Multi-NWP Model Assessment Regarding High-Impact Weather Simulation

Jakarta, 20 October 2026
Delivered on EUMeTrain Event Week
on Tropical Meteorology Meeting

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Why should European forecasters care about tropical NWP?

"If you take a state-of-the-art NWP model developed and extensively used in Europe and run it over the tropics, should you expect the same level of forecast performance?"

Not necessarily. The tropics introduce different dominant processes, different predictability limits, and different interactions between convection, topography, land-sea contrasts, and large-scale circulation.

The model reference used by BMKG

1. IFS
2. CAWO
3. GFS
4. ACCESSG
5. ARPEGE
6. IFS ENS
7. GEFS
8. AROME
9. AIFS
10. BMKG_MOS_IFS
11. INANWP (Before May 2026)
12. WRFDY (Before Apr 2026)

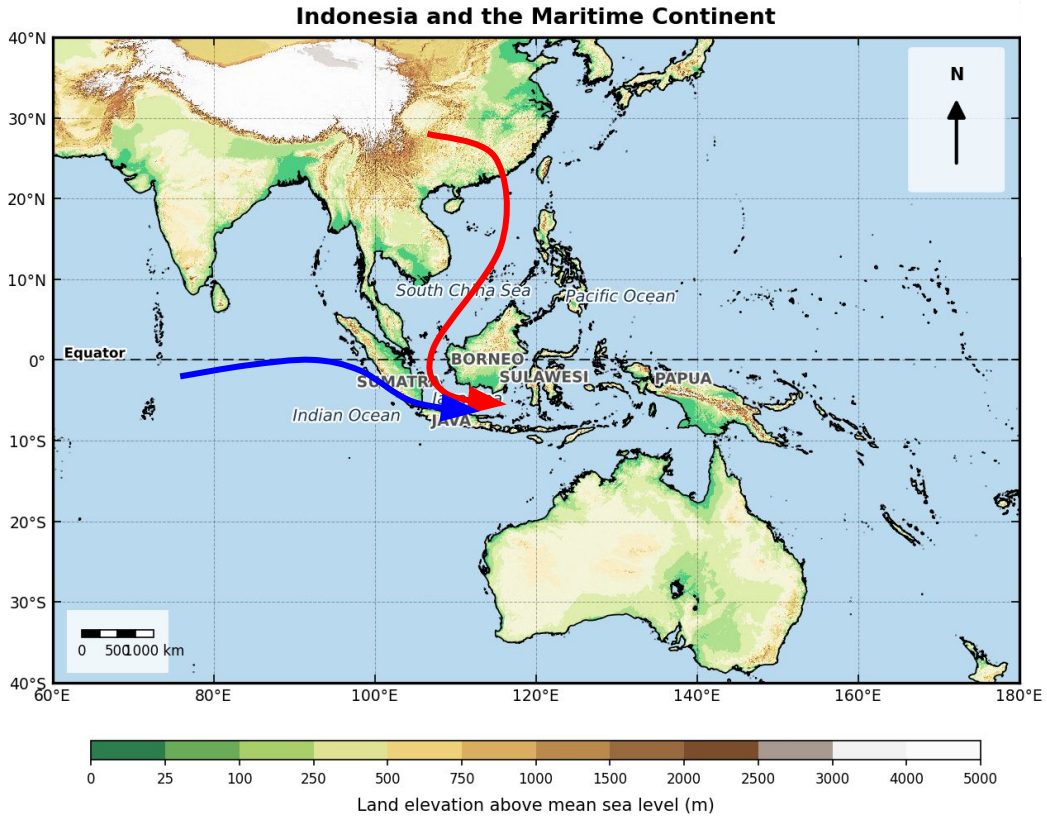
NB:

Green highlighted: the main references

Yellow highlighted: the additional references

Unhighlighted: the complementary references

Indonesia's Landscape



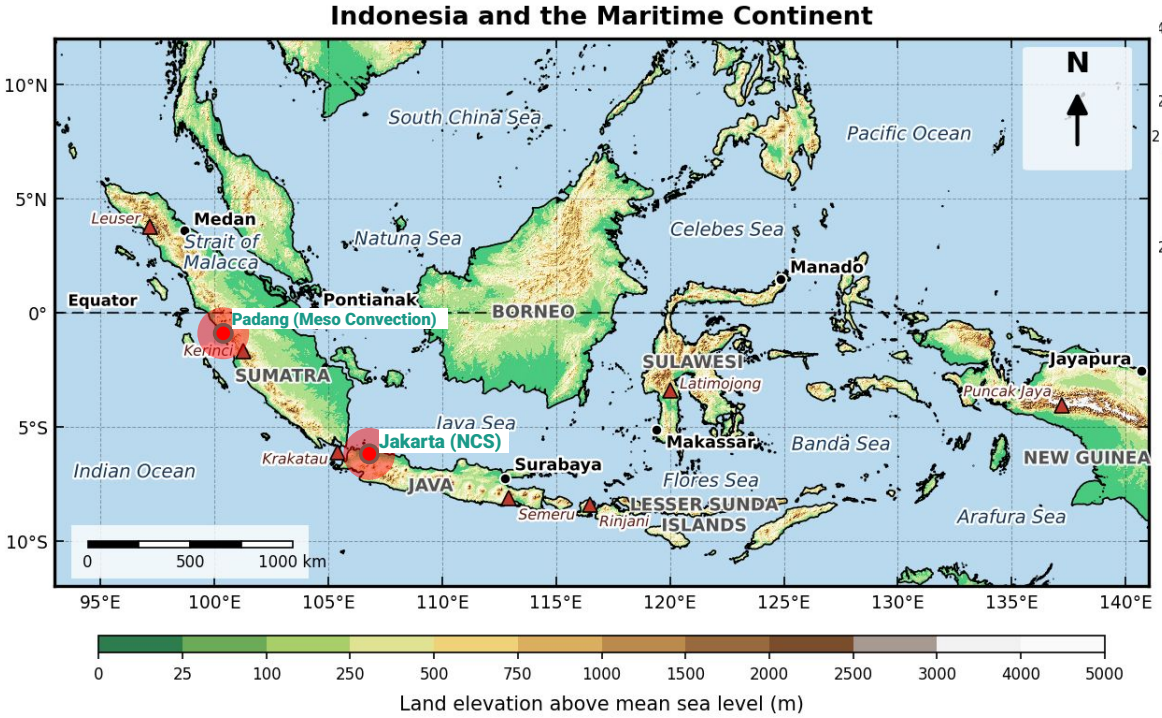
The Common Atmospheric Drivers of Extreme Events:

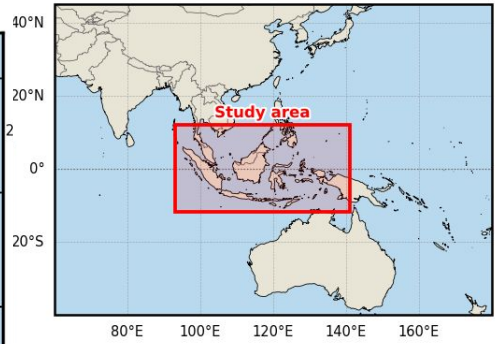
- **Tropical cyclone**
- **Monsoon Surge**: Northerly Cold Surge (NCS)
- **Large-scale tropical variability**: MJO, Equatorial waves
- **Organized mesoscale convection**: Near coast squall lines
- **Local diurnal convection**

Case Studies

- **Impact**: Floods
- **Atmospheric drivers**:
  - **NCS**: 19 Feb 2026
  - **Mesoscale Convection**: 10 Oct 2026
- **Research Questions**:
  - Do the NWP enable to capture the heavy rainfall signal?
  - Do the NWP enable to capture the regional and local atmospheric drivers?
  - What is the best lead time to release early warning?

