Weather regimes in South East Asia: Sub-seasonal predictability of the regimes and the associated high impact weather

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EGU 2021 – Subseasonal to seasonal prediction: processes and impacts

INTRODUCTION

Newton Fund WCSSP project: Weather regimes for Southeast Asia

- Identify weather regime patterns for Southeast Asia
  - **two sets of weather regime** patterns that describe the large-scale circulation variability across Southeast Asia using different statistical clustering approaches: a **single-tiered** and a **two-tiered** clustering method.
- Relate the weather regime patterns to **known modes of tropical variability and high impact weather** in Southeast Asia
  - See companion presentation by **Emma Howard** (EGU21-7472: Weather regimes in South East Asia: connections with synoptic phenomena and high impact weather)
- Demonstrate the use of weather regime patterns in **improving long-range forecasts for high impact weather** risk in Southeast Asia
  - **Main focus of this talk**

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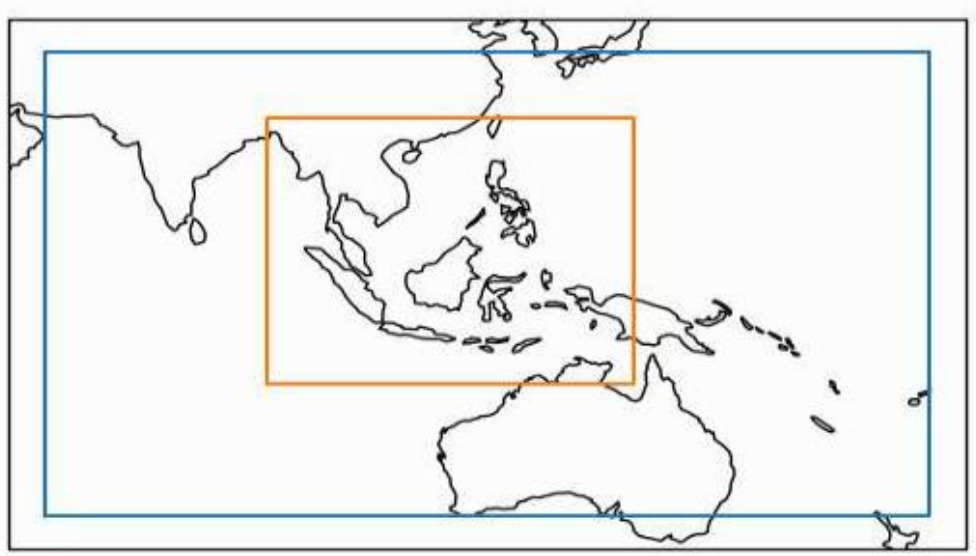
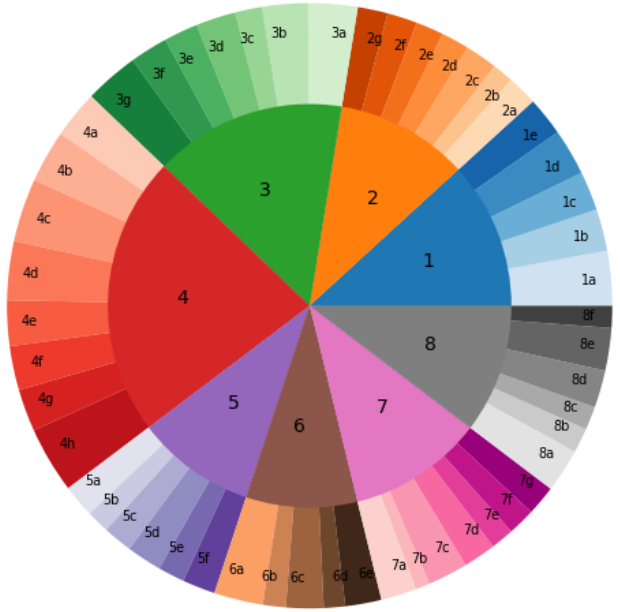
Methodology

- We apply a **two-tiered approach**:
  - First, we perform cluster analysis on a large **planetary-scale tropical domain (35S-35N, 60E-180E)**, which separates patterns of large-scale variability, including the seasonal cycle and ENSO. (**Tier 1: 8 clusters**)
  - Following this, we perform a secondary clustering analysis for each tier 1 regime on the **Southeast Asia domain (15S-25N,90E-140E)**. In this case, we limit the input data to dates identified as belonging to each tier 1 regime. (**Tier 2: 5-8 subclusters per tier 1 cluster, 51 subclusters in total**)



