Biomass and Soil Moisture simulation and assimilation in Hungary in the framework of ImagineS project

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Outline

- ImagineS project (2012-2016)
- Surfex and LDAS (Land Data Assimilation System)
  - ISBA-A-gs in SURFEX
  - Data assimilation: Extended Kalman Filter
- Validation
  - 1D (against in-situ measurements from Hegyhátsál)
  - 2D (against satellite data)
  - Agricultural utilization
  - Drought indicators

ImagineS

- Implementation of Multi-scale Agricultural Indicators Exploiting Sentinels
- EU-FP7 project: http://fp7-imagines.eu
- Period: 40 month (Nov. 2012. – June 2016.)
- 8 Institutions (Fr, Sp, Be, UK, Hu), From this 2 SME
- Aims:
  - Improve the retrieval of basic biophysical variables coming from PROBA-V and LandSat-8 for Copernicus Global Land Service.
  - Assimilation of these satellite data into Surface model → monitoring of the evolution of the vegetation and the soil.
  - Demonstrate the added value of this products for the community of users

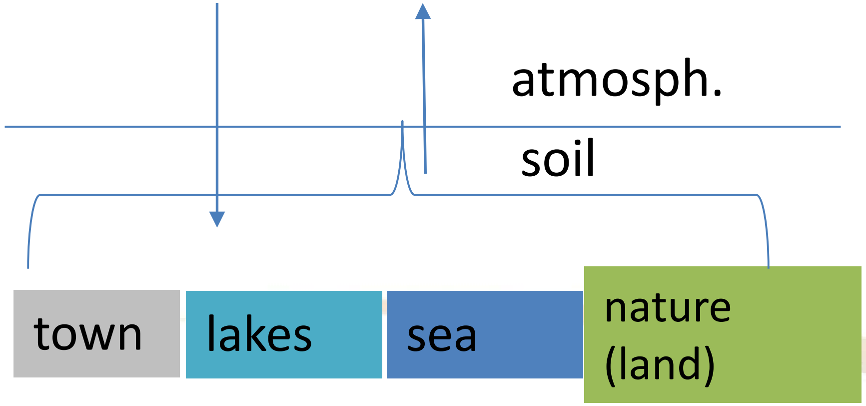
Surfex model

- **SURFEX (SURface EXternalisée) 7.3**

Surfex :

- Soil-Vegetation (ISBA)
- Town (TEB)
- Lakes, Sea, Sea ice
- Surfeca Boundary Layer (SBL)

Atmospheric forcings (u,v,T,q,P, rad.)



- Runs only over nature tile
- Nature tile is separated 12 patches (grassland, C3, C4 plants , deciduous tree …. etc)

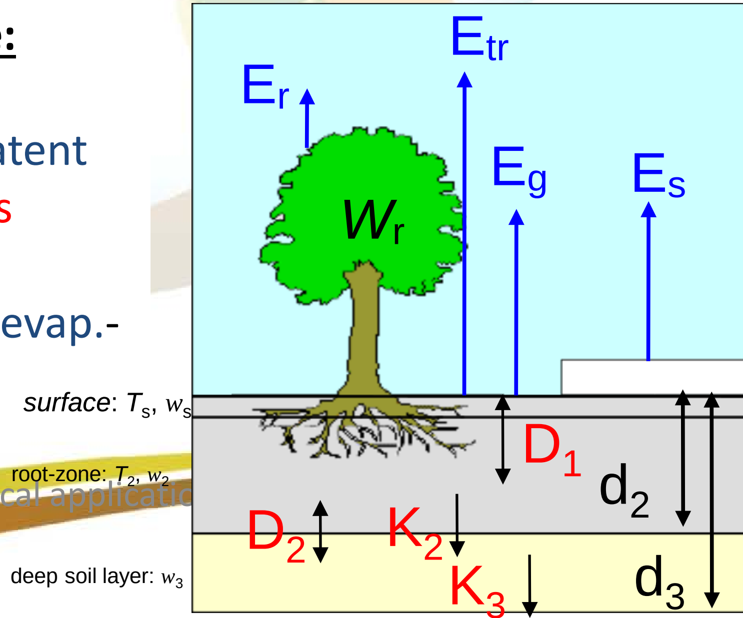
ECOCLIMAP II

- Soil processes with ISBA scheme + photosynthesis model - > ISBA-A-gs (3-layer Force-Restore scheme)
- Prognostic eq. for the evolution of T, w, intercepted w
- Evolution of the vegetation (photosynthesis ⇔ mortality)

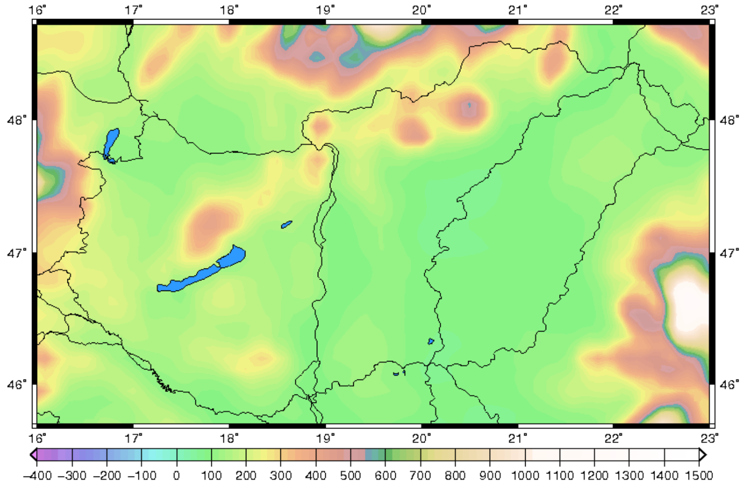
ISBA Force – Restore scheme:

Temp. change=net radiation-latent and sensible heat – towards its mean value

Soil Moisture change=precip.-evap.-diffusion-drain



• Surfex was run over Hungary with 8 x 8 km resolution, 24 h forecast with 6 h outputs freq.
• Atmospheric forcings come from ALADIN NWP model (air temperature, humidity, wind speed, precipitation) + LandSAF long and short wave radiation
• Run with offline mode -> no influence to the atmosphere



OUTPUTS:

- LAI (Leaf Area Index)
- WG2 (Volumetric soil moisture content)
- GPP (Gross Primary Product), NEE (Net Ecosystem Exchange)
- ETR (Evapotranspiration), LE (Latent Heat Flux)

VALIDATION:

- 1D (against in situ measurements of Hegyhátsál)
- 2D (against satellite)
- agricultural utilization: simm. biomass vs. yield statistics (National measurements, WOFOST crop model)

