Tropical rainfall nowcasting with Commercial Microwave Links

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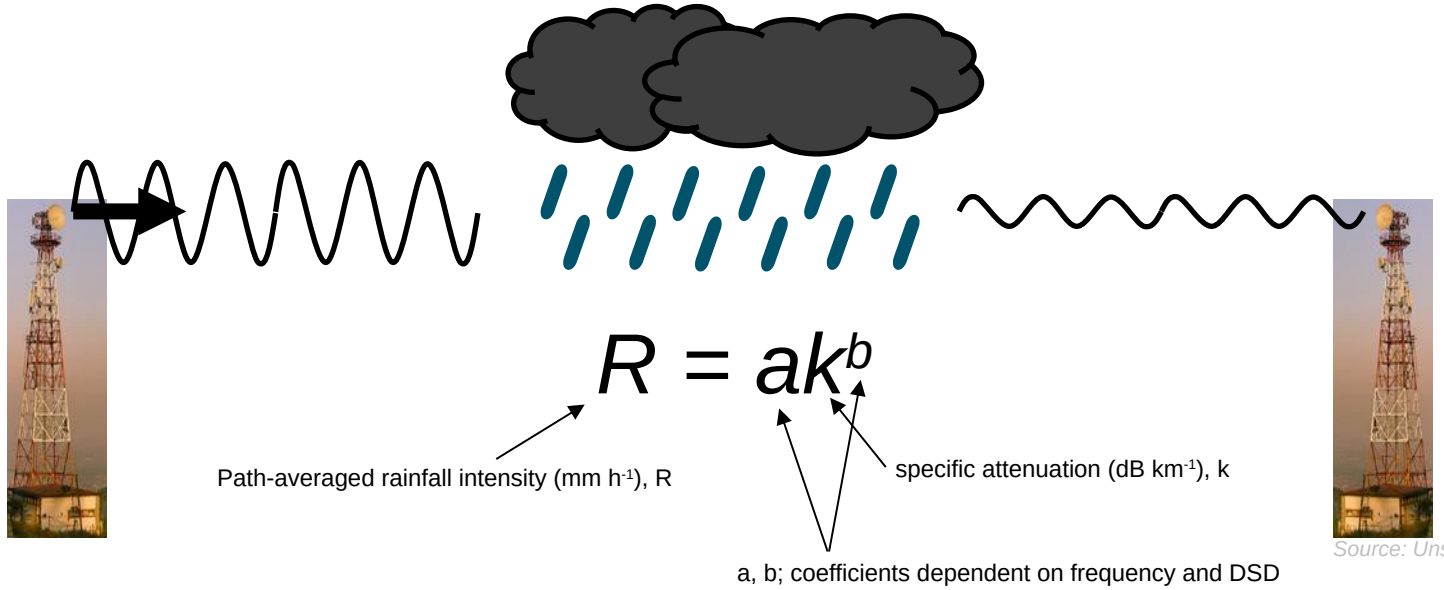
Rainfall retrieval from CMLs

- Path averaged rainfall intensities derived from signal attenuation along the path
  - Attenuation of the microwave signal through scattering and absorption by raindrops
- Mobile network operators typically log received signal levels (RSL) for quality control purposes
  - Minimum and maximum RSL every 15 minutes

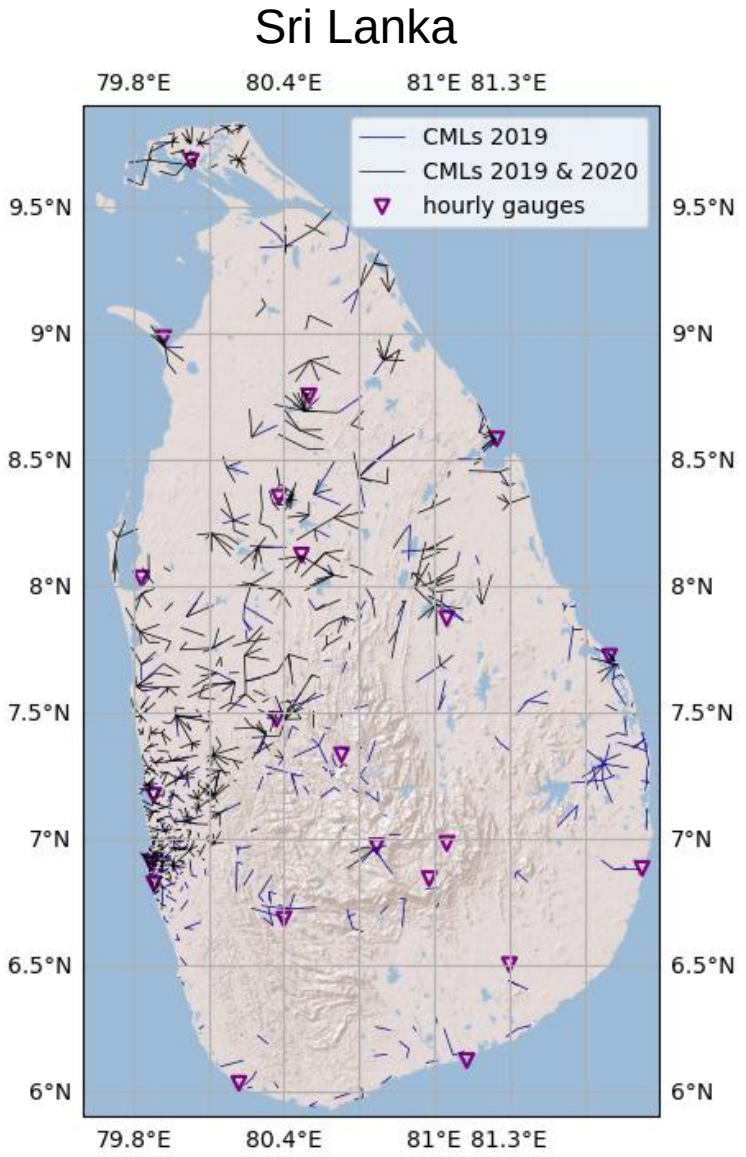


Source: Unsplash

Tropical CML data set

- CML data from one of the mobile network operators in Sri Lanka
- Minimum and maximum RSL levels every 15 minutes
- **From 2570 sub-links across 1328 unique link paths**

