Reasonable worst-case scenarios from ensemble rainfall forecasts and their use in surface water flood forecasting

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WCO3, ICTP, 08/09/2023

Preprint: Maybee *et al, NHESS,* 2023-83

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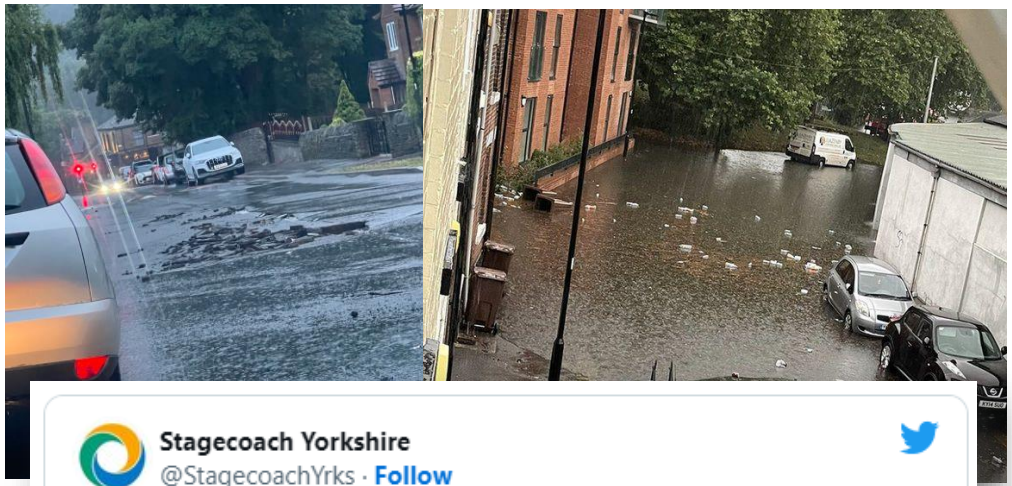
Surface Water Flooding (SWF)

- Heavy rainfall creates flood before reaching major watercourse; flash/pluvial floods.
- In UK primarily due to heavy, localised convective summer showers.

***e.g.* around Sheffield, Yorkshire, 16/08/2022:**



Stagecoach Yorkshire
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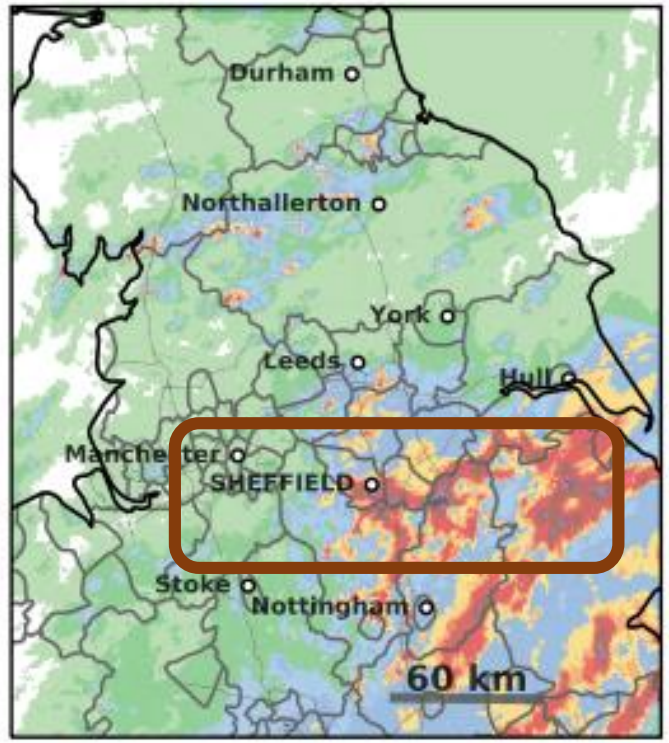
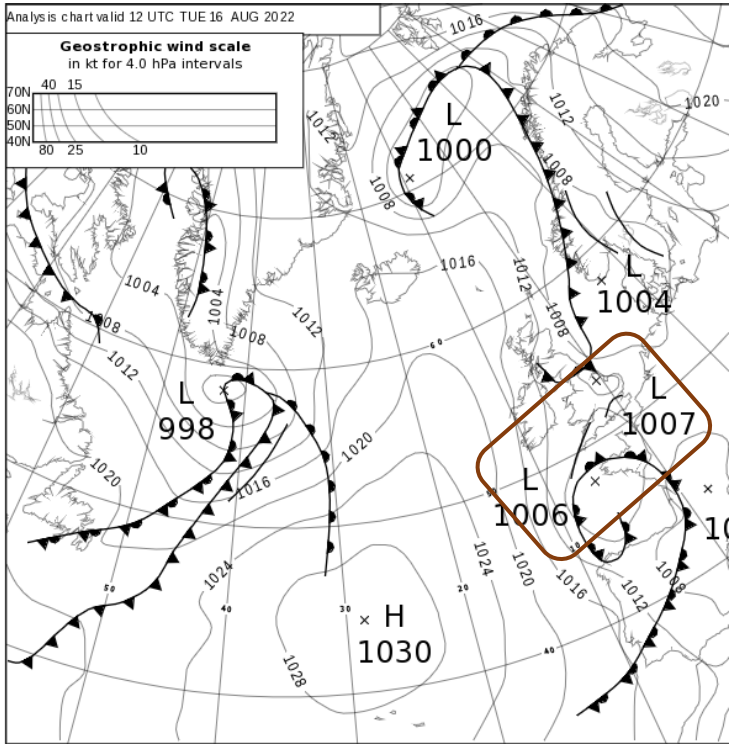
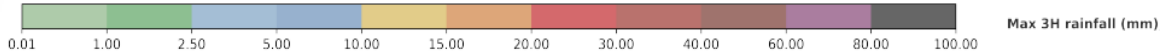
#sheffbus Due to flash flooding that has lifted some of the road surfacing on Abbeydale Road, Sheffield and other areas, our service 86 will terminate in Sheffield city centre





