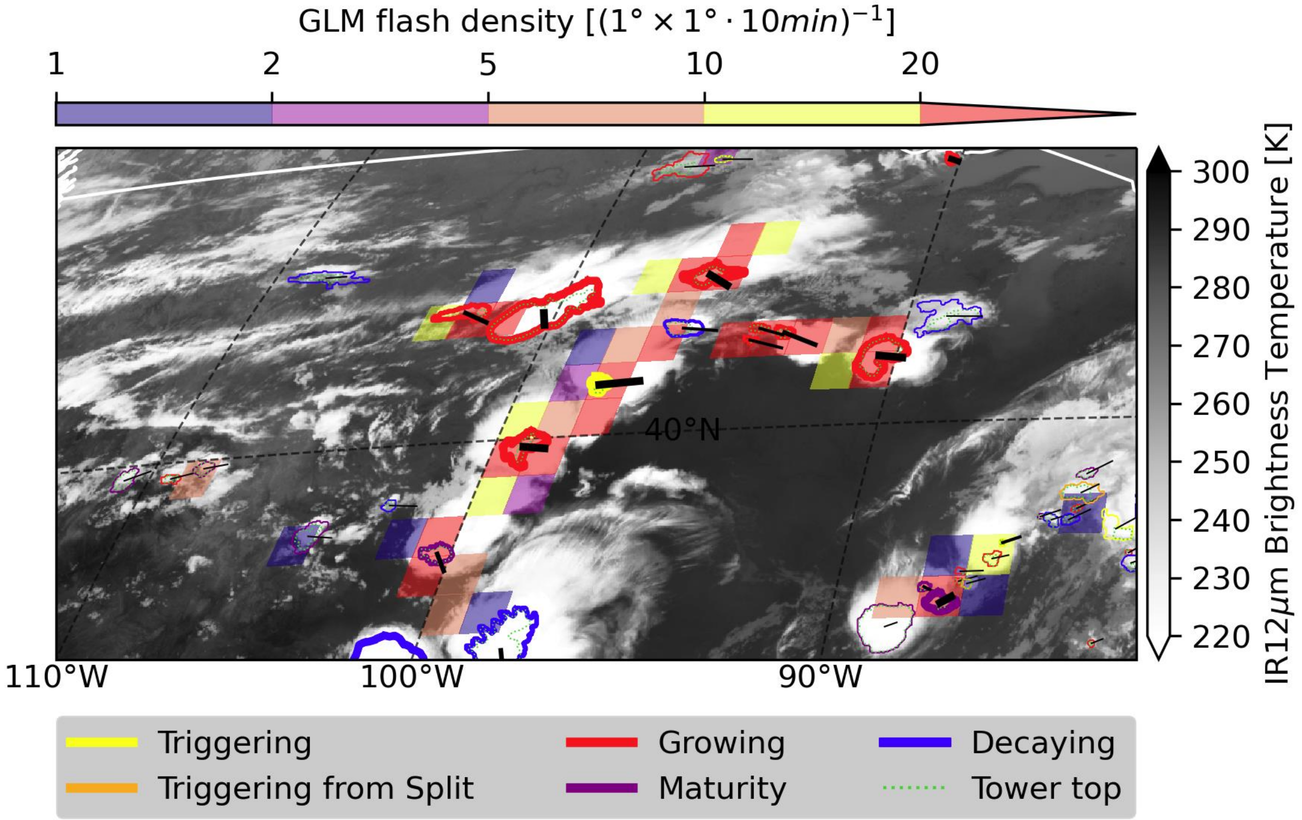


Methods

EUMETSAT NWCSAF nowcasting software

- **Nowcasting** based on satellite imagery (here GOES-16)
  - NWP data and observations, e.g., lightning records, as optional import
- Identification of cloud cells
- **Cloud cell characteristics and GEO lightning**
- **Automated storm tracking**: Rapid Developing Thunderstorm Convective Warning (RDT-CW) package

RDT-CW significant cells on top IR12 background image and GLM flash density
(2020-06-05 03:10Z-03:20Z)



