Revealing the impact of deforestation on hydrology using remote sensing and land surface modeling

A case-study over the Dry Chaco

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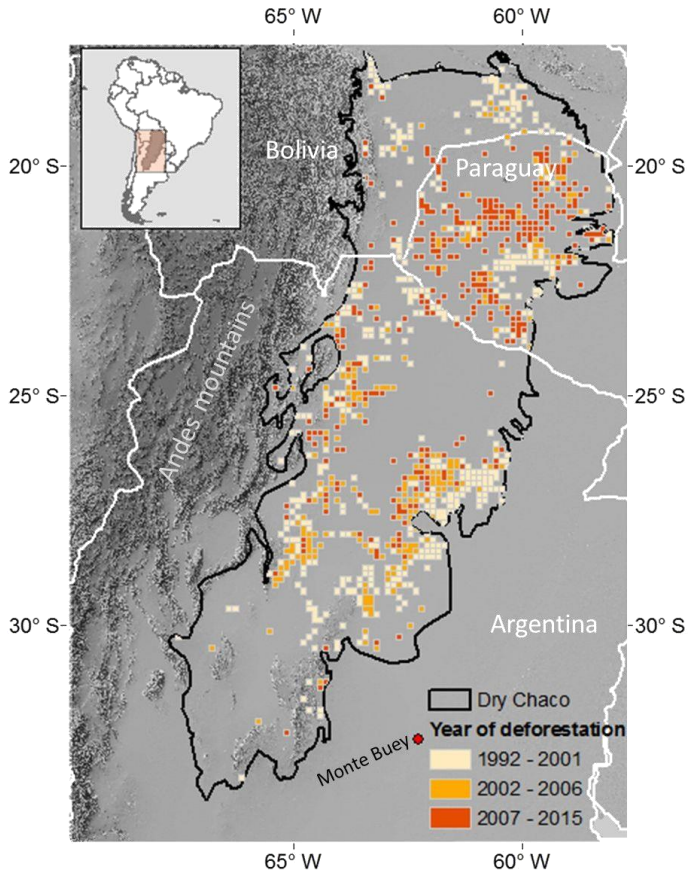
Context



Geographic location of the Dry Chaco ecoregion together with the spatio-temporal pattern of deforestation obtained from the ESA-CCI land cover product (upscaled to 0.125° resolution).

- The Dry Chaco is the largest continuous dry forest in the world, covering parts of Argentina, Bolivia and Paraguay
- Since 1980, the region is characterized by deforestation for soybean production and cattle-ranching whereby 20% of the original forest has been lost
- Deforestation alters the hydrological balance and may increase the risk for dryland salinization

Main objective: Modeling the impact of deforestation on the water cycle by using land surface models (LSMs)

Methodology

3 different LSMs (CLM, CLSM and NOAH), coupled within the NASA Land Information System, are used to model the Dry Chaco's hydrology

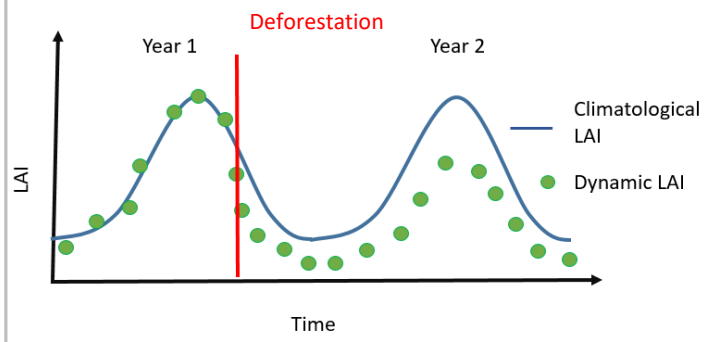
General simulation information

- Timeframe: 1992-2015
- Spatial resolution: 0.125°
- Forcing data: Merra-2 *(Reichle et al. 2017)*
- Soil data: HWSDv1.21 (*De Lannoy et al. 2014*)

Deforestation is implemented by replacing
(i) climatological vegetation data by satellite-derived dynamic vegetation data

(ii) the static land cover map by yearly updated land cover data

(i) Satellite-derived vegetation data



By replacing (blue line) climatological vegetation parameters (LAI/GFV) by (green dots) satellite-derived vegetation, the impact of deforestation is implemented in LSMs

