Improving the temporal and spatial vegetation variability in land surface models based on satellite observations

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Summary

Motivation

- Vegetation largely controls land surface-atmosphere interactions
- Vegetation variability is not adequately represented in state-of-the-art LSMs → **weaknesses** in modelled land surface hydrology

Key findings

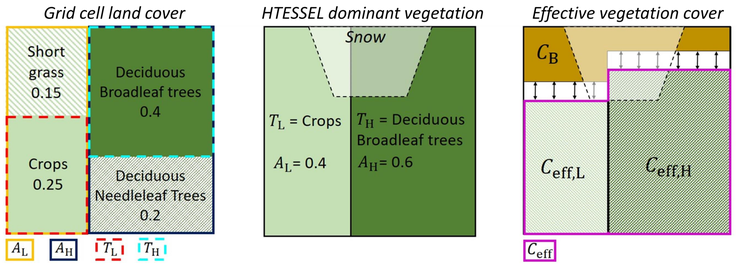
- Inter-annually varying vegetation **significantly improved** correlation of model evaporation and near-surface soil moisture
- These improvements are related to soil moisture-evaporation **feedbacks** activated with the model developments
- These feedbacks are visualized in an **interpretation framework** that we developed to enhance our model understanding

- Our findings emphasize the importance of vegetation variability in LSMs for climate reanalyses and predictions
- Key challenge: predicting vegetation evolution

Do you want to know more?

- This work is submitted to ESD soon
- More on vegetation variability and hydrology in land surface models in Van Oorschot et al., 2021

HTESSEL vegetation representation



$T_{L/H}$: low/high dominant vegetation type
$A_{L/H}$: low/high vegetation cover fraction
C_{eff} : effective vegetation cover
C_B: bare soil cover = $1 - C_{eff}$

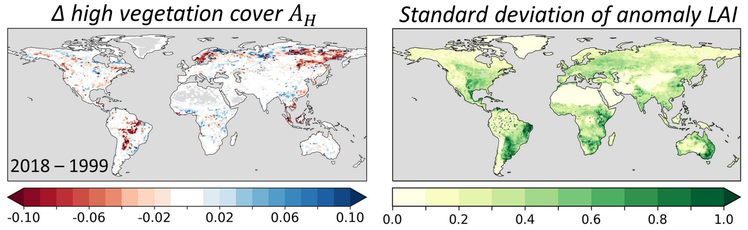
How to improve vegetation variability?

(1) Inter-annually varying LC

- ESA-CCI Land Cover
- Local changes: e.g. Amazon and North-East Siberia reduced high vegetation cover

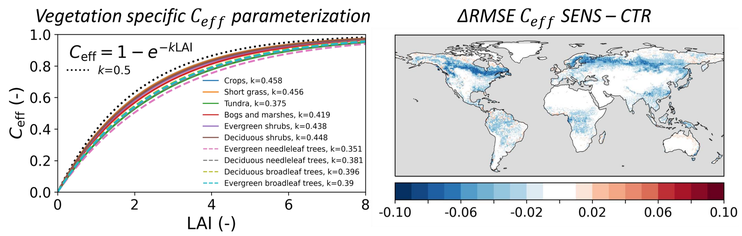
(2) Inter-annually varying LAI

- Copernicus LAI
- Representing LAI anomalies during e.g. dry (- anomaly) and wet (+ anomaly) years



(3) Vegetation specific effective vegetation cover parameterization

- Copernicus LAI and FCover
- $C_{eff} = 1 - e^{-k\mathrm{LAI}}$ → $\mathrm{FCover} = 1 - e^{-k\mathrm{LAI}}$
- Non-linear least squares optimization of *k* for vegetation types
- **Reduced errors** of model C_{eff} with respect to FCover



