Global convection-allowing ensemble forecasts with MPAS

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With thanks to the entire MPAS team

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High-resolution MPAS ensemble forecasts

- Deterministic high-resolution forecasts not accurate after a few hours
  - Need ensembles!
- Can high-res global ensembles provide skillful and reliable 3–5-day forecasts of severe weather and precipitation?

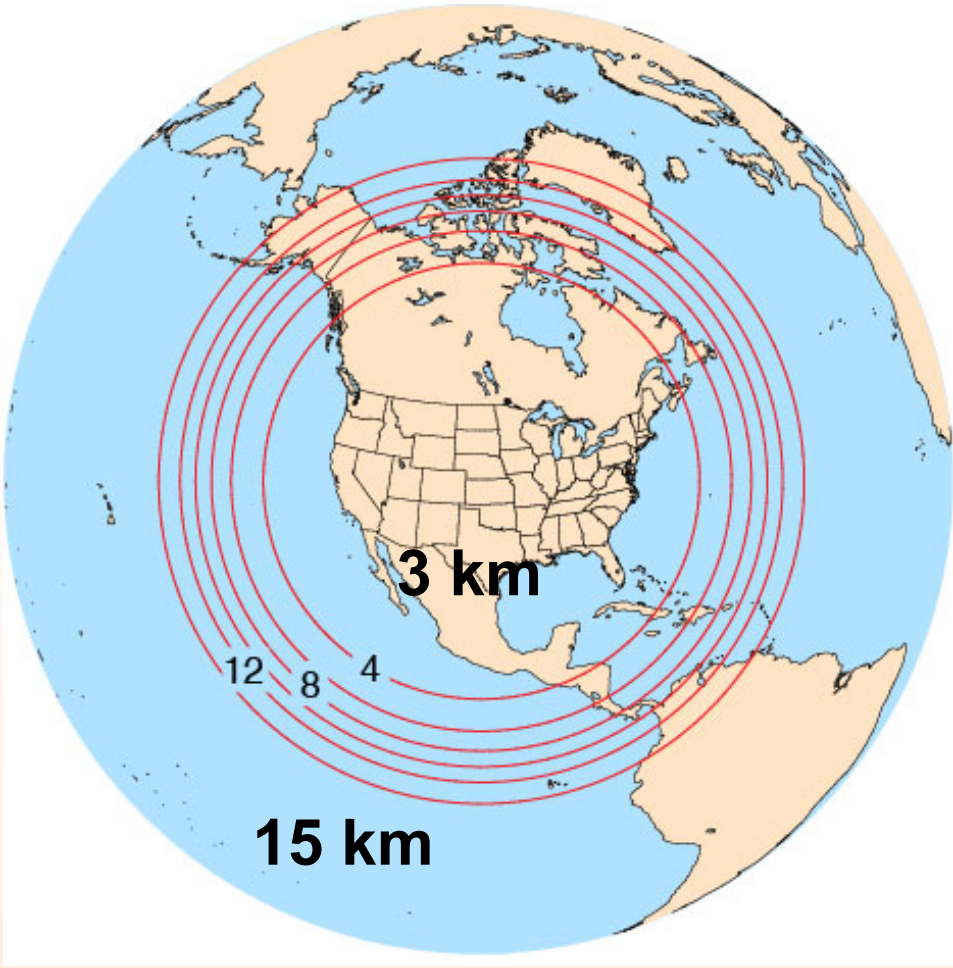
Three ensemble sets

1. Quasi-uniform MPAS 15-km mesh

2. Variable resolution MPAS 15-/3-km mesh

3. NCEP GEFS forecasts (~34-km grid spacing)

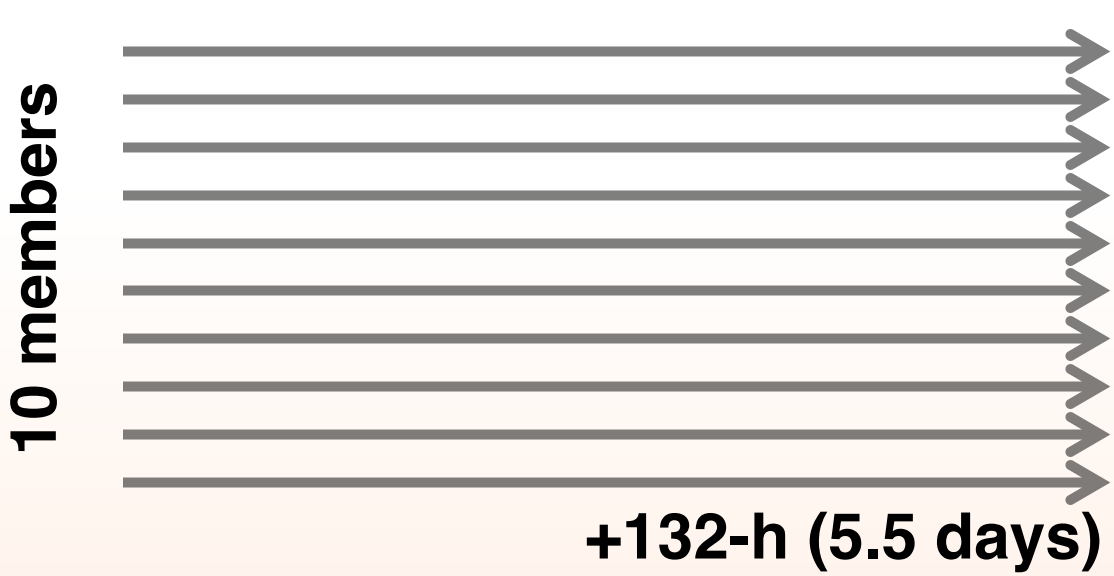
10-member ensemble forecasts

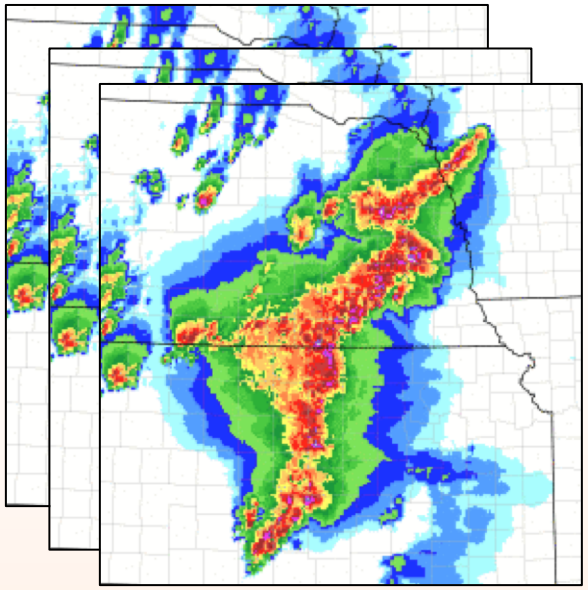


Variable resolution 15-/3-km mesh

Ensemble forecasts

35 forecasts (23 April 2017 – 27 May 2017)





Initialization: 00 UTC from GEFS analyses

MPAS single-physics ensembles using WRFV3.9 versions of
MYNN / Thompson / RRTMG / Grell-Freitas scale-aware

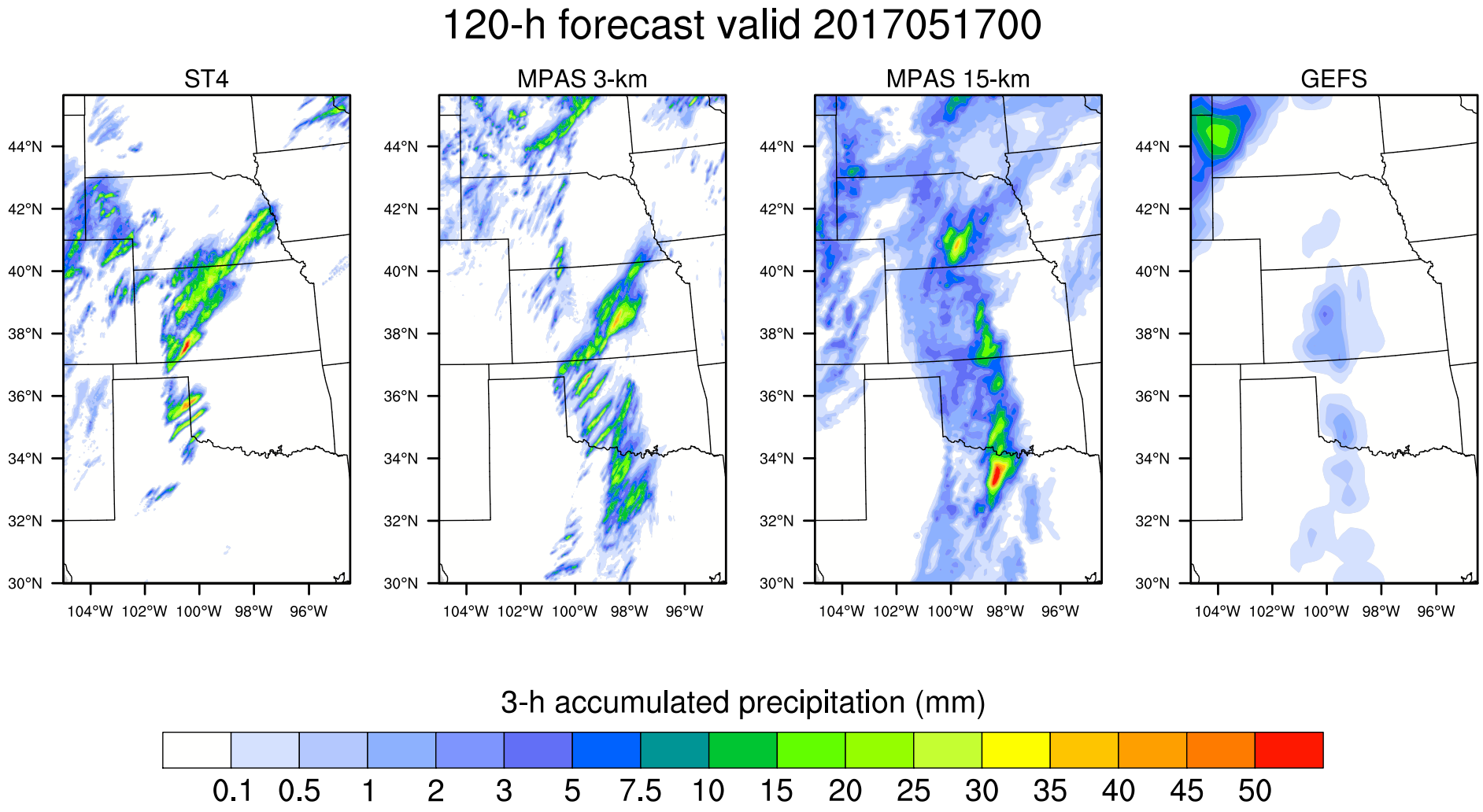
Forecast verification

- 3-h probabilistic precipitation forecasts
  - Verification region: CONUS east of the Rockies
  - NCEP Stage IV observations as "truth"
  - Forecast data interpolated to Stage IV grid
- Surrogate severe weather (3-km MPAS only)
  - Based on 2-5-km updraft helicity
  - Verified against SPC storm reports
- All statistics aggregated over 35 forecasts
  - Statistics computed with bias-corrected forecasts

