Revisiting sensitivity to horizontal grid spacing in convection-allowing models over the central–eastern United States using a large dataset

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Background and motivation

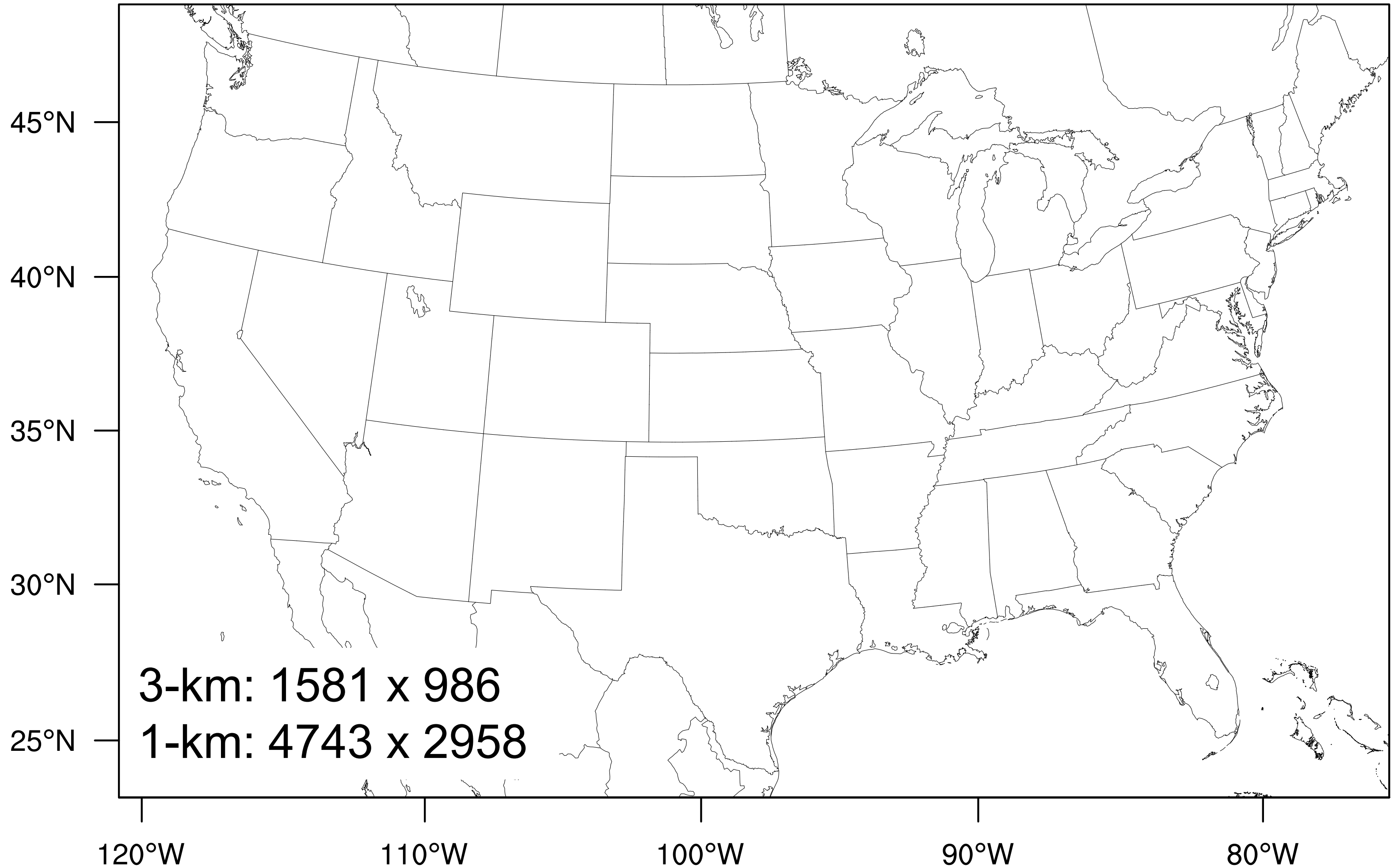
- There is still ambiguity about resolution requirements over the central–eastern CONUS for next-day forecasts
  - Several studies suggested 4-km forecasts were comparable to 1- and 2-km forecasts
  - But, a few suggested *improvements* from 1-km grid spacing

- Could relatively small sample sizes have anything to do with discrepancies?
  - 20–40 cases common in previous CONUS studies

