Earth Observations to Combat Invasive Aquatic Vegetation

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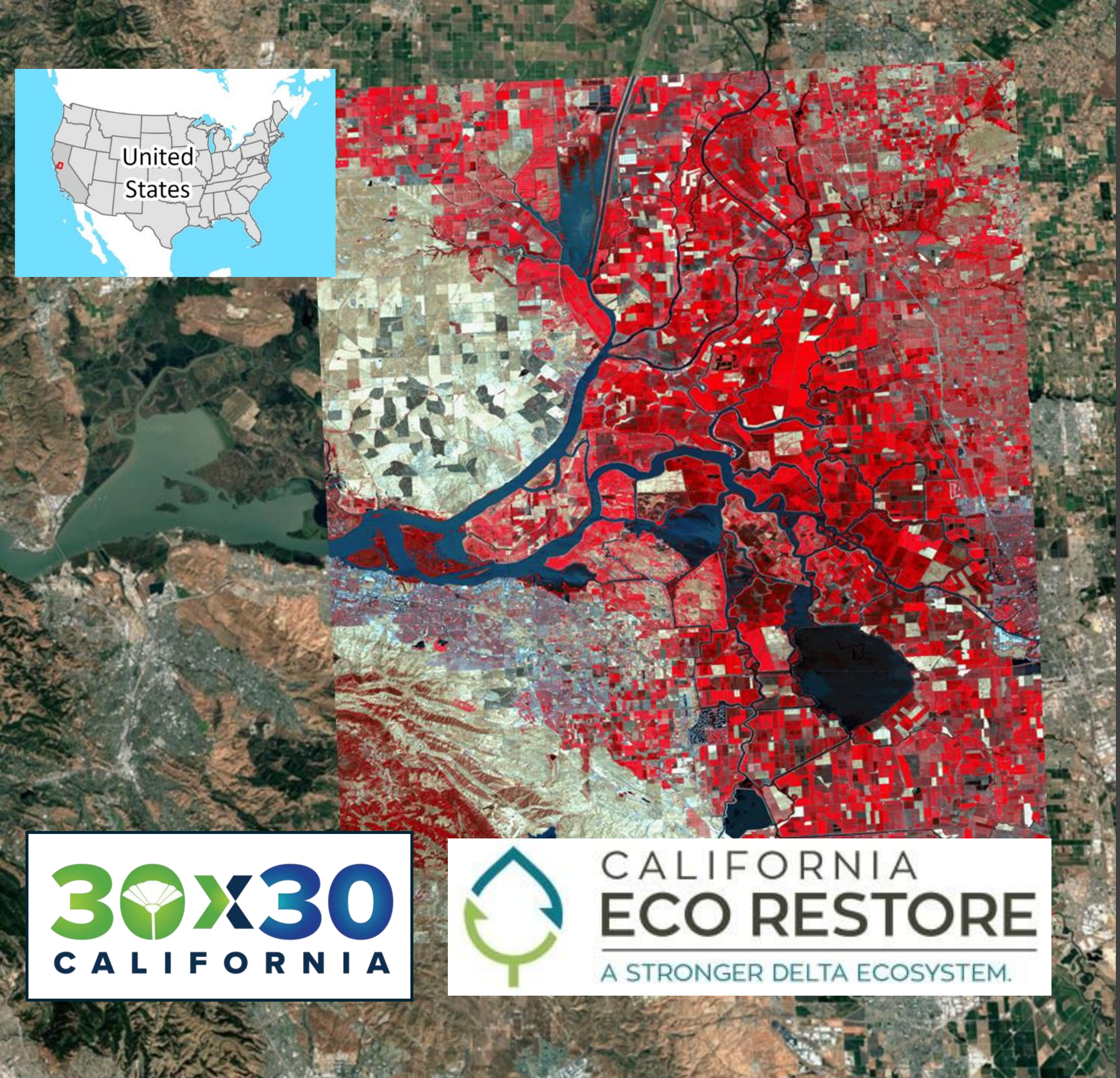
UC MERCED | CALIFORNIA DEPARTMENT OF FISH & WILDLIFE | DEPARTMENT OF WATER RESOURCES, STATE OF CALIFORNIA | Delta Stewardship Council | USBR • USFWS • SWRCB • CDFW • USGS • NMFS • USACE • USEPA • DWR



