New Leaf Area Index data for CORDEX FPS-SESA WRF simulations

J. Milovac(*), K. Warrach-Sagi(**), and J. Fernandez(*)

(*)Meteorology Group. Instituto de Física de Cantabria (Universidad de Cantabria - CSIC), Santander, Spain
(**)Institute of Physics and Meteorology, University of Hohenheim, Stuttgart, Germany

http://meteo.unican.es   Contact: milovacj@unican.es

1. Introduction and motivation

Leaf area index (LAI) is an important quantity in land surface models (LSM) that characterizes phenology by accounting for the one-sided green leaf area per unit ground surface area. LAI affects net land surface radiation by modulating albedo and energy partitioning between latent and sensible heat flux. Phenology also has a direct influence on intercepting precipitation, evapotranspiration and runoff.

In atmospheric models LAI is often read through lookup tables, using extreme values or monthly climatology per land use category. As the resolution of climate models increases towards kilometer scales, LSMs are becoming more complex and a more detailed representation of the land-surface heterogeneity is becoming a prerequisite. Such more detailed LAI information can be obtained from static maps based on satellite observational data. State-of-the-art LSMs are also able to compute LAI using a dynamic vegetation model.

In the Weather Research and Forecasting **(WRF)**[1] model default **LAI maps** are based on the **MODIS** satellite-derived climatology. Simulations over European domain have shown that LAI from MODIS data exhibit unrealistically low values for croplands, especially over Germany, while the new data set available at the climate data store **(CDS)**[2], based on **SPOT** (Satellite Pour l'Observation de la Terre)[3] satellite observations, showed improvement.

2. Data and Experimental setup

LAI-SPOT global data set on CDS is available on 1 km resolution for the period between 1998 and 2014. We prepared the new LAI dataset to be readable with WRF based on **15-year (1999-2014) climatology.**

We created an experiment in which we run WRF for 3 months over FPS-SESA domain (Fig. 1) with MODIS and SPOT LAI input maps on the convection permitting scale to investigate how the change in the input LAI maps affects the final results over central South America (CSAM analysis domain, red square in Fig 1, Fig.2).

MODEL SETUP

WRF version: 4.3.3.1
Simulation period: 23.10.2018 - 01.02.2019
Forcing: ERA5
Horizontal resolution: 4km
Vertical levels: 50
LSM: NOAH-MP
PBL: MYNN 2.5
Microphysics: Thompson
Radiation: RRTMG *(Aerosols treatment included)*

