Dual-polarisation X-band radar estimates of precipitation assessed using a distributed hydrological model for mountainous catchments in Scotland

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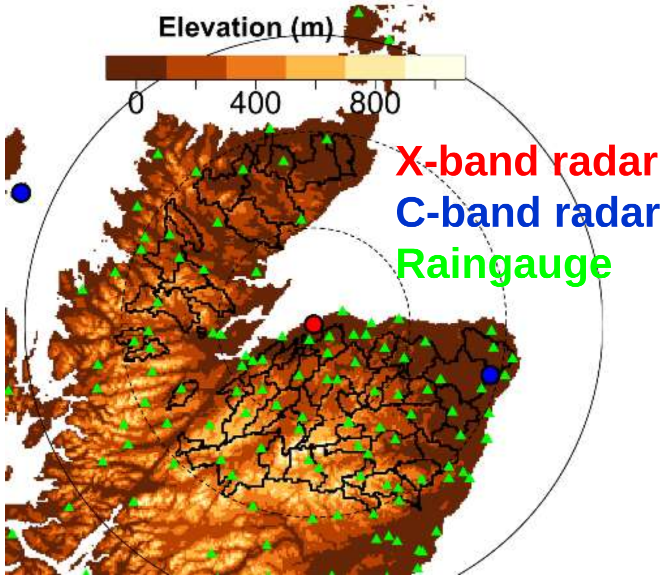

- NCAS's mobile X-band dual-polarisation weather radar was sited in a mountainous region of Northern Scotland where the national C-band network has only remote coverage.

- Data have previously been assessed against raingauge measurements. Here we present a hydrological assessment using UKCEH's G2G distributed hydrological model.

Hydro-JULES

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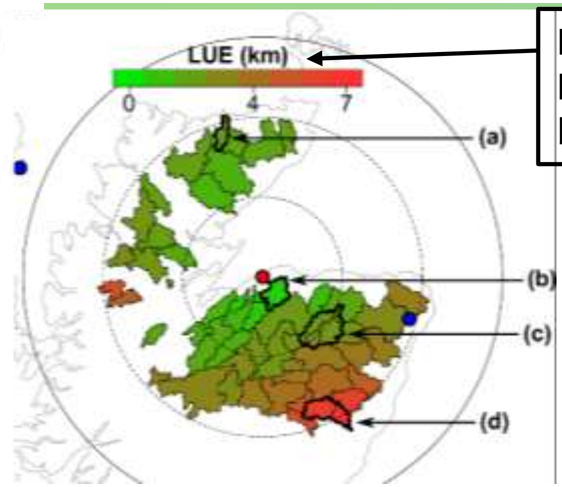
X-band Quantitative Precipitation Estimates (QPEs)

Predominantly using single-polarisation.

Fully using dual-polarisation variables.