- **21 hourly reference rain gauges**



Overeem et al. (ERL, 2021) & Walraven et al. (JHM, 2024)

Tropical CML data set

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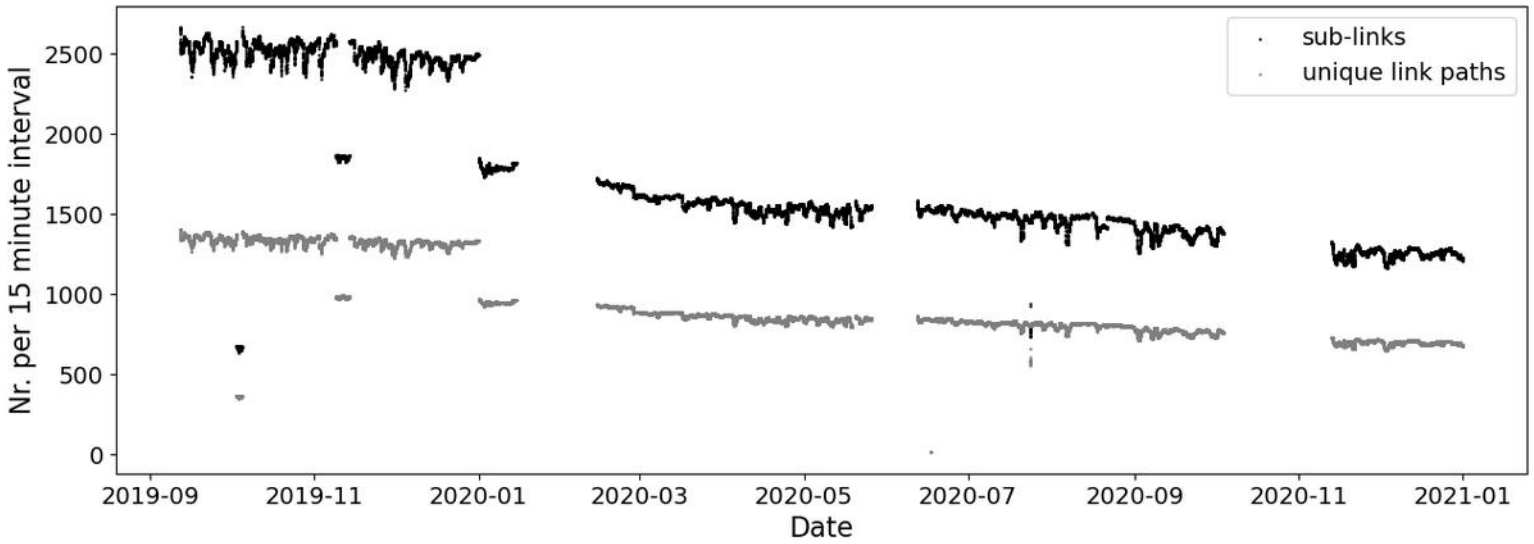
- Minimum and maximum RSL levels every 15 minutes
- From 2570 sub-links across 1328 unique link paths
- **For 15 months (Sept. 2019 – Dec. 2020)**



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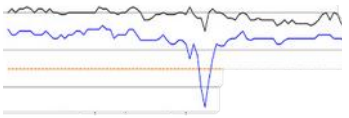
Methods: Estimating QPE and QPF

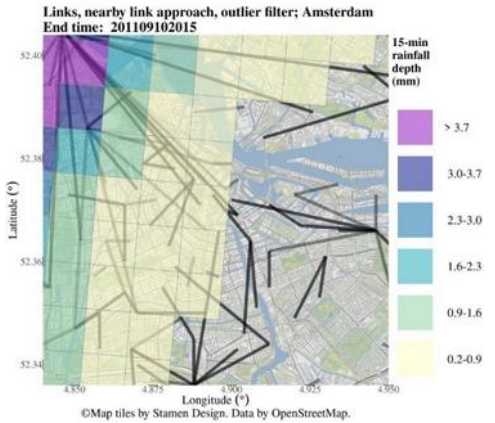
- **From dB to mm hr^{-1}**

- **From observation to forecast**

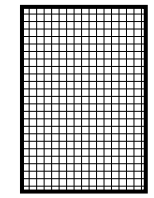
Open-source R-package
"RAINLINK"

15-minute min/max RSL





2D rainfall field



2x2km grid

https://github.com/overeem11/RAINLINK
Overeem et al. (AMT, 2016)

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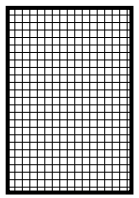
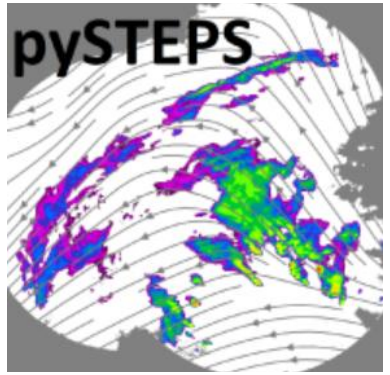
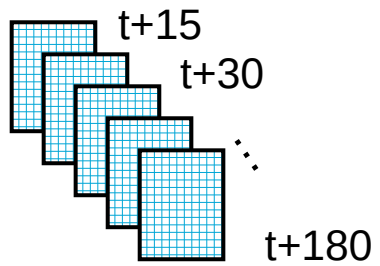