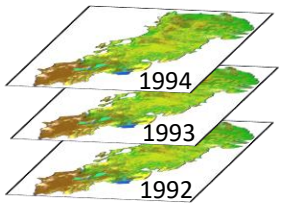
GLASS LAI

- Temporal res: 8-day
- Spatial res: 0.05°
- *Liang et al. (2013)*

GIMMS NDVI

- Temporal res: 15-day
- Spatial res: 0.083°
- Converted to Greenness Vegetation Fraction (GVF)
- *Tucker et al. (2005)*

(ii) Yearly updated land cover data



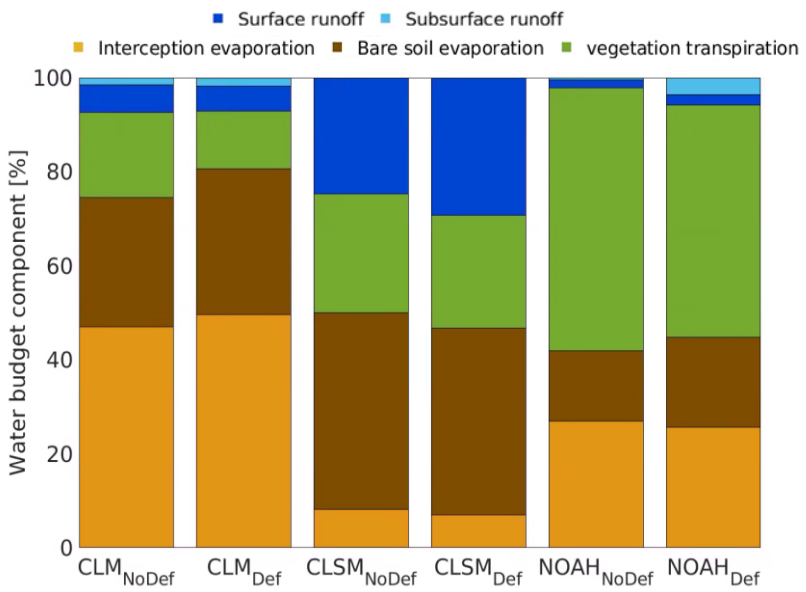
Land cover data is updated yearly in LSMs using the ESA-CCI land cover data.

ESA-CCI Land cover

- Period: 1992-2015
- Temporal res: 1 year
- Spatial res: 300 m
- *Bontemps et al. (2013)*

Results

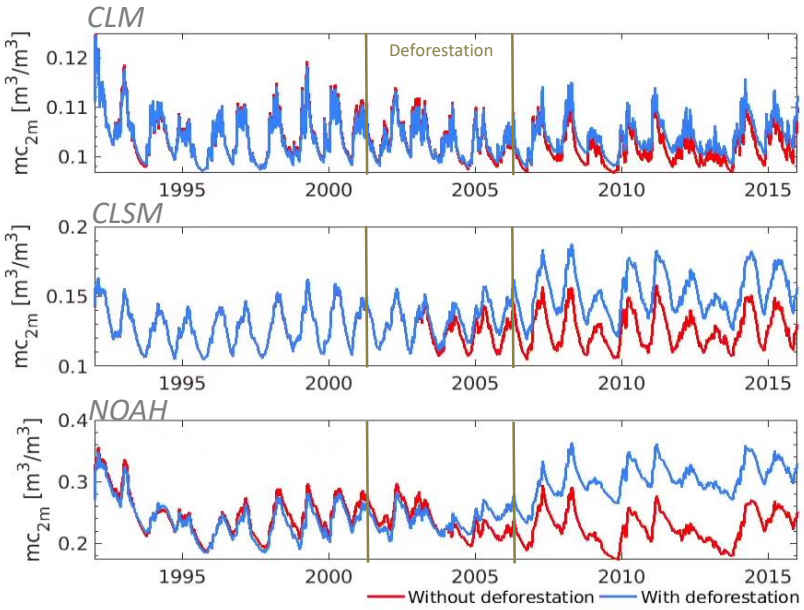
(i) Deforestation impact on hydrology



Distribution of the annual water balance for the period 2007-2015 for pixels deforested between 2002 and 2006 for simulations without (NoDef) and with (Def) implemented deforestation.

Key-message
The models yield a different initial partitioning of the water budget, whereby also the modeled impact of deforestation varies from model to model.

