

A dynamic water splash in shades of blue and white, with a central dark grey horizontal band. The water is captured in mid-air, creating a sense of movement and freshness.

# Virtual Water Values (ViWA)

GROW – Collaborative Project ViWA:  
Multiscale Monitoring of Global Water Resources and  
Options for their Efficient and Sustainable Use

# PROMET – Processes of Mass and Energy Transfer

## A Short Overview

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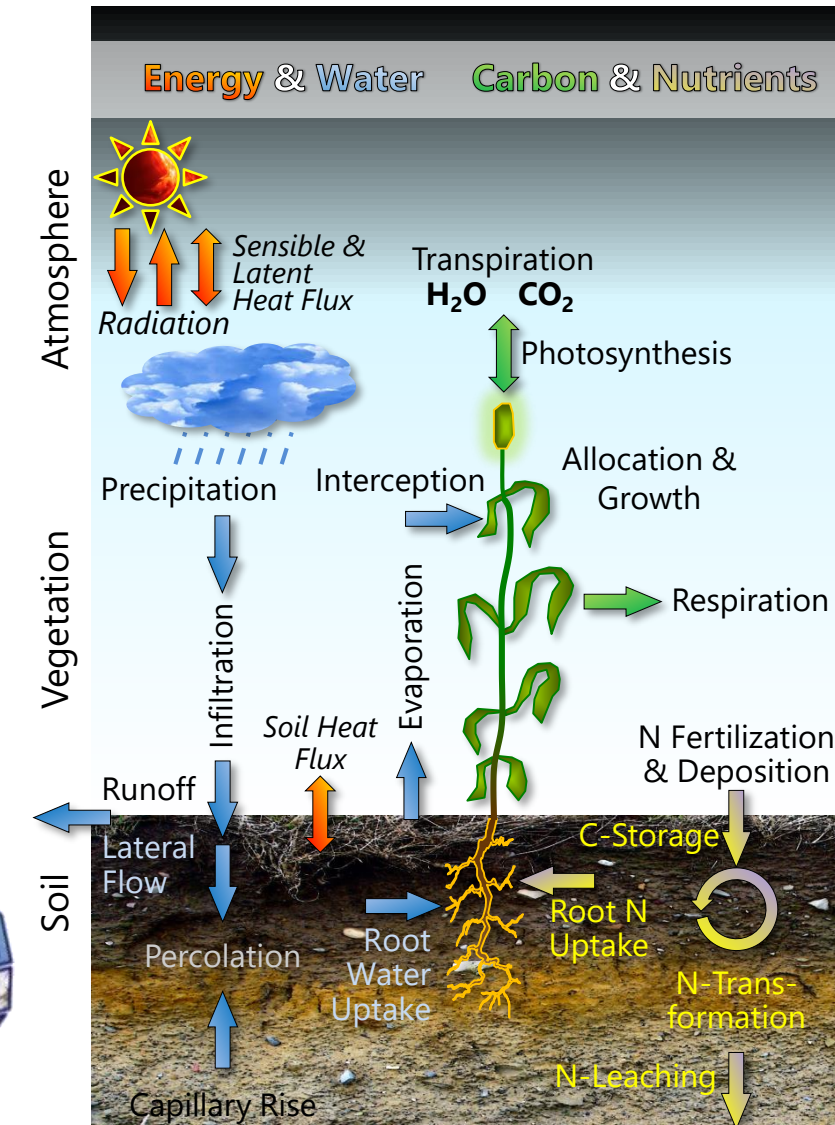
<sup>2</sup>VISTA – Remote Sensing Applications in Geosciences | Munich | Germany

# 1 - What is PROMET?

## PROMET (Processes of Mass and Energy Transfer)

is an integrated simulation model, which:

- represents the coupled environmental processes and their interactions on the land surface,
- couples a hydrologic land surface model and a dynamic vegetation model by applying physical and physiological laws and principles,
- is spatially distributed in its process representation,
- allows to consider human interference through changing boundary conditions (climate) and technologies,





