

Remote Sensing of Water Quality in California's Water Systems

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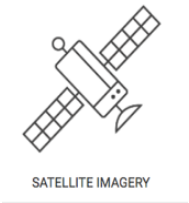
THE METROPOLITAN WATER DISTRICT OF SOUTHERN CALIFORNIA
34NORTH WEB · DATA · GIS
UNIVERSITY OF CALIFORNIA UCMERCED
OSU Oregon State University
BAY-DELTA LIVE
USGS science for a changing world
DEVELOP
NASA
DEPARTMENT OF WATER RESOURCES STATE OF CALIFORNIA
JPL Jet Propulsion Laboratory California Institute of Technology

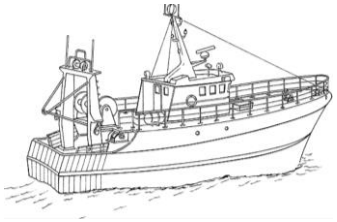


Overall vision. To advance the capability of multiple stakeholders in California's water resources to routinely access and utilize Earth observations-based water quality products to support operational or institutional decision-making related to water management practices.

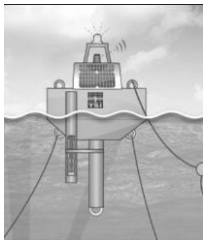


SATELLITE

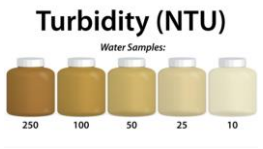
AIRCRAFT

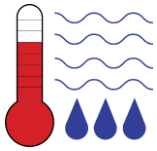


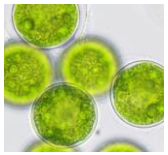
FIELD CRUISES



MONITORING STATIONS



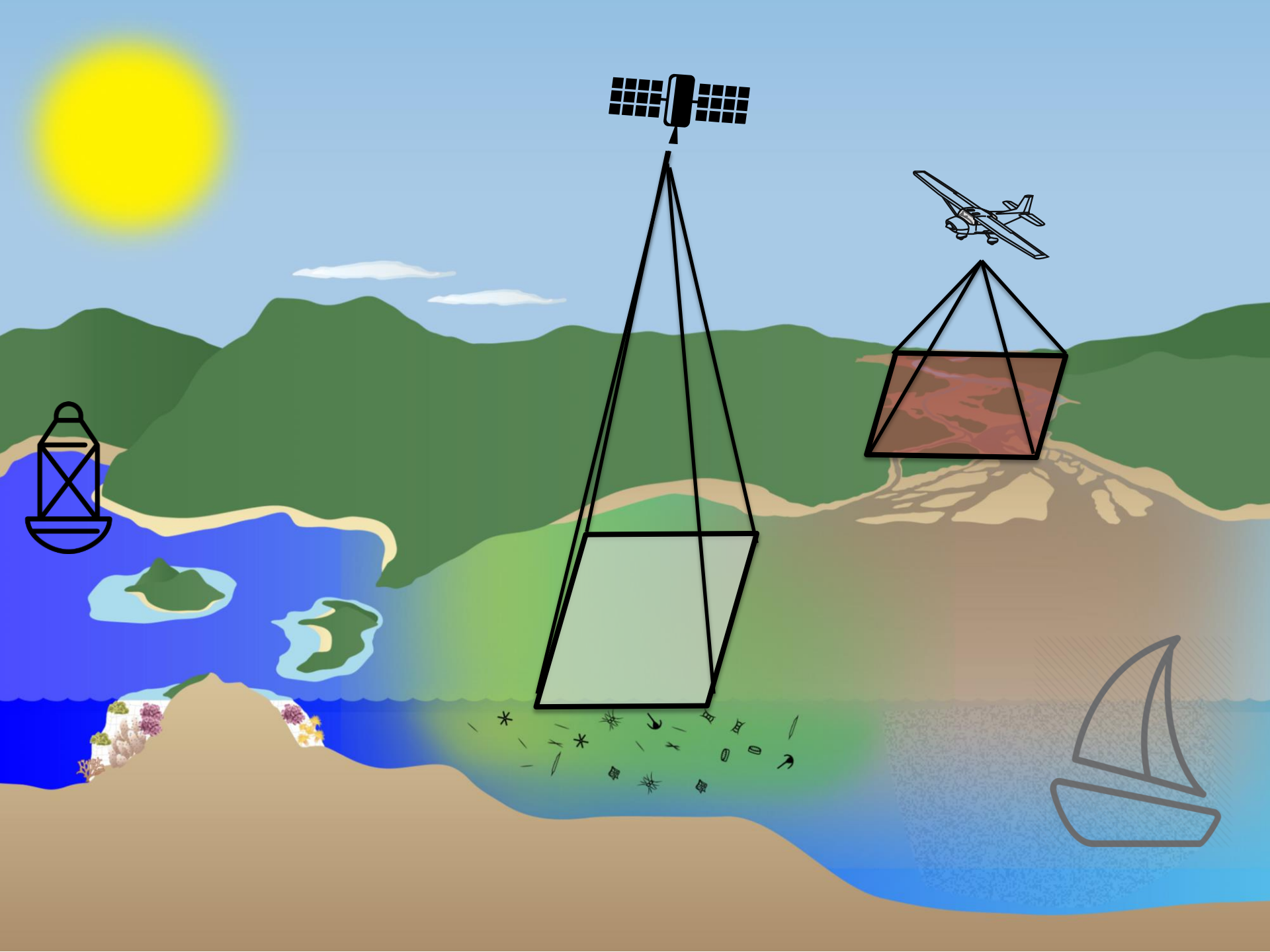


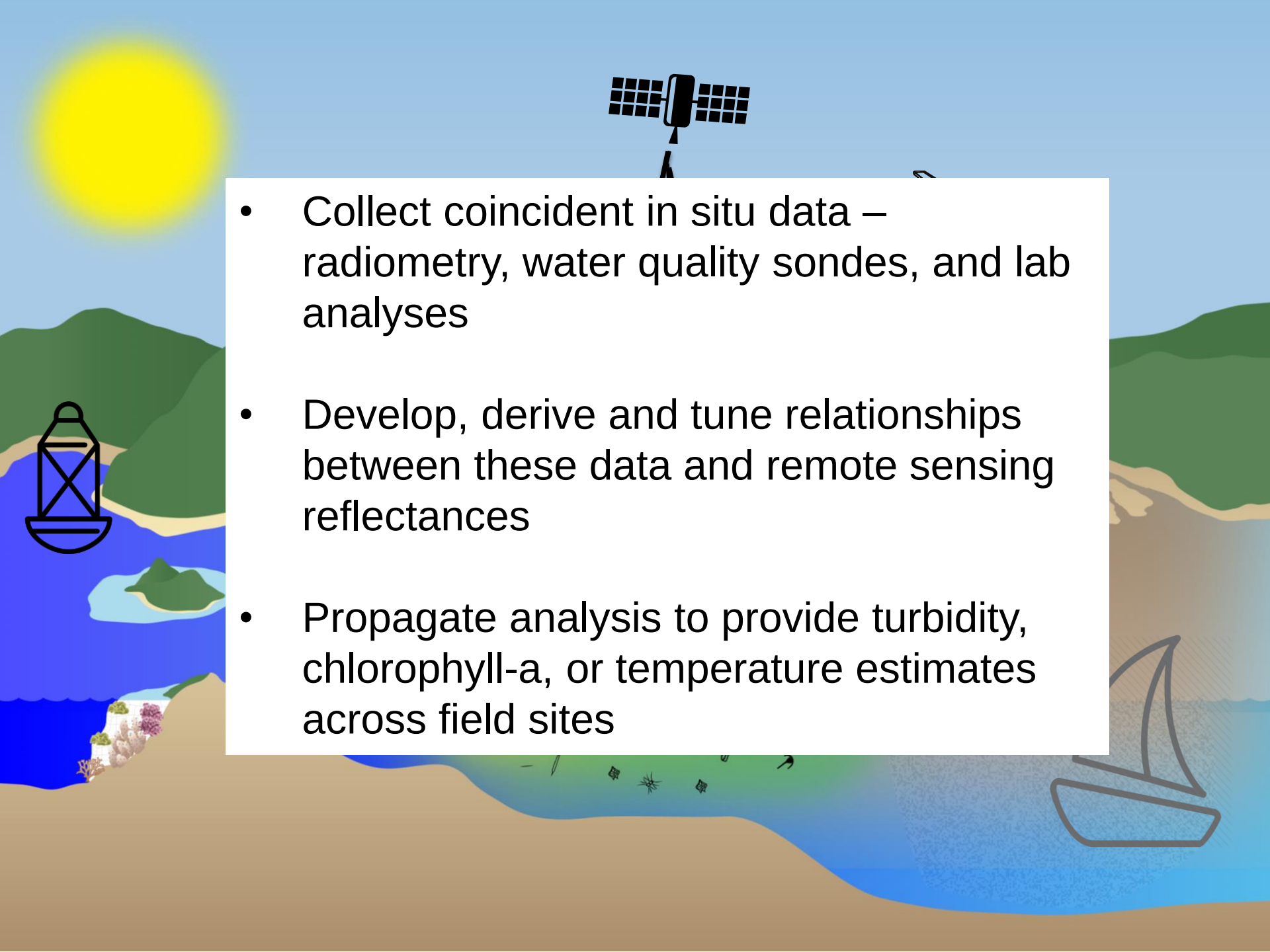




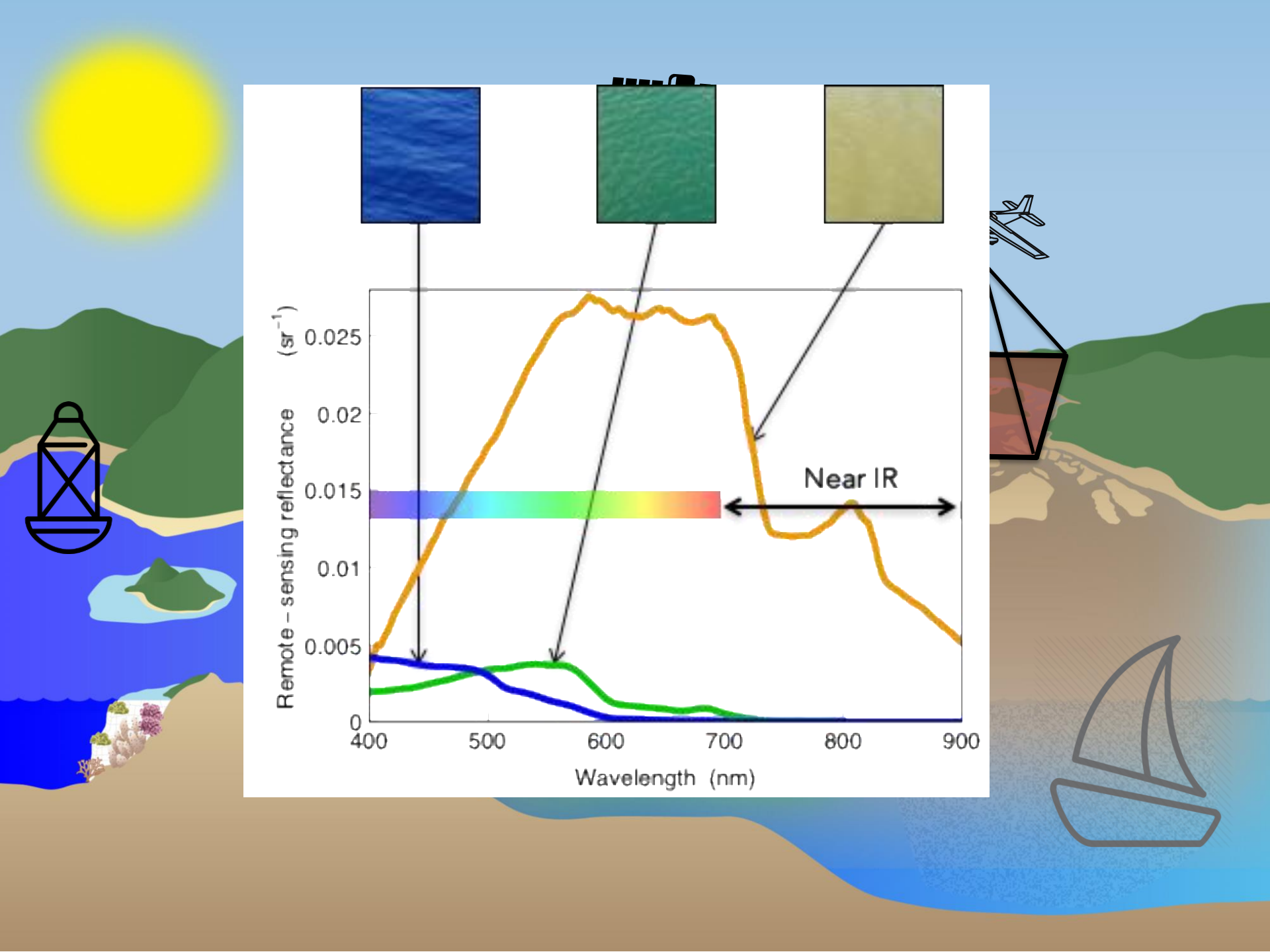
Objectives.

