Rainfall estimation using a non-stationary geostatistical model and uncertain measurements

F. Cecinati*[1], A. Wadoux[2], M. A. Rico-Ramirez[1] , G.B.M. Heuvelink[2]
[1] University of Bristol, Department of Civil Engineering
[2] Wageningen University, Environmental Sciences

*francesca.cecinati@bristol.ac.uk

Weather Radar and Hydrology Symposium, Seoul, 12th April 2017

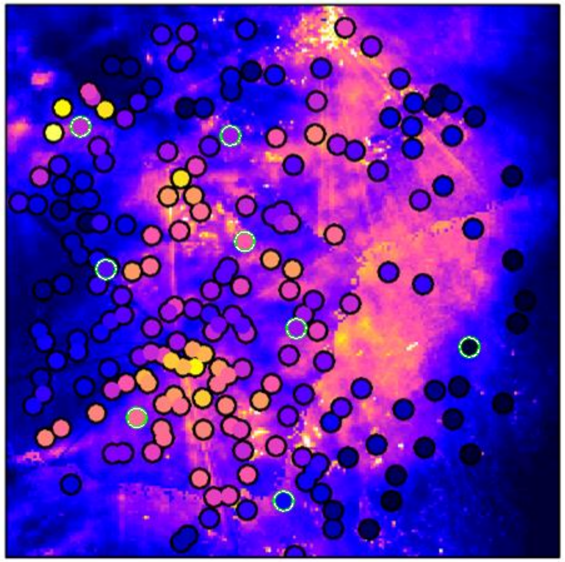
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 607000.

www.quics.eu

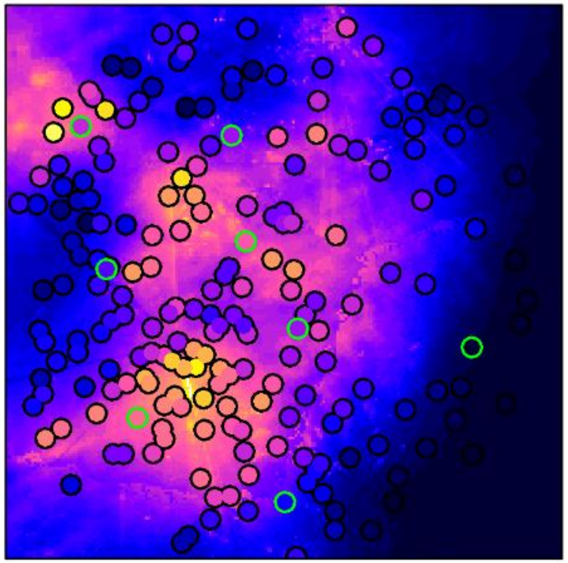
Merging radar - rain gauges: Kriging with External Drift (KED)

1. KED: one of the best performing and most efficient methods
2. Estimate based on kriging interpolation of rain gauges
3. Mean as a linear function of the radar
4. Kriging Variance allows to calculate uncertainty

Radar and Rain Gauges



KED and Rain Gauges



Uncertainties in KED

1. Interpolation
2. Rain gauge measurement uncertainty
3. Radar uncertainty
4. …more

We address 1, 2, and 3

Interpolation and trend estimation uncertainty

Measurements only in a limited number of points..

...but the estimation is areal

How uncertain is such estimation?

- Based on the geo-statistical model
- Measured by the kriging variance

Rain gauge measurement uncertainty

- ***Variogram nugget:*** variance at short distance. Can represent measurement errors. It is spatially uniform.

- ***Kriging for uncertain data (KUD)***: assigns a specific nugget for each rain gauge, at each time step (space and time variant).