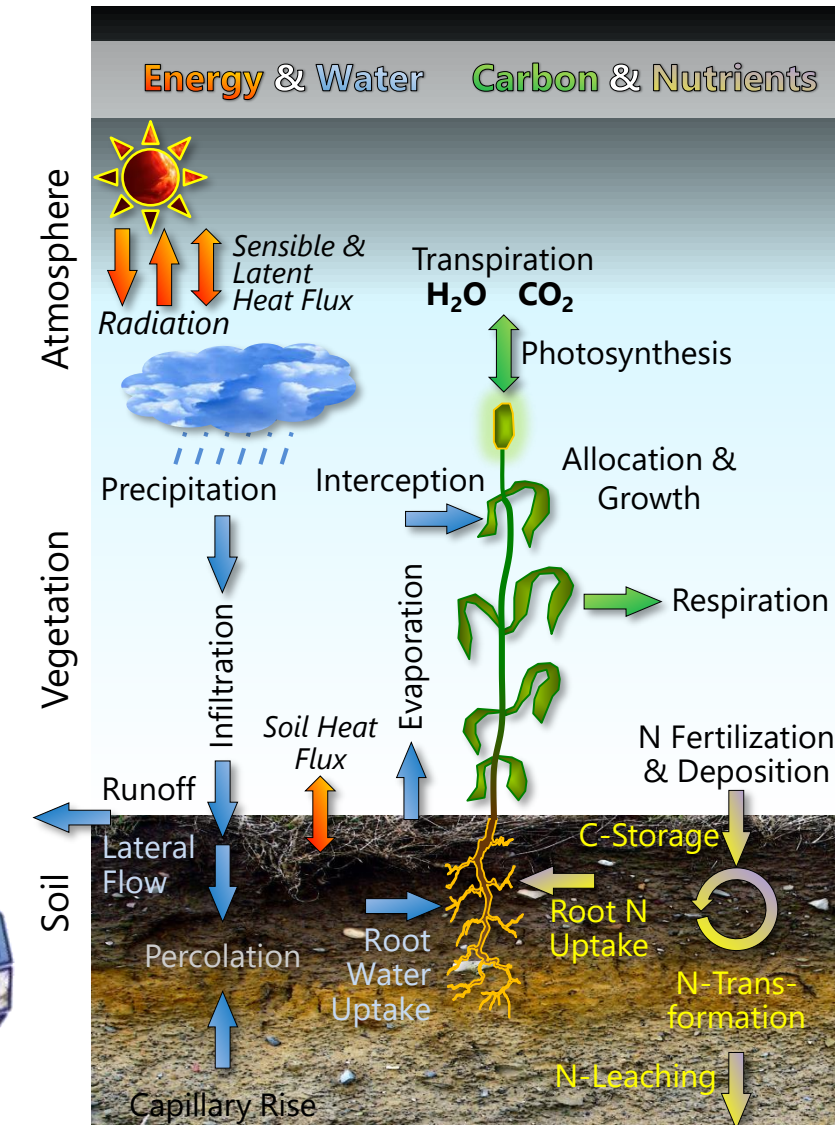
# 1 - What is PROMET?

## PROMET (Processes of Mass and Energy Transfer)

is an integrated simulation model, which:

- strictly closes the matter ( $H_2O$ , C, N etc.) and energy balances,
- has been used on different scales from the local field scale (10 m) up to the global scale (1 km),
- is not calibrated but nudged by selecting universally valid parameters and
- is parallelized and running on high-performance computing platforms.

