Localised FSS with a new factorisation to diagnose skill and skill improvements over time

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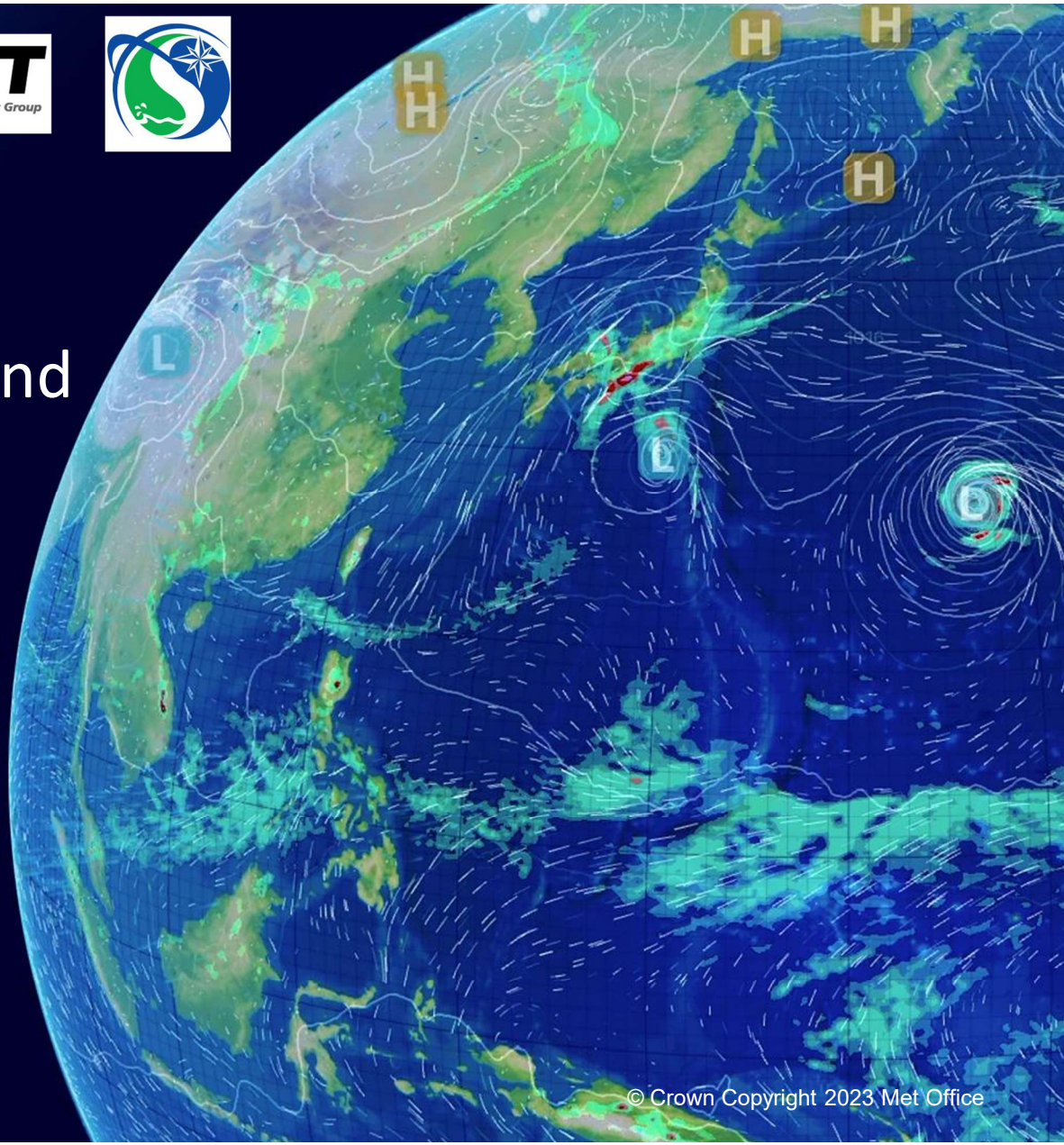
EWGLAM 2023



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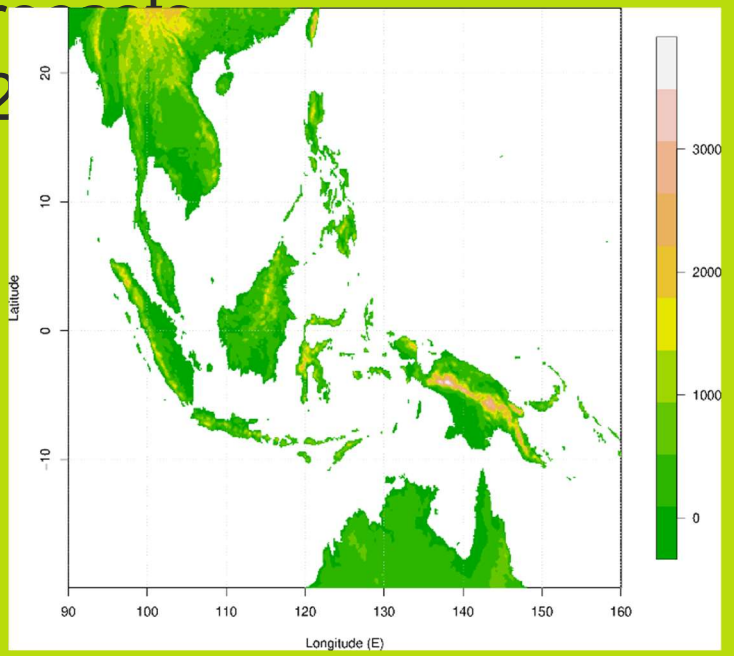
Overview

1. Precipitation over the Maritime Continent (MC)
2. What is the “localised FSS”?
3. Lead Time Potential (LTP)
4. Global precipitation forecast performance over the MC
   - Daily skill
   - Skill compared to persistence
   - Skilful Spatial Scale and LTP
   - Skill as a function of height
5. Trends in UK precipitation forecast performance

