Comparison of gauge-radar merging methods for obtaining UK rainfall.

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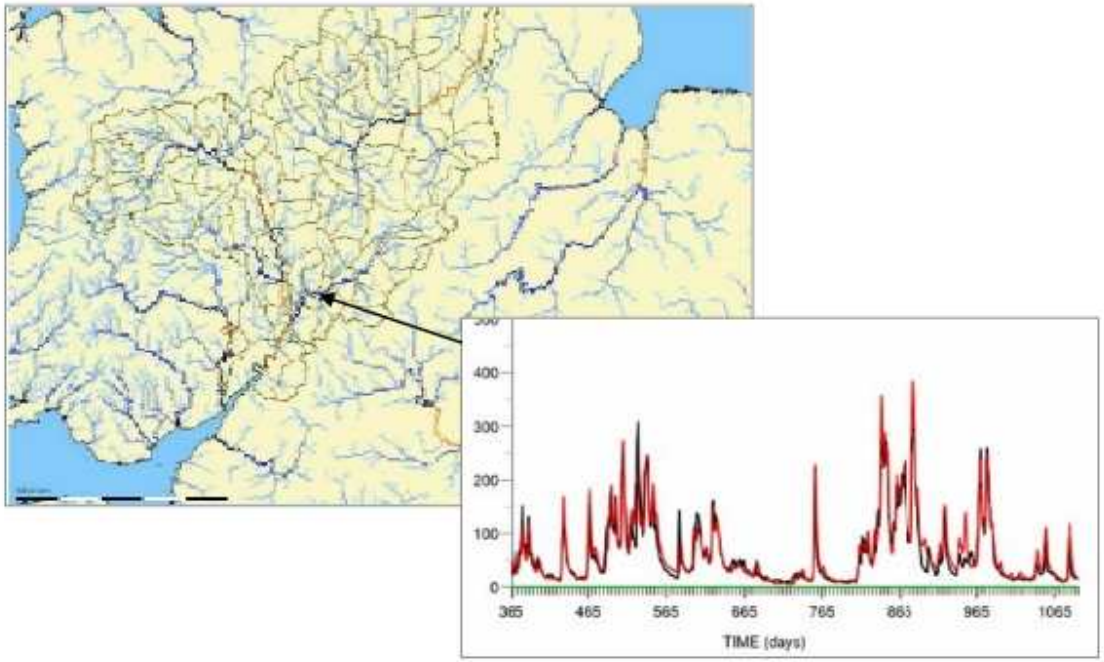
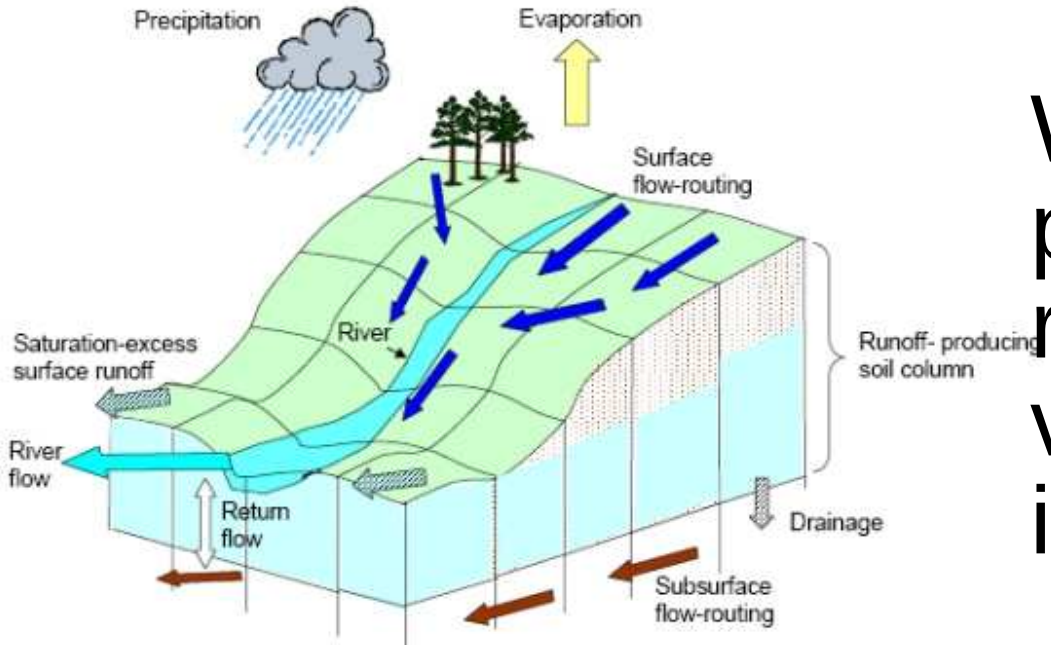
grid2grid river flow model

G2G Combines real-time measured rainfall with forecast product.





