Virtual Water Values (ViWA)

GROW – Collaborative Project ViWA:

Multiscale Monitoring of Global Water Resources and Options for their Efficient and Sustainable Use

Partners

Dept. of Geography, University of Munich

Prof. Dr. Wolfram Mauser (coordinator)
Dr. Tobias Hank

Institute for the World Economy, Kiel

Dr. Ruth Delzeit
Prof. Dr Gernot Klepper

Helmholtz Center for Environmental Research (UFZ), Leipzig

Prof. Dr. Sabine Attinger

Institute for Environmental Planning, University of Hanover

Prof. Dr. Christina von Haaren

Helmholtz-Zentrum Geesthacht, Climate Service Center Germany, Hamburg

Prof. Dr. Daniela Jacob
Dr. Susanne Pfeiffer

Leibniz Supercomputing Centre (LRZ) of the Bavarian Academy of Sciences, Munich

Prof. Dr. Dieter Kranzlmüller
Dr. Jens Weissmüller

VISTA Geoscience Remote Sensing GmbH, Munich

Dr. Heike Bach
Philipp Klug

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Federal Ministry of Education and Research

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GRoW
WATER AS A GLOBAL RESOURCE

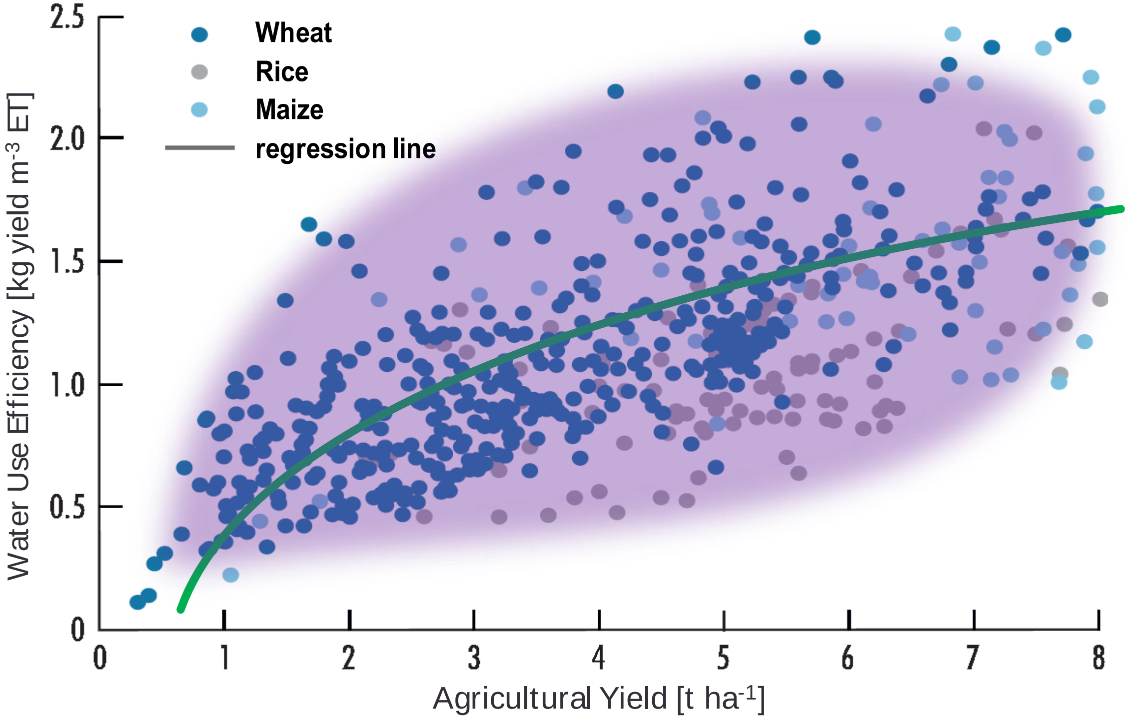
in the framework program FONA (Research for Sustainability)

FONA
Forschung für Nachhaltige Entwicklung
BMBF

ViWA - the point of departure

- 96% of today's water use is through food and energy production in agriculture. Water use efficiency links food and energy production to water consumption (water-food-energy nexus).

- Sustainable development postulates that natural resources, like water, be used with the highest possible sustainable efficiency; globally – regionally – locally.



- The question for ViWA therefore is not
  - "how much virtual water is used by agriculture"

  but

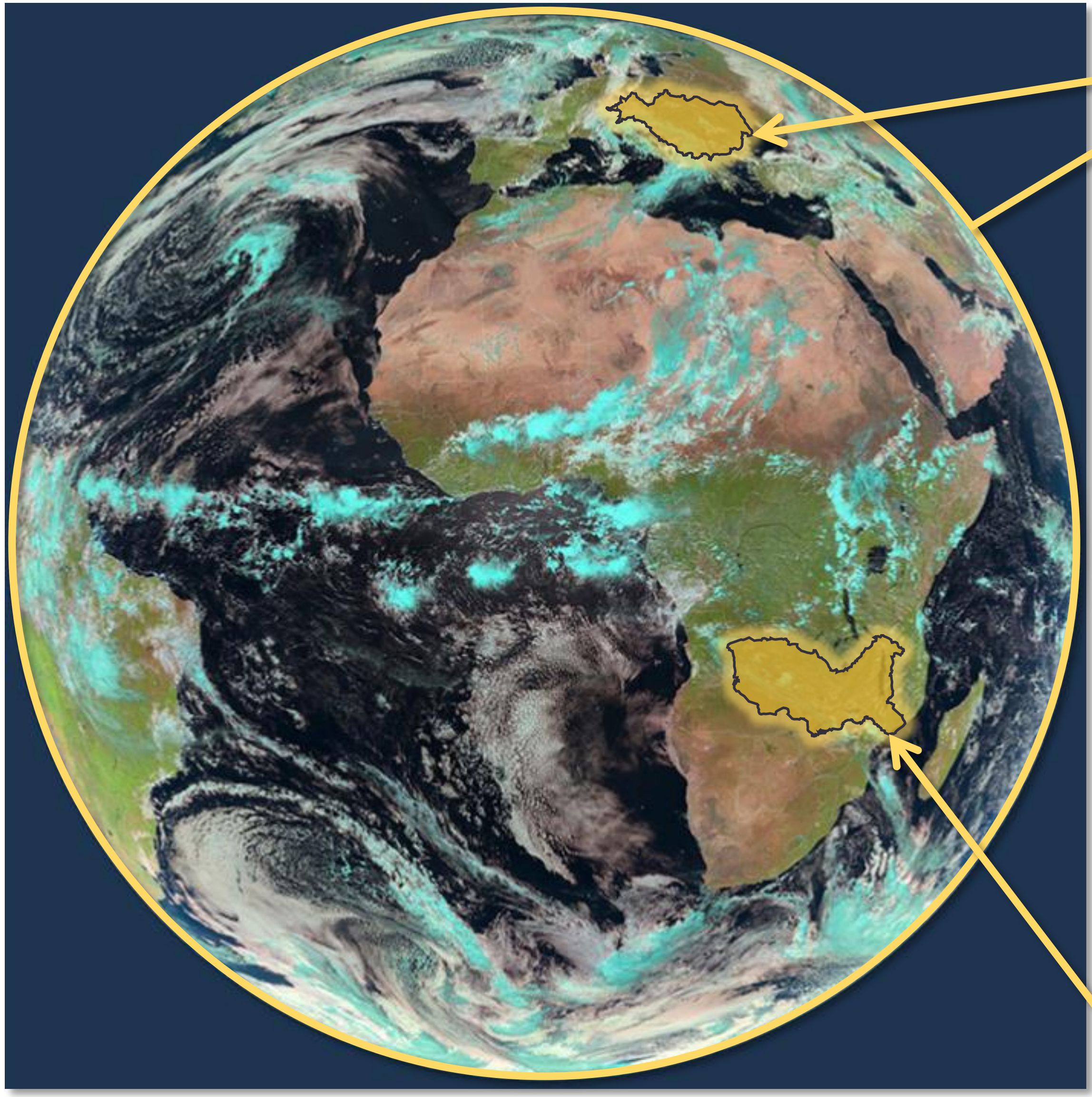
  - "how can the water footprint of crops be made more efficient and sustainable"

ViWA – research goals

- to develops a new real time monitoring/modelling system for global agricultural water use efficiency (WUE) and sustainable water availability based on the latest COPERNICUS Sentinel satellite data streams,
- to simulates impact scenarios of agricultural WUE on global agricultural trade through coupling DART-WATER (CGE-model) and PROMET (biophysical model) to identify trade options that favor more sustainable water use and
- to carry out a sustainability evaluation of global (mainly agricultural) and regional water use and to develop indicators for unsustainable water use, which can continuously be monitored globally with high resolution.

ViWA concept – global, regional ...

ViWA
Virtual Water Values



Danube
817.000 km^2

Global

Key issues global:

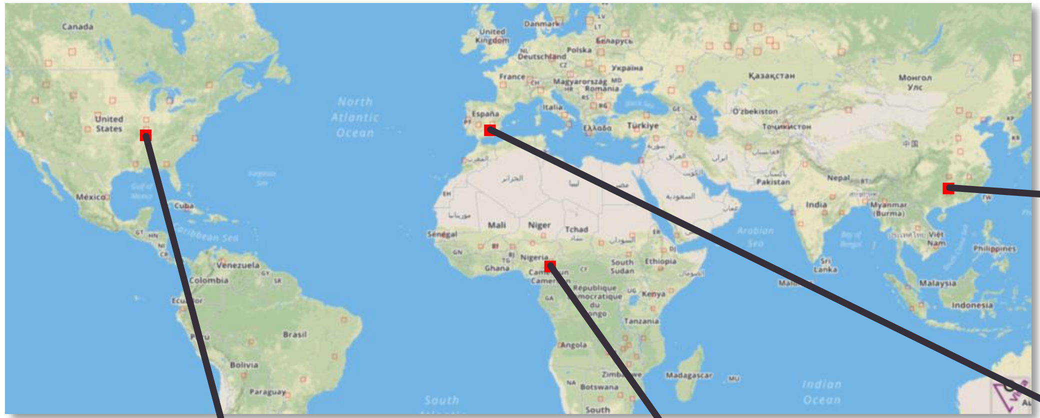
- Monitor Actual Water Use Efficiency of Agriculture
- Identify regional water scarcities and lack of efficiency
- Determine unsustainable water use in agriculture
- Analyse trade-offs of options of more efficient water use through global trade

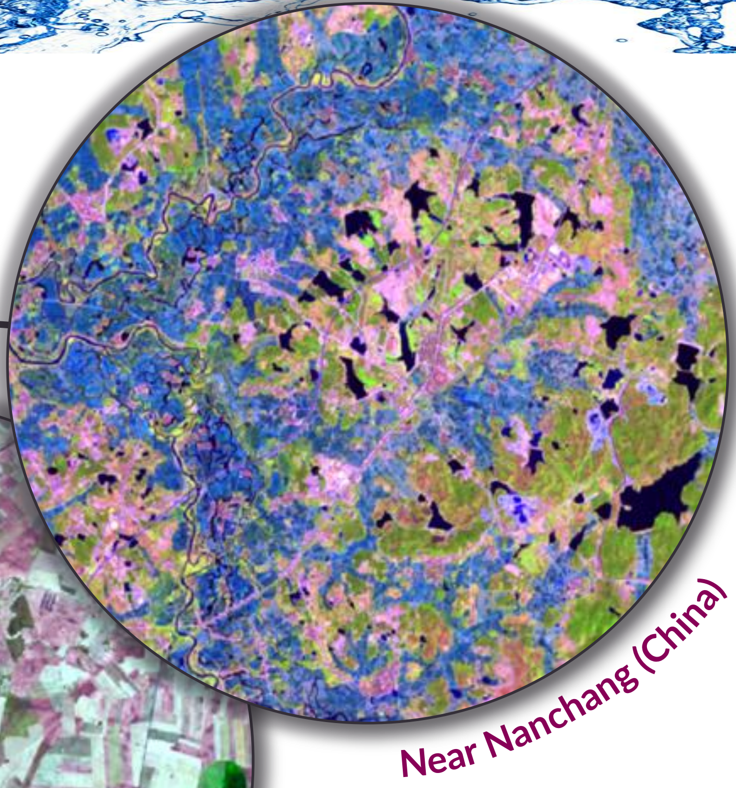
Key issues regional:

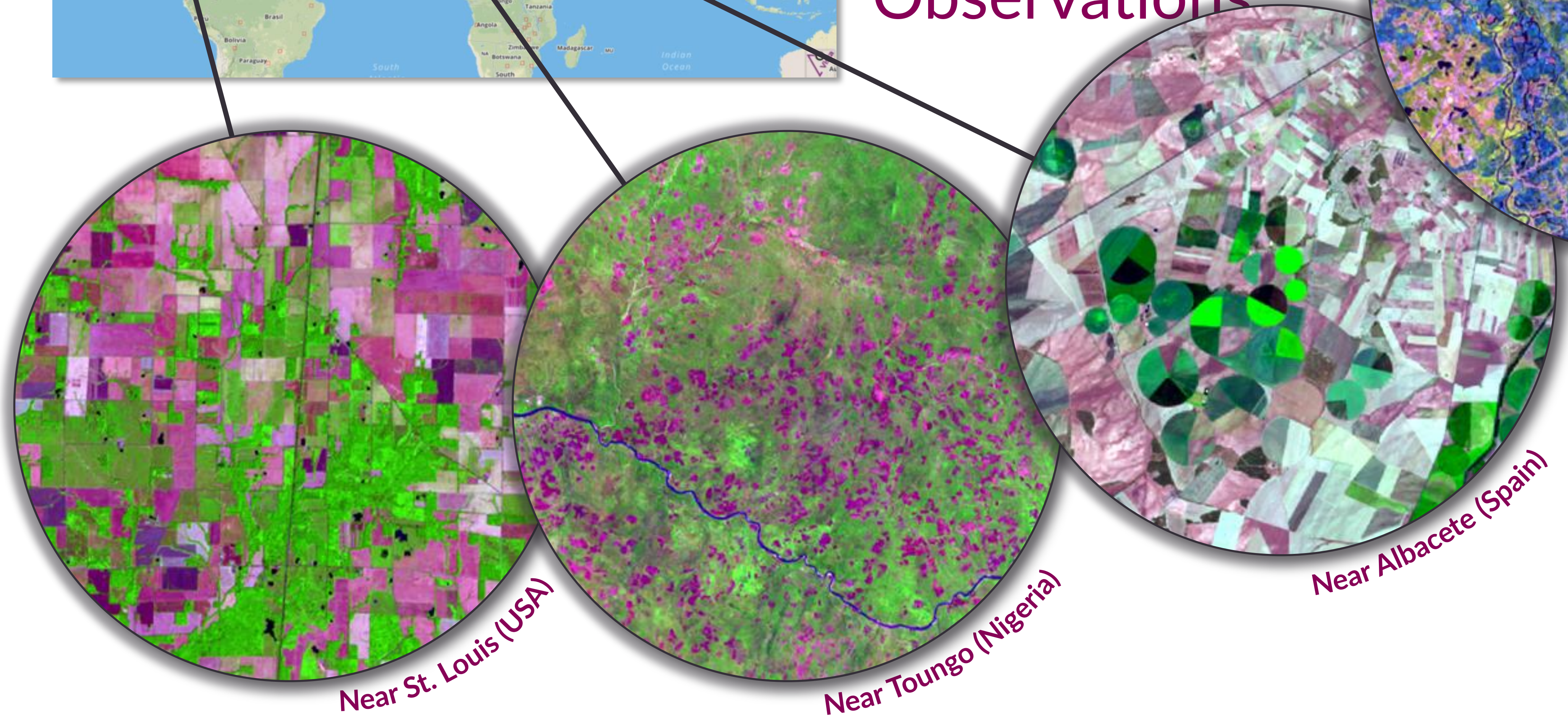
- Validate global results in detail
- Analyse real and virtual water flows in detail
- Investigate water resources scenarios and resulting competition among sectors and ways to solve conflicts
- Assess sustainability of water uses

Zambezi
1.390.000 km^2

...and local: Time Series of Sentinel-2 Observations



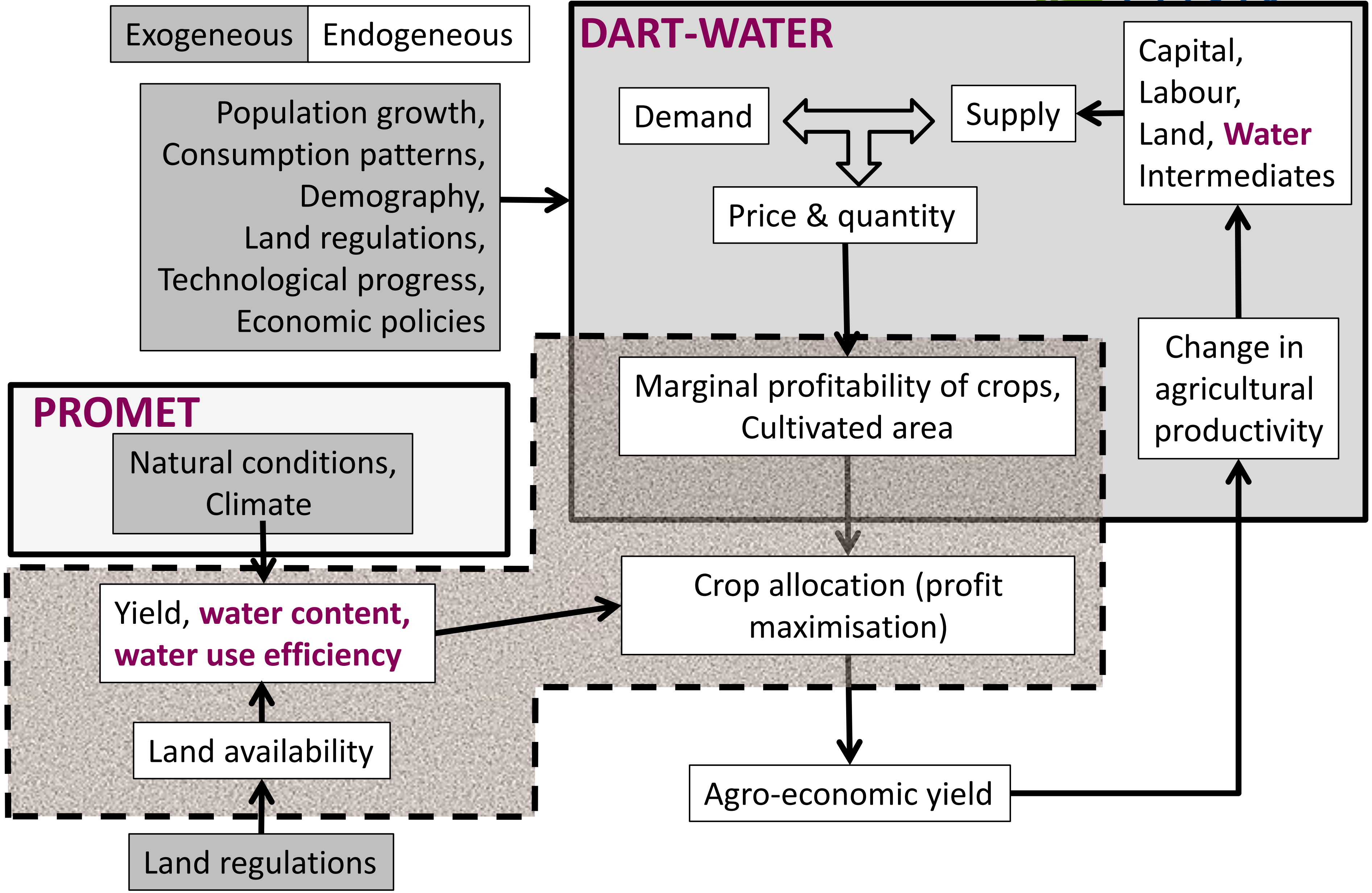




Hi-res global meteorological model drivers

ERA INTERIM 50 km
dynamically downscaled to
12.5 km resolution

DART-WATER-General Computable Equilibrium global trade model and its coupling with PROMET



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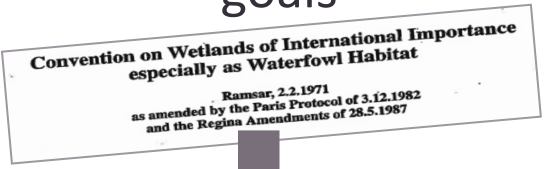
Environmental Sustainability Assessment

ViWA Virtual Water Values

International regulations + further goals


Convention on Wetlands of International Importance especially as Waterfowl Habitat

Ramsar, 2.2.1971
as amended by the Paris Protocol of 3.12.1982
and the Regina Amendments of 28.5.1987

Literature review


Global and Planetary Change

Current and future irrigation water requirements in pan-Europe: An integrated analysis of socio-economic and climate scenarios

Rüdiger Schaldach *, Jennifer Koch, Tim Aus der Beek, Ellen Kynast, Martina Flörke

Geodata

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open source

Scenario Modeling

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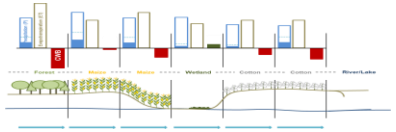
Governance analysis

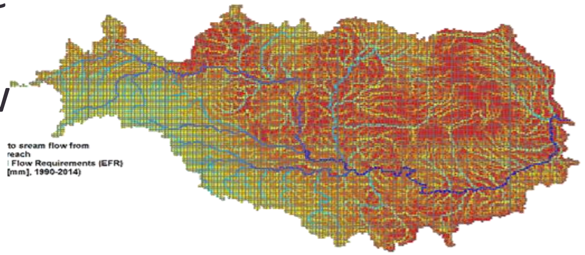
Standards classified by legitimacy → Measuring → Assessment → Scenario analysis → Recommendations

e.g.: Minimum water supply to sustain ecosystems' functions *(rf. Watercourse Convention, CBD, Ramsar Convention)*

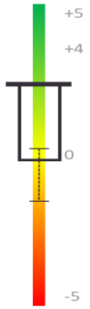
Quantitative indicators
- Domestic water use
- Environmental Flow Requirements



Hot Spots & Cold Spots



Change of sustainability



- Crop management
- Protection of vulnerable habitats

Leibniz Universität Hannover

From global to regional to global again
ViWA results we will show:

- Example of simulations of 291 global 1 km simulations of agricultural management options carried out using approx. 5 mio CPU-hours on the High Performance Computing system SuperMUC

- Example of Sentinel satellite data and model analysis in Saxony and Germany

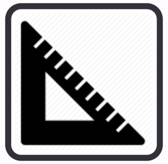
- Example of water-food nexus analysis in the Danube pilot catchment with special emphasis on impact of irrigation