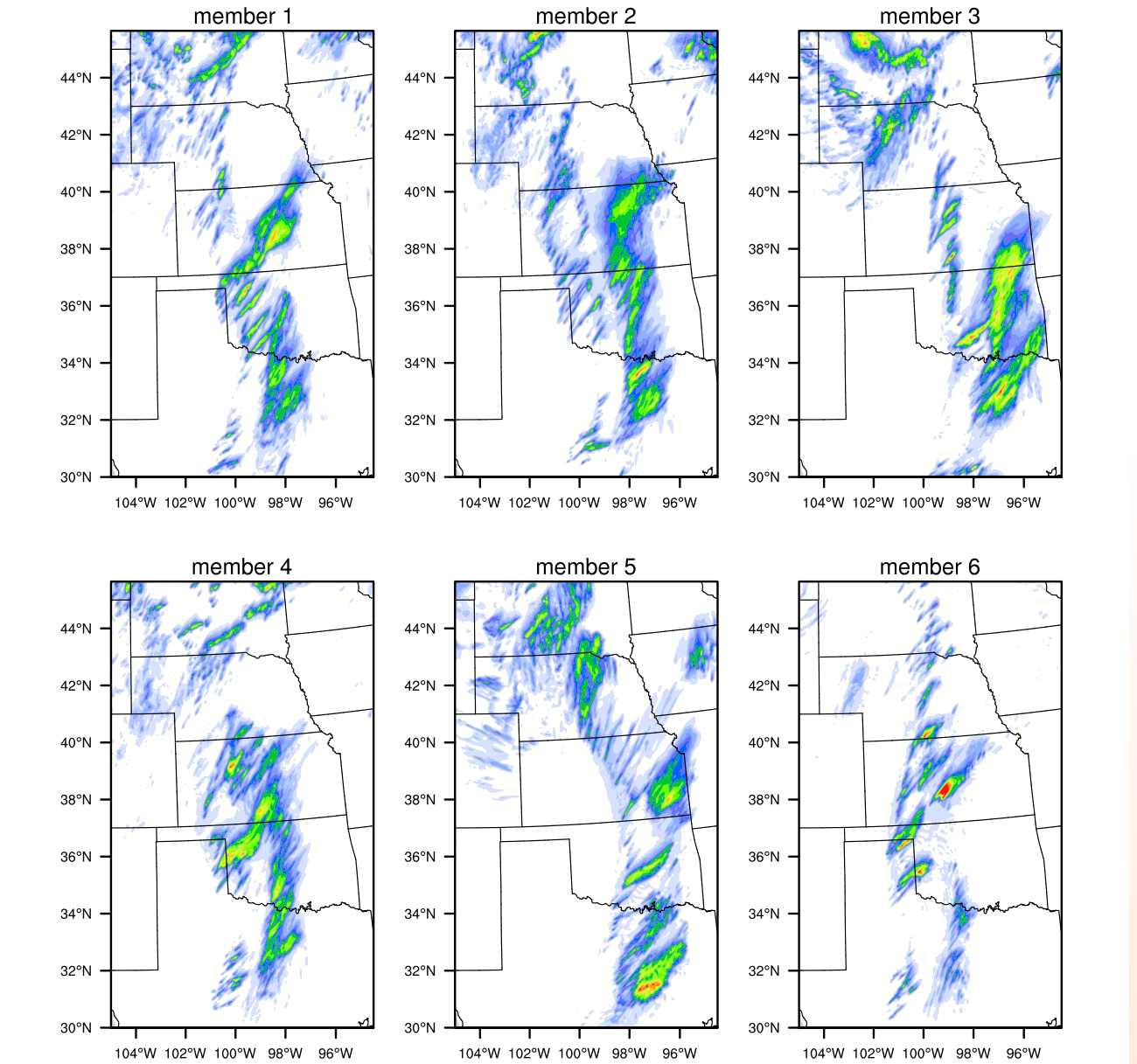
Probabilistic event definition

- "Probability of an event occurring *within x* km of a point"
  - "Neighborhood maximum ensemble probability" (NMEP; Schwartz and Sobash 2017)
  - Consistent with SPC convective outlooks
  - Arguably, verifying probability of event occurrence *within* a distance of a point is more appropriate than verifying probability of event occurrence *at* a point for medium-range predictions