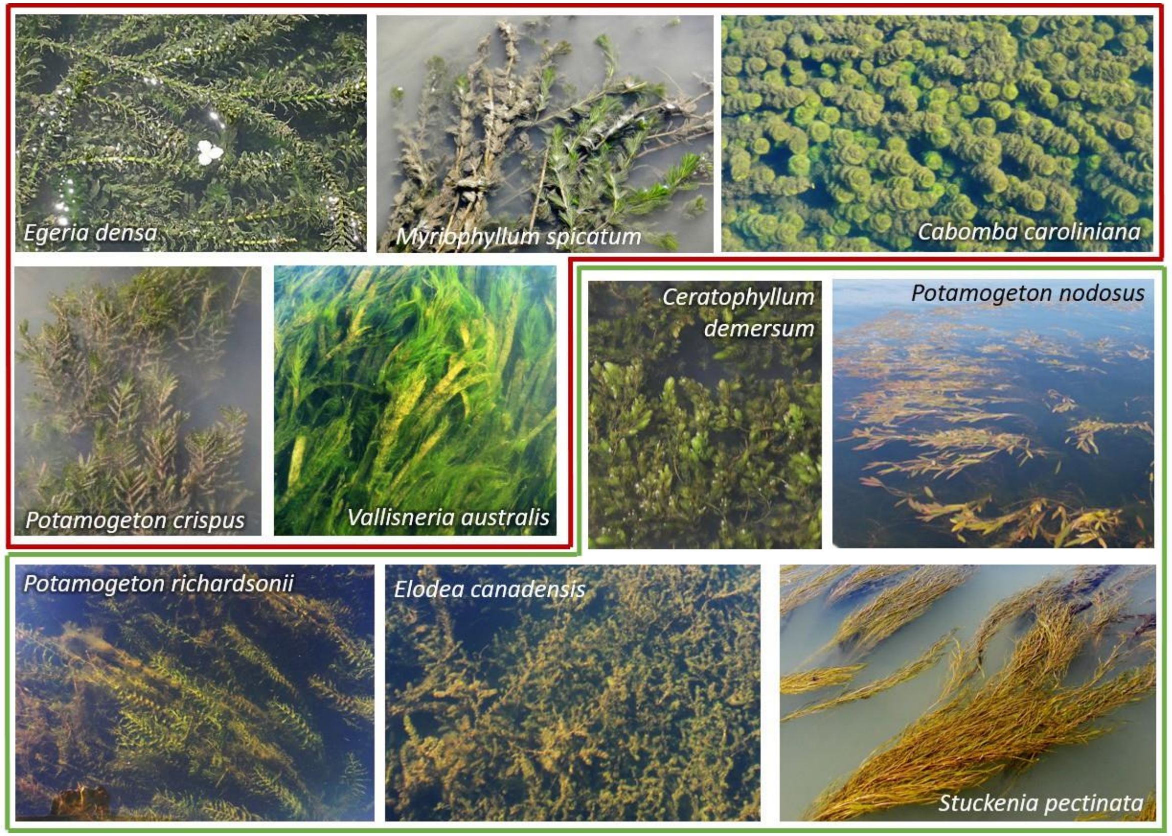
The Sacramento – San Joaquin Delta

- Water source for 27 million people.
- $5.3 billion economic output
- One of 25 global hotspots for biodiversity.
- One of the most invaded ecosystems in the world.
- Highly vulnerable to climate variability & change.
- Biodiversity conservation and restoration are **required by law**.

Invasive aquatic vegetation (IAV) represent a major threat to global biodiversity

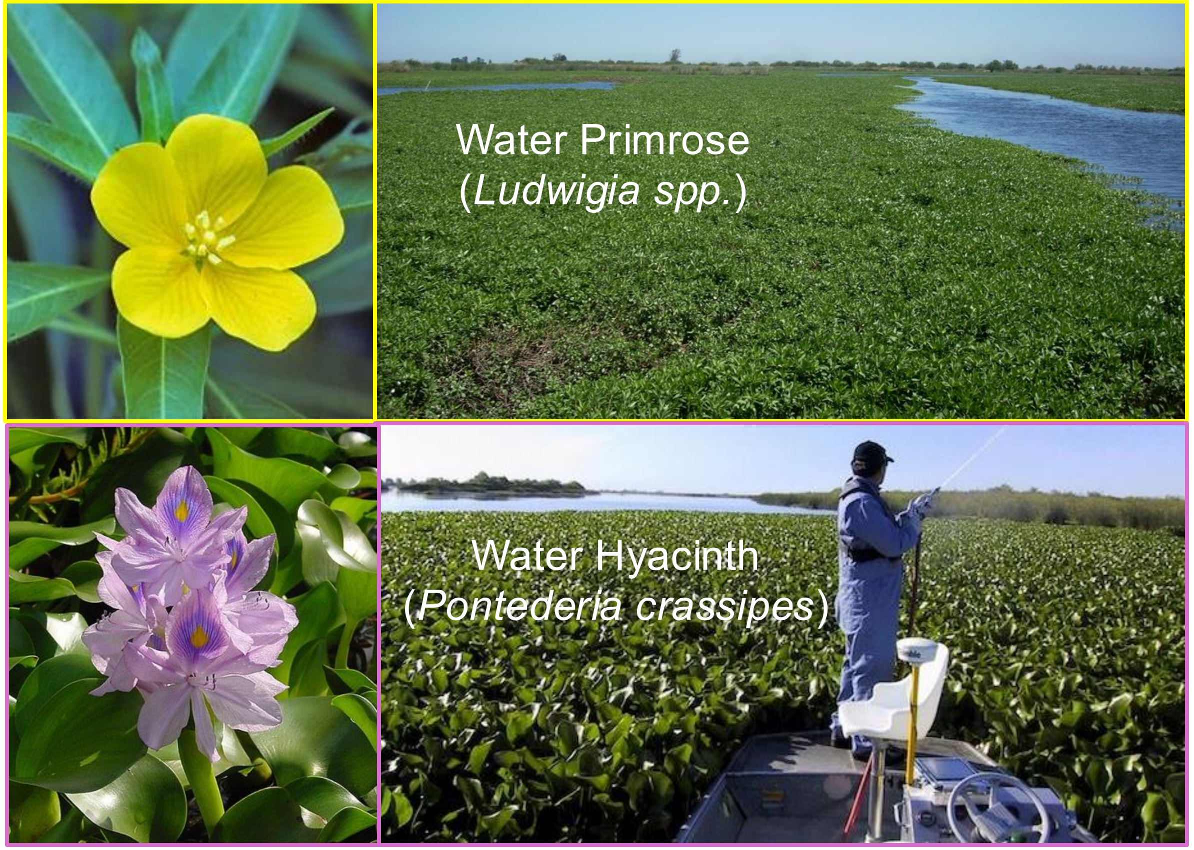
Submerged Aquatic Vegetation (SAV)

