Evaluating Rescaling Approaches for Improved Carbon and Water Flux Representation Through LAI Assimilation in a Land Surface Model

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FWF Der Wissenschaftsfonds. fwo esa

Background

- CONSOLIDATION project (FWF + FWO)
  - Study long-term trends in vegetation and soil moisture + interactions
  - Combine satellite observations with land surface models

  → Data assimilation (DA)
  - Joint DA of soil moisture (SM) and vegetation data
- CCI+ CCN Soil moisture (ESA)
  - LAI+SM DA for improved root zone soil moisture
- Related research:
  - LAI DA into LDAS-Monde (Fairbairn et al. 2017, Albergel et al. 2017, 2020)
  - LAI DA into Noah-MP (Kumar et al. 2019)
- No consideration of the effect of bias on LAI DA so far

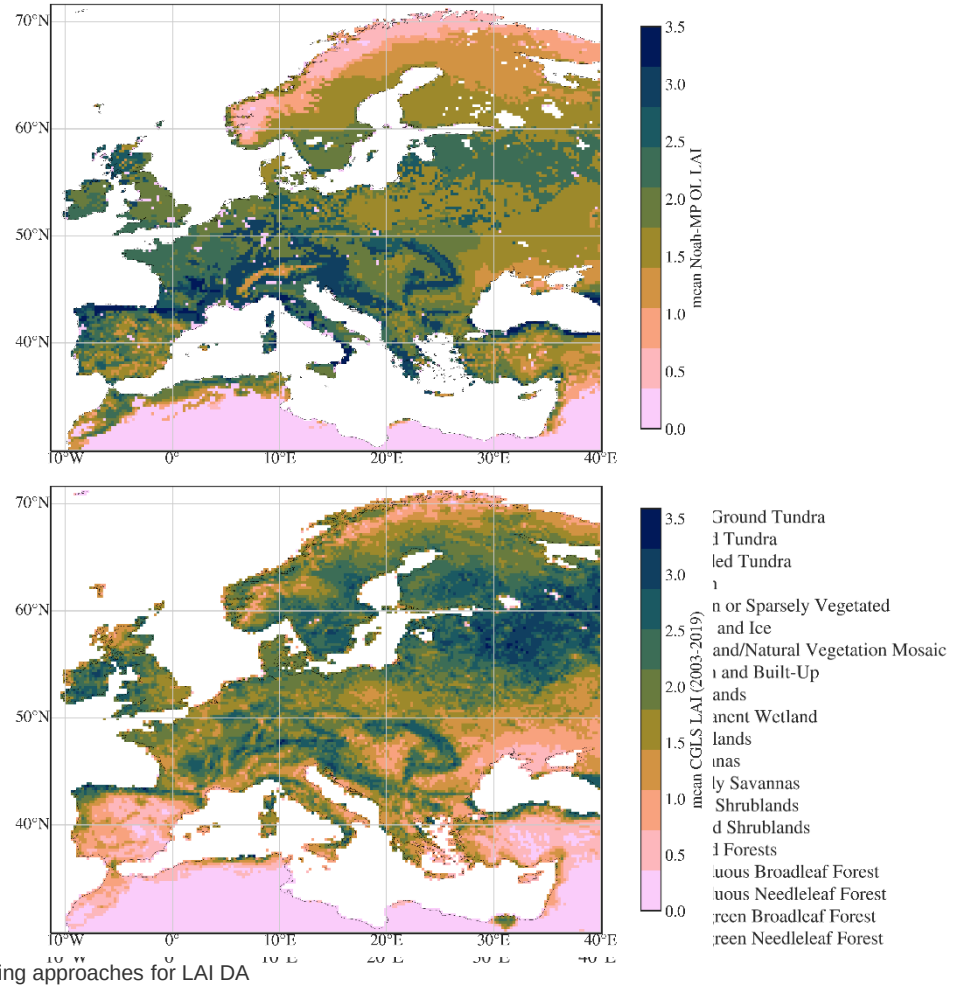
Can rescaling for bias correction in LAI DA help to improve carbon and water flux estimates?

Der Wissenschaftsfonds.

Albergel et al., 2017, 10.5194/gmd-10-3889-2017
Albergel et al., 2020, 10.5194/hess-24-4291-2020
Fairbairn et al., 2017, 10.5194/hess-21-2015-2017
Kumar et al., 2019, 10.1175/JHM-D-18-0237.1

