

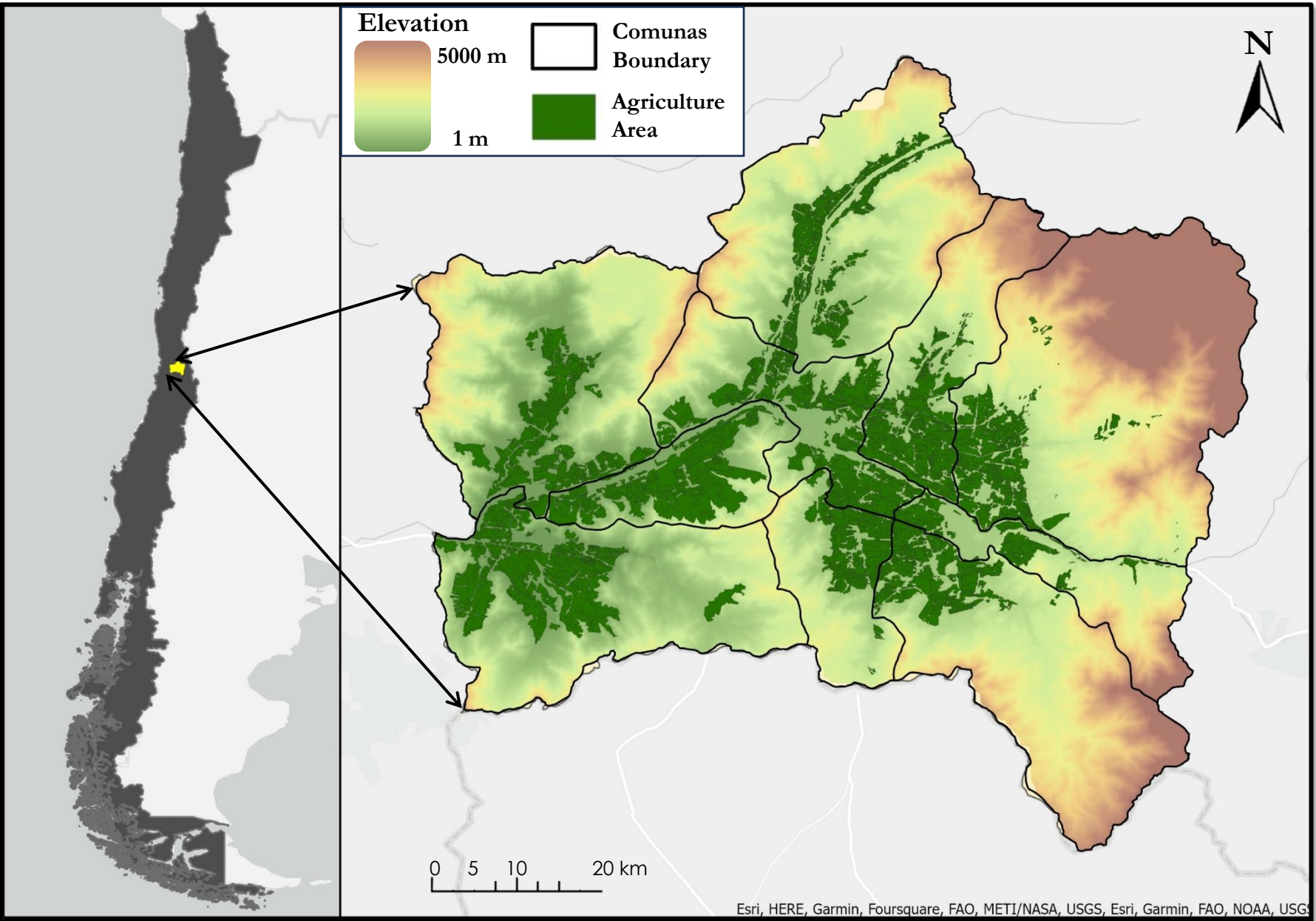
## Aconcagua Basin Agriculture

Analyzing Hydrological Norms, Soil Moisture, Evapotranspiration, and Vegetation Indices to Assess Crop Yields and Water Usage in the Aconcagua Basin of Central Chile During Megadrought Conditions

