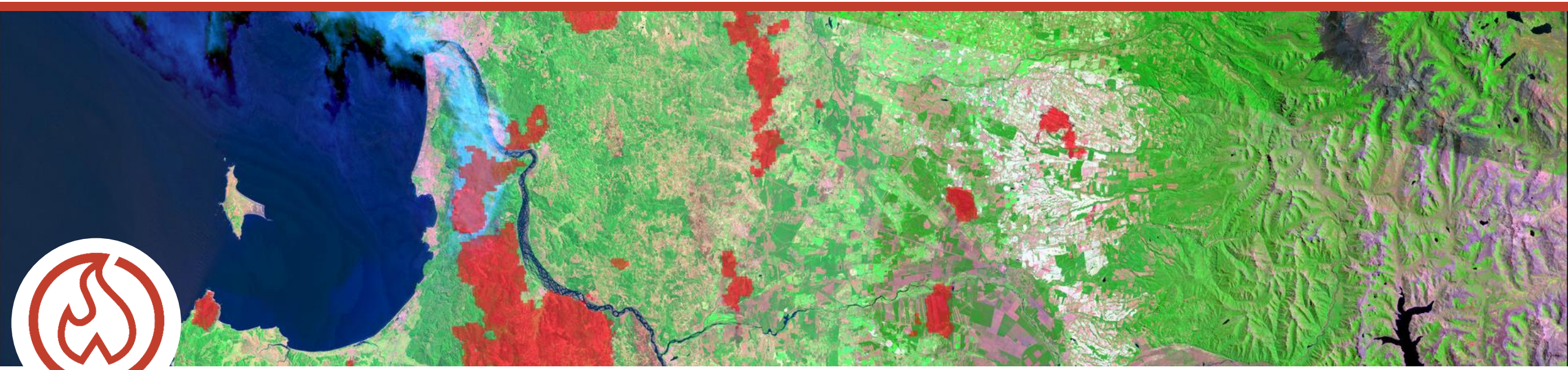
National Aeronautics and Space Administration



Chile Wildland Fires

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

Benjamin D. Goffin • Aashutosh Aryal • Quinton Deppert

25TH EVELOP ANNIVERSARY

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

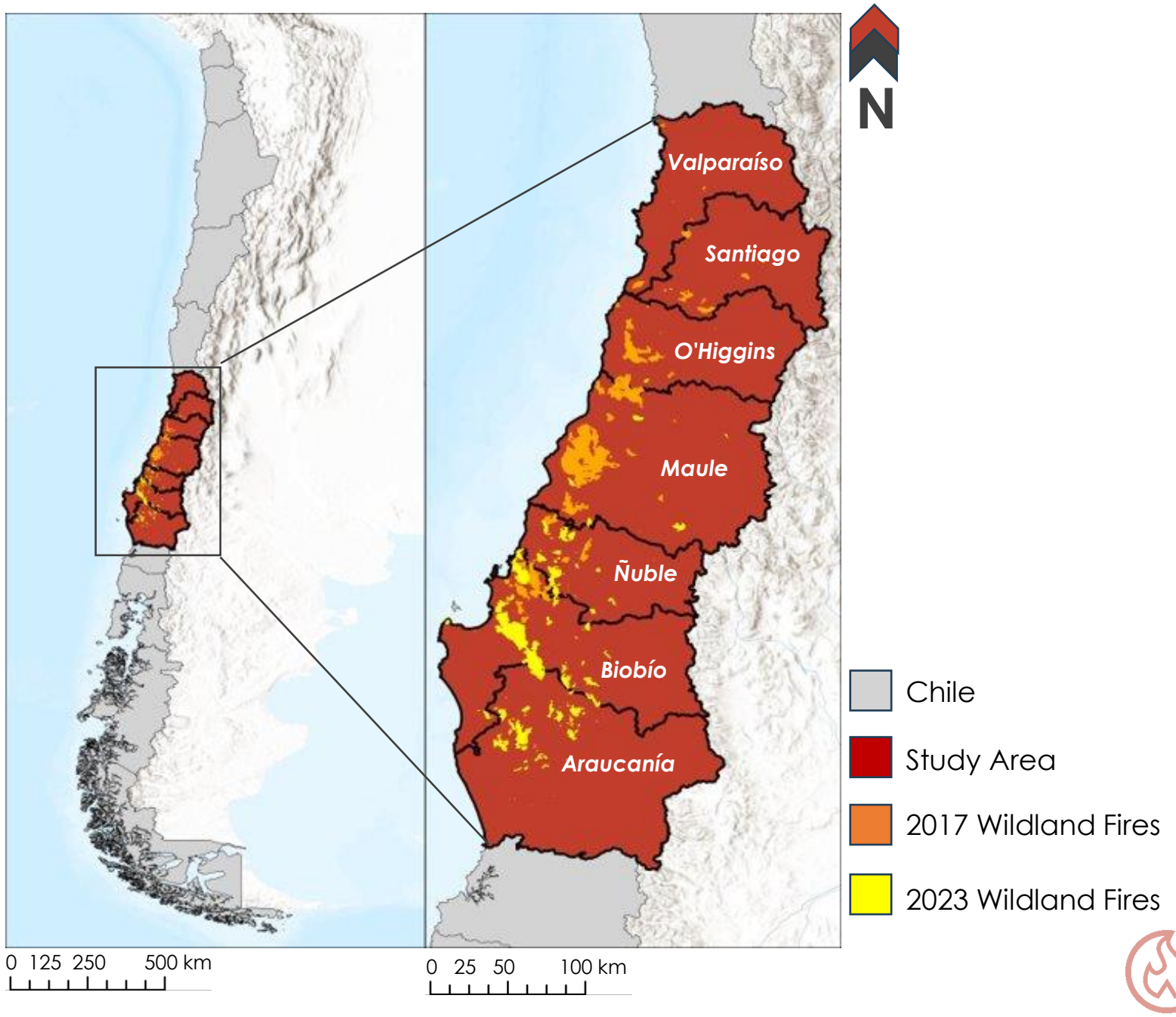
The goal of this project was to enhance future wildfire management efforts by:

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

Image credit: CONAF

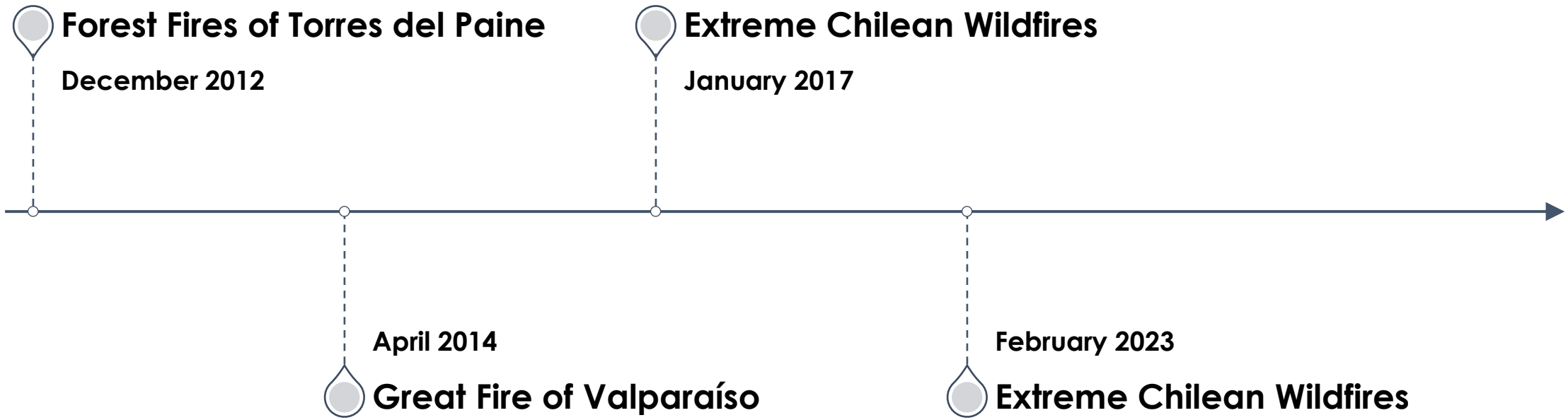
STUDY AREA

- Central and South-Central Chile (CSCC)



Basemap credit: Esri, CGIAR, HERE, Garmin, FAO, NOAA, USGS

STUDY PERIOD

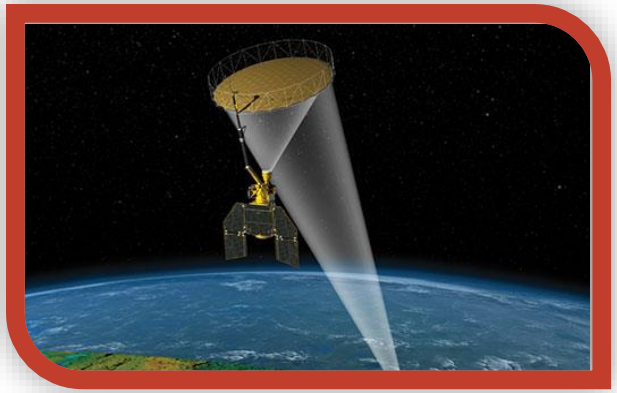


EARTH OBSERVATIONS

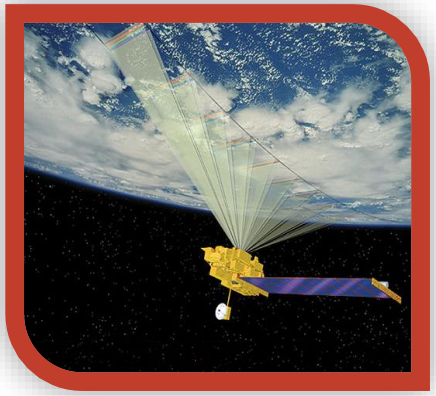
GPM

Landsat 9 OLI-2

SMAP



Terra MODIS



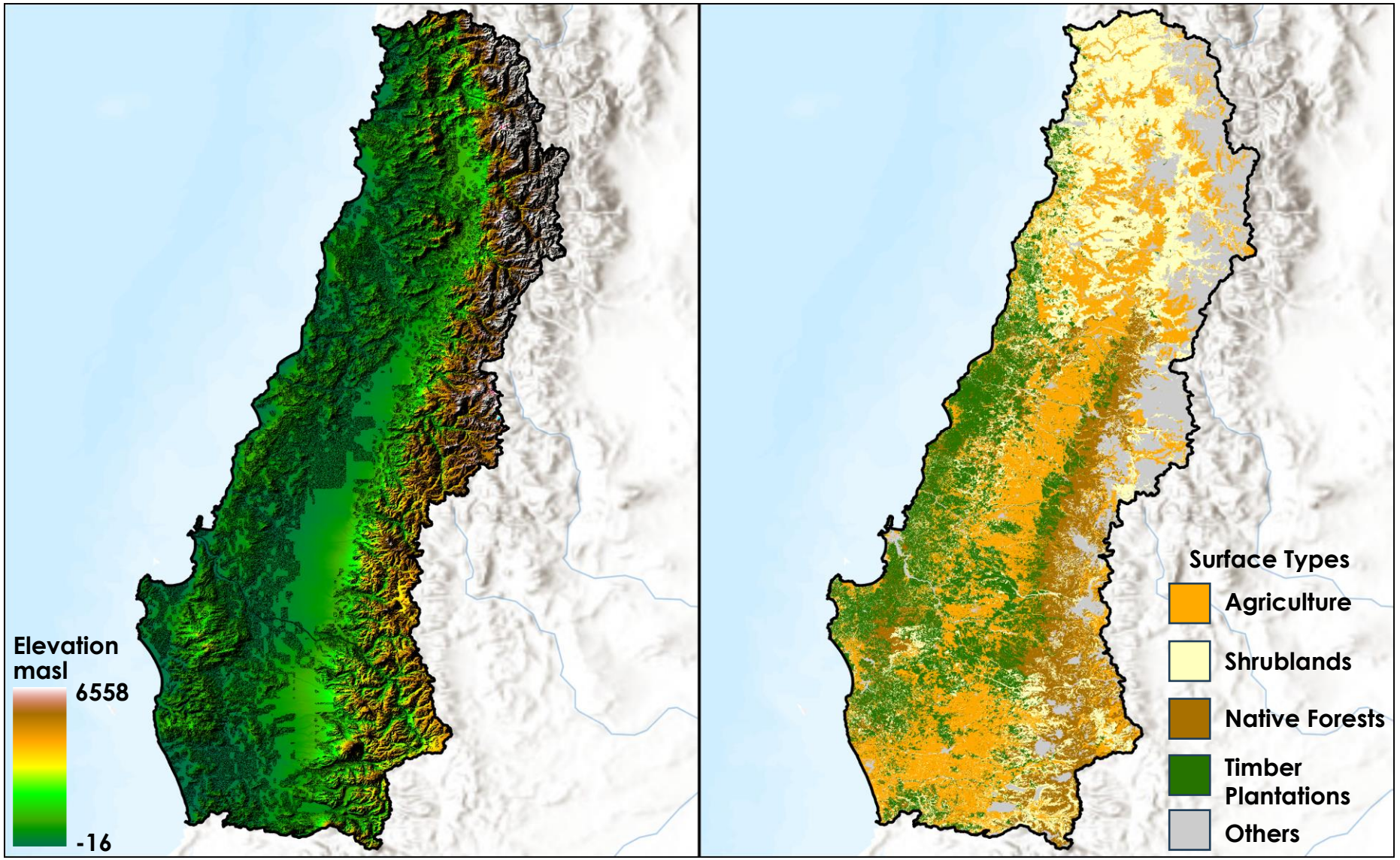
Aqua MODIS

Image credit: NASA

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

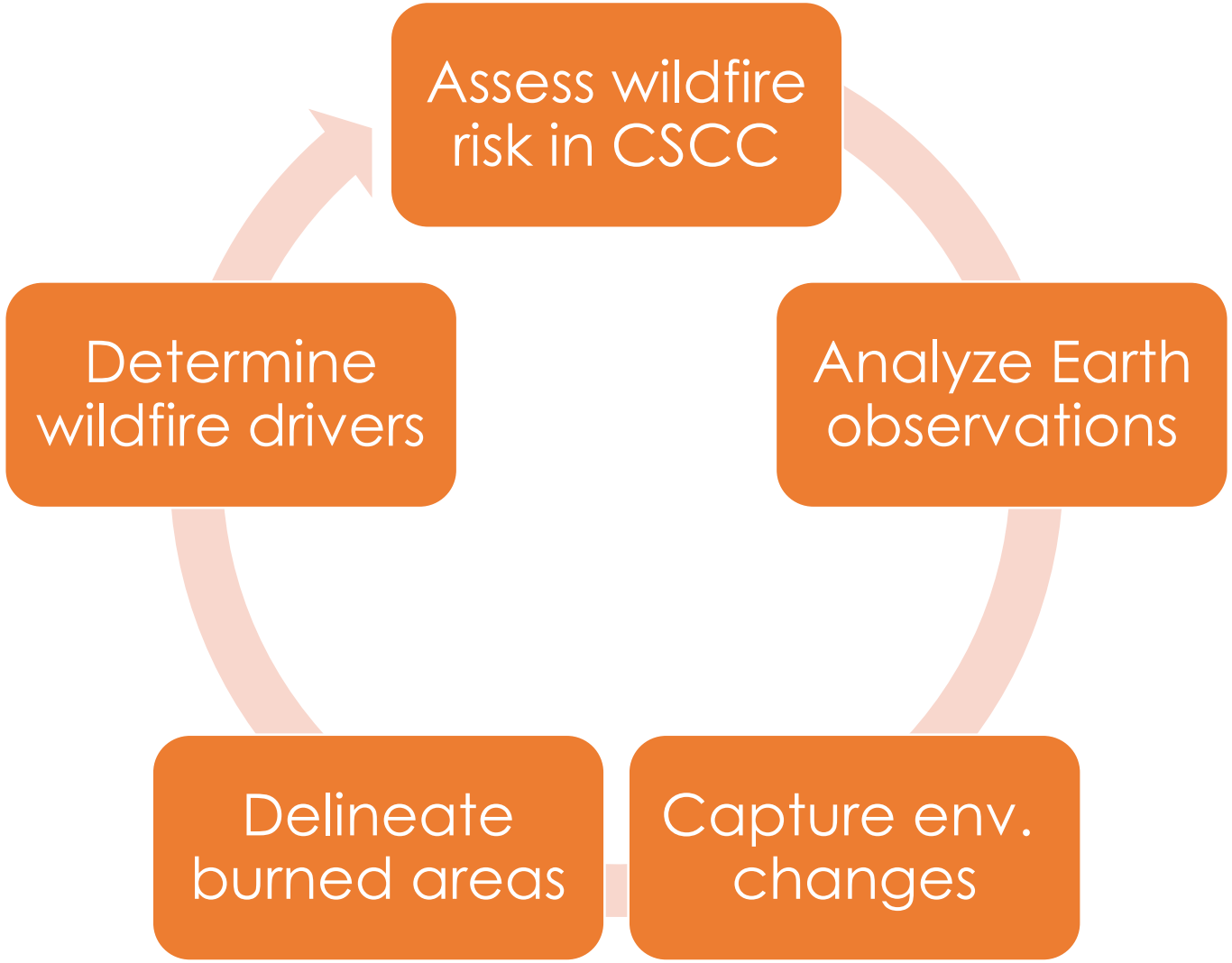


Dataset: NASADEM 30m

Fuel Surface Model: Jorge Andrés Saavedra Saldías (CONAF)