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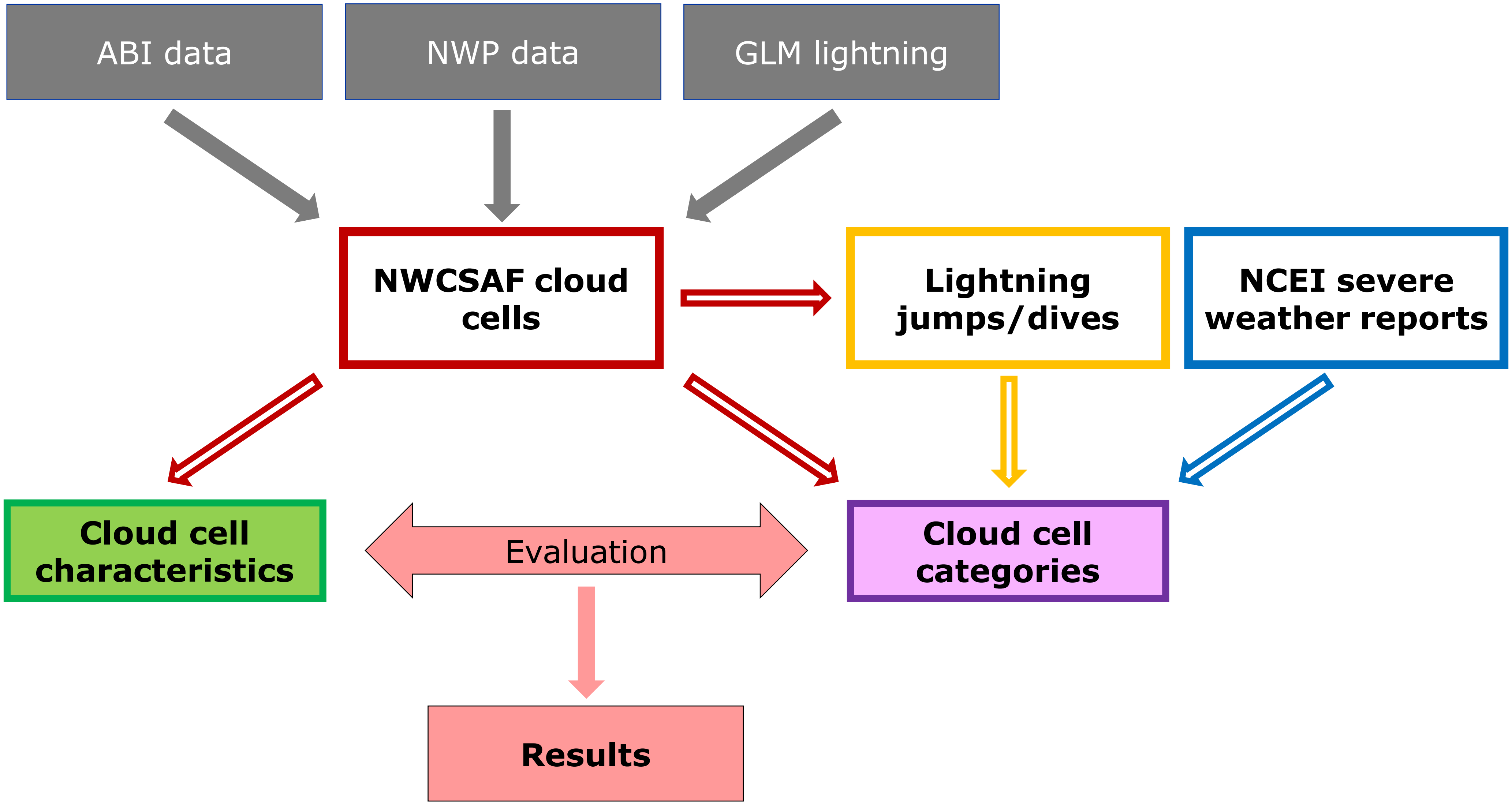
Data and methods

- 14 summer, 3 spring, and 12 winter days in 2020 and 2021 with 2.4 million cells, **about 48,000 thunderstorms** analyzed
- **GOES-16** Advanced Baseline Imager (**ABI**) and Geostationary Lightning Mapper (**GLM**) observations
- ECMWF Numerical Weather Prediction (**NWP**) data and National Centers for Environmental Information (**NCEI**) **severe weather reports**
- Automated detection of **Lightning Jumps (LJs)** / **Lightning Dives (LDs)**
- **51 cloud cell characteristics**: ABI channels and physical characteristics
- **Cloud cell categories**: distinguish cloud cells based on occurrence of GLM lightning (identify thunderstorms), NCEI reports, LJs, and LDs

