Surface Assimilation using EKF method in Hungary

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Outline

- Surface assimilations in Hungary
  - AROME-Surfex EKF
  - LDAS (Land Data Assimilation System) in ImagineS project
- EKF data Assimilation
- ImagineS project (2012-2016)
- Validation
  - 1D (against in-situ measurements from Hegyhátsál)
  - 2D (against satellite data)
  - Agricultural utilization, drought indicators

Main differences between the 2 EKF

2 EKF

- Observations (2): SYNOP T2m, Rh2m => gridded information with CANARI
- Control vectors (4):
  - TG1, TG2, WG1, WG2
- Works only NATURE tile but only in 1 patch
- SEKF (B is constant)
- Surfex 6.0

LDAS

- Observations (2): Gridded satellite informations (LAI, SSM)
- Control vectors (3):
  - LAI, WG1, WG2
- Works only in NATURE tile, but for all pacthes (max. 12)
- EKF (B is time dependent)
- Surfex 7.3

Observation settings

AROME EKF

- SYNOP T2m, Rh2m => gridded information with CANARI

&NACVEG:

- SIGH2MO=0.01 (default: 0.1) – HU2m observation error
- SIGT2MO=0.1 (def.: 1.0) – T2m obs. error

&NAM_CANAPE:

- REF_A_H2=45000 (def.: 50000) – HU2m observation horizontal scope
- REF_A_T2=40000 (def.: 50000) – T2m observation horizontal scope
- REF_S_H2=1.0 (def.: 0.3) - HU2m sigma_o
- REF_S_T2=16.0 (def.: 3.0) – T2m sigma_o

LDAS

- Gridded satellite informations (LAI, SSM):
  - LAI: SPOT-VEG 1km res. 10 days samping.
  - SWI (Soil Water Index): MetOp. ASCAT 10 km res. 1 day sampling. SSM=SWI*(wmax-wmin) +wmin

Extended Kalman Filter Assimilation

$$x_t^a = x_t^b + \mathrm{K}(y_t^o - H(x_0^b))$$

- Analysis at time t

$$\mathrm{K} = \mathrm{B}\mathrm{H}^T(\mathrm{H}\mathrm{B}\mathrm{H}^T + \mathrm{R})^{-1}$$

- Kalman Gain

$$\mathrm{A} = (\mathrm{I} - \mathrm{K}\mathrm{H})\mathrm{B}$$

- Analysis increment

$$\mathrm{H} = \frac{\partial \mathrm{y_t}}{\partial \mathrm{x}_0}$$

- **H**: Jacobian matrix of the observation operator (Taylor expansion of *H* obs. operator, tangent linear hipotesis)

$$H_{ij} = \frac{\partial y_i}{\partial x_j} \approx \frac{y_i(x + \delta x_j) - y_i(x)}{\delta x_j}$$

- The elements of the Jacobian matrix

Jacobians

AROME-EKF

- H: model TG1, TG2, WG1, WG2 -> obs. T2m, Rh2m

$$H_{ij} = \frac{y_i(x+\delta x_j) - y_i(x)}{\delta x_j}$$

- H contains the forward model (prognostic Canopy scheme)