Case Studies





Legend
- City
- Mountain / volcano
- Coastline
- Sea (single colour)
- Equator

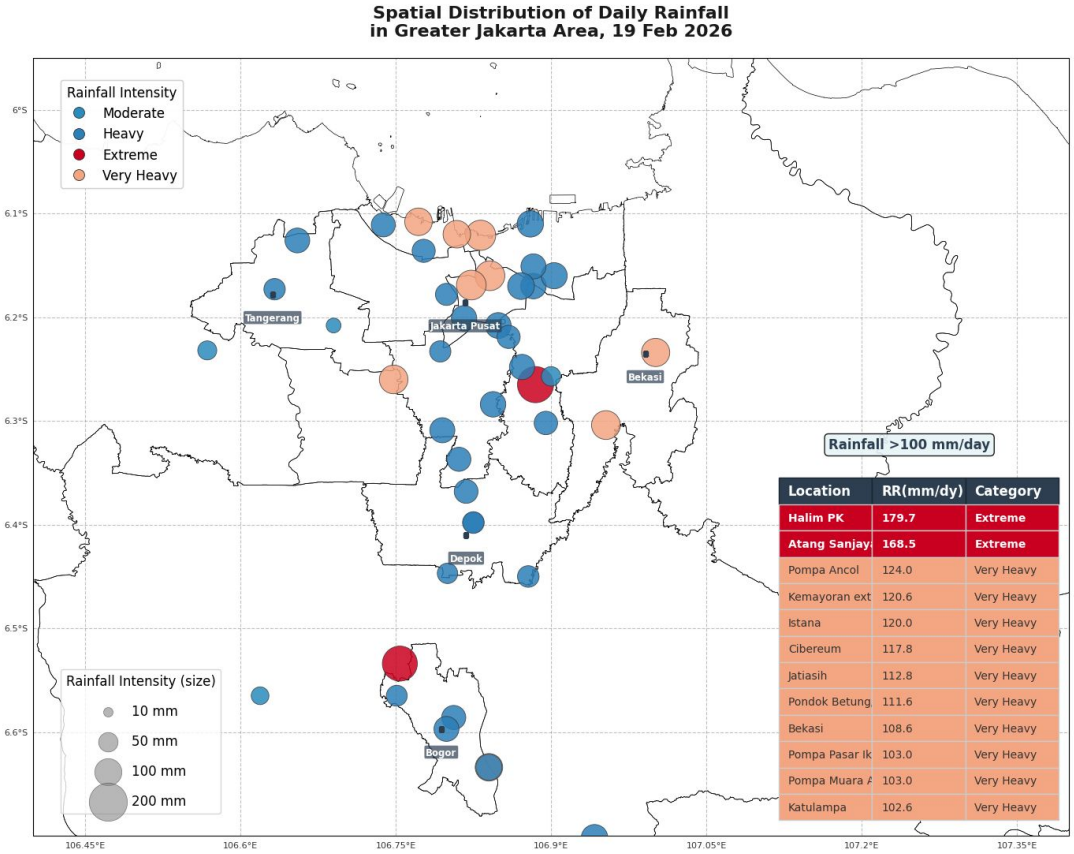
Tropical meteorology context
- The equator crosses Sumatra, Borneo and Sulawesi; the ITCZ shifts seasonally.
- Shallow Sunda and Sahul shelves supply warm, moist air.
- Mountain ranges drive orographic rain and the diurnal land–sea breeze cycle.
- Narrow straits (Malacca, Sunda, Makassar, Lombok) channel the flow.

Coordinate system: WGS 84 (EPSG:4326). Elevation: ETOPO 2022 (60 arc-sec, NOAA NCEI).
Hillshade: azimuth 315°, altitude 45°. Country borders: Natural Earth.

CASE 1 - An Extreme Rainfall Led Widespread Flood

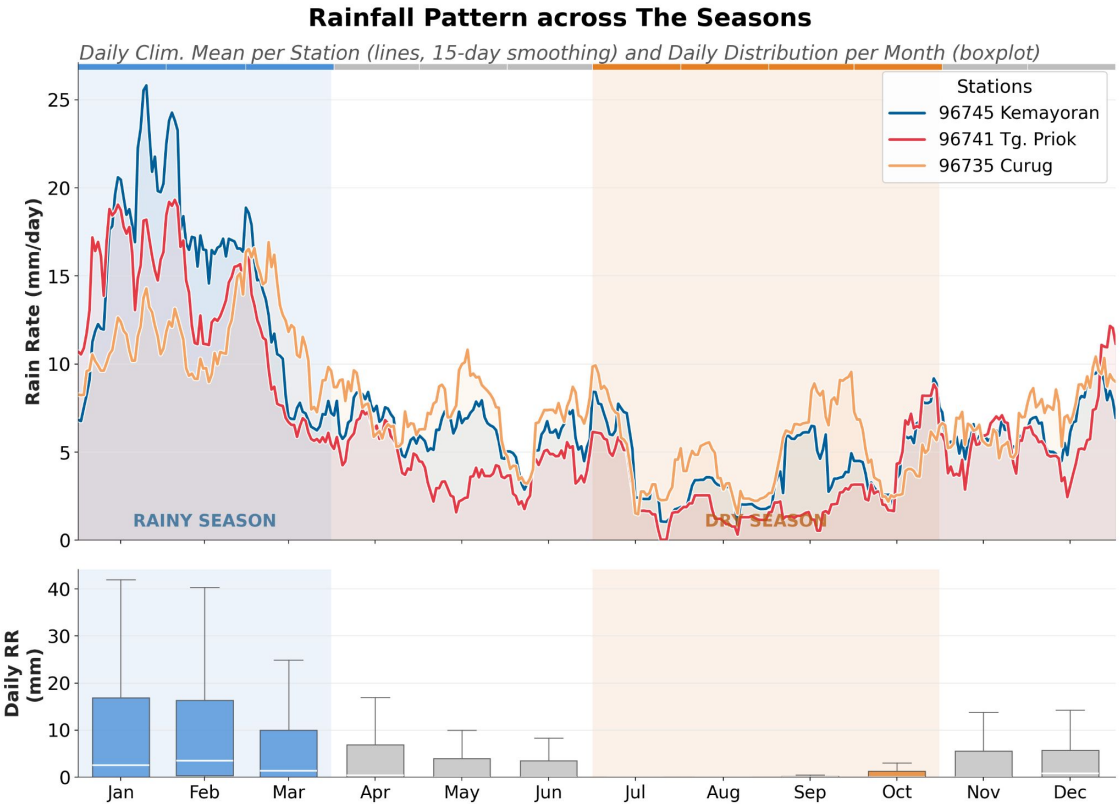
Jakarta, 19 Feb 2026

127 neighborhoods and **6 road sections** are submerged (tempo.co)



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Rain Pattern



- **Rainy season:** Nov-Mar (Asian Monsoon)
- NCS is a stronger Asian Monsoon intensity

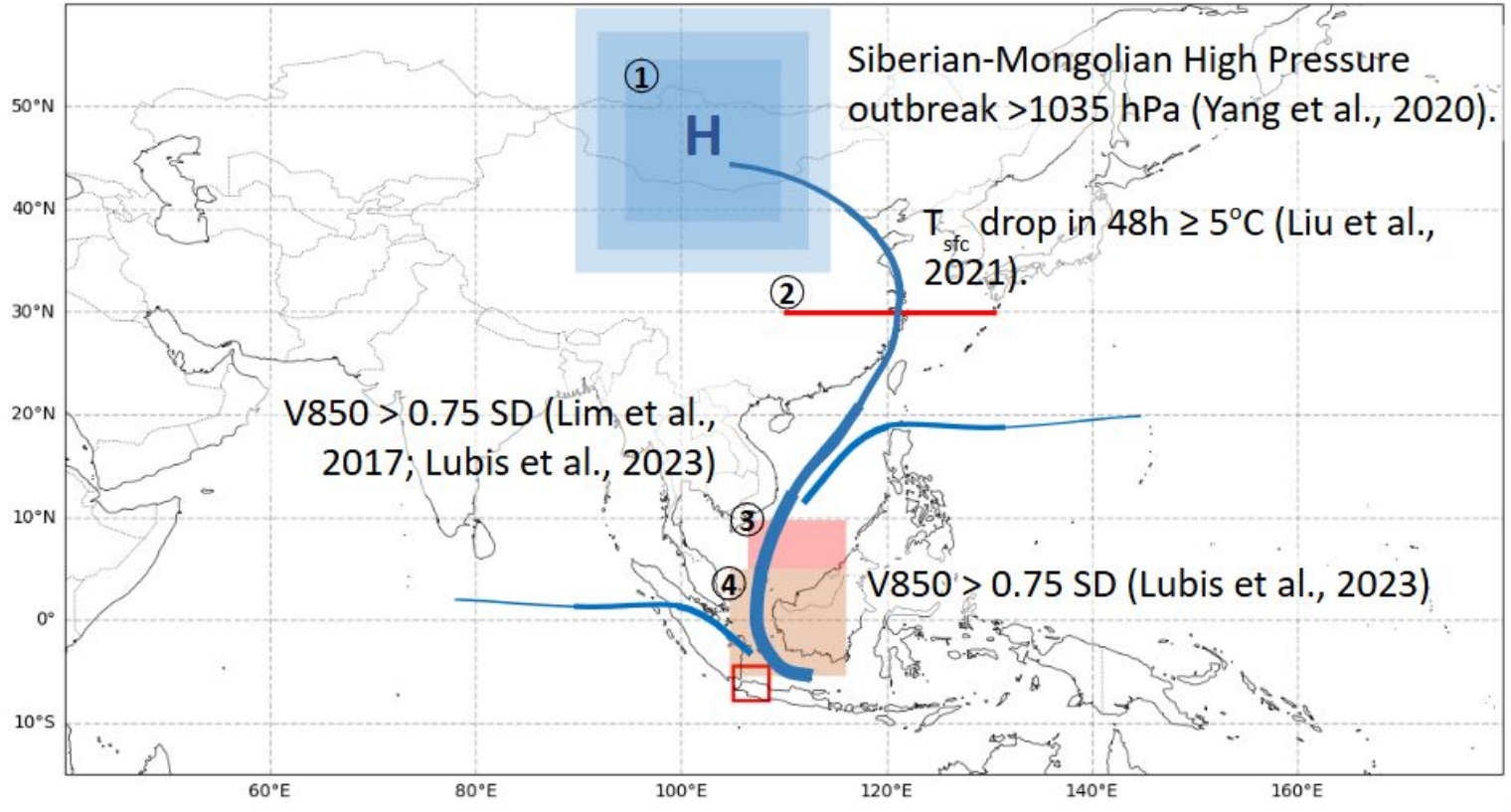
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Meteorological Background

1. **During Asian Monsoon domination,** The Indonesian Maritime Continent is strongly influenced by influenced by **Northerly Cold Surge (NCS)**→ extratropical-origin disturbance.
2. **NCS**→ a cool and dry air advection that **enhances low-level convergence** over western Indonesia.
3. **NCS+local features interaction**→ higher hydrometeorological disasters potential.