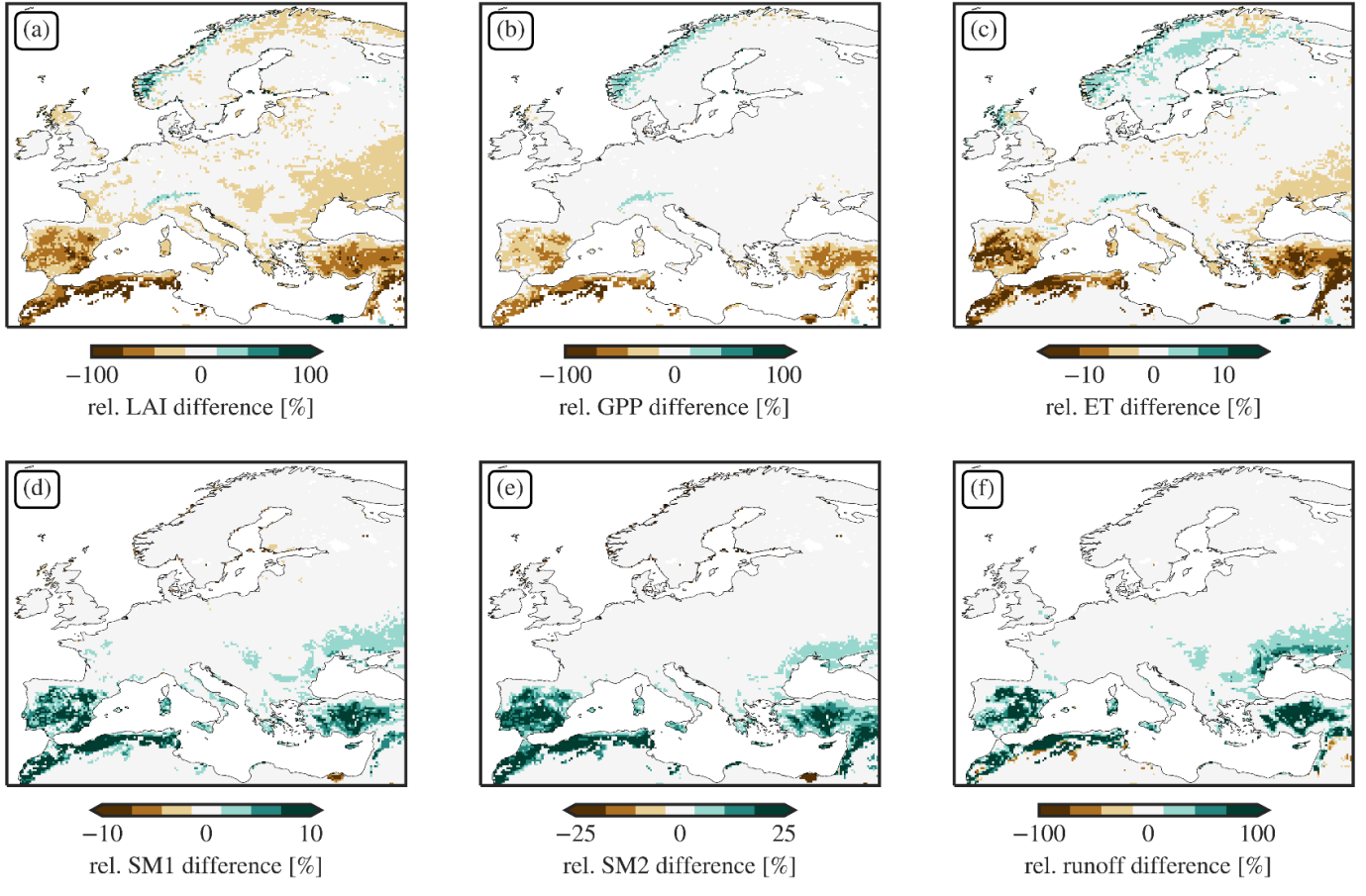
Data assimilation setup

- Noah-MP land surface model v4.0.1 (Niu et al. 2011, Yang et al. 2011)
  - 0.25° model resolution
  - Forced with ERA5
  - Dynamic vegetation enabled
- Copernicus Global Land Service (CGLS) LAI (Verger et al. 2014)
  - Resampled to 0.25°
  - No bias correction → bias-blind DA
- NASA Land Information System (LIS, Kumar et al. 2006, Peters-Lidard et al. 2007)
  - Ensemble Kalman Filter (EnKF)
  - Perturbation settings following Kumar et al. (2019)