Javiera Canales Valenzuela • Carmen Martha Petras • Daniela Quintero Garcia

25<sup>TH</sup> DEVELOP

ANNIVERSARY

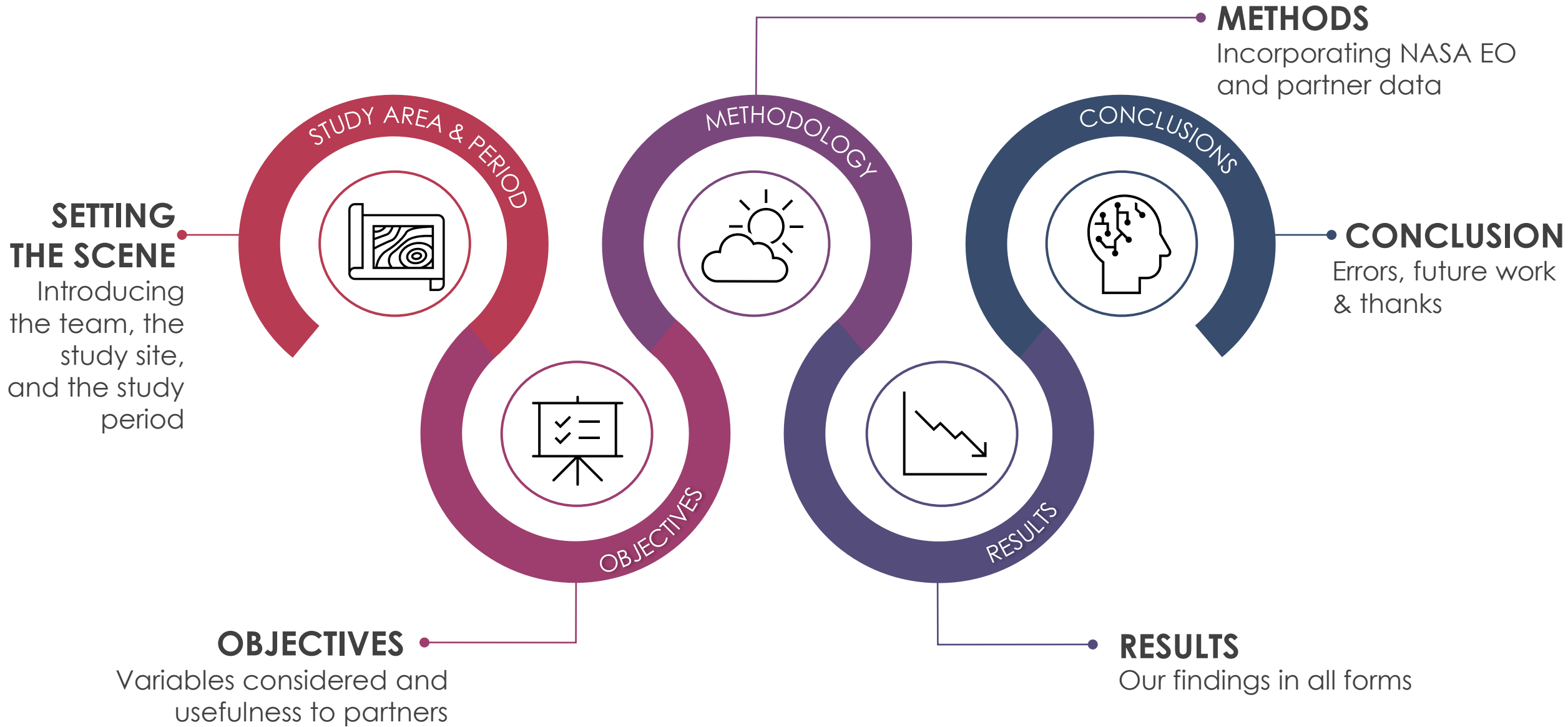


# Study Area

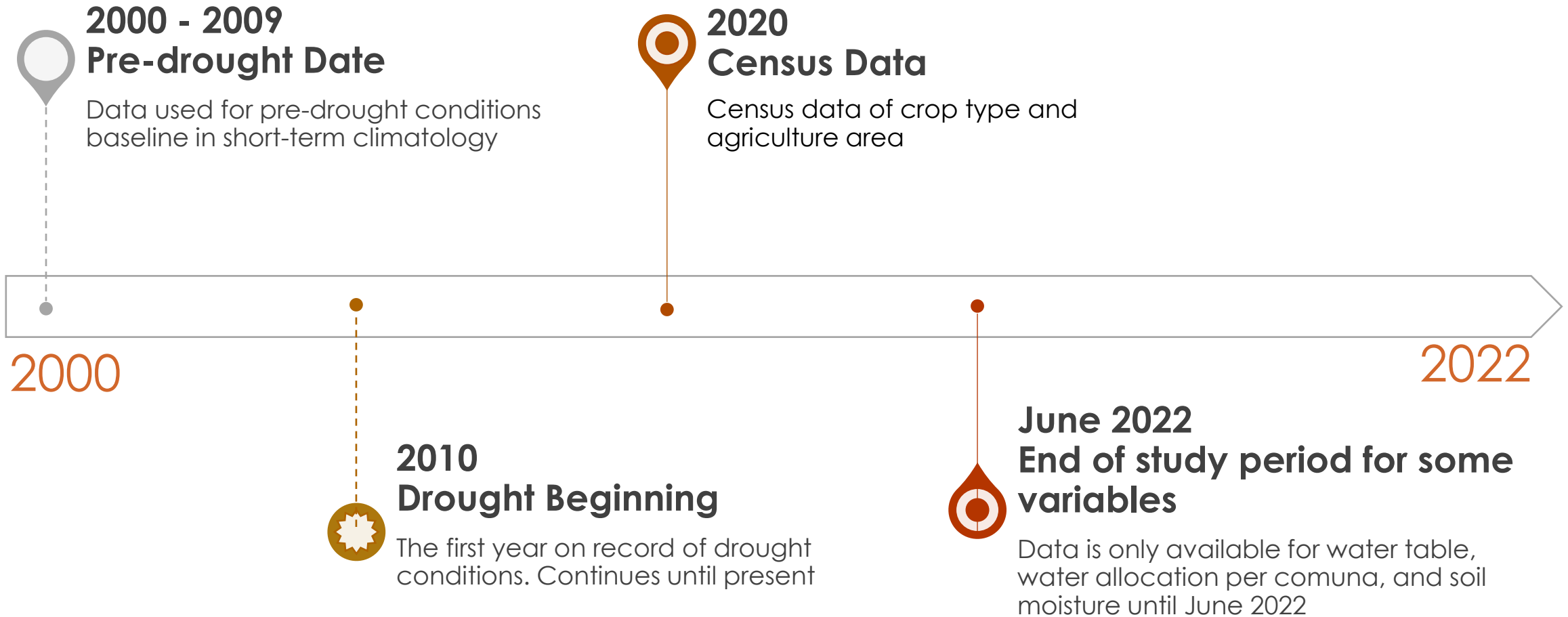
- Aconcagua Basin within the Macrozona Centro region
- Mediterranean
  - Growing season: October – April
- Agriculture hub
  - 12% of national agriculture
- Significant snowmelt contribution



# Contents

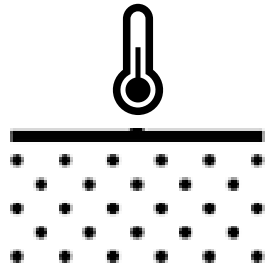


# Study Period



# Objectives

Inform agriculture and water allocation decisions using Earth observation analysis in the Aconcagua River Basin (ARB)



**LAND  
SURFACE TEMPERATURE**

**LST**

- Hydrology



**PRECIPITATION**

**P**

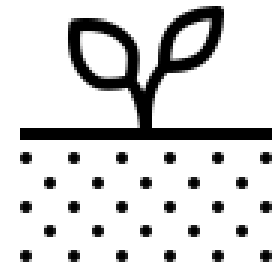
- Hydrology
- Irrigation



**EVAPOTRANSPIRATION**

**ET**

- Hydrology
- Irrigation
- Water stress
- Crop demand



**SOIL MOISTURE**

**SM**

- Irrigation
- Water stress
- Crop demand



# Partners



## **CIREN** (Centro de Información de Recursos Naturales)

- Agricultural producers, researchers, public institutions, consulting firms
- Remote sensing and hydrological experts
- Government consultant