Forecast of 3-h accumulated precipitation

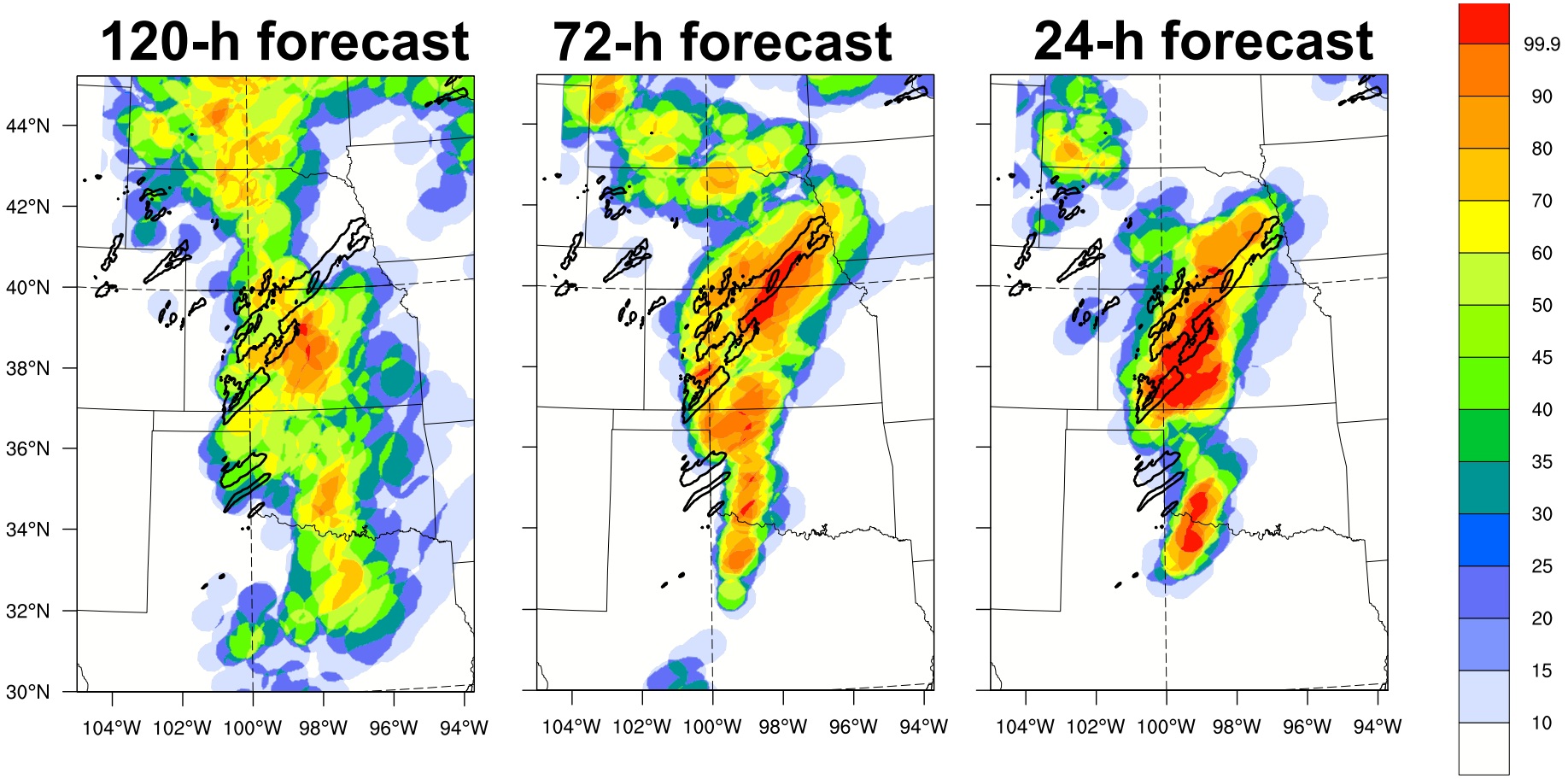


3-km ensemble forecast of 3-h accumulated precip

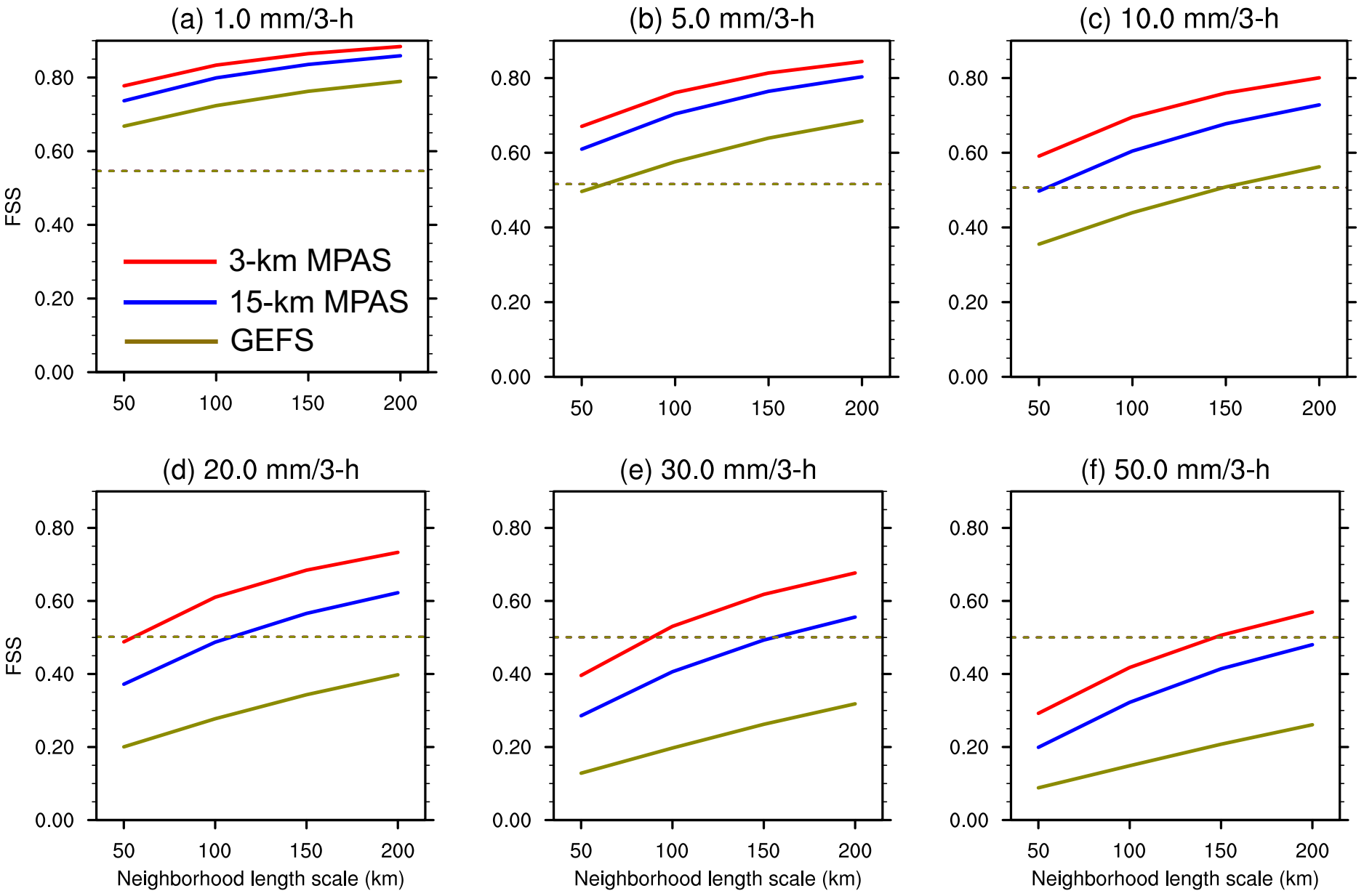


Probability of 3-h precipitation > 10 mm within 50 km of each point

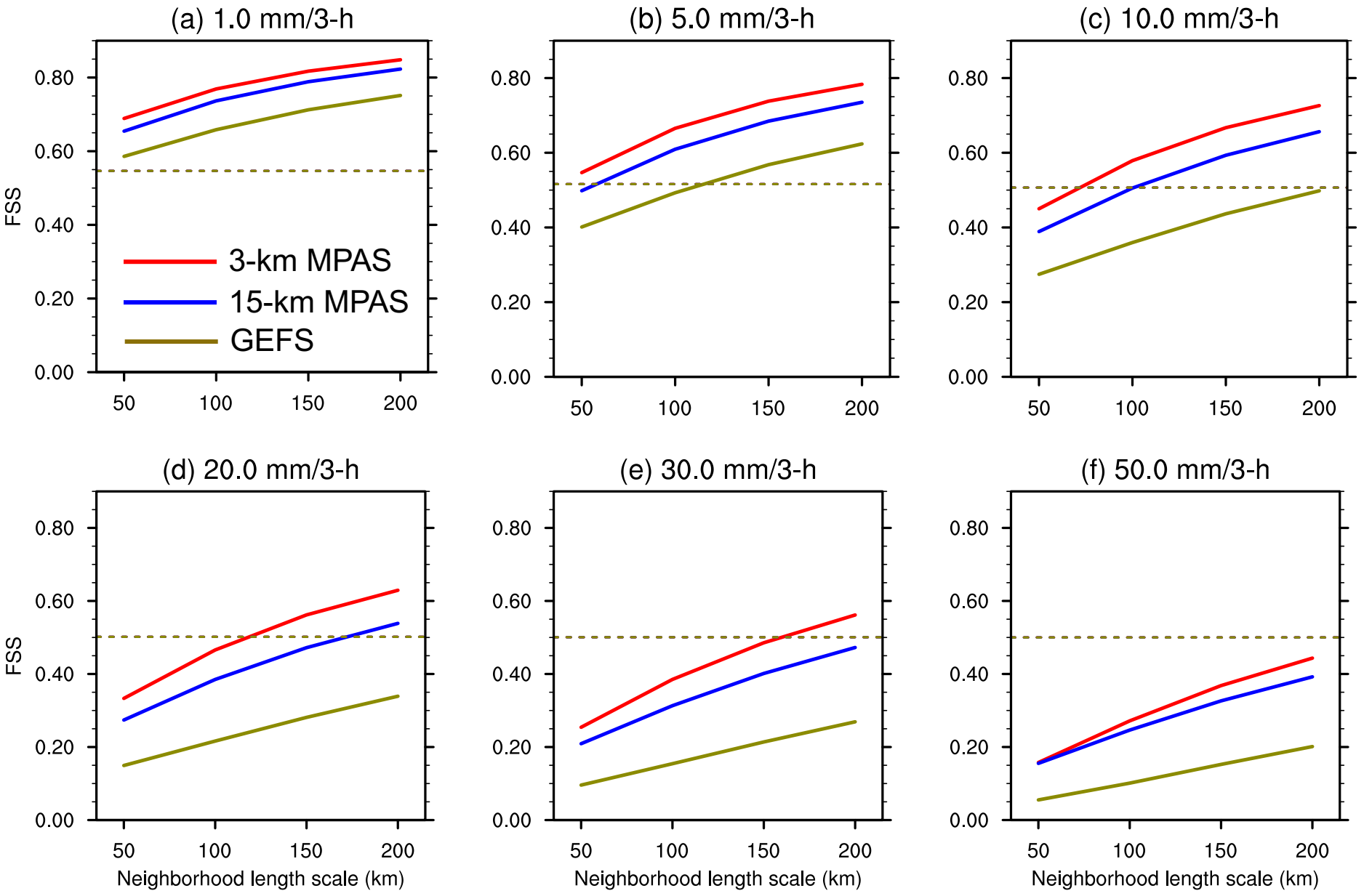
- 3-km MPAS forecasts



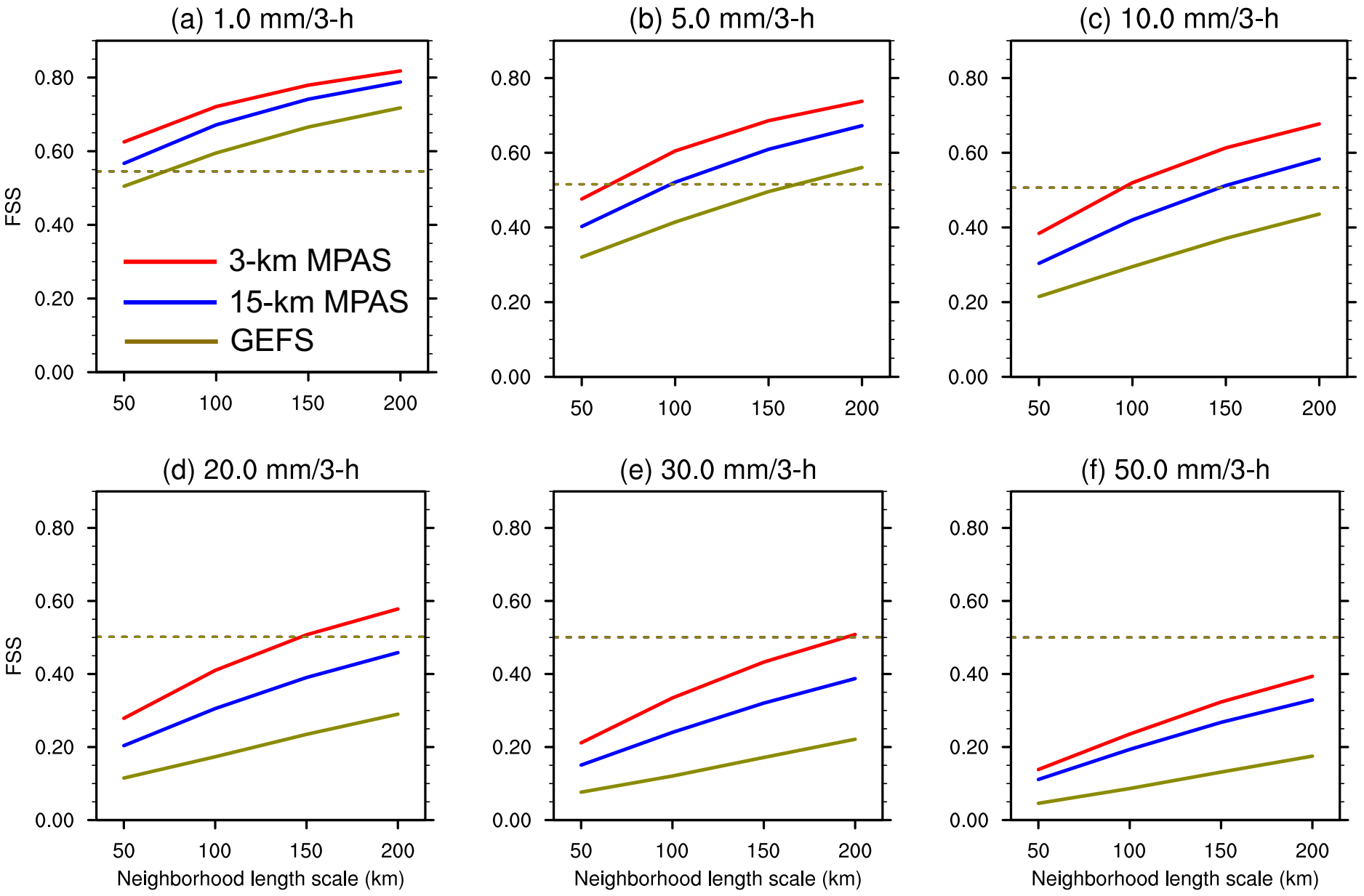
Fractions skill scores (hours 18-36; day 1)



Fractions skill scores (hours 66-84; day 3)

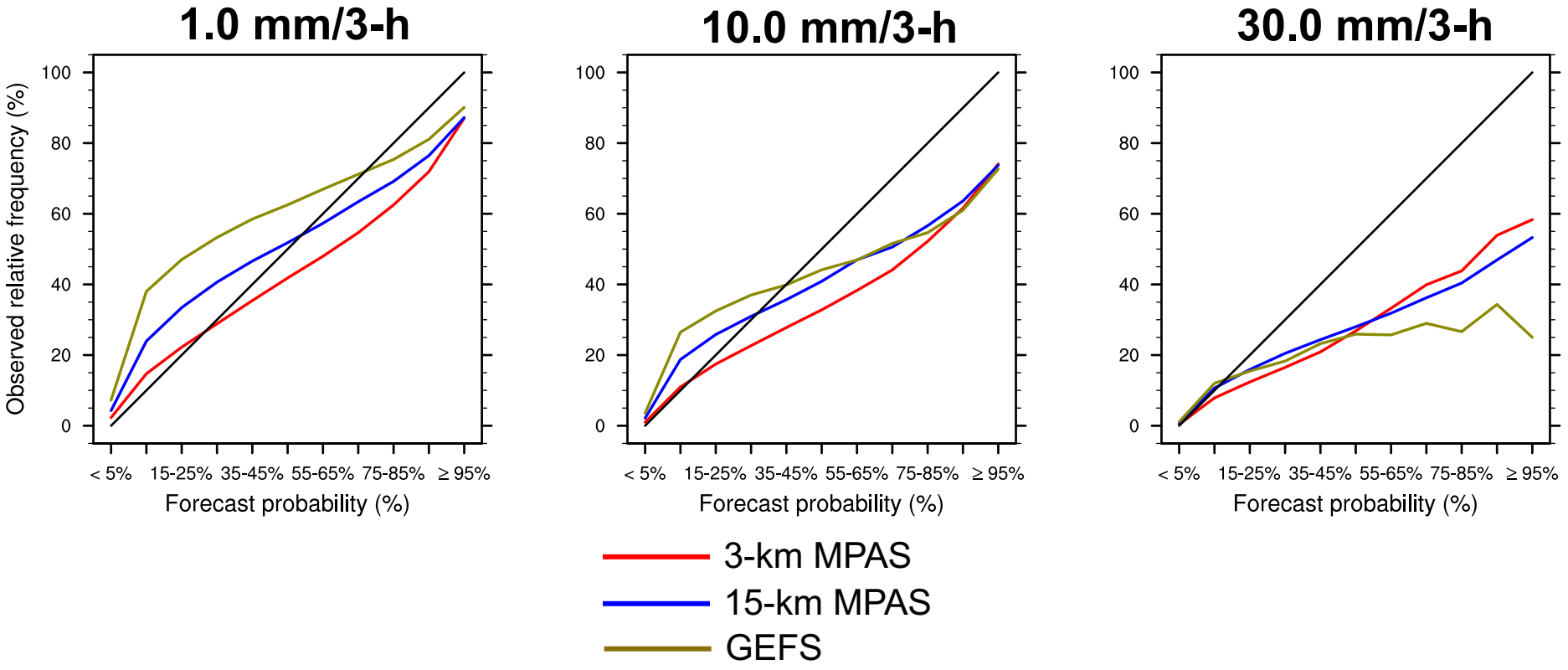


Fractions skill scores (hours 114-132; day 5)