LDAS

$$H^k_{ij} = \alpha^k \frac{\partial y_i^k}{\partial x_j^k} = \alpha^k$$

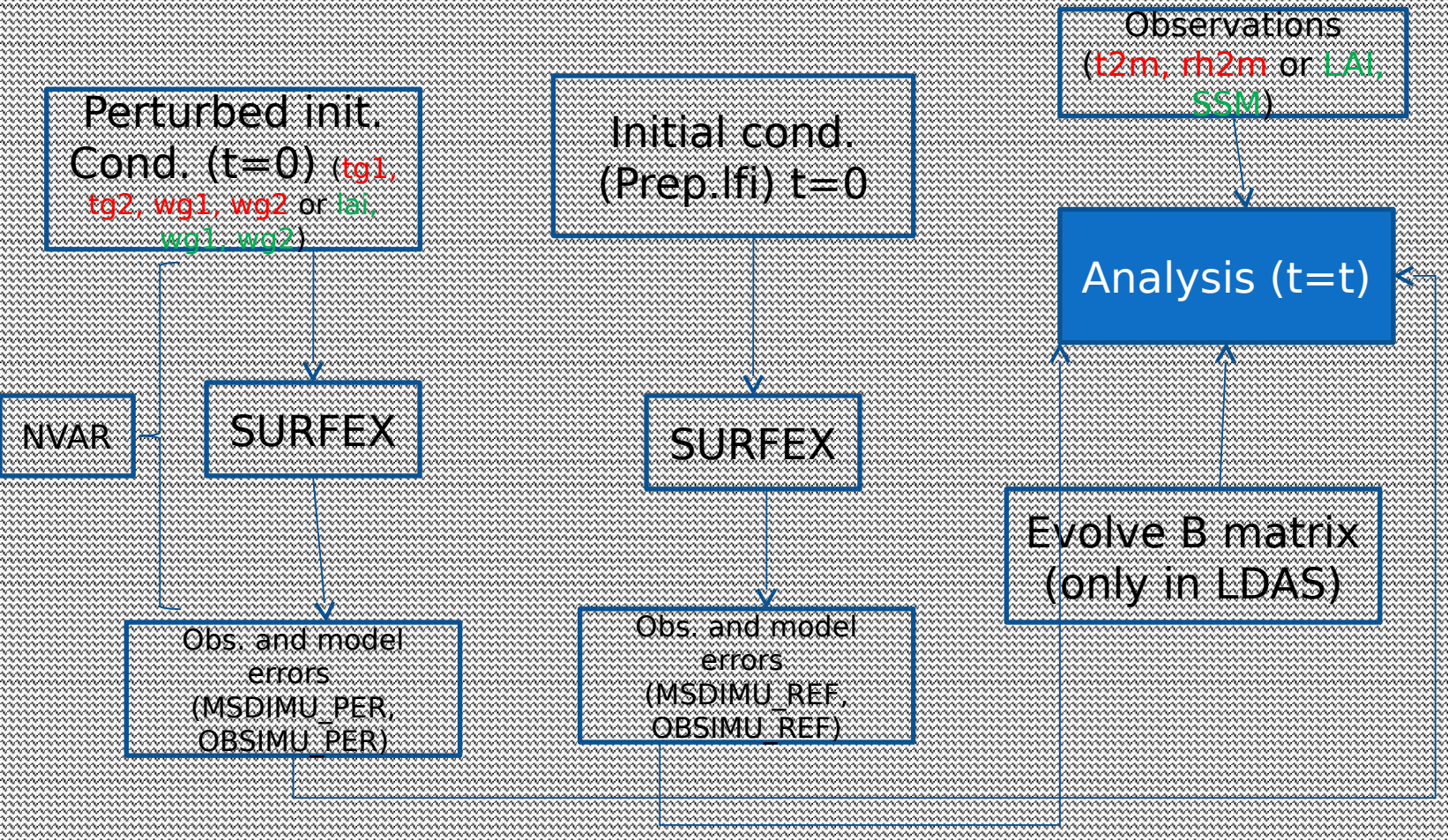
- H: model LAI, WG1, WG2 -> obs. LAI, SSM
- H doesn't contains the forward model

$$\frac{\partial y_i}{\partial x_j} = I$$

Patch fraction

If yi=xj

EKF Flow charts



Qestion

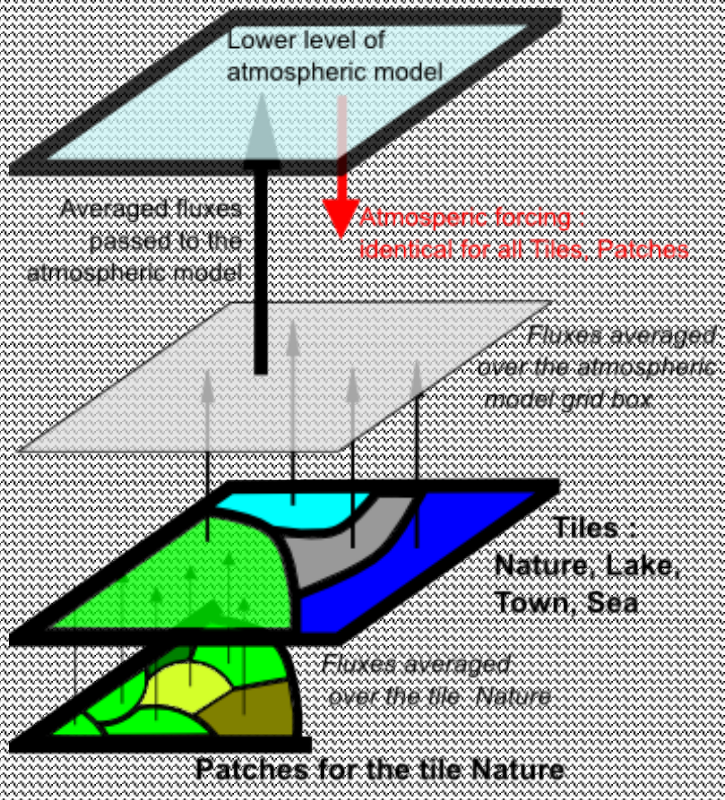
- In Arome EKF the analysis is applied at the end of the assimilation window or at the beginning? (in the flow chart the analysis is applied at the end)