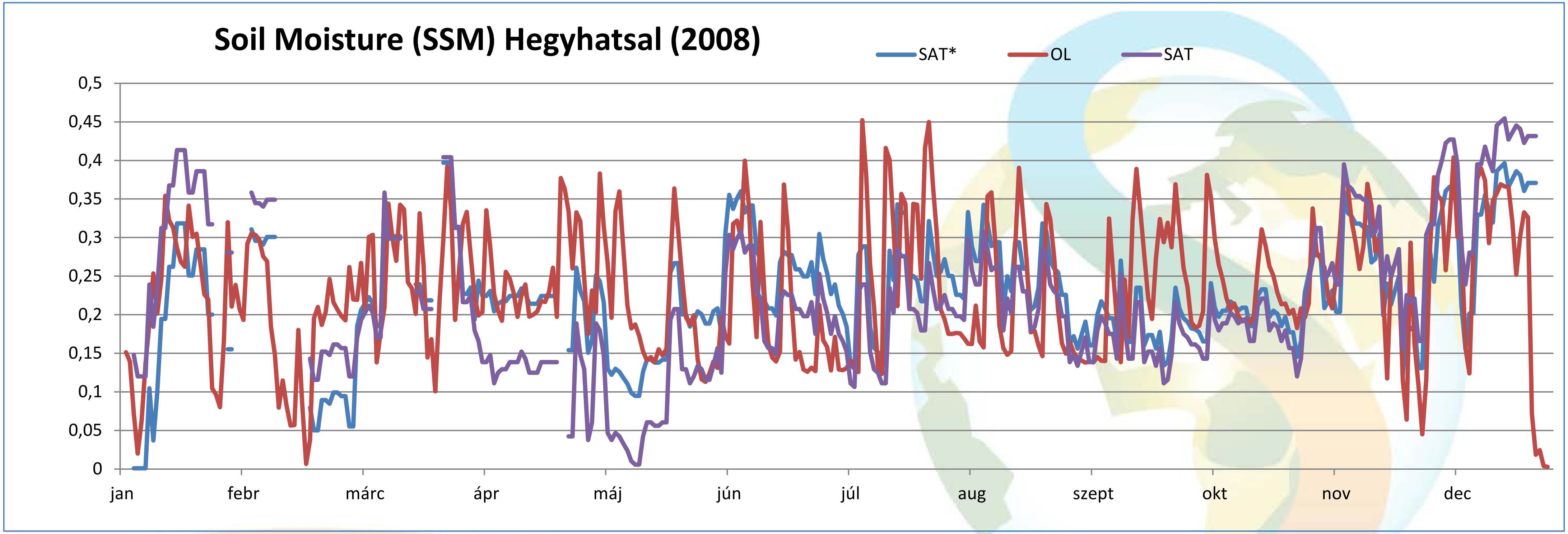
Data assimilation in SURFEX

- **Improve the accuracy of initial fields: LAI and Soil Moisture satellite obs. are assimilated (downloaded from http://land.copernicus.eu/)**
  - LAI: SPOT-VEG (till may 2014) and PROBA-V (from may 2014) 1km res. 10 days sampling.
  - SWI (Soil Water Index) [0,1]: MetOp. ASCAT 10 km res. 1 day sampling. SSM=SWI*(w_{max}-w_{min})+w_{min} W_{max} and W_{min} derived from the model climatology

- ASCAT SSM and model climatology SSM have different BIAS, interannual variability => ASCAT SSM need to rescaled by **CDF matching technique** (removes differences between satellite observations and model data by ensuring statistical consistency)

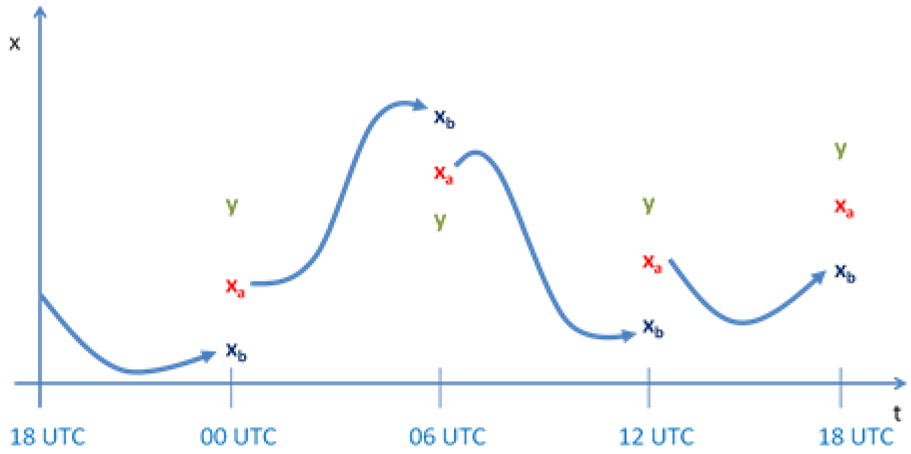
Linear matching:

$$SSM'_{sat} = p_1 + p_2 \cdot SSM_{sat} \quad \text{where} \quad p_1 = \overline{SSM}_{mod} - p_2 \cdot \overline{SSM}_{sat} \qquad p_2 = \frac{stdev(SSM_{mod})}{stdev(SSM_{sat})}$$


Soil Moisture (SSM) Hegyhatsal (2008)
SAT*
OL
SAT
0,5
0,45
0,4
0,35
0,3
0,25
0,2
0,15
0,1
0,05
0
jan
febr
márc
ápr
máj
jún
júl
aug
szept
okt
nov
dec

EKF assimilation

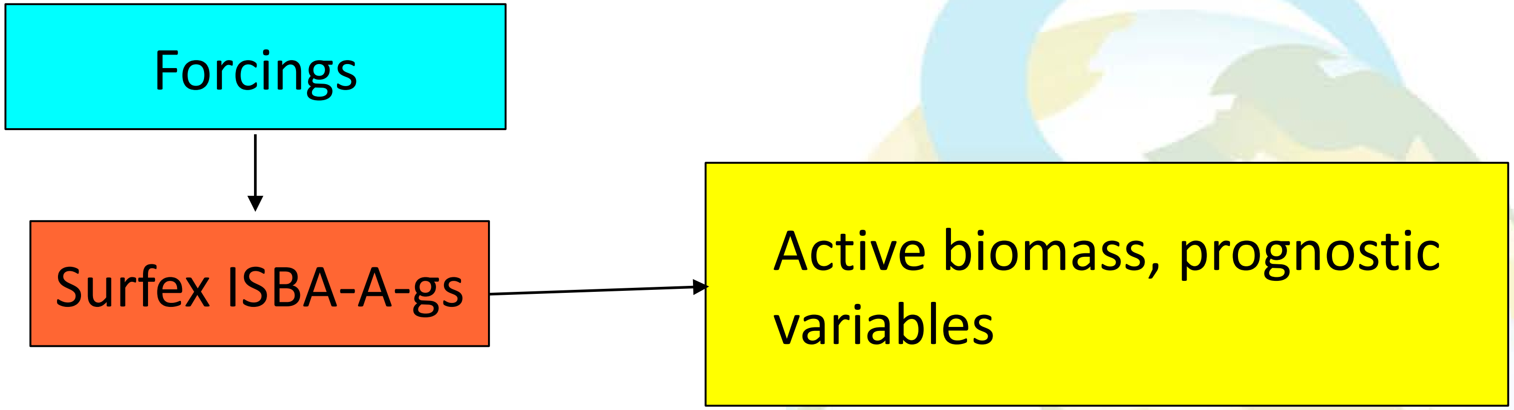
- Goal: improve the initial fields => Data assimilation
- In data assimilation the satellite obs. are consider (LAI, SSM) + background (earlier forecast) + dinamics of the atmosphere.
- To produce analyis (LAI, WG1, WG2) at the initial time as close as possible to the obs.