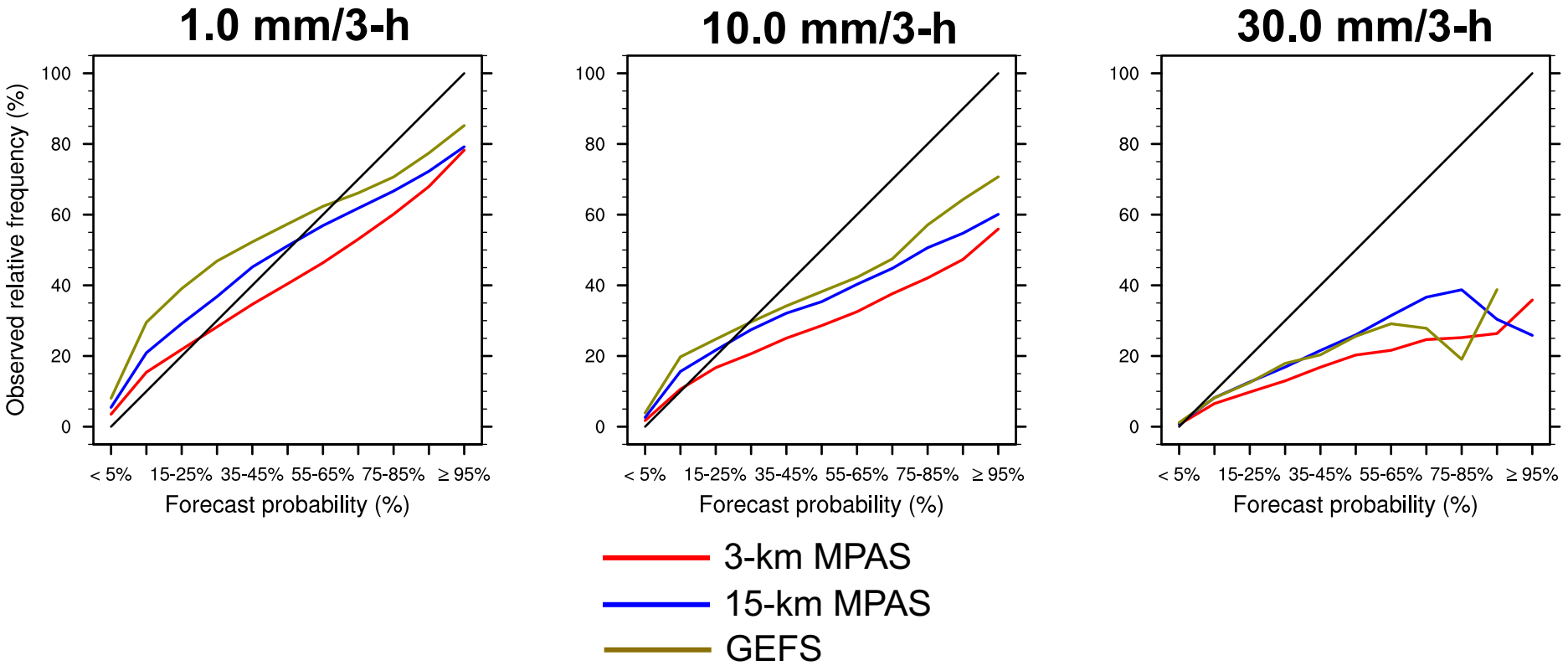
Reliability of precipitation forecasts

- Reliability diagrams for 3-h accumulated precipitation aggregated over 35 forecasts over hours 18-36 (day 1)
  - 50-km neighborhood length scale



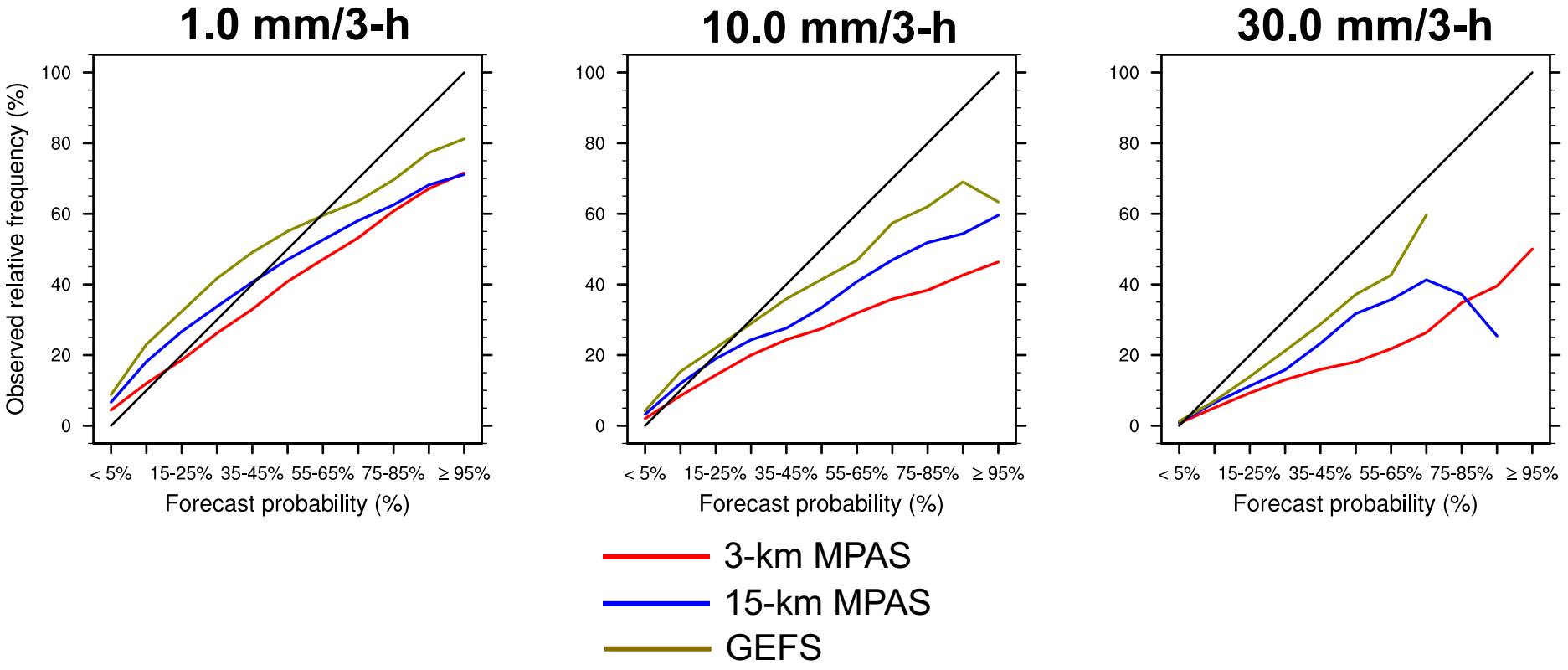
Reliability of precipitation forecasts

- Reliability diagrams for 3-h accumulated precipitation aggregated over 35 forecasts over hours 66-84 (day 3)
  - 50-km neighborhood length scale



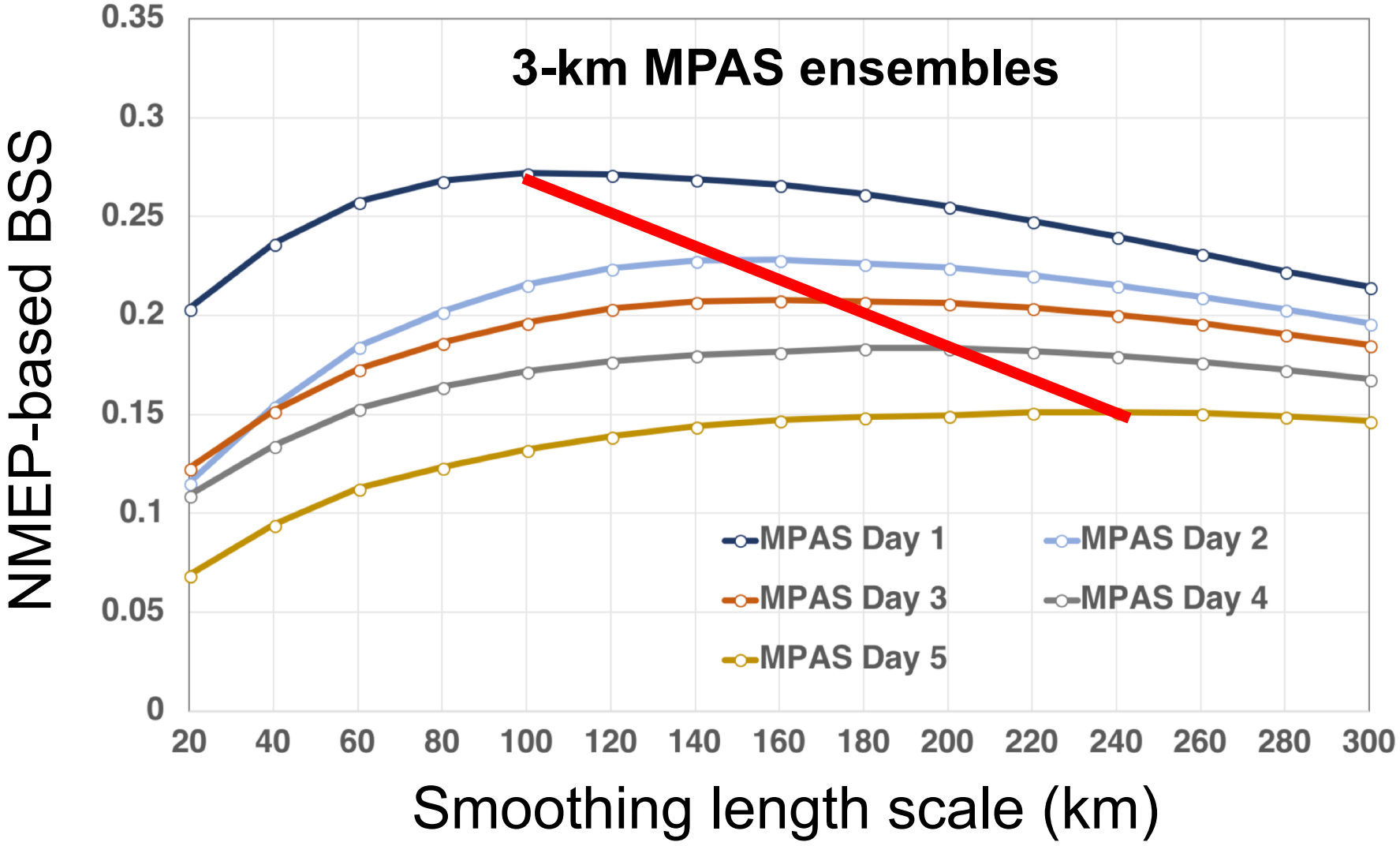
Reliability of precipitation forecasts

- Reliability diagrams for 3-h accumulated precipitation aggregated over 35 forecasts over hours 114-132 (day 5)
  - 50-km neighborhood length scale