We ran 497 corresponding 3- and 1-km forecasts

Computational domain

- 36-h forecasts, GFS initial and boundary conditions

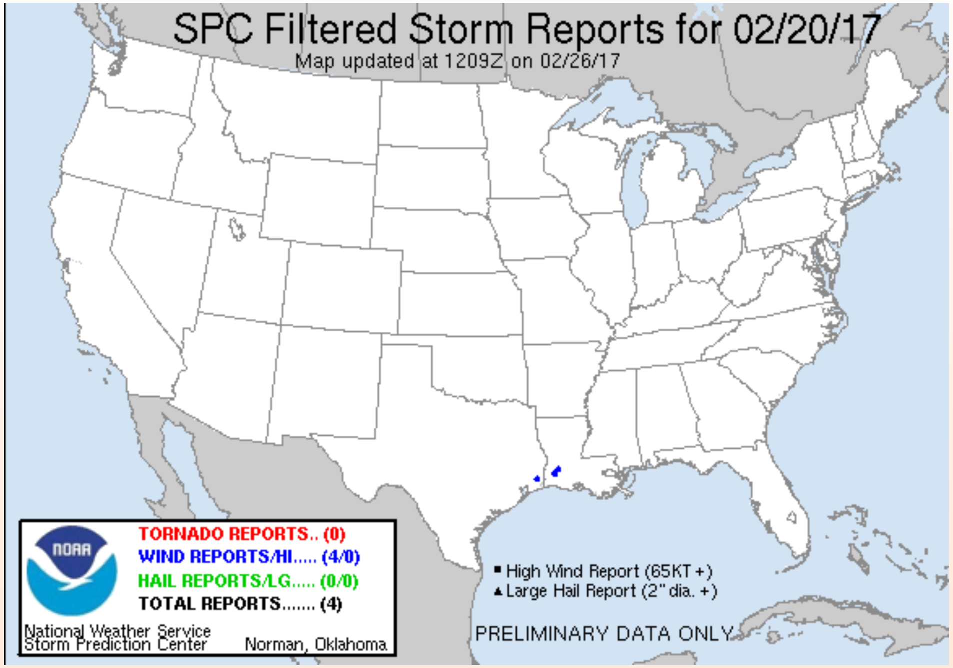


WRF settings and physics

- Forecast model: WRF-ARW (version 3.6.1)
- 40 vertical levels, 50-hPa top
- Physics (*basically 'CONUS' physics suite*)
  - Thompson microphysics
  - RRTMG longwave and shortwave radiation
  - MYJ PBL
  - NOAH land surface model
  - Aerosol, ozone climatologies for RRTMG
- 3- and 1-km forecasts identical except for grid spacing and time step

Case selection

- Cases drawn from SPC severe weather event archive
  - Inclusion in archive based on many criteria
- Produced 3- and 1-km forecasts for all events in archive between Mar 15 and July 15 each year for 2011–2016
- Subjectively selected cool season events
  - Focused on events with more storm reports



Seasons and case distribution

- Spring: Mar 15 – Jun 14 (279 forecasts)
- Summer: Jun 15 – July 15 (140 forecasts)
- Cool season: Oct 15 – Mar 14 (78 forecasts)

