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Recent advances in regional crop and water modeling

Gabriëlle De Lannoy, Louise Busschaert,
Shannon de Roos, Dirk Raes, Michel Bechtold

Adaptation of Agriculture to Water Scarcity at the World Scale, 18/10/2023, World Food Day
KU Leuven, Department of Earth and Environmental Sciences, Belgium

Agricultural management
Water management
2000-
2019
Stable cropland
Expansion 9%
Potapov et al., 2021
Food security
Grown
for
Biofuel
Energy

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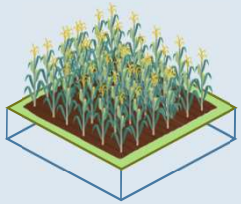
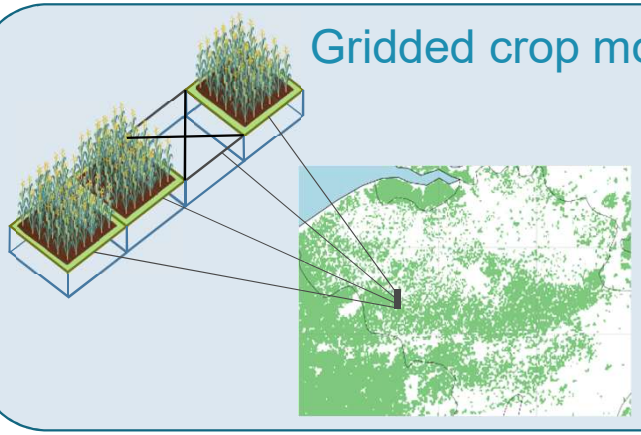
Global (regional) gridded crop modeling

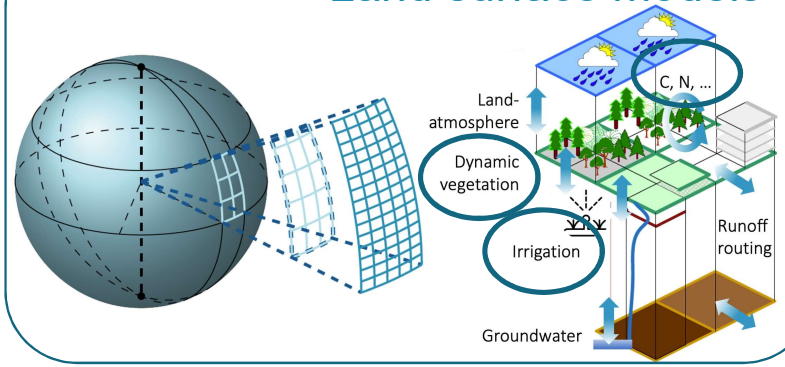
Field-based crop models

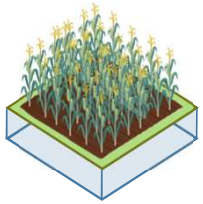


Gridded crop models

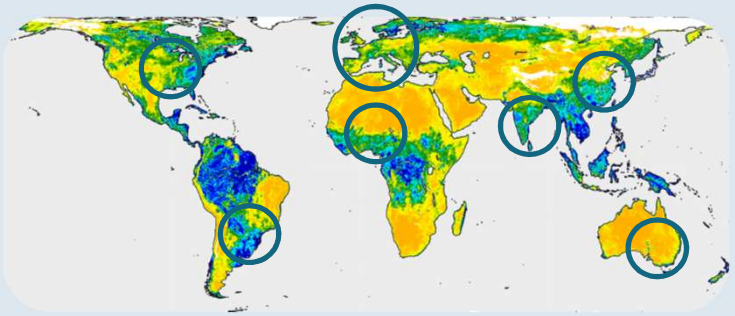


Land surface models





Land surface-crop models



De Lannoy et al., 2022

AquaCrop v7.1

- AquaCrop model: water-driven crop growth, agricultural management, many crop types, robust, few parameters