Global high-resolution ensembles: Example Maize LAI

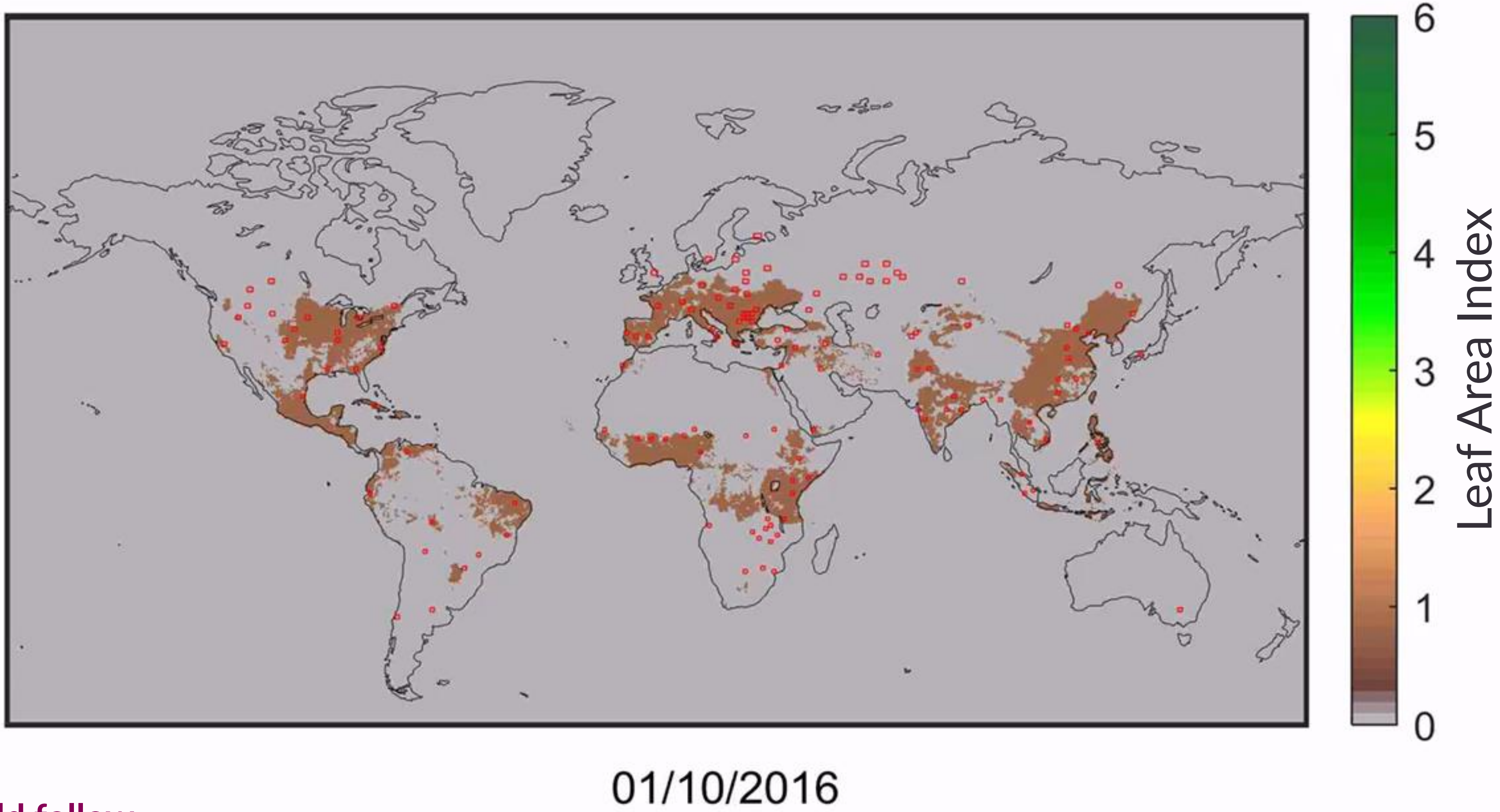
 = Maize

 = standard

 = **rainfed**

 = 30 arcsec
~1km

 = 1 h



290 more movies could follow

Regional: The Danube Basin subset: Maize LAI

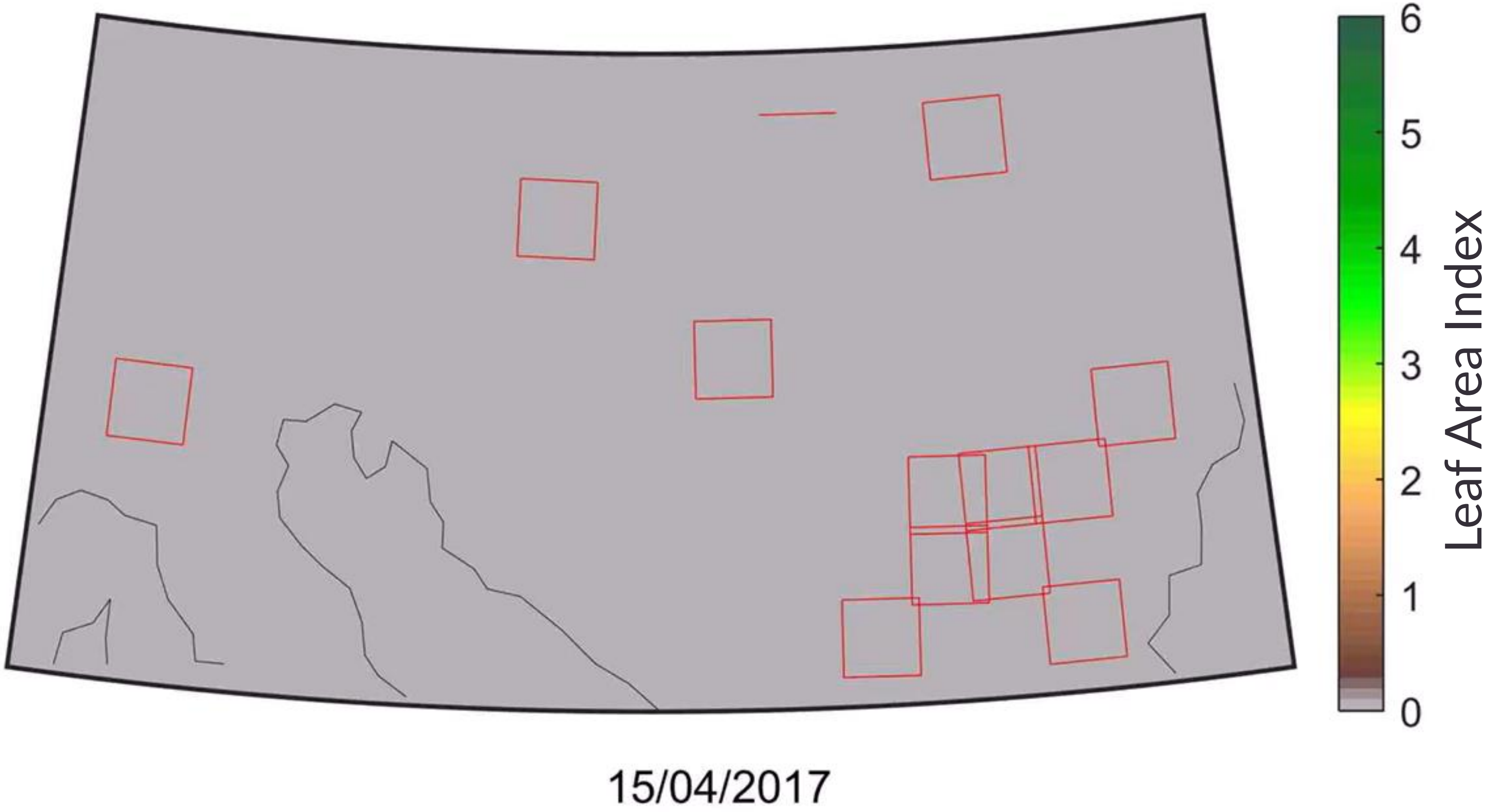
= **Maize**

= standard

= **rainfed**

= 30 arcsec
~1km

= 1 h



Regional: The Danube Basin subset: Maize Yield

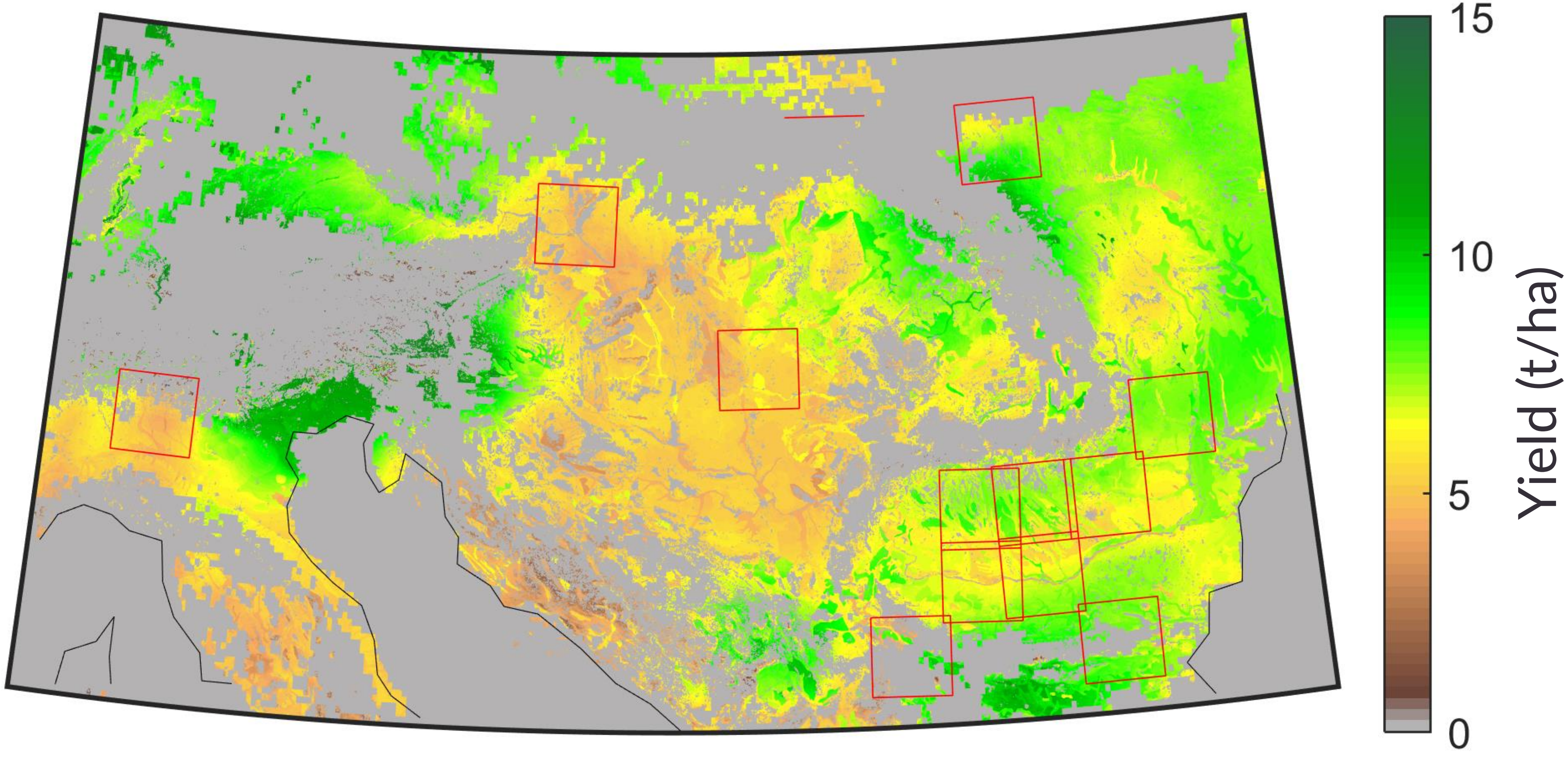
= **Maize**

= standard