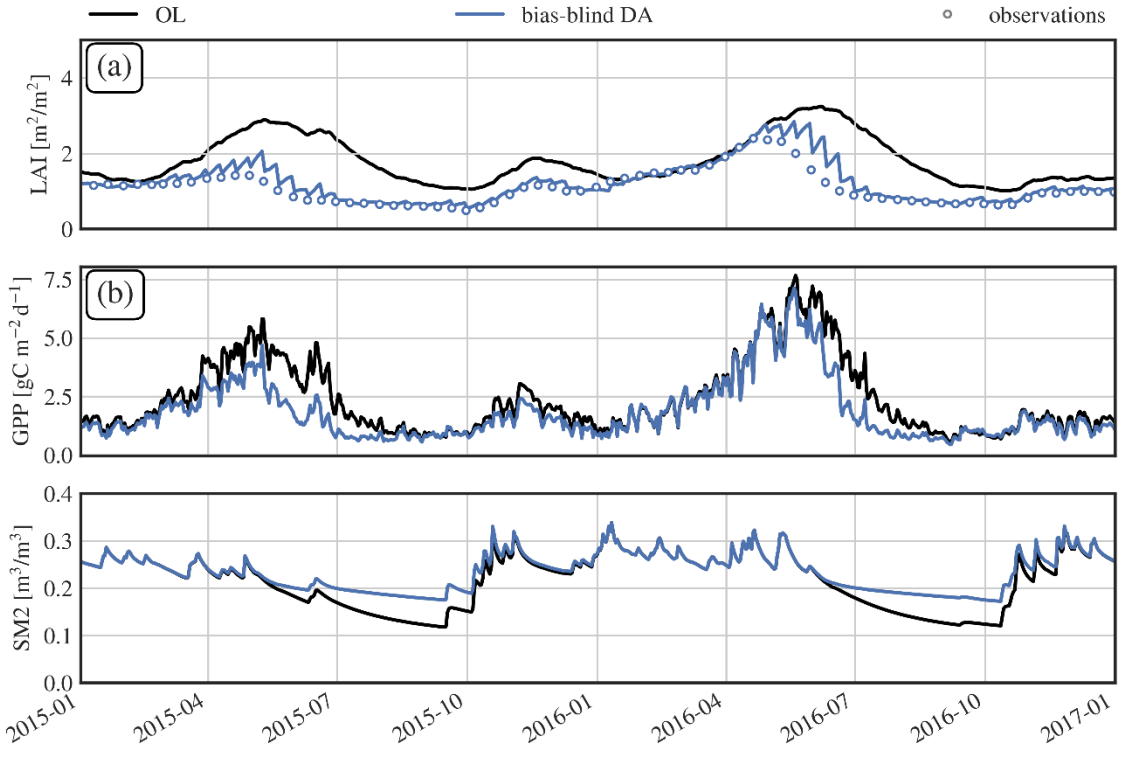


Kumar et al., 2006, 10.1016/j.envsoft.2005.07.004
Niu et al., 2011, 10.1029/2010JD015139
Peters-Lidard et al. 2007, 10.1007/s11334-007-0028-x
Verger et al., 2014, 10.1109/JSTARS.2014.2328632
Yang et al. 2011, 10.1029/2010JD015140

Bias-blind LAI DA impact



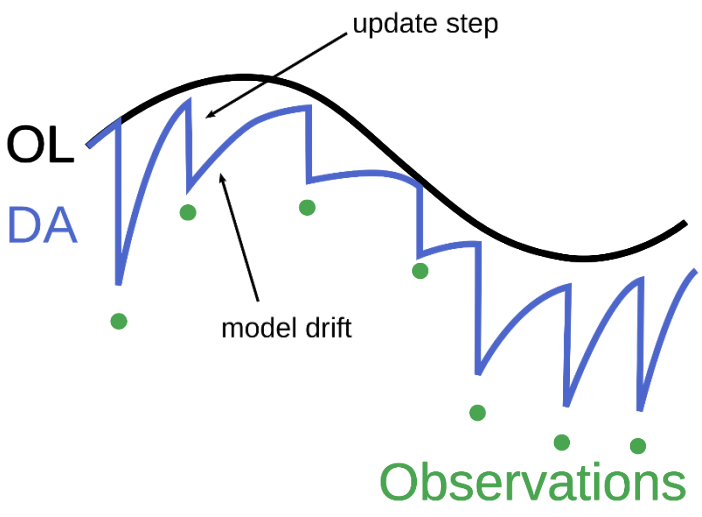
Effect of LAI DA on LAI timeseries



OL (=model run without DA), observations, and DA for grid cell in central Spain: Effects on soil moisture and GPP

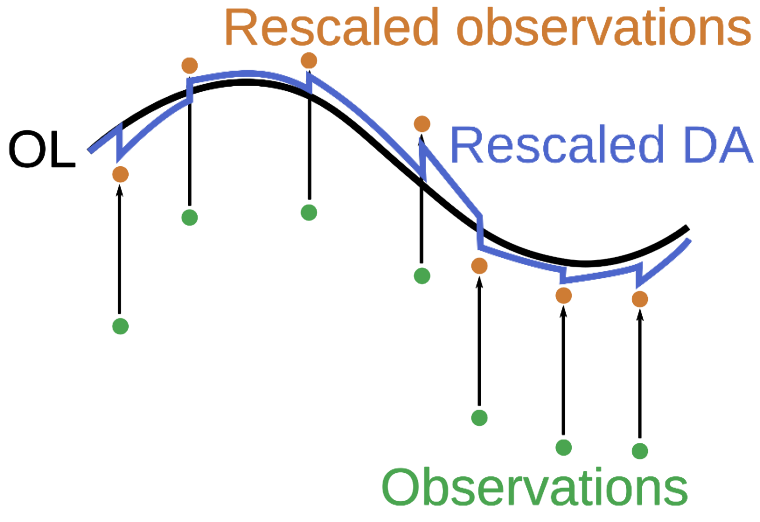
Why use rescaling methods?

