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
- Surfexa 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)
- 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

Training course on the use of satellite products for drought monitoring and agro-meteorological applications, Budapest, 24-28 April, 2017
• 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\text{max}-w\text{min})+w\text{min} W\text{max} and W\text{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:

\[ SSM_{sat}' = p_1 + p_2 \cdot SSM_{sat} \quad \text{where} \quad p_1 = \frac{SSM_{mod} - p_2 \cdot SSM_{sat}}{SSM_{sat}} \quad p_2 = \frac{\text{stdev}(SSM_{mod})}{\text{stdev}(SSM_{sat})} \]
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• 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 analysis (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

Forcings → Surfex ISBA-A-gs → Active biomass, prognostic variables

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SWI, LAI satellite obs.
RESULTS (2D)

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

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

![Map showing LAI variability for May, June, July, August, and September for SAT, ASS, and OP datasets.](image-url)
Root-zone soil moisture anomalies in 2012 (AnoWG2 (models) and AnoSWI10 (satellite))

--- | --- | --- | --- | ---
SAT
ASS-3L
OP-3L

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LAI soil moisture anomalies in 2014 (very moist year)

<table>
<thead>
<tr>
<th>SAT</th>
<th>ASS-3L</th>
<th>OP-3L</th>
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<tr>
<td>Mai</td>
<td>June</td>
<td>July</td>
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2014. precip

-3 -2 -1 0 1 2 3

AnoLAI

AnoSWI10 / AnoWG2

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Statistics (LAI)

Area mean LAI (2008-2015)

LAI BIAS and RMSE

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)
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)

http://fp7-imagines.eu/
After 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