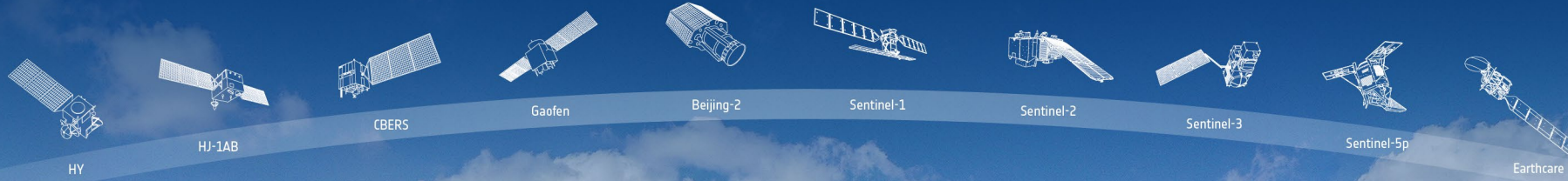




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# 2025 DRAGON 6 SYMPOSIUM

14-18 JULY 2025

[PROJECT ID. 95338]

QUANTIFYING THE IMPACTS OF COMPOUND HOT-DRY EXTREMES ON  
AGRICULTURE AND WATER RESOURCES FROM EARTH OBSERVATION  
(AGRIWATER)



# 2025 Dragon 6 Symposium



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**WEDNESDAY, 16/JULY/2025: 09:00 - 09:45**

**ID. 95338**

**PROJECT TITLE: QUANTIFYING THE IMPACTS OF COMPOUND HOT-DRY EXTREMES ON AGRICULTURE AND WATER RESOURCES FROM EARTH OBSERVATION**

**PRINCIPAL INVESTIGATORS: DANIEL DOKTOR, GUOYONG LENG**

**CO-AUTHORS: LOUIS TRINKLE, JAKOB ZSCHEISCHLER, ANA BASTOS, ANNA BALENZANO, FRANCISCO JOSÉ CUESTA VALERO, ALMUDENA GARCÍA-GARCÍA, SHIQIANG ZHANG, SHENGZHI HUANG, XIAOYONG LIAO, JINWEI DONG, JIAN PENG**

**PRESENTED BY: LOUIS TRINKLE**



中国科学院地理科学与资源研究所  
Institute of Geographic Sciences and Natural Resources Research, CAS



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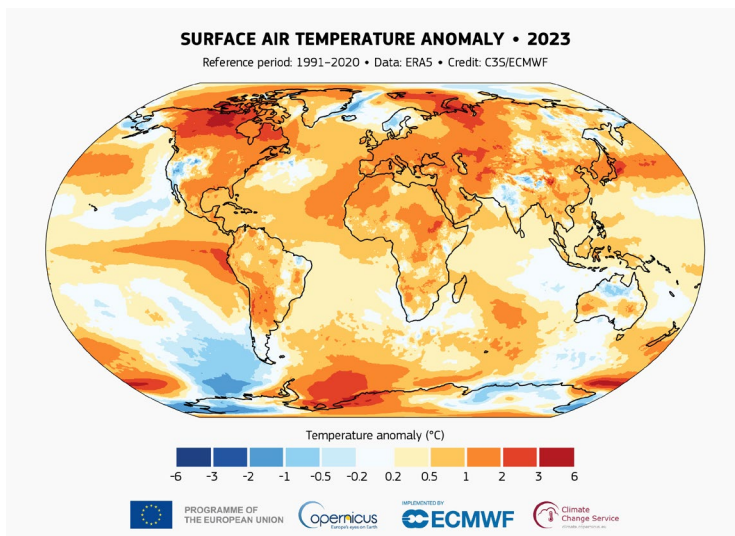
# Motivation of the project



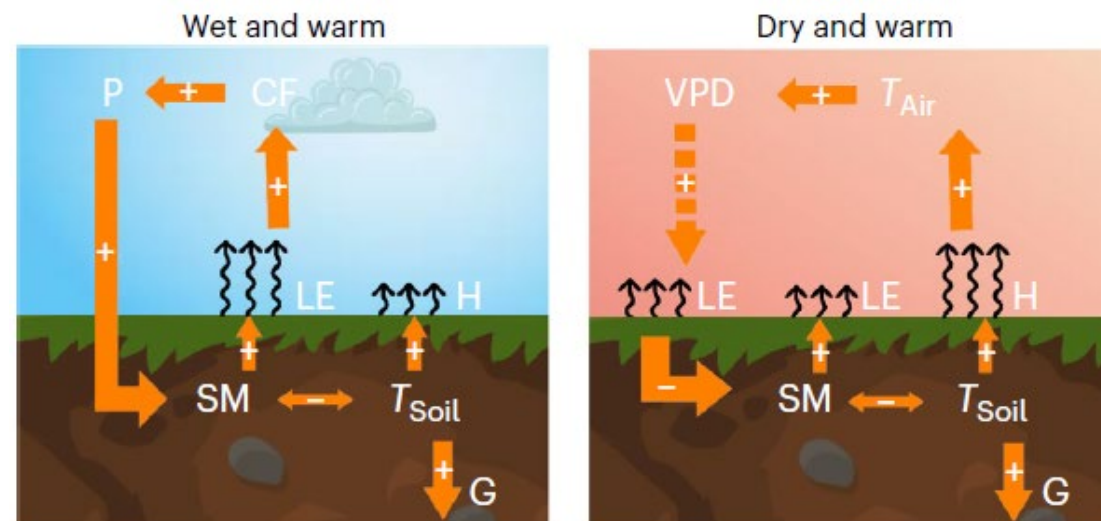
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**Climate warming**  
(Copernicus Climate Change Service)



**Land-atmosphere feedback**  
(García-García, A. et al., 2023)



**Large numbers of compound hot-dry extremes in both China and Europe**  
**Negative impacts on the agriculture, water supply, ecosystem stability, and human health**



**Significance of quantifying spatiotemporal characteristics of compound hot-dry extremes and their impacts on the agricultural water system**

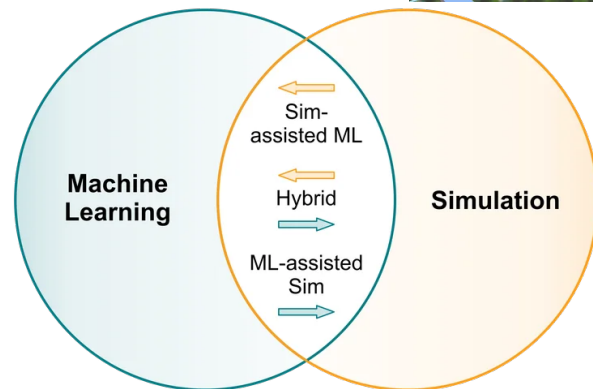
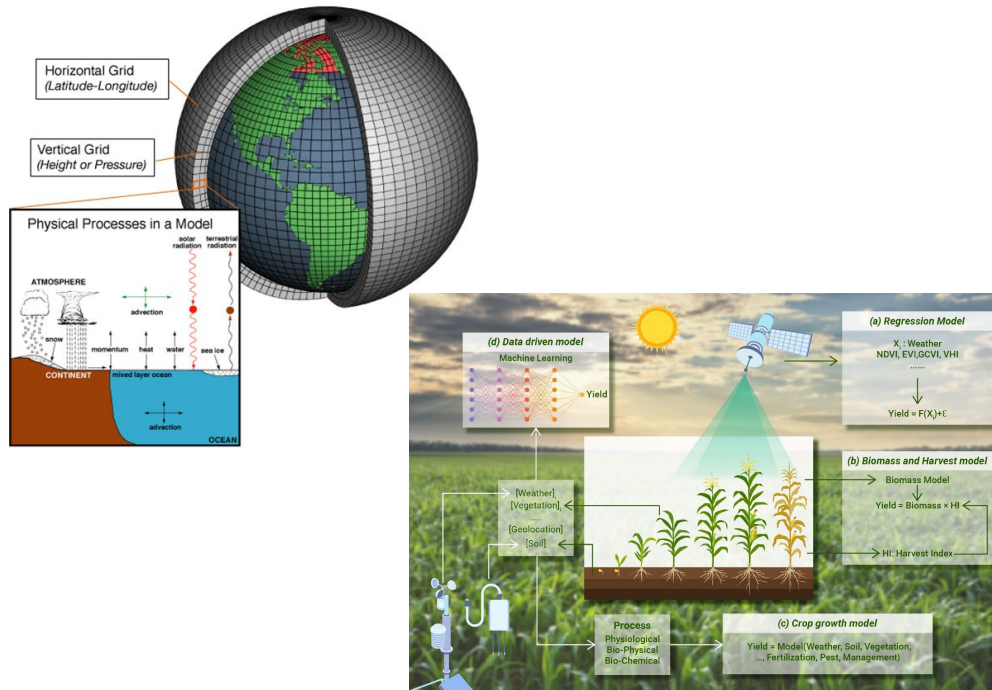
# Motivation of the project