INVASIVE

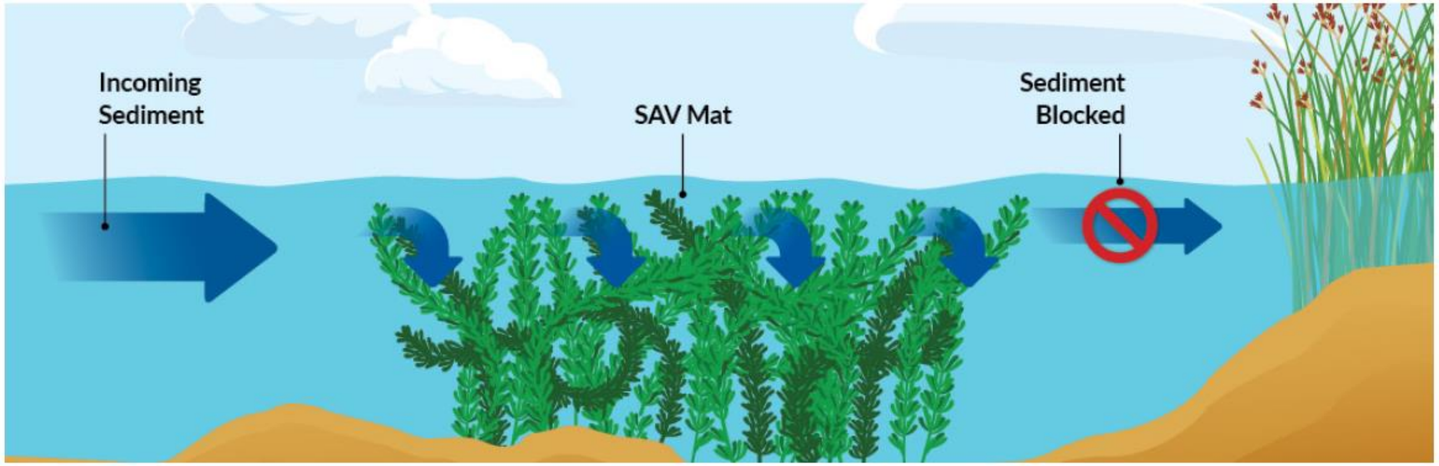


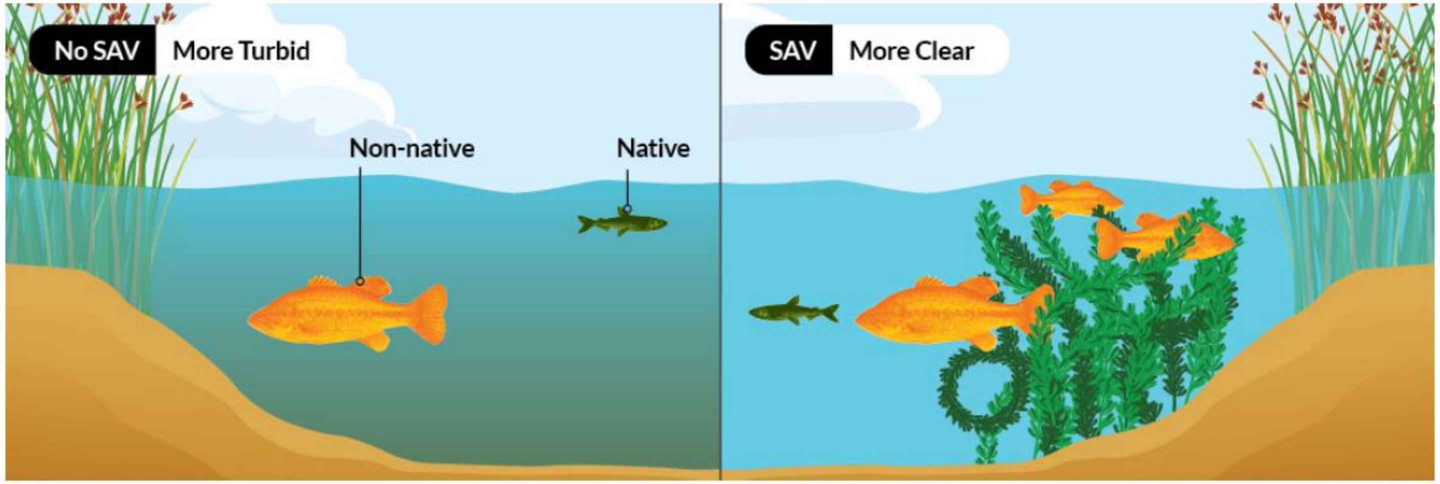
NATIVE

Floating Aquatic Vegetation (FAV)



Invasive aquatic vegetation (IAV) represent a major threat to global biodiversity





Ecological Impacts:

- Alter environmental conditions
- Reduce native biodiversity
- Replace key habitats
- Increase invader establishment

Human Impacts:

- Increase agricultural costs
- Cost CA $14.5 million to manage/year
- Increase flood risk
- Increase disease risk

Previous Mapping Efforts

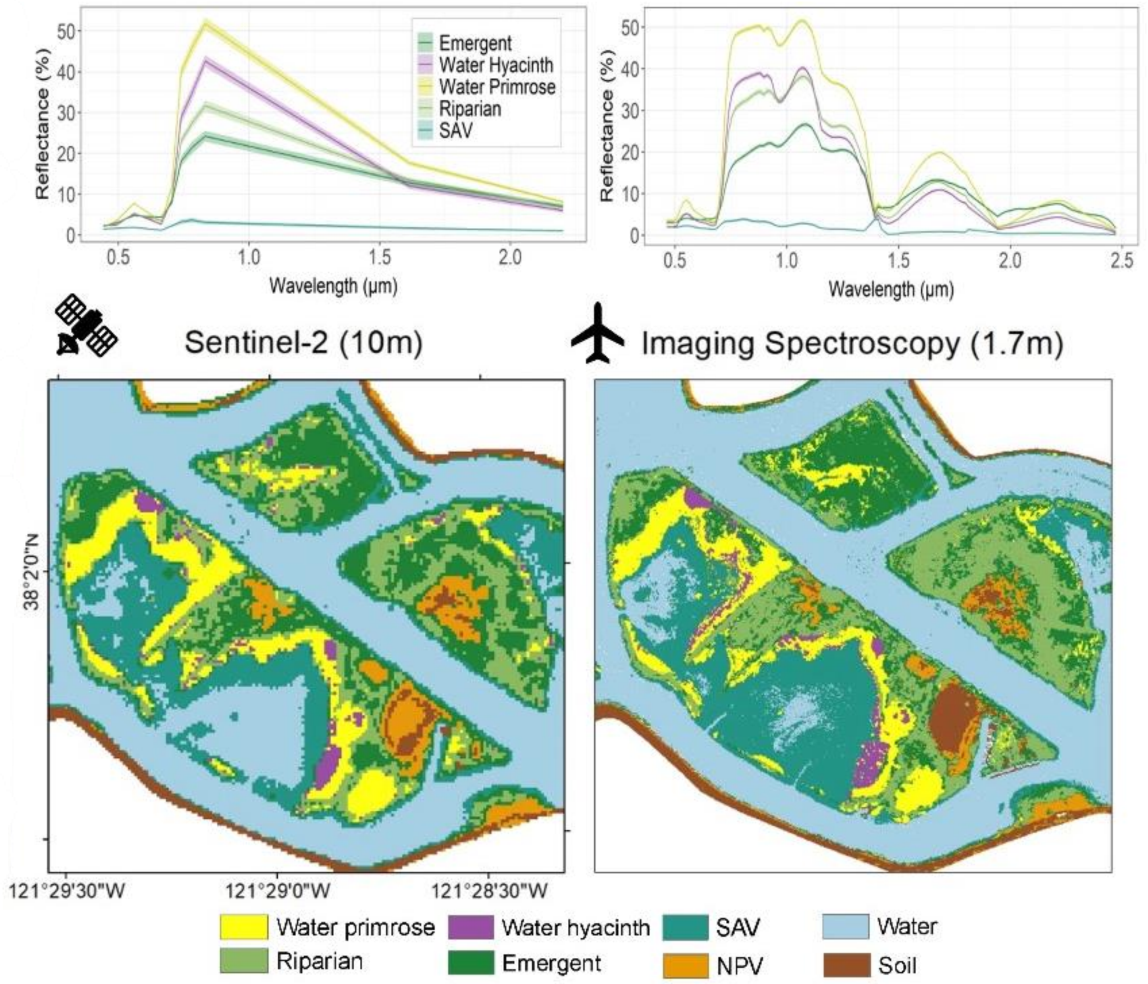
Long Time-Series Airborne Imaging Spectroscopy (AIS)

- Annual vegetation classification maps of the Delta have been produced from AIS annually since 2004.
- CSTARS (UC Davis)
- https://doi.org/10.5063/F1HH6HJX

IAV Mapping with Satellite Remote Sensing

- Advancement and successful development of IAV classification maps using Sentinel-2 data.
- Ade et al. (2022)

** Not intended to replace AIS dataset, just fill data gap.



Earth Observations to Combat IAV

Project Goals

1. Operationalize the first sustainable mapping effort for vegetation in the Delta.
2. Advance modeling tools to assess IAV responses to past and future management actions.
3. Co-develop IAV mapping tool and integrate into the decision-making frameworks of stakeholders.

