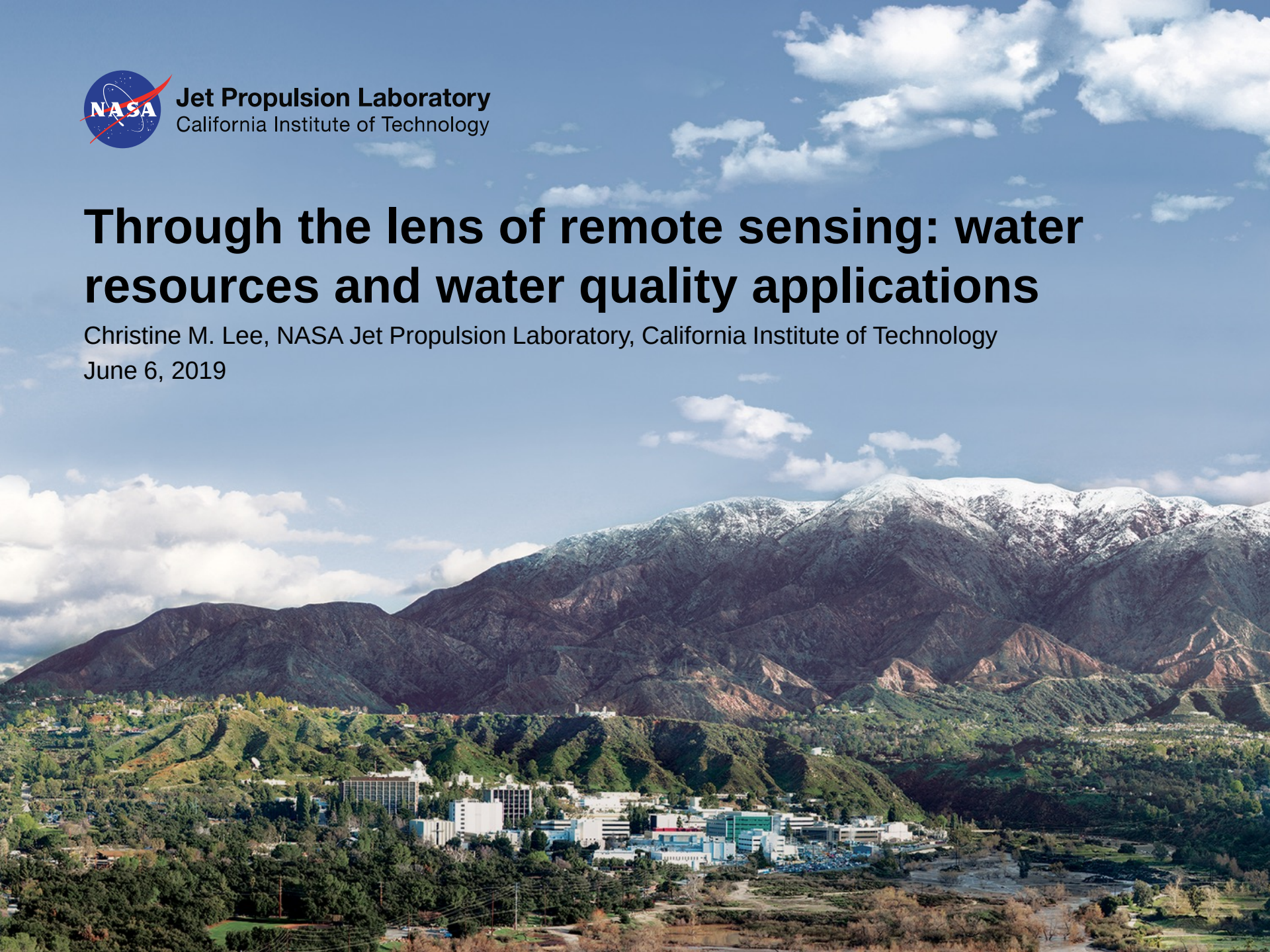


Jet Propulsion Laboratory
California Institute of Technology

Through the lens of remote sensing: water resources and water quality applications

Christine M. Lee, NASA Jet Propulsion Laboratory, California Institute of Technology

June 6, 2019

89.3 KPCC Member-supported news for Southern California

ENVIRONMENT & SCIENCE

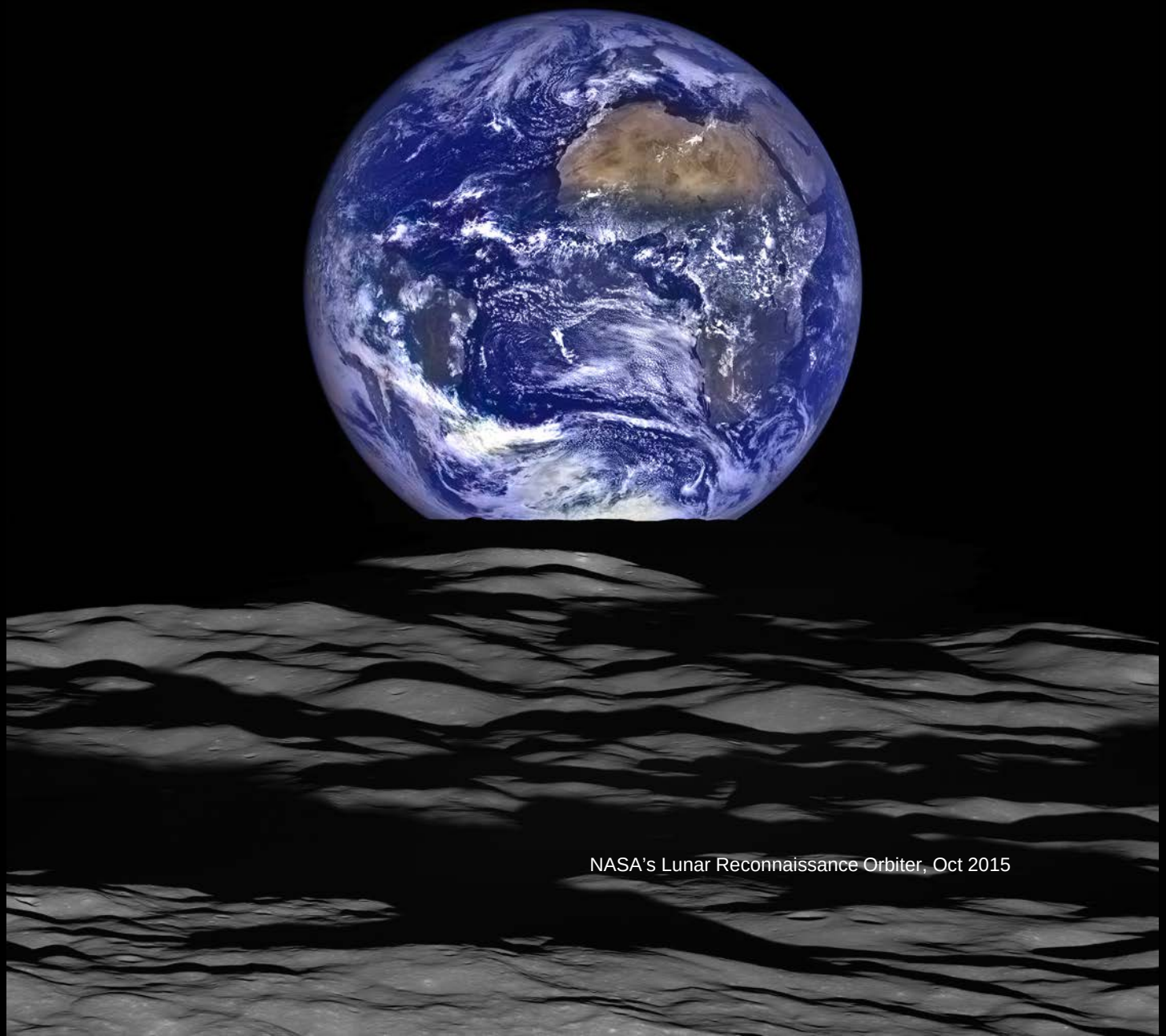
Drought kills 27 million more trees in California

Dead trees in Sequoia National Park in May 2016. The Southern Sierra Nevada was one of the hardest-hit areas by drought and high temperatures, resulting in millions of dead trees. USFS REGION 5

Emily Guerin | December 12, 2017

Another 27 million trees died in California last year due to the lingering effects of drought, according to new aerial

total number of trees killed statewide to a staggering 129 million since 2010.