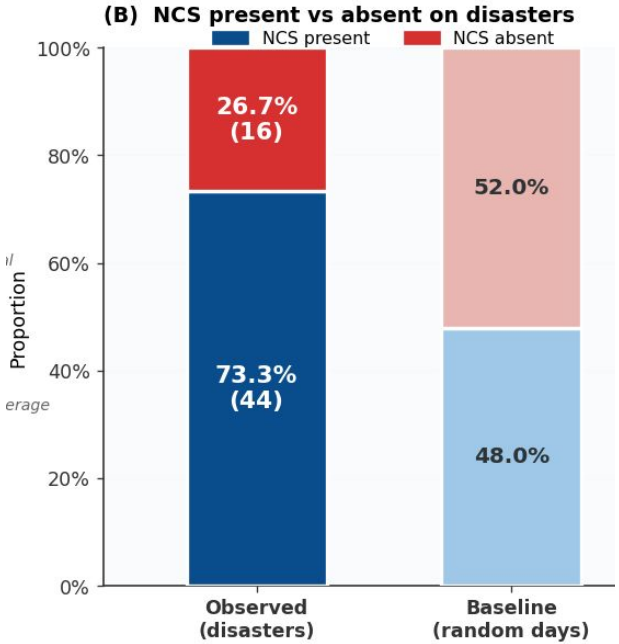
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NCS


①
H
Siberian-Mongolian High Pressure outbreak >1035 hPa (Yang et al., 2020).
T sfc drop in 48h ≥ 5°C (Liu et al., 2021).
②
V850 > 0.75 SD (Lim et al., 2017; Lubis et al., 2023)
③
④
V850 > 0.75 SD (Lubis et al., 2023)
50°N
40°N
30°N
20°N
10°N
0°
10°S
60°E
80°E
100°E
120°E
140°E
160°E

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Disaster and NCS co-occurrence in Jakarta



(C) Key metrics

SUMMARY

73.3%

of disasters coincided with NCS

NCS threshold	**Q75 = 0.00**
Valid window	**±2 days**
Disasters (coverage)	**60**
NCS in window	**44**
95% CI of $\hat{p}$	**[0.61, 0.83]**
Daily baseline	**0.480**

⚠ *Small n → findings are indicative, not definitive*

- **Asian Monsoon period**: Nov-Mar

Why Jakarta?

- **High population density**

  (in 2023 there are 74.249.651 people [BPSIndonesia, 2023]).

- **Vulnerability to floods and landslide** (2785 events in 2020-2024 [BNPB Indonesia, 2025])

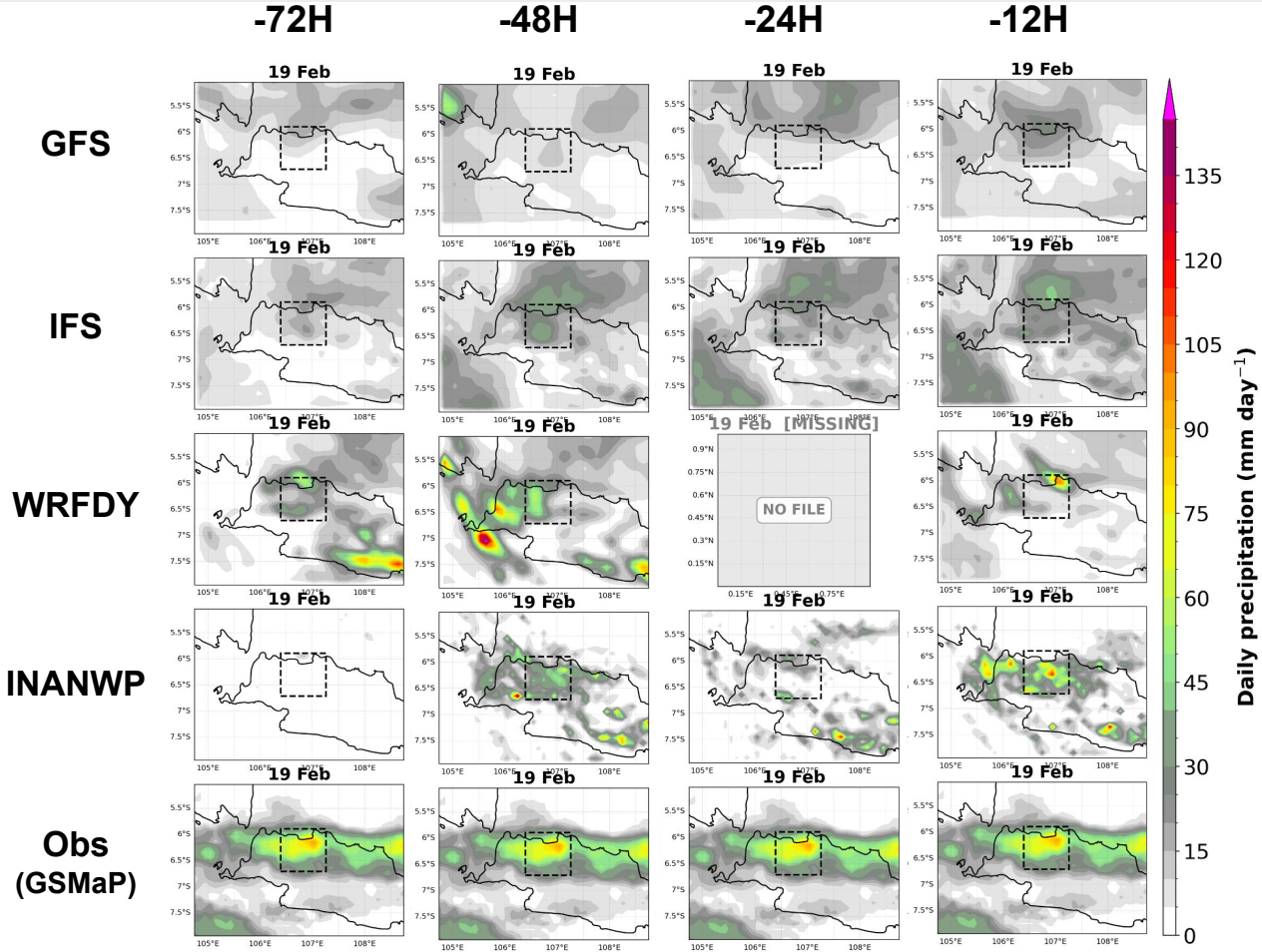
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Data

1. **Global model**:
    - GFS (NOAA)
    - IFS (ECMWF)
2. **Mesoscale model**:
    - INANWP (WRFDA-based model)
    - WRFDY (non-assimWRF-based model)
3. **Ensemble model**:
    - IFS Ensemble
4. **Observation:** GSMaP-JAXA

CASE 1 - Jakarta's Flood (19 Feb 2026)

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Precipitation

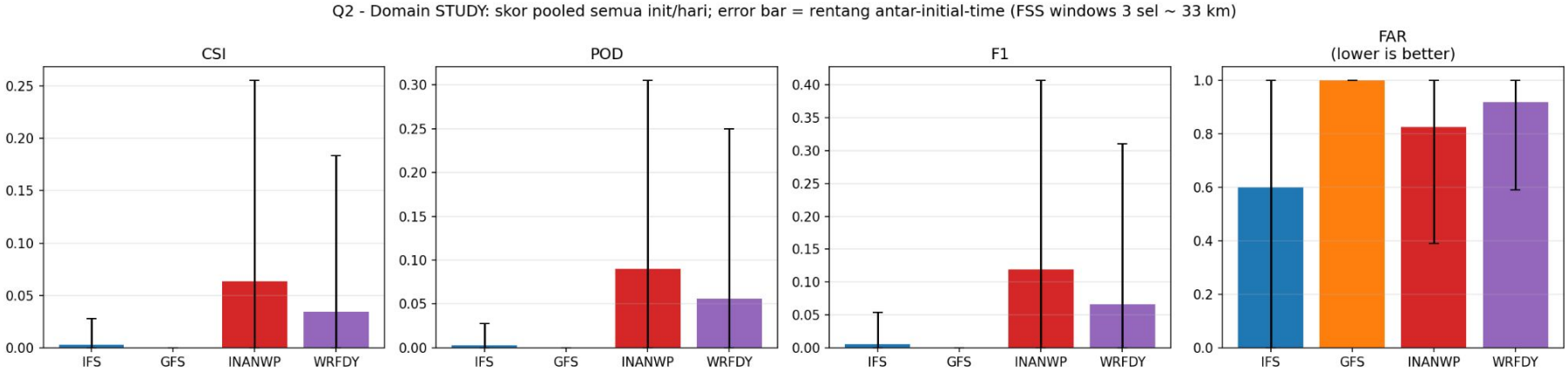
GSMaP indicates a widespread rainfall event, while the models differ in the intensity and spatial organization of it.

INANWP and WRFDY produce more pronounced local rainfall features.