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

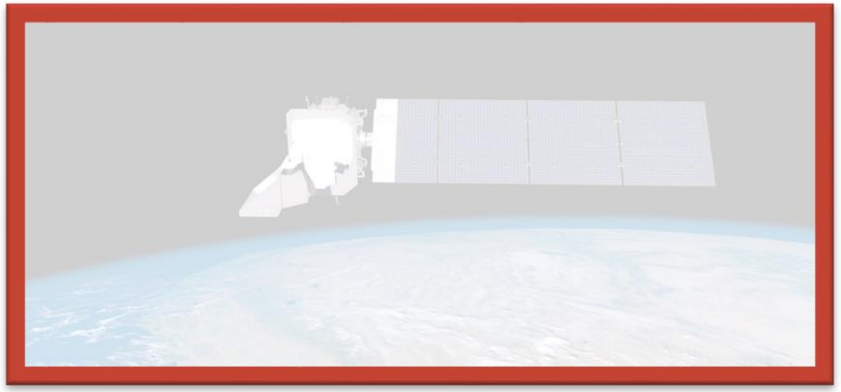
METHODOLOGY



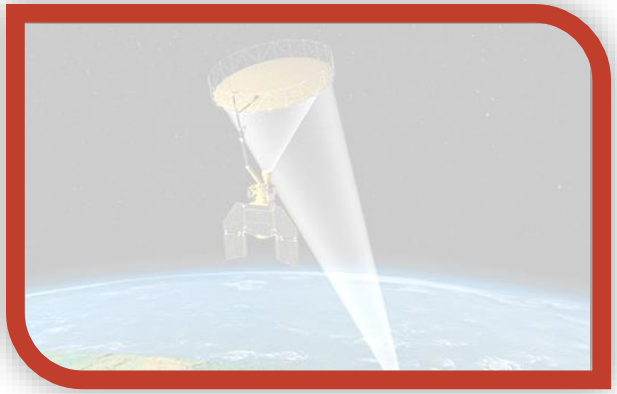
RESULTS – Precipitation deficit

GPM

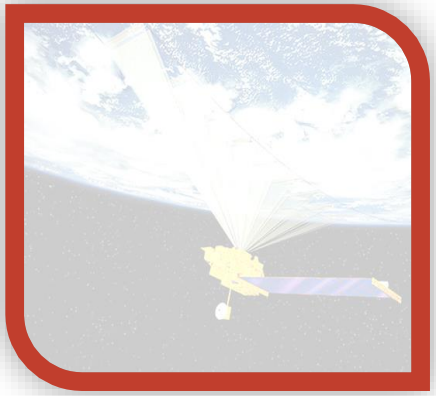
Landsat 9 OLI-2



SMAP



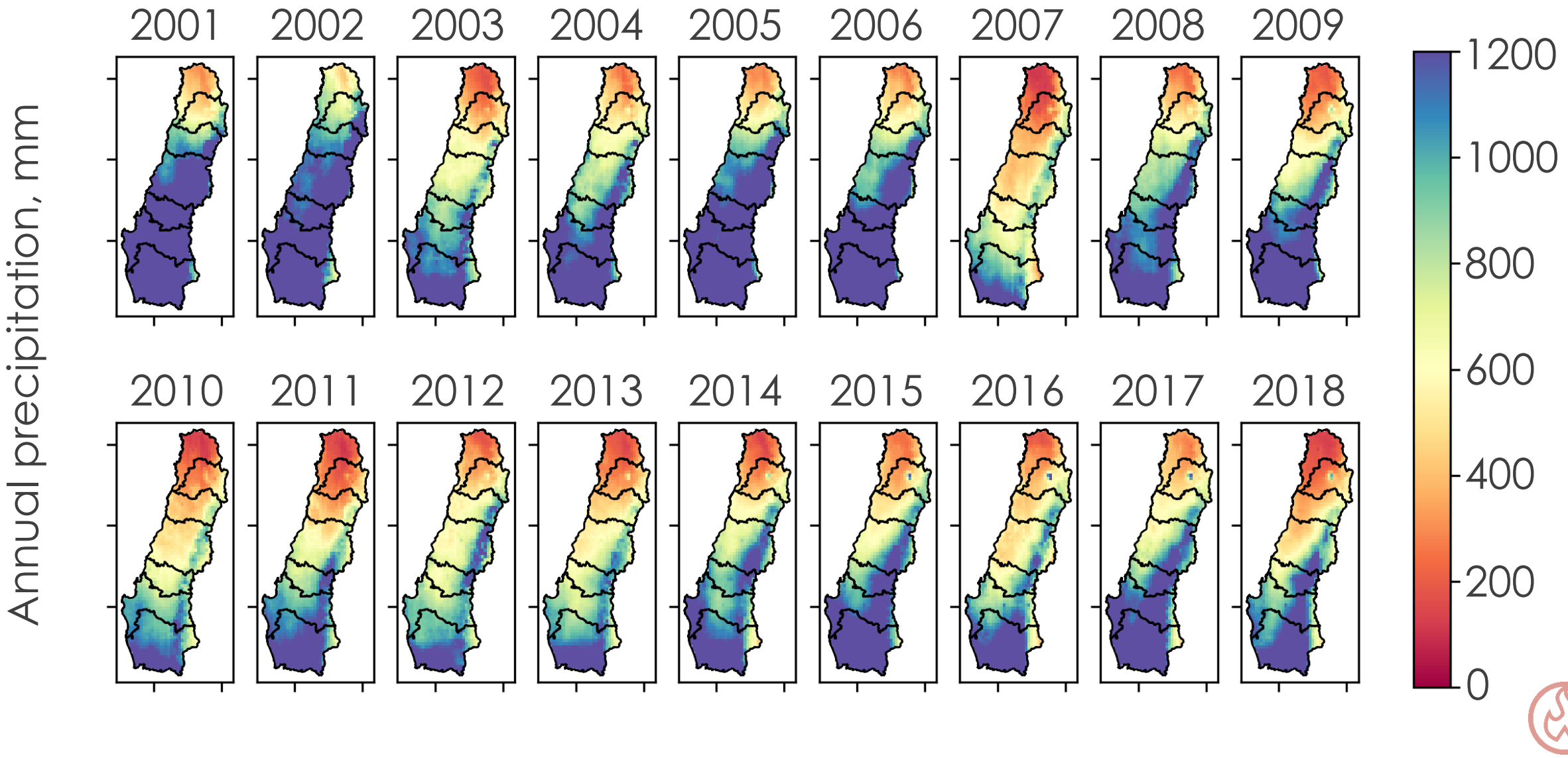
Terra MODIS



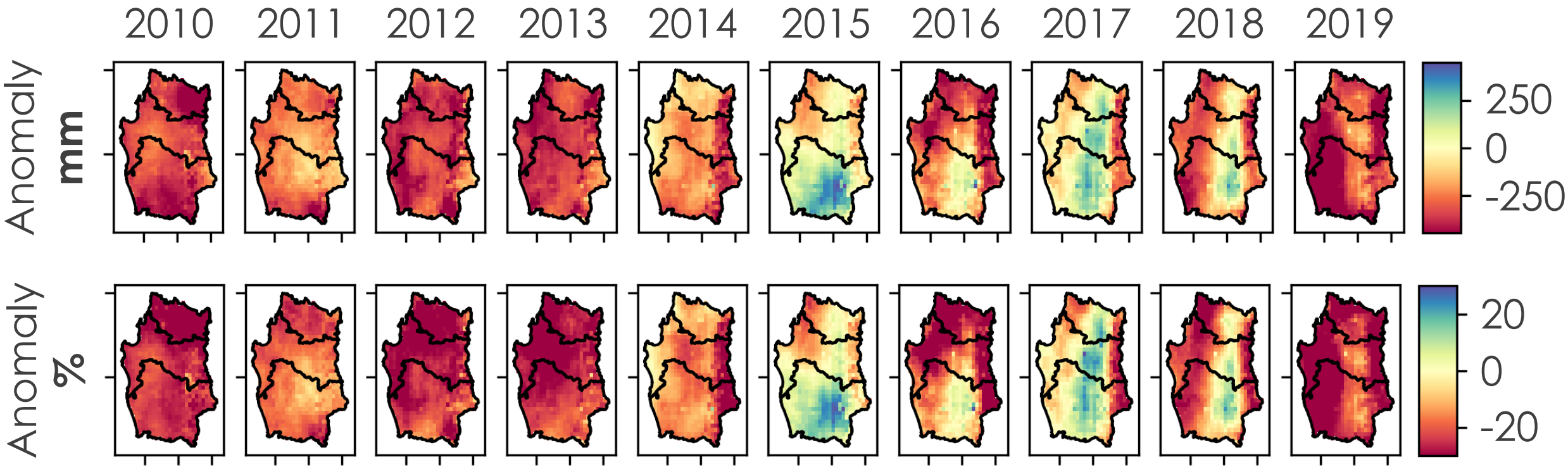
Aqua MODIS

Image credit: NASA

RESULTS – Precipitation Variability

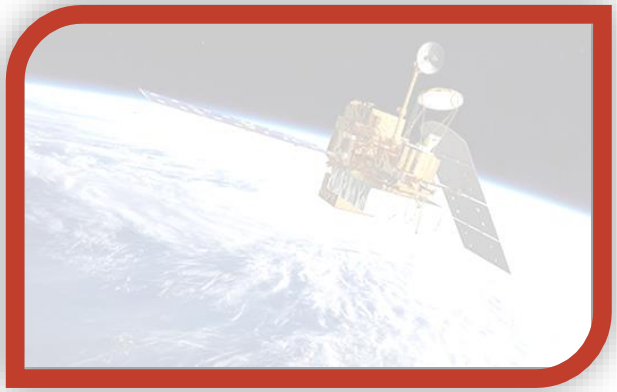


RESULTS – Precipitation Deficit

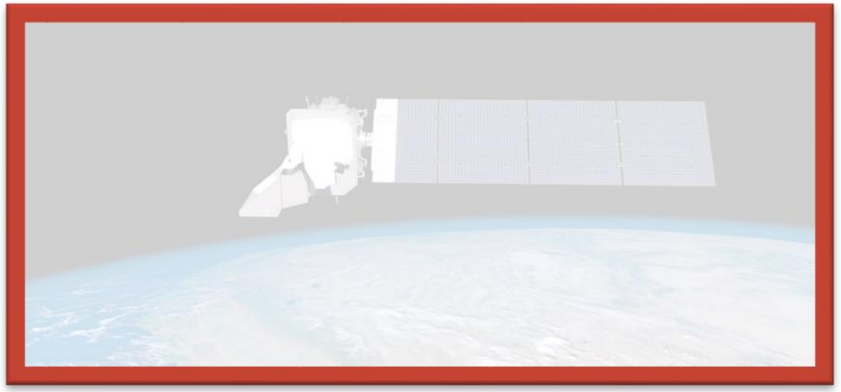


RESULTS – Vegetation anomalies

GPM



Landsat 9 OLI-2



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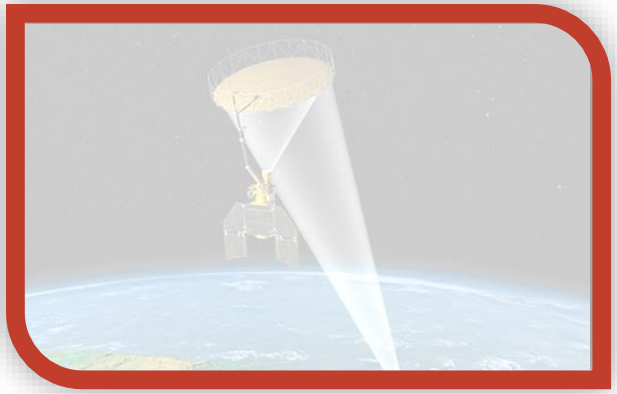

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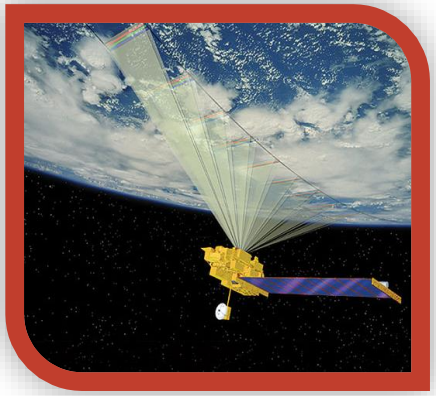
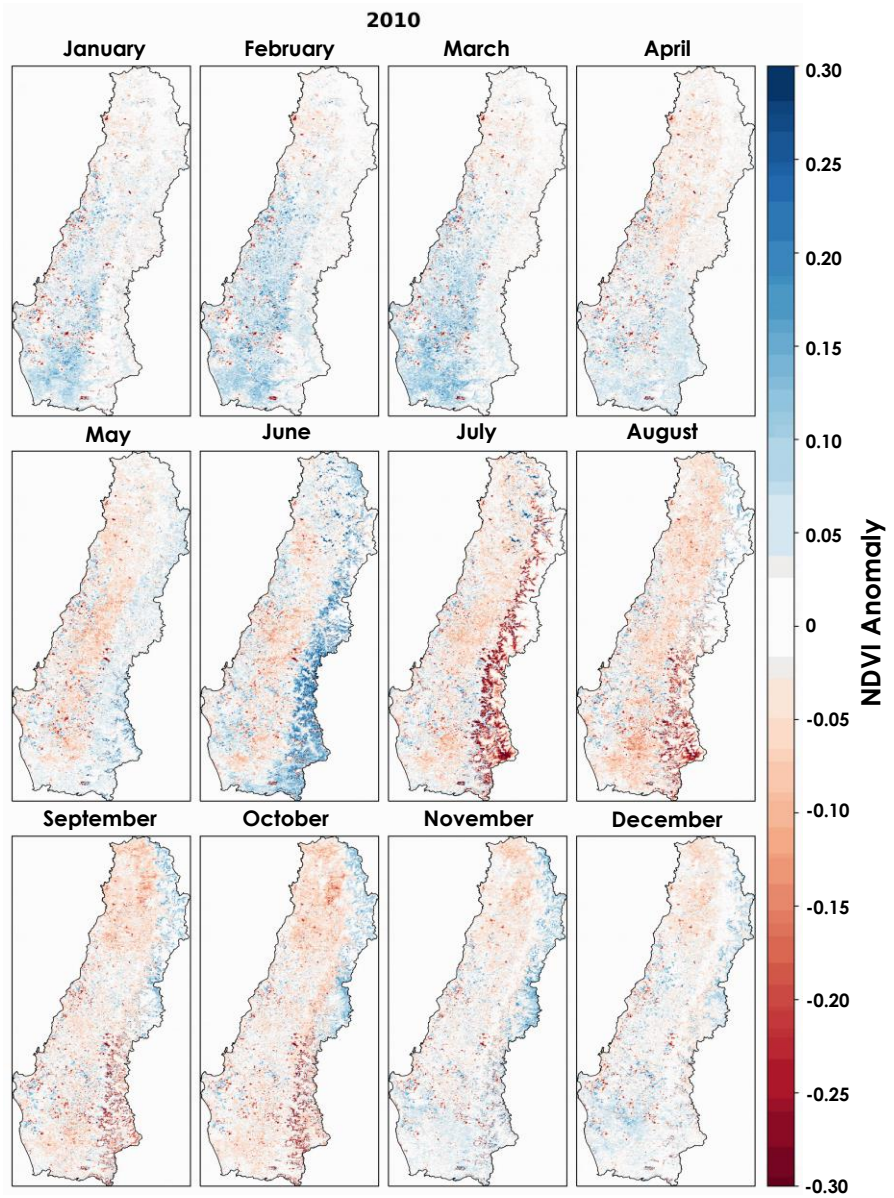