We also want to produce a national rainfall product and verify NWP rainfall in real time.

Gauge QC checks

- Initial merging analysis hampered by over reporting “rogue gauges”, which had a disproportionate effect on the rainfall field.
- Need to identify badly performing gauges.
- QC combines automated real-time analysis with manual “rogue gauge” list.
- It is crucial that genuine heavy rainfall is not filtered out by the QC.

Range QC check

60 minute values

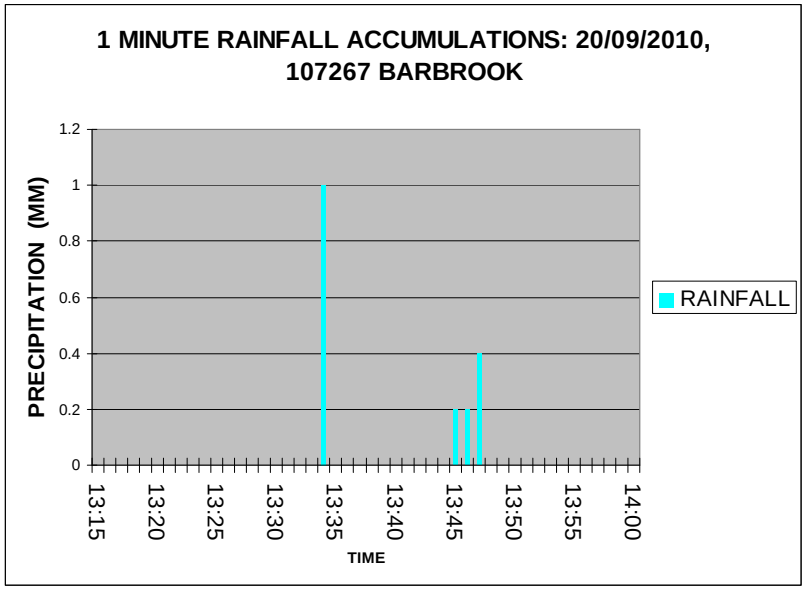
<= 10mm OK

>10mm; <=40mm ?

> 40mm Suspect

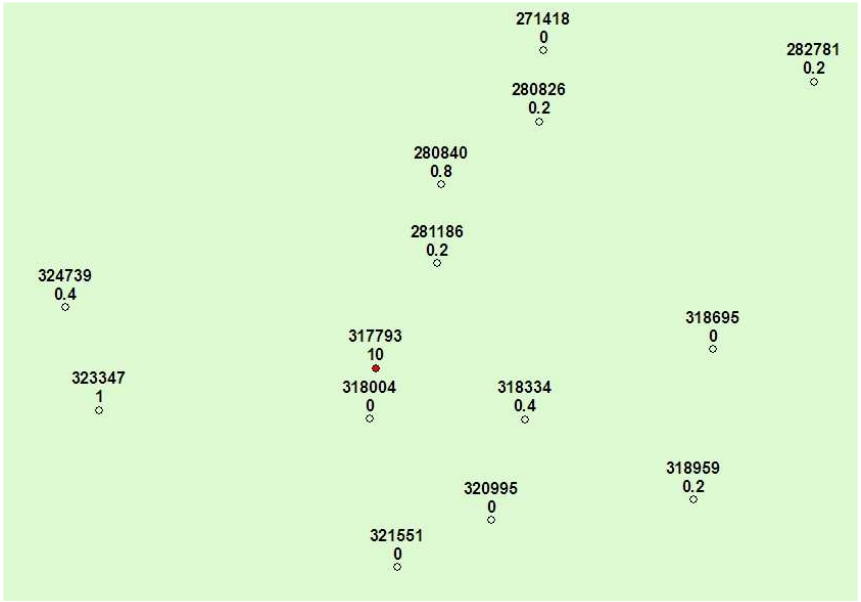
+ isolated rain QC

(a sudden burst is statistically rare)



+ Spatial QC check

(does gauge stand out from neighbours)



+ tip-time analysis

(used to identify double tips and partially blocked gauges)

Merging schemes

- How long does they take to run?
- How do they perform in different weather patterns?
- Cross-validation is used to analyse the different methods. This involves removing a sub-set of gauges from the merging scheme to validate against.
- Binary statistics (CSI,PSS), are calculated from a 2×2 contingency table with rainfall above a set threshold.
- Continuous statistics (RMSF, RMSE) are also obtained with cross-validation gauge above set threshold.