Illustrating concepts over MC

Using Global UM operational for
from December 2021 (GA7, N12
GPM IMERG v7

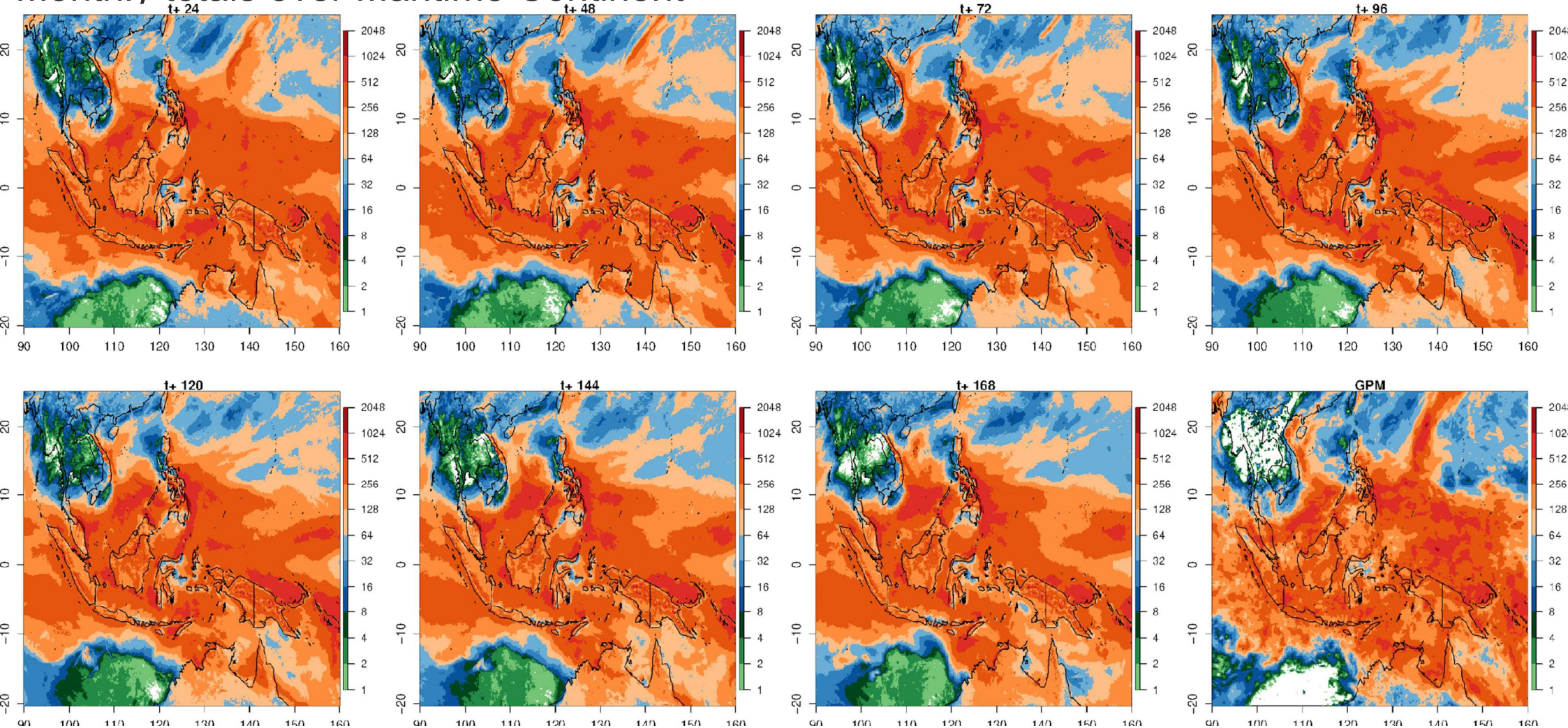


*GM oper is used due to ease of access and broad scale dynamics being unaffected by boundary conditions.

Met Office BMKG MiGHT Malaysian Industry-Government Group for High Technology Newton Fund

Monthly totals over Maritime Continent

Dec 2021, GA7



The *Localised* FSS (LFSS). What is it?

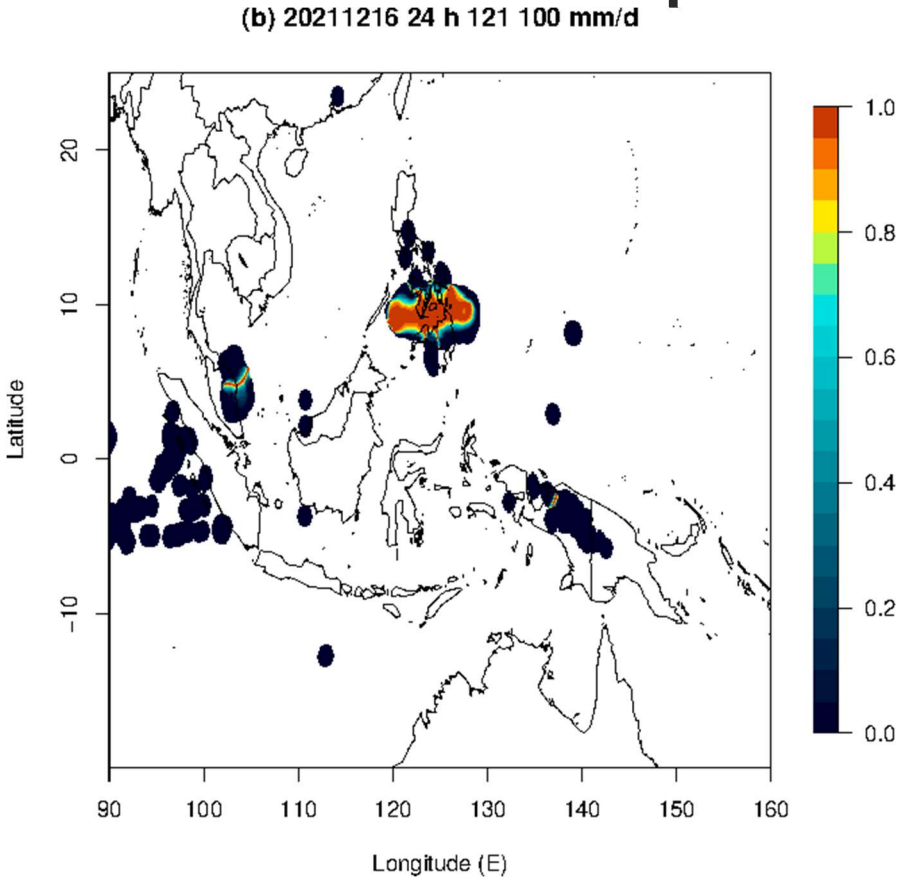
- **FSS on the grid** (see Woodhams et al. 2018) enables one to maintain the geographical location whilst casting the net ever wider to compensate for potential double penalty errors.
- It is “localised” because the **location of the central grid point remains fixed** and the scores for that location (and neighbourhoods centred on this location) are aggregated over time.
- Why is this useful and/or important?
  - Local effects are accounted for
  - Local skill is assessed taking the impact of any double penalty into account
  - Systematic patterns in spatial skill can be identified
  - Grid points with vastly different climatologies are not aggregated in space (this is especially relevant when FSS -or any score- is computed over large domains)
  - Vastly different model performance across large domains is not “hidden” or cancelled out, especially if there are systematic regional signals

“Factorisations” of the FSS…

- **Skilful Spatial Scale (SSS)** defined as L(FSS > 0.5 + f0/2) has been around since Roberts and Lean (2008). Here the FSS is framed in terms of a displacement and the useful or skilful spatial scales.
- ***NEW* Lead Time Potential (LTP, Mittermaier 2023)** defined as maximum lead time where FSS > 0.5. Here the FSS is framed in terms of how long a forecast is skilful for at a given location and in terms of measuring improvement whether forecast performance is staying higher for longer (in a new model version), i.e. whether hours or days are gained in terms of skill.

