# rtop – an R package for interpolation along the stream network

J. O. Skøien (1), G. Laaha (2), D. Koffler (2), G. Blöschl (3), E. J. Pebesma (4), J. Parajka (3), and A. Viglione (3)

European Geosciences Union General Assembly 2013
Vienna | Austria | 07 – 12 April 2013

## Motivation

- Increased interest in geostatistical methods for variables which have a non-point support
- Examples:
  Regionalisation of runoff variables
  Health statistics
- Support can be spatial and/or temporal
- Methods includes integrals of variogram/covariance functions
- Several solutions to this problem, open source still missing

## Theory

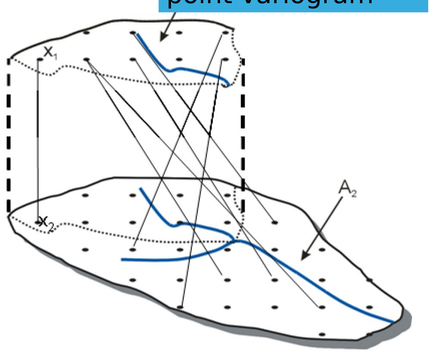
- Based on top-kriging method (Skøien et al, 2006)
- Variogram values between observations and between observations and prediction locations found by integrating a point variogram over a large number of points in each of the catchments:

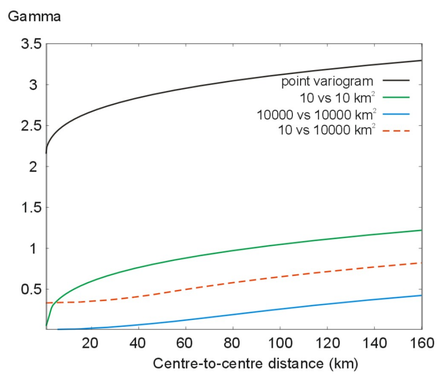
$$\gamma_{12} = 0.5 * Var(z(A_1) - z(A_2)) = \frac{1}{A_1 A_2} \int_{A_1} \int_{A_2} \gamma_p(|\mathbf{x}_1 - \mathbf{x}_2|) d\mathbf{x}_1 d\mathbf{x}_2 -$$

$$0.5 * \left[ \frac{1}{A_1^2} \int_{A_1} \int_{A_1} \gamma_p(|\mathbf{x}_1 - \mathbf{x}_2|) d\mathbf{x}_1 d\mathbf{x}_2 + \frac{1}{A_2^2} \int_{A_2} \int_{A_2} \gamma_p(|\mathbf{x}_1 - \mathbf{x}_2|) d\mathbf{x}_1 d\mathbf{x}_2 \right]$$

- Variogram as cloud variogram or 3-D binned variogram, with areas on the 2nd and 3rd axis
- Variogram model found by optimization – by fitting regularized variogram values to cloud or binned sample variogram
- Prediction method able to take measurement uncertainty into account
- Kriging equations otherwise as normal

Semivariance found by regularization of a point variogram




Point variogram and semivariograms for different catchment size classes

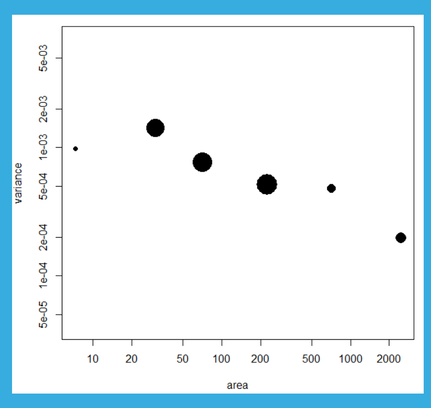
## Open source implementation

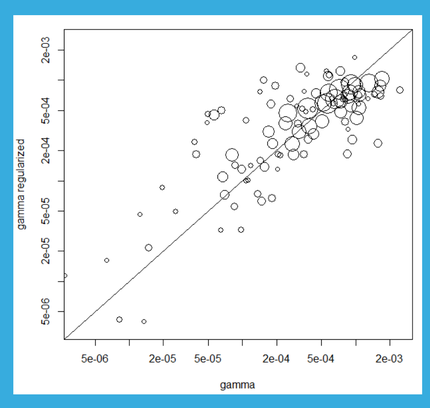
- Method implemented in statistical environment R (R Development Core Team, 2013) – easy distribution
- Using existing methods for spatial objects (Bivand et al., 2008) and for creating graphical output
- Package will soon be submitted to CRAN, currently available from R-forge.
- Installation from R-forge:
  > install.packages("rtop", repos="http://R-Forge.R-project.org")

