Representing model error and observation error uncertainty for data assimilation of polarimetric radar measurements

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für Wetterforschung

Goal

Aim: Optimize the use of polarimetric radar observations to initialize numerical weather prediction models

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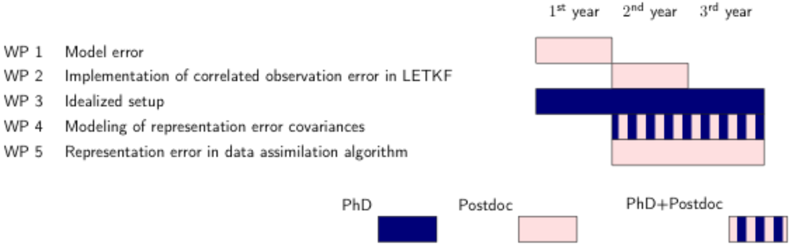
For data assimilation:

1. Specify model error for hydrometeors during data assimilation
2. Specify observation error for polarimetric radar observations that includes estimates of representation error

Strategy



Supervised with expertise in data assimilation (T. Janjic) and microphysical parameterization (A.Seifert, D. Klocke).

WP1 Model error, Postdoc

We seek an optimal strategy of perturbing hydrometeors during data assimilation in order to improve their forecast accuracy.

- Can we use higher resolution model simulations to gain expertise on how to best perturb hydrometeors?
- Would it be useful to introduce uncertainty in parameters of the microphysical scheme? If yes, which parameters should we perturb?
- use of stochastic microphysics schemes?

WP1 Model error, Postdoc

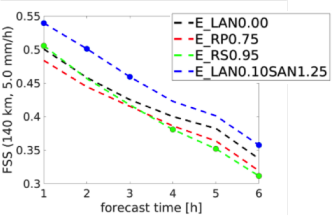
Tools:

- use operational COSMO-KENDA
- extend our current work on specification of model error uncertainty for radar reflectivity data assimilation with LETKF
- verify the results with polarimetric radar observations

We expect easier assimilation of polarimetric radar observations later.

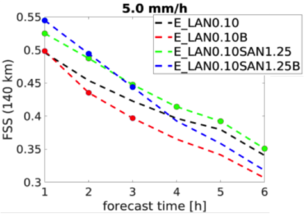
Previous work Model error

1. Additive noise Insufficient model resolution is one source of model error. Currently we are perturbing u, v, T and qv based on differences between 1.4km and 2.8km COSMO-DE runs. Weakly forced case, June 2016.



Zeng et al. 2018a

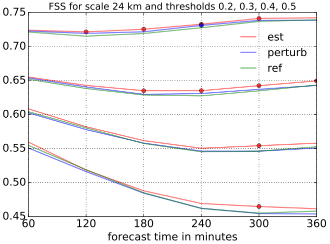
2. Boundary layer uncertainty:
   1. Stochastic boundary layer scheme (Kober and Craig 2017)
   2. warm-bubble (Lozar et al.)



Zeng et al. 2018b

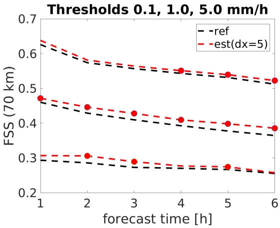
Previous work Model error

3. Parameter perturbations or estimation In order to tackle model error due to uncertain parameters. In this case roughness length is either perturbed or estimated during DA. Verification against VIS/NIR data.



Ruckstuhl et al. 2018a

Estimation of roughness length now verified against radar data that is not assimilated in this case.



Ruckstuhl et al. 2018a

WP1 Model error, Postdoc

First steps

- Use as additive noise climatological samples in which in addition to higher resolution double-moment microphysics is used
- Introduce uncertainty in parameters of the microphysical scheme and test the sensitivities
- Verify previous results with polarimetric radar data

WP2 Implementation of correlated observation errors in LETKF, Postdoc

Polarimetric radar observations have correlated observation errors and it has been shown that accounting for correlated observation errors leads to a more accurate analysis and to improvements in the forecast skill score.

First steps:

- Technical changes in KENDA for implementation of correlated observation error
- with first crude approximation to the observation-error covariance matrix based on experience in WP3.

WP3 Idealized setup, PhD

- use idealized COSMO-KENDA with simplified observation operators (cooperation with observation operator development project)
- high resolution model simulations
- Simulate observations of polarimetric radar data will be drawn from a nature run.

WP3 Idealized setup, PhD

- Perform data assimilation experiments with LETKF
- derive statistics for observation error
- investigate the benefits of including correlated observation errors
- Explore the use of retrievals, namely the drop size distribution (DSD)
- By using different levels of microphysics schemes in the nature run and the assimilation, investigate the effects of model errors caused, for example, by differential sedimentation and how this behavior can be improved using the methods developed in WP1.

WP4 Modeling of representation error covariances, Postdoc and PhD

Statistics of error due to unresolved scales and observation operator error will be estimated in idealized setups from higher resolution simulations. These will be compared with Desrozier (2005) estimates. Finally, the representation error will be parameterized.

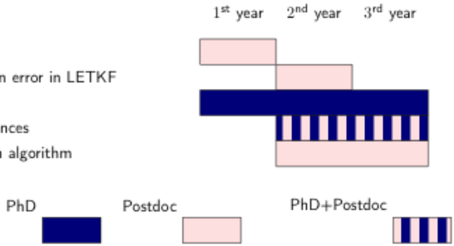
- χ^2 statistics
- Although not design for the representation error statistics, we will explore stochastic parametrization of Sakradzija et al. 2016 for representation error of polarimetric measurements.
- The approach similar to Waller et al. 2014 will be taken here for the observation operator part of the representation error where simplified observation operators as well as full observation operator as truth will be used.

WP5 Representation error in data assimilation algorithm, Postdoc

- To include representation error in the LETKF algorithm, first the possibility of correlated observation error in LETKF need to be capacitated which will be done in WP2.
- The methods for including representation error in the Kalman filter framework as proposed in Janjic and Cohn (2006) and Janjic et al. 2017 will be investigated.
- The computationally efficient algorithm will be developed.

Summary

WP 1	Model error
WP 2	Implementation of correlated observation error in LETKF
WP 3	Idealized setup
WP 4	Modeling of representation error covariances
WP 5	Representation error in data assimilation algorithm



Collaborations

- Simplified observation operator for idealized experiments (Year 1)
- Polarimetric data for verification, for example during summer months 2016 (Year 1)
- Observation operator (Year 3)
- Polarimetric data for assimilation during summer months (Year 3)