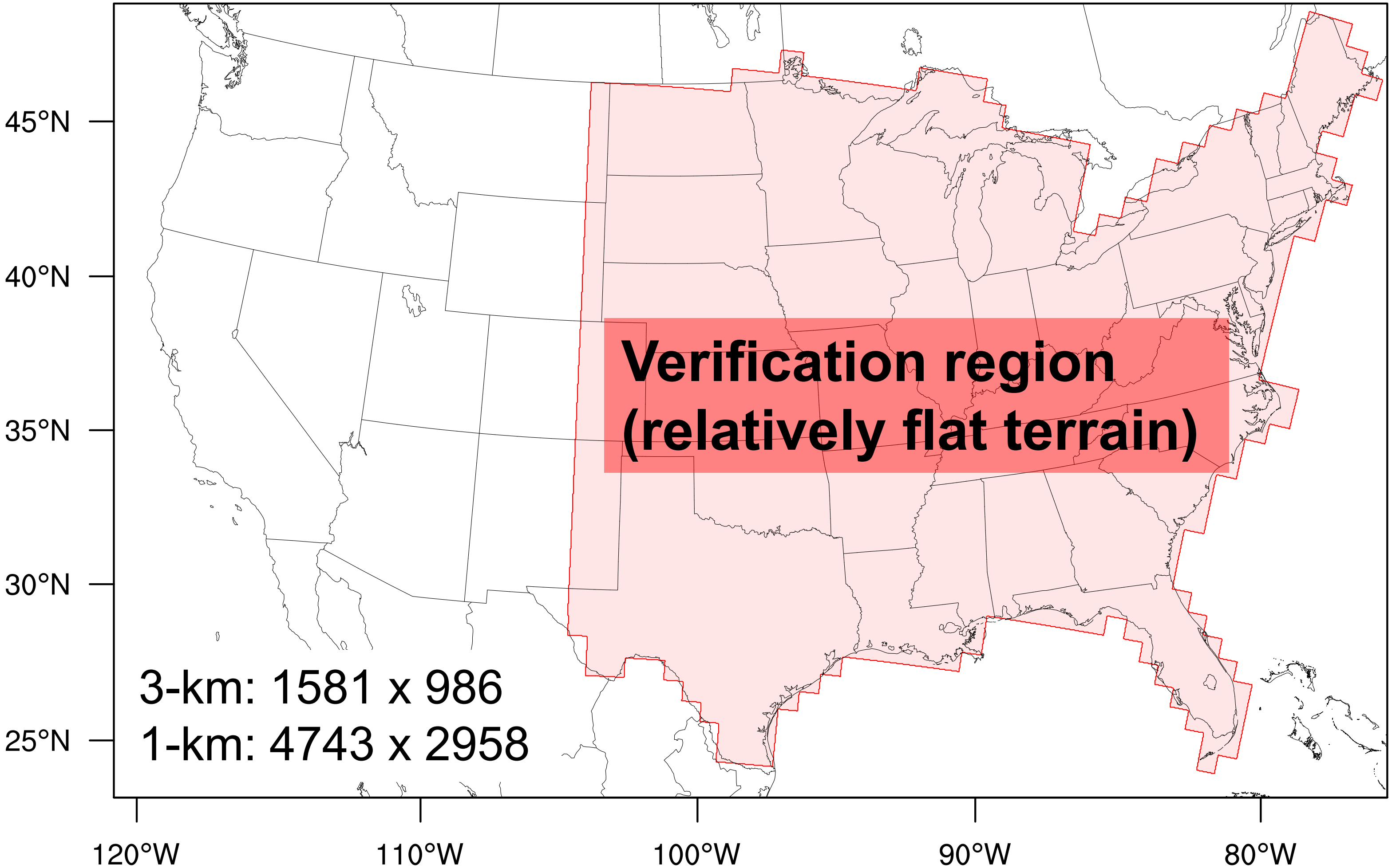
497 total forecasts

Verification

- Focus on 1-h accumulated precipitation from "next-day" 18–36-h forecasts
  - Avoided the spin-up period
- NCEP Stage IV observations as "truth"
- Fractions skill score (FSS) quantifies displacement errors
  - Uses a neighborhood approach (*r* denotes neighborhood length scale)
- Bootstrap resampling to assess statistical significance