ImagineS

- Implementation of Multi-scale Agricultural Indicators Exploiting Sentinels
- EU-FP7 project: http://fp7-imagines.eu
- Period: 40 month (Nov. 2012. – Febr. 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 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

LDAS in Hungary

- SURFEX (SURface Externalisée) 7.3



SURFEX tiling and coupling with an atmospheric model

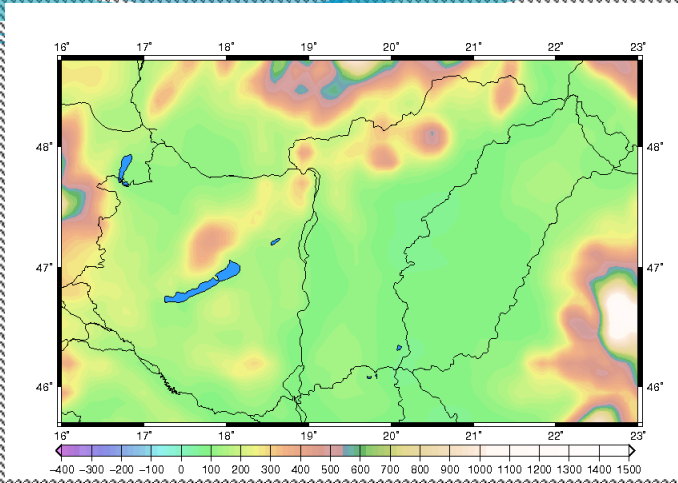
Source: http://www.cnrm.meteo.fr/surfex/spip.php?rubrique8

- Each gridbox is represented by 4 surface types: Nature, Lake, Town Sea -> Tiles
- Nature tile is separated 12 patches (grassland, C3, C4 plants , deciduous tree .... etc)

ECOCLIMAP II

- In nature tile the interaction between the Soil, Atmosphere and Biosphere is described with ISBA + photosynthesis model - > ISBA-A-gs (3 layers Force-Restore scheme)
- Prognostic eq.-s for T, w + diffusion + drainage

- 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)

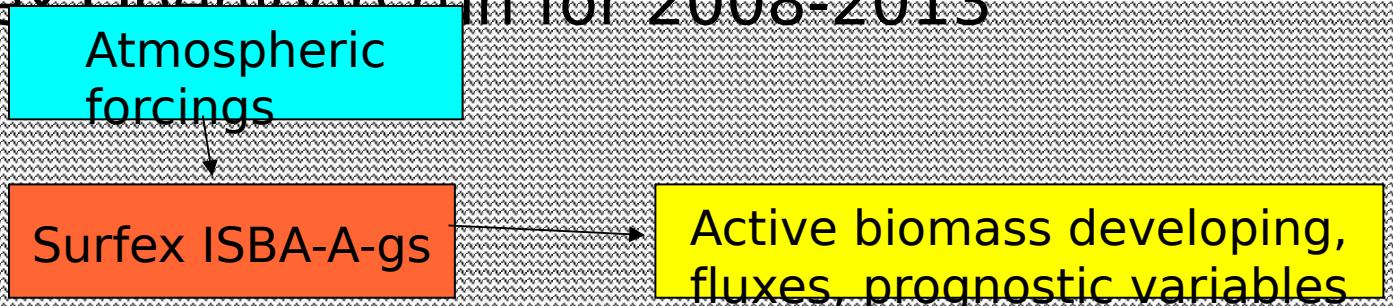
Latent

VALIDATION:

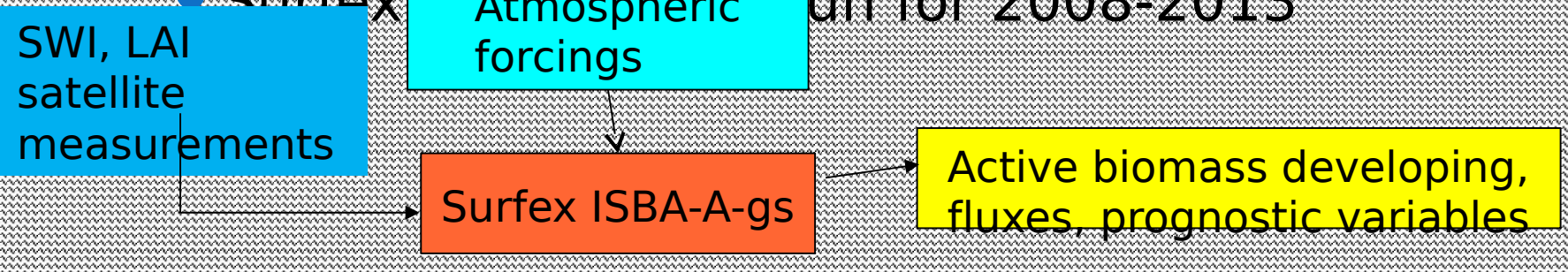
- 1D (against in situ measurements of Hegyhátsál)
- 2D (against satellite)
- agricultural utilization: simm. biomass vs. yield statistics (National measurements, WOFOST crop model)