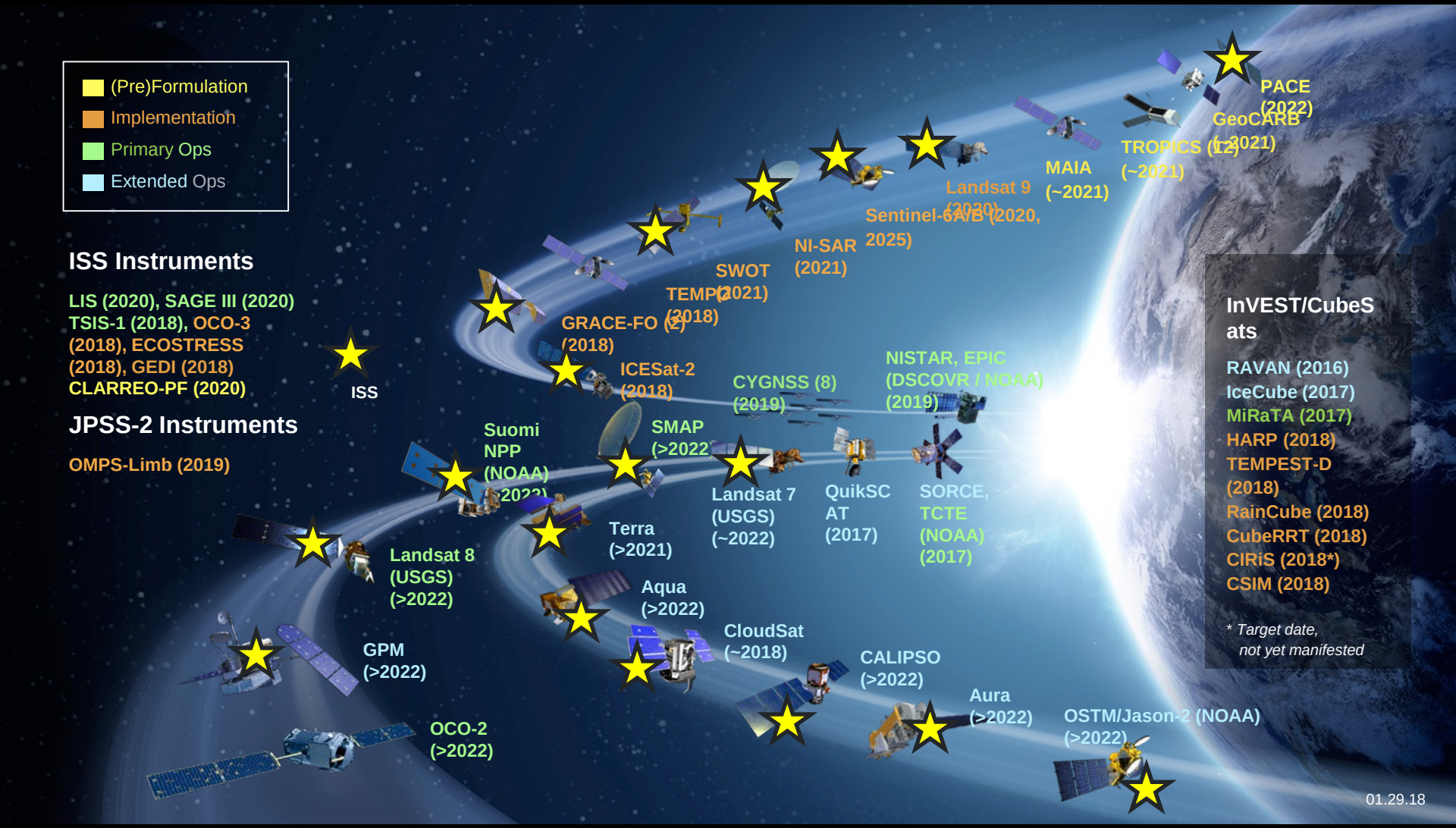


NASA’s Lunar Reconnaissance Orbiter, Oct 2015

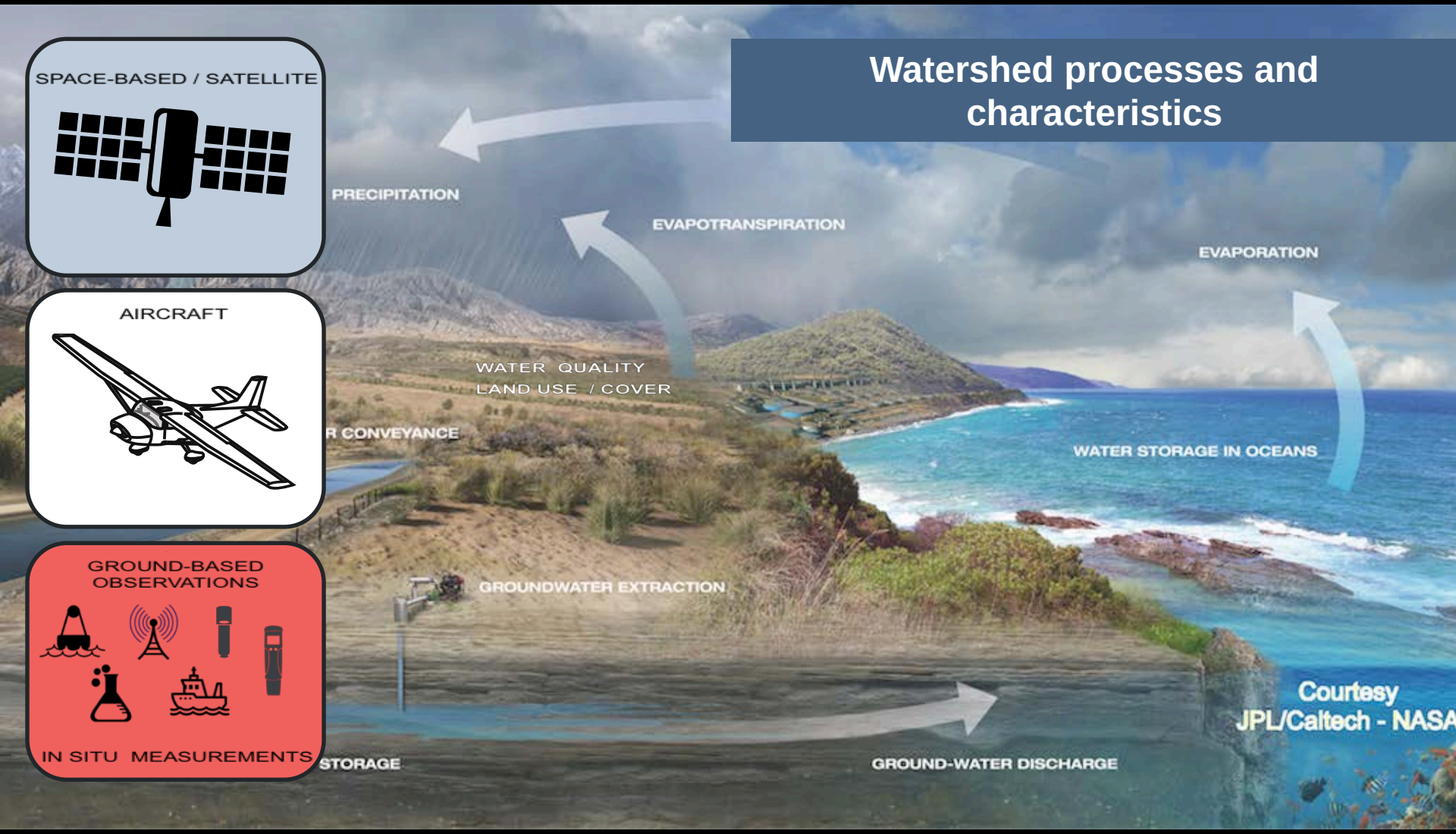
Algal Blooms in Lake Erie, around Monroe, acquired by Sentinel-2 on 3rd August 2017. Data Courtesy of ESA/Copernicus.

NASA Earth Science Assets

Missions: Present through 2023



Adapting global-scale missions to regional to local scale applications



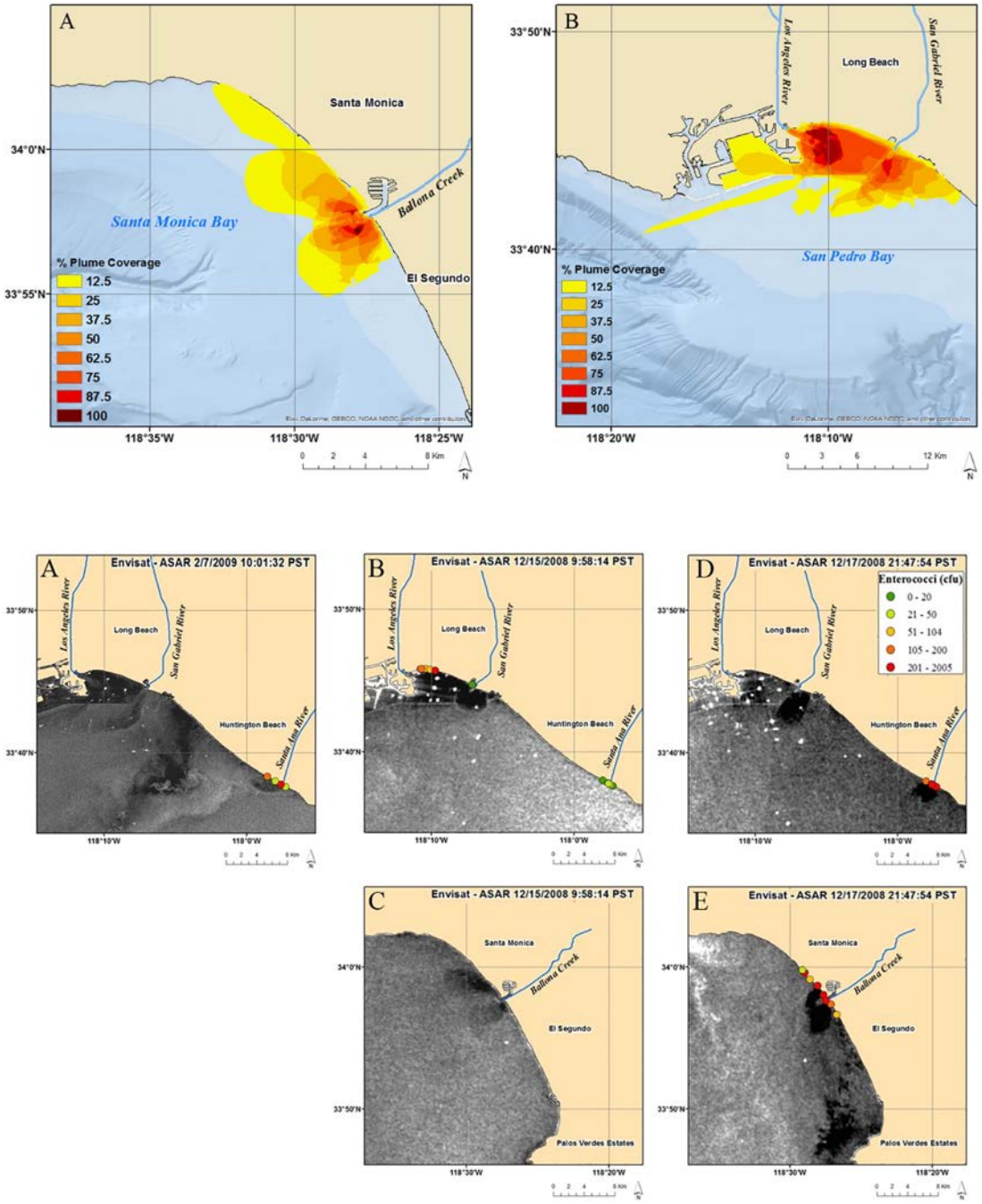
Examples of water resources management applications in California

Examples of water resources management applications in California

Water quality

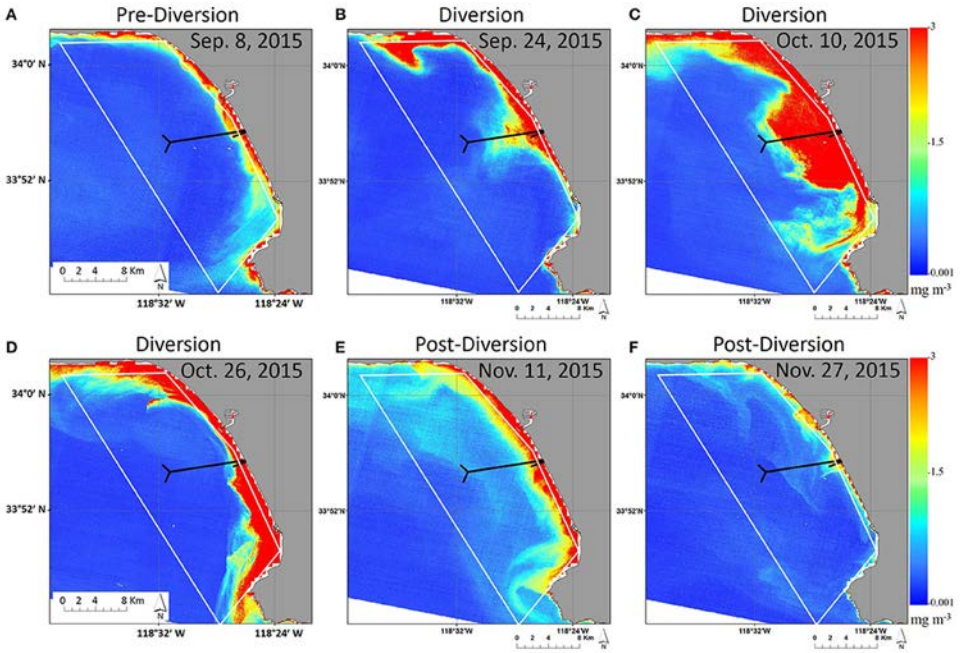
Infrastructure

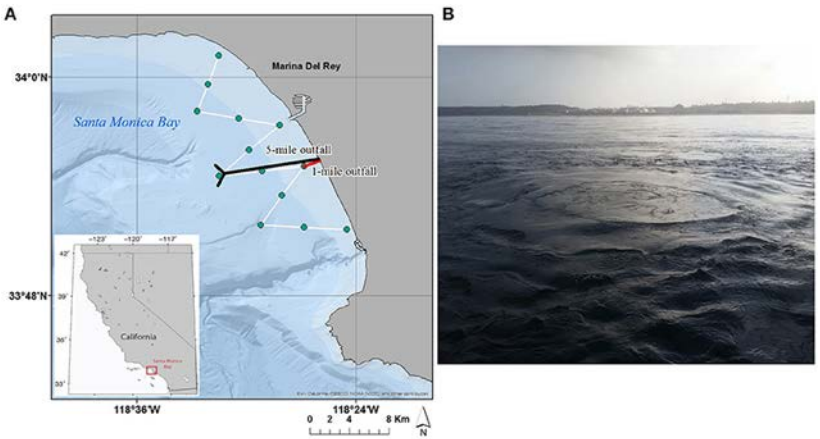
Water supply

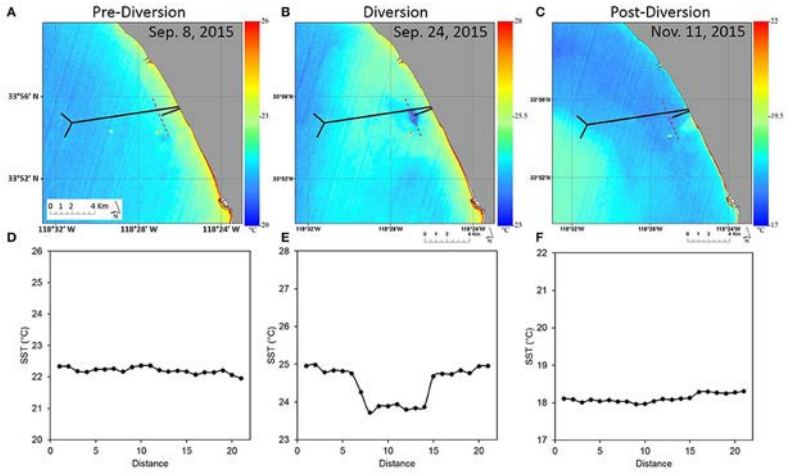


Retrospective analysis of stormwater plumes in Santa Monica Bay, evaluating enterococci samples collected coincident with plume detection (synthetic aperture radar)