EARTH SCIENCE
APPLIED SCIENCES

Delta Stewardship Council
A CALIFORNIA STATE AGENCY

Goal 1: Operationalize S2 Class Mapper

Updates:

- Updated/improved cal-val datasets
- Feature Reduction
- Created riparian mask

Future work:

- Increase the number of in-situ cal-val observations
- Incorporate winter and spring in-situ observations
- Assess model performance against AIS class maps.

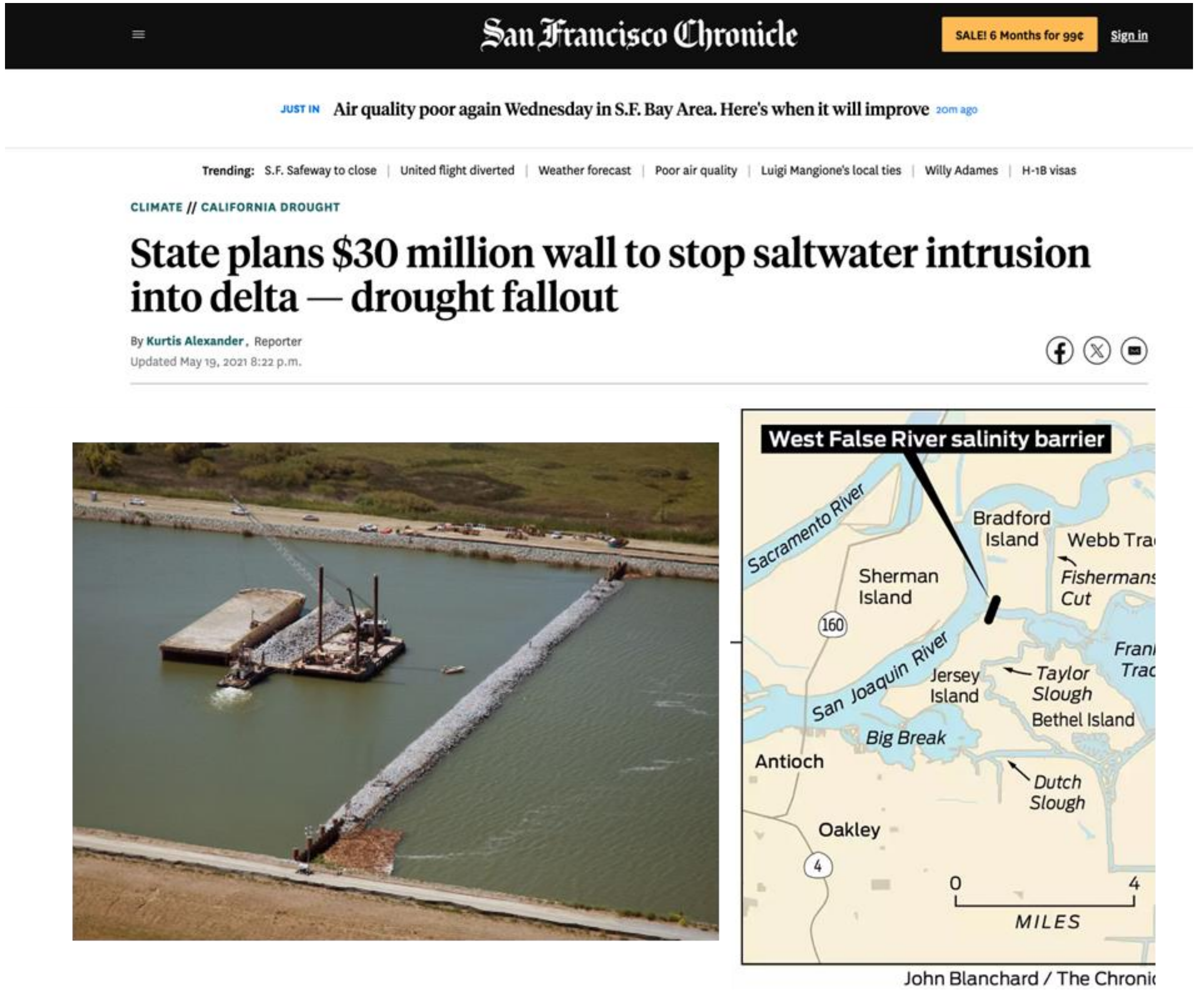
Class	Acc. Stat	AIS	S2 2022	S2 2025
	OA	0.92	0.87	0.90
	Kappa	0.90	0.85	0.88
Emergent	PA	0.93	0.85	0.92
	UA	0.88	0.77	0.92
Hyacinth	PA	0.90	0.79	0.87
	UA	0.88	0.84	0.90
Primrose	PA	0.94	0.91	0.94
	UA	0.95	0.83	0.88
SAV	PA	0.83	0.86	0.87
	UA	0.91	0.84	0.90
Water	PA	0.92	0.88	0.90
	UA	0.91	0.90	0.90

Goal 2: SDMs to Assess IAV Responses to Management Actions

Species Distribution Model (SDM)

Predictor Variables	Why did we choose these predictors?
UnTrim 3D • Salinity • Turbidity • Speed Bathymetry • Depth	• Management decisions affect these variables • Need to understand their impact on IAV

Response Variable = AIS derived IAV class maps


San Francisco Chronicle

SALE! 6 Months for 99¢ Sign in

JUST IN Air quality poor again Wednesday in S.F. Bay Area. Here's when it will improve 20m ago

Trending: S.F. Safeway to close | United flight diverted | Weather forecast | Poor air quality | Luigi Mangione's local ties | Willy Adames | H-1B visas