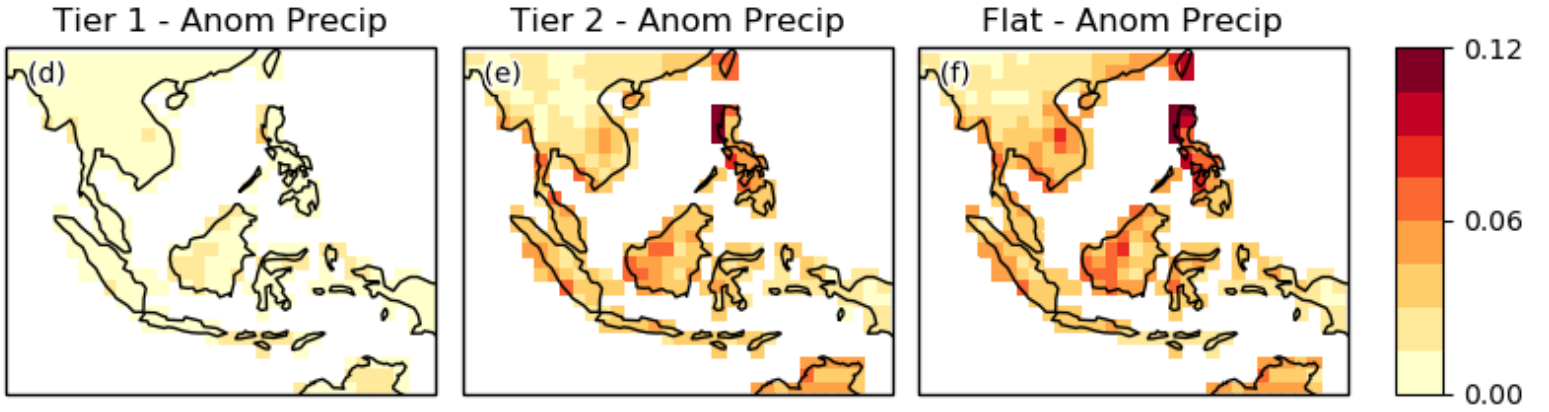
- We compare the two-tiered approach to a **flat approach** consisting of **51 patterns** obtained by clustering analysis on the Southeast Asia domain only.
- In each case, **k-means clustering** is performed using **daily mean ERA-5 850-hPa wind vectors** from 1979-2018. EOF analysis is used to reduce the dimensionality of the datasets.
- No seasonal sub-setting was considered beforehand.



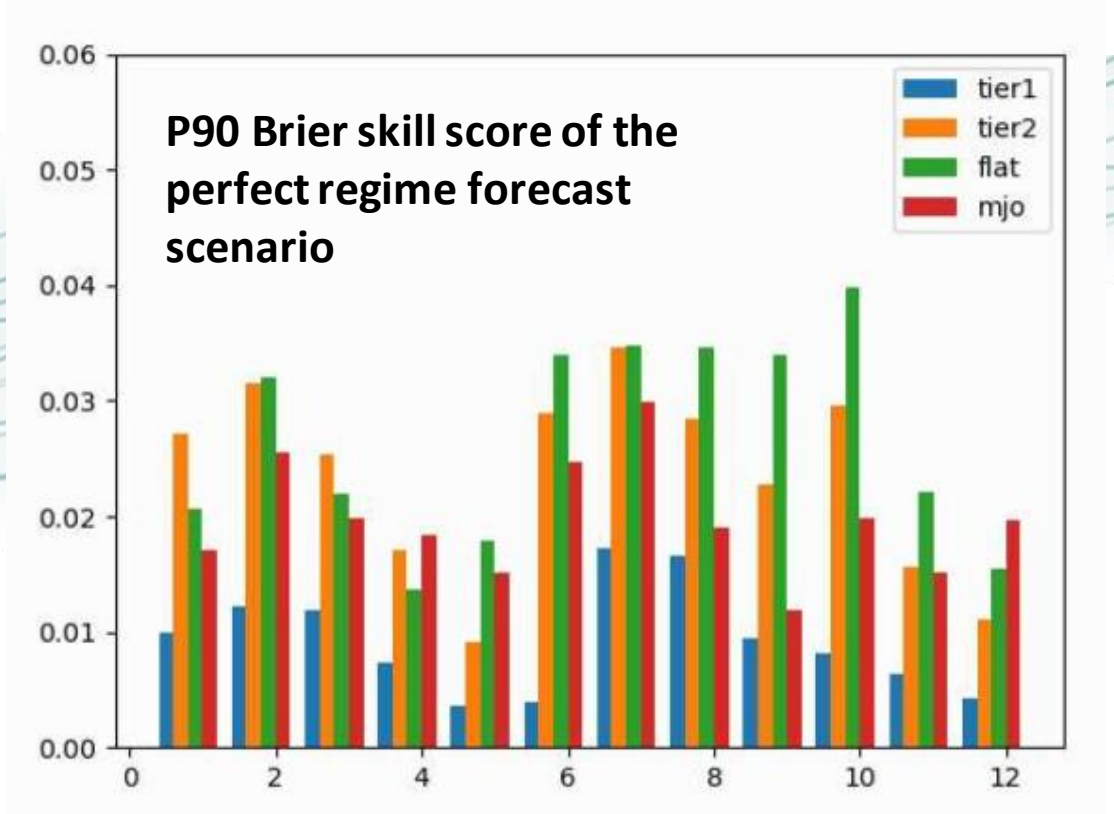
Relative frequencies of tier 1 (inner circle) and tier 2 (outer circle) regimes.

See Emma Howard's 'display material' for more details: Weather regimes in South East Asia: connections with synoptic phenomena and high impact weather

Connection with precipitation and extremes



- variance explained largely due to the seasonal cycle --> reduced when it is removed
- Benefits of flat largely due to TC representation



- Considering all **land grid points**
- There is **positive potential forecast skill** for both tiers in the tiered approach, and for the flat regimes.
- The potential skill is **larger (and comparable) for tier2 and flat** patterns than for tier1 patterns.
- There is a **seasonal cycle** in forecast skill most noticeable in the regional weather pattern sets (tier2, flat).