**PROMET participates in AgMIP – the Agricultural Models Intercomparison and Improvement Project**



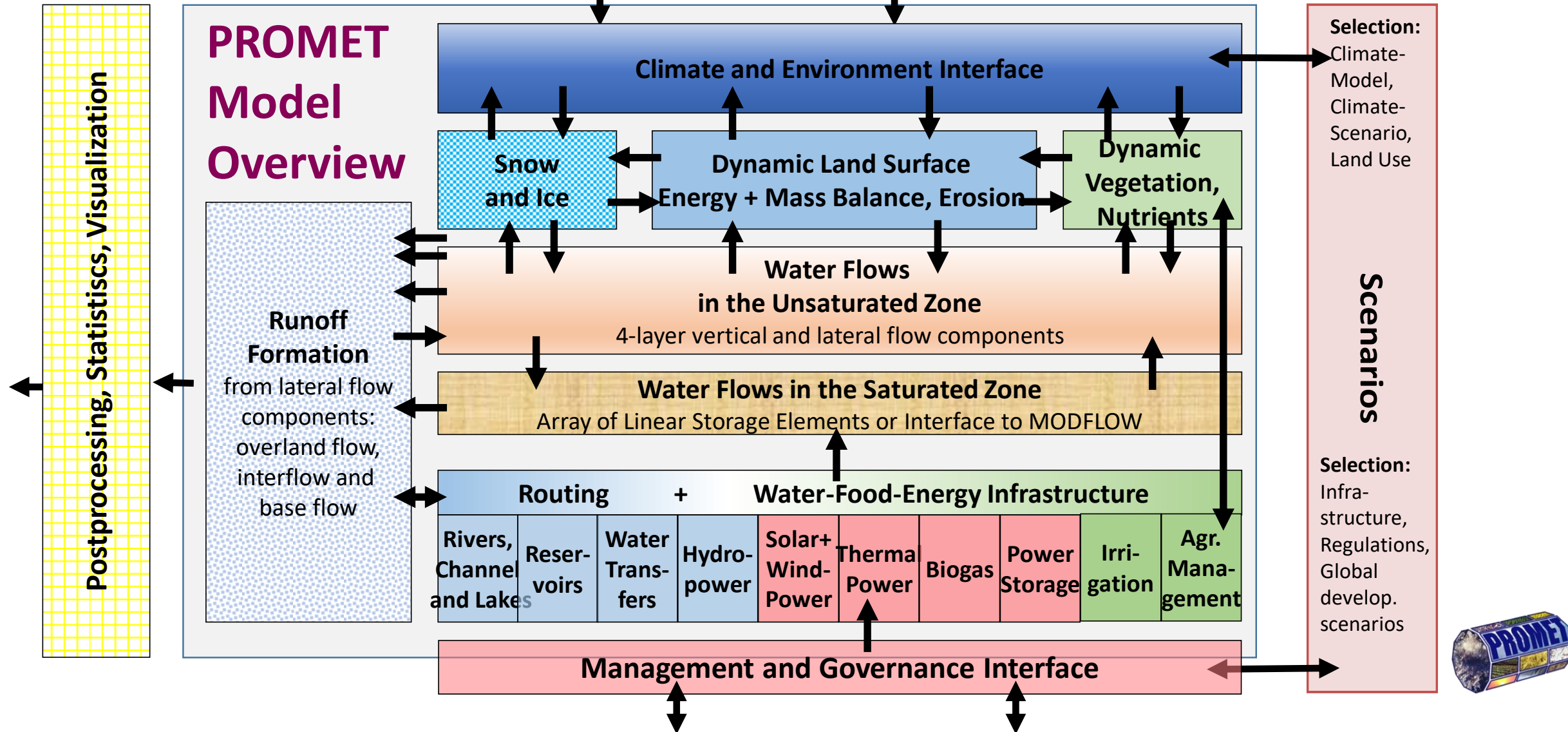
## Remote Sensing

Land Use, Plant Growth, Phenology, Agr. Management  
from COPERNICUS Sentinel

## Meteorological Drivers

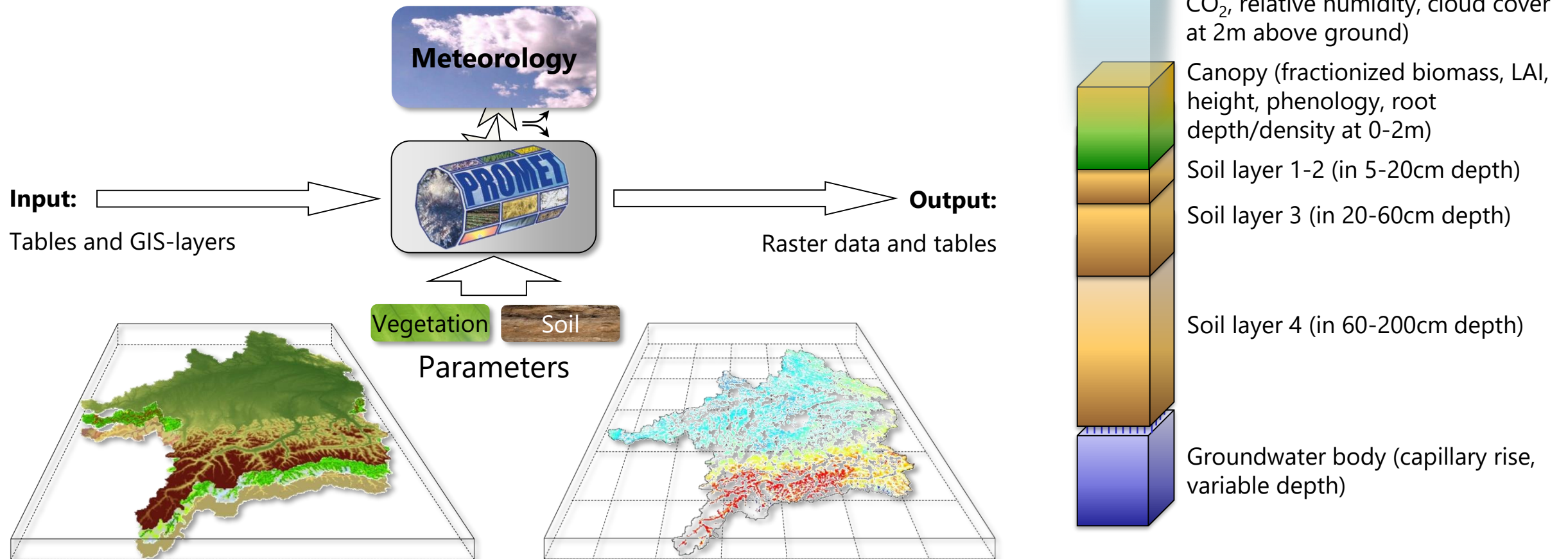
Bias-correction, Downscaling of Meteo- and Climate Model Outputs (ERA-5, CORDEX, etc.) and Station Data (DWD)

# PROMET Model Overview



## 2 - PROMET | Model Overview

Spatial representation on regular or irregular grids:

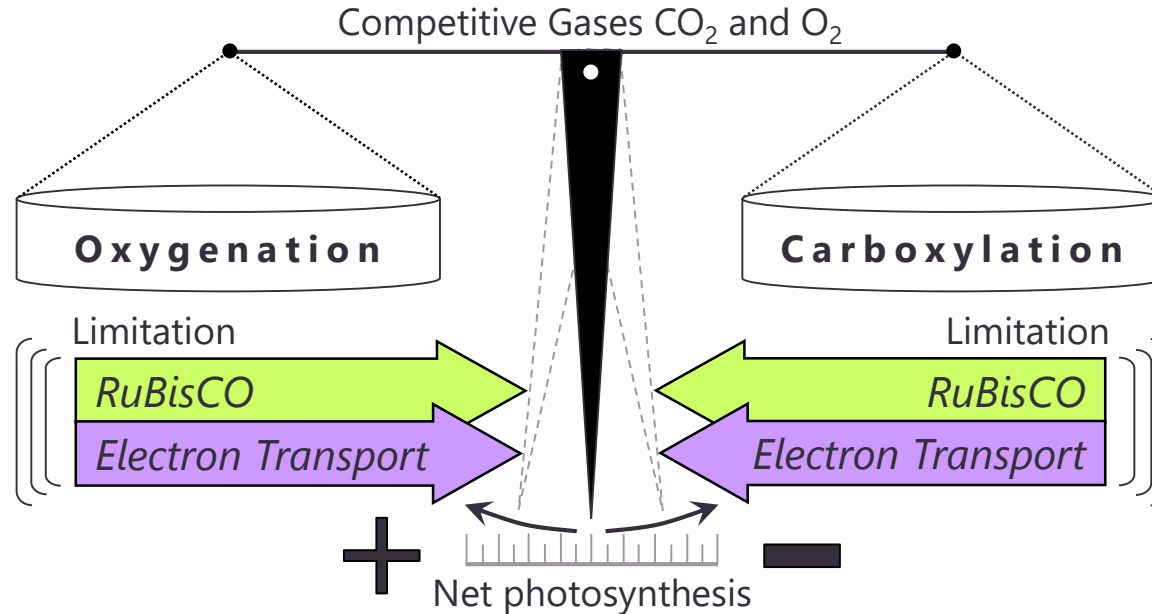


# 3 - PROMET | Dynamic Vegetation Model

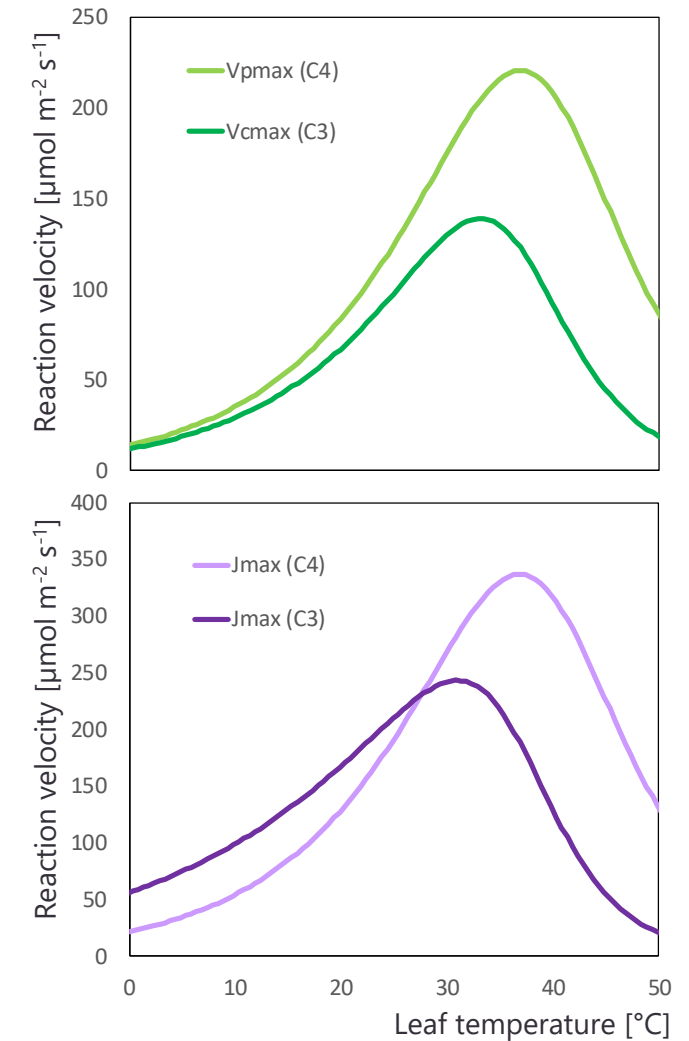
C<sub>3</sub> photosynthesis:  
**Farquhar, von Caemmerer and Berry (1980)**

C<sub>4</sub> metabolism:  
**Chen et al. (1994)**

Stomatal conductance:  