CLIMATE // CALIFORNIA DROUGHT

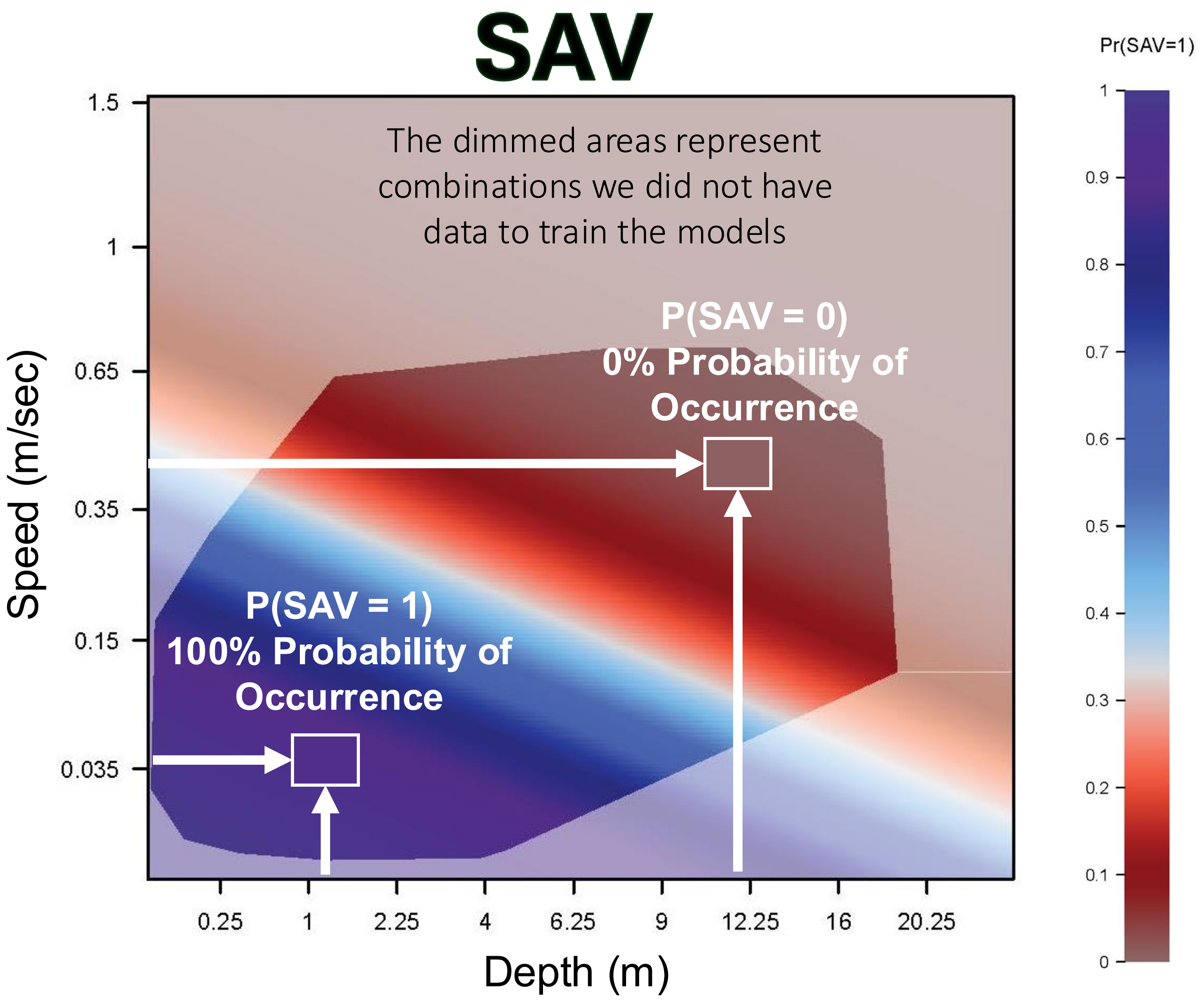
State plans $30 million wall to stop saltwater intrusion into delta — drought fallout

By Kurtis Alexander, Reporter

Updated May 19, 2021 8:22 p.m.