Workflow

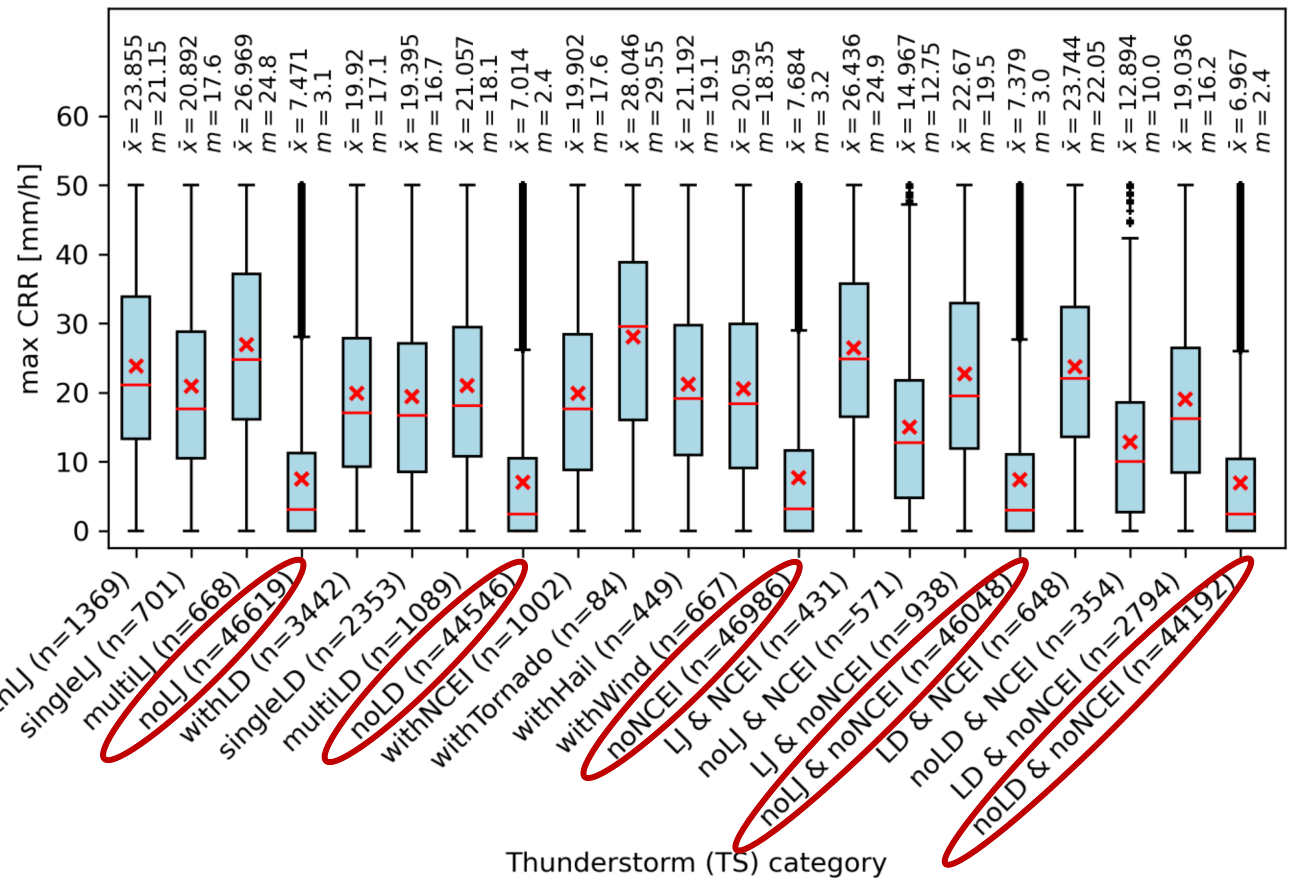

ABI data
NWP data
GLM lightning
NWCSAF cloud cells
Lightning jumps/dives
NCEI severe weather reports
Cloud cell characteristics
Evaluation
Cloud cell categories
Results

Results overall
- Storm categories

Ex.: Max convective rain rate (CRR)

- Comparison of **thunderstorm** categories
- **High CRR** most likely for cloud cells with **LJs, LDs and/or severe weather events**
- LJ/LD count with low correlation to max CRR

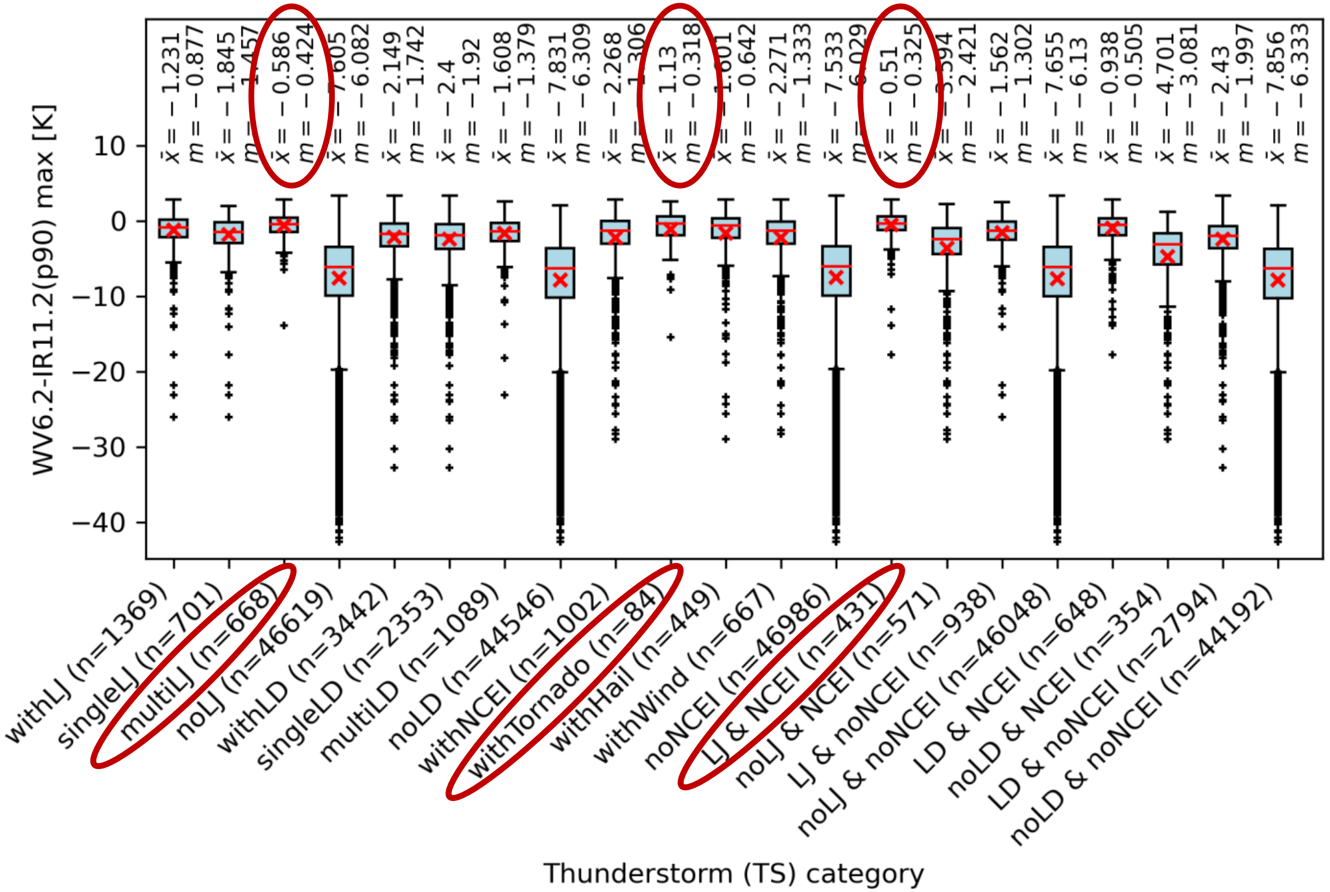
Fig.: Maximum estimated CRR during the cell lifecycle for thunderstorm cell categories. $\bar{x}$ shows the mean, m the median for each category.