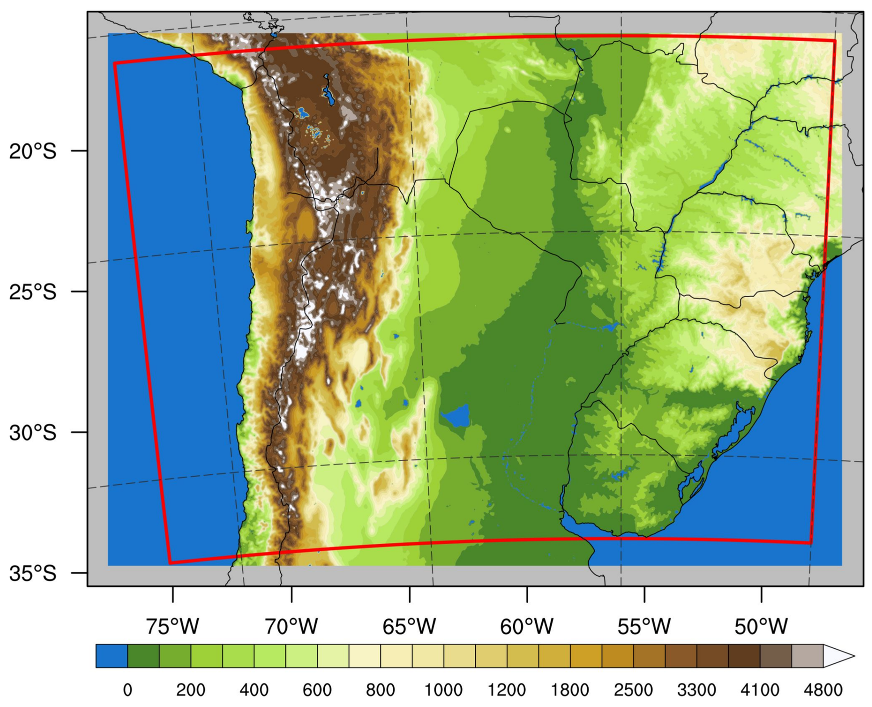

Figure 1: WRF domain of FPS-SESA simulations. The analysis CSAM domain within the red boundaries.

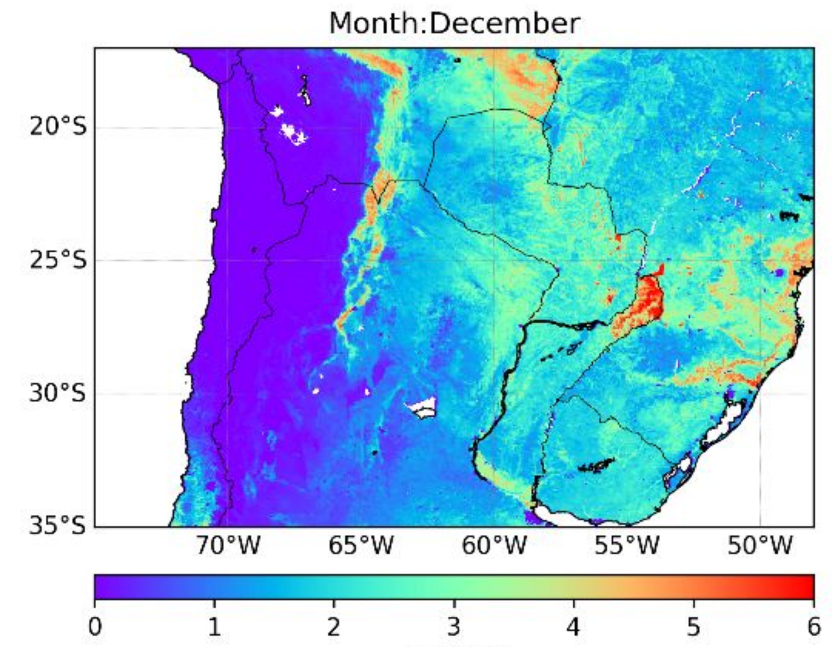

Figure 2: Monthly LAI [m2 m-2]] for December over CSAM domain, interpolated to the regular grid.