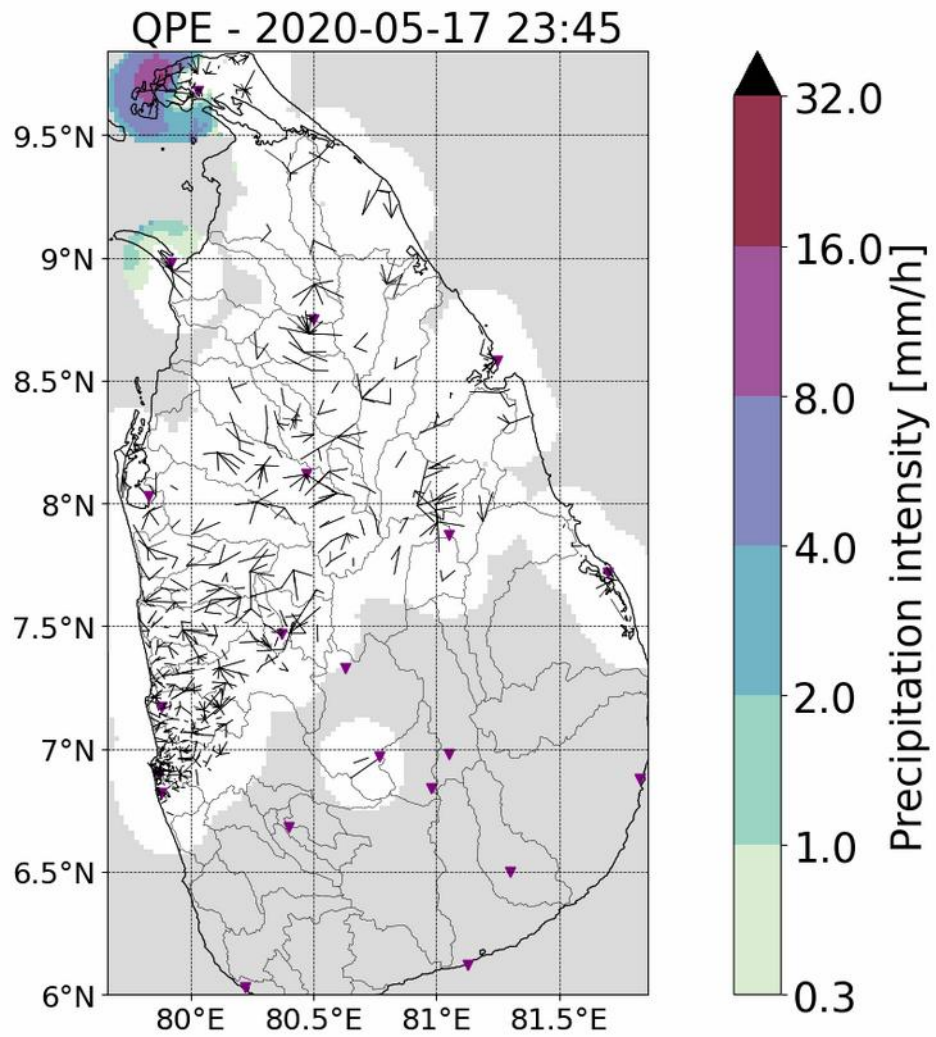
Nowcast: lead time up to 3 hours



- 20 ensembles
- Lucas Kanade optical flow
- Semi-Langrangian advection

Quantitative precipitation estimates (QPE)

- QPE from interpolated CML rainfall maps
- Areas more than 18 km from a link are masked
- Case study 1h event:
  18 May 2020 **02:30 – 03:30**
  (and the three preceding hours)



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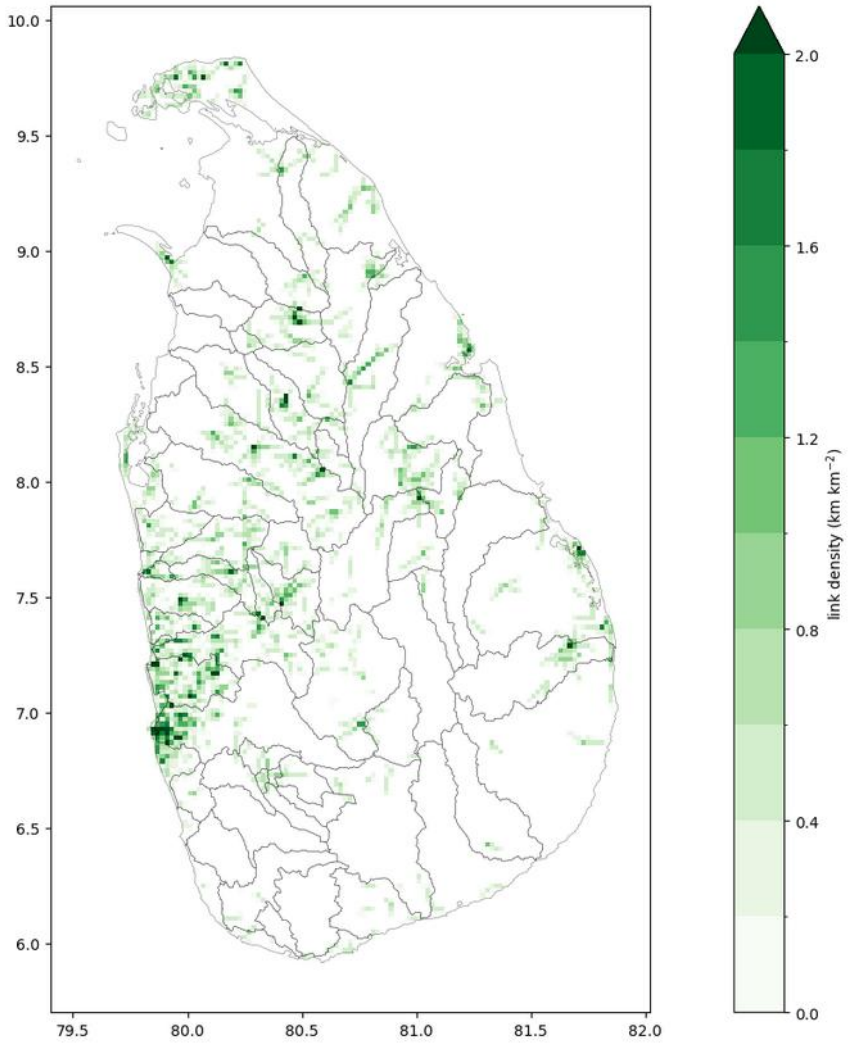
What influences skillfulness?