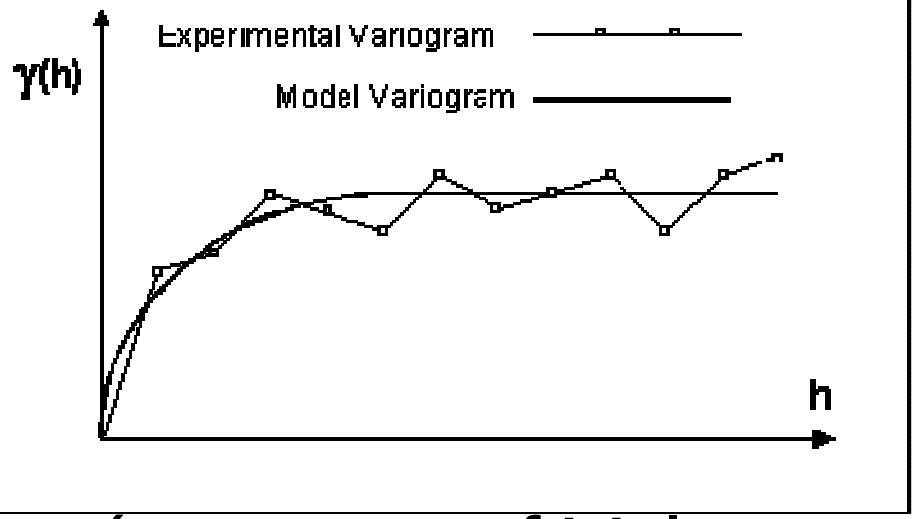
Merging scheme set-up

- Multi-quadric surface fitting (MQ) based on Cole+Moore (2008). A single matrix inversion (No. gauges × No. gauges), so surface field knows whole domain.
- Large MQ matrix sometimes fails to invert.
- Block Kriging used for Gauge only, KRE (based on Ehret 2008) and KED. A matrix is inverted for each 1km^2 grid square, to save processing time only nearest ≈16 gauges used.
- Kriging can be run with spherical or non-parametric (Velasco-Forero 2009) variograms.

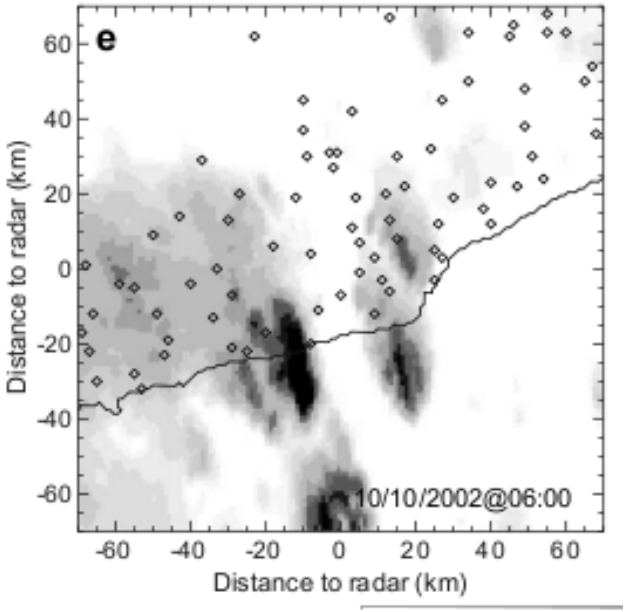
Non-parametric variograms may improve merged product but…