Retrospective analyses of stormwater plumes in SM Bay.
Credit: Holt et al. 2017

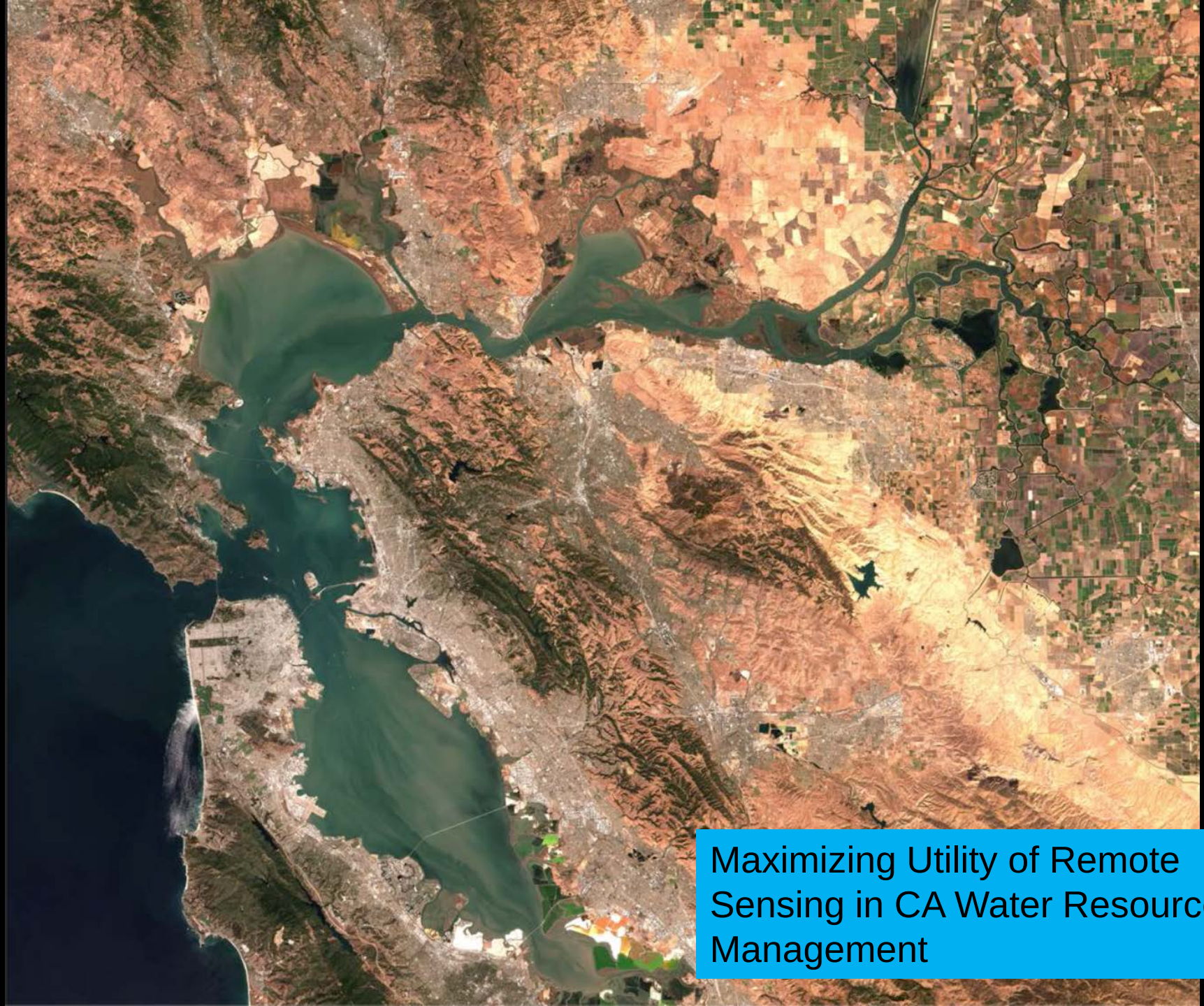






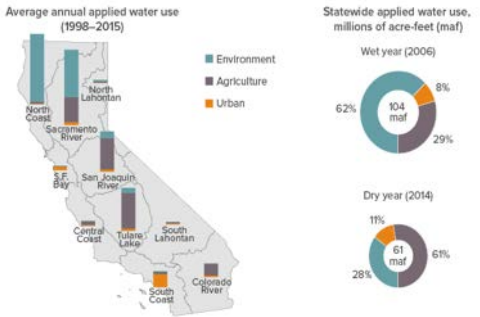
Evaluating diversions impacts from HTP using sea surface temperature and chlorophyll response

Credit: Trinh et al 2017

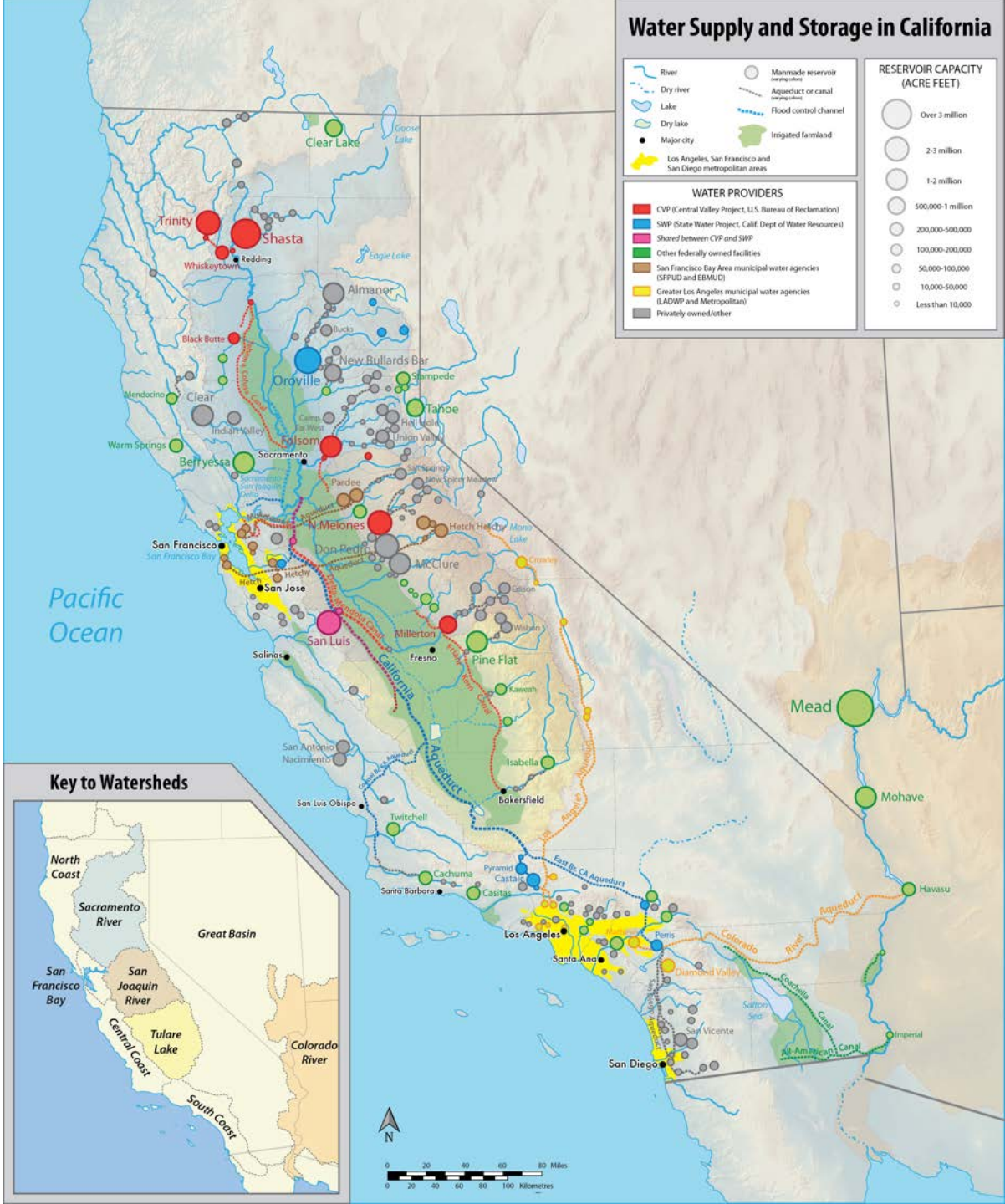


Maximizing Utility of Remote Sensing in CA Water Resources Management

California's water is required for a variety of beneficial uses and transported long distances.



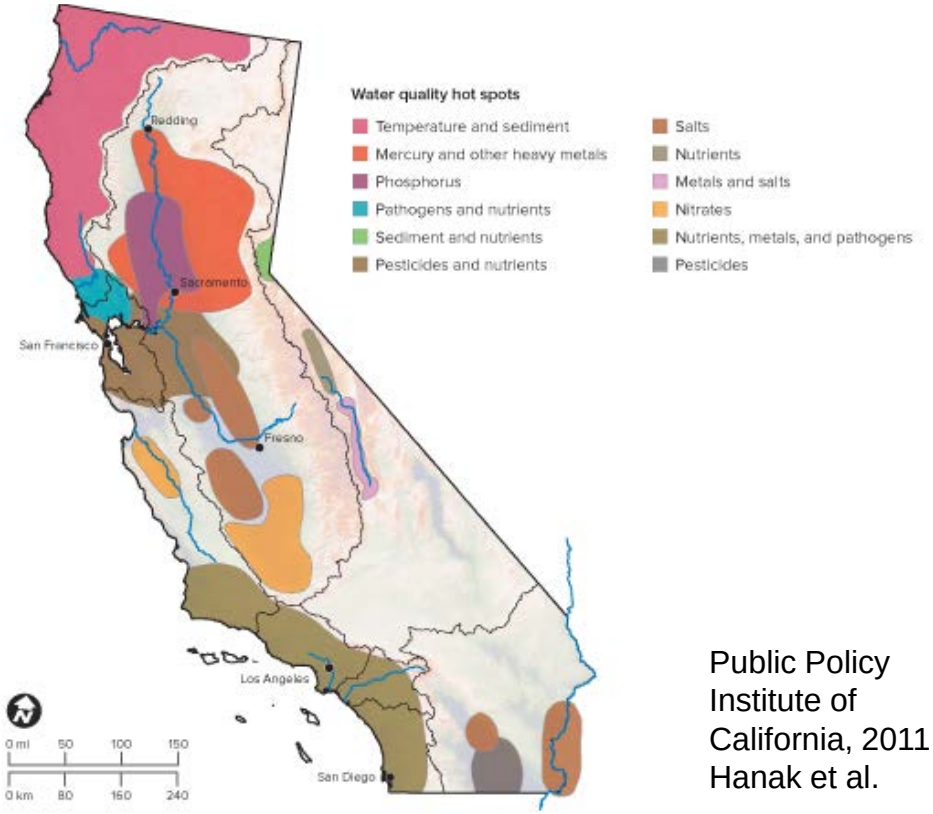
SOURCE: Department of Water Resources, *California Water Plan Update 2018 (Public Review Draft)*. NOTES: The figure shows applied water use. The statewide average for 1998–2015 was 77.2 maf.