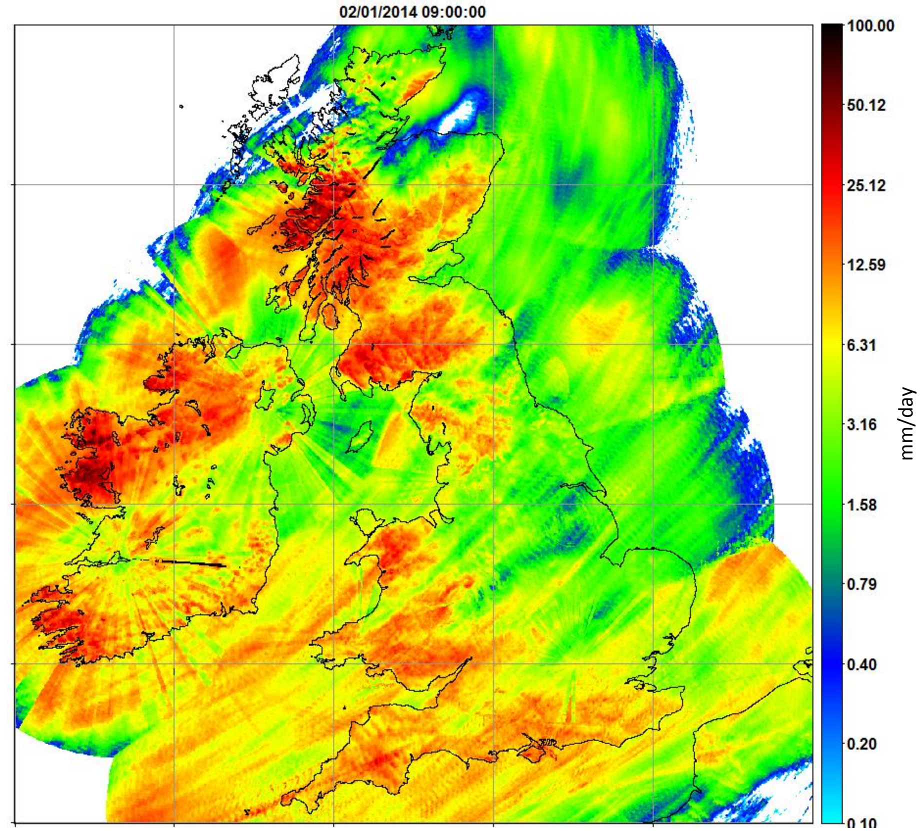
Radar Measurement uncertainty

- Radar is used differently in KED:

  Mean = linear function of radar
- Spatially uniform radar errors are not influent
- In reality radar errors are spatially distributed

⬇

KED with non-stationary variance



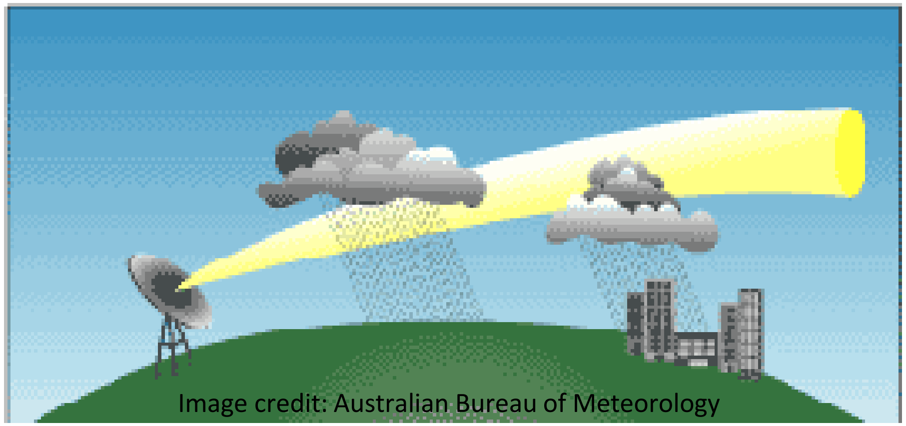
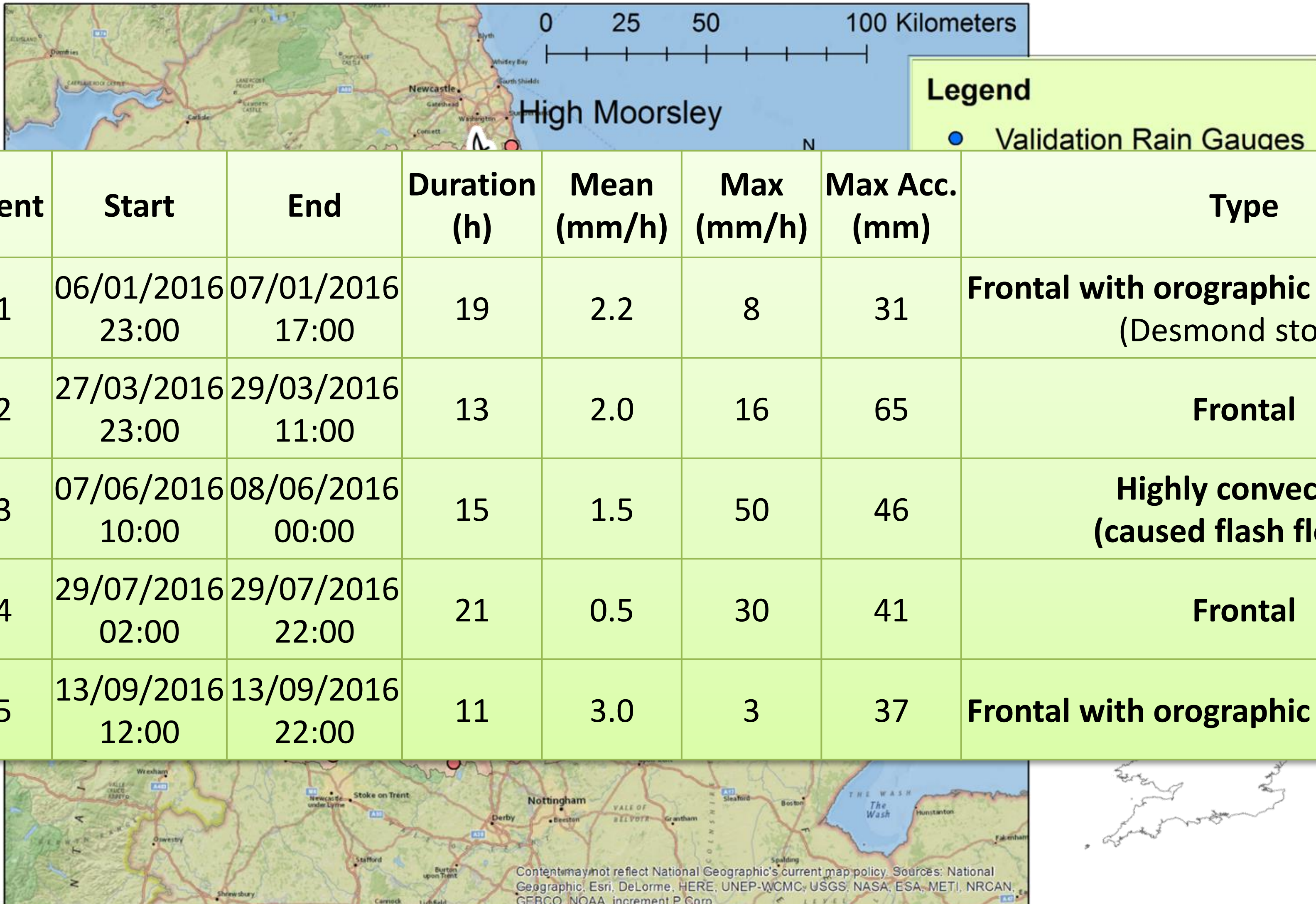