## **Embassy of Chile, Agricultural Office**

- Project collaborator



# Methodology Overview

## Input Data



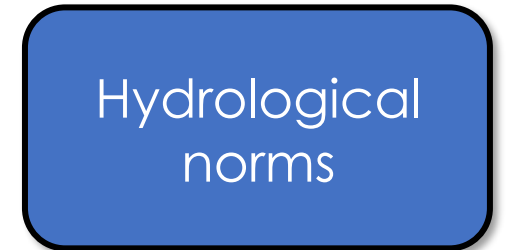
## Acquisition



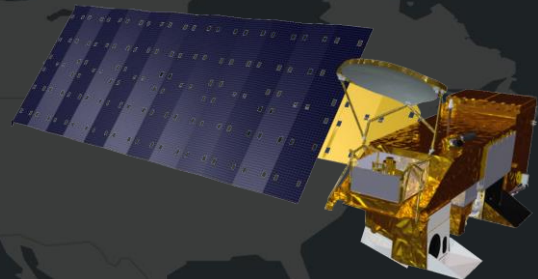
## Processing



## Main Outputs



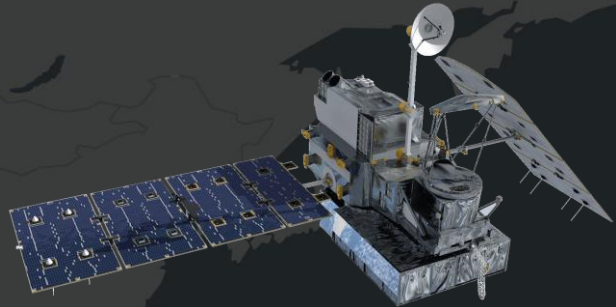
# Earth Observations



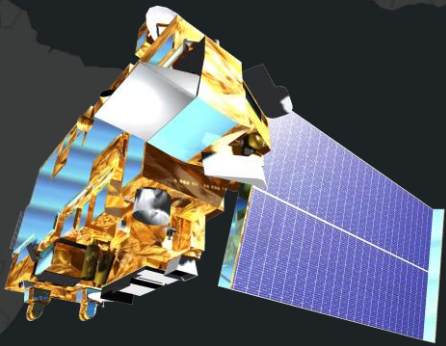
**Aqua (MODIS)**  
*LST*



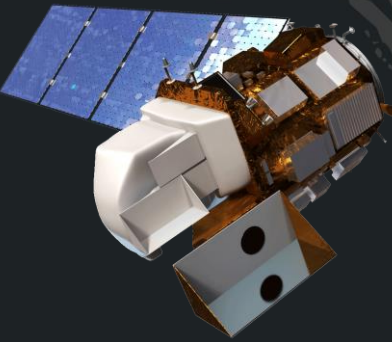
**SMAP (SAR)**  
*Soil Moisture*



**GPM (IMERG)**  
*Precipitation*



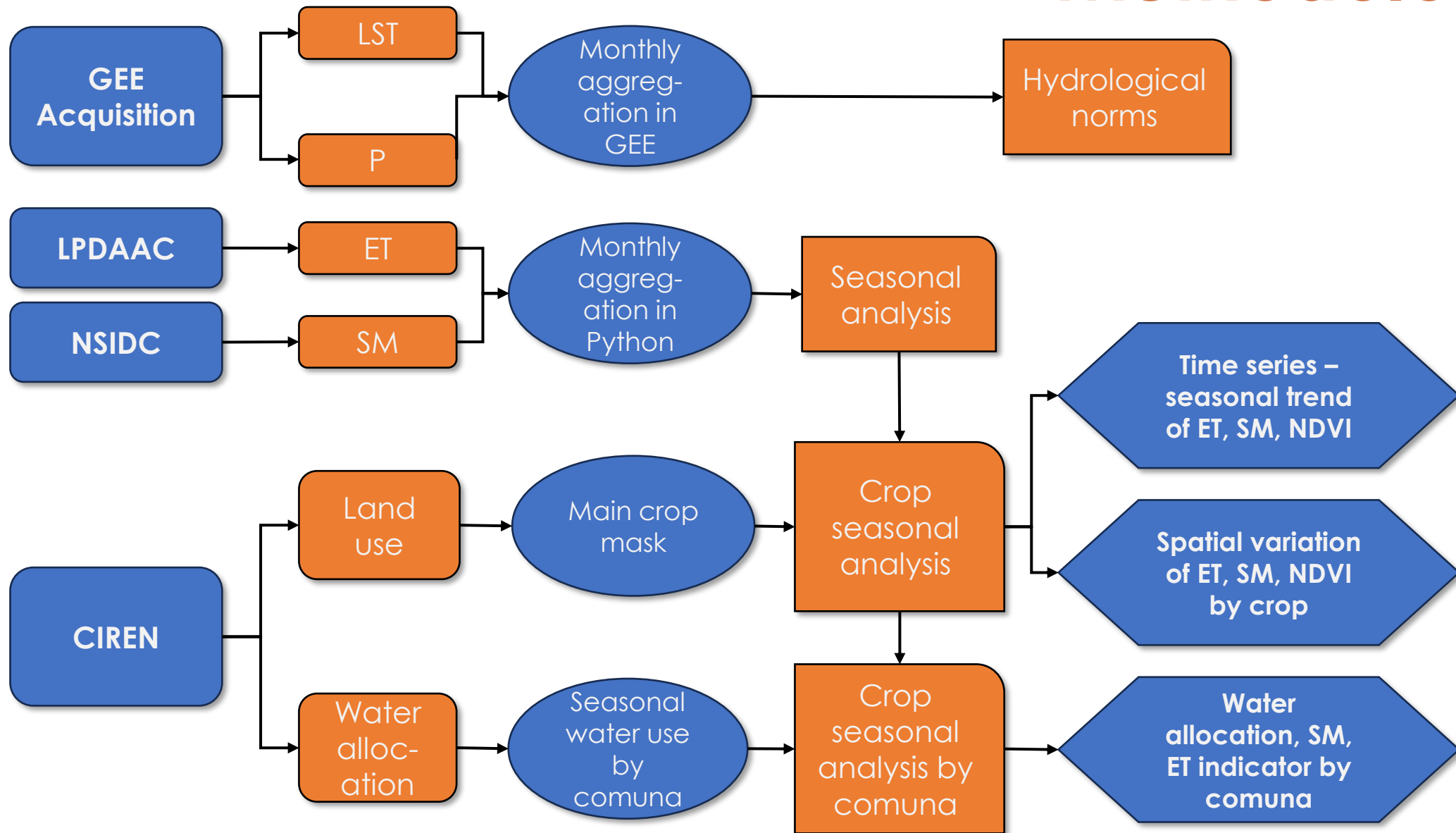
**Terra (MODIS)**  
*LST*  
*Evapotranspiration*