Model runs

- Surfex Openloop run for 2008-2013



- Surfex [illegible]un for 2008-2013



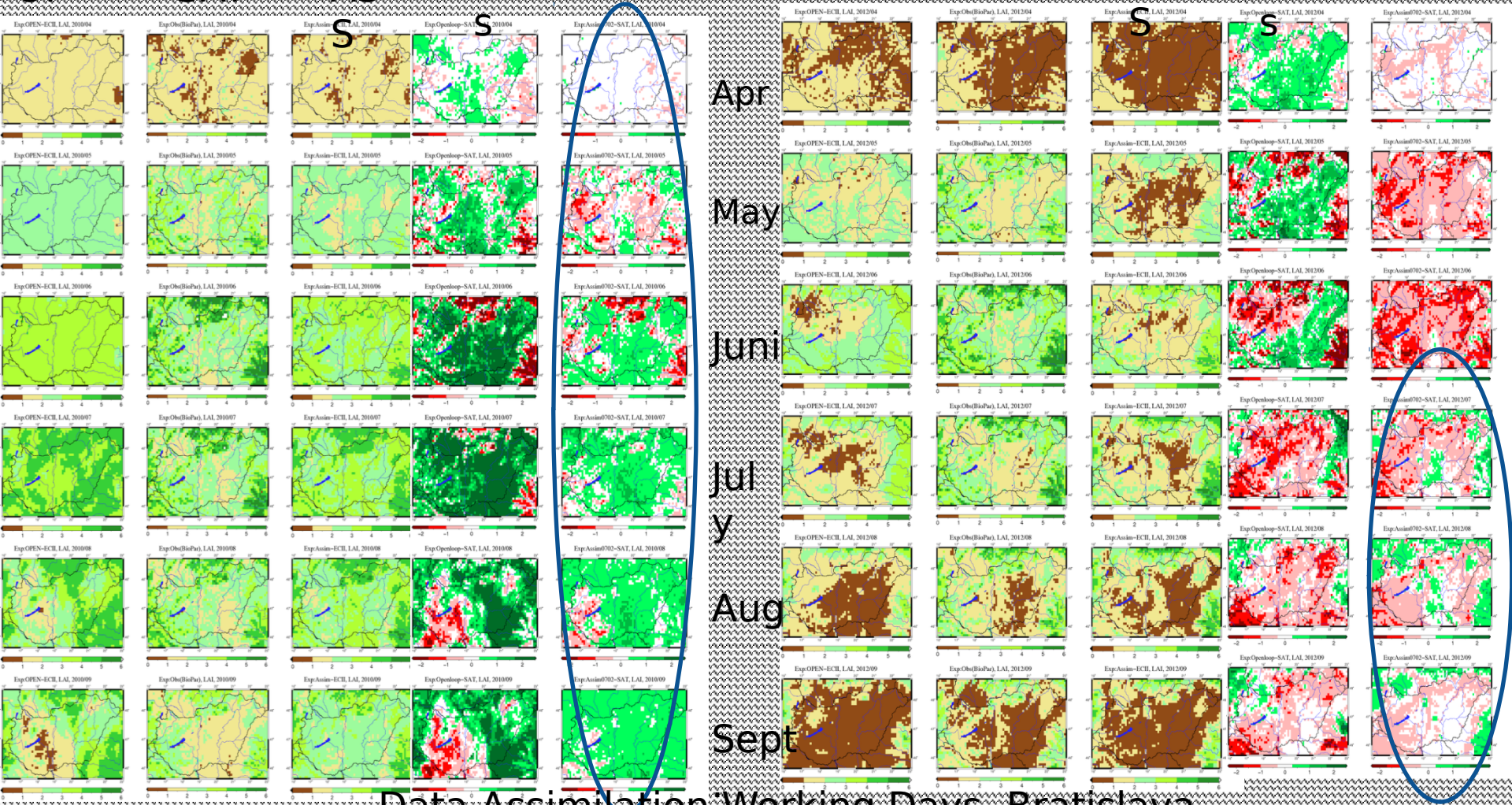
Results (2D)