Image credit: Australian Bureau of Meteorology

QUICS

WAGENINGEN UNIVERSITY & RESEARCH

Case Study

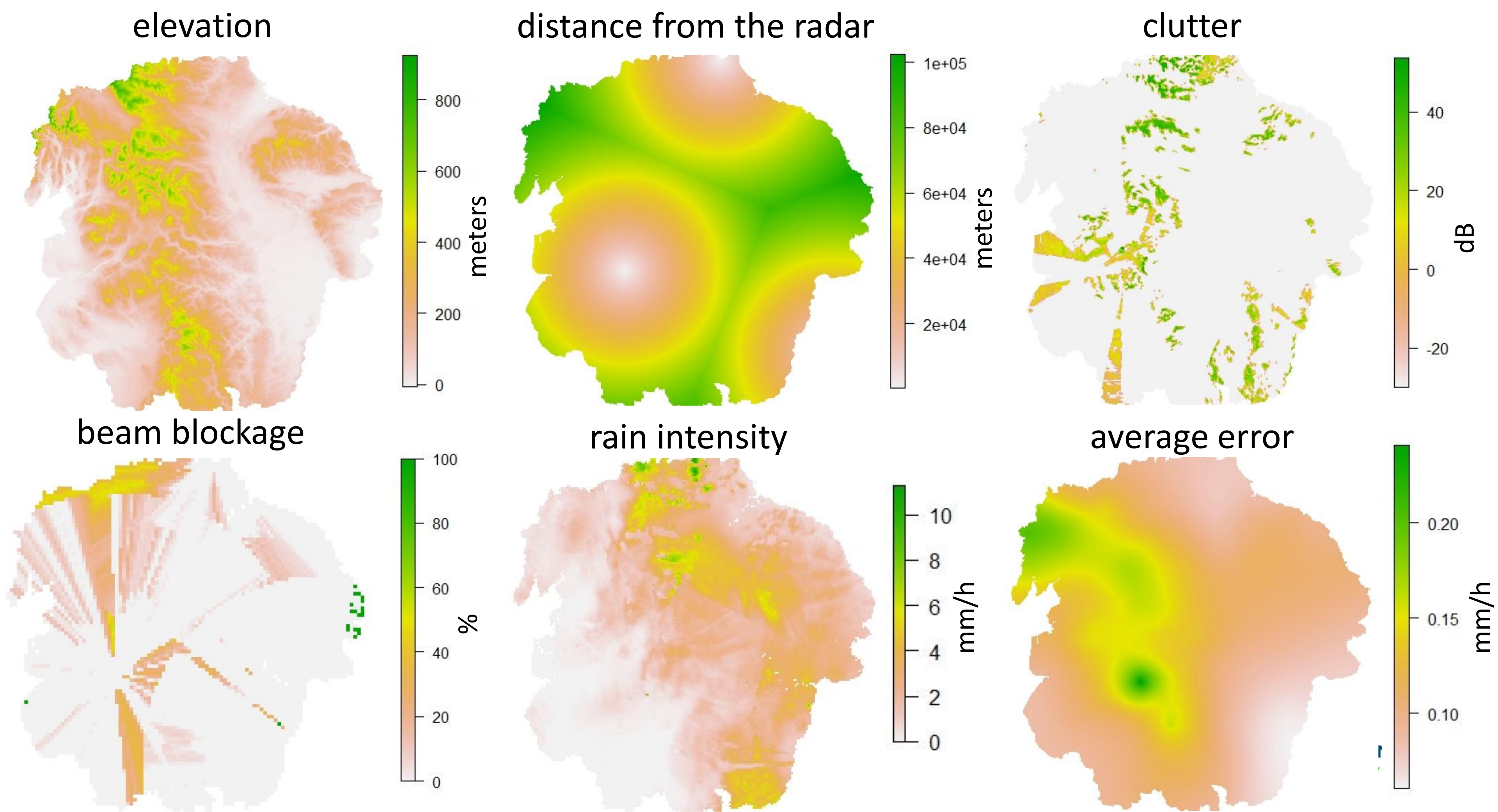


Event	Start	End	Duration (h)	Mean (mm/h)	Max (mm/h)	Max Acc. (mm)	Type
1	06/01/2016 23:00	07/01/2016 17:00	19	2.2	8	31	**Frontal with orographic enhancement** (Desmond storm)
2	27/03/2016 23:00	29/03/2016 11:00	13	2.0	16	65	**Frontal**
3	07/06/2016 10:00	08/06/2016 00:00	15	1.5	50	46	**Highly convective (caused flash floods)**
4	29/07/2016 02:00	29/07/2016 22:00	21	0.5	30	41	**Frontal**