**Landsat 8 (OLI)**  
*NDVI*



# Methodology

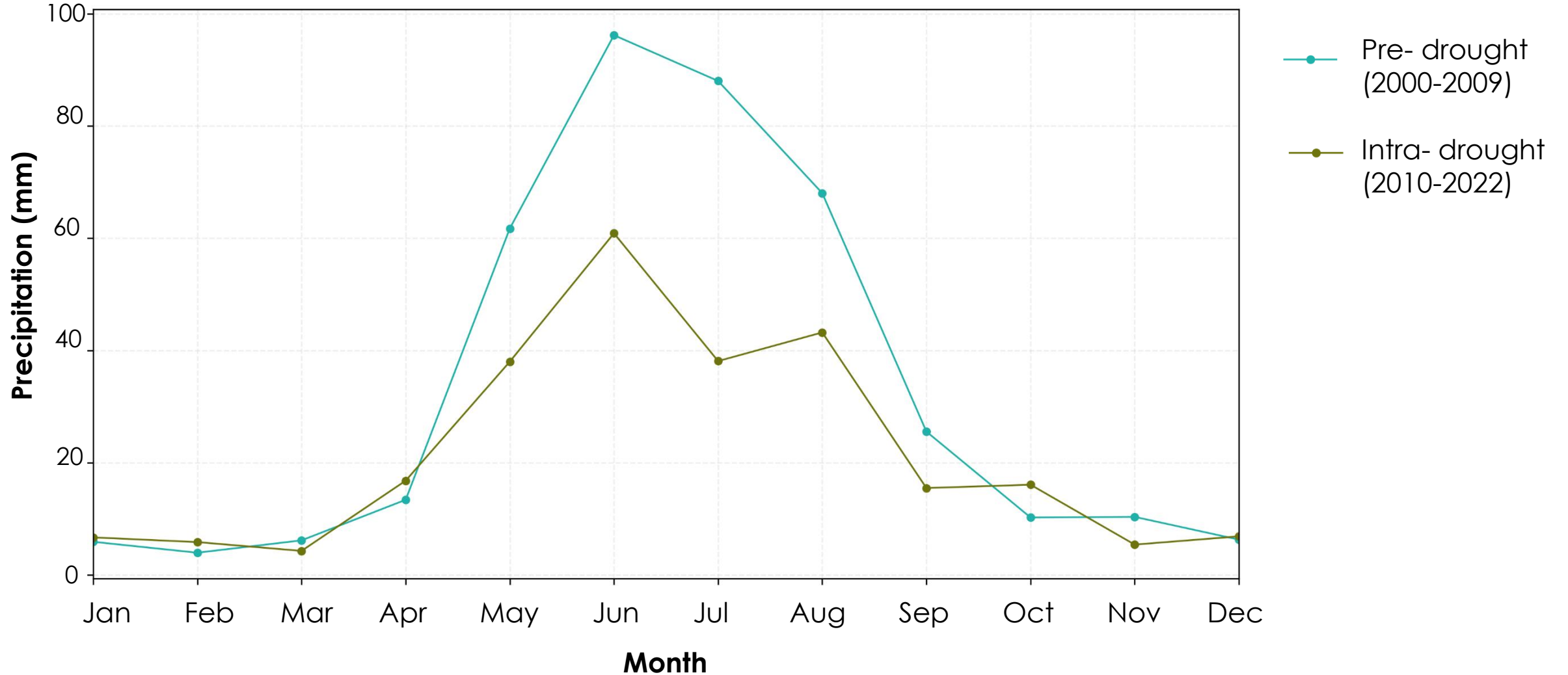


# RESULTS

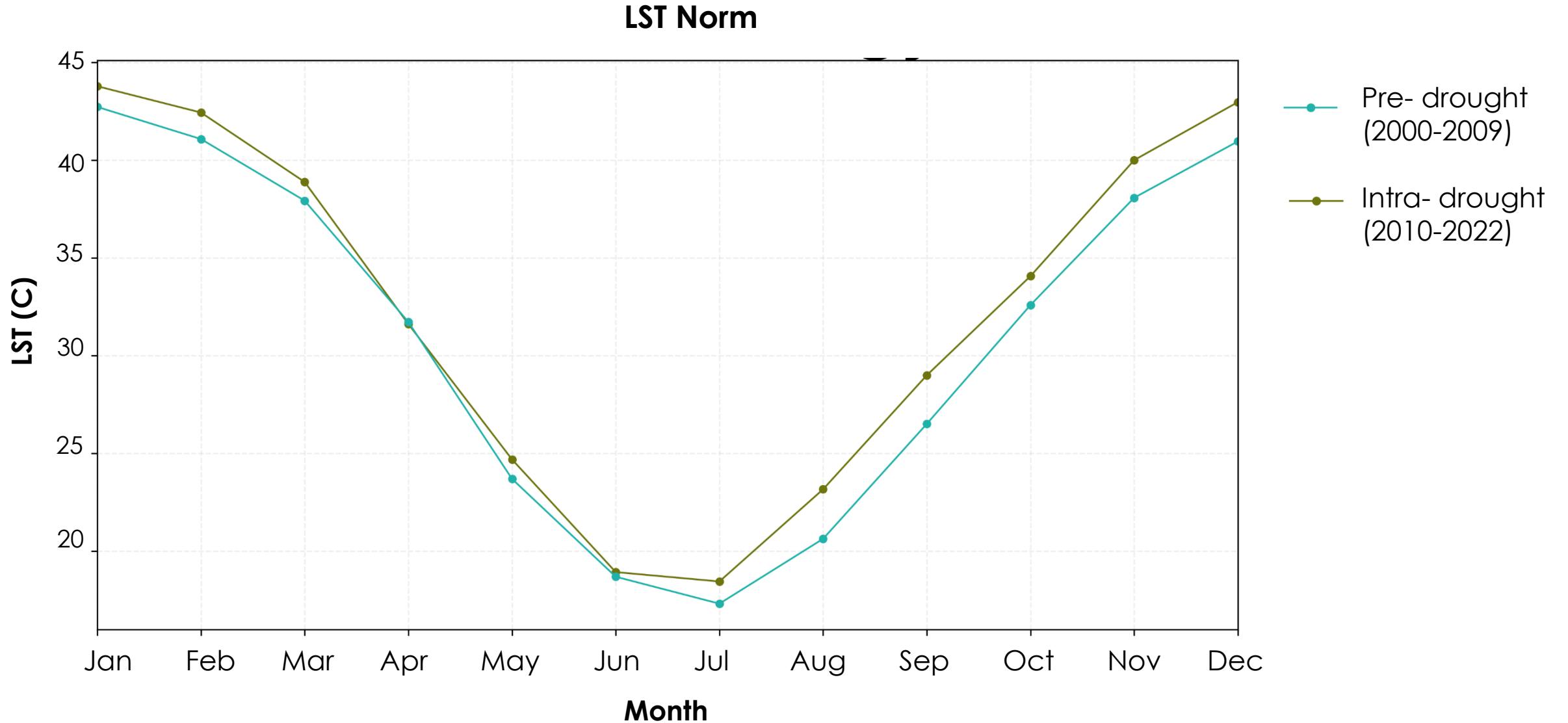


# Hydrological Norms: Precipitation

Precipitation Norm