- **Link density per catchment**
- Total number of links per catchment

- Catchment size
- Catchment location w.r.t. dominant wind direction
- Catchment location w.r.t. to land/sea borders

Link density per pixel (2x2 km)



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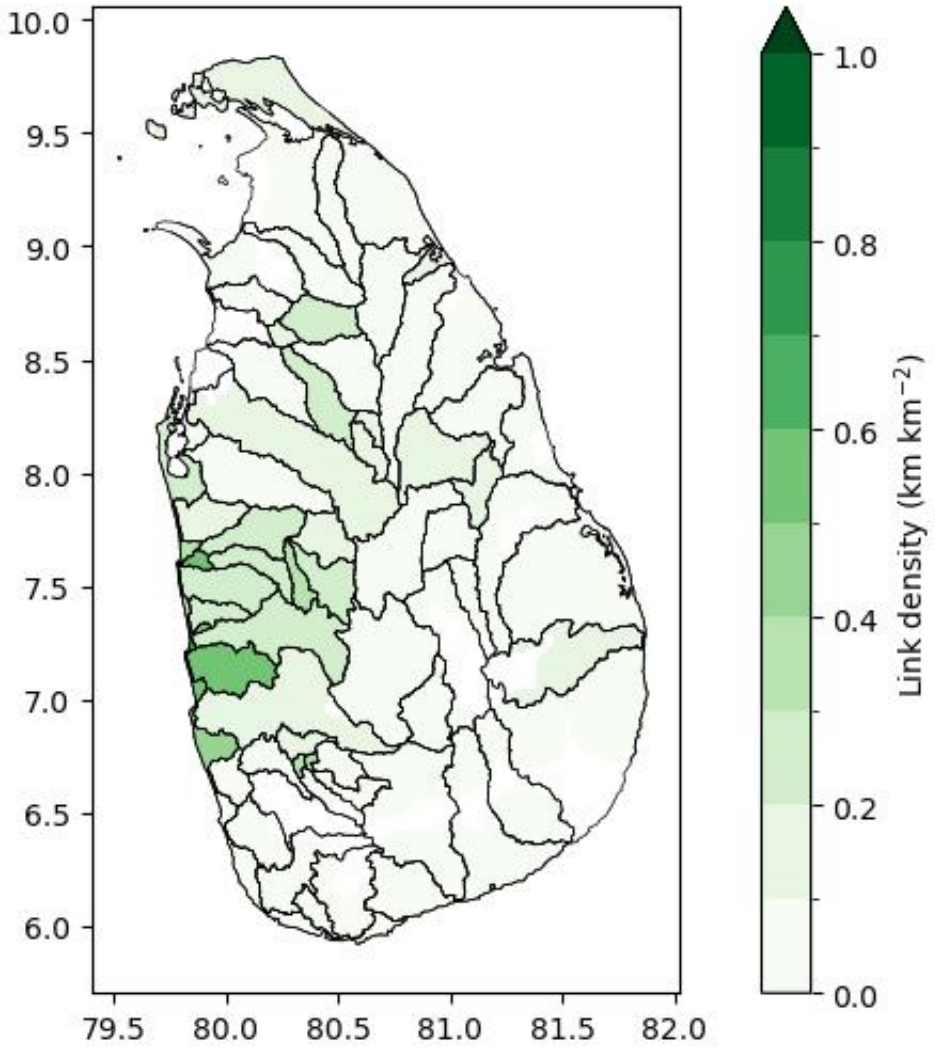
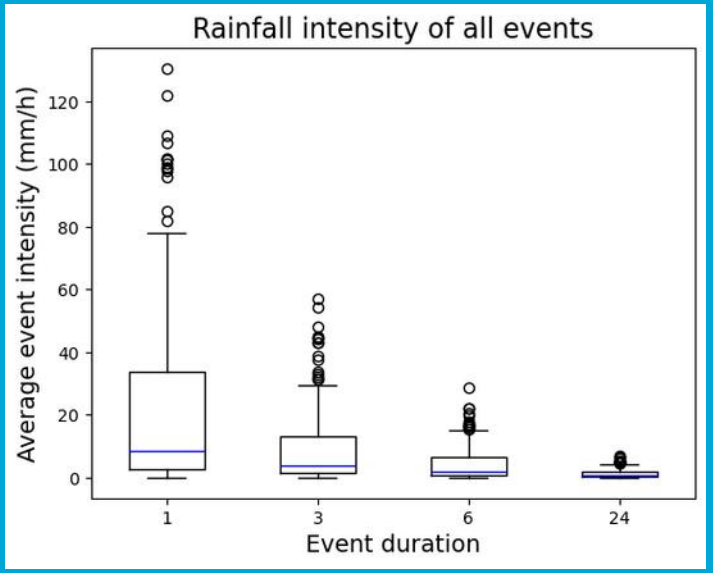
Avg. link density per catchment