5	13/09/2016 12:00	13/09/2016 22:00	11	3.0	3	37	**Frontal with orographic enhancement**

UK Environment Office provided rain gauge data
UK Met Office provided radar data

KED with non-stationary variance

Standard deviation = linear function of covariates

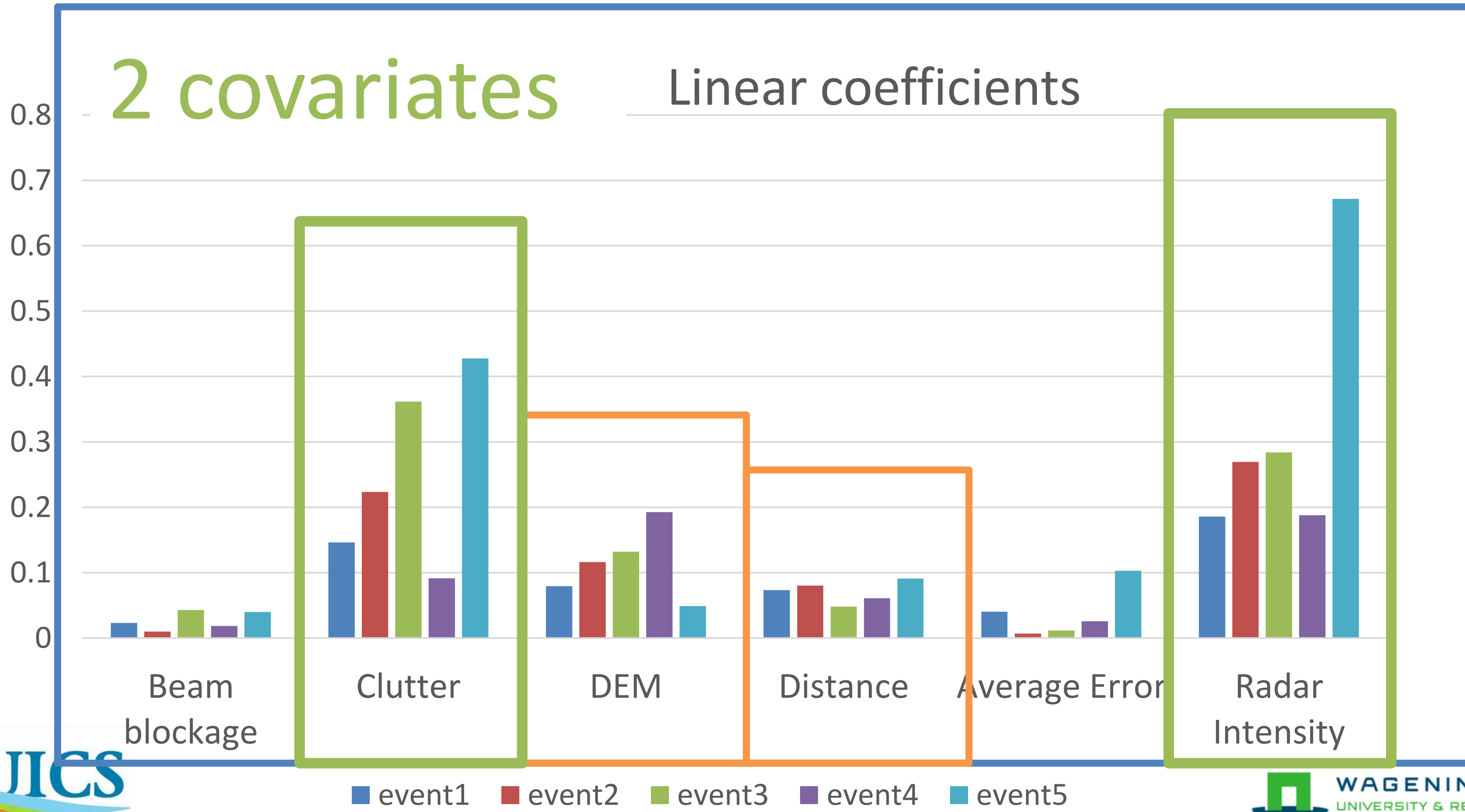


Maximum Likelihood

- Geo-statistical model (2 parameters)
- Mean = linear function of the radar (2 parameters)
- Standard deviation = linear function of the n covariates (n+1 parameters)