Aqua MODIS

Image credit: NASA

RESULTS – Vegetation Anomalies



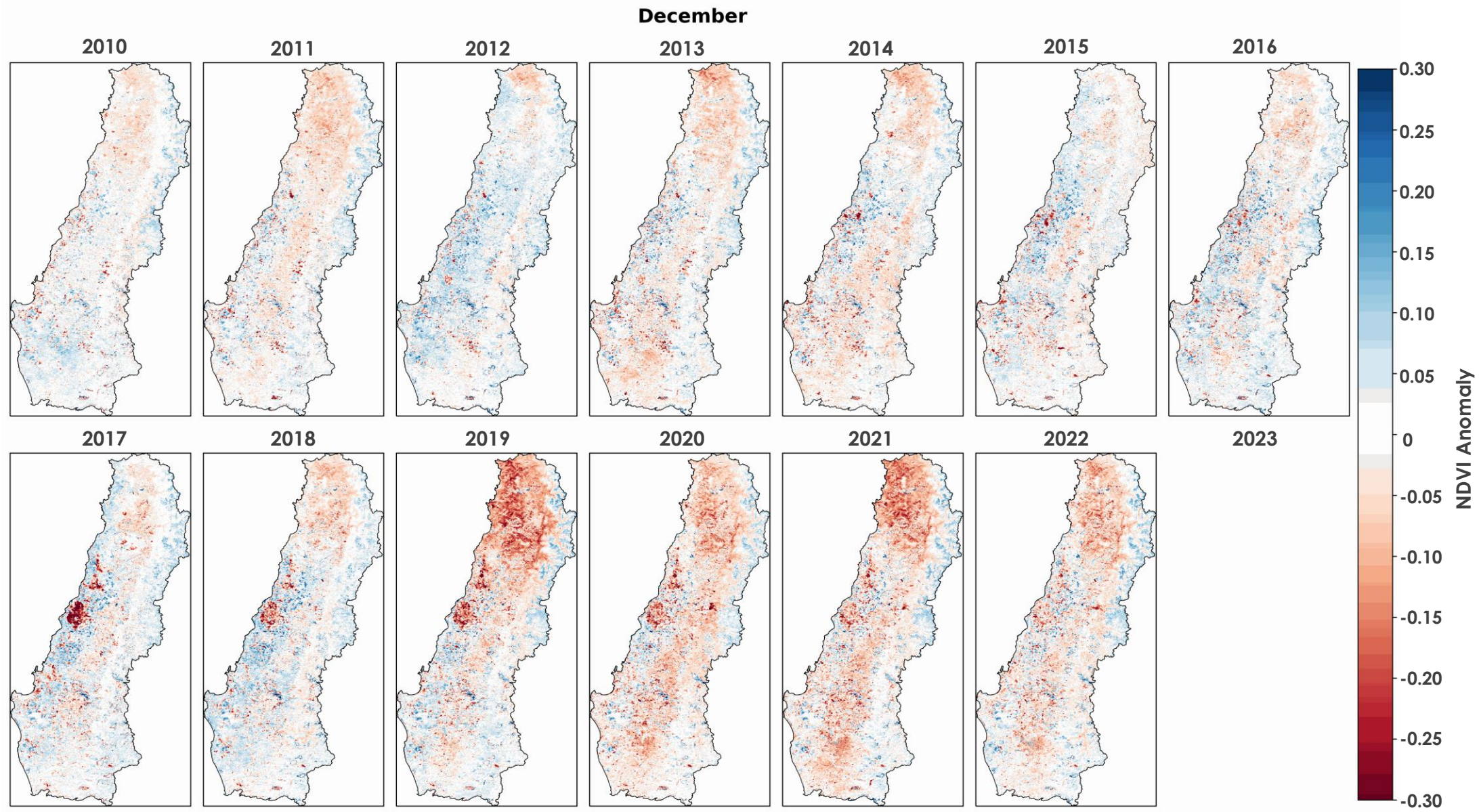
Variables:

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

Findings:

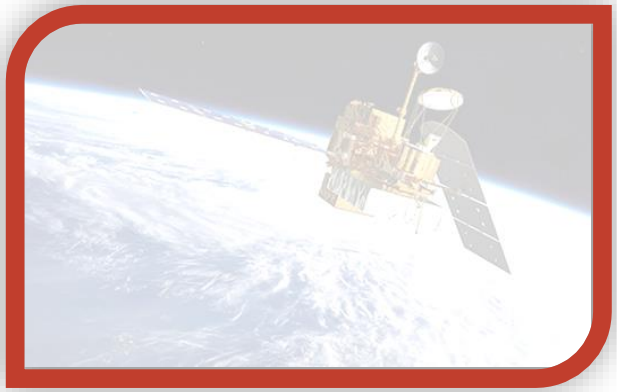
- ✓ Vegetation in stress
- ✓ Deteriorating vegetation health
- ✓ Increase in negative NDVI anomalies during megadrought period

RESULTS – Vegetation Anomalies (Fire Season)



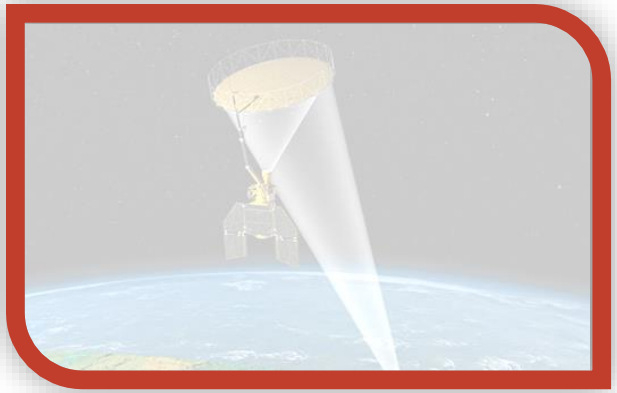
ANALYSIS – Wildland Fires Delineation

GPM



Landsat 9 OLI-2

SMAP



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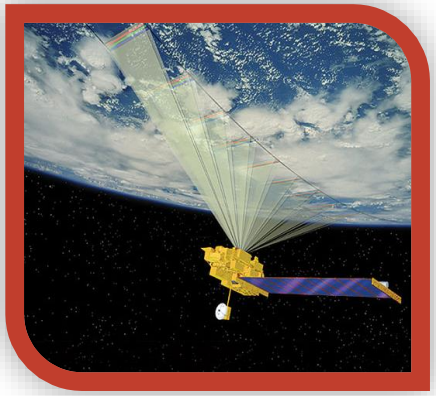
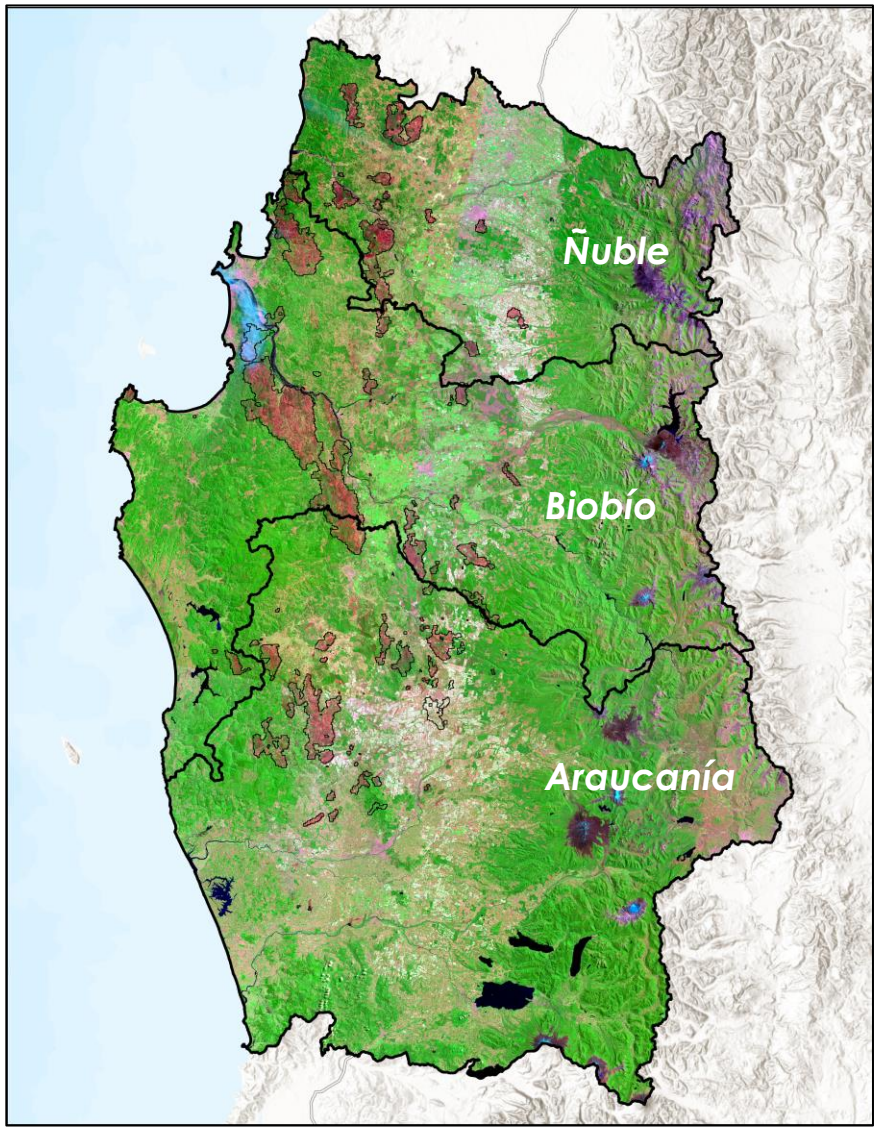


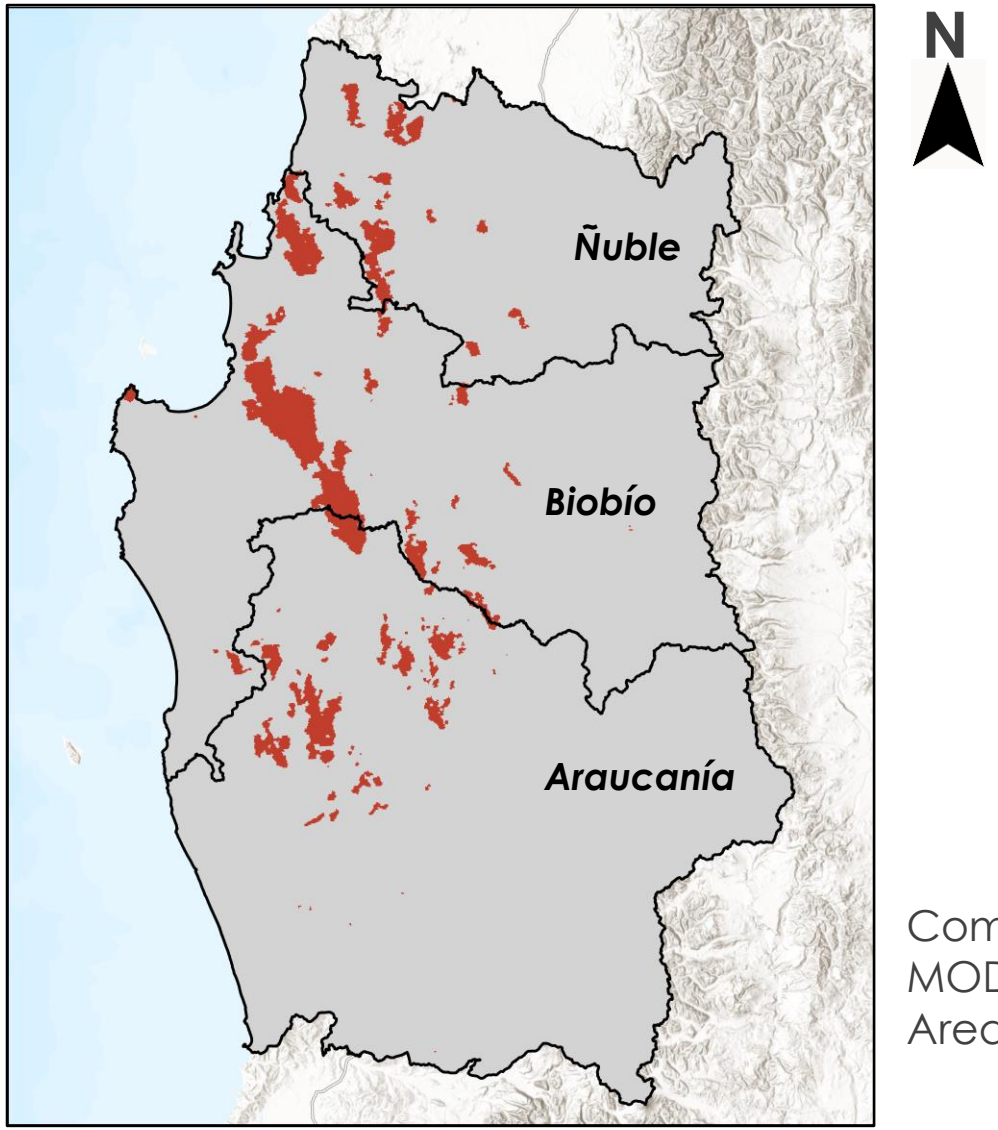
Aqua MODIS

Image credit: NASA

ANALYSIS – Wildland Fires Delineation



Landsat 9
OLI-2



N

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

February 2023 Wildland Fires Burned Areas

- February 1-6 Wildland Fires Burned Areas (73% Coverage)
- Focus on 3 Regions: ***Ñuble***, ***Biobío***, and ***Araucanía***