= **rainfed**

= 30 arcsec
~1km

= 1 h



Evapotranspiration, soil moisture, water stress etc. are also available globally

Regional: The Danube Basin subset: Maize Yield

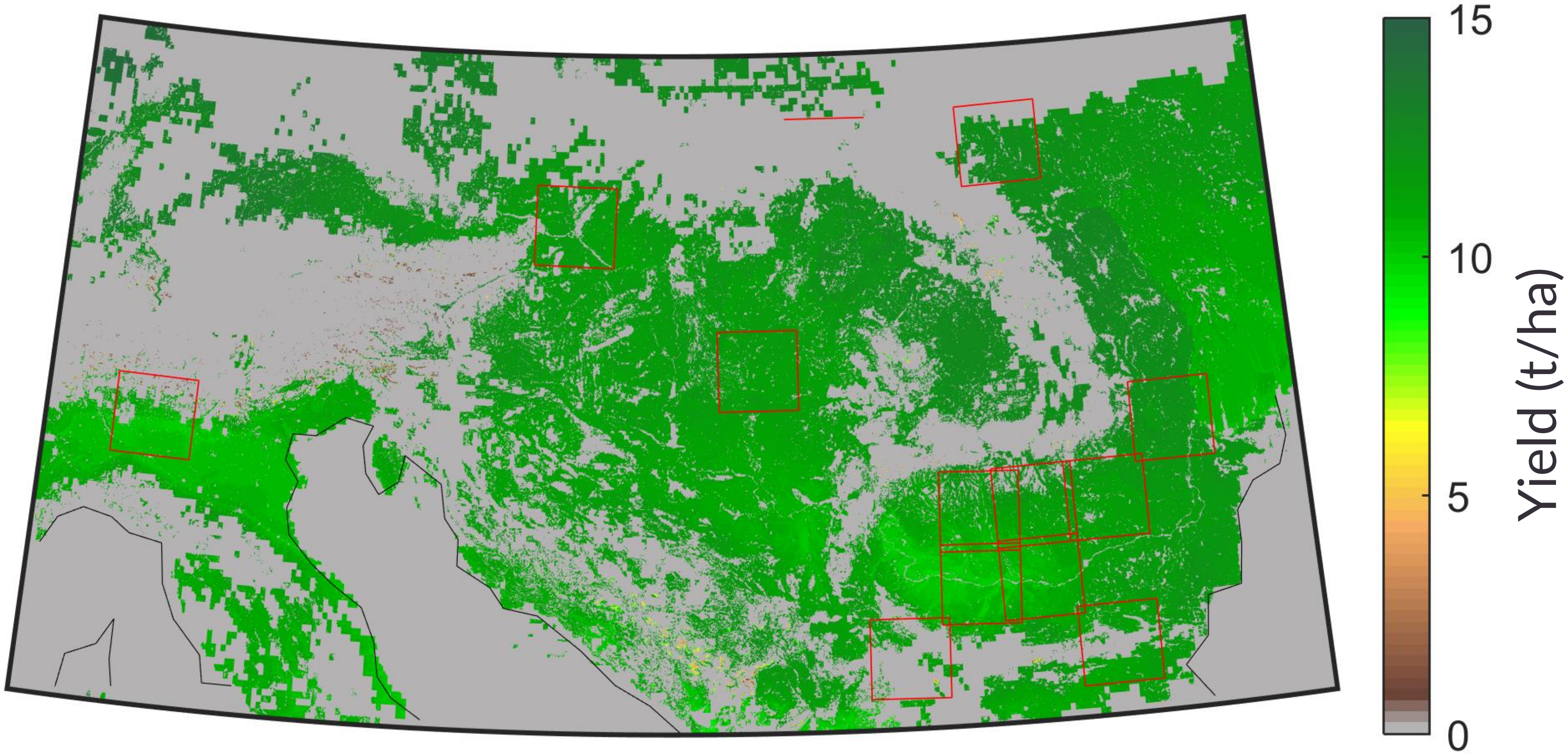
= **Maize**

= standard

= **irrigated**

= 30 arcsec
~1km

= 1 h



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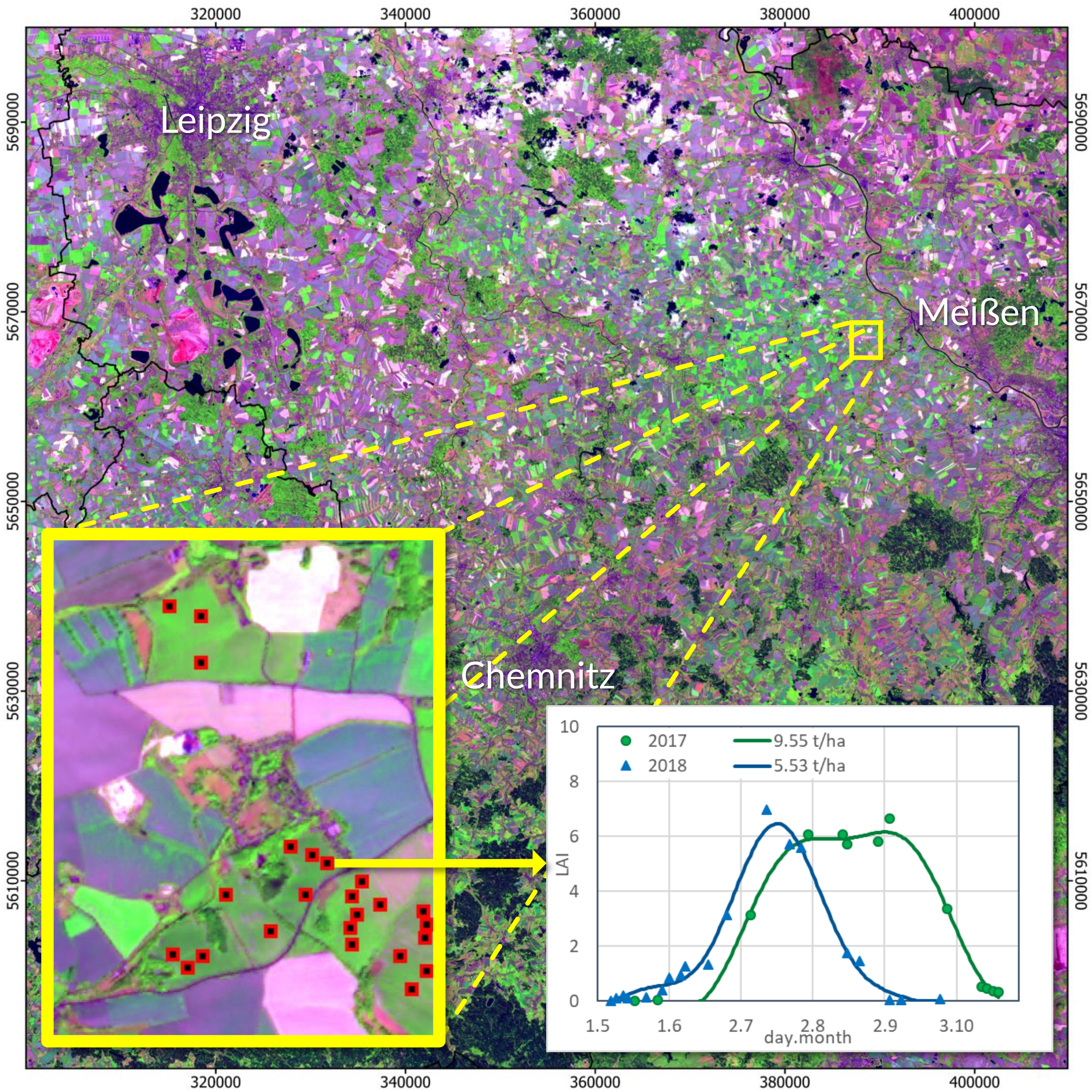
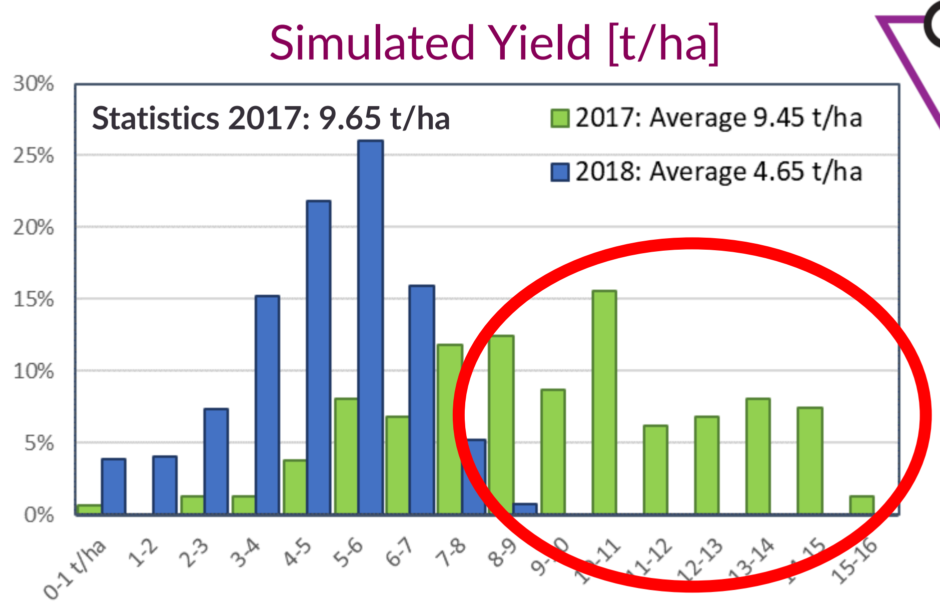
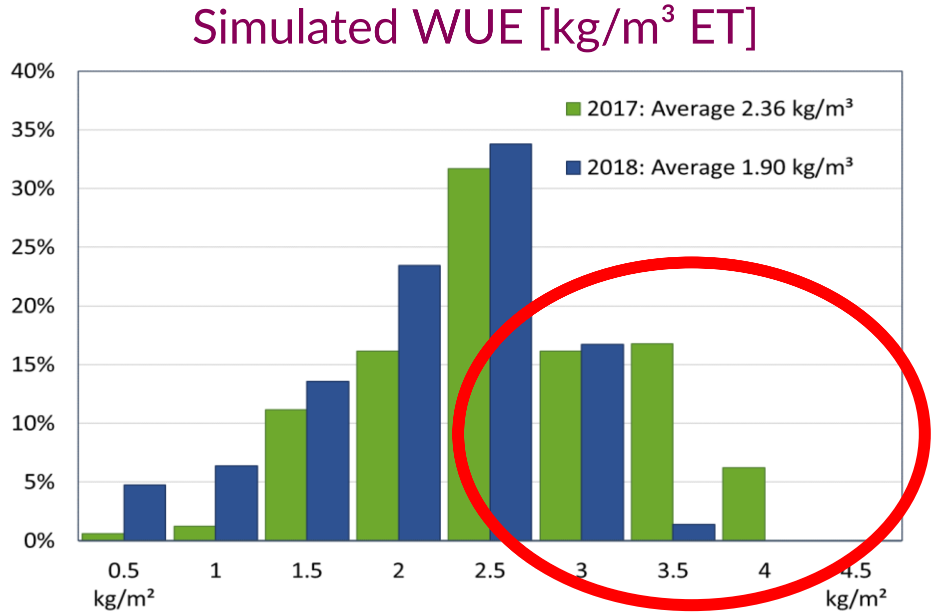


