Updating soil moisture and vegetation by assimilating Sentinel-1 backscatter: Impact on streamflow simulations

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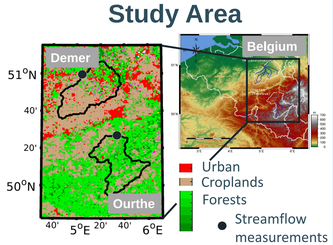
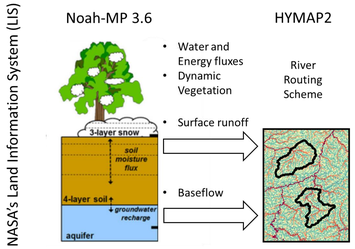
Introduction

- Streamflow forecasts suffer from errors in the initial conditions of the catchment-scale soil moisture
- **Objective:** Assessment of the potential of improving streamflow simulations through the assimilation of Sentinel-1 backscatter data into a land surface model with a routing module at 1 km resolution

Study Area



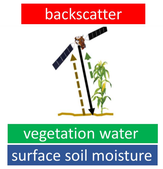
Land Surface Model and Routing Scheme



- Globally-applicable setup:
- ✓ Globally available input data
- ✓ No parameter tuning on streamflow observations
- Meteorological forcing: MERRA-2
- Spatial resolution: 1 km

Water Cloud Model (WCM)

C-band microwave radiation (Sentinel-1)



$$\sigma^0 = T^2\sigma^0_{soil} + \sigma^0_{veg} + \cancel{\sigma^0_{double}}$$

$$\sigma^0_{veg} = A.V_1.\cos\theta(1-T^2)$$

$$T^2 = \exp\frac{-2(B.V_2)}{\cos\theta}$$

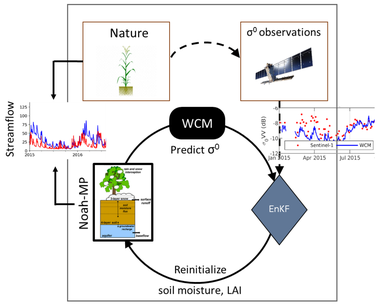
$$\sigma^0_{soil} = C + D.SSM$$

$$V_1 = V_2 = f(LAI)$$

○ calibration
○ input from LIS

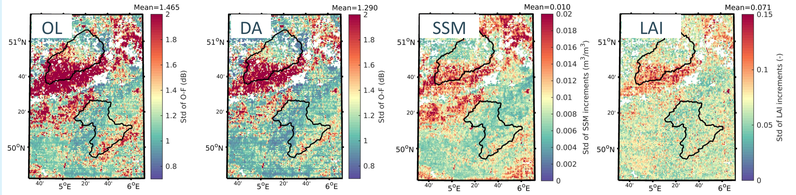
- Observation operator: connecting the LSM variables (surface soil moisture, SSM, and leaf area index, LAI) to backscatter (σ^0) predictions
- Calibrated pixel-by-pixel using Bayesian inference

Data Assimilation Scheme



- Ensemble Kalman filter: state updating of SSM and LAI using Sentinel-1 σ^0 at VV and VH pol. simultaneously
- Open-loop (OL) and Data Assimilation (DA) experiments with perturbations in forcing and state variables (SSM and LAI)
- Time period: 2015-2019

Data Assimilation Diagnostics



- Highest observation-minus-forecast (O-F) residuals (both VV and VH) over croplands
- DA reduces O-F by ~12%
- Higher increments in SSM and LAI over croplands

References

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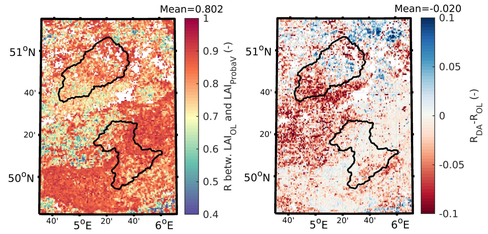
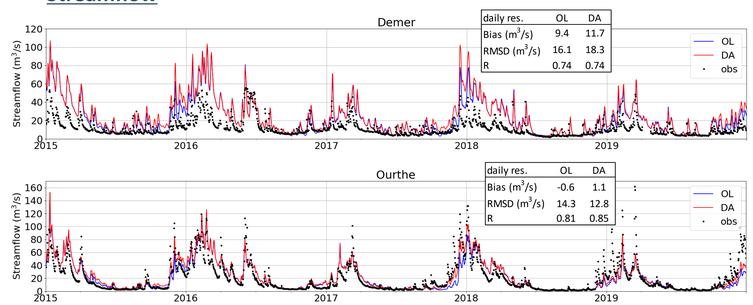
Skill Assessment

Leaf Area Index



- Pearson correlation with Proba-V LAI (1 km)
- Impact of assimilation varies and can be positive and negative
- Strong deterioration often in areas with poor LAI model performance

Streamflow



- Demer: Deterioration in Bias and RMSD, no change in R
- Ourthe: Improved skill in R and RMSD, minor change of bias

Conclusions

- Improving the streamflow predictions of a land surface model with a routing scheme by assimilating Sentinel-1 backscatter seems possible
- Prelim. results indicate an impact of DA in the first part of the flood period

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