- Field to continental scale *(de Roos et al., 2021, Busschaert et al., 2022)*

Graphical User Interface

GitHub

Version-controlled Fortran code

https://github.com/KUL-RSDA/AquaCrop

Stand-alone executables

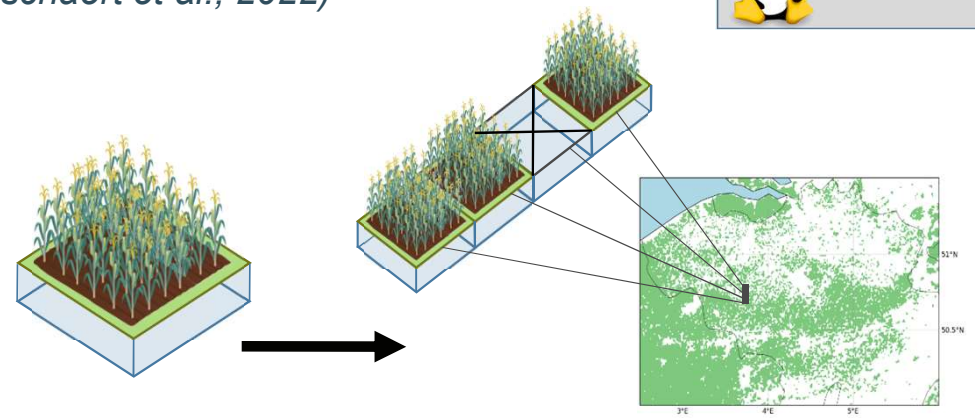
NASA

NASA Land Information System

LIS

NASA's Land Information System

AQUACROP



https://www.fao.org/aquacrop/en/

Released open source: Sept 2022

aquacrop@fao.org

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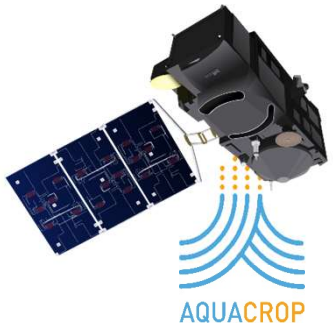
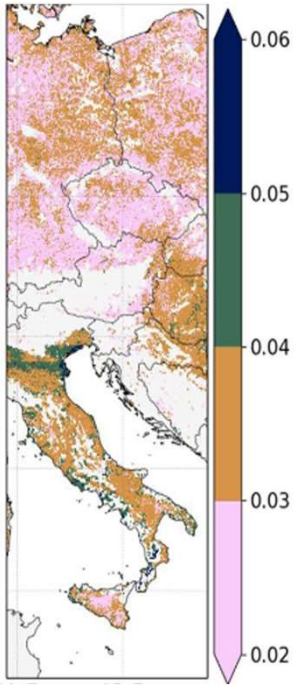
Regional evaluation