Unscaled (bias-blind) DA



Dee, 2005, 10.1256/qj.05.137
De Lannoy et al., 2007, 10.1029/2006WR005449

Rescaled (bias-aware) DA

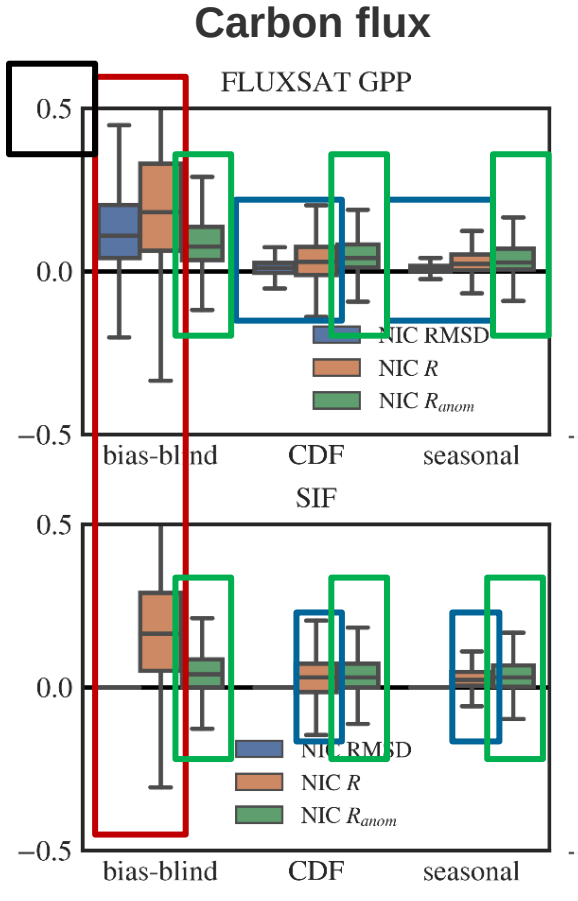


Rescaling methods:

- CDF-matching
- Seasonal rescaling

Reichle & Koster, 2004, 10.1029/2004GL020938
De Lannoy & Reichle, 2016, 10.1029/2004GL020938

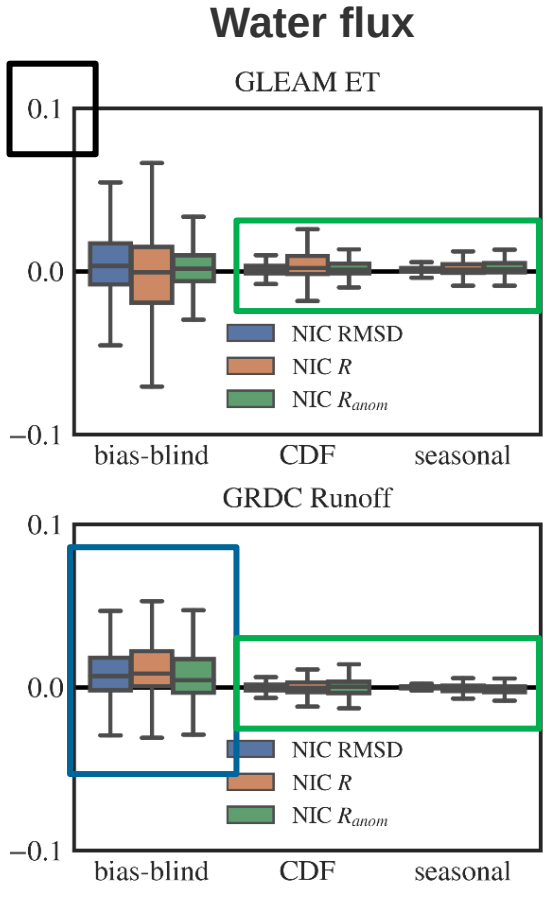
Evaluation against reference data



- Large impacts on metrics
- Large R/RMSD changes in bias-blind DA
- Low R/RMSD changes in rescaled DA
- Anomaly correlation not strongly affected