Model jumpiness captured in INANWP should be treated with caution

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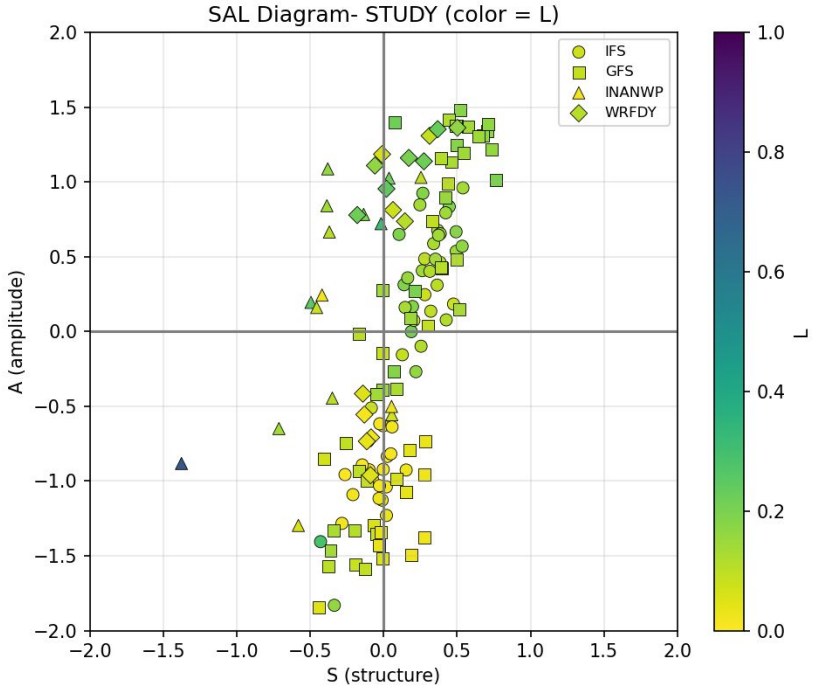
Grid Based Metrics

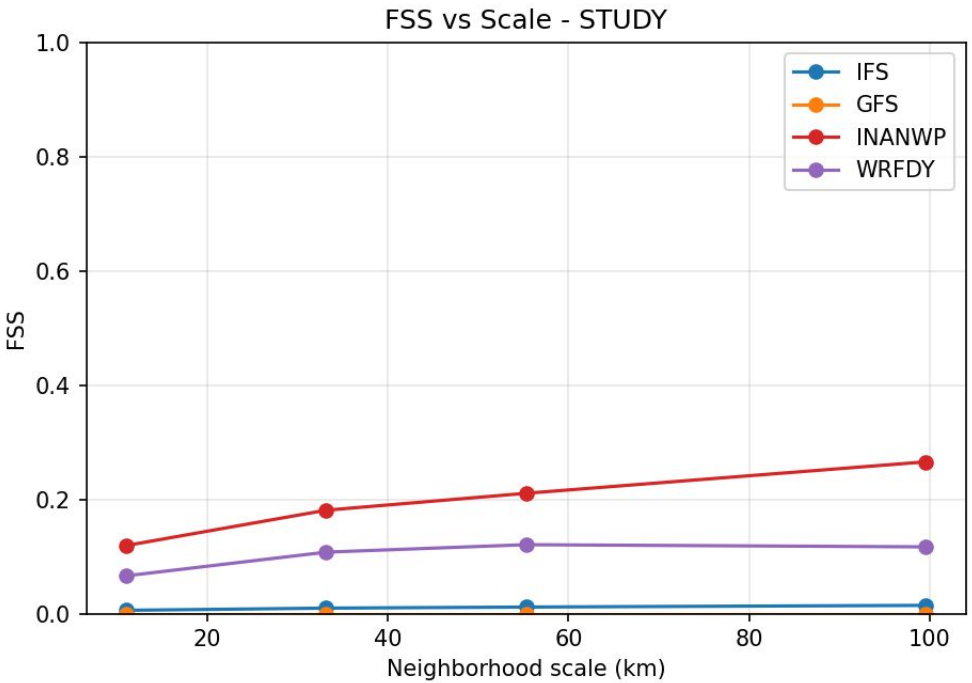


- INANWP achieves the strongest categorical heavy-rainfall detection.
- Both regional configurations show higher FSS than GFS and IFS, indicating improved neighbourhood-scale precipitation agreement.
- The remaining low detection skill and substantial false alarms indicate that regional-model improvements do not eliminate forecast uncertainty.

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Object Based Metrics

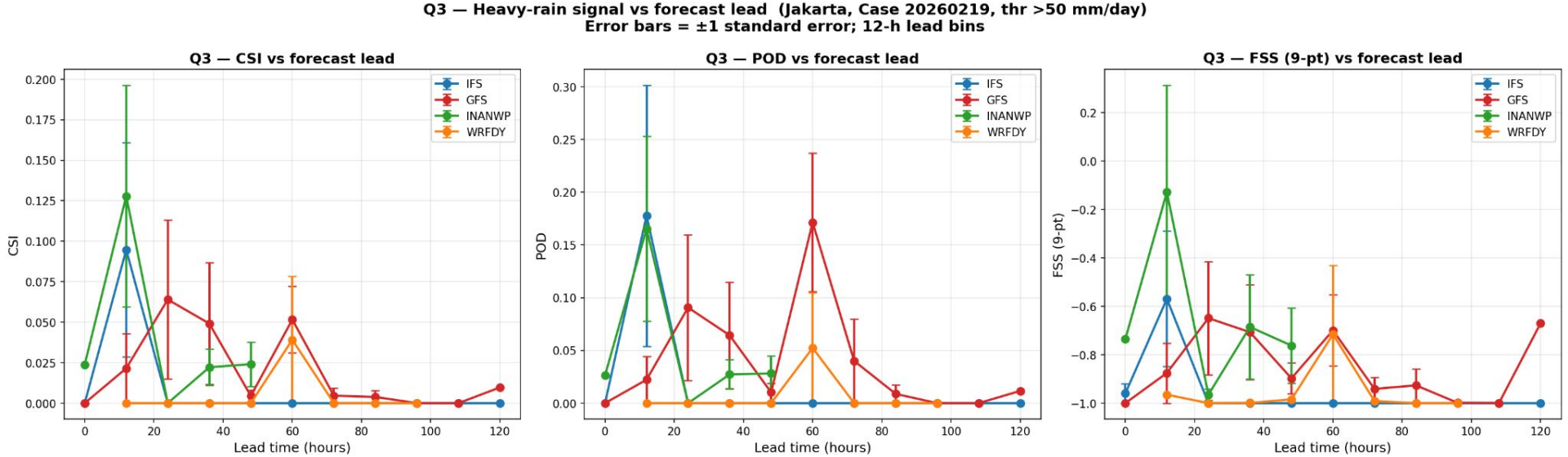




- Again, INANWP achieves the highest performance in SAL and FSS.

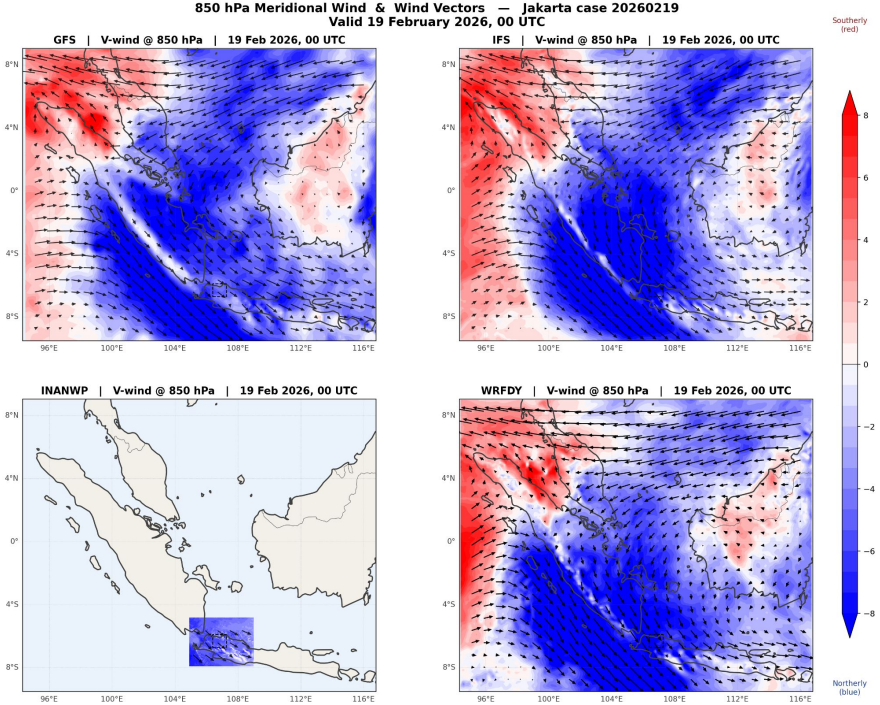
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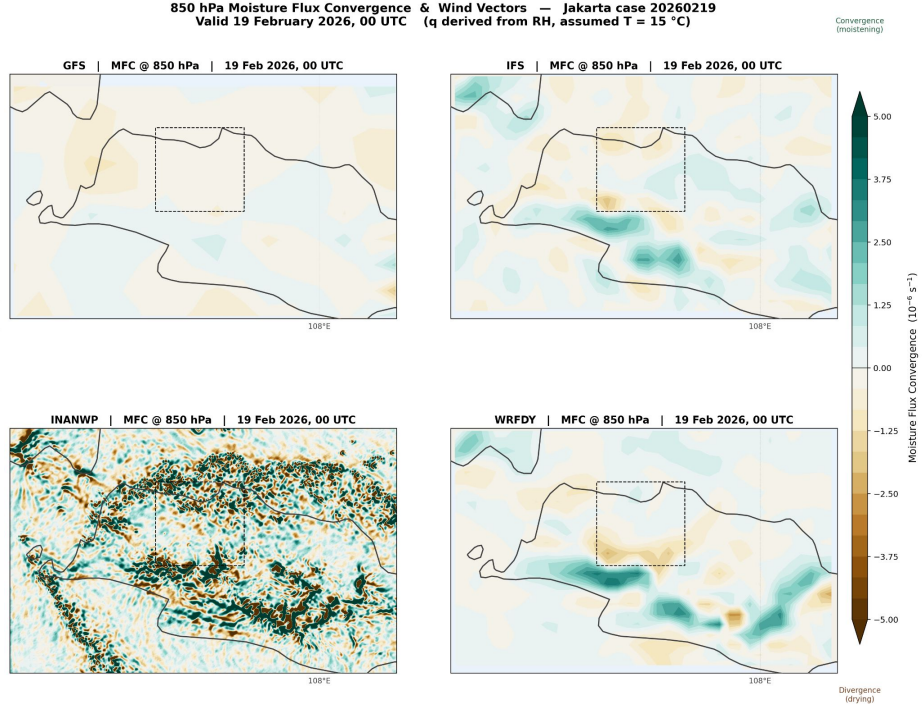
Performance vs Lead Time



- Heavy-rainfall skill varies substantially with forecast lead time and initialization.
- GFS and WRFDY exhibit intermittent skill peaks rather than continuous detection skill.