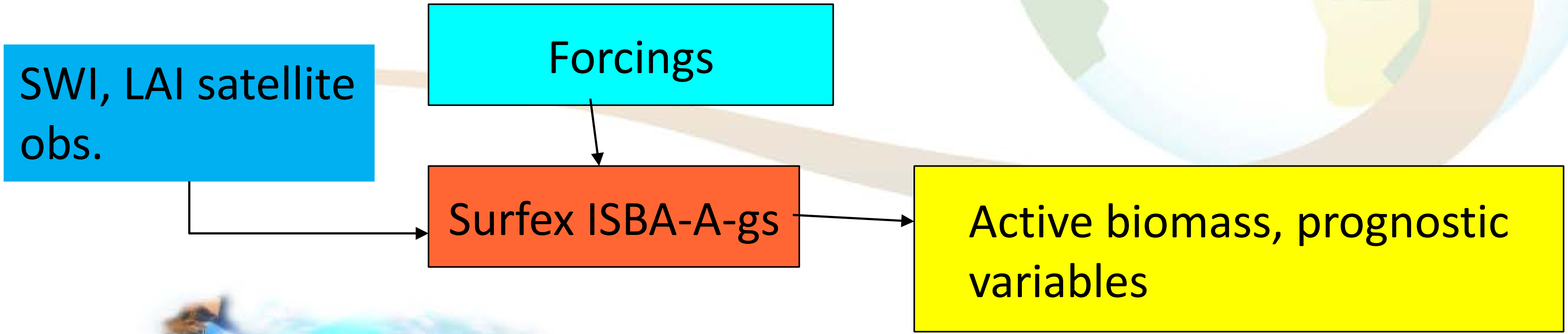
Assimilation technic: **Extended Kalman Filter (EKF)**

Model runs

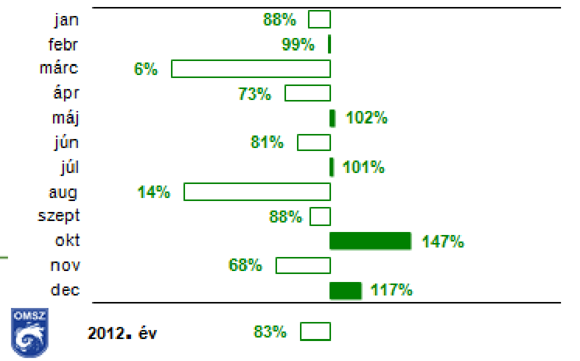
- Surfex run **without data assimilation** for 2008-2015 (Openloop)



- Surfex run **with data assimilation** for 2008-2015



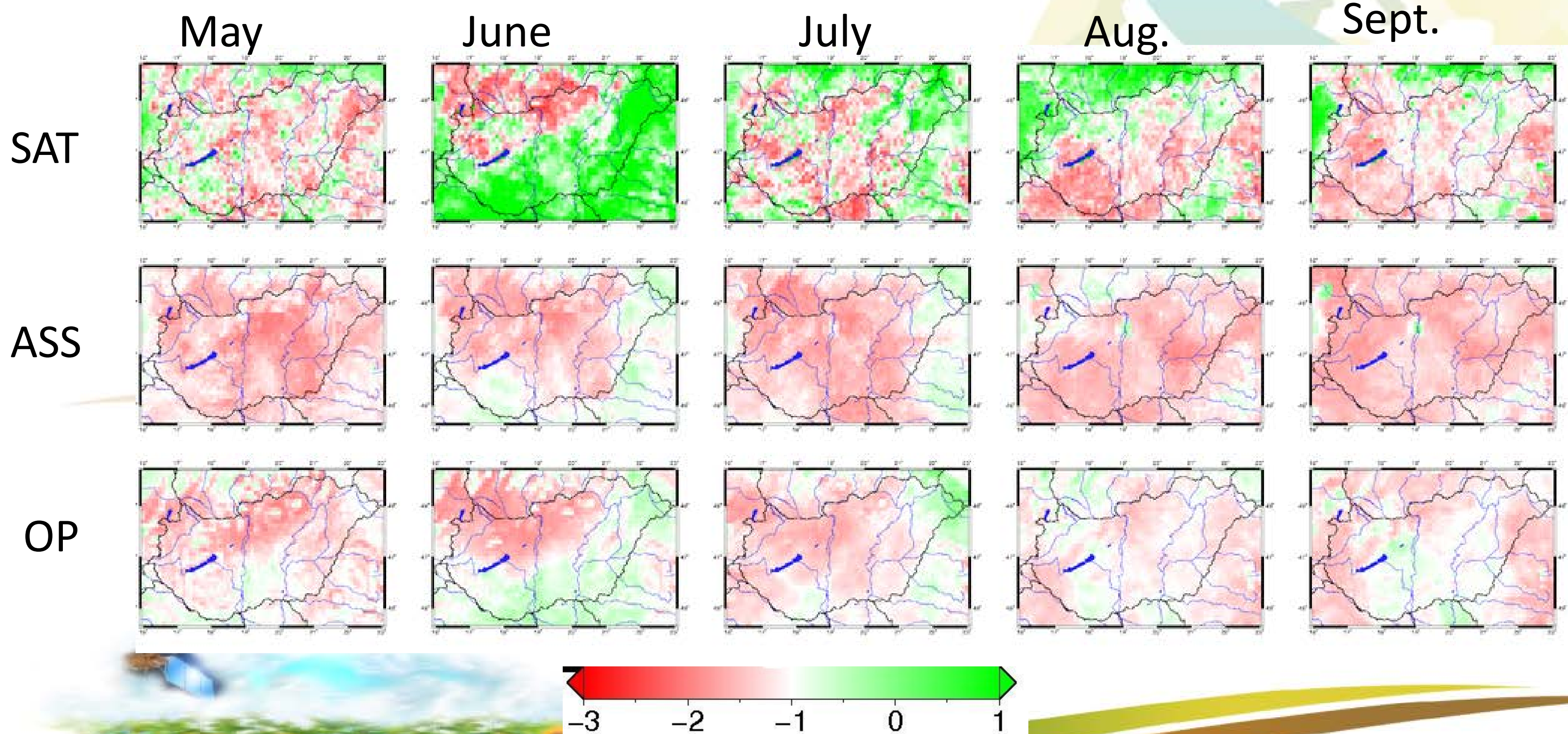
RESULTS (2D)