California's wa
required for a
beneficial use
transported lo
distances.

SOURCE: Department of Water Re
Water Plan Update 2018 (Public Re
The figure shows applied water use
average for 1998–2015 was 77.2 m

And faces diverse water quality challenges depending on source, land use and development and other issues.

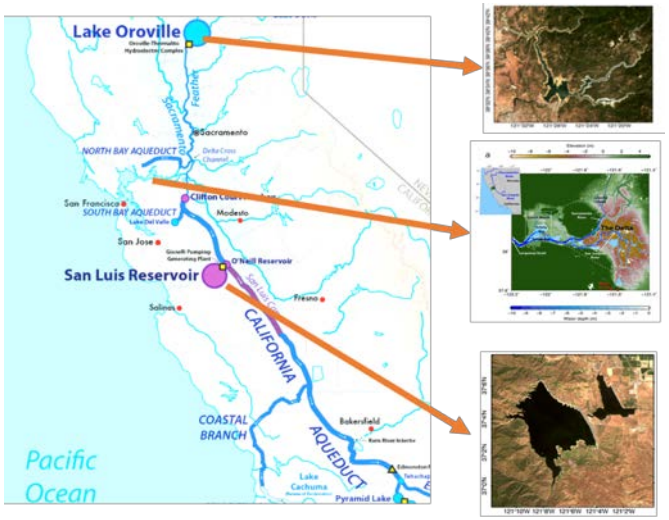


Public Policy Institute of California, 2011
Hanak et al.

Goals of Effort

- **Enhance water quality and resources management**
- **Improve access to remote sensing-derived water quality data**
- **Operationalize production through Bay Delta Live portal**

Project Sites in California



BayDeltaLive

Hypomesus transpacificus – the "Delta Smelt"

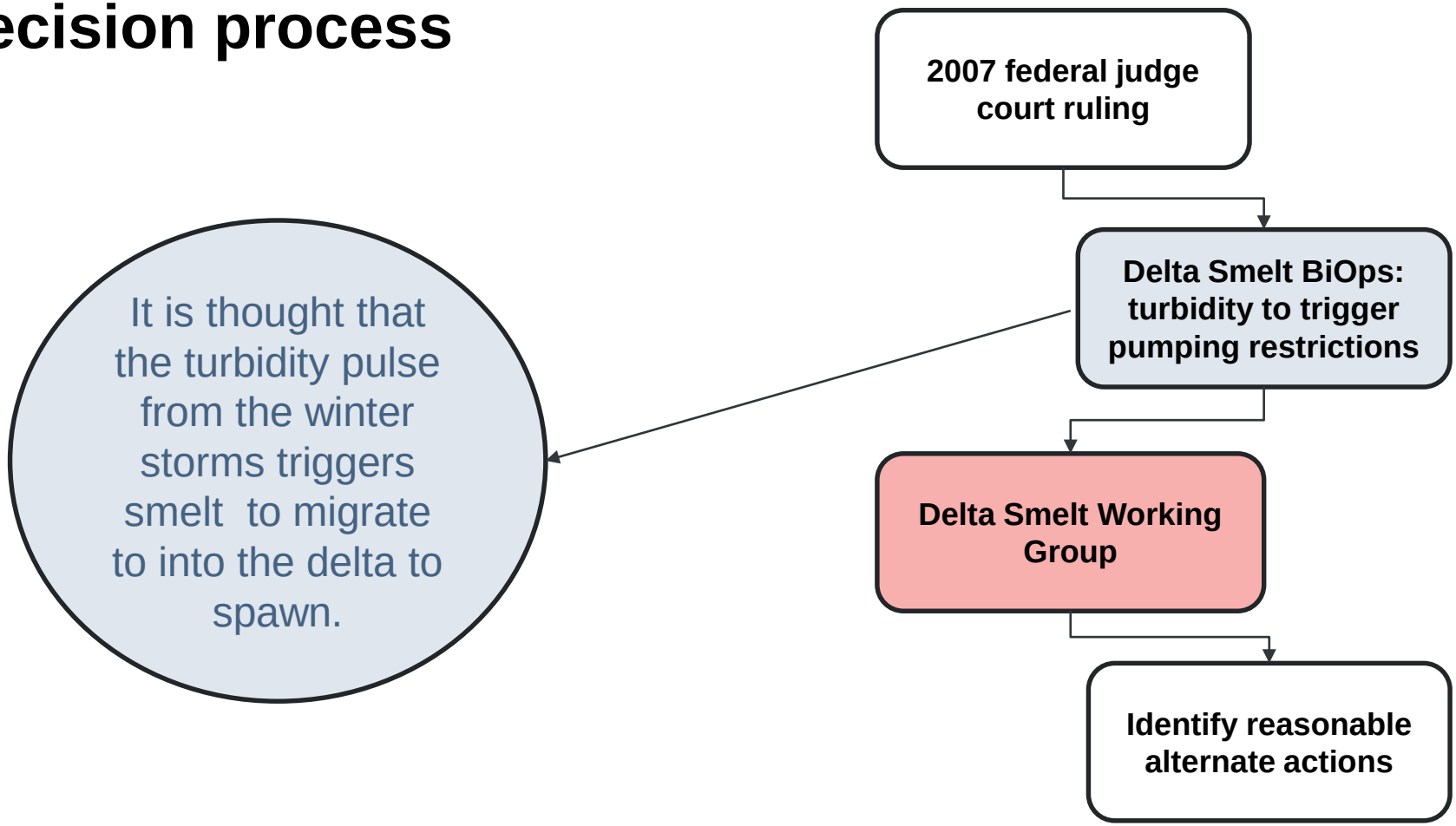
2007 federal judge court ruling

Delta Smelt BiOps: turbidity to trigger pumping restrictions

Delta Smelt Working Group

Identify reasonable alternate actions

Decision process



Decision process

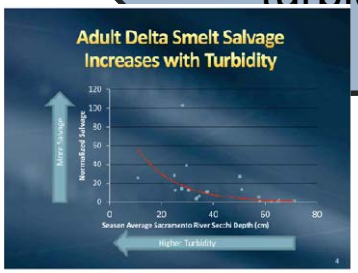
2007 federal judge court ruling

Delta Smelt BiOps: turbidity to trigger pumping restrictions

Delta Smelt Working Group

Identify reasonable alternate actions

More delta smelt were found entrained in pumps during periods of increased turbidity.



Hutton, Fullerton et al., Metropolitan Water District

Turbidity

Turbidity

$$T = \frac{A_T^{\lambda}\rho_w(\lambda)}{(1-\rho_w(\lambda)/C^{\lambda})} \quad [\mathrm{FNU}]$$

A^{λ}_{T} and C^{λ} represent absorption and backscatter terms in turbid systems and can be determined using in-field measurements. ρ_w is calculated using Rrs term, adjusted for water refractive properties. *Nechad et al 2009*

Turbidity

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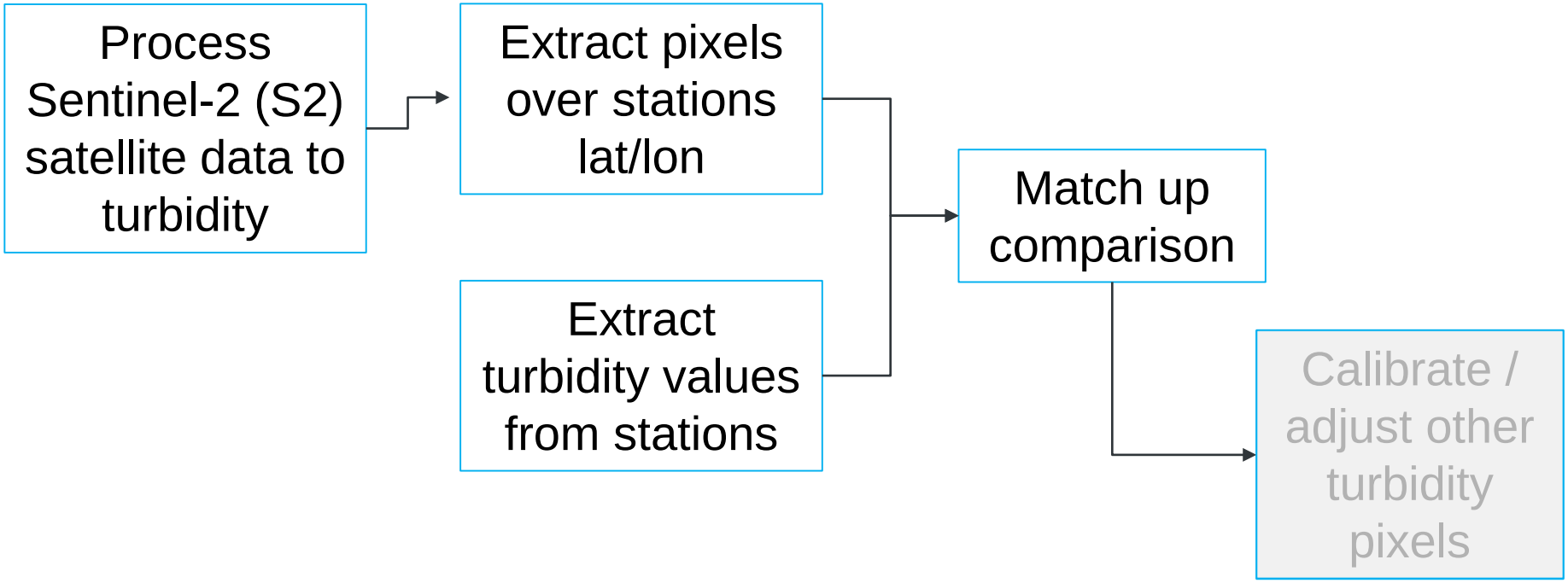
A^{λ}_T and C^{λ} represent absorption and backscatter terms in turbid systems and can be determined using in-field measurements. ρ_w is calculated using Rrs term, adjusted for water refractive properties. *Nechad et al 2009*

Summary of Data Sources	Temporal Resolution	Spatial Resolution	Spatial Coverage
Water Quality Stations	15 minutes intervals	point data	63[1] stations over 5600 square miles
Sentinel-2A/B	4-5 days 55 clear sky acquisitions 2016-2018	20-m x 20-m pixels (average value over 20-m x 20-m)	36M+ pixels over 5600 square miles

Table 1. Overview of differences in data sources.