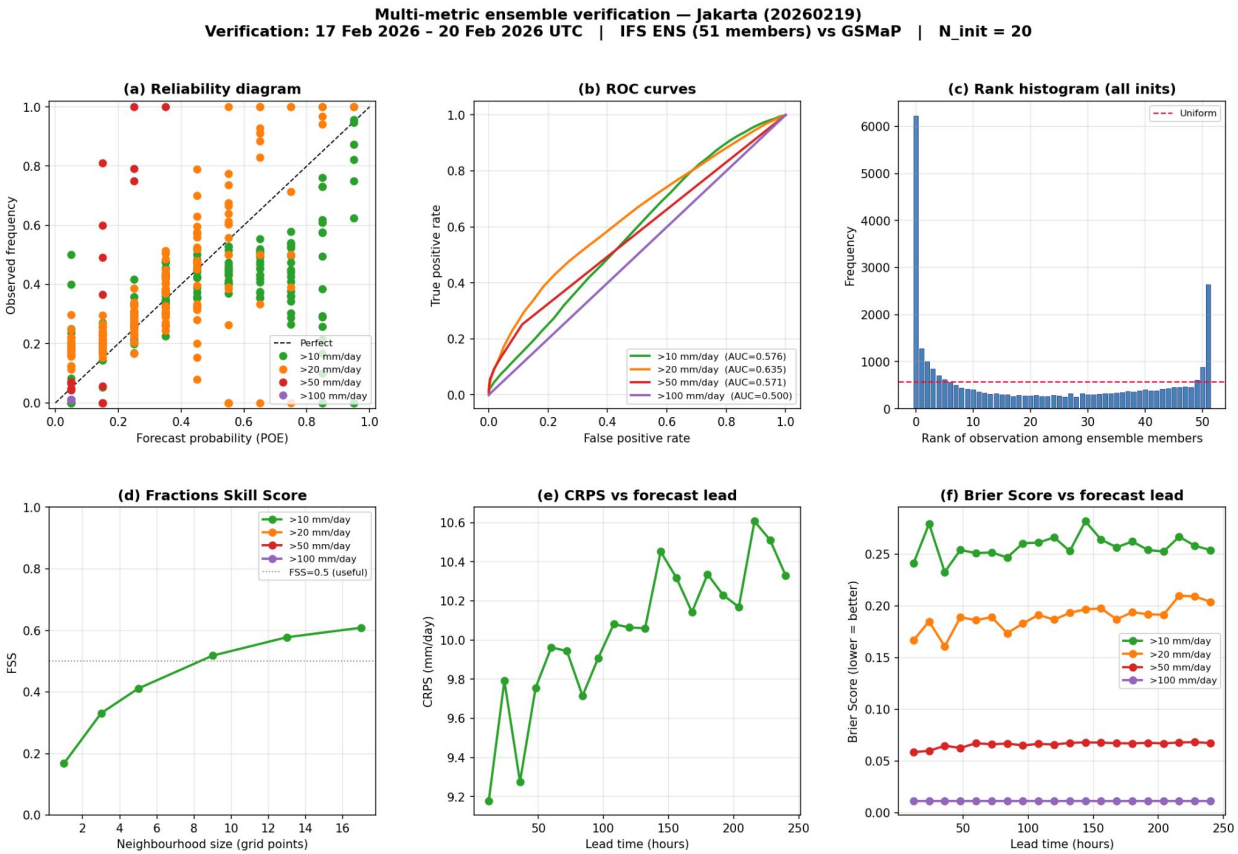
Meridional Wind and Moisture Flux Convergence





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IFS ENSEMBLE



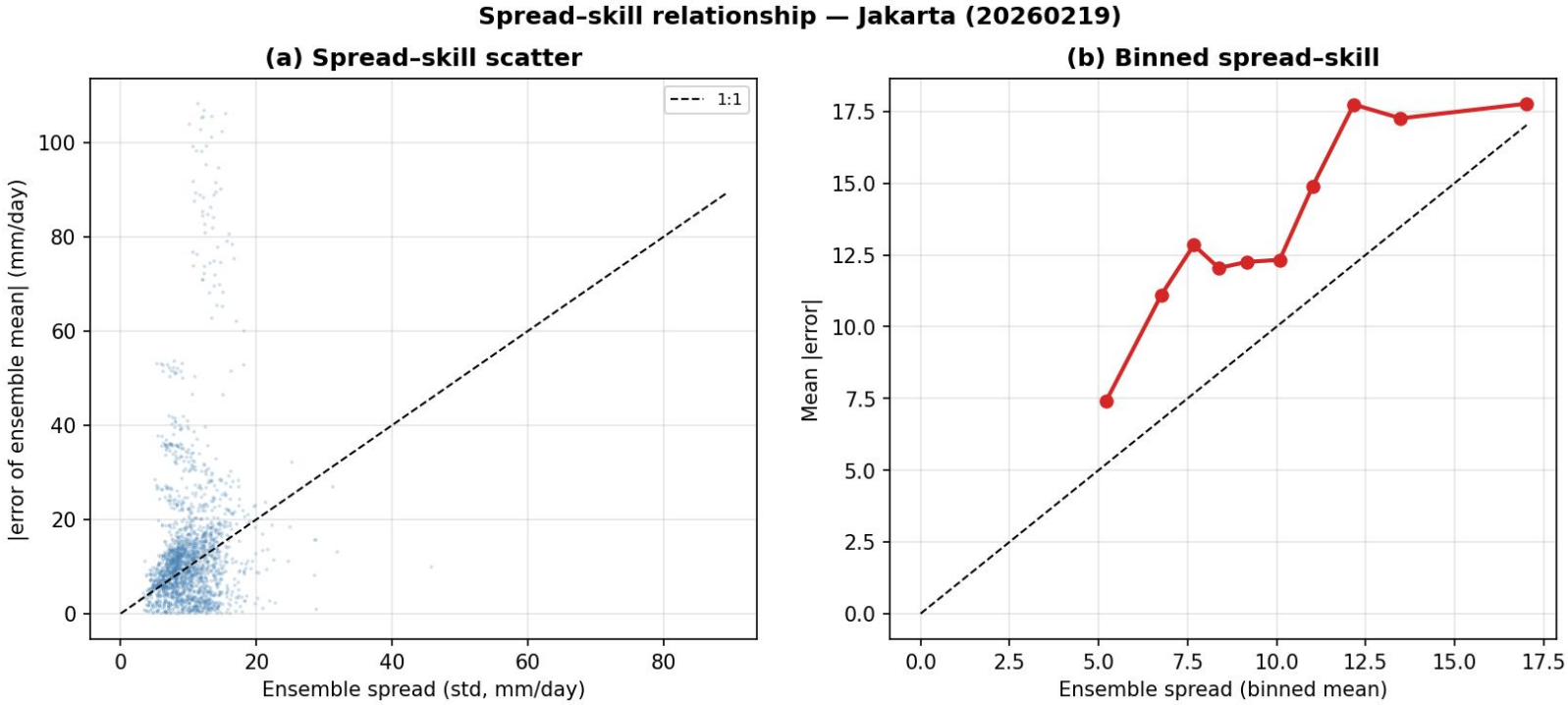
IFS ensemble discrimination is weak in this case, with reported ROC AUC values of approximately 0.50–0.58.

CRPS generally deteriorates with increasing forecast lead time, indicating declining probabilistic forecast quality.

The results suggest limited ability to distinguish event occurrence from non-occurrence under the evaluated configuration and thresholds.

