Changes in non-photosynthetic vegetation cover and liquid water thickness during California's record drought

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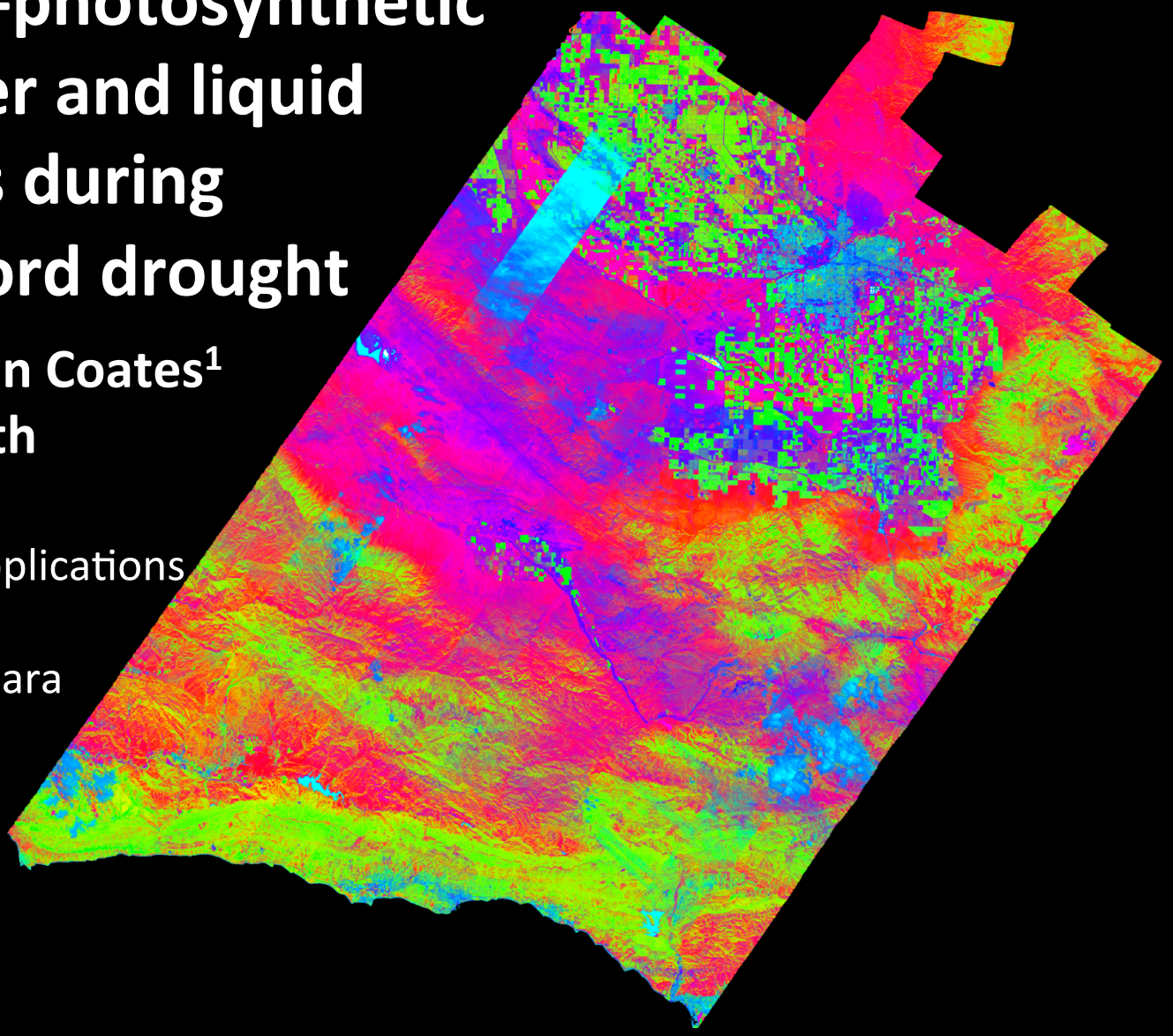


Drought

- Impacts on Ecosystems
  - Loss of hydraulic conductance/ dieback
  - Increased risk of fire and insect attack
  - Increased vegetation mortality
  - Decreased vegetation cover and changes in forage availability/ quality
  - Reduced primary productivity
  - Reduced carbon uptake
- Agricultural and Social Impacts
  - Irrigation & culinary water shortages
  - Decreased crop yields
  - Increased food costs
  - Huge economic costs (billions)

Chaparral dieback, Feb. 2014 (Steve Davis)

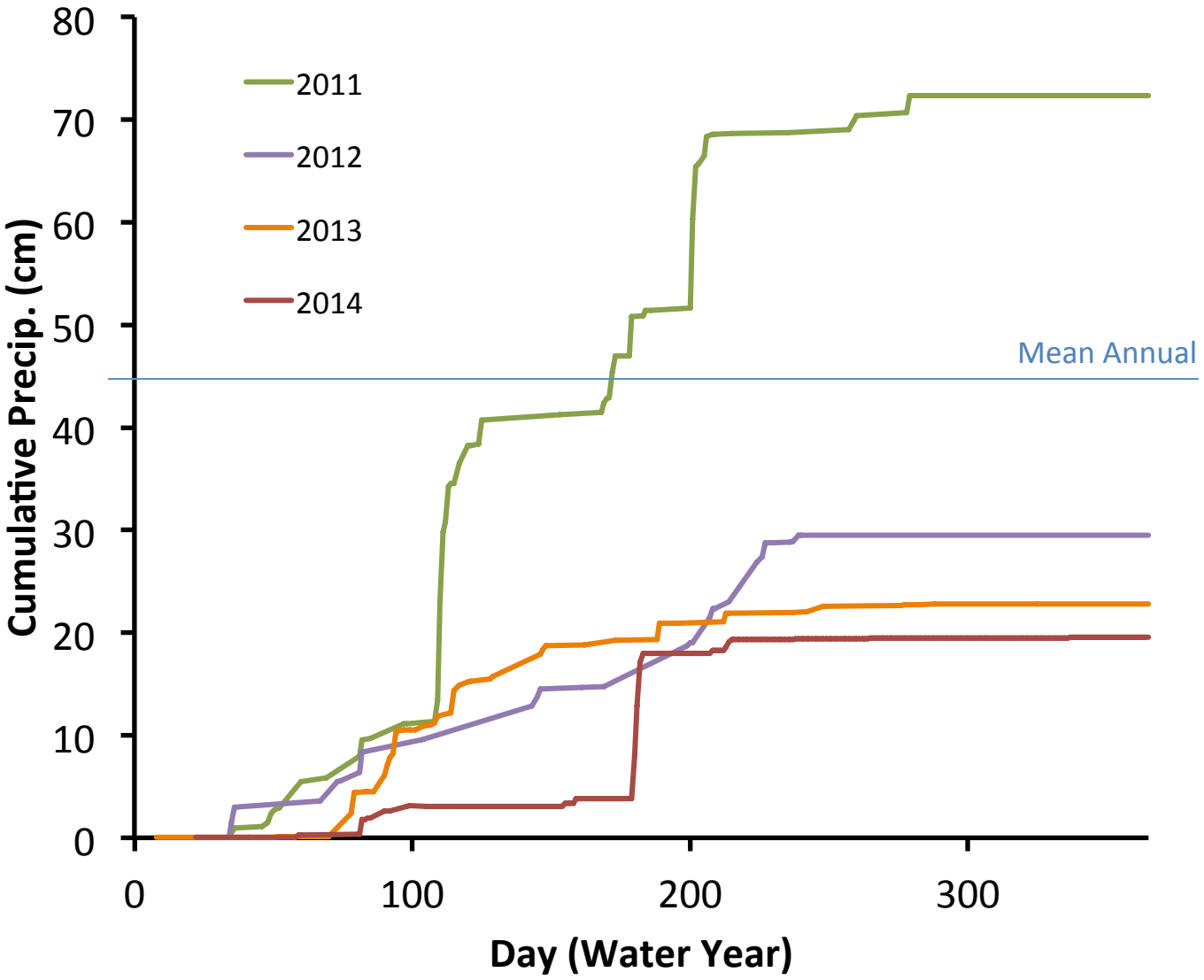
HyspIRI-Relevant Questions

- How does drought impact fractional cover of photosynthetic vegetation and non-photosynthetic vegetation (NPV)?
  - HyspIRI VSWIR data can easily resolve differences between NPV and soil
- How does drought impact canopy water content?
  - New three-phase atmospheric correction provides a standard liquid water thickness product
- How do changes in vegetation fractional cover and liquid water thickness vary by species/plant functional type?
  - HyspIRI VSWIR data can be used to map dominant species and PFTs
- How do changes in fractional cover and transpiration drive changes in land surface temperature?
  - Complementary abilities of HyspIRI VSWIR and TIR

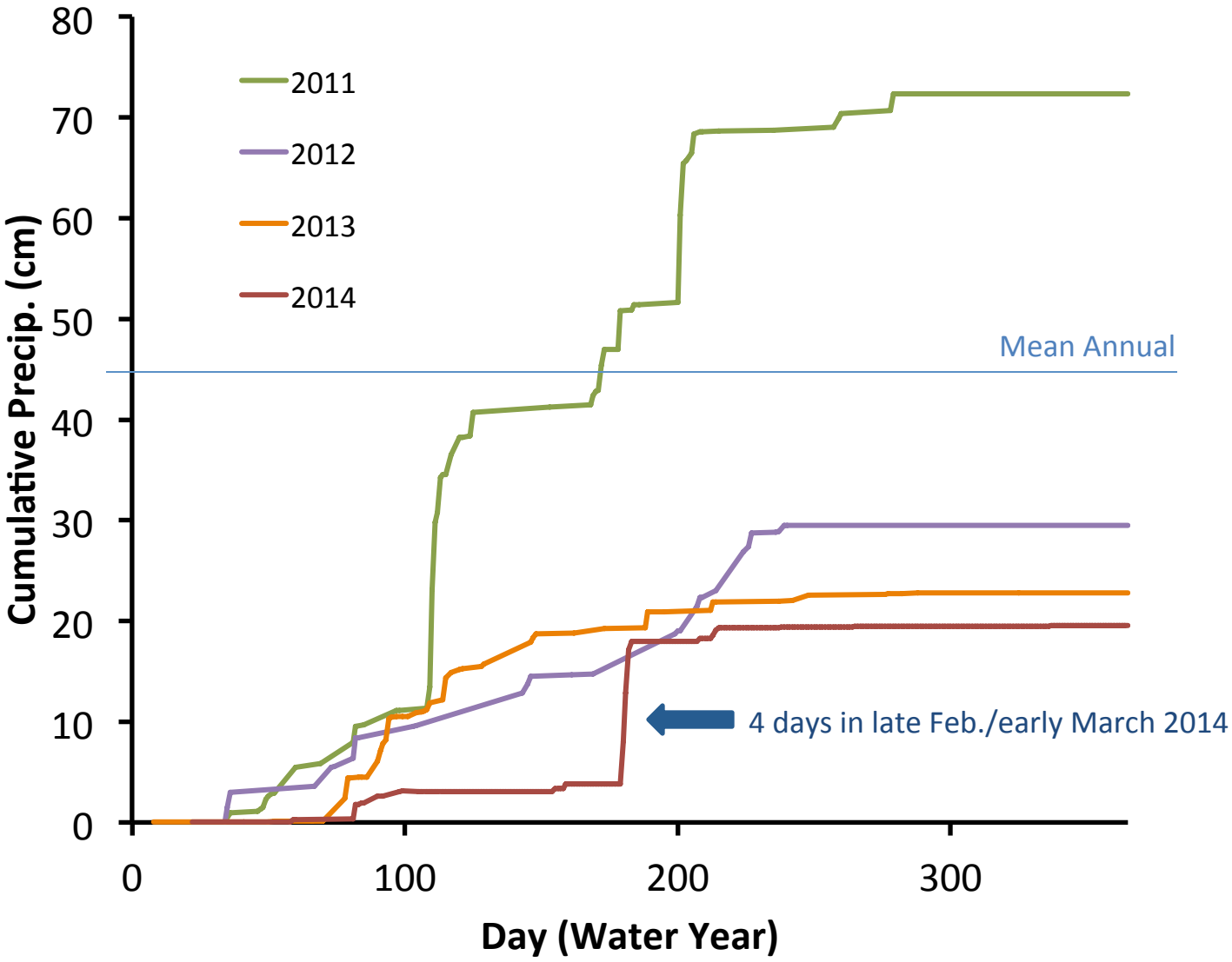
Driest Three-Year Periods, 1900-2014, Santa Barbara, California