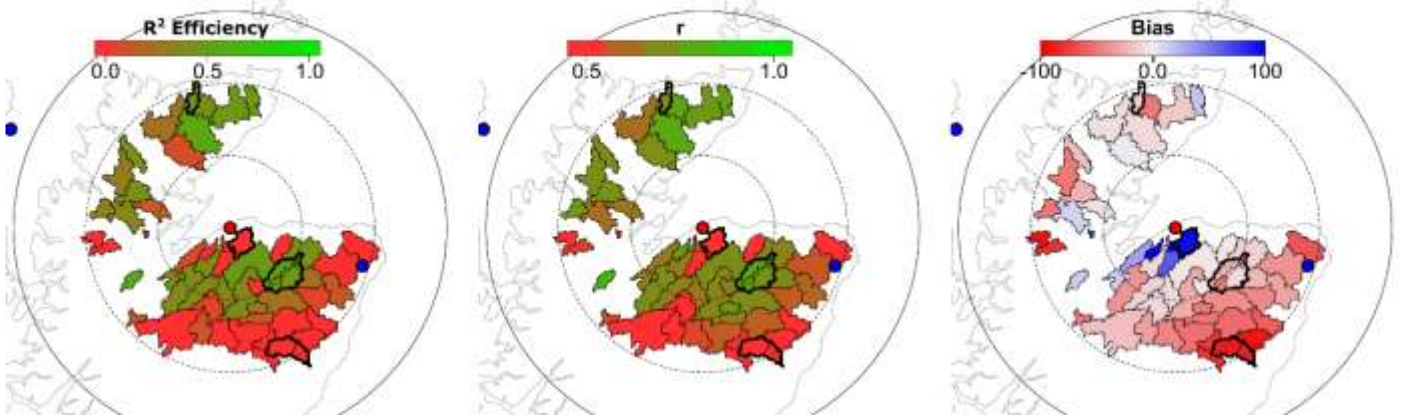
Precip. Type	DESCRIPTION
R(Z)	A simple estimate based on the unfiltered horizontal reflectivity with no post-processing beyond calibration.
R(Z+DTM)	A reflectivity-based estimate with simple clutter mitigation and a beam blockage correction using Digital Terrain Model (DTM) data.
R(Z+DTM+QC)	As per R(Z+DTM) but additionally removing spurious radar echoes.
R(Z+DTM+QC+At)	As per R(Z+DTM+QC) but applying a dual-polarisation based attenuation correction to the beam blockage correction and reflectivity filter.
R(ZC)	Similar to R(Z+DTM+QC+Att) except using a specific attenuation derived clutter map to correct beam blockage.
R(A_h)	Specific attenuation is converted to rain-rate using a fixed R(A) relationship. R(ZC) is used as a fall-back.
R($A_{h,THR}$)	As per R(A_h) except only applying the R(A) relationship where the total differential phase shift exceeds 5°.
R(Z(A_h))	Specific attenuation is converted to reflectivity before calculation of rain-rate. This is used when total differential phase shift is greater than 5°; otherwise R(ZC) is used as a fall-back.
R(KDP-Z)	Smoothly blends an estimate based on the specific differential phase for high intensity precipitation with the R(ZC) estimate at lower intensities (<20mm/h).
R(Dual-Pol)	As per R(Z(A_h)) except using R(KDP-Z) for infilling.