Biomass – 1 km

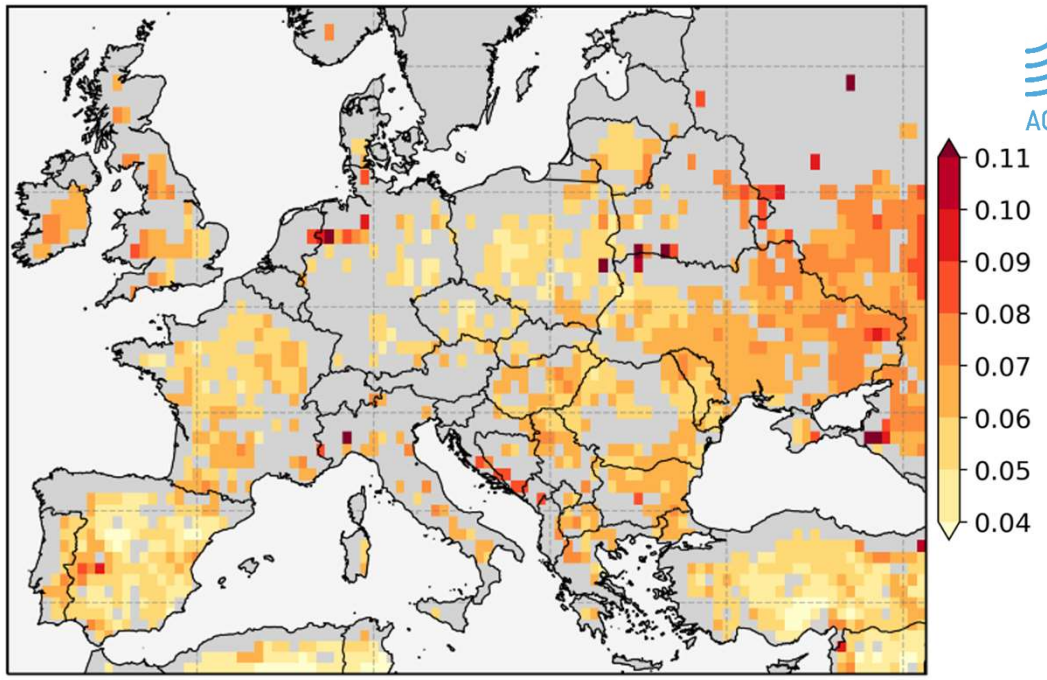


(a) Biomass [T. ha^{-1}. day^{-1}]
ubRMSD(AquaCrop, DMP)
Mean: 0.03, STDEV: 0.01



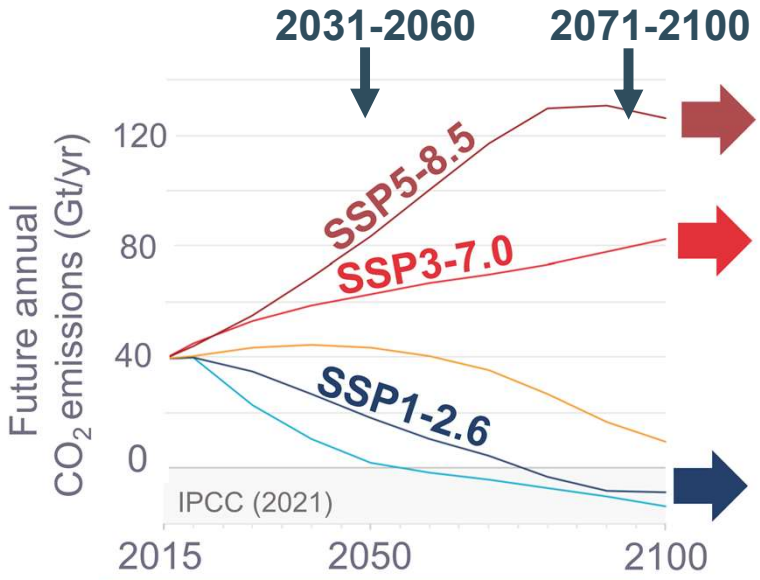
Soil moisture – 50 km

(b) SSM [m^{-3}. m^{-3}]
ubRMSD(AquaCrop, SMAP)
Mean: 0.06, STDEV: 0.01



de Roos et al., 2021; Busschaert et al., 2022

Net irrigation forecasts

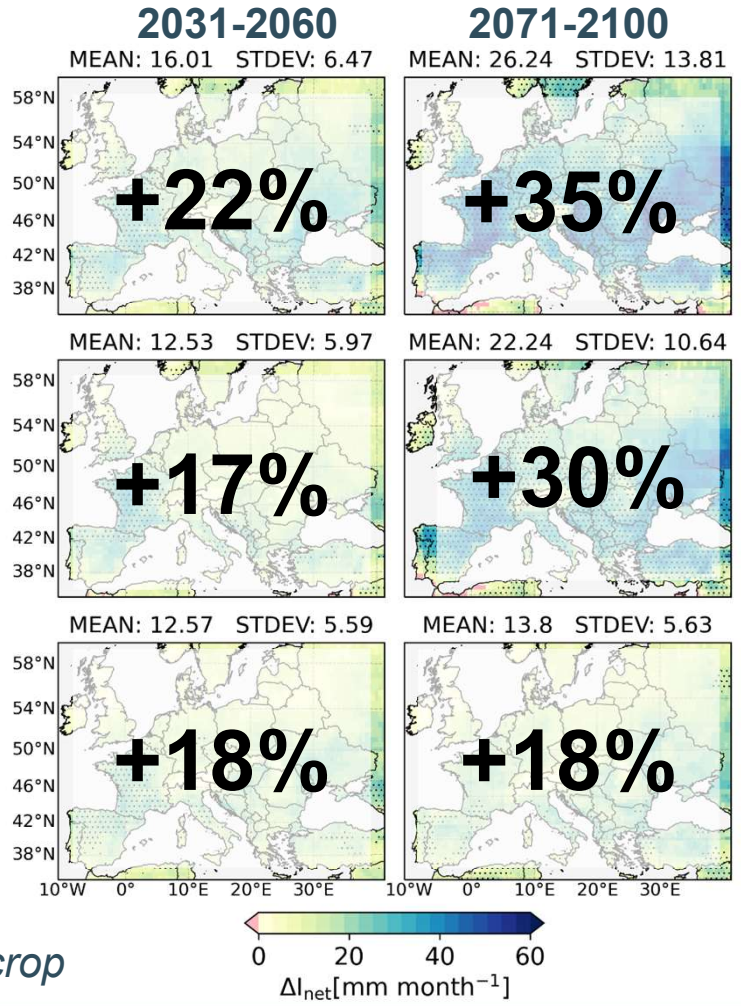


ISIMIP3

Inter-Sectoral Impact Model Intercomparison Project
5 GCMs
3 climate scenarios

AQUACROP

Irrigation (I_{net})