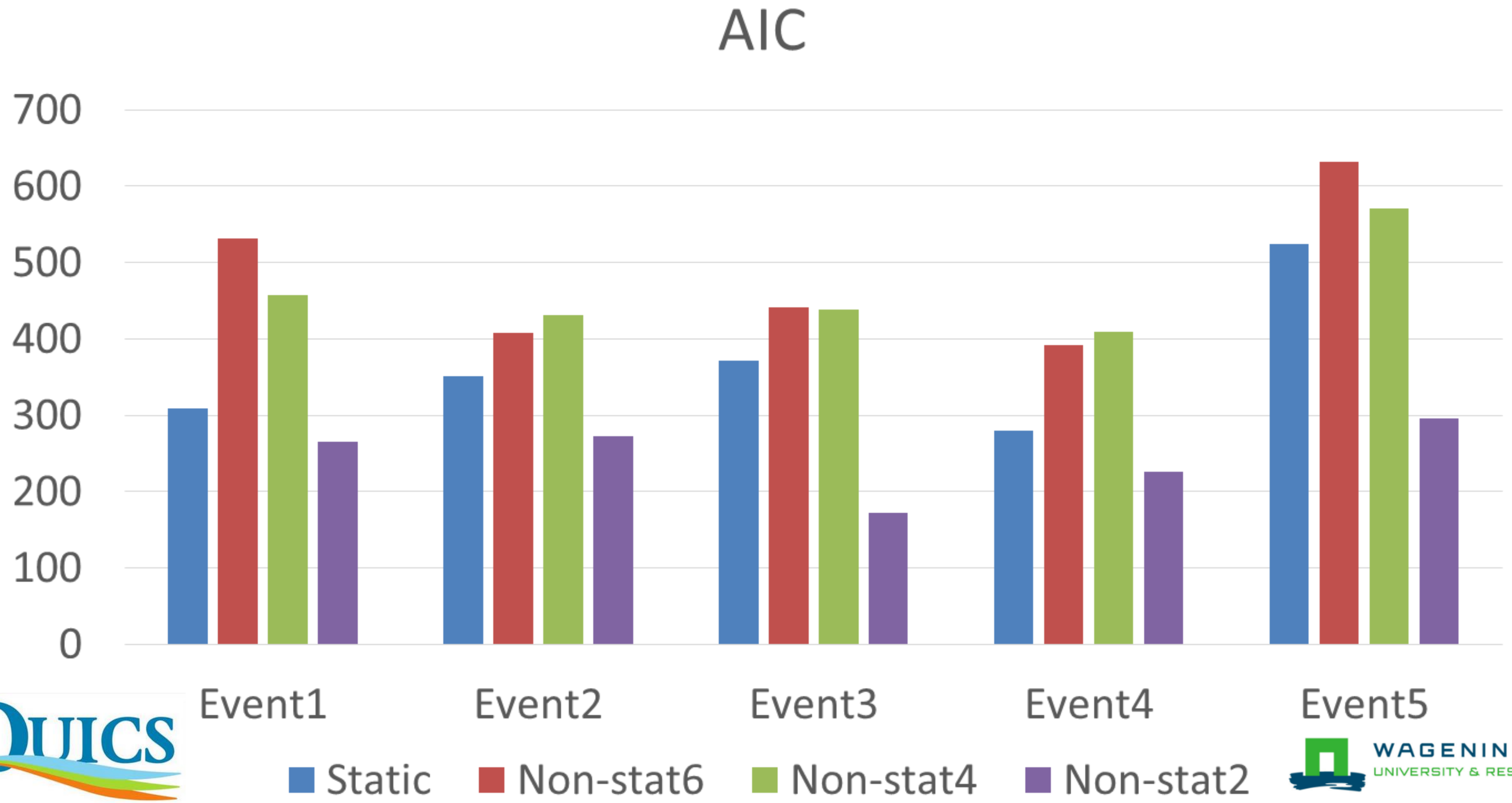
Selection of covariates

Improve estimation reducing parameters:
Which covariates are more important?