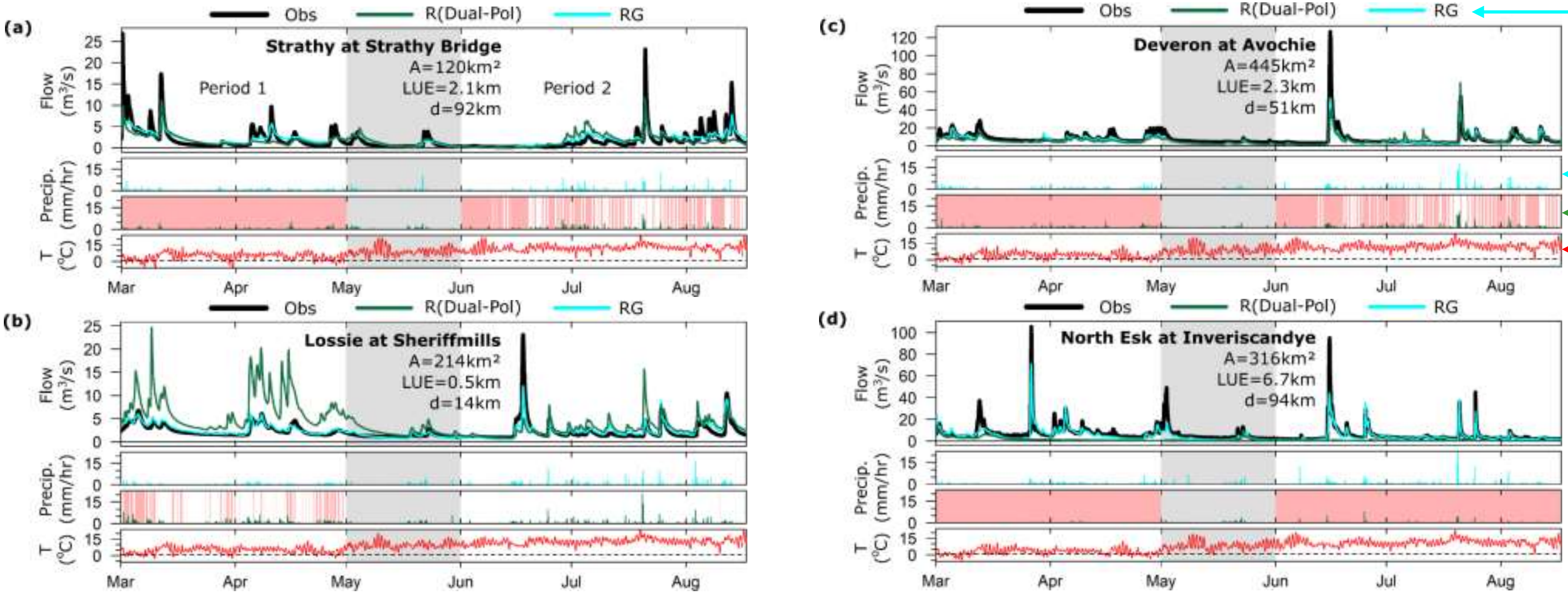
Hydrological assessment



Lowest Usable Elevation of X-band beam

Performance statistics calculated on modelled flow using R(Dual-Pol) input





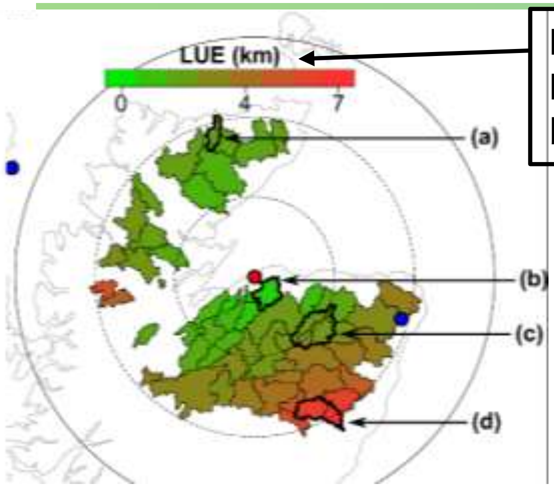
RG: Raingauge interpolation input

Raingauge precip.

R(Dual-Pol) precip.

Temperature (ground level)