Not mitigated

High emissions

Mitigated

Assuming a constant C3 crop

Busschaert et al., 2022

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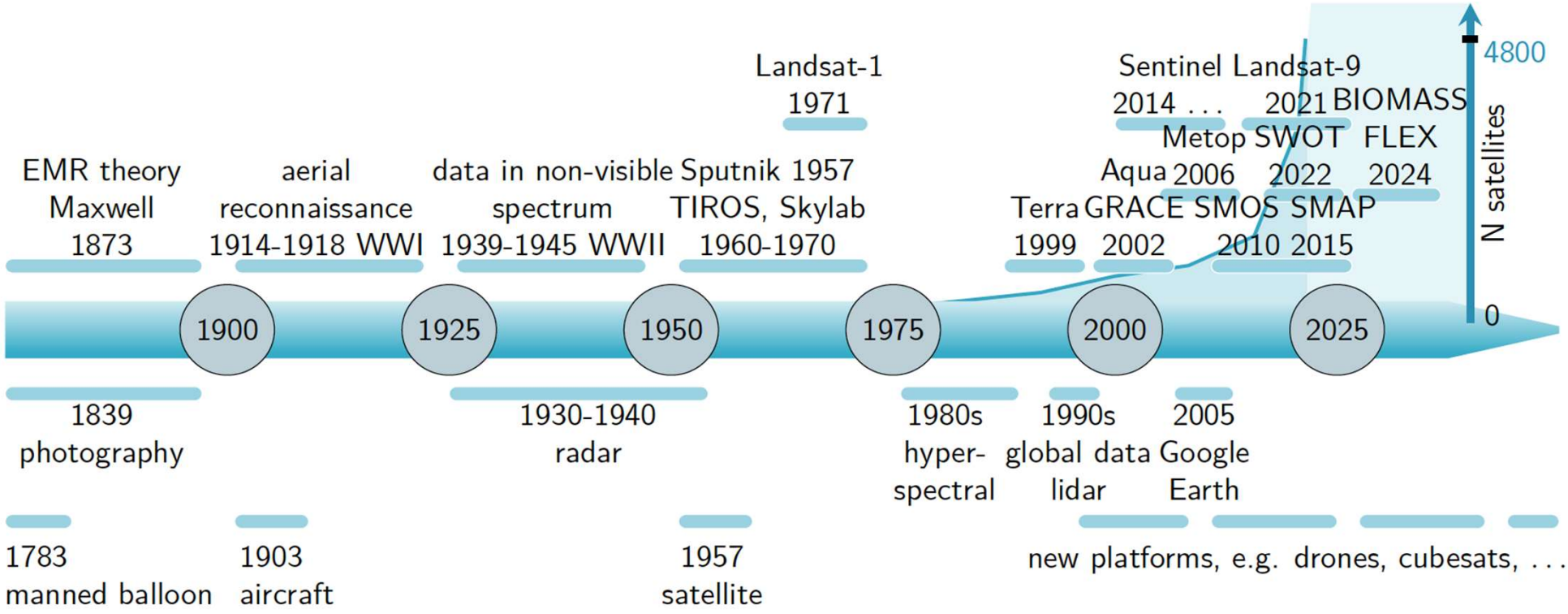
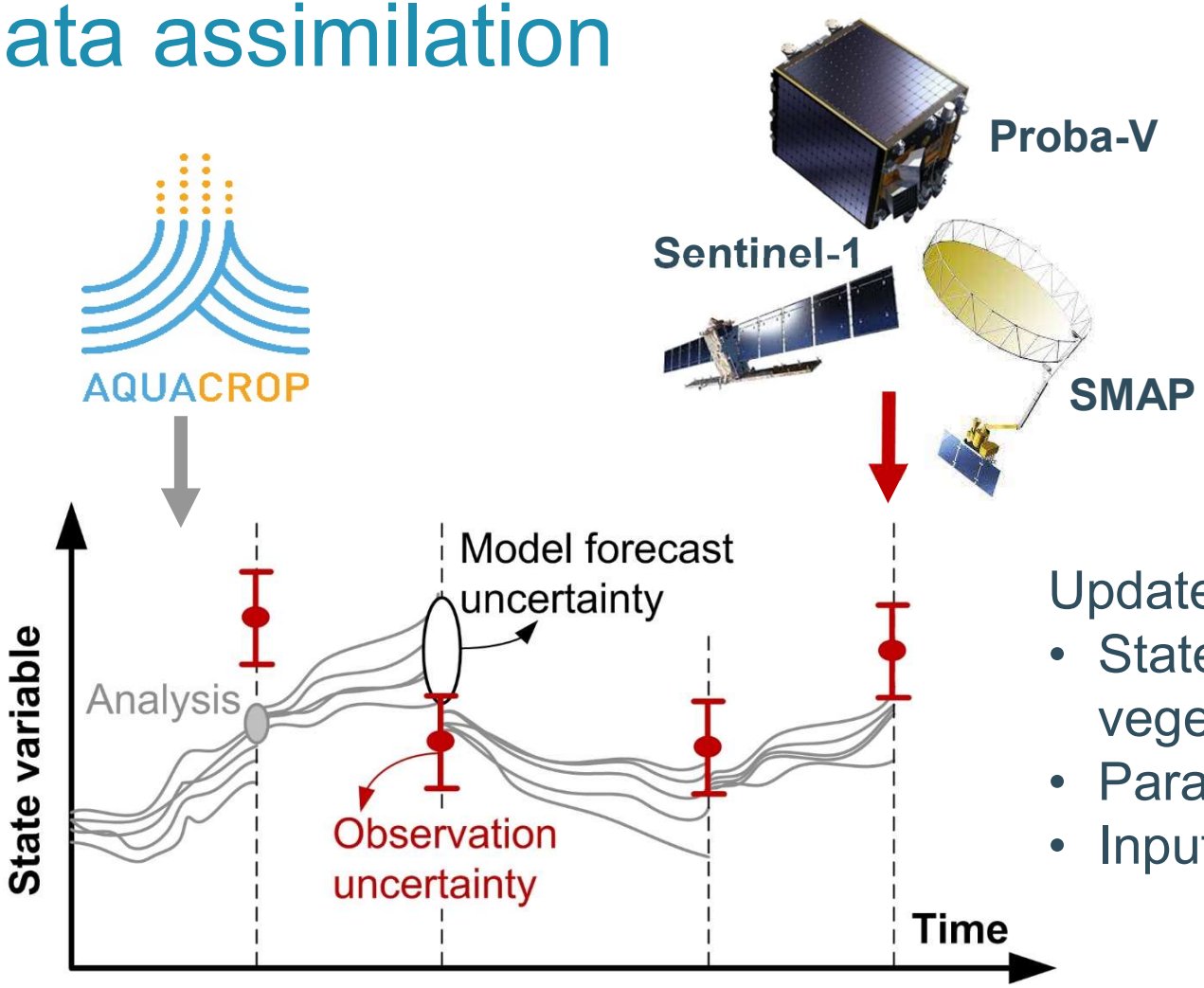
Satellite data assimilation