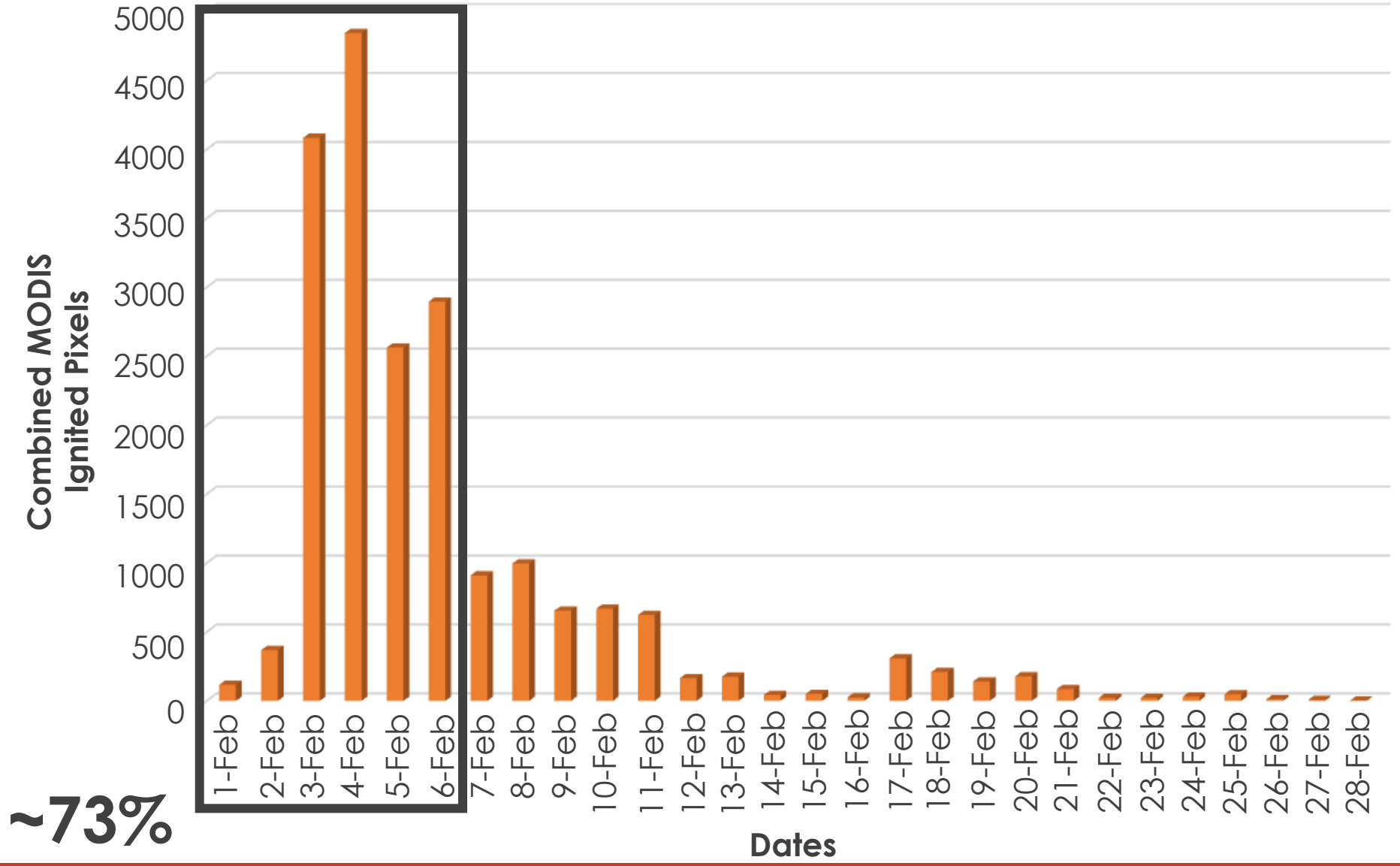
Timber Plantations (Conifer and Eucalyptus)

- Affected Adult Conifer Plantations (22%)
- Affected Adult Eucalyptus Plantations (17%)

Elevation Range (100-300 meters)

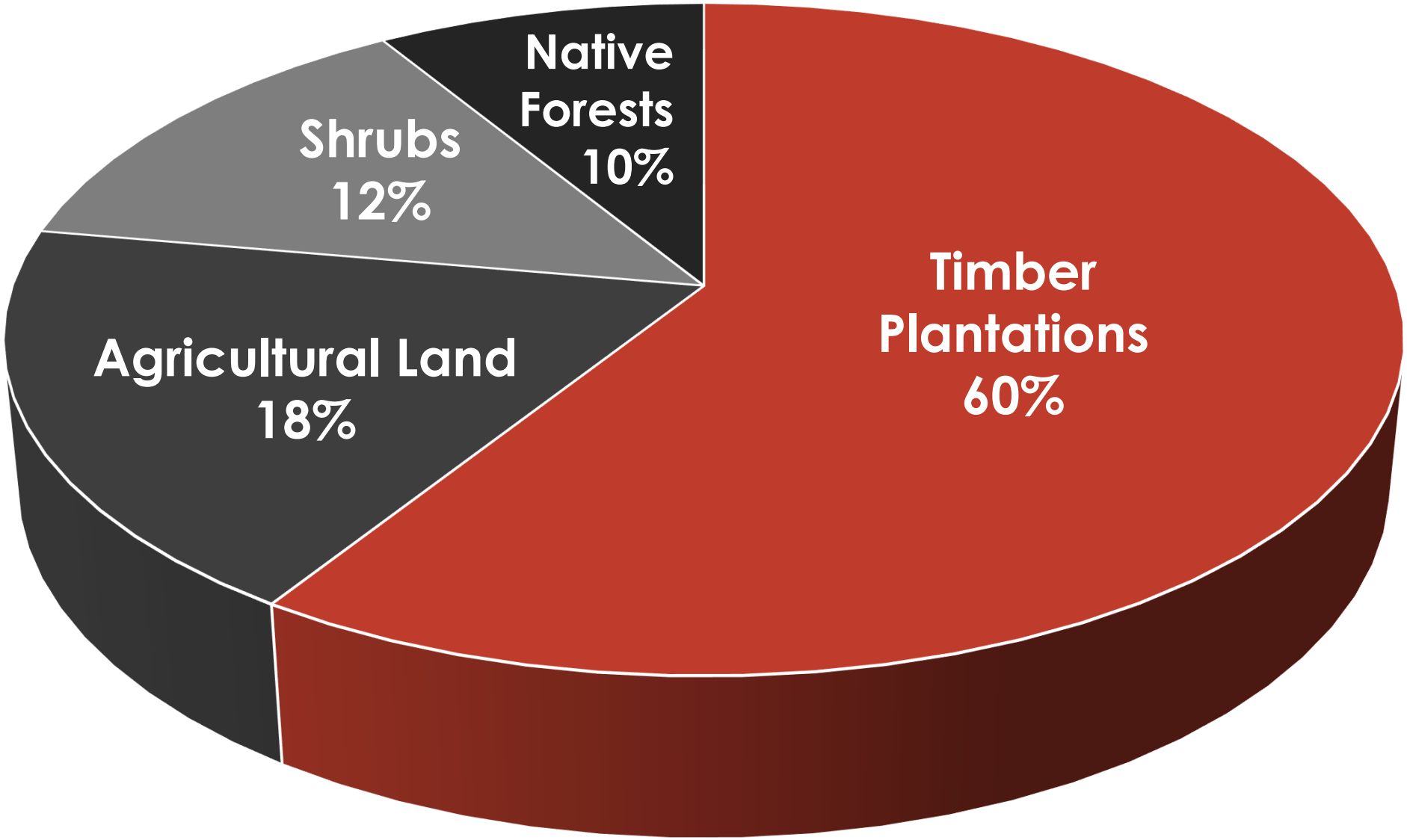
- 59% Conifer plantations in burned areas
- 58% Eucalyptus plantations in burned areas

RESULTS – Wildfire Timeline

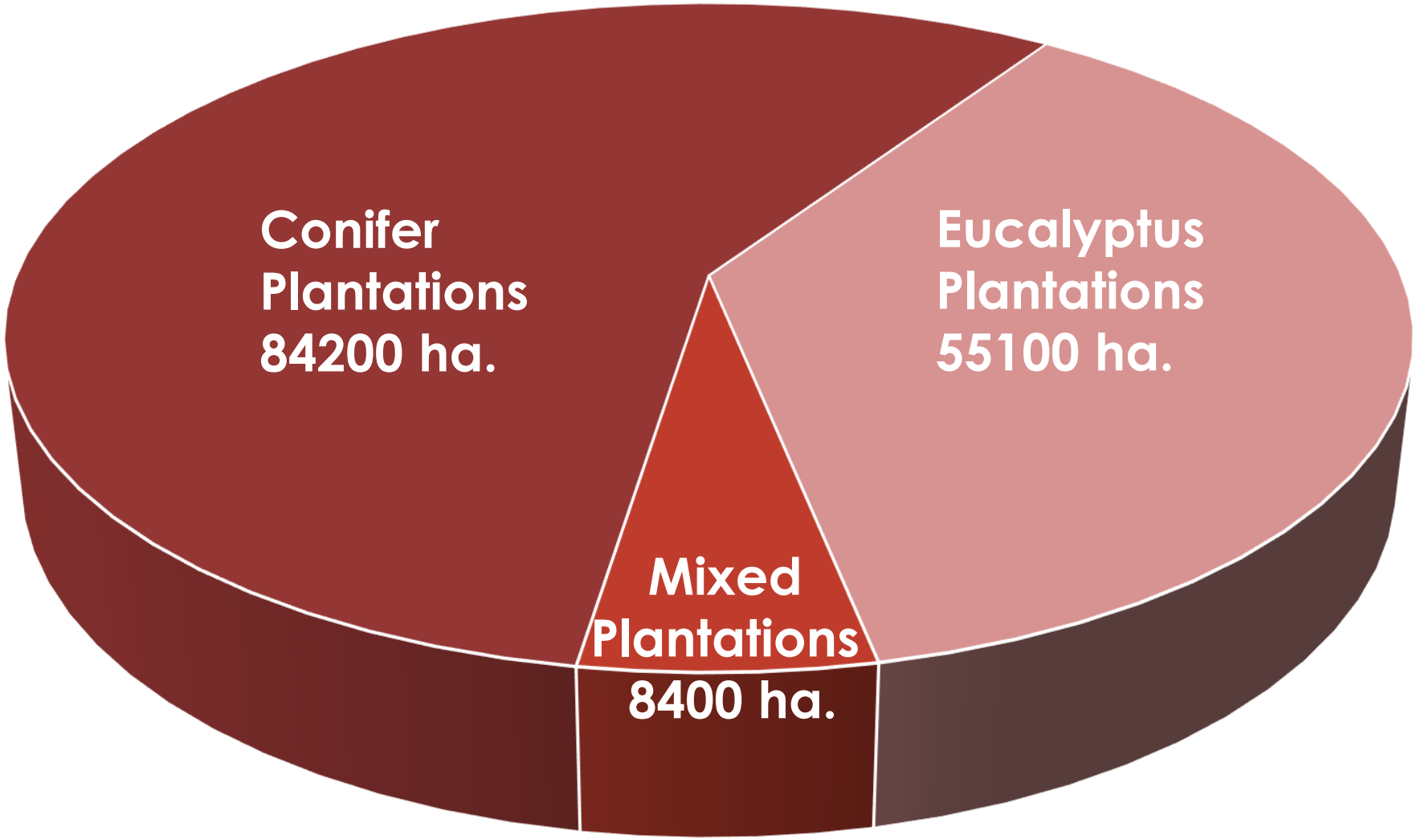


~73%

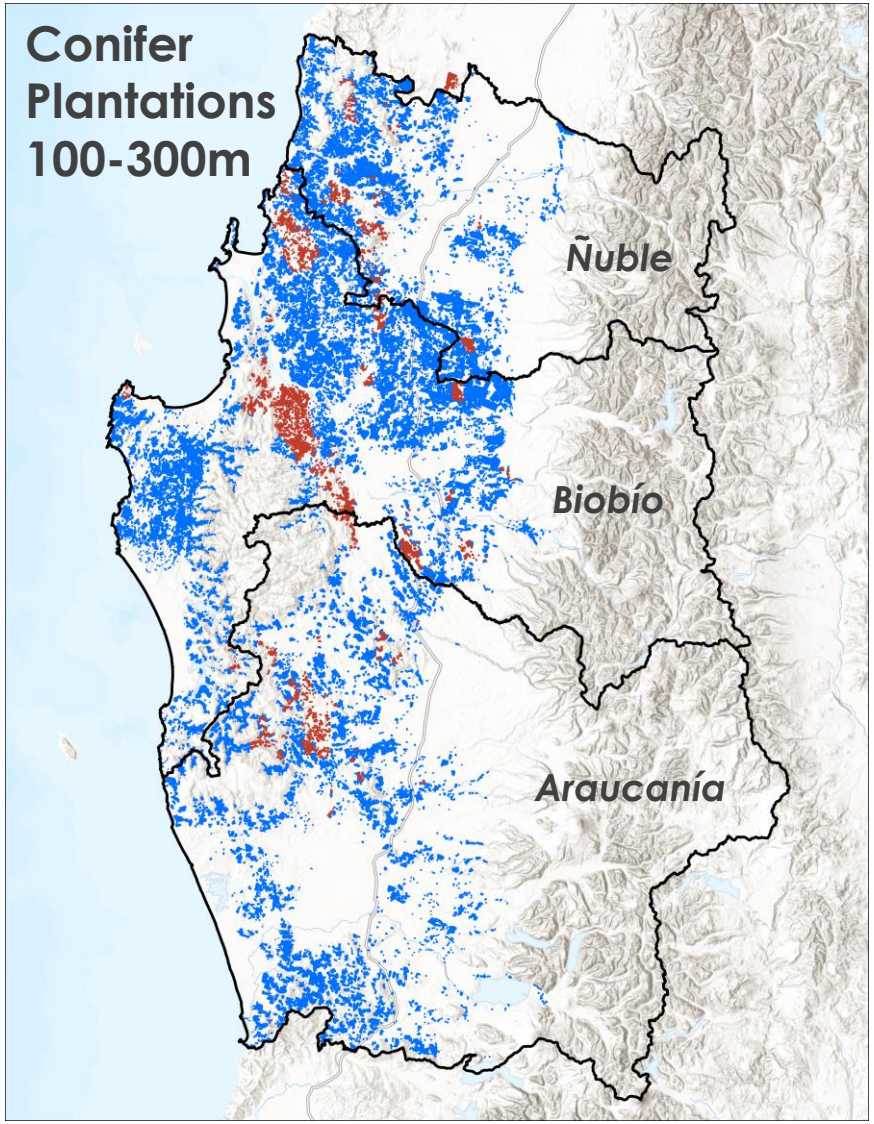
RESULTS – Land Cover Types Affected in Feb 1-6