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IFS ENSEMBLE



CASE 2

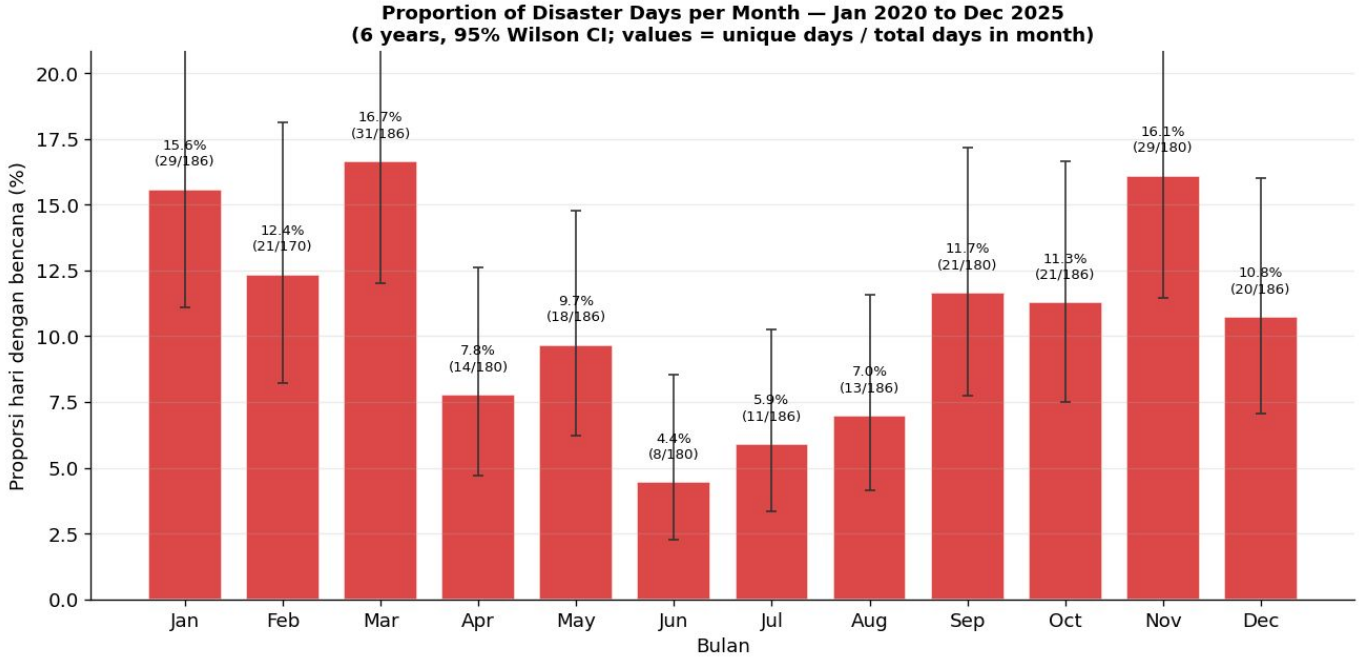
Flood Event

in Padang, West Sumatera

Heavy rainfall hit Padang caused a massive flood under very strong El Nino period (Kompas.com).

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Disaster Event in West Sumatera

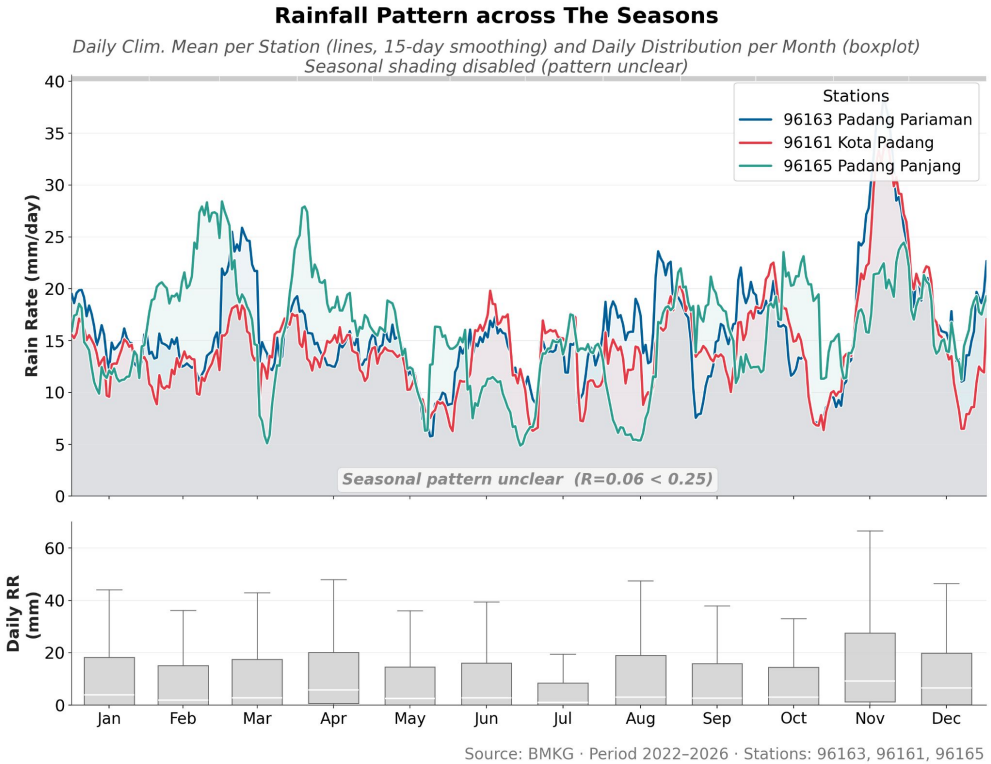


Disasters occur throughout the year.

Very strong El Nino is undergoing in October 2026→ hydrometeorological disaster become interesting

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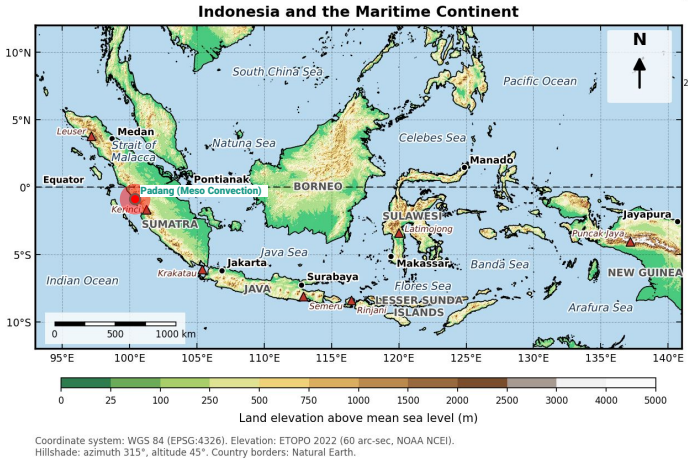
Rainfall Pattern



Source: BMKG · Period 2022–2026 · Stations: 96163, 96161, 96165

Non-seasonal rain pattern.

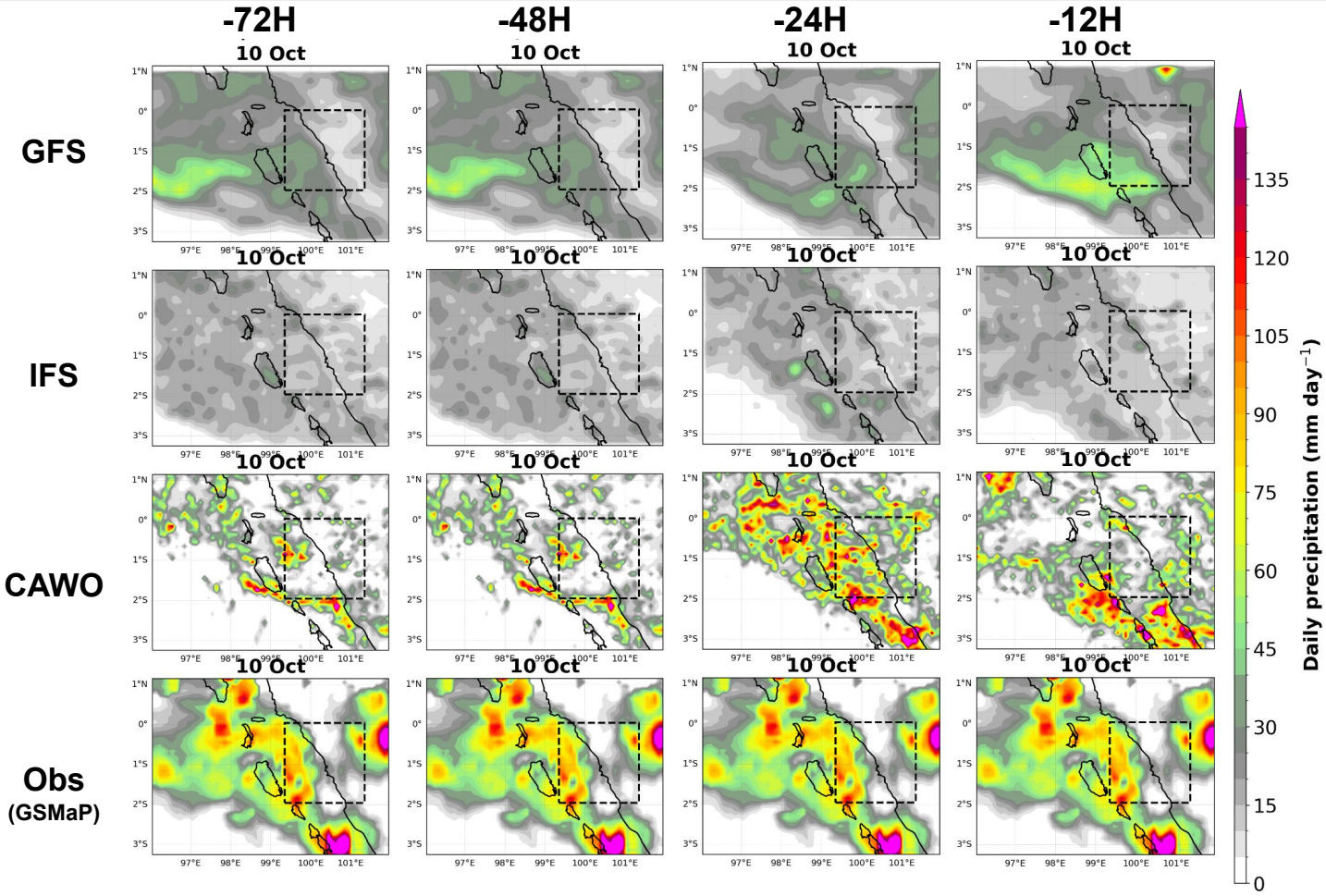
Westerly moisture transport, interacting local circulations, plays important role.



