Radar-gauge combination by ordinary and external drift kriging

A systematic application for hourly QPE in Switzerland

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Objective

- 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

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

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

\[ \text{Precip}(x) = \alpha + \beta \cdot \text{Radar}(x) + Z(x) \]

- trend, deterministic part
- stochastic component

**OKRE**
- Special case with $\beta=1$
- Model for gauge/radar differences
- Simple, radar receives sustained emphasis.

**KED**
- $\beta$ 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 Deobbe 2009
Implementation Detail

- Data transformation
  - Box-Cox transformation
  - Gauges and Radar
    - **Constant**: $\sqrt{\lambda}=0.5$
    - **Case dependent**: MLE of $\lambda [0.2, 1.5]$

Trans-Gaussian Kriging
Cressie 1993, Schabenberger and Gotway 2005

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**Implementation Detail**

- **Data transformation**
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  - **Constant**: $\sqrt{\lambda}=0.5$
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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)
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

Radar

OKGAU

KED
parametric, sqrt transf.

OKRE
Parametric, sqrt transf.
Example: Convective Event

2008.06.25, 15:00-16:00

Radar

OKGAU

KED
parametric, sqrt transf.

OKRE
parametric, sqrt transf.
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
- KED.p sr
- OKGAU.p sr
- OKRE.p sr

Parametric, sqrt transf
Distribution of BIAS

Radar

KED
parametric sqrt transf.

2008, 4774 wet hours

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Systematic Evaluation

- **BIAS [dB]**
  - Predicted/Measured total water amount [dB]
  - 2008, 4774 wet hours

- **HK**
  - Hanssen-Kuiper Discr. with threshold 0.5 mm

- **MAD5 [mm]**
  - Mean absolute difference for > 5 mm
  - Parametric, sqrt transf

**Systematic error**

**Dry-wet distinction**

**Intense precipitation**
Mean Error

Rel MRTE

KED OKRE

mean error

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

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

easy: 40%
difficult: 60%

>=10 wet.stats <10 wet.stats

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Mean Error

**Rel MRTE**

- **KED**
- **OKRE**

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mean error
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Error RMS / observation variance (root transformed values)

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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)