- Both of these can also be computed in a localised sense.

LFSS as a map



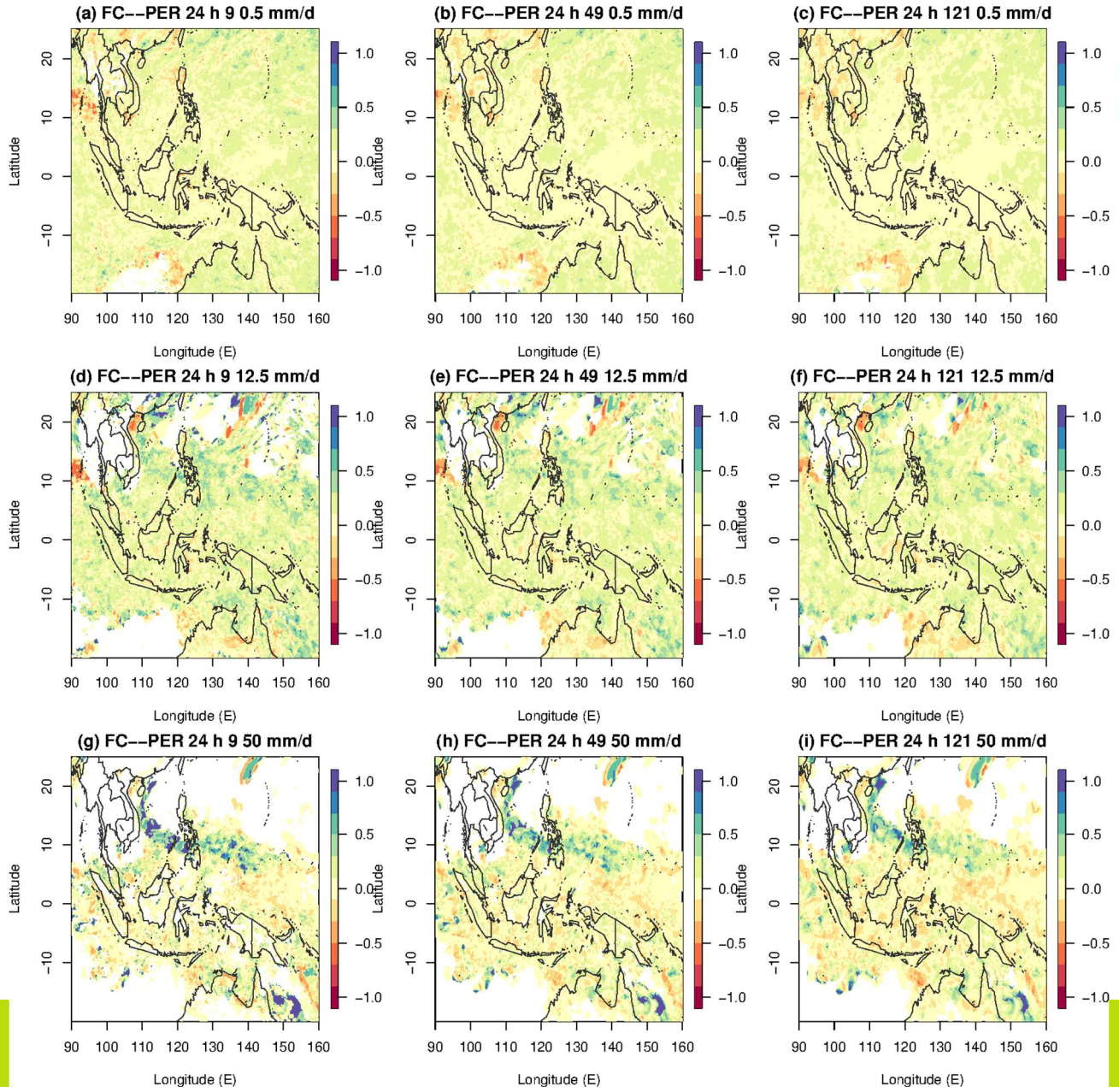
- LFSS can be computed for individual forecasts to create a sequence of maps showing how the forecast performs for an event (e.g., the landfall of Rai over the Philippines)
- Example of t+24h forecast using a ~130 km neighbourhood (121 grid points) and a daily threshold of **100 mm**.
- Can also compute the LFSS for a GPM-based **persistence forecast to see what value the global NWP forecast adds in this region.**

Mittermaier (QJ, submitted)

LFSS maps for Dec 2021

Maps as a function of threshold & n'hood size.

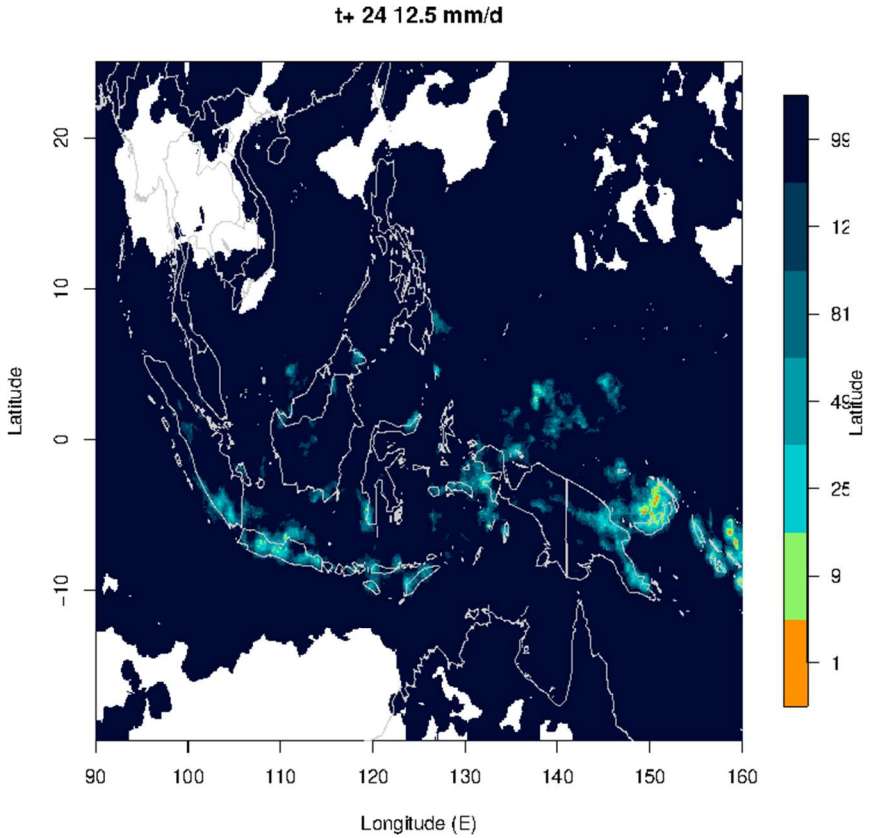
Provides rich detail to unpack the performance over high ground, coastal zones, just off-shore etc.