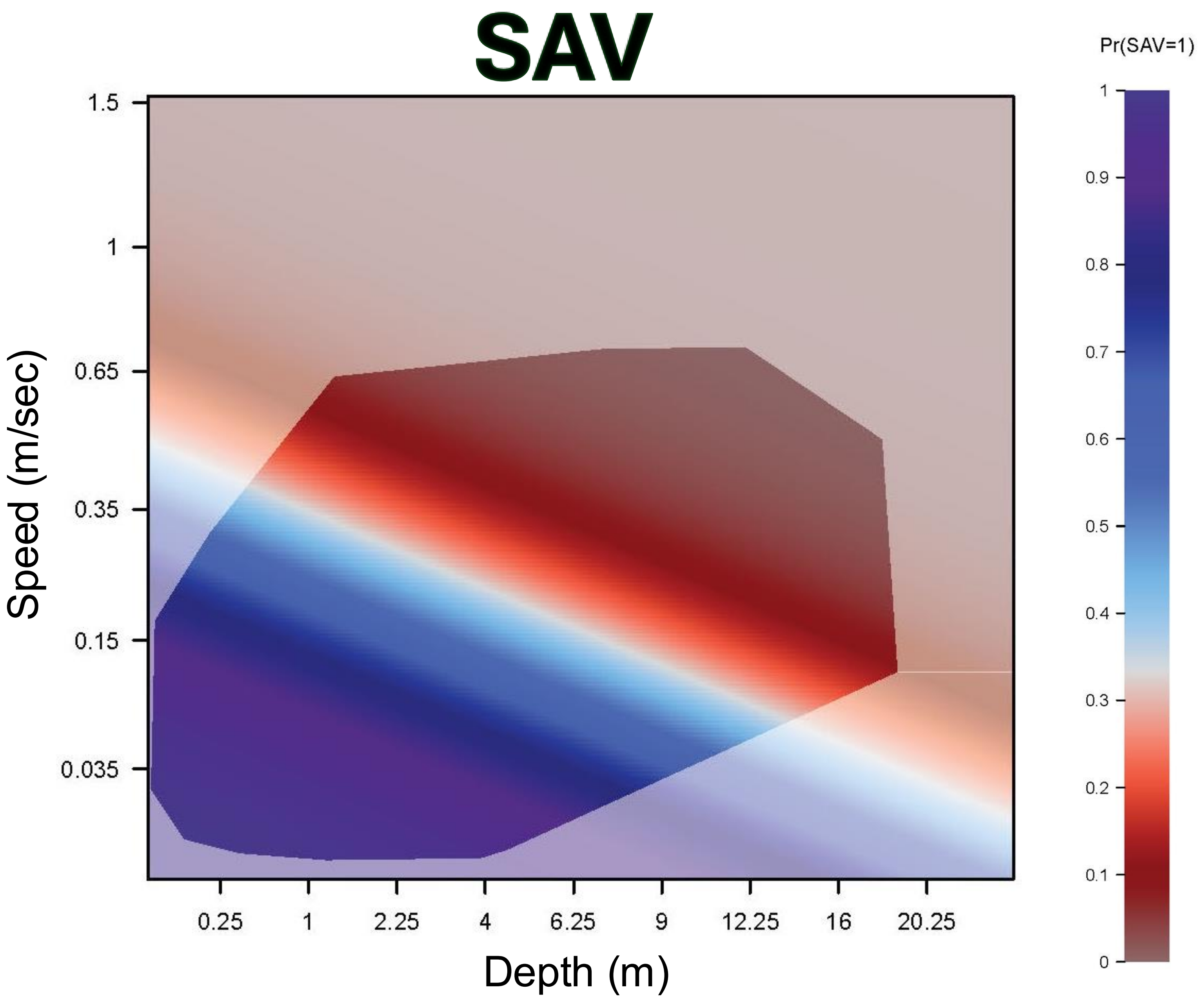
How to interpret heat maps

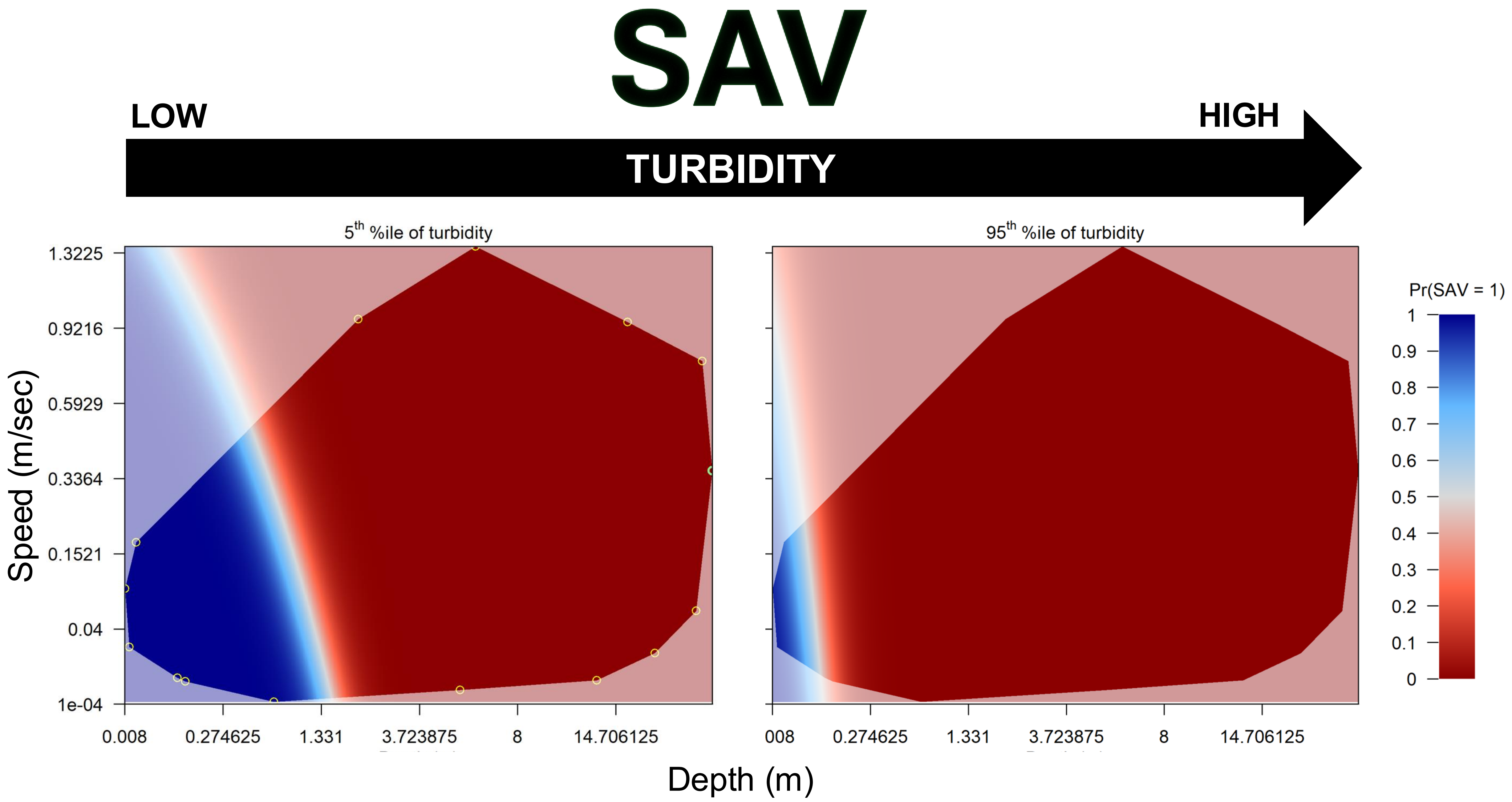
Simulate **probability of occurrence** for all possible **environmental combinations**