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## Knowledge gaps:

**Coarse spatial resolution for extreme analysis**

Land-atmosphere feedback on extremes

**Lack of precise crop information**

Small attention on different impacts of compound hot-dry extremes on different crops

**Lack of an effective combination of machine learning and models**

Lack of comprehensive analysis in trade-offs among adaptation strategies

# Objectives of the project



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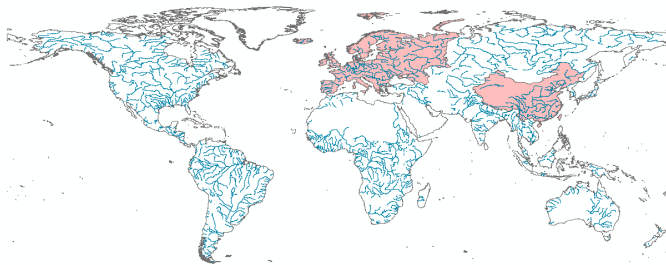
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AGRIWATER

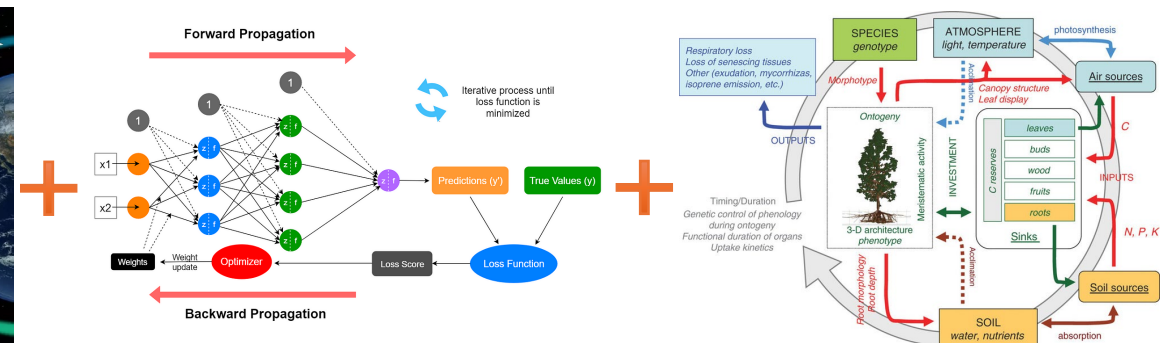
Precise detection and advanced mechanism analysis of compound hot-dry extremes

Comprehensive analysis in impacts of compound hot-dry extremes on agricultural water systems

Systematic adaptation strategies for compound hot-dry extremes



Europe and China; past two decades





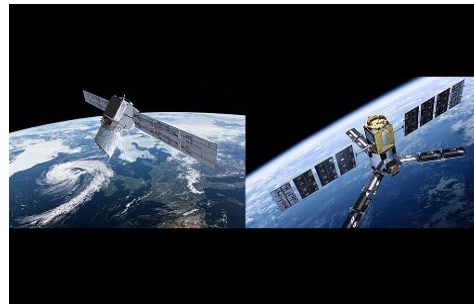
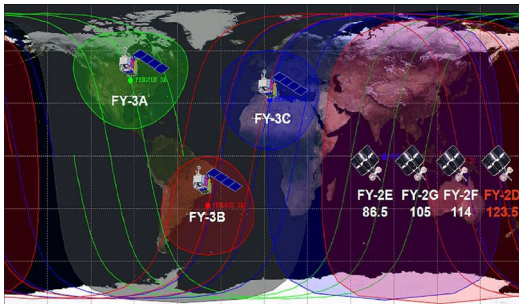
## Detection and physical understanding of compound hot-dry extremes

(D. Doktor, J. Peng, J. Zscheischler, S. Huang, and S. Zhang)

Collecting observations of meteorological variables, soil moisture, and crop yields (field experiment, routine meteorological data from China Meteorological Administration)

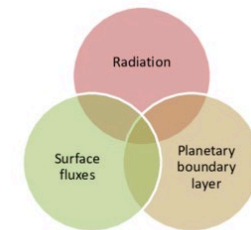
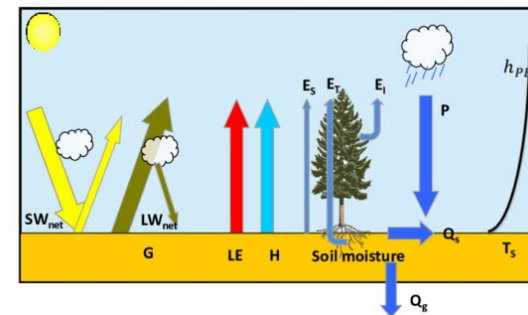
### High-resolution remote sensing archives

(e.g., Chinese FY series, ESA SMOS retrievals, and ESA Sentinel missions)



### Detecting compound hot-dry extremes

(Copulas, quantile regression, and mechanistical model analysis (HOLAPS))





## Impacts of compound hot-dry extremes on agriculture and water resources

(G. Leng, D. Doktor, J. Peng, A. Bastos, A. Balenzano, X. Liao, and J. Dong)

### Advanced optical images

(e.g., Chinese GF and ESA Worldview missions)



**Crop classification**  
**Growth monitoring**

**Productivity simulation**  
**and prediction**

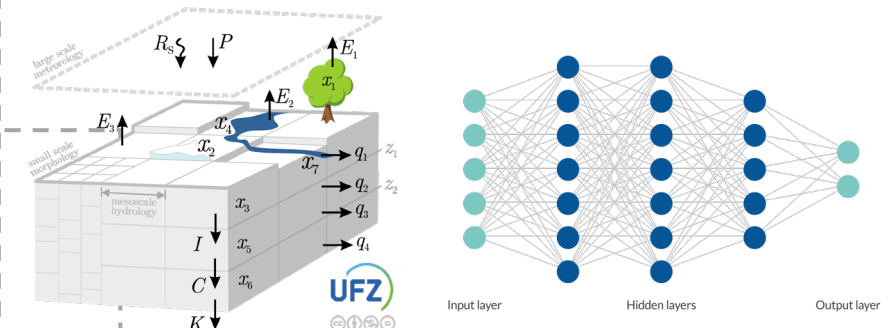
**Decision Support Systems**  
**for Agrotechnology**  
**Transfer (DSSAT) modelling**



**DSSAT**  
Decision Support System for Agrotechnology Transfer

### Hydrological models and machine learning methods

(mHM, SWAT, HBV, and VIC; DNN)



**Hydrological processes**  
**Relationships between crop and**  
**climate variables**



## Adaptation strategies of compound hot-dry extremes

(D. Doktor, G. Leng, A. Bastos, J. Zscheischler, S. Huang, and S. Zhang)

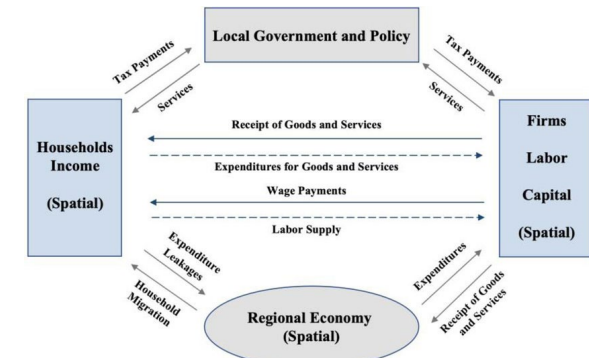
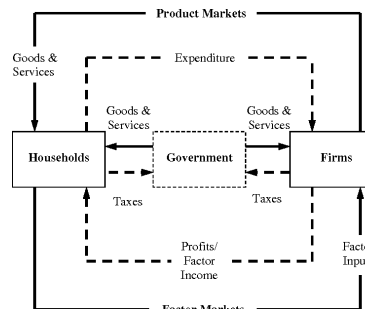
### Potential adaptation strategies

- Adjusting the proportions of crop planting
- Improving water use efficiency
- Obtaining alternative water sources
- Modifying agronomic practices
- Adopting water-conservation technologies
- .....