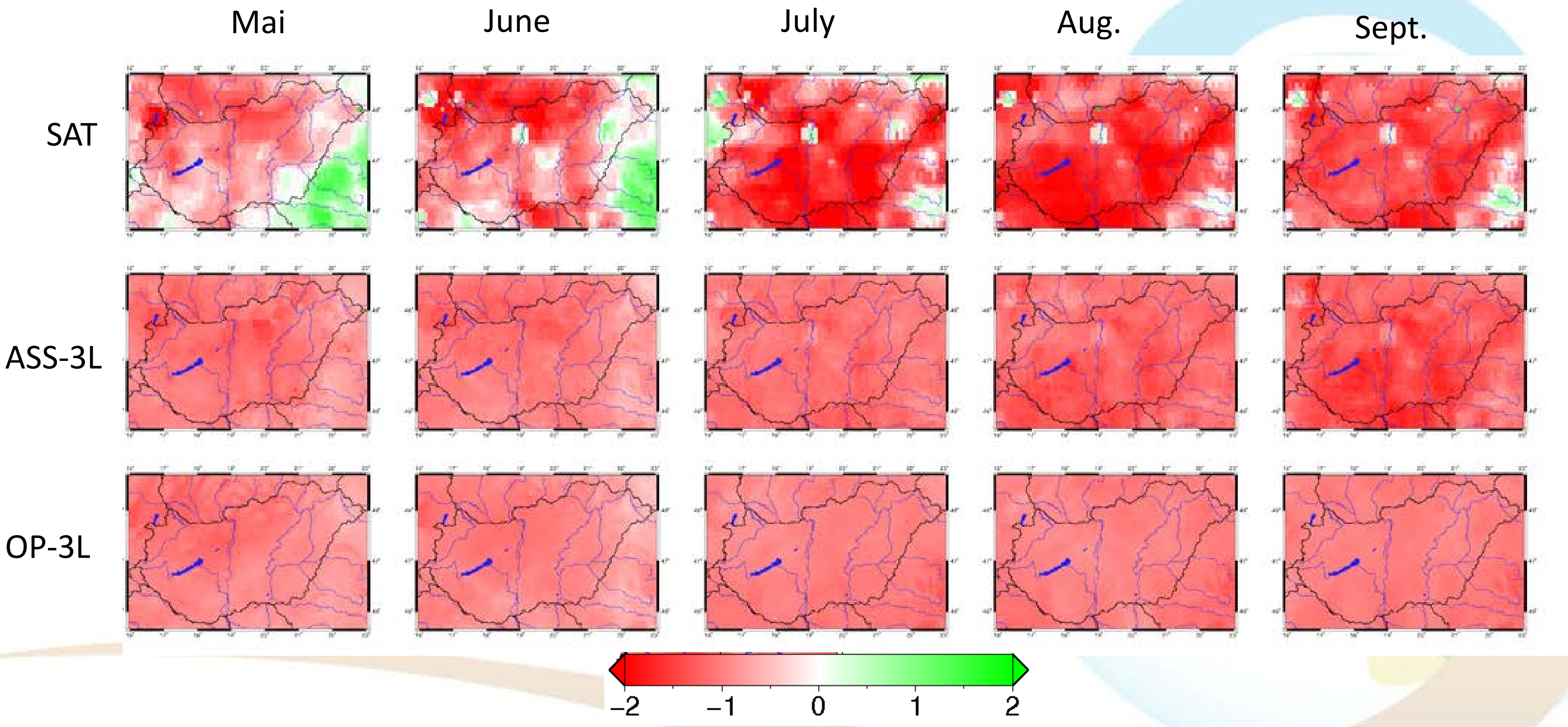
- Openloop offline run 2008-2015
- Assimilation run 2008-2015

$$AnoX = \frac{X - \langle X \rangle}{stdev(X)}$$

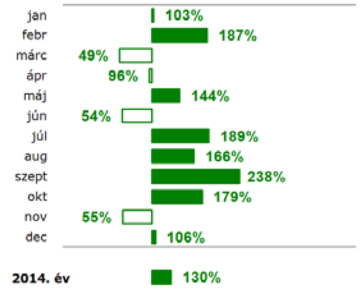
Inter-annual variability of LAI for 2012 (extreme dry)