Ex.: WV6.2-IR11.2 (trajectory max of cell 90th percentiles)

- Brightness temperature difference (BTD)
- WV6.2: upper troposphere WV (~340mb)
- IR11.2: cloud top height
- **small negative values and positive values mean high cloud tops in moist upper troposphere**

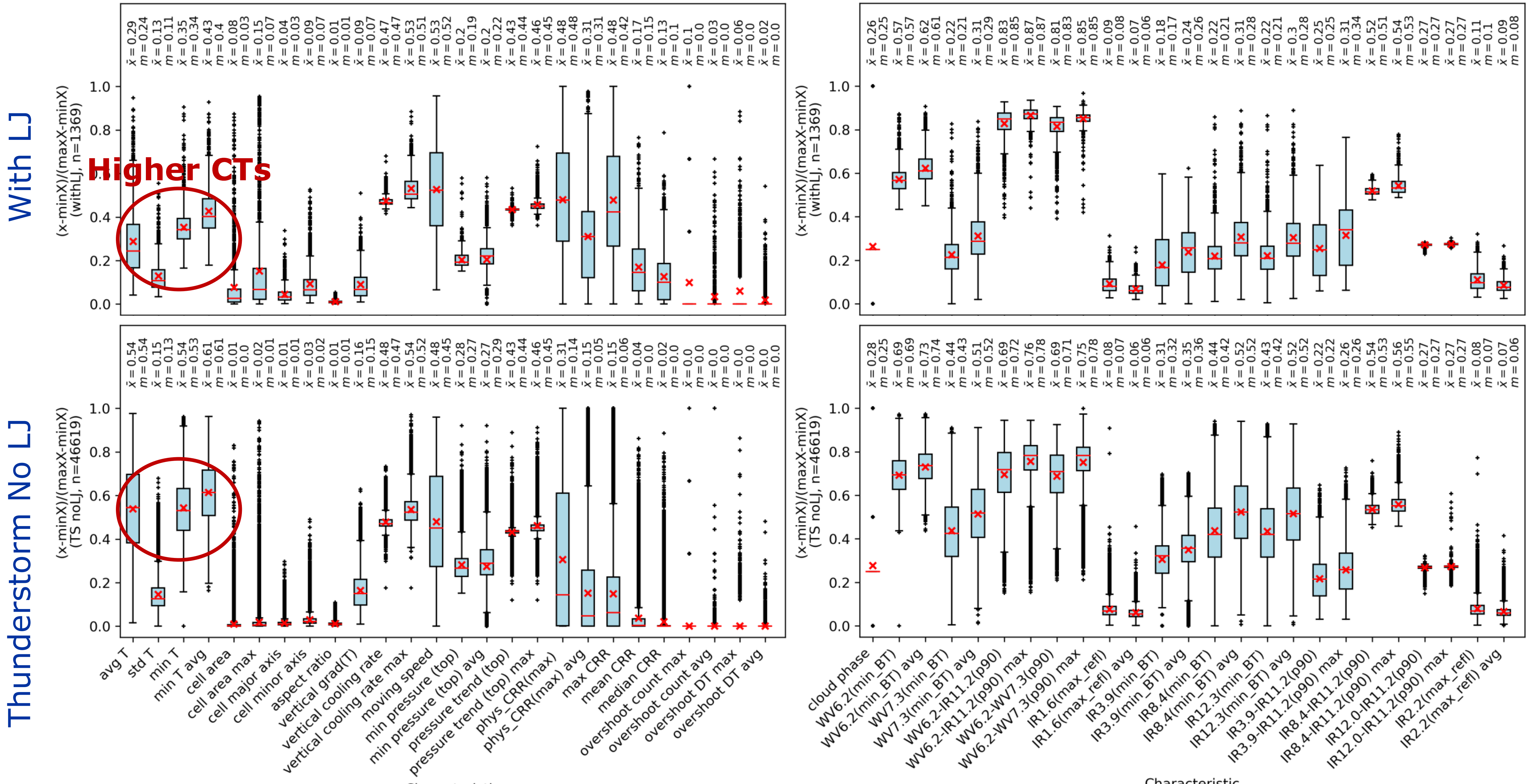
Fig.: Brightness temperature difference (BTD) of WV6.2-IR11.2. The maximum of the 90th percentiles BTD for each time step during the cloud cell lifecycle for thunderstorm cell categories. $\bar{x}$ shows the mean, m the median for each category.