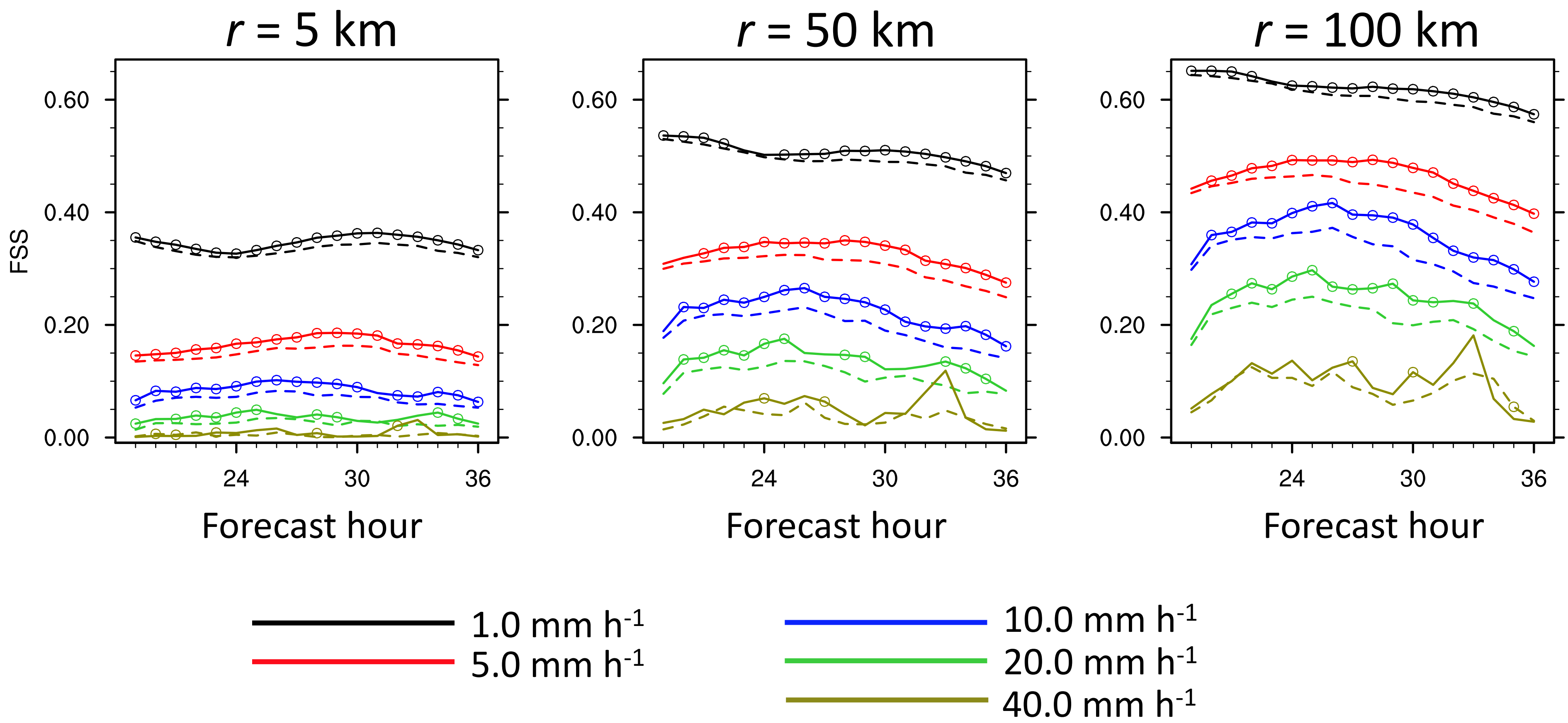
Verification domain

- 36-h forecasts, GFS initial and boundary conditions



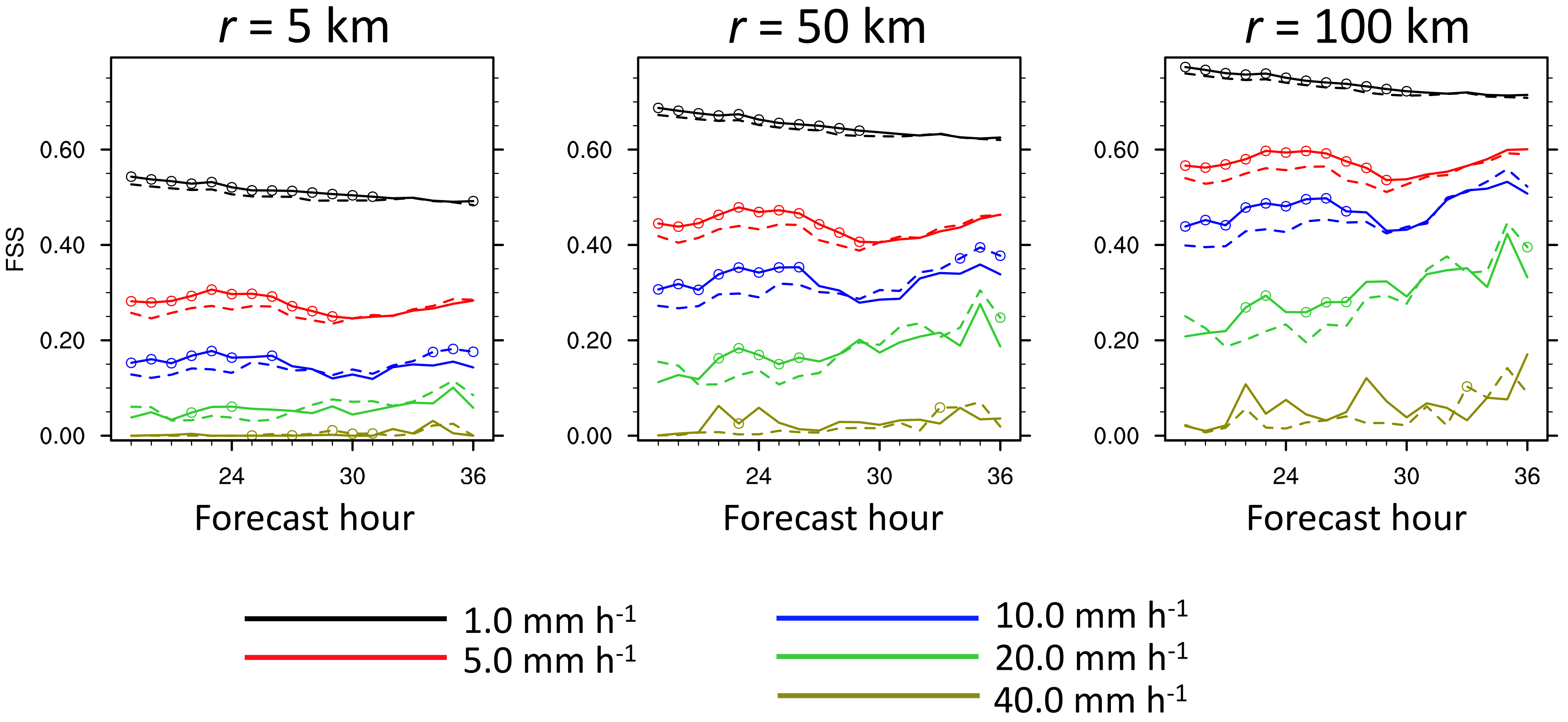
Spring FSSs

- Dashed: 3-km, Solid: 1-km (279 forecasts)