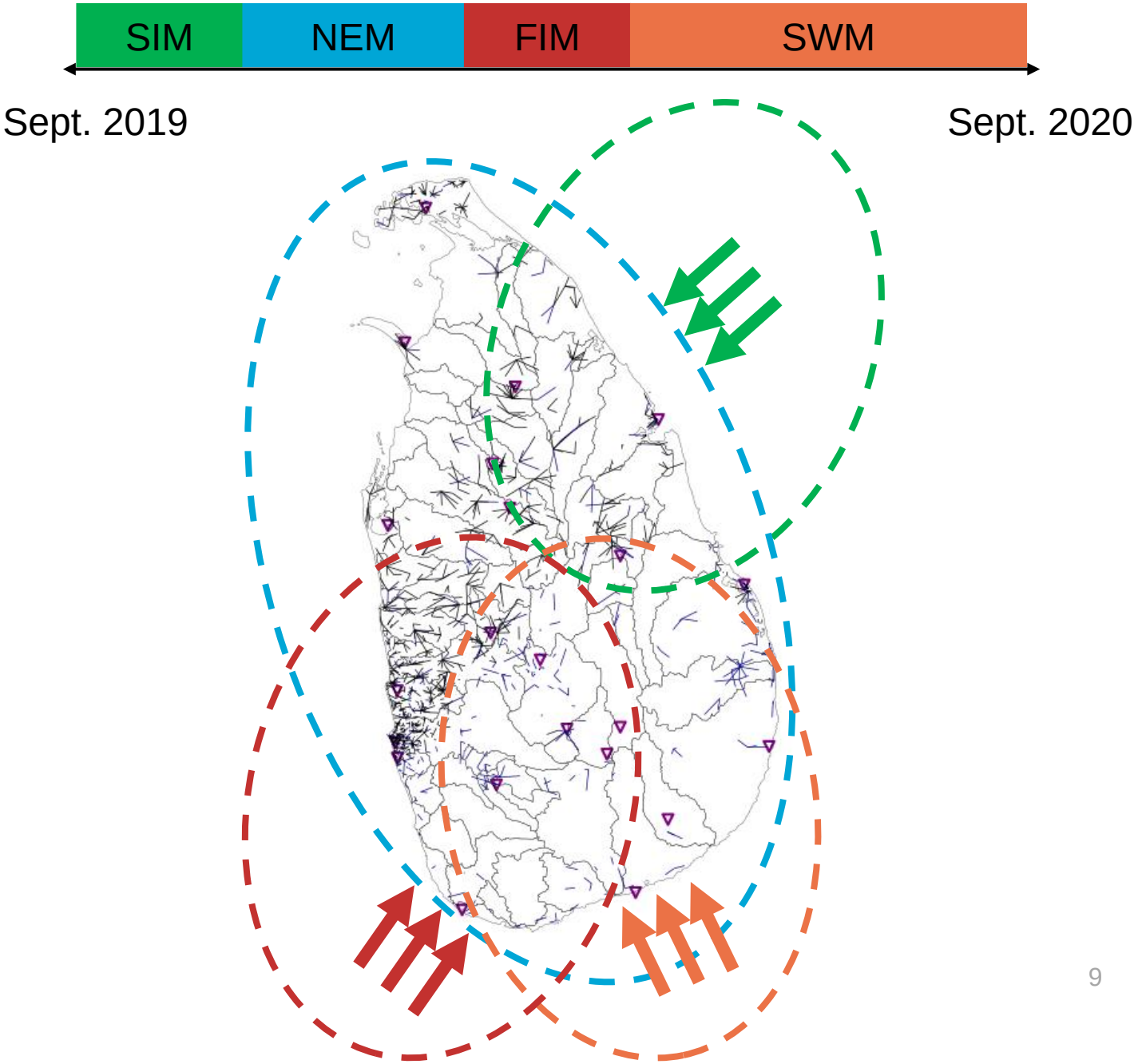


From a "hydrological perspective":
what factors influence the forecast skill?

Selecting events to nowcast

- 68 catchments
- 4 seasons
- 4 durations (1, 3, 6, and 24 hrs)
- 2 events per duration





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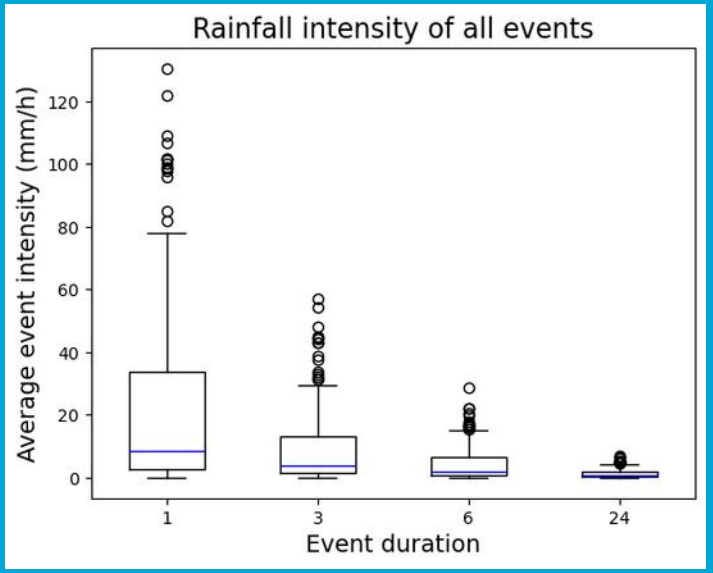
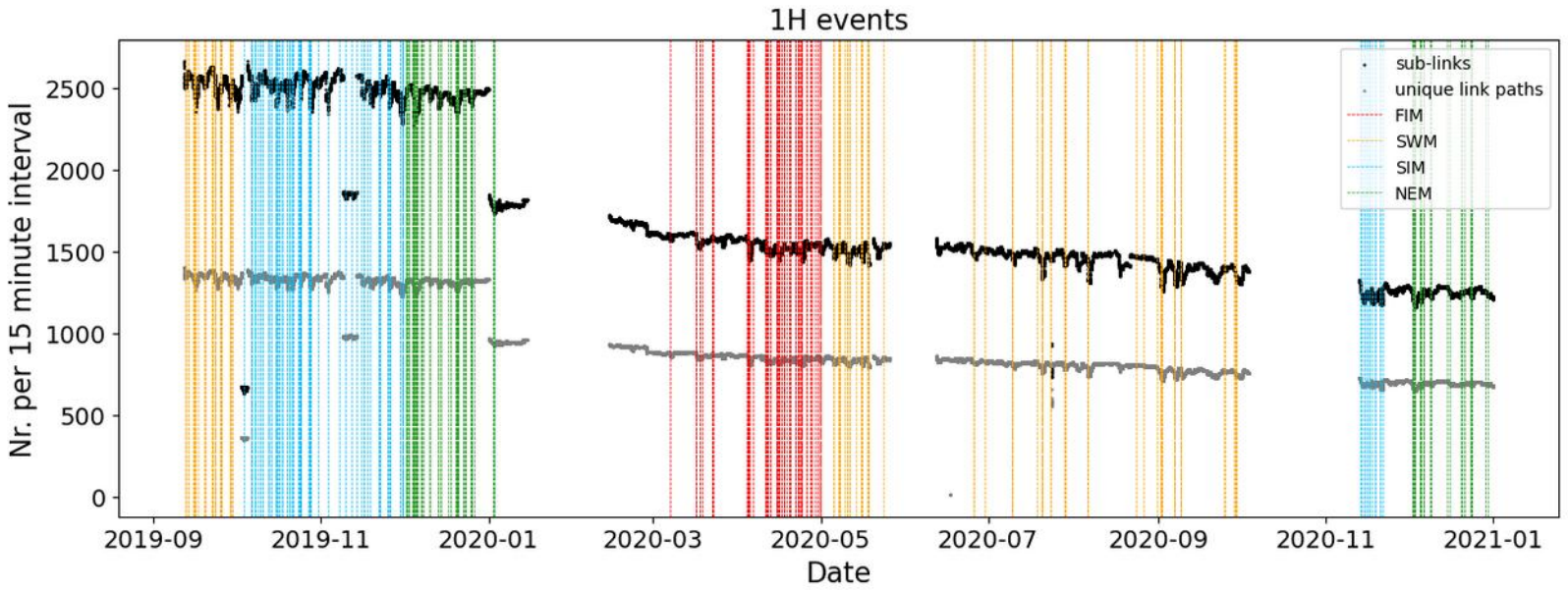
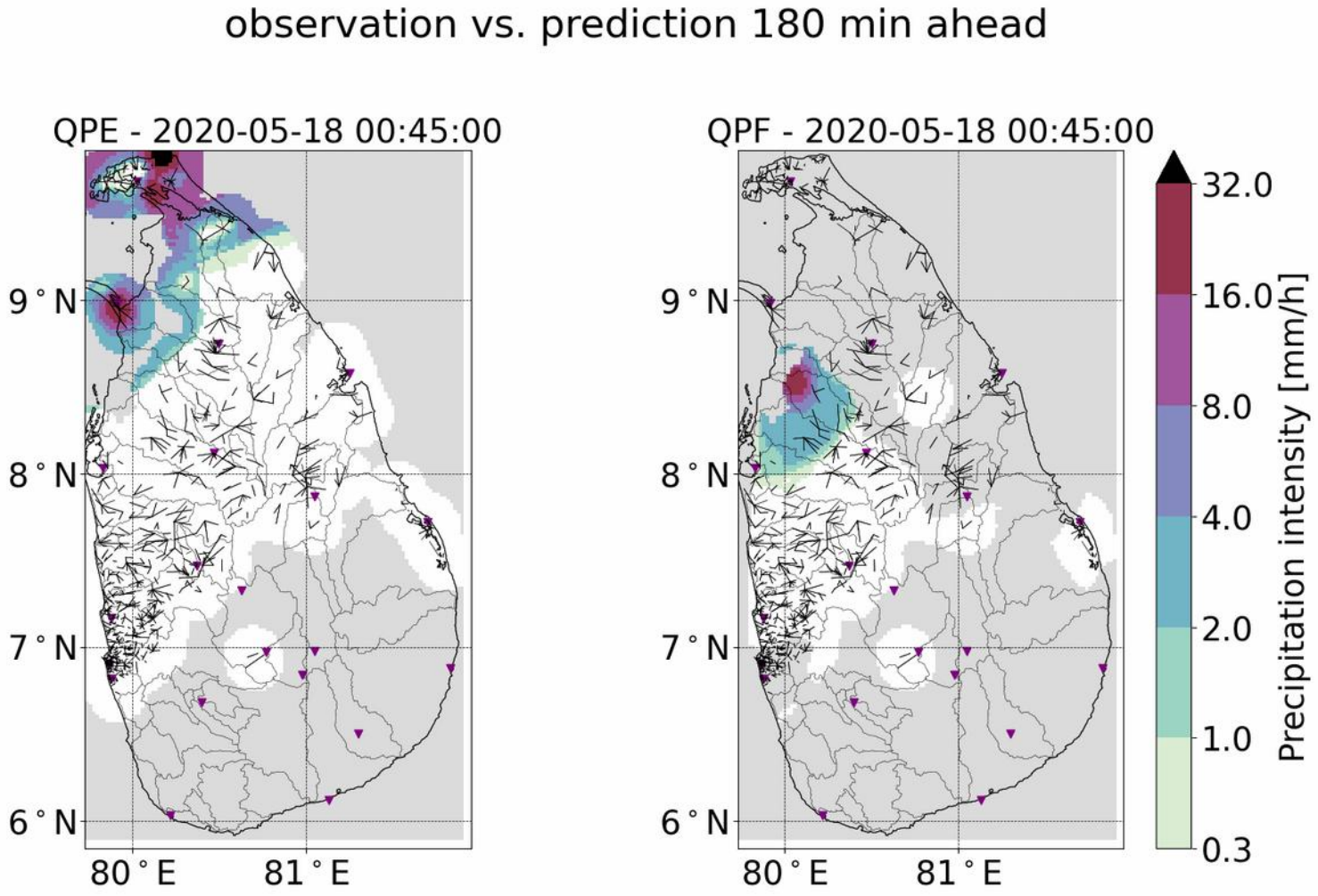