Higher resolutions
More variables

De Lannoy et al., 2022

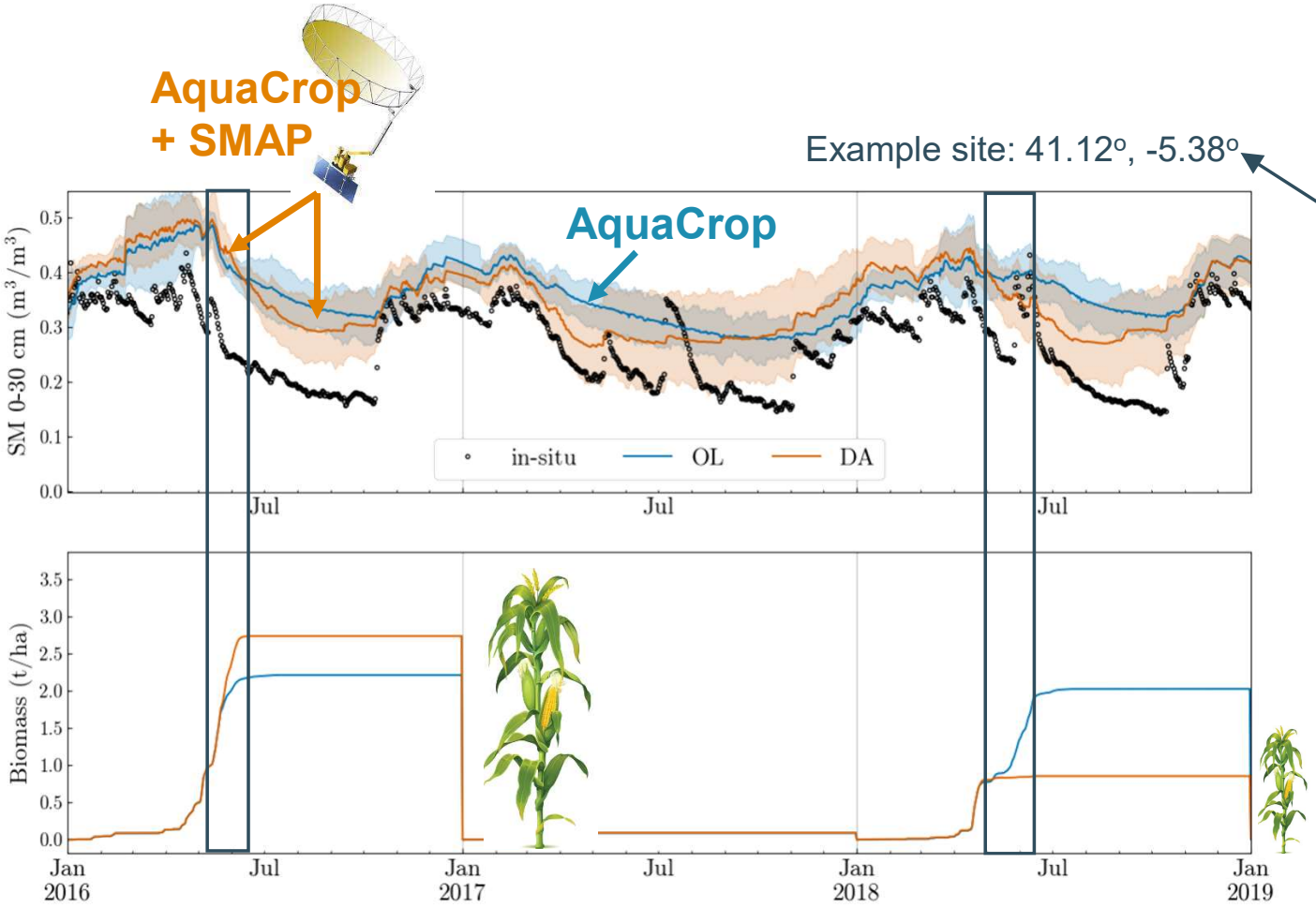
Satellite data assimilation

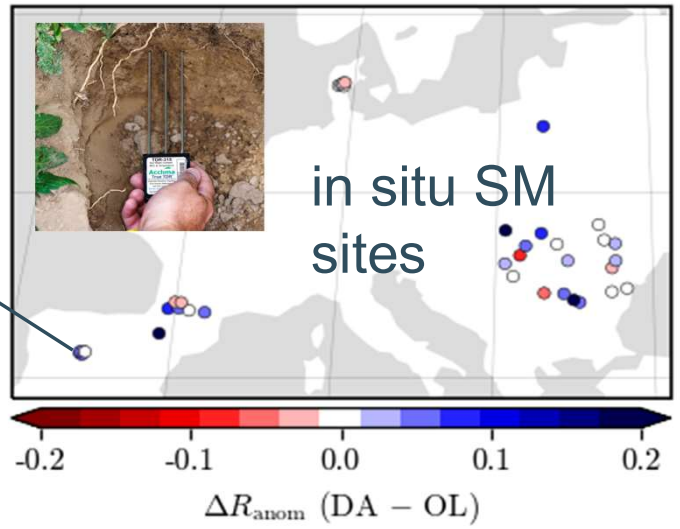


Update

- State (soil moisture, vegetation)
- Parameters
- Input

Satellite data assimilation





- Correct soil moisture ➔ change in biomass
- Better soil moisture, irrigation, biomass estimation

Conclusions and outlook

- AquaCrop v7.1 open source
- Flexible spatially distributed soil, meteo, crop input: **climate scenarios**, **satellite data assimilation**

  → impact of new crop varieties vs regional water use / irrigation needs?