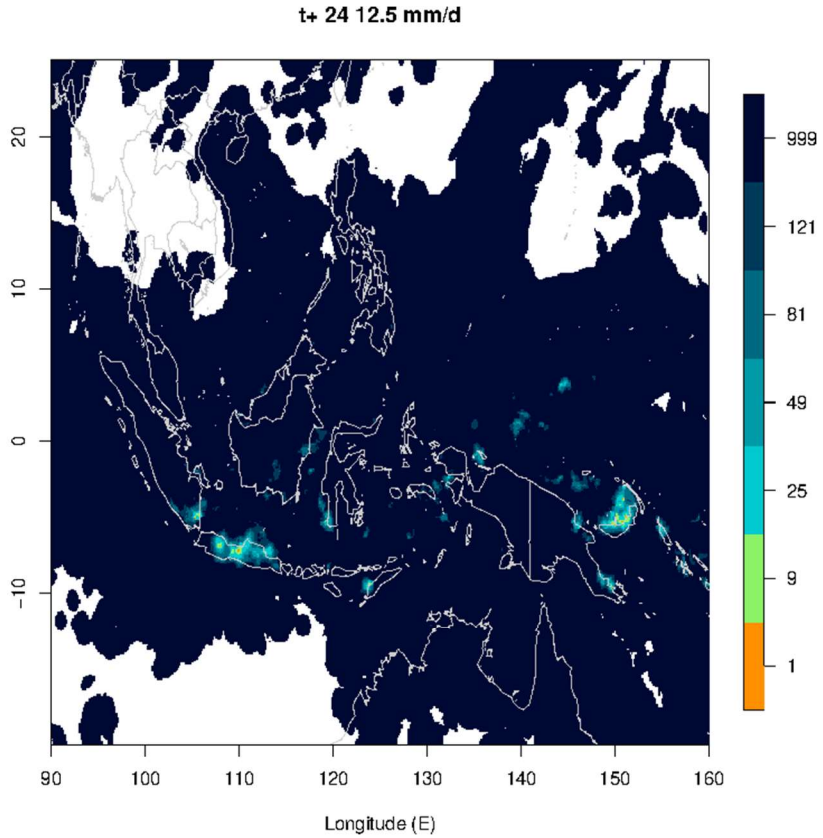


Comparison to persistence shows that NWP model adds skill over persistence, with larger positives for higher thresholds and for tropical cyclones.

Mittermaier (QJ, submitted)