LAI

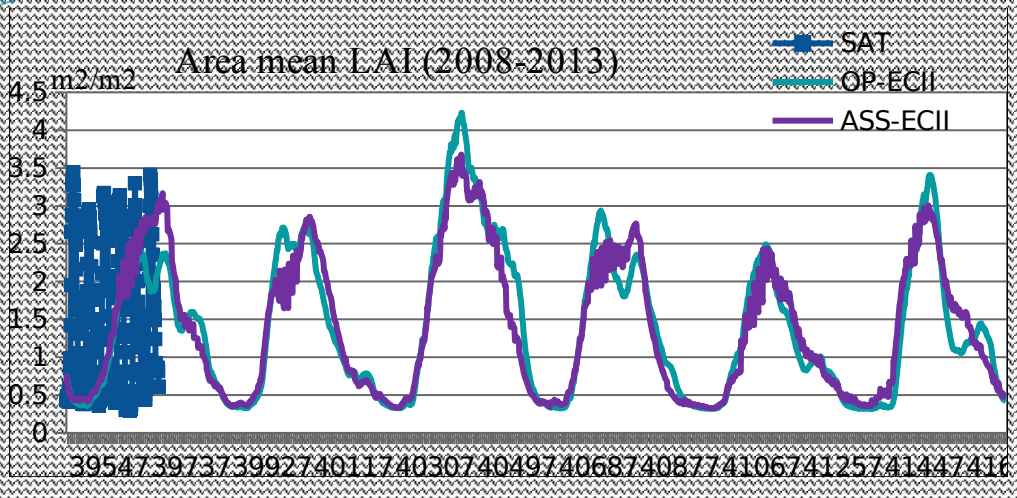
2010 (wet)

2012 (dry)

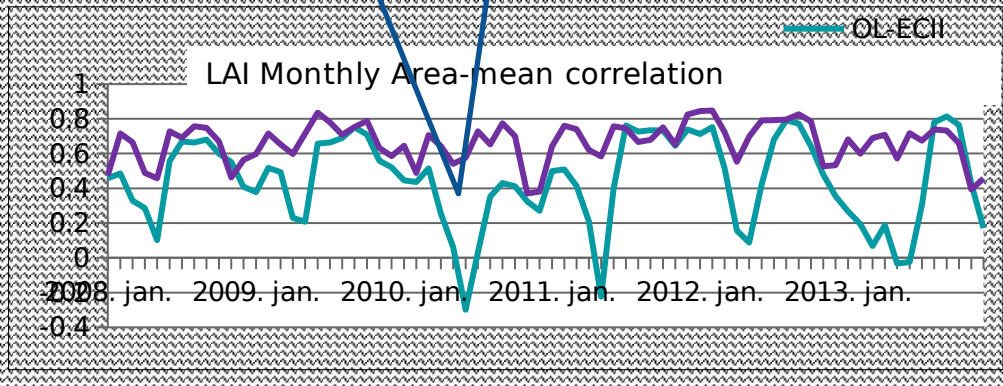
OP SAT ASS Difference OP SAT ASS Difference

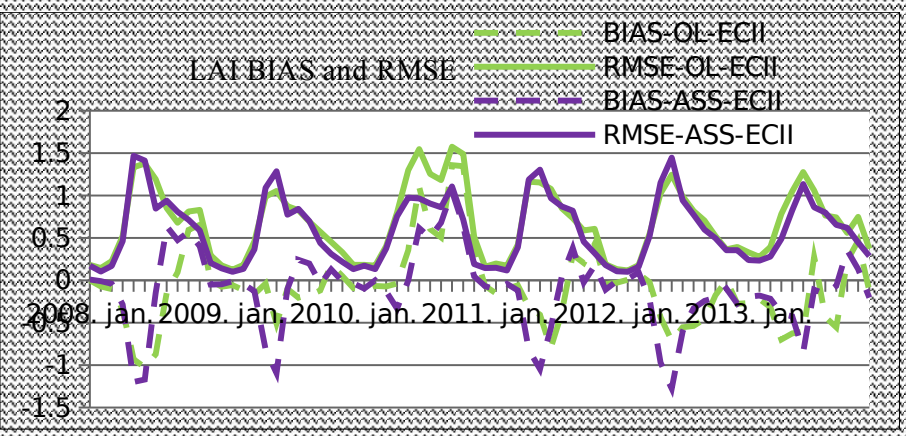


Statistics



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





Data Assimilation Working Days,
Bratislava, 30 September - 2 October

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)