- **Combine modeling and satellite data**

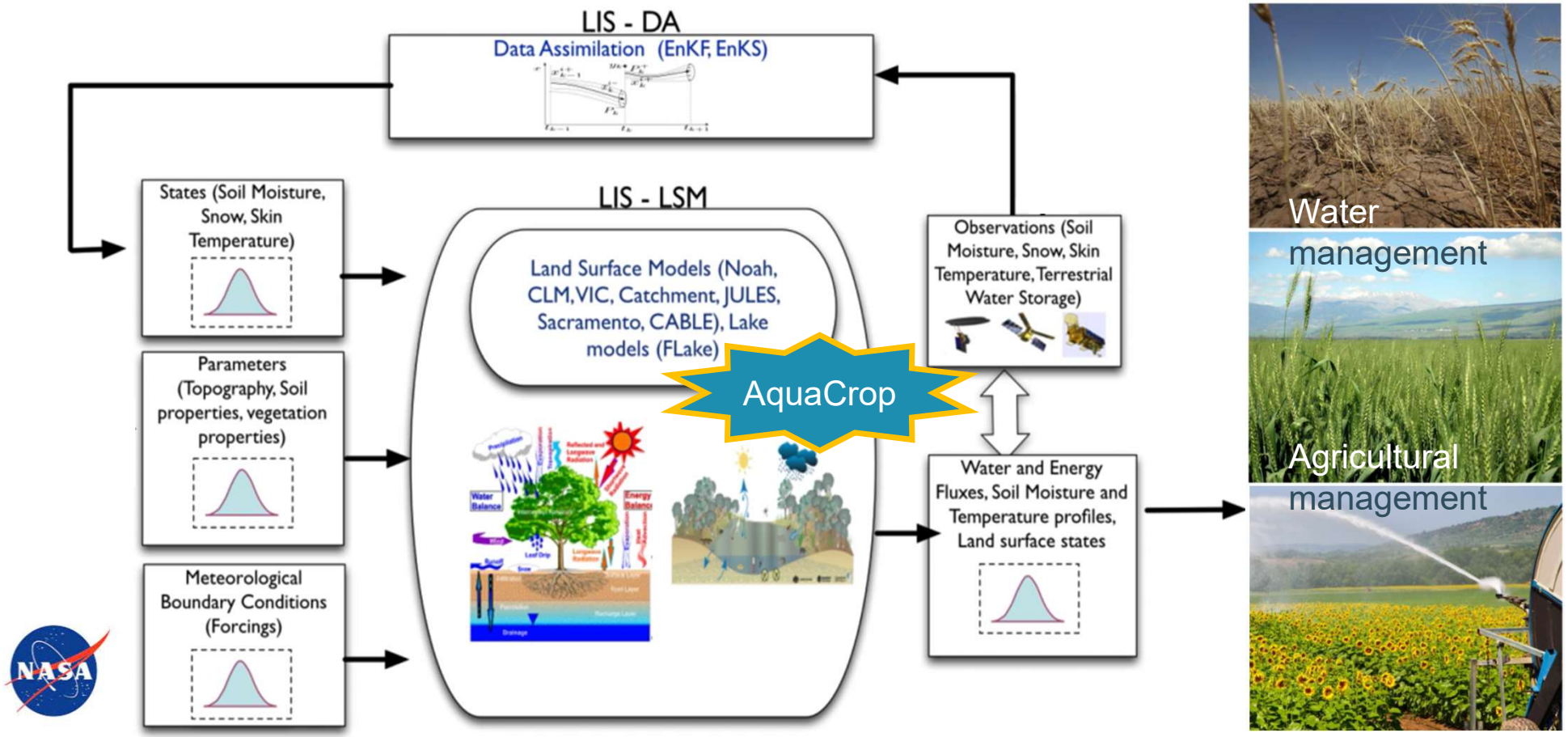
  → best current knowledge → informed response

- **High spatial resolutions** needed for **regional** water and agricultural management