Evaluation of regime representation by GloSea5

DATA:

- Glosea5 hindcasts from S2S dataset (1.5° resolution!)
- Hindcasts corresponding to starts in Jul 2017 – Jun2018
- Hindcast period: 1993-2015
- 4 starts per month: 1st, 9th, 17th and 25th days of each month
- 7 ensemble members

METHOD:

- For each start date, lead time and ensemble member, regimes were assigned by minimizing the Euclidian distance to the **ERA5 centroids.**
- **Note:** only 00UTC 850hPa winds available through S2S database

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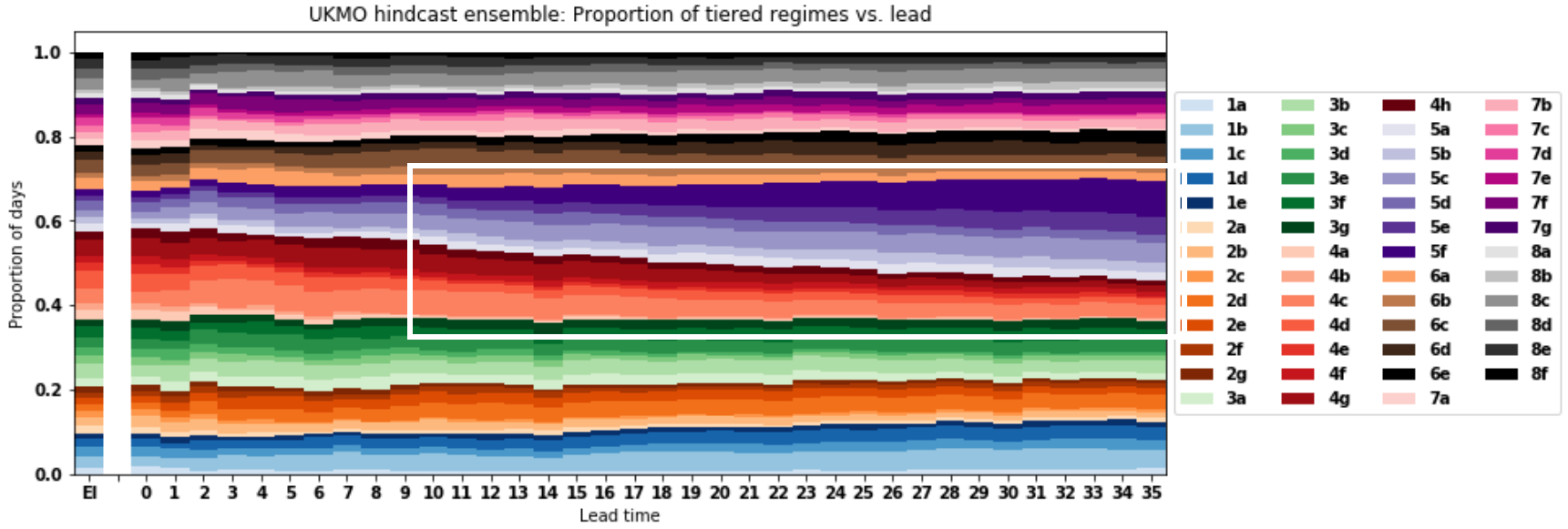
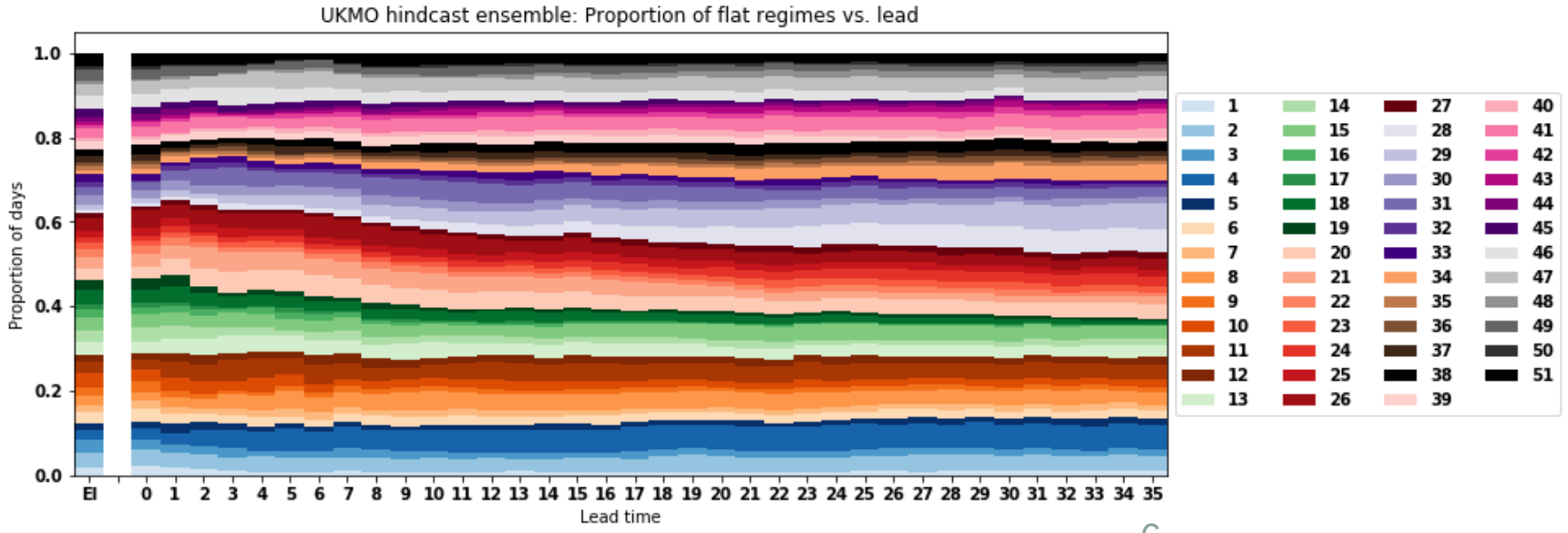
Evaluation of regime representation by GloSea5