Water Years	3-year Precip. (cm)
2012-2014	72.8
1959-1961	76.1
1988-1990	76.7
1947-1949	85.3
1948-1950	86.8
1987-1989	87.3
1946-1948	87.4
1989-1991	87.6
1970-1972	87.7
1949-1951	89.9
Median (1900-2014)	134.7

Santa Barbara Cumulative Precipitation

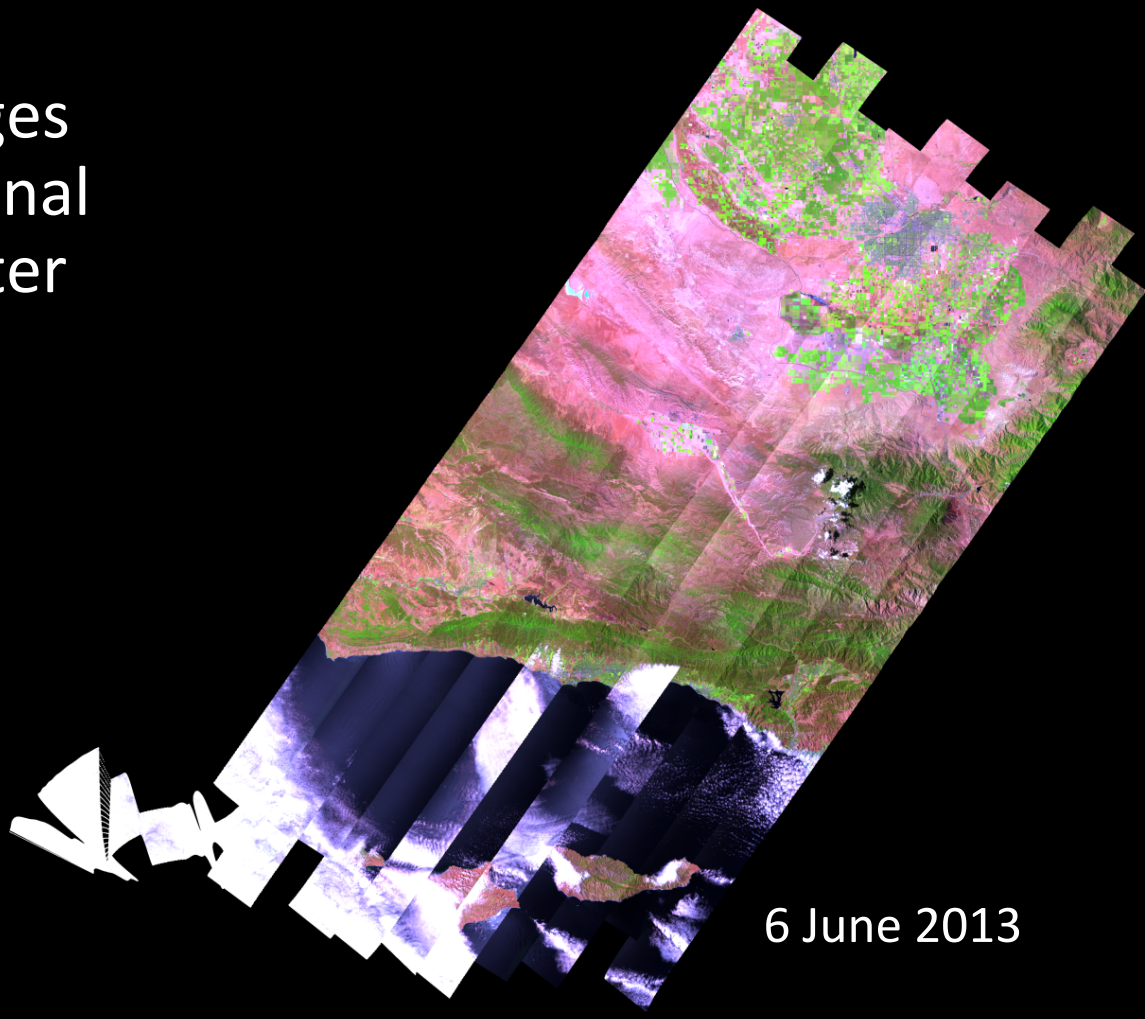


Santa Barbara Cumulative Precipitation



Methods

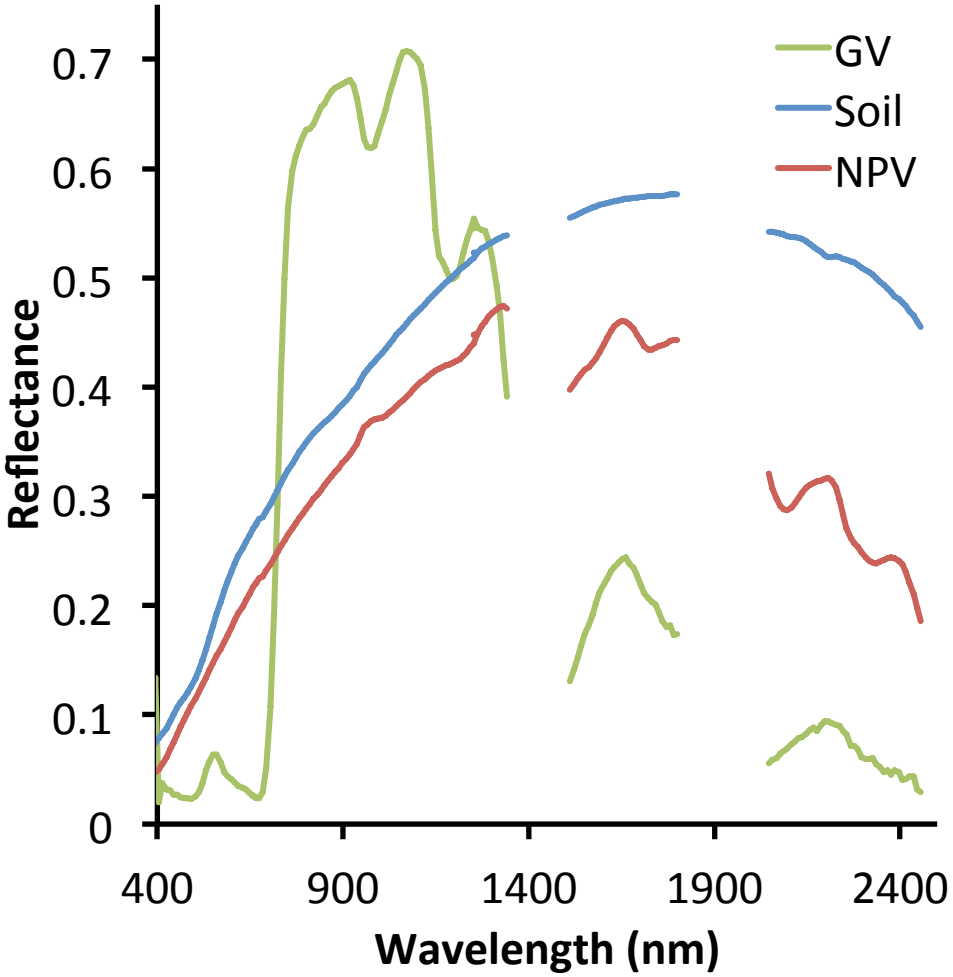
- We examined changes in vegetation fractional cover and liquid water thickness
- HyspIRI Preparatory Campaign data collected in:
  - April 2013
  - June 2013
  - Nov. 2013
  - April 2014