**Ball, Woodrow and Berry (1986)**



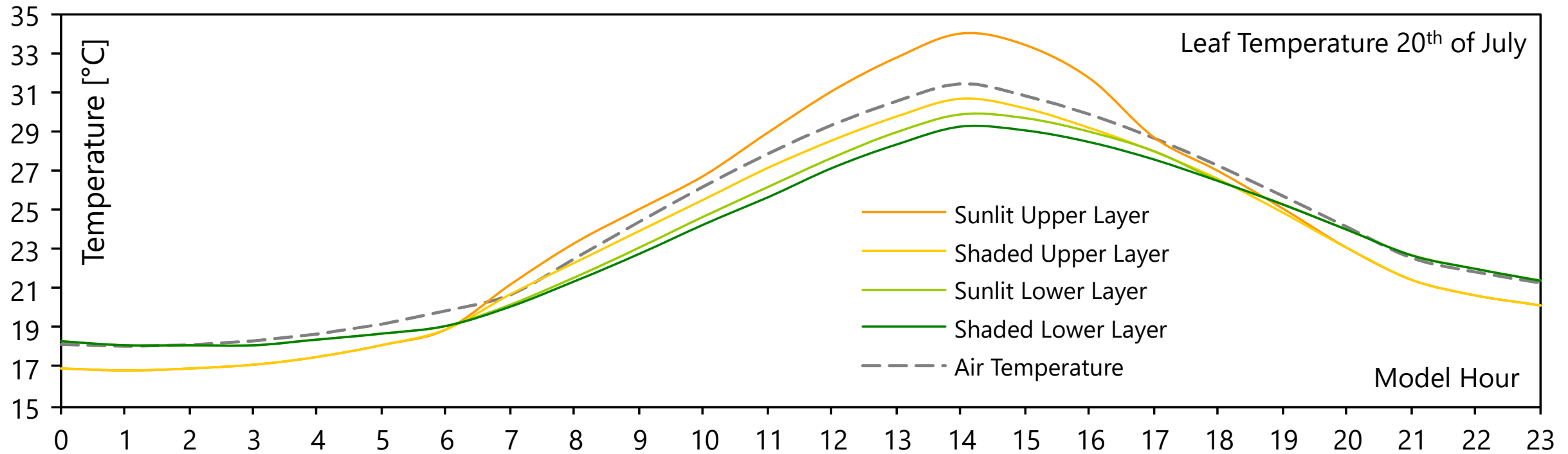
- + Stomatal conductance (drought stress, CO<sub>2</sub>-scenarios...)
- + Phenology (breeds, yield formation...)
- + Carbon allocation (canopy structure, radiative transfer...)
- + Management (sowing, mowing, harvesting...)
- + etc., etc., etc.





