Implementing a dynamic Leaf Area Index in the AROME-Hungary model: First steps

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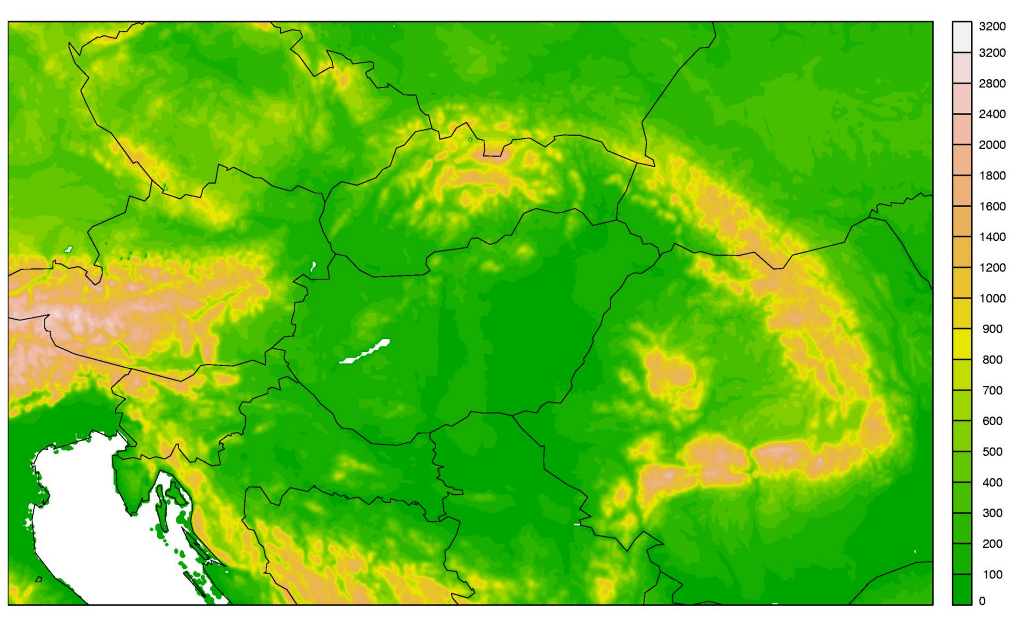
Background

OMSZ has been involved in the simulation and assimilation of vegetation properties since 2008. During two EU-funded projects (Geoland2 and ImagineS) a Land Data Assimilation System (LDAS) was applied to monitor the above-ground biomass, surface fluxes (carbon and water) and the associated root-zone soil moisture at the regional scale in quasi real time. In this system the Surfex model is used (in offline mode), which applies the ISBA-A-gs photosynthesis scheme to describe the evolution of vegetation. An Extended Kalman Filter (EKF) method is used to assimilate Leaf Area Index (LAI, from SPOT/Vegetation and Proba-V) and Soil Wetness Index (SWI, from ASCAT/Metop) satellite measurements. Simulations were compared to observations (LAI and soil moisture satellite measurements) over the whole country and also at a selected site in West Hungary (Hegyhátsál), results show that the LDAS system is capable to simulate the evolution of vegetation with an acceptable accuracy (Tóth et al., 2016).

SURFEX land surface model

The SURFEX model was used to simulate in offline-mode the Leaf Area Index over the model domain of AROME-Hungary (2.5 x 2.5 km resolution). In SURFEX each surface grid point is separated into 4 different tiles: nature, sea, lake and town, but here only the nature tile was used. The nature tile is further divided into 12 patches according to the vegetation or surface types: bare soil, rock, permanent snow, deciduous tree, coniferous tree, broadleaf evergreen tree, C3 crops, C4 crops, irrigated crops, grassland, tropical grassland, parks and gardens. The nature tile is simulated with **ISBA** (Interaction between Soil, Biosphere and Atmosphere) scheme, which contains a photosynthesis model, **ISBA-A-gs**. This model is suitable to describe the evolution of the vegetation. The biomass is a prognostic variable. Growing of biomass is due to photosynthesis (CO_2 assimilation) while the decline can be due to soil moisture stress or senescence. The model takes into account the soil moisture stress in the photosynthesis.

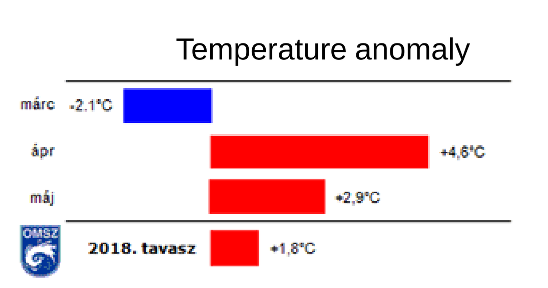
The ISBA 3-layer soil scheme is used (surface 0-1 cm, root zone 0-2 m and deep soil 2-3 m). The soil prognostic variables (temperature, water content and intercepted water content) are calculated with the force-restore method.