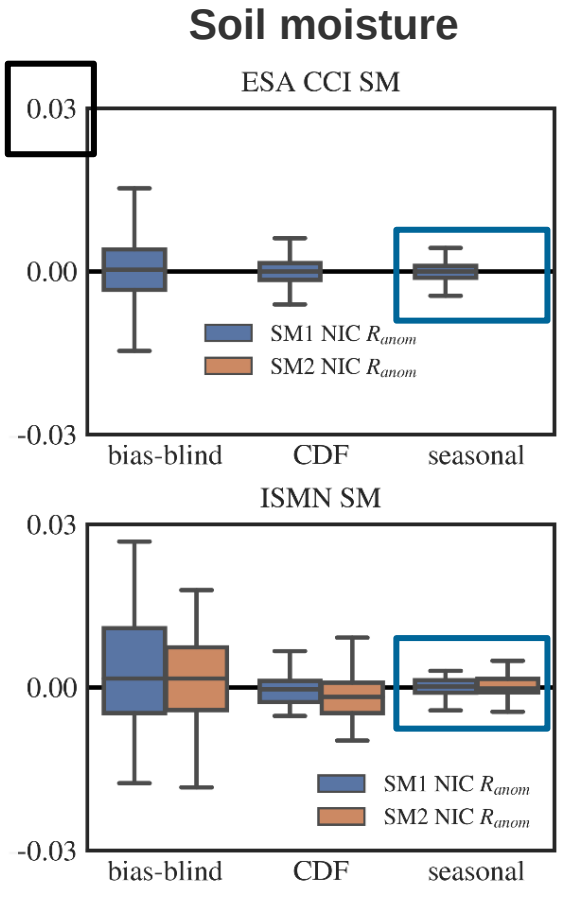
Evaluation against reference data

- Medium-sized impacts
- Slightly positive impact on runoff
- Low impacts for rescaled DA



Evaluation against reference data

- Low impacts on metrics
- Seasonal rescaling has lowest impact



Summary & Conclusions

1. Large biases between Noah-MP and CGLS LAI exist
   - Especially in dry climates
2. Bias-blind LAI DA strongly affects model hydrology
3. Short-term flux estimates after biased DA updates contain unphysical drifts
   - Caused by model drift to equilibrium LAI
4. Rescaling techniques for a priori bias correction can help
   - CDF-matching: preserves more of the original information, e.g. on phenology
   - Seasonal rescaling: more effective at reducing bias
   - Rescaling allows LAI DA without affecting model hydrology

Alternative to rescaling: Model calibration or parameter update DA for LAI DA into land surface models?

- Resulting in estimates in observation space
- Stronger persistence of DA updates
- But: can similarly strongly affect model hydrology

Thank you for your attention

Article submitted to HESS:

Scherrer, S., De Lannoy, G., Heyvaert, Z., Bechtold, M., Albergel, C., El-Madany, T.S., Dorigo, W., Effects of a biased LAI data assimilation system on hydrological variables and carbon uptake over Europe