Coordinate system: WGS 84 (EPSG:4326). Elevation: ETOPO 2022 (60 arc-sec, NOAA NCEI).
Hillshade: azimuth 315°, altitude 45°. Country borders: Natural Earth.

CASE 2 - Padang's Flood (10 Oct 2026)

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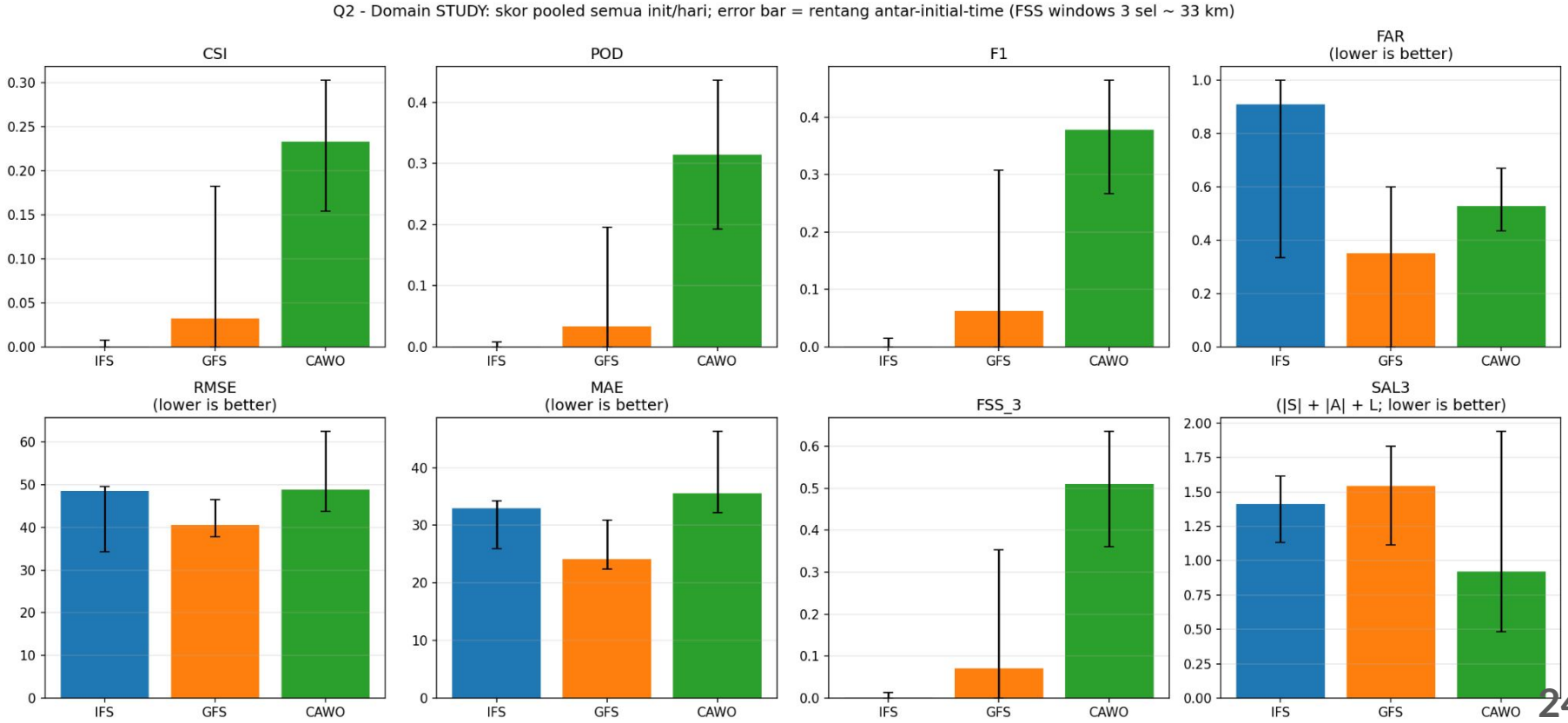


Precipitation

5 days prior event

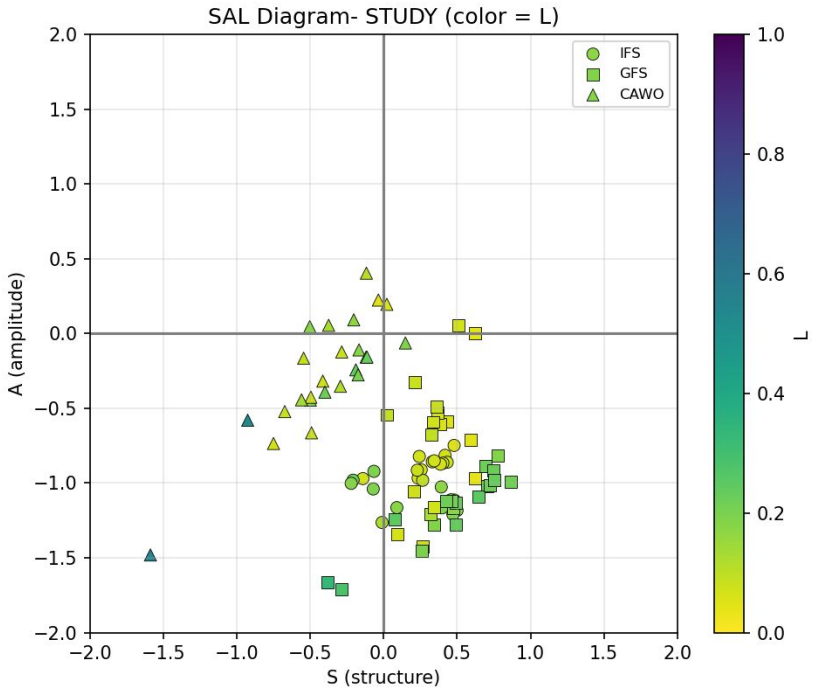
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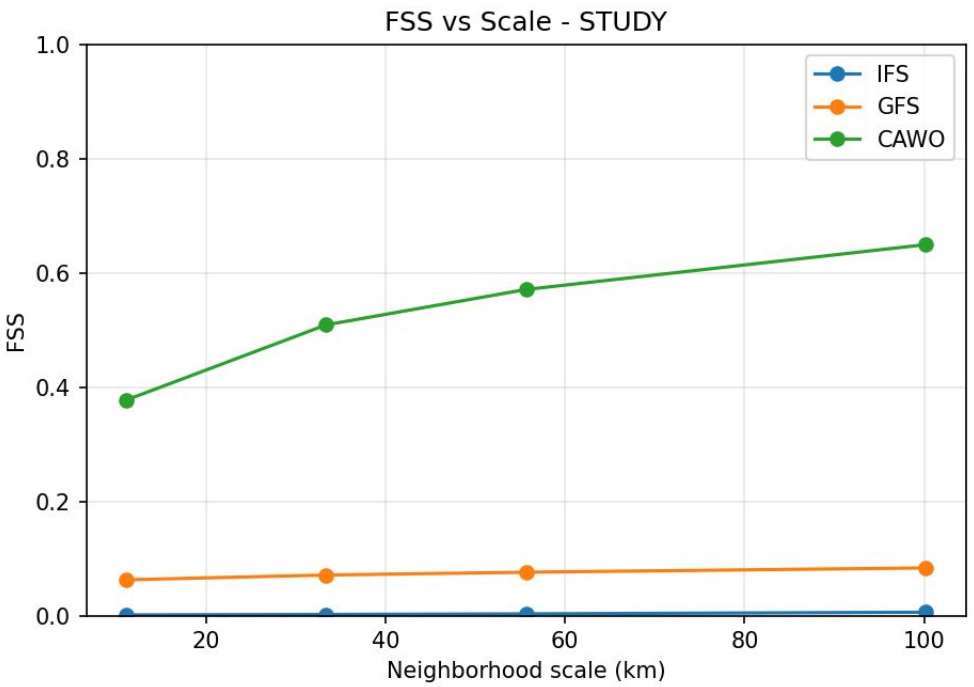
Grid Based Metrics