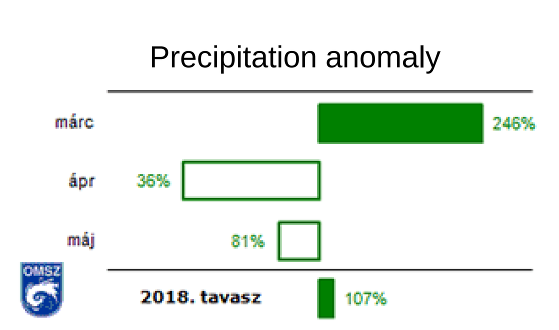


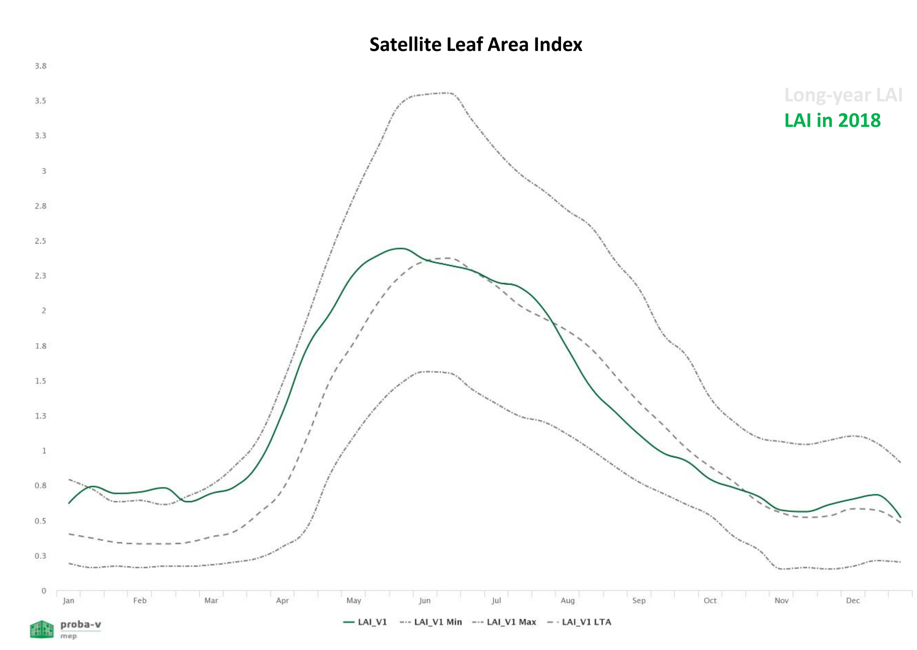
Domain and orography of the operational AROME-Hungary model.

Case study – Spring 2018

The selected time interval was February until May 2018. This period was characterized by a wet and cold March followed by dry and very hot April and May. This resulted in a very quick growth of the vegetation during April and May, producing LAI values well above the long term mean.







Yearly evolution of the observed Leaf Area Index (LAI) over non-irrigated croplands in Hungary. Data derived from the Proba-V satellite (visualization with Proba-V MEP). Grey lines: minimum, maximum and mean over the period 1999-2013; green line: year 2018.

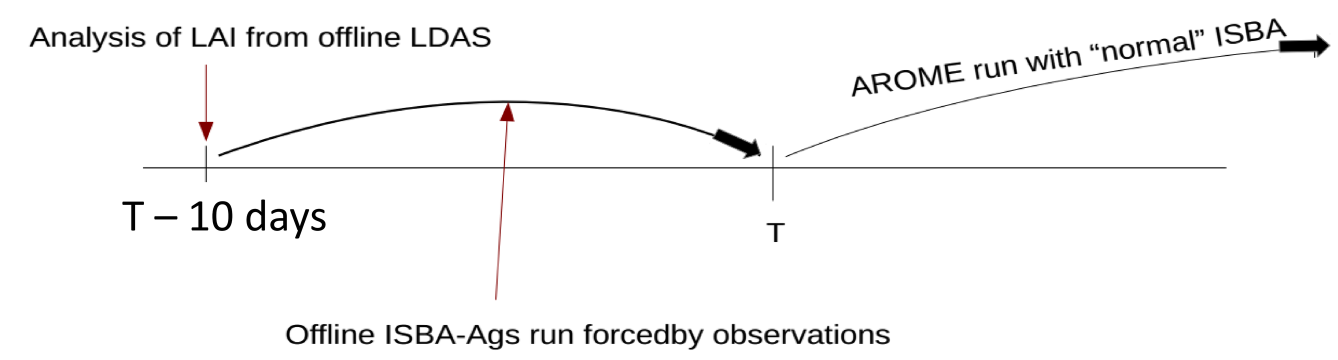
SURFEX_v8.1 offline was run in "open loop" mode, i.e. without data assimilation using atmospheric forcings derived from AROME forecasts. The run was started in February using climatological LAI values and then vegetation was computed prognostically until the end of May.