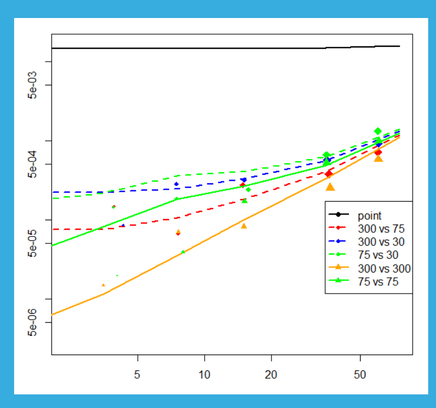
## Usage

```
> library(rtop)
> # <read data> help functions exist
> rtopObj = createRtopObj(observations,
  predictionLocations, params)
> rtopObj = rtopFitVariogram(rtopObj)
> rtopObj = rtopKrige(rtopObj)
> rtopObj = checkVario(rtopObj, cloud =
  TRUE, identify = TRUE, acor =
  0.000001)
```

## Diagnostic output from variogram fitting



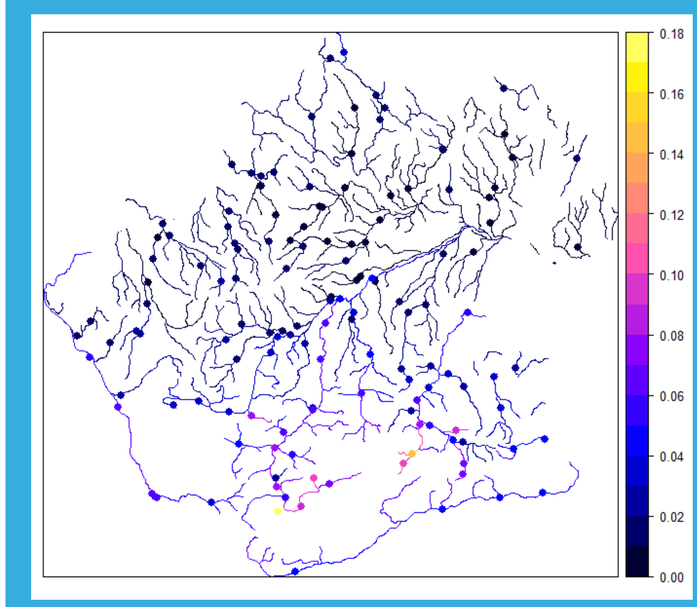




| Area – variance relationship | Scatter plot sample variogram – fitted variogram values | Sample variogram (dots) and fitted variogram values as function of distance for different combinations of catchment areas |
|---|---|---|

## Kriging results

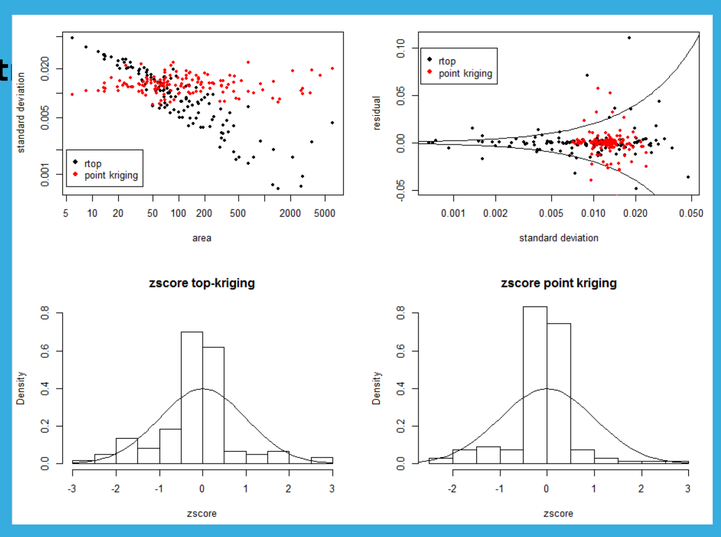
- **Example: summer flow from Upper Aust**
- **Compared with point kriging**

