

Chile Wildland Fires

Augmenting Wildfire Risk Assessment Efforts with Satellite-based
Measurements of Soil Moisture and Vegetation Health in Central and
South-Central Chile

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TEAM

- Aashutosh Aryal
- Quinton Deppert
- Benjamin Goffin – Team Lead



PRESENTATION OUTLINE

- Community concerns
- Partners
- Objectives
- Study Area & Period
- Methodology & Data
- Results
- Conclusions
- Limitations & future work
- Acknowledgements



COMMUNITY CONCERNS

Since 2010, parts of Chile have experienced:

- A megadrought
- Unprecedented wildland fires
- Increasing threats to...
 - Forested resources
 - Communities living at wildland-urban interface

Image credit: CONAF



PARTNERS

Corporación
Nacional
Forestal
(CONAF)

Embassy of
Chile,
Agricultural
Office



Image credit: CONAF



OBJECTIVES

The goal of this project was to enhance future wildfire management efforts by:

- Incorporating NASA EO's of
 - Vegetation health
 - Soil moisture
- Comparing the conditions of
 - Actual burn sites
 - Control areas

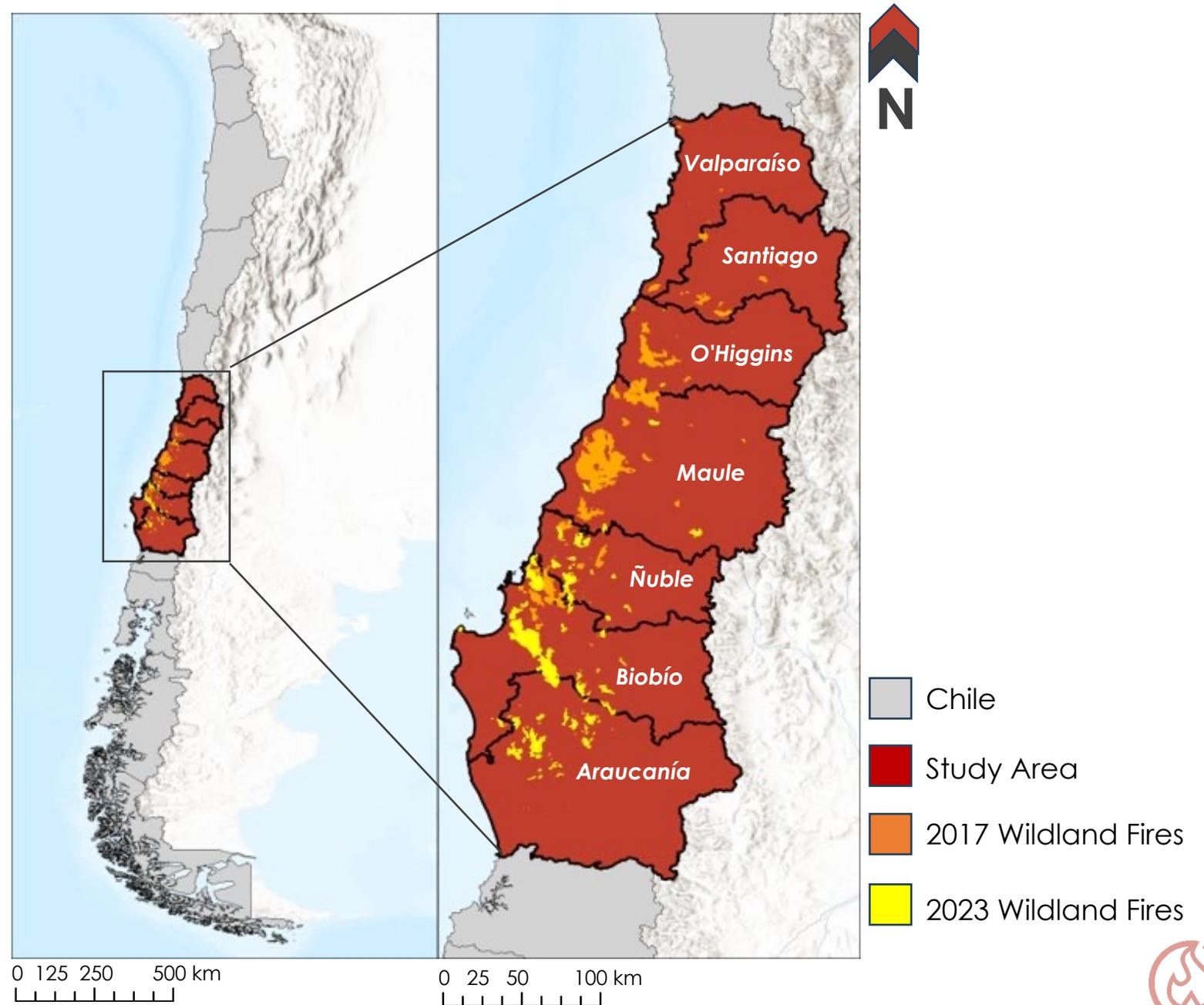


Image credit: CONAF



STUDY AREA

- Central and South-Central Chile (CSCC)



STUDY PERIOD



EARTH OBSERVATIONS

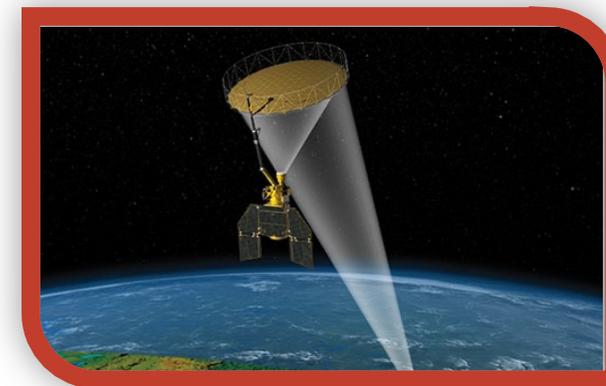
GPM



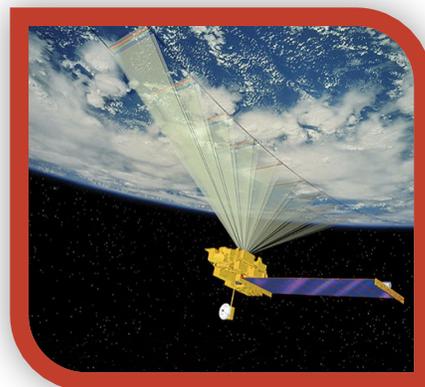
Landsat 9 OLI



SMAP



Terra MODIS



Aqua MODIS

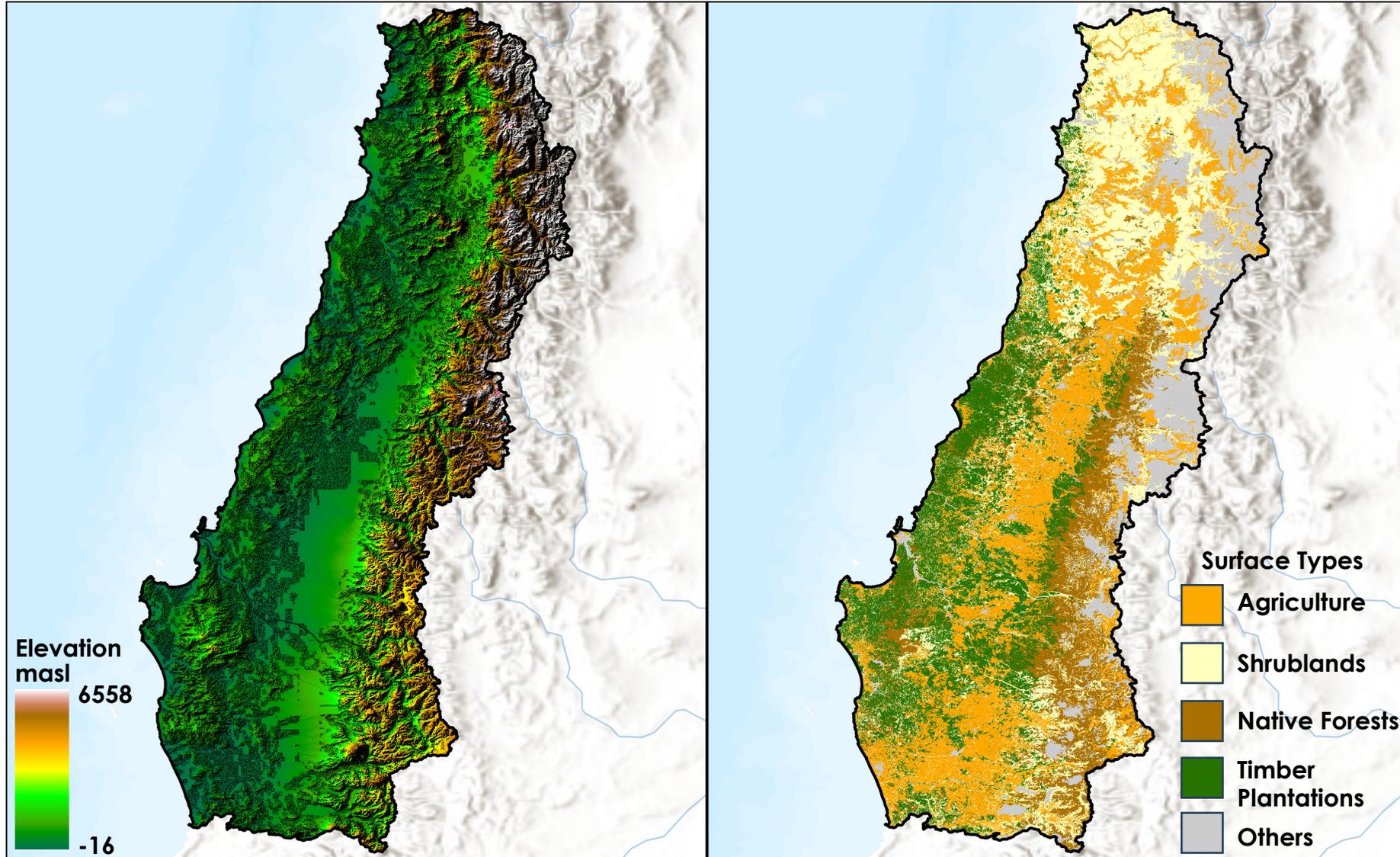


EARTH OBSERVATIONS

Platform & Sensor	Parameter	Spatial Resolution	Temporal Resolution
Landsat 9 OLI-2 (LaSRC v1.5.0)	Surface Reflectance	30 m	16 Days
Terra + Aqua MODIS (MCD64A1 v061)	Burned Area	500 m	Daily
Terra MODIS (MOD13A3 v061)	NDVI	1 km	Monthly
Terra MODIS (MOD16A2 v006)	ET	500 m	8 Days
GPM IMERG (GPM_3IMERGDF v006)	Precipitation	0.1 degrees	Daily
SMAP Radiometer L3 (SPL3SMP_E v005)	Soil moisture	9 km	2-3 Days
SMAP L4 (SPL4SMGP v007)	Soil moisture	3 km	Daily



ANCILLARY DATA



Fuel Surface Model:
Jorge Andrés Saavedra Saldías (CONAF)



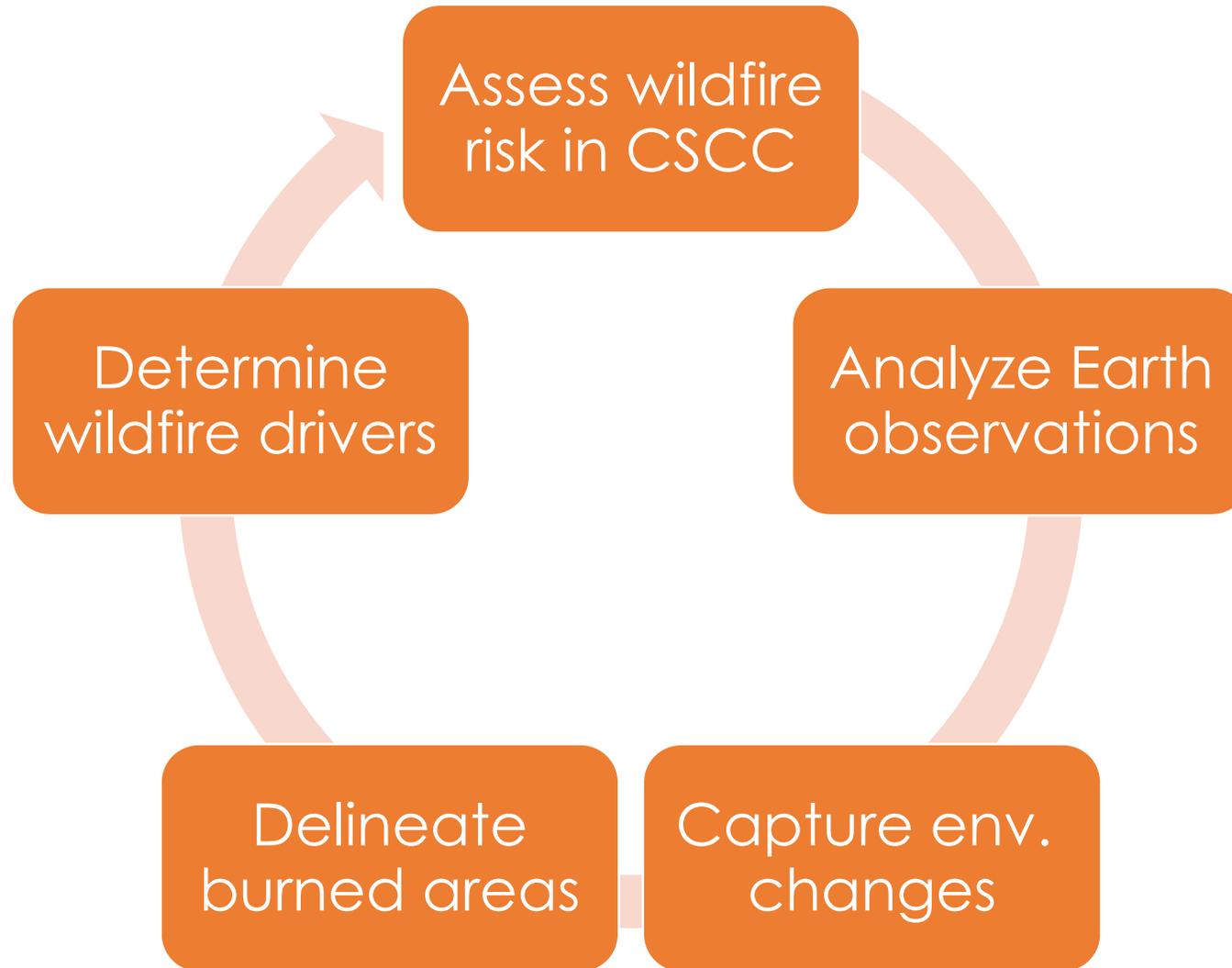
Base map credits: Esri, CGIAR, HERE, Garmin, FAO, NOAA, USGS