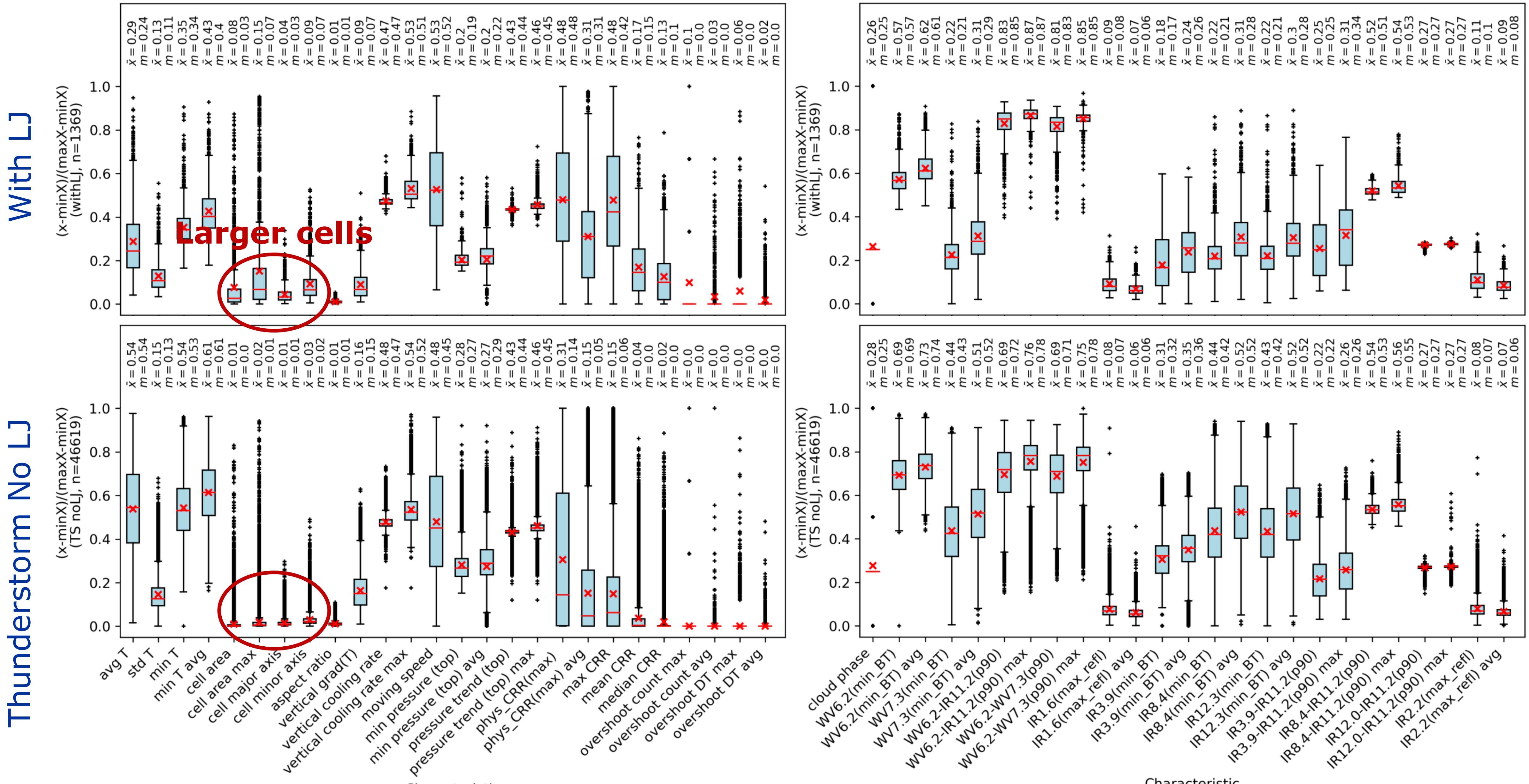
Results details – LJs

- Normalized characteristics: **range 0 to 1**
- Normalization based on overall minimum and maximum
  → **compare different categories**