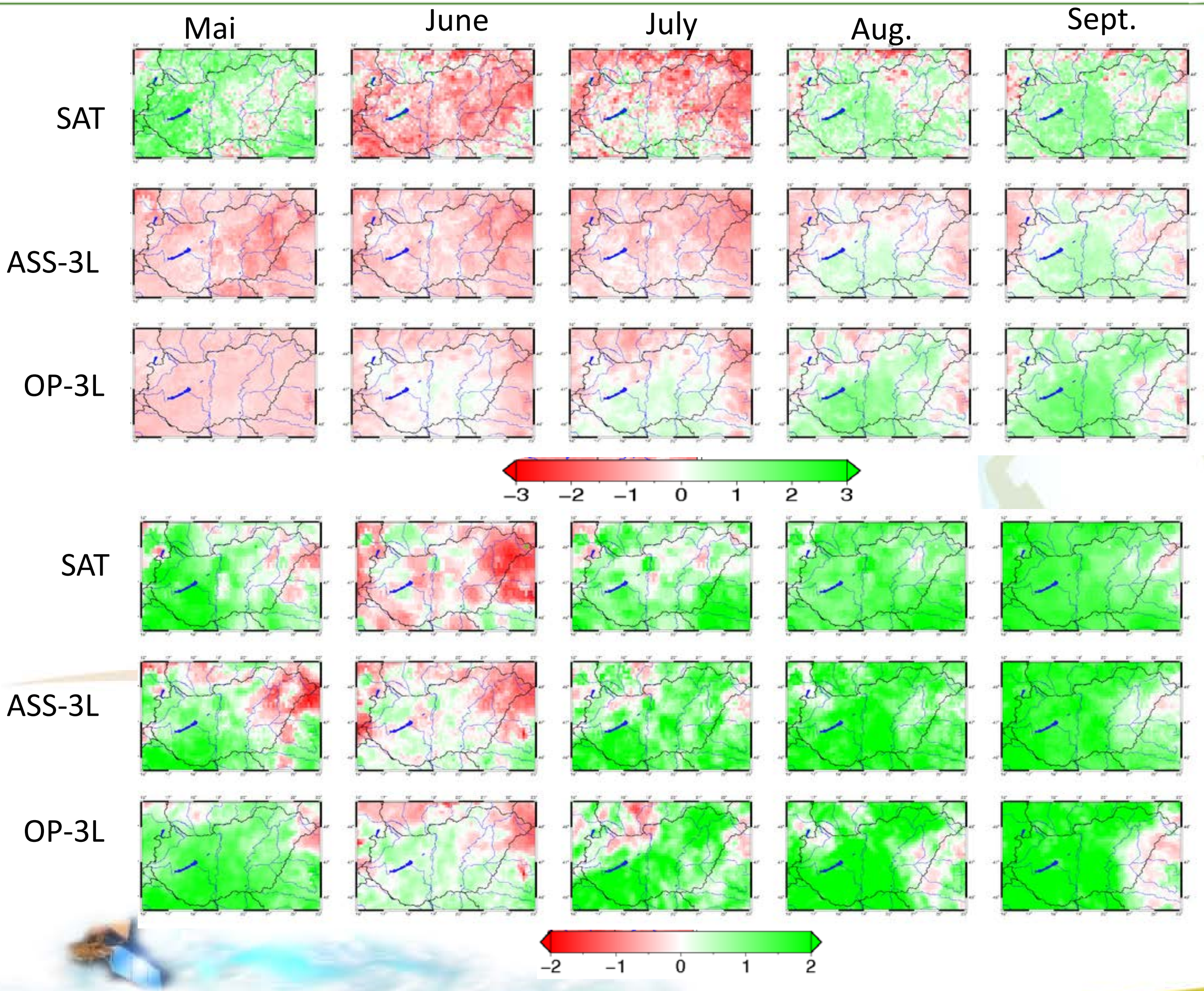


Root-zone soil moisture anomalies in 2012 (AnoWG2 (models) and AnoSWI10 (satellite))



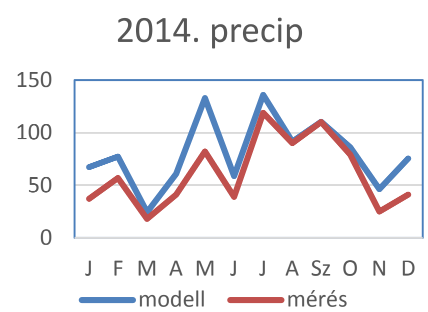
LAI soil moisture anomalies in 2014 (very moist year)