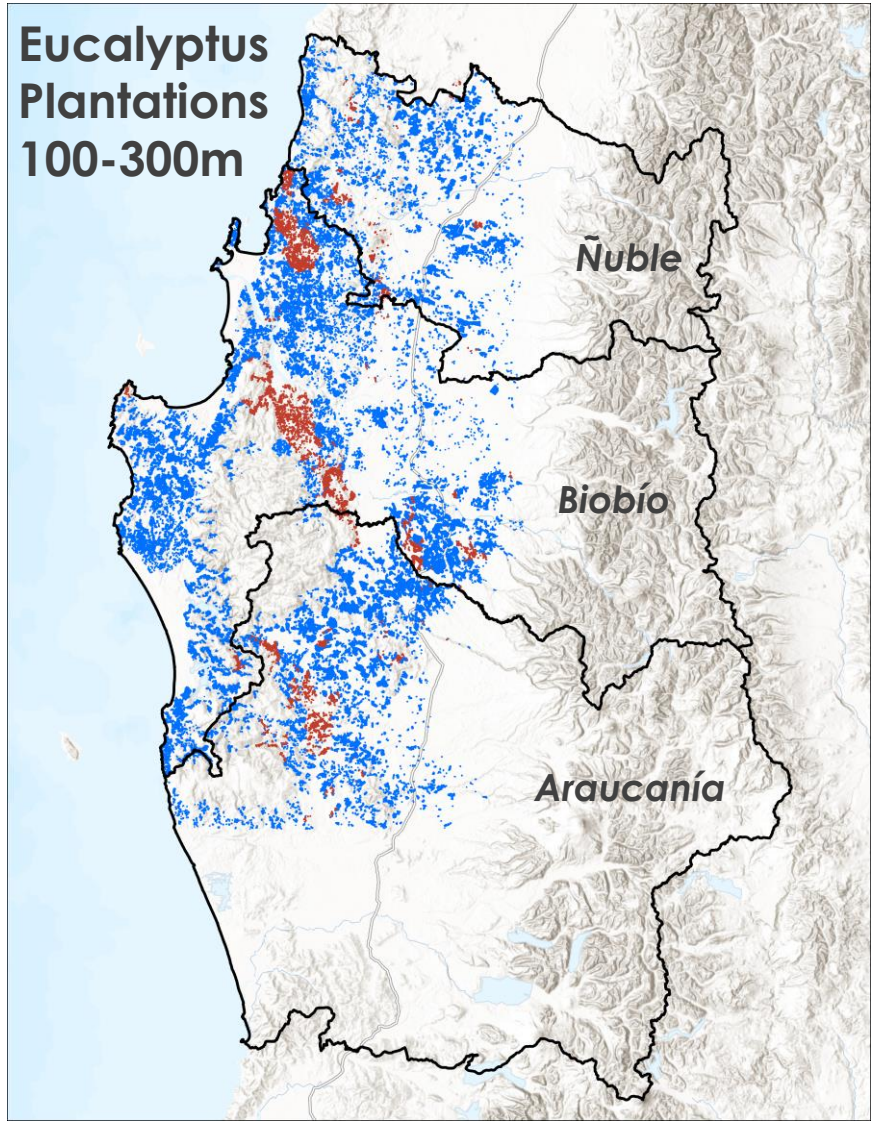


RESULTS – Plantation Types Affected in Feb 1-6



RESULTS – Wildfire Against Control Areas





N

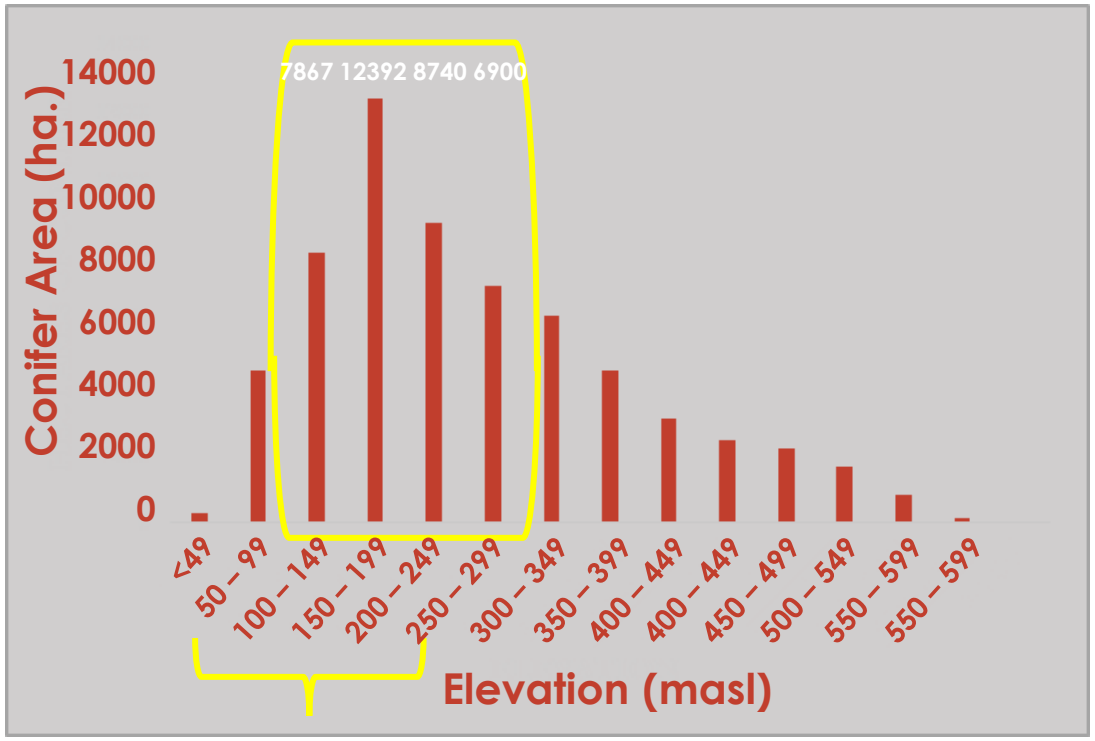
Burned Areas

Control Areas

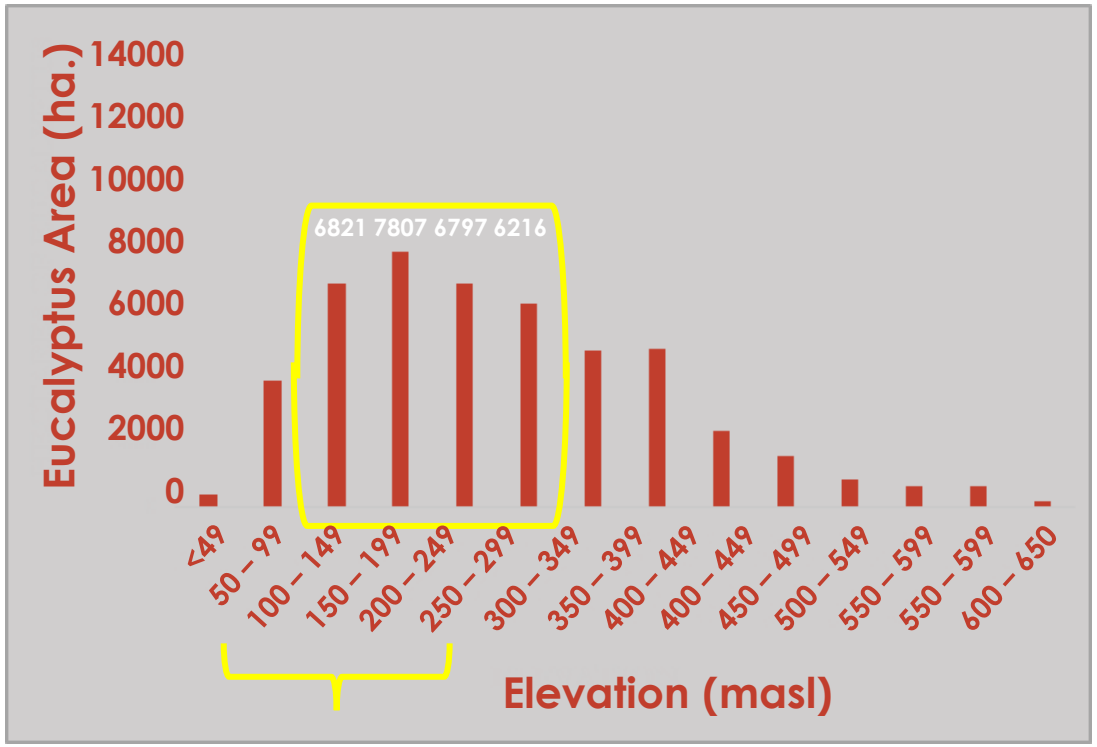
0 10 20 40 km

Basemap credits: Esri, CGIAR, HERE, Garmin, FAO, NOAA, USGS

RESULTS – Elevation Range Affected in Feb 1-6



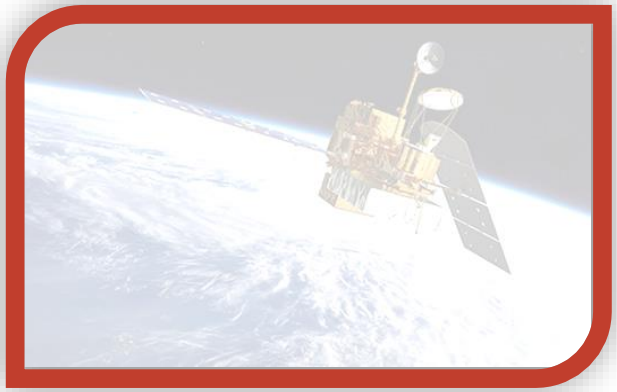
~59%



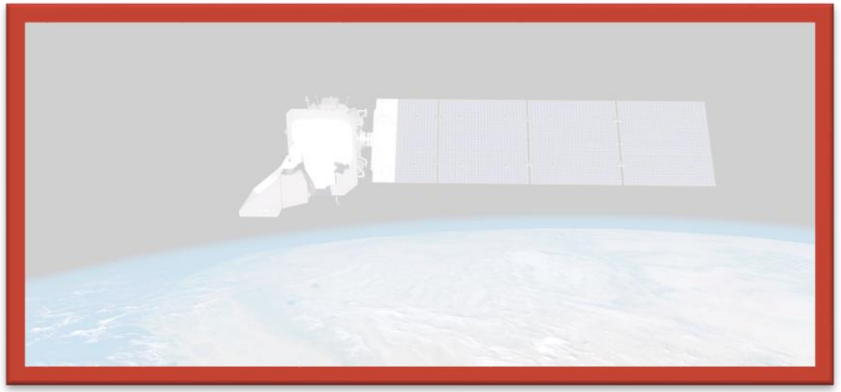
~58%

RESULTS – Soil Moisture as a Predictor

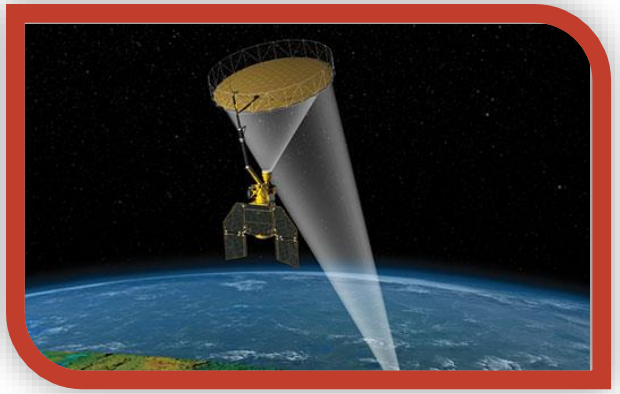
GPM



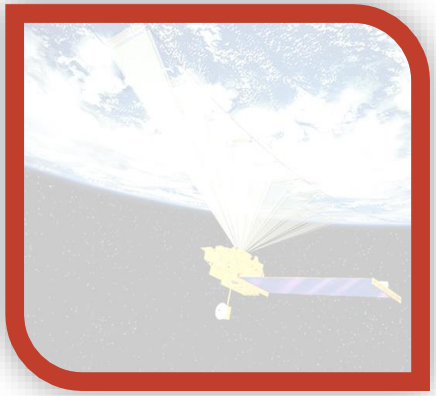