Dataset:
NASADEM
30m

Elevation
masl
6558
-16

0 25 50 100 km

METHODOLOGY

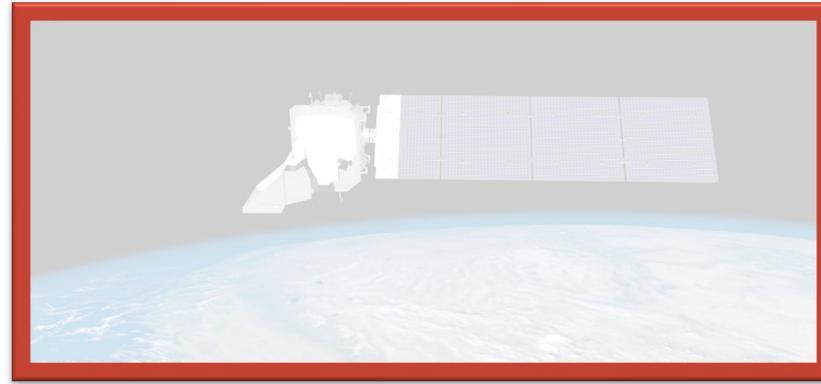


RESULTS – Precipitation deficit

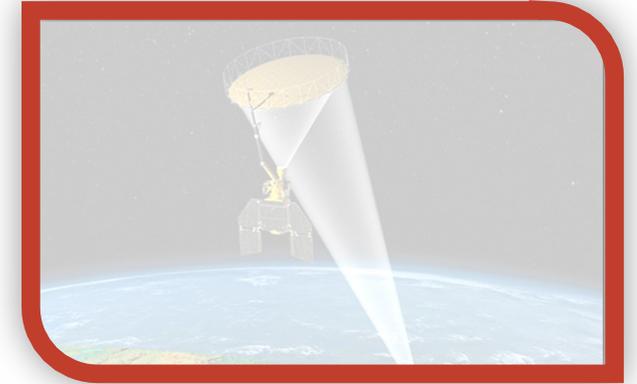
GPM



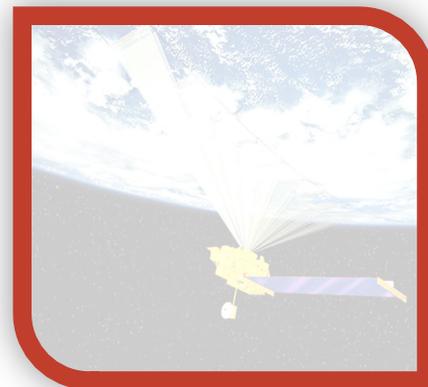
Landsat 9 OLI



SMAP



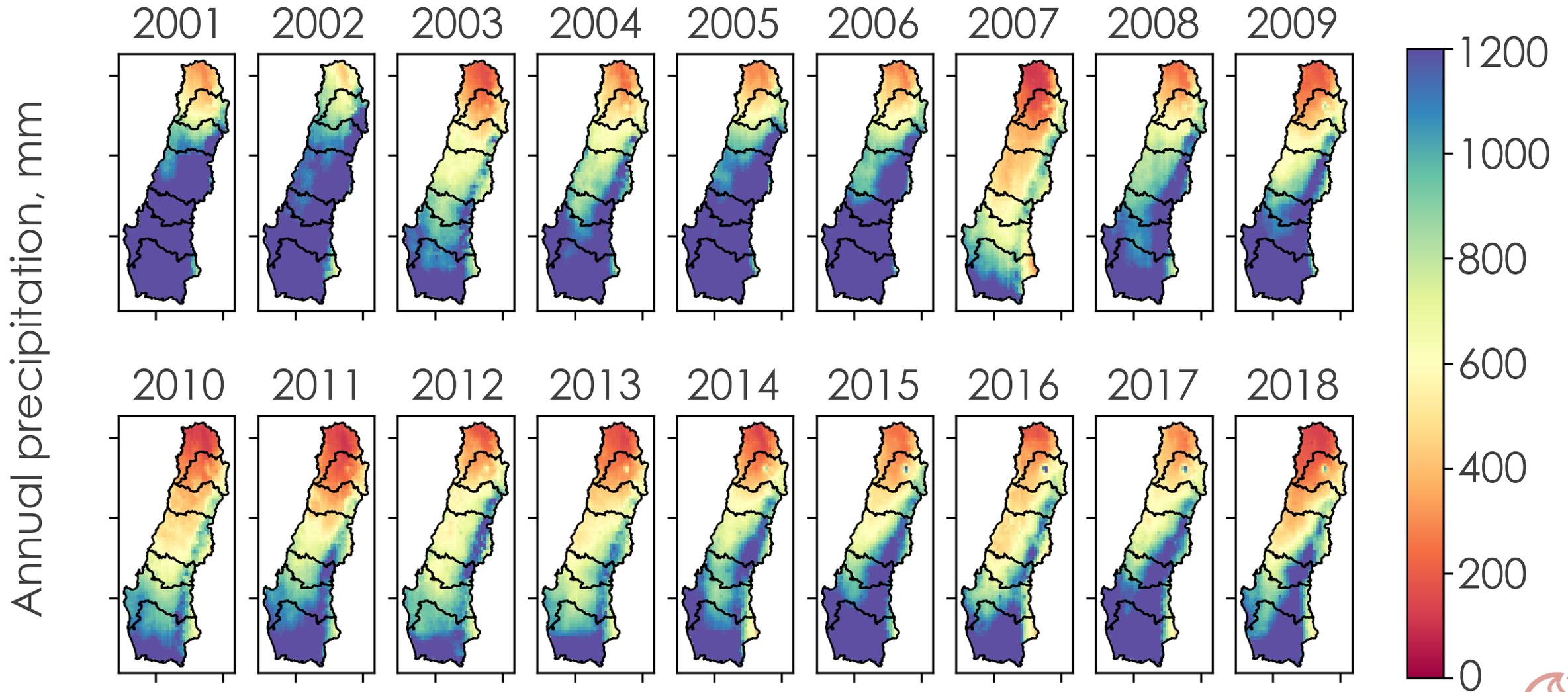
Terra MODIS



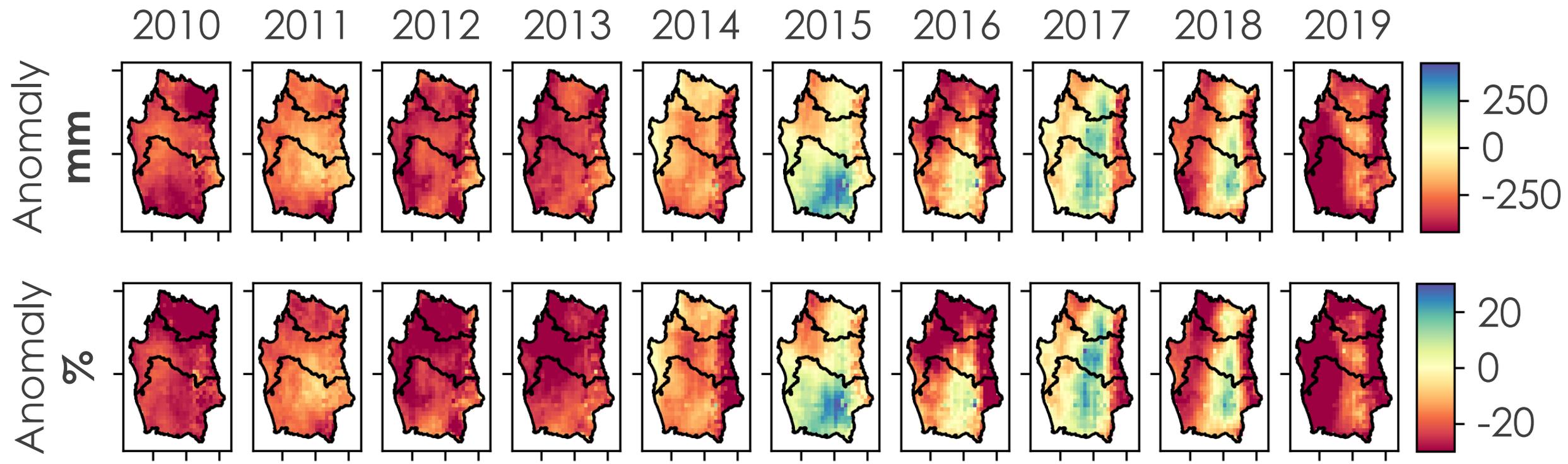
Aqua MODIS



RESULTS – Precipitation Variability

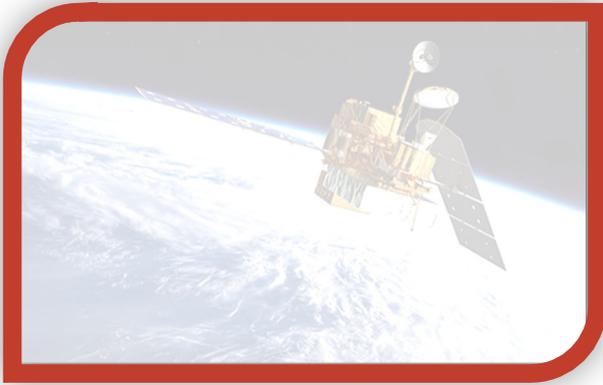


RESULTS – Precipitation Deficit

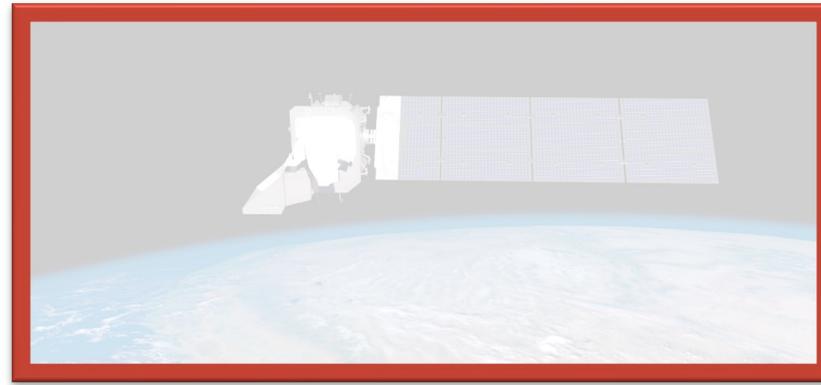


RESULTS – Vegetation anomalies

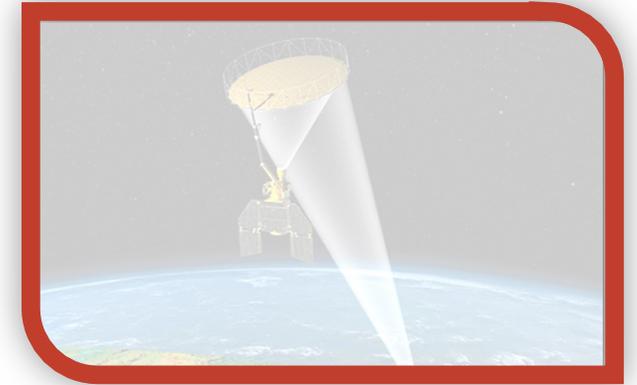
GPM



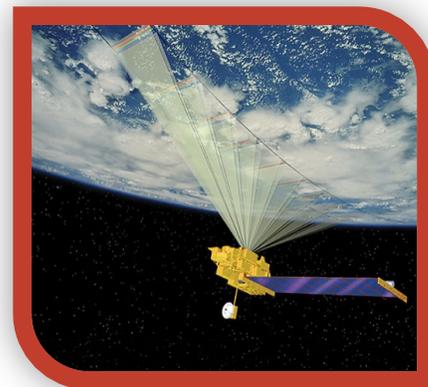
Landsat 9 OLI



SMAP



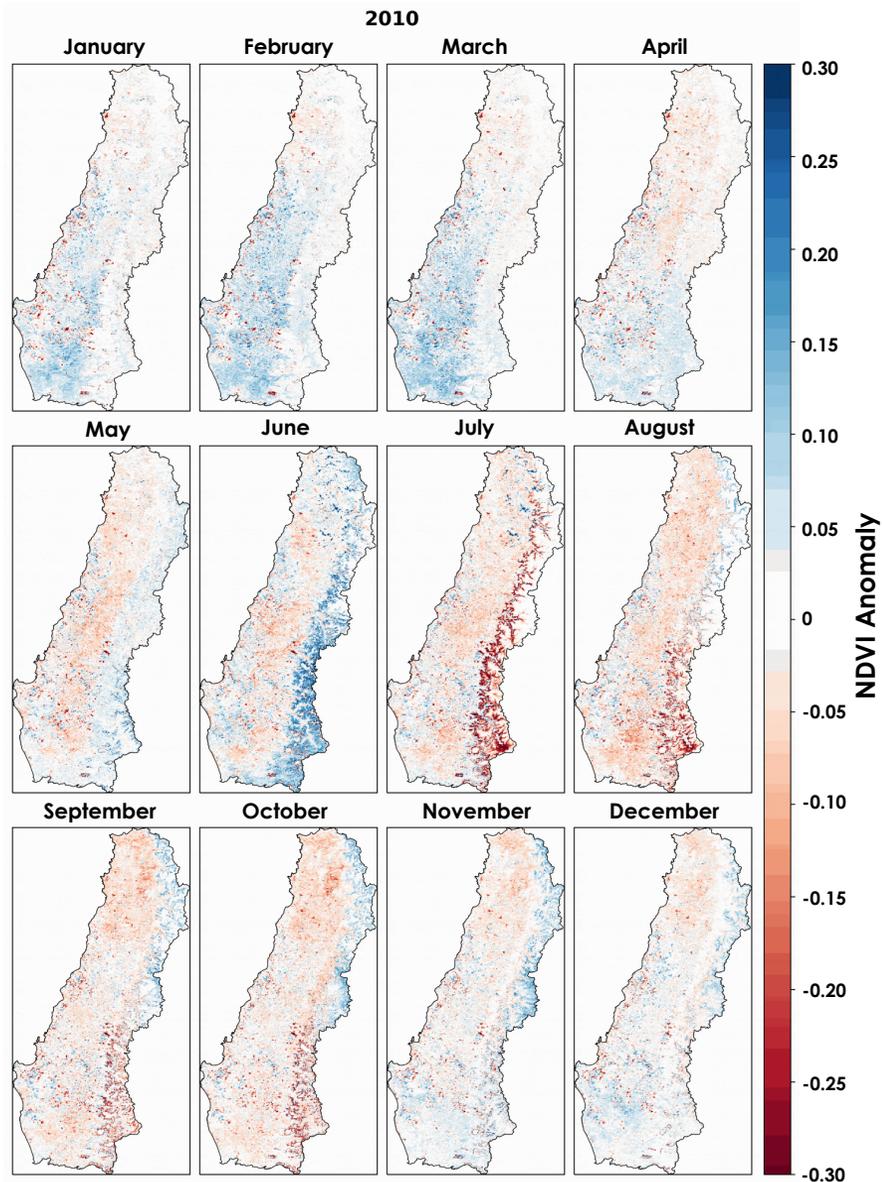
Terra MODIS



Aqua MODIS



RESULTS – Vegetation Anomalies



Variables:

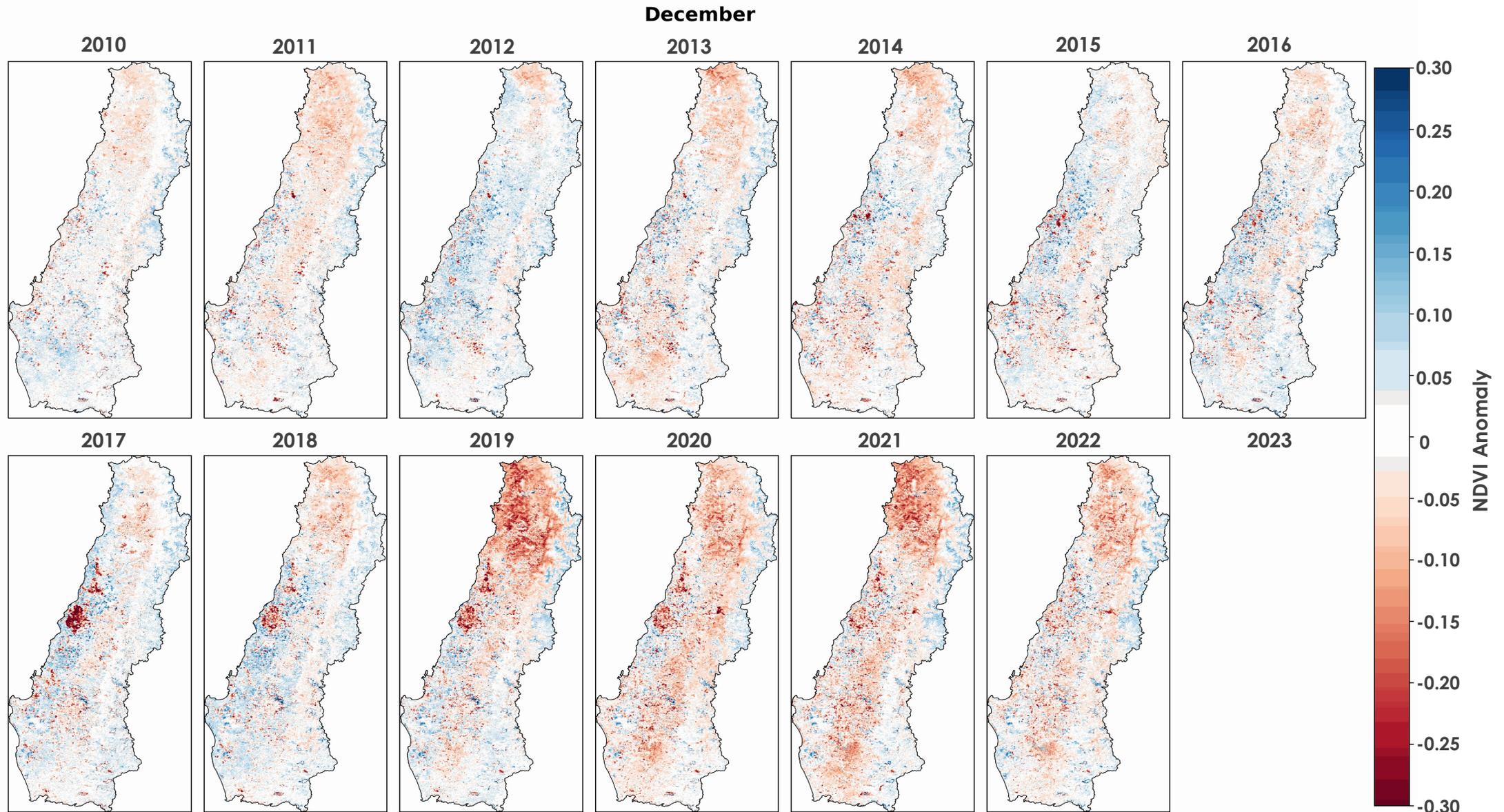
- Monthly NDVI anomalies
- Period: 2010-2023 (Drought Period)
- Baseline Period: 2001-2009 (Pre-Drought Period)