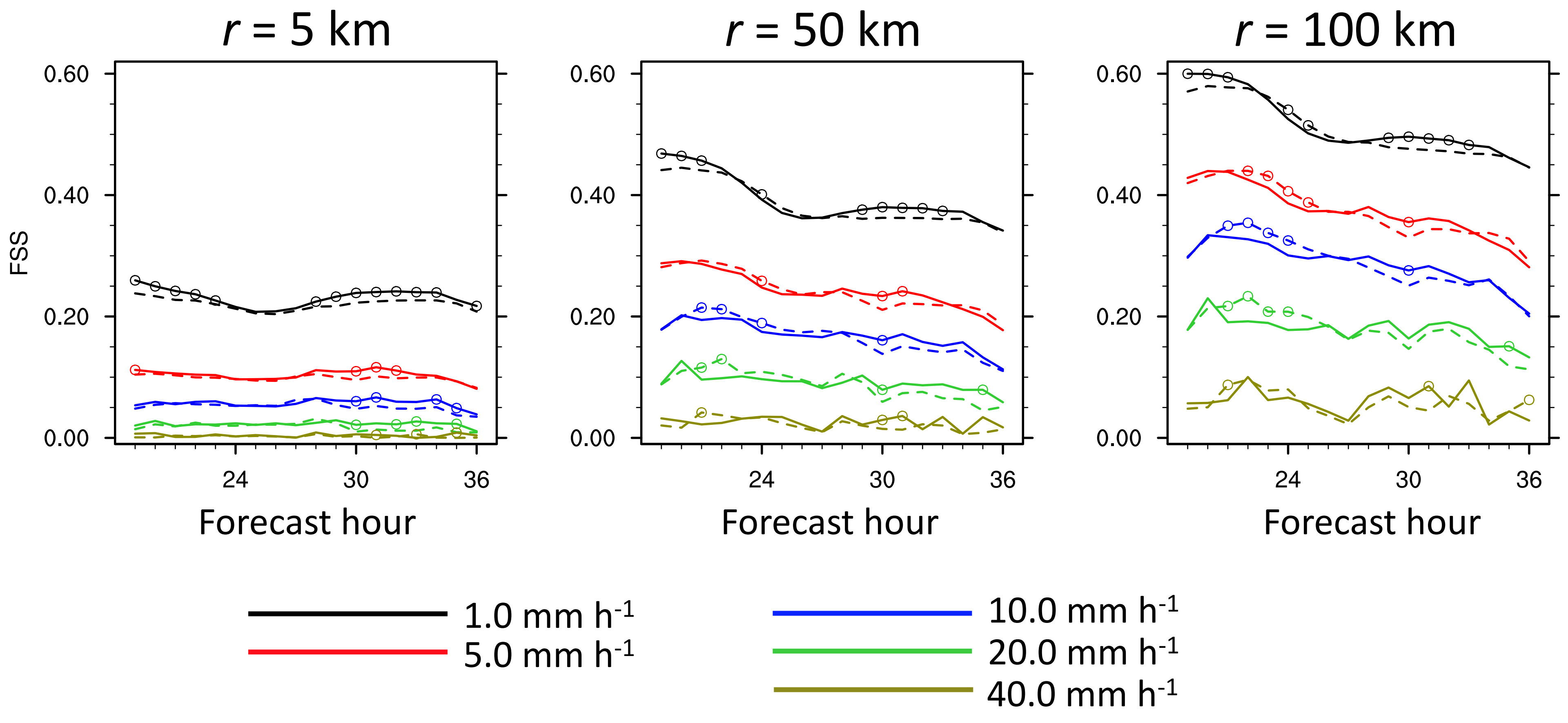
Cool season FSSs

- Dashed: 3-km, Solid: 1-km (78 forecasts)



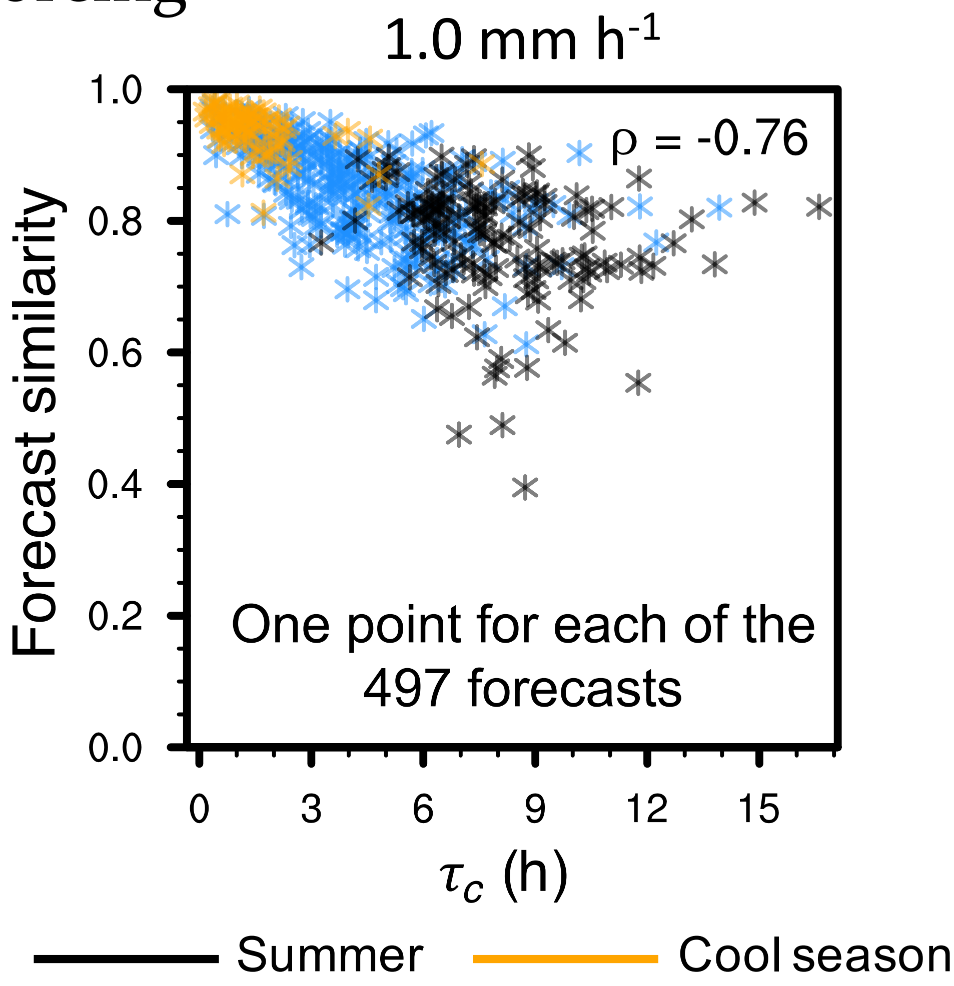
Summer FSSs

- Dashed: 3-km, Solid: 1-km (140 forecasts)