Reference

Tóth, H., Szintai, B., Kullmann, L., 2016: Biomass and Soil Moisture simulation and assimilation over Hungary in the framework of ImagineS project. ALADIN-HIRLAM Newsletter No. 7, 58-64.

Dynamic vegetation in AROME-Hungary

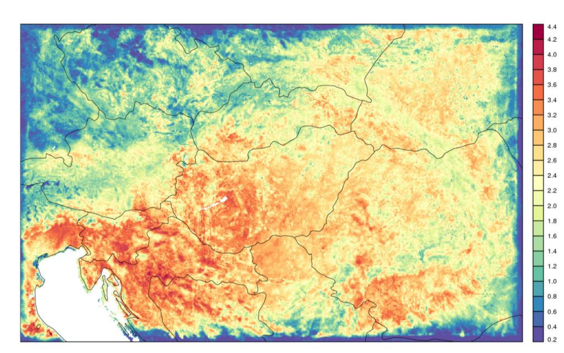
In current state-of-the-art NWP models LAI is considered as an external parameter where monthly values are derived from long-term averages. Such an approach is not capable of describing vegetation anomalies e.g. during severe droughts, when LAI values (especially over non-irrigated grasslands and croplands) could be considerably lower than long-year averages of the selected month. A solution for this inaccuracy could be to implement satellite observed vegetation parameters in the NWP model. The main difficulty with such an approach is that high resolution (e.g. that of Proba-V) satellite vegetation products have a time lag of 10 days. To overcome this the following is planned: satellite vegetation observations are assimilated in an offline land data assimilation system which is capable to deliver a soil and vegetation state analysis 10 days prior the actual date (T-10d). From T-10d we integrate the offline surface model with prognostic vegetation until the current date; and the resulting vegetation state (at time T) could be merged with the operational analyses of AROME.



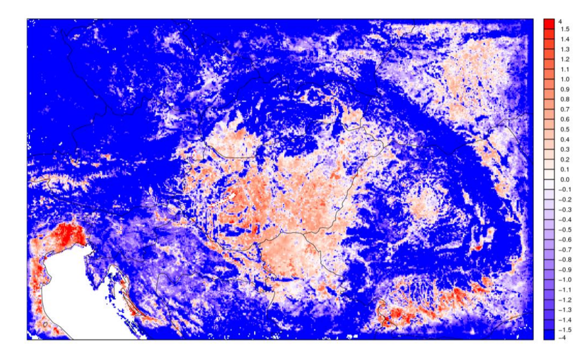
Results

Results are shown from the "open loop" run of SURFEX ISBA-Ags at the end of the period on 31 May 2018.

Patch-averaged LAI

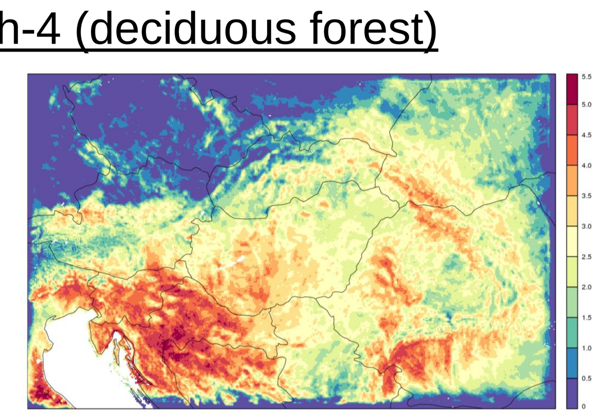


LAI values on 31 May 2018 computed by the Open-loop run of Surfex ISBA-Ags

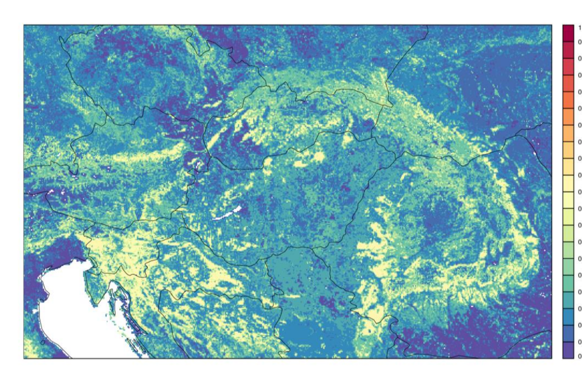


Difference from the LAI from the climatology file

Patch-4 (deciduous forest)