Hydrological assessment



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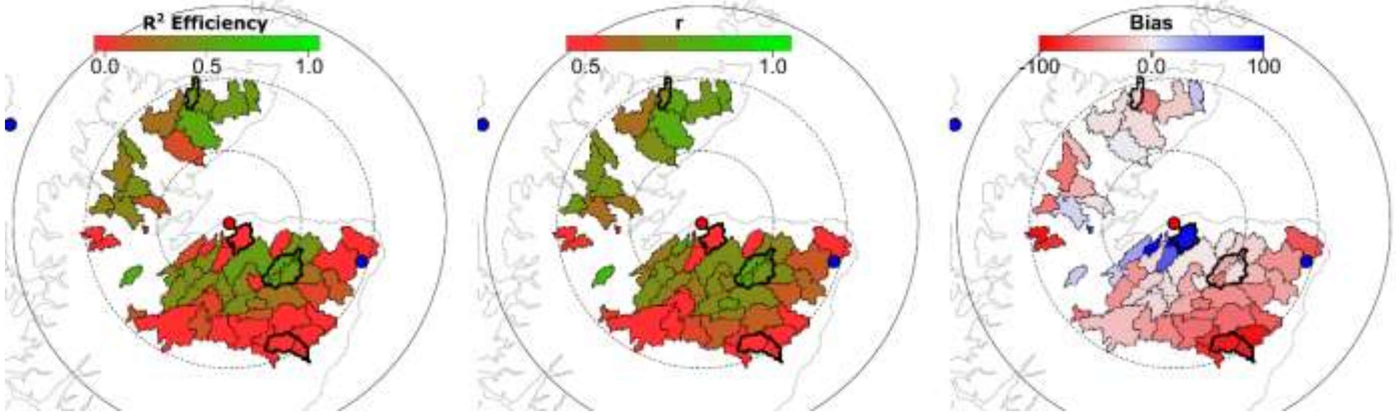
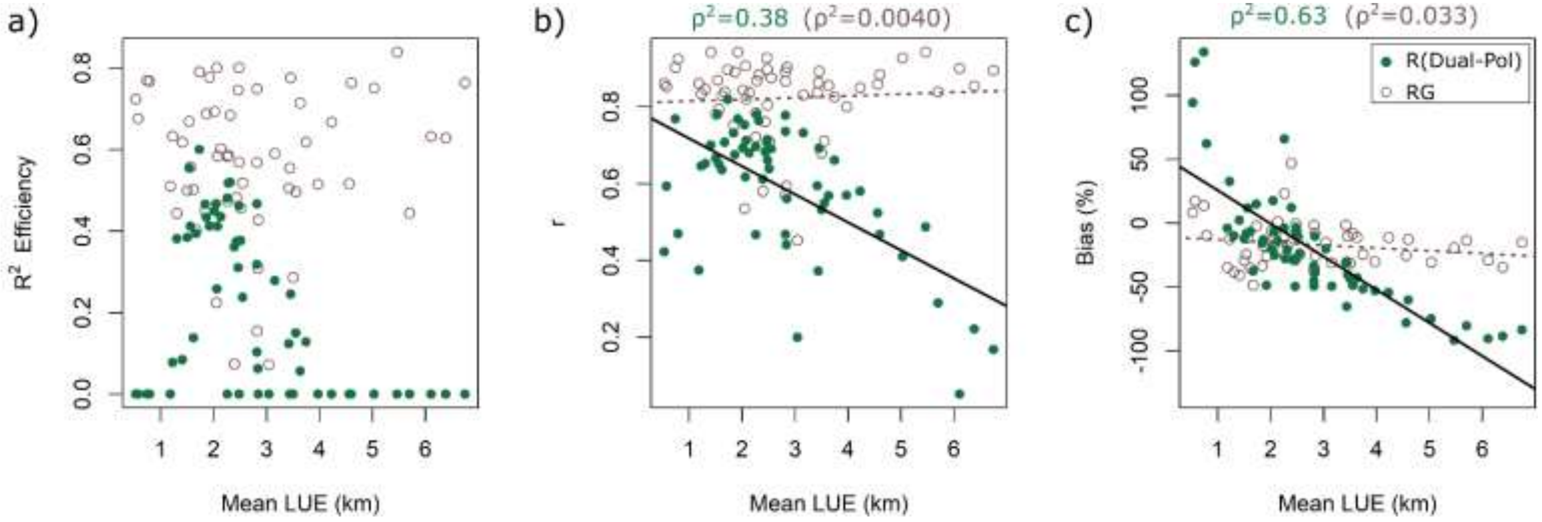


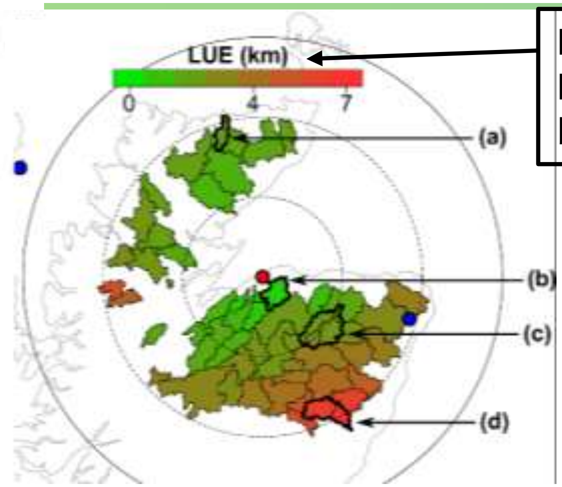
- Catchments with mean LUE > 4 km always have a strong negative bias (worse than -50%) as the radar beam overshoots most precipitation.