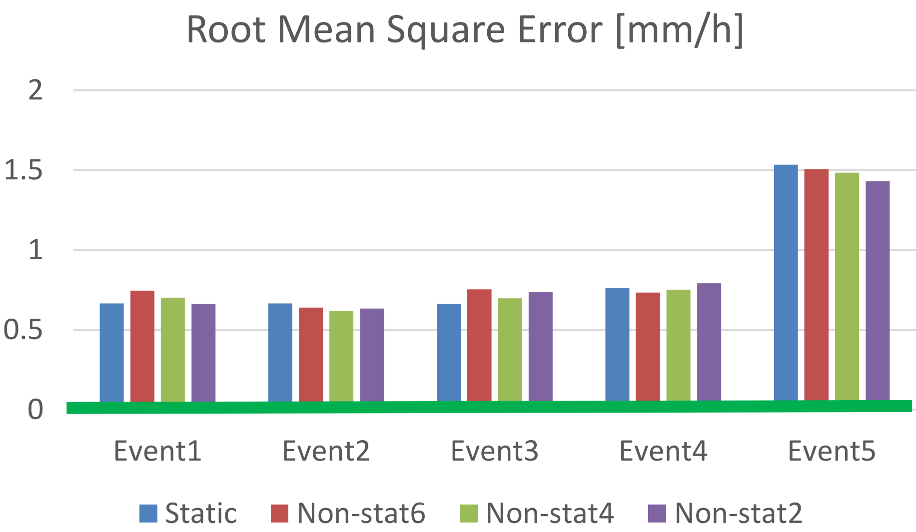


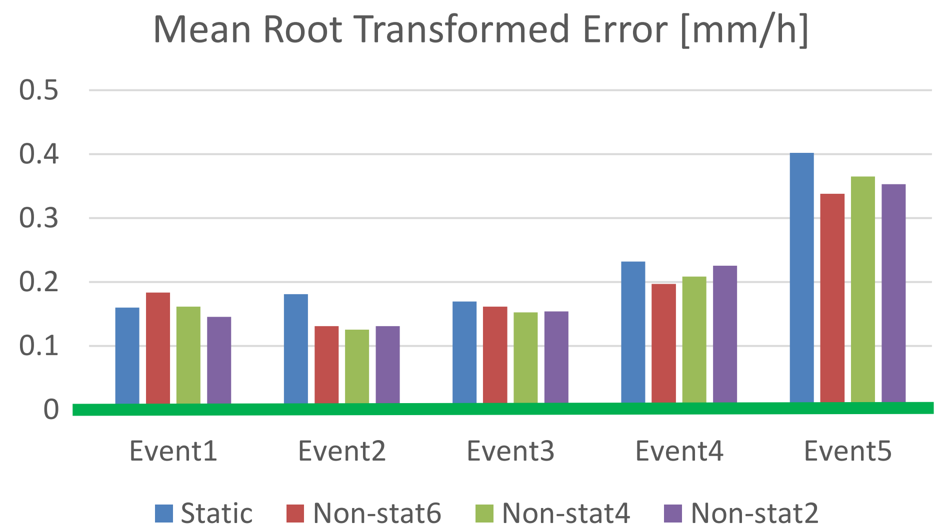
Results: estimation skills

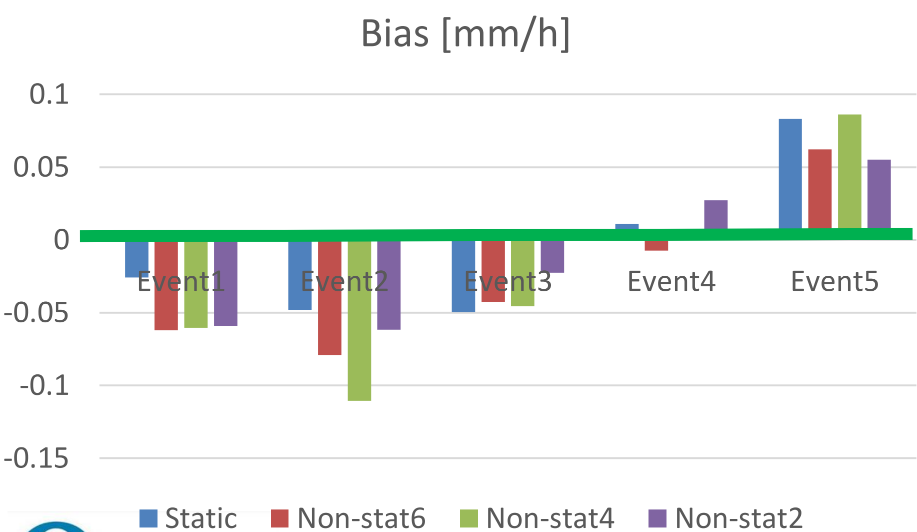
Akaike information criterion (AIC) = measure of relative quality of statistical models for a given set of data