Findings:

- ✓ Vegetation in stress
- ✓ Deteriorating vegetation health
- ✓ Increase in negative NDVI anomalies during megadrought period

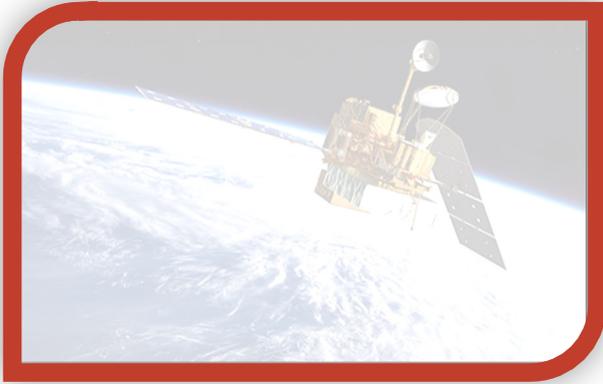


RESULTS – Vegetation Anomalies (Fire Season)

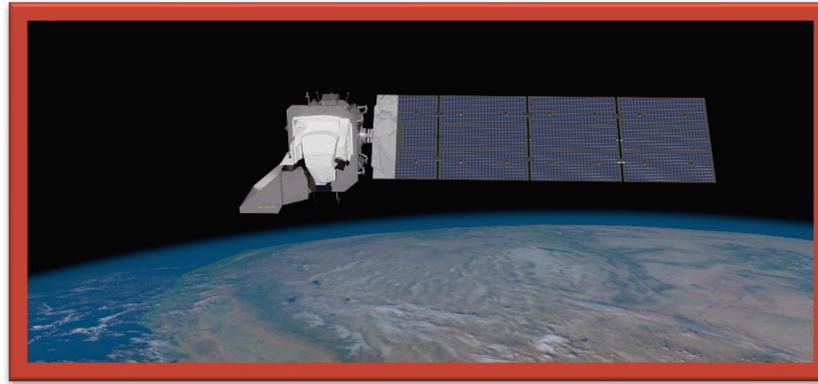


ANALYSIS – Wildland Fires Delineation

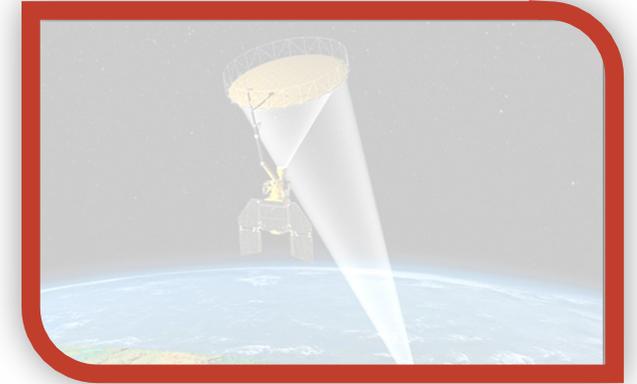
GPM



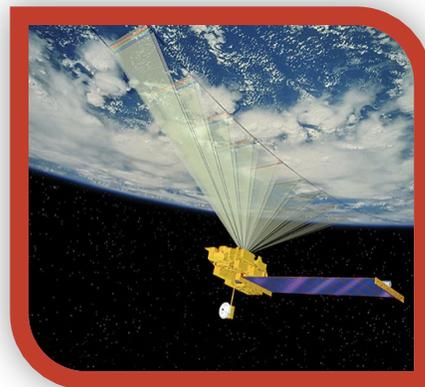
Landsat 9 OLI



SMAP



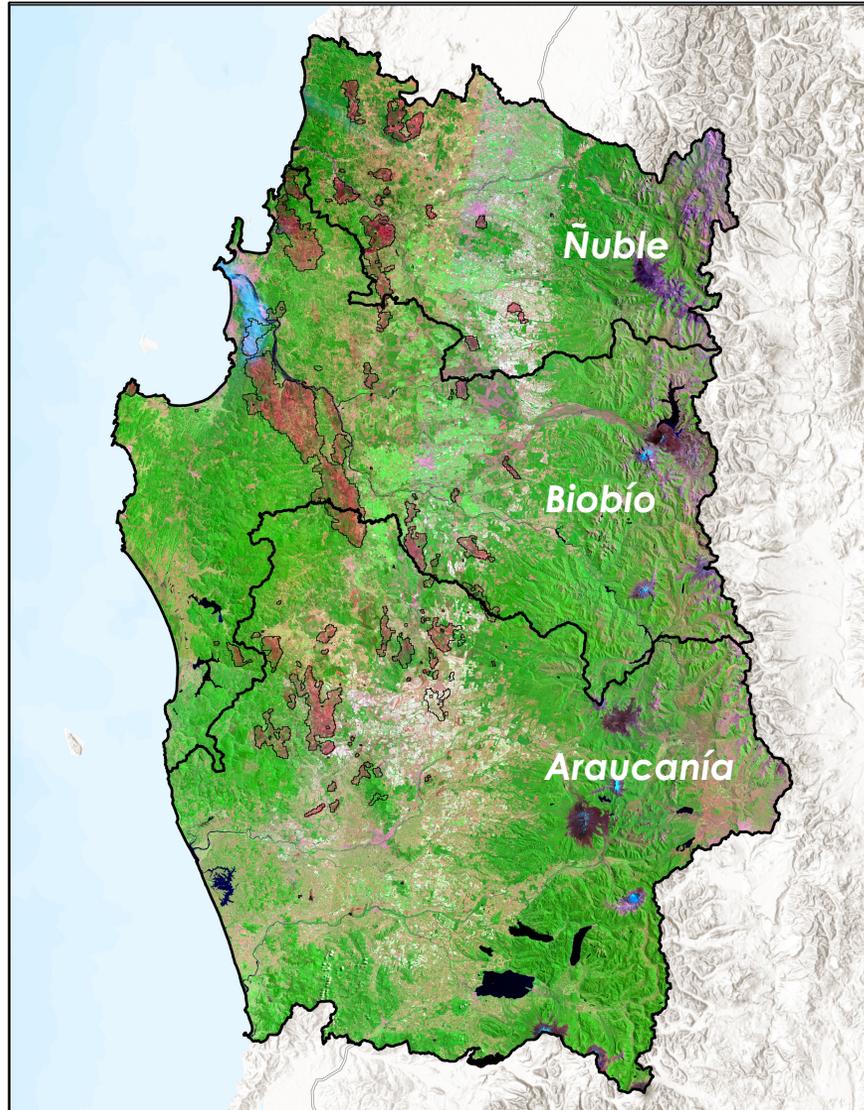
Terra MODIS



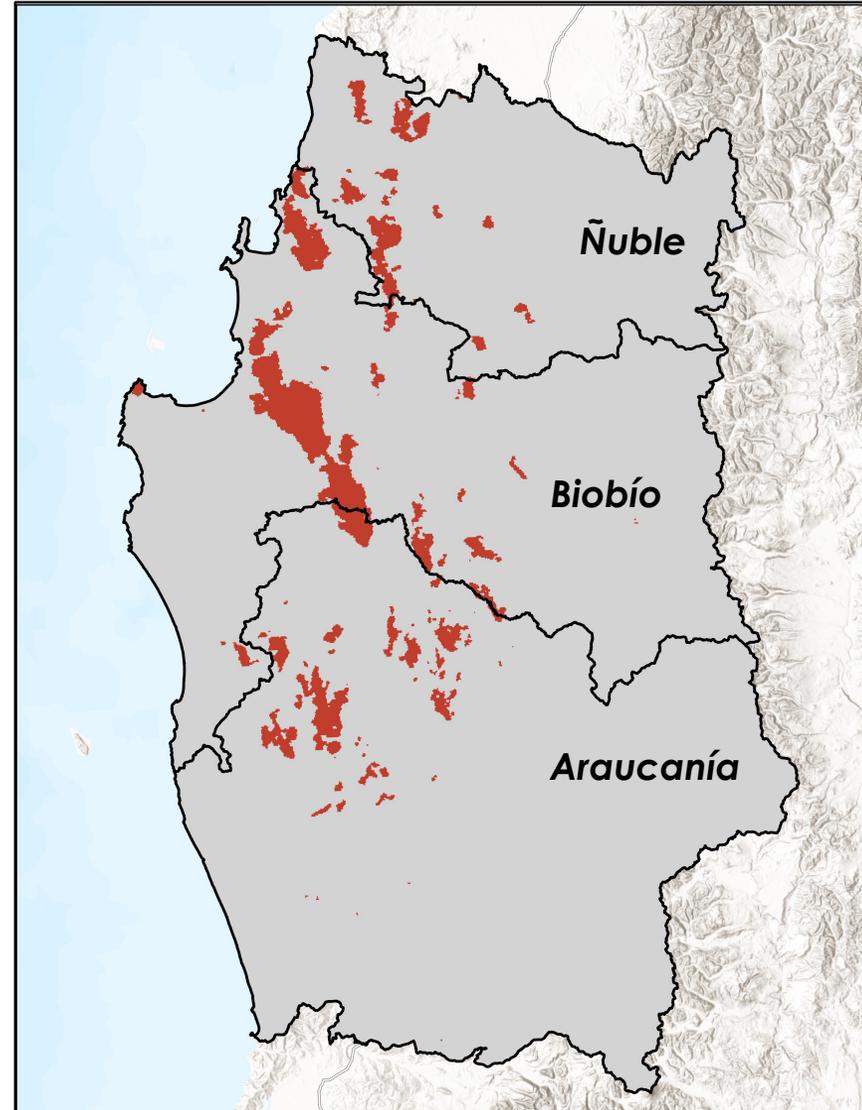
Aqua MODIS