Some biases in the modeled features of the regimes were clear:

- A drift towards Tier 5 regime 5 (eastern shift of the Boreal monsoon) in the **frequencies**
- An overestimation of the **duration** of the tiered regimes and a slight underestimation in the case of the flat ones

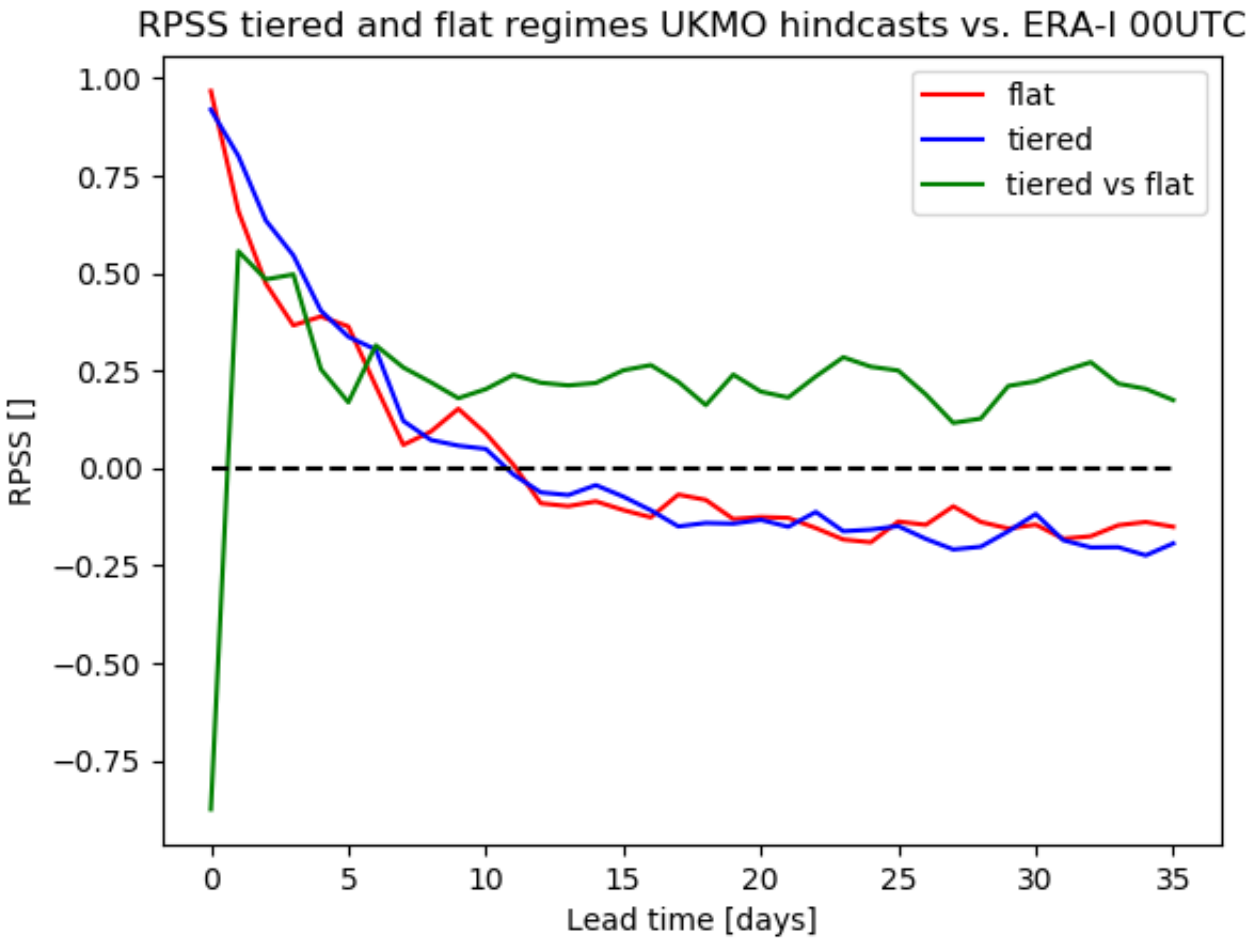
ERA5

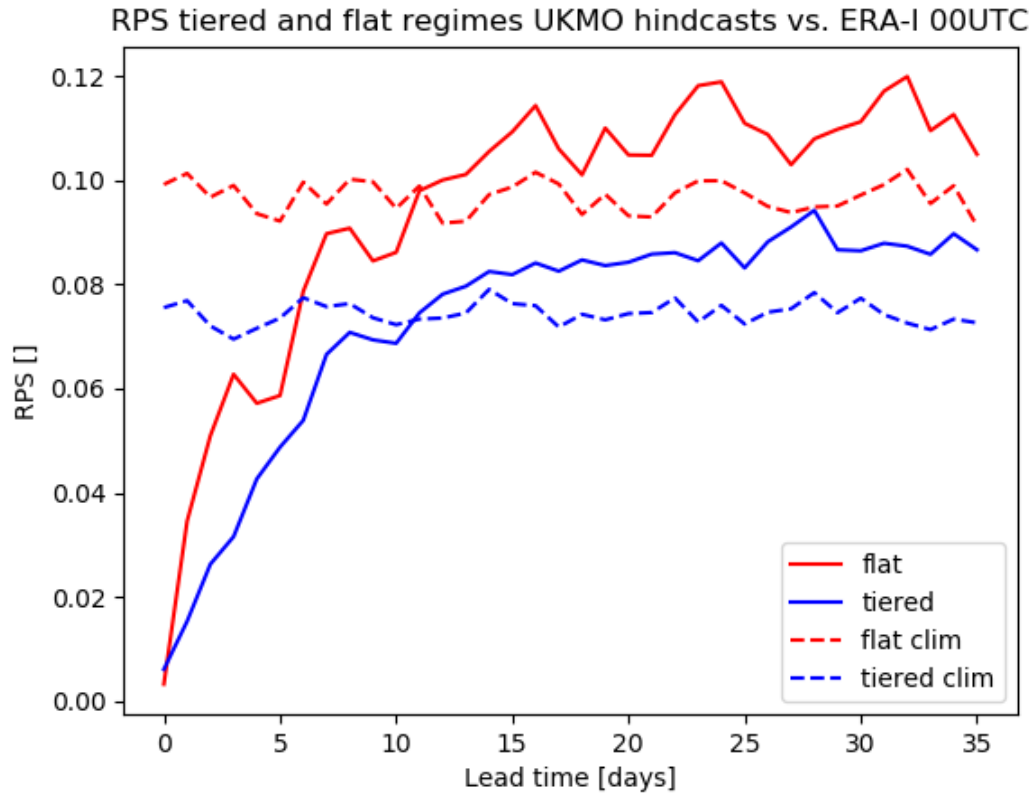
a)	Mean	Median	P90	P99
Tier 1	6.8 (6.6)	3.0	18.0	45.0 (42.7)
Tier 2	2.4	2.0	5.0	11.0
Flat	2.4	2.0	5.0	10.0

GloSea5

b)	Mean	Median	P90	P99
Tier 1	**8.7**	4.0	25.0	59.0
Tier 2	**2.5**	2.0	5.0	13.0
Flat	2.3	2.0	4.0	10.0

Skill of the assignment
Tier 2 / flat regimes - RPSS