Trade-offs

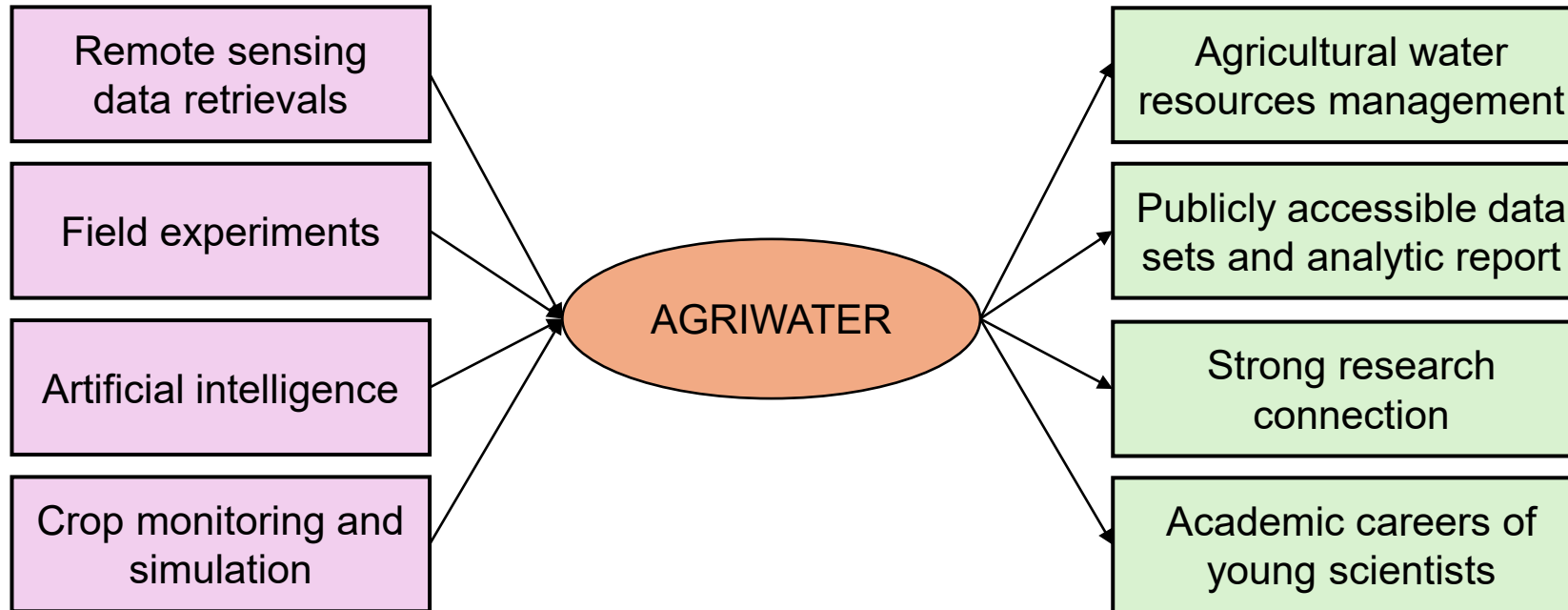
### Economic impacts

Computable General Equilibrium (CGE) modelling



Trade-offs

# Expected outcomes



- **Improve the capability of monitoring compound hot-dry extremes at a high spatiotemporal resolution**
- **Enhance the understanding of agriculture responses to climate extremes**
- **Provide adaptation strategies for agriculture water resources management**

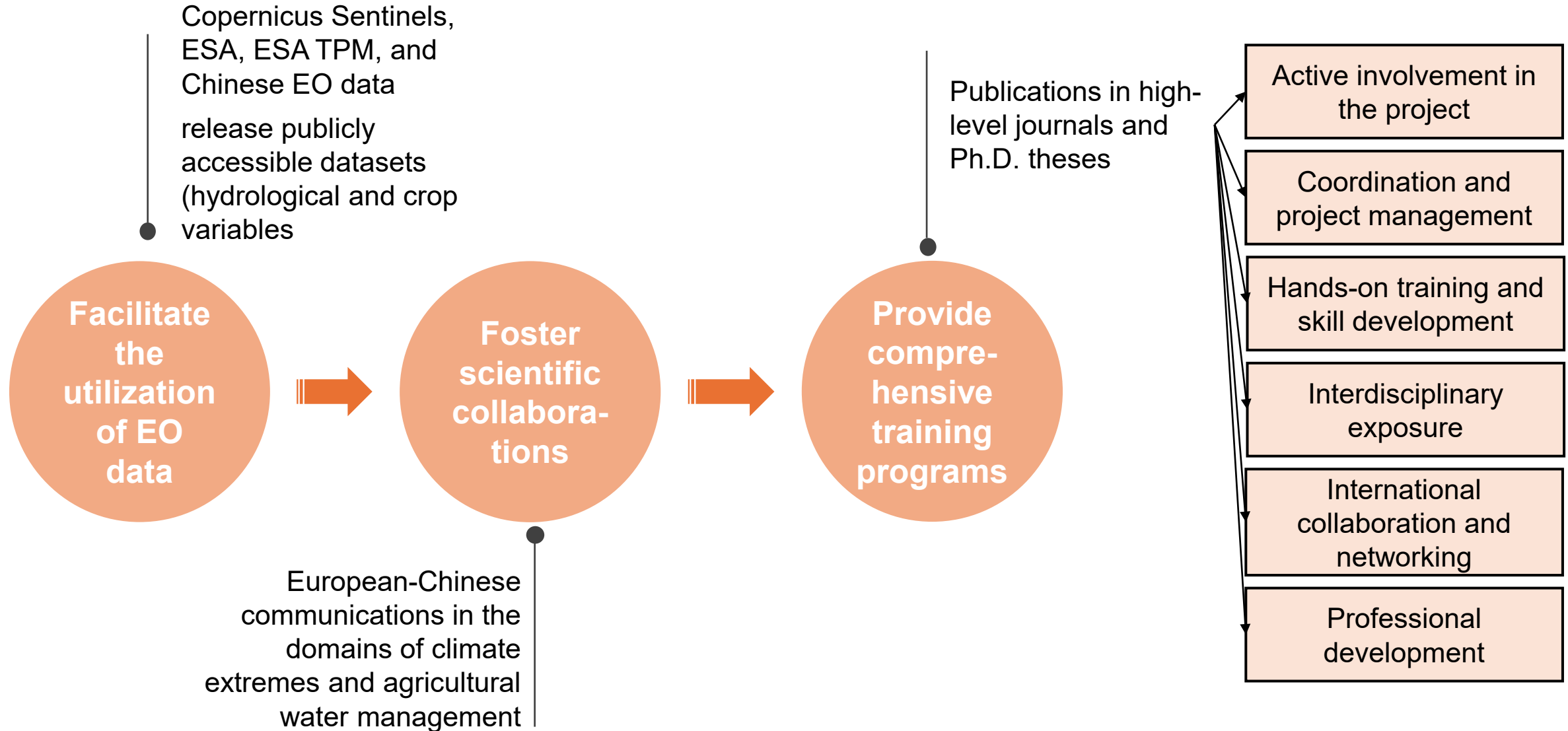
# Contribution to the objectives of the Dragon 6 call



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## ESA/Copernicus Missions

- Sentinel-1 IW
- Sentinel-2 MSI (NDVI and NDWI)
- Sentinel-3 SLTSR (land surface temperature)
- SMOS L1 and L2 (soil moisture)
- ESA CCI soil moisture
- ESA CCI land cover
- ESA CCI land surface temperature
- ENVISAT-AATSR
- ERS-2