Skilful Spatial Scale





Smaller is better
Pick out similar areas
Forecast provides benefit

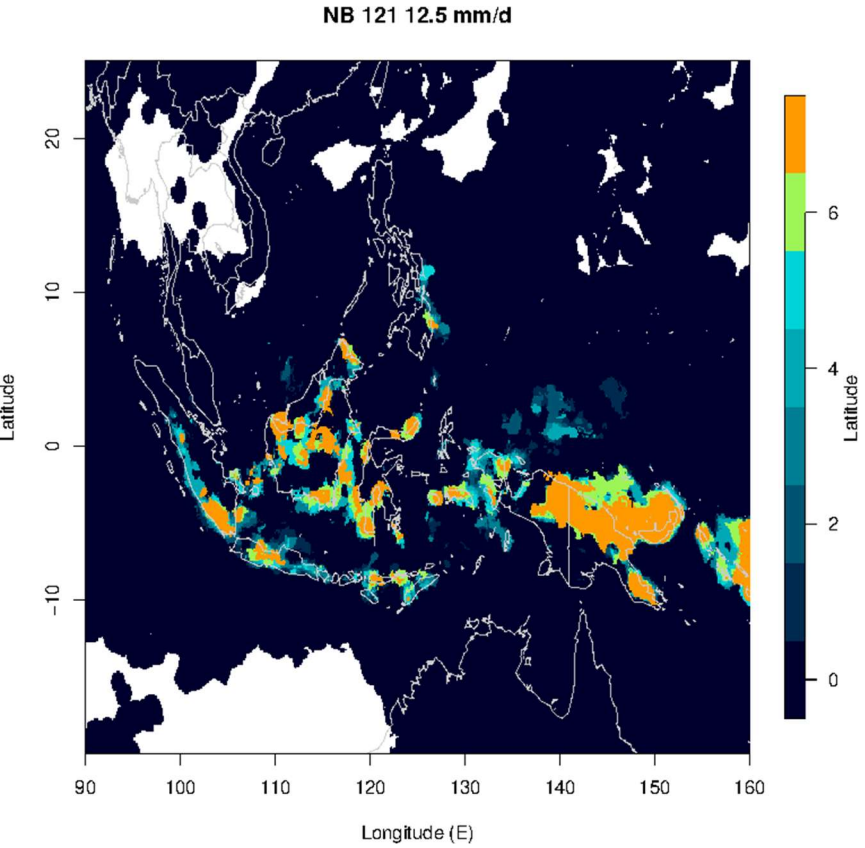
For Dec 2021

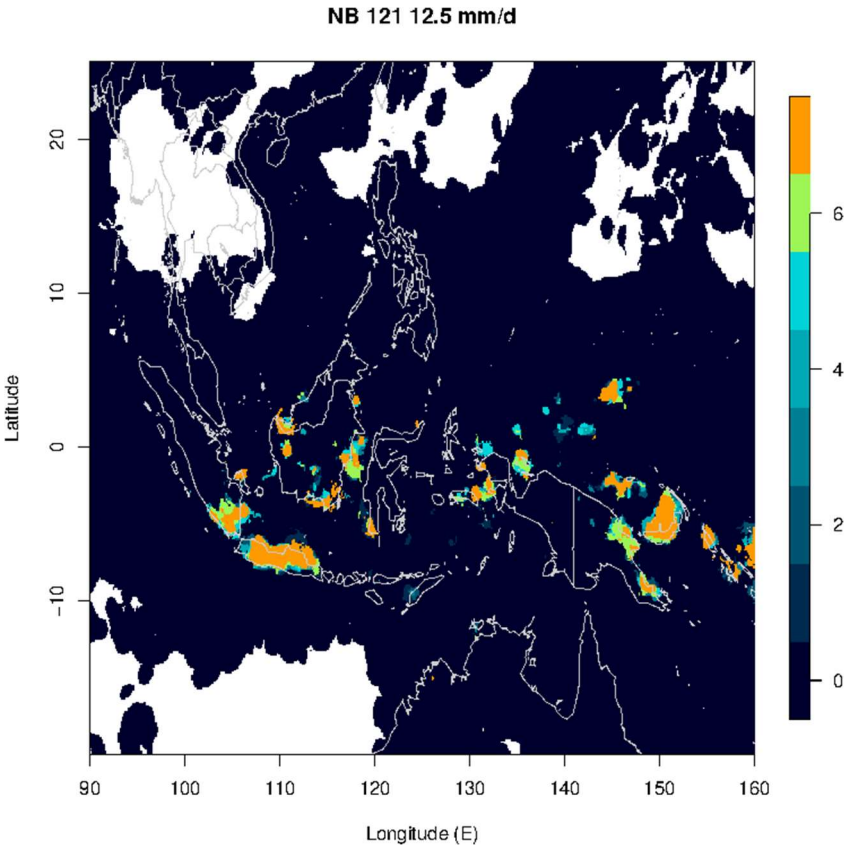
Forecast

Persistence

Mittermaier (QJ, submitted)

LTP





In days

Picks out some different locations

Forecasts provide more skilful guidance further ahead

Forecast

Persistence

For Dec 2021

Mittermaier (QJ, submitted)

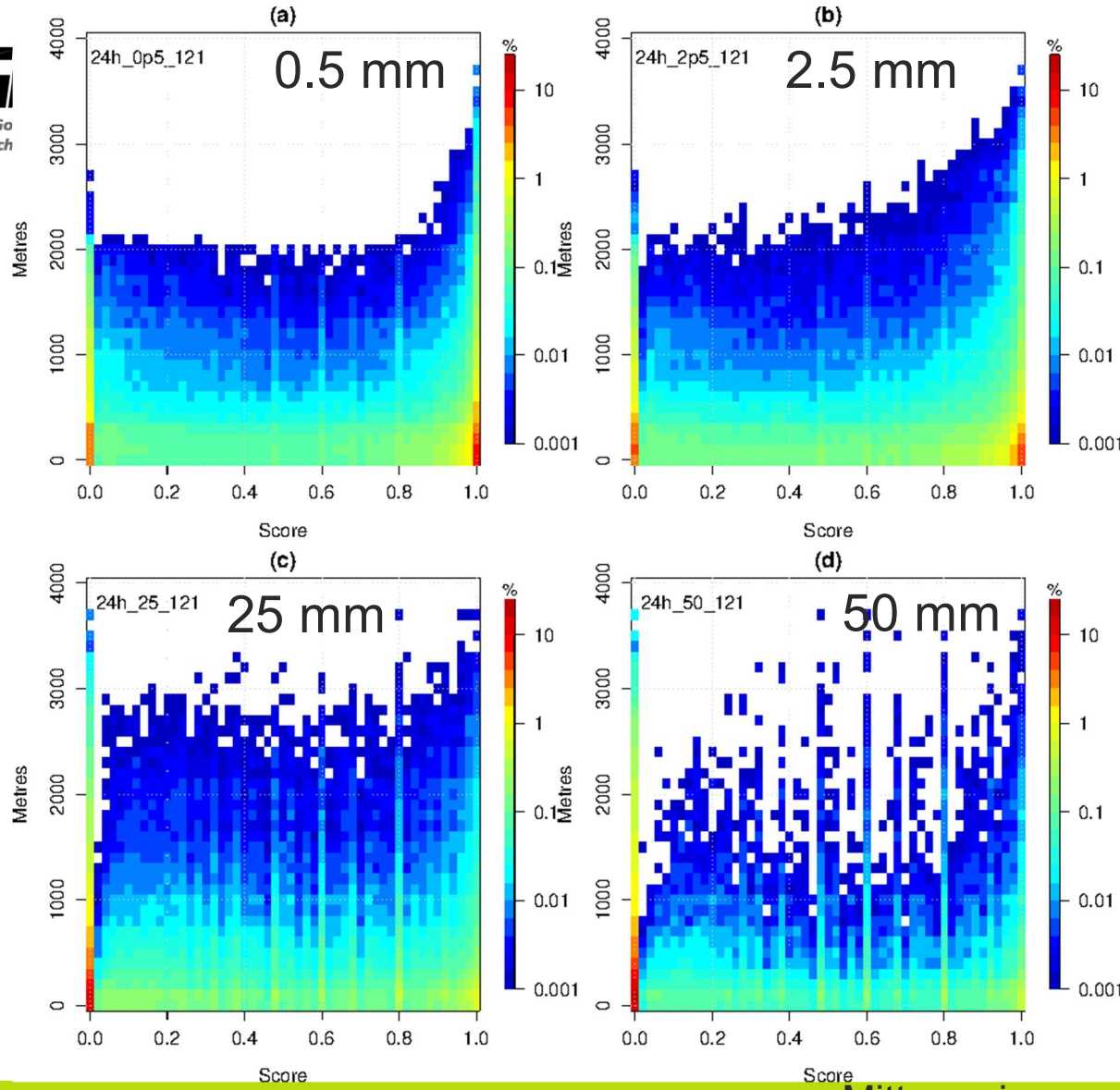
Scientific premise

Fact: **Topography** has a strong modulating influence on precipitation.

Question: Can we do a better job of **understanding the spatial distribution of precipitation** using different observation types and new tools near coasts, over land and high ground?

Stratification by height

- LFSS values stratified using GM orography for different thresholds and the largest neighbourhood size (121)
- High ground affects predictability and skill of daily precipitation.
- Provides valuable input on the variability in skill over land and how to aggregate results to ensure systematic signals are preserved.