Surrogate severe verification

- MPAS severe weather Brier Skill Score (BSS) for Days 1-5



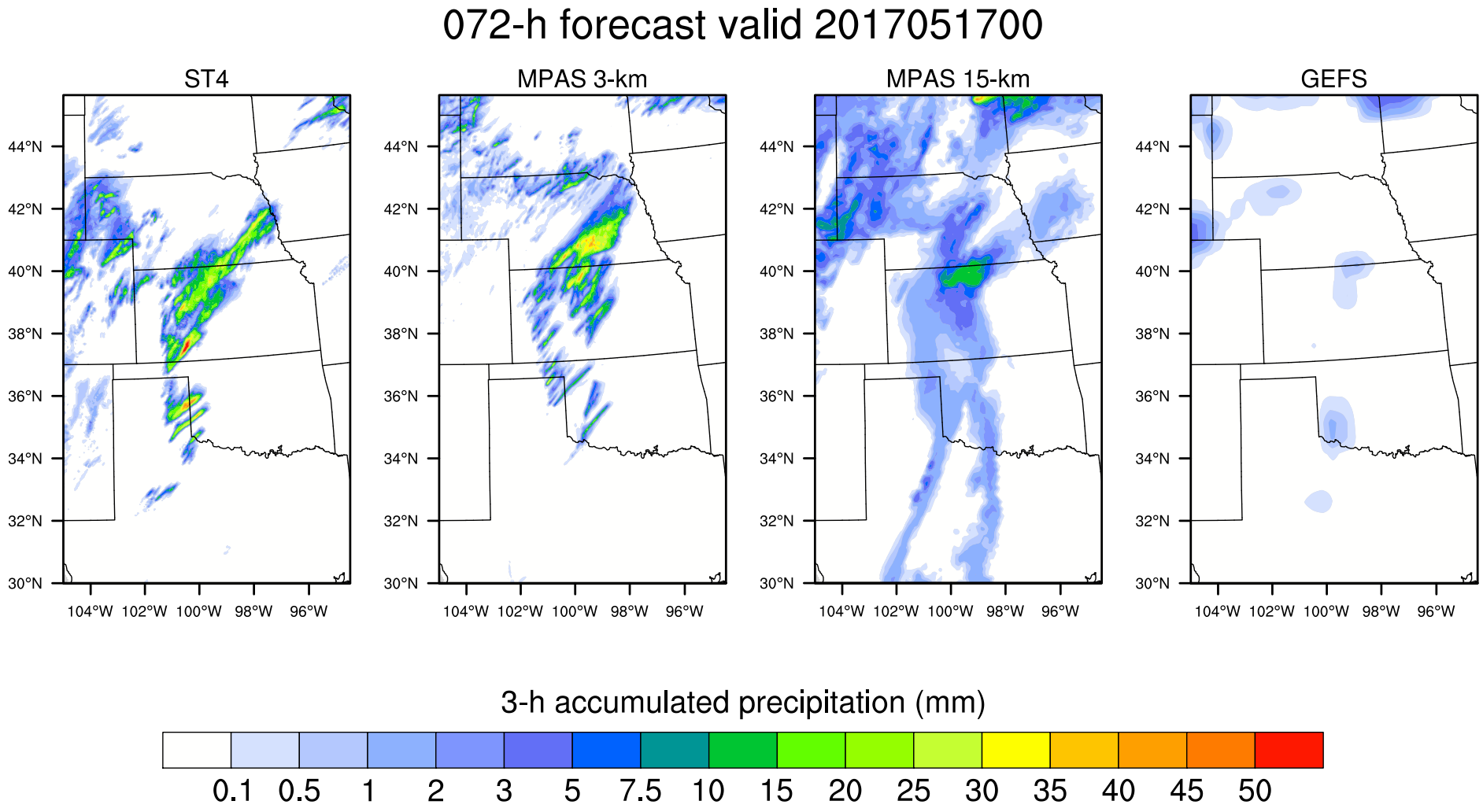
Summary and future work

- 3-km MPAS ensemble forecasts appear to have probabilistic skill through 5.5 days
  - Reliability not great

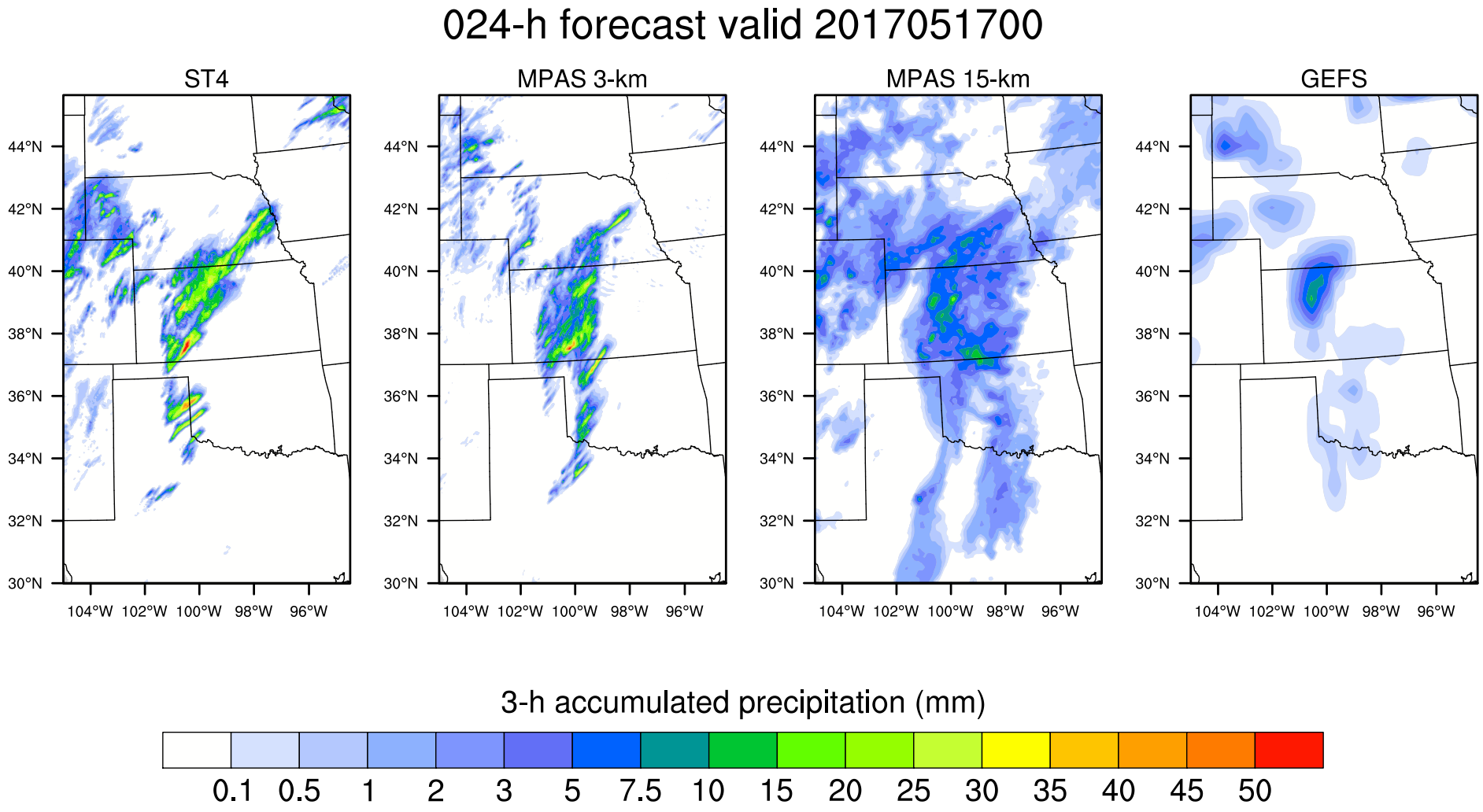
- Better forecasts by data assimilation on variable-resolution 15-/3-km grid?

- Compare global ensembles to MPAS regional ensemble runs
  - Lateral boundary condition impact on spread?

Forecast of 3-h accumulated precipitation

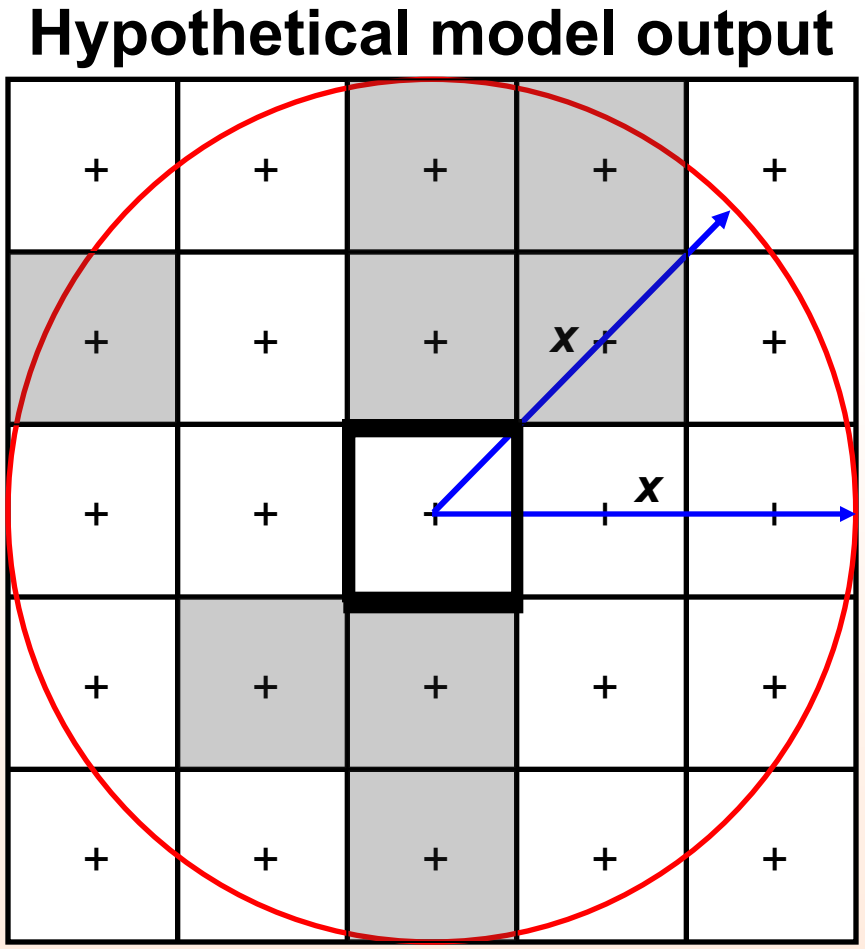


Forecast of 3-h accumulated precipitation



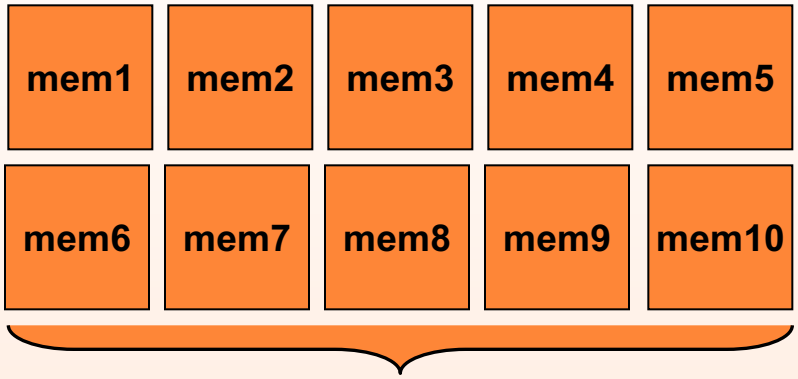
Verification method

- Pick an event
- The event has occurred in the shaded boxes
- If, at a point, an event occurs anywhere within the neighborhood, give the point a value of 1