3. Spatial bias: SPOT-MODIS

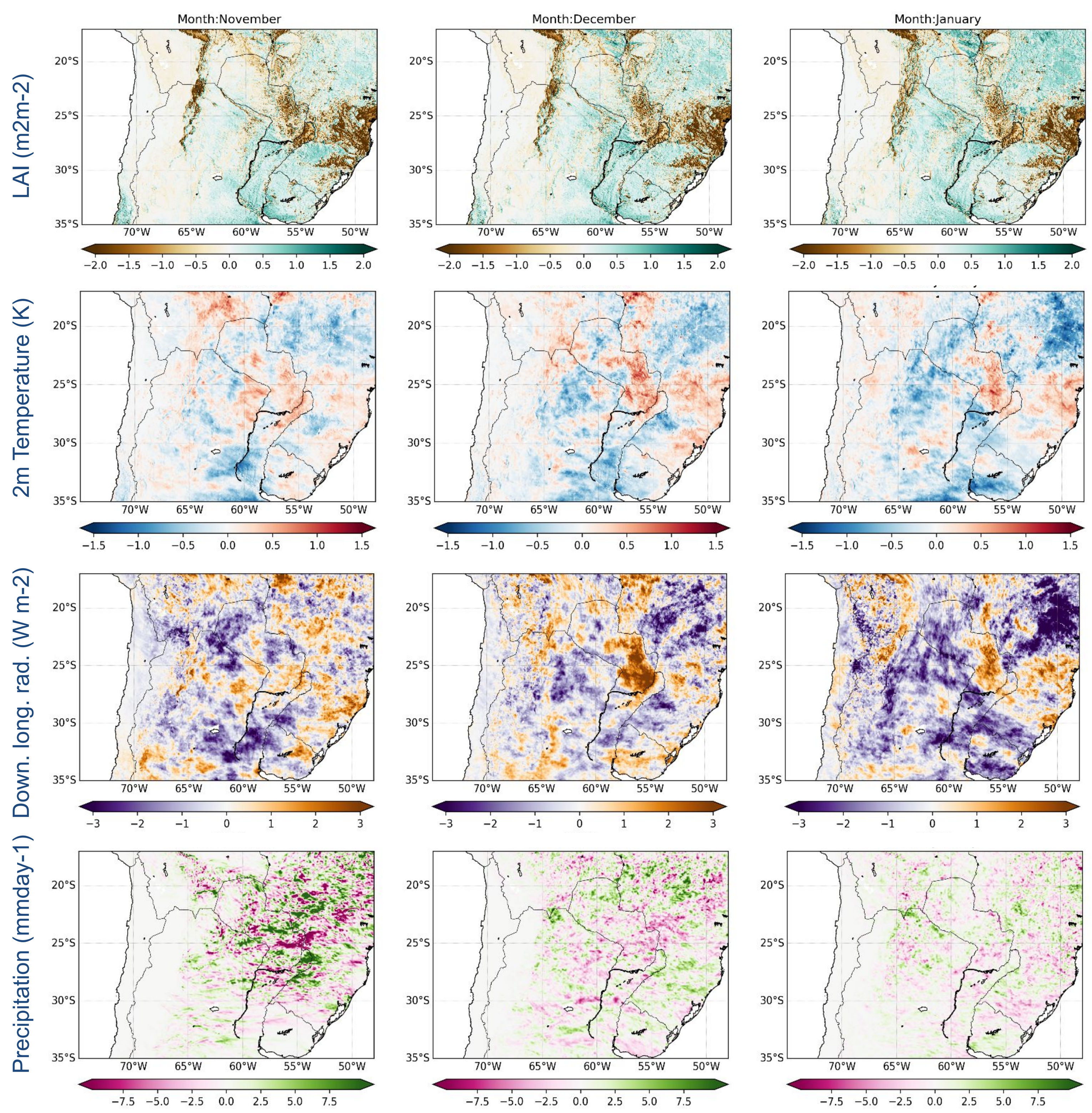

Figure 3: Monthly mean bias between SPOT and MODIS simulations of: a) LAI (raw 1), b) 2m temperature (rtas, raw 2), c) downward longwave radiation (rlds, raw 3), d) precipitation (pr, raw 4))

Spatial pattern of the **bias** between SPOT and MODIS monthly LAI (Fig 3, raw 1) fits to the pattern of the spatial bias of monthly means of surface and near surface variables (Fig 3, raw 2 and 3). Results for precipitation more noisy - no significant pattern recognised (Fig 3, raw 4).

4. Time series: SPOT, MODIS, ERA5

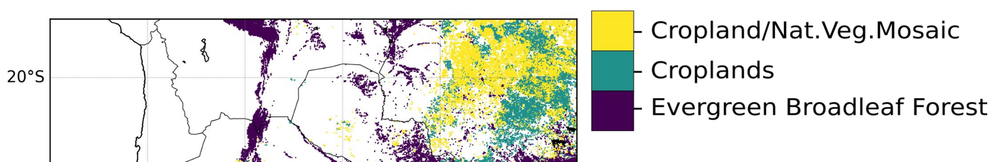

Figure 4: Land use categories which coincides with the highest differences in LAI between SPOT and MODIS source.