Regime-conditioned forecasts of extreme precipitation over SE Asia

Given a method (flat or tiered) and event threshold (e.g., P75):

GloSea5 hindcasts for start s, lead l

forecast probability of precipitation at X exceeding P75:
fcst_p75(s,l,X)

Probability of **being in regime** r:
pr(s,l,r)

Conditional forecast probability of precipitation at X exceeding P75:
cond_fcst_p75(s,l,X)=Σ_r [pr(s,l,r)*cond_p75(X,r)]

ERA5 reanalysis
&
GPM precip

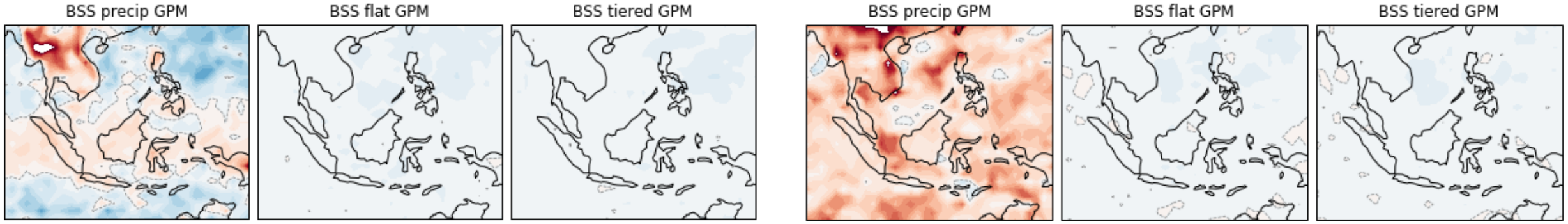
Probability of precipitation at location X **exceeding P75 conditioned by the occurrence of regime r**:
P(precip(X)>P75 | regime=r)
cond_p75(X,r)