- Beam elevation has a stronger influence than range in this mountainous region, despite a stronger sensitivity to range in radars at X-band than at longer wavelengths.

- Several nearby catchments suffer large positive bias due to an antenna elevation pointing error affecting Period 1.



Hydrological assessment



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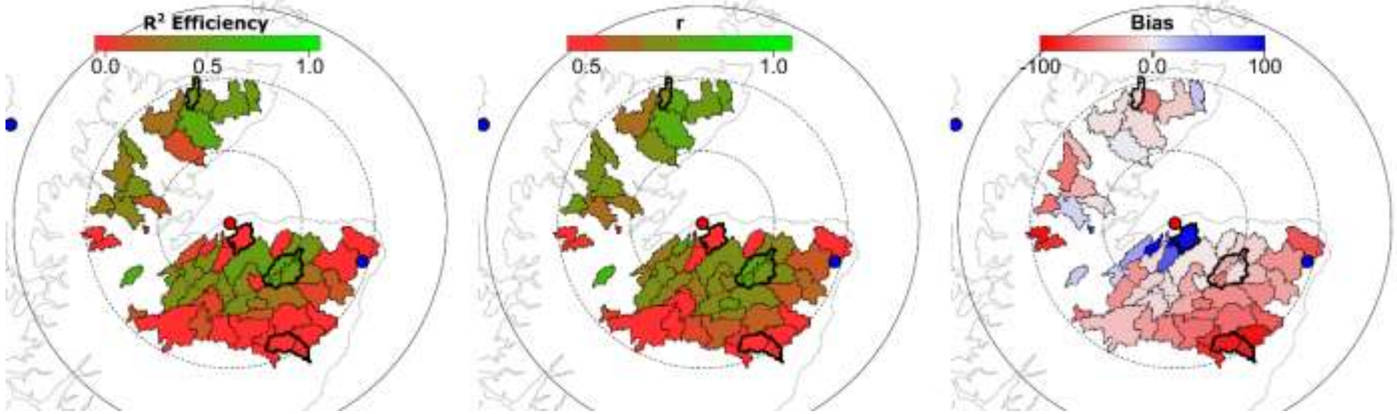
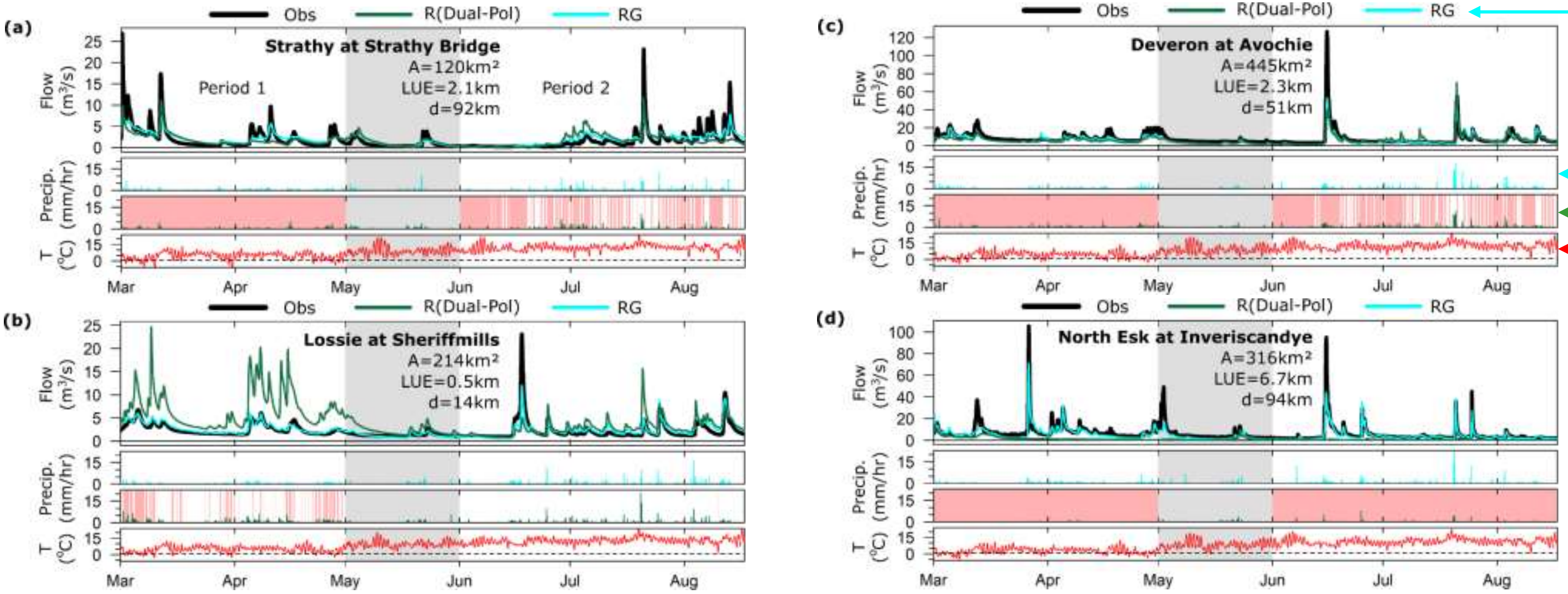