6 June 2013

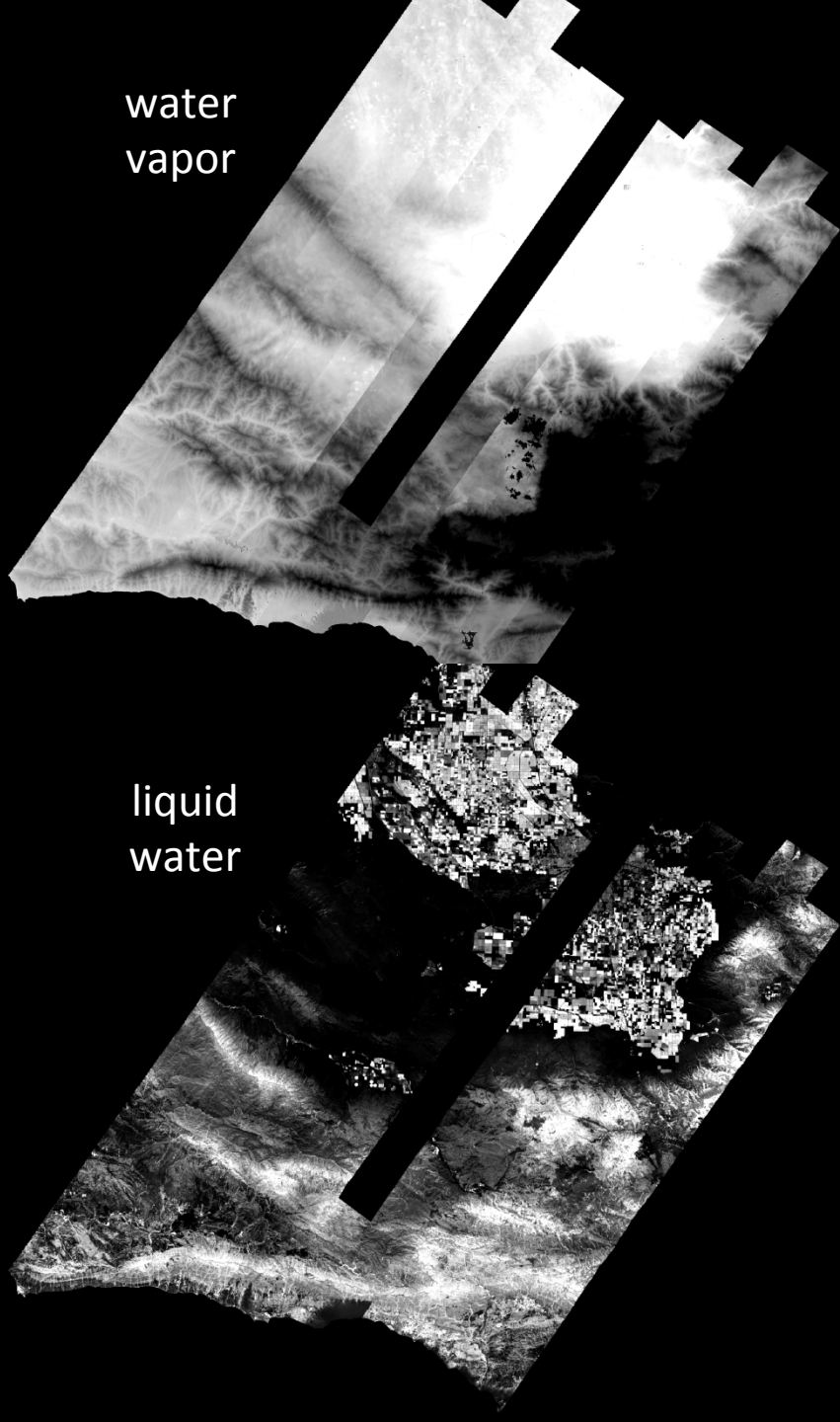
Spectral Mixture Analysis

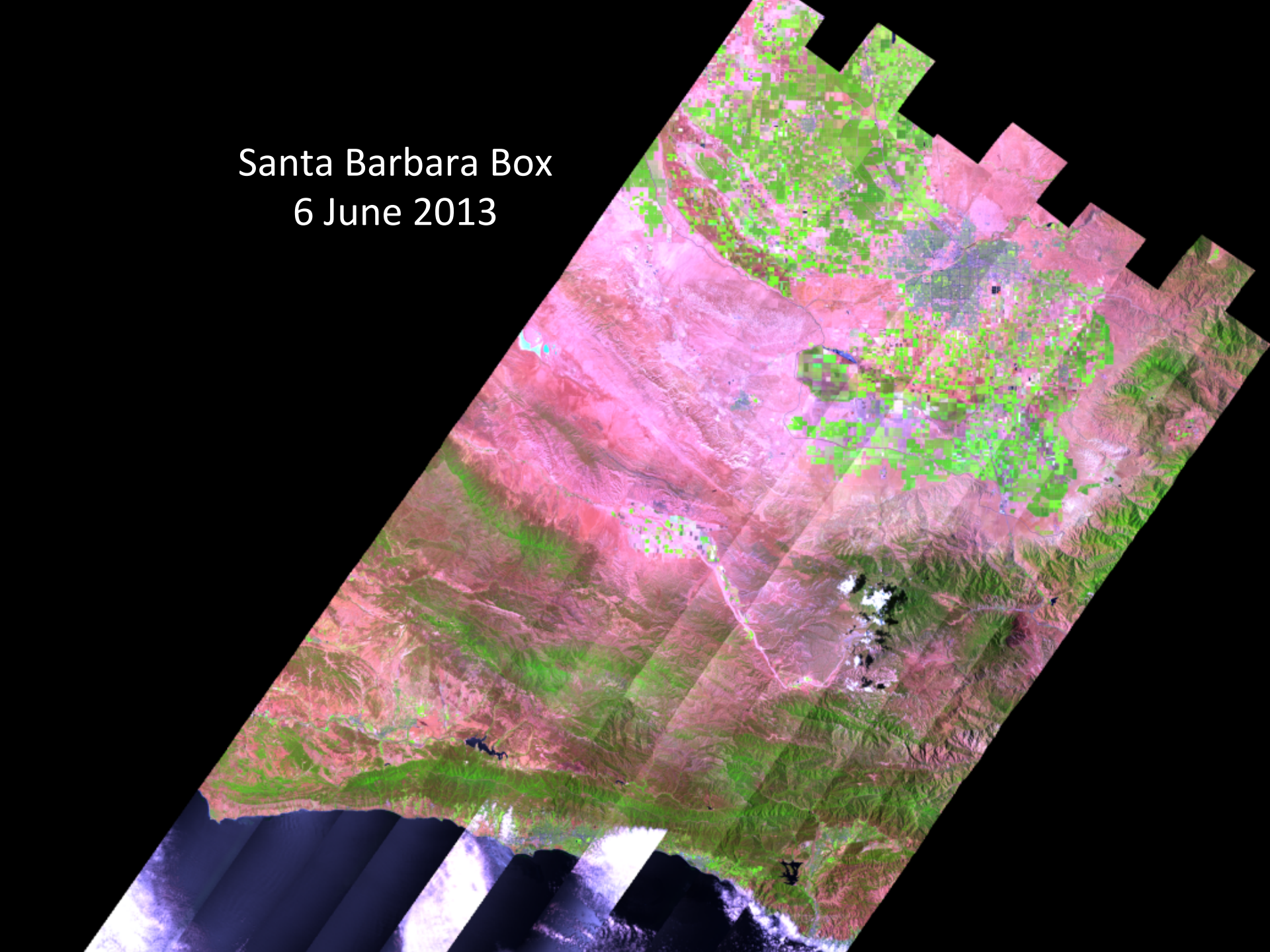
- Spectral mixture analysis models each pixel as a linear mixture of endmember spectra
  - Green (photosynthetic) vegetation
  - Non-photosynthetic vegetation
  - Soil
  - Shade
- Lab spectra were used to find endmembers from a multi-temporal spectral library of AVIRIS image spectra
- Selection was based on RMSE for modeling library, brightness
- GV, NPV, and soil fractions were shade normalized

