



UNGEONOW 2024  
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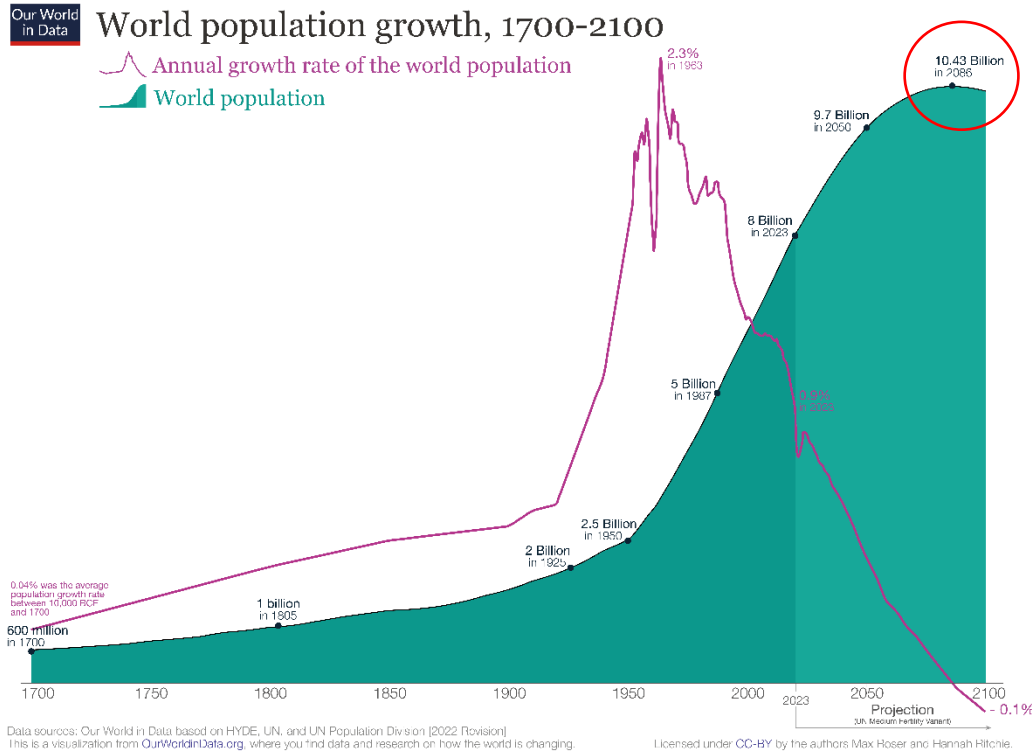
# Earth Observation for Water Resource Sustainability in Smart Agriculture

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## Population 'explosion' in the 21<sup>st</sup> century



Urgency for new agricultural practices to meet the high demand of food!



## Traditional agriculture

- Labor intensive
- Simple tools
- Dependent on the experience of farmers
- Low efficiency

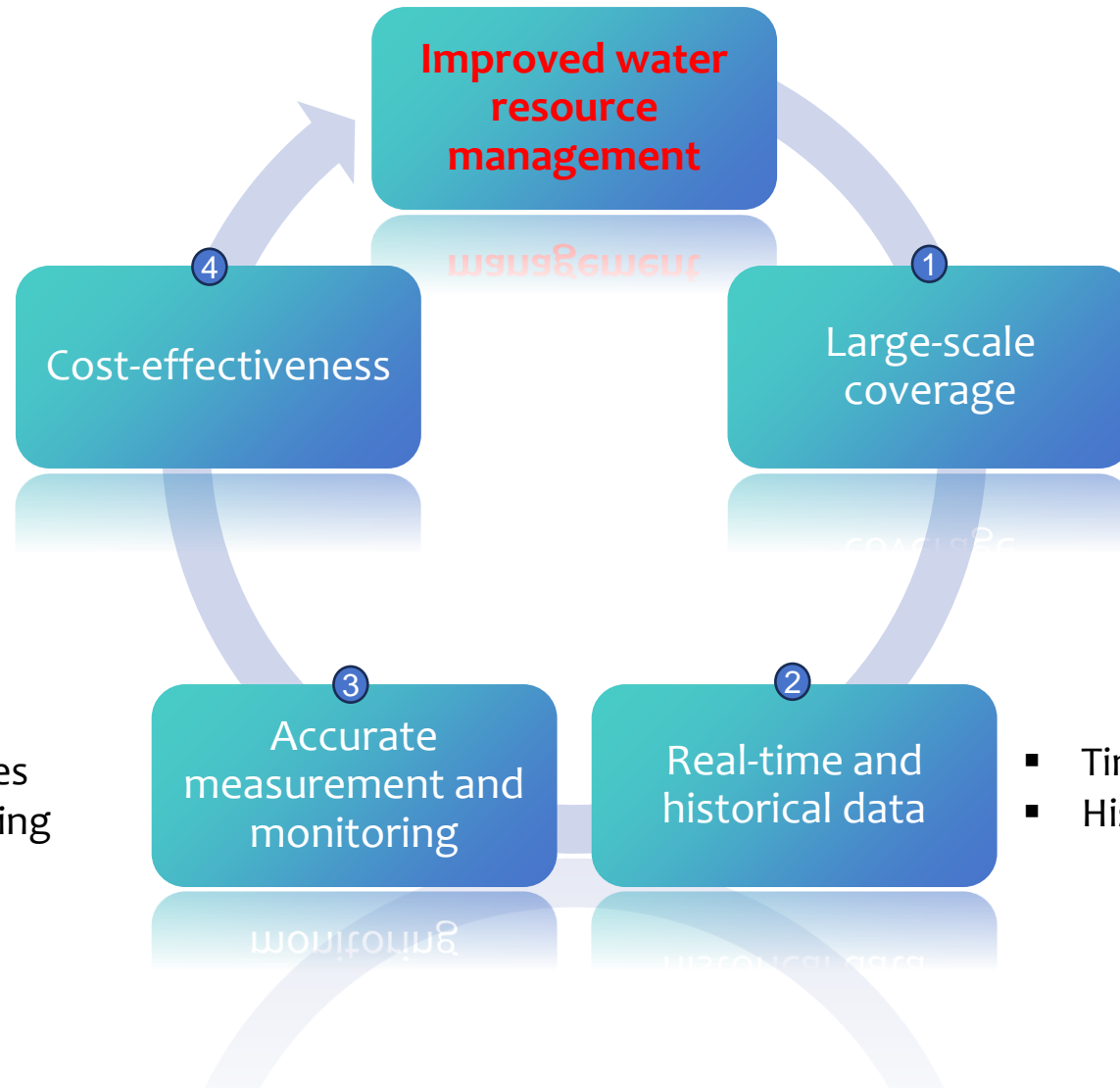


## Smart agriculture

- Optimized human labor use
- Incorporation of advanced mechanization
- Utilization of high-tech measures (e.g., EO, ML, 5G)
- Enhanced productivity and efficiency



## Smart Agriculture



- Reduced labour costs
- Scalability

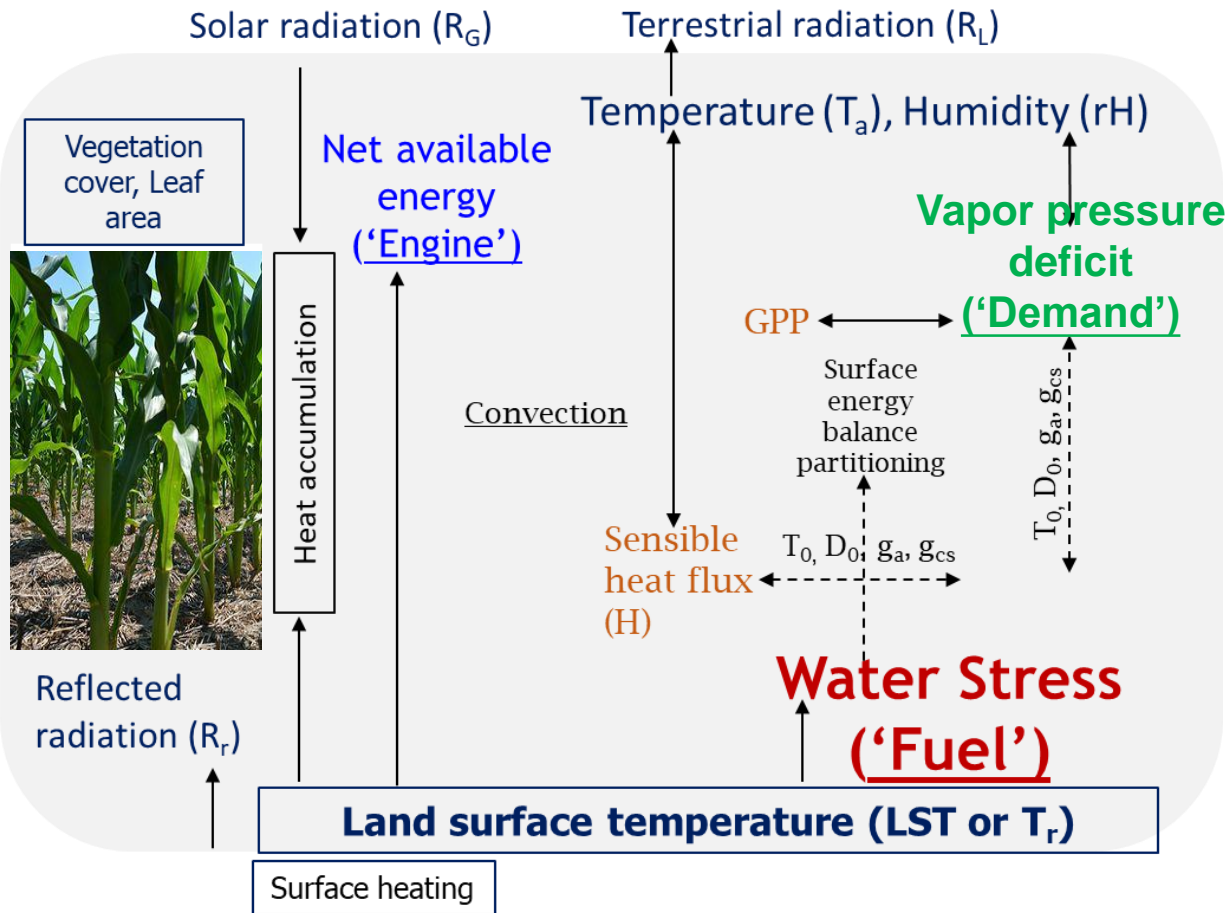
- Extensive areas
- Uniform data collection

- Advanced EO technologies
- Skilled models for retrieving
  1. soil moisture
  2. irrigation
  3. evapotranspiration
- ....

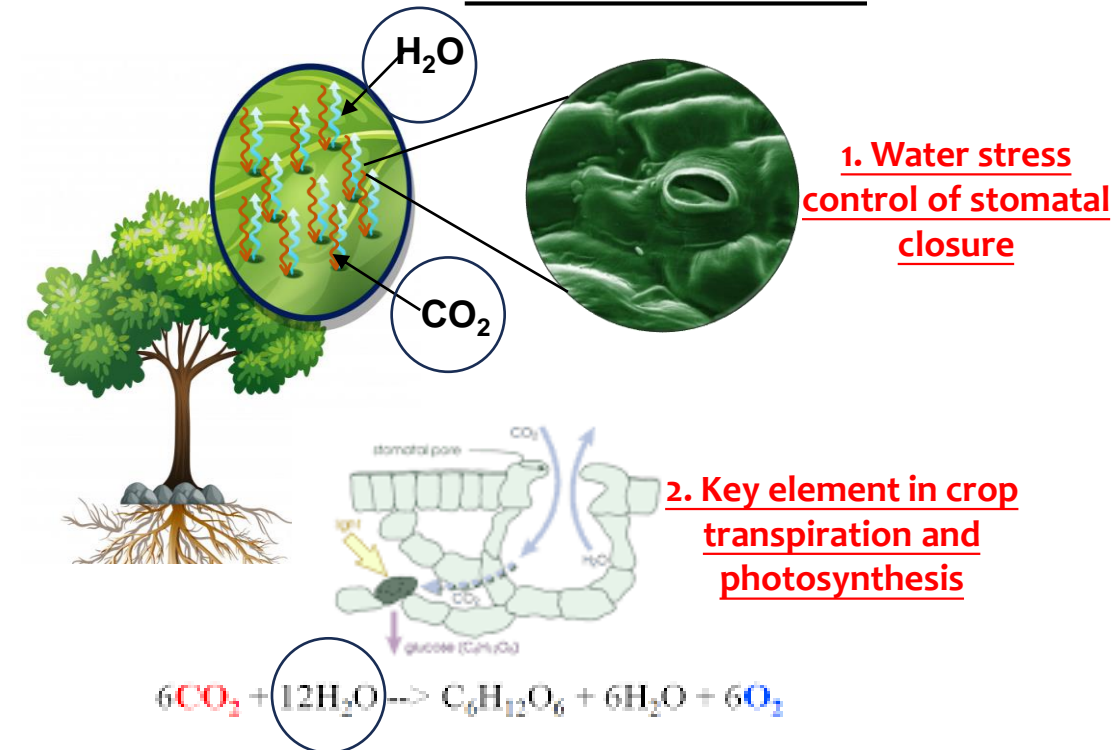
- Timely information
- Historical trends



## Crop physiological processes



## Role of water



### Crop transpiration (ET)

- Cooling leaf temperature
- Water movement and nutrient uptake from soil

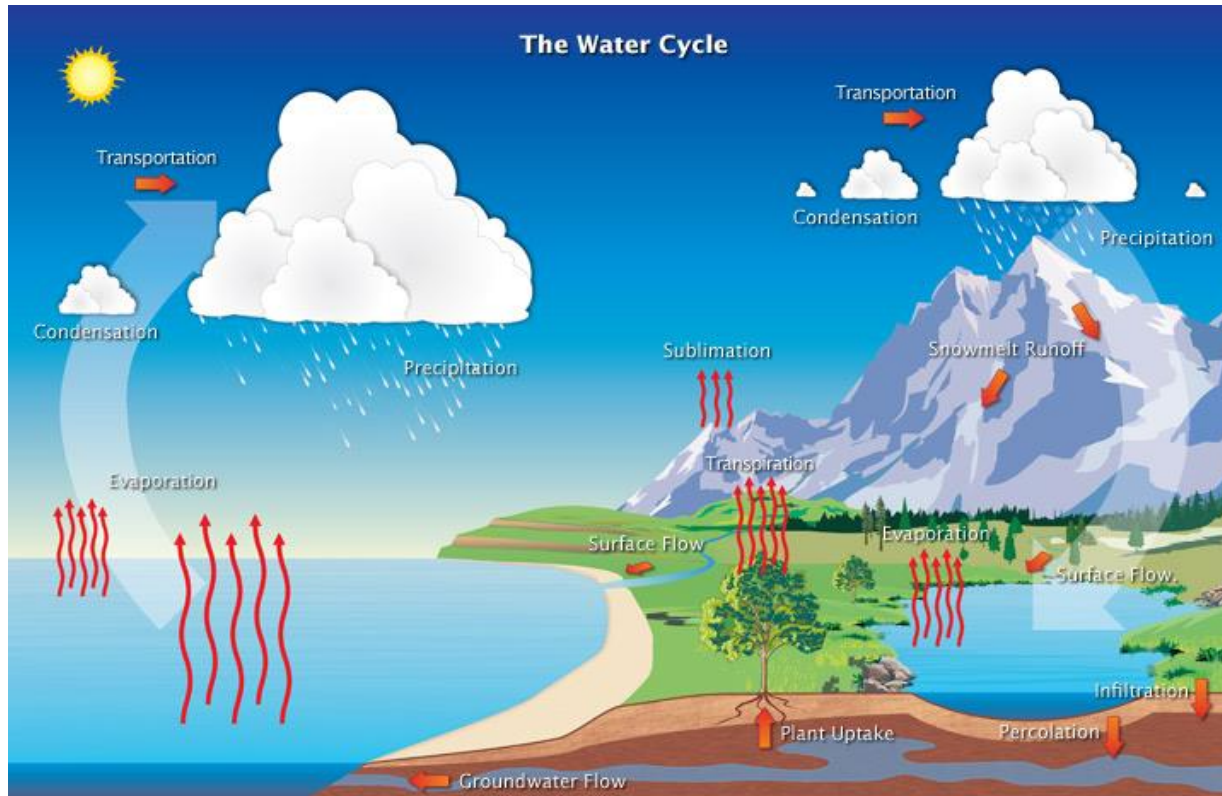
### Crop photosynthesis (GPP)

- Converting light energy into chemical energy
- Maximizing reproductive success and yield

$T_0$  = aerodynamic temperature;  $D_0$  = aerodynamic VPD

(Credit to Mallick et al. 2023, GRL)

## Terrestrial ecosystem



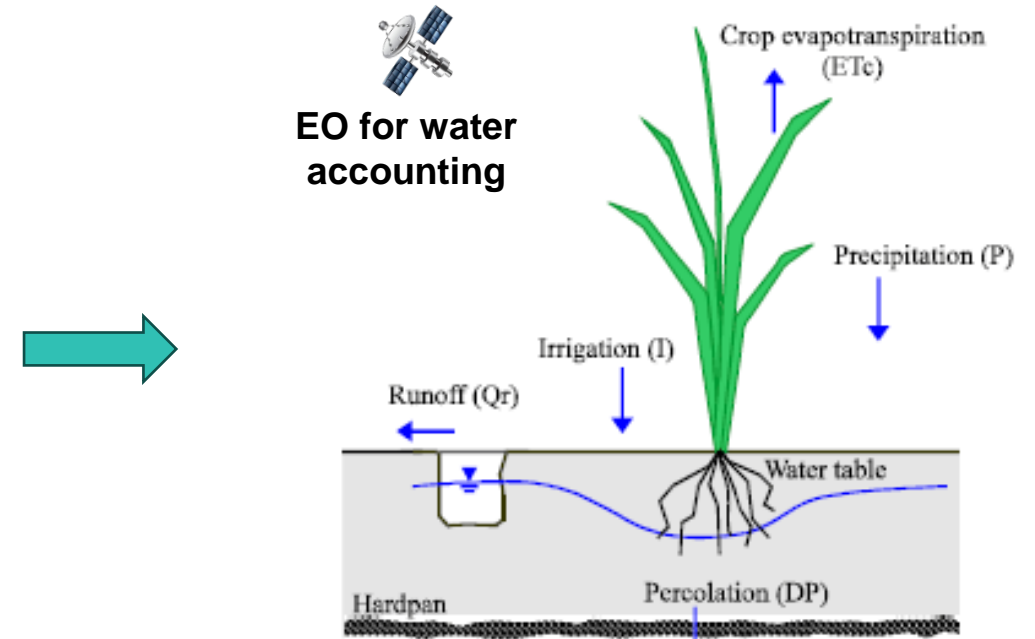
$$P = ET + R + \Delta S$$

$P$  = precipitation;  $ET$  = evapotranspiration

$R$  = runoff (surface and subsurface flow)

$\Delta S$  = change in storage (soil moisture, groundwater, surface water)

## Agriculture ecosystem



$$P + I = ET + R + D + \Delta S$$

$P$  = precipitation;  $I$  = irrigation

$ET$  = evapotranspiration

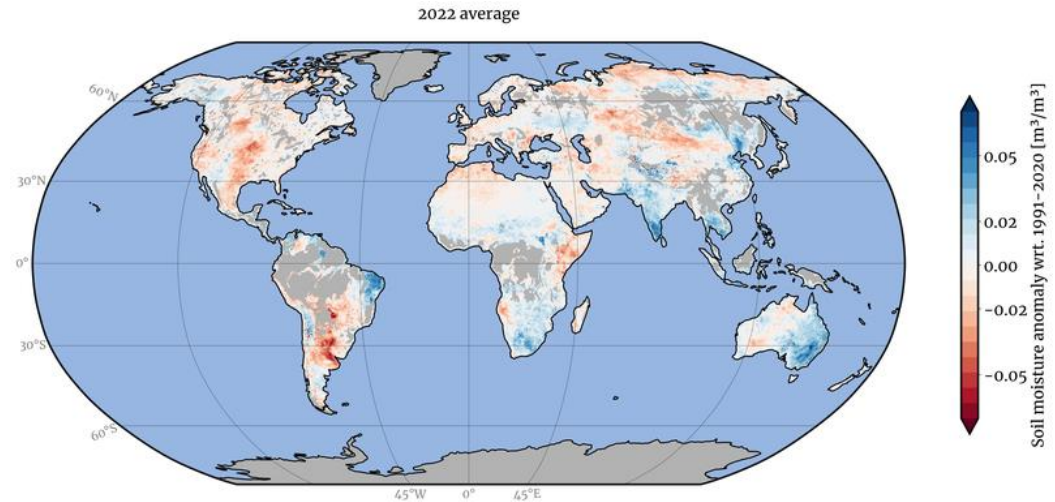
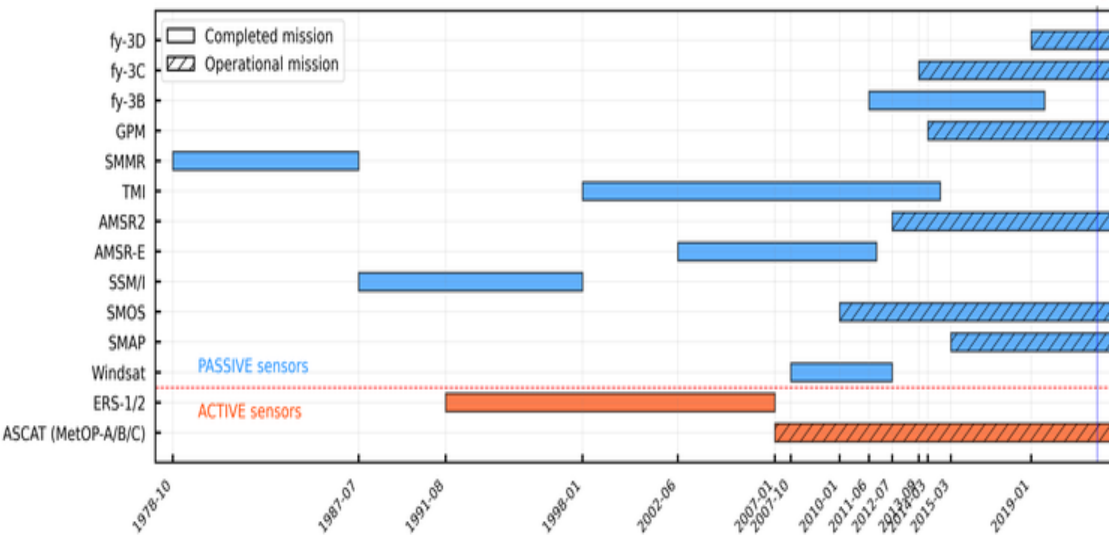
$R$  = runoff (surface and subsurface flow)

$D$  = Drainage (percolation or water loss to groundwater)

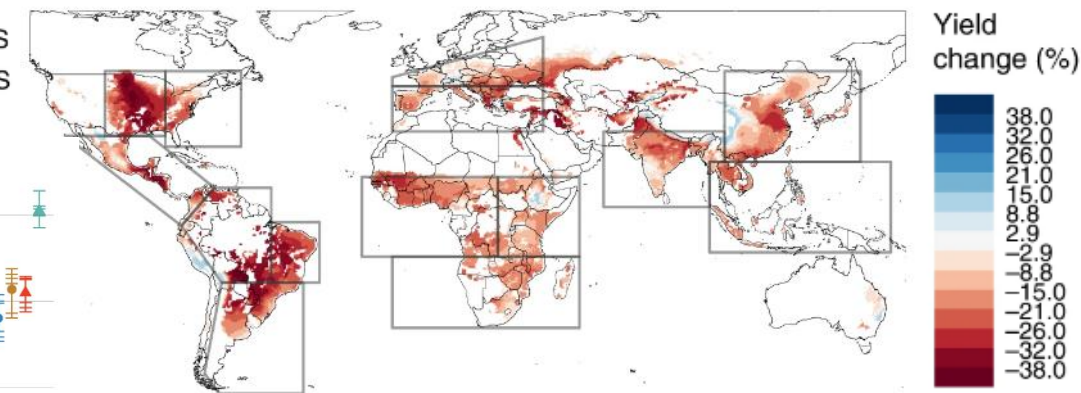
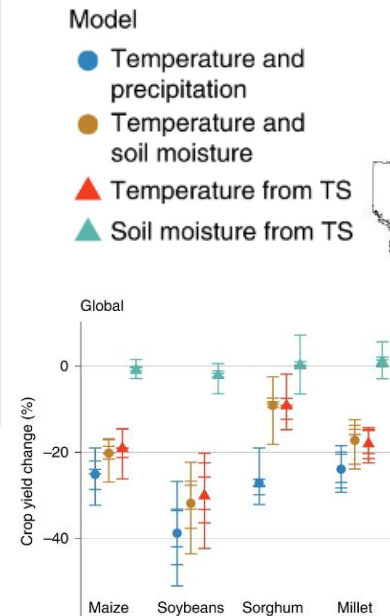
$\Delta S$  = change in soil moisture storage

## ESA Climate Change Initiative (CCI) Soil Moisture project

- ❑ Led by Earth Observation Data Centre, Austria
- ❑ Global climate data record of soil moisture spanning over 40 years
- ❑ 3 separate soil moisture products derived from active, passive, and combined
- ❑ Daily temporal resolution, 0.25° spatial resolution



Soil moisture anomalies for 2022 (baseline 1991-2020)  
(Credit to ESA Climate Office)



(Credit to Proctor et al. 2022, Nature Food)

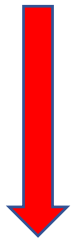
# Role of EO in Agriculture Irrigation Management



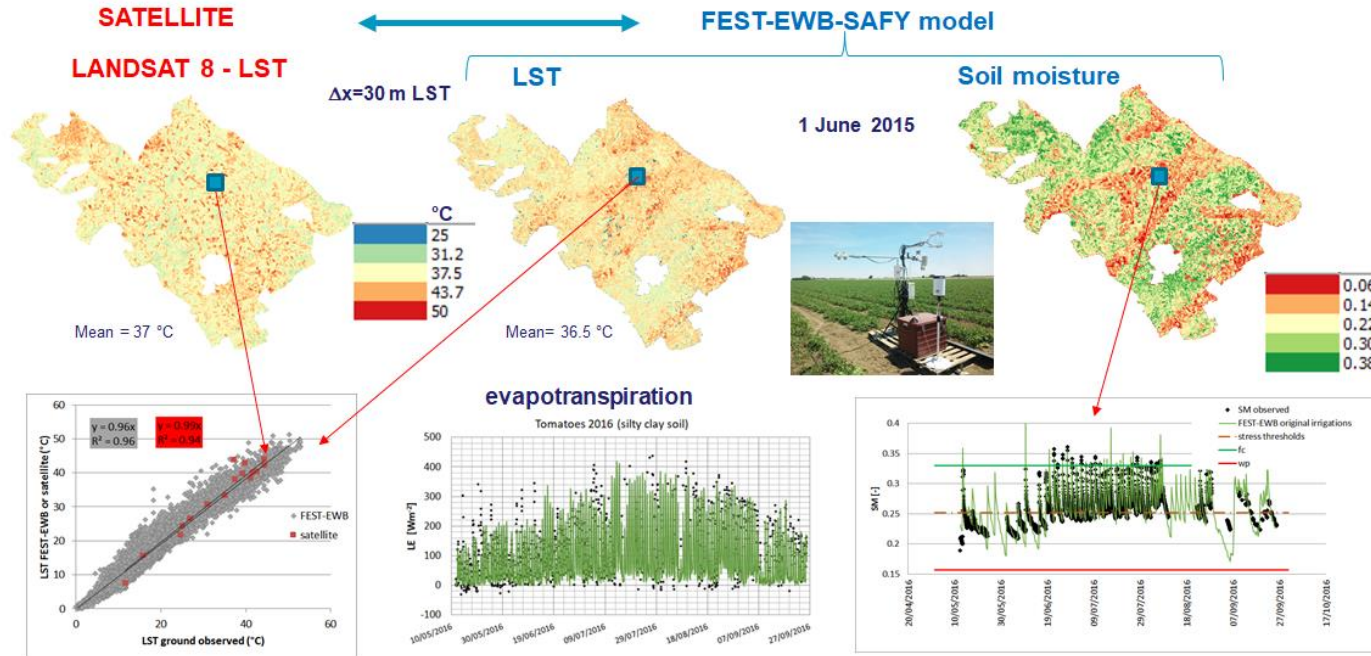
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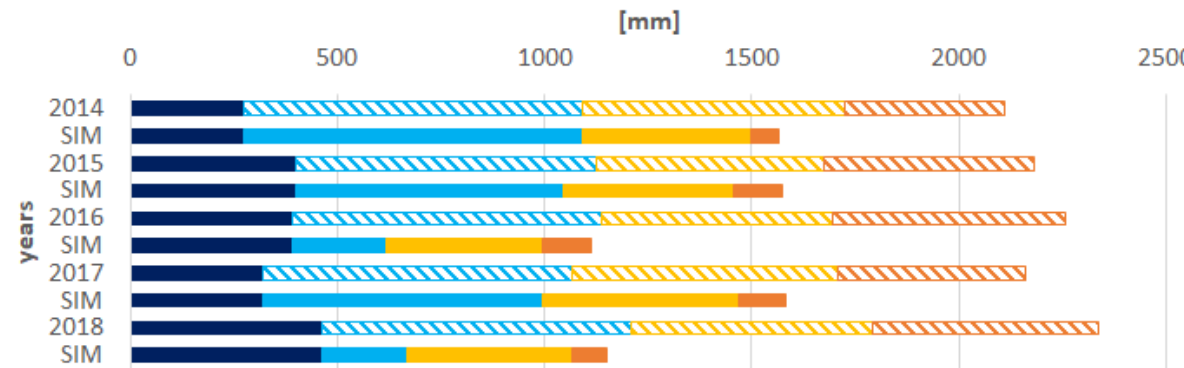
**FEST-EWB model calibration at basin scale against LST and SM, validation with local EC stations**



**Irrigation optimization**  
(FAO strategy on soil moisture thresholds)



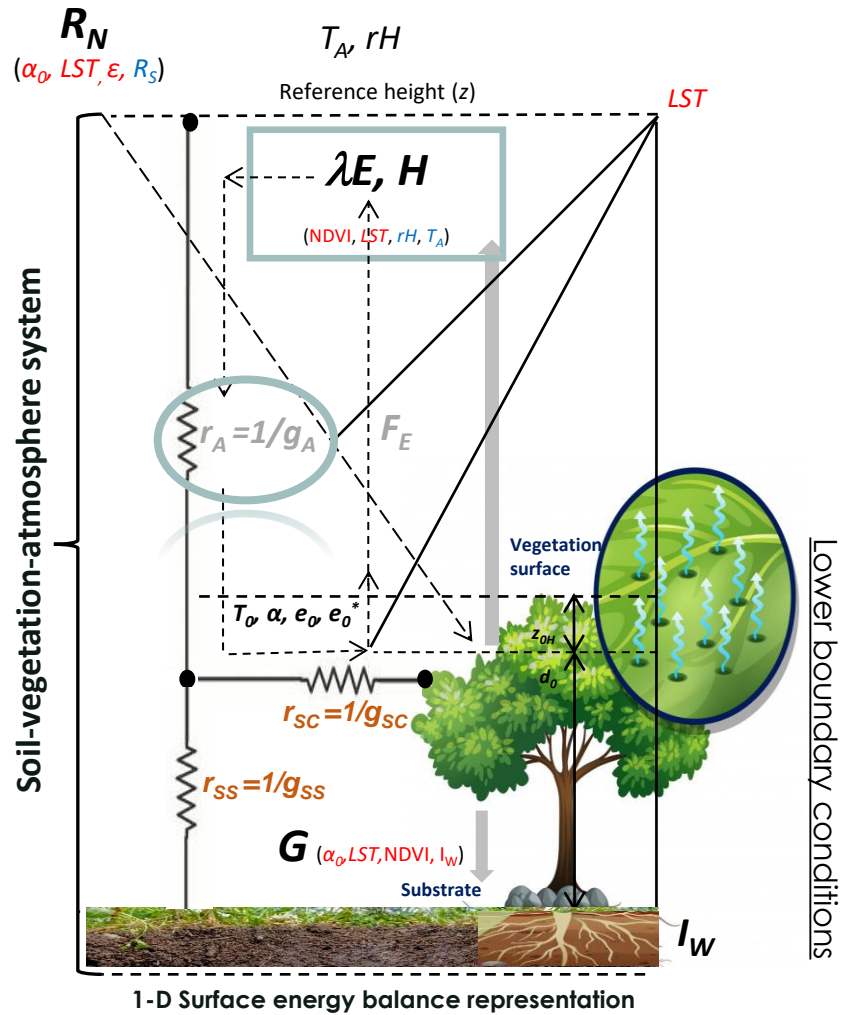
**Corbari & Mancini 2022, Irrigation Science**



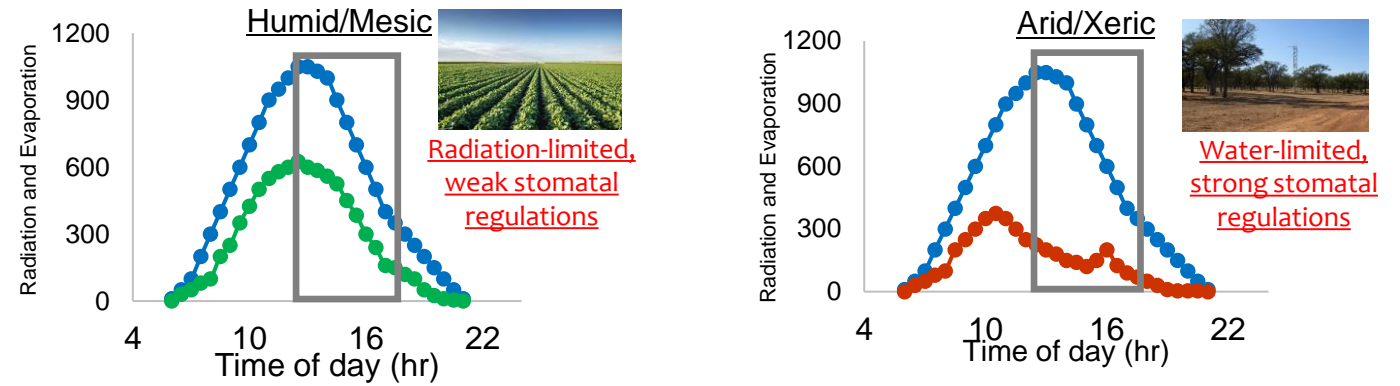
■ Rainfall ■ Irrigation ■ ET ■ Drainage ■ SMARTIES irrigation ■ SMARTIES ET ■ SMARTIES drainage



## Upper boundary conditions



## Contrasting diurnal patterns across ecosystems



### D1: Refined LST retrieval algorithm and reconstructed DTC

- D1.1 Novel TES algorithm of retrieving LST considering vegetation structure
- D1.2 Reconstructed DTC by combining multi-source satellite data

### D2: Analytical model for canopy conductance and ET

- D2.1 Two-source STIC model for retrieving canopy stomatal conductance and E simultaneously
- D2.2 Finding the optimum LST retrieval algorithms for  $g_s$  and ET over different biomes

### D3: ET temporal upscaling model

- D3.1 Finding the patterns of  $g_c$  and E diurnal dynamics across different surface and atmosphere conditions
- D3.2 Novel E temporal upscaling model

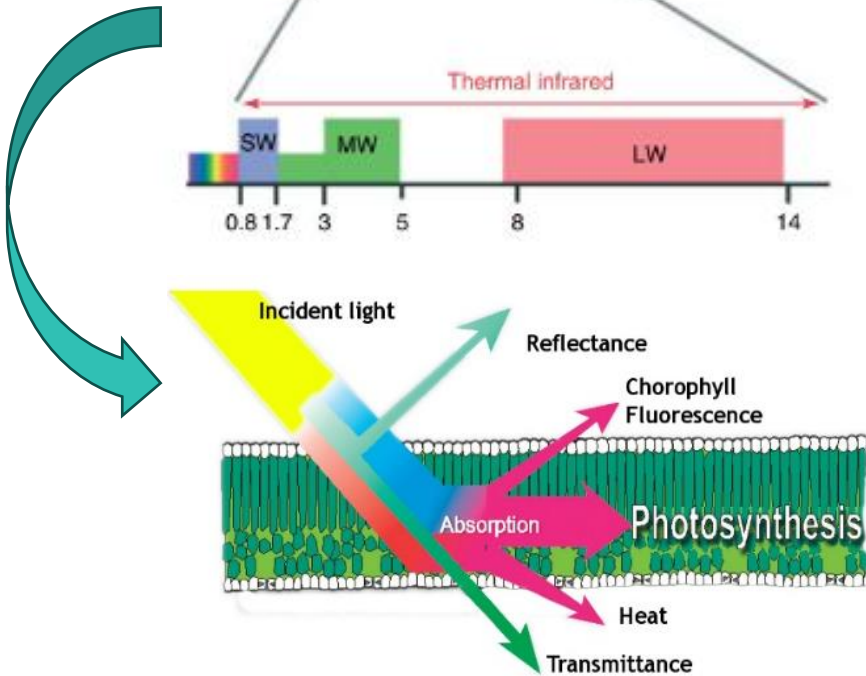
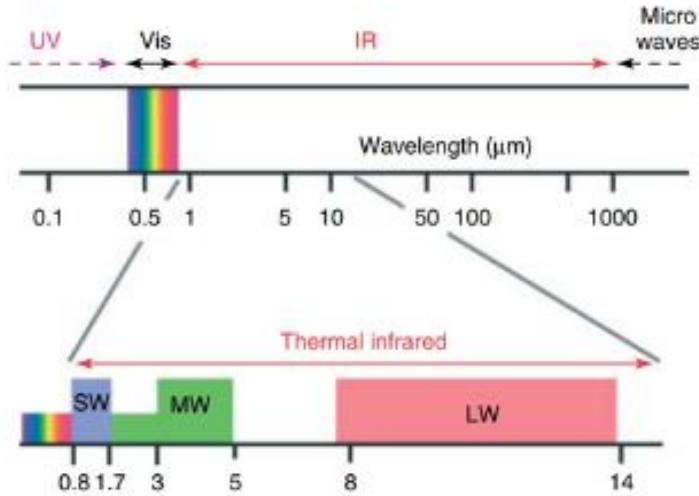
### D4: Publication

- D4.1 Four peer-reviewed publications in high impact journals in accordance with FNR Chronos-Hub regulations

High-accuracy daily ET at a high spatial resolution

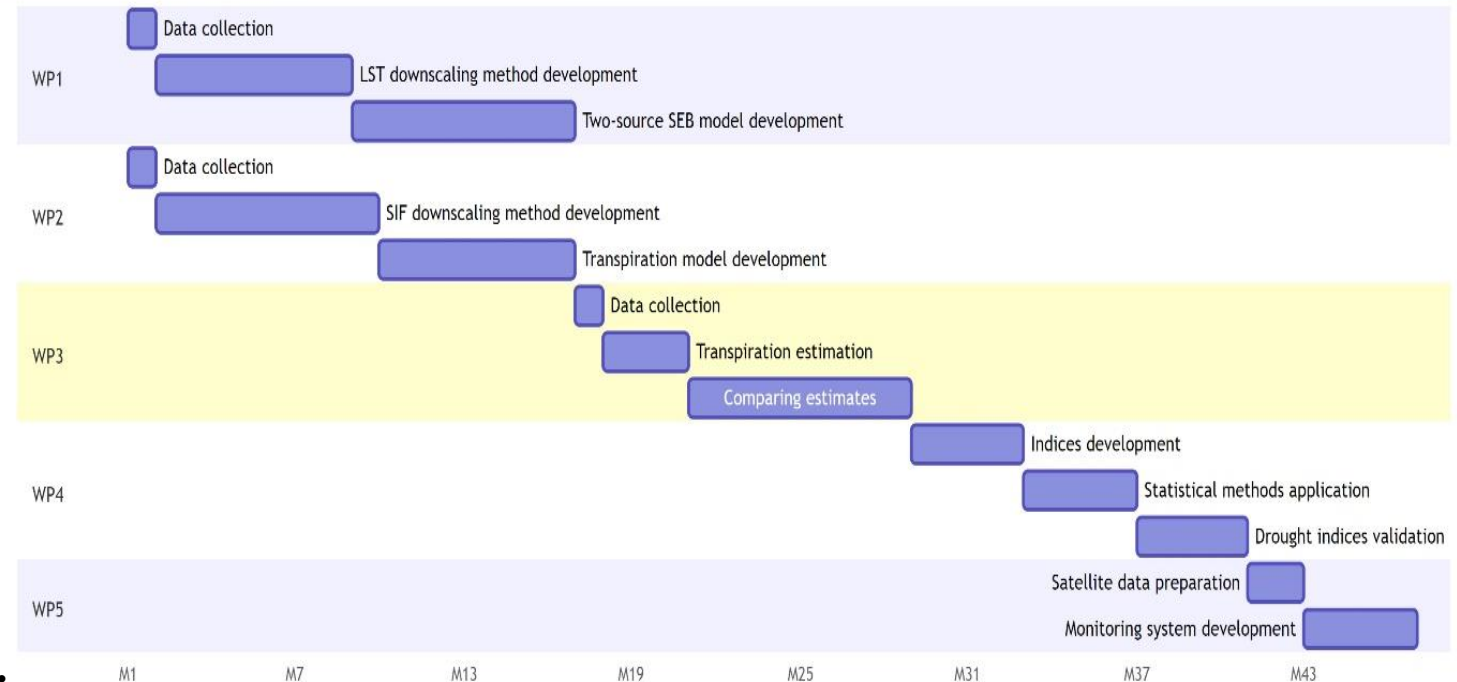


## Thermal infrared (TIR) remote sensing



## Solar-induced fluorescence (SIF) remote sensing

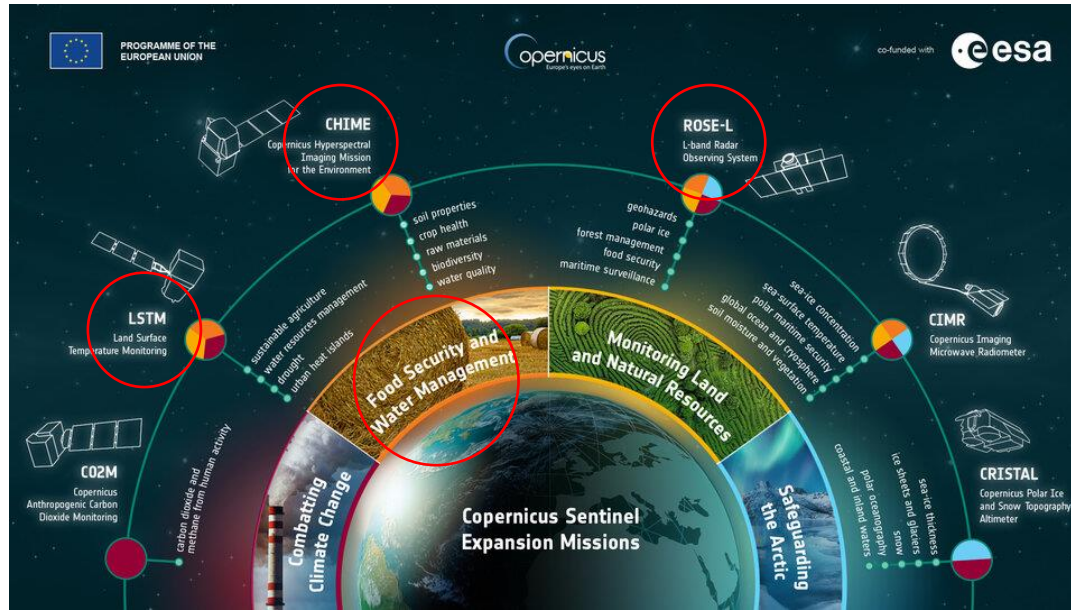
2024-2025	2026	2027	2028	
<b>WP1: ET Partitioning and LST Downscaling</b> Lead: Patrick Matgen	<b>WP2: SIF Downscaling and Transpiration Modeling</b> Lead: Yelu Zeng	<b>WP3: Transpiration Estimates Intercomparison</b> Lead: Tian Hu	<b>WP4: Development of Drought Indices</b> Lead: Yelu Zeng	<b>WP5: Crop Water Stress Monitoring System</b> Lead: Tian Hu



# Research in our team: AgriCEM project



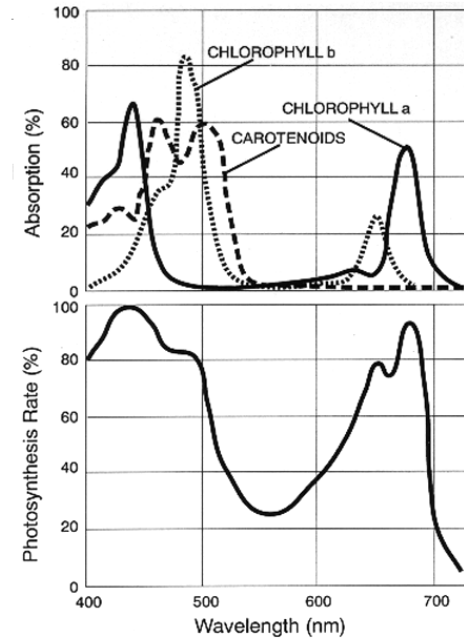
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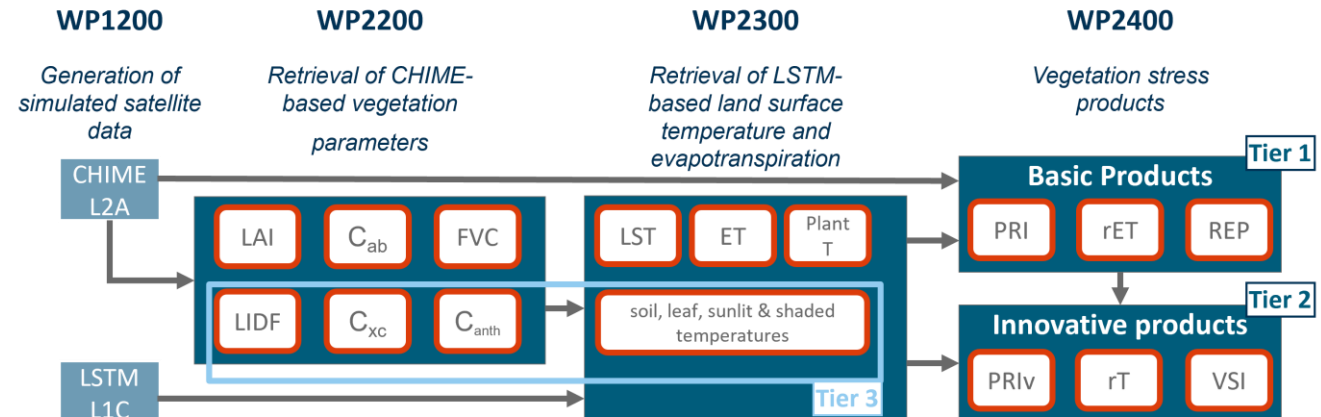
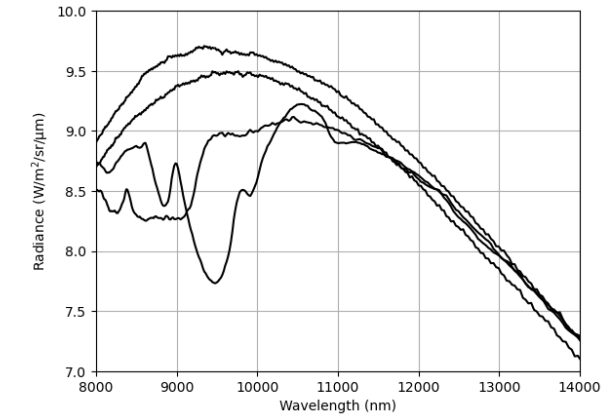
Future six Sentinel Expansion missions and examples of applications

- ❑ Algorithm development of vegetation structural and physiological parameters
- ❑ Combined use of hyperspectral VNIR and high-resolution TIR observations
- ❑ Synthetical crop stress index incorporating plant transpiration and photosynthesis

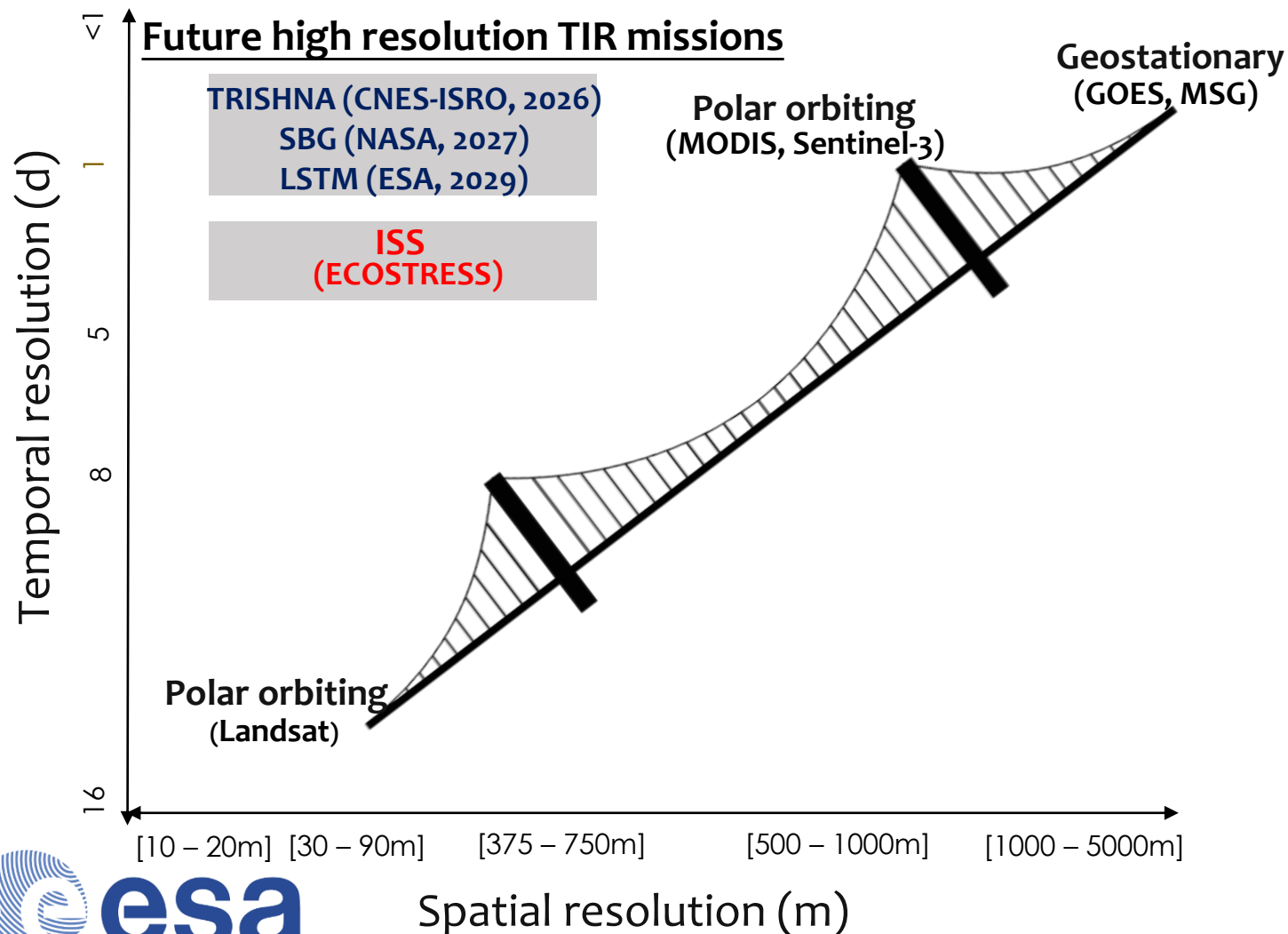
## CHIME (VNIR)



## LSTM (TIR)



## State-of-the-art and next-generation thermal missions



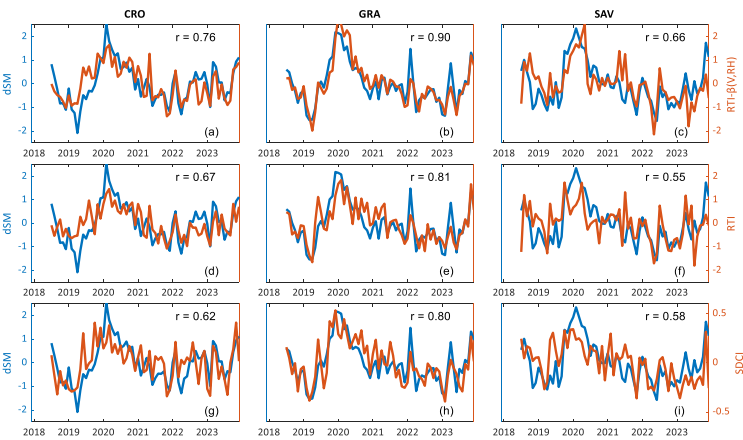
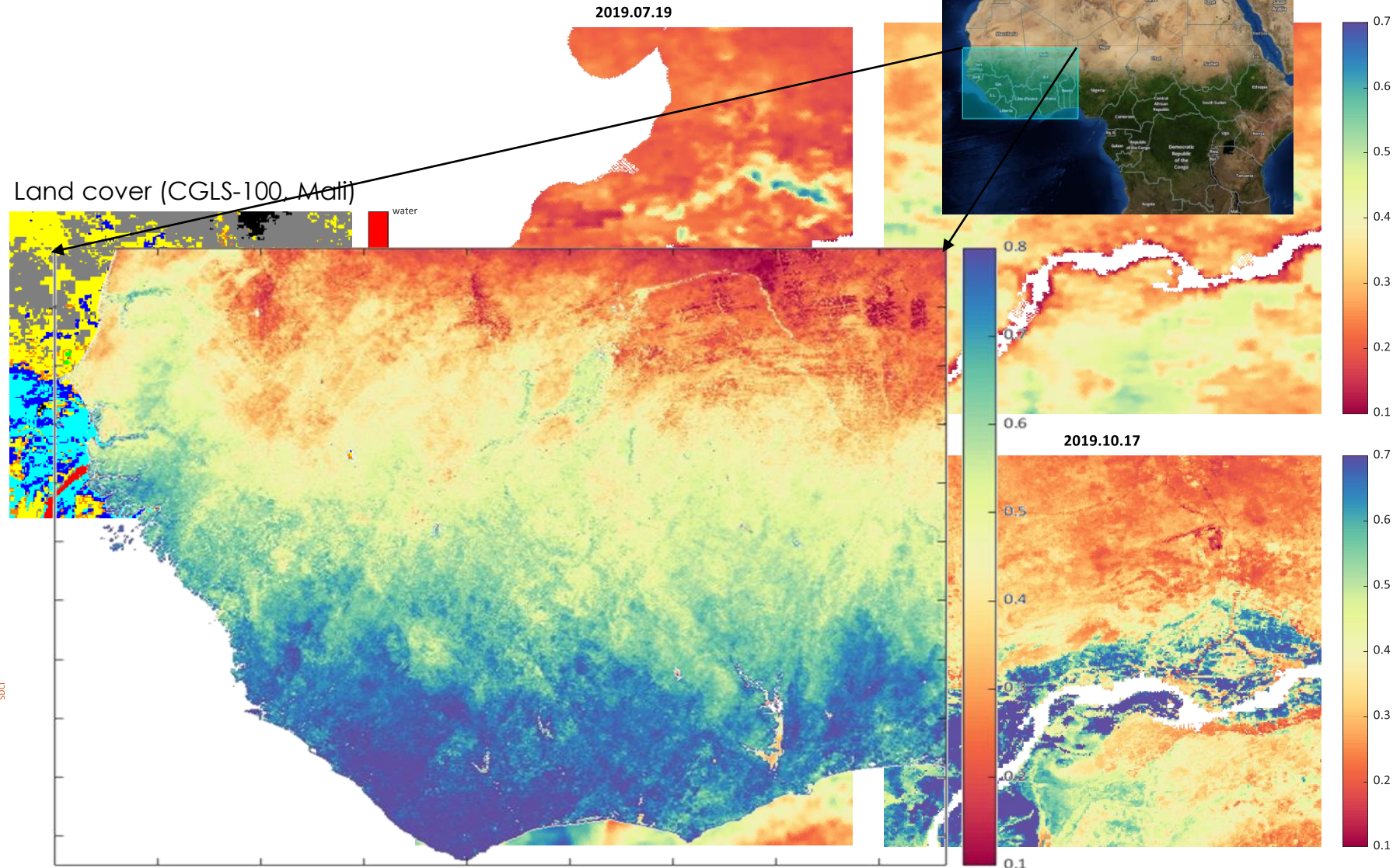
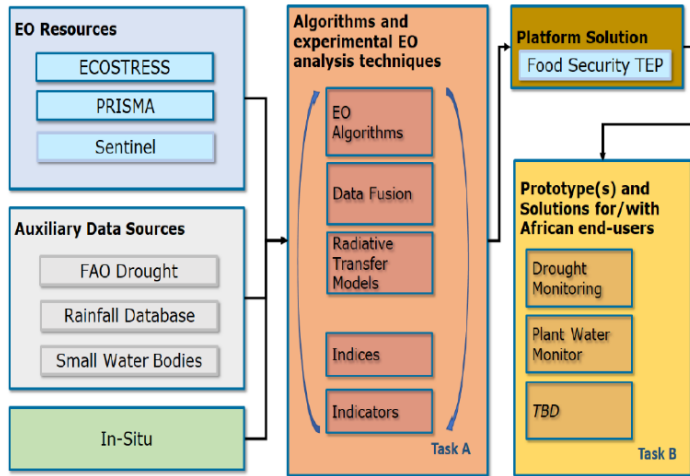
### European ECOSTRESS Hub (Pathfinder)

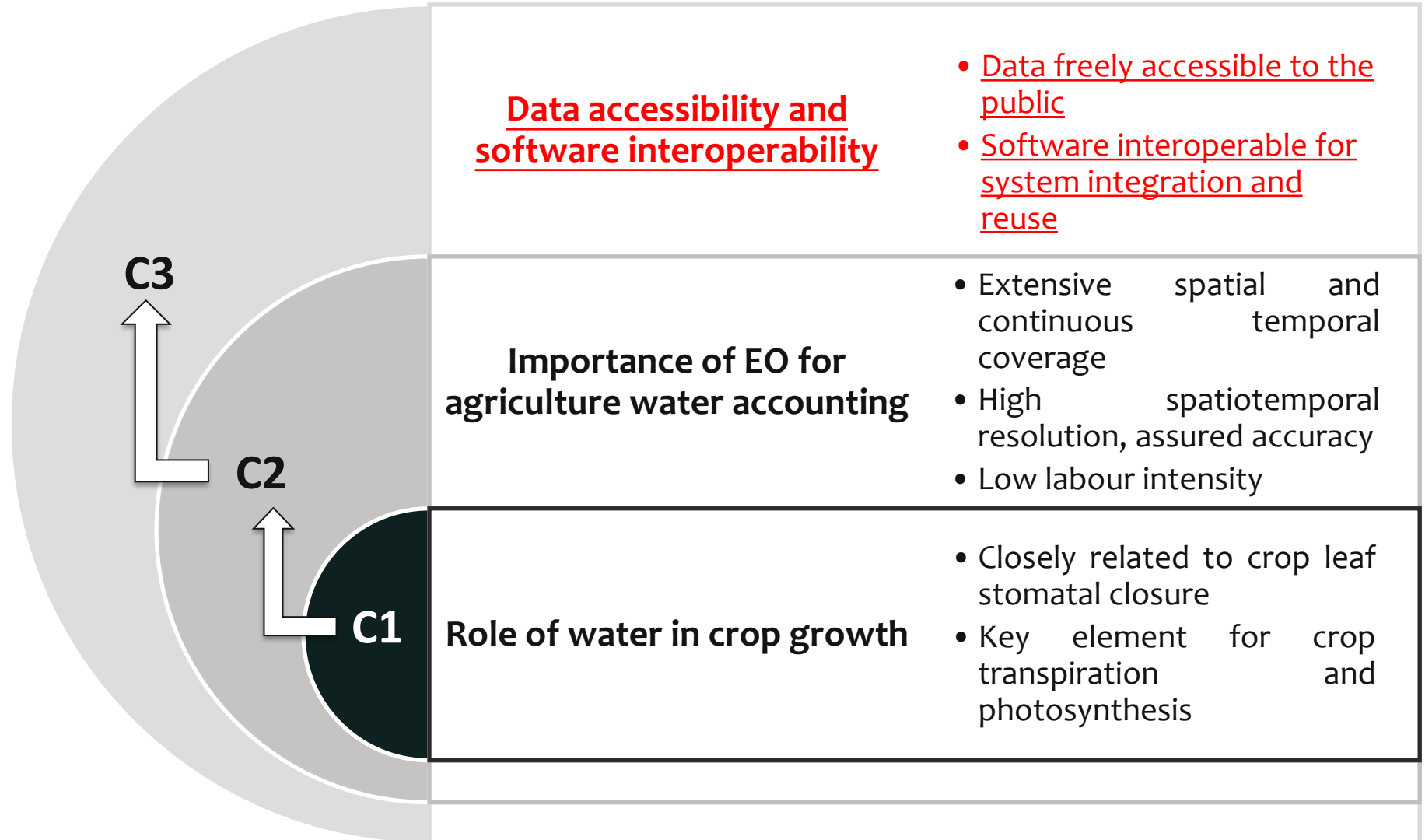
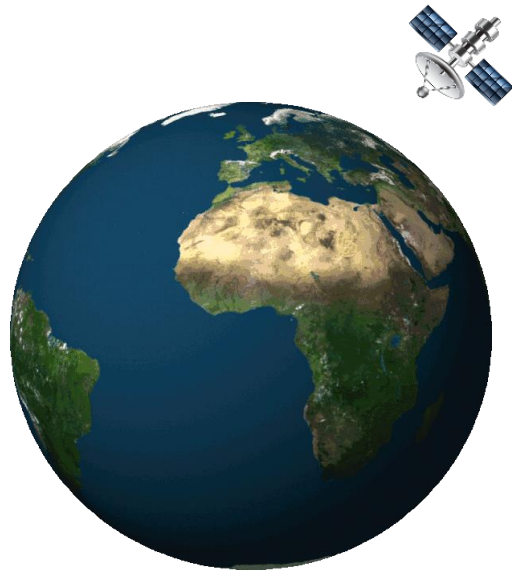
- ❖ **Scientific Objective:** Preparing LST, ET (at both instantaneous and daily scales), and GPP retrieval models for the future TIR missions
- ❖ **Operational Objective:** Providing a time series (~10 yrs) of clear-sky LST, ET, and GPP data at a high spatiotemporal resolution with assured accuracy

Landing page:  
<https://ecostresshub.eu/>

Data storage:  
<https://www.wasdi.net/>

## Land surface temperature for crop water stress monitoring in Africa







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# THANK YOU

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