Cloud cell characteristics – LJ vs no LJ



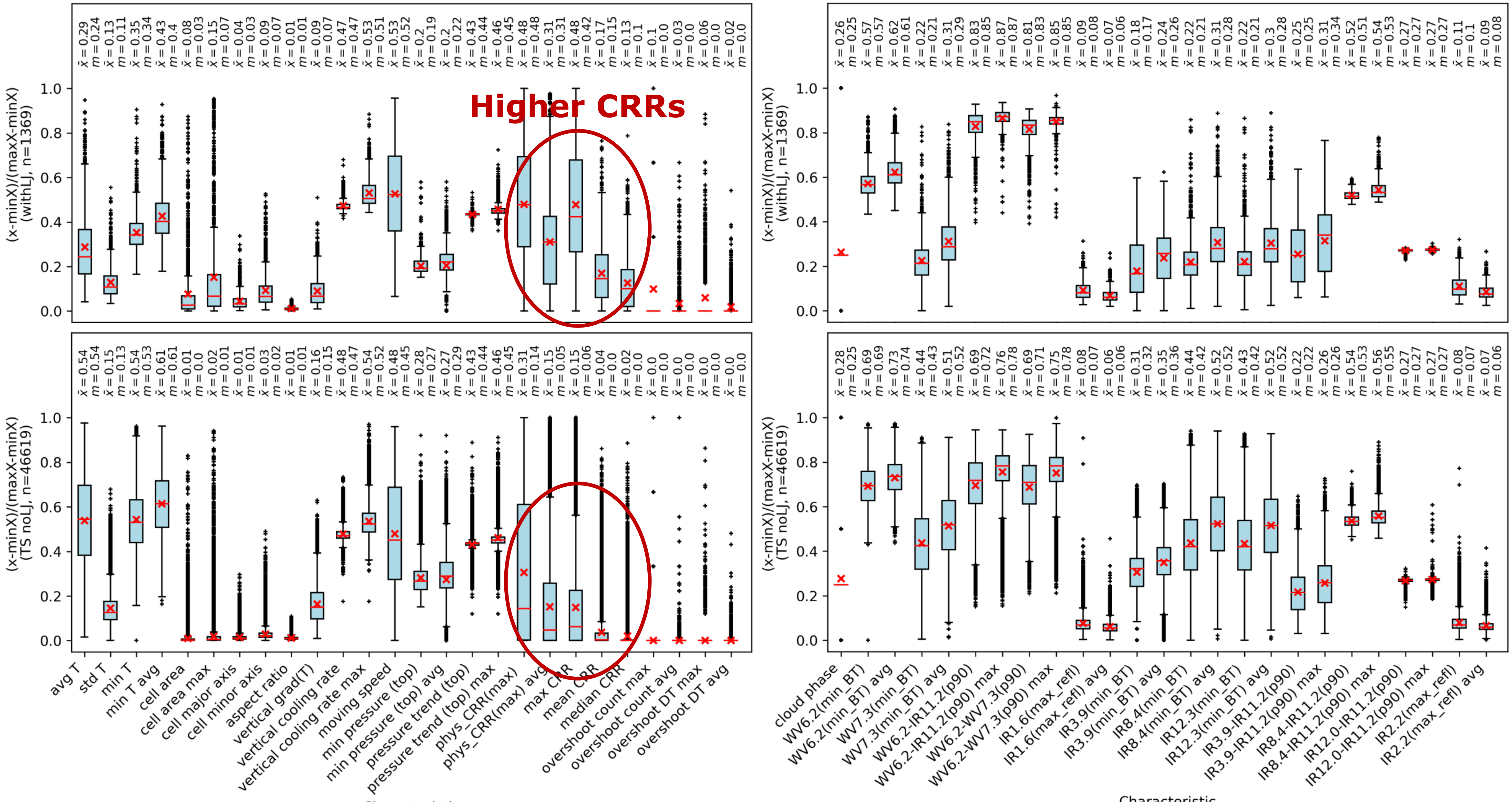
Cloud cell characteristics – LJ vs no LJ