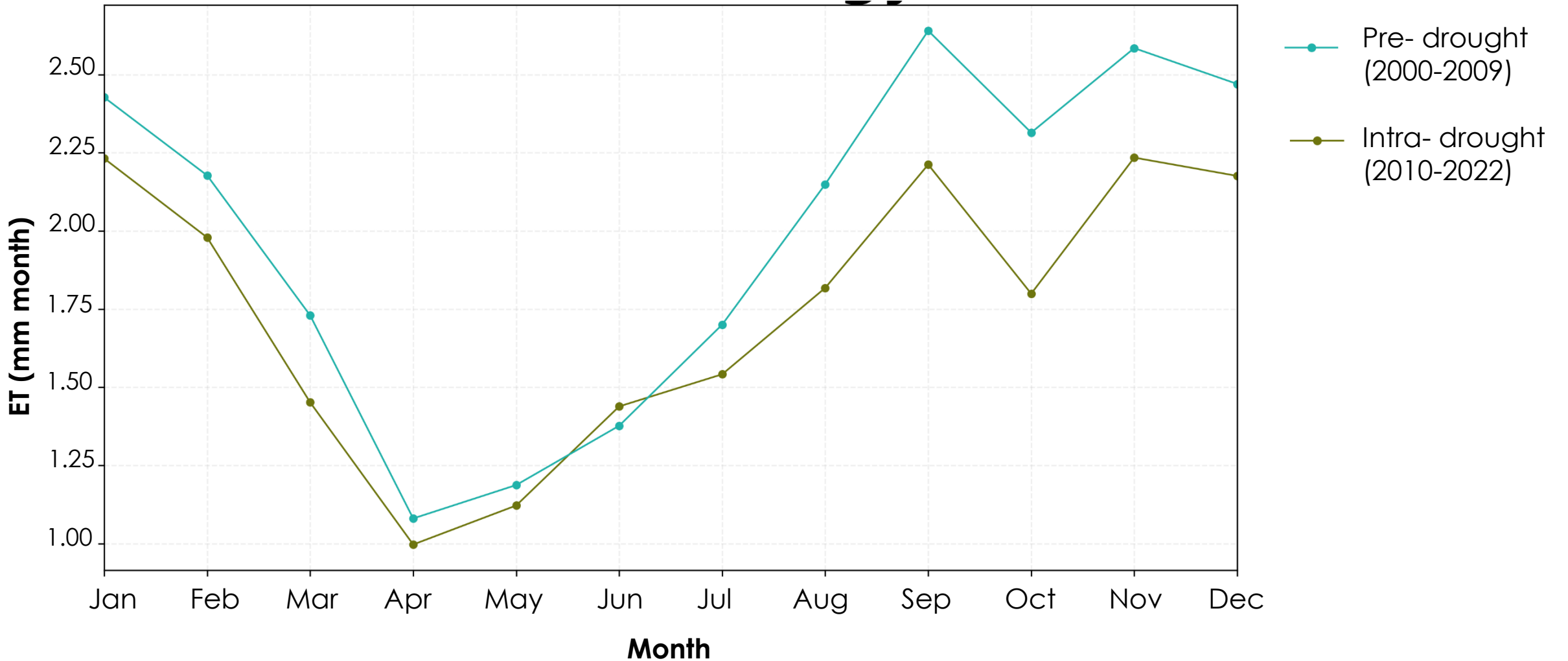


# Hydrological Norms: Land Surface Temperature



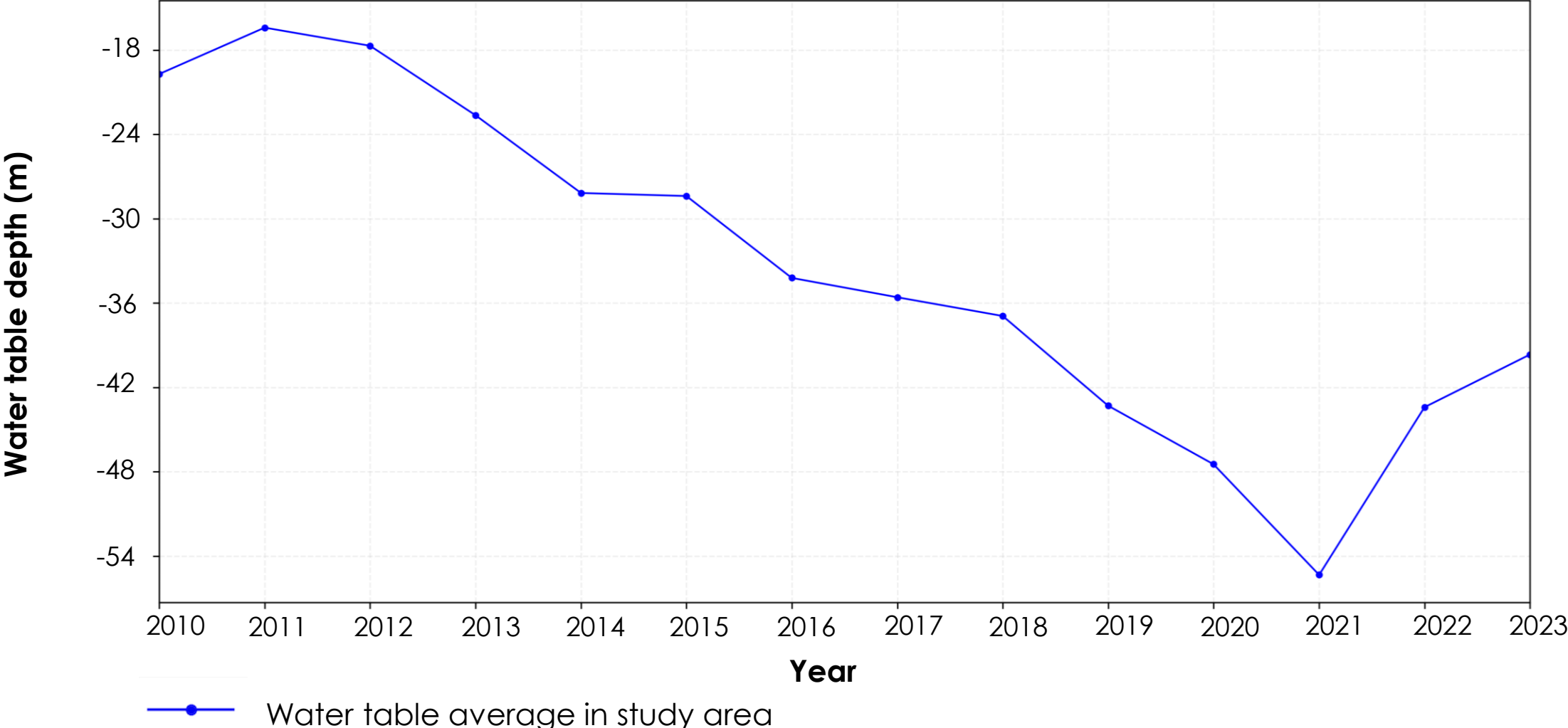
# Hydrological Norms: Evapotranspiration