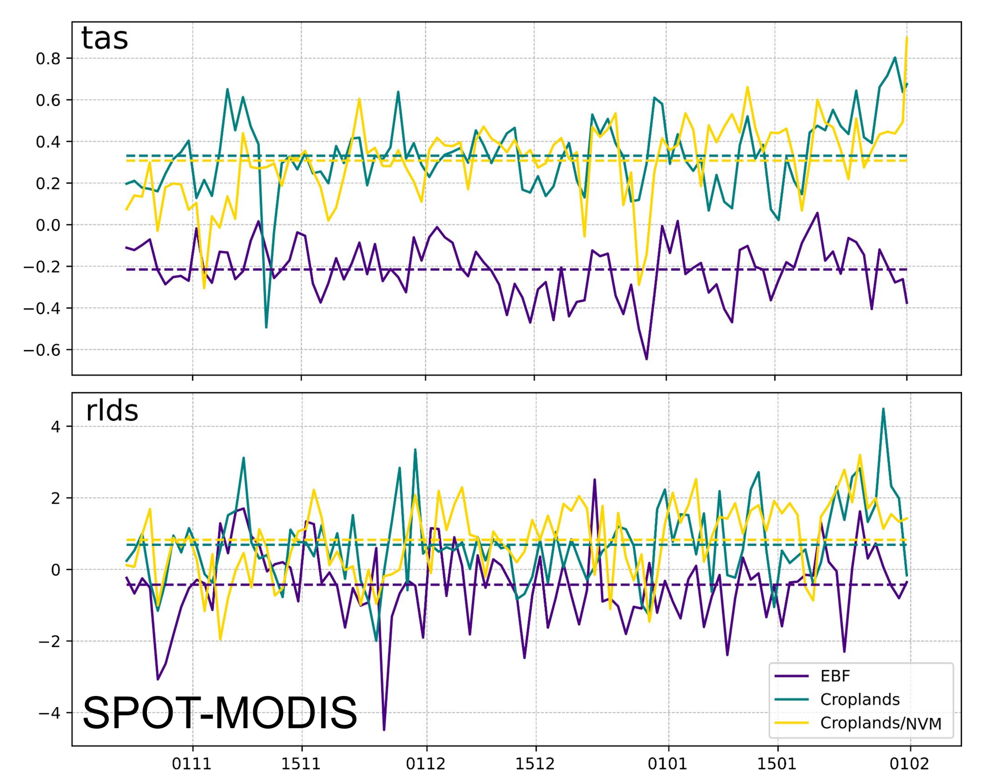

Figure 5: Time series of mean bias between SPOT and MODIS tas and rlds averaged over areas with 3 land use categories where bias in LAI is the highest. Dashed lines show time series means.