Comparing turbidity derived from satellite data and USGS and other station data



Compar ta and USGS a

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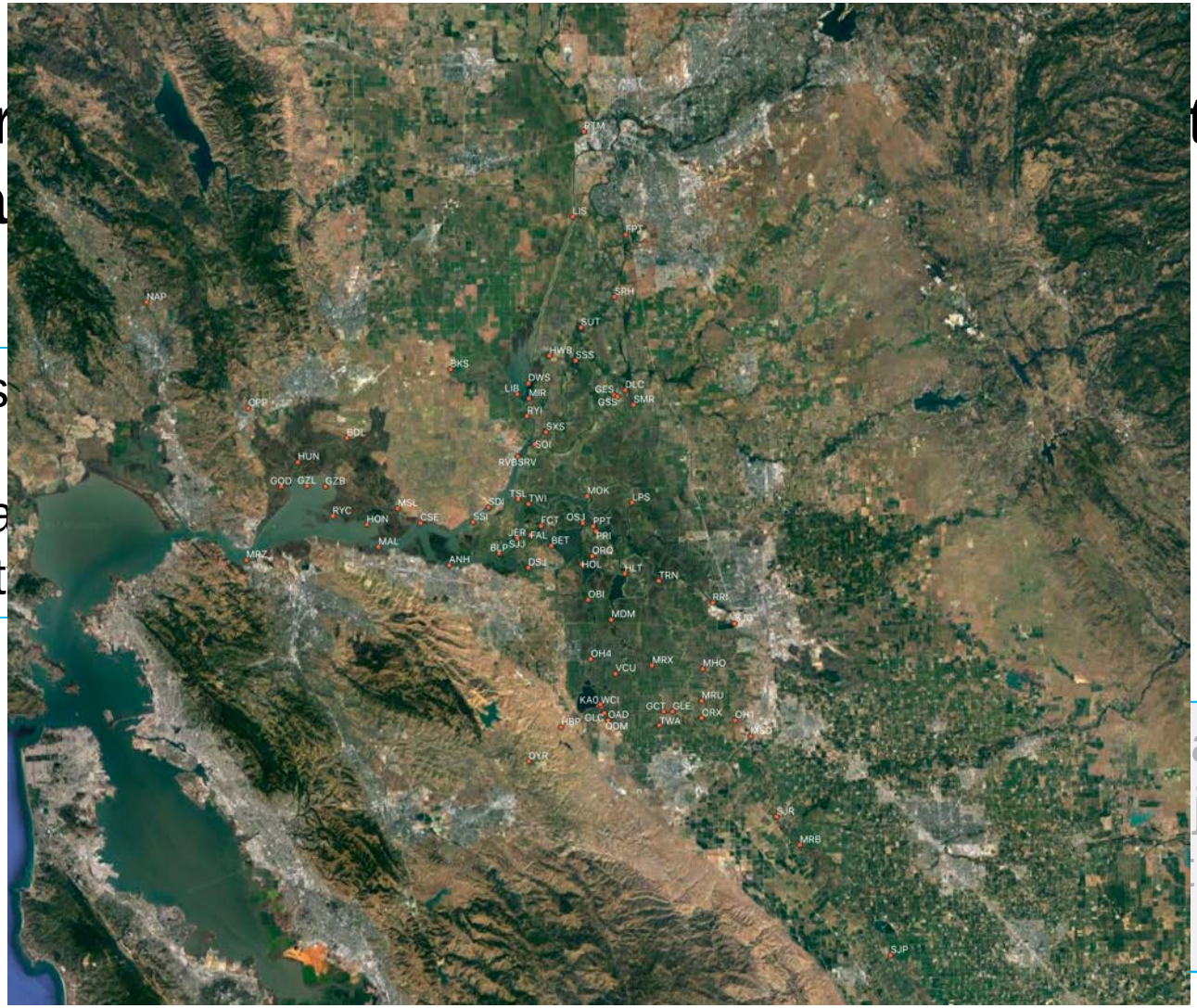
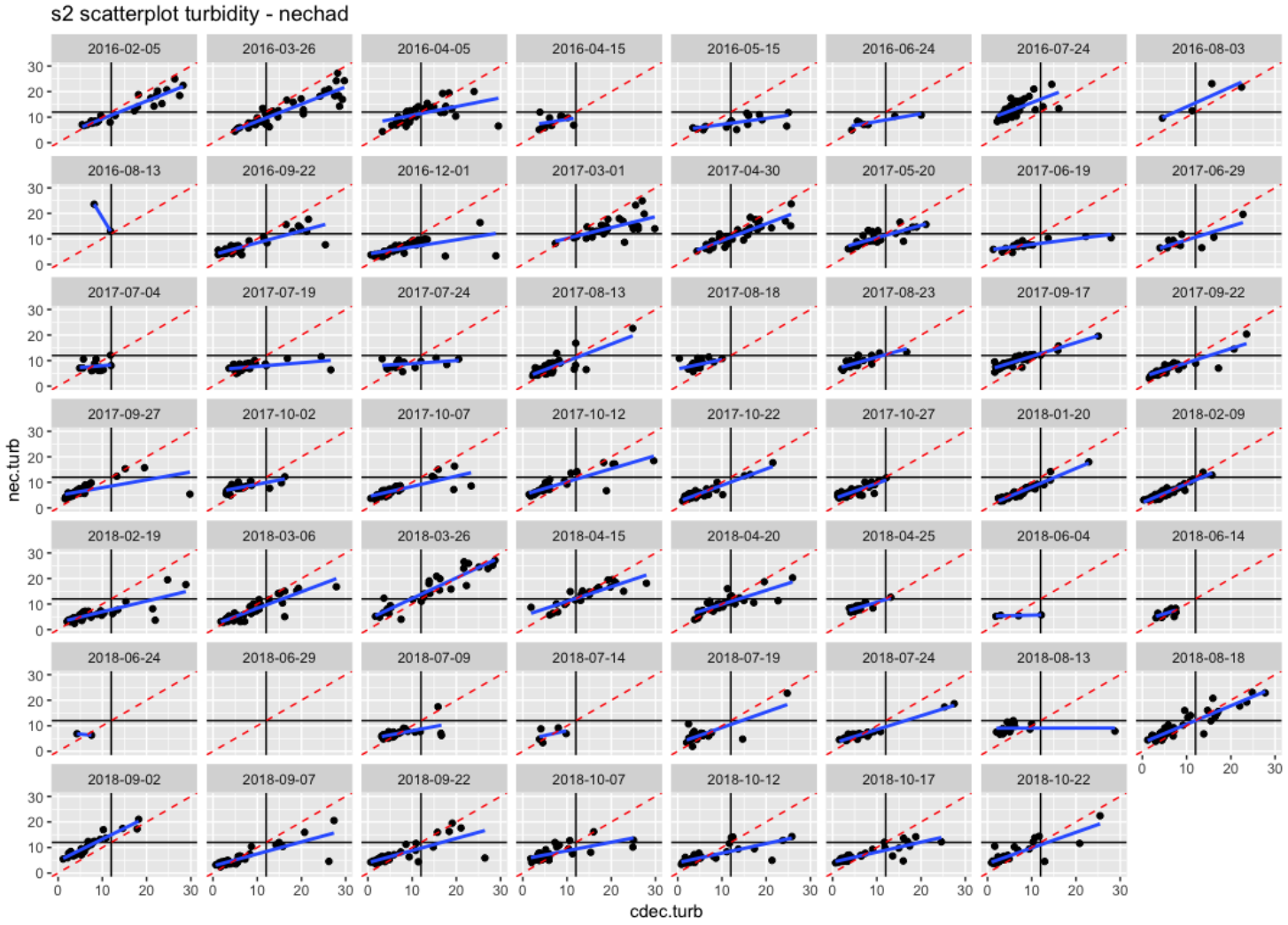
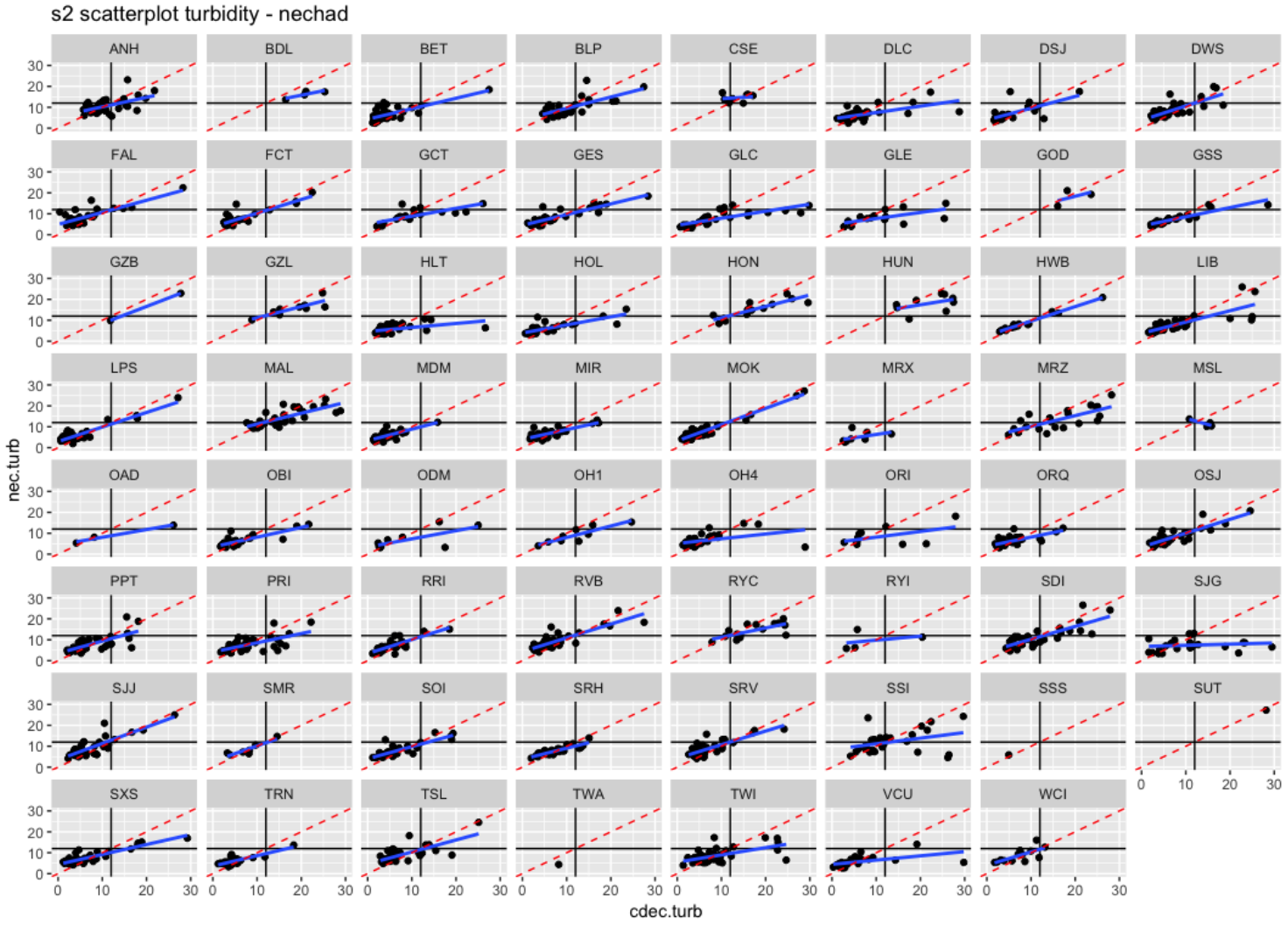


alibrate /
just other
urbidity
pixels

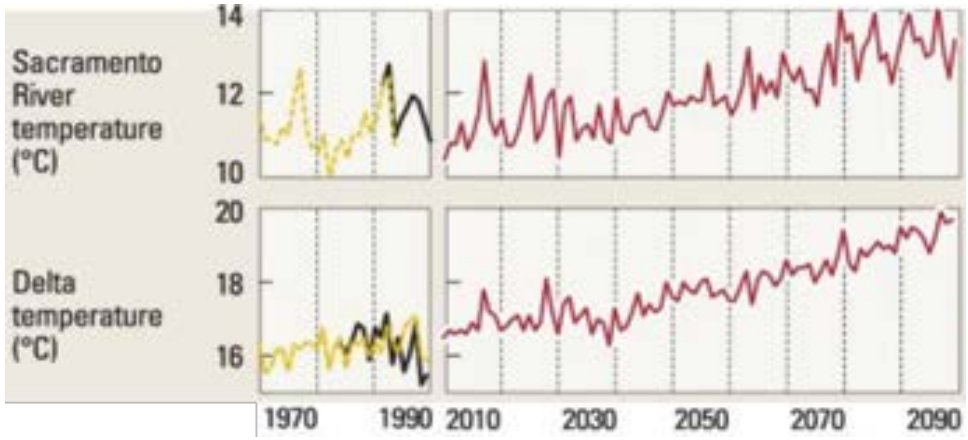


For Sentinel-2, we looked at 2016-2018, which amounted to approximately 55 dates with station matchups, and N=1540 in total, here separated out by date.