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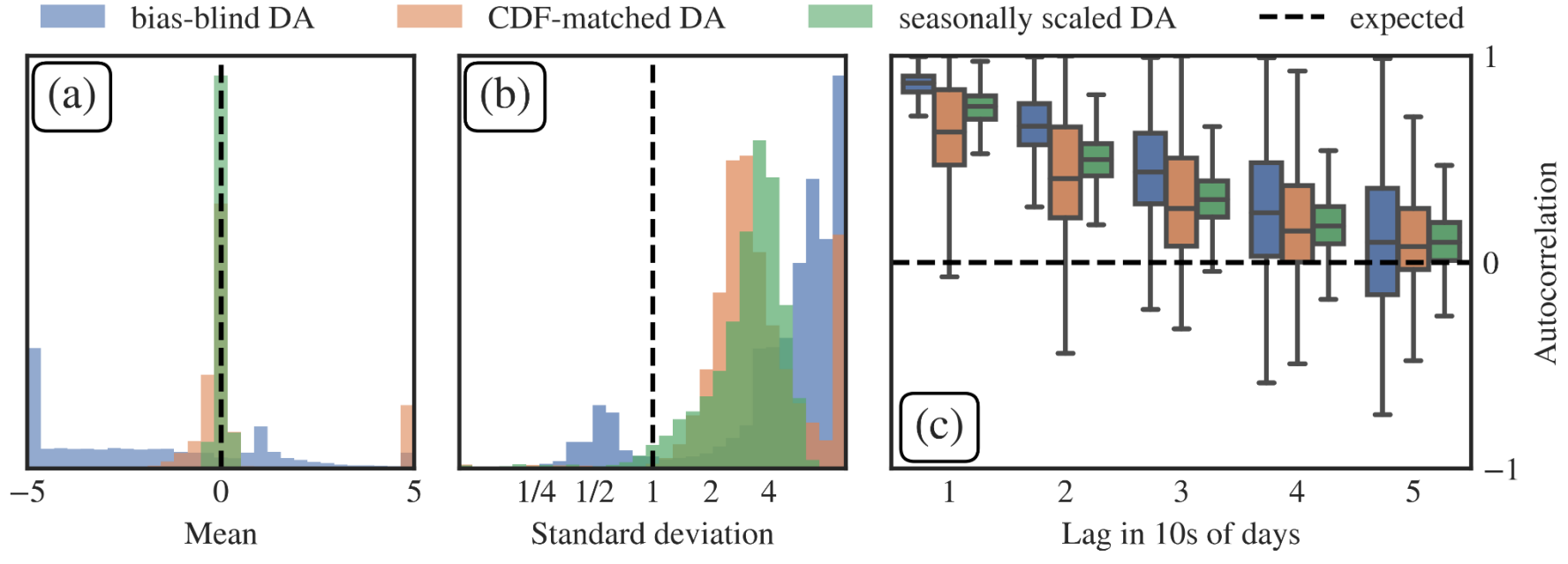
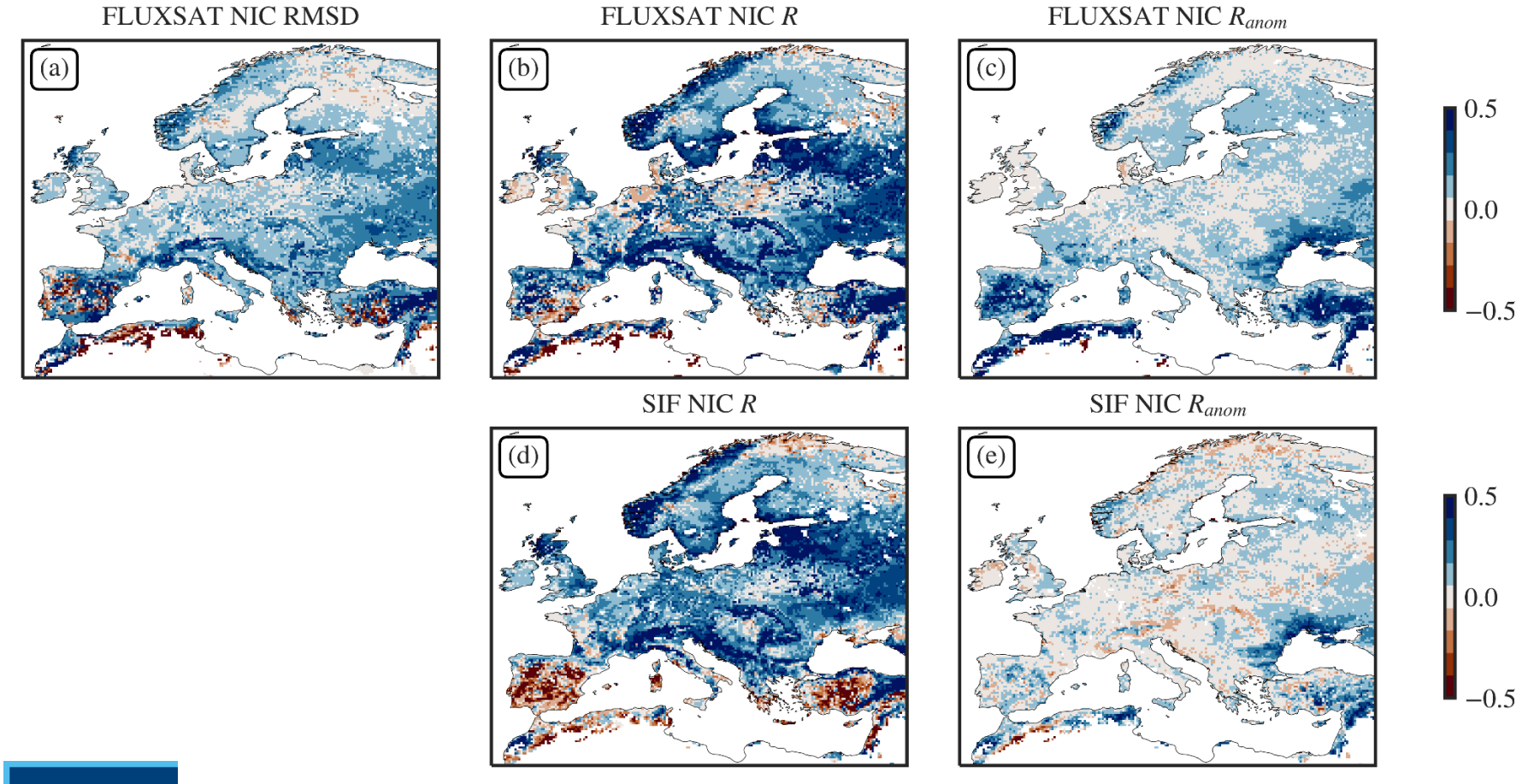
Backup slide I: DA diagnostics