ET Norm



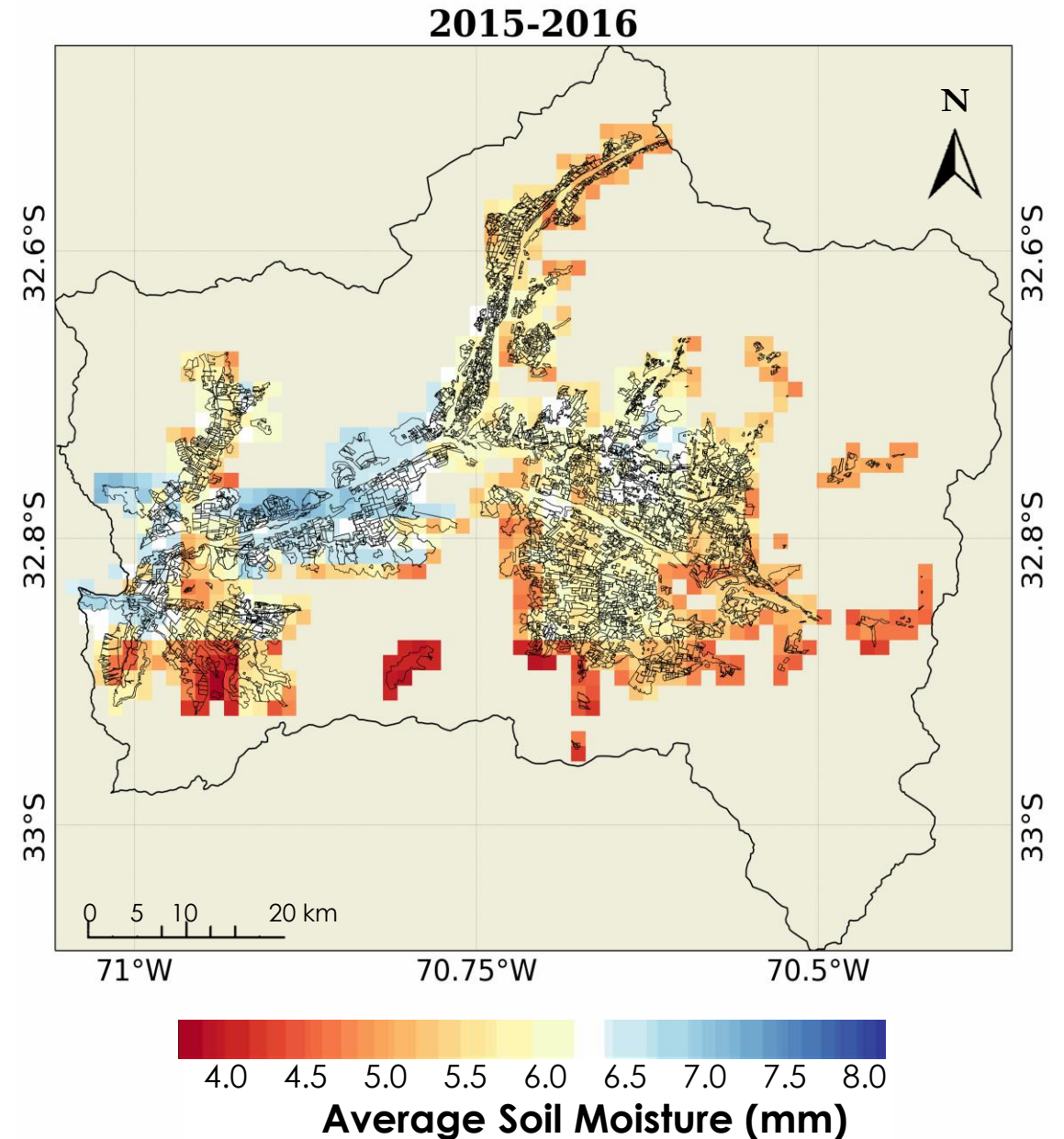
# Water Table in Region

Water table time series



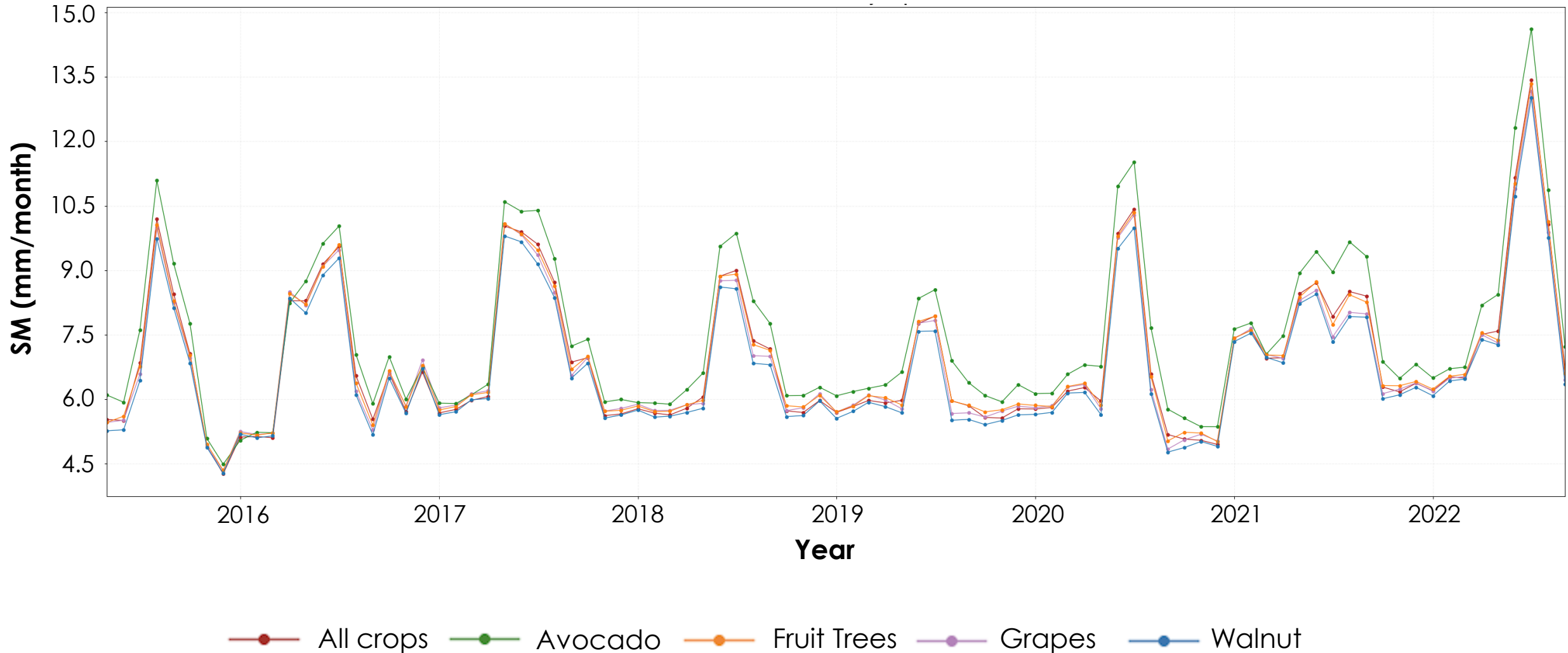
# Seasonal Analysis: SM

- Spatial changes of soil moisture from 2010 to 2022
- Soil moisture over the past two years shows an upward trend
- Avocado crops have experienced the most significant rise in soil moisture