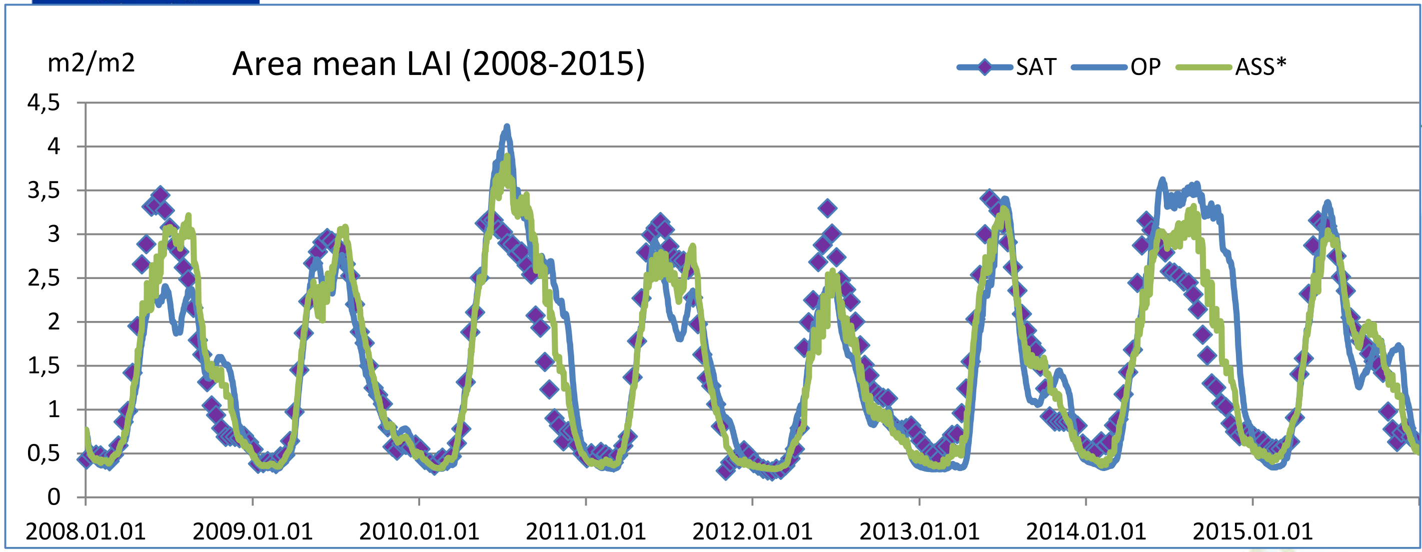


AnoLAI

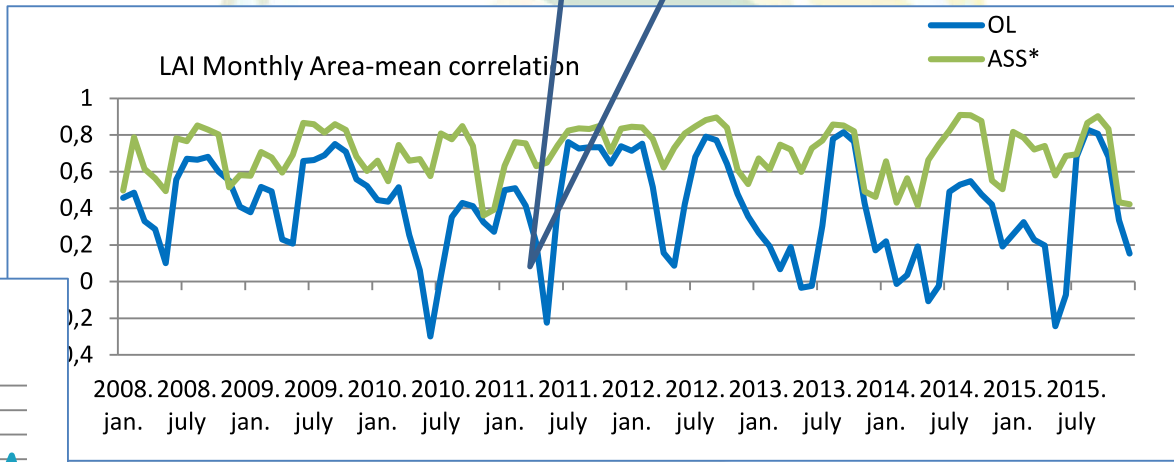
AnoSWI10 / AnoWG2

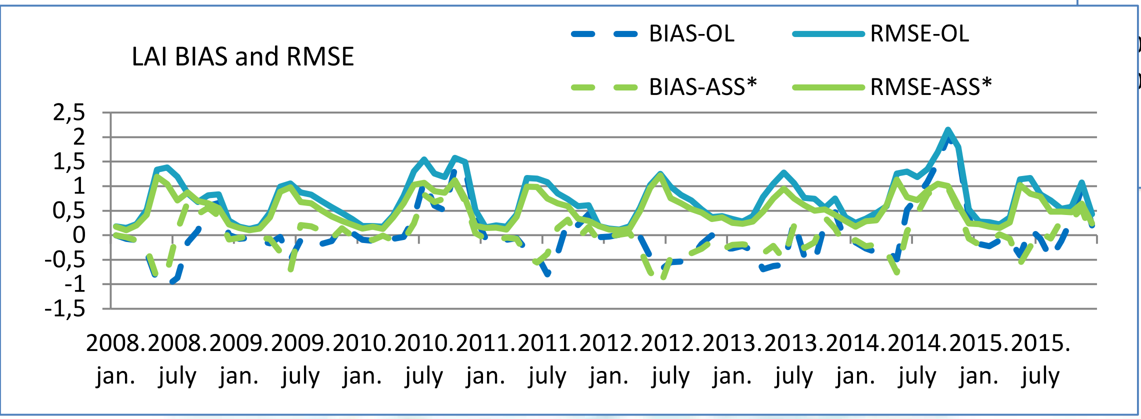


Statistics (LAI)



Low correlation for OL runs at every spring, early summer period

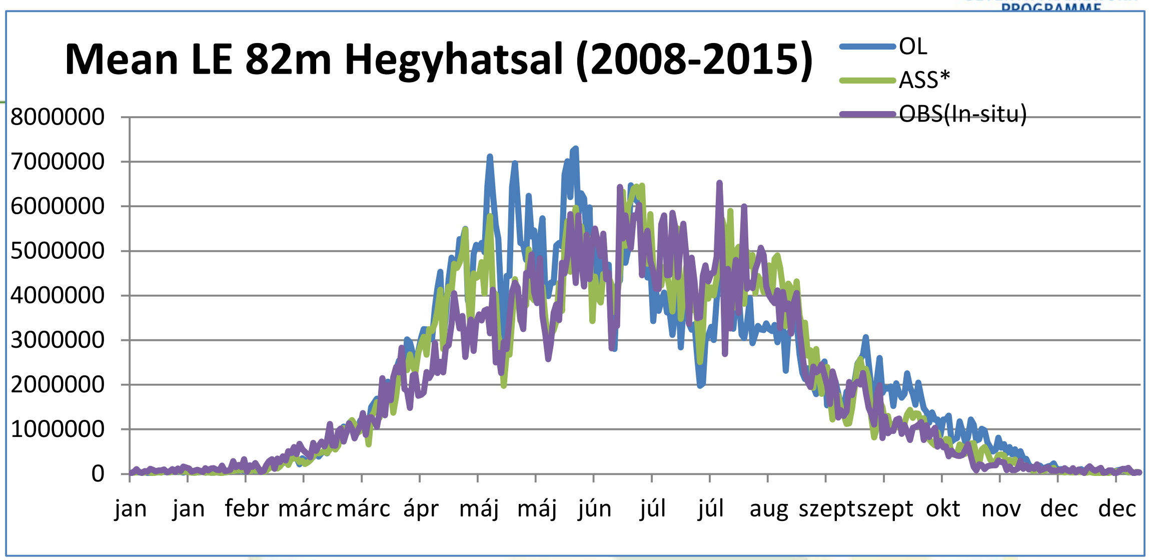


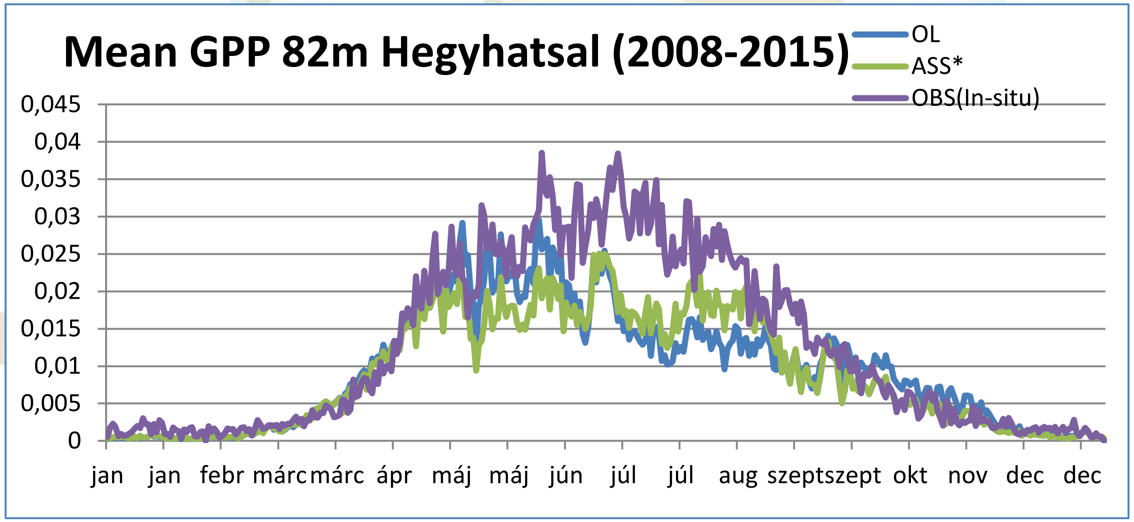


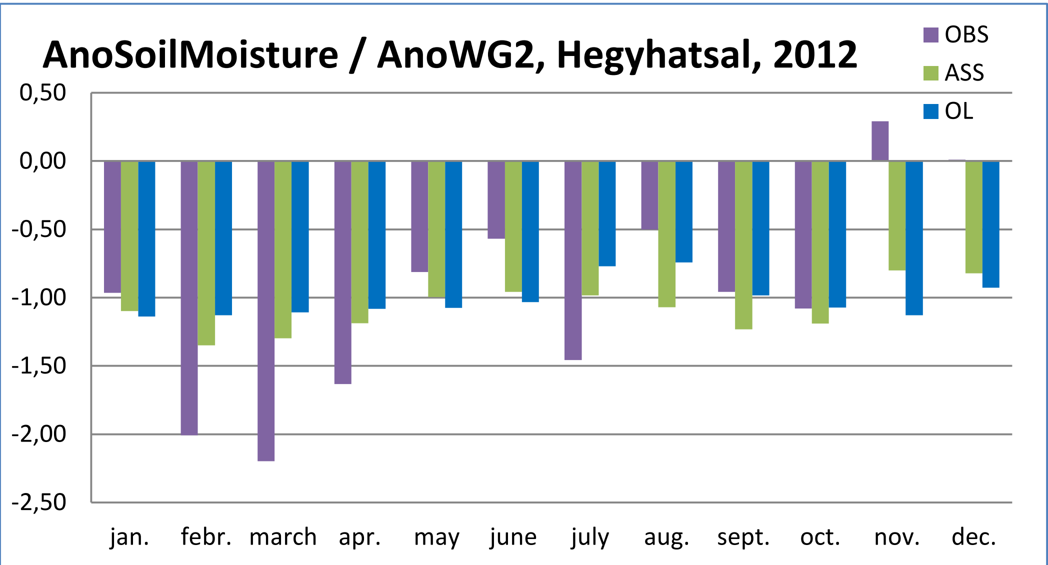
Results (1D)