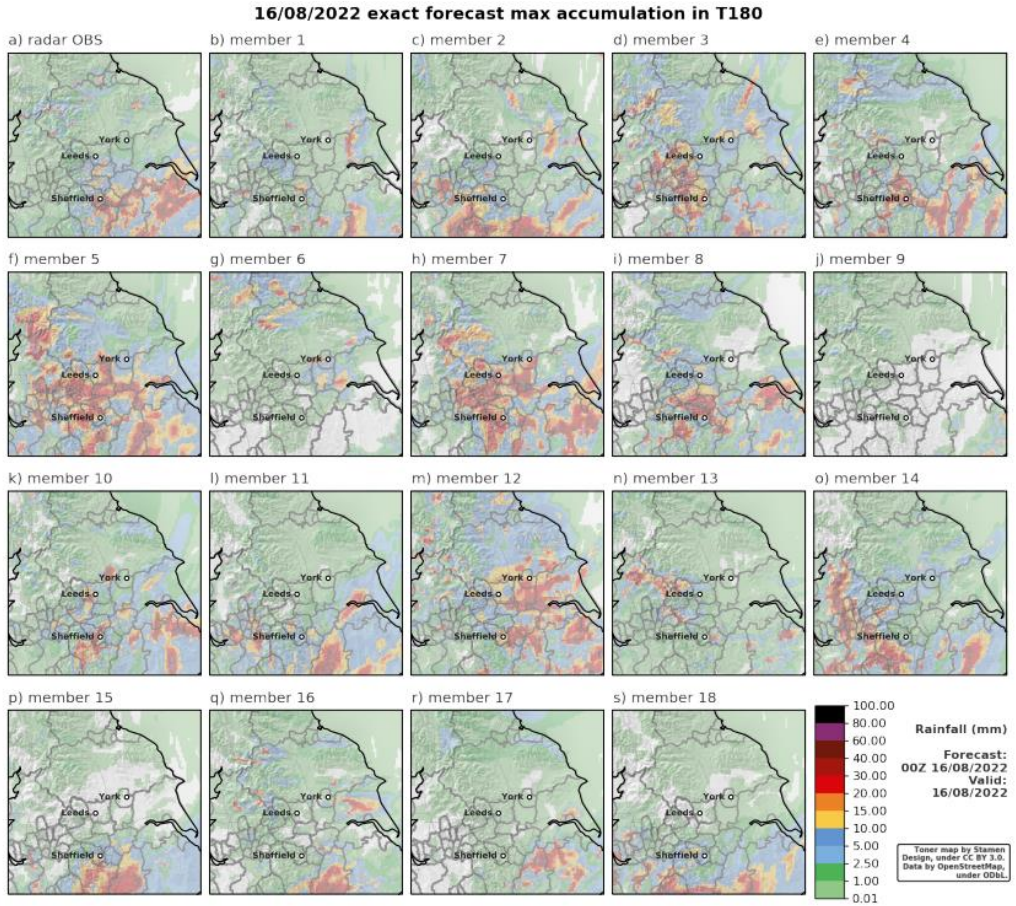


Forecasting requires accurate:

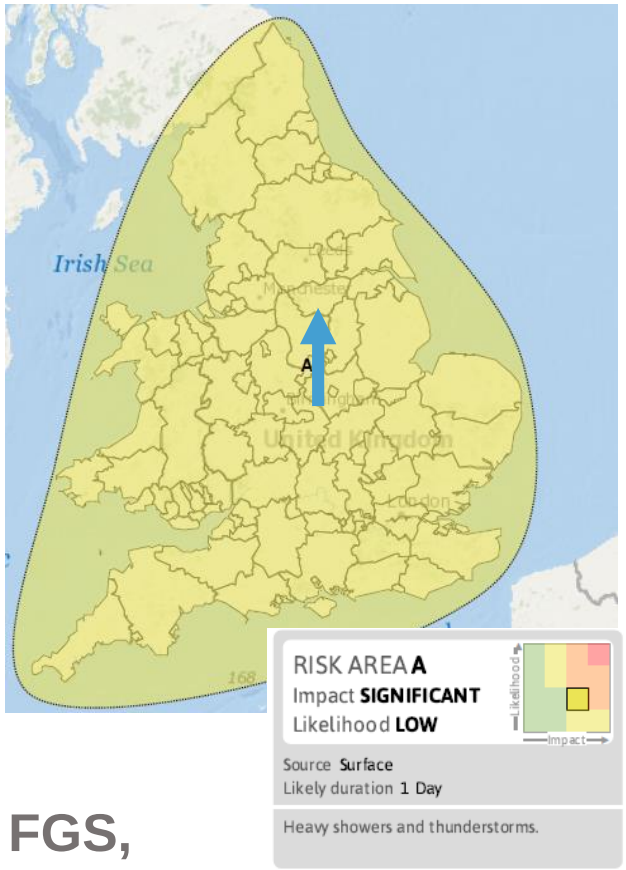
- **Precipitation estimates:** duration, intensity, spatial extent.
- **Catchment information:** topography, soil moisture, drainage.