BSS comparison for P90

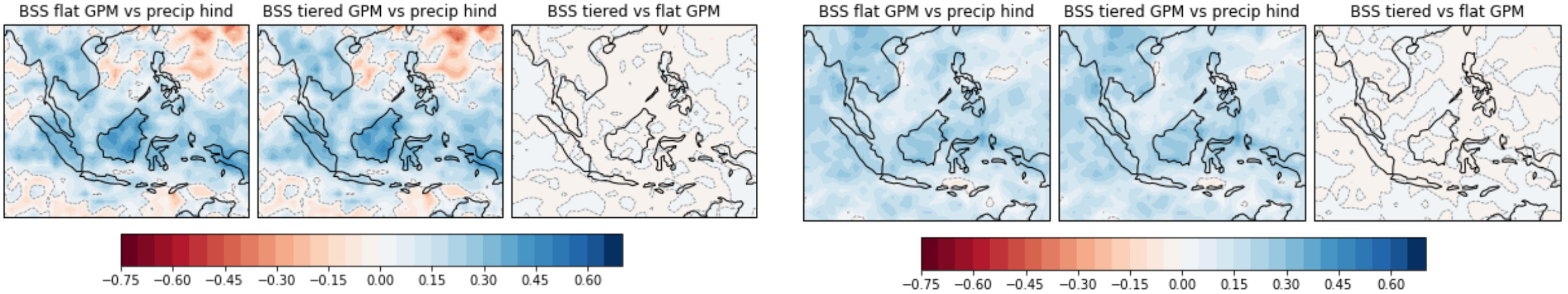
Lead 0

Lead 5

BSS against GPM climatology

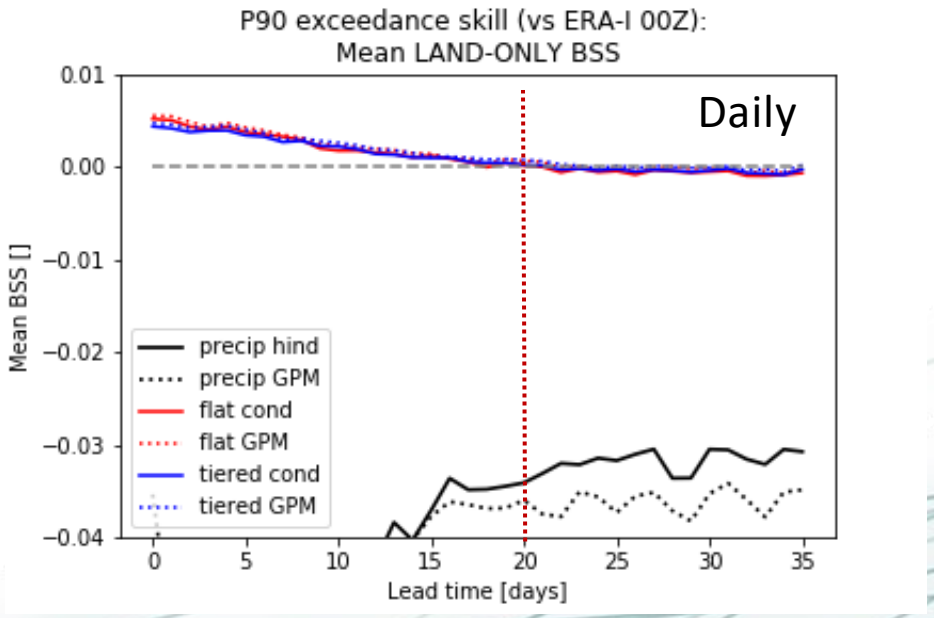


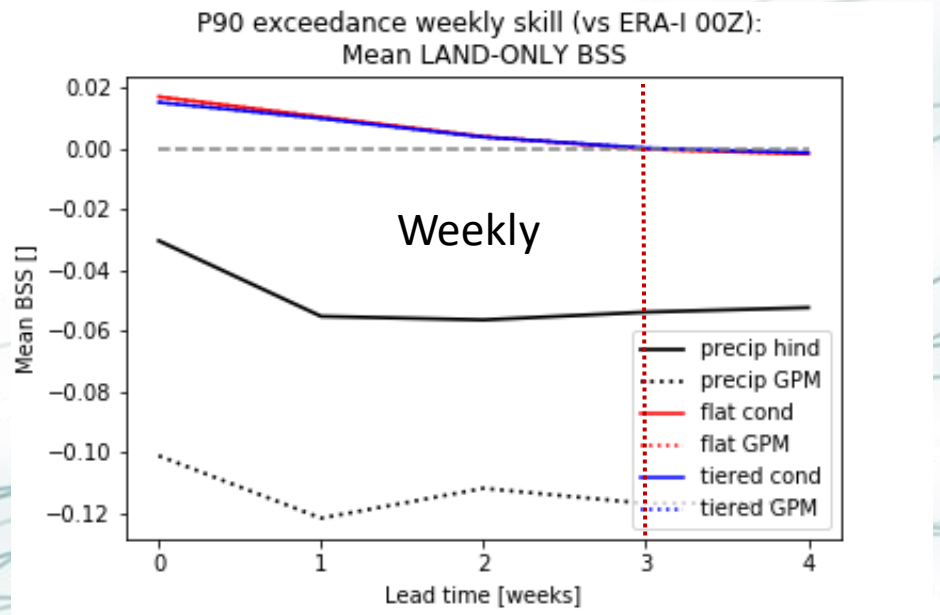
Method comparison



- The predictive skill of the simulated precipitation in lost by lead day 5, but the regime-conditioned hindcasts remain skilful

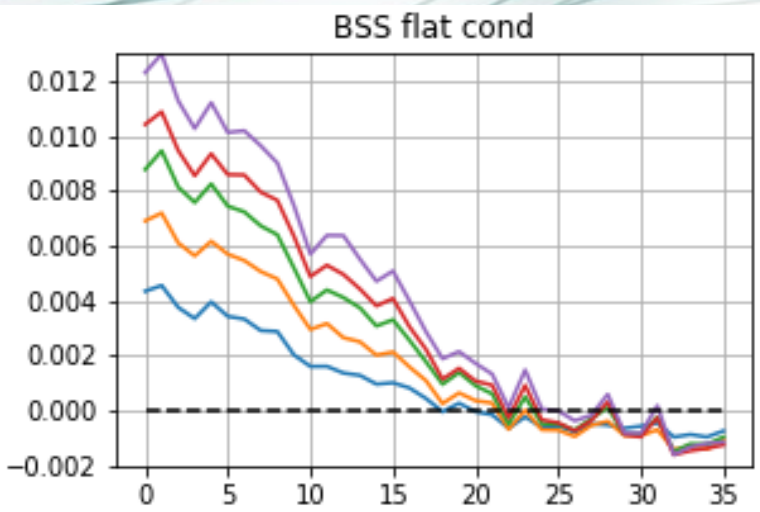
Average skill over land: effect of temporal and spatial aggregations

