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Radar-gauge combination by ordinary and external drift kriging

A systematic application for hourly QPE in Switzerland

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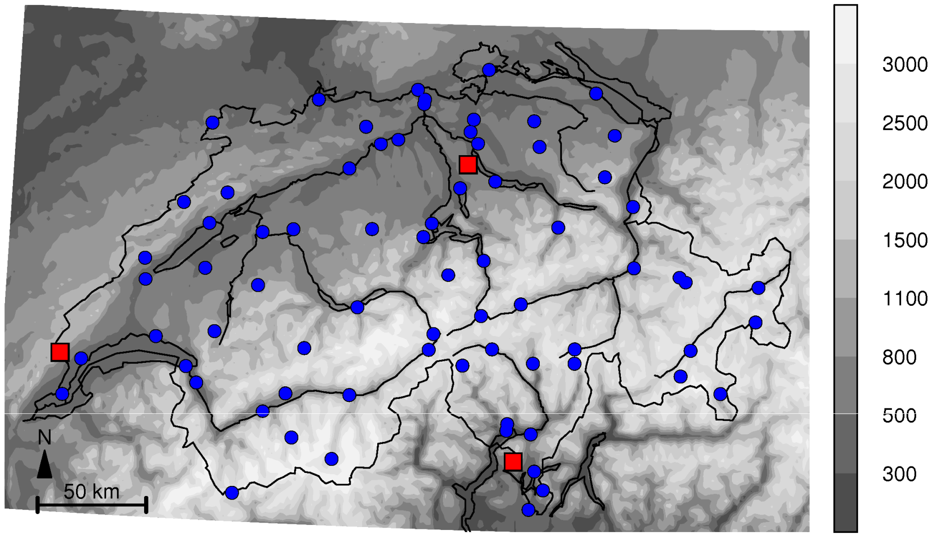
Objective



Radar: Composite from 3 C-Band radars, advanced processing (Germann et al. 2006)

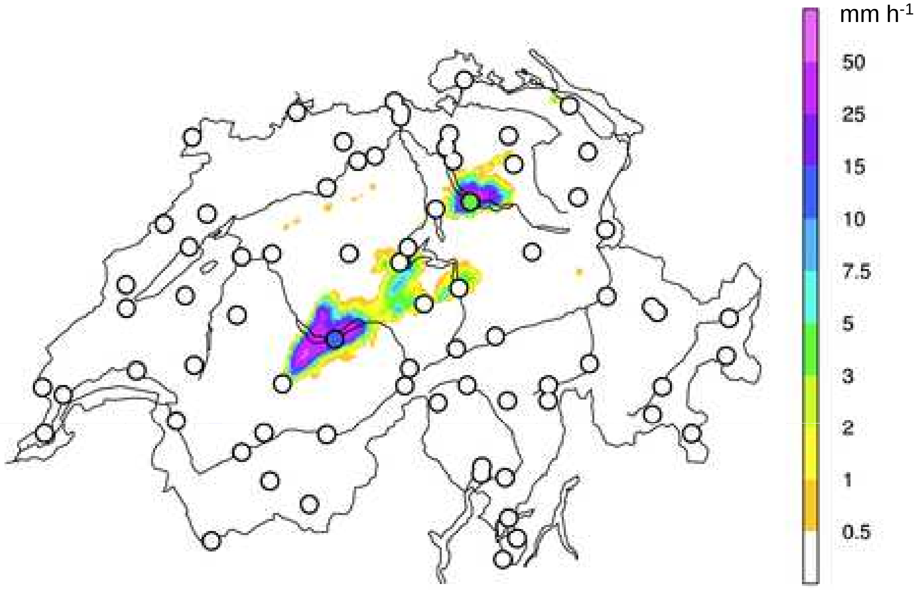
Gauges: 75 Stations, automatic and manual QC (MeteoSwiss 2010)

- Towards operational radar-gauge combination for Switzerland, **hourly** and **real-time**.
- Potential and limitations of two established geostatistical techniques

  Ordinary kriging of radar errors

  Kriging with external drift
- Systematic evaluation for one year

Challenges



- Complex topography limits spatial representativity of gauges, radar visibility, ...
- Sparse wet gauge samples cause problems for estimation.
- Data characteristics are in conflict with theoretical assumptions in geostatistics. (hourly!)
- Role of technical detail
  - Robust estimation procedures
  - Fall-back strategy for difficult conditions
  - Data transformation

Combination Concepts

$$Precip(\mathbf{x}) = \underbrace{\alpha + \beta \cdot Radar(\mathbf{x})}_{\text{trend, deterministic part}} + \underbrace{Z(\mathbf{x})}_{\text{stochastic component}}$$

OKRE

- Special case with β=1
- Model for gauge/radar differences
- Simple, radar recieves sustained emphasis.

KED

- β estimated each hour
- Radar integrated through linear trend model
- More flexible (additive and multiplicative correction)

e.g. Haberlandt 2007, Schuurmans et al. 2007, Goudenhoofdt and Delobbe 2009

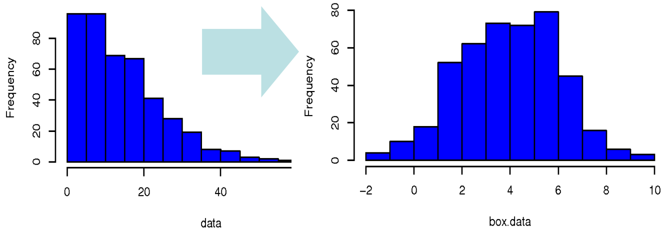
Implementation Detail

- Data transformation

  Box-Cox transformation

  Gauges and Radar

  - **Constant:** sqrt (λ=0.5)
  - **Case dependent:** MLE of λ [0.2, 1.5]



Trans-Gaussian Kriging
Cressie 1993, Schabenberger and Gotway 2005

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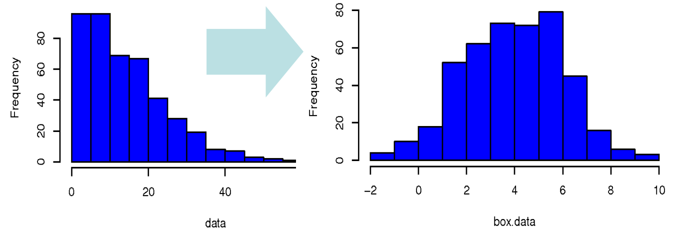
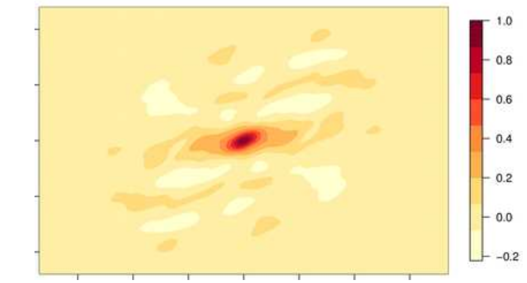


Trans-Gaussian Kriging
Cressie 1993, Schabenberger and Gotway 2005

- Spatial autocorrelation (stochastic part)

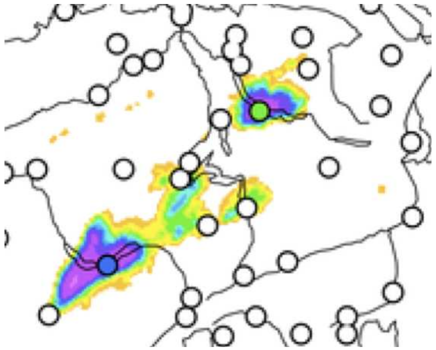
  - **Parametric** variogram:
    exponential, isotropic with nugget.
  - **Non-parametric** correlation map:
    estimated from radar field, non-isotropic,
    similar to Velasco-Forrero et al. 2009
    recursive estimation (Schiemann et al. 2010)



Schiemann et al. 2010

Implementation Detail (cont.)

- Fall-back strategy
  - all hours with < 10 wet gauges
  - prescribed variogram shape (climatological)
  - only 2 (3) parameters to estimate

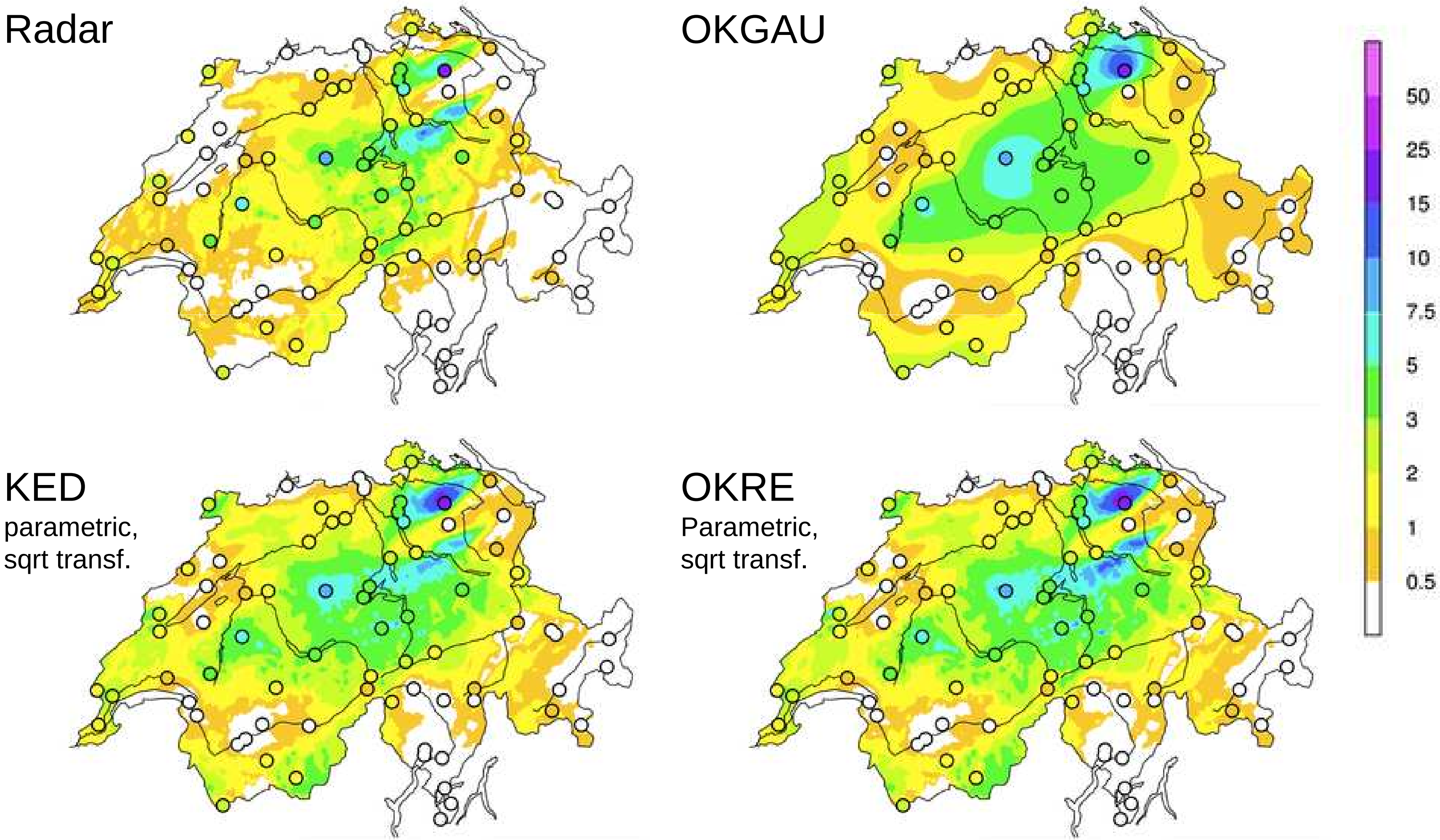


- Parameter estimation (parametric case)
  - Restricted Maximum Likelihood (probabilistic concept)
  - Trend and variogram parameters in one step
  - Fully data driven, no empirical variogram (binning, max range)
  - High robustness

Schabenberger and Gotway 2005, Diggle & Ribeiro 2007

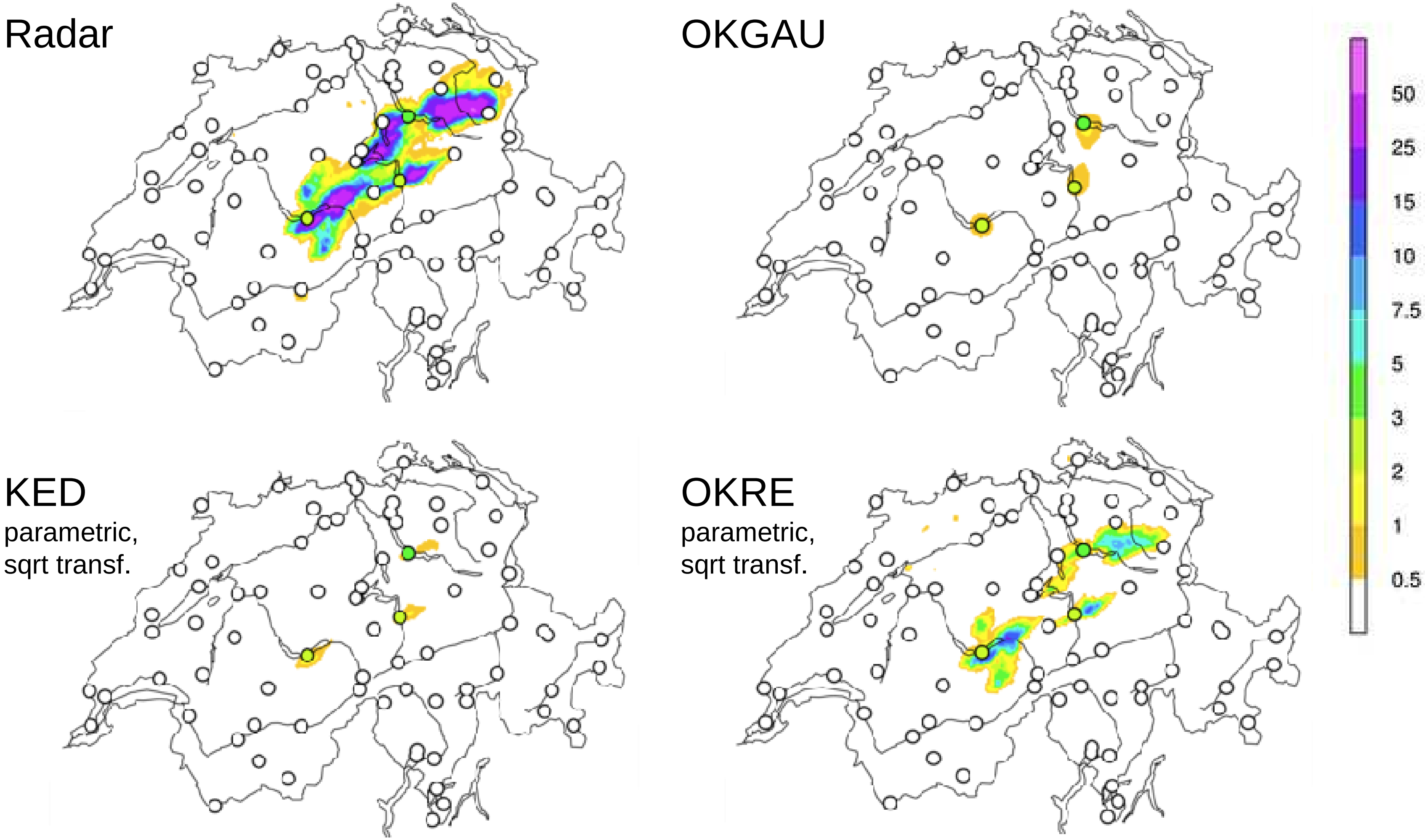
Example: Large-scale Event

2005.08.21, 16:00-17:00



Example: Convective Event

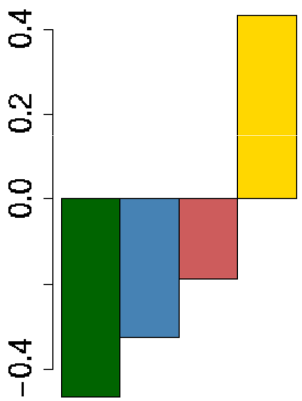
2008.06.25, 15:00-16:00



Systematic Evaluation

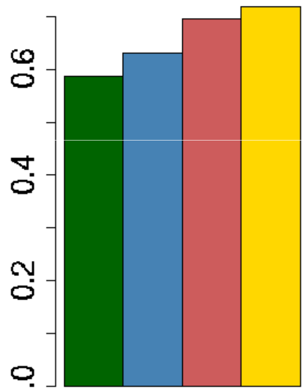
systematic error	dry-wet distinction	intense precipitation

BIAS [dB]



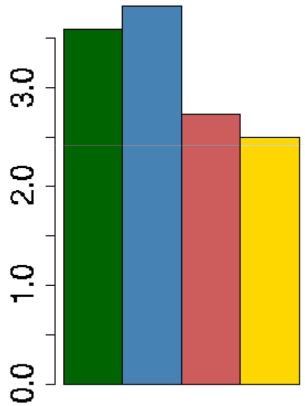
predicted/measured
total water amount [dB]

HK



Hanssen-Kuiper Discr.
with threshold 0.5 mm

MAD >5mm



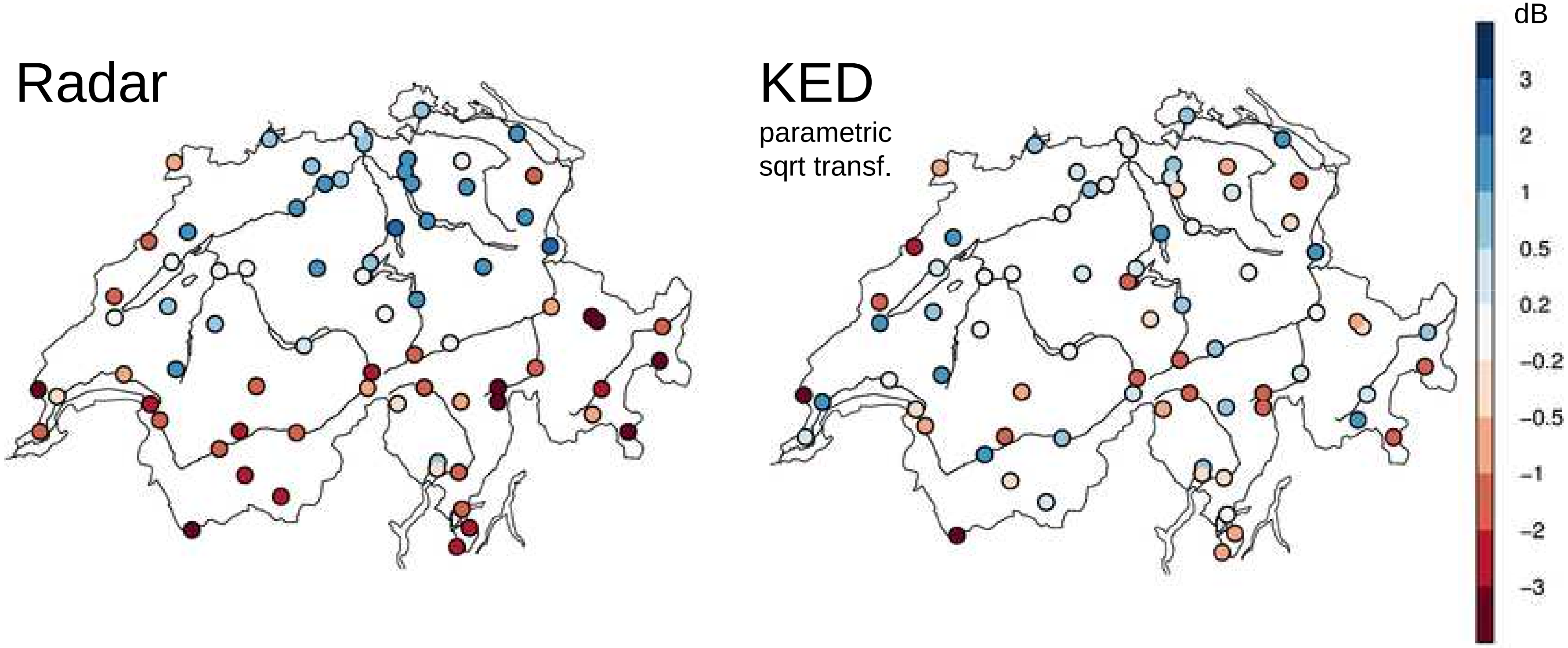
mean absolute
difference for > 5 mm

2008, 4774 wet hours

RADAR
OKGAU.p.sr
KED.p.sr
OKRE.p.sr

parametric, sqrt transf

Distribution of BIAS



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Systematic Evaluation

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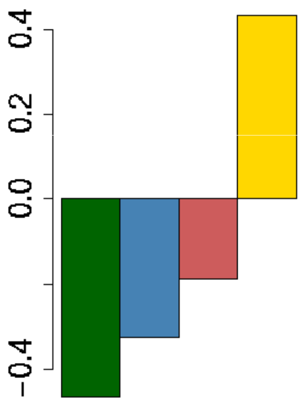
BIAS [dB]	HK	MAD5 [mm]

BIAS [dB]



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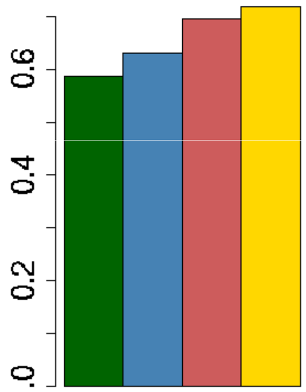

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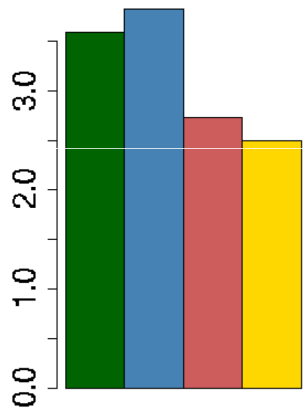

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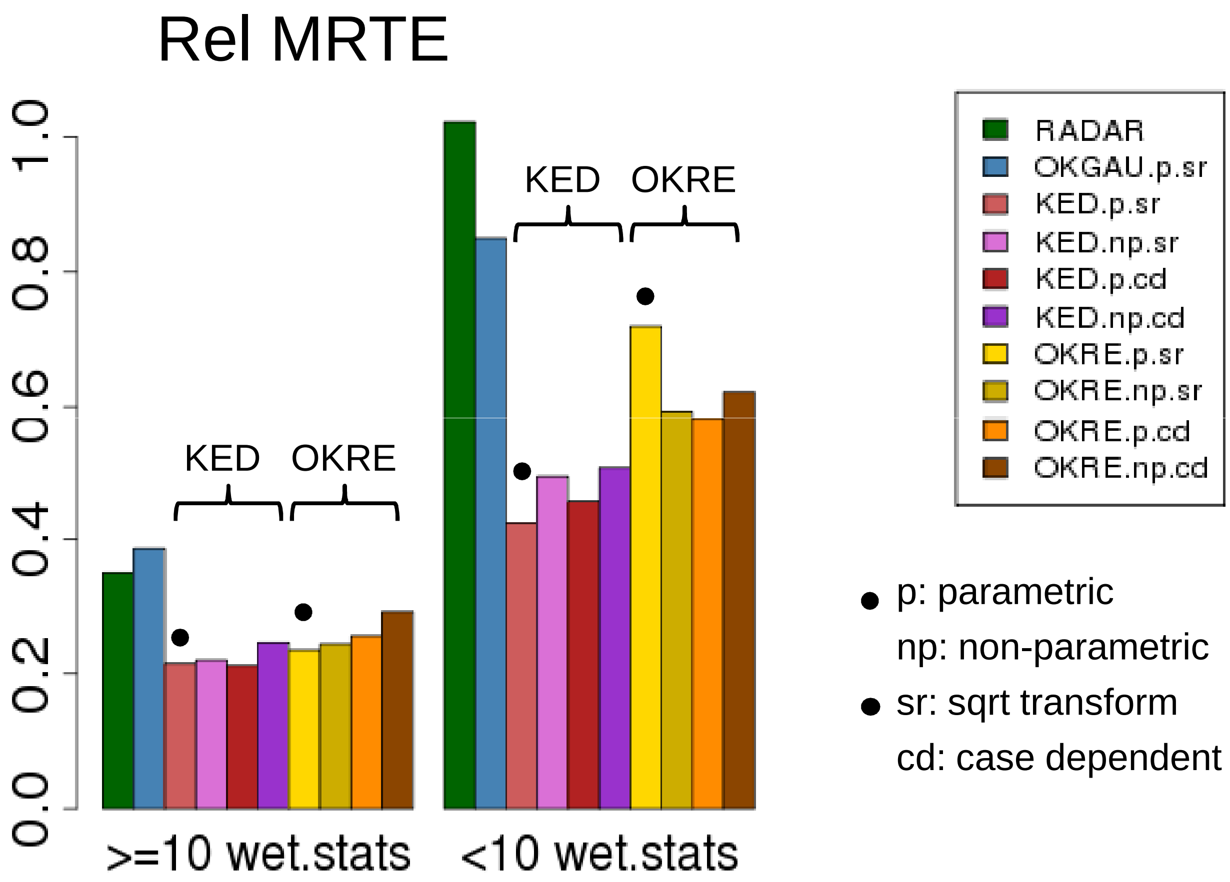
Mean Error

mean error



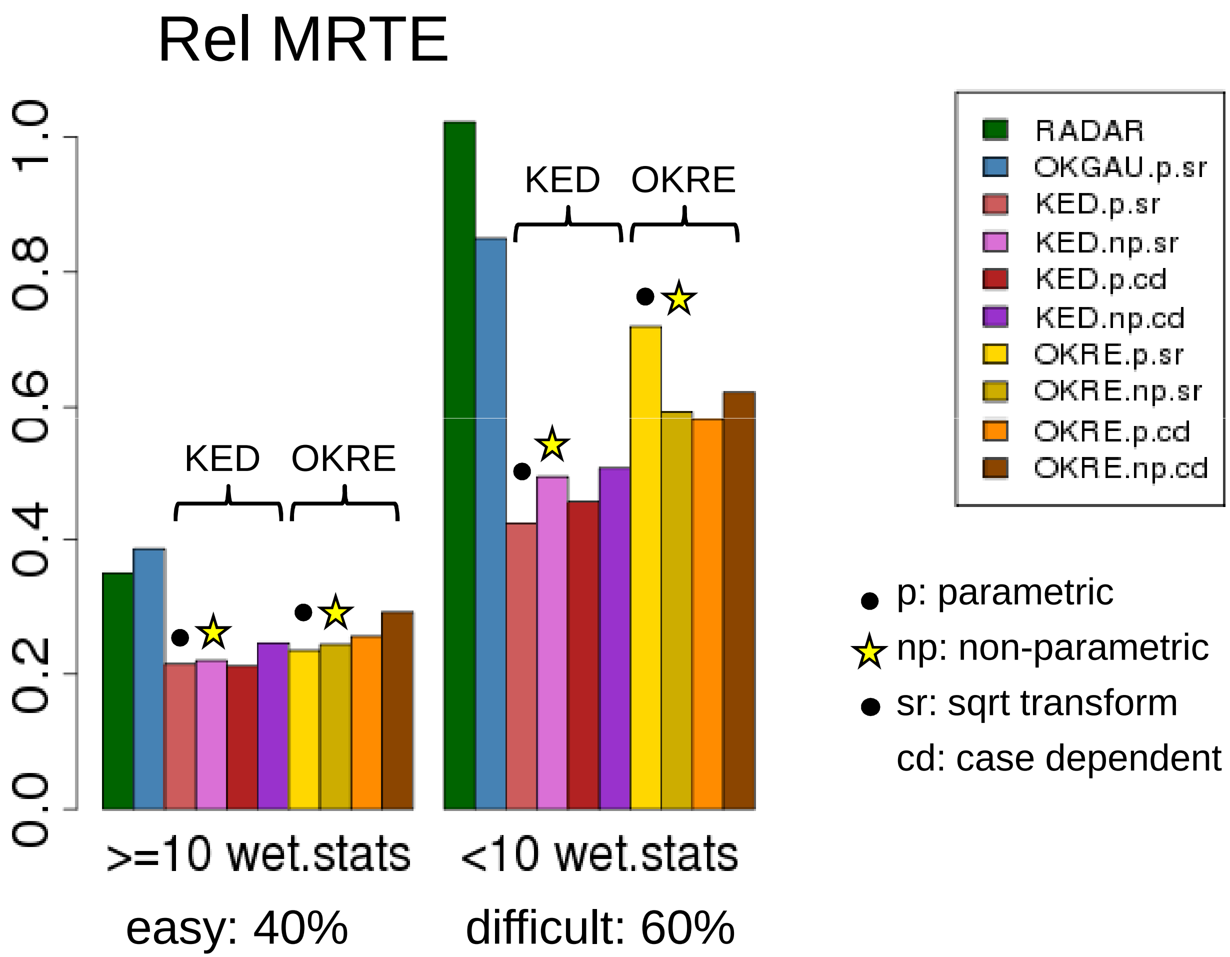
easy: 40% difficult: 60%

- p: parametric
  np: non-parametric
- sr: sqrt transform
  cd: case dependent transform

error RMS / observation variance (root transformed values)
Some sort of 1 - Nash-Sutcliffe

Mean Error

mean error



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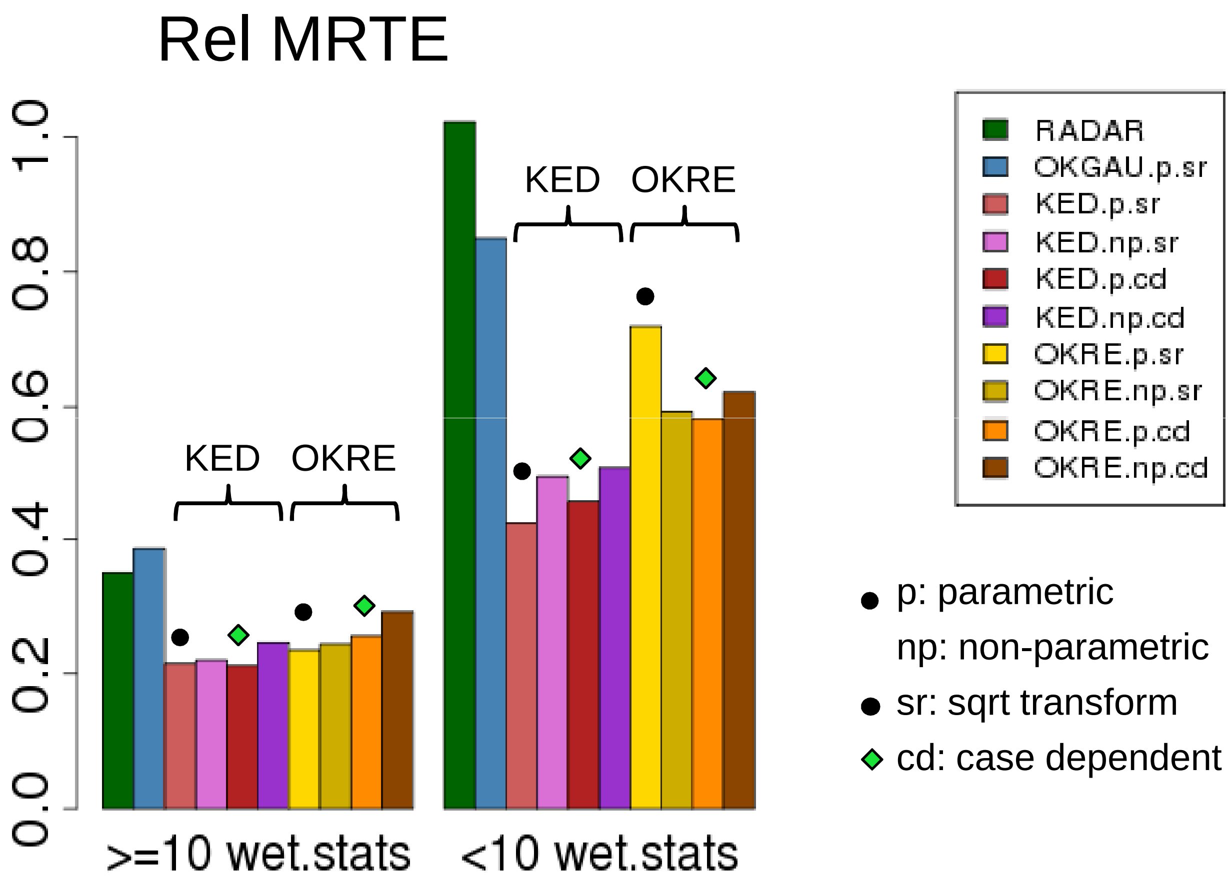

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Conclusions

- Conventional geostatistical merging improves hourly QPE in CH:
  - corrects radar errors, incorporates small-scale radar structures
  - also for hours with difficult sampling conditions
- Additional model flexibility of KED is advantages over OKRE particularly in difficult cases and for overall bias correction.
- Transformation is important for coping with model assumptions.
  - Fix transformation sufficient for best estimates
  - Flexible transformation necessary for uncertainty estimates.
- Non-parametric correlogram shows no clear improvement over parametric variogram, except for OKRE in difficult cases.
- Non-compliance of classical geostatistics with precipitation intermittence is a main limitation. Further work needed to extend classical merging concepts.

See also:

Presentation 3A.6 (this session):

Sideris et al.: Real-time spatiotemporal merging of radar and raingauge measurements in Switzerland.

Poster 20 QPE:

Keller et al.: A comparative evaluation of three geostatistical radar-rain gauge combination methods in Switzerland.

Publication in press at J. Hydrometeorol.:

Erdin et al.: Data transformation and uncertainty in geostatistical combination of radar and rain gauges. (available from authors)