Operational UK SWF forecasting

- **MOGREPS-UK:** convection permitting, 2.2km hourly lagged 18 member ensemble.
- **Flood Guidance Statements:** rain-to-grid hydraulic modelling and forecaster input.
- **SWFHIM:** gridded SWF specific hazard impact model. Informs FGS.



MOGREPS-UK, 00UTC 16/08/22



FGS, 16/08/22

2023 Summer Testbed

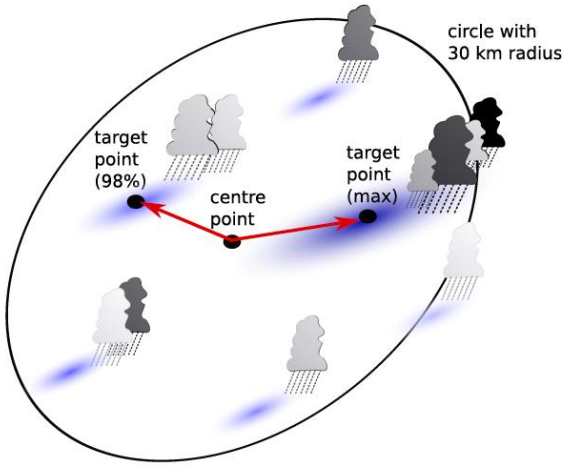
- Full suite of Met Office convective-scale forecast tools/visualisations.
- 5 weeks (June/July).
- Session dedicated to SWF evaluation, “live” and past cases.

RWCRSs for SWF forecasting: FOREWARNS

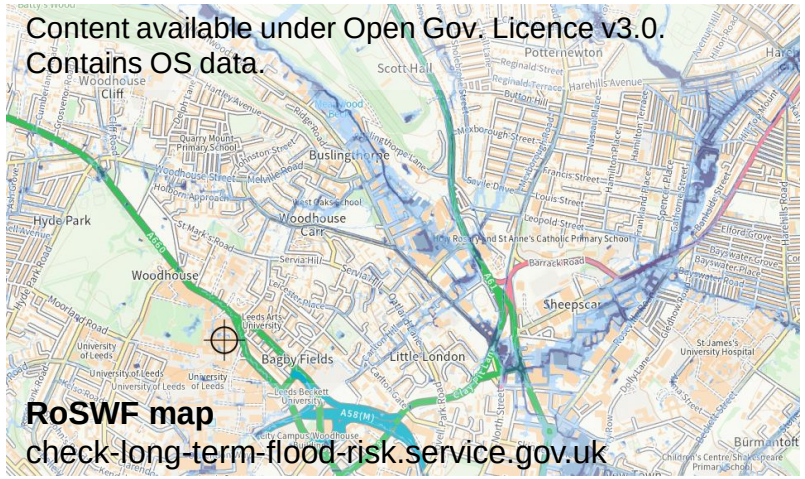
FOREWARNS (***F**lood f**ORE**casts for Surface **WA**ter at a **R**egio**N**al **S**cale*) provides enhanced regional SWF detail for a reasonable worst-case rainfall scenario (RWCRS).

Input rainfall field: deterministic or ensemble forecast, radar observations.

Input rainfall field → **Reasonable Worst Case Rainfall Scenarios:** Percentile-based neighbourhood processing → **Threshold look-ups:** Catchment level comparison against model values underpinning static **Risk of SWF maps**. → **Local return period of SWF**

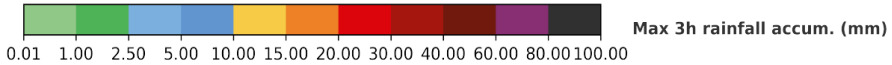


Method an evolution of Böing *et al., Met. Apps.* (2020) & Birch *et al., J.F.R. Manag.* (2021)



Flood modelling: Vesuviano *et al.*, *J.F.R. Manag.* (2021)