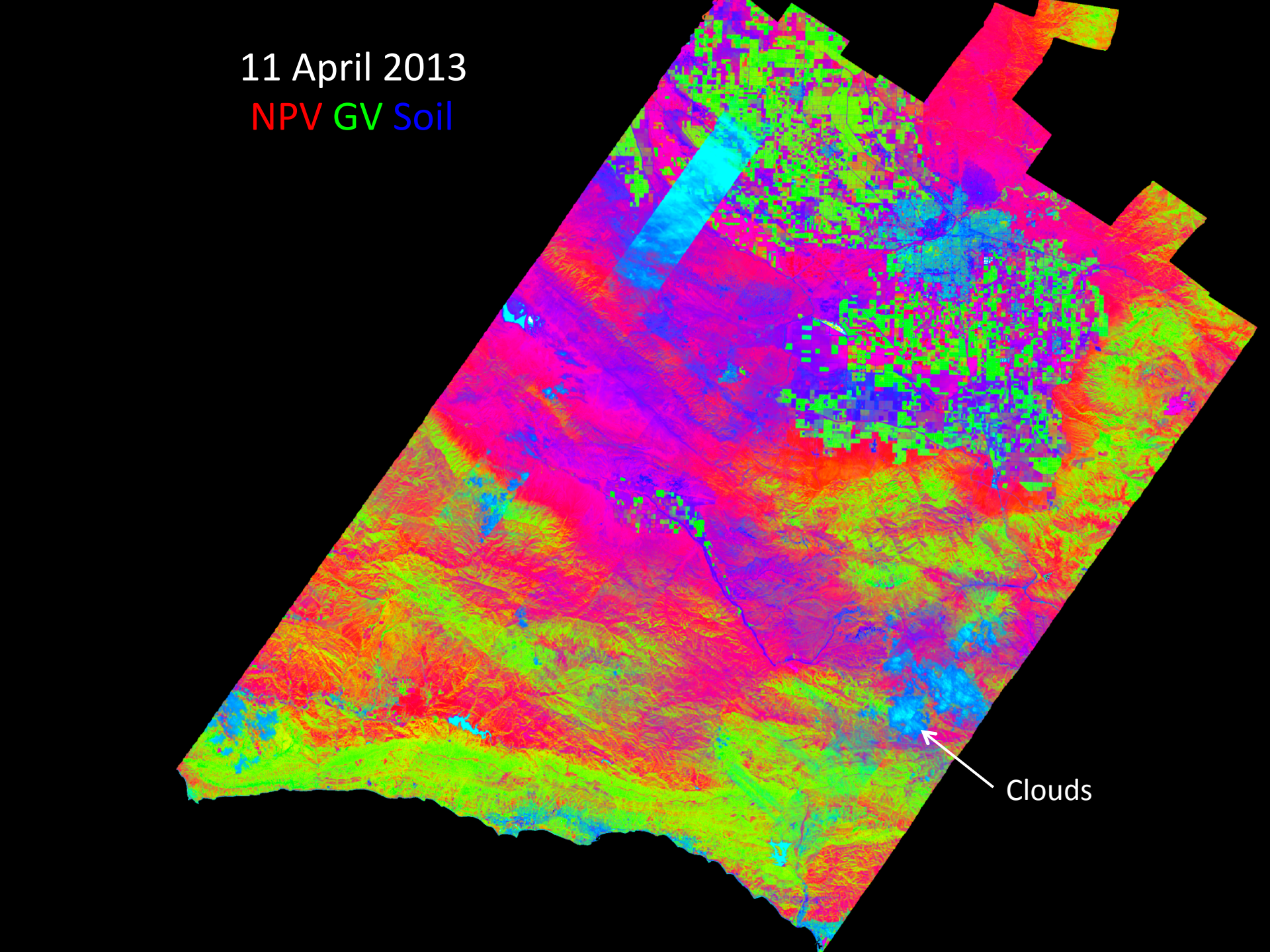


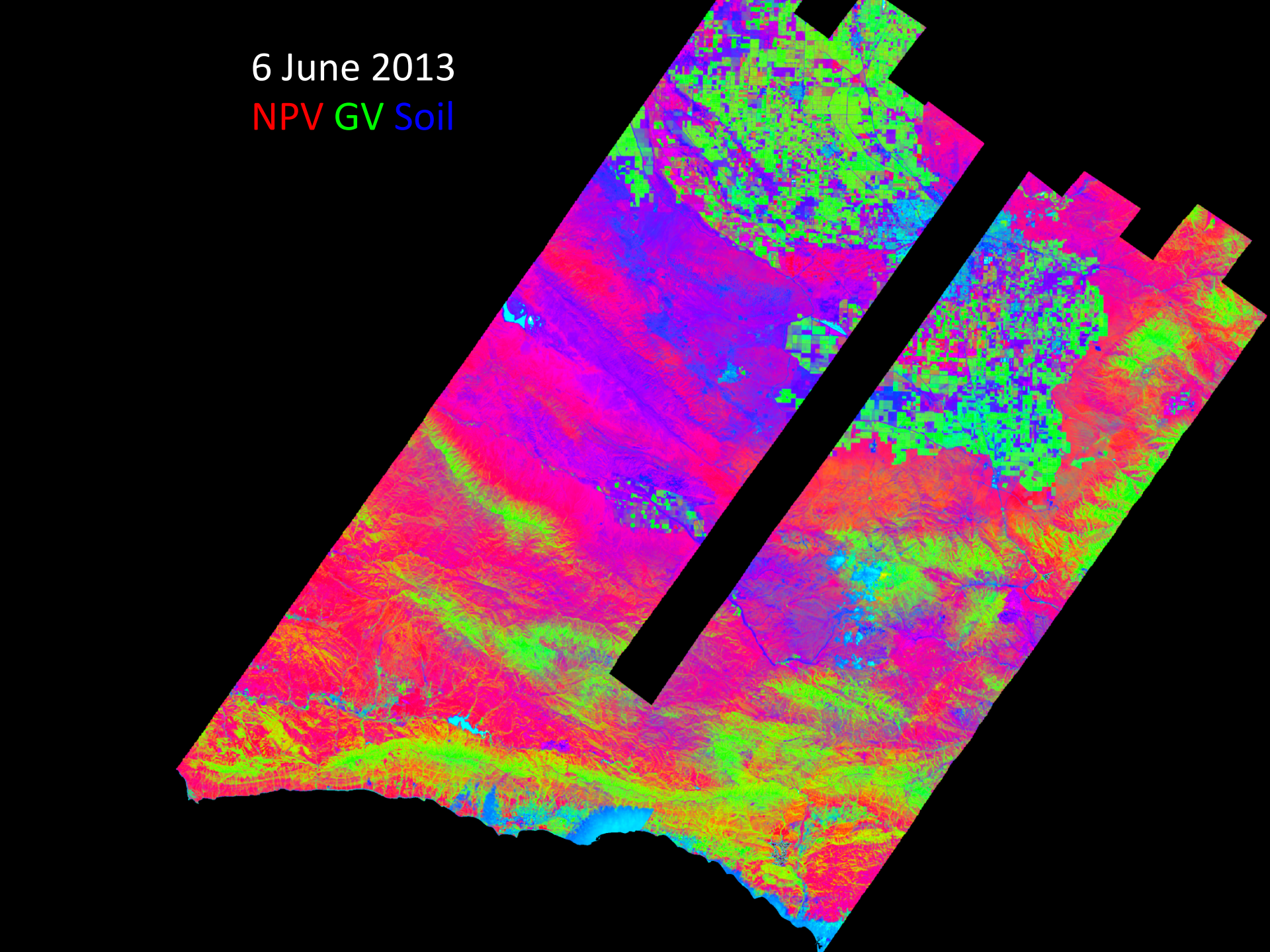
Liquid Water Thickness

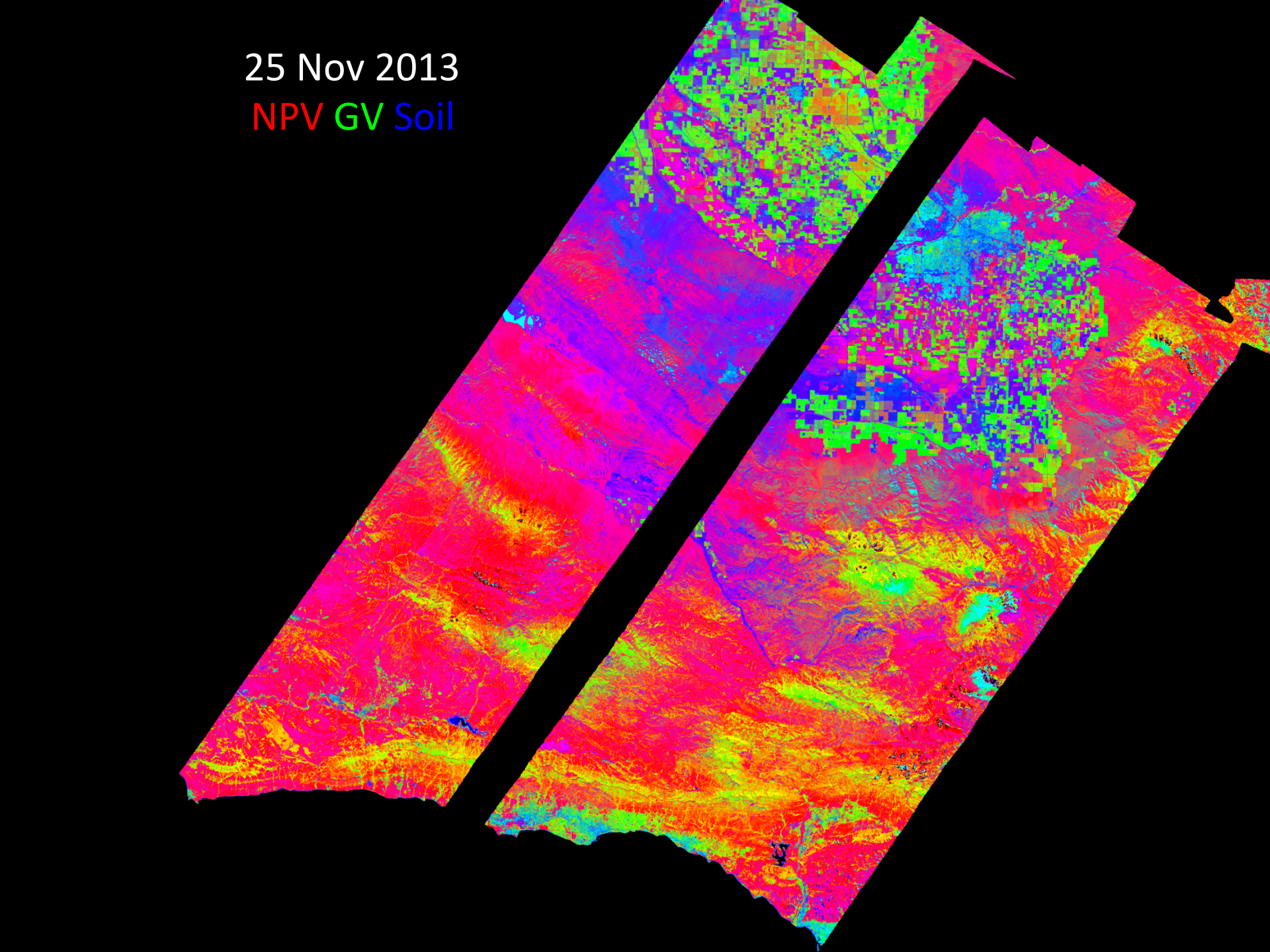
- ATREM-based atmospheric correction for AVIRIS-C (Thompson, Gao, et al.)
- Water vapor correction is improved by estimating column absorption by all three phases of water
  - Water vapor
  - Liquid water
  - Ice
- Liquid water thickness retrieved by three-phase algorithm provides a measure of canopy water content