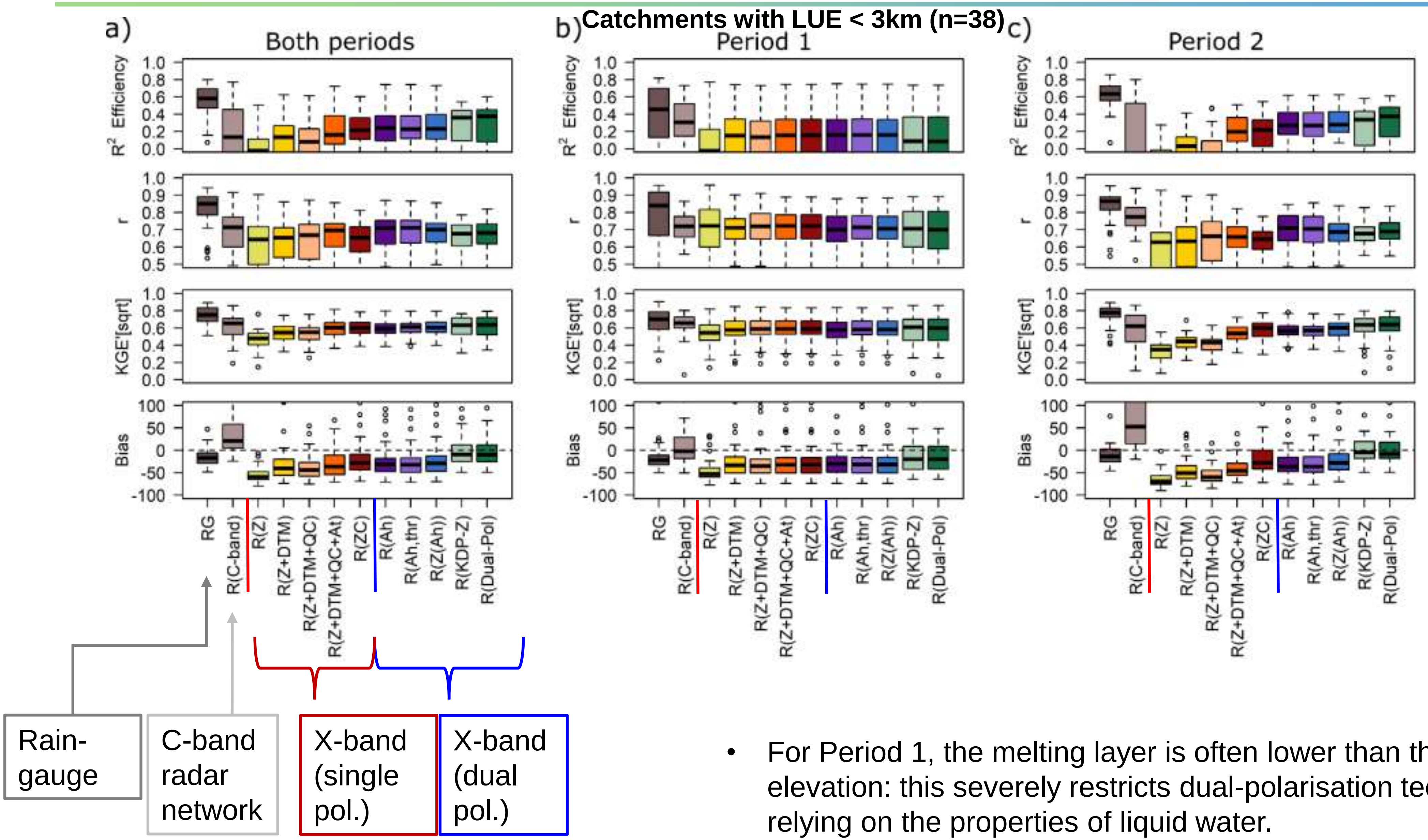
RG: Raingauge interpolation input

Raingauge precip.

R(Dual-Pol) precip.

Temperature (ground level)

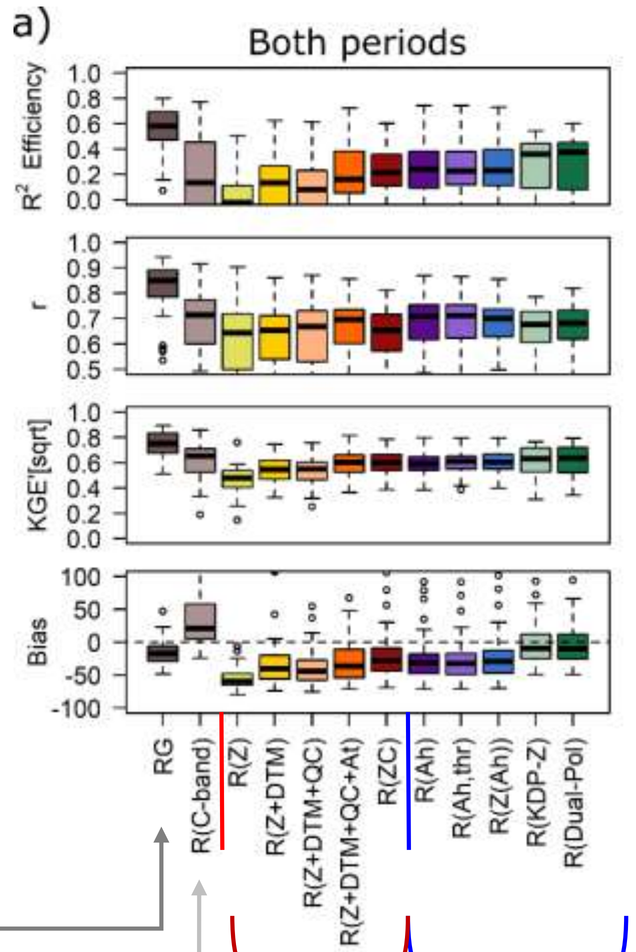
Comparing all QPEs across all catchments



- For Period 1, the melting layer is often lower than the beam elevation: this severely restricts dual-polarisation techniques relying on the properties of liquid water.

Comparing to national C-band radar network

(NB2: Raingauge interpolation produces the best performance in these catchments.)



Rain-gauge

C-band radar network

X-band (single pol.)

X-band (dual pol.)