## Chinese EO data

- FY-3A/B VIRR
- FY-2G VISSR
- FY-3C/D/E MERIS, MWHS, MWRI

## Ancillary data

- Field experiments (e.g., EC towers, CRNS, boreholes)
- Reanalysis data from ECMWF and corrected NCEP and MERRA data
- Routine meteorological data from CMA

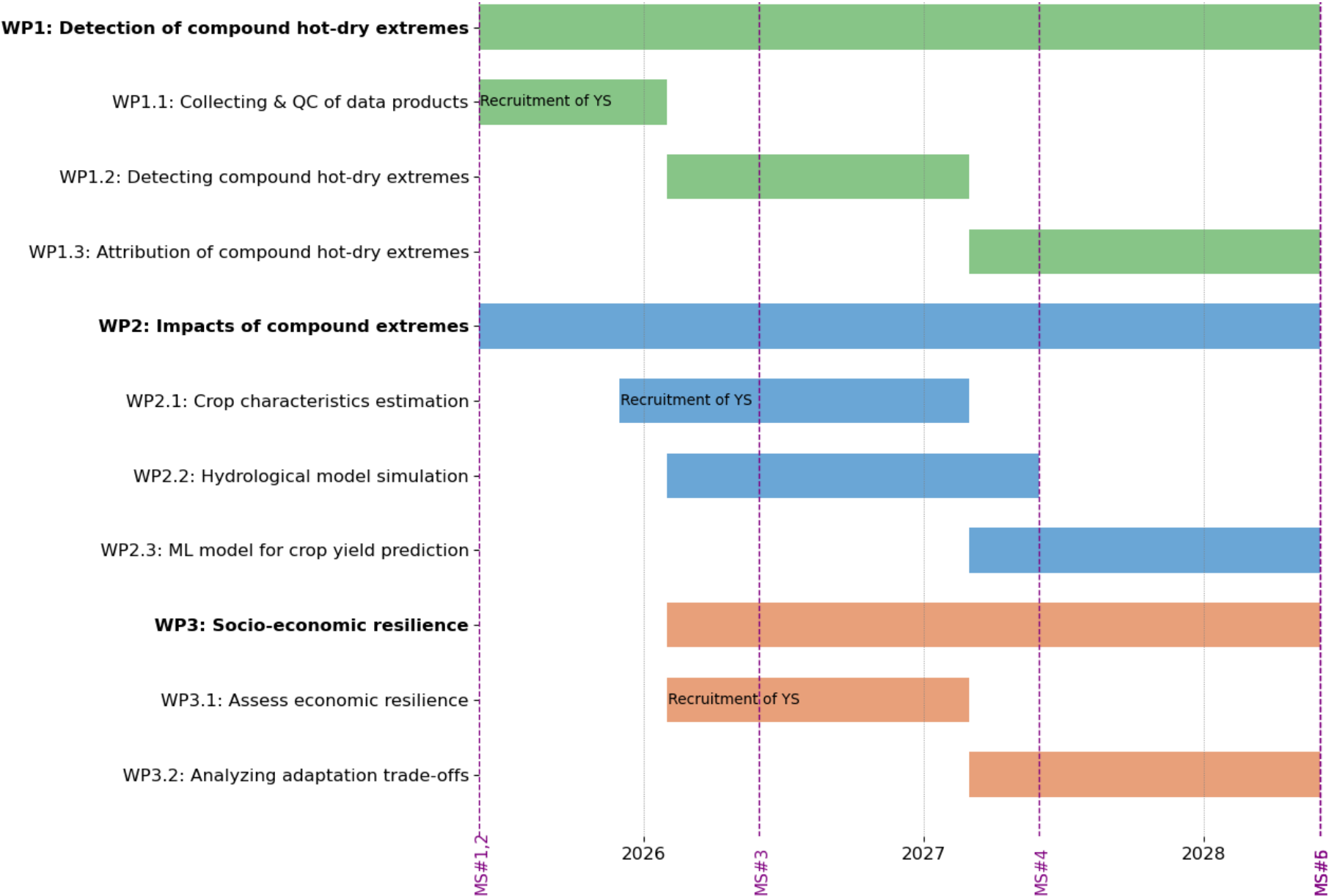
# Schedule of the project



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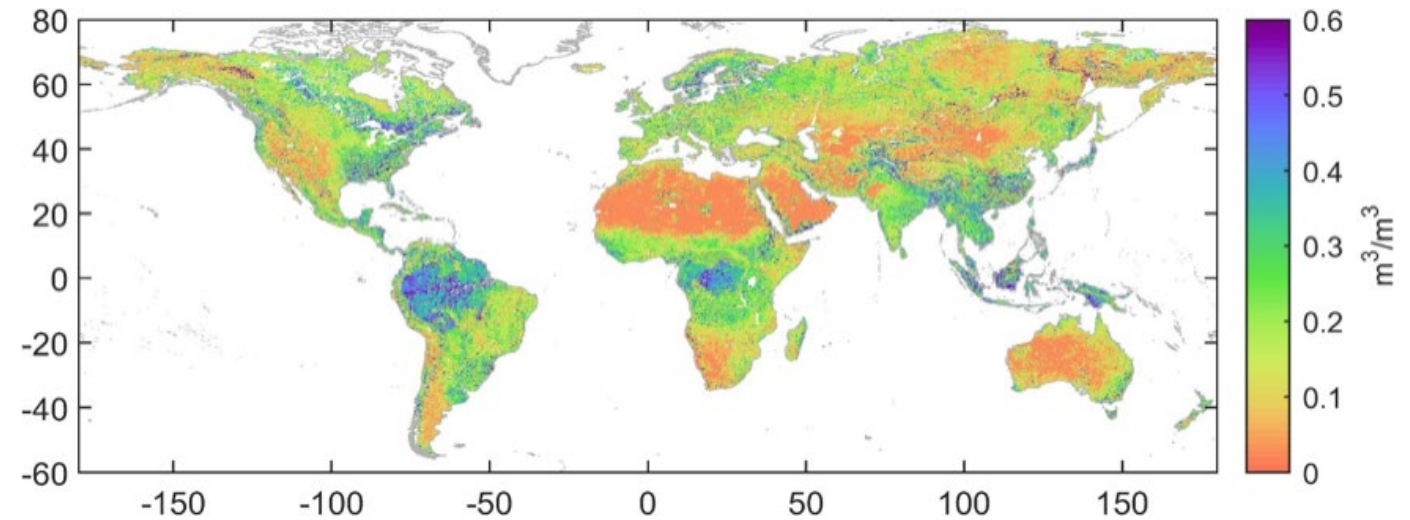
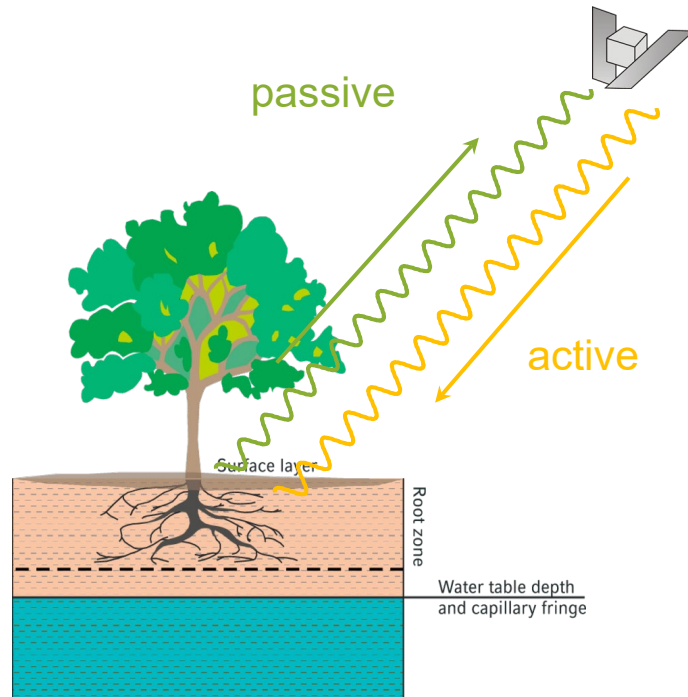
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Lead by European Young Scientist