## 3 - PROMET | Dynamic Vegetation Model

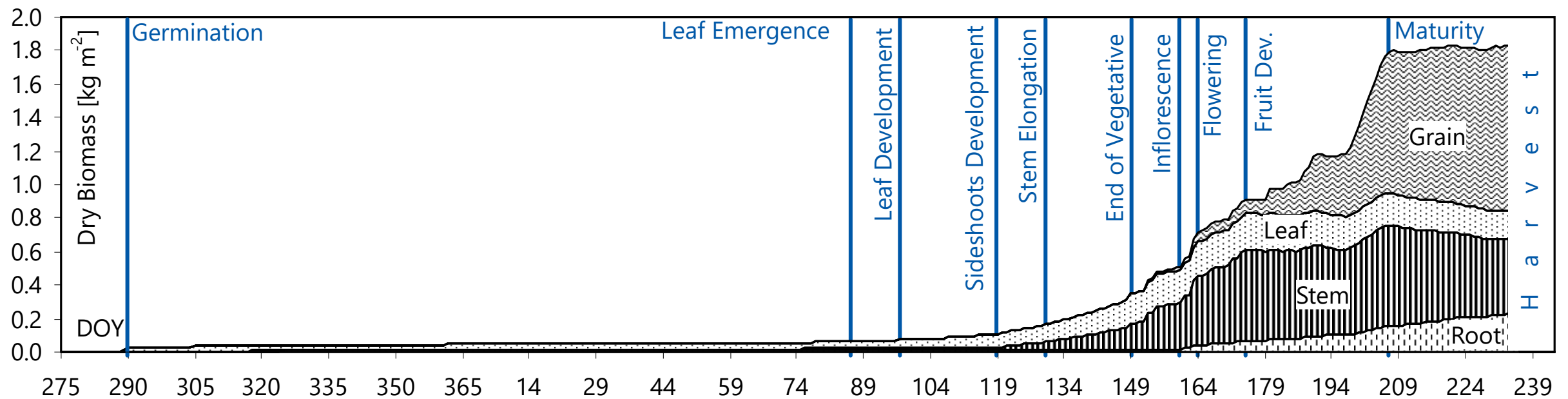
Exemplary results for leaf temperature:



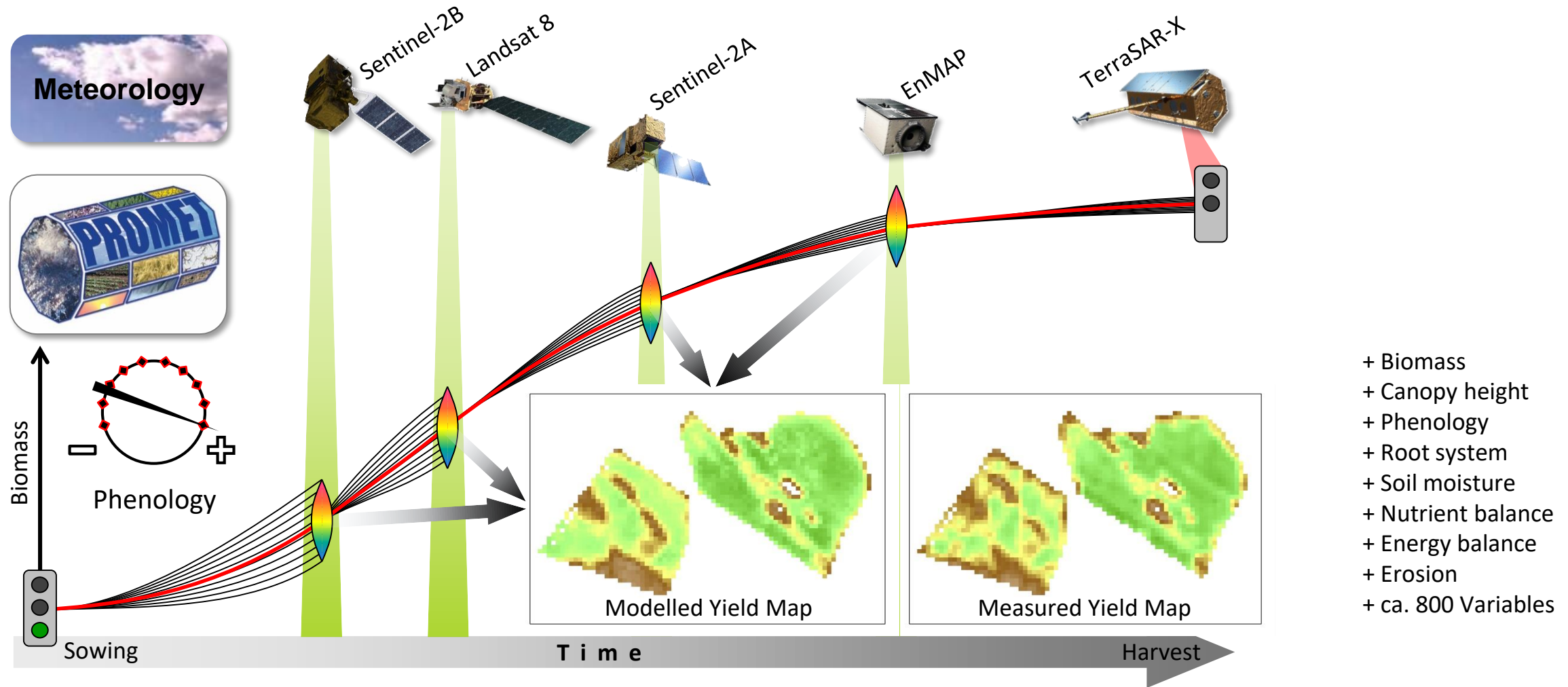


## 3 - PROMET | Dynamic Vegetation Model

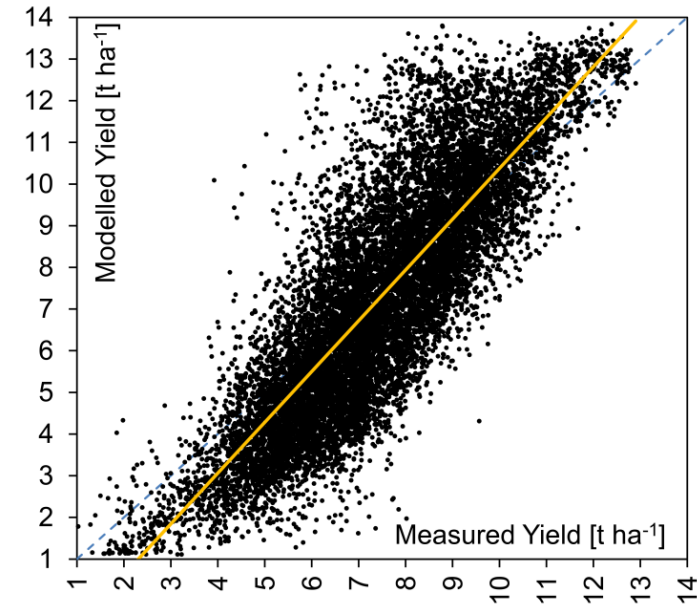
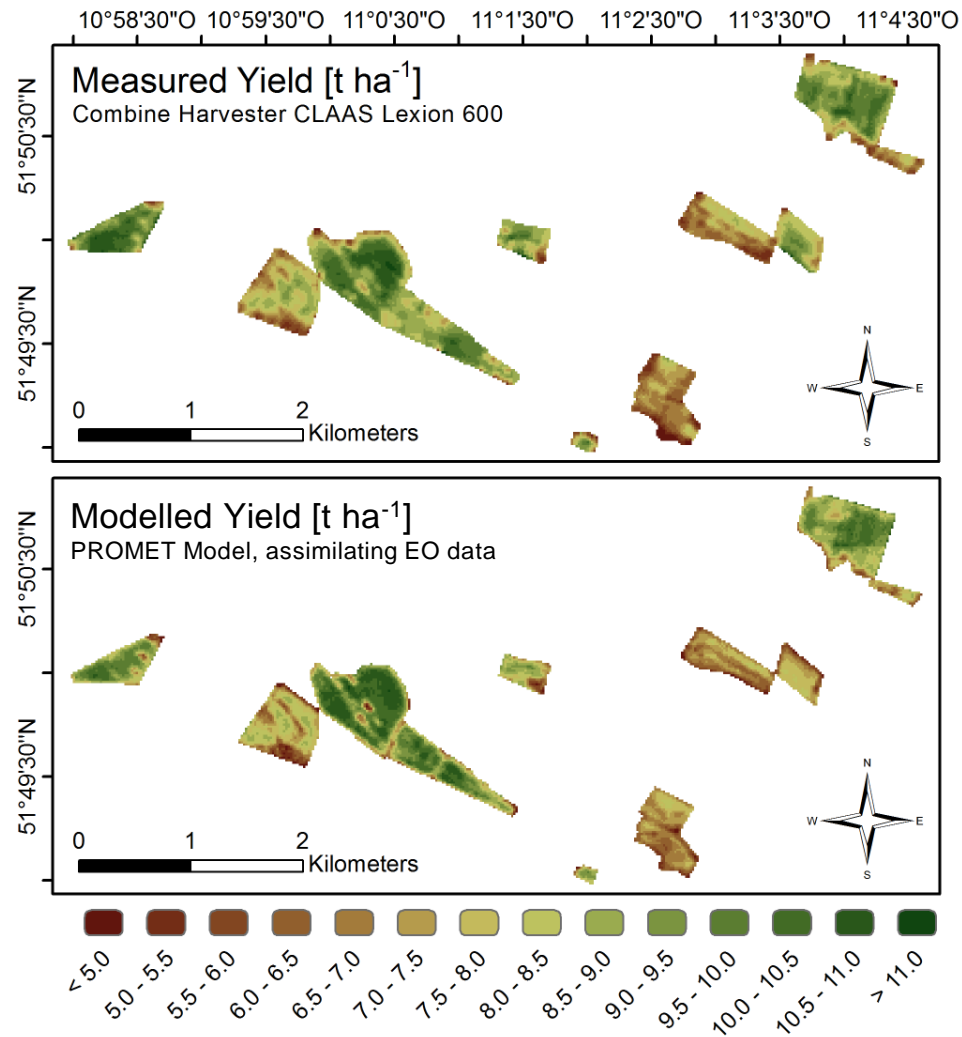
Simulated phenological development allows for a growth-dependent distribution of the assimilates into the compartments of the canopy:



# 4 - PROMET | Remote Sensing Data Assimilation



# 4 - PROMET | Remote Sensing Data Assimilation



A	=	525.4 [ha]
R <sup>2</sup>	=	0.70 [-]
RMSE	=	1.59 [t ha <sup>-1</sup> ]
Ø Meas. / Mod.	=	7.42 / 7.23 [t ha <sup>-1</sup> ]

## 5 - Conclusion: PROMET | Unique Features

- PROMET closely couples a hydrologic land surface scheme with a dynamic vegetation model and a nutrient cycle model on the process level. It strictly conserves mass and energy.
- PROMET can be informed with remote sensing measurements through assimilation. Spatially distributed time series of parameters like land use (change), leaf area index, chlorophyll concentration, radar rainfall, leaf angle distribution and seeding dates have been used.
- PROMET has successfully been applied on a large span of scales from local to global.
- PROMET contains the basic water-food-energy technologies and infrastructures to simulate coupled impacts of (water and agriculture) management options on water availability, use efficiency and crop yields.



## 6 - More Info:

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