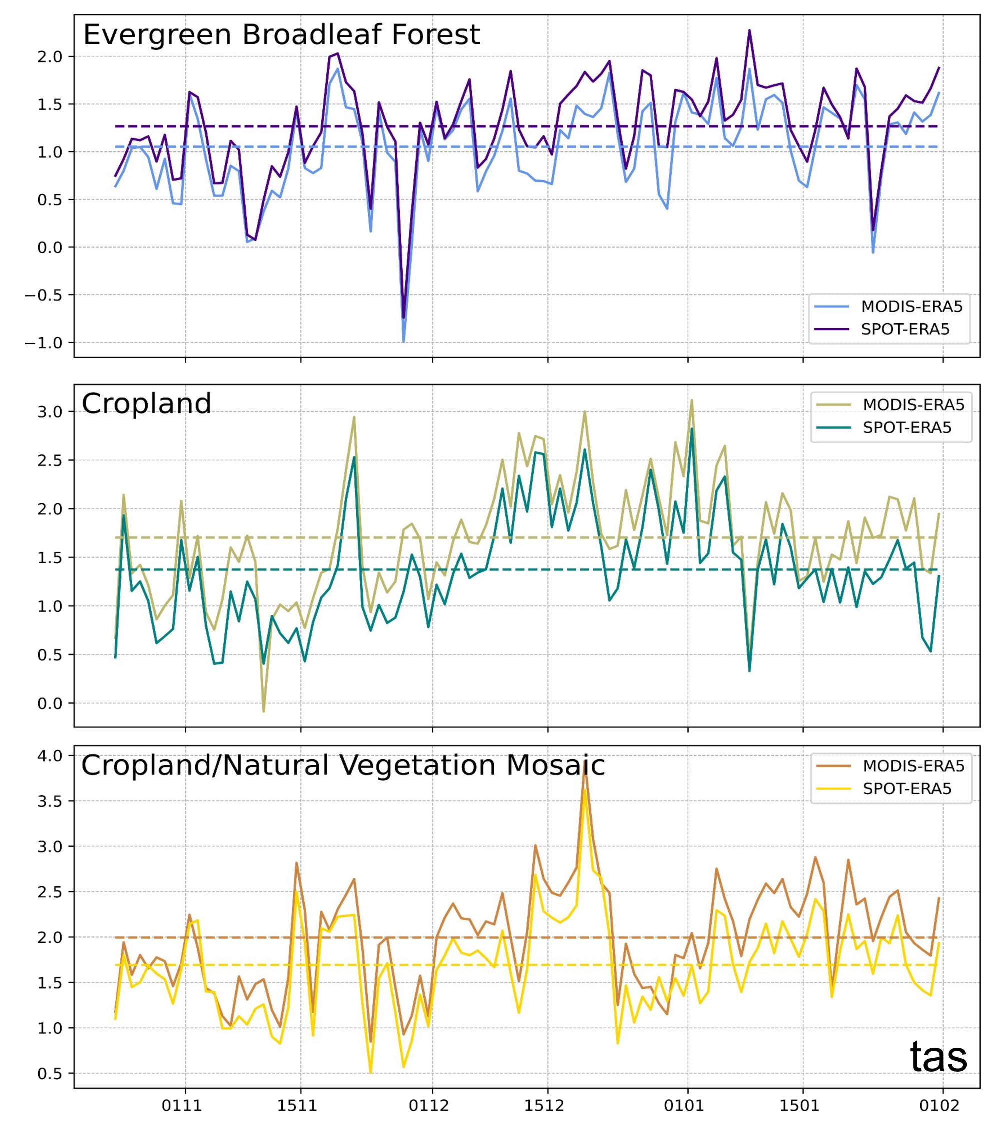

Figure 6: Time series of mean bias of tas between the simulations and ERA5 averaged of areas with EBF (top panel), croplands (middle panel), and croplands and NVM (bottom panel). Dashed lines as in Fig 4.

5. Discussion and concluding remarks

- Over Brazilian Santa Catalina and Bolivian eastern Altiplano plateau the **SPOT** data accounts for **more than 2 m2 m-2 lower LAI** than MODIS (Fig 3). This coincides with the evergreen broadleaf forest (EBF) land use (Fig 4). Notably higher values for LAI SPOT accounts over croplands and natural vegetation mosaic areas (NVM).
- Preliminary results indicate that these differences **affect near-surface variables:** decreases tas and rlds over croplands/NVM, and increases over EBF (Fig 3, Fig 5).
- In comparison with ERA5, over croplands/NVM new SPOT data decreases bias, while over the area covering EBF, the bias is notably increased for tas (Fig. 6).

References

(1)WRF:Skamarock, W. C. et al. (2019). A Description of the Advanced Research WRF Model Version 4.1 (No. NCAR/TN-556+STR). doi:10.5065/1dfh-6p97
(2)CDS: https://cds.climate.copernicus.eu/cdsapp#!/dataset/satellite-lai-fapar?tab=form
(3)SPOT: M. Buchhorn et al. (2017): Copernicus global land operations "Vegetation and Energy" CGLOPS-1, Product User Manual

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