- Water quality product development: strengthen existing algorithms across airborne and satellite platforms for three water supply resources in the CA State Water Project
- Make products accessible: develop / automate processing pipeline and make water quality data available on public portal
- Support testing / use of data: develop use cases with partners to test complementary remote sensing data in existing studies





- Collect coincident in situ data – radiometry, water quality sondes, and lab analyses
- Develop, derive and tune relationships between these data and remote sensing reflectances
- Propagate analysis to provide turbidity, chlorophyll-a, or temperature estimates across field sites


Remote – sensing reflectance (sr^{-1})
0.025
0.02
0.015
0.01
0.005
0
Near IR
400
500
600
700
800
900
Wavelength (nm)

Parameter	Method	Reference
Turbidity	Semi-empirical two band algorithm	Dogliotti el al 2015
Chlorophyll-a	Red band absorption – 3 band algorithm	Moses et al 2012
Temperature	Landsat retrieval with atmospheric and emissivity corrections	Malakar et al, in press

Parameter	Method	Reference
Turbidity	Semi-empirical two band algorithm	$T = \frac{A_T^{\lambda} \rho_w(\lambda)}{\left(1 - \frac{\rho_w(\lambda)}{C^{\lambda}}\right)}$
Chlorophyll-a	Red band absorption – 3 band algorithm	$\text{Chl-}a \propto \left(R_{666}^{-1} - R_{704}^{-1}\right) \times R_{723}$
Temperature	Landsat retrieval with atmospheric and emissivity corrections	$L_s = B(T_s) = \frac{\frac{L - L^{\uparrow}}{\tau} - (1 - \epsilon) L^{\downarrow}}{\epsilon}$

Supporting regional investigations and monitoring

Note: all product pipelines will be delivered / available for all three sites

Example case studies

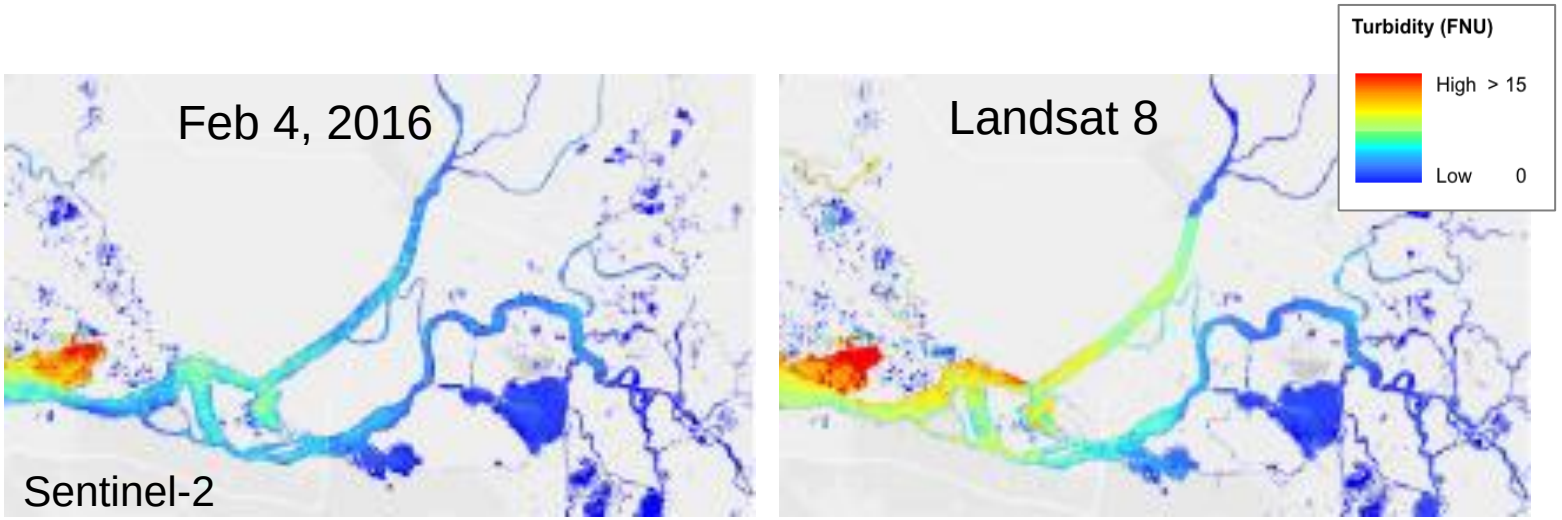
- Turbidity in the SF Delta
  - Turbidity thresholds for smelt are established in the “BiOps.” Relationship with fish surveys, salinity, and pump ops.