In-situ measurements of Hegyhátsál. Data are available from two levels:

- 3 m height over a grassland area (valid for only the grassland patch):
  - -LAI (weekly)
  - -Soil Moisture (daily) (derived from 10-30 cm depth)
  - -Carbon fluxes: GPP, Reco and NEE (daily)
  - -Water flux: Latent Heat (LE) (daily)
- 82 m height (valid for the whole grid-point):
  - -Carbon fluxes: GPP and NEE (daily)
  - -Water flux: LE (daily)

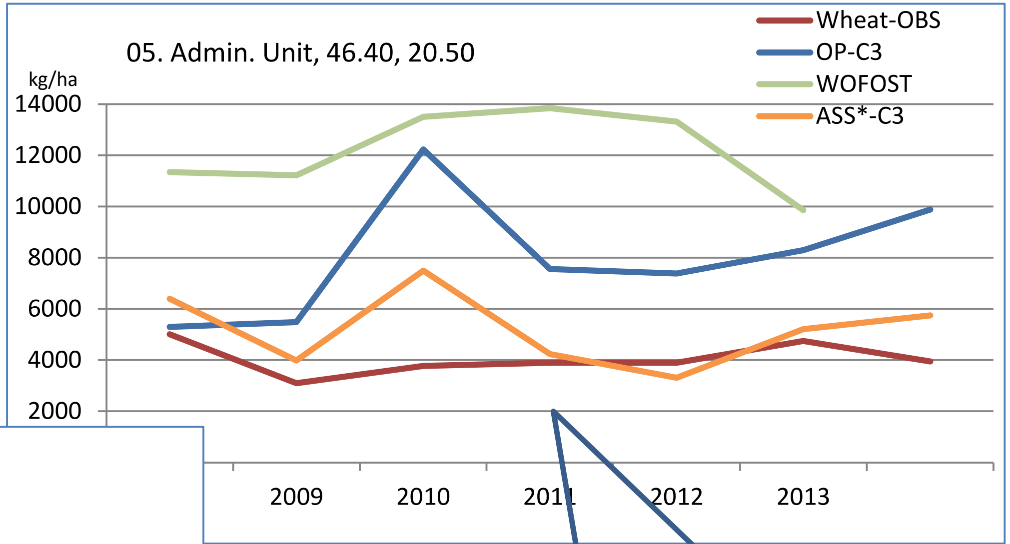


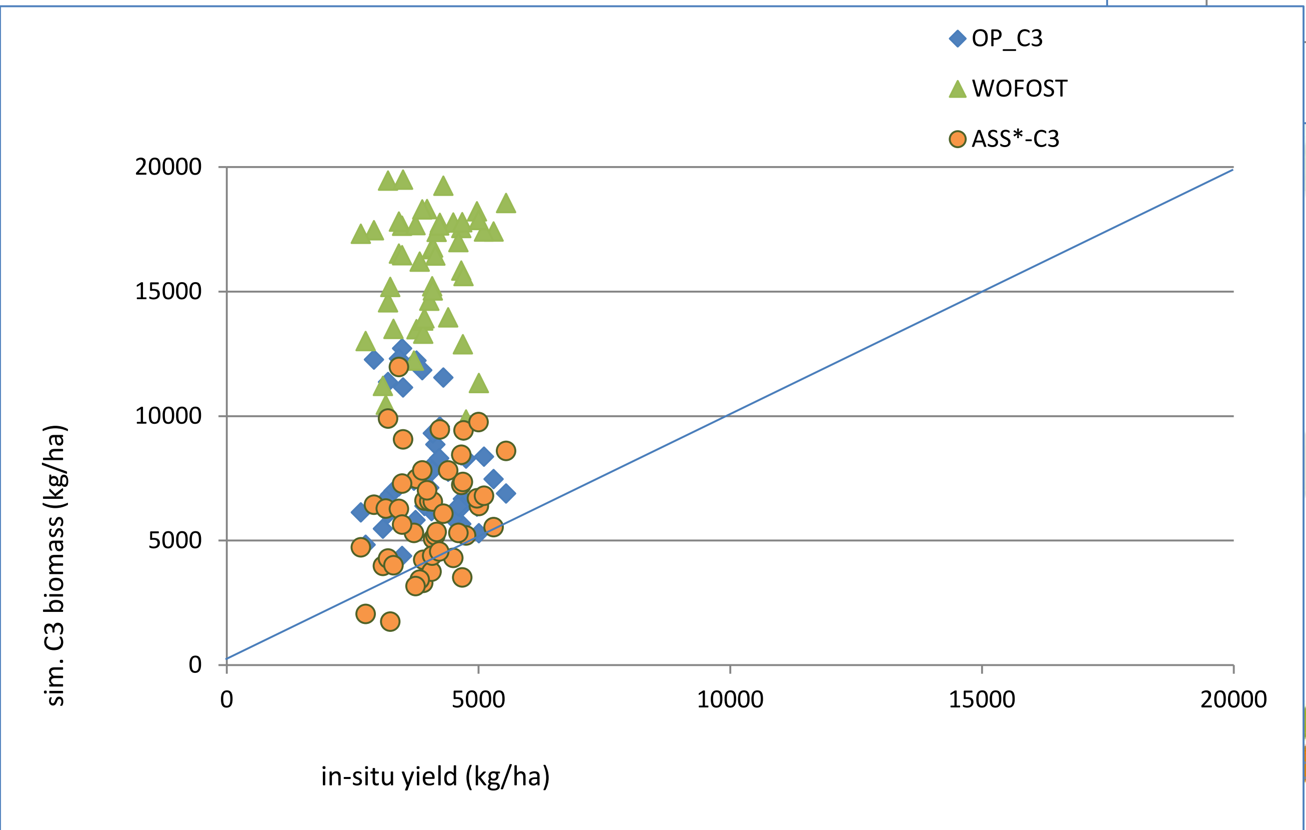




Crop estimation

Simulated C3 BIOMASS vs. measured yield and vs. WOFOST for 2008-2013



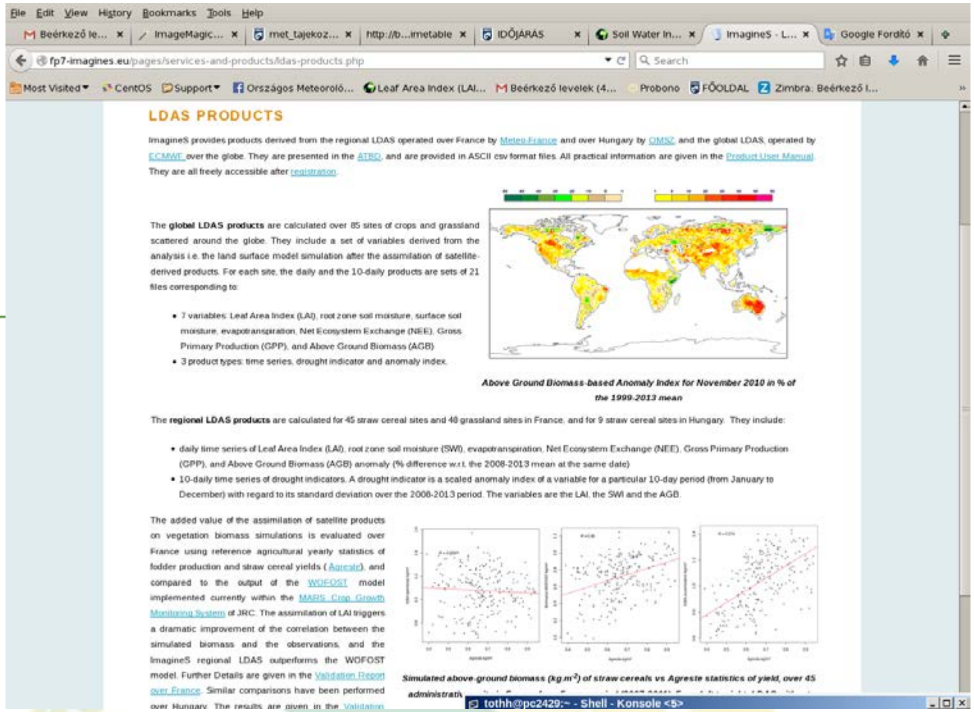


Good agreement between LDAS BIOMASS and yield, except for 2010 (extreme wet year)

Correlations:
OP: -0.13 (without 2010: 0.28)
ASS*: 0.25 (without 2010: 0.56)