Another example: 30th July 2019

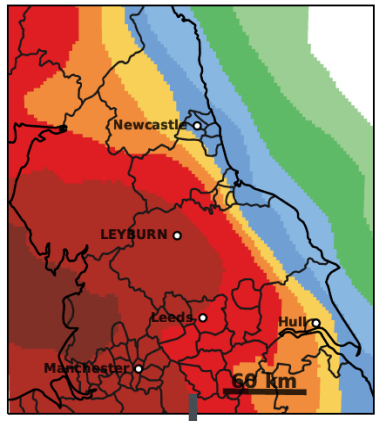


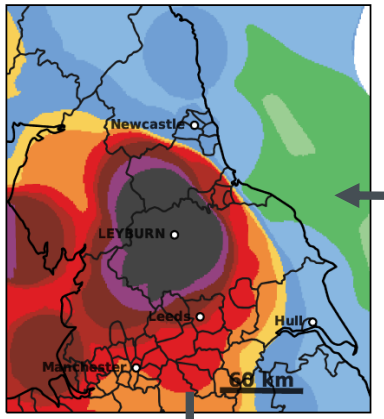
Forecast

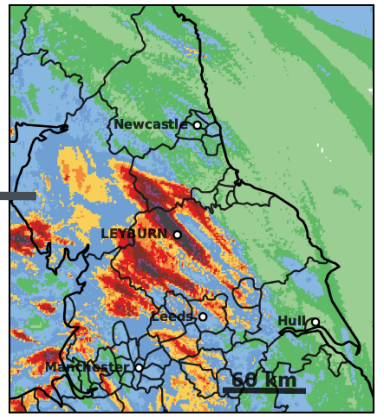
RWCRS from 00:00 UTC **MOGREPS-UK** ensemble:

- Convection permitting
- 2.2km grid resolution
- 18 members

Porson *et al.*, *QJRMS* (2020)

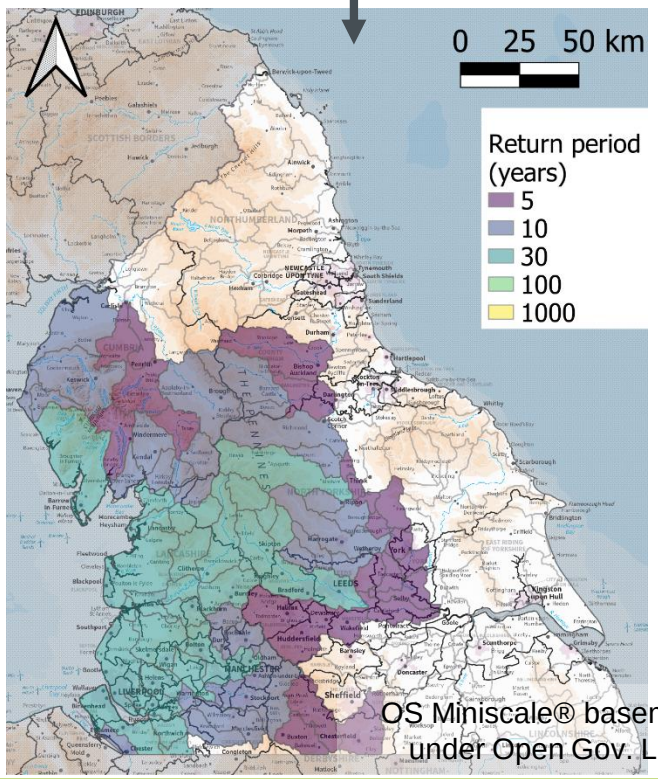


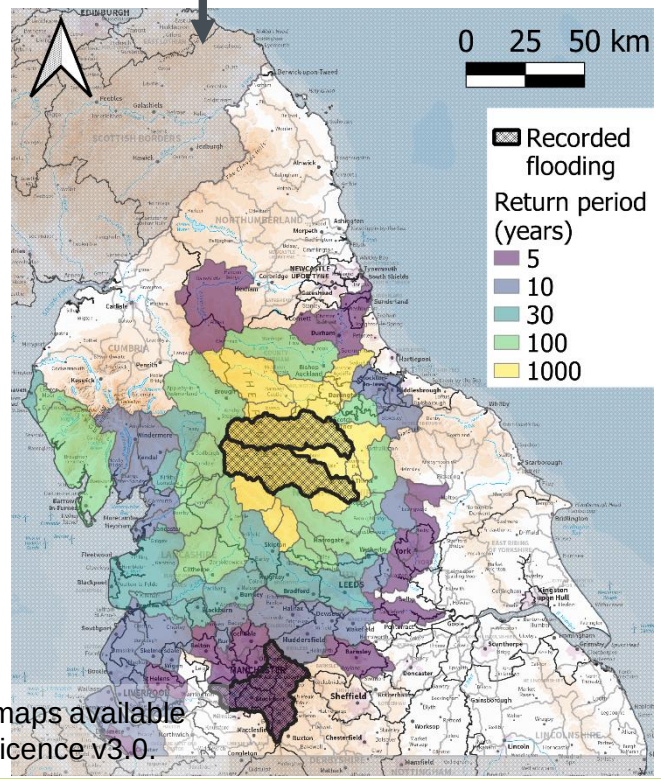




Observations

RWCRS from Nimrod radar network observations.