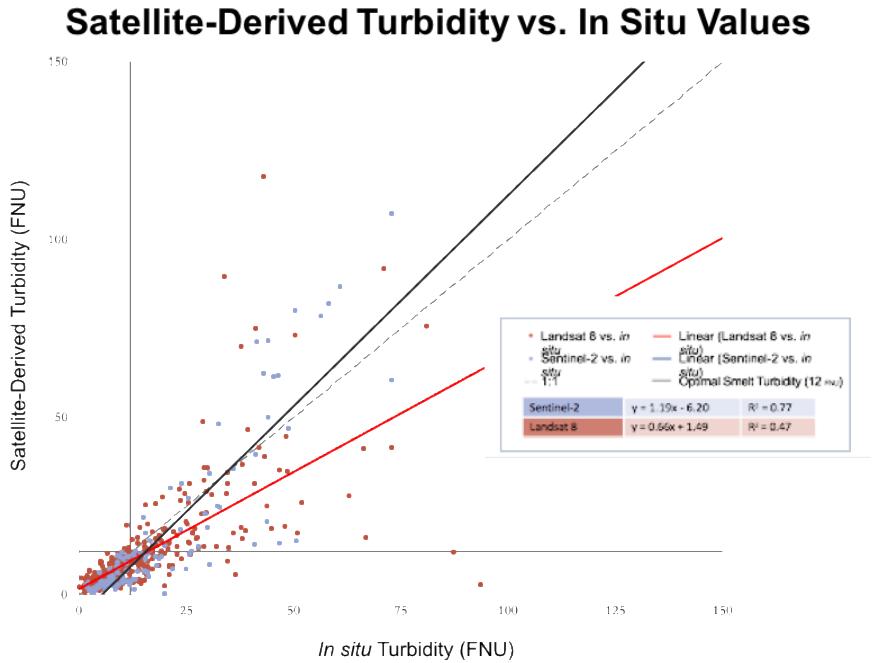
- Chlorophyll in San Luis Reservoir
  - Recent algal blooms are of concern for both operations and recreation.

- Temperature in Oroville, SLR, and Delta
  - Use of temperature to help manage flows to be protective of fish habitat

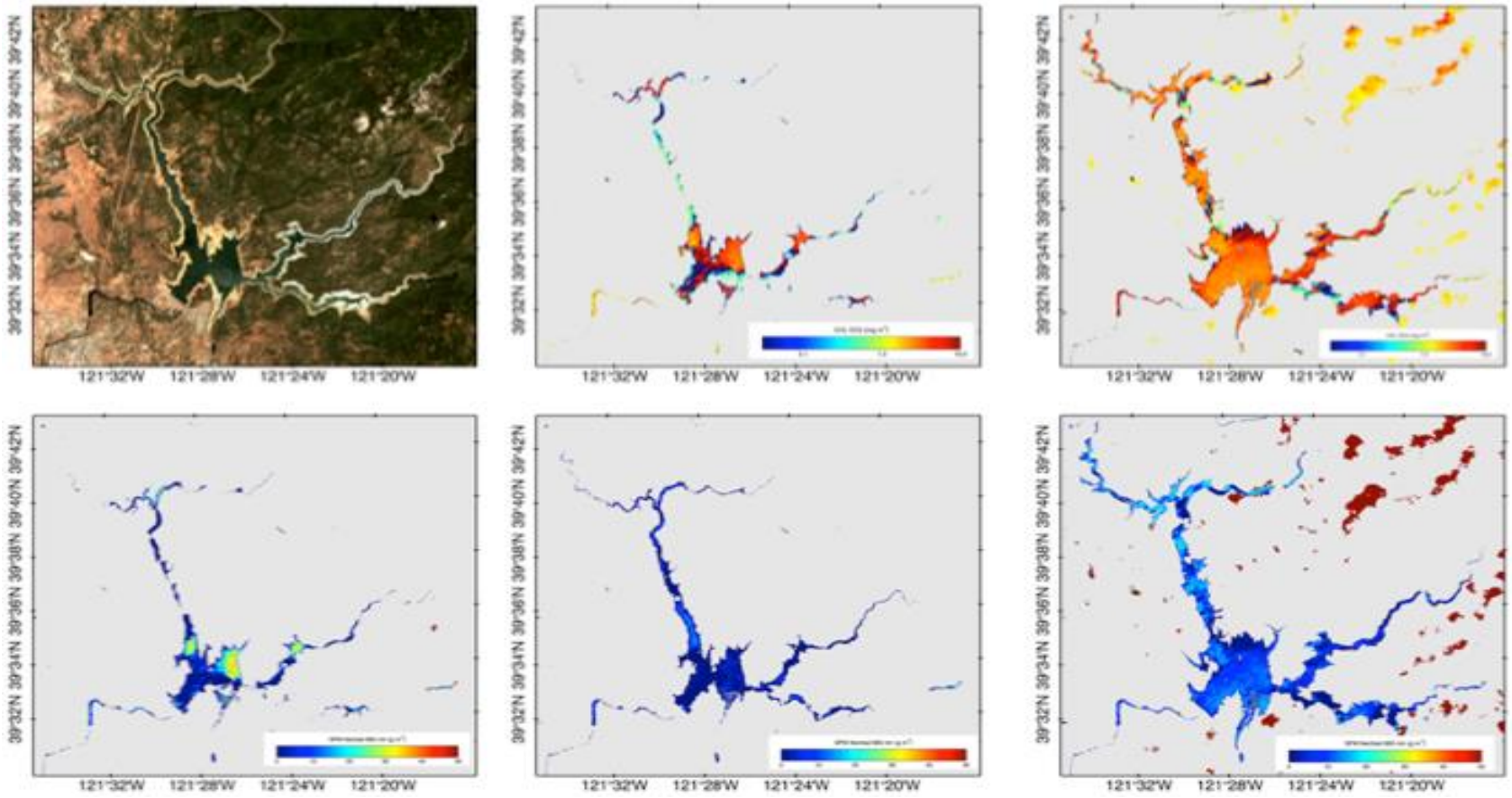
- Critical: partnering with locally based managers to update these case studies as well as for on site coordination.

Comparisons with turbidity stations in San Francisco Bay and Delta – Preliminary Data