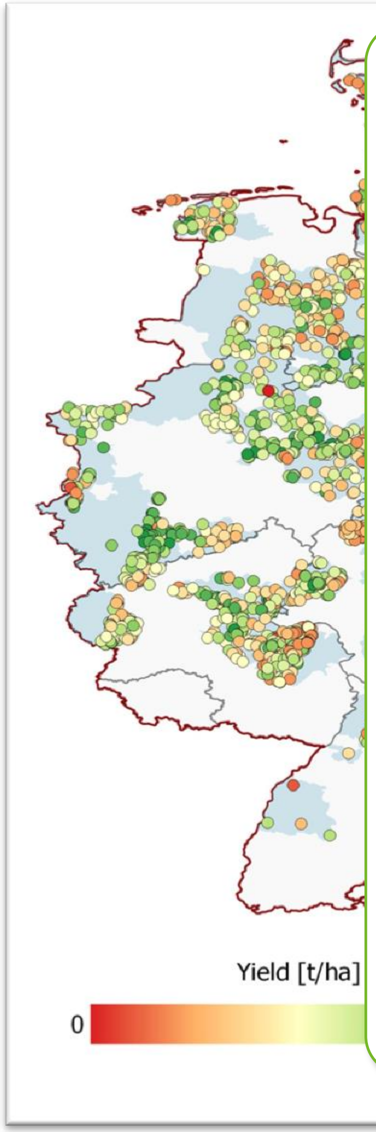




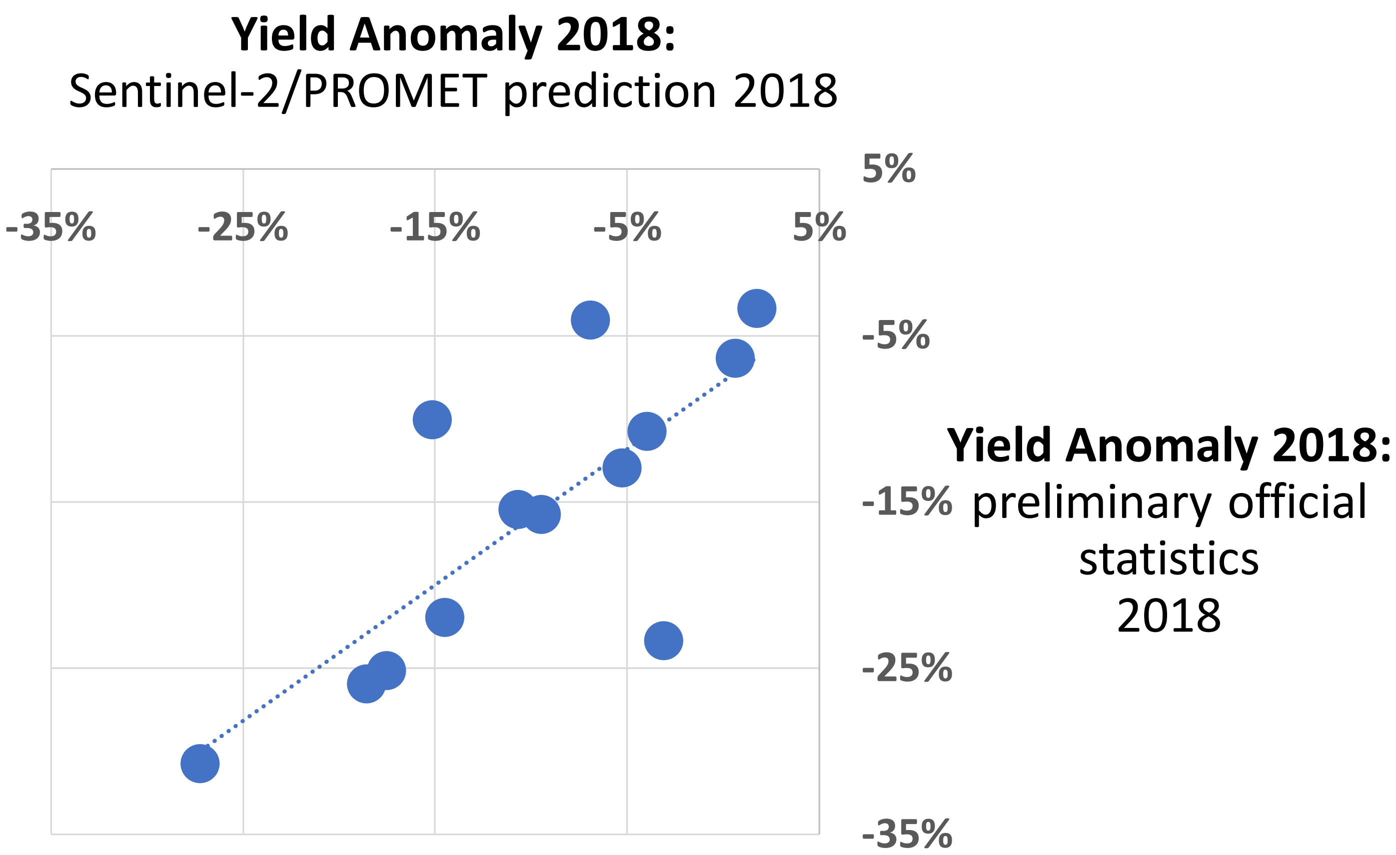
Sentinel-2 tile of July 3rd 2018 with a subset showing one selected maize pixel and its LAI developments

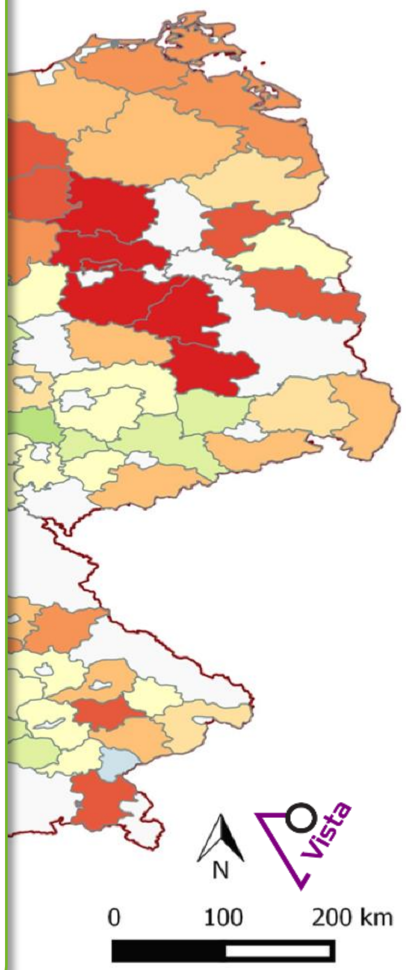
Winter Wheat: predicted Yields of Drought Year 2018

ViWA
Virtual Water Values



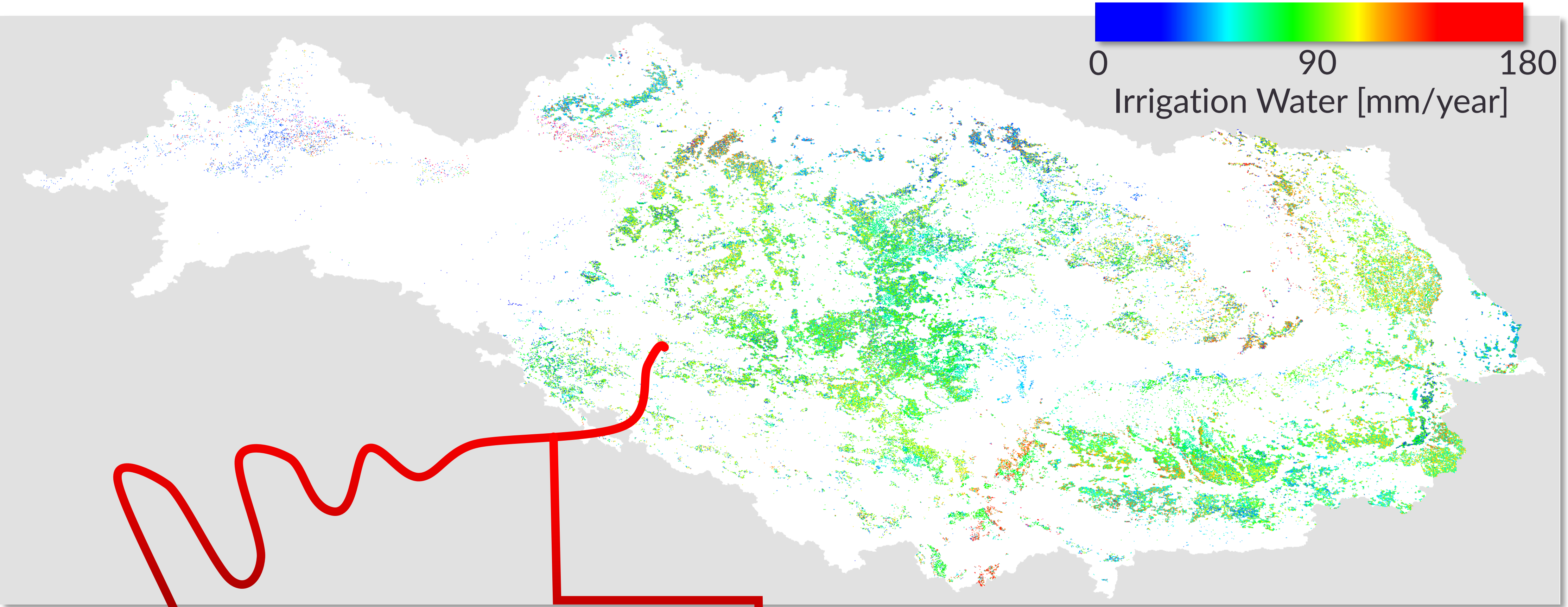
Yield Anomaly Prediction on the States Level

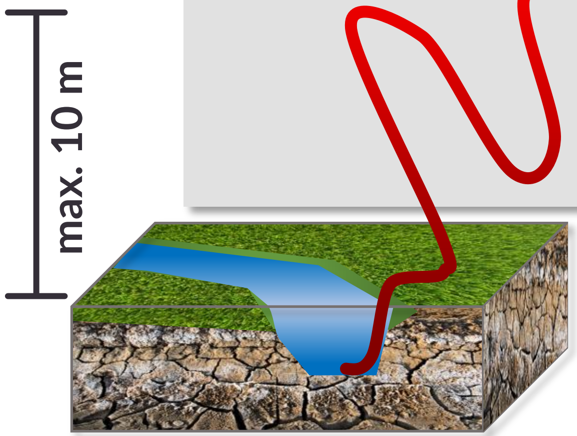




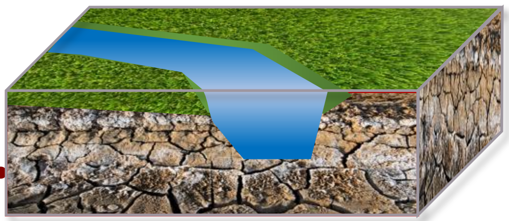
Simulated aver. ann. Irrigation Demand 2015-2017

ViWA Virtual Water Values



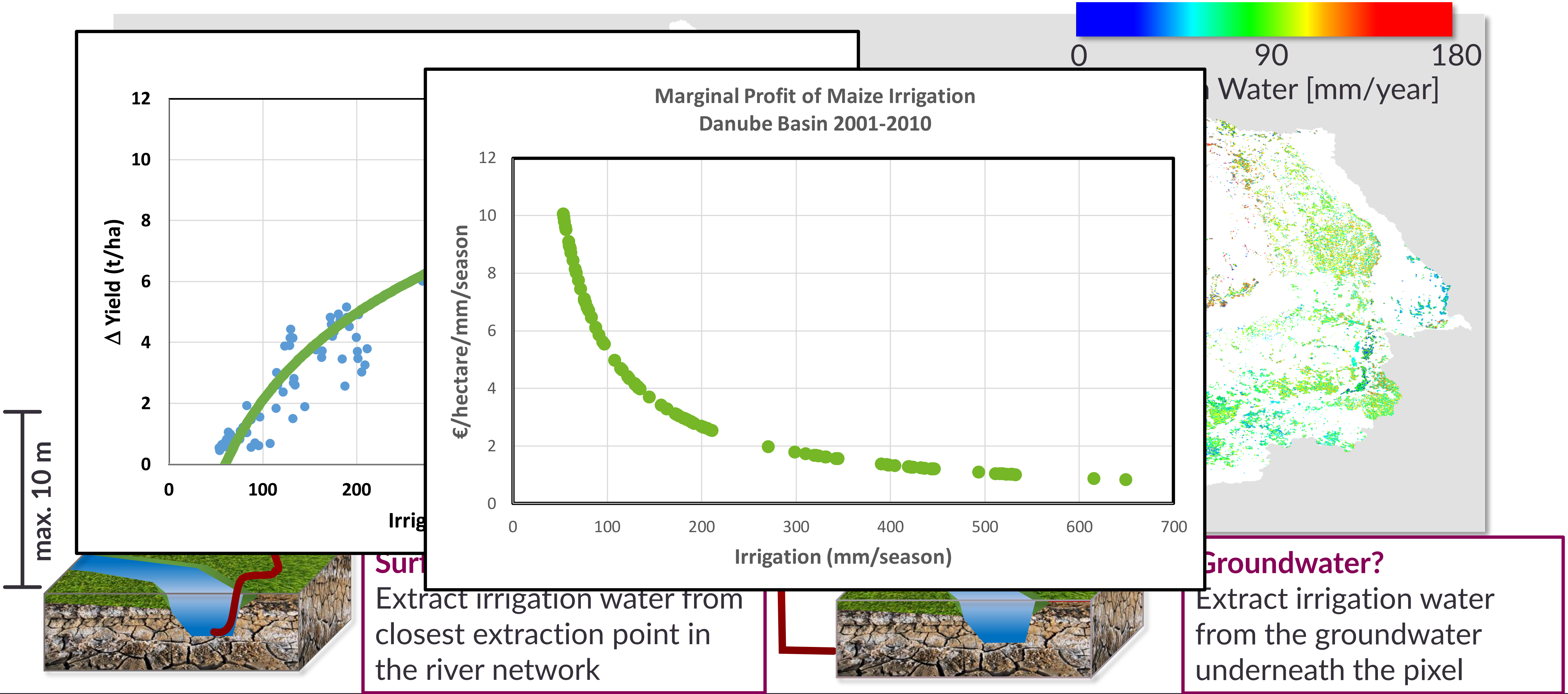


Surface water?
Extract irrigation water from closest extraction point in the river network