Sept. 2019 Sept. 2020



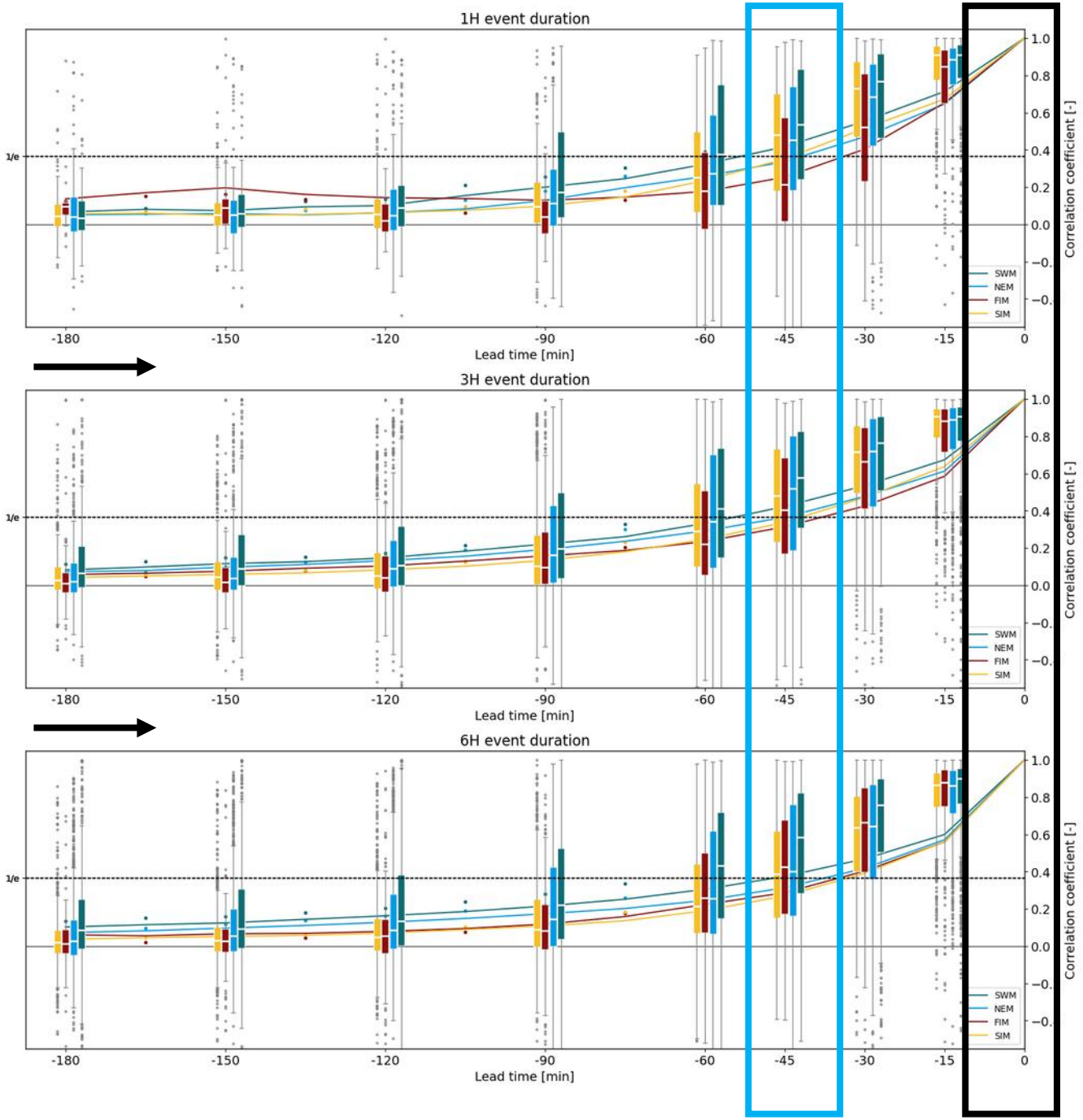
The “early-warning perspective”