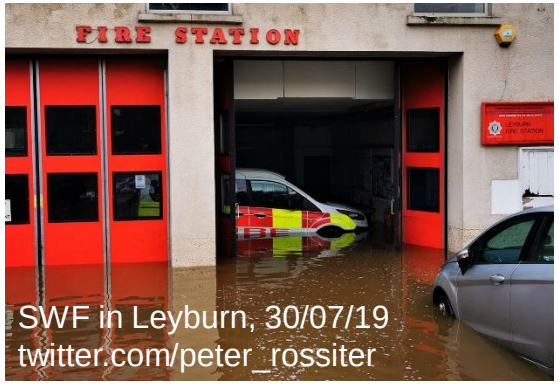
OS Miniscale® basemaps available under Open Gov. Licence v3.0.

FOREWARNS output

- Based on 1, 3 and 6 hour accums.
- Covers full day
- Timing of SWF available

Records obtained from official reports, news media and Global Flood Monitor.

GFM: de Bruijn *et al.*, *Sci. Data* (2019)



SWF in Leyburn, 30/07/19
twitter.com/peter_rossiter

Forecast verification: methods

No comprehensive observational records exist for SWF.

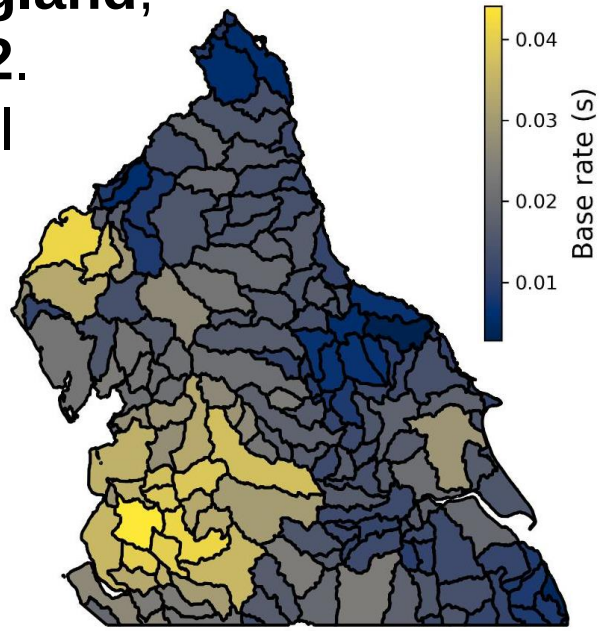
Lower bound: qualitative, anecdotal records (Twitter!)

TRUE FLOOD EVENTS

Upper bound: precipitation proxies – here, radar benchmarking of FOREWARNS.

- Found 82 days with flood recorded in **Northern England**, **May–October 2013–2022**.
- Recorded catchment-level locations.

- Generate proxy for all 82 flood days.
- Generate **daily** observational record, summer **2019–2022**.



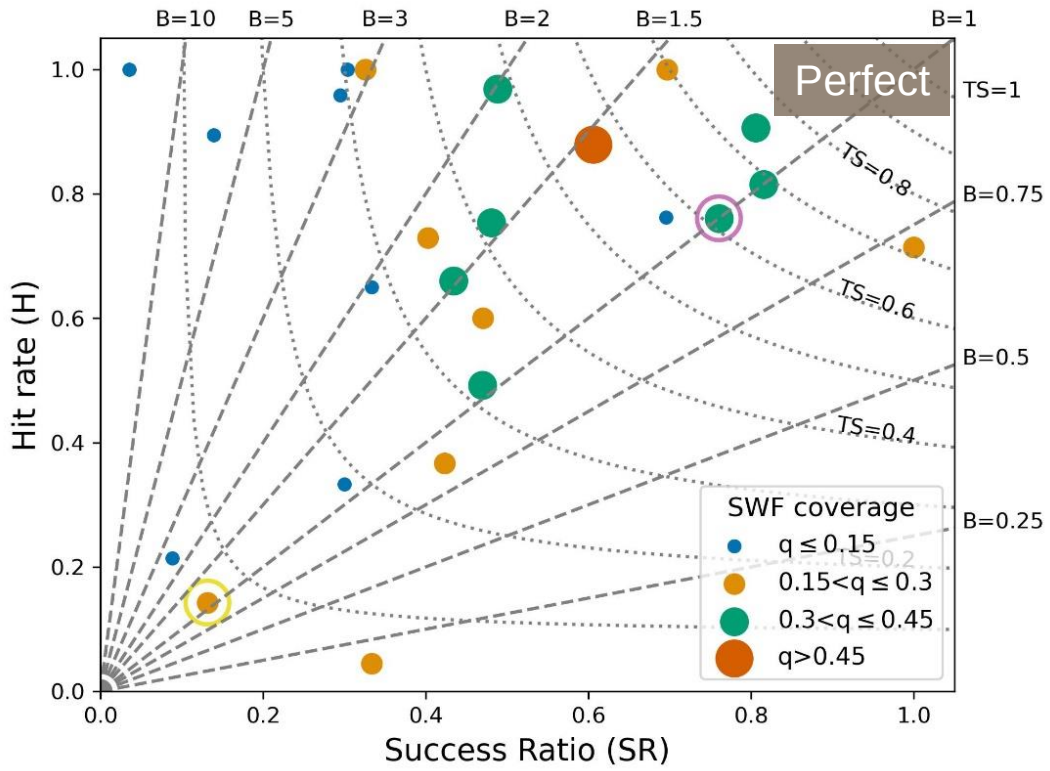
Frequency of proxy SWF events, May–Oct. 2019–2022

Objective verification: catchment-level contingency tables.
Subjective: regional-level, visual assessment (10 assessors).