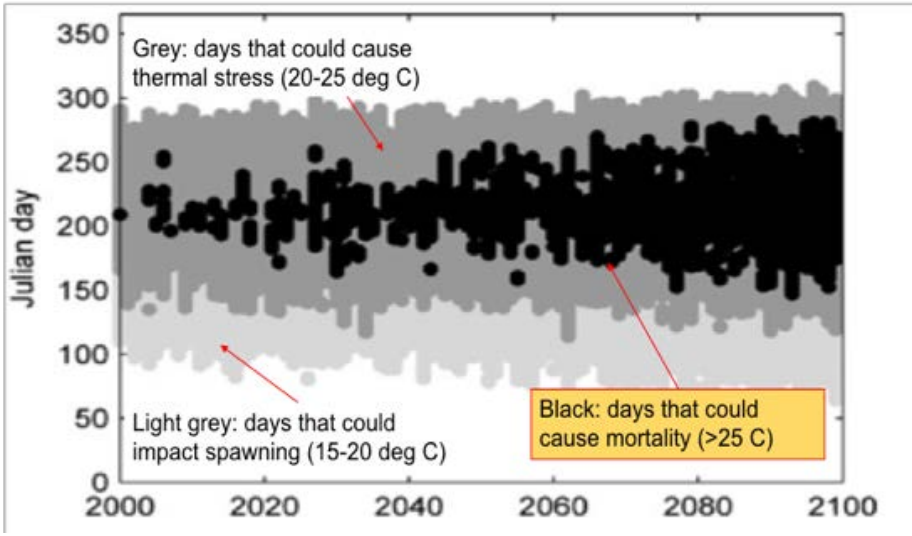


Same dataset but organized by station.

Water temperature is another critical water quality issue in the Bay Delta.



PROJECTED CHANGES IN ANNUAL MEAN TEMPERATURES IN THE BAY DELTA (CLOERN ET AL 2011)



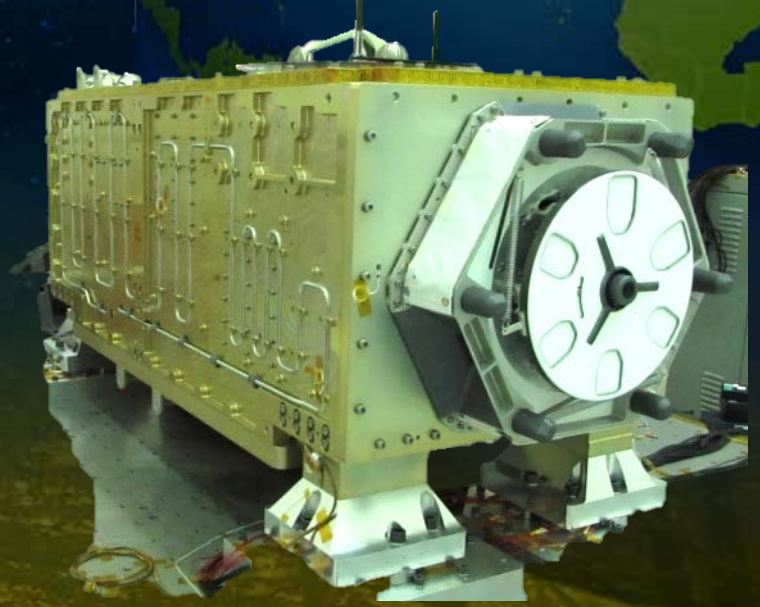
DEPICTS THE PROJECTED # DAYS WHERE HIGH TEMPERATURES ARE DETRIMENTAL TO DELTA SMELT. (WAGNER ET AL 2011)

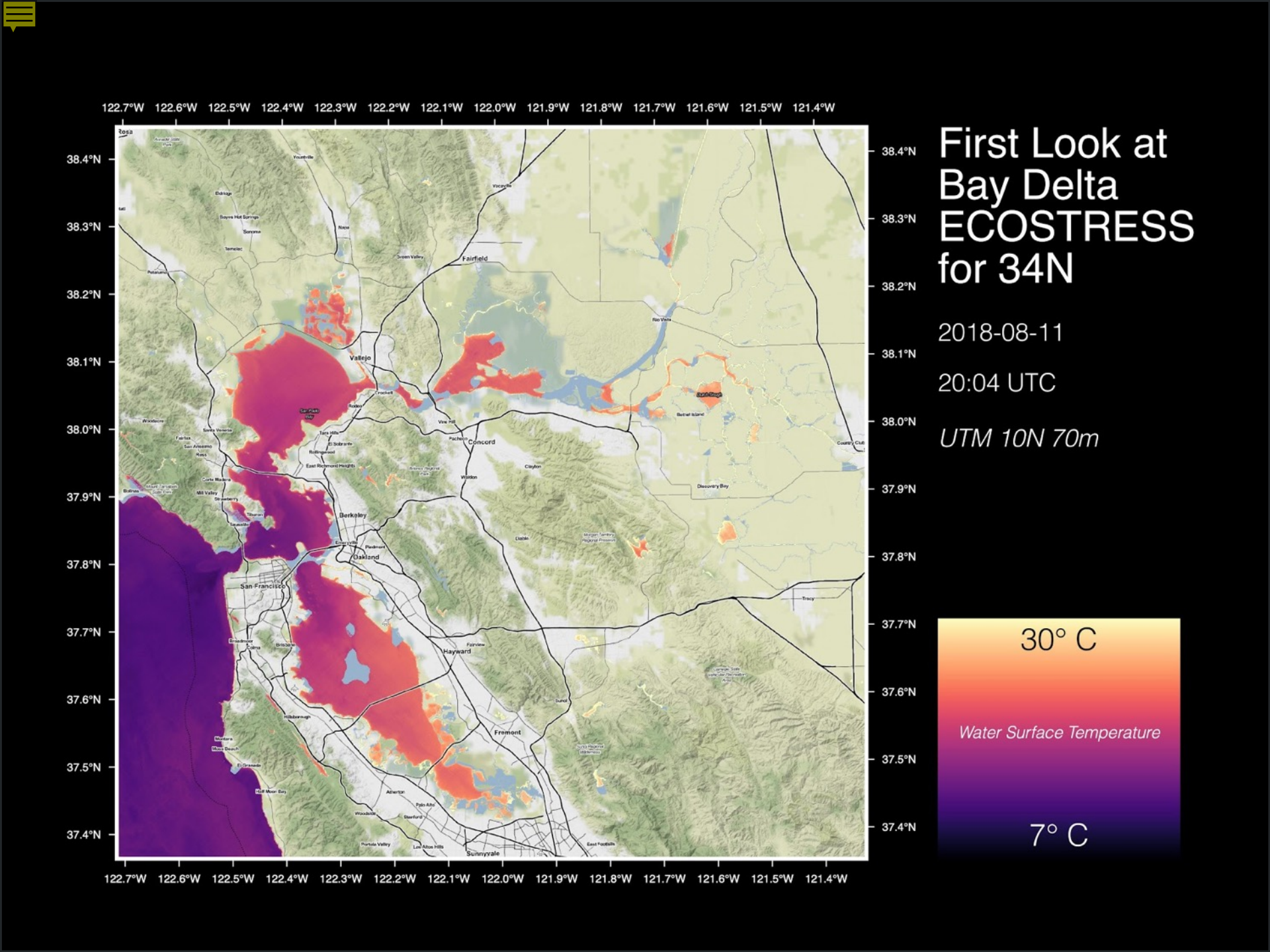
ECOSTRESS

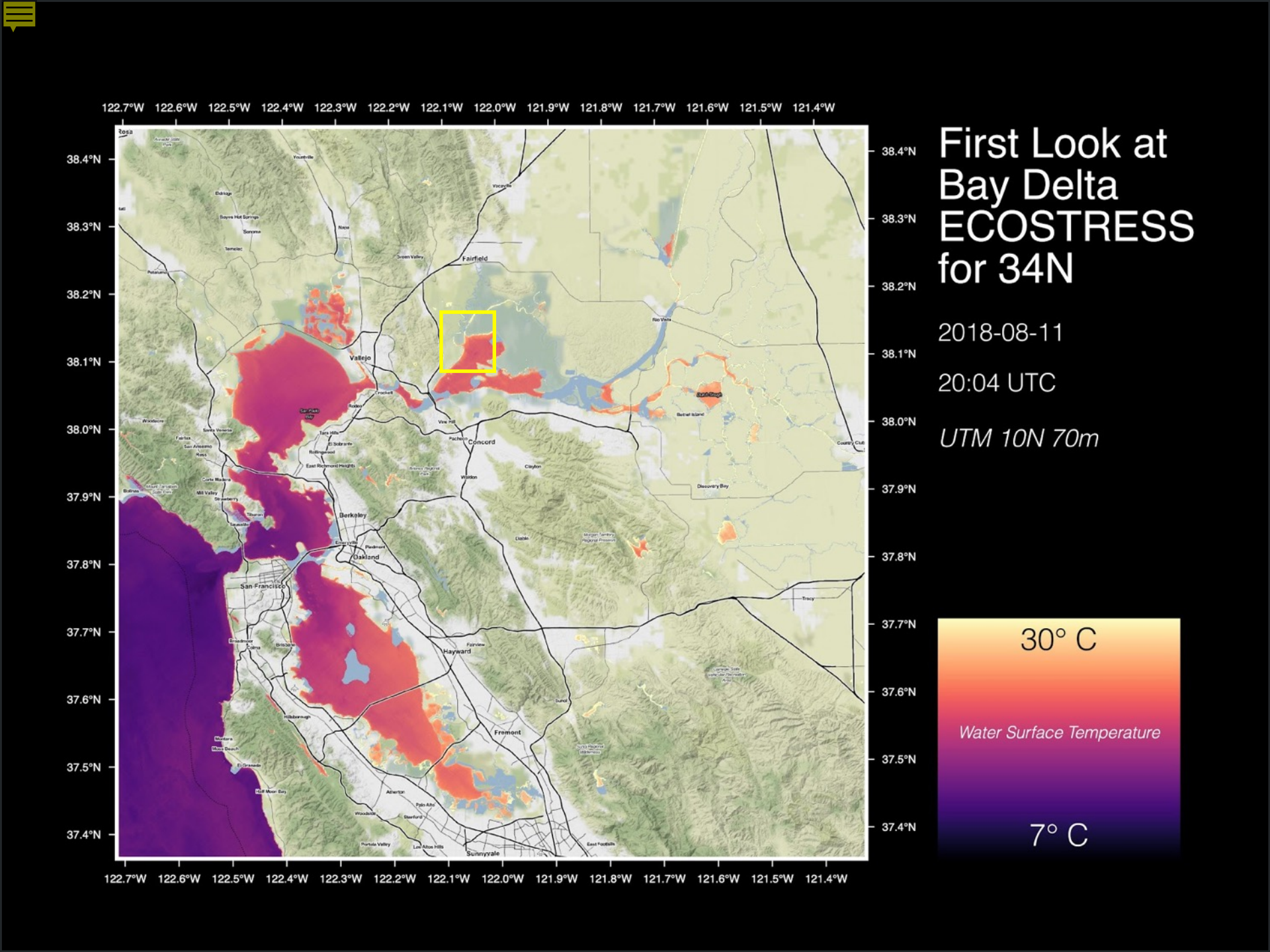
The First of a New Series of Missions to the International Space Station