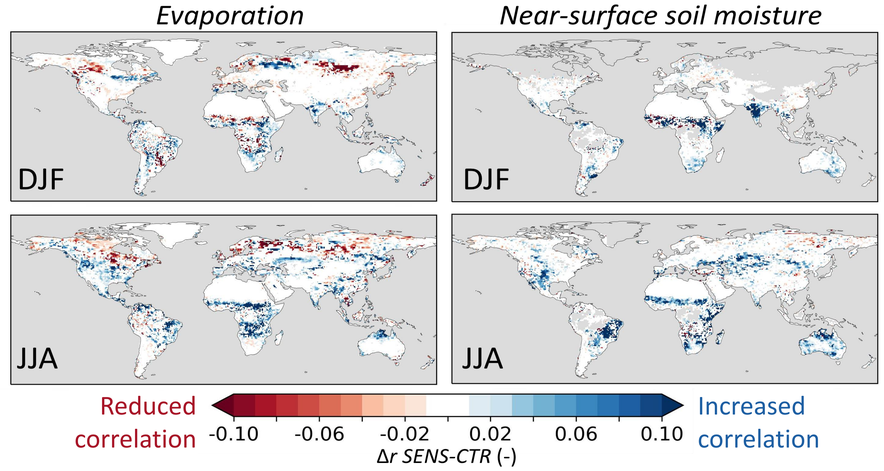
Offline model experiments

	CTR*	SENS*
LC	Fixed 1993	Inter-annually varying
LAI	Seasonal cycle	Inter-annually varying
C_{eff}	*k*=0.5	*k* vegetation specific

*Also individual model changes were evaluated

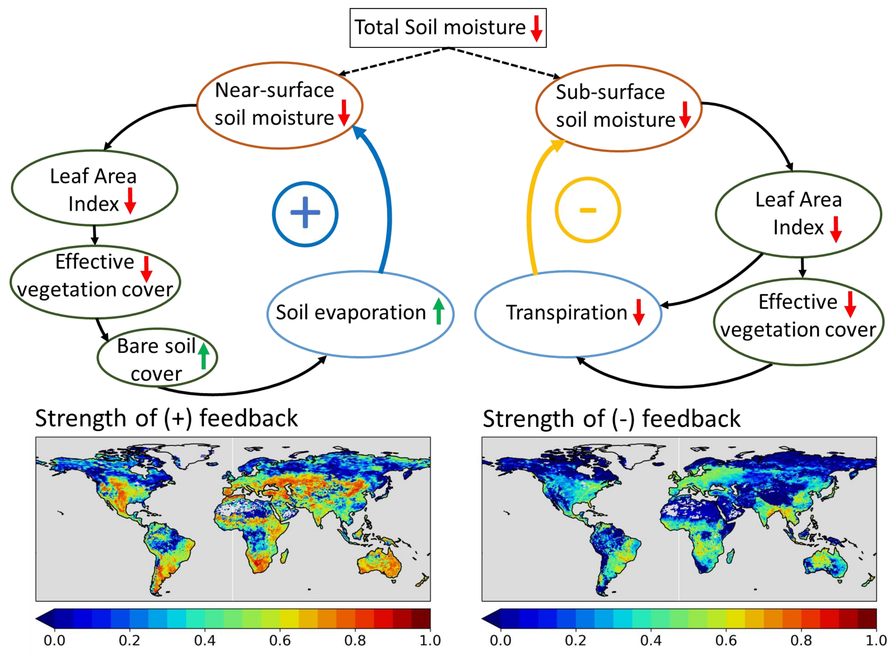
- ERA5 atmospheric forcing
- Evaluation of Evaporation (*E*) and Soil Moisture (SM)
- Reference data: DOLCEv3 *E* and ESA-CCI SM

Improved vegetation → improved correlation



Why does correlation improve?

Inter-annually varying vegetation activates soil moisture-evaporation feedbacks



References

Van Oorschot, F., Van Der Ent, R. J., Hrachowitz, M., and Alessandri, A.: Climate-controlled root zone parameters show potential to improve water flux simulations by land surface models, Earth System Dynamics, 12, 725–743, https://doi.org/10.5194/esd-12-725-2021, 2021

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