How long before the event takes place can we already predict it?

Correlation coefficient

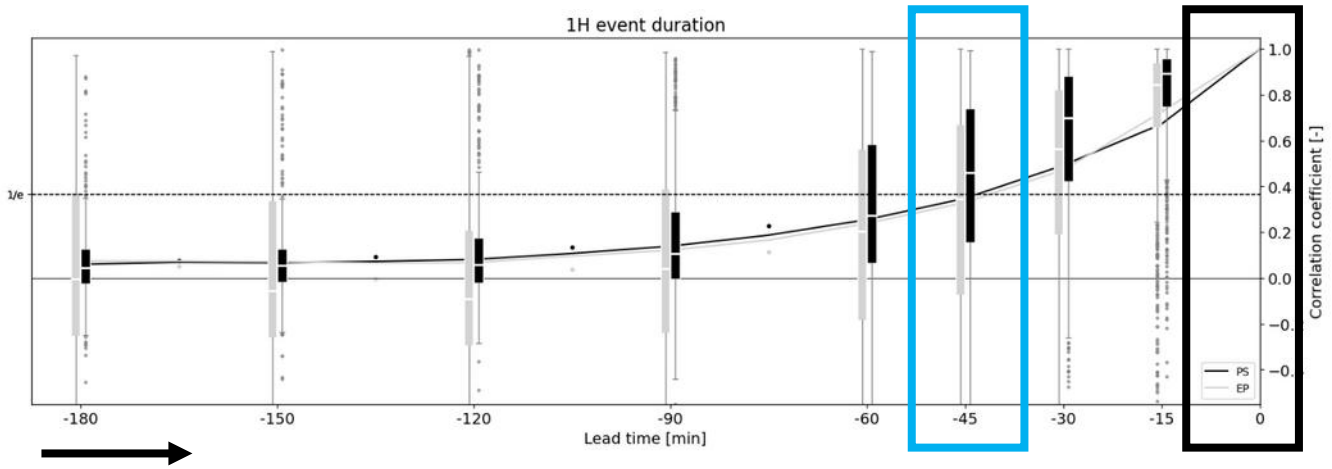
- Correlation based on a pixel by pixel comparison within the catchments
- Skillful from 45 minutes before the event and onwards
- No large differences across the seasons
- Skillful lead time seems fairly insensitive to event duration (i.e. average intensity)