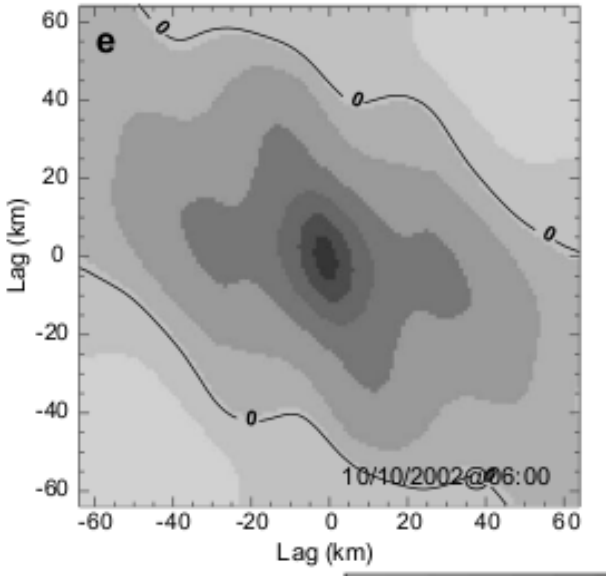
- Take longer to process
- Work better on smaller temporal and spatial scales.

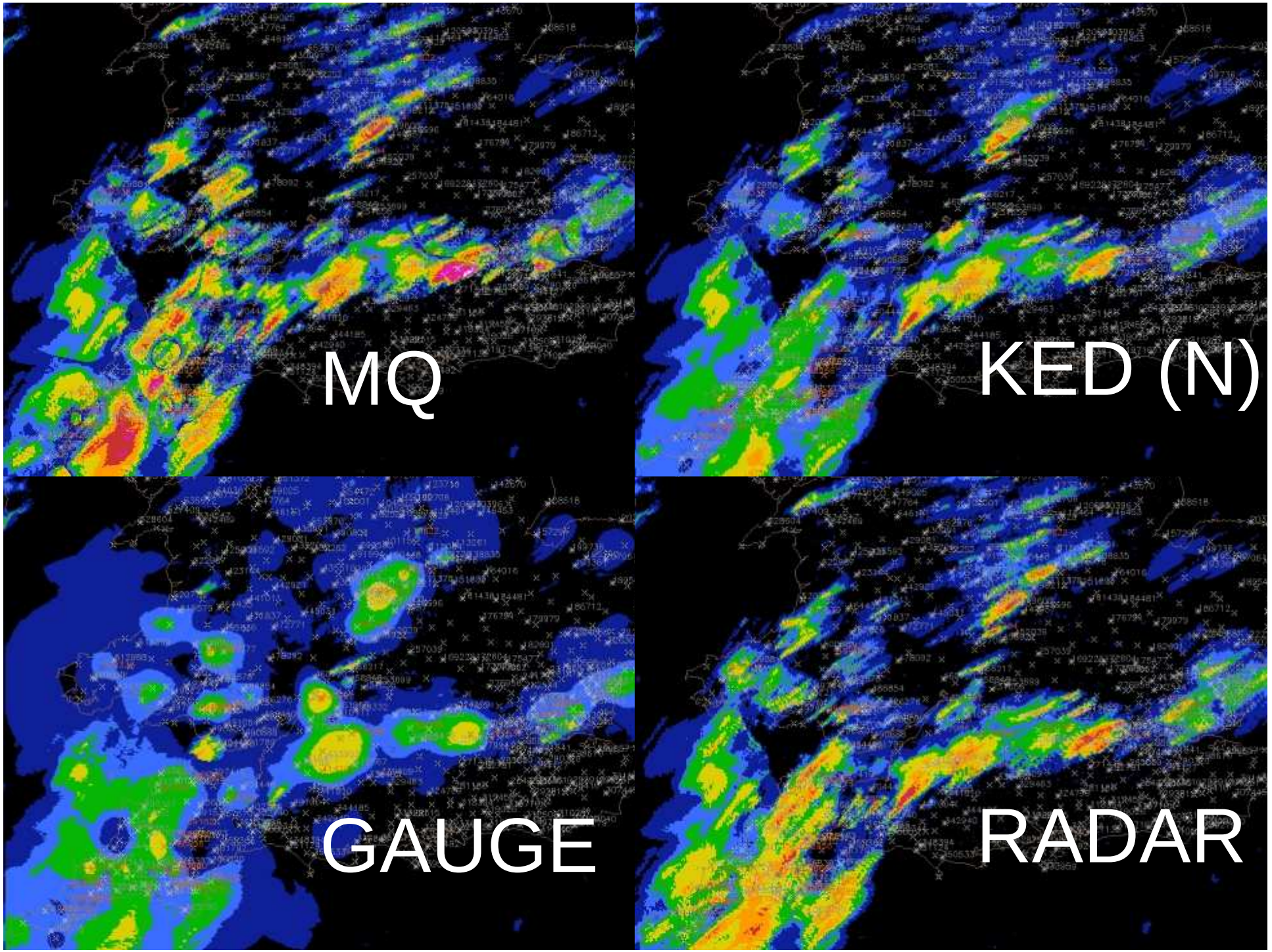
Spherical Variogram



Non-parametric variogram (courtesy of Velasco-Forero)