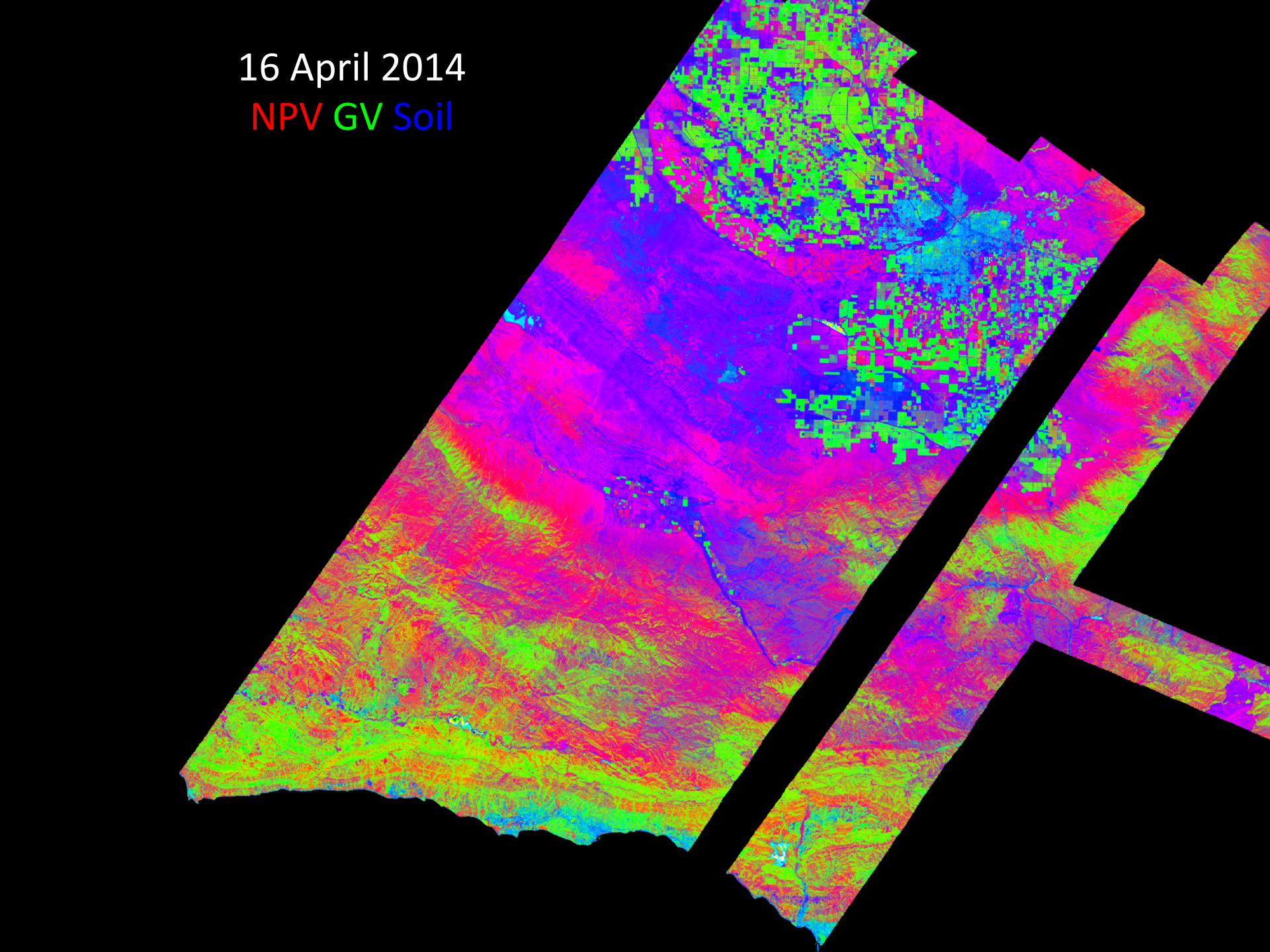


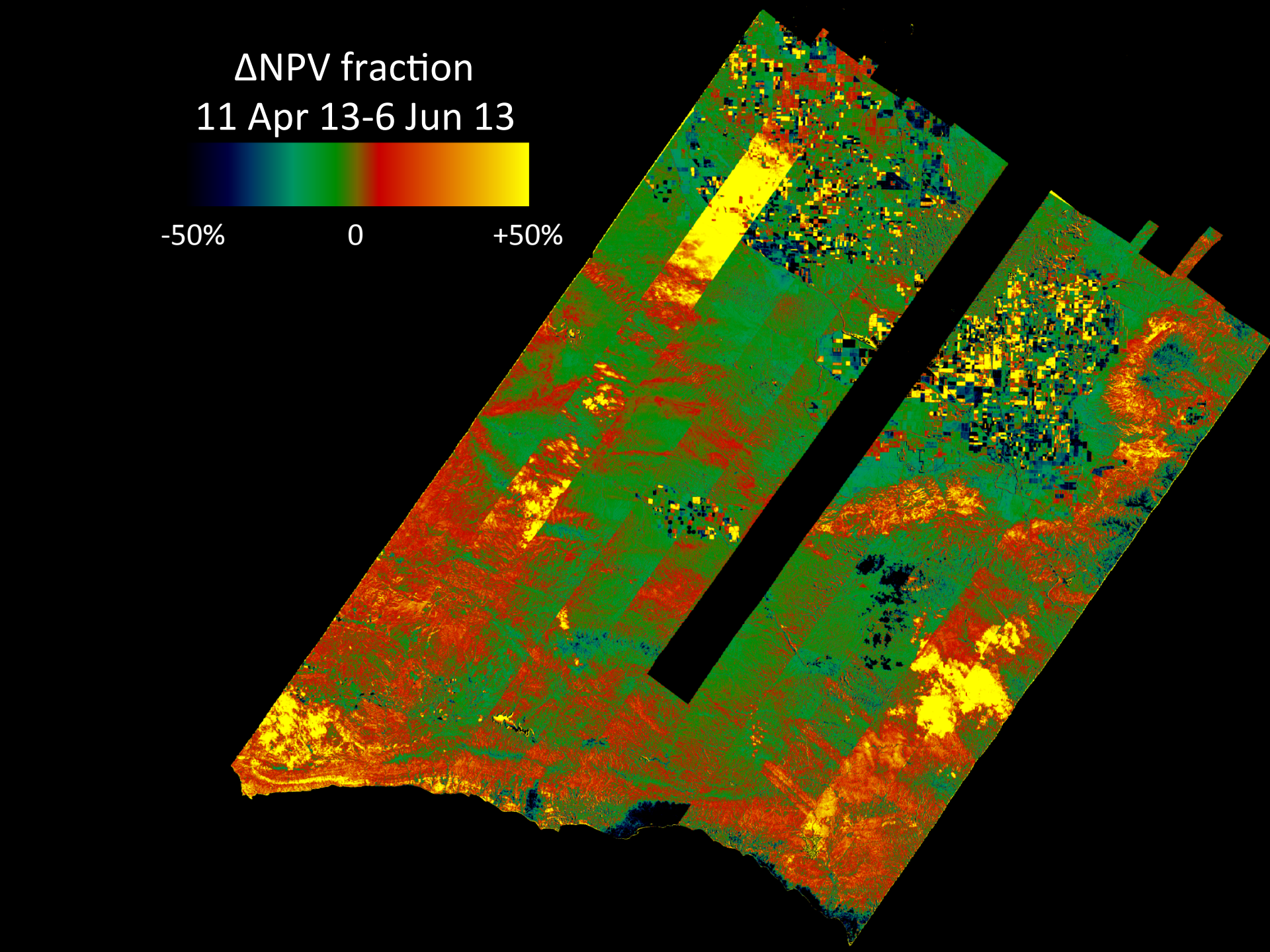

Santa Barbara Box
6 June 2013

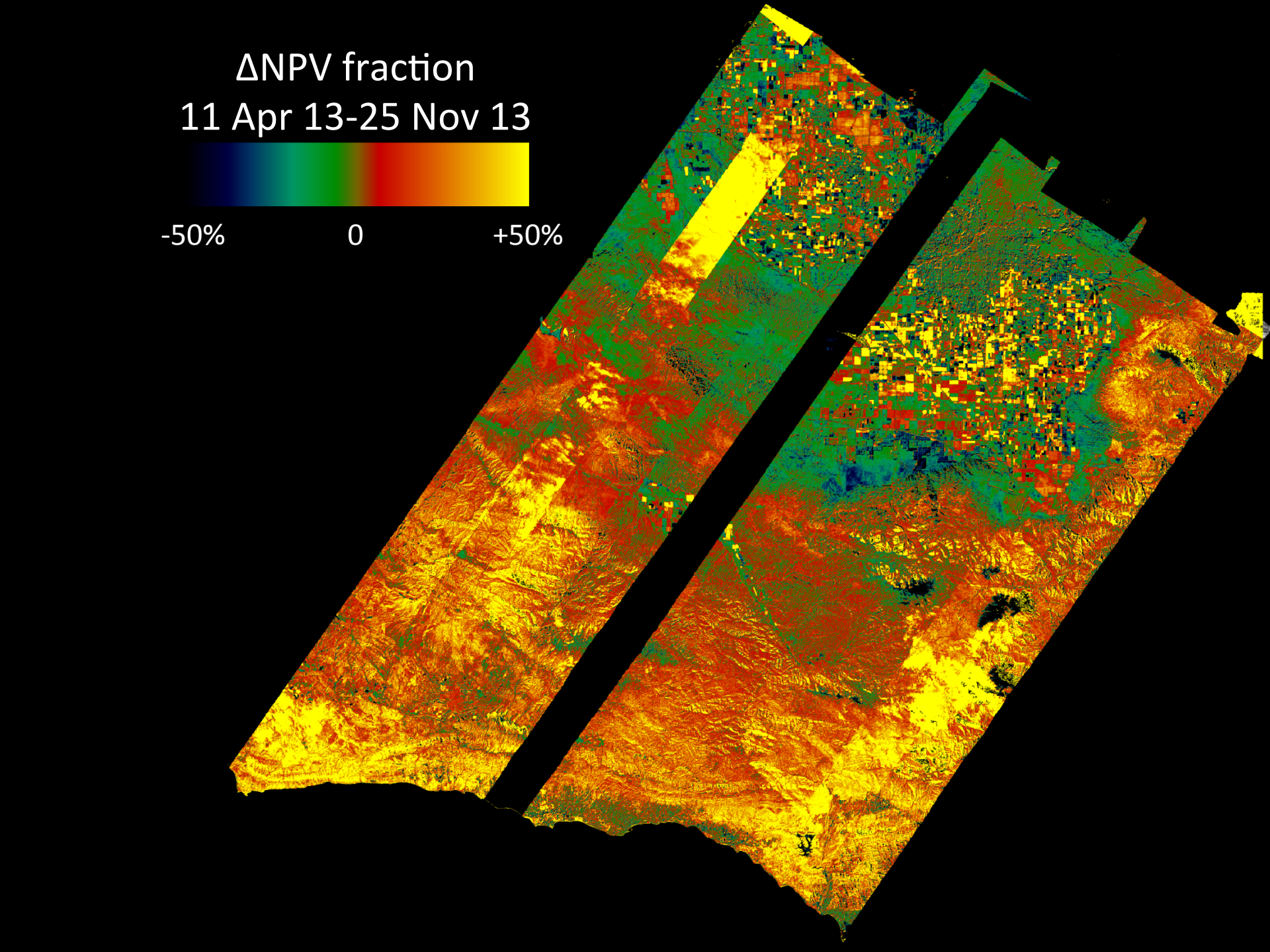

11 April 2013
NPV GV Soil
Clouds


6 June 2013
NPV GV Soil


25 Nov 2013
NPV GV Soil


16 April 2014
NPV GV Soil