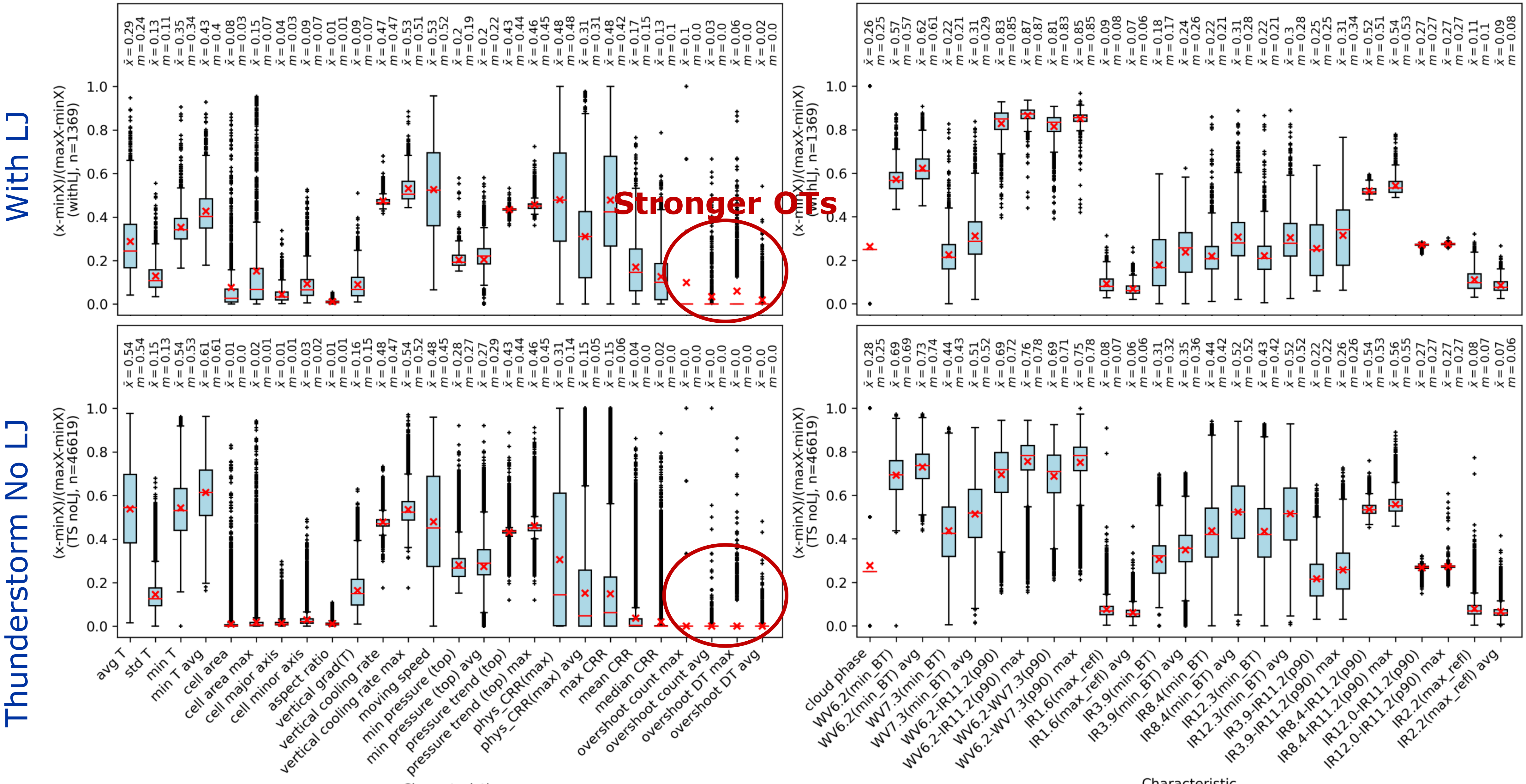
Cloud cell characteristics – LJ vs no LJ