NMEP method

- If, at a point, an event occurs anywhere within the neighborhood, give the point a value of 1, otherwise 0
  - Do this for all ensemble members individually
  - Average across the ensemble at each point to get a probability between 0 and 1



10 binary fields generated via neighborhood approach

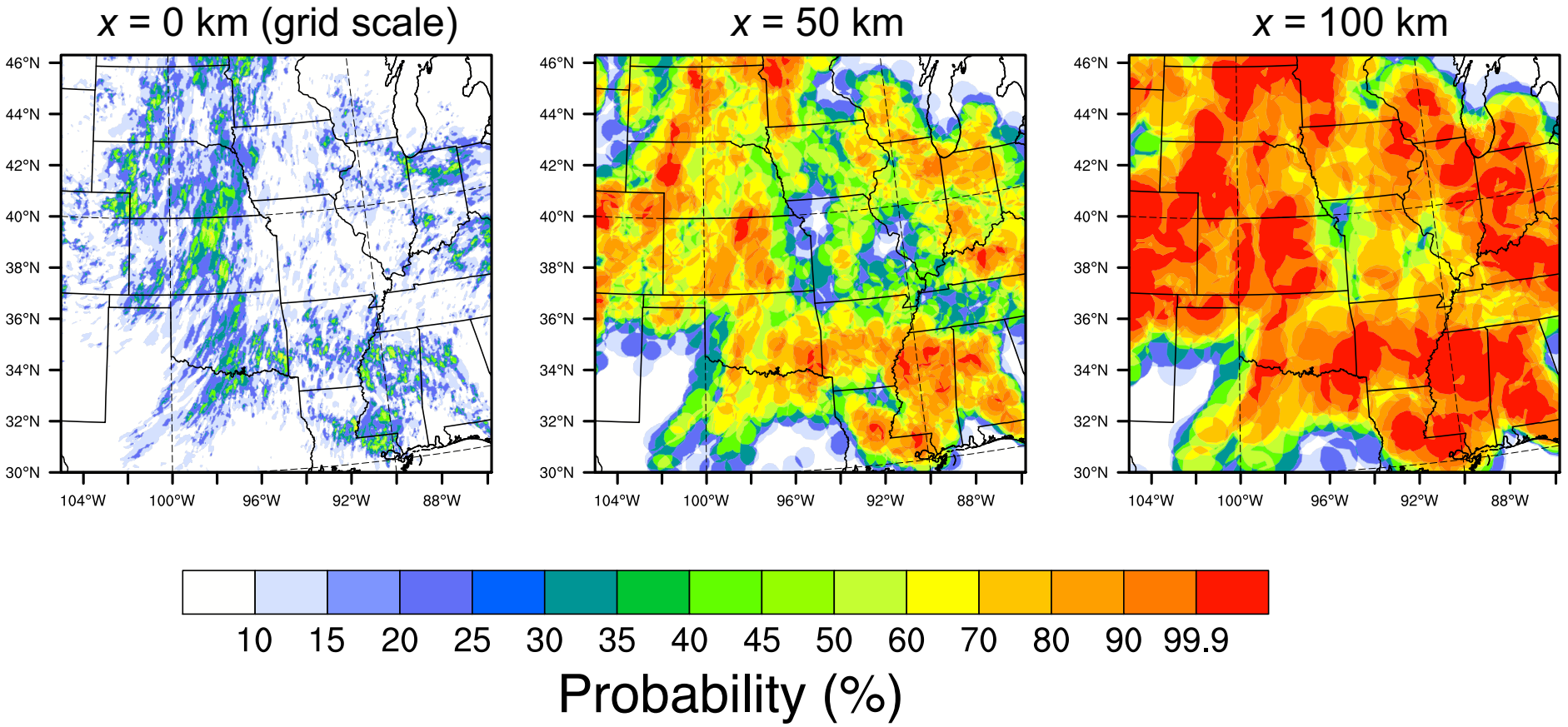
AVERAGE

"Neighborhood Maximum Ensemble Probability" (NMEP)

Schwartz and Sobash (2017)

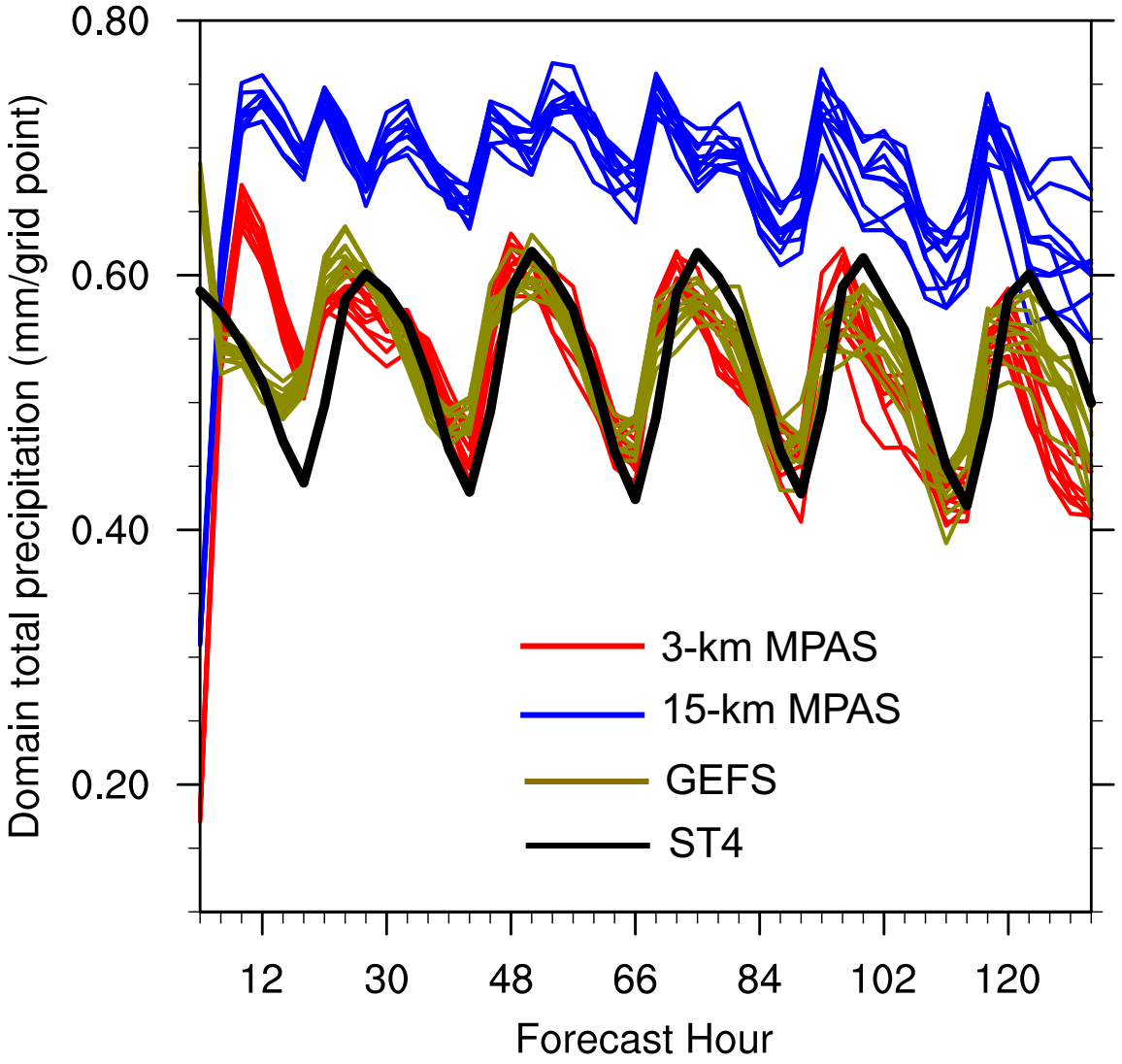
NMEPs for a 10-member ensemble

- NMEPs of 1-h precipitation ≥ 1.0 mm/h
  - *x*: neighborhood length scale (radius of a circle)