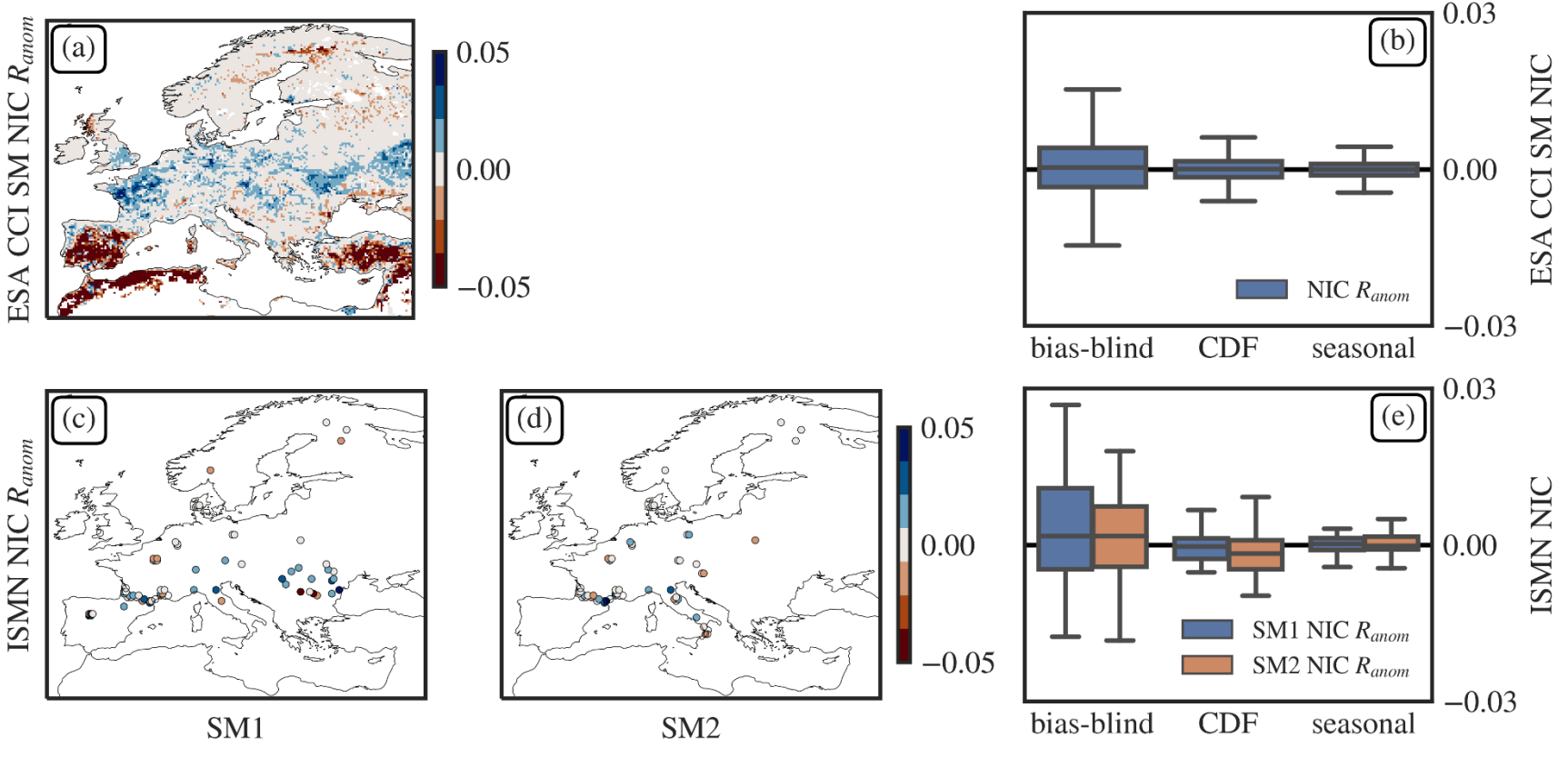


Backup slide II: GPP NIC maps



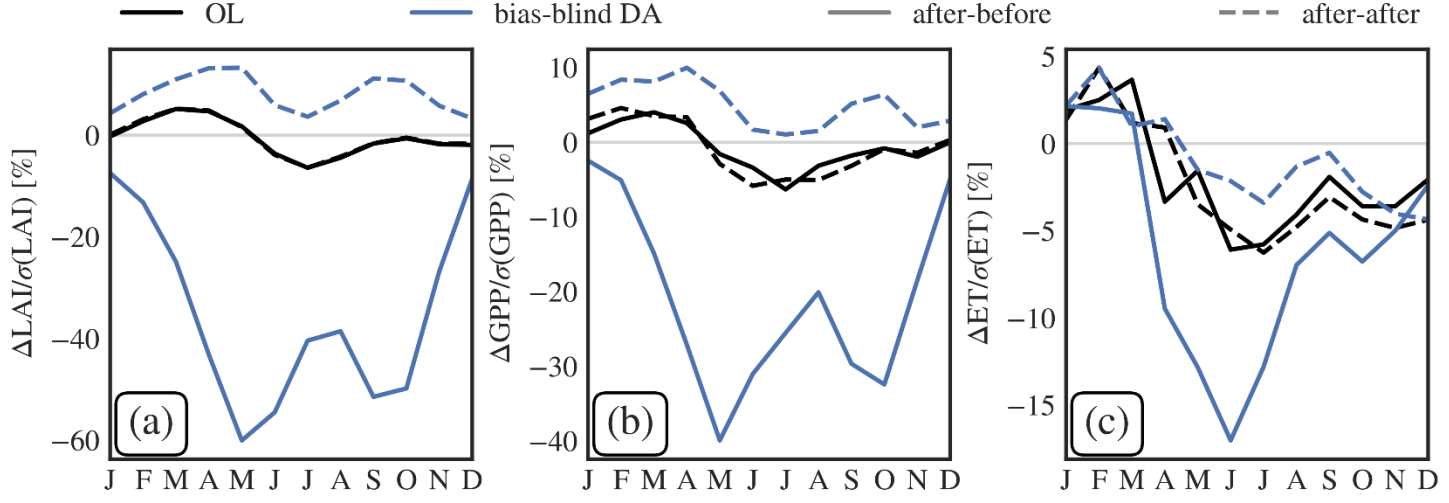
Scherrer et al., Rescaling approaches for LAI DA