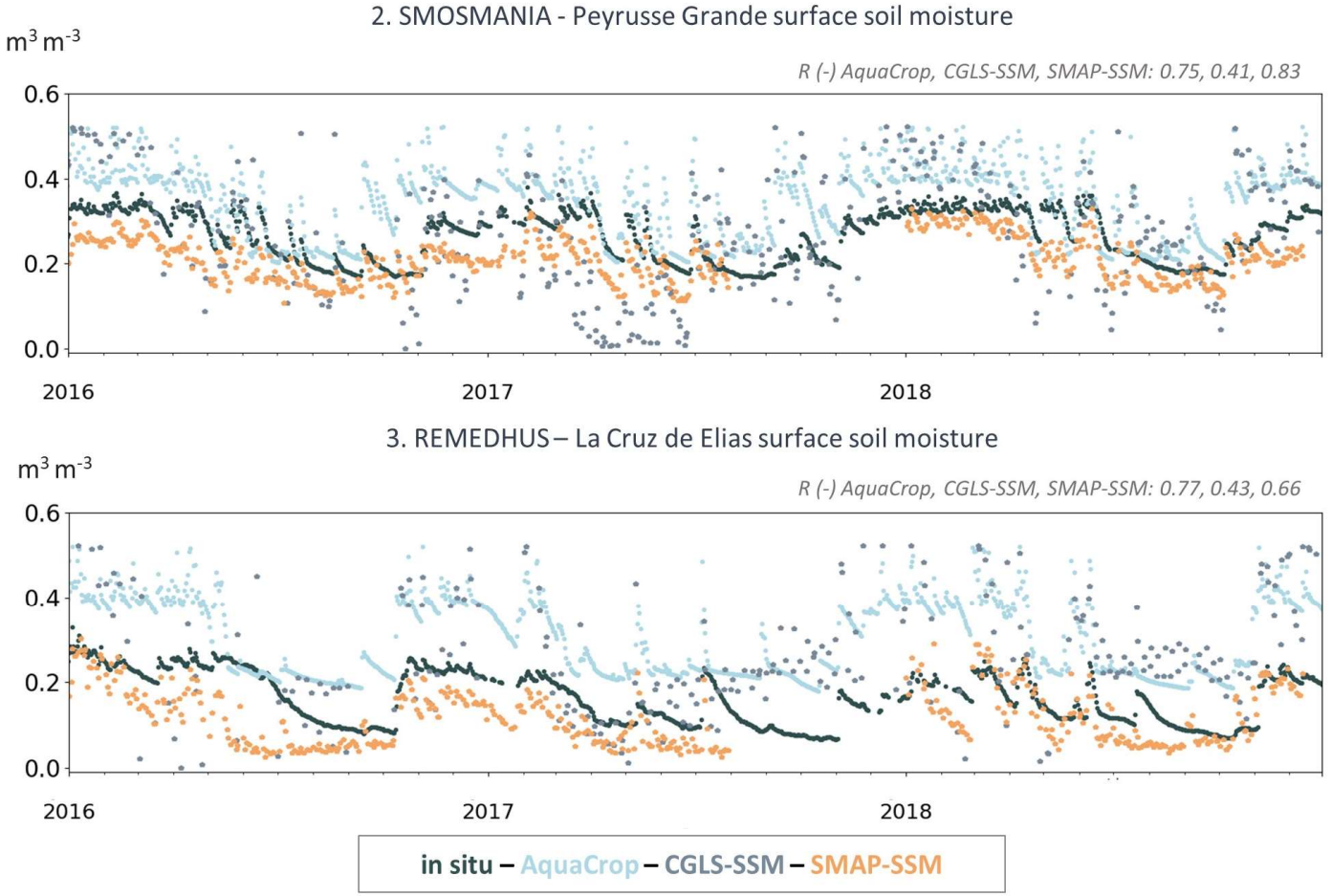
https://www.fao.org/aquacrop/en/

Extra

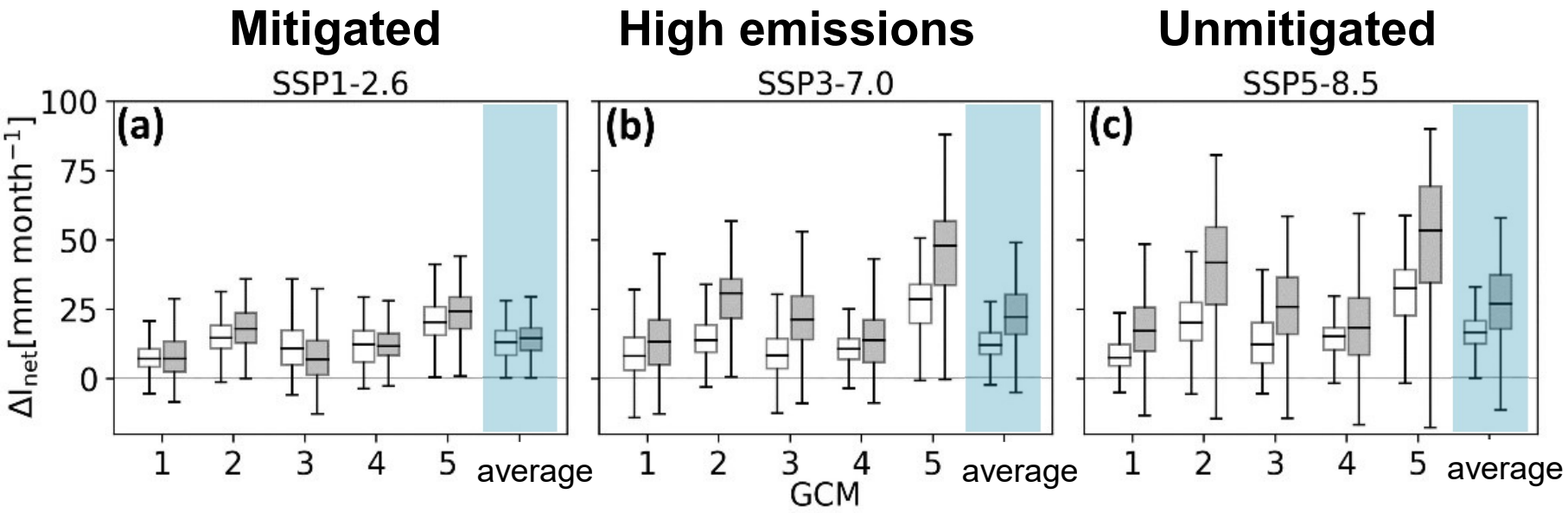
AquaCrop in NASA LIS



Regional crop modeling



Net irrigation forecasts



Future I_{net} depends on the emission scenario but **more strongly on the GCM**