ΔNPV fraction
11 Apr 13-6 Jun 13
-50%
0
+50%


ΔNPV fraction
11 Apr 13-25 Nov 13
-50%
0
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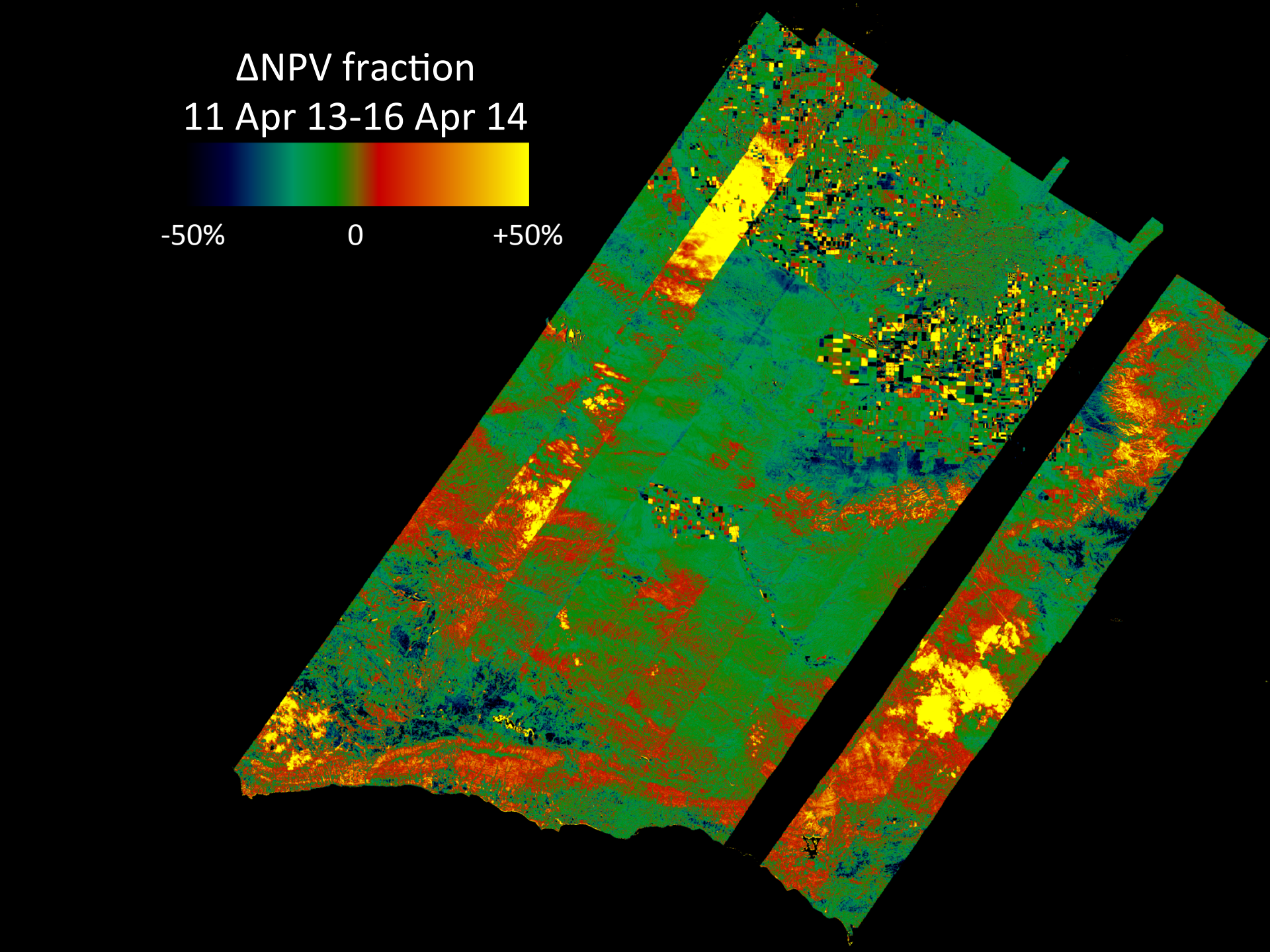
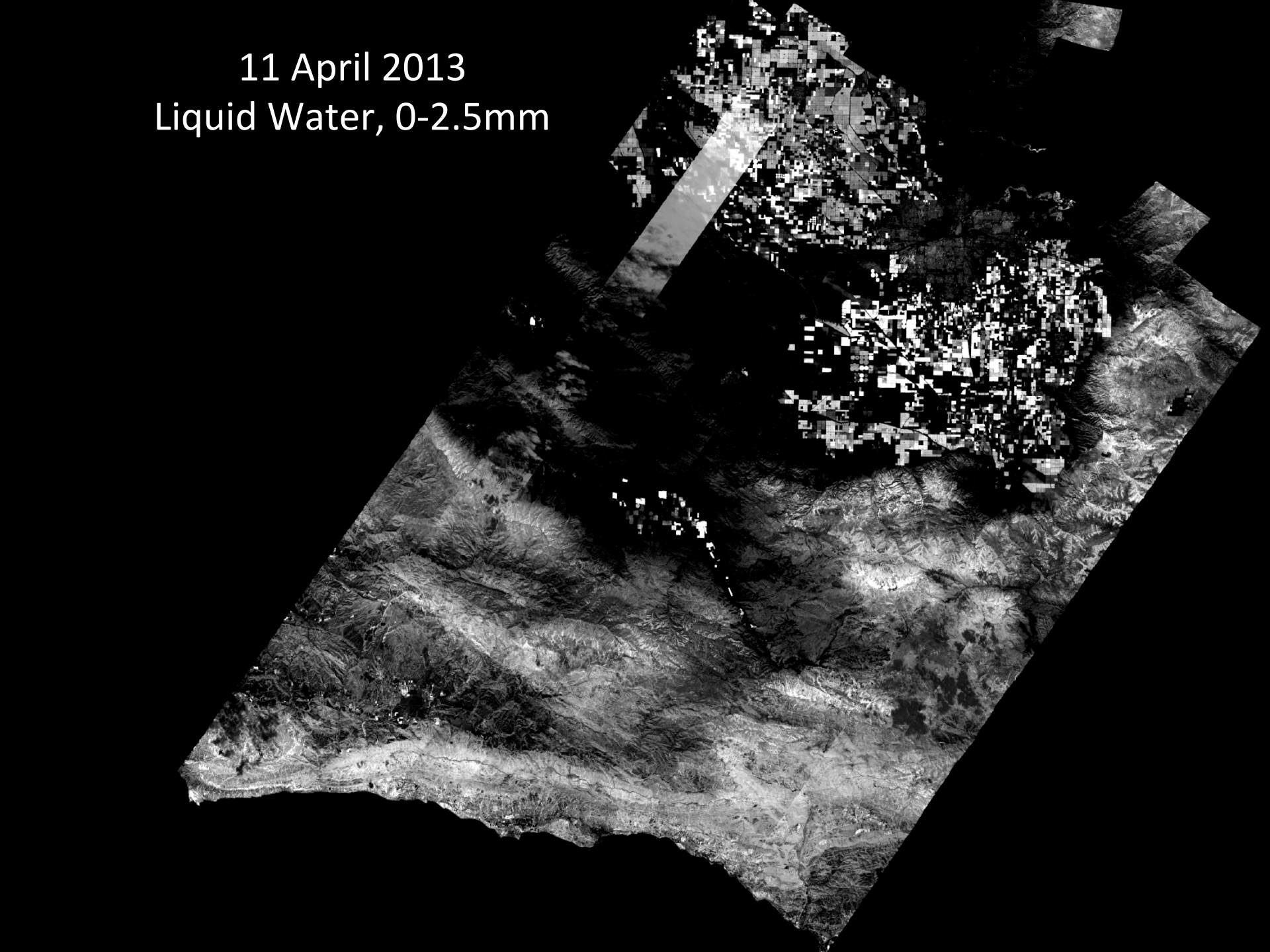
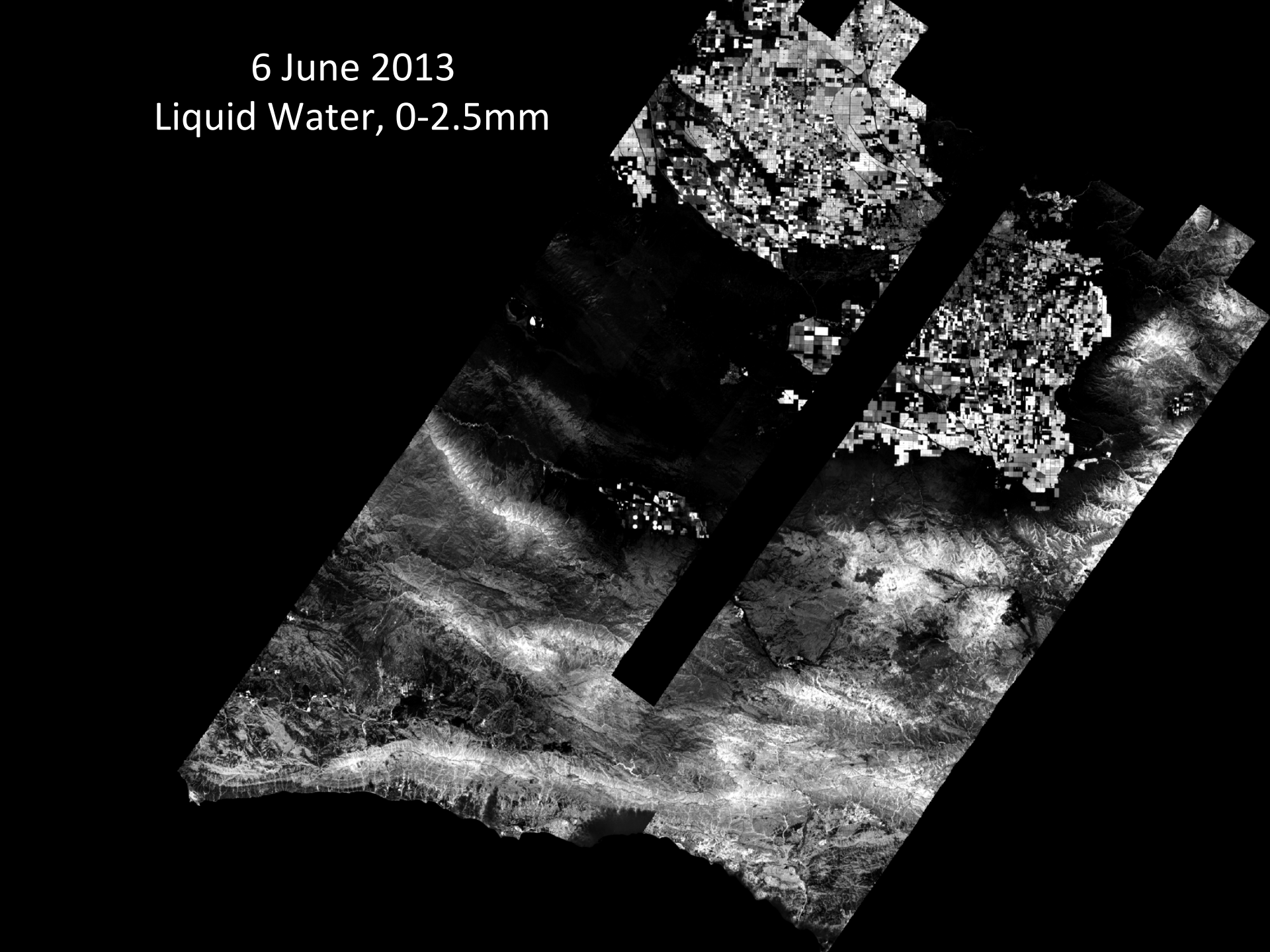