(ii) Deforestation impact on soil moisture

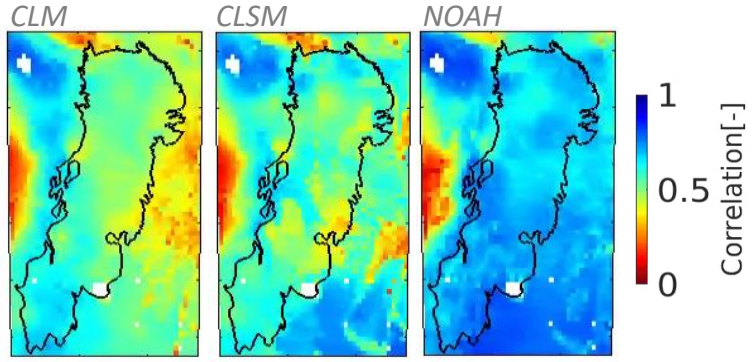


Time series of soil moisture (2m) for pixels deforested between 2002-2006 for simulations without (red) and with (blue) deforestation.

Key-message
All models indicate an increase in soil moisture after deforestation, the exact magnitude of increase is model-dependent.

(iii) Model evaluation with independent data

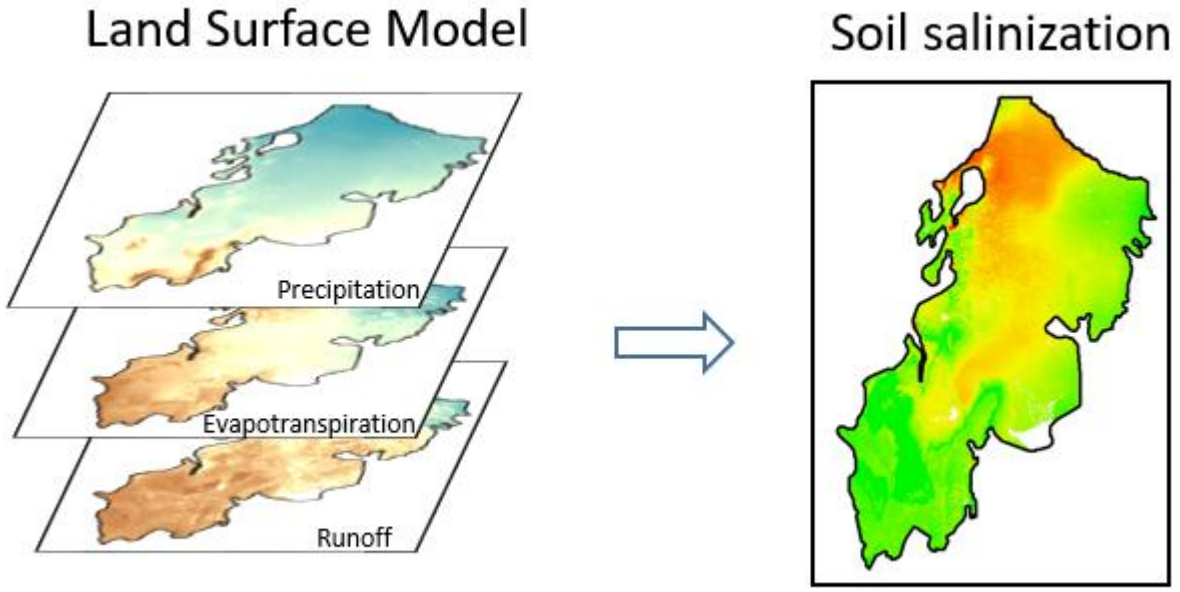
Validation data:
Precipitation: in situ data
Soil moisture: in situ data, SMOS
Evapotranspiration: GLEAM ↓



Spatial maps of the correlation coefficients [-] between GLEAM-derived and modeled evapotranspiration for the different models (period 1992-2015).

Key-message
When evaluated against GLEAM, NOAH outperforms CLM and CLSM. When compared to the other validation data, no LSM is significantly better than another.

Scope for further research



- Hydrological output from LSMs will be used to assess the risk of dryland salinization over the Argentinean Dry Chaco
- Dryland salinization occurs under specific hydrological conditions and deforestation may accelerate this process
- Our improved simulations with implemented deforestation can provide new insights in the link between deforestation, hydrological changes and salinization

References:

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