Backup slide III: SM NIC maps

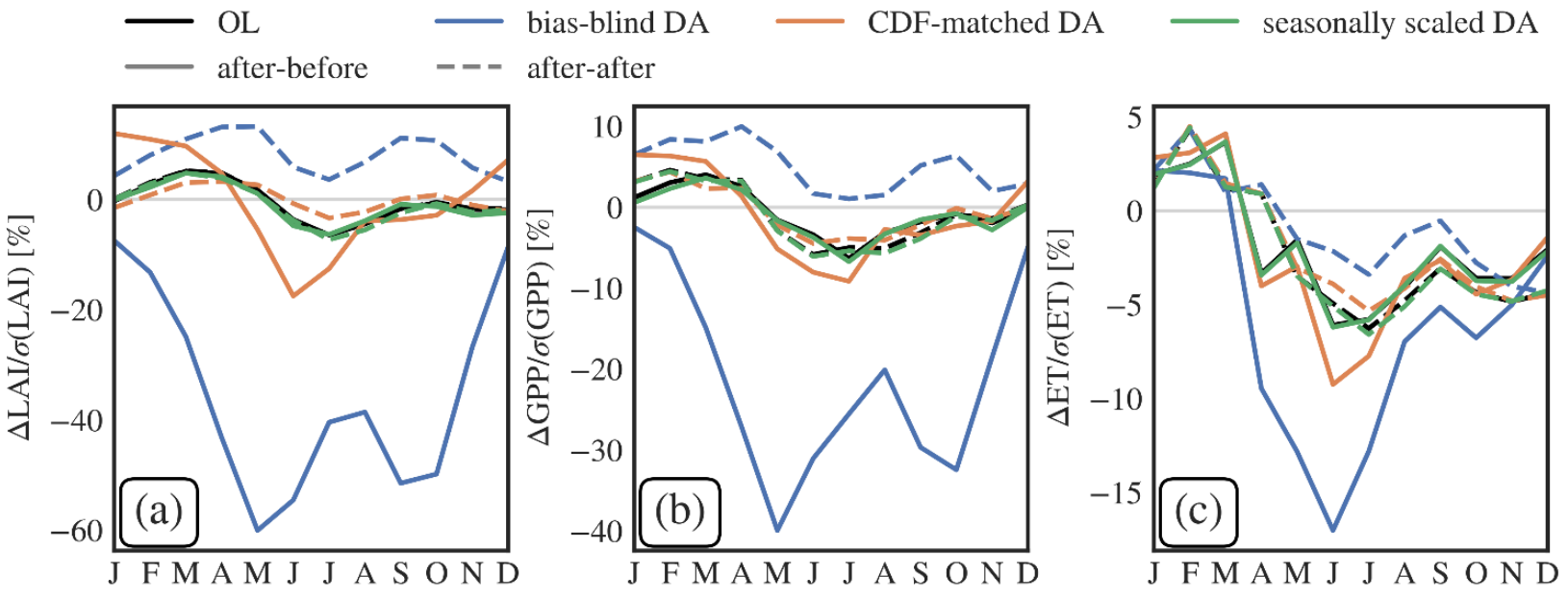


Does the sawtooth pattern propagate to short-term flux estimates?

- Normalized multi-year median **after-before** differences per month:
  - Variable(1 day after DA update time) minus variable(1 day before DA update time)
  - Shows impact of DA update
- Normalized multi-year median **after-after** differences per month:
  - Variable(2 days after DA update time) minus variable(1 day after DA update time)
  - Shows short-term model drift component after DA update



Effect of bias correction on sawtooth pattern



Rescaling reduces drift artefacts in flux estimates!

Effect of bias correction on sawtooth pattern

Rescaling reduces impact on SM!