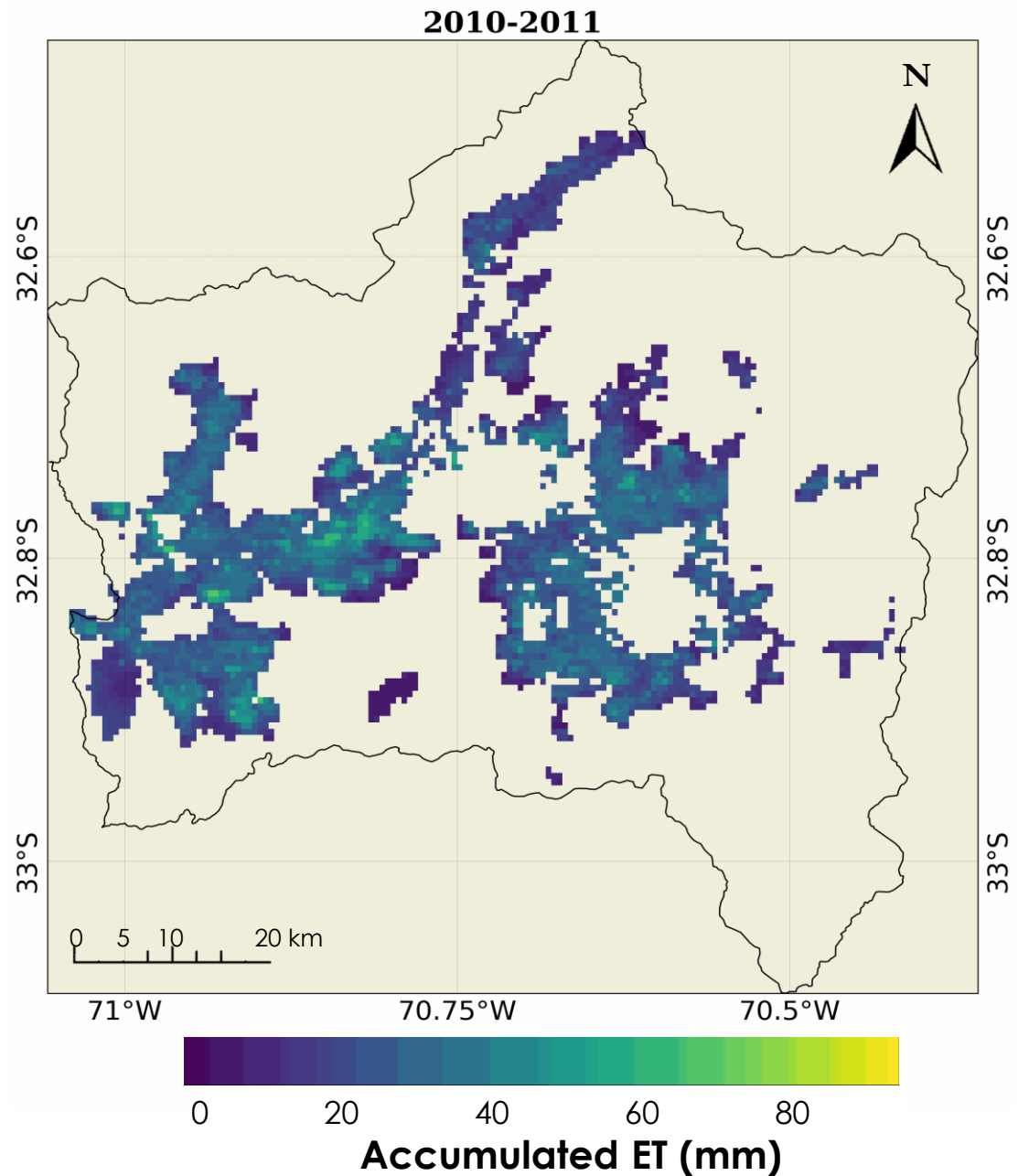
# Seasonal Analysis: SM by Crop

Soil Moisture by crop



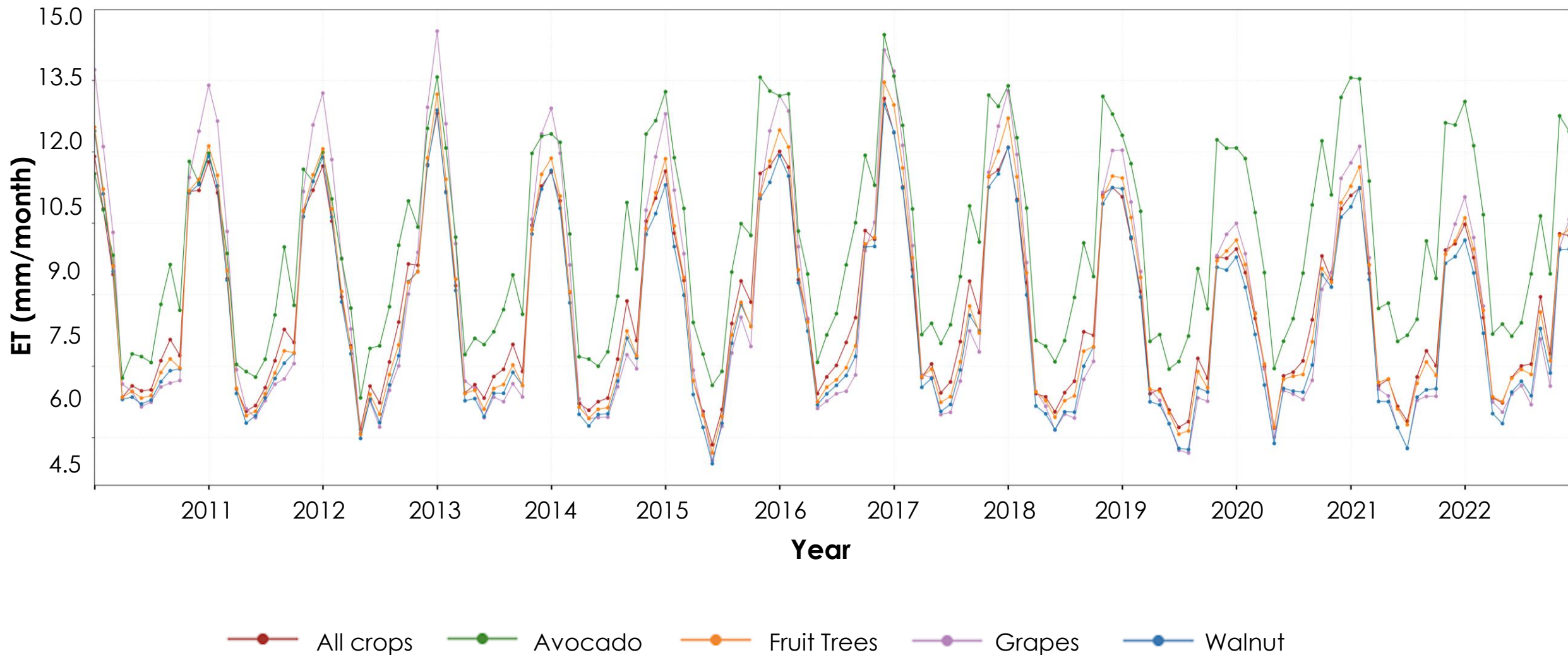
# Seasonal Analysis: ET

- Spatial change in evapotranspiration from 2010 to 2023
- Major ET activities on the avocado crops

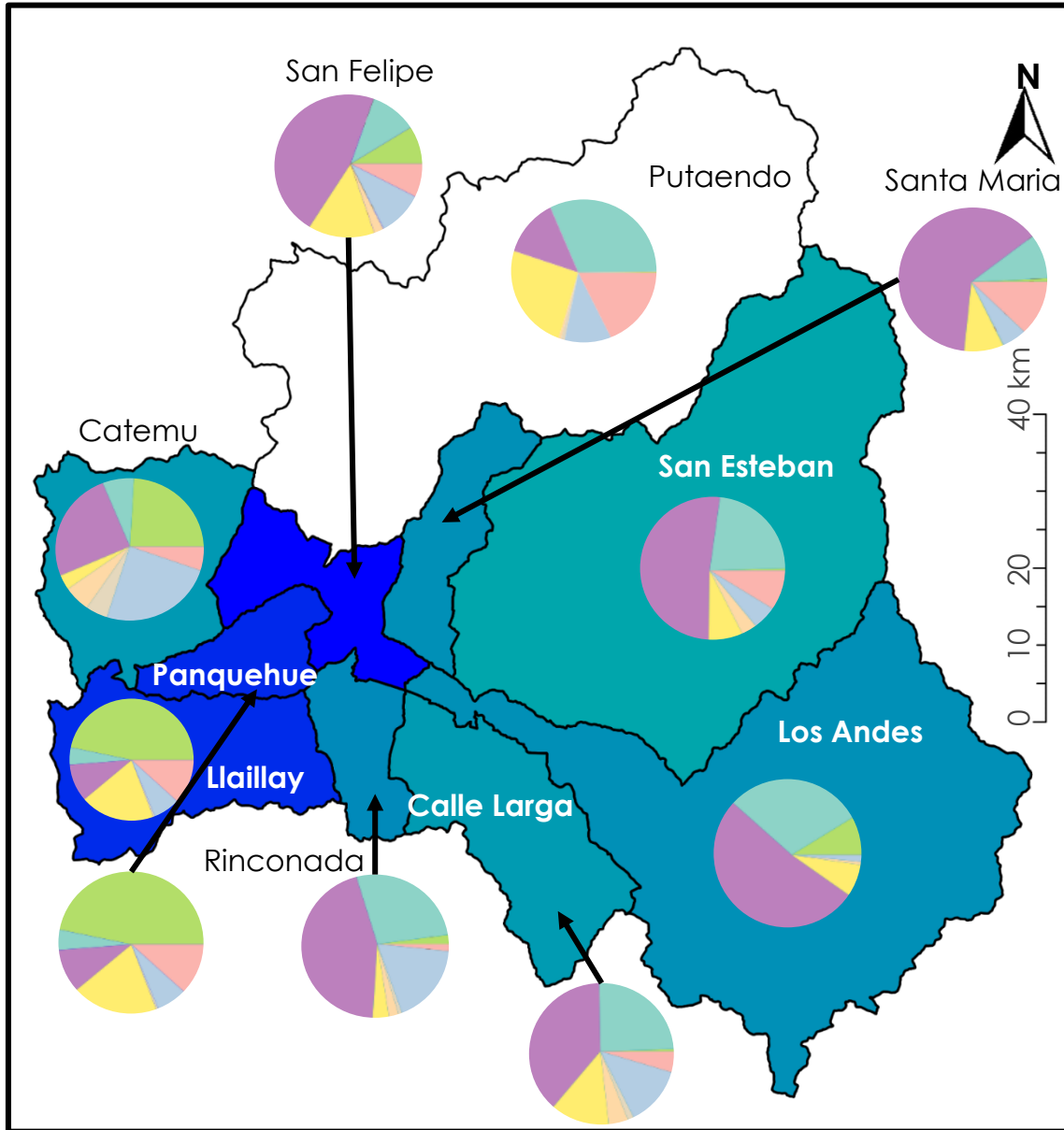


# Seasonal Analysis: ET by Crop

## Evapotranspiration by crop



# Water Allocation and Crop Type



## Crop Type

- Legumes and tubers
- Feed
- Other crops
- Avocado
- Walnut tree
- Table grapes
- Fruit trees
- Cereals



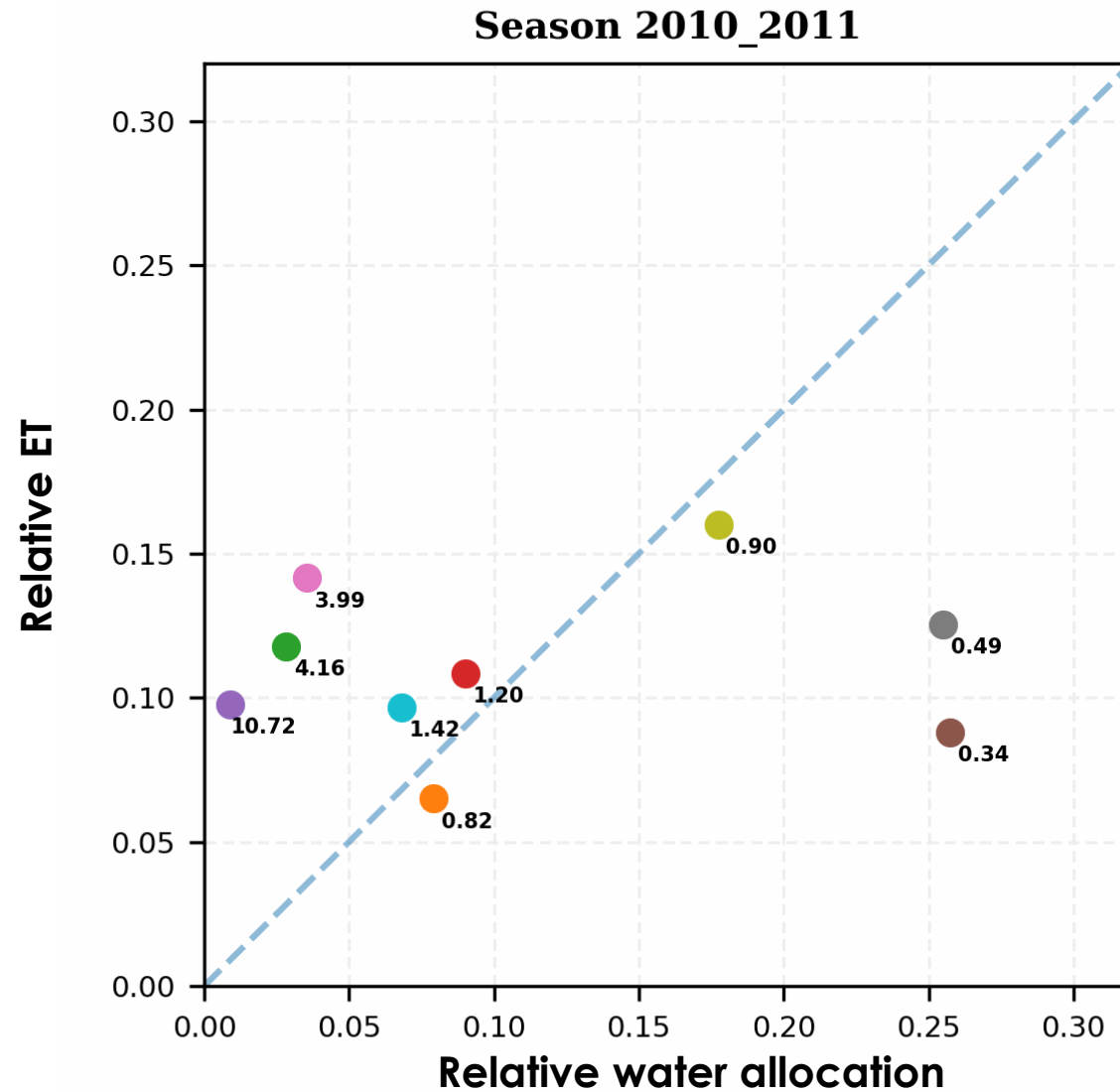
**Fig. 4:** Water allocation (m<sup>3</sup>/s, WA) and dominant crop type per comuna within central ARB in the 2020-2021 growing season. WA is normalized by agriculture area in each comuna.



## Water Allocation, ET, SM

Comuna	Ratio of ET and SM to water allocation 2020-2021		
	WA (m <sup>3</sup> /s)	ET/WA	SM/WA
San Felipe	0.72	20.40	1.21
Panquehue	0.56	59.83	1.72
Llailay	0.54	52.92	1.67
Rinconada	0.15	135.03	5.53
Santa Maria	0.13	120.01	7.15
Los Andes	0.12	85.19	6.86
Catemu	0.09	267.07	9.95
Calle Larga	0.08	264.64	11.14
San Esteban	0.03	486.12	26.66

# Seasonal Relative Analysis



- Los Andes
- Calle Larga
- Rinconada
- San Esteban
- San Felipe
- Catemu
- Llailay
- Panquehue
- Santa María

# Conclusions

1

## Crop Demand

Avocado, grapes, and walnut trees are the most water-demanding crops in the study area

2

## Water Stress

Shrinking groundwater supply, decreasing precipitation, and the increasing water allocation indicate water stress may increase in the coming years

3

## Intensification of Water Use

San Esteban, Calle Larga, and Catemu have an exaggerated pattern of water use for agriculture than, compared to other comunas

4

## Strategy

CIREN can use SM and ET normalized by water allocation to indicate comunas with farmlands that are heavily irrigated



# Errors



## Water Table and Allocation

Water allocation is missing for 1 comuna from 2010 onwards and 3 comunas 2020 onwards



Water table is not regularly recorded, and method of recording is unknown



Average WT errors due to elevation  $\Delta$





## Water Table and Allocation



## Crop Data and Agricultural Area

Crop census data is only available for 2020

Agriculture area chosen for one year (2020) and changes slightly from year-to-year



# Errors



## Water Table and Allocation



## Crop Data and Agricultural Area



## Earth Observations



Soil moisture: poor performance in 1 km downscale model for dry months. Missing data for cloudy days

Evapotranspiration: Assumes a constant biome and model derived from coarse meteorological data



# Errors



## Water Table and Allocation



## Crop Data and Agricultural Area



## Earth Observations

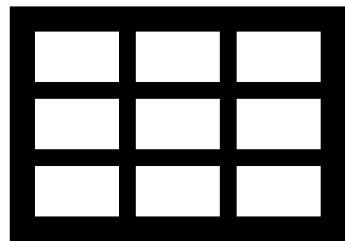


## Validation of Results

Lack of in situ data for comparison and validation



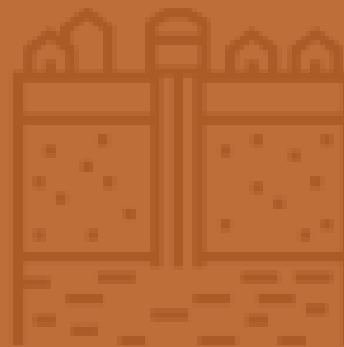
# Future Work



Re-grid SM, ET,  
and NDVI  
to construct a  
hydrological  
model with SM,  
ET, SWE, and  
glacier melt



Crop specifics  
and yield  
estimates from  
satellite imagery



Soil subsidence  
analysis due to  
groundwater  
depletion using  
SAR data



Feed variables  
into climate  
prediction  
model (CMIP6)  
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tutorial



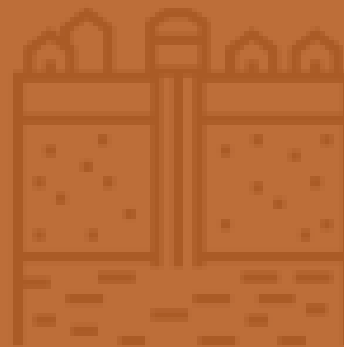
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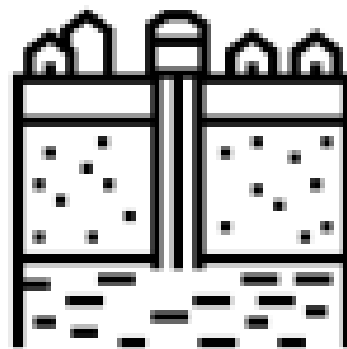
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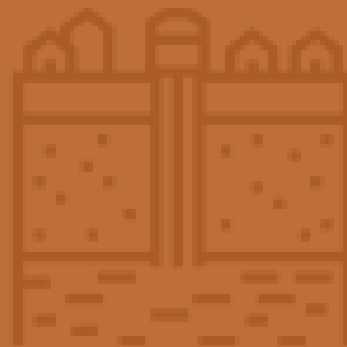
# Future Work



Re-grid SM, ET, and NDVI to construct a hydrological model with SM, ET, SWE, and glacier melt



Crop specifics and yield estimates from satellite imagery



Soil subsidence analysis due to groundwater depletion using SAR data



Feed variables into climate prediction model (CMIP6) and create a tutorial



# Acknowledgments

- **Dr. Venkat Lakshmi**, University of Virginia (Science Advisor)
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