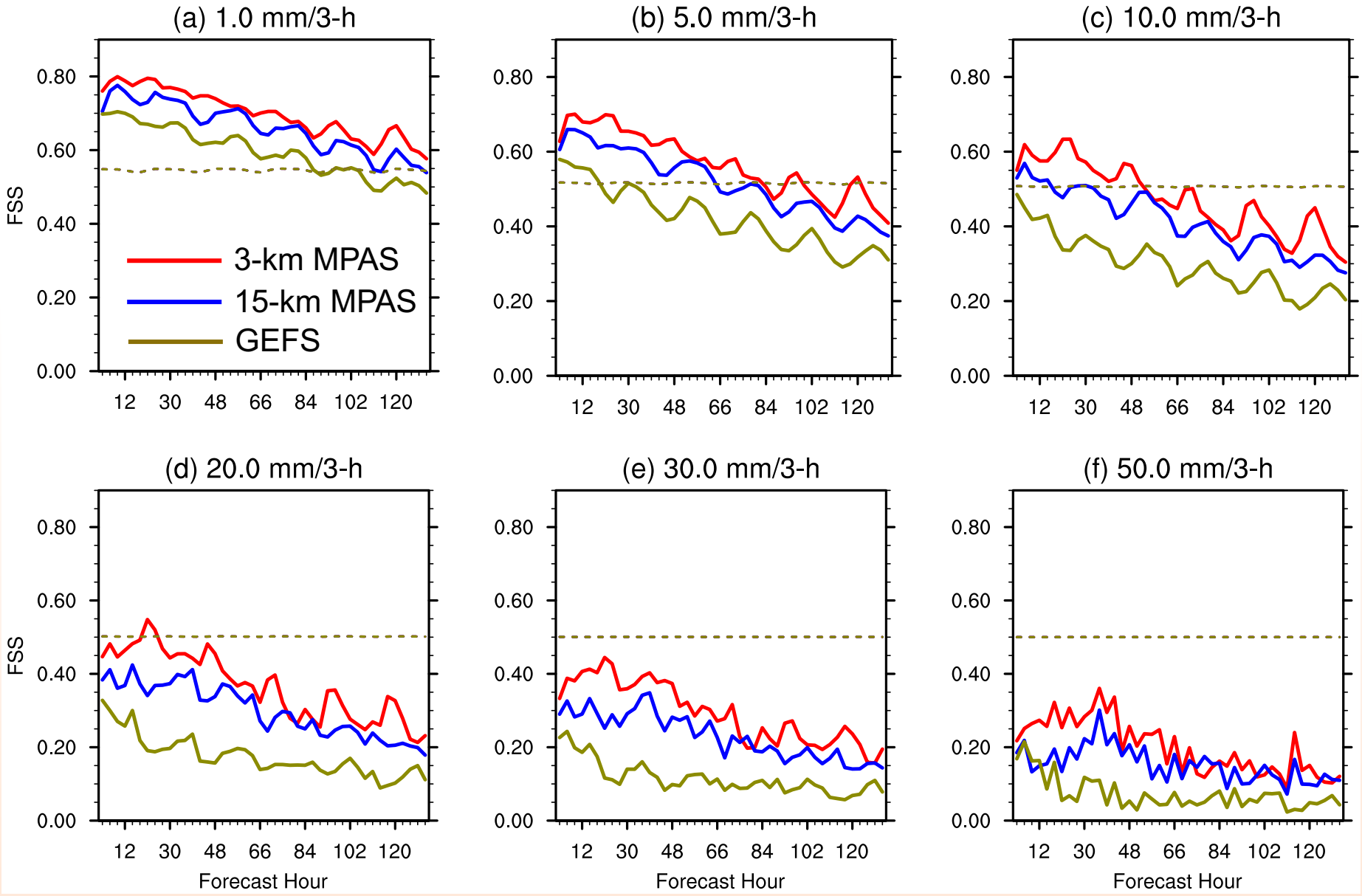


Total precipitation

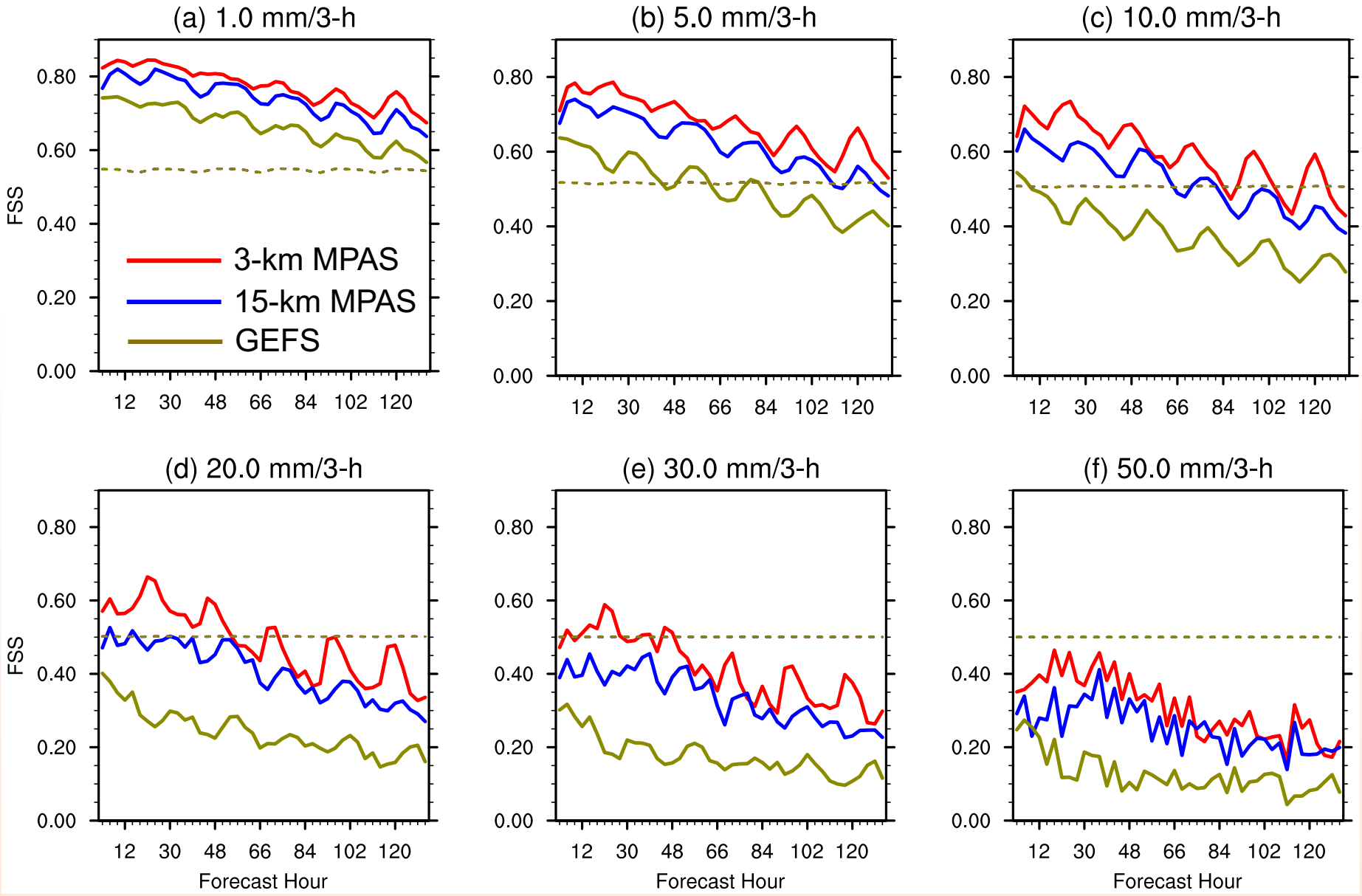
- Domain total precipitation (normalized by number of grid points)
- Aggregated over 35 forecasts



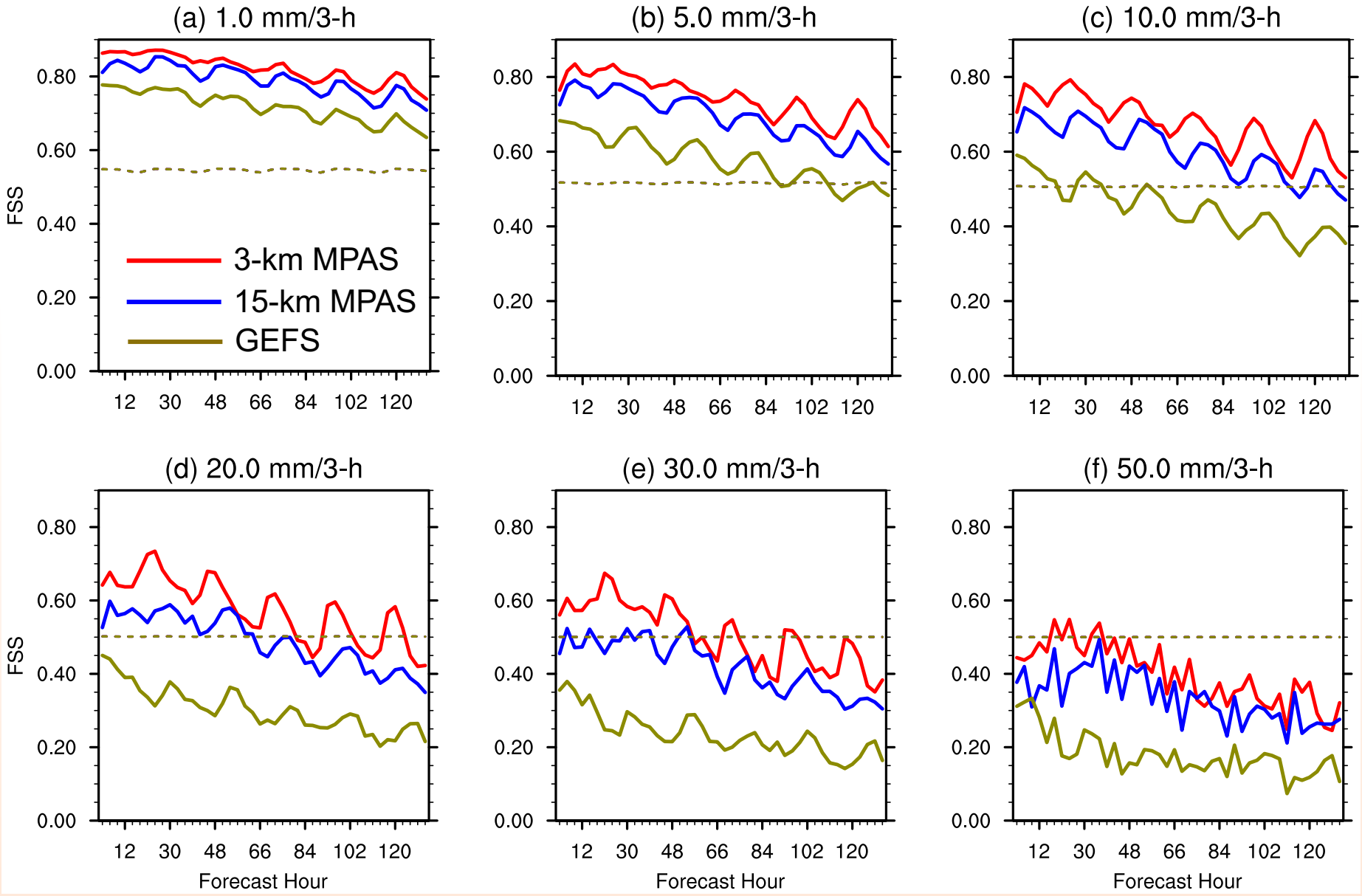
Fractions skill scores (x = 50 km)



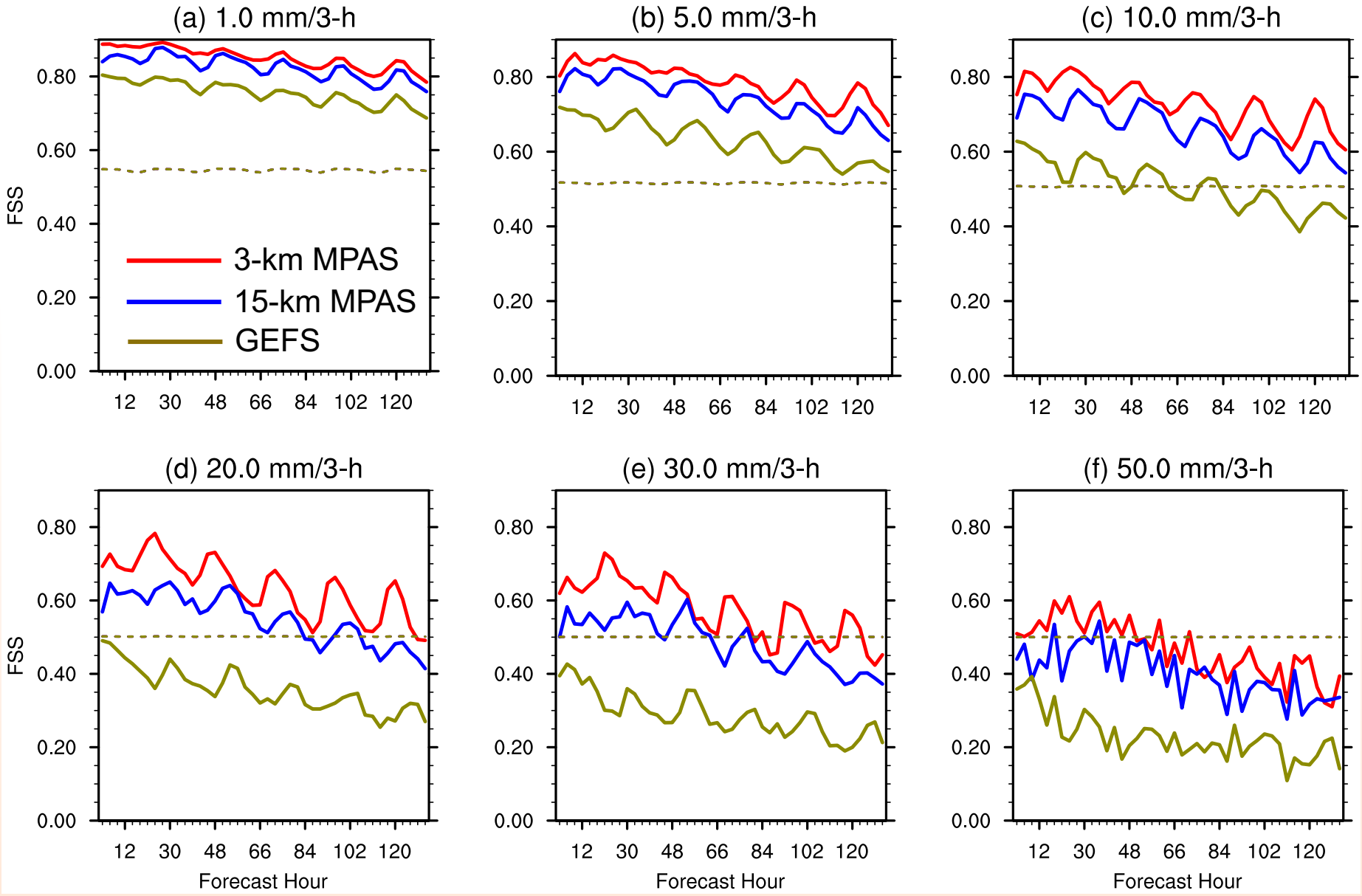
Fractions skill scores (x = 100 km)