Groundwater?
Extract irrigation water from the groundwater underneath the pixel

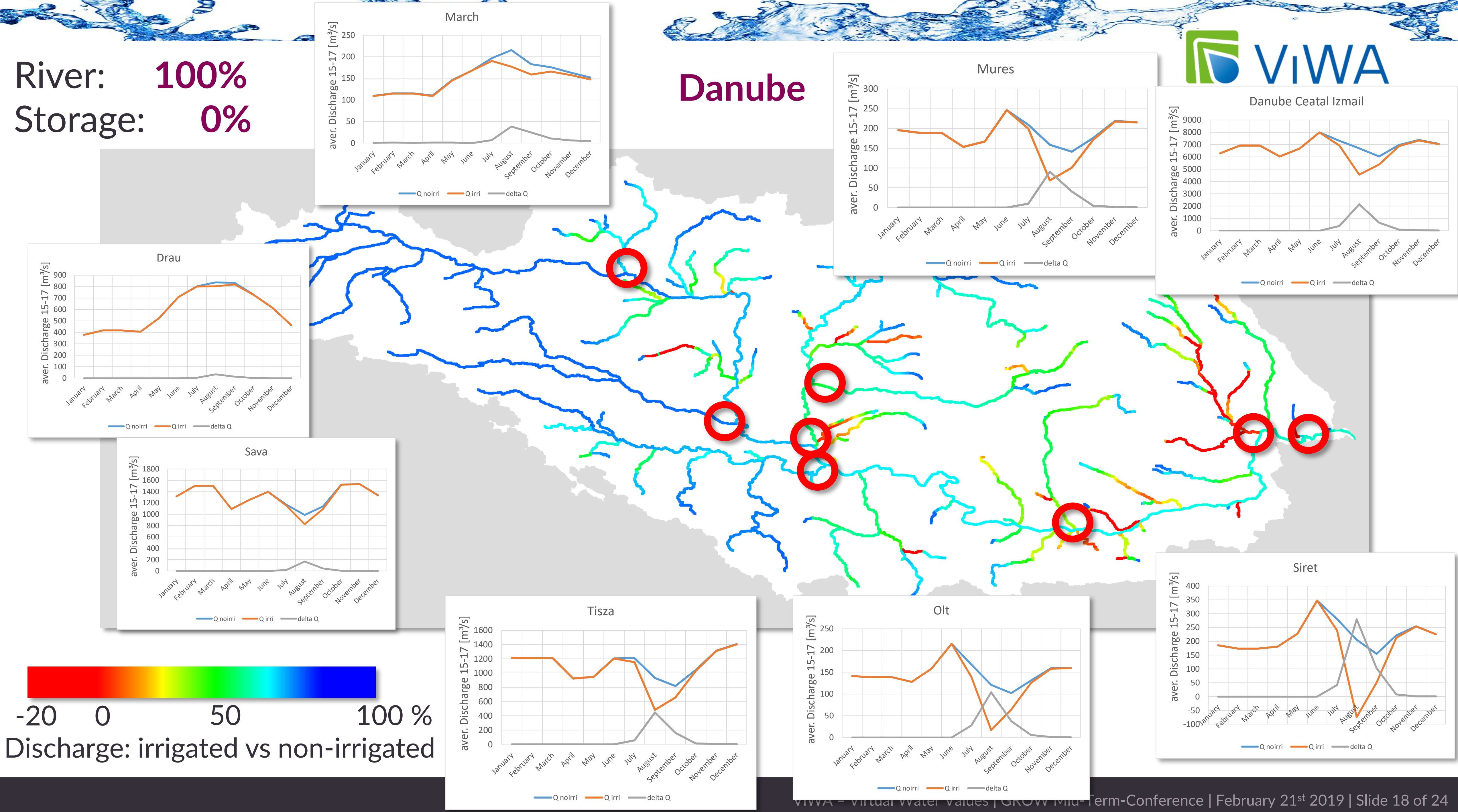
Simulated aver. annual Irrigation Demand 2015-2017



River: **100%**

Storage: **0%**

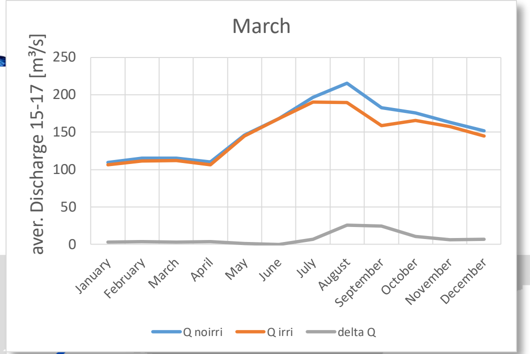
Danube

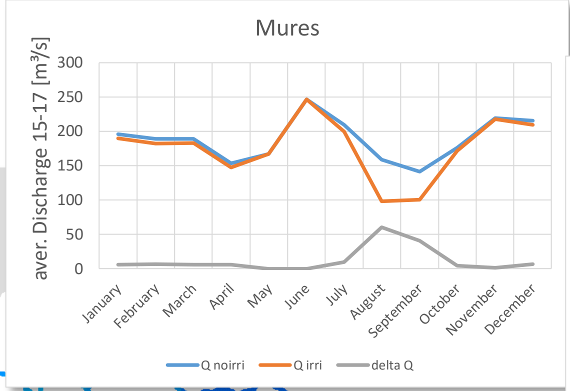


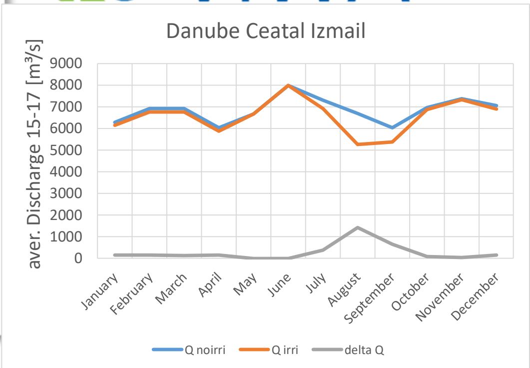
River: 66%

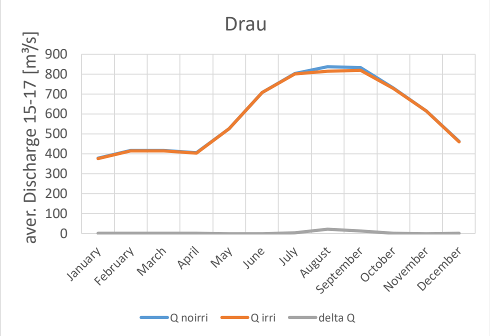
Storage: 33%

Danube





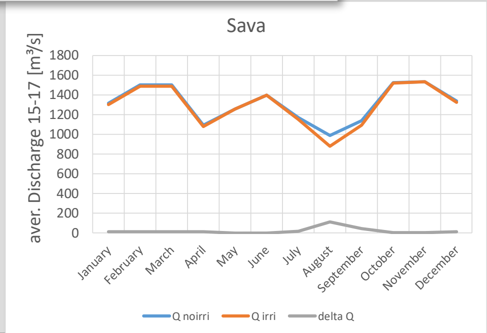


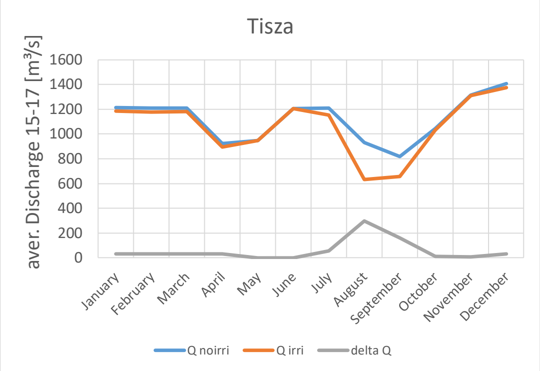


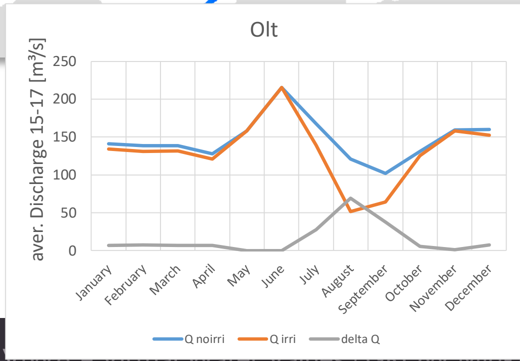
Sustainability Indicators e.g.:

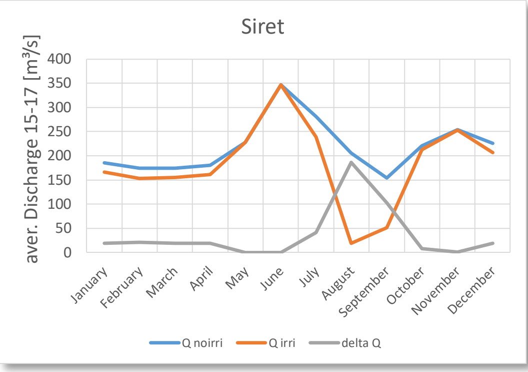
Environmental Flow Requirements (EFR) – water that needs to flow from each pixel in the rivers and lakes to ensure healthy aquatic ecosystems

EFR = 60% of mean Discharge (high sustainability)





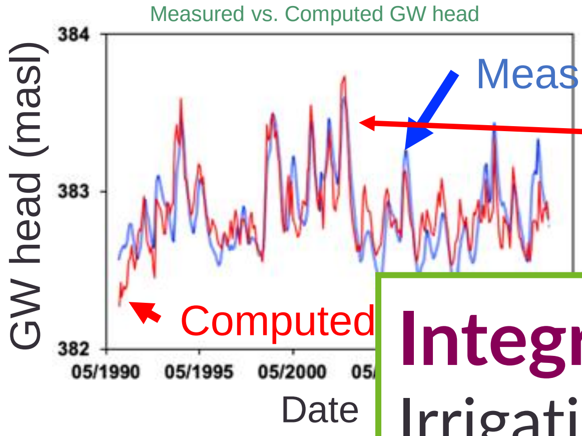




-20 0 50 100 %

Discharge: irrigated vs non-irrigated

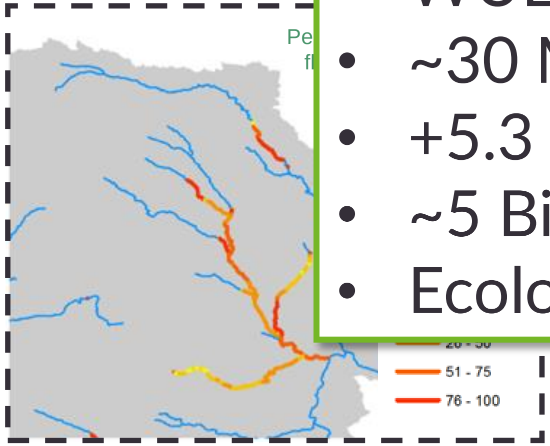
Irrigation from groundwater? Towards global groundwater models