STEPS (probabilistic)
vs.
Eulerian persistence

- Correlation based on a pixel by pixel comparison within the catchments

- STEPS slightly more skillful and precise than Eulerian persistence

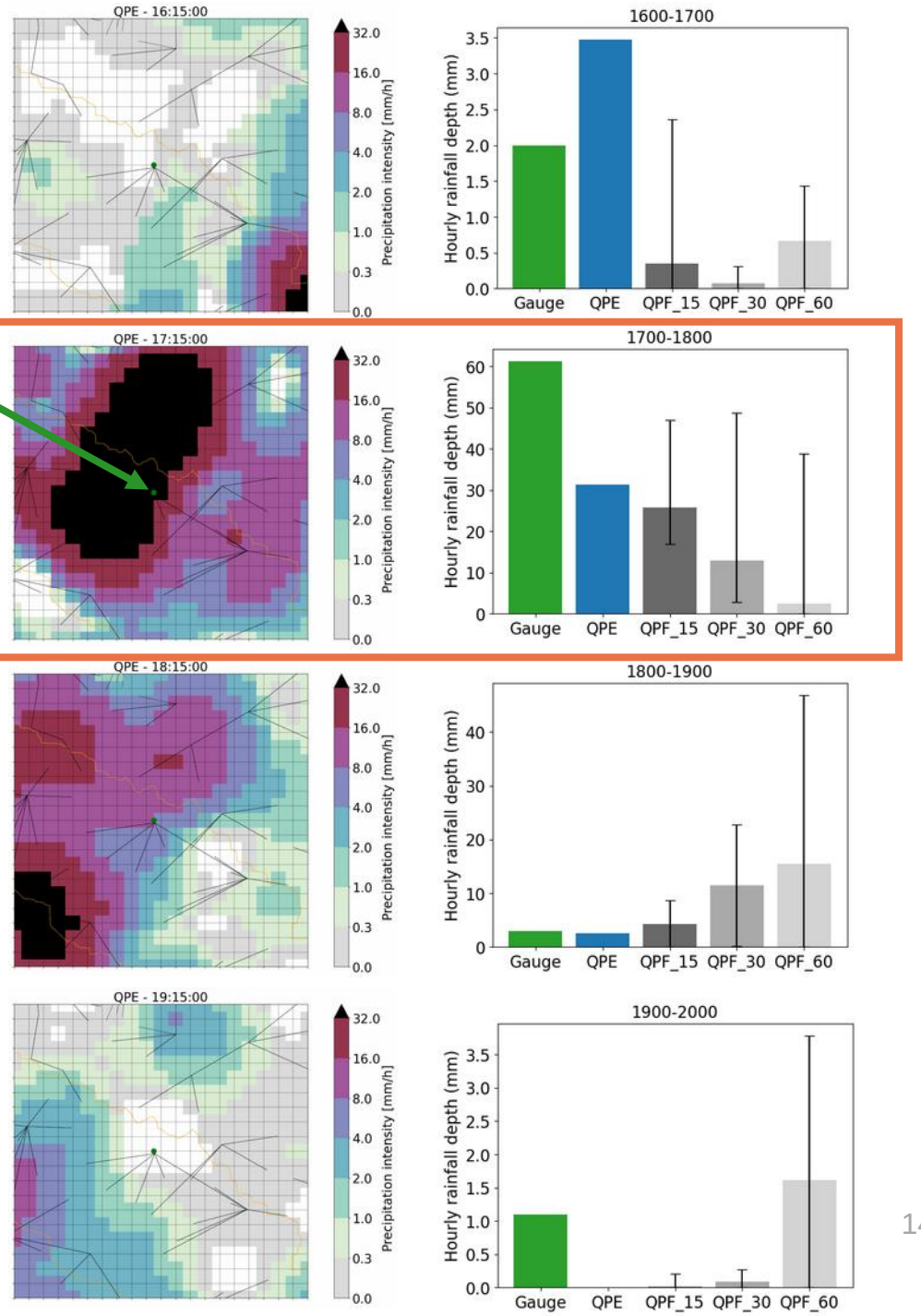


QPF vs. point reference

- Event from 17h00 – 18h00:
  - QPF15: input from 16h45 – 17h45
  - QPF30: input from 16h30 – 17h30
  - QPF60: input from 16h00 – 17h00

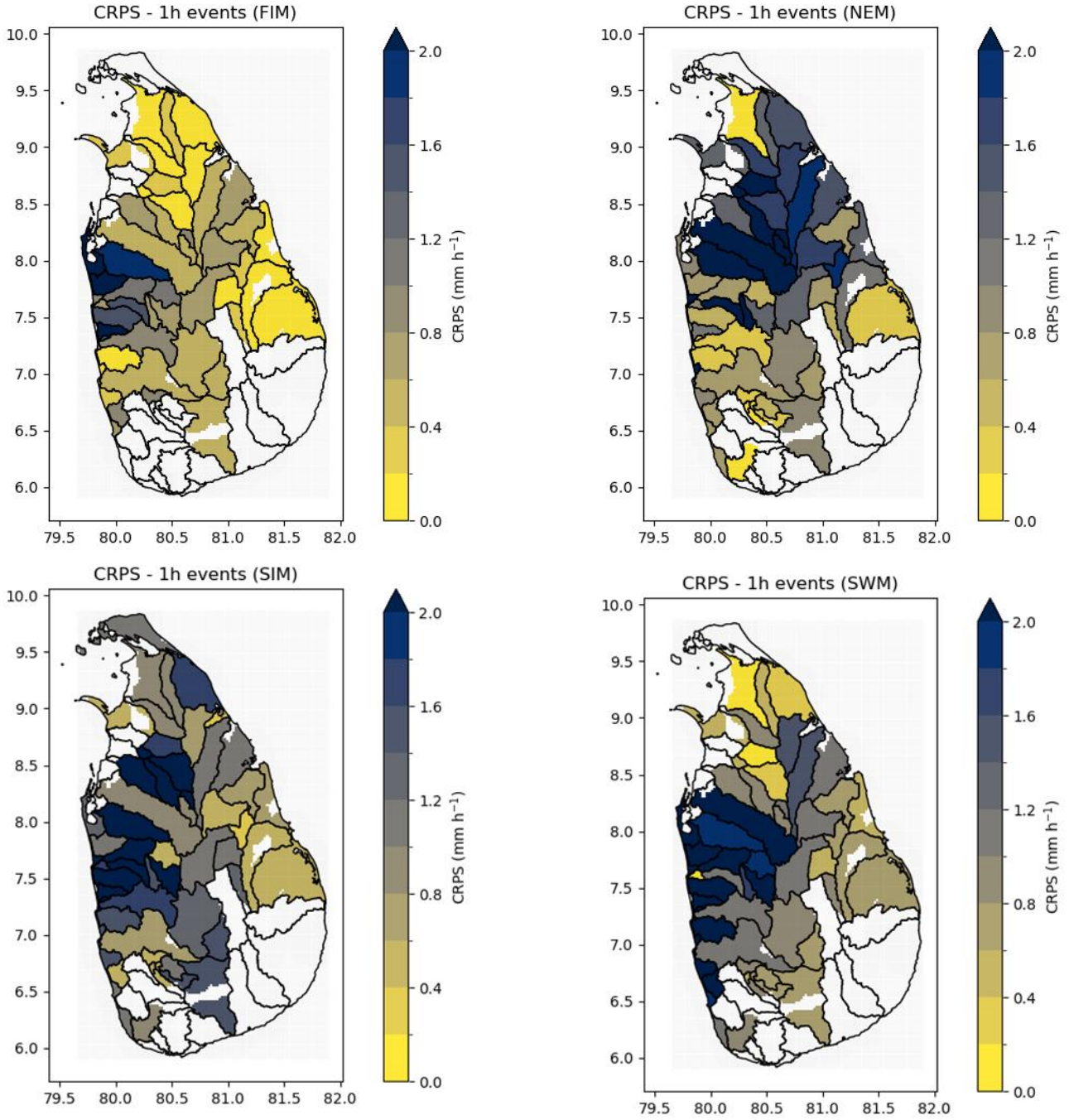
- Error bars indicate the spread in the ensembles

Rain gauge 17-18h: **61.2 mm**



Continuous Ranked Probability Score

- CRPS based on a pixel by pixel comparison within the catchments
- The error in monsoon seasons is (of course..) higher
  - Though this coincides with location of landfall of the dominant wind direction



Take home messages

Predictions can be skillful almost an hour before an event takes place

This can improve further if we approach this from a more hydrological / catchment perspective

Higher CML coverage can increase skill by eliminating ‘blind spots’

Your QPF will only be as good as your QPE

It’s time to start applying the data we **do** have!

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Thank you for your attention.

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