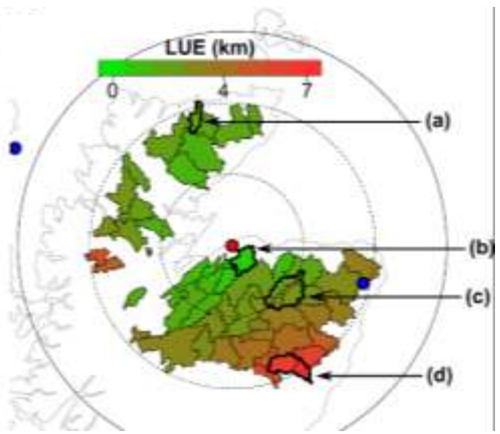
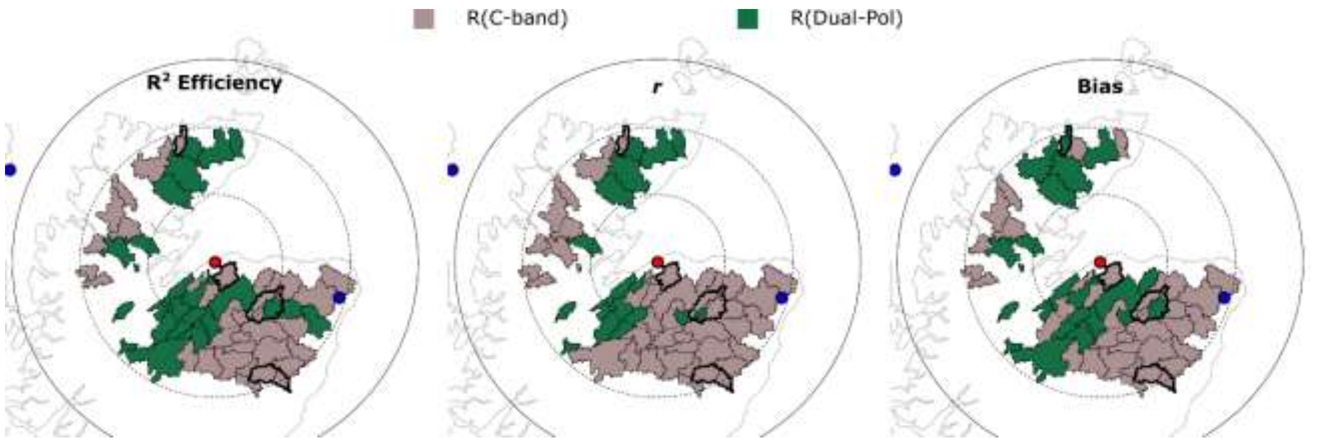


Figure: Catchments are coloured according to the QPE that produces the best performance in the modelled river flow. This is strongly influenced by the beam elevation of the respective radar.



(NB: no raingauge merge or similar corrections are applied to X-band QPEs, in contrast to those from the national C-band network.)

References

email: johwal@ceh.ac.uk

Presented work: Radar Applications in Northern Scotland

- Wallbank, Cole, Moore, Dufton, Neely, Bennett (2022) Dual-polarisation X-band radar estimates of precipitation assessed using a distributed hydrological model for mountainous catchments in Scotland. Under Review (Journal of Hydrology).

- Neely, Parry, Dufton, Bennett, Collier (2021) Radar Applications in Northern Scotland (RAiNS). J. Hydrometeor. 22(2), 483–498.

- Bennett (2019) RAINS: NCAS mobile X-band radar scan data from Kinloss Barracks, Forres, Scotland, Version 1. Centre for Environmental Data Analysis, 26 February 2019.

- https://sci.ncas.ac.uk/rains/

Grid-to-Grid hydrological model:

- Bell, Kay, Jones, Moore, Reynard (2009) Use of soil data in a grid-based hydrological model to estimate spatial variation in changing flood risk across the UK. J. Hydrol. 377(3–4), 335–350.
- Moore, Cole, Bell, Jones (2006) Issues in flood forecasting: ungauged basins, extreme floods and uncertainty. IAHS Publ. 305, 103-122.

Ongoing work: Radar Applications in Northern England

- https://sci.ncas.ac.uk/raine/

- 2yrs+ worth of data