How to interpret heat maps

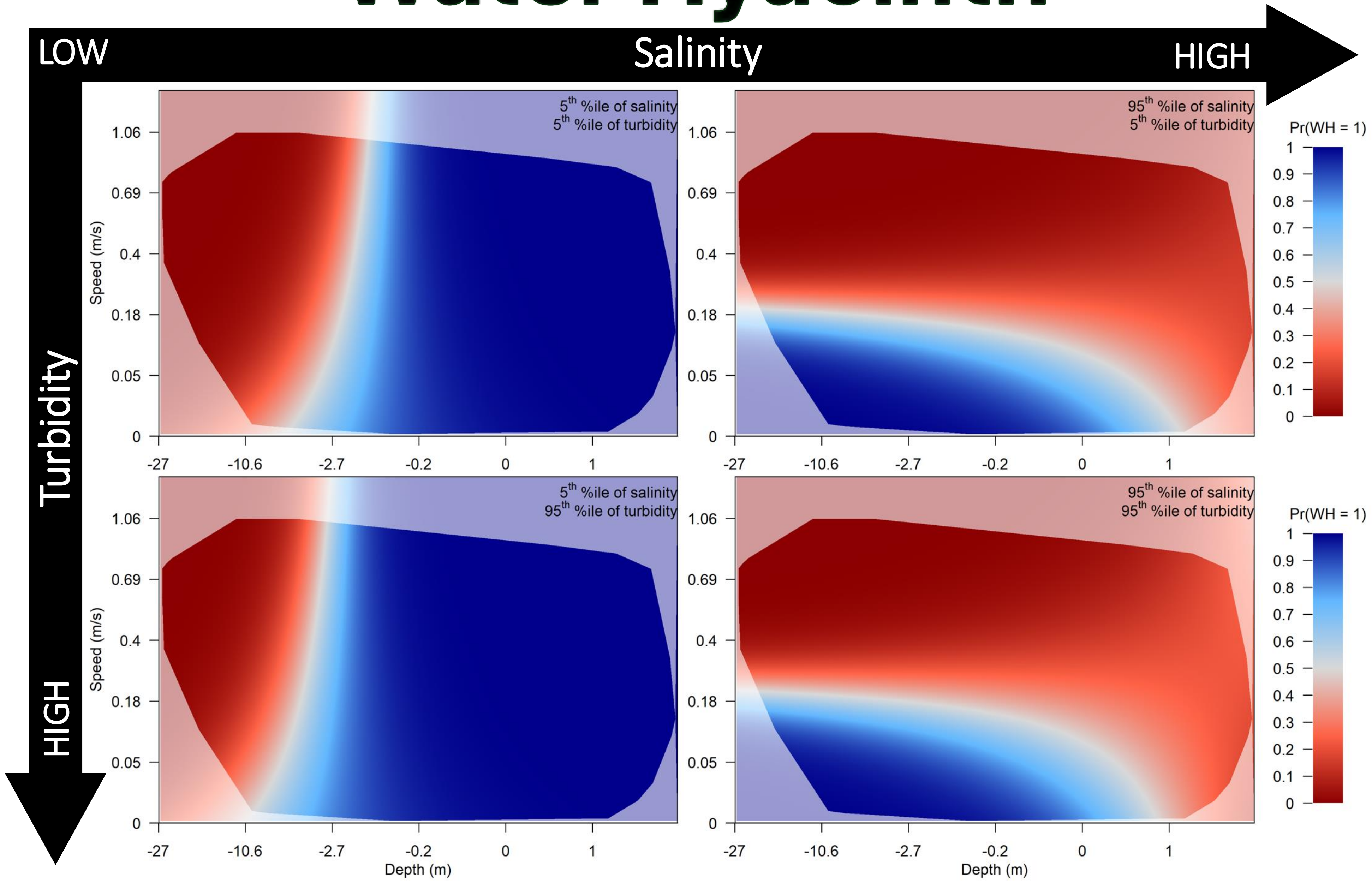
SAV can colonize at greater depths, especially when velocities (speed) are low.




SAV
LOW
HIGH
TURBIDITY
5th %ile of turbidity
95th %ile of turbidity
Speed (m/sec)
1.3225
0.9216
0.5929
0.3364
0.1521
0.04
1e-04
0.008
0.274625
1.331
3.723875
8
14.706125
008
Depth (m)
Pr(SAV = 1)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0

Water Hyacinth

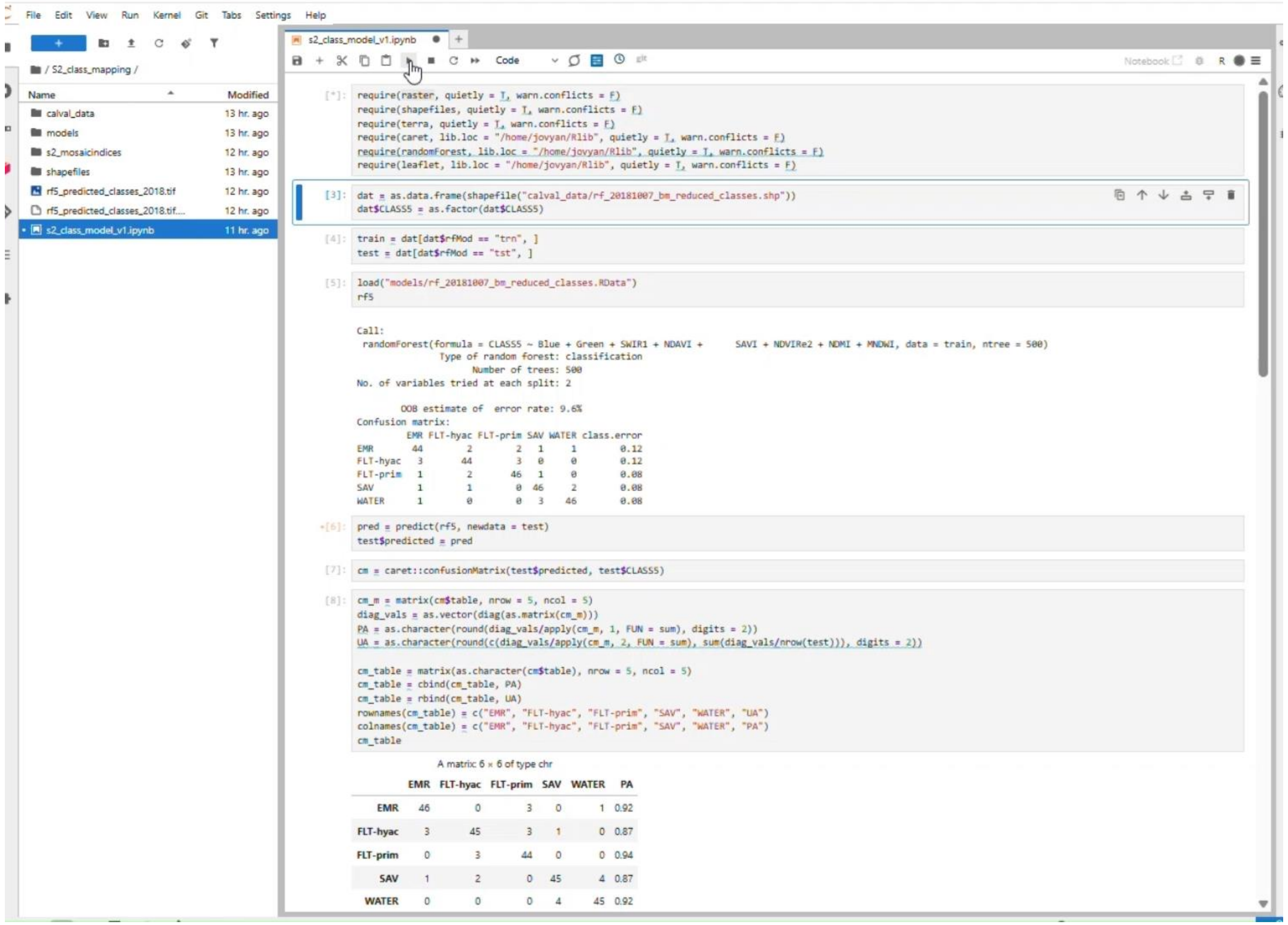
CHANNEL HABITATS



Goal 3: IAV Mapping Tool

Testing CSIRO's EASI Platform for deployment on the cloud

- Partnered with the state through climate action MOU
- Cloud-based analysis
- Python and R supported through Jupyter Notebooks.
- Platform maintenance made easy?