## Global 1 km soil moisture from Sentinel 1 & 2



- Establishing the workflow to detect global soil moisture patterns
- Filling the gap of no global high resolution products
- Improving high resolution hydrological simulations

# Highlight 2: Water/energy fluxes during climate extremes

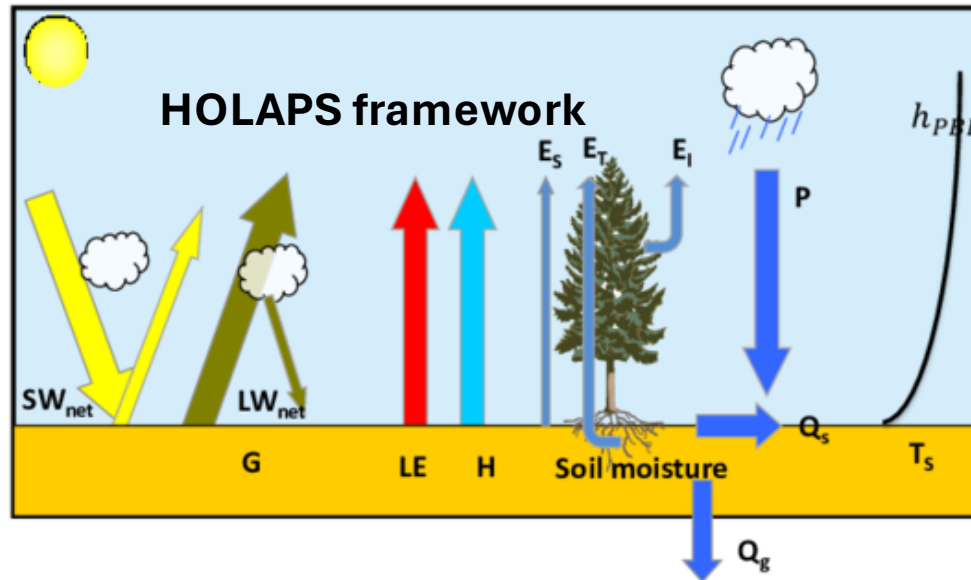


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- Combining atmospheric and land physical modelling with remote sensing
- Hybrid scheme for transpiration estimation
- Physical internal consistency

García-García and Peng 2024, Remote Sensing of Environment

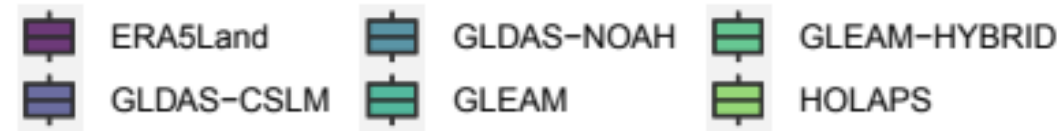
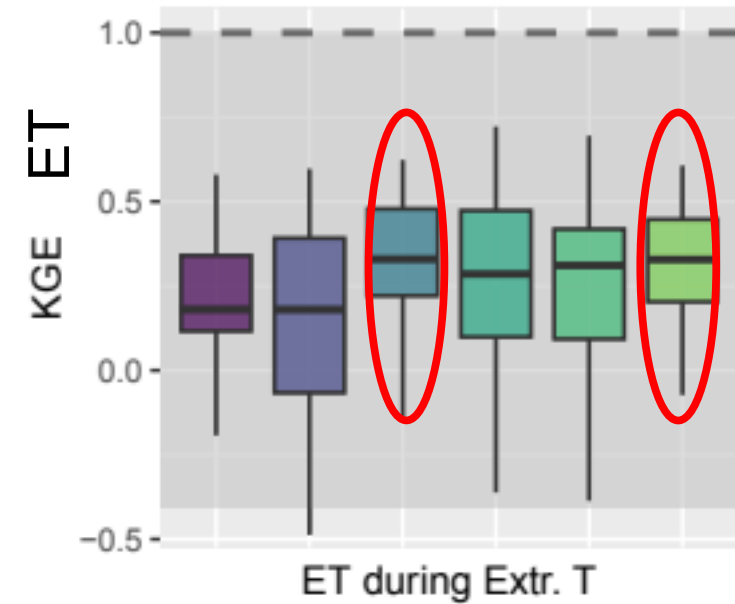
# Highlight 2: Water/energy fluxes during climate extremes



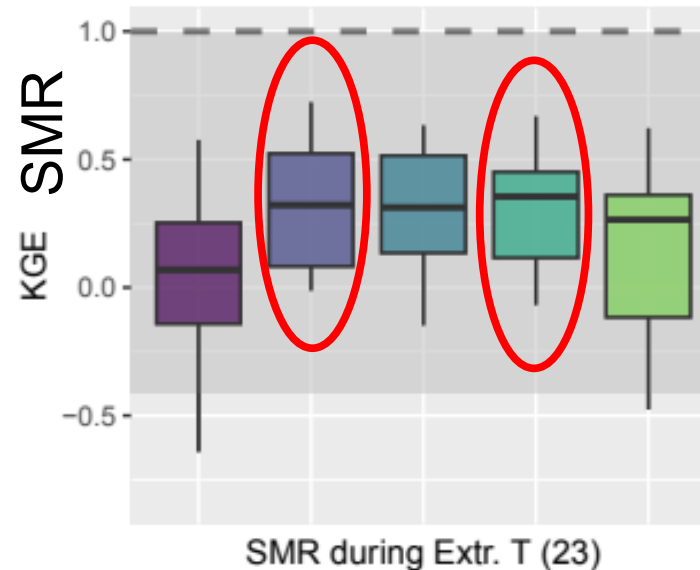
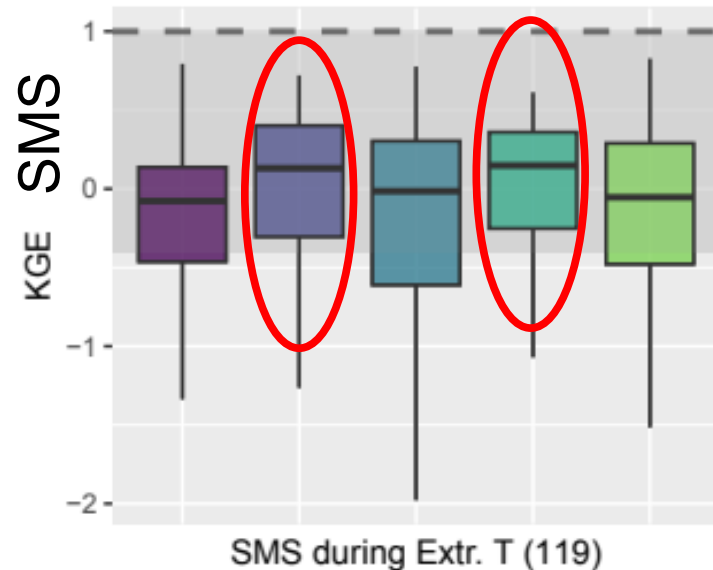
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International  
Soil Moisture  
Network



- HOLAPS and GLDAS-NOAH show best performance during hot conditions for ET
- GLDAS-CSLM and GLEAM best performance for SM

# Highlight 3: Increase in heat storage by the global subsurface

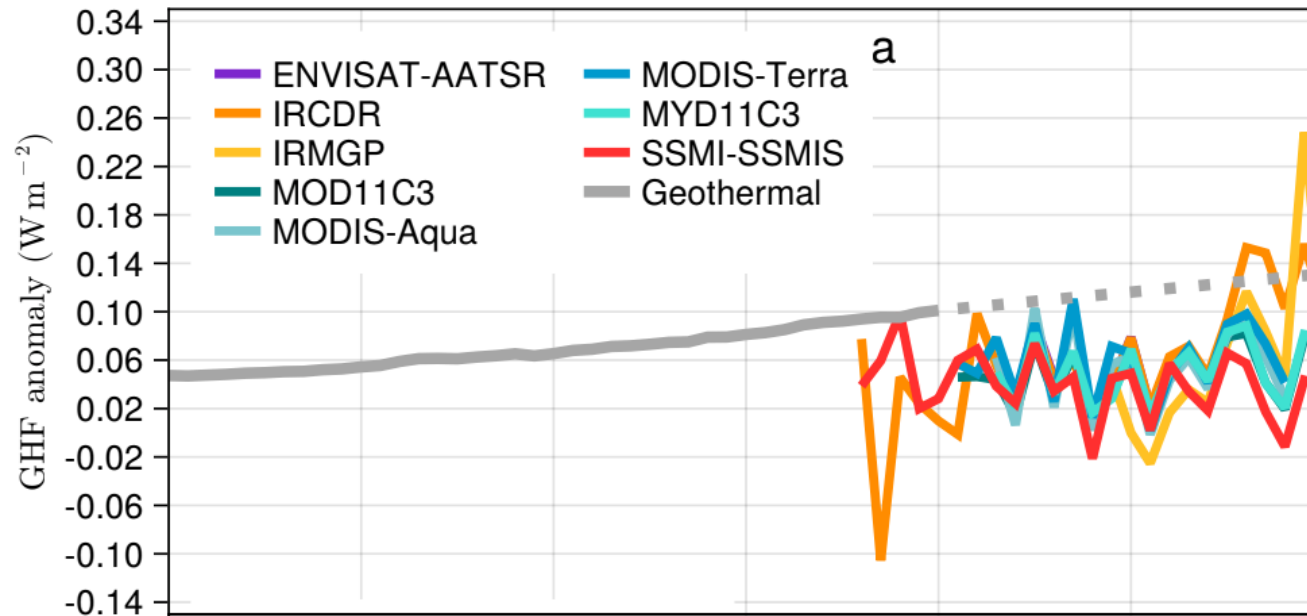


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- Global estimates of ground heat flux are derived from six satellite land surface temperature products
- Our estimates compare better than ERA5-Land against observations from Eddy-covariance stations
- Robust increase in observed heat storage by the global subsurface

# Highlight 4: In-season crop yield forecasting system



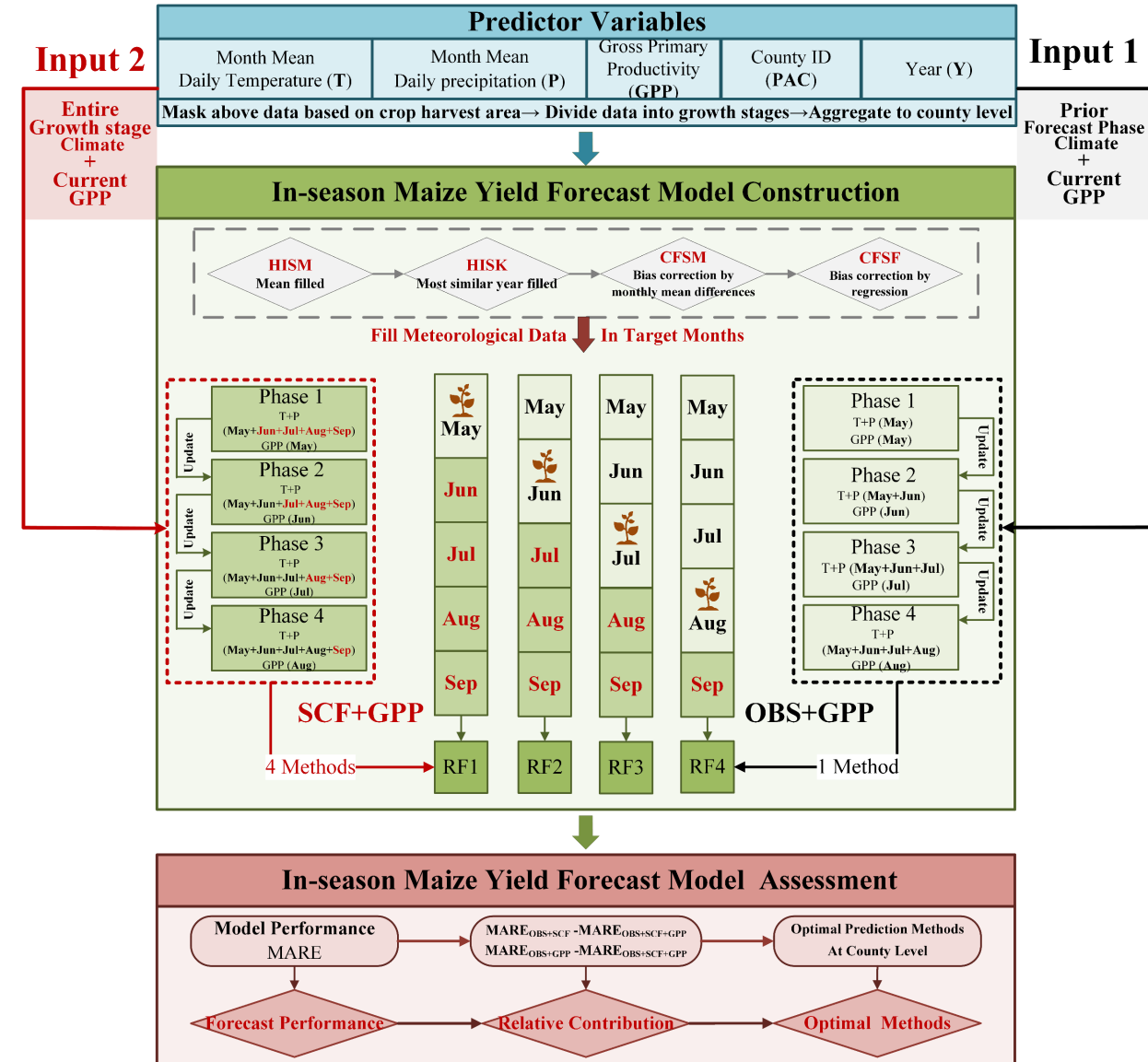
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## Lead by Chinese Young Scientist

- Seasonal yield prediction models at each forecast phase are constructed by combining climate forecasts and satellite observations
- Benefits of climate forecasts and satellite observations at each forecast phase are quantified
- Optimal in-season yield prediction method is determined at each forecast phase for each county



# Highlight 4: Satisfactory in-season crop yield forecasting

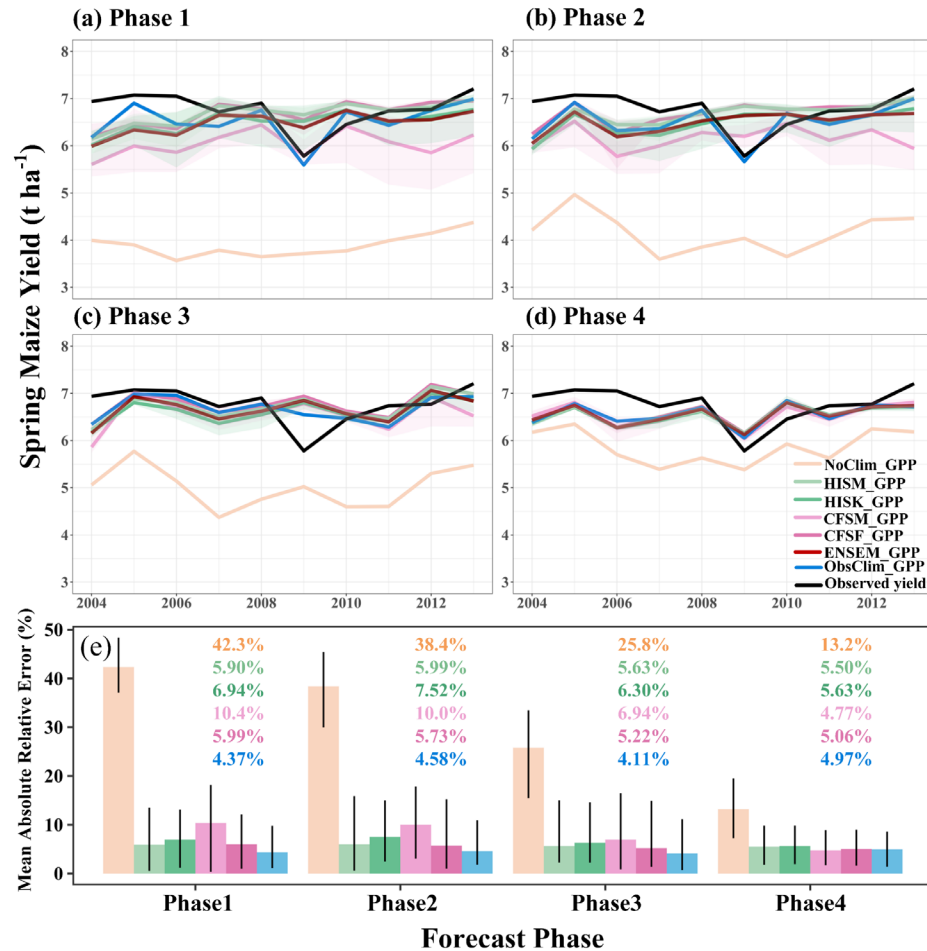


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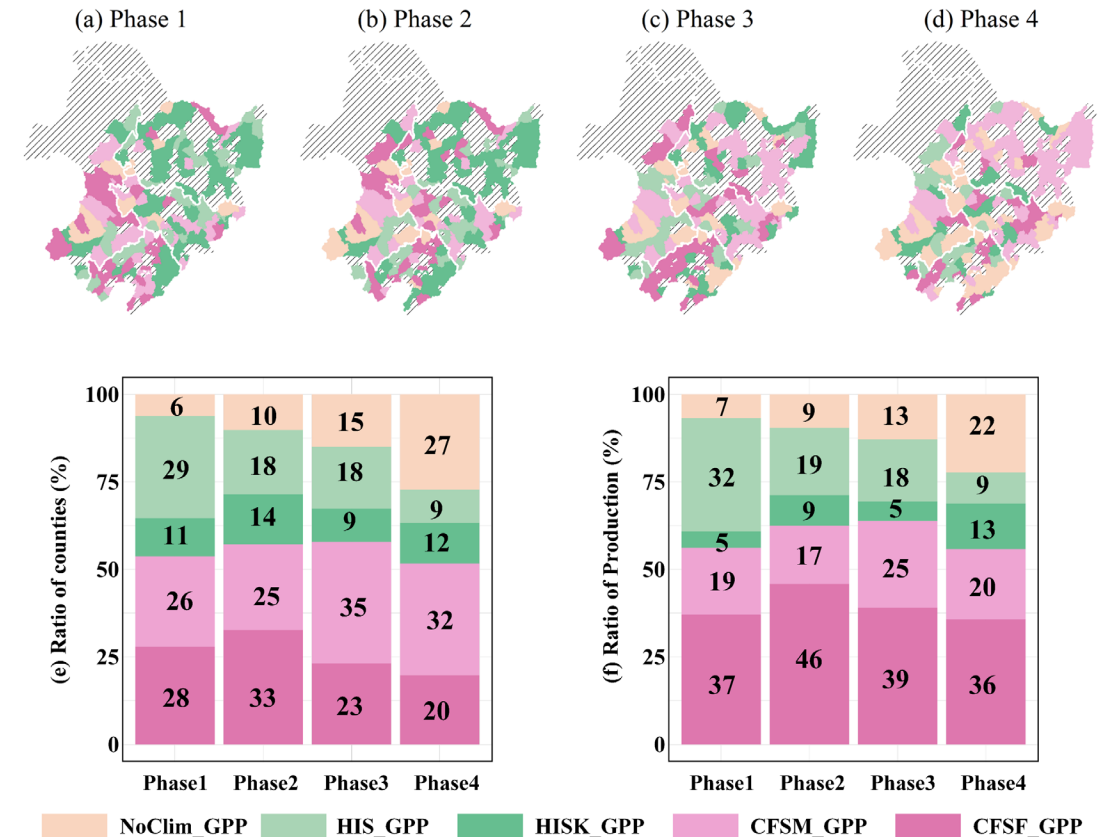


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- Phase-dependent maps indicating the best climate forecast model are produced for each county in Northeast China



- Better forecast can be obtained one month before harvest by correcting the dynamical climate forecast models' data



# Highlight 5: Increase in heat storage by the global subsurface

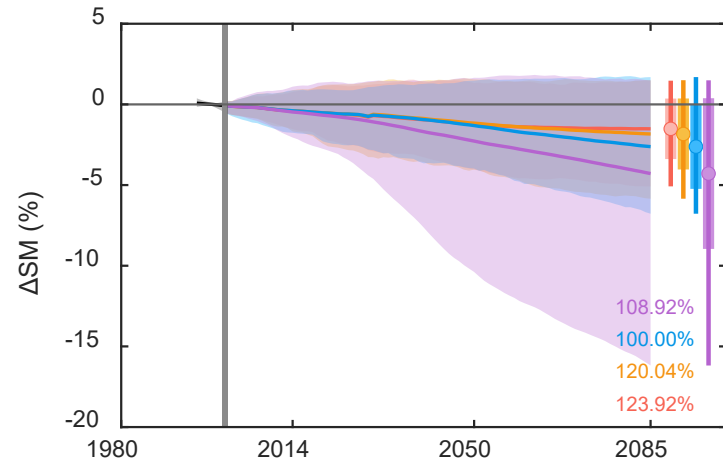


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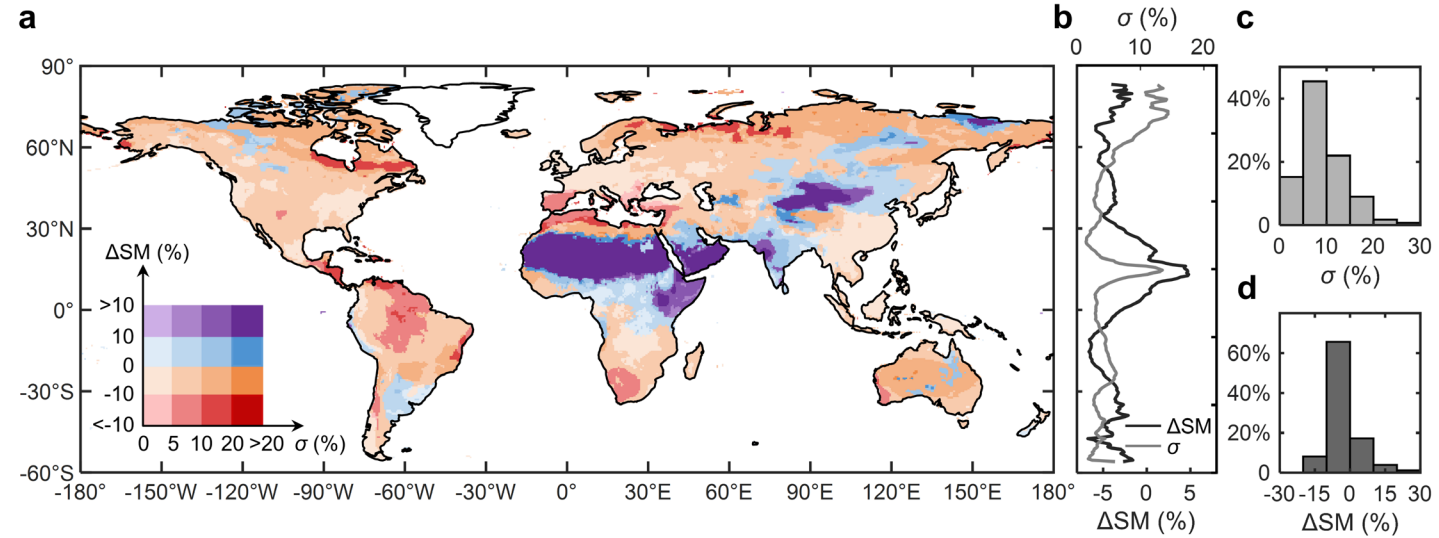


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## Lead by Chinese Young Scientist



## Bivariate emergent constraints on soil moisture

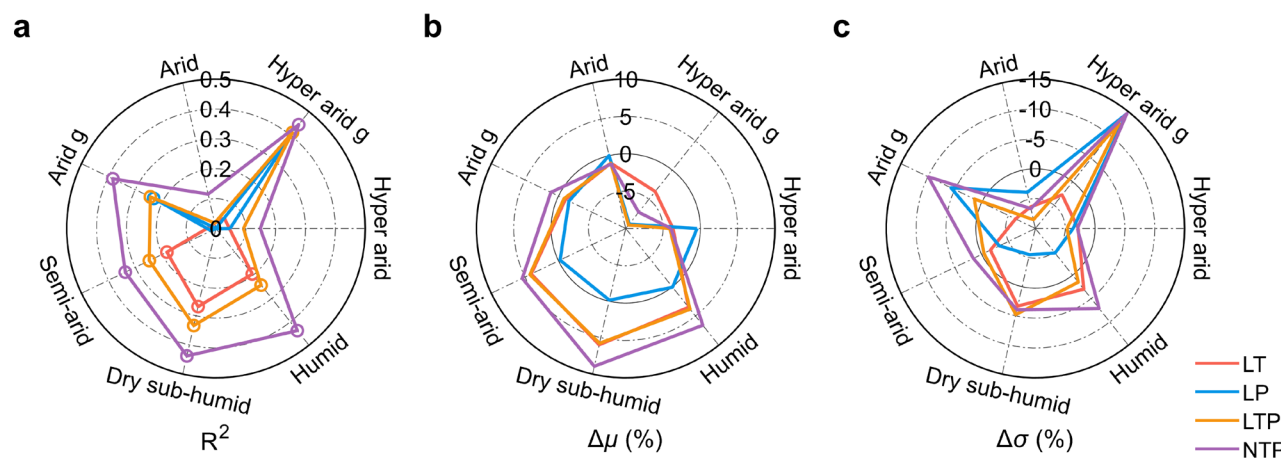
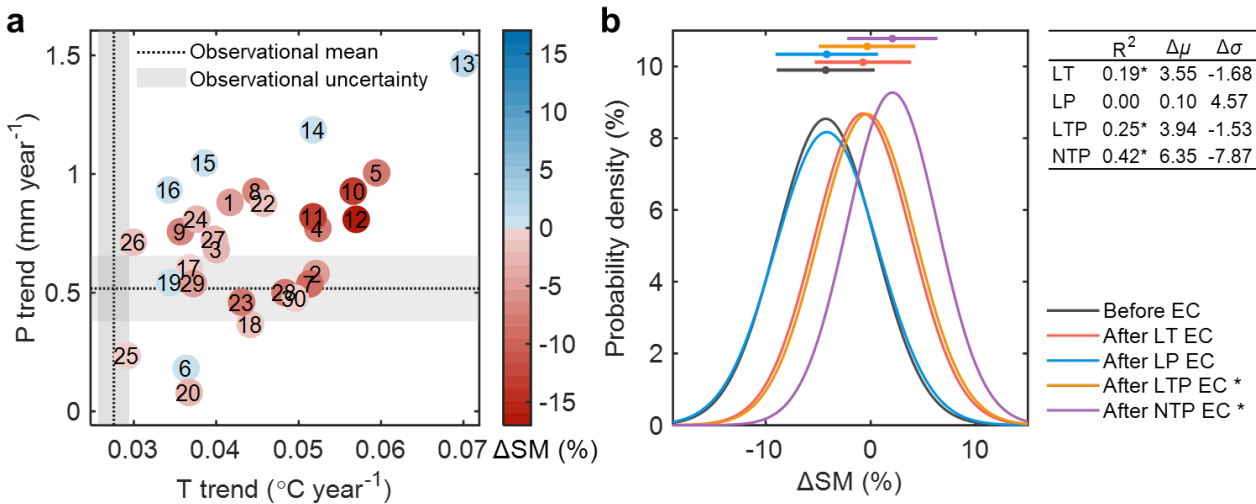


- Based on CMIP6 outputs, future surface (0-10cm) soil moisture is expected to decrease over a wide range, especially for the high emission scenario of SSP5-8.5
- Along with the widespread drying, large uncertainties (i.e., one standard deviation across model ensemble) are associated with  $\Delta SM$

# Highlight 5: Increase in heat storage by the global subsurface



## Bivariate emergent constraints on soil moisture



- Here we extend the commonly used univariate EC to a bivariate method and reduce the uncertainty in  $\Delta SM$  by 7.87%, which is four times more effective than traditional method
- The bivariate EC change the sign of  $\Delta SM$  from negative to positive for semi-arid, dry sub-humid and humid regions and global land but exacerbates the drying trend in arid and hyper-arid regions

# Exchange of young scientists



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| Name      | Institution                                                     | Project name                                                                                                                    | Host institution                                  |
|-----------|-----------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------|
| Chenxi Lu | Institute of Geographic Sciences and Natural Resources Research | Phd project: A mechanistic and scalable in-season crop yield forecast framework based on solar-induced chlorophyll fluorescence | Helmholtz Centre for Environmental Research - UFZ |
| Lei Yao   | Institute of Geographic Sciences and Natural Resources Research | Phd project: Explore water storage change under climate change based on observational constraint                                | Helmholtz Centre for Environmental Research - UFZ |
| Siyu Ma   | Northwest University                                            | Postdoc project: Water resources resilience during climate extremes from satellite remote sensing                               | Helmholtz Centre for Environmental Research - UFZ |



**ID 184. Soil Hot Extremes Are Increasing Faster Than Air Hot Extremes: Possible Implications for Agriculture, *Almudena Garcia-Garcia et al.***

**ID 194. Ground Heat Flux Estimates From Machine Learning Techniques, *Francisco Jose Cuesta-Valero et al.***

**ID 143. Synergies of Cosmic-Ray Neutron Sensors and Remote Sensing Products for Spatial Mapping of Soil Moisture and Vegetation, *Louis Trinkle et al.***



- **EO Data Utilization**

Copernicus Sentinels (S1, S2, S3), ESA CCI products, ENVISAT, SMOS, and Chinese FY-series data have been explored for detecting and analyzing compound hot-dry extremes.

- **Field Data Collection**

Field campaigns conducted in China and Europe collected soil moisture, meteorological data, energy fluxes to validate EO-derived variables.

- **Modeling & Analysis**

mHM, HOLAPS, and machine learning algorithms have been applied to simulate crop responses and hydrological impacts under compound extremes.

- **Scientific Outcomes**

Several peer-reviewed papers led by young scientists have been published or in preparation

- **Capacity Building**

Active involvement of young researchers, hands-on training in EO processing, and international academic exchanges between EU and China.



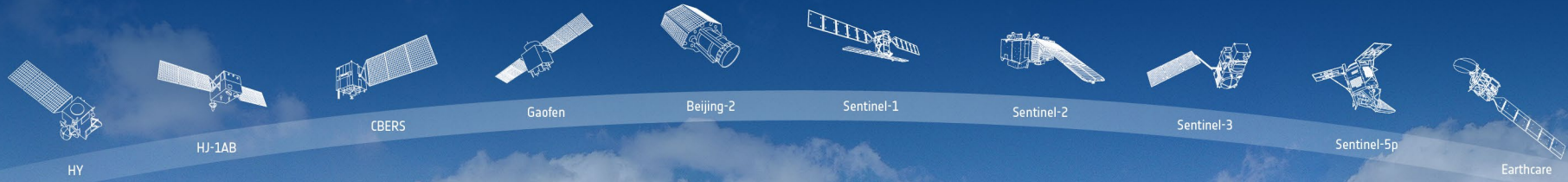
- **Refine detection & modeling**  
Improve spatial-temporal accuracy of extreme event detection; continue model–data integration.
- **Field campaigns**  
Extend in-situ observations across varied agro-climatic zones in China; harmonize with European datasets.
- **Expand adaptation strategy analysis**  
Assess economic trade-offs and co-benefits of different climate adaptation approaches.
- **Support young scientists**  
Promote joint publications, encourage new exchanges, and organize workshops and a follow-up poster session.
- **Strengthen collaboration**  
Deepen ESA–Chinese EO data integration; increase accessibility of public datasets and shared workflows.



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Many thanks!  
非常感谢!