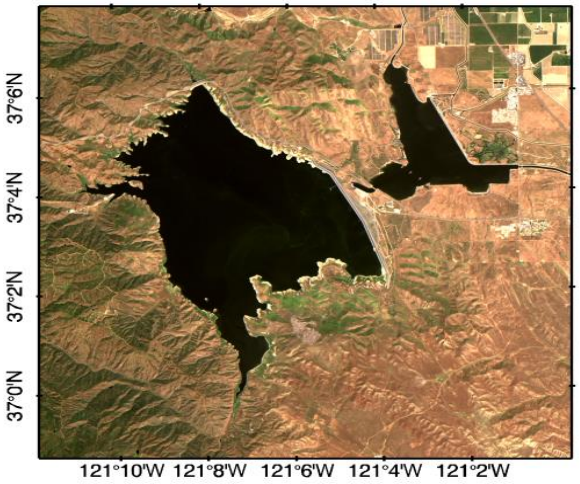


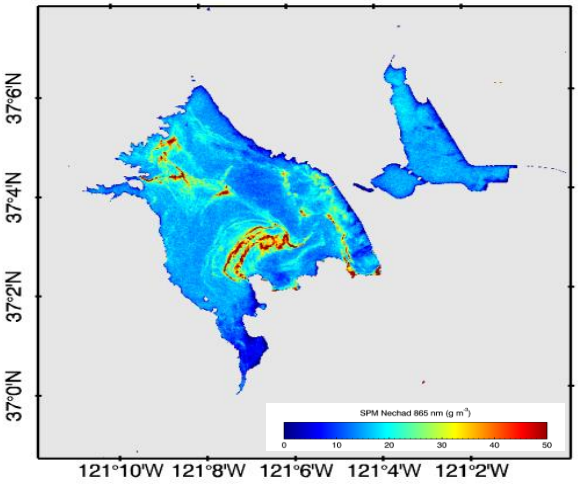


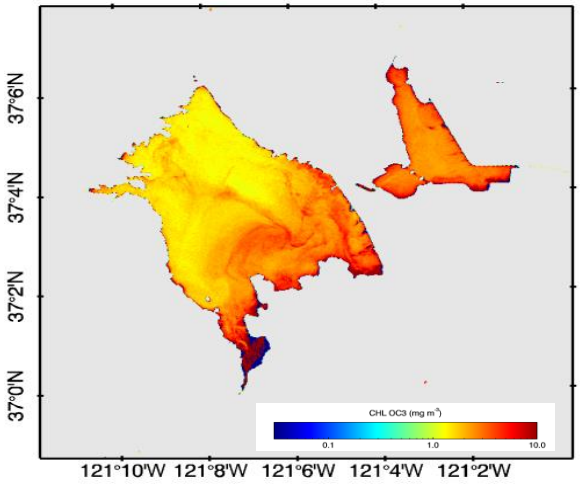
Example Maps – Lake Oroville – suspended particulate matter and chlorophyll – April through July 2016



Example Maps – San Luis Reservoir – April 2016







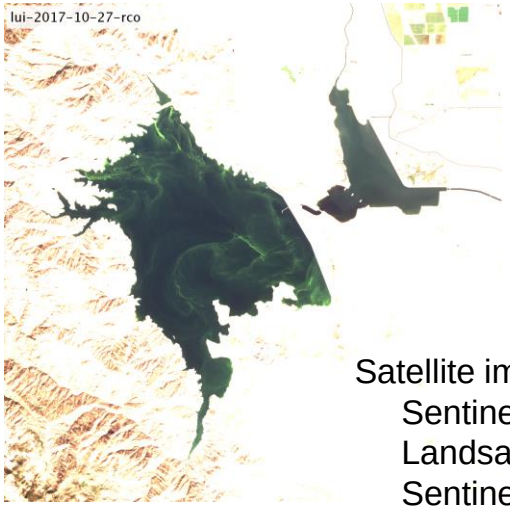
Recent Cruises (2017)

2017-11-01 AVIRIS-NG Overflight in North Bays and Delta

2017-11-14 San Luis Reservoir

2017-11-17 Golden Gate to Rio Vista

San Luis Reservoir - Cyanos



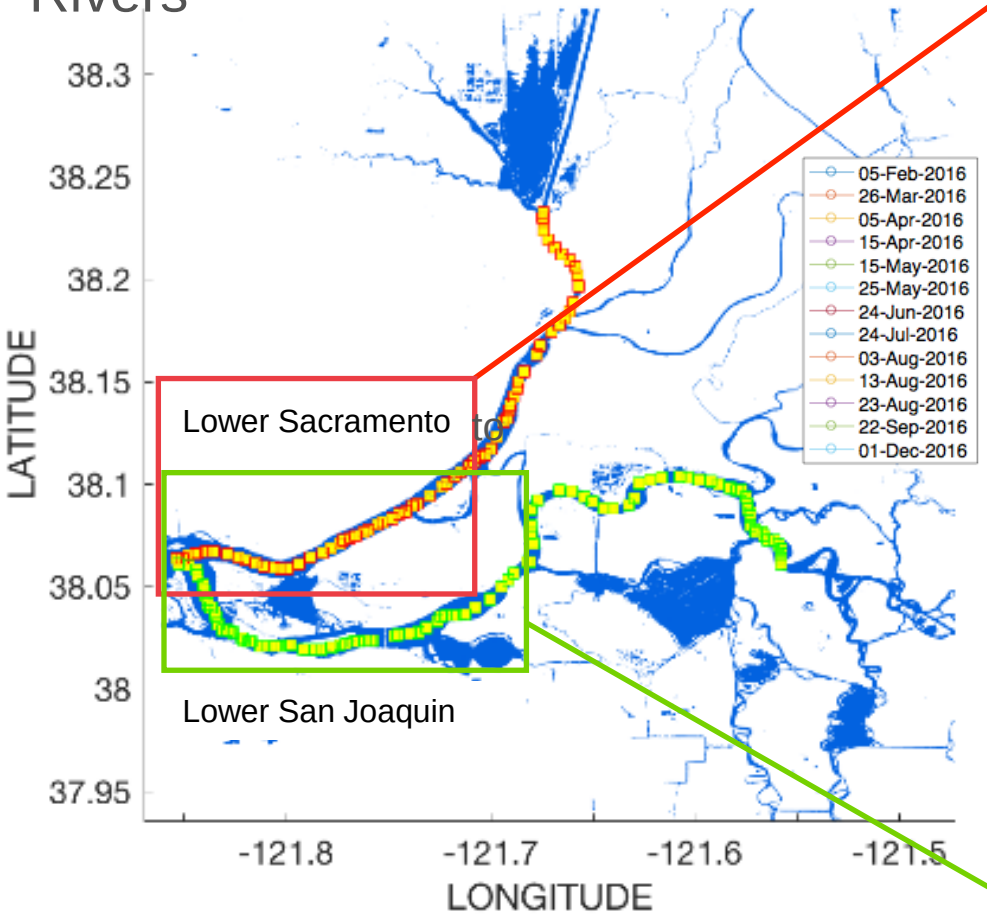
Satellite imagery from:
- Sentinel-2a
- Landsat-8
- Sentinel-3
- VIIRS

