A new algorithm combining geostatistics with the surrogate data approach
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- Constrained simulation
  - Combining surrogate and kriging
  - New non-Gaussian algorithm
- Results
  - Examples
  - Statistical properties
  - Radiative transfer results

Problem
- How to compare
  - Radiation point-measurements
  - Measured microphysical cloud properties
  - 3-Dimensional cloud field

Motivation
- Radiative transfer is non-local
- Radiative transfer is strongly nonlinear
- Can not measure a full 3D cloud field
- Can measure many (statistical) cloud properties
- Generate cloud field based on statistics measurements

Cloud structure - nonlinear
Cloud structure – non-local

Surrogate clouds
- Stochastic modelling
- Reproduce a measured field
- Well-suited for clouds and 3D radiative transfer
  - Theory: Venema et al., Tellus A, pp. 104-120, 2006
  - Case study: Schmidt et al., JGR, pp. 765–780, 2007
- (LWP) distribution & power spectrum

Kriging
- Geostatistical interpolation method
- Estimate of the mean
- Uncertainty in input and output

Combining kriging and surrogates
- Constrained stochastic simulation
- Typical problem for many geophysical studies
  - Limited measurements, but need a field
  - Specify the distribution accurately (nonlinear)
  - Specify the spatial correlations (“non-local”)  
  - Field constrained by measurements

Combining kriging and surrogates
- Contradicting requirements
- Kriging smoothes, surrogates have structure
- Relative to kriged field, structure adds noise
- Mathematical formulation is different
- How to combine these two worlds?
Surrogates & kriging - algorithm

Stratocumulus validation data
- Computed with Large Eddy Simulation (LES)
- We use only Liquid Water Path (LWP)
  - 2D fields of column integrated amount of water in cloud droplets (g m\(^{-2}\))

Methodology this study

One measurement – sampling - PDF
Five measurements – sampling

One measurement – sampling - ACF

Conclusions

- Generate realistic structure conditioned on means
  - Smaller root mean square error
  - Point measurements on ground
  - Less case studies needed to study 3D radiative transfer

- Main limitation is sampling
  - Especially one zenith pointing instrument
  - Noisy and biased estimate

Outlook

- Validation
  - 3D radiative transfer calculations

- Estimate the statistics
  - Cloud mask
  - Estimation of distribution using nearby data

- Apply to other problems
  - Michael Herbst and Stefan Kollet