Simon J. Hook (PI) and the ECOSTRESS Team

Jet Propulsion Laboratory,
California Institute of Technology,
Pasadena, CA




First Look at Bay Delta ECOSTRESS for 34N
2018-08-11
20:04 UTC
UTM 10N 70m
30° C
Water Surface Temperature
7° C
122.7°W 122.6°W 122.5°W 122.4°W 122.3°W 122.2°W 122.1°W 122.0°W 121.9°W 121.8°W 121.7°W 121.6°W 121.5°W 121.4°W
38.4°N
38.3°N
38.2°N
38.1°N
38.0°N
37.9°N
37.8°N
37.7°N
37.6°N
37.5°N
37.4°N
Vallejo
Fairfield
Concord
Berkeley
Oakland
San Francisco
Hayward
Fremont
Sunnyvale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Fairfield
Vallejo
Concord
Berkeley
Oakland
San Francisco
Hayward
Fremont
Sunnyvale
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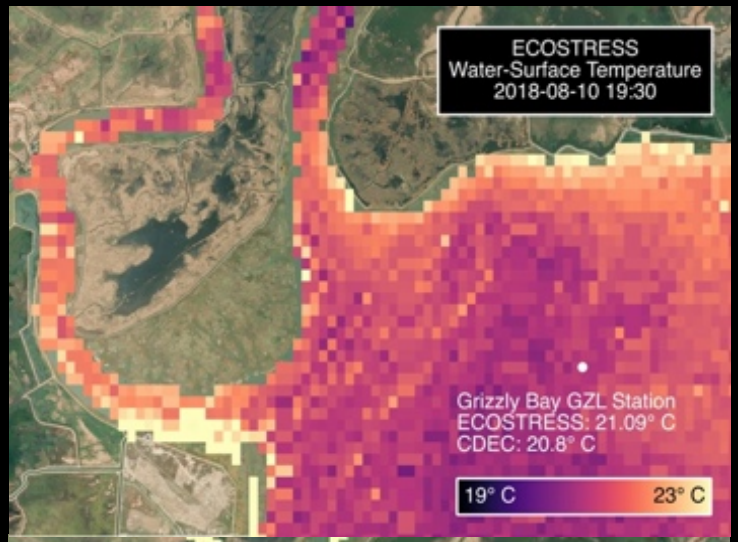
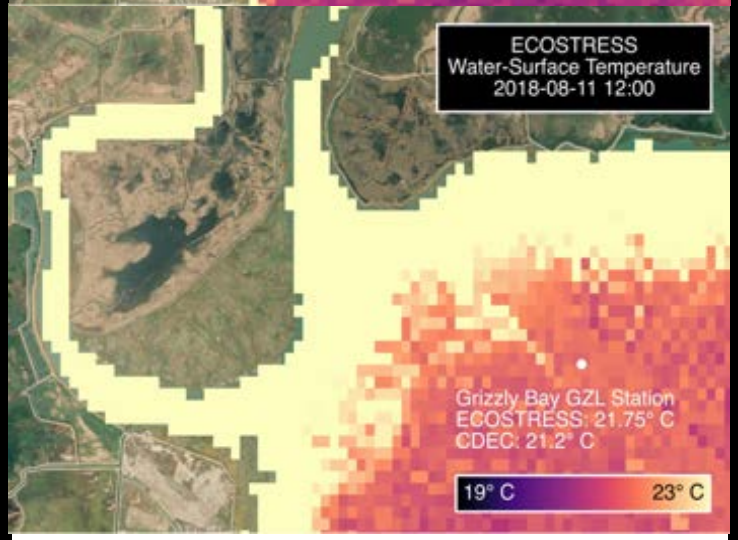
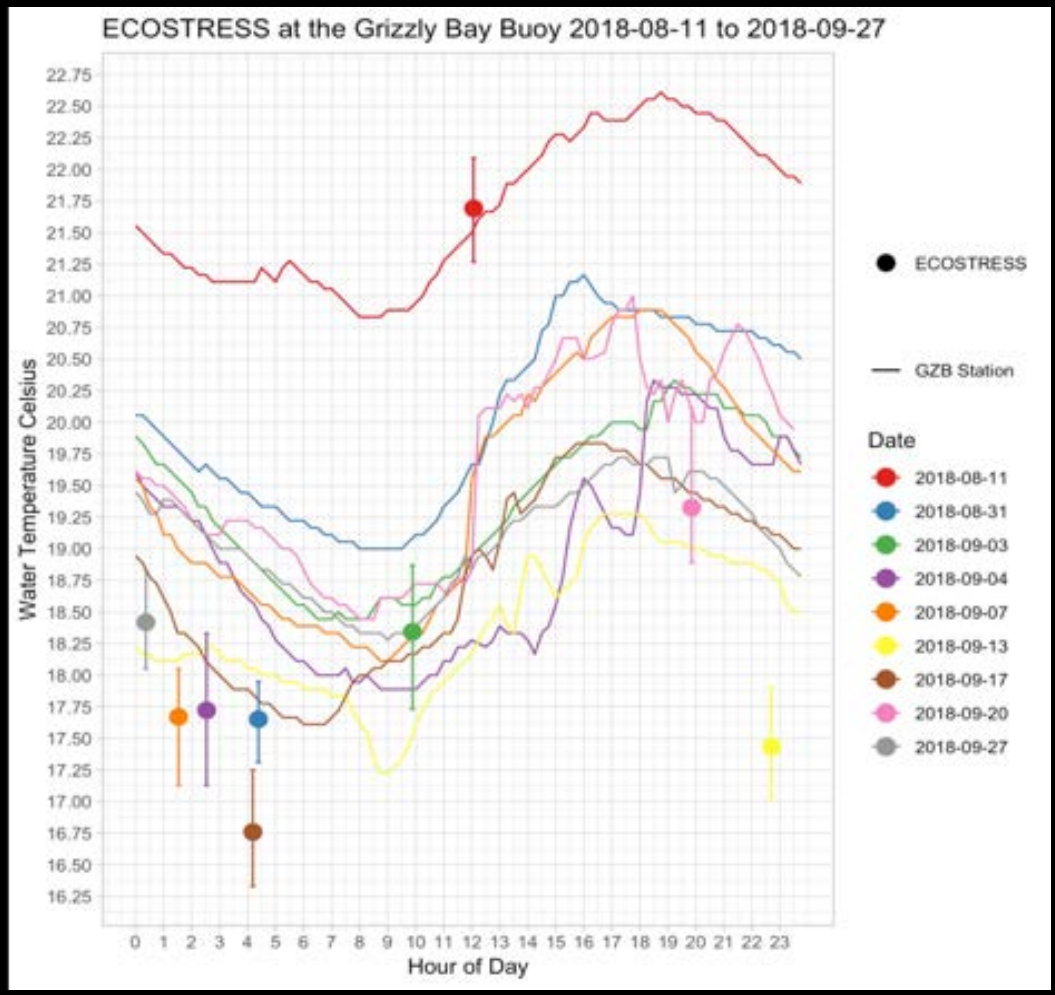




CHANGES IN SPATIAL DISTRIBUTION OF ECOSTRESS SURFACE TEMPERATURE IN GRIZZLY BAY USING TWO ACQUISITIONS (WITHIN 24 HOURS). THE LEFT PANEL WAS ACQUIRED ON 8/10/2018 AT 630PM PT AND THE RIGHT PANEL WAS ACQUIRED ON 8/11/2018 AT 1200PM PT.



CHANGES IN
TEMPERAT
(WITHIN 24
8/10/20
AC

Work Plan for Monitoring and Assessment of Proposed Suisun Marsh Salinity Control Gates Action, 2019

By Department of Water Resources Division of Environmental Services

June 3, 2019

-27

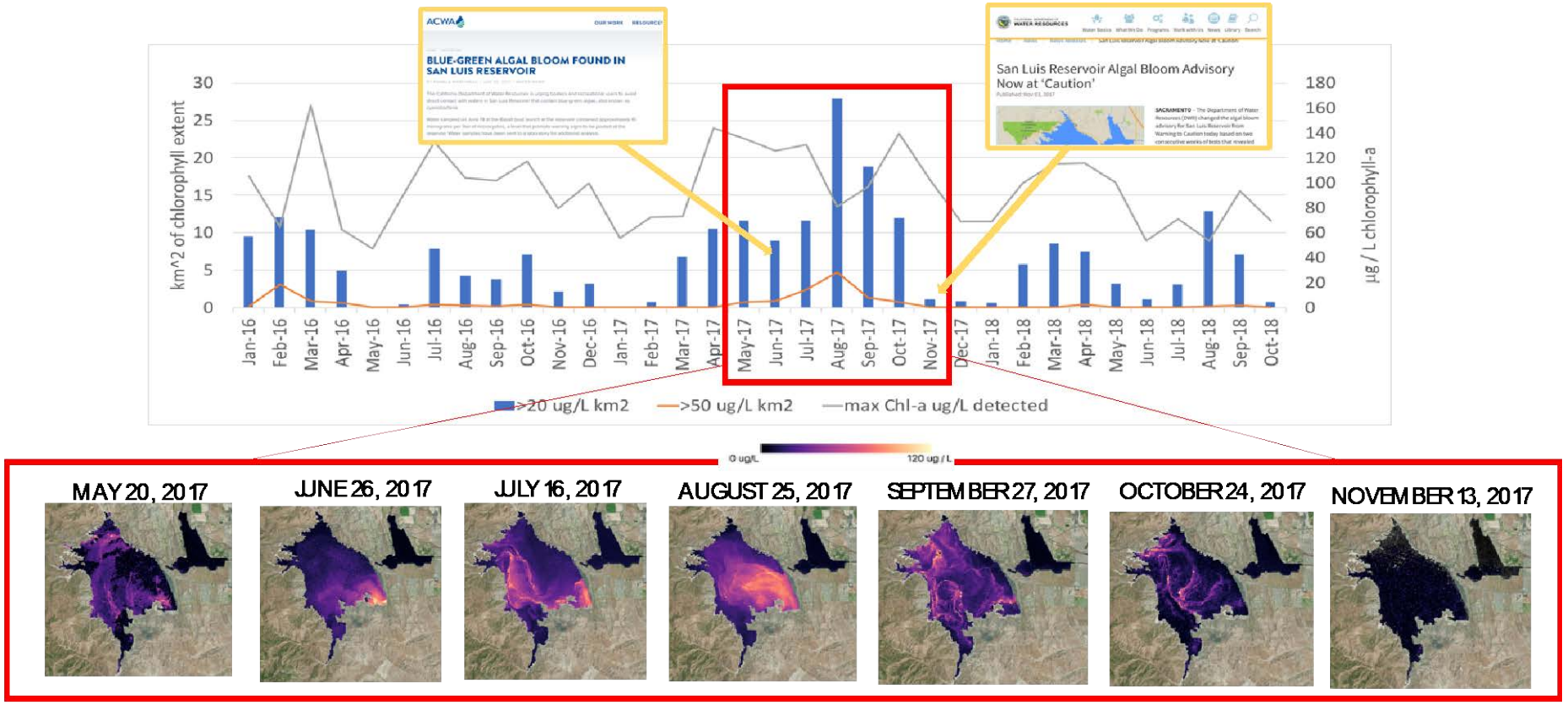
ECOSTRESS

GZB Station

Date

2018-08-11
2018-08-31
2018-09-03
2018-09-04
2018-09-07
2018-09-13
2018-09-17
2018-09-20
2018-09-27

San Luis Reservoir (also part of the California State Water Project) with multiple uses, including water supply holding grounds, recreation, habitat.