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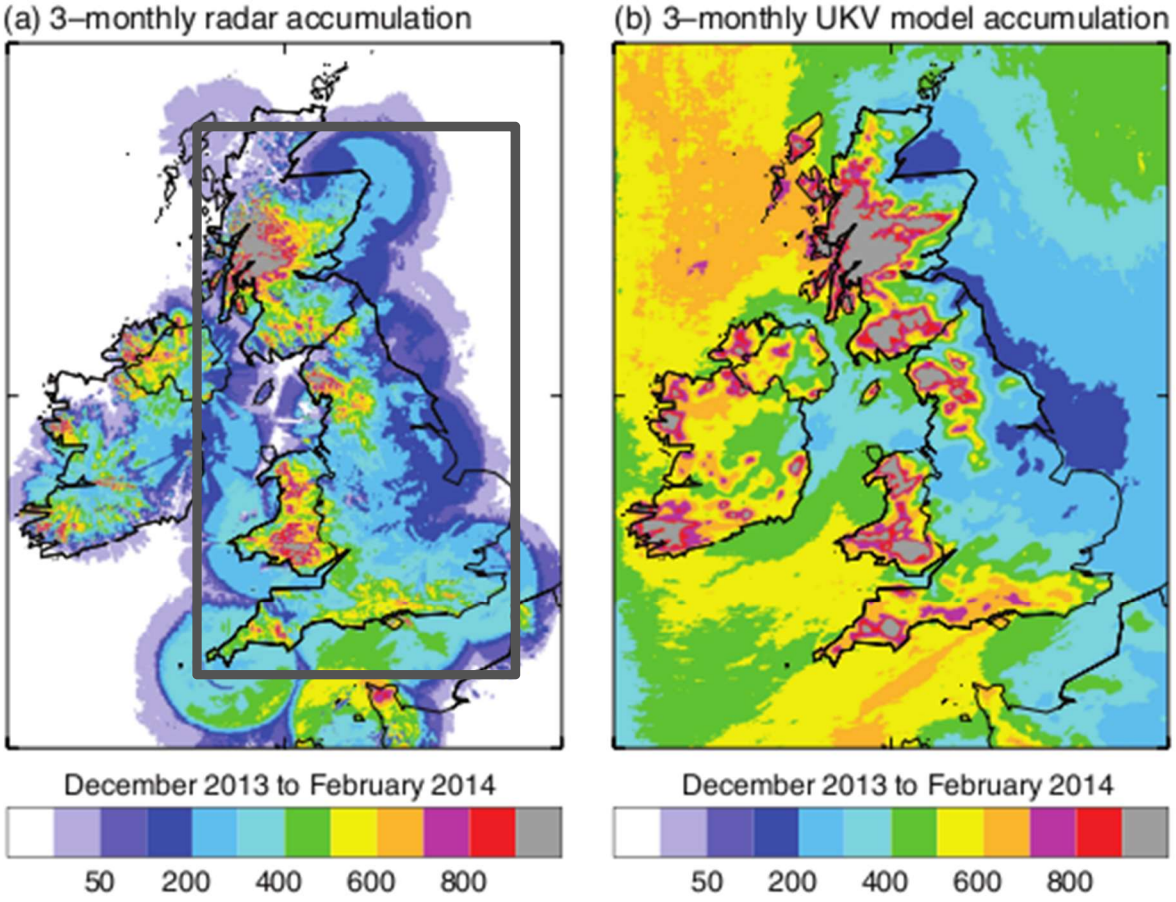
UKV long-term trends in performance

- Since 2008.
- FSS calculated routinely since early 2008, using VER code in the operational verification suite (Area 555).
- Initial comparison of benefit of UK4 over NAE published in Mittermaier *et al.* 2013.
- Three models span period since then: **NAE (12 km), UK4 (4 km) and UKV (1.5 km).**
- Parallel suites 19 to 45.
- *NAE and UK4/UKV have run at offset times: for comparison the t+9h UK4 could be compared to a t+6h or a t+12h NAE for 6h accumulations.*

Area 555

Radar quality: why percentile thresholds are needed

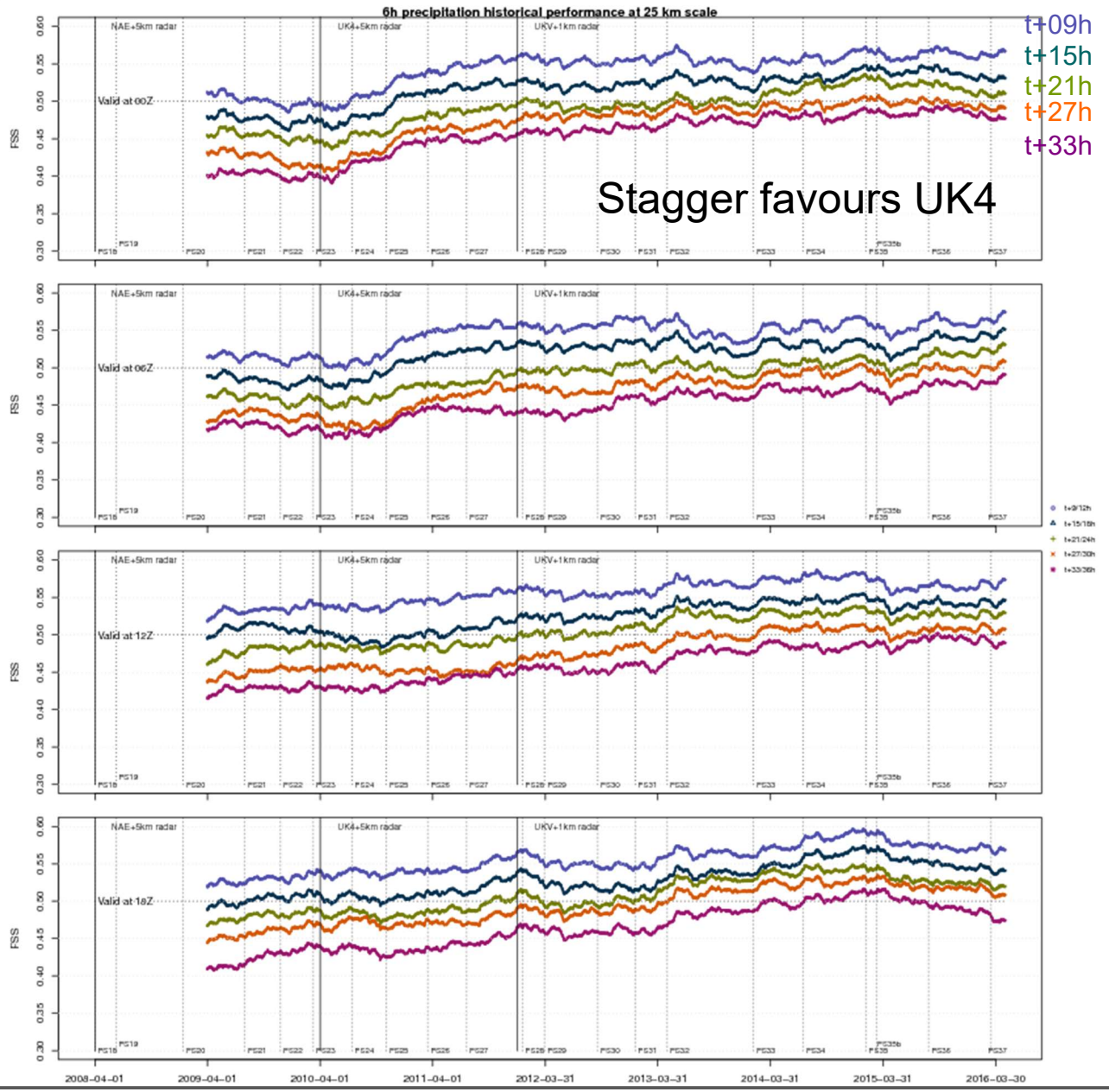


From Lewis *et al*. 2016 Met. Apps

- Nothing else can provide the spatial detail like radar
- Radar quantitative precipitation estimate (QPE) errors can be large, often ~20%, can be > +/- 50+%
- Best to retain the spatial distribution information whilst removing any biases → use percentile thresholds
- Consider biases separately.