ANALYSIS – Wildland Fires Delineation



Landsat 9
OLI-2



Combined
MODIS Burned
Area

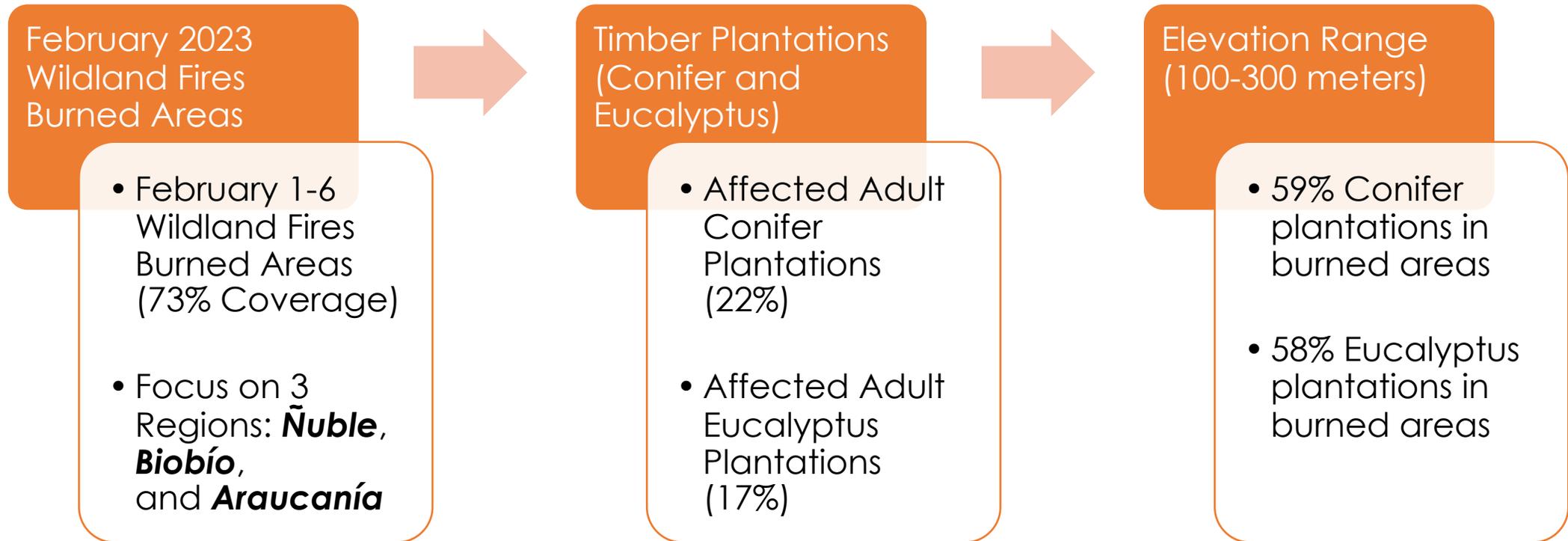
0 10 20 40 km

Base map credits: Esri, CGIAR, HERE, Garmin, FAO, NOAA, USGS

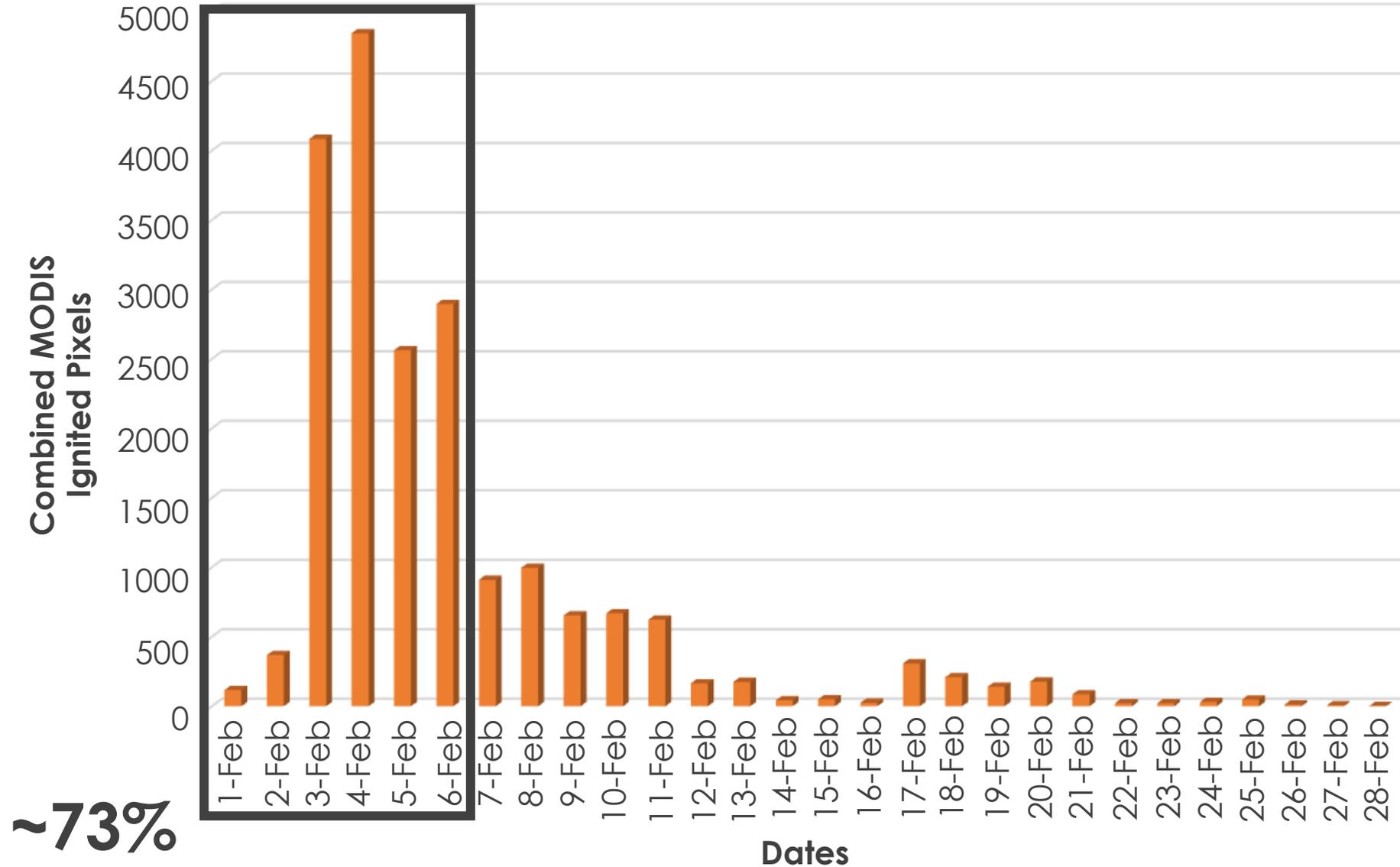


ANALYSIS – Wildland Fires Delineation

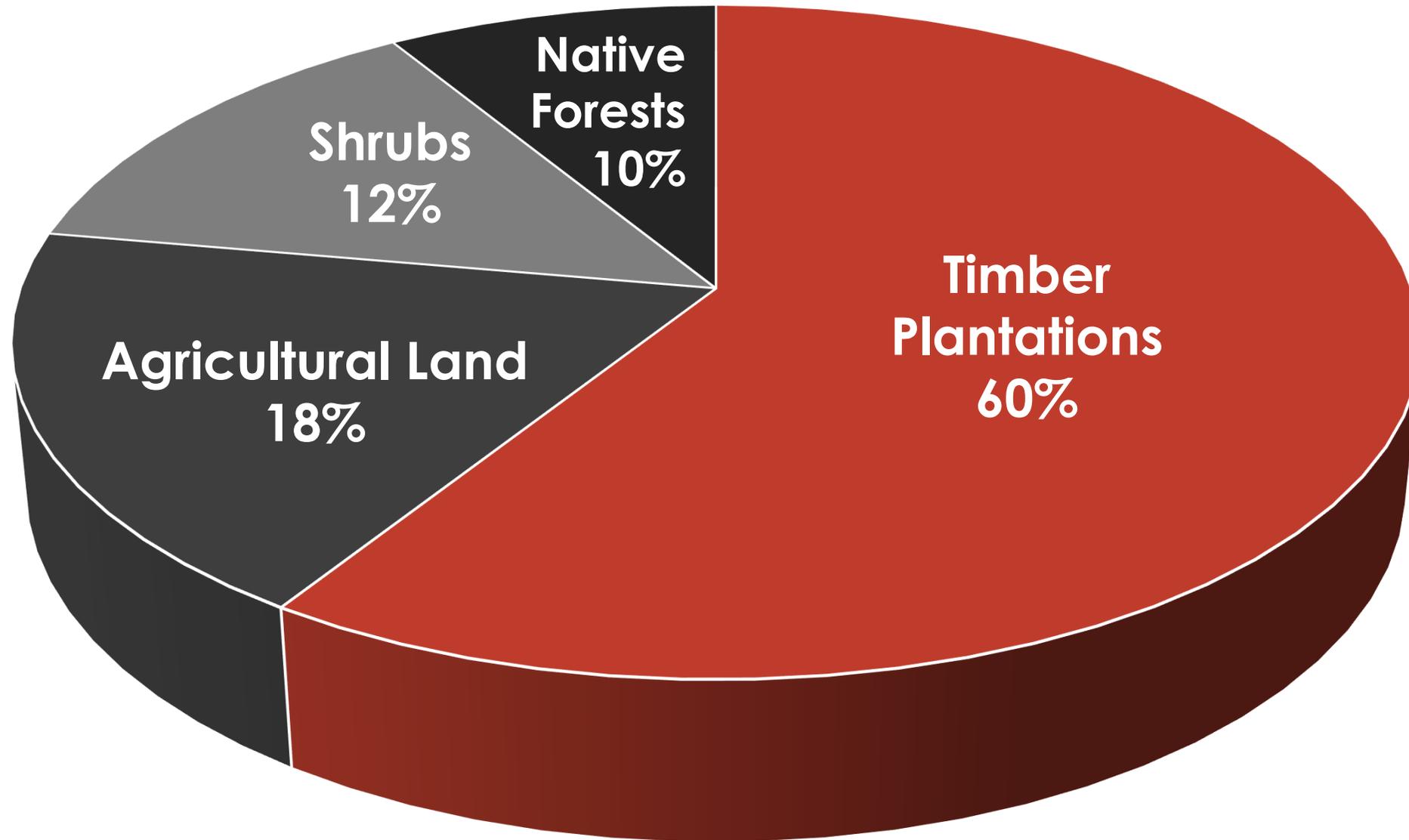
Selection Criteria



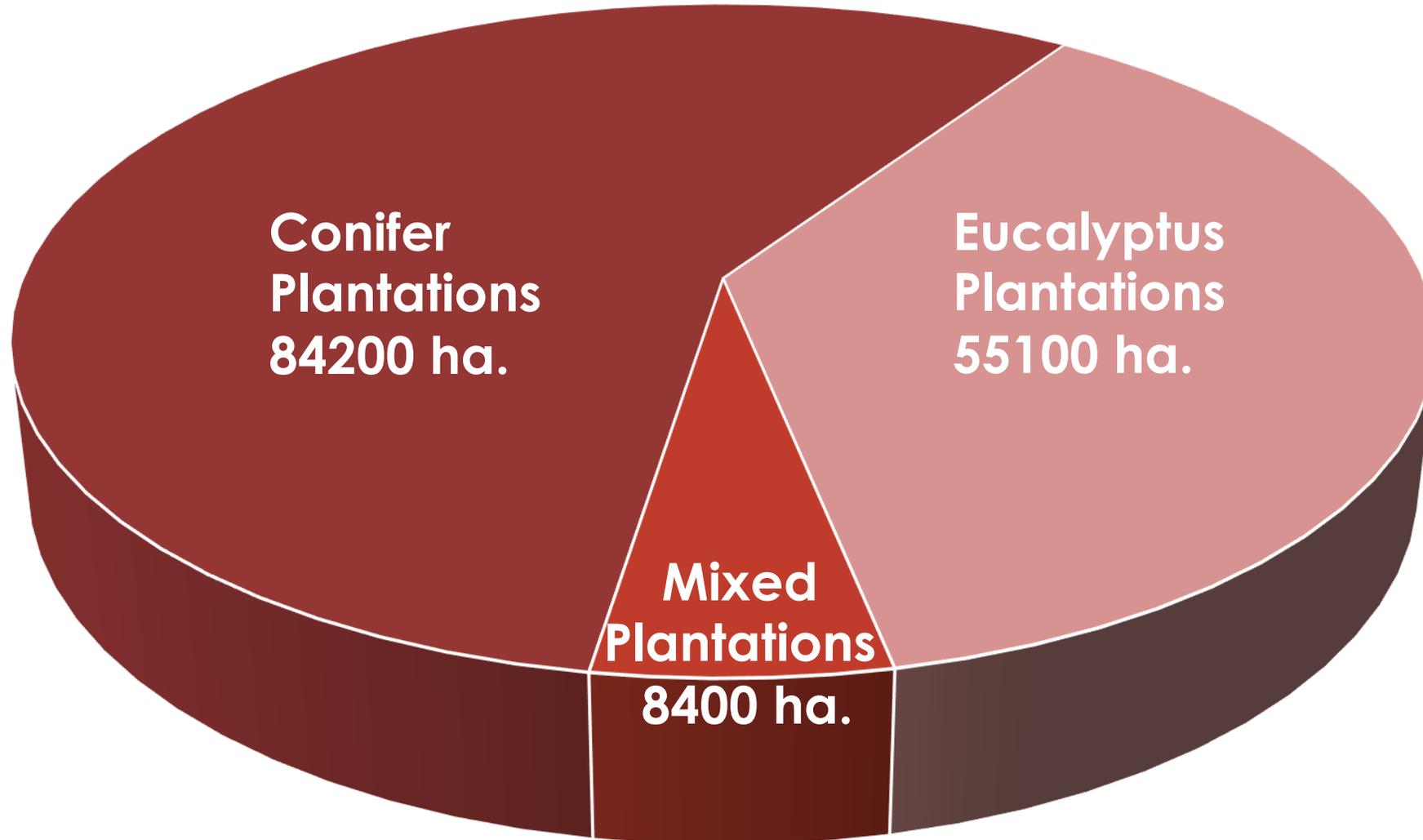
RESULTS – Wildfire Timeline



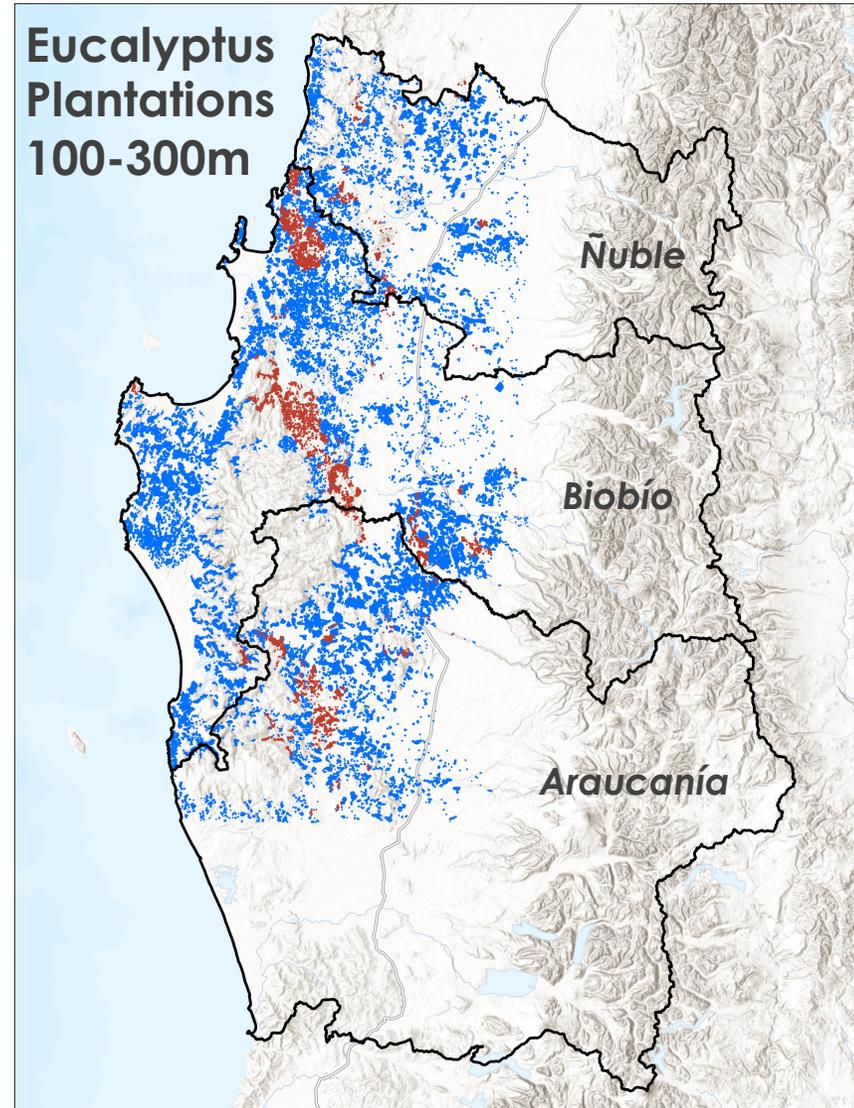
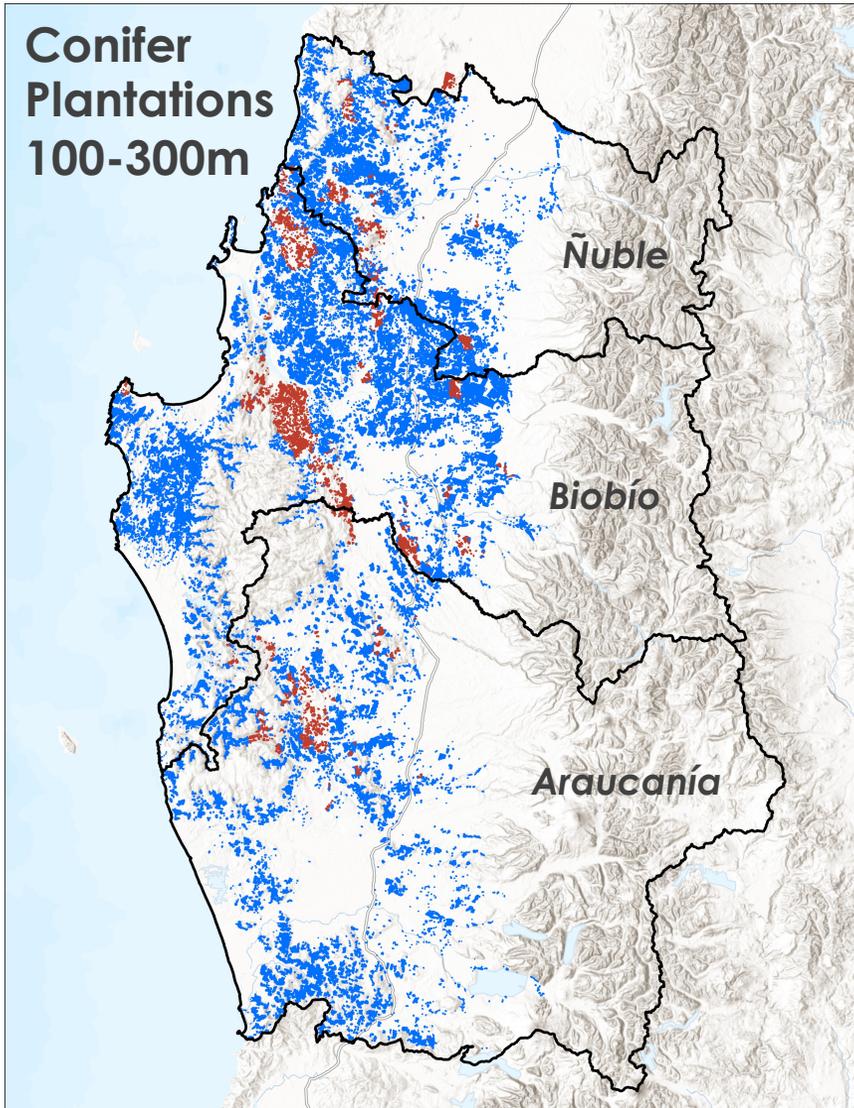
RESULTS – Land Cover Types Affected in Feb 1-6