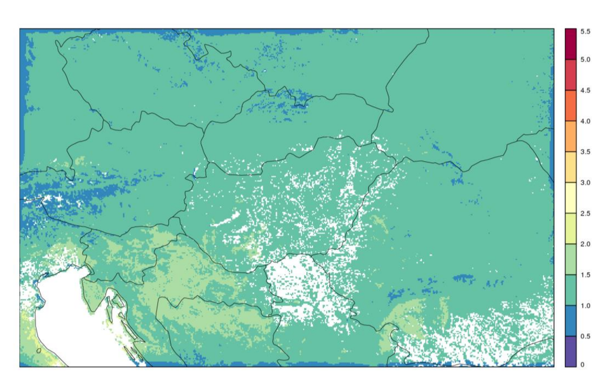


LAI values on 31 May 2018 on patch-4

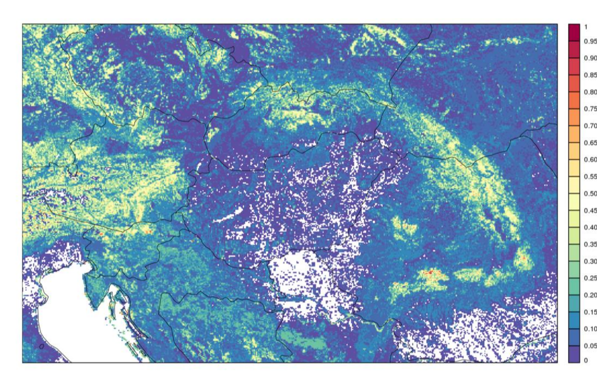


Patch-fraction of patch-4

Patch-5 (needleleaf forest)

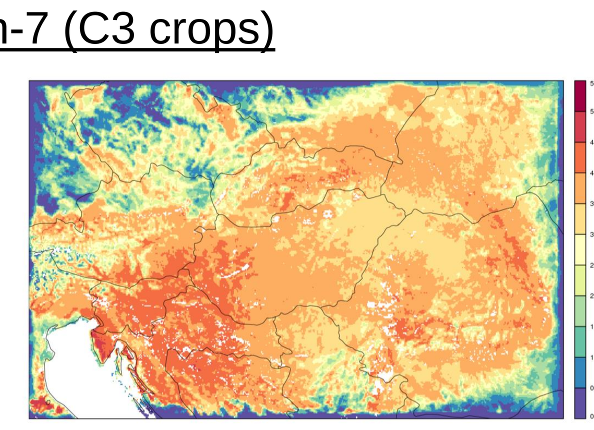


LAI values on 31 May 2018 on patch-5

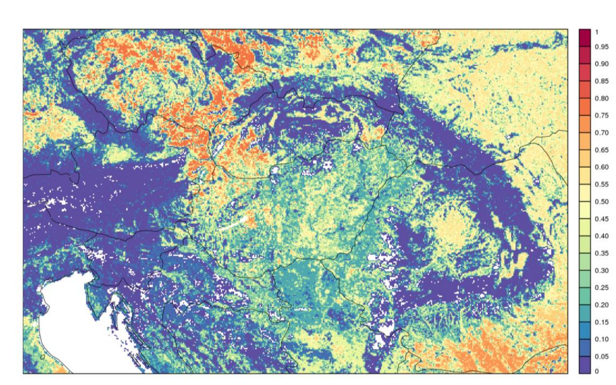


Patch-fraction of patch-5

Patch-7 (C3 crops)



LAI values on 31 May 2018 on patch-7



Patch-fraction of patch-7

Over non-irrigated croplands ISBA-A-gs gives higher LAI values than the climatology file, which is realistic for the selected period. For areas covered with forests LAI values from ISBA-A-gs are considerably lower than in the climatology. This behaviour is rather unrealistic and will be investigated in future.

Plans

In near future the following steps are planned with the aim of introducing a daily updated LAI in the operational AROME model at OMSZ: (1) assimilating LAI and SWI satellite observations in SURFEX offline; (2) using atmospheric forcings computed from interpolated measurements (synop and Radar); (3) running longer time periods with AROME with the daily updated LAI obtained from SURFEX offline.