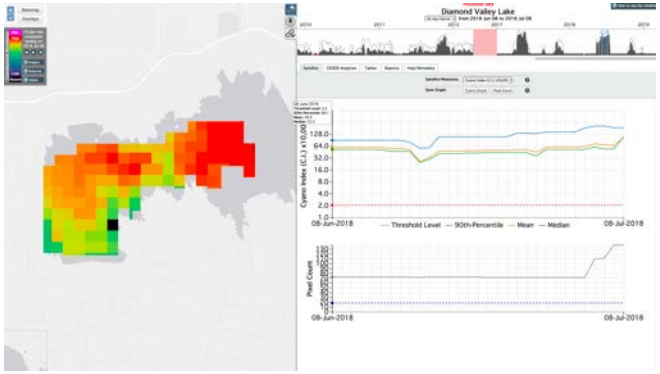


JPL proposal to partner with MWD SD to improve mapping of harmful algal blooms, collaboration with UCLA/Ozcan and Batalin

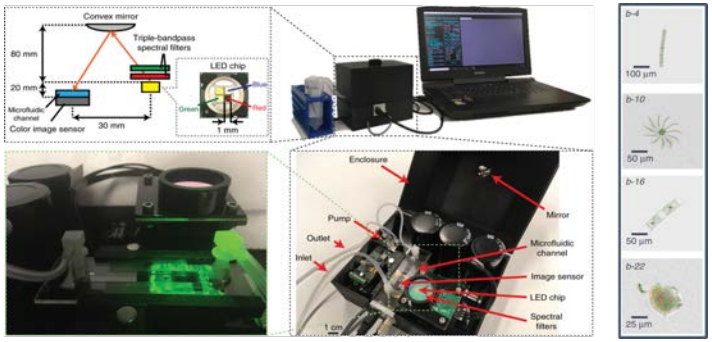
Site Name	Owner	Uses
Lake Skinner	MWDSC	Drinking Water Supply, Recreation
Lake Mathews	MWDSC	Drinking Water Supply
Lake Perris	CA DWR	Drinking Water Supply, Recreation
Diamond Valley Lake	MWDSC	Drinking Water Supply, Recreation
Silverwood Lake	CA DWR	Drinking Water Supply, Recreation
Castaic Lake	CA DWR	Drinking Water Supply, Recreation
Pyramid Lake	CA DWR	Drinking Water Supply, Recreation

MWDSC service area and reservoirs and uses.

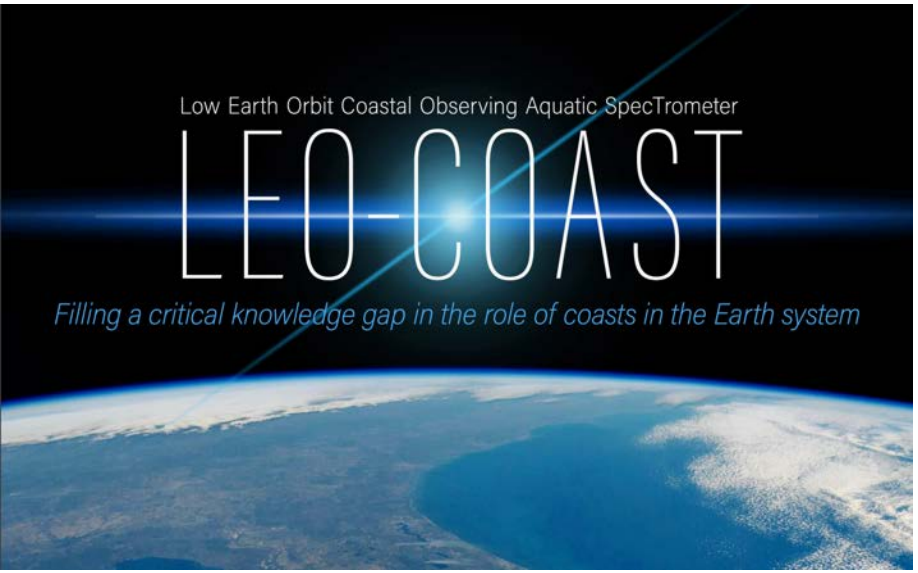
A taste-and-odor producing detrimental cyanobloom in Diamond Valley Lake in 2014.



Cyanobacterial Index values in Diamond Valley Lake using Sentinel-3 data. Source: cchab.sfei.org



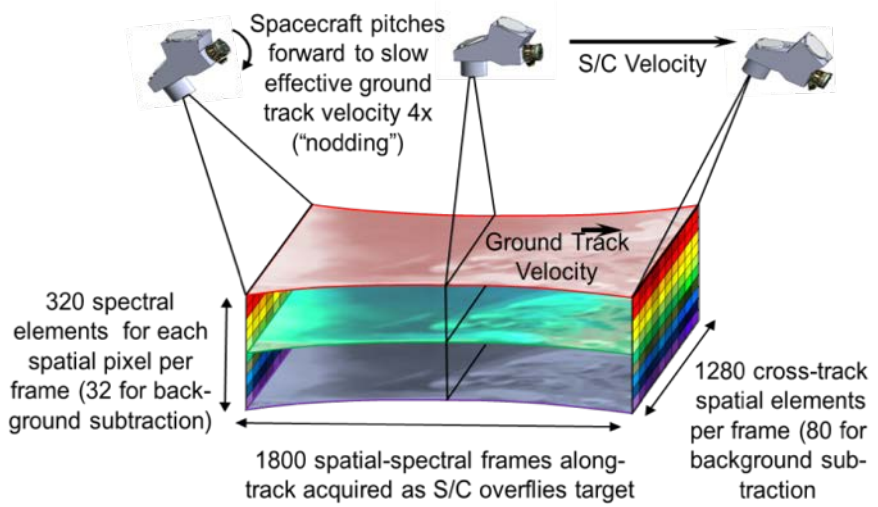
Setup for the in-situ automated high-throughput imaging flow cytometry platform based on lensfree computational microscopy principles.



The COAST Instrument

Innovating Coastal Observations

- VSWIR 380 -2510 nm hyperspectral imager in a 1-day/ 16 orbit repeat cycle
- High SNR for aquatic products
- Frequent lunar and Earth calibration views
- Sun-glint avoidance
- Easy to accommodate – heritage LEOStar-2 and Pegasus launch demonstrated as feasible, other options available



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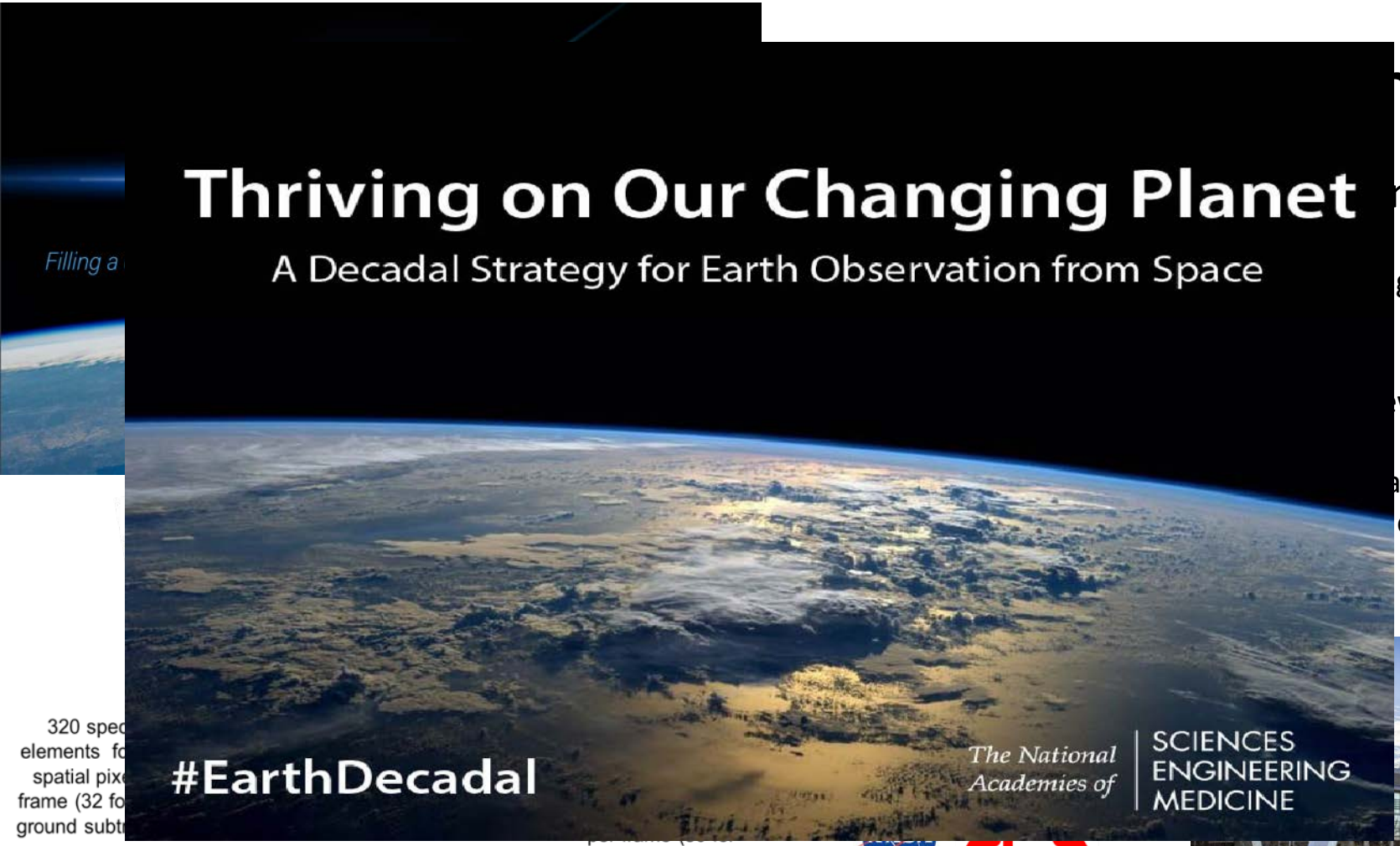
APL JOHNS HOPKINS APPLIED PHYSICS LABORATORY

NASA JPL Jet Propulsion Laboratory California Institute of Technology



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320 spec
elements fo
spatial pix
frame (32 fo
ground subtr

1800 spatial-spectral frames along-track acquired as S/C overflies target

background sub-traction

Jet Propulsion Laboratory
California Institute of Technology