ΔNPV fraction
11 Apr 13-16 Apr 14
-50%
0
+50%


11 April 2013
Liquid Water, 0-2.5mm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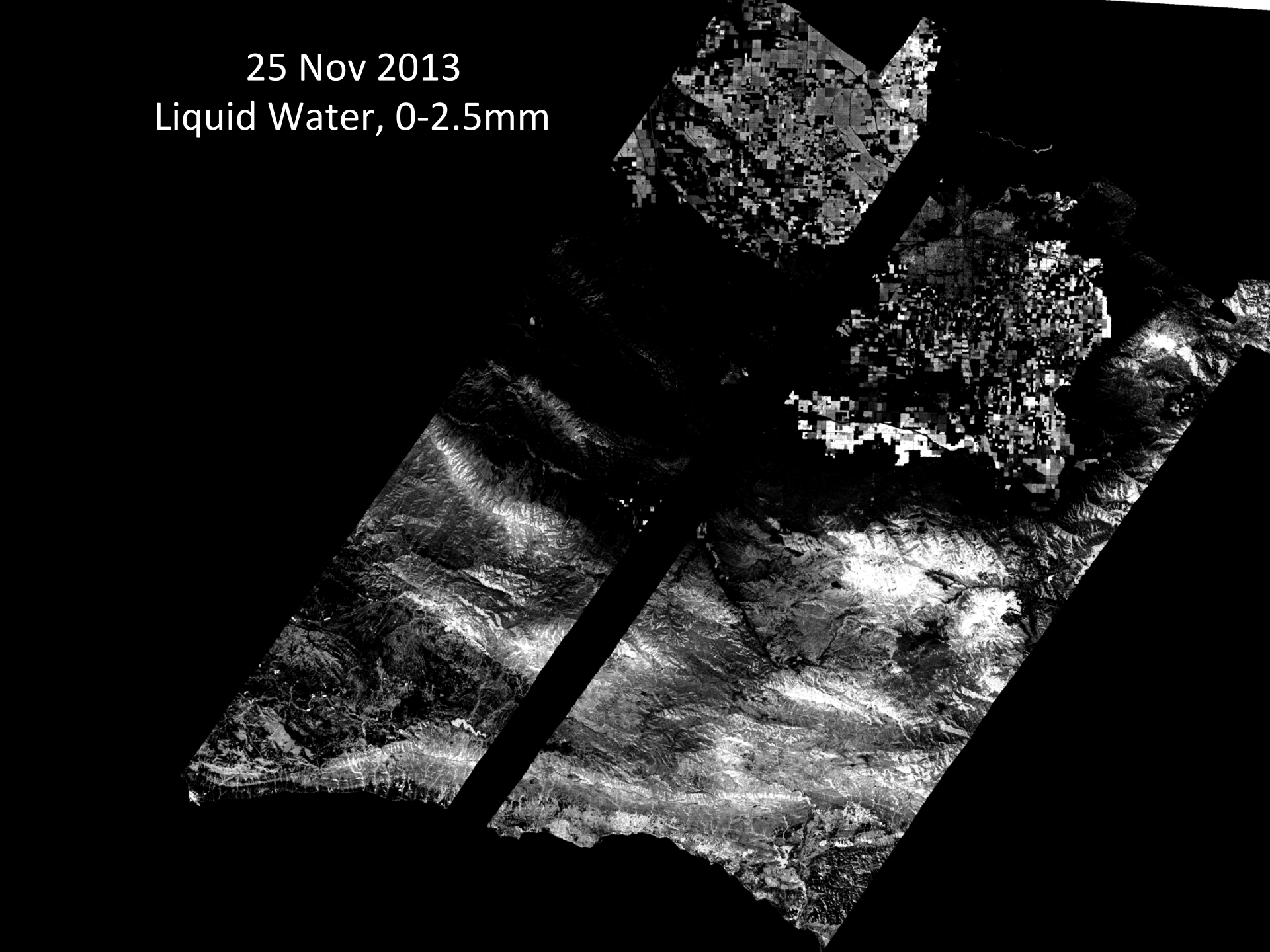
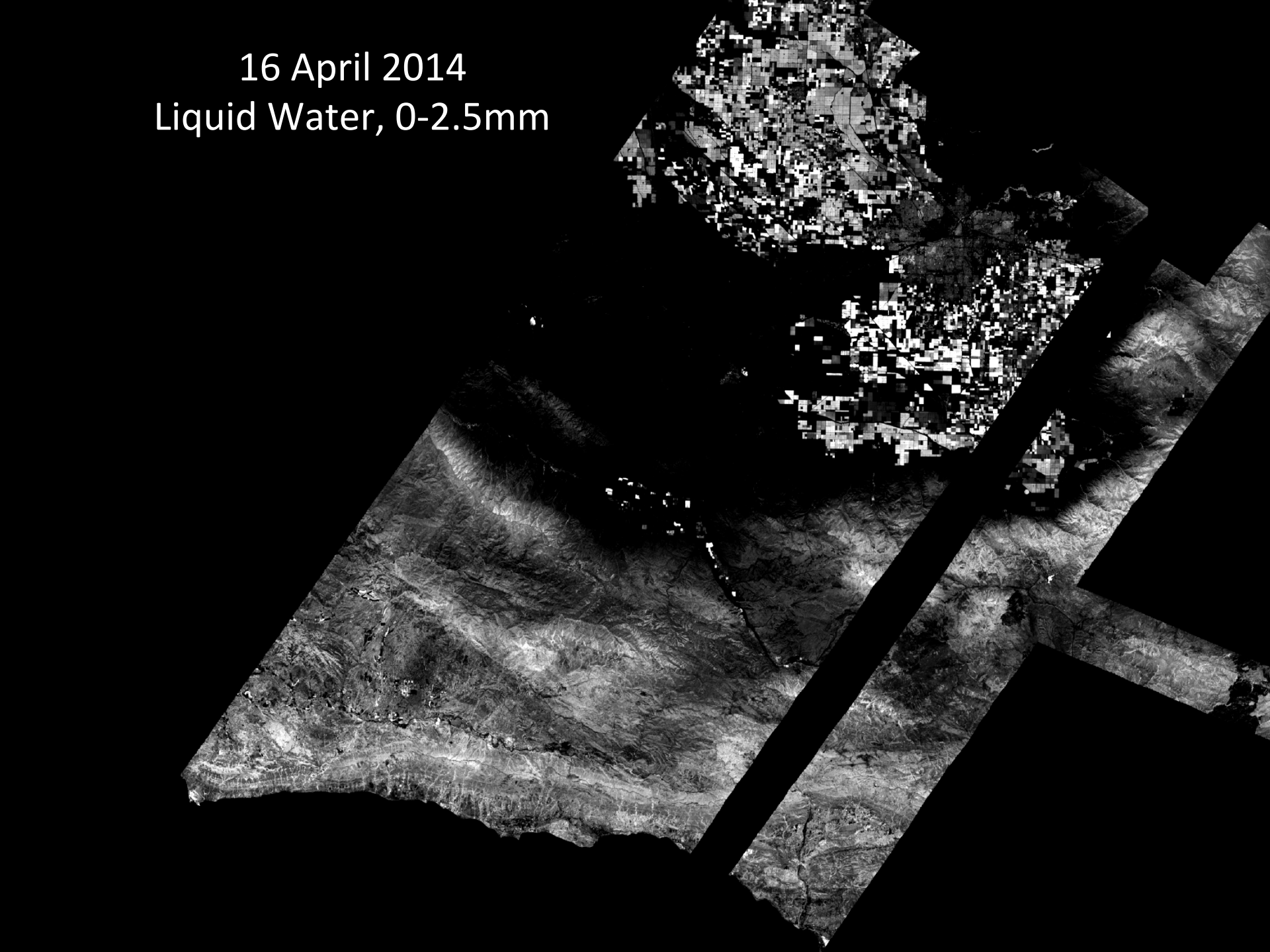
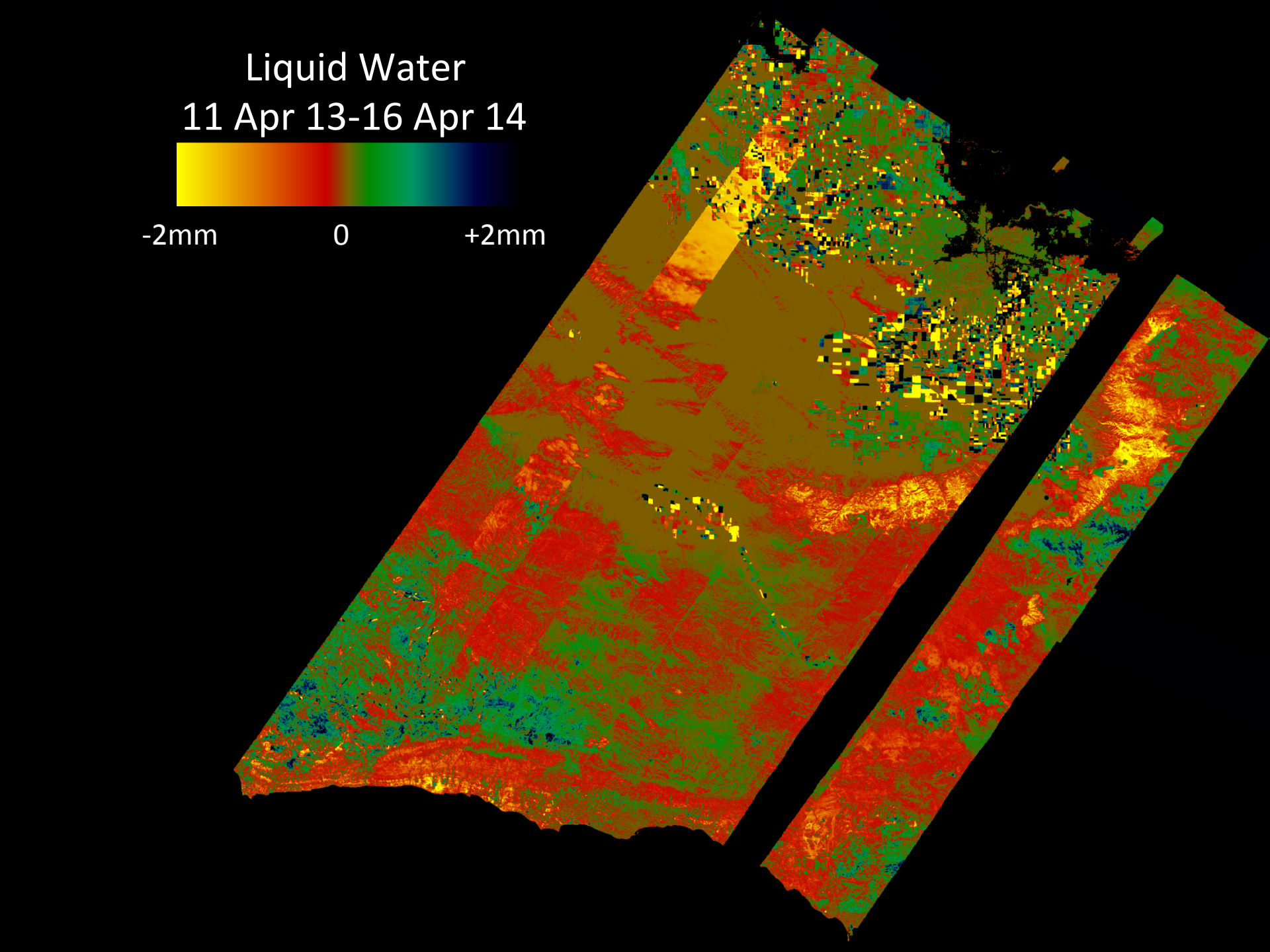

25 Nov 2013
Liquid Water, 0-2.5mm


16 April 2014
Liquid Water, 0-2.5mm

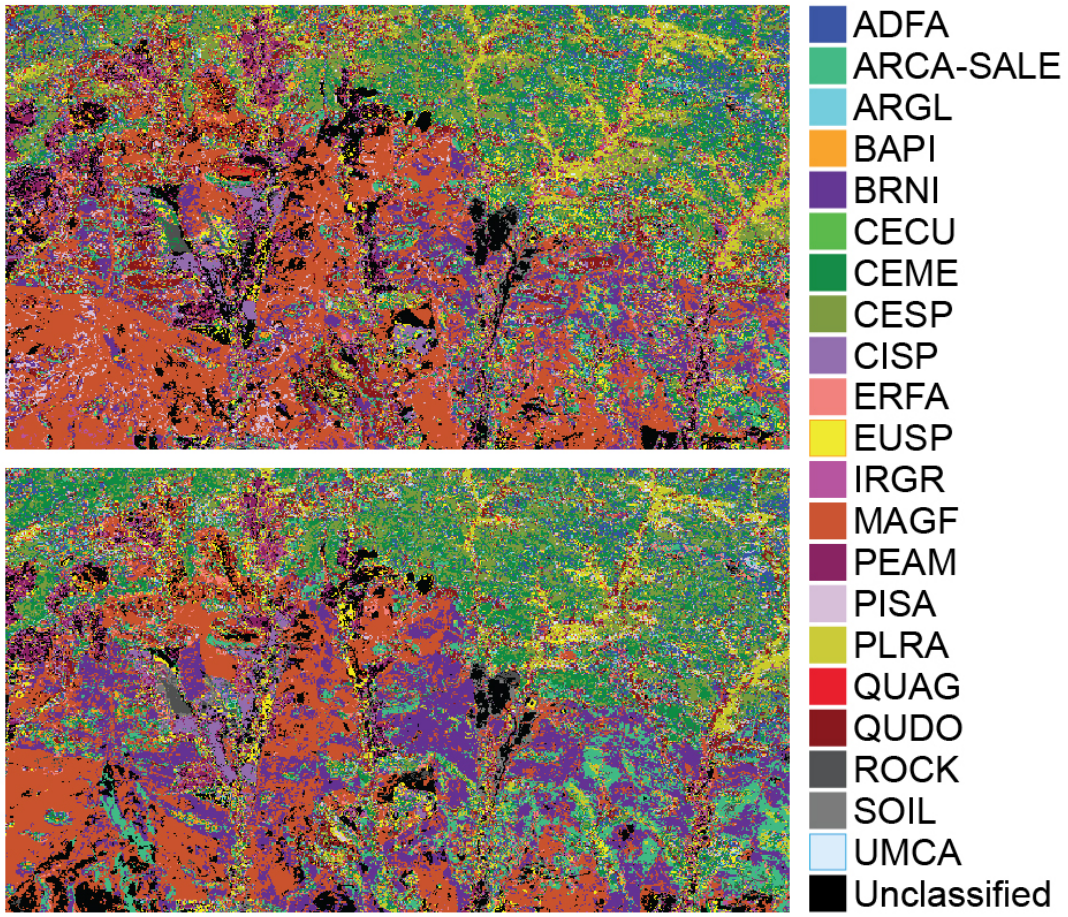

Liquid Water
11 Apr 13-16 Apr 14
-2mm
0
+2mm

Results

- NPV fraction increased and liquid water decreased from April 2013 through November 2013
  - June changes: Senesced grasslands/coastal sage scrub, some dieback in chaparral canopies
  - Changes by November: Extensive dieback in chaparral canopies
- Rainfall in spring 2014 allowed some recovery
  - Decreased NPV, increased liquid water
  - Recovery was limited in some areas