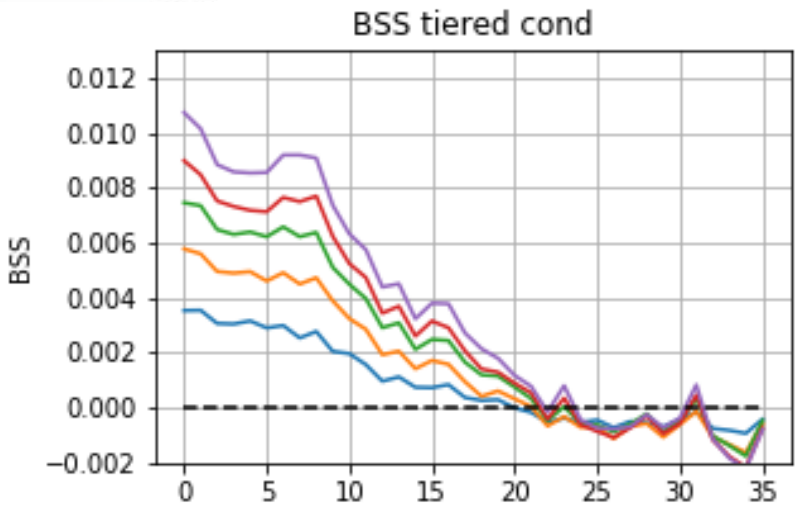


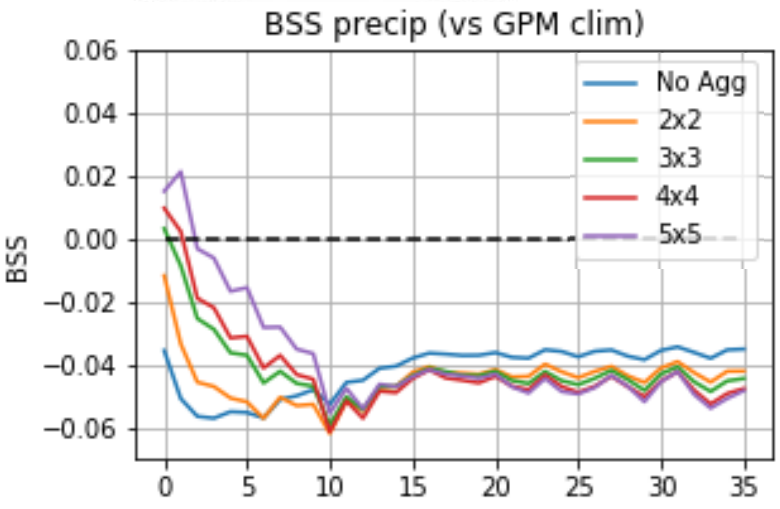


What is the probability of having **at least one day of exceedance** in the week?

What is the probability of having at least one gridpoint of exceedance in a k x k gridpoints 'neighbourhood'?