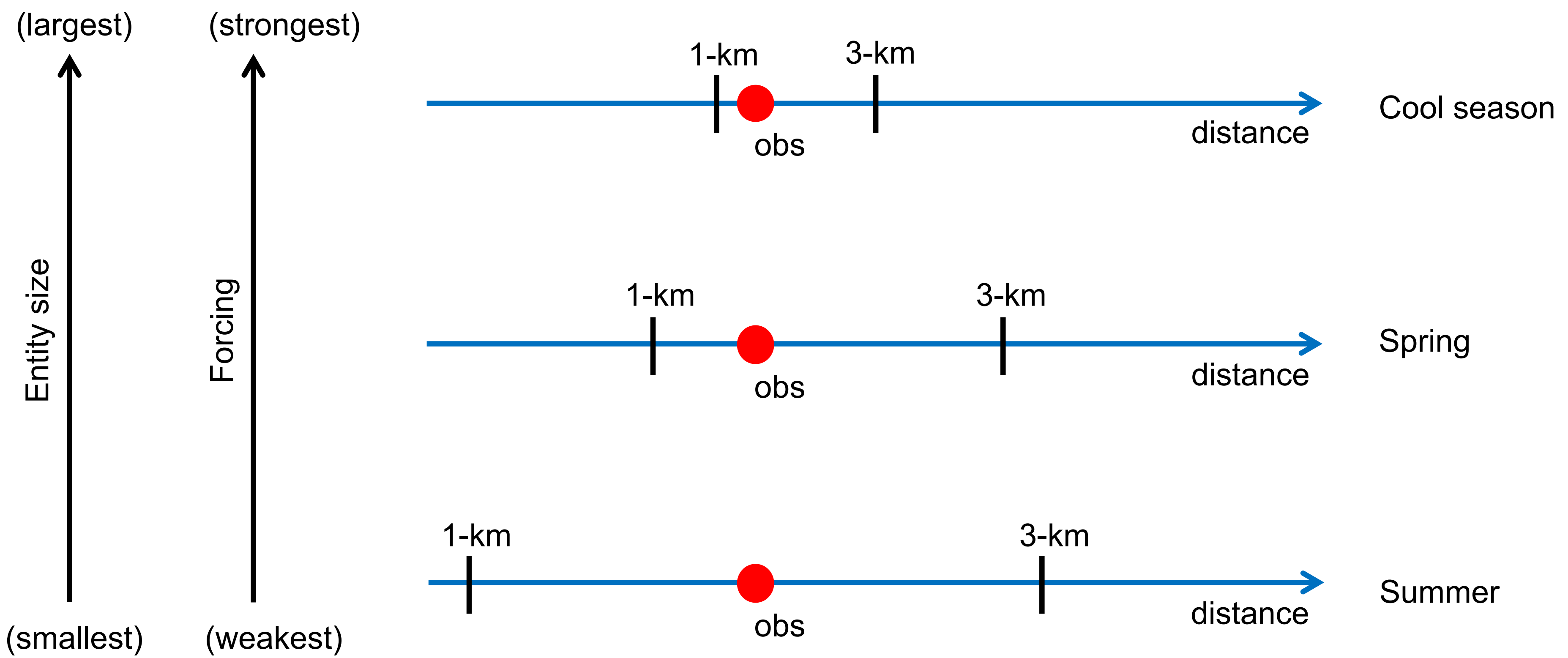


Forecast similarity and convective adjustment time scale

- Convective adjustment time scale (τ_c): CAPE/(1-h precip)
- Bigger values mean weaker forcing
- *y* axis: FSS for 3- and 1-km forecasts *compared to each other*, using *r* = 100 km, aggregated over 18–36-h forecasts; forecast similarity



Synthesis



- By 18 h into a high-resolution forecast, predictability is lost on scales < 200 km
  - If something is unpredictable, finer grid spacing won't help