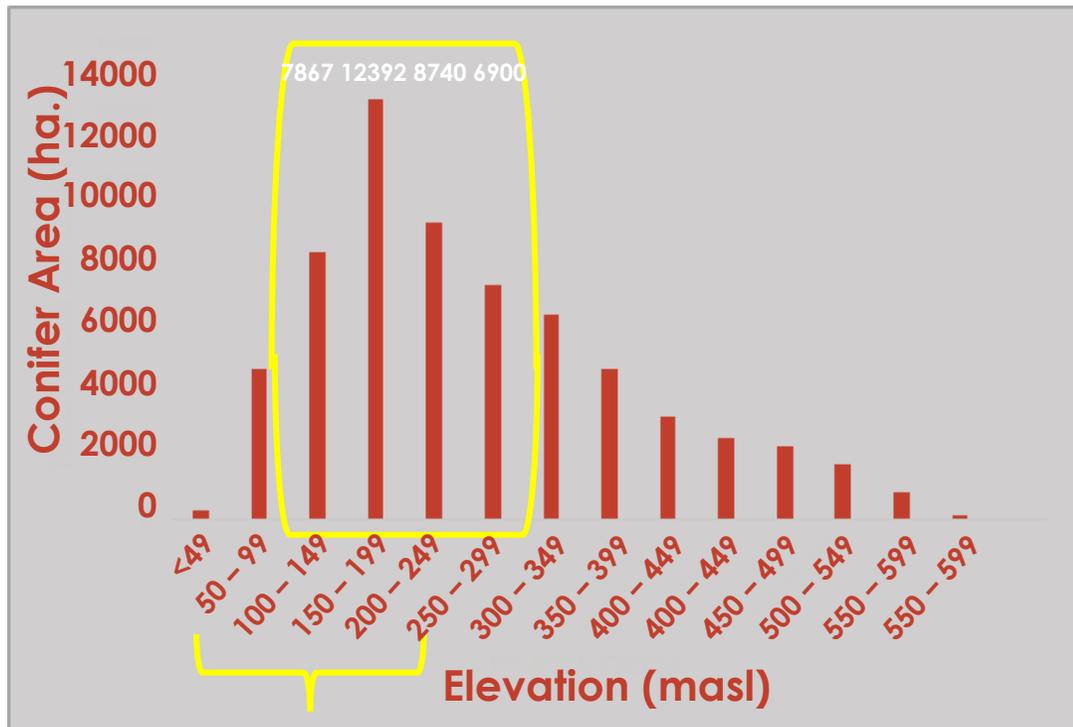
RESULTS – Plantation Types Affected in Feb 1-6



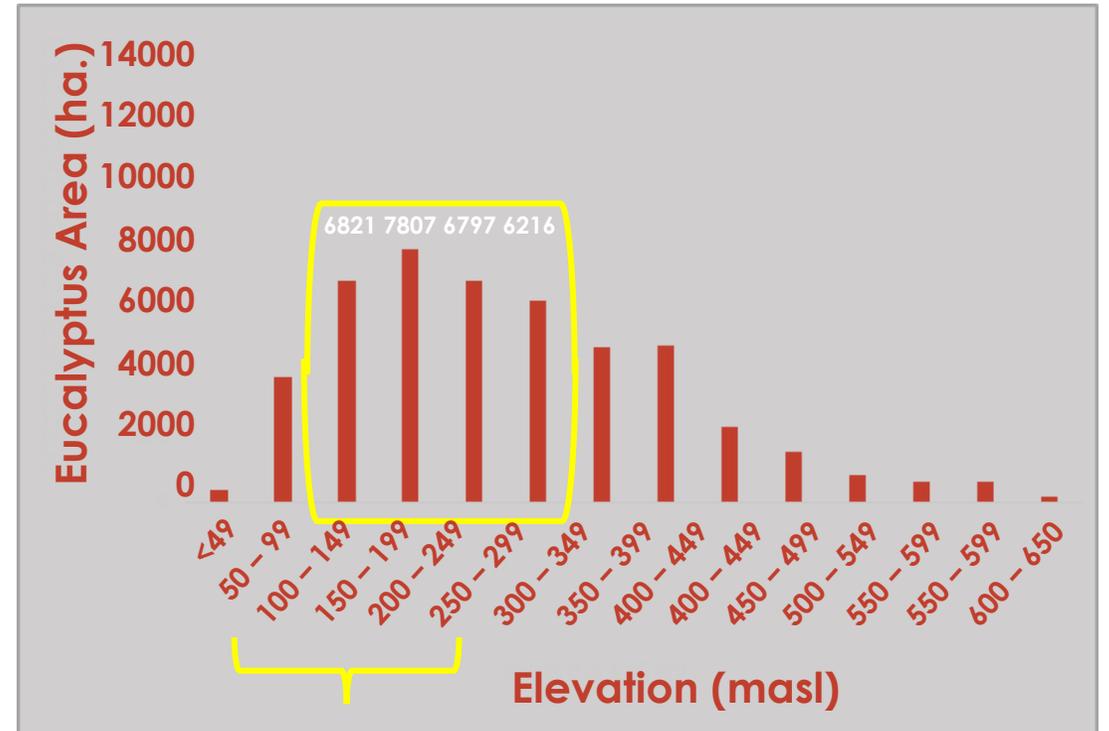
RESULTS – Wildfire Against Control Areas



RESULTS – Elevation Range Affected in Feb 1-6



~59%

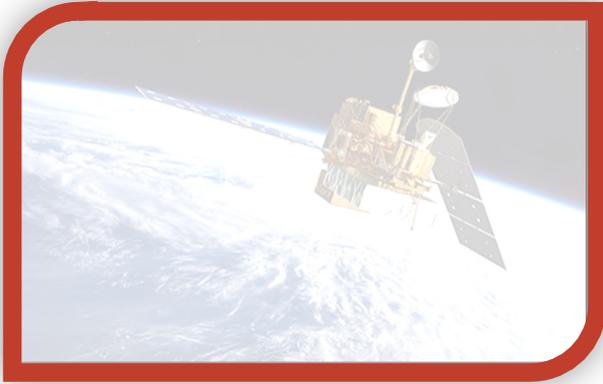


~58%

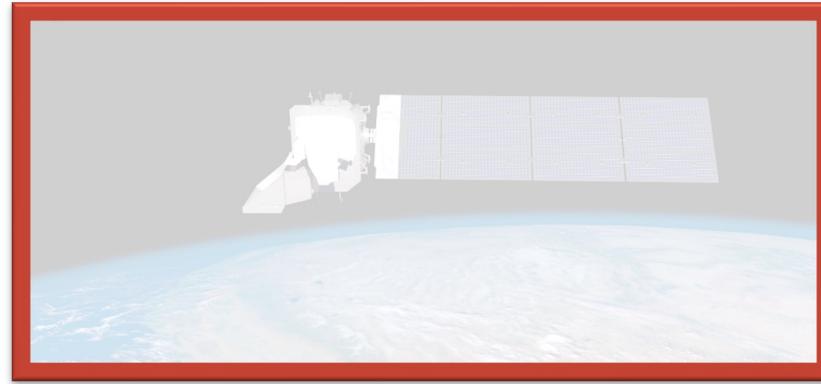


RESULTS – Soil Moisture as a Predictor

GPM



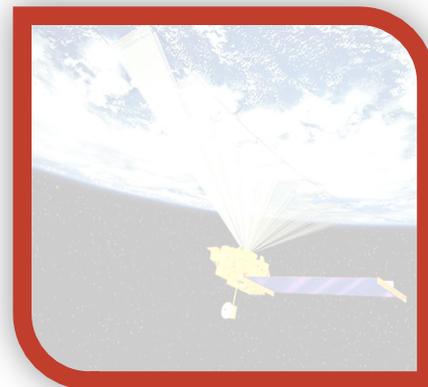
Landsat 9 OLI



SMAP



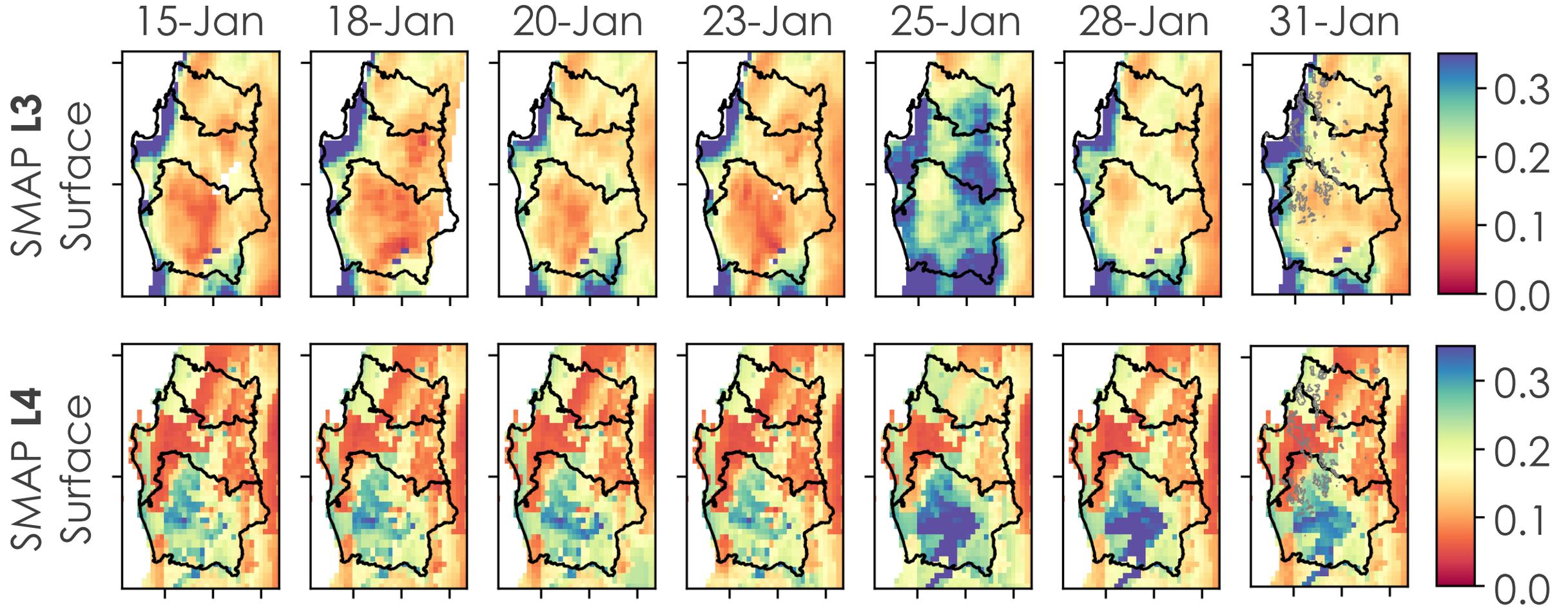
Terra MODIS



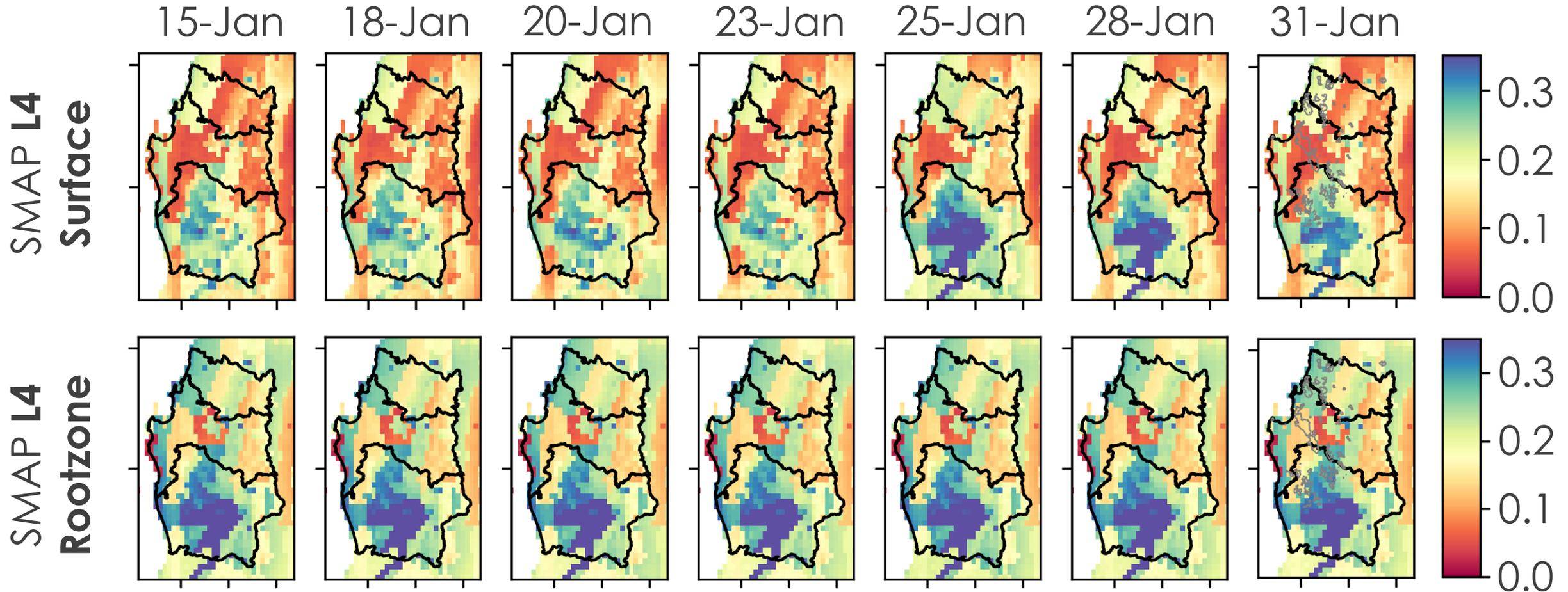
Aqua MODIS



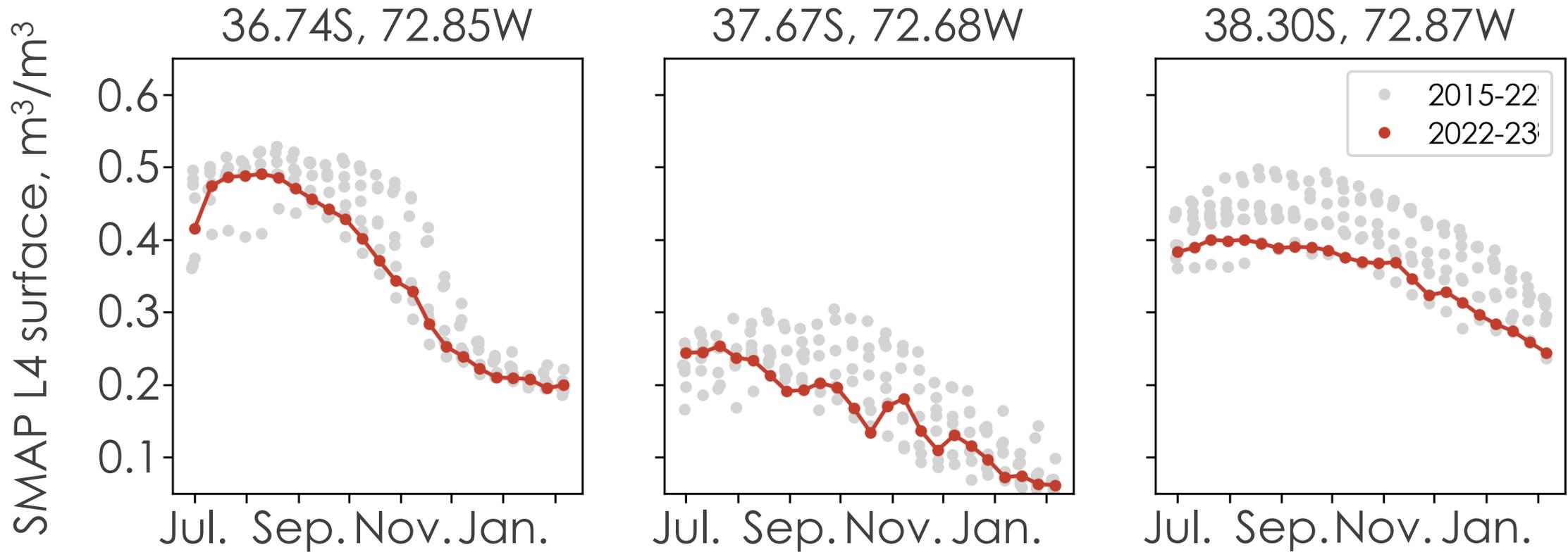
RESULTS – Soil Moisture as a Predictor of Fire