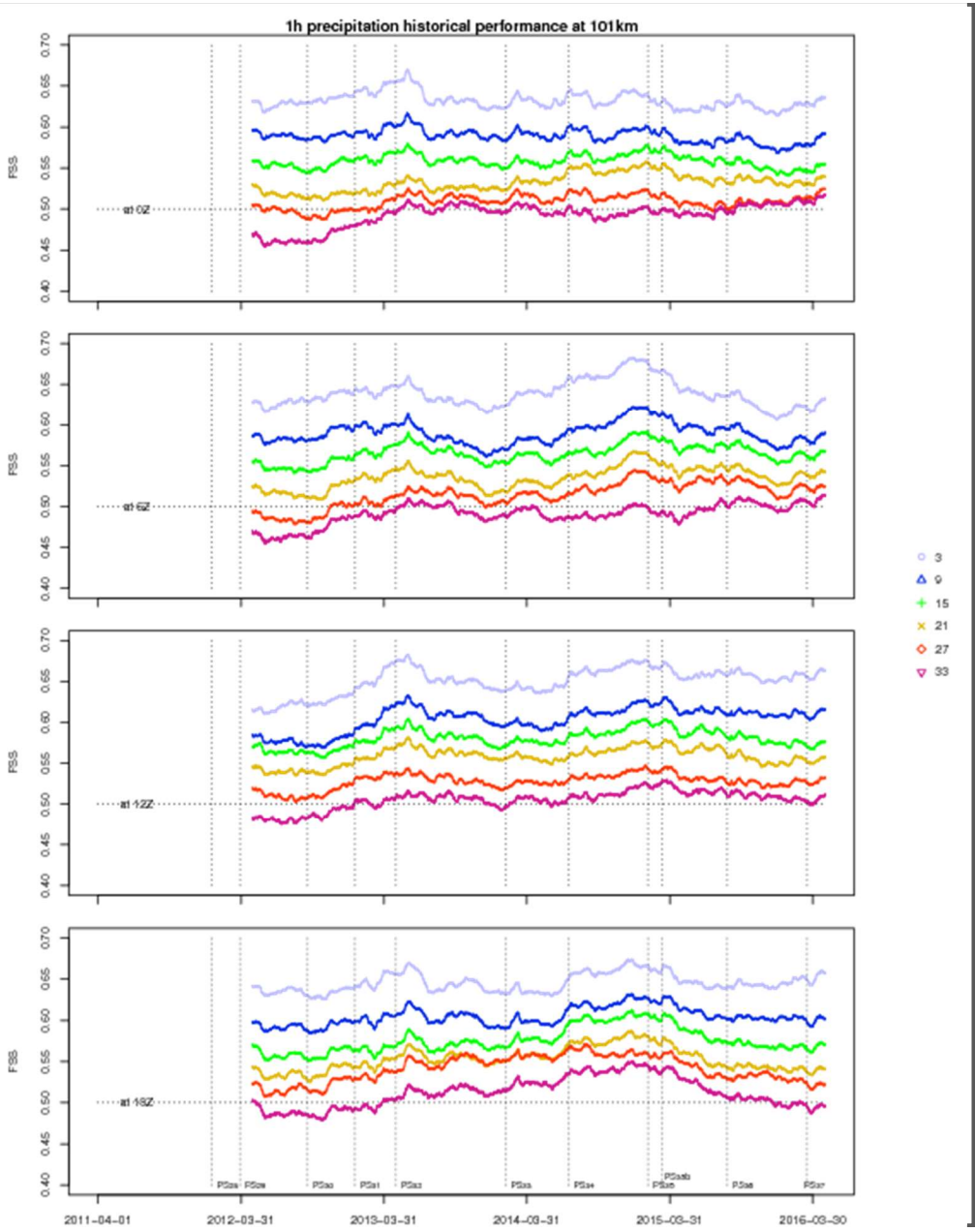
Combined 6h time series

- Two ways to combine stagger/offset between NAE and UK4.
- Models joined to coincide with changes to the UK index.
- **Generally positive trend**.
- Diurnal variations in skill.
- PS35 had a marked impact on afternoon forecast skill, affecting longer leader times more strongly.