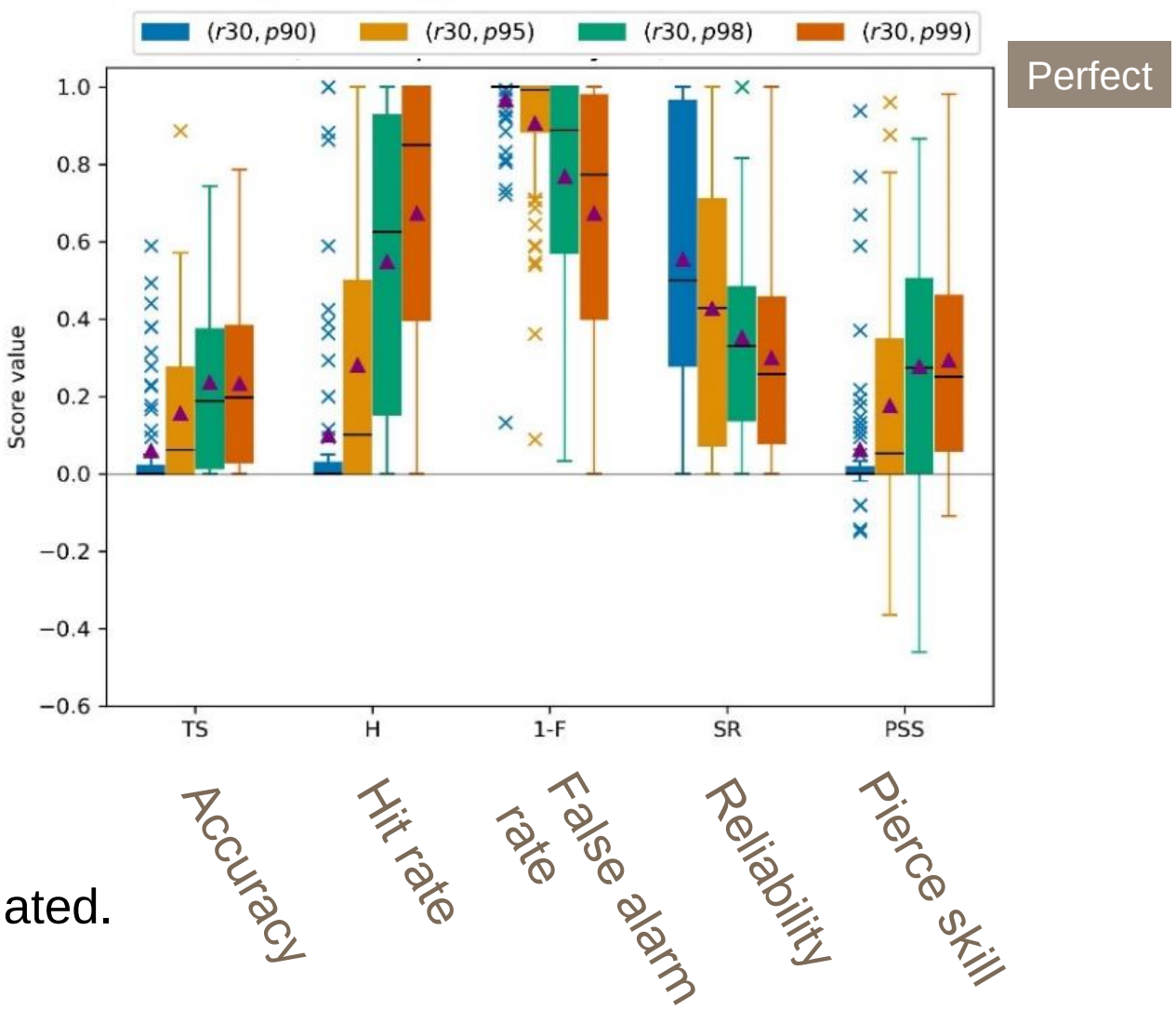
Precipitation proxies: Herman & Schumacher, *J.Hydrometeo.* (2018)