Other findings

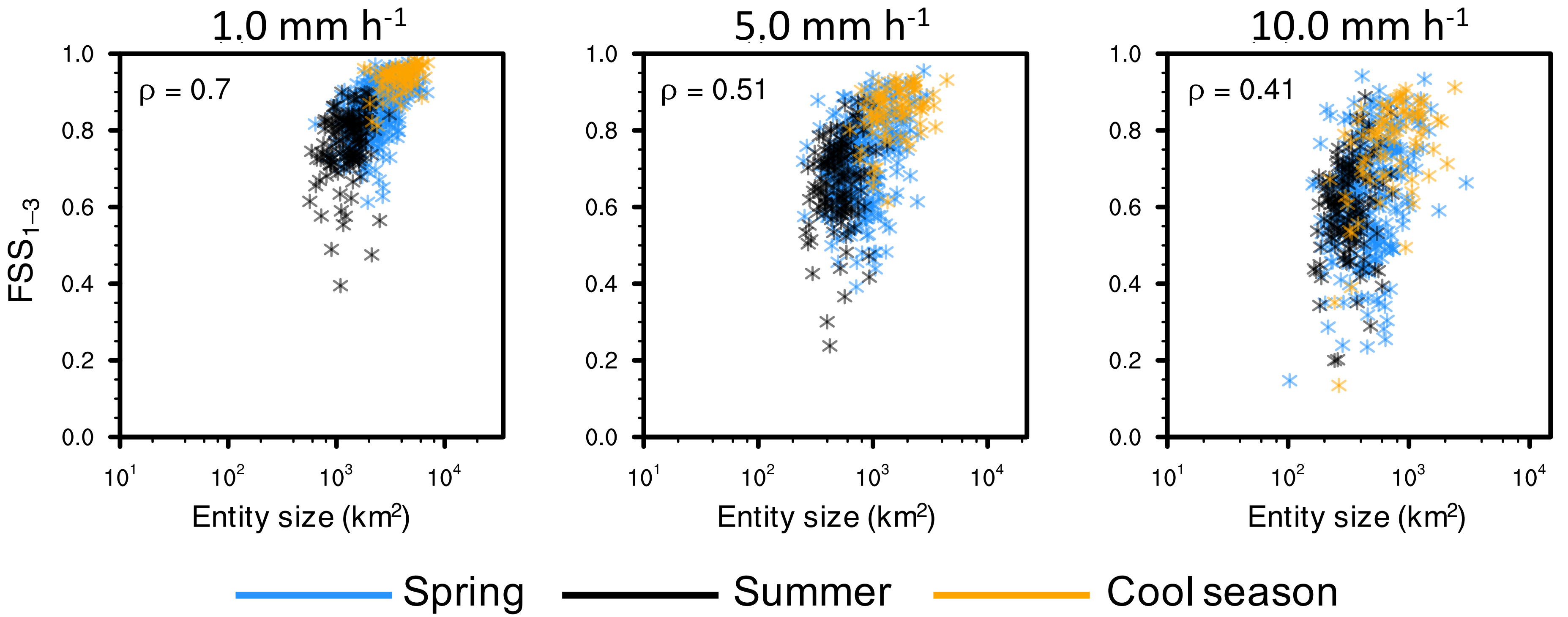
- Precipitation biases varied regionally and seasonally
- Relative 3- and 1-km forecast skill varied regionally
  - Biggest benefit from 1-km over regions with higher CAPE, larger storm sizes
- Tornado forecasts improved in 1-km forecasts
  - Better representation of low-level rotation
  - Not because of better placement of features
  - See Sobash et al. (2019; WAF early online release)

Summary

- Evidence 1-km forecasts have benefits over 3-km forecasts during spring
- Springtime results differ from much previous work
  - Sample size differences probably not the reason
  - Model upgrades/improvements probably not the reason
- Improved initial conditions in this study may have led to differences compared to previous work
  - Primarily "hybrid" analyses; previous studies used 3DVAR ICs
  - More work needed to understand how analysis quality may impact forecast sensitivity to horizontal grid spacing

Forecast similarity and entity size

- An "entity": contiguous area of precipitation exceeding a threshold (basically an object)



- *y* axis: FSS for 3- and 1-km forecasts *compared to each other*, using *r* = 100 km, aggregated over 18–36-h forecasts