+AVIRIS-NG 11-01 overflight

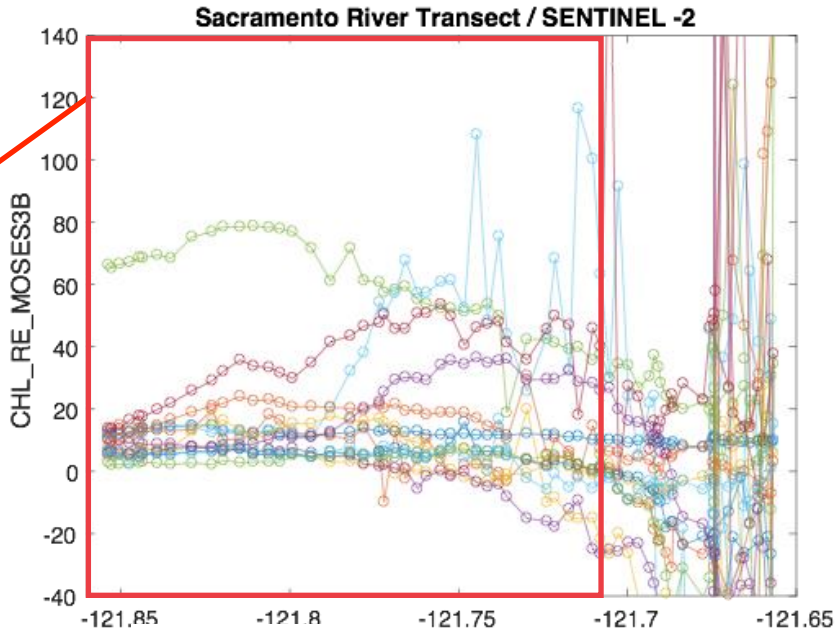
Sentinel-2A (MOSES 3B) derived Chll-a

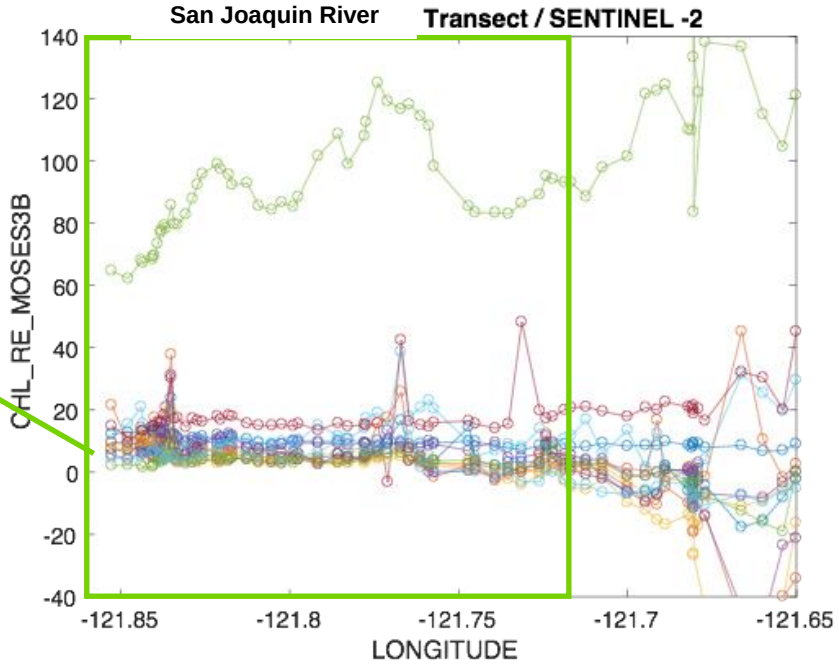
Sacramento and San Joaquin Rivers

Rivers



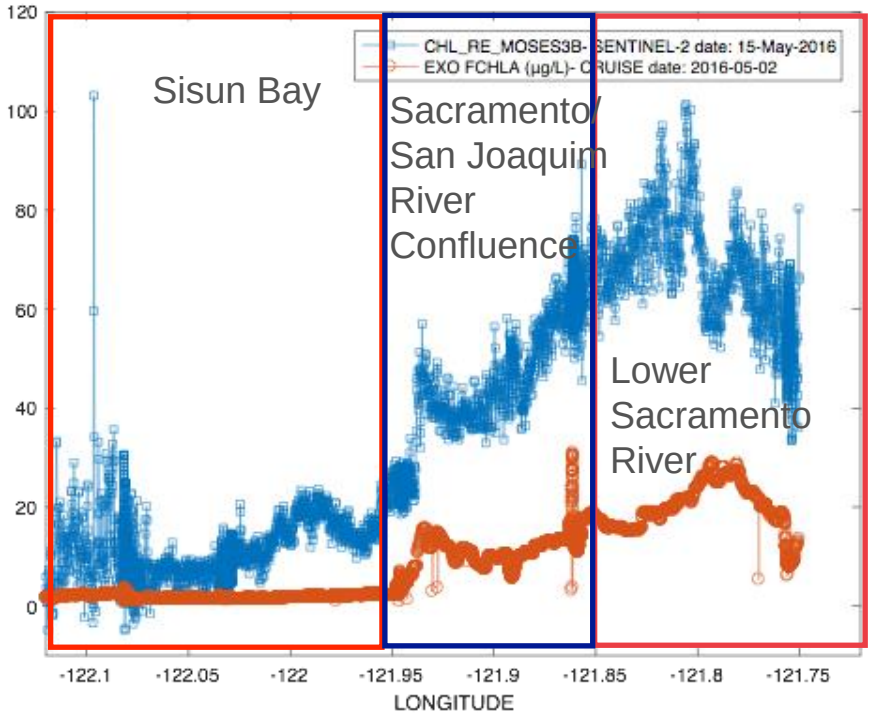
CHL_RE_MOSES3B / Sentinel-2

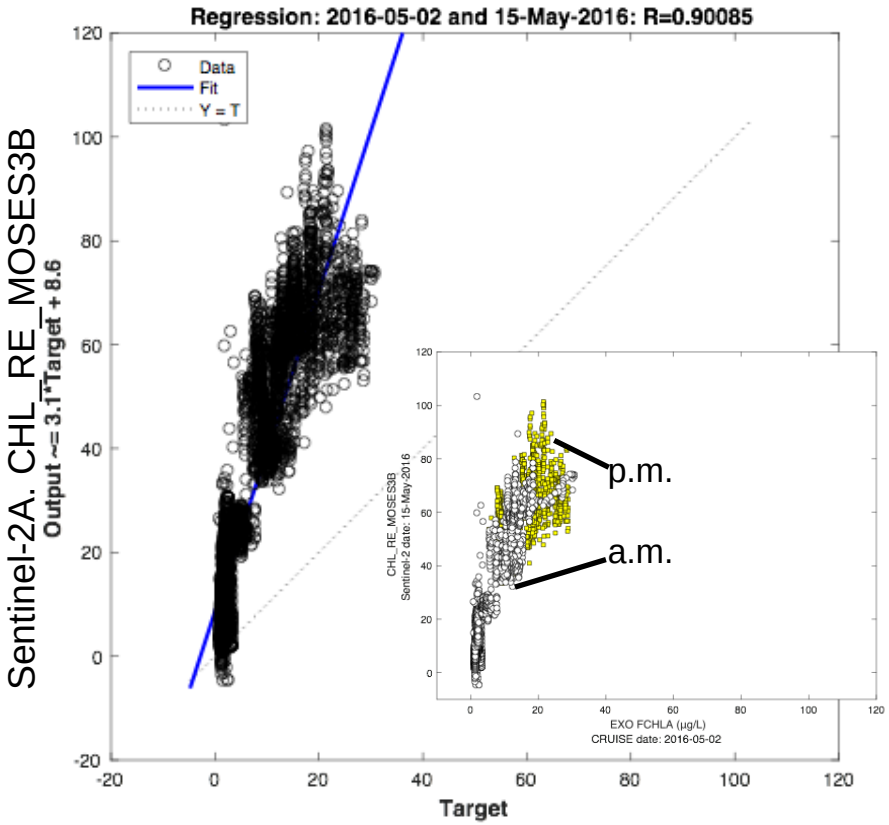




MAY-15 Sentinel-2
MAY-02 CRUISE

Subset data East to -121.75deg

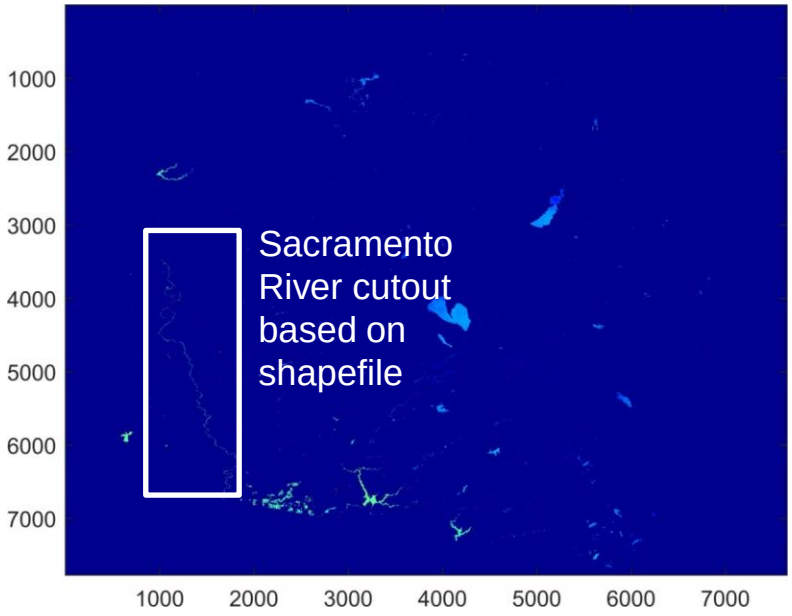


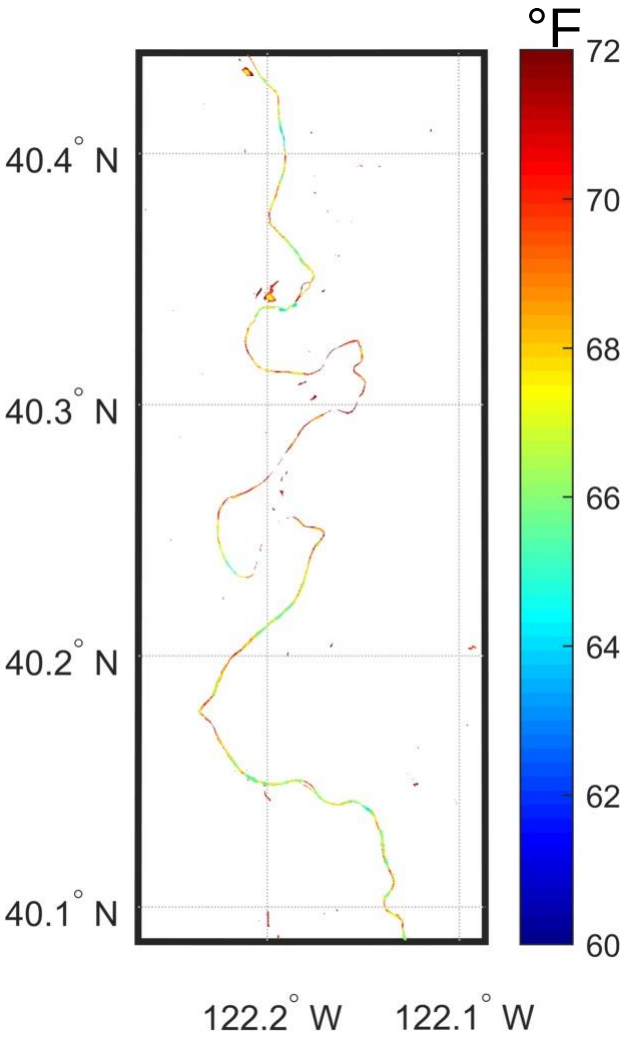