Spatial forecast verification

Roebber diagram



Skill scores

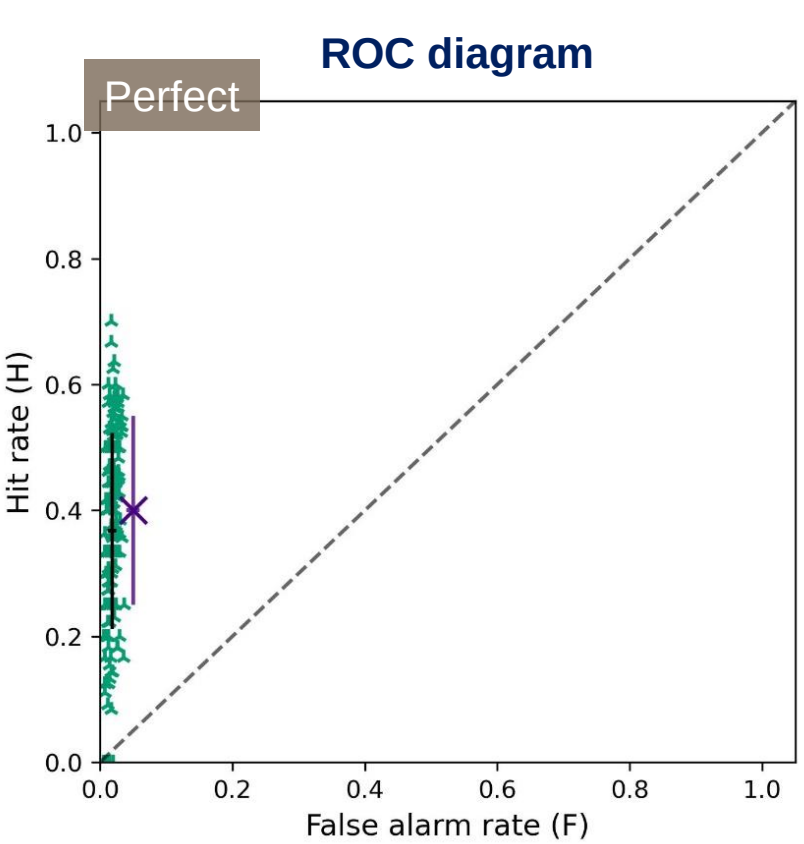


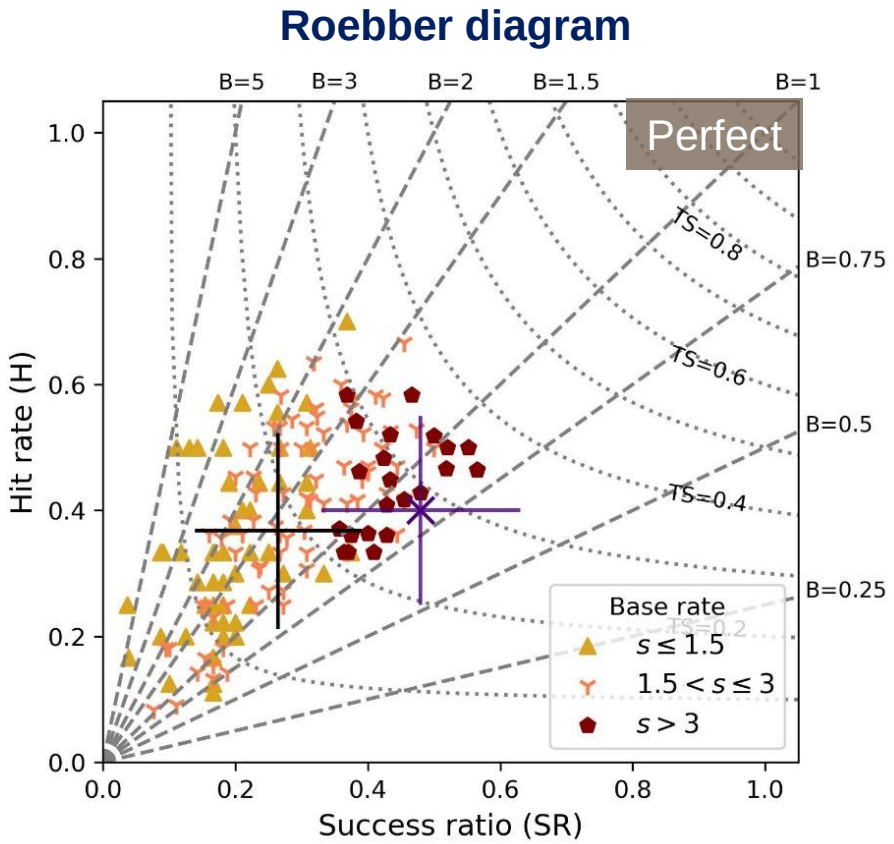
Look at score for 82 individual forecasts with known floods, combining 166 catchments.

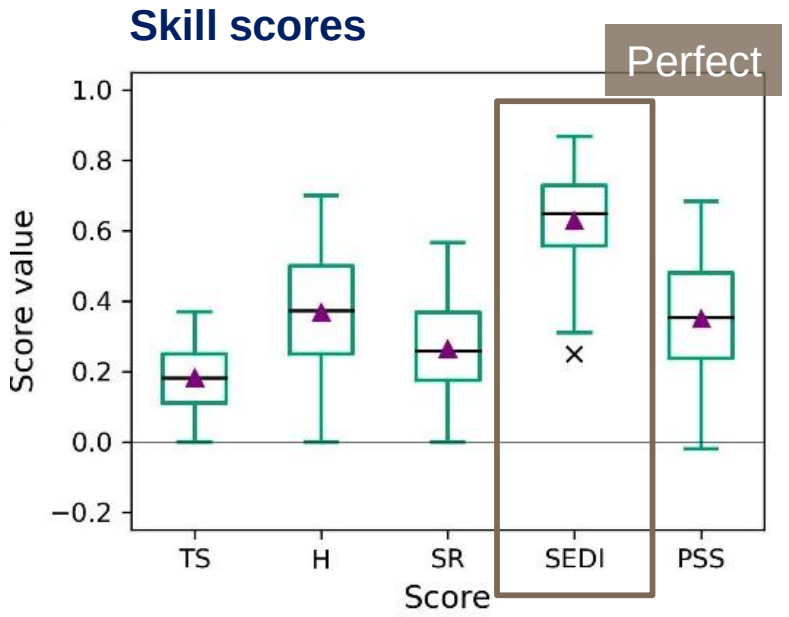
→ high location hit rates, but extents overestimated. 98th %le best balance of scores.