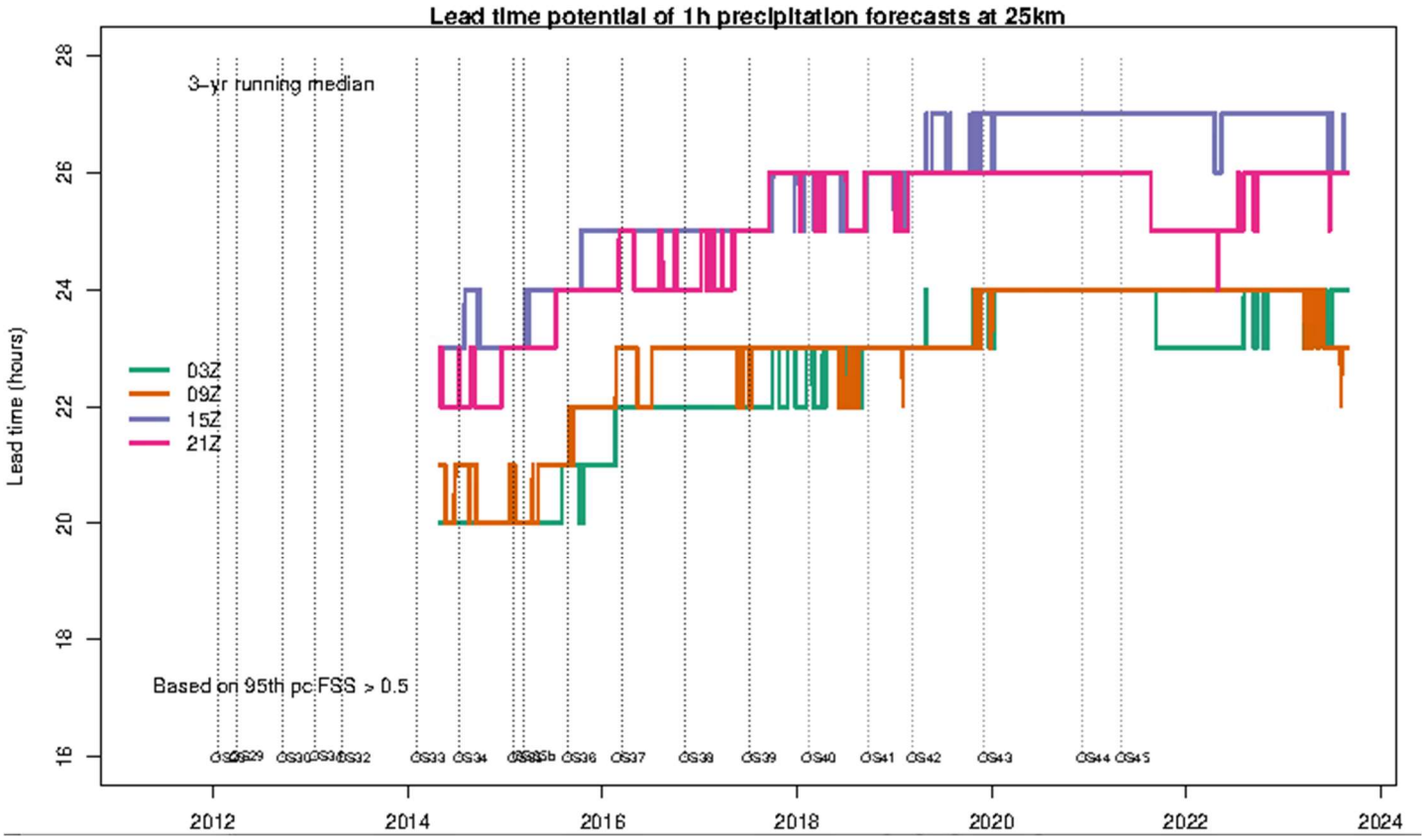


Trends in hourly scores

- Scores lower than for 6h accumulations, each hour is similar, but different.
- **Neighbourhoods of at least 101 km required to achieve useful skill at t+36h.**
- Non-linear convergence/improvement in skill for successive lead times, over time.
- Interesting (diverging) patterns of impact from PS35 changes.
- **Positive trend more noticeable at longer lead times, and prior to PS35, especially at 18Z.**



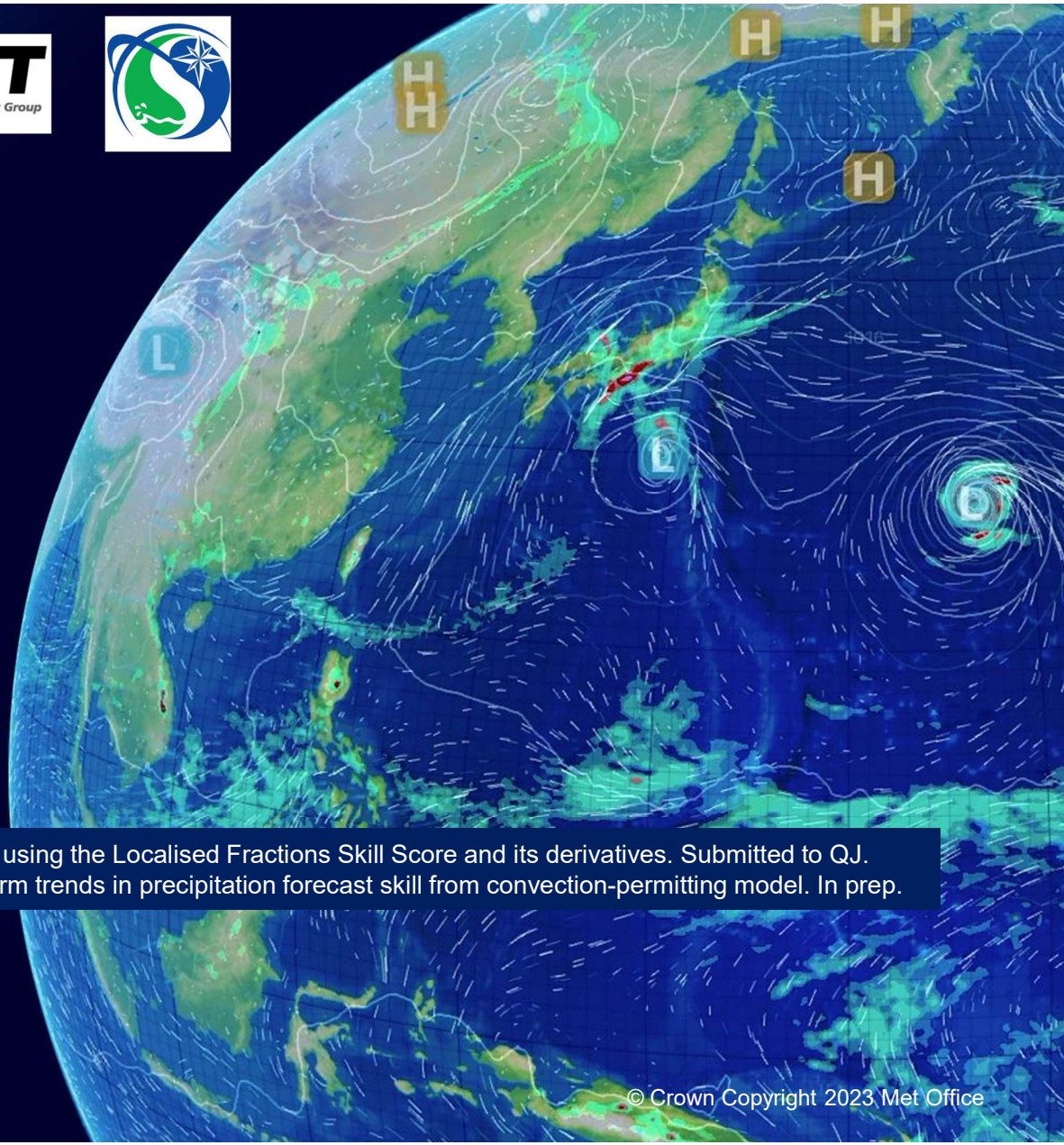
LTP for the UKV since 2011



- ~5 hours of skill in lead time gained
- Clear difference in the performance of the afternoon /evening initialisations to the morning ones

3-year running median of the LTP (in units of hours) for 4 of the initialisations

Thanks for listening!
Questions?



Mittermaier, M.P., 2023: Precipitation forecast skill over the Maritime Continent using the Localised Fractions Skill Score and its derivatives. Submitted to QJ.
Mittermaier, M.P. and M. Bush, 2023: Examining evolution and origin of long-term trends in precipitation forecast skill from convection-permitting model. In prep.

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