Next Steps and Plans

S2 Class Models:

- Construct 2021-2025 cal-val datasets
- Test all-season vs. season S2 models

SDMs:

- AVIRIS-3 flights continue for 2025
- Additional environmental variables:
  - Bulk Water Temperature
  - Surface Temperature
  - Fine resolution bathymetry
- Try more sophisticated models, address scale and hydro-cells

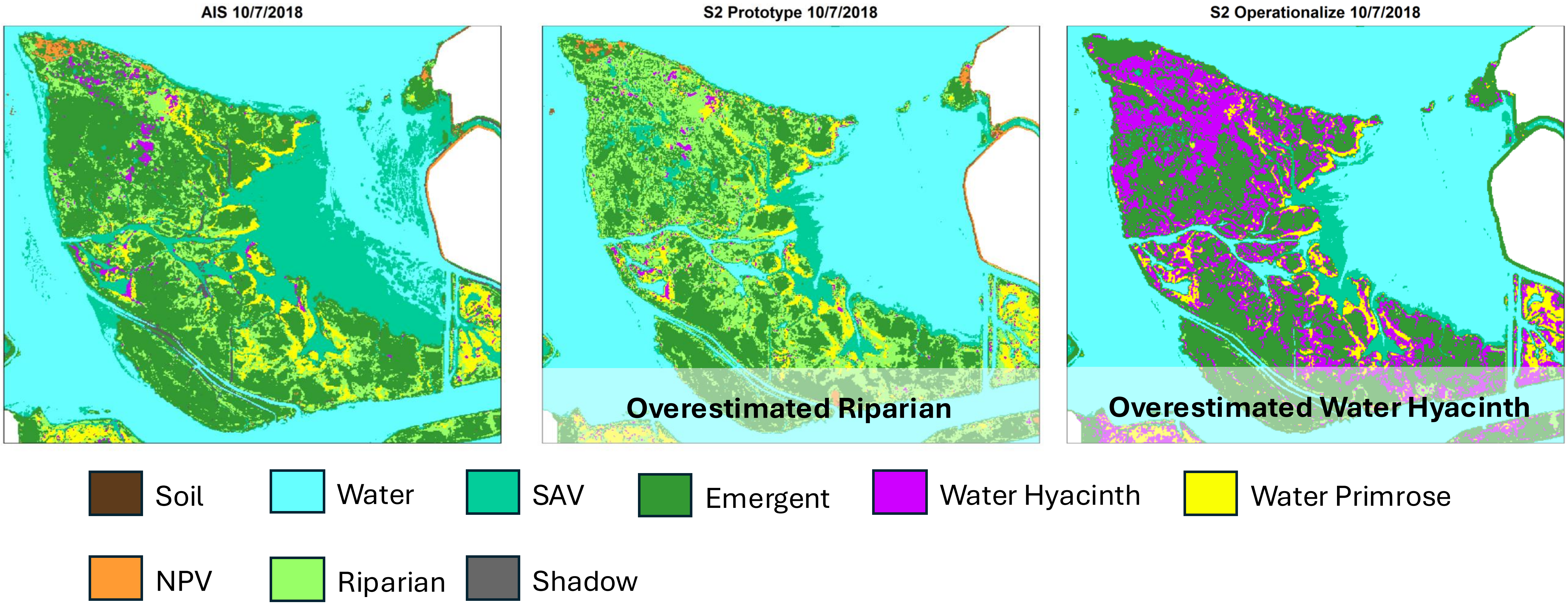
Mapping tool:

- Iterate with stakeholders
- Ensure suitability for decision-making frameworks

Delta Stewardship Council
A CALIFORNIA STATE AGENCY

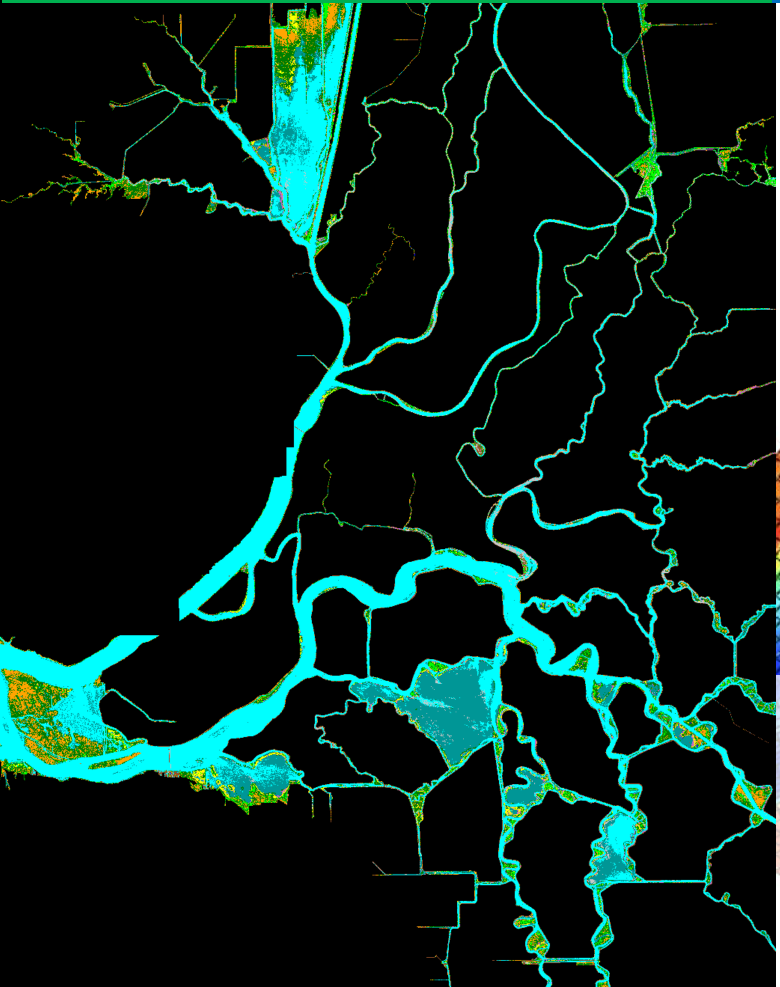
Agency	Primary Role in IAV Management
Delta Stewardship Council (DