Comparing two different methods to describe radar precipitation uncertainty

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25 November 2015

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- Marie Curie Early Stage Researcher in QUICS ITN

Background:

- MEng in Environmental and Water Quality Engineering – MIT
- MSc in Environmental and Energy Engineering – Università di Genova
- BSc in Environmental Engineering Università di Genova

Weather Radars

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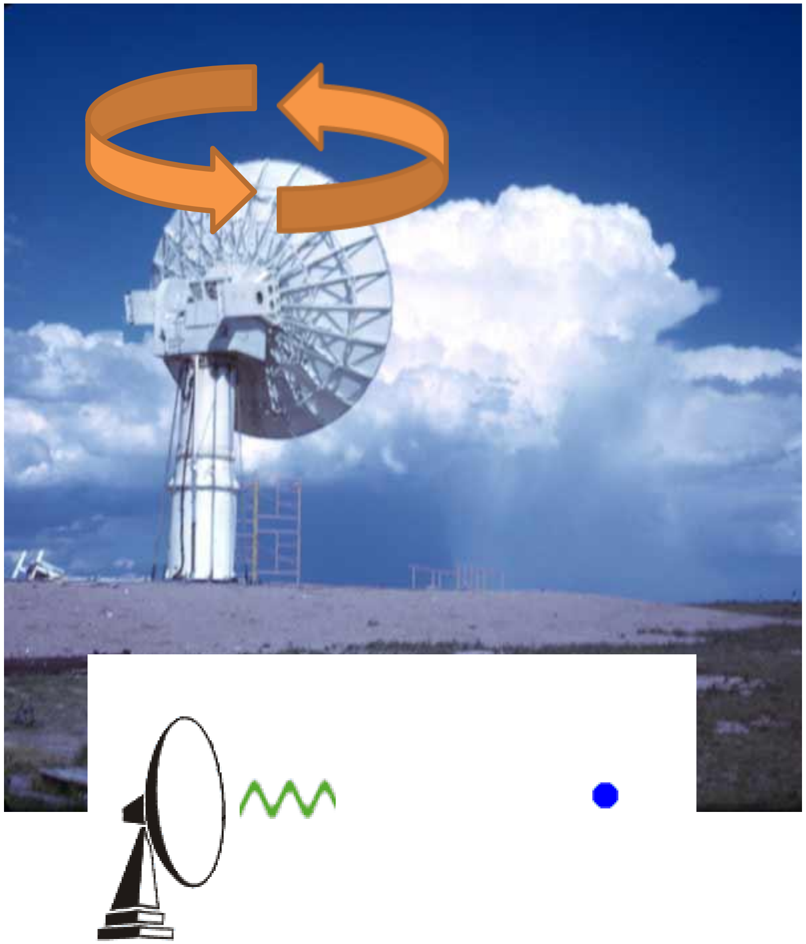

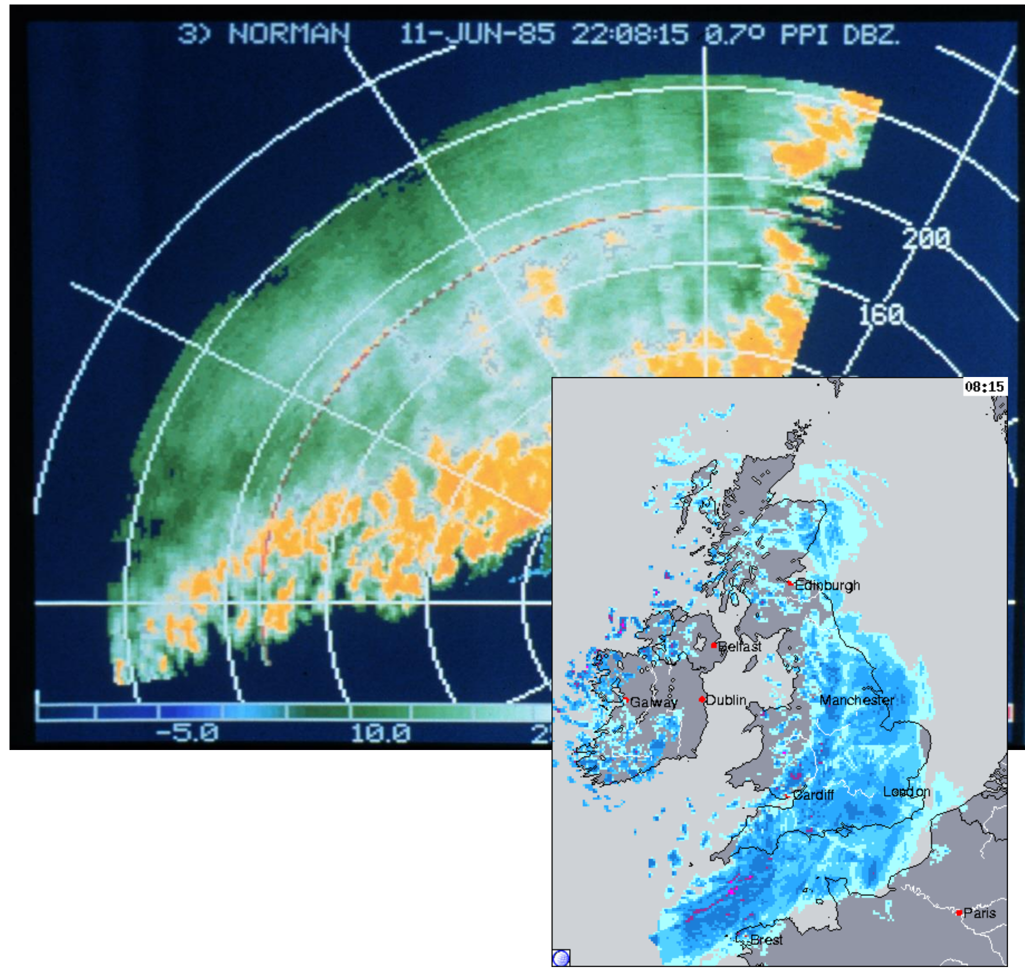

Radar Errors

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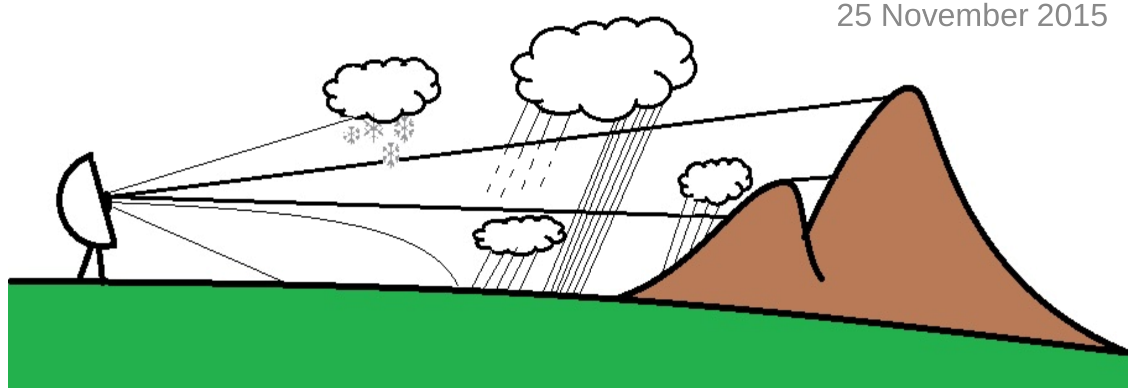
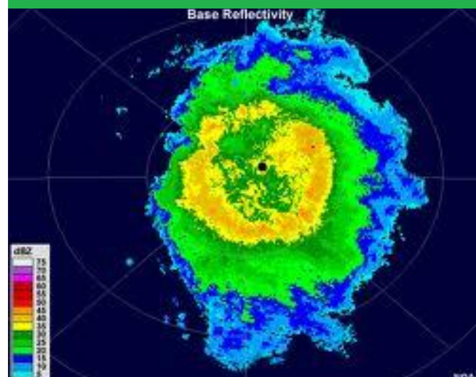
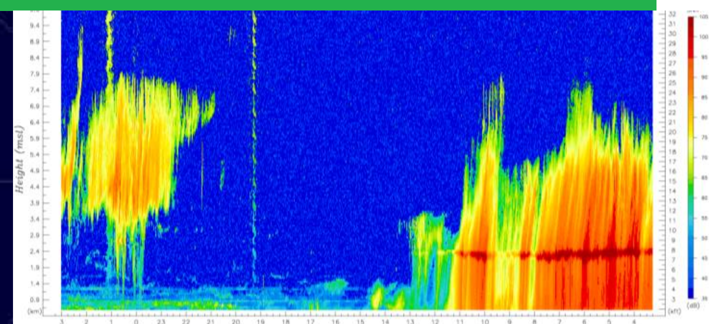
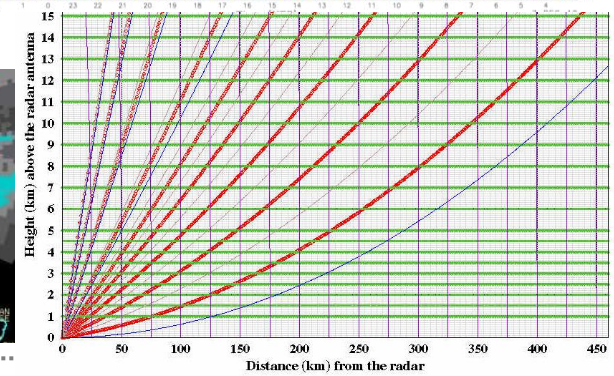
- Attenuation
- Shielding
- Partial beam blocking
- Ground clutter
- Beam overshooting
- Earth curvature
- Anomalous propagation
- Bright band
- Drizzle/snow/hail
- Evaporation
- Orographic lifting
- Conversion from backscattering to rainfall rates
- Sampling and averaging
- .....









Radar Error Estimation

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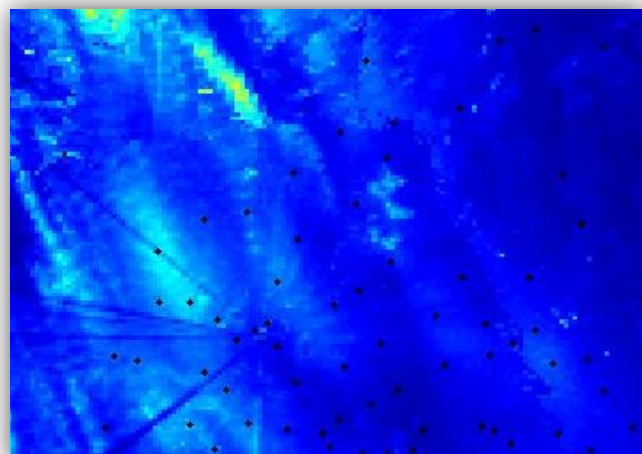
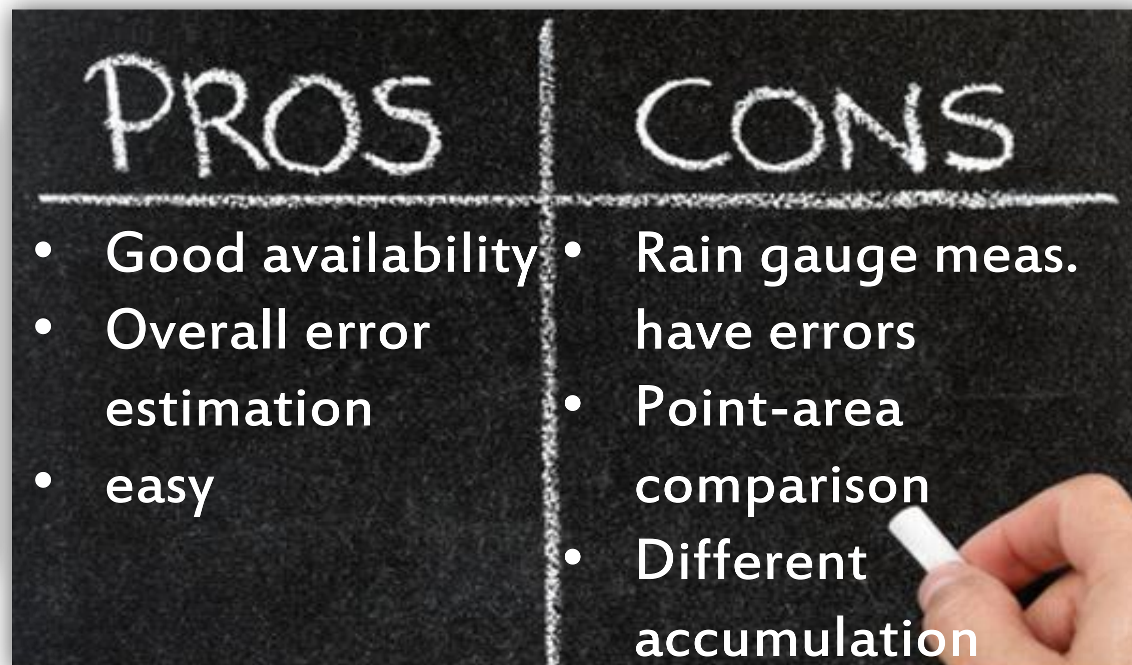
- How to estimate the errors?

1. Comparison with “true rainfall”
   - Best approximation: quality checked rain gauges

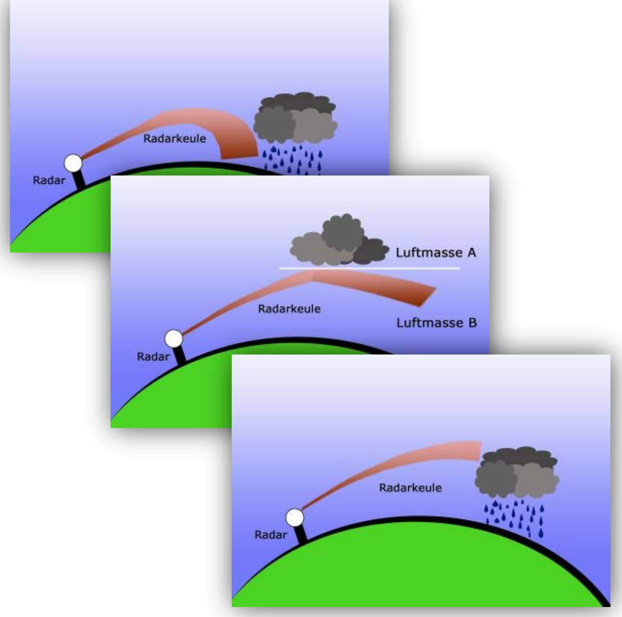




Radar Error Estimation

- How to estimate the errors?

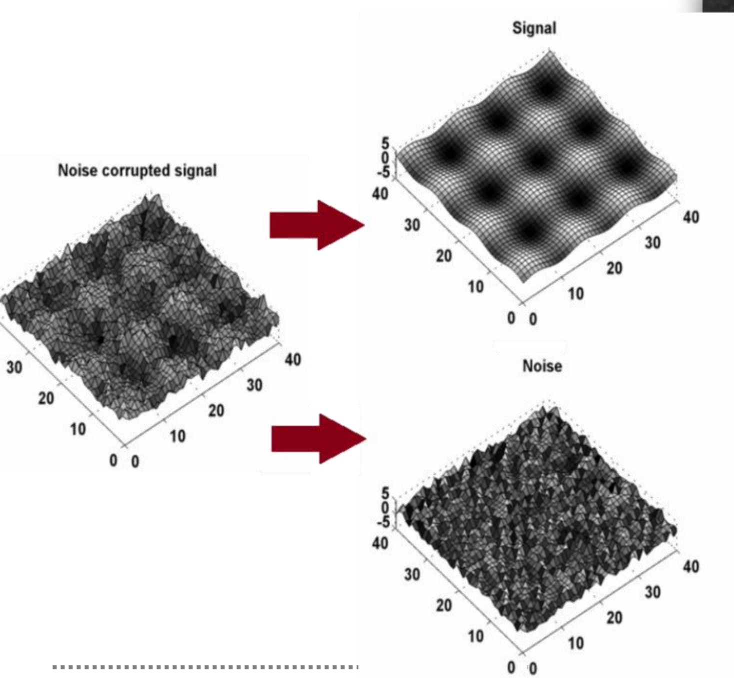
2. Error by error modelling
   - Physically model the error for every source

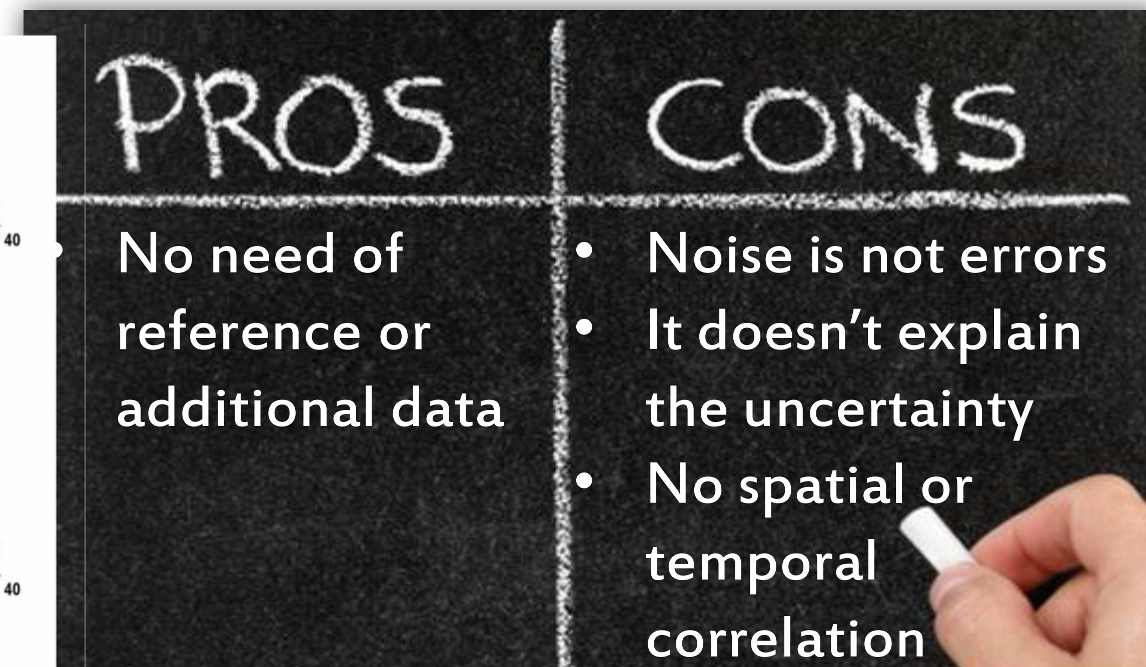


Radar Error Estimation

- How to estimate the ~~errors~~? X Noise

3. Noise separation
   - Determine which part of the radar acquisition is signal and which is noise





Error propagation

When we use rainfall data for hydrology we want

- *A quantification of the errors*
- *To know how they propagate in the models*

RADAR RAINFALL ENSEMBLES

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Radar Ensembles

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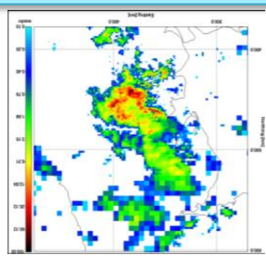
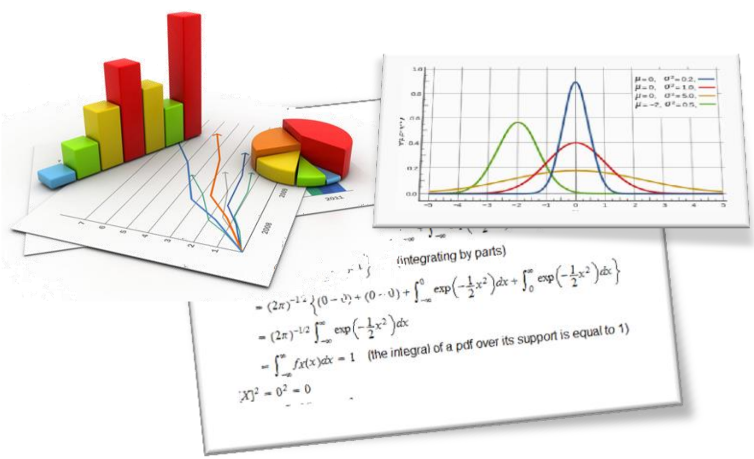
Observations

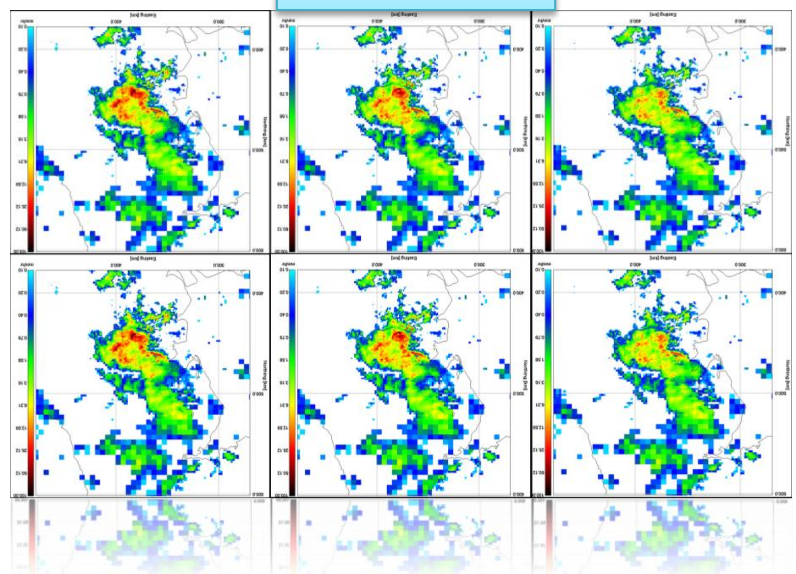


Error Statistics



"Different probable rainfall fields consistent with the observed radar rainfall maps and their error structure"
Villarini et al. 2009

Ensembles



Radar Ensembles

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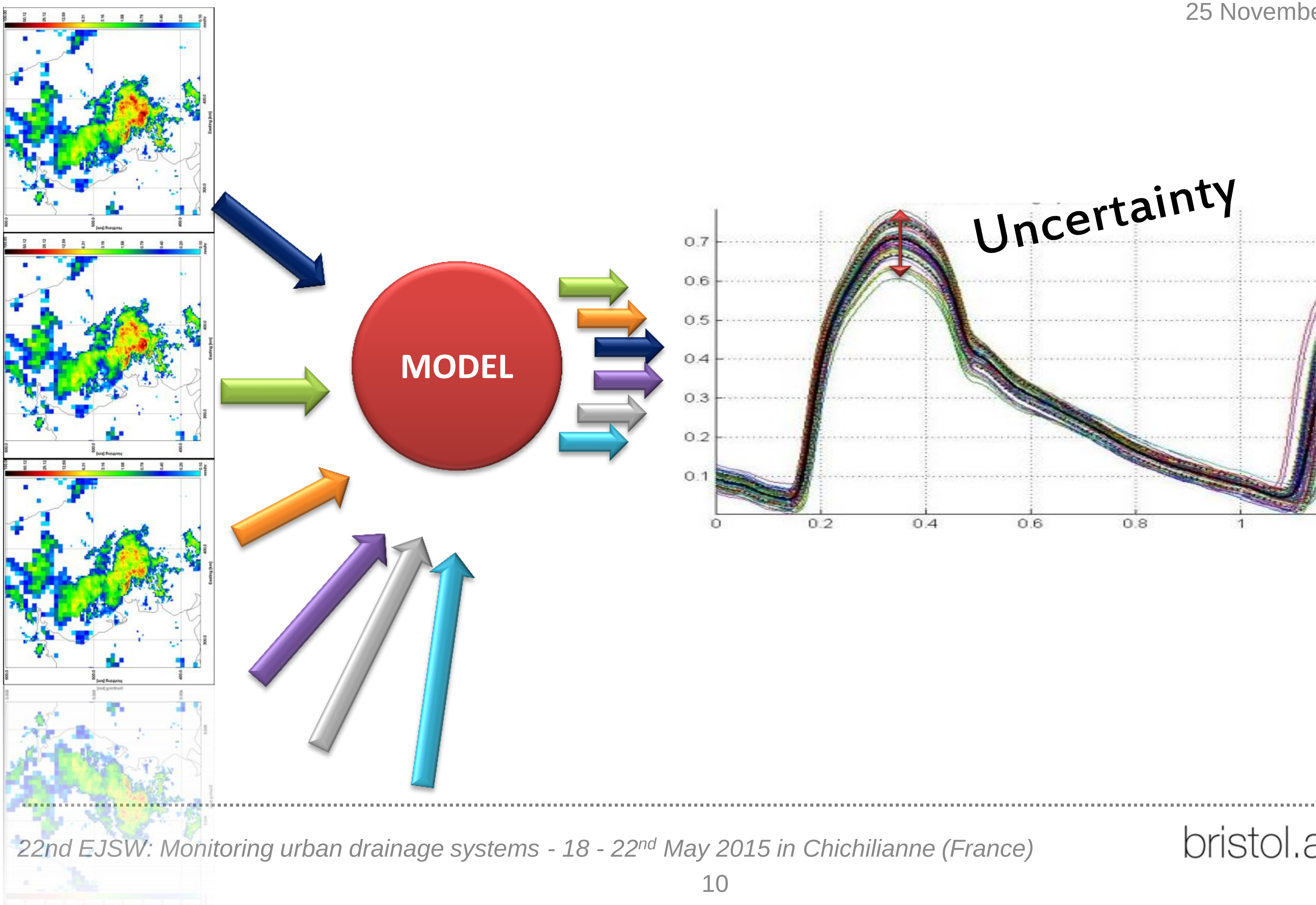
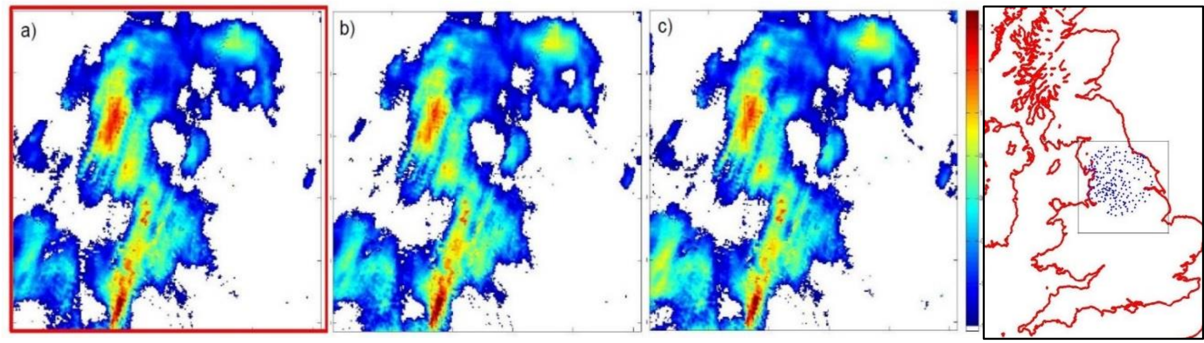


Covariance approach

- How to generate ensembles?

1. REAL method:

(Germann et al. 2009)



Errors

$$\epsilon = 10\,log(G) - 10\,log(R)$$

Covariance matrix of the errors

$$C_{kl} = Cov\{\epsilon_{x_k}, \epsilon_{x_l}\}$$

Random Gaussian vectors

$$y_{t,i} \sim N(0,1)$$

Covariance matrix decomposition

$$C = L \cdot L^T$$

Ensemble error components

$$\delta_{t,i} = \mu + L y_{t,i}$$

Original radar data

Ensembles

$$10\,log[\Phi_{t,i}] = 10\,log[R_{t,i}] + \delta_{t,i}$$

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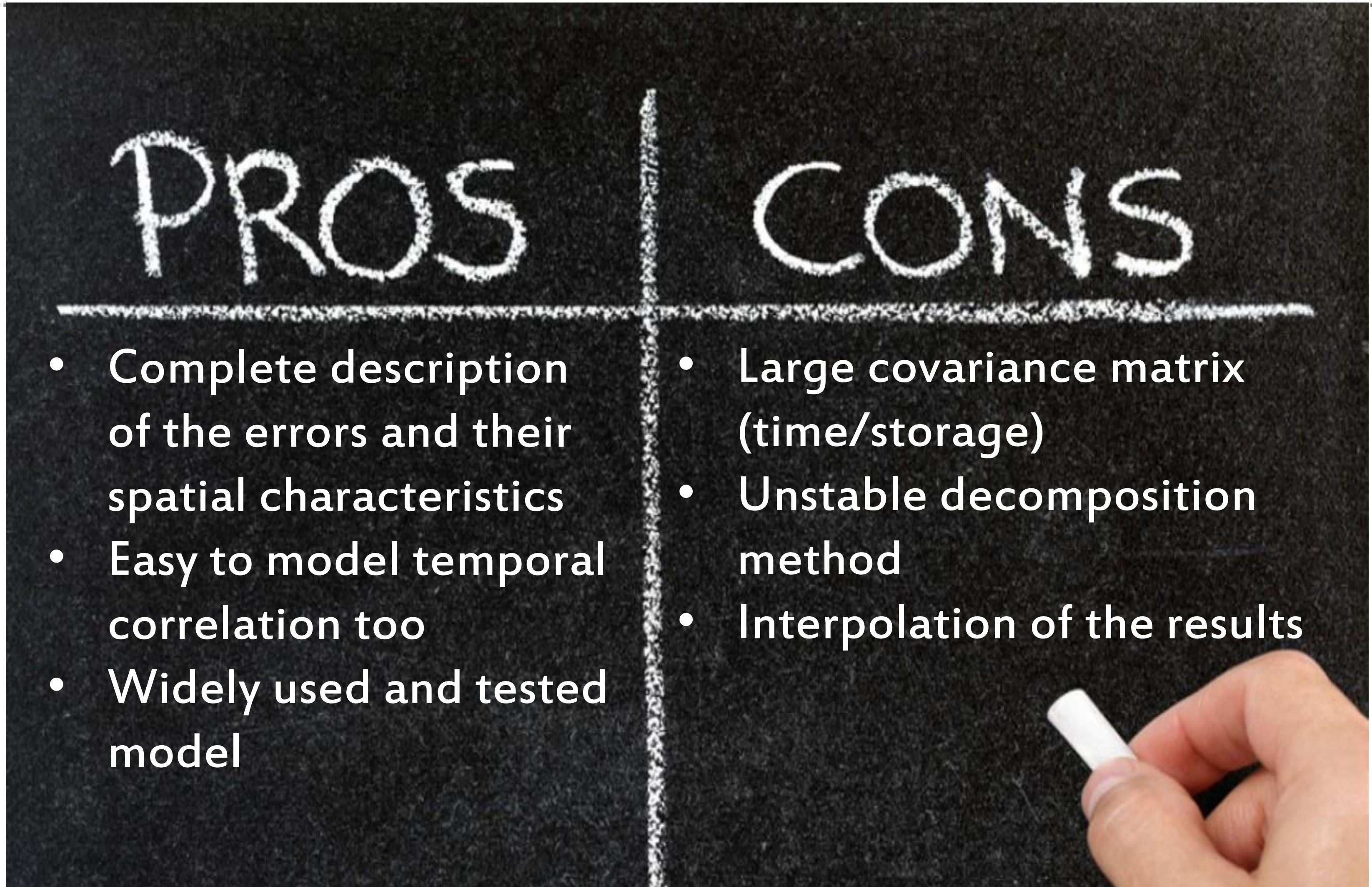
Covariance approach



Noise separation method

- No rain gauge need
- Decomposition of the radar image

(Pegram et al. 2011)

FFT of radar images

$$R(f) = FFT\big(R(x)\big)$$

Separation of signal power

$$S(f) = R(f).\frac{P_S(f)}{P_R(f)}$$

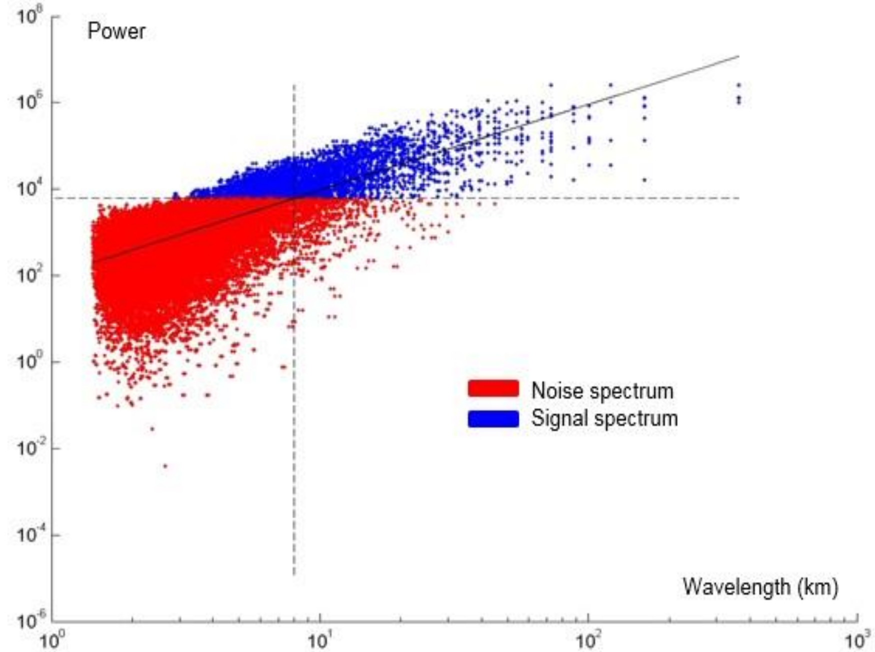
Random noise scaled to noise power

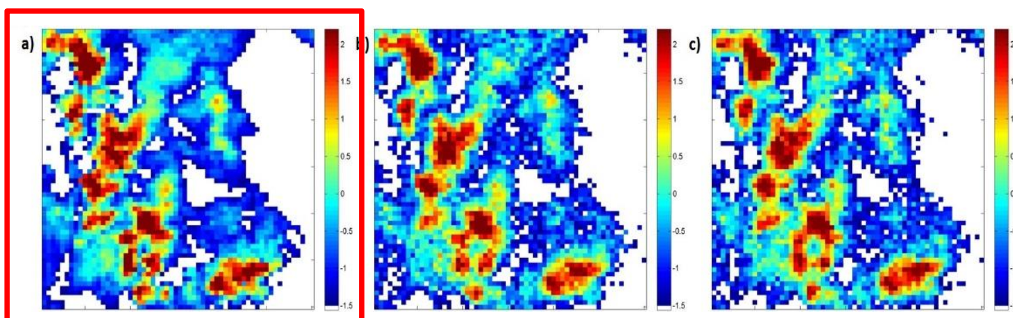
$$N^k(f) = W^k(f) \cdot P_N(f)^{\frac{1}{2}}$$

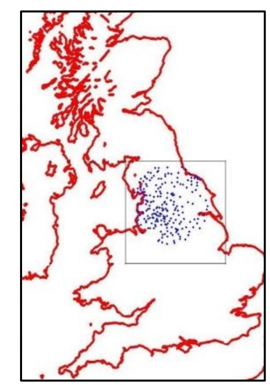
Ensemble composing

$$E^k(f) = S(f) + N^k(f)$$

$$E^k(x) = iFFT\big(E^k(f)\big)$$







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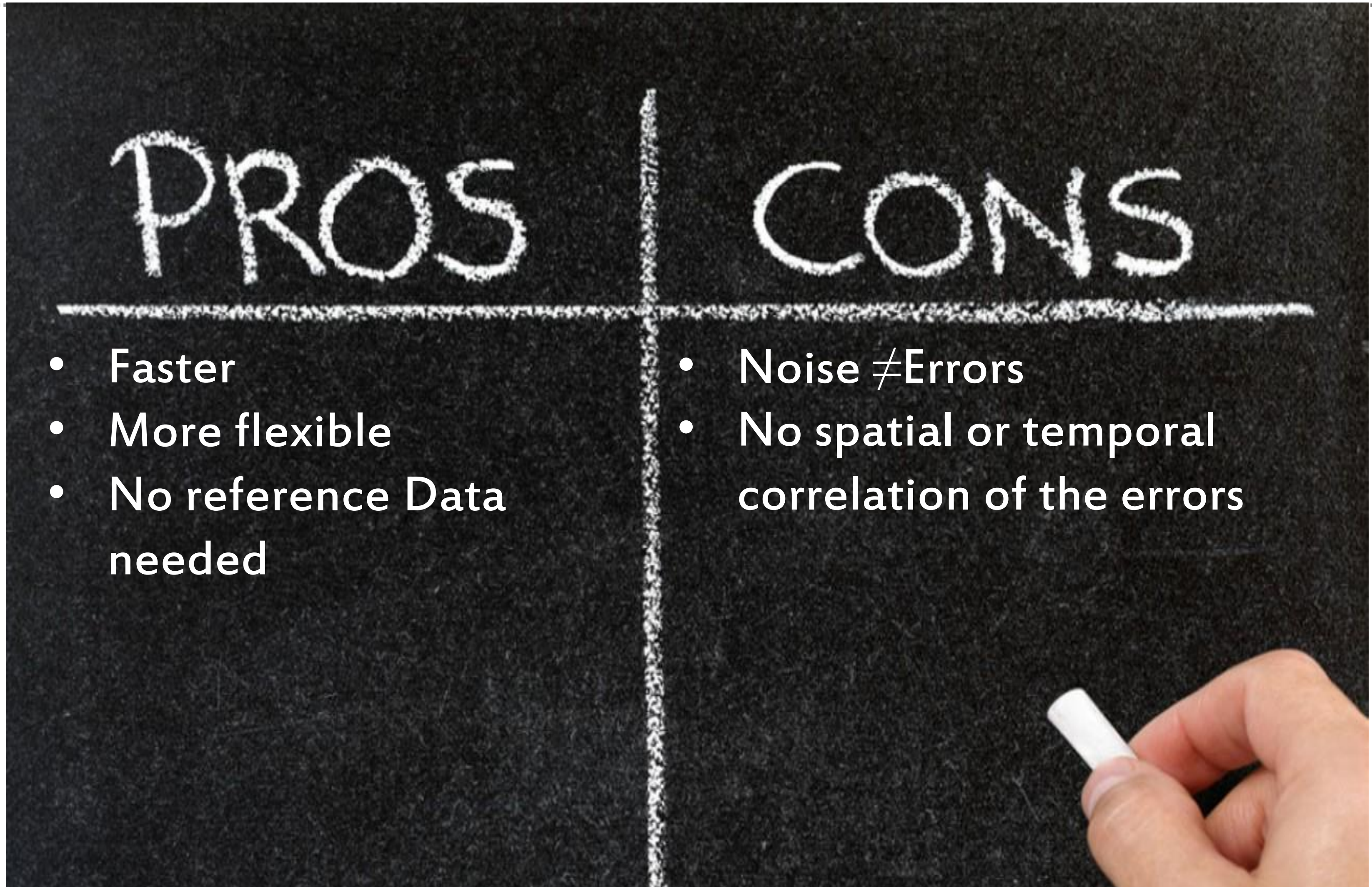
Noise separation method



Pros
- Faster
- More flexible
- No reference Data needed

Cons
- Noise ≠ Errors
- No spatial or temporal correlation of the errors

Comparison: rainfall accumulation

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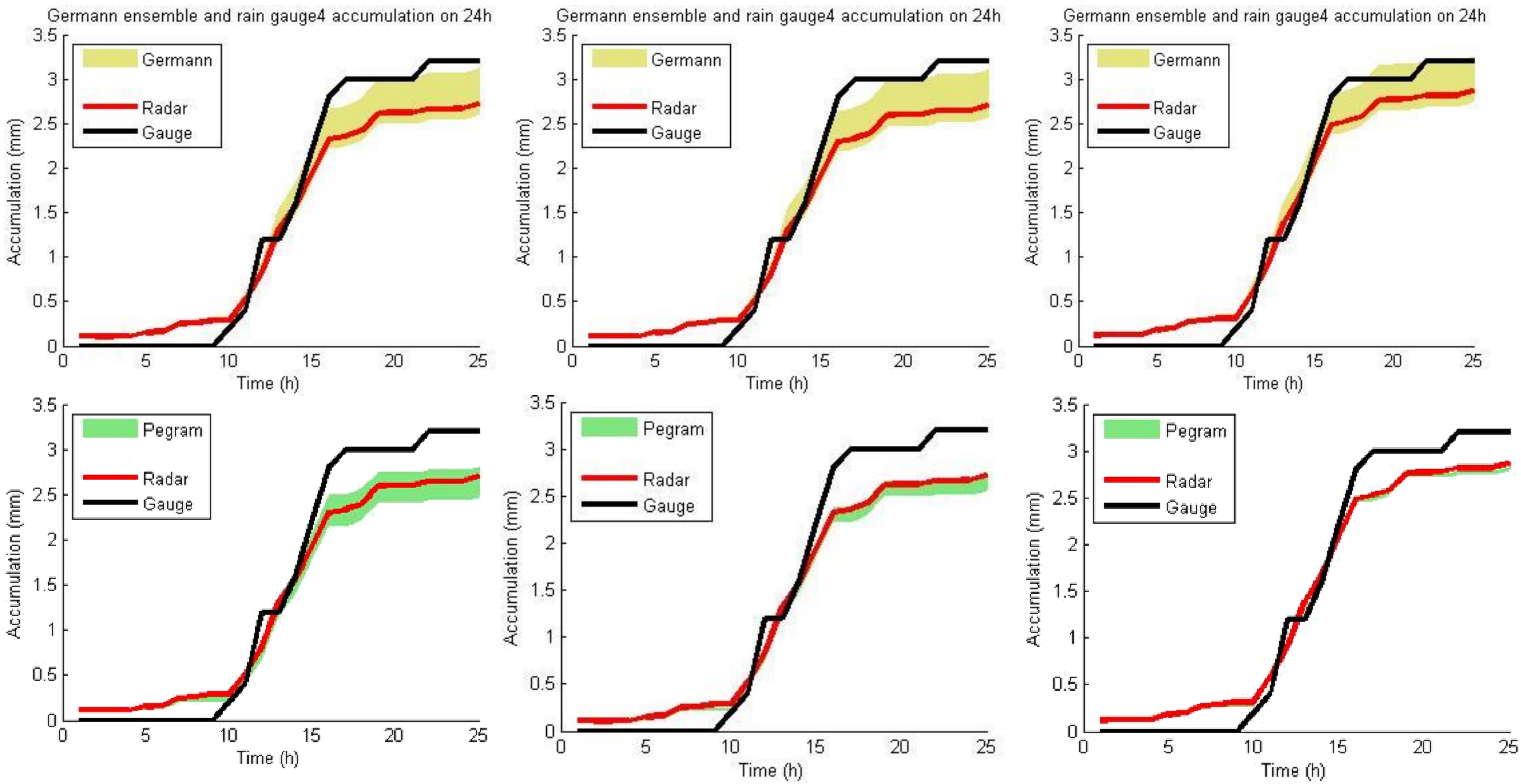

Comparison: spatial correlation

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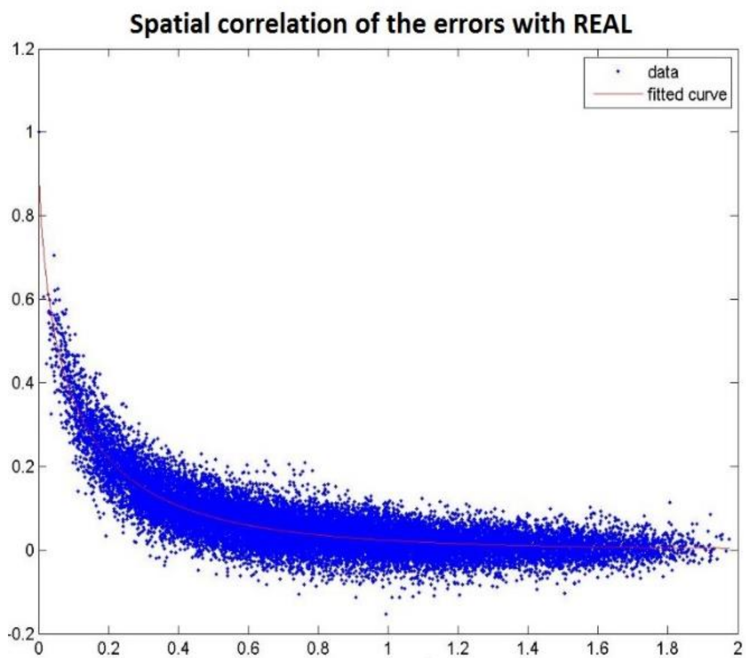
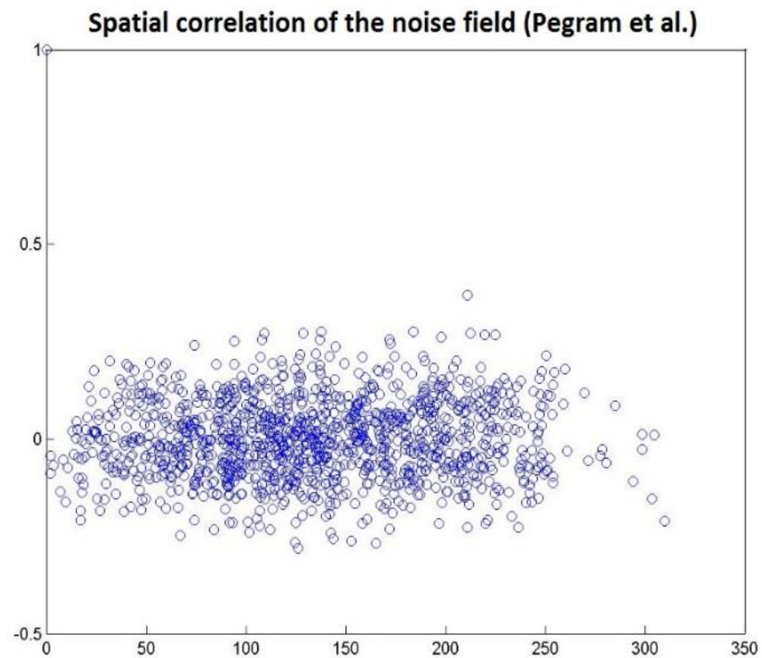


Correlation

Distance (100km)



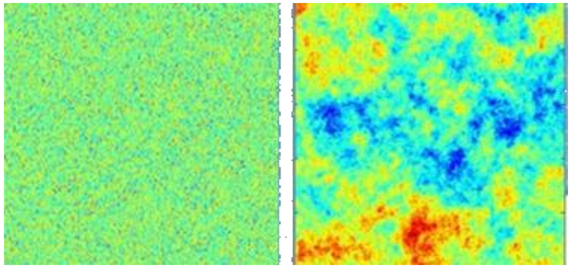
Correlation

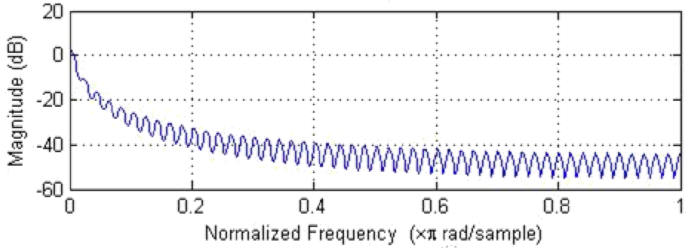
Distance (km)

Future development

- We are developing a new method

The basic idea is to filter a random field with a lowpass filter designed to obtain a field with the same semivariogram and variance of the measured errors



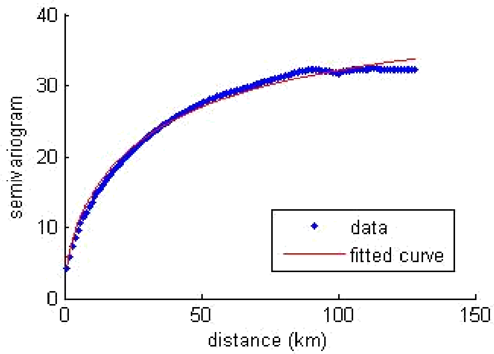


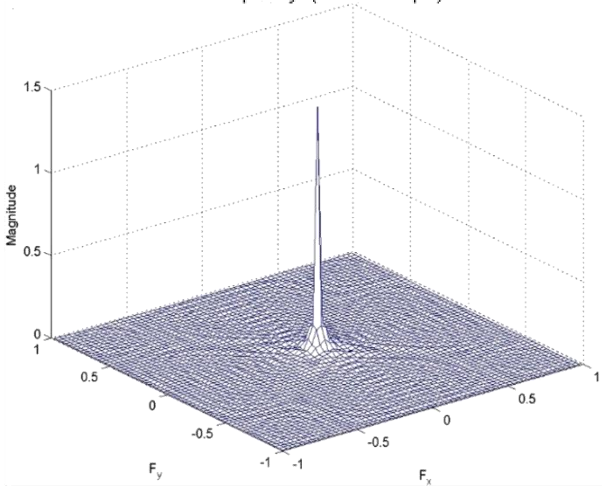
Maintaining spatial dependence

Faster: semivariogram vs covariance

No interpolation needed

More flexible





Conclusions

- Traditional methods work well but can be slow and not very flexible nor robust to outliers and large datasets
- Many other methods in literature present the same problems
- Pegram et al. present a very different method, but it is not suitable to reproduce radar error characteristics
- We are developing a method that use a different approach from the traditional ones, but maintains the error characteristics in space and time.
- Results so far are promising and we plan to present it at the 37th AMS Radar Conference (14-18 Sep 2015 in Oklahoma) and later this year we plan to publish it in a journal

Thank you!!!

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