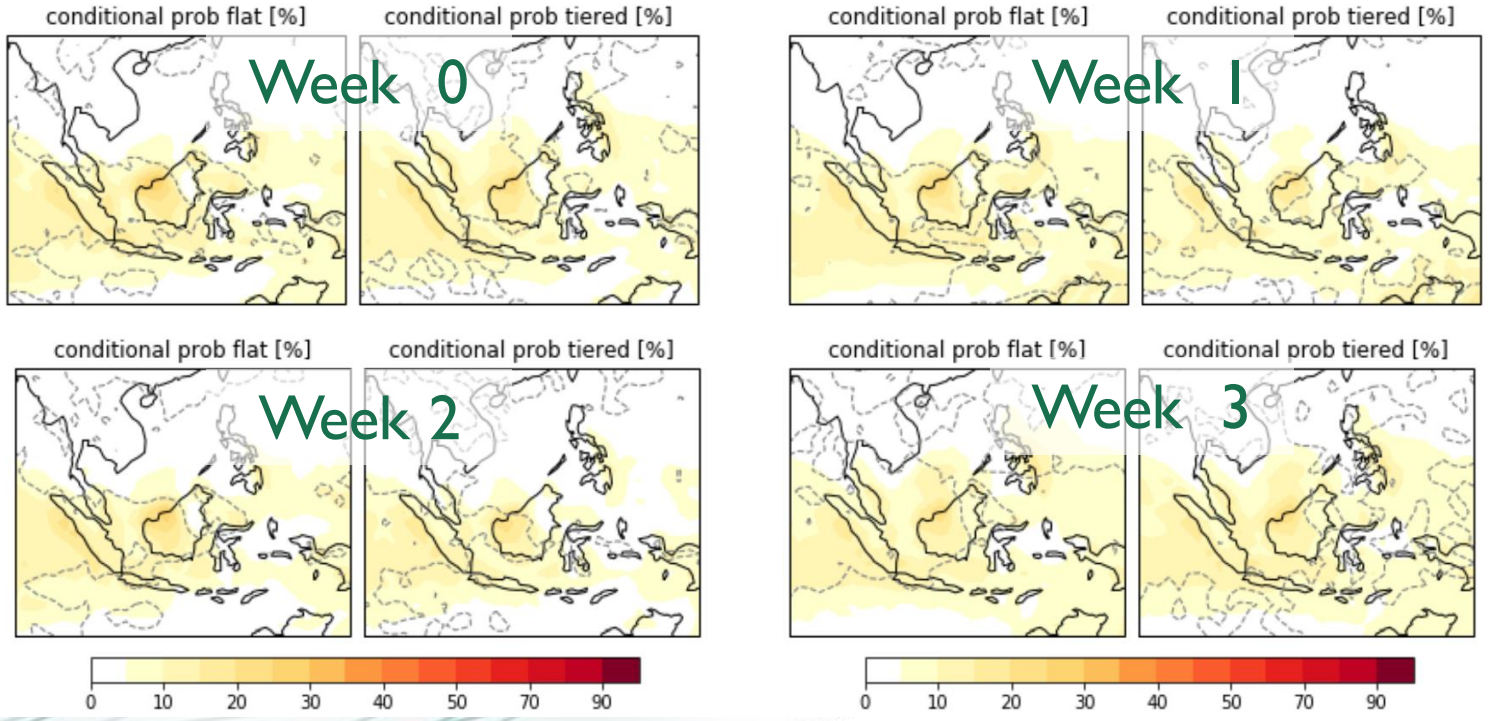


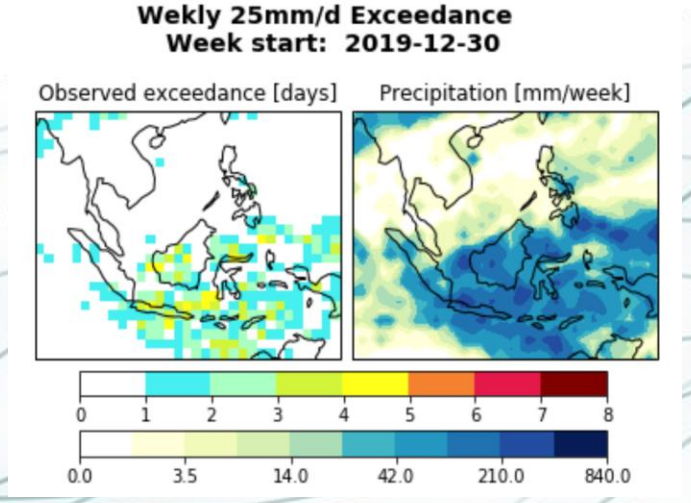




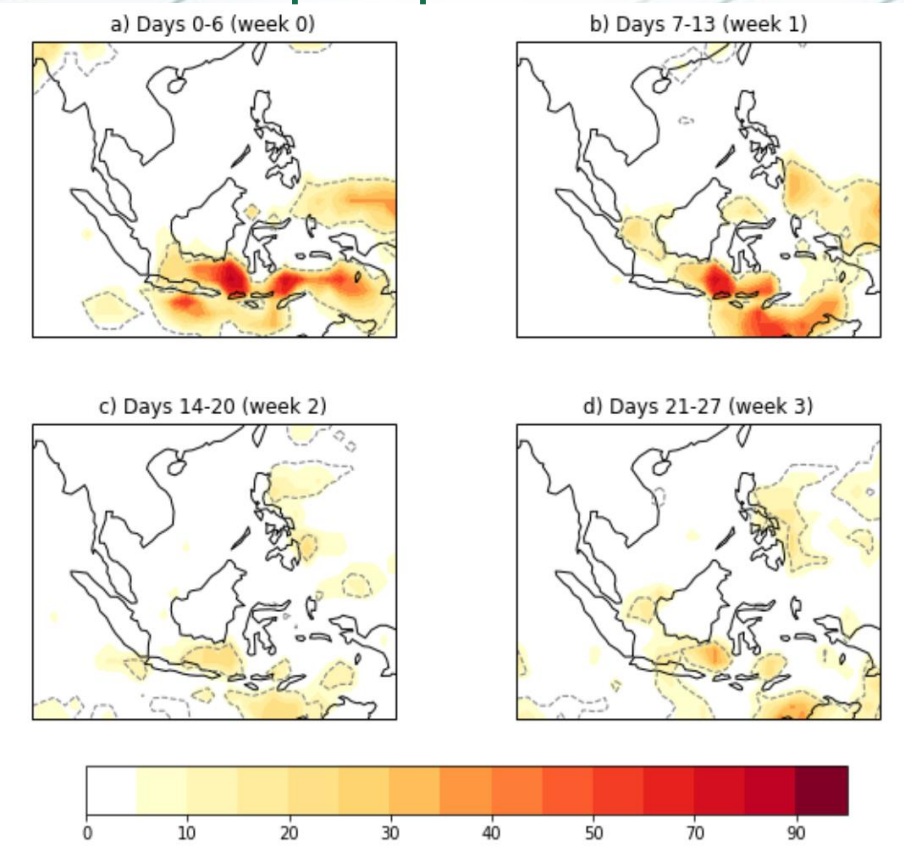
Case study: greater Jakarta, 30 Dec 2019- 5 Jan 2020

Regime-conditioned forecasts – weekly 25 mm/day exceed





Simulated precipitation forecasts



The application of the methods to a specific case study outside of the hindcast set shows promising results:

- Regime-conditioned hindcasts predicted exceedances above the climatological odds even at lead week 3
- Simulated precipitation forecasts lost all signal over land by lead week 1

Summary

- **Two sets of weather patterns** were selected for Southeast Asia: they capture both **large-scale variability** (ENSO, monsoons) and **synoptic weather** phenomena (cold surges, MJO/BSISO, tropical cyclones, Borneo vortices, equatorial waves).

- **Both sets** of weather patterns show **potential predictability** for forecasting the **increased likelihood of high impact weather,** carrying **more information than the climatology and** a perfect seasonally varying knowledge of **the MJO phase.**

- The GloSea5 prediction system has an adequate representation of both sets of regimes (but with certain biases). The system shows **positive skill for the assignment** of the weather patterns up to **~ lead day 12**.

- Initial assessment of the skill of the **regime-conditioned probabilities of precipitation exceedance** shows **better skill than the simulated precipitation**, and positive skill extending up to **~ lead day 20** (average for all land points).

- Allowing for **temporal and spatial aggregation** of the probabilities yields **higher skill, though not necessarily longer skill** thresholds.

Met Office

Newton Fund

For questions, comments and suggestions contact

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THANKS!

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