Landsat 9 OLI-2



SMAP



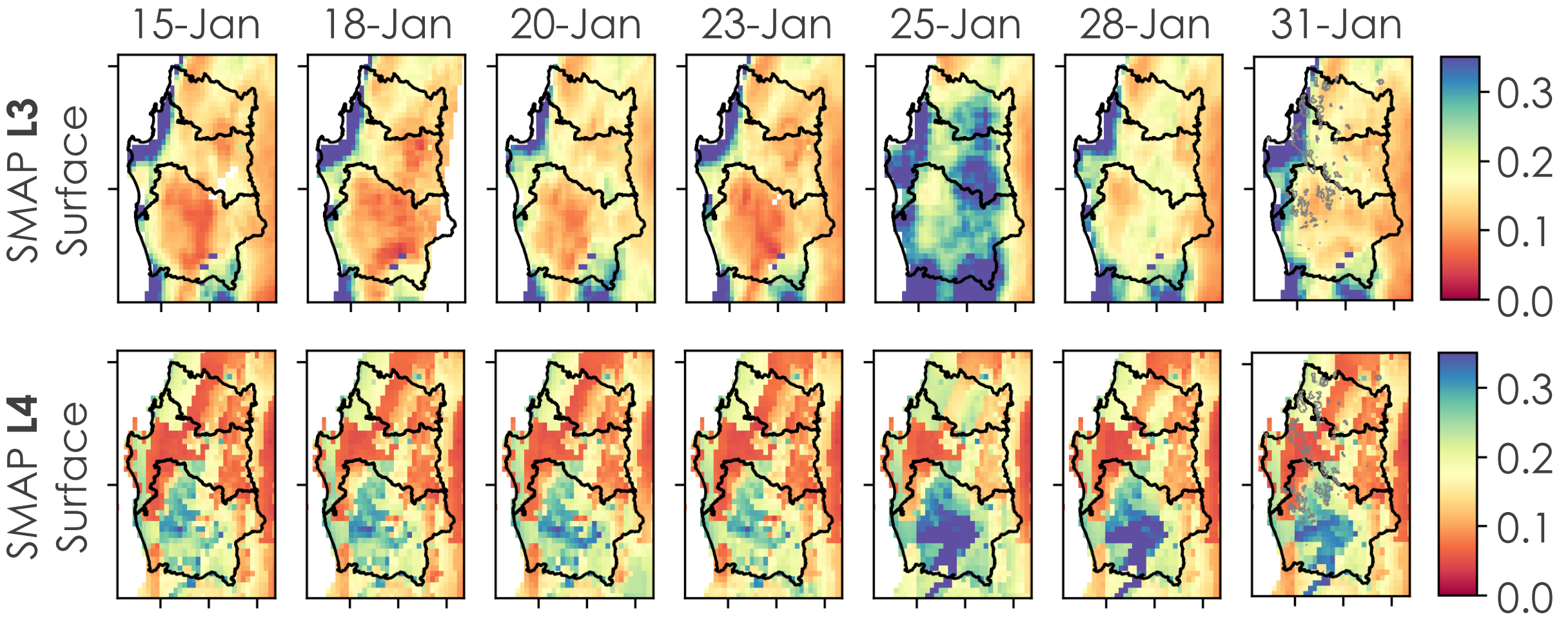
Terra MODIS



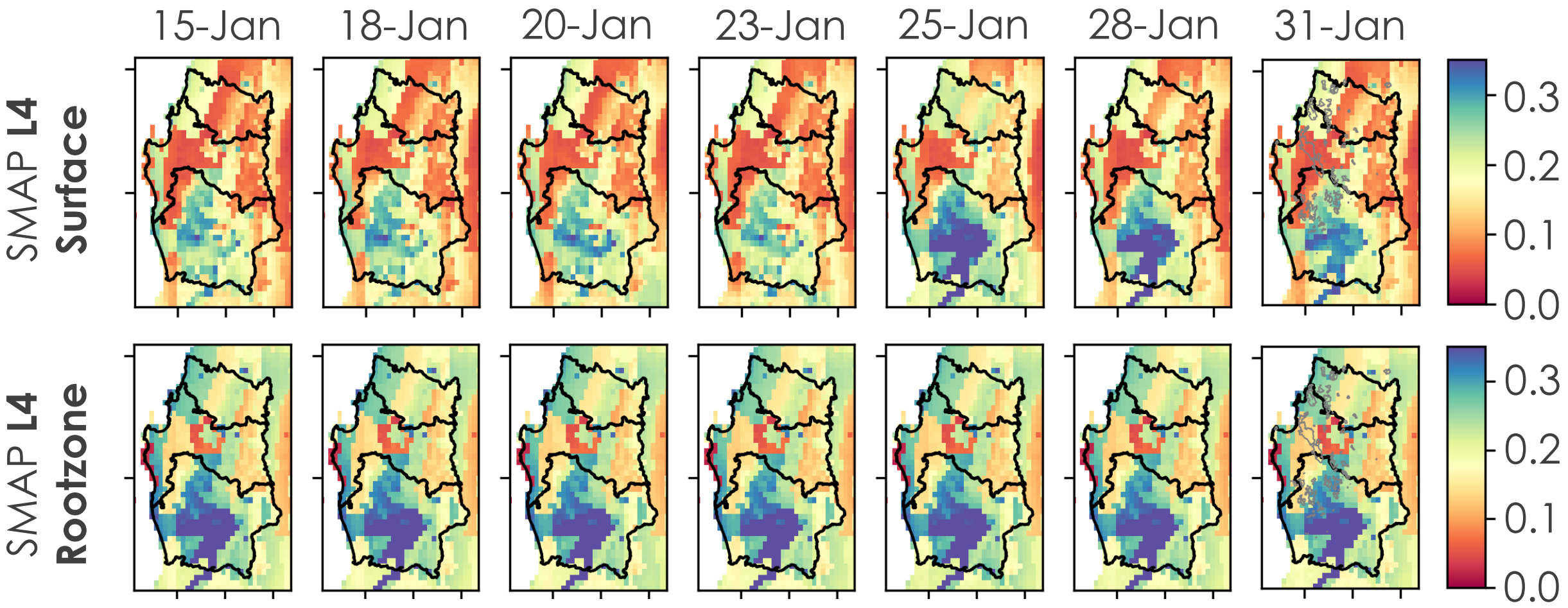
Aqua MODIS

Photo credit: NASA

RESULTS – Soil Moisture as a Predictor of Fire



RESULTS – Soil Moisture as a Predictor of Fire



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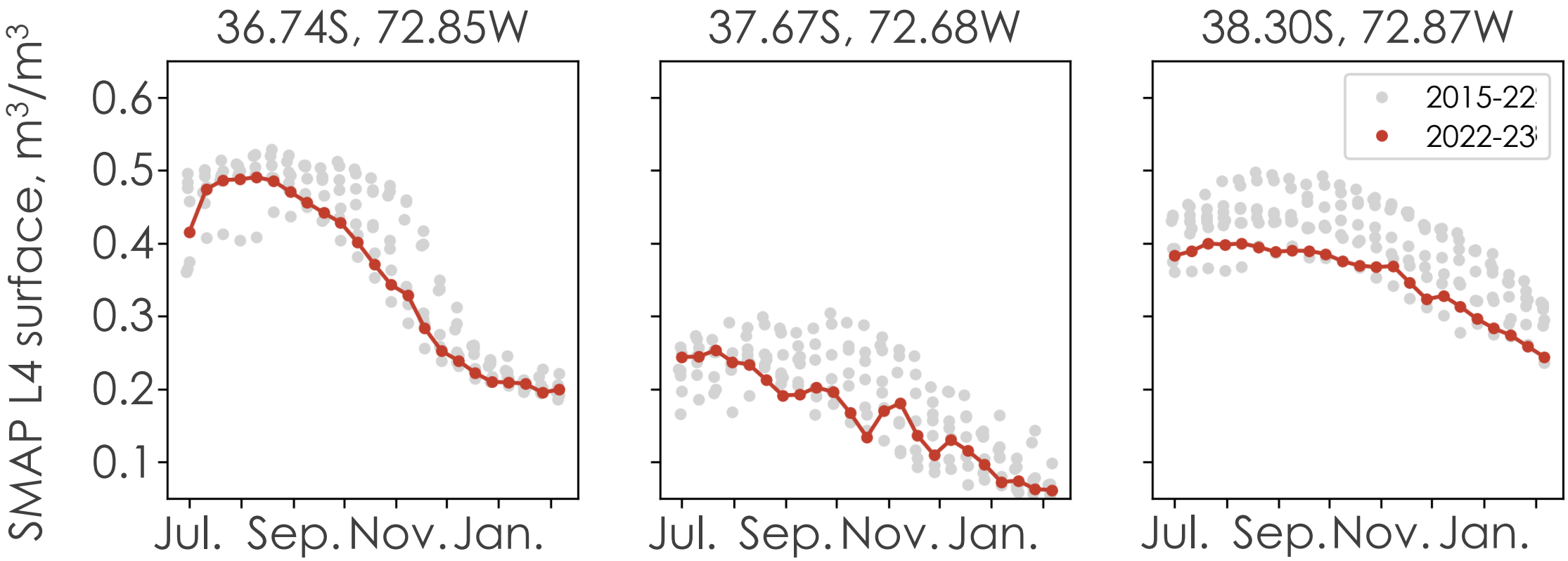
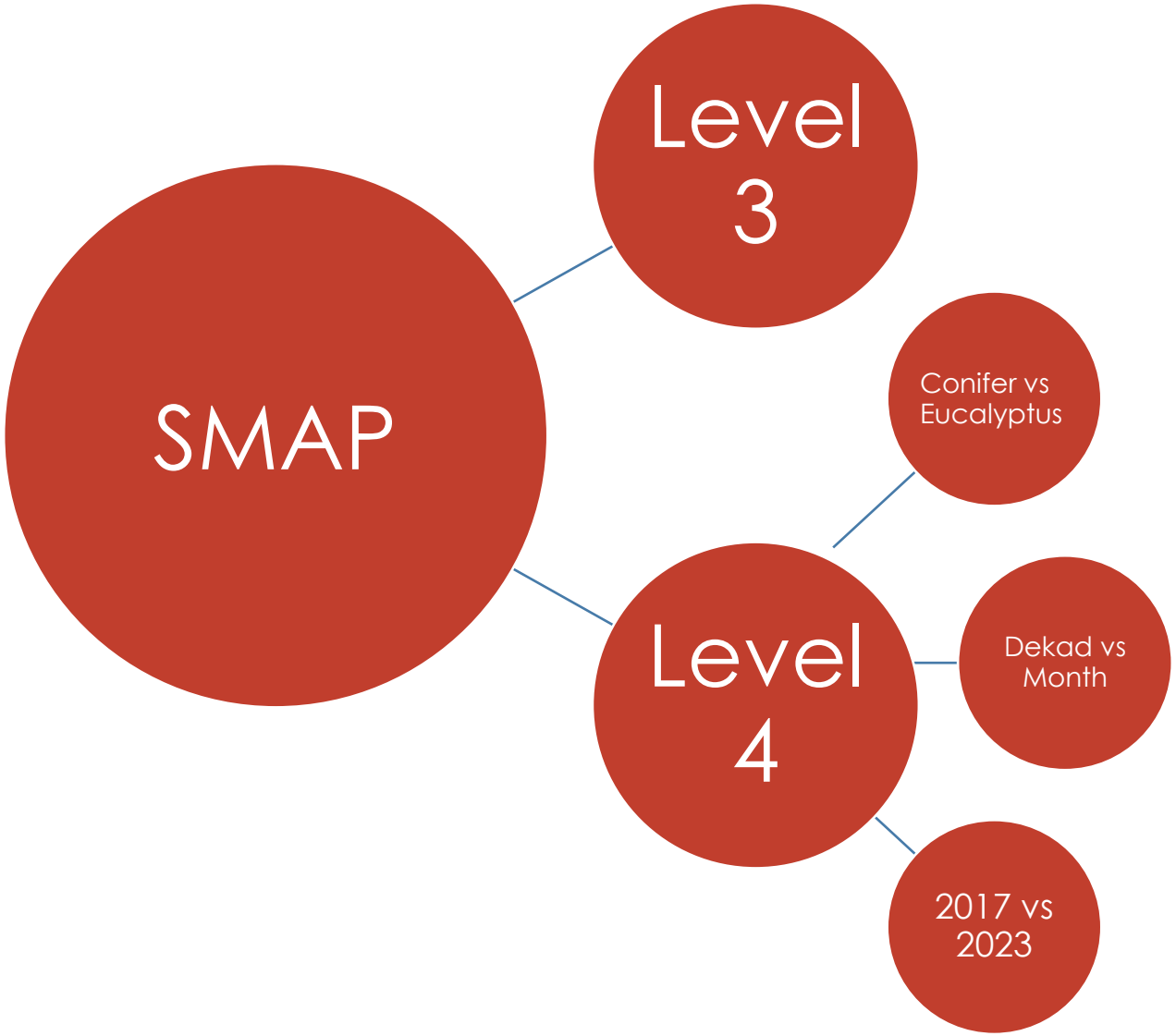
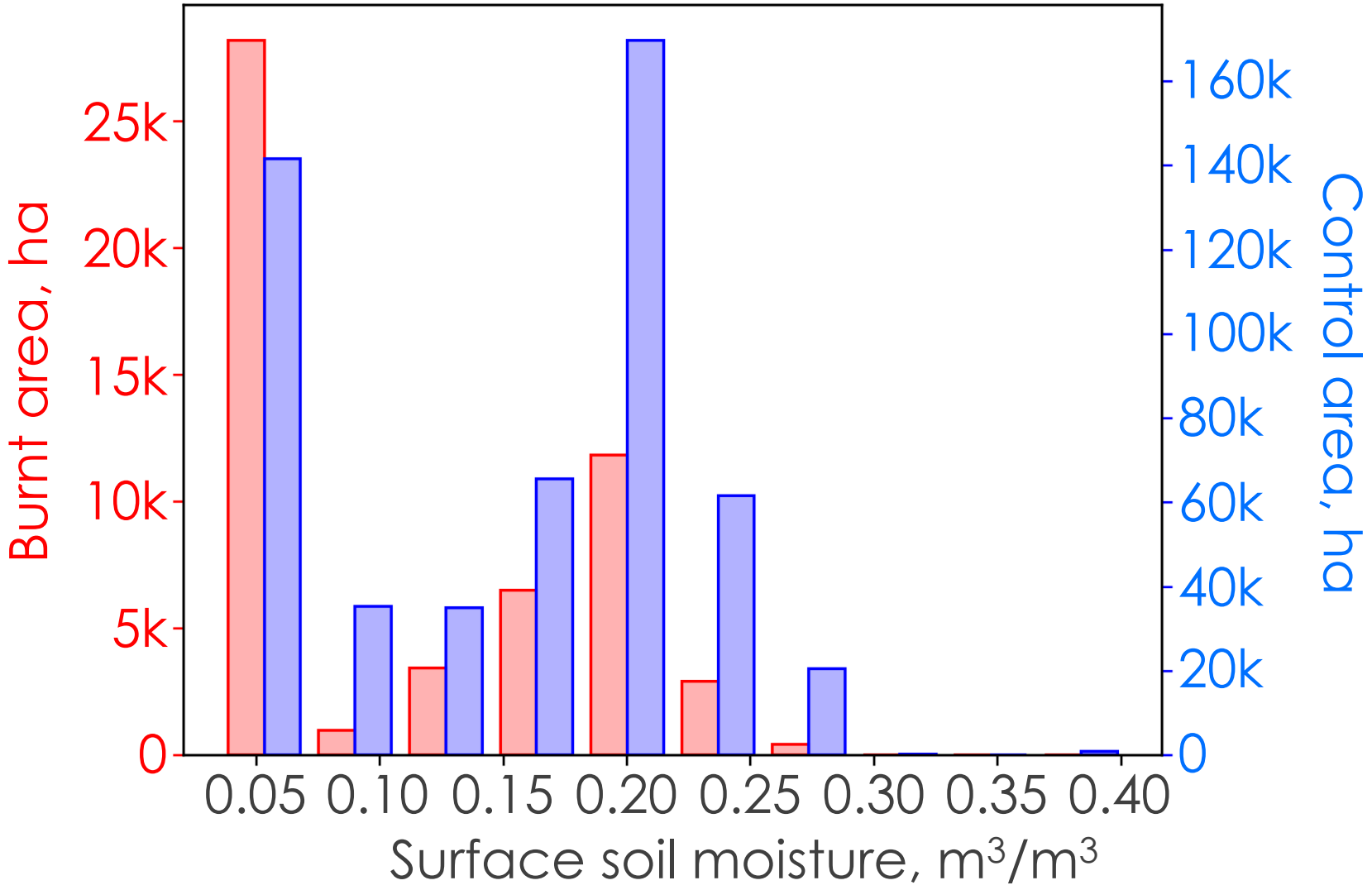


RESULTS – Soil Moisture as a Predictor of Fire



RESULTS – Soil Moisture as a Predictor of Fire



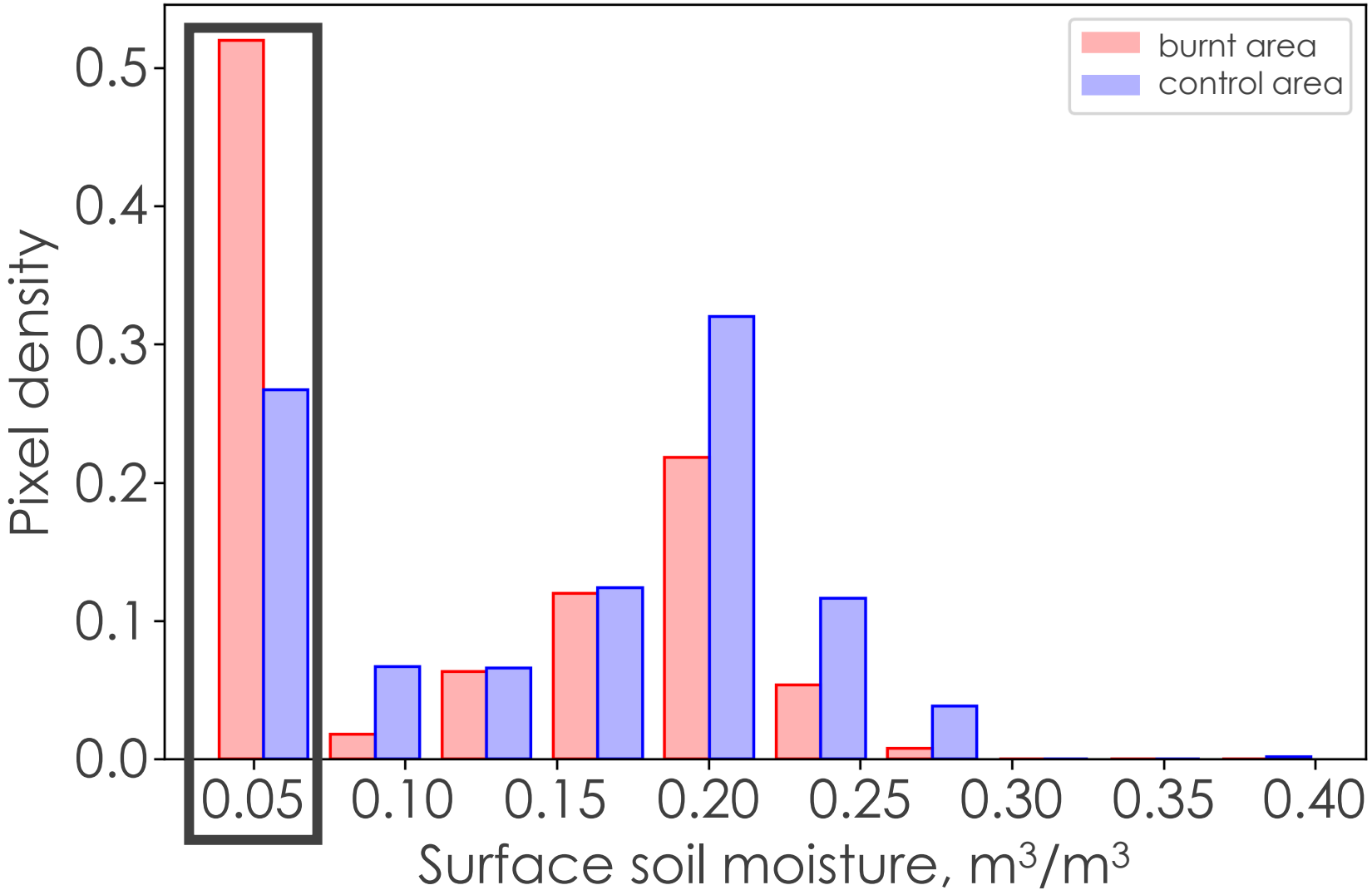
Variables:

- 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



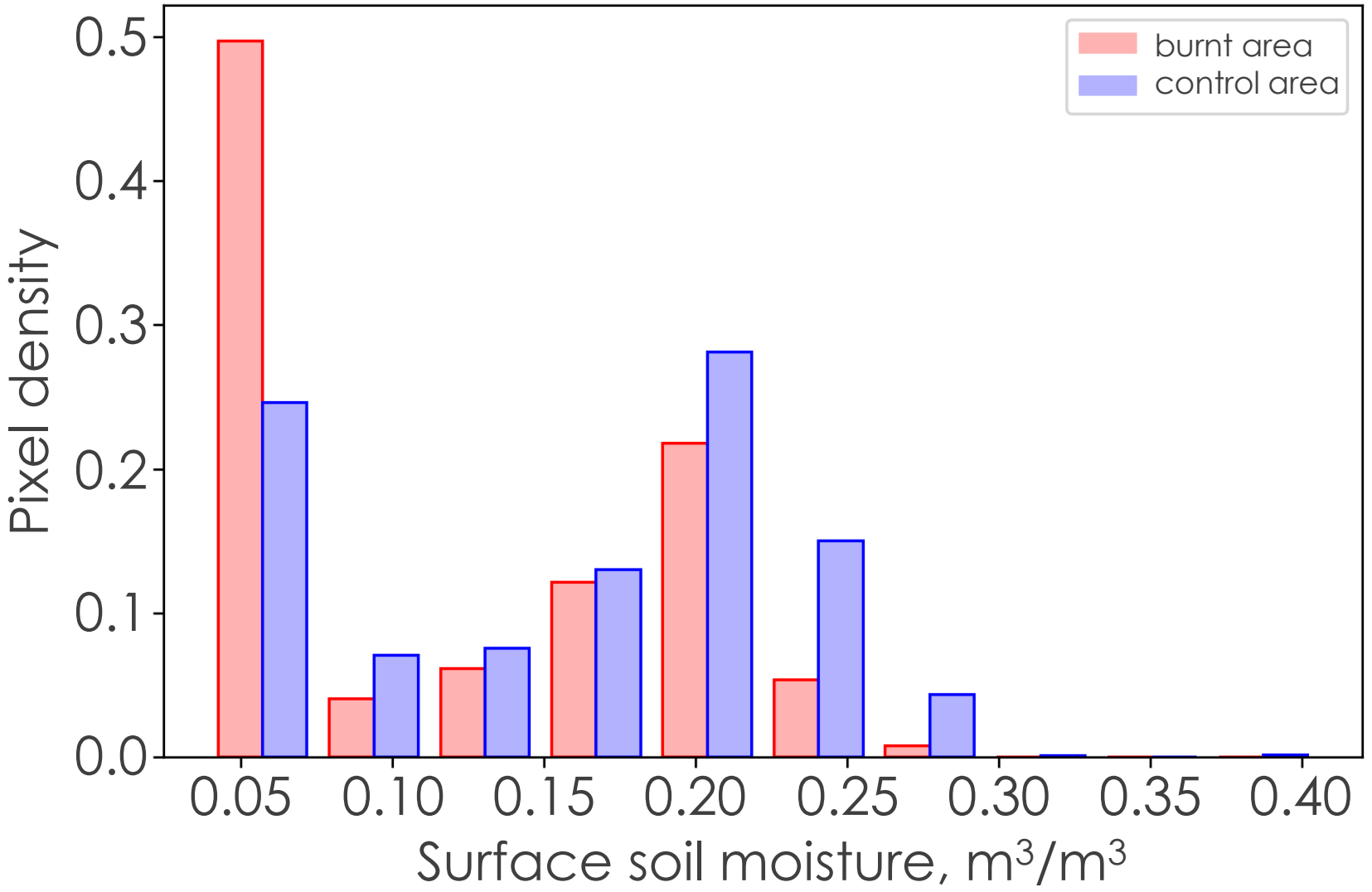
Variables:

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

Finding:

- ✓ Below 0.075 m^3/m^3,
- ✓ 52% of burned area
- ✓ 27% of control area

RESULTS – Soil Moisture as a Predictor of Fire



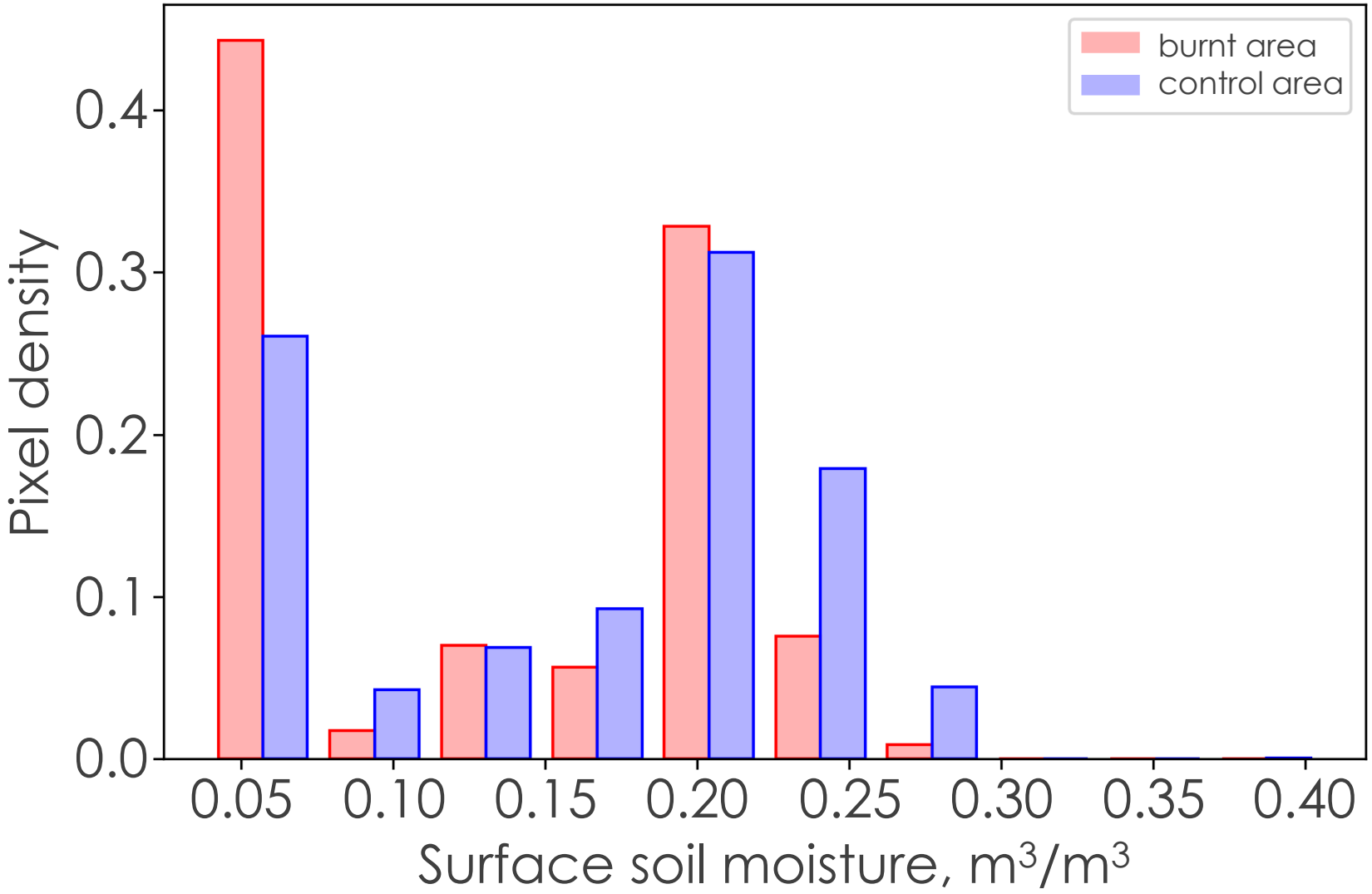
Variables:

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

Finding:

- ✓ Consistent across lead period

RESULTS – Soil Moisture as a Predictor of Fire



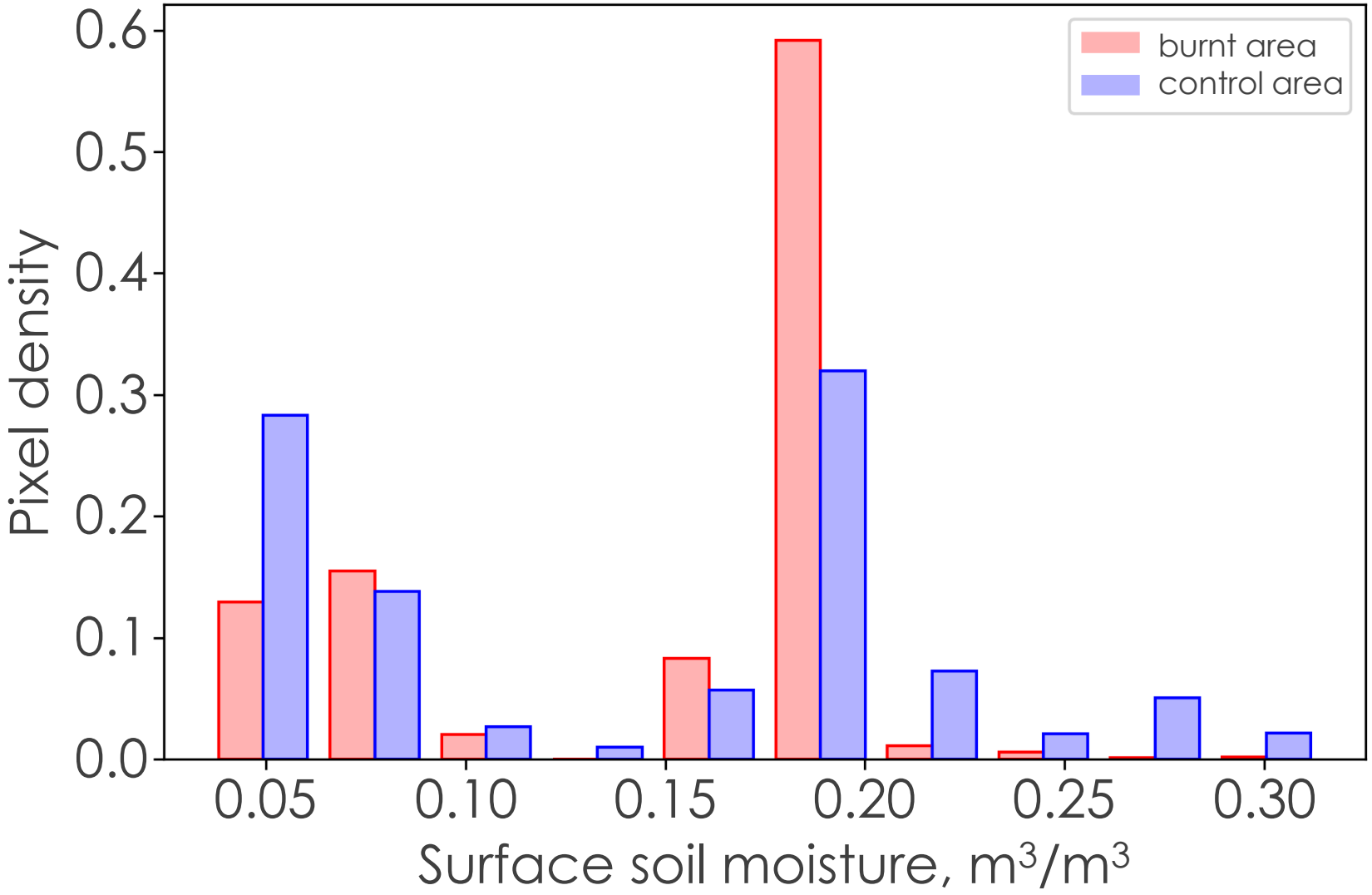
Variables:

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

Finding:

- ✓ Similar distribution across forest types

RESULTS – Soil Moisture as a Predictor of Fire



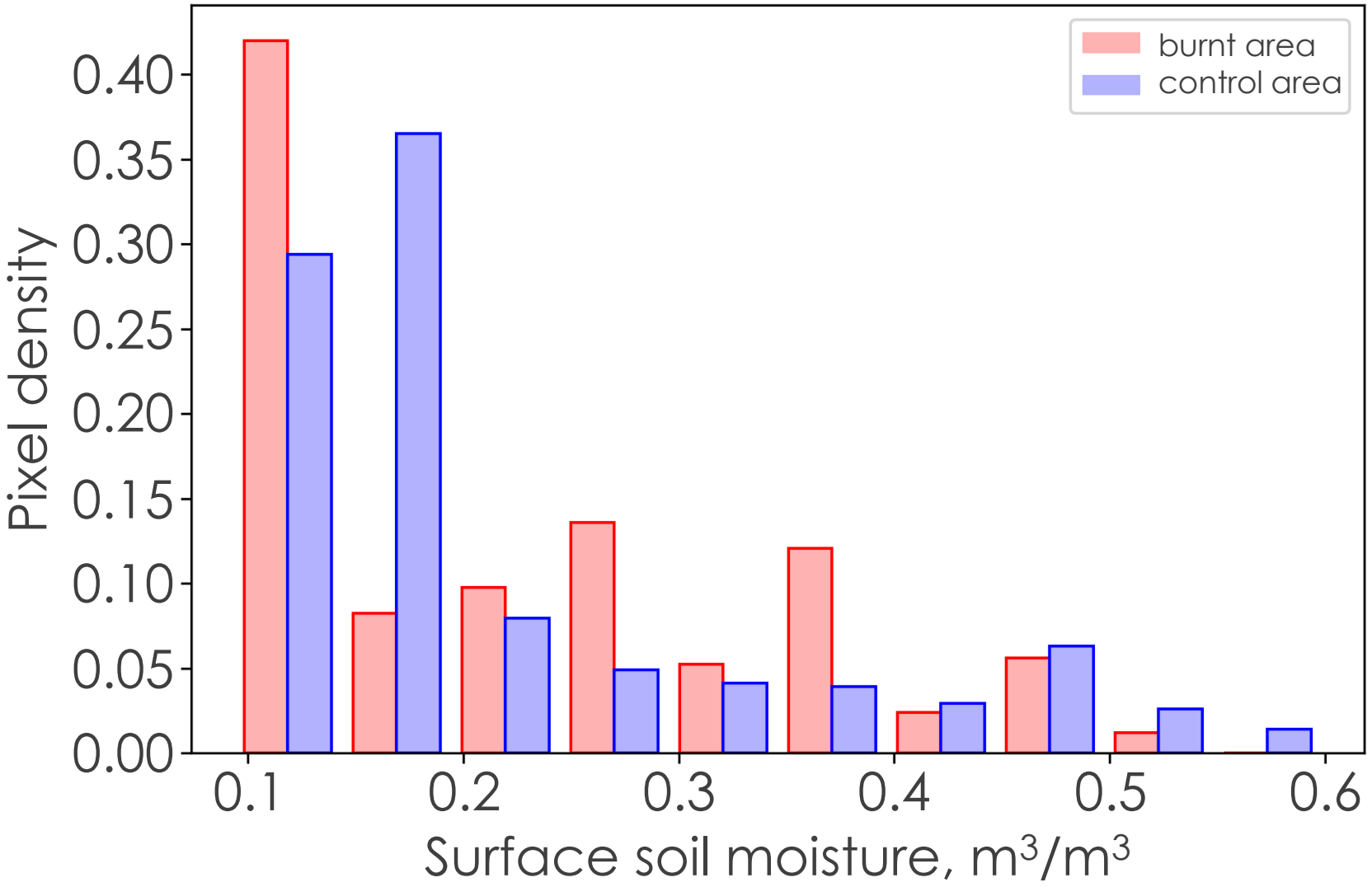
Variables:

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

Finding:

- ✓ Potentially different terrestrial conditions across fire events

RESULTS – Soil Moisture as a Predictor of Fire



Variables:

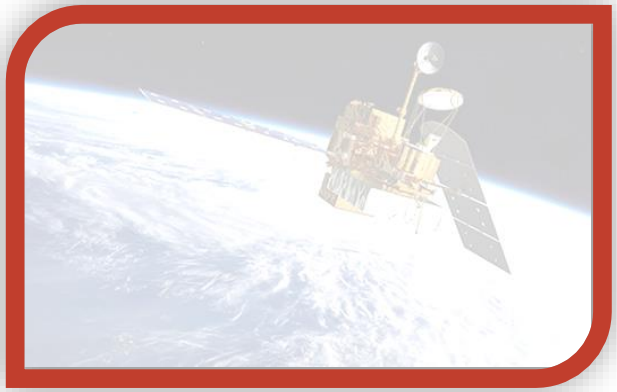
- **L3**, surface, **dekad**
- **Eucalyptus** plantation
- **2017** fire

Finding:

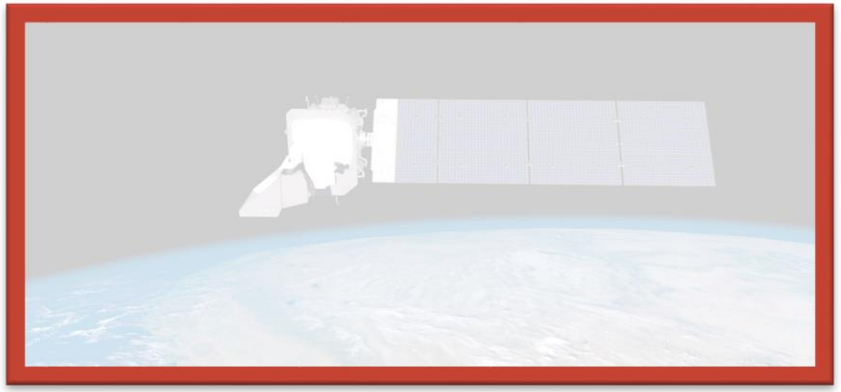
- ✓ Inconsistent values across dataset levels

RESULTS – Evapotranspiration as a Predictor

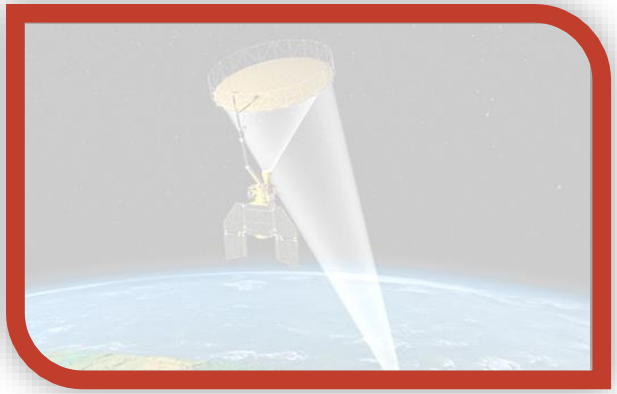
GPM



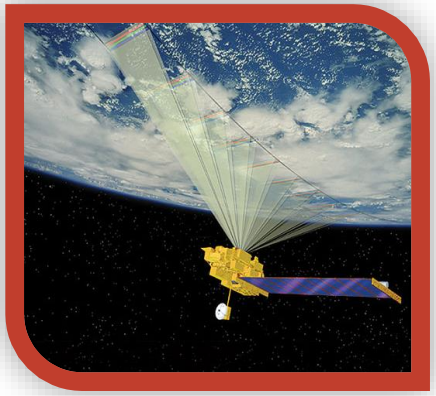
Landsat 9 OLI-2



SMAP



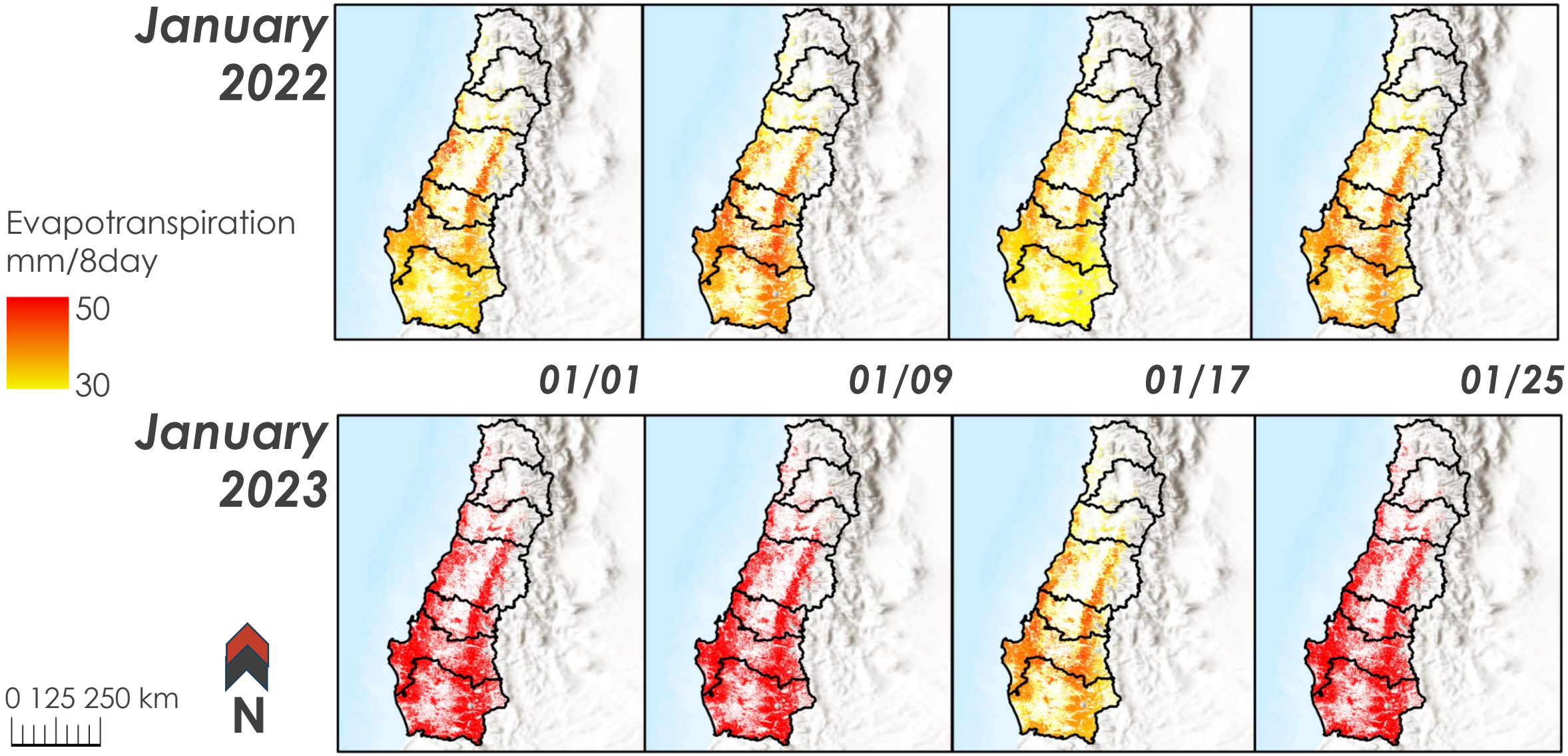
Terra MODIS



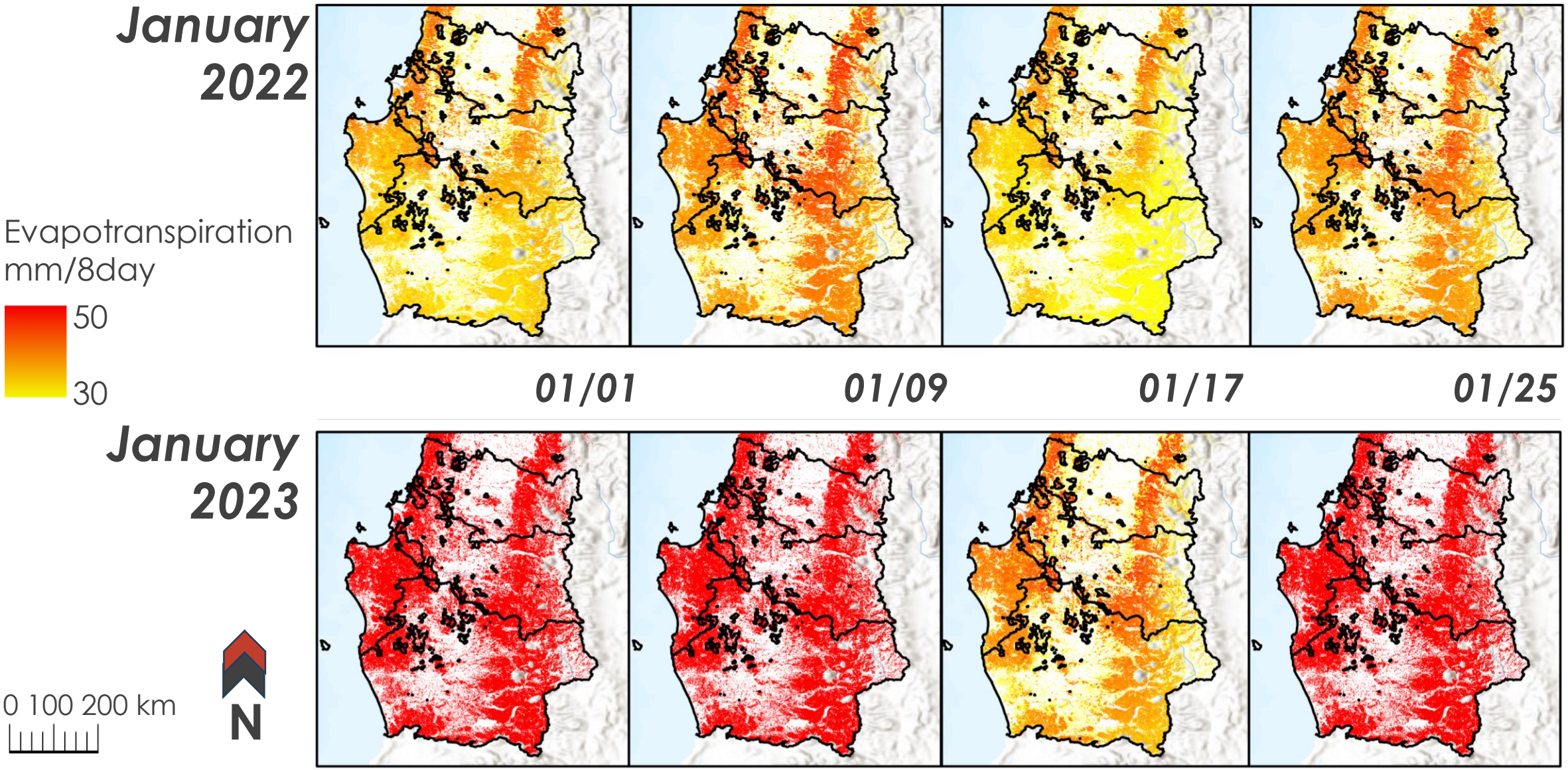
Aqua MODIS

Photo credit: NASA

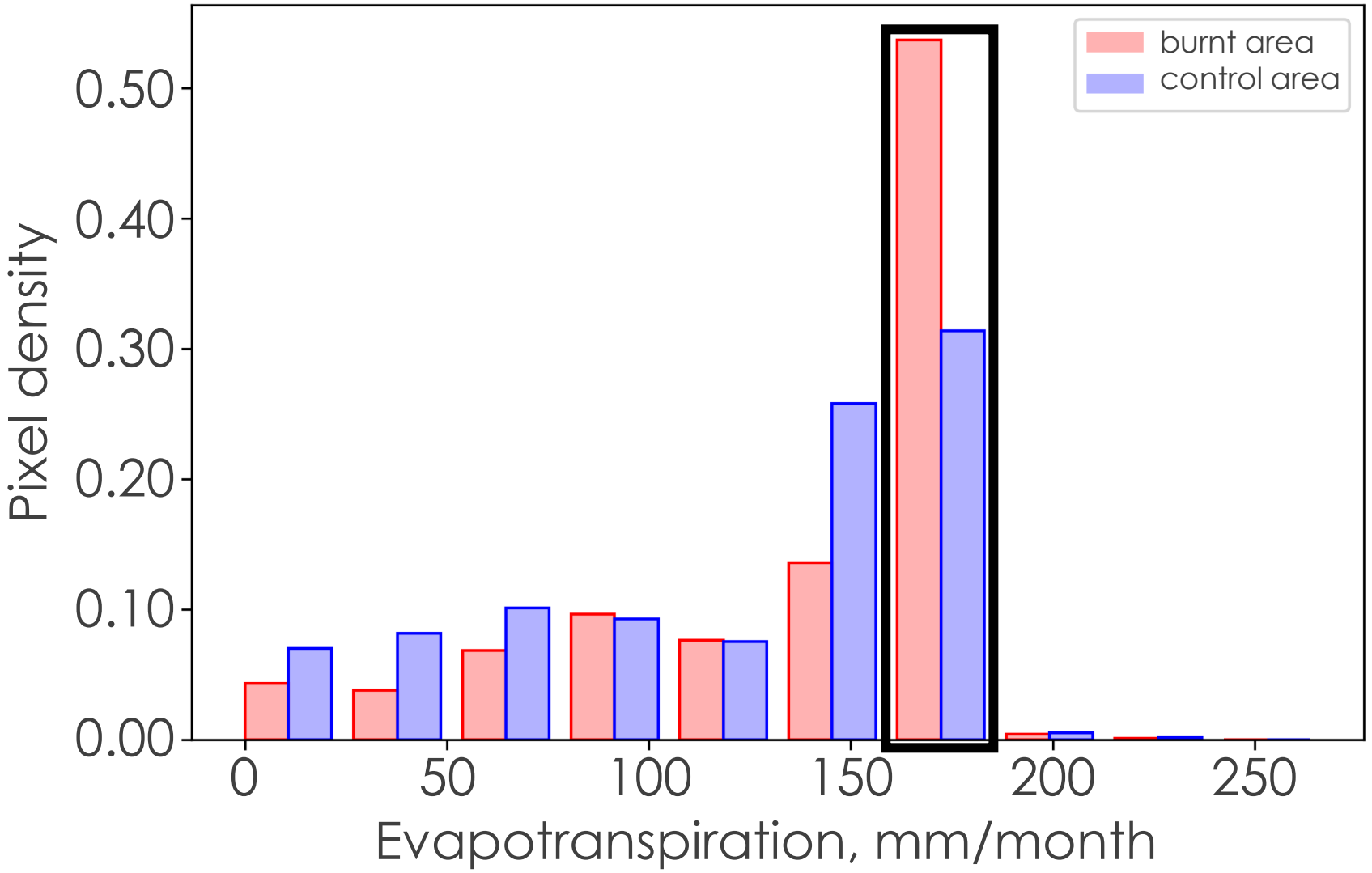
RESULTS – Evapotranspiration as a Predictor



RESULTS – Evapotranspiration as a Predictor



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 m^3/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

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Image Credit: CONAF

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