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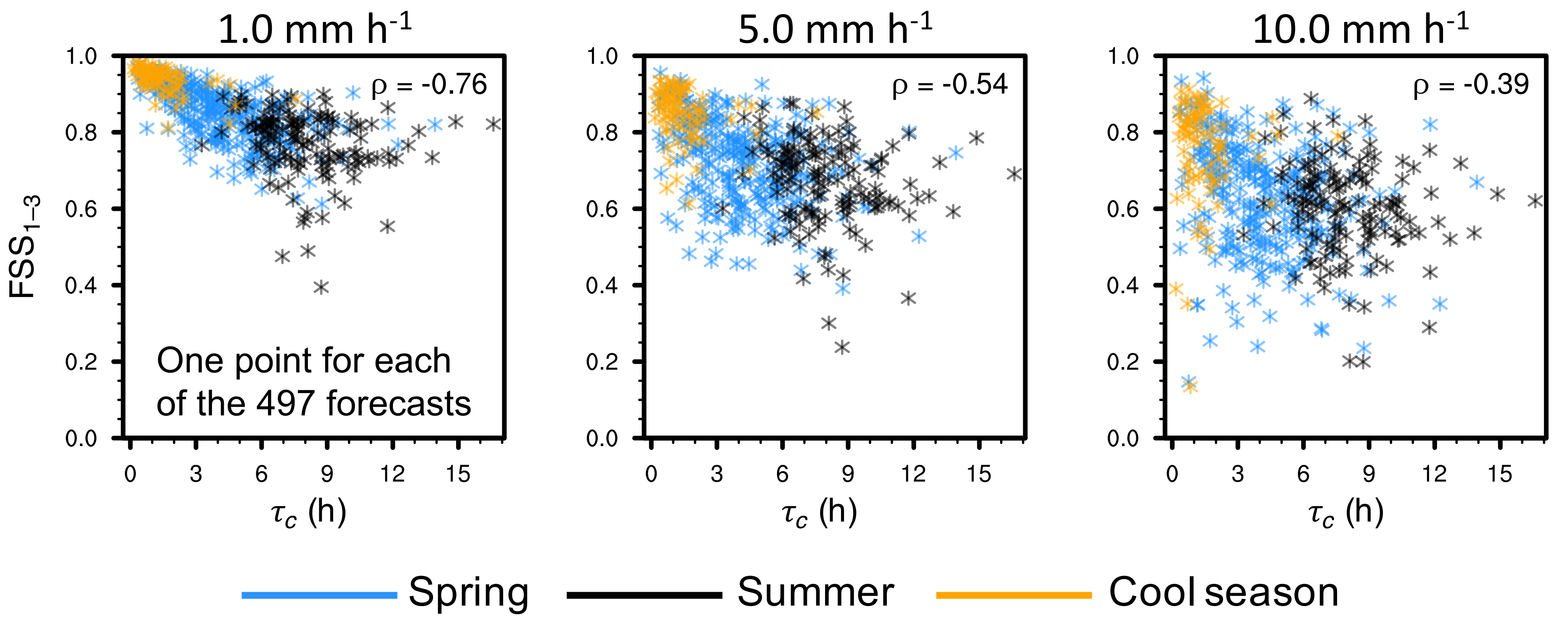
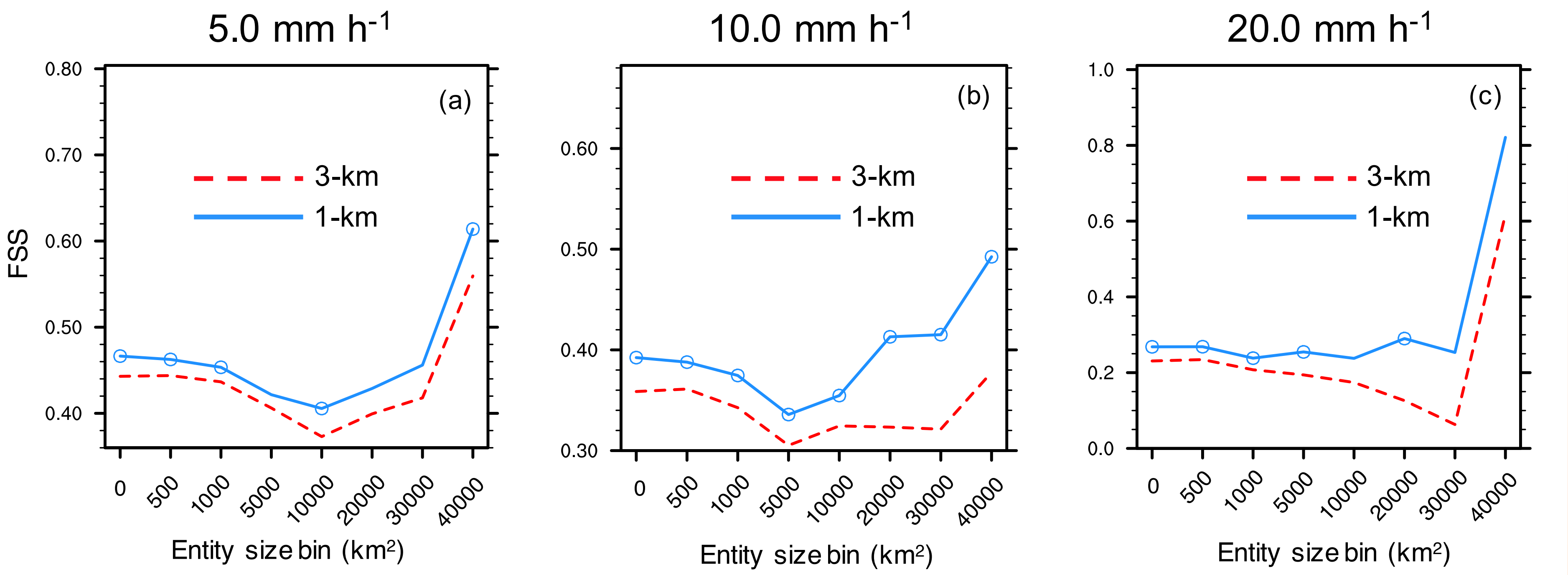


- y axis: FSS for 3- and 1-km forecasts *compared to each other*, using r = 100 km, aggregated over 18–36-h forecasts

FSS as a function of entity size

- An “entity”: contiguous area of precipitation exceeding a threshold (basically an object)



- FSSs for r = 100 km, aggregated over all 279 springtime 18–36-h forecasts