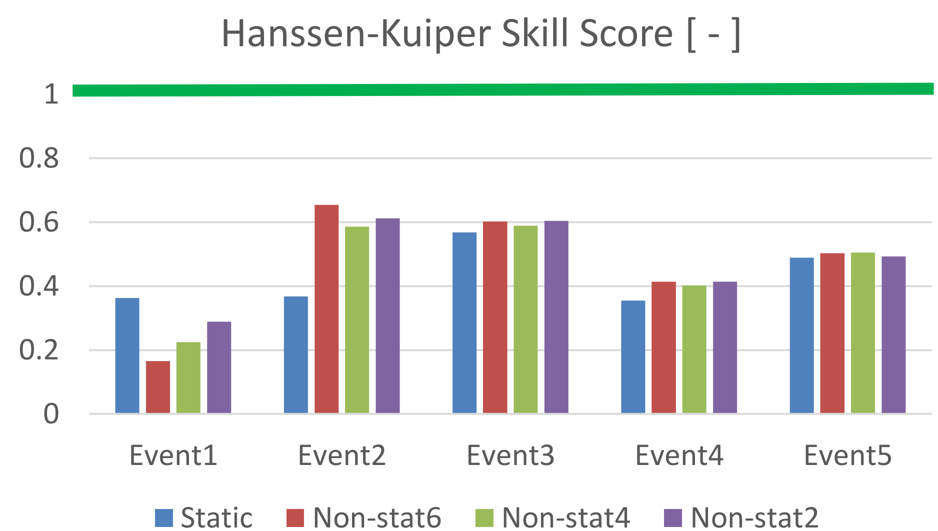


Results: deterministic validation







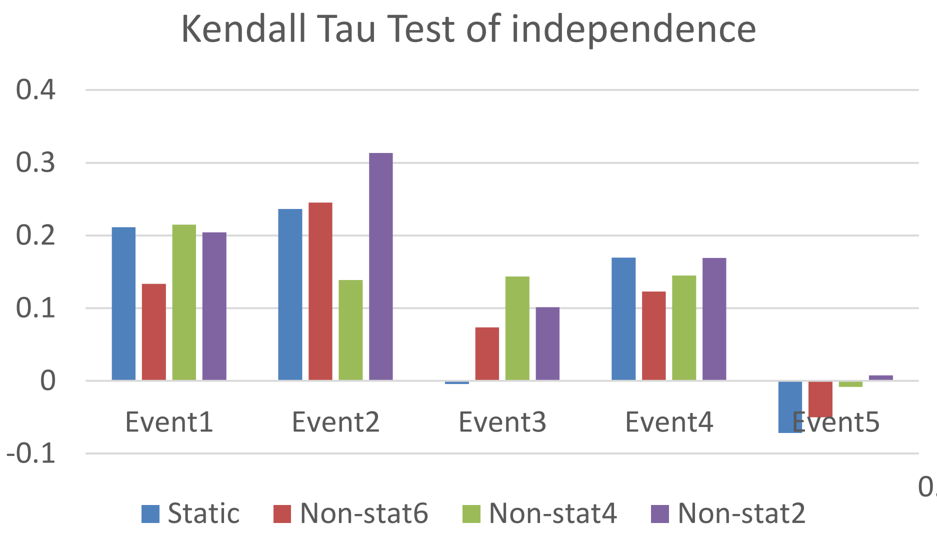


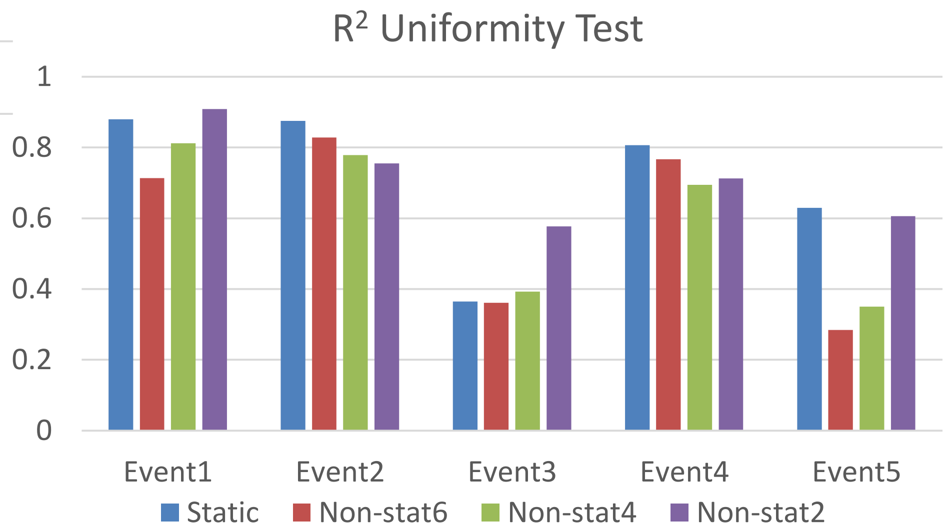
QUICS

WAGENINGEN UNIVERSITY & RESEARCH

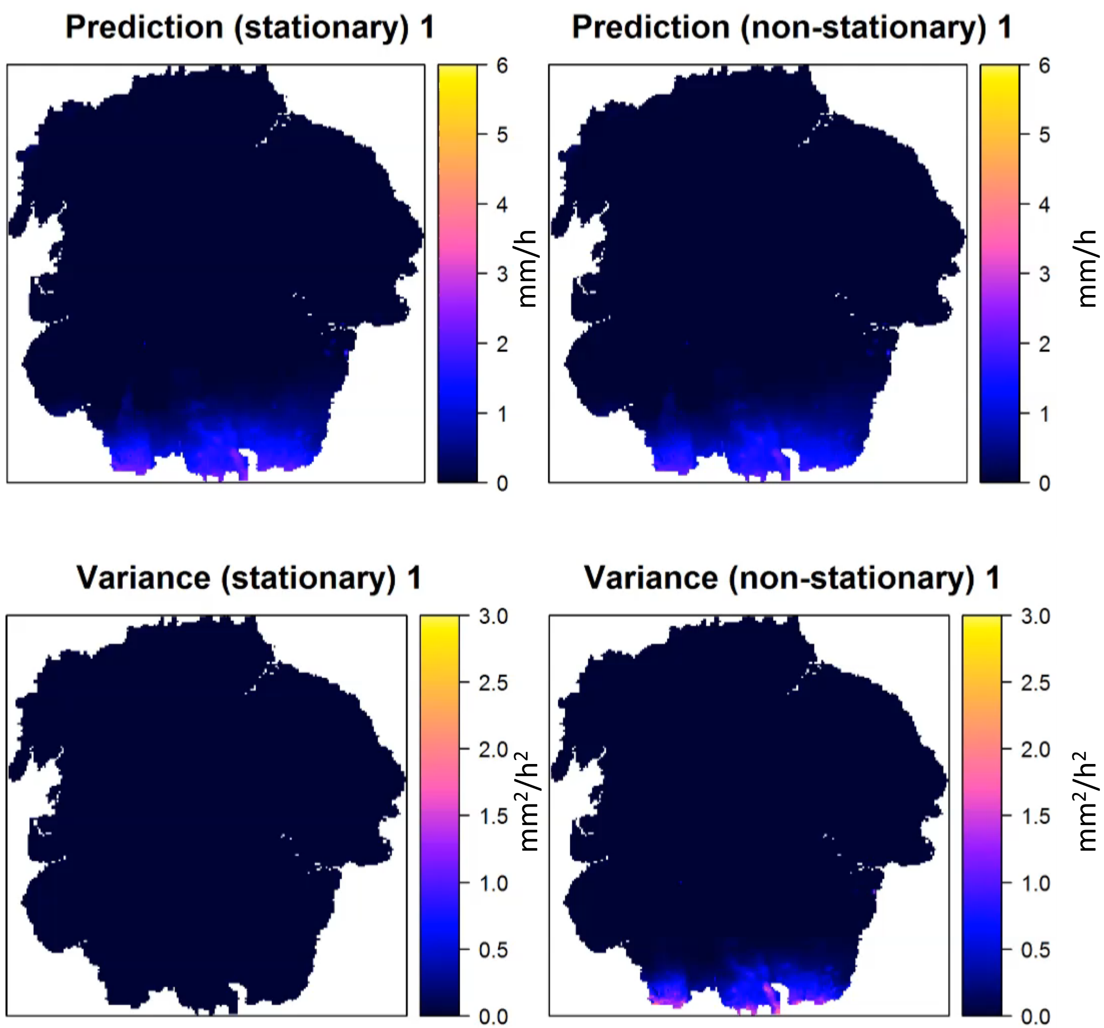
Results: probabilistic validation

The set of observation percentiles should be independent and uniformly distributes





Results



Prediction (stationary) 1
Prediction (non-stationary) 1
mm/h
0
1
2
3
4
5
6
Variance (stationary) 1
Variance (non-stationary) 1
mm²/h²
0.0
0.5
1.0
1.5
2.0
2.5
3.0

Conclusions

- The method shows potential, but needs some improvements
- Balance between more information and parameter identifiability
- More effective for convective events (event3)

Space for improvement

- Time variant covariates
- Time variant selection of relevant covariates
- Transformation of covariates to better suit a linear function
- Test other optimisation methods

Thank you!!!

francesca.cecinati@bristol.ac.uk

Acknowledgements:

This work was carried out in the framework of the Marie Skłodowska Curie Initial Training Network QUICS. The QUICS project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 607000. The authors would like to thank the UK Met Office and the Environment Agency, which provided the radar rainfall data and the rain gauge data to develop this study, and the British Atmospheric Data Centre for providing access to the datasets.

References:

Brus D.J., Heuvelink G.B.M. 2007. ***Optimization of sample patterns for universal kriging of environmental variables***. Geoderma 2007;138(1):86–95

Laio, F., Tamea, S., 2006. ***Verification tools for probabilistic forecasts of continuous hydrological variables*.** Hydrol. Earth Syst. Sci. Discuss. 3, 2145–2173.

Mazzetti, C., Todini, E., 2009. ***Combining Weather Radar and Raingauge Data for Hydrologic Applications, in: Flood Risk Management: Research and Practice***. Taylor & Francis Group, London.

Met Office, 2012. ***Met Office Integrated Data Archive System (MIDAS) Land and Marine Surface Stations Data (1853-current****)*. NCAS Br. Atmos. Data Cent.

Wadoux, A., Brus D.J., Rico-Ramirez M.A., Heuvelink G.B.M**., *Sampling design optimisation for rainfall prediction using a non-stationary geostatistical model*.** Under review. Advances in Water Resources