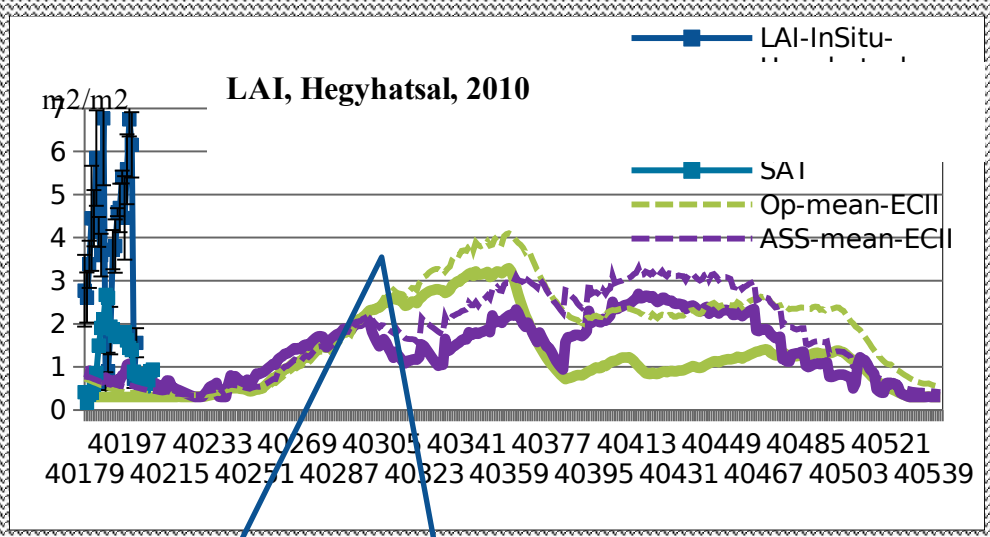
  -Carbon fluxes: GPP, Reco and NEE (daily)

  -Water flux: Latent Heat (LE) (daily)

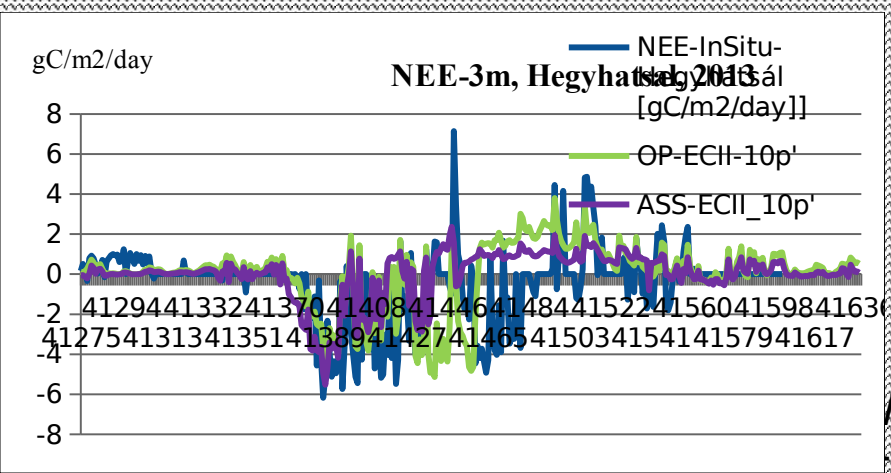
- 82 m height (valid for the whole grid-point):

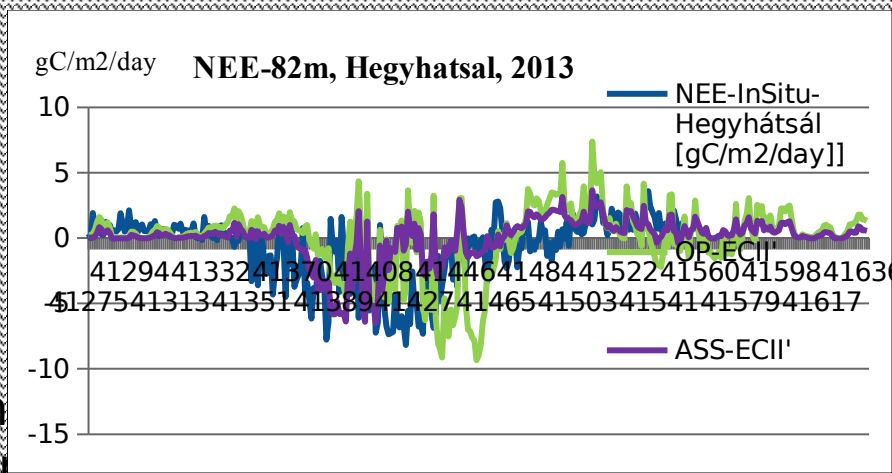
  -Carbon fluxes: GPP and NEE (daily)

  -Water flux: LE (daily)