Further: **Met Office summer testbed.** Daily subjective forecast generation/assessment.

Temporal forecast verification







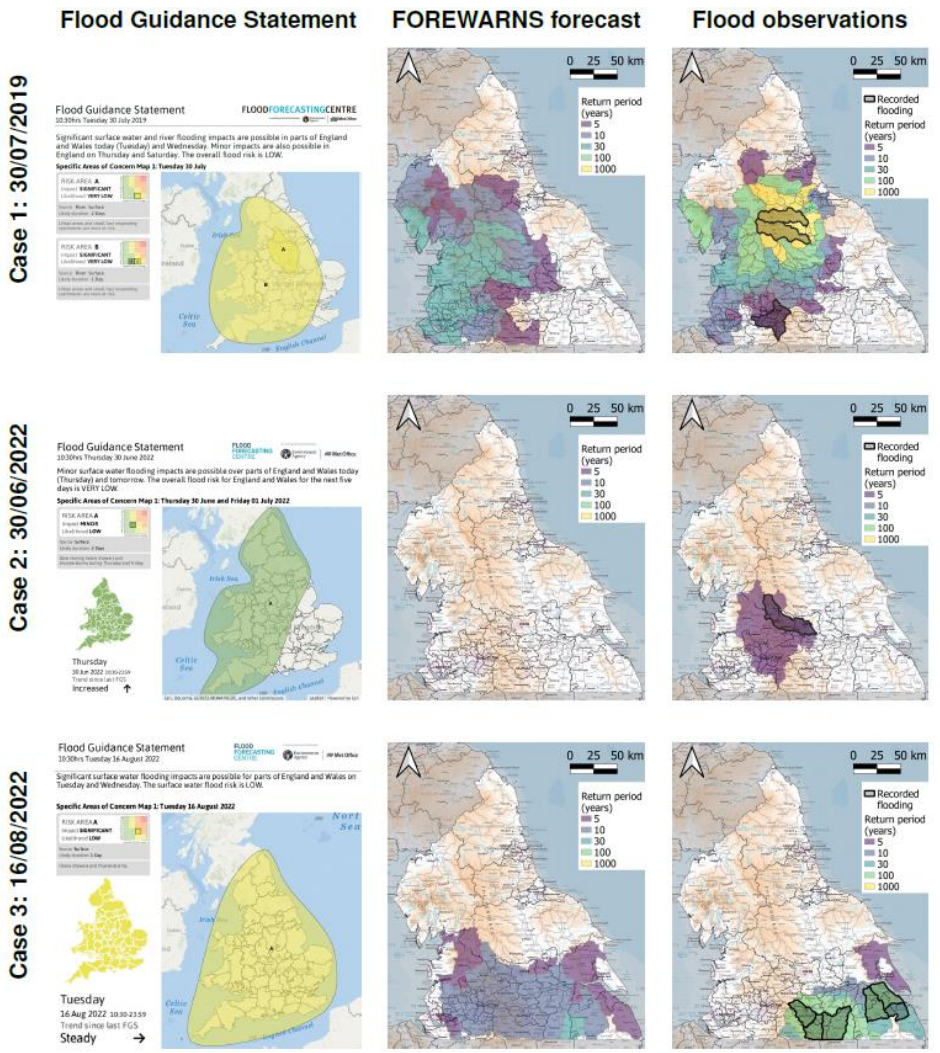
Scores for 166 individual catchments, combining 725 forecasts (3 years' summers).

→ false alarm rate matches low frequency *s* of events.
→ forecasts more reliable for areas with more SWF (higher *s*).
→ good scores for SEDI measure designed for evaluating rare event forecasts.

SEDI score:
Ferro & Stephenson, *WAF* (2011)

Conclusions

- **FOREWARNS**: novel method for enhanced, regional-scale SWF forecasting combining
  - reasonable worst-case rainfall scenarios;
  - catchment-level threshold look-ups.
- Verification methods developed over Northern England. Forecasts perform well, especially for user requirements.
- Not shown here, but workshop held with responders, who would adopt forecasts for action planning.
- National forecast system included in Met Office Summer 2023 testbed. Scored well by forecasters.



Discussion

- Method is not UK specific.
- **Urgent need for improved SWF observation records.**
- Development planned: RWCRS probability calculations; **nowcasting**; Met Office testing.

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