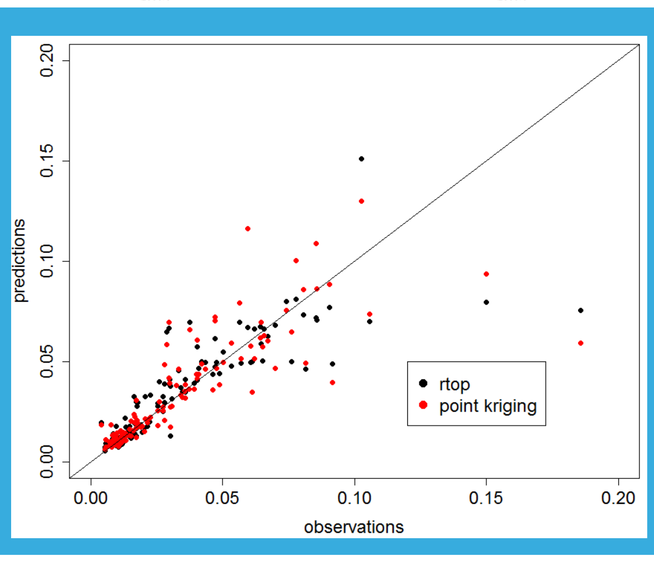



**Above: predictions of specific runoff, observations as dots.**

**Top right: different summary statistics of cross-validation**

**Right: scatter plot of predictions and observations from rtop and point kriging**




## Comparisons

- The method show good results in comparison with other regionalization methods in different studies (published and unpublished):

Archfield, S. A., A. Pugliese, A. Castellarin, J. O. Skøien, and J. E. Kiang, *Topological and canonical kriging for design-flood prediction in ungauged catchments: an improvement over a traditional regional regression approach?* Hydrol. Earth Syst. Sci. Discuss., 9, 12193-12226, 2012

Castiglioni, S., A. Castellarin, A. Montanari, J.O. Skøien, G. Laaha, and G. Blöschl, *Smooth regional estimation of low-flow indices: Physiographical space based interpolation and top-kriging.* Hydrology and earth system sciences, 2011. **15**(3): p. 715-727.

Vormoor, K., T. Skaugen, E. Langsholt, B. Diekkrüger, and J.O. Skøien, *Geostatistical regionalization of daily runoff forecasts in Norway.* International Journal of River Basin Management, 2011. **9**(1): p. 3-15.

Skøien, J.O. and G. Blöschl, *Spatio-temporal Top-kriging of runoff time series.* Water Resources Research, 2007. **43**: p. W09419.

Skøien, J.O., R. Merz, and G. Blöschl, *Top-kriging - geostatistics on stream networks.* Hydrology and Earth System Sciences, 2006. **10**: p. 277-287.

## Conclusions

- In this case – Cross-validation only marginally better than point kriging – depends on distribution of observation locations
- Much more reliable variance predictions
- Takes area properly into account
- Implementation in R makes installation and use extremely simple

European Union, 2012

www.jrc.ec.europa.eu

**Acknowledgements**
This work has been funded by the European Commission by DG INFSO, through the projects UncertWeb and INTAMAP, and from The Austrian Academy of Sciences, project HÖ 18. The views expressed herein are those of the authors and are not necessarily those of the funders.

Contact Jon Olav Skøien
European Commission • Joint Research Centre
Institute for Environment and Sustainability
Tel. +39 (0332) 789206 • Email: jon.skoien@jrc.ec.europa.eu

*Joint Research Centre*