MQ
KED (N)
GAUGE
RADAR

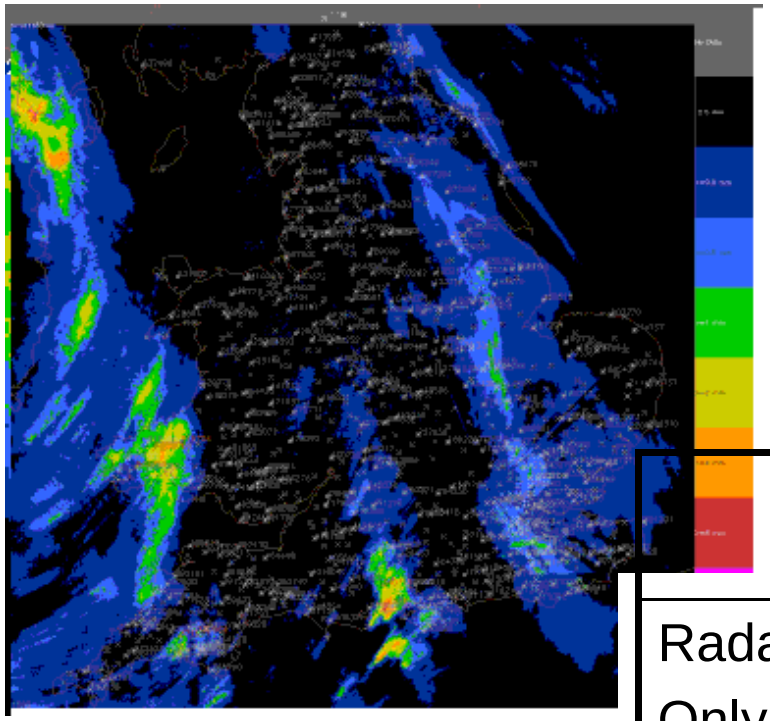
X-Validation -> Merged V	Above	Below	Total
Above	A (Hit)	B (False Alarm)	A + B
Below	C (Miss)	D (Correct Rejection)	C + D
Total	A+C	B+D	A+B+C+D=n

Binary threshold 4mm/hr Aug 2011

(x-val above threshold)

fB = (a+b)/(a+c)

	Critical Sucess Index	Peirce Skill Score	Frequency BIAS fB
Radar Only	0.200	0.273	0.825
KED	0.569	0.634	0.768
KRE (Ehret)	0.553	0.668	0.914
MultiQuadric	0.766	0.814	0.886
Gauge Only Kriging	0.490	0.517	0.581
KED (non-p)	0.911	0.941	0.976



Continuous threshold 4mm/hr

RMSF is resistant to outliers

RMSE is not resistant to outliers

	RMSE	RMSF	MAE	Pearson correlation
Radar Only	2.98	0.426	2.22	0.201
KED	1.13	0.094	0.69	0.878
KRE	1.43	0.153	0.84	0.803
MQ	2.62	0.583	1.72	0.590
Gauge Only	1.27	0.106	0.78	0.853
KED (non-P)	0.83	0.086	0.33	0.924

Times (not optimised)

- Radar – n/a
- MQ ≈ seconds
- Gauge only kriging (spherical) ≈ 3 minutes
- KRE (spherical) ≈ 3 minutes
- KED (spherical) ≈ 5 minutes
- KED (nonP) ≈ 12 minutes

Met Office

Questions?

S.J.Cole and R.J.Moore (2008) - MQ
U.Ehret et al (2008) – KRE
C.A.Velasco-Forero (2009) – KED+nonP
I.T.Jolliffe + D.B.Stephenson – Statistics

With/out gauge QC 2mm/hr threshold

	CSI binary	fB binary	RMSE continuous	RMSF (cont)	MAE (cont)	Pearson (cont)
MQ with QC	0.768	0.847	0.82	0.178	0.41	0.943
MQ no QC	0.371	1.253	4.19	0.465	2.51	0.297
KED(N) with QC	0.908	0.928	0.22	0.029	0.08	0.994
KED(N) no QC	0.484	0.755	2.39	0.386	1.49	0.408