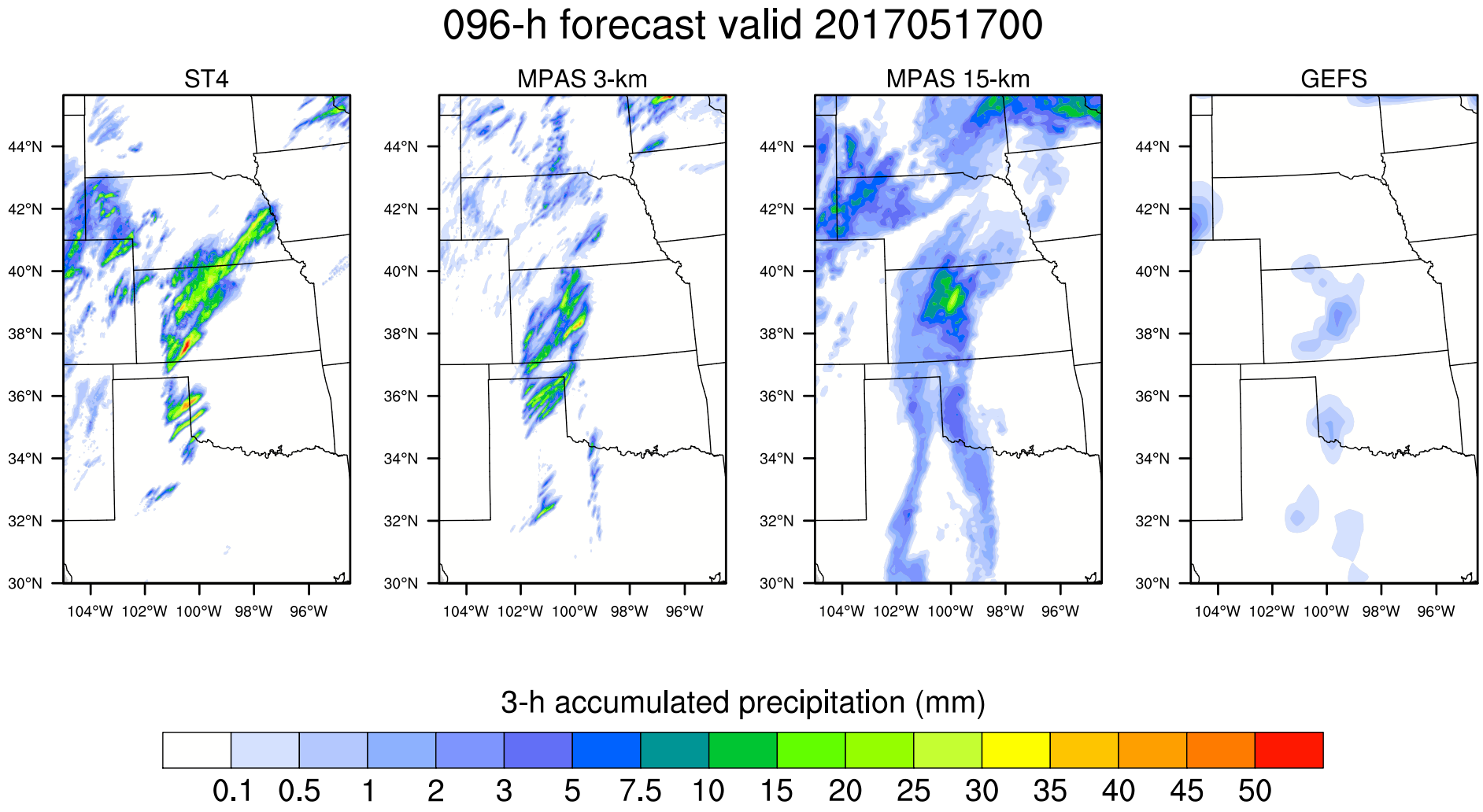
Fractions skill scores (x = 150 km)



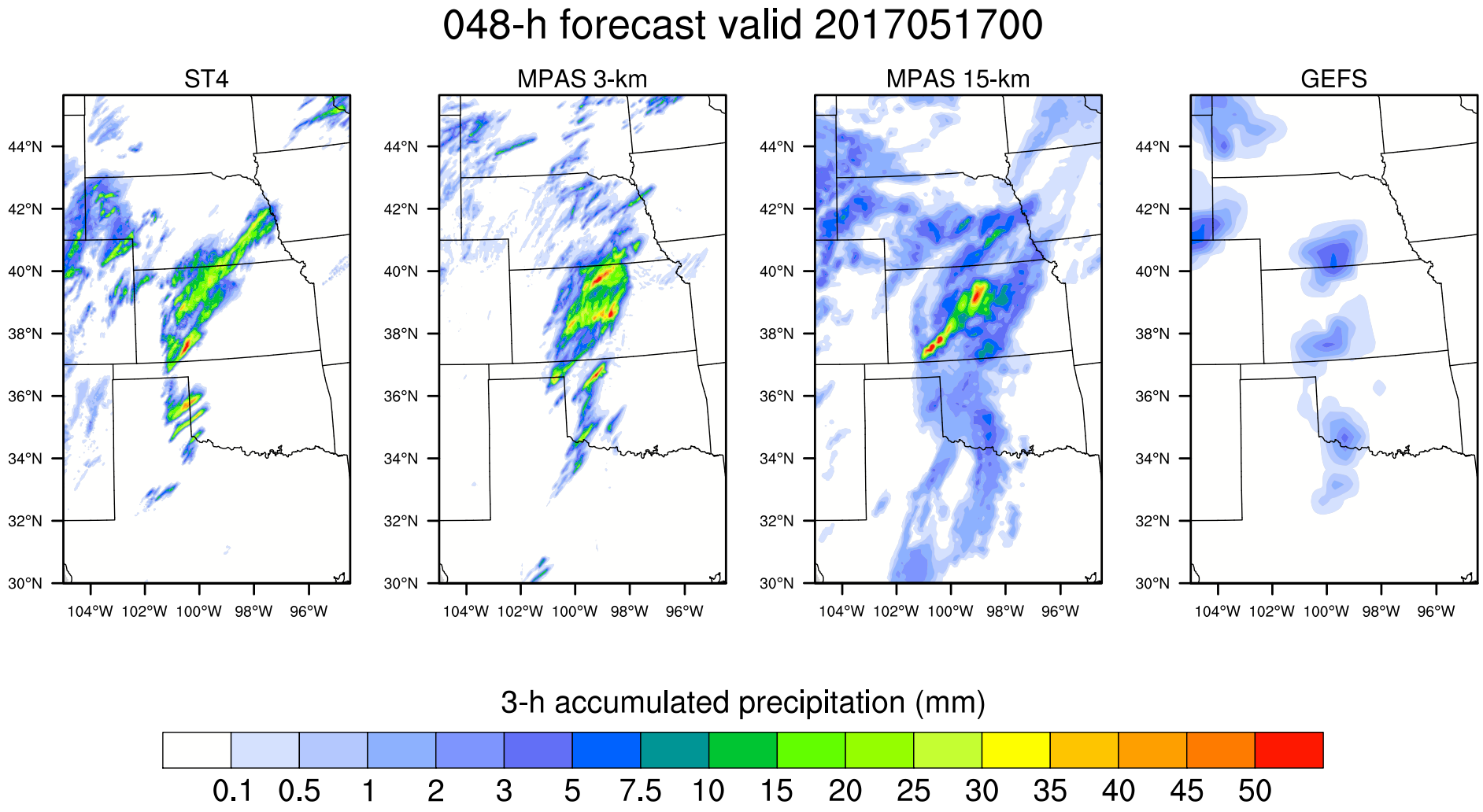
Fractions skill scores (x = 200 km)

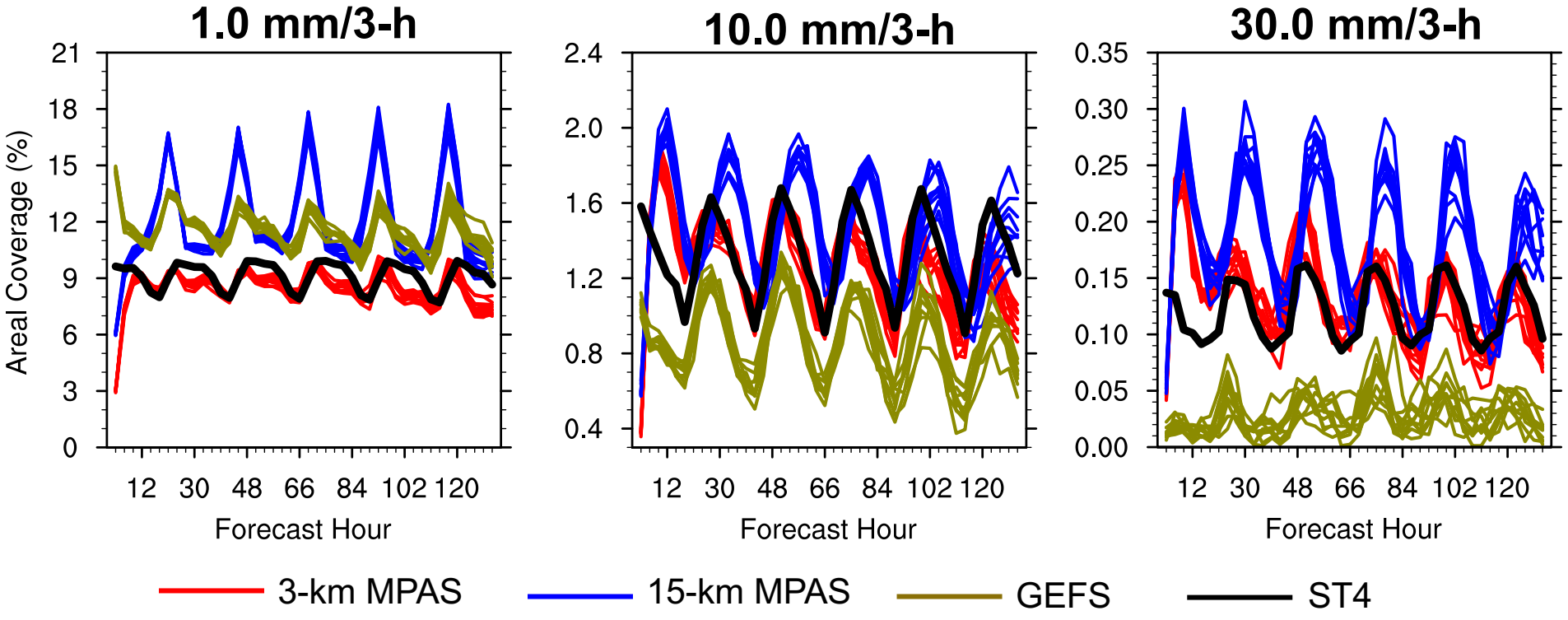


Forecast of 3-h precipitation



Forecast of 3-h precipitation



Areal coverages

- Fractional coverages of precipitation exceeding certain thresholds
- Aggregated over 35 forecasts