With LJ

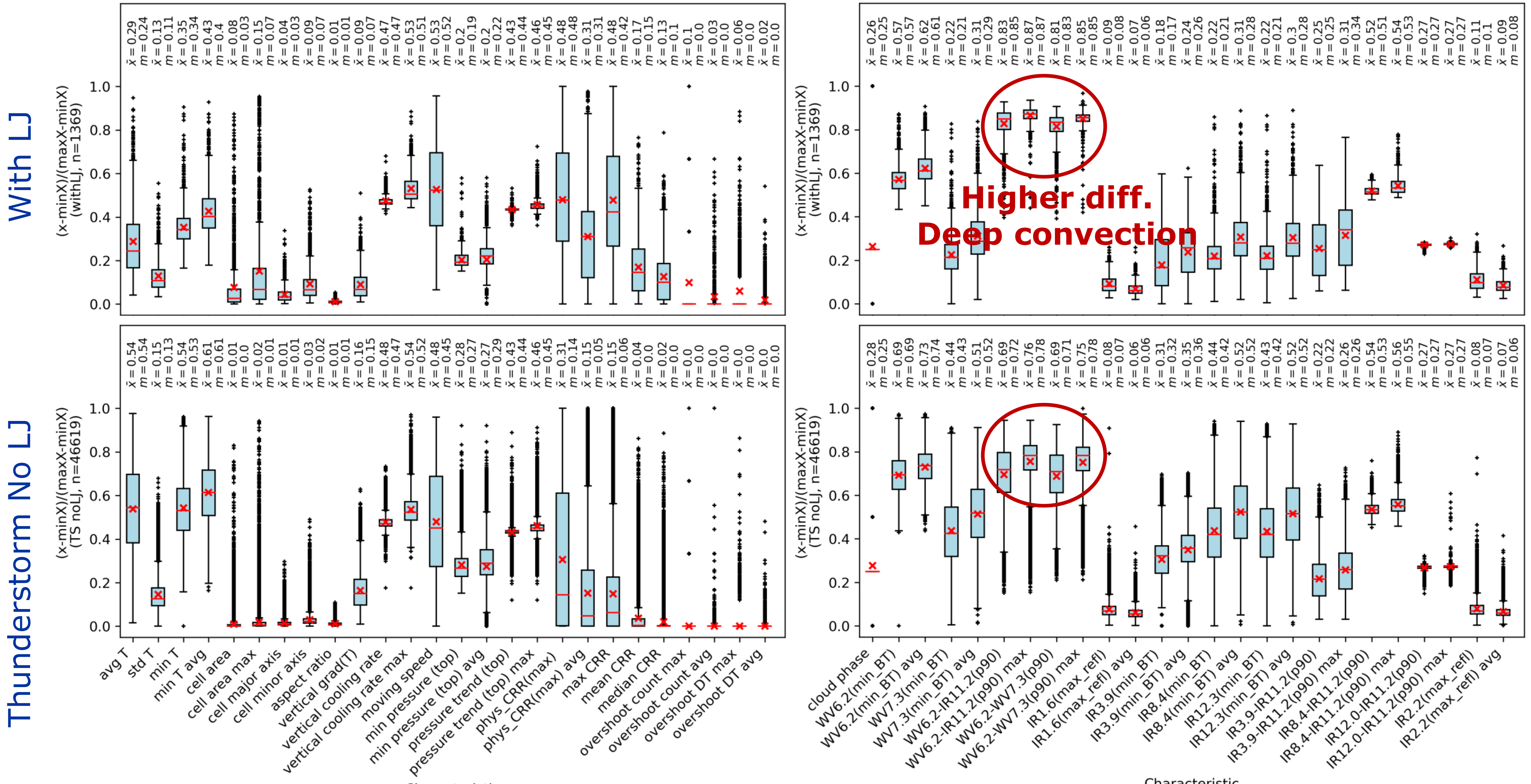
Thunderstorm No LJ



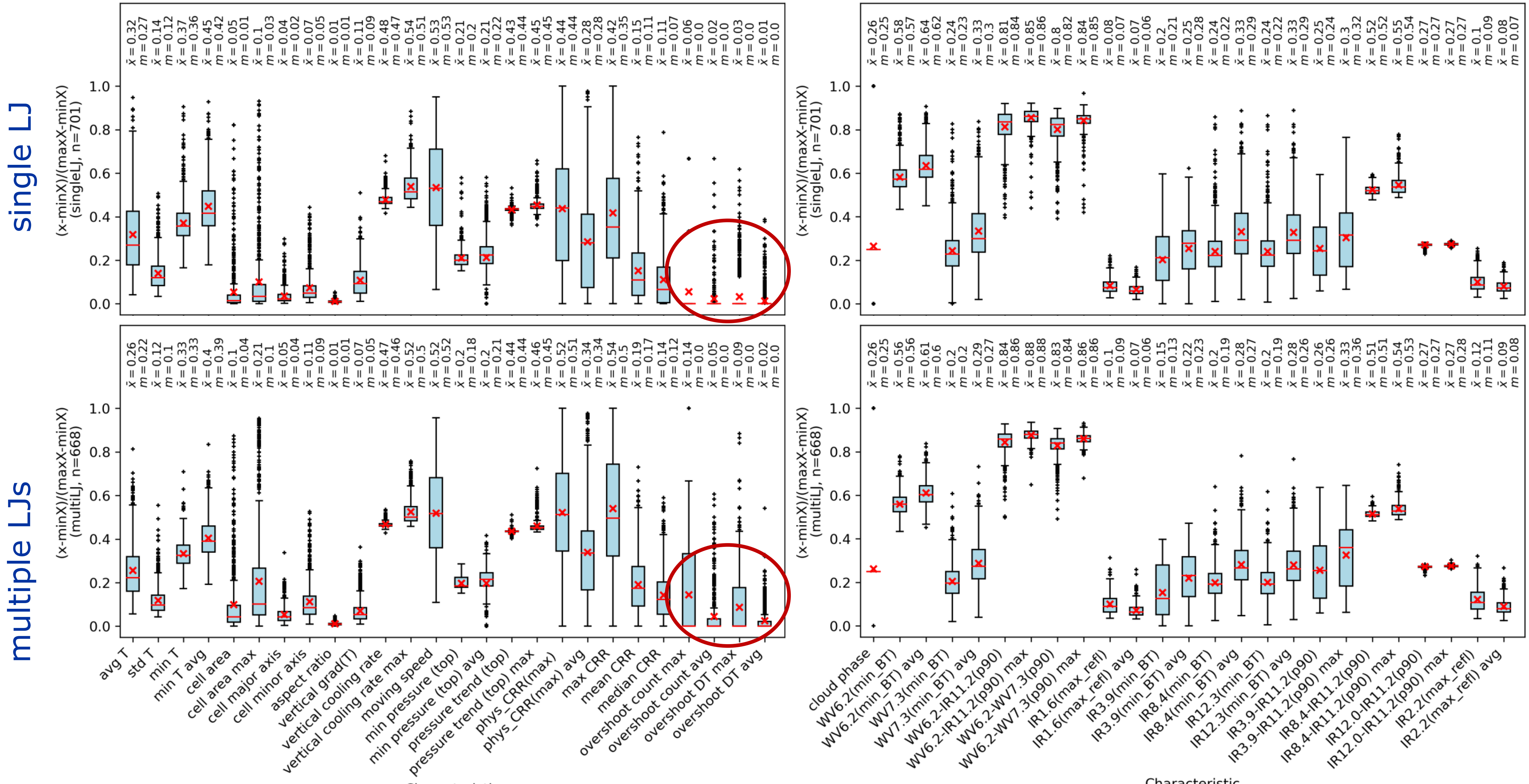
Cloud cell characteristics – LJ vs no LJ



Cloud cell characteristics – LJ vs no LJ



Single LJ vs multiple LJs



Summary

- Cloud cell categorization through GLM lightning trends (LJs, LDs) and NCEI severe weather reports
- Satellite-based physical cloud cell characteristics
- **LJs, LDs**: Indication of well organized, **deep convection, high rain rates**
- **Multiple LJs**: Above-average overshooting top count and strength → **correlation with updraft strength**
- Cloud cells with **LJs** and/or **LDs**: similar characteristics as cloud cells that produced **severe weather**
- **Next:** Summer/winter difference (?), paper on recent results

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THANK YOU

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