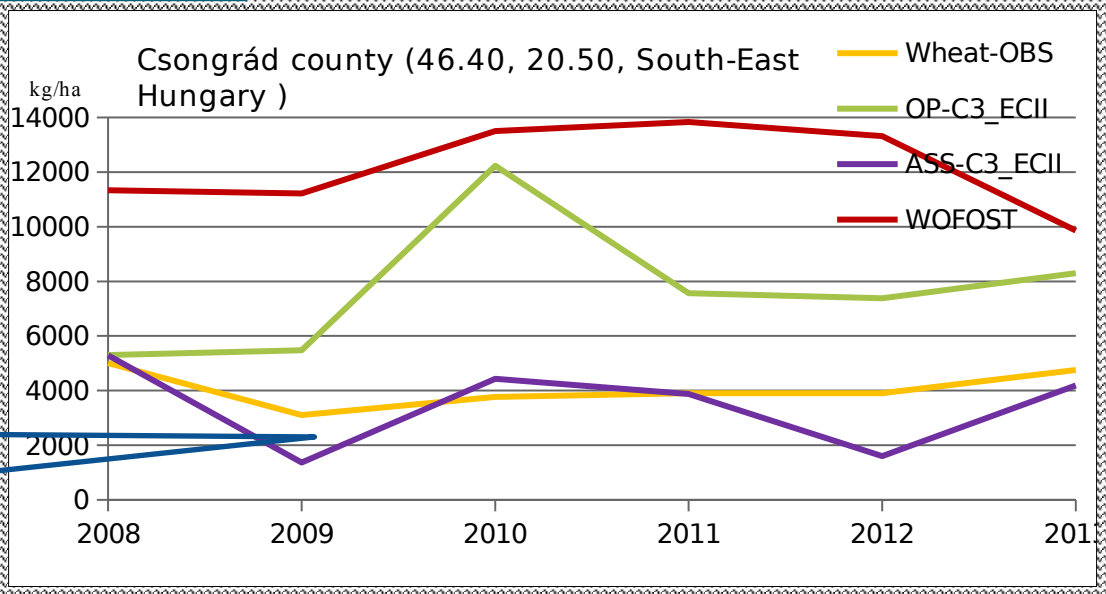
Satellite measurements (red points) are assimilated in LDAS, while the in-situ obs. very different from the sat.





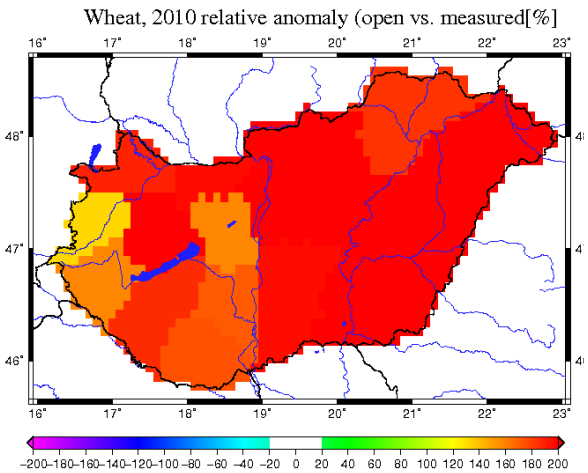
Crop estimation

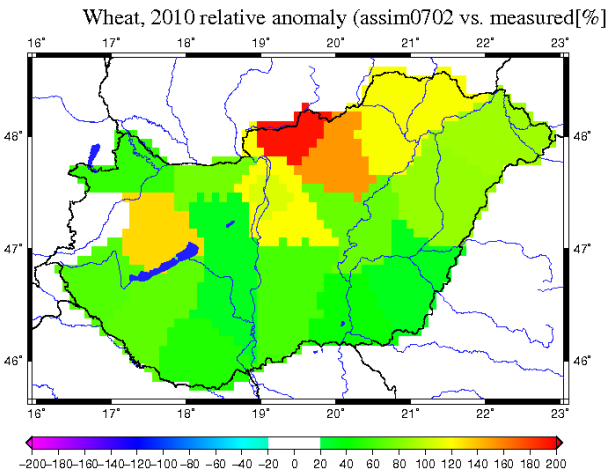
Simulated C3 BIOMASS vs. measured yield and vs. WOFOST for 2008-2013



Good agreement between LDAS BIOMASS and yield

Relative anomaly ma ((sim-obs)/obs) for a counties in Hungary: huge overestimation for Openloop





Drought indicators

- Step 1: Scaled anomalies for 10-day period (LAI and SWI)