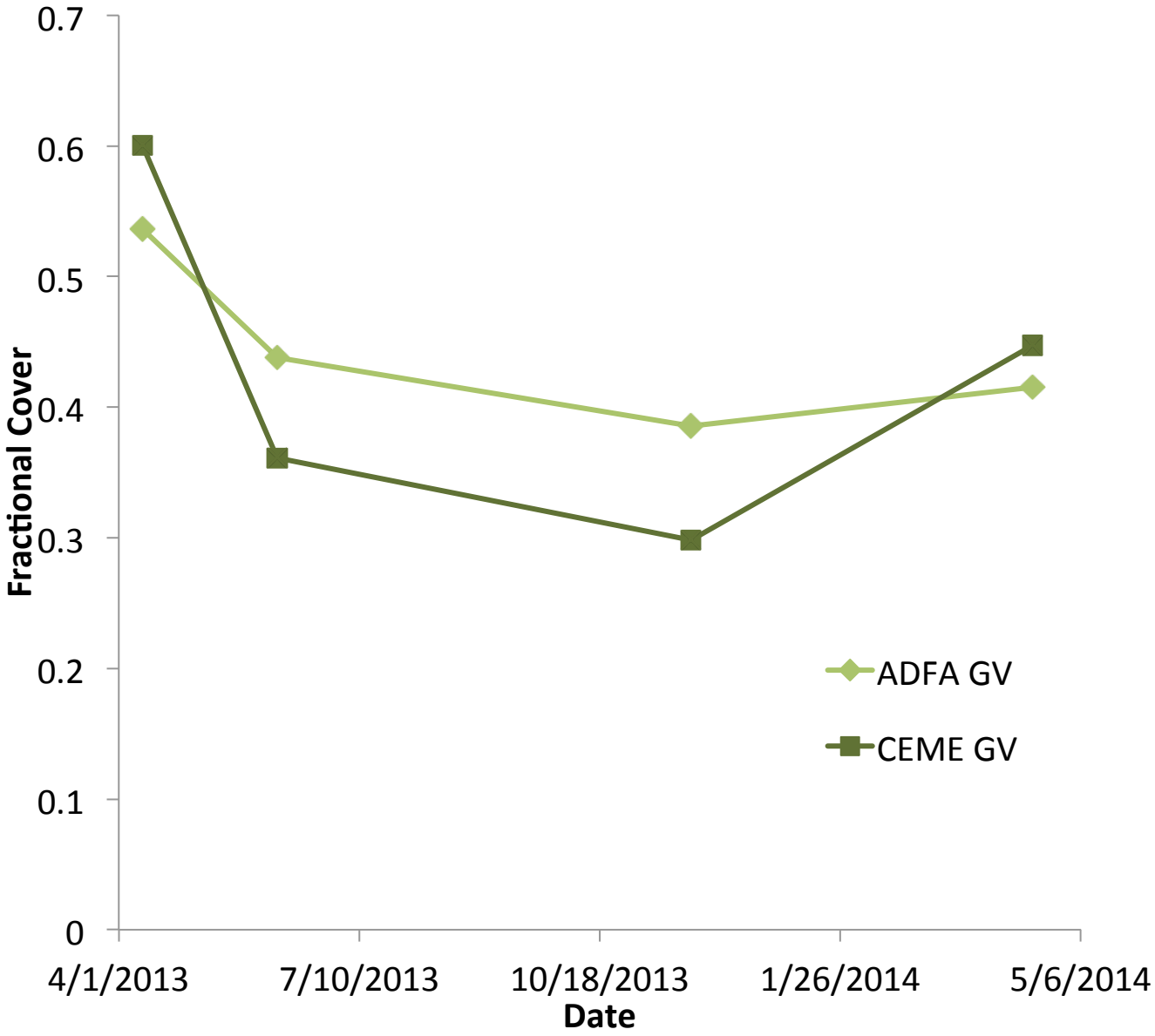
- Multiple Endmember Spectral Mixture Analysis (MESMA) can be used to map dominant species cover
- Within-species changes in fractions can be examined for spatial variation in phenology and response to drought

Multi-temporal classification



Dudley et al.

A Tale of Two Species…



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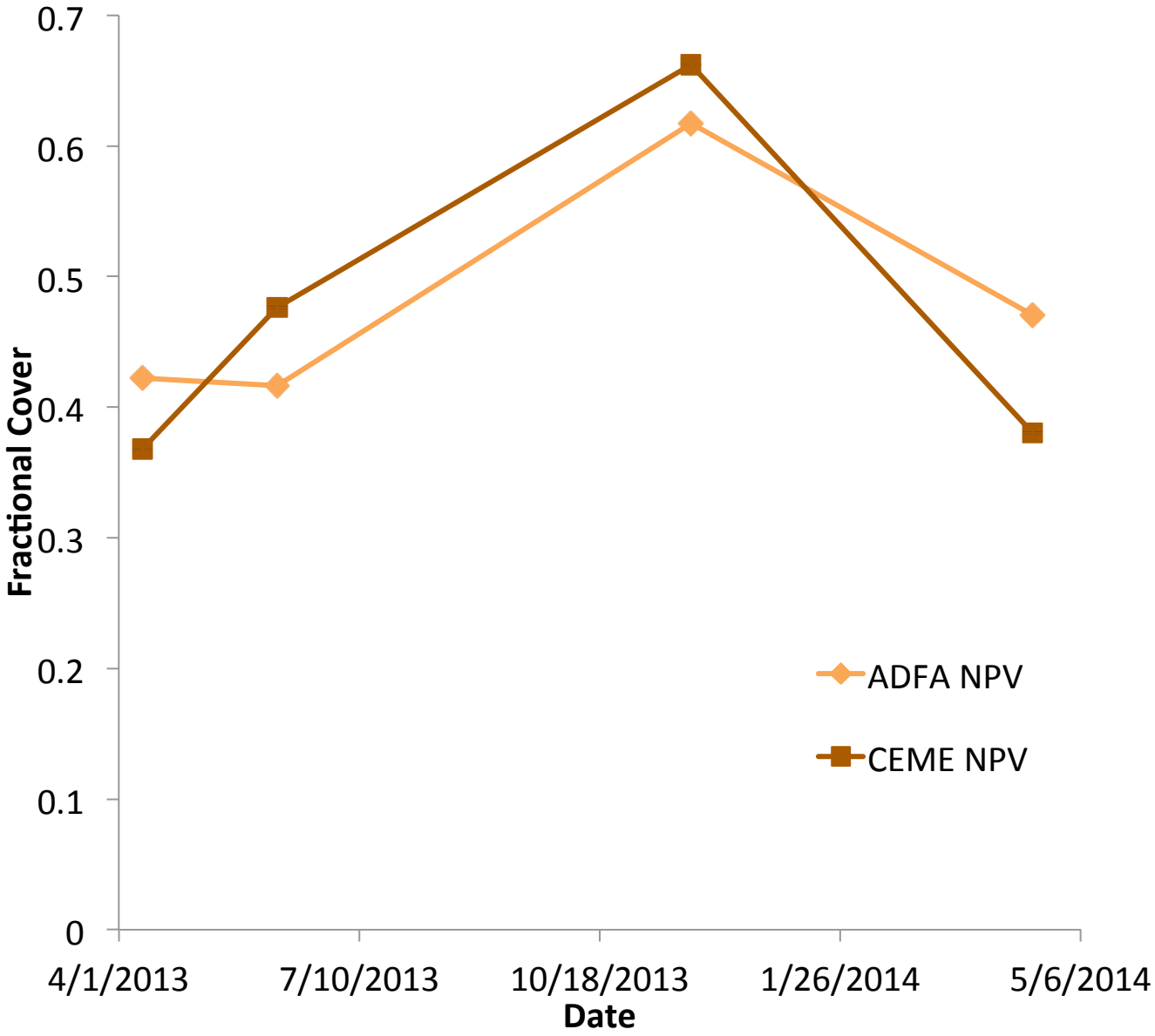

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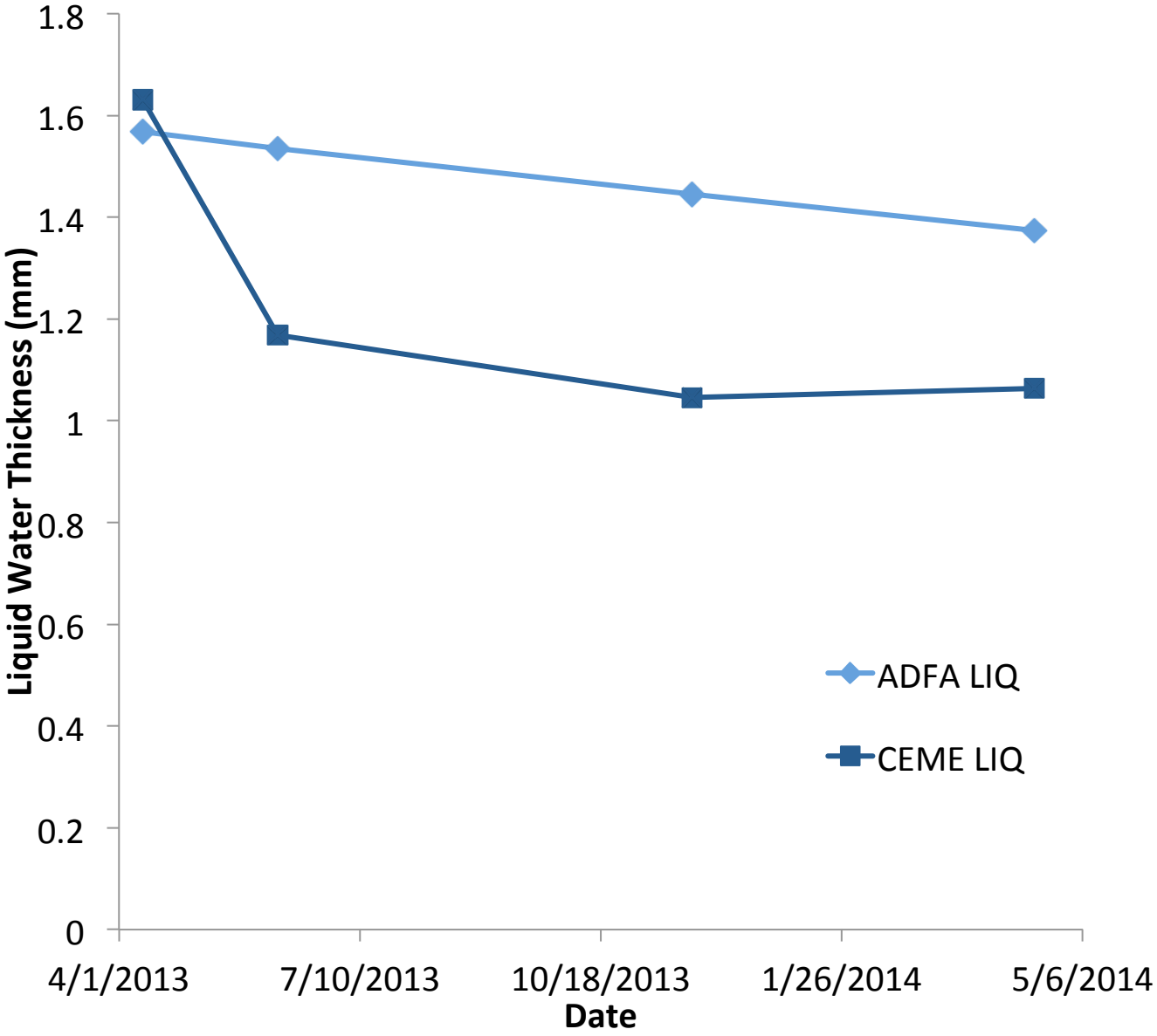

Conclusions, Questions, and Continuing Work

- Increases in NPV and decreases in liquid water coincide with seasonal and long-term drought
- Chamise and Ceanothus exhibit different responses to long-term drought, spring rainfall event
- Does chaparral dieback continue into summer and fall 2014? Are gains from spring 2014 rain temporary? How does vegetation status in fall 2014 compare to fall 2013?
- Which species show signs of rapid recovery when (or if) precipitation returns? Where is mortality occurring?
- Is agricultural productivity in the Central Valley reduced? i.e., are they still irrigating?
- What can we learn about evapotranspiration through combined VSWIR and TIR (MASTER) measurements?

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