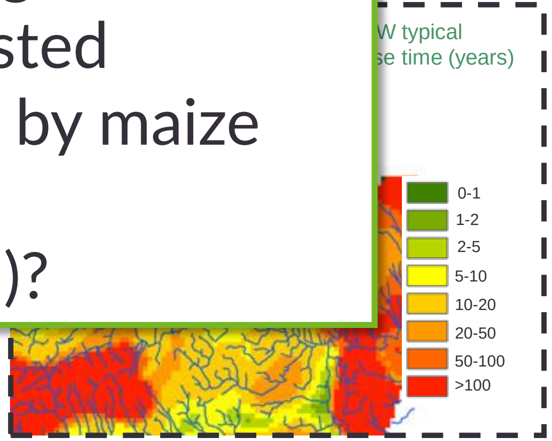


Integrated results

Irrigating maize would mean to the Danube:

- WUE increase from 1.8 to 2.7 kg/m^3
- ~30 Million t more maize harvested
- +5.3 Billion m^3 water transpired by maize
- ~5 Billion € plus in revenue
- Ecology (EFR, Groundwater etc.)?





- New **(efficient) approach** to establish regional scale groundwater models worldwide.
- Groundwater abstractions may decrease regional groundwater levels by a few meters (0.5 – 5 m), but the **regional GW response might be observable only after long time**.

ViWA Virtual Water Values

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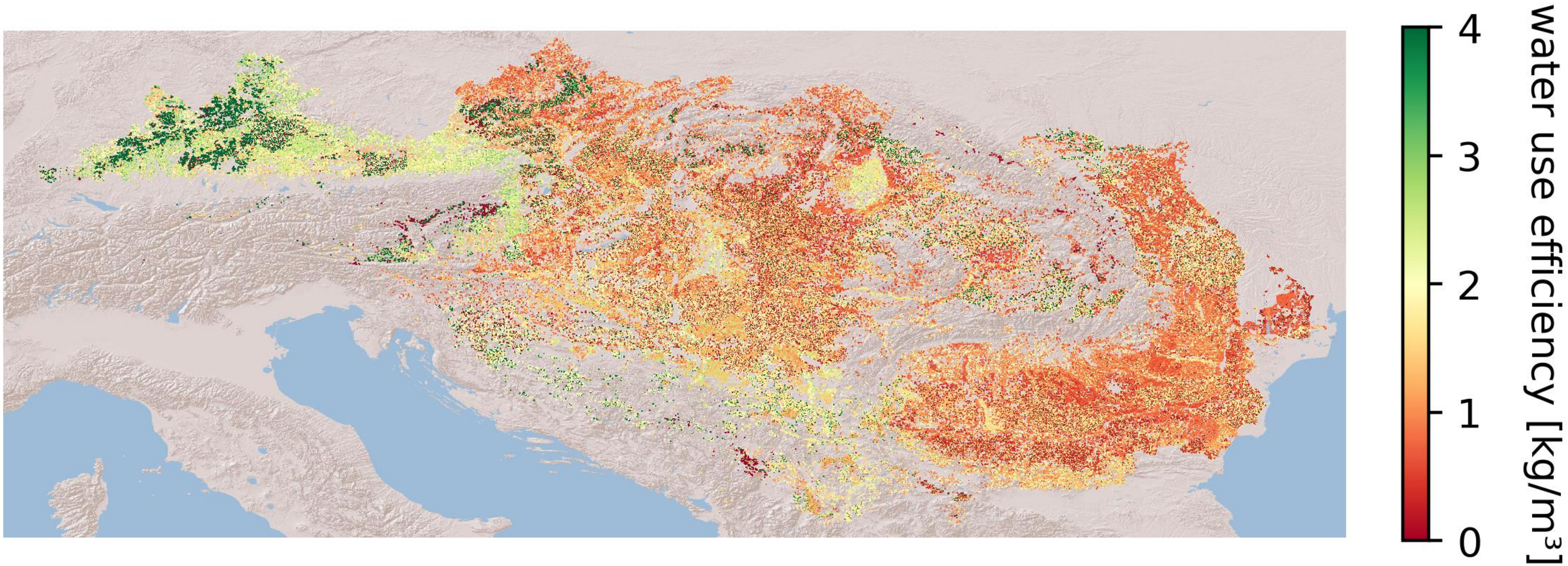
WUE of Agriculture in the Danube (2015-17)

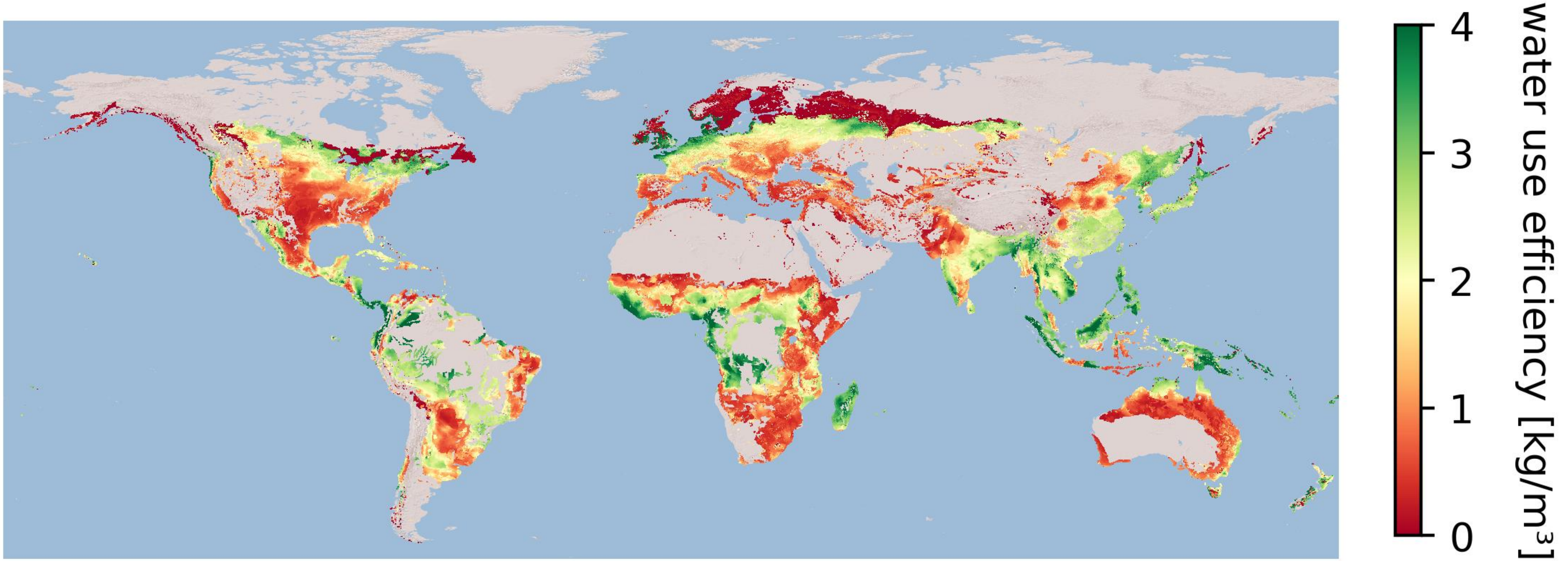


 = **Realistic crop mix**

 = Realistic

 = Rainfed

Back to the Global Picture: Hot- and Cold-Spots of WUE

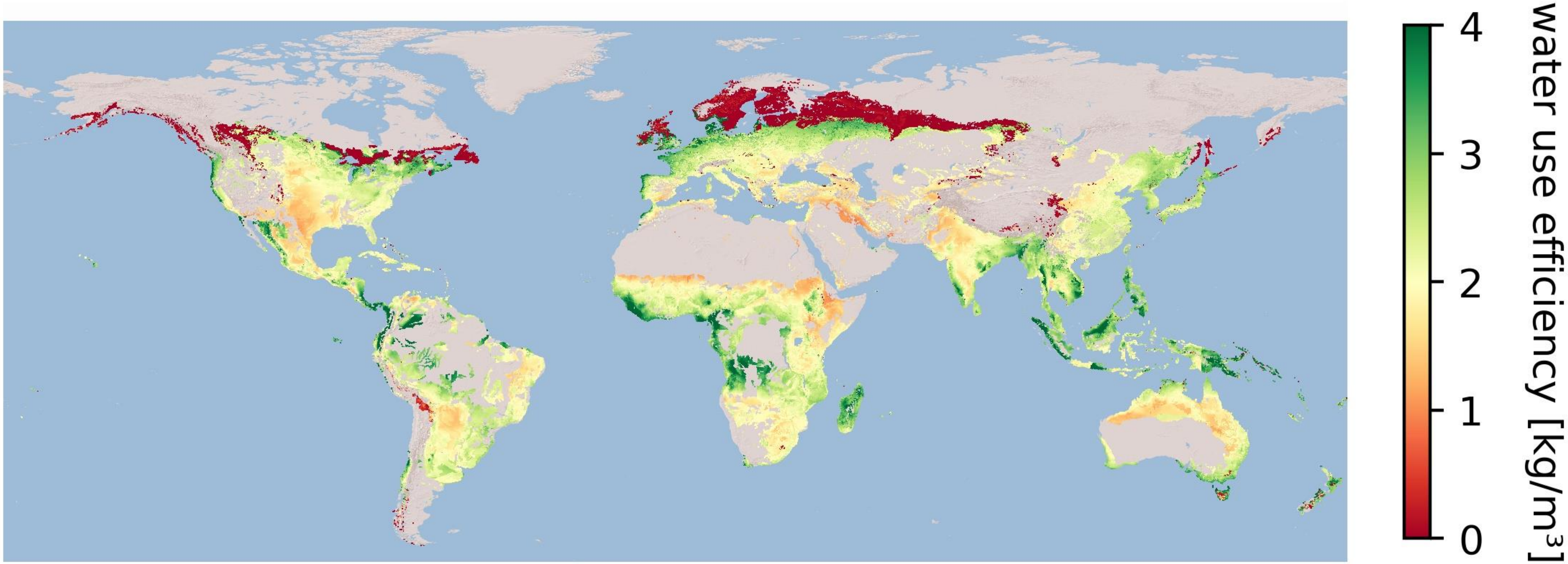


= **Maize**

= Realistic

= Rainfed

Back to the Global Picture: Hot- and Cold-Spots of WUE



= **Maize**

= Realistic

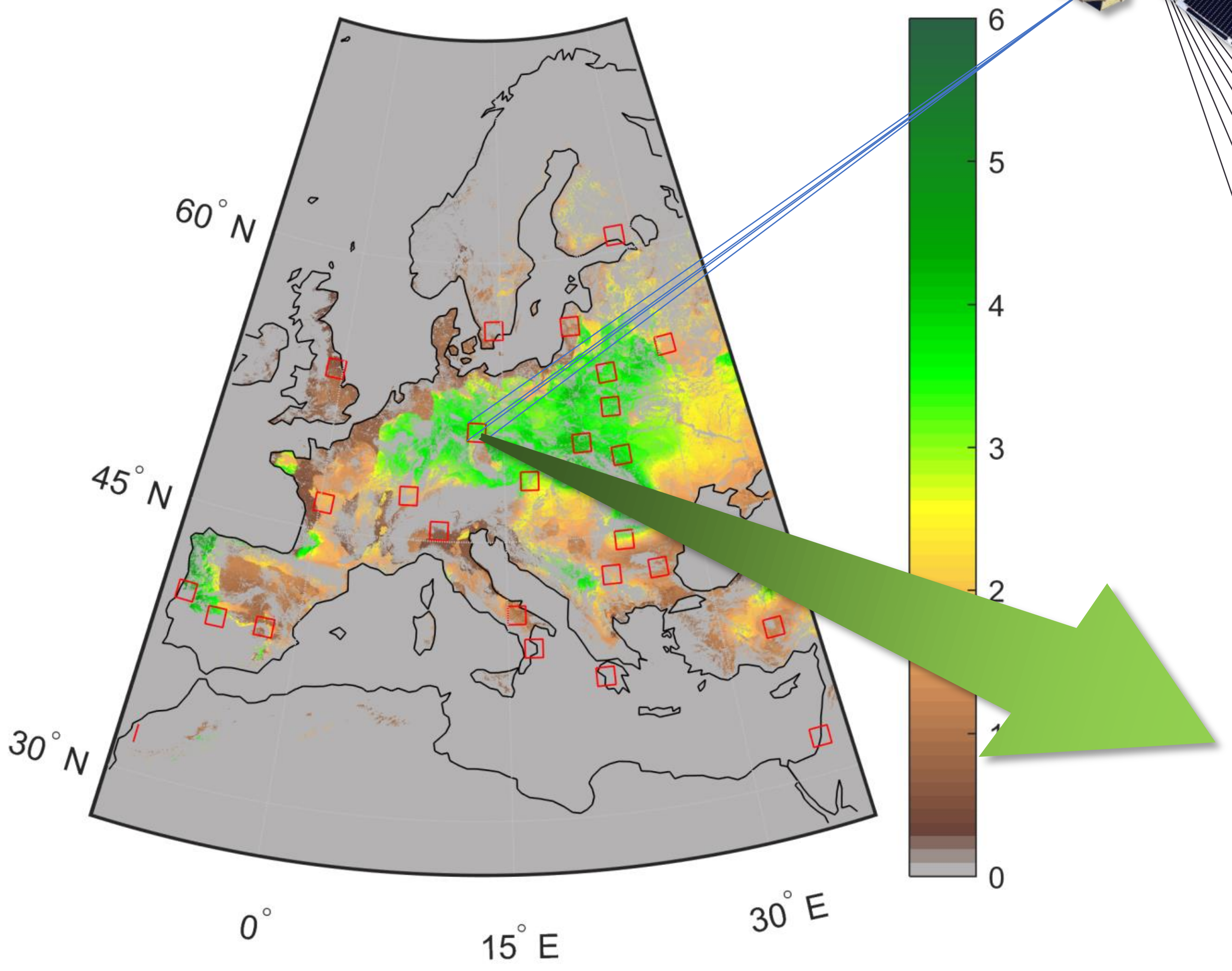
= Irrigated

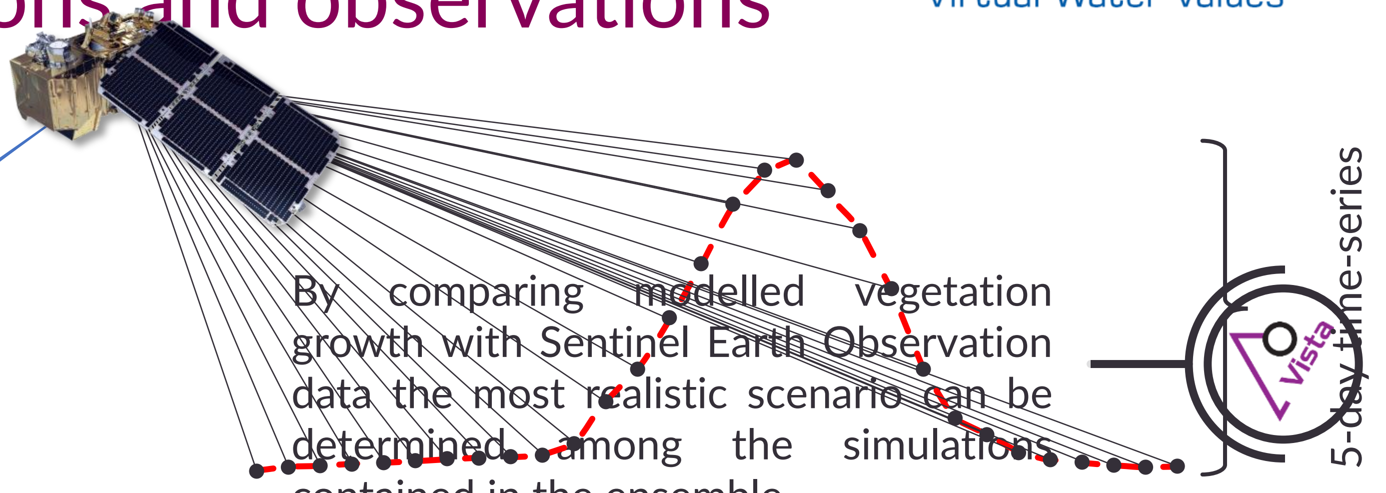
ViWA – next steps:

- Fully develop **DART-Water** to include virtual water value in global trade, couple with PROMET, develop and explore scenarios to foster global improvements in agricultural WUE
- Integrate Sentinel satellite observations and ensemble simulations to **complete the WUE monitoring system**
- Further develop **Danube case** (hydropower, thermal power, industry, households) and develop and use **sound indicators** for sustainable water use in the Danube Basin
- Extend approach to the **Zambesi Basin**

PROMET – combine simulations and observations

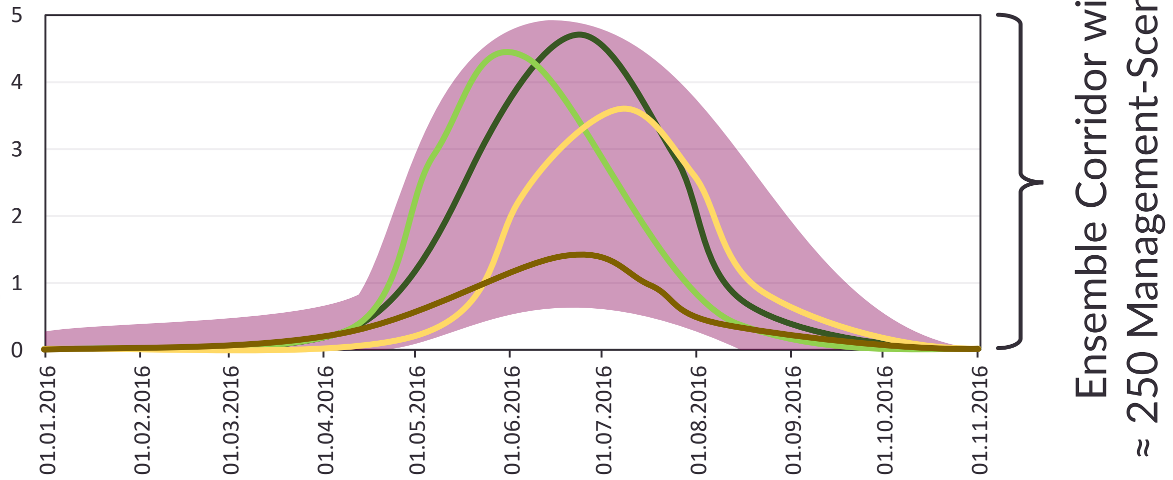
Virtual Water Values





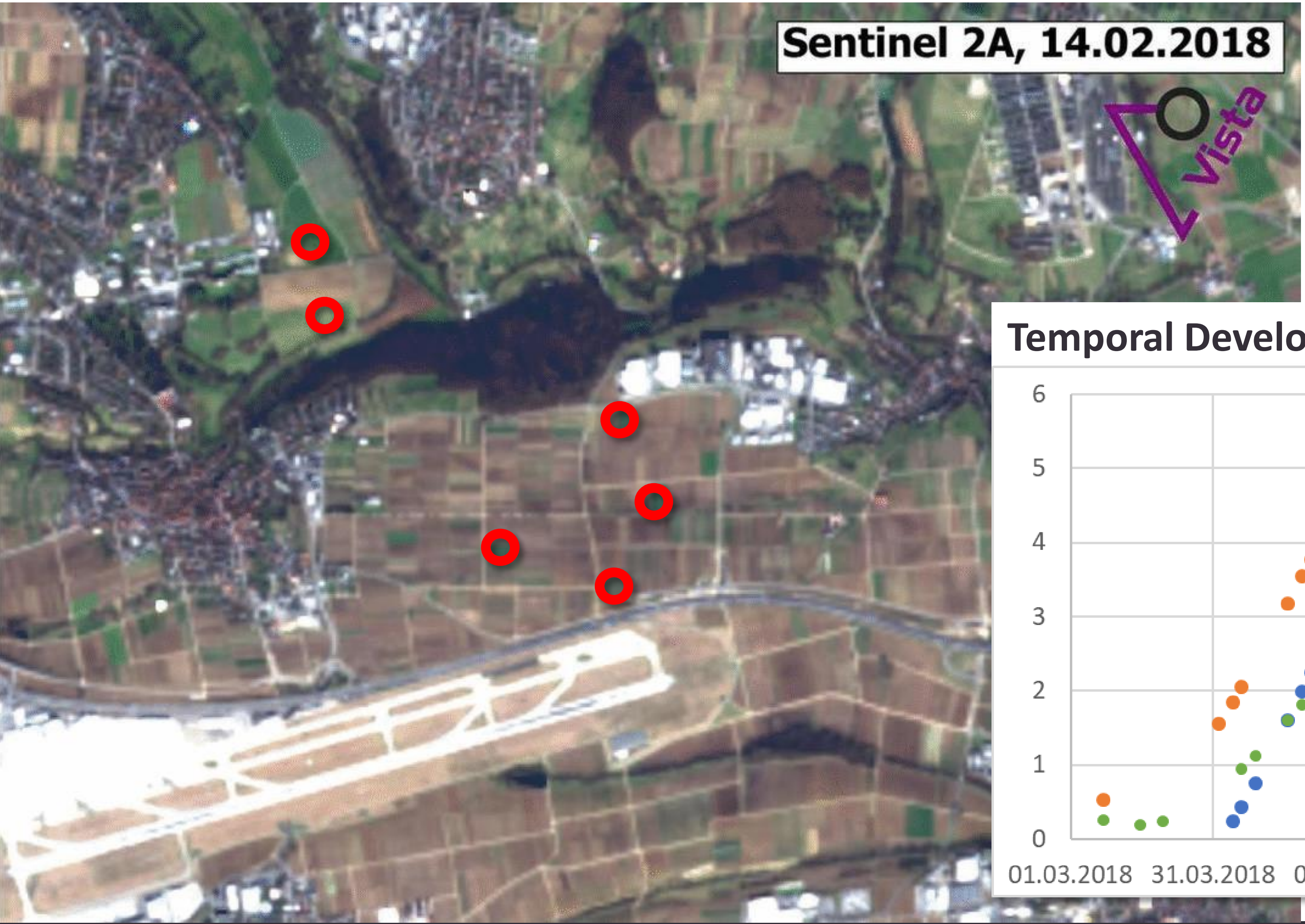
By comparing modelled vegetation growth with Sentinel Earth Observation data the most realistic scenario can be determined among the simulations contained in the ensemble.

LAI simulated for different scenarios on each pixel



Local: Dynamic Yield-Estimation - Filderstadt 2018

ViWA
Virtual Water Values



Winter Wheat
Pixels

Temporal Development of observed Leaf Area Index (LAI)