WO: 0.15 (without 2010: 0.32)

LDAS products

http://fp7-imagines.eu/

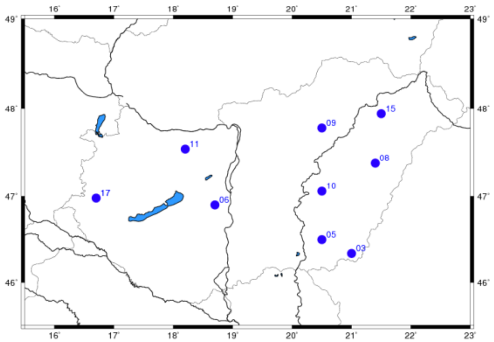


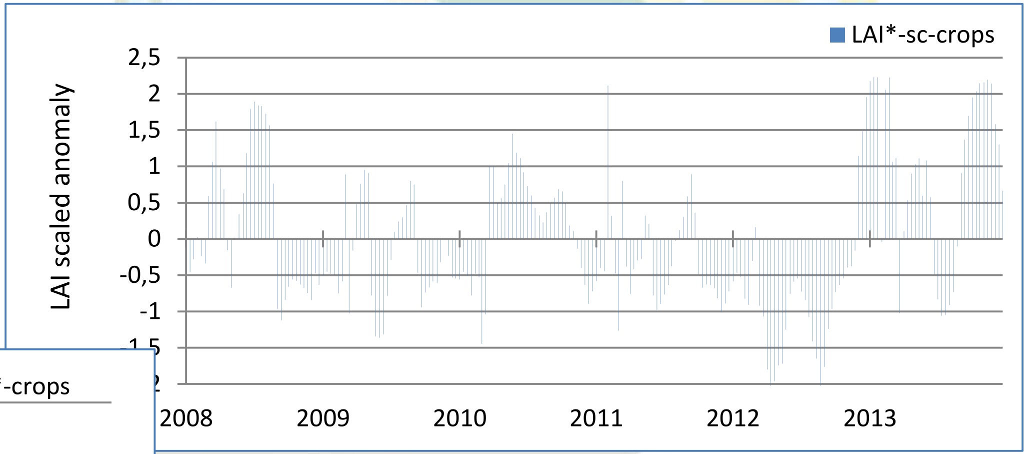
Free download data: 9 straw cereals Hungarian points for 2008-2013:

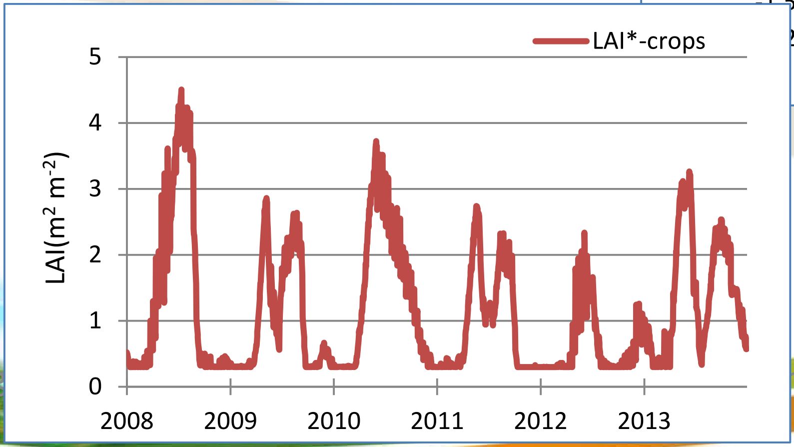
- daily data: GPP, LAI, Evaporation, NEE, SWI, Above-ground biomass anomaly
- drought indicators for 10-day period: AnoLAI, AnoSWI and AnoAGB

+ 45 straw cereals and 48 grassland points from France (Meteo France)

+ 85 sites from the globe (ECMWF)







Aftrer the project

- Use Surfex assimilation for drought monitoring (more indexes) and forecasting (based on monthly and seasonal ECMWF atmospheric forcings)
- Adaptation of Surfex 8 with diffusion soil scheme (with 11 soil layers)
- Assimilation of Sentinels data
- Find end-users

http://fp7-imagines.eu