BMKG

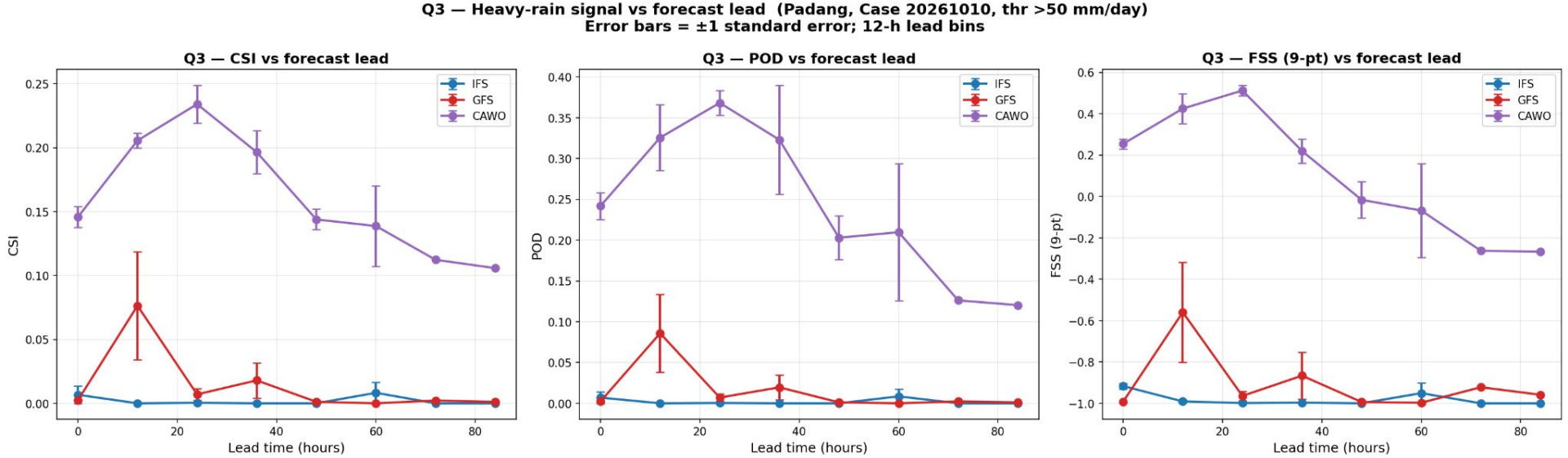
Object Based Metrics





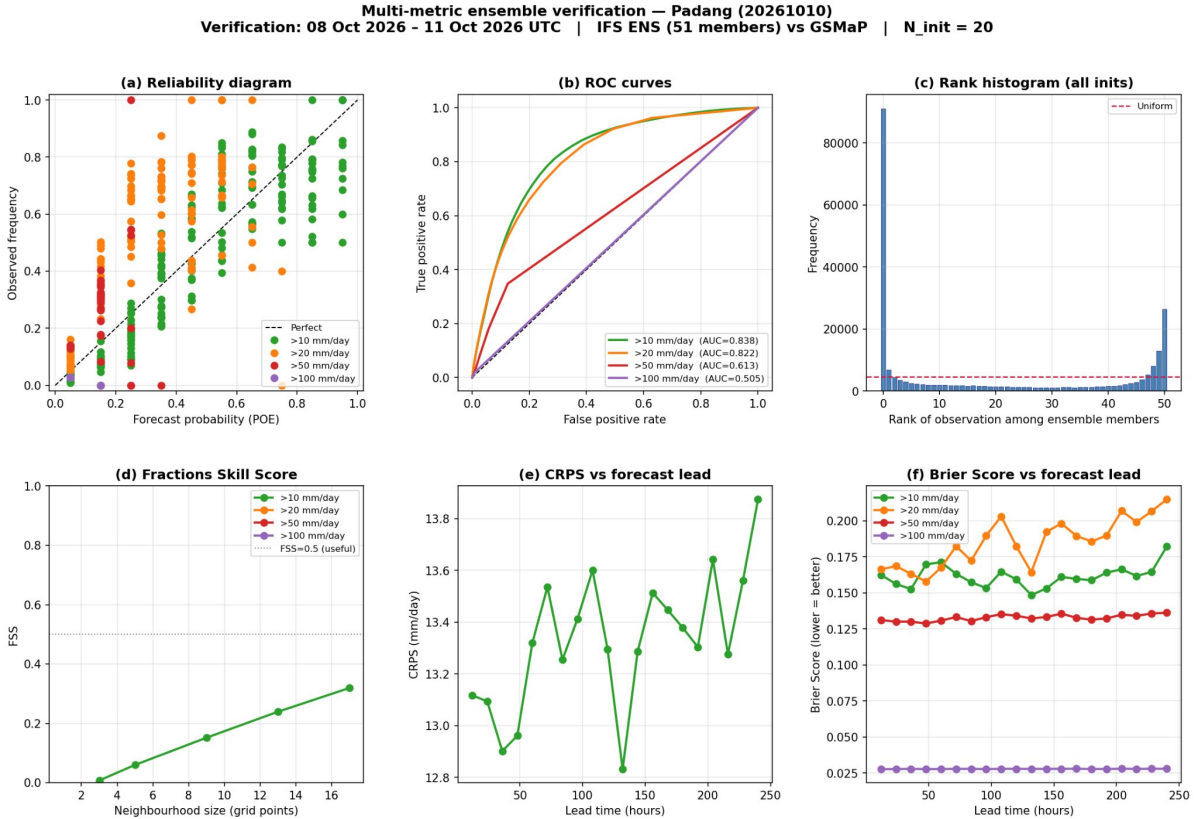
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Performance vs Lead Time



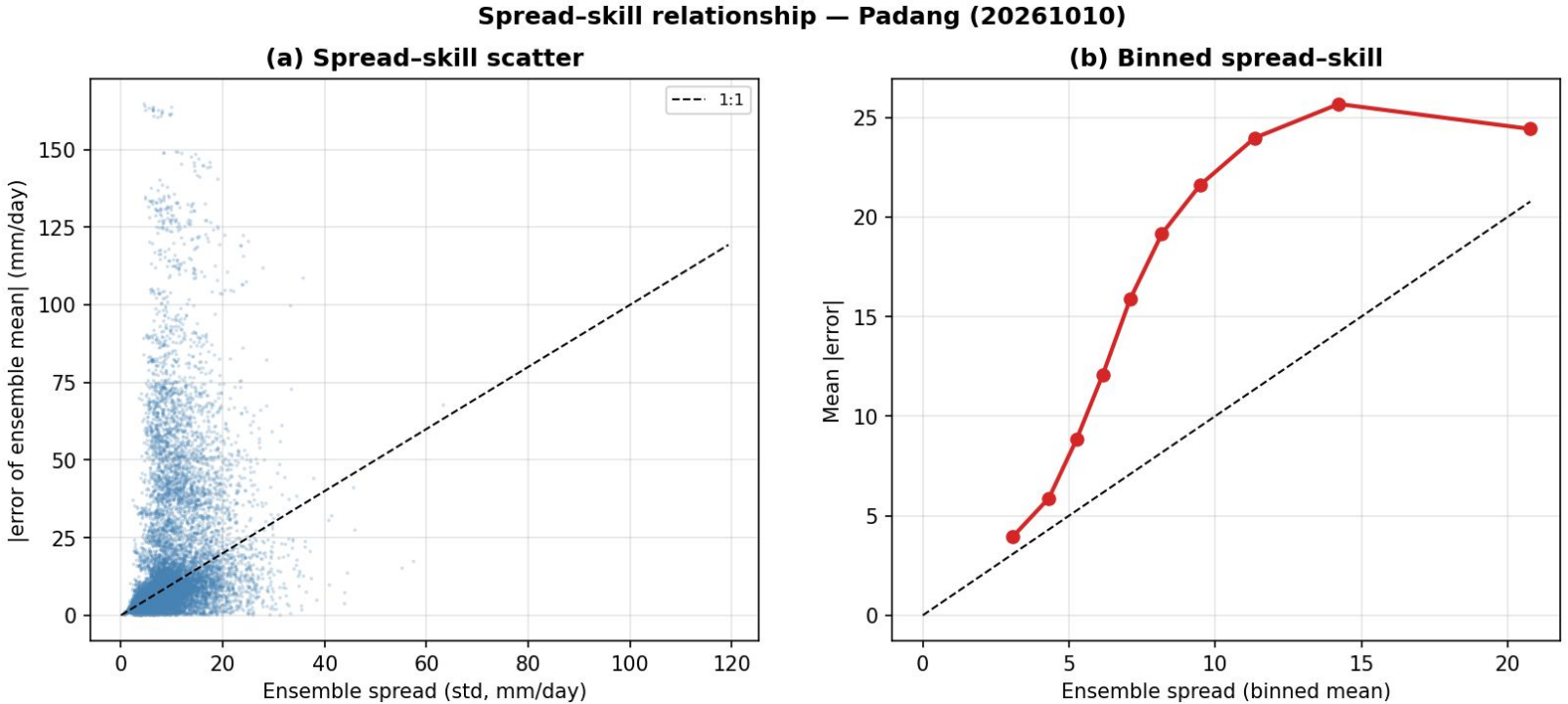
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IFS ENSEMBLE



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Conclusion

- Model performance is regime-dependent. INANWP provides the strongest categorical detection in the Jakarta case, while CAWO performs best in several rainfall-detection and spatial-verification metrics for Padang.
- Regional models show added value, but not uniformly. Improvements in detection and spatial structure coexist with false alarms, magnitude errors, and sensitivity to forecast lead time.
- Physical fidelity matters. The NCS-related northerly flow in Jakarta and westerly moisture transport in Padang provide distinct dynamical contexts for interpreting model performance.
- Verification must be multidimensional. Grid-based metrics, neighbourhood FSS, object-based diagnostics, and precipitation-error measures evaluate different aspects of forecast quality.
- Extreme-rainfall predictability remains challenging. The IFS ensemble shows weak discrimination in Jakarta and a substantial loss of discrimination at the highest rainfall threshold in Padang.
- Ensemble uncertainty is not yet fully reliable. Underdispersive spread–skill relationships indicate that forecast confidence may be overstated if ensemble spread is used without calibration.
- Operational guidance must be lead-time-specific. The best model and the most useful warning window depend on the event mechanism and the forecast metric relevant to the decision.