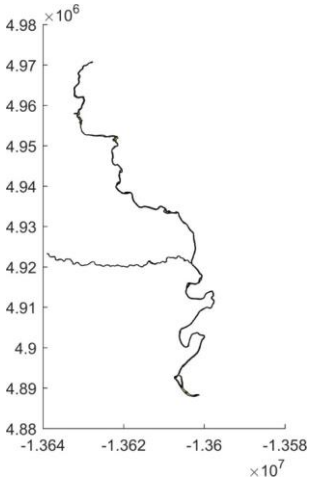
USGS Cruise data: EXO FCHLA ug/L

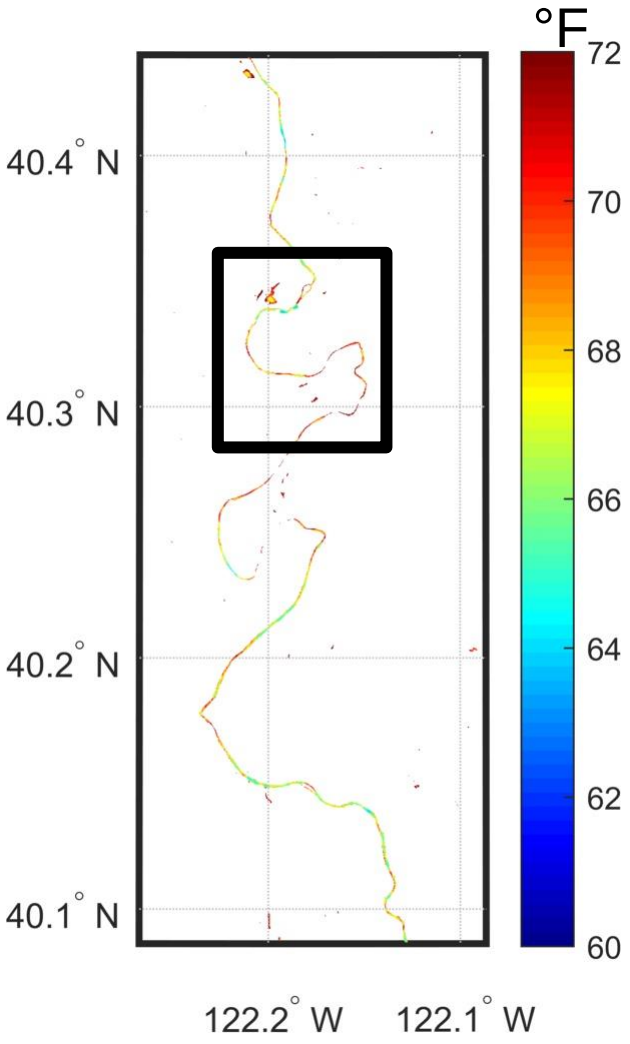
USGS Flow-through data, Bergamaschi

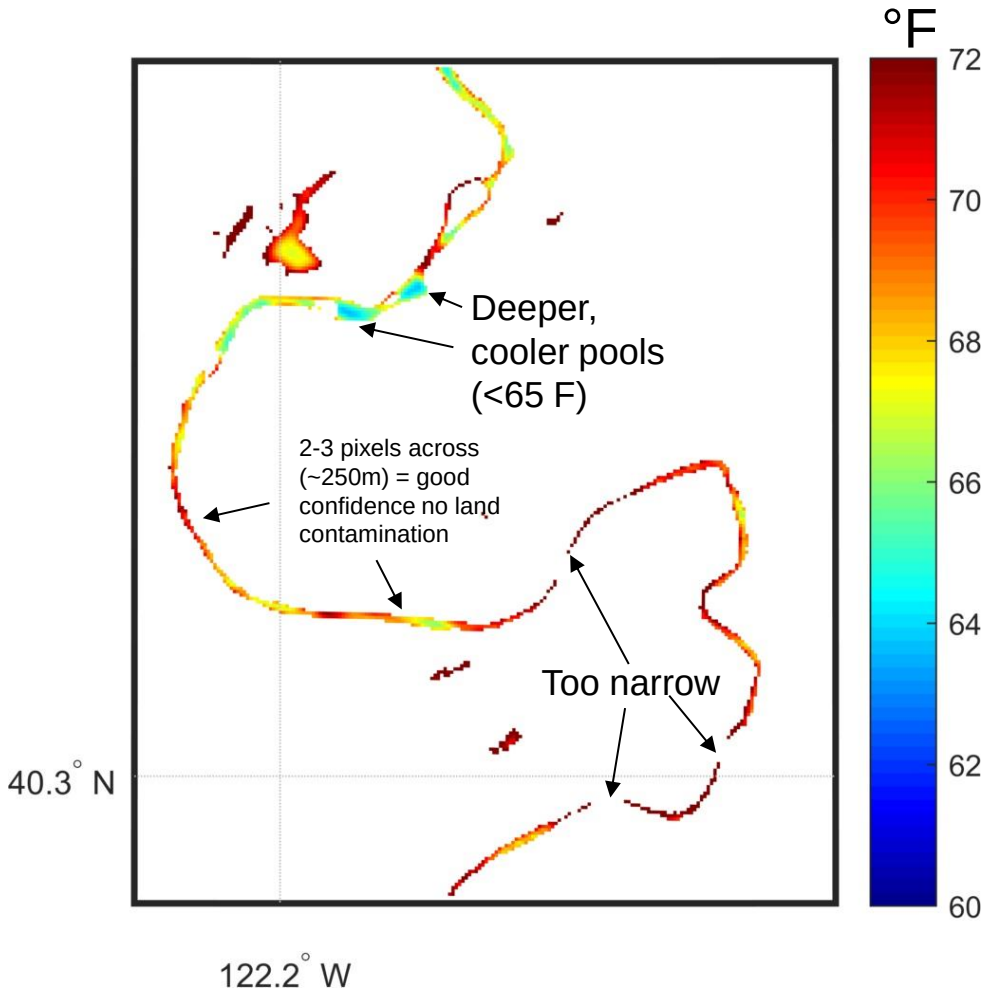
Landsat-8 water surface temperature in Sacramento River subarea








°F
72
70
68
66
64
62
60
40.4° N
40.3° N
40.2° N
40.1° N
122.2° W
122.1° W


°F
72
70
68
66
64
62
60
Deeper,
cooler pools
(<65 F)
2-3 pixels across
(~250m) = good
confidence no land
contamination
Too narrow
40.3° N
122.2° W



Key Messages.

- Data we are using is free – we are focusing on product accessibility and utility through site studies / monitoring efforts, publishing when possible
- Need ground based data, goal is to supplement existing efforts
- Partnerships are critical

Maximizing Utility of Remote Sensing for Water Resources and Quality Management in California's Water Systems

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