https://doi.org/10.5194/hess-26-3731-2022

Busschaert et al., 2022

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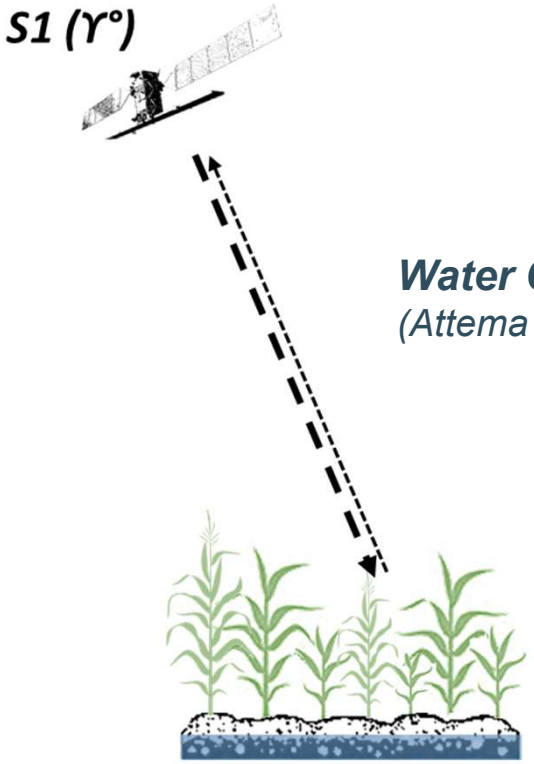
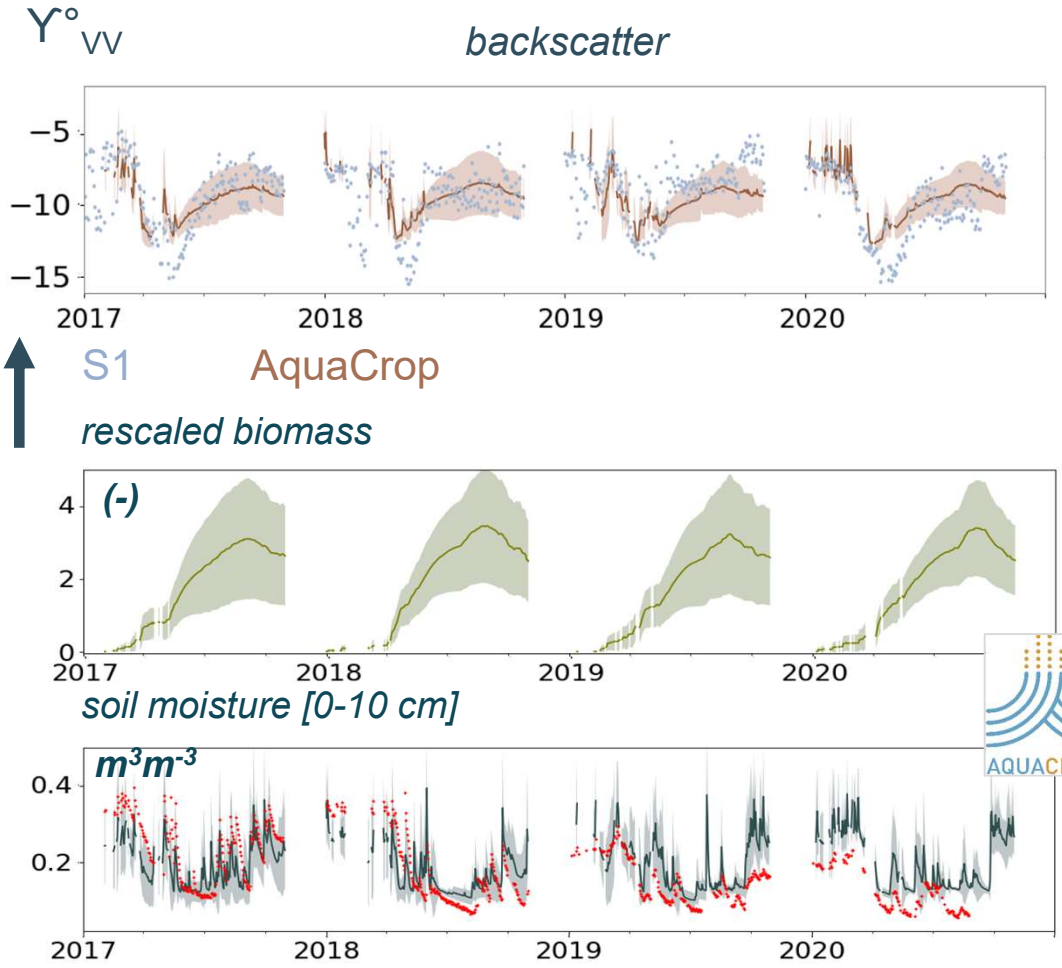
Satellite data assimilation



Water Cloud Model (WCM)
(Attema & Ulaby, 1978)