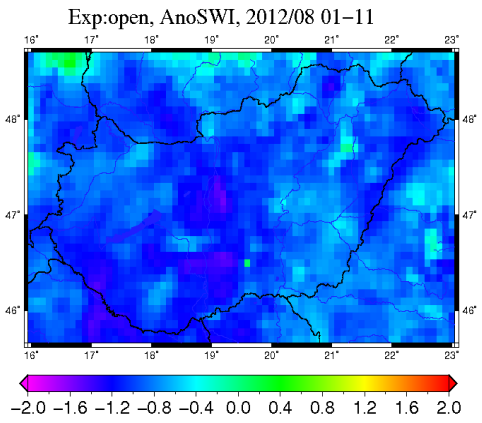
$$AnoLAI(i,yr) = \frac{DLAI(i,yr)}{stdev(DLAI(i))}$$

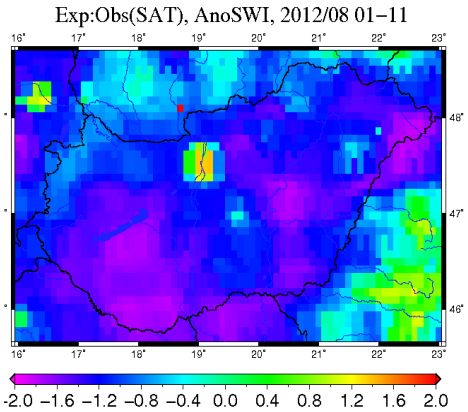
Where, DLAI is the diff. Between LAI for particular month or 10-day period of year (yr) and its average of interannual value. stdevDLAI is the standard deviation of DLAI

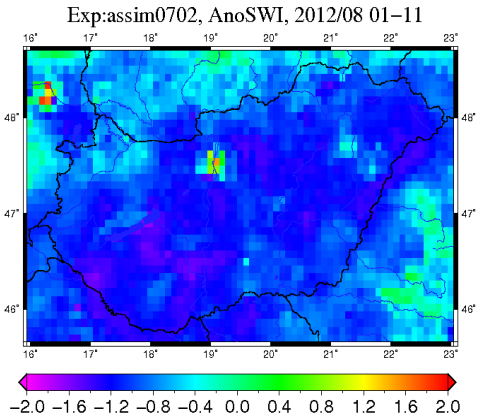
- Step 2: provide the complementary of LAI and SWI => useful tool as a drought indicators

Drought in Hungary in 2012 August

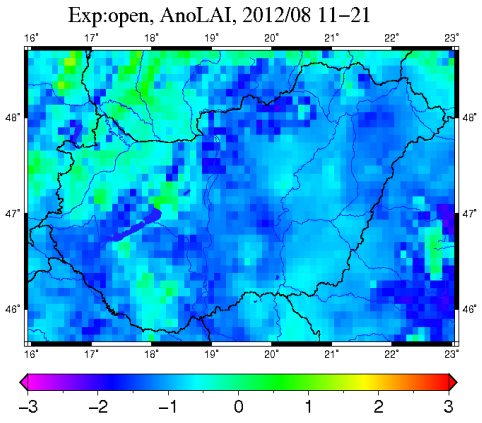
AnoSWI for 1-10. 08. 2012 => AnoLAI 11-

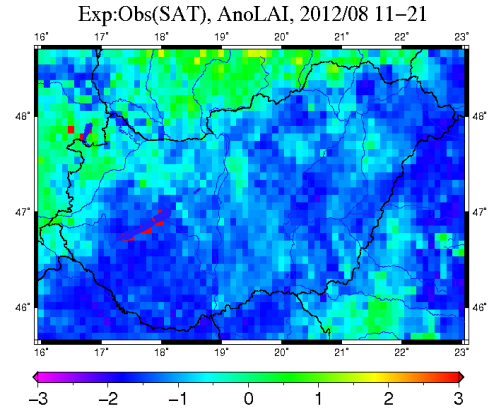


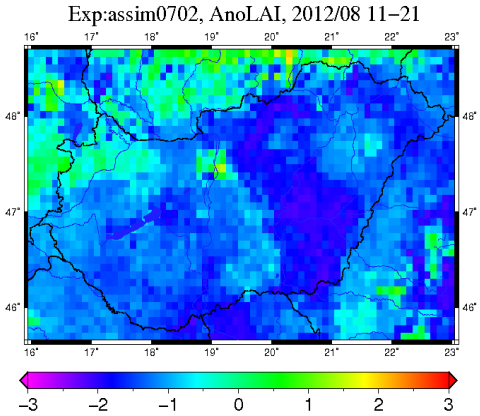




AnoSWI could be a good prior to conclude the trend of LAI







ImagineS Plans

- Assimilation of PROBA-V LAI for 2014-2015
- Mini workshop for end-users
- Drought indicators (SWI and LAI anomalies)