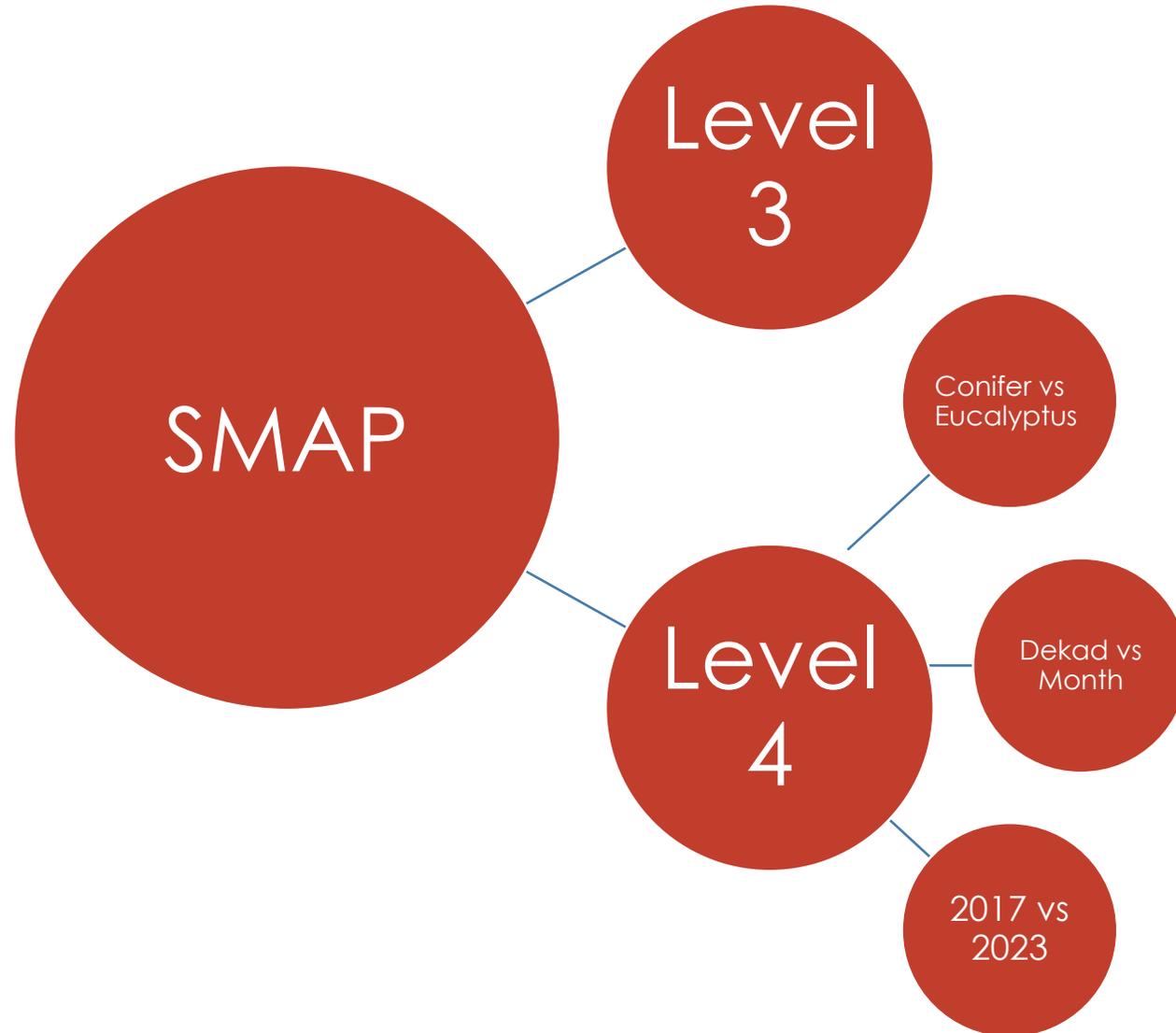
RESULTS – Soil Moisture as a Predictor of Fire



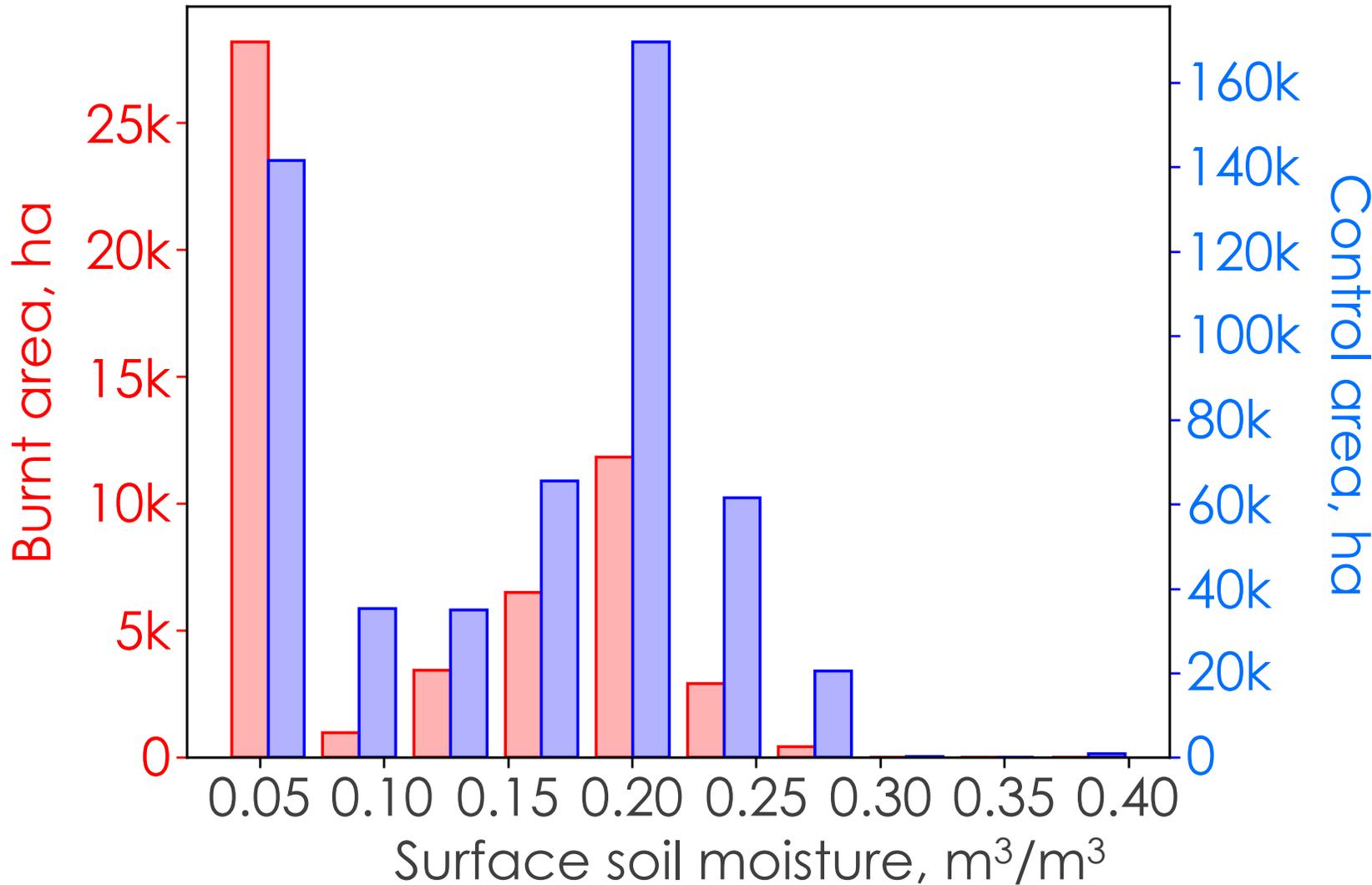
RESULTS – Soil Moisture as a Predictor of Fire



RESULTS – Soil Moisture as a Predictor of Fire



RESULTS – Soil Moisture as a Predictor of Fire



Variables:

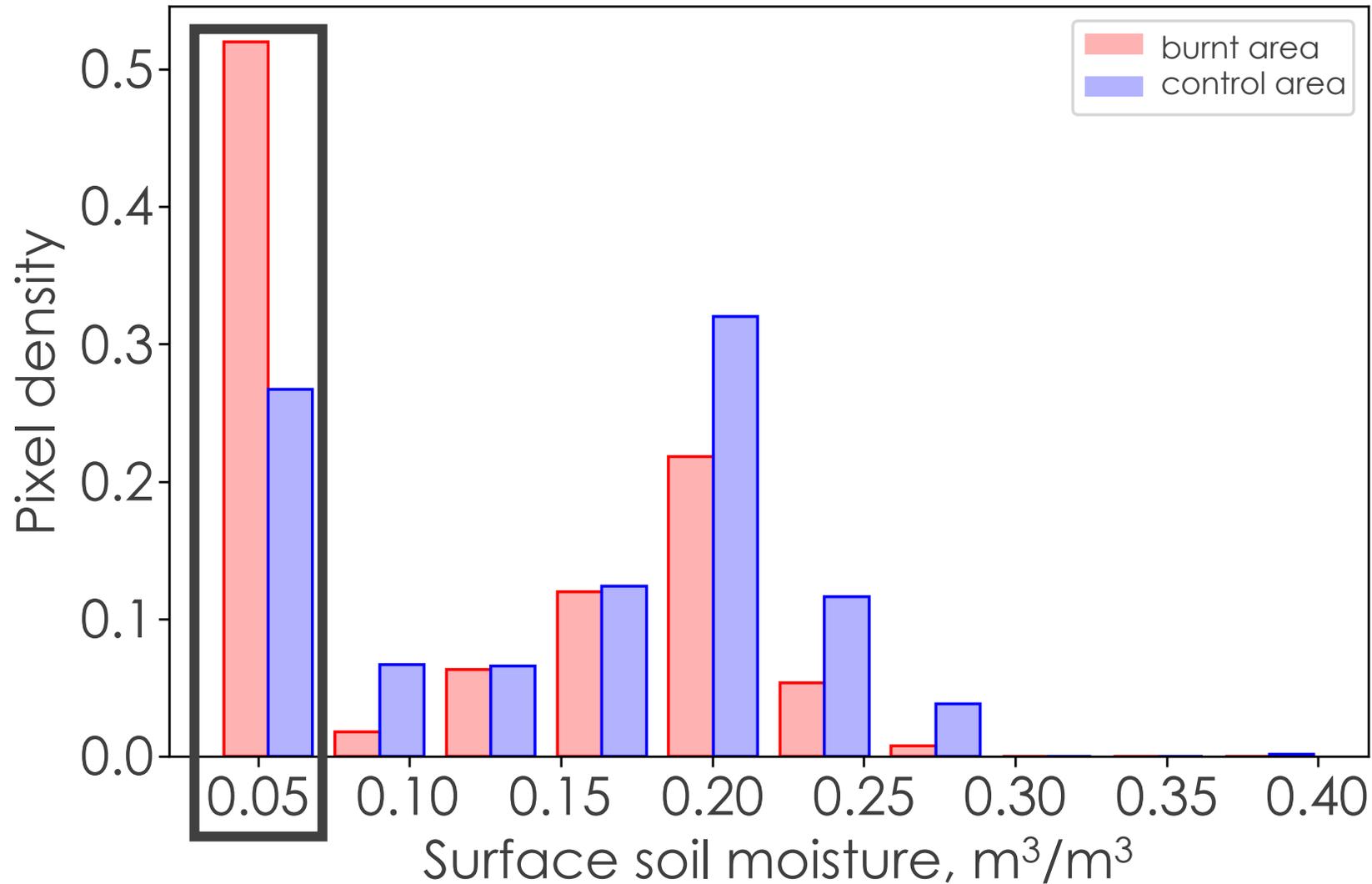
- L4, surface, month
- Conifer plantation
- 2023 fire

Finding:

- ✓ Below $0.075 m^3/m^3$,
- ✓ 28,200 ha burned
- ✓ 141,000 ha of control



RESULTS – Soil Moisture as a Predictor of Fire



Variables:

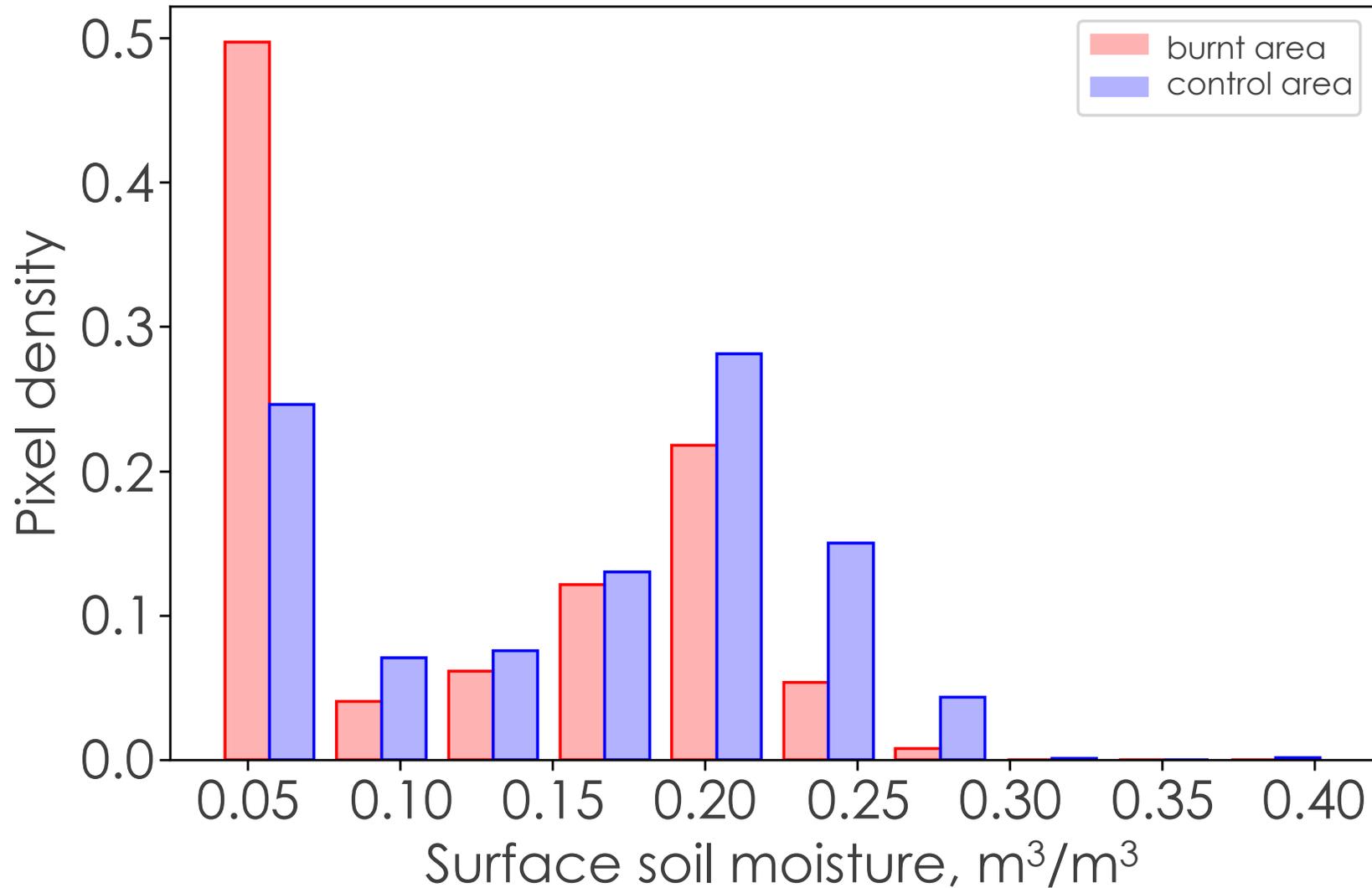
- L4, surface, month
- Conifer plantation
- 2023 fire

Finding:

- ✓ Below 0.075 m³/m³, 52% of burned area
- ✓ 27% of control area



RESULTS – Soil Moisture as a Predictor of Fire



Variables:

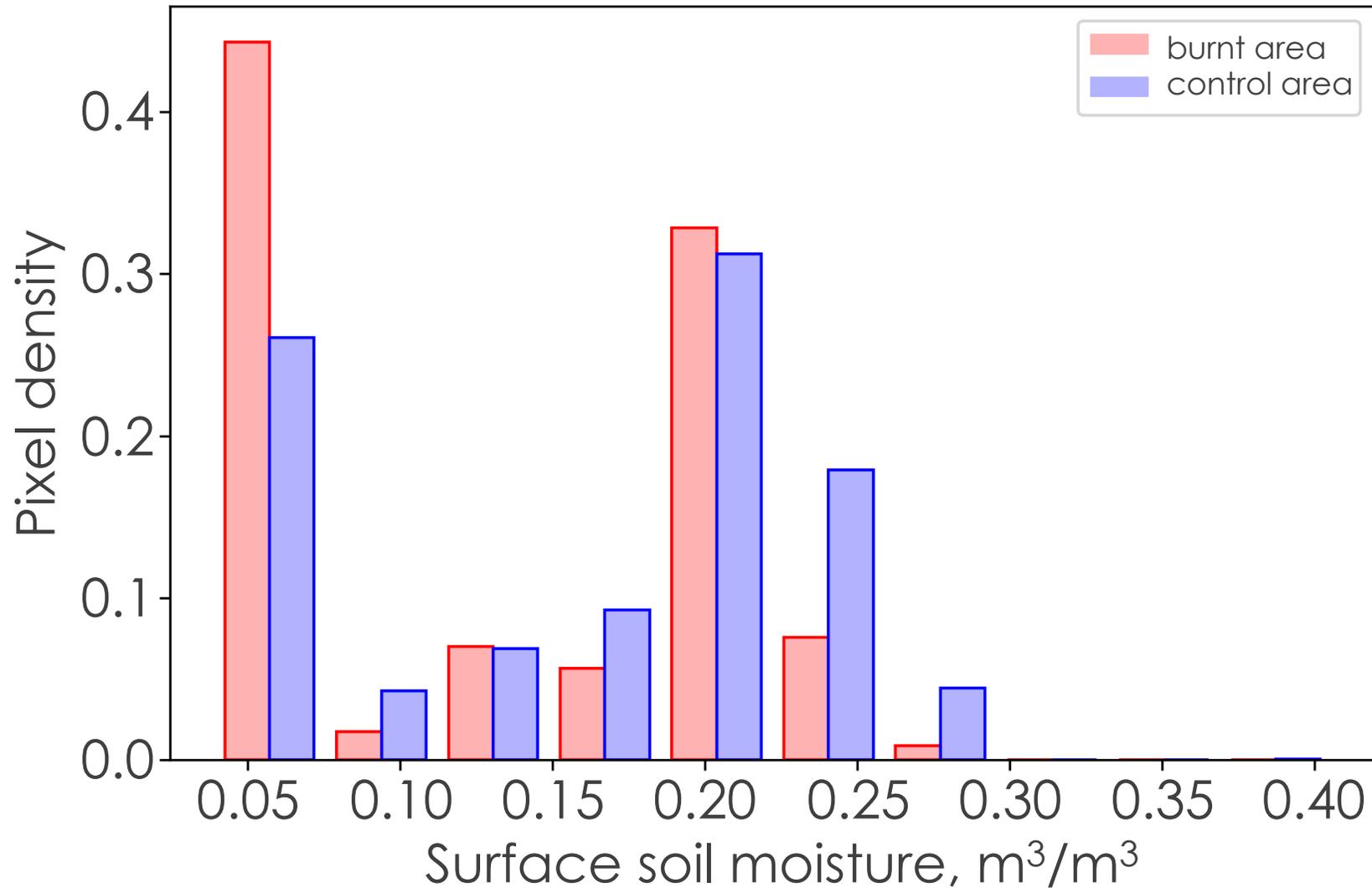
- L4, surface, **dekad**
- Conifer plantation
- 2023 fire

Finding:

- ✓ Consistent across lead period



RESULTS – Soil Moisture as a Predictor of Fire



Variables:

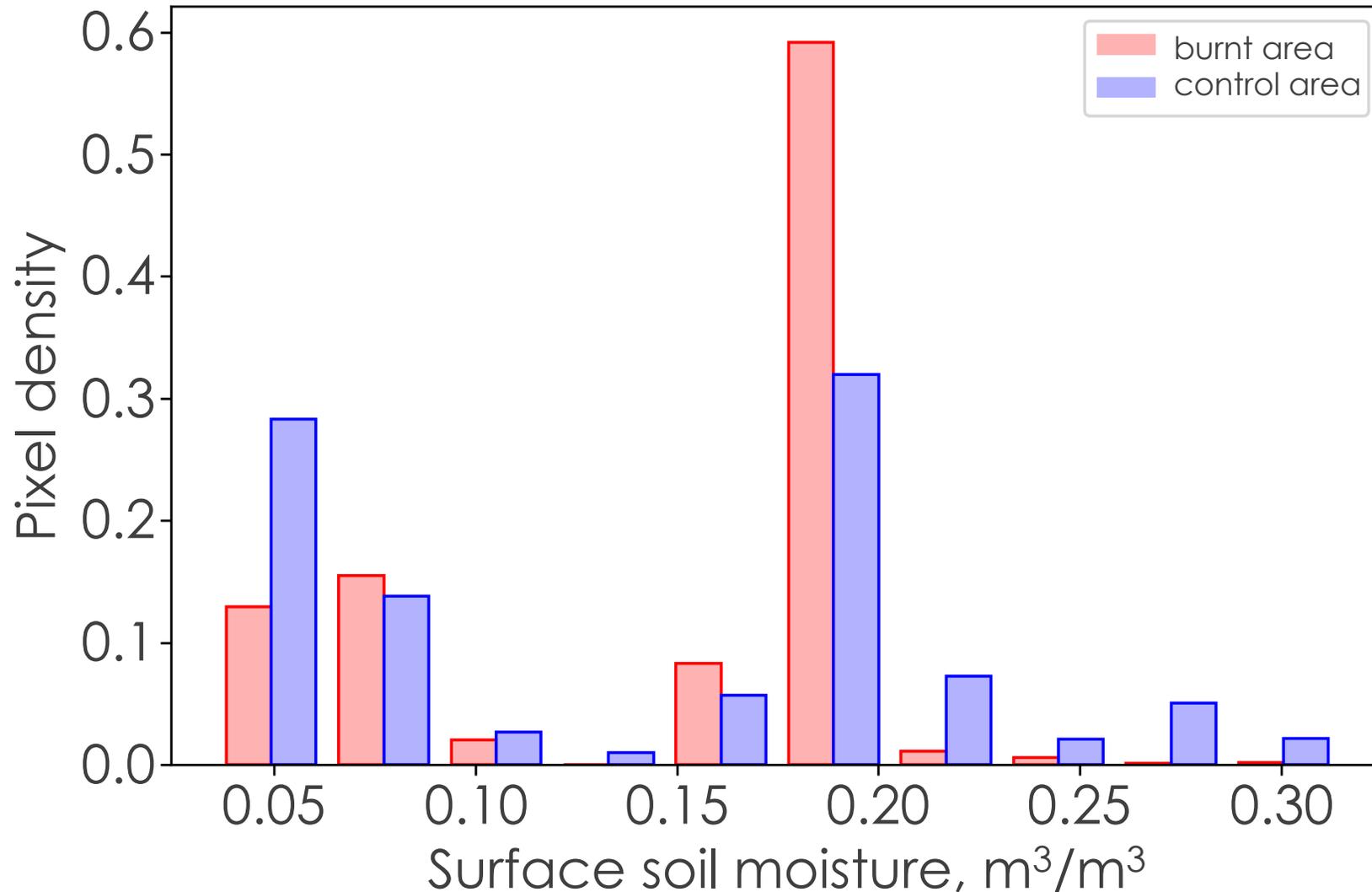
- L4, surface, **dekad**
- **Eucalyptus** plantation
- 2023 fire

Finding:

- ✓ Similar distribution across forest types



RESULTS – Soil Moisture as a Predictor of Fire



Variables:

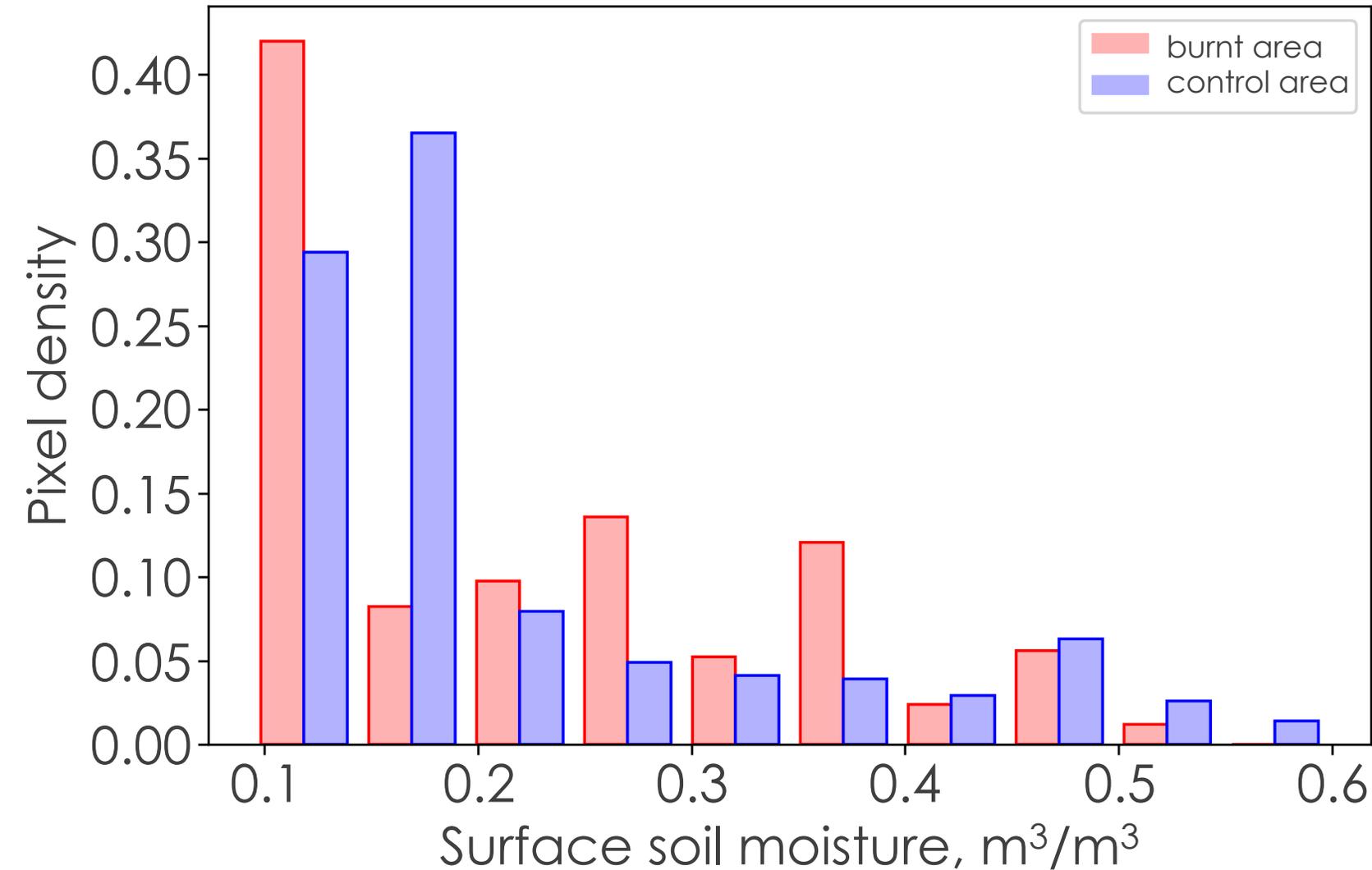
- L4, surface, **dekad**
- **Eucalyptus** plantation
- **2017** fire

Finding:

- ✓ Potentially different terrestrial conditions across fire events



RESULTS – Soil Moisture as a Predictor of Fire



Variables:

- **L3**, surface, **dekad**
- **Eucalyptus** plantation
- **2017** fire

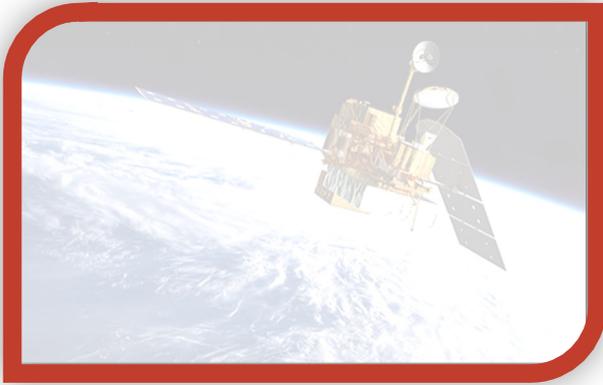
Finding:

- ✓ Inconsistent values across dataset levels

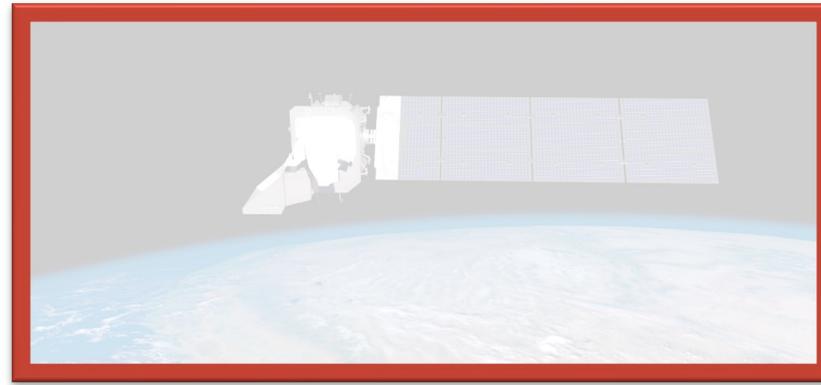


RESULTS – Evapotranspiration as a Predictor

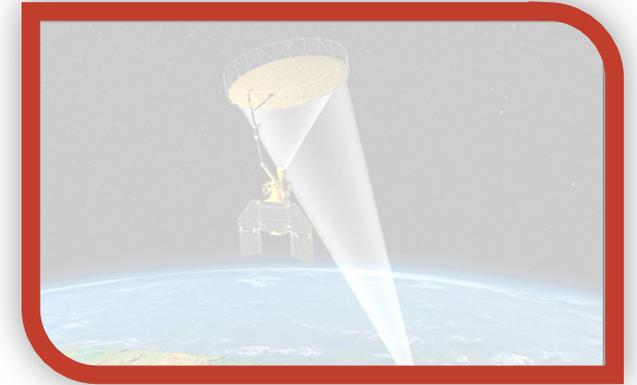
GPM



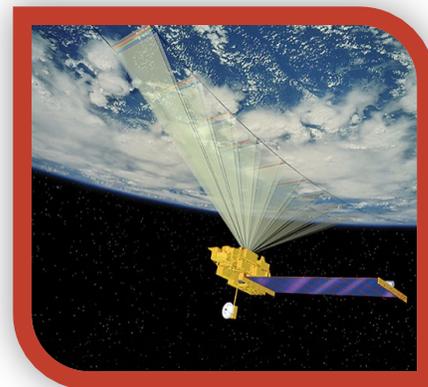
Landsat 9 OLI



SMAP



Terra MODIS

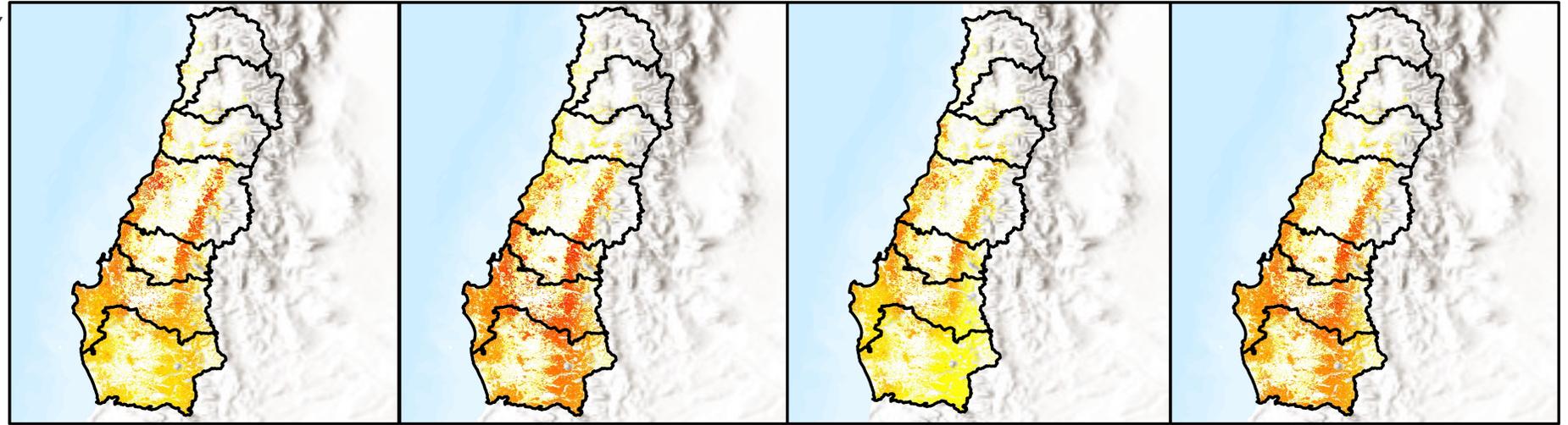


Aqua MODIS



RESULTS – Evapotranspiration as a Predictor

January
2022



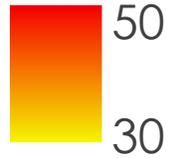
01/01

01/09

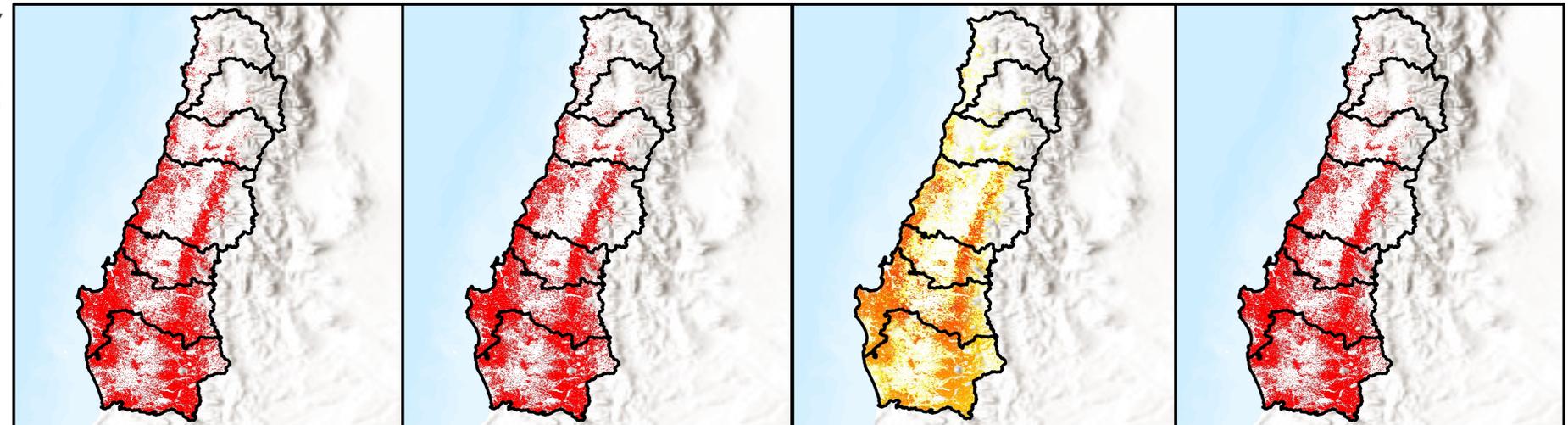
01/17

01/25

Evapotranspiration
mm/8day



January
2023

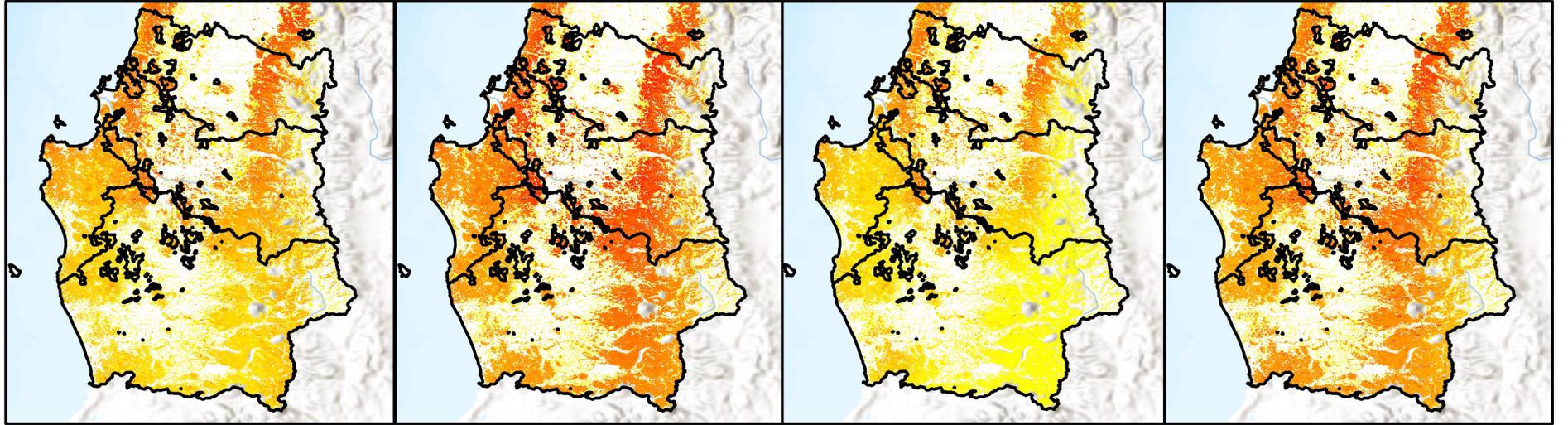


0 125 250 km

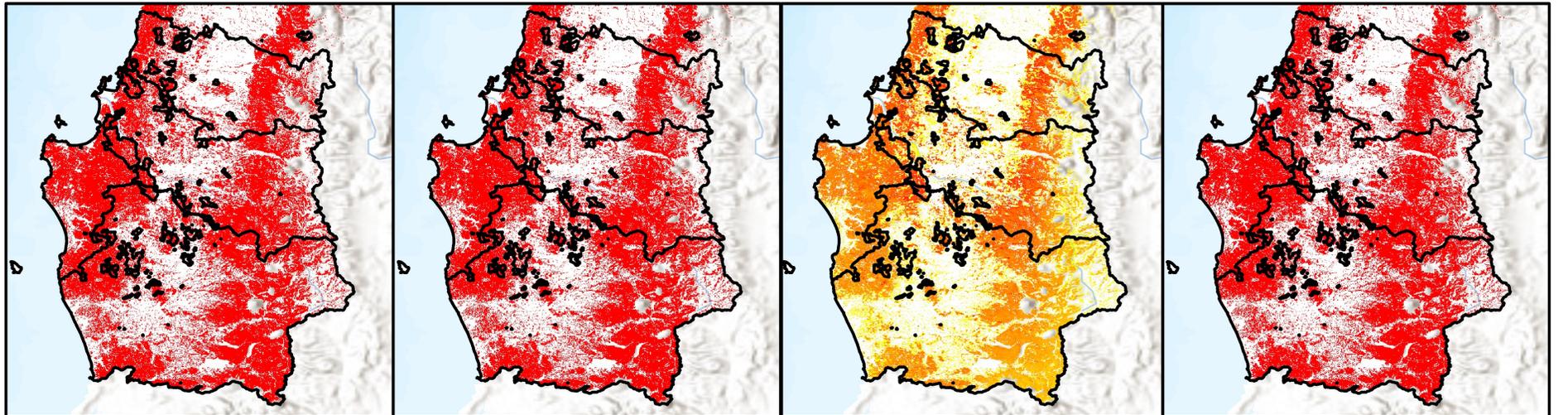



RESULTS – Evapotranspiration as a Predictor

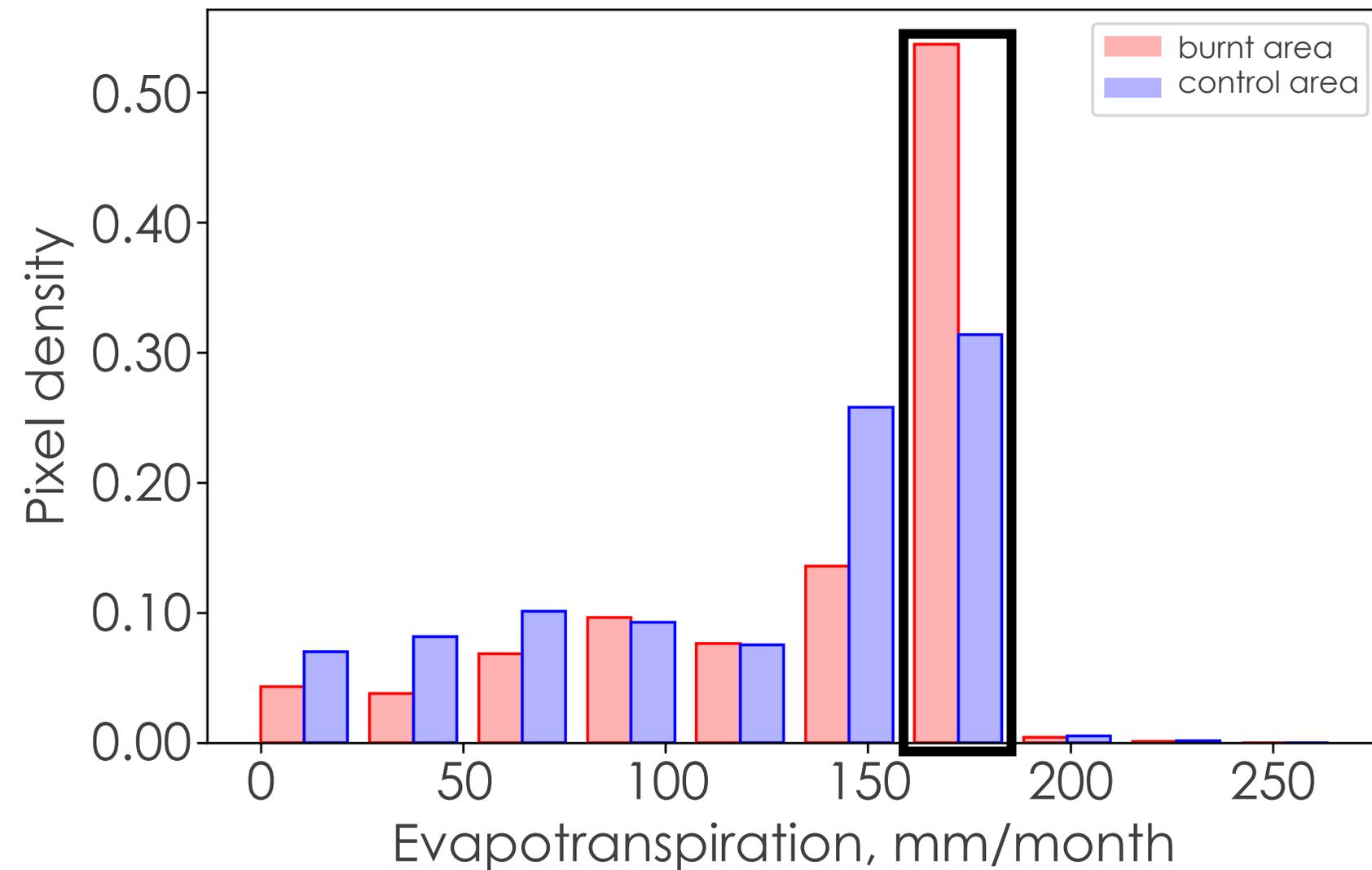
January
2022



January
2023



RESULTS – Evapotranspiration as a Predictor



Variables:

- **Month**
- **Conifer** plantation
- **2023** fire

Finding:

- ✓ Distribution opposite to that of SM
- ✓ Values greater than 170 mm/month found in 54% of burn areas



CONCLUSIONS [1/2]

Using NASA EO and partners' input:

- ✓ We delineated the spread of the **2017 and 2023 Chilean wildfires**
- ✓ We selected **burned and control areas** with homogeneous characteristics
- ✓ We captured the effect of the ongoing **megadrought** based on anomalies in
 - **precipitation** and
 - **NDVI**

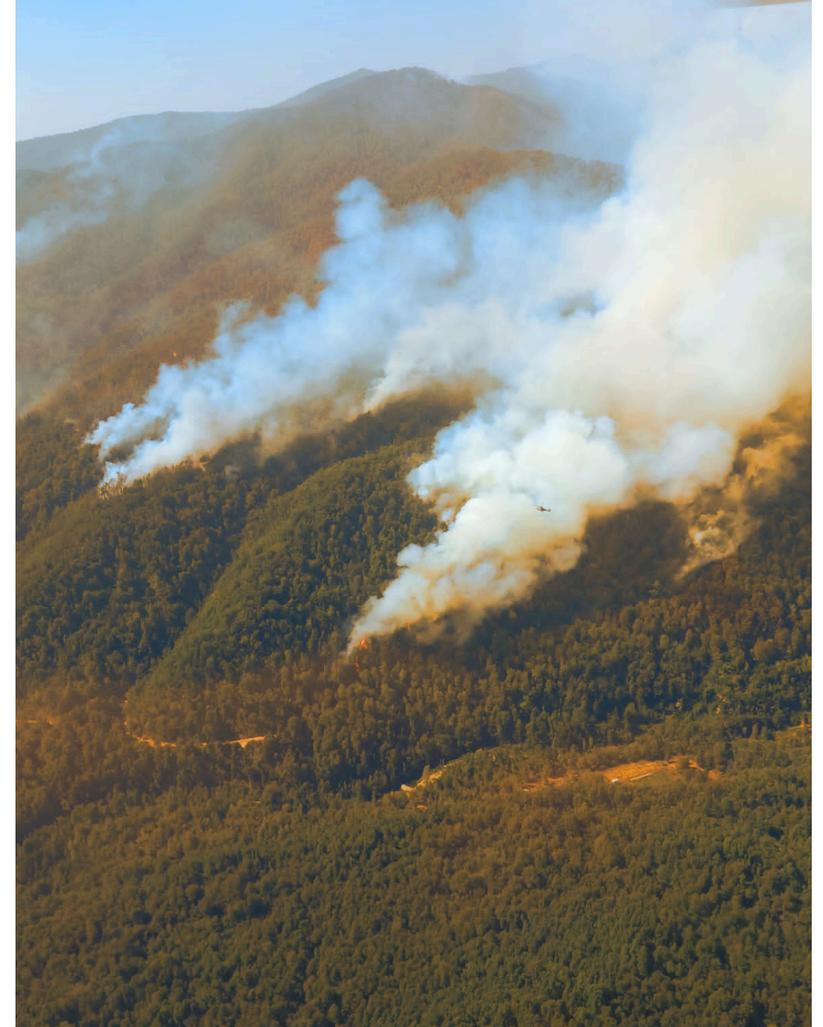


Image Credit: CONAF



CONCLUSIONS [2/2]

Using NASA EO and partners' input:

- ✓ We found that burned areas may exhibit certain **pre-fire conditions** in SM and ET
- ✓ Our data suggests **critical thresholds** for
 - Surface SM (L4) below $0.075 \text{ m}^3/\text{m}^3$
 - ET above 170 mm/month
- ✓ These measures can help assess **future wildfire risks** and allocate resources to prevent and suppress wildland fires.



Image Credit: CONAF



LIMITATIONS [1/2]

- ❖ Remote sensing
 - Limited return period, at times impacted by cloud cover
 - ET and NDVI characterize fuel in the upper canopy, not ground dryness
 - SMAP pixels are coarse and encompass different cover types
 - Various processing levels produce conflicting information

Image Credit: CONAF



LIMITATIONS [2/2]

- ❖ Environmental processes
 - Dynamics of underground fire within organic matter
 - Localized effect of fast and dry, easterly wind from Argentina
 - Lacked in-depth data about land-use/land-cover
 - Lacked access to in-situ soil moisture or ET measurements to validate Findings

Image Credit: CONAF



FUTURE WORK

Next methodological steps:

- Further investigate what low SM and high ET corresponds to
- Validate threshold against burn areas and ignition points
- Compare new risk forecast against previous red-flags

Science communication goals:

- Publish in Sustainable Horizons
- Present at AGU Fall Meeting



Image Credit: CONAF



Acknowledgments

- **Partners**

- Gonzalo Esteban Tapia Koch (CONAF)
- Jorge Andrés Saavedra Saldías (CONAF)
- Fernando Vásquez (Embassy of Chile)
- Andrés Rodríguez (Embassy of Chile)

- **DEVELOP Science Advisors**

- Dr. Kenton Ross (NASA LaRC)
- Dr. Venkat Lakshmi (University of Virginia)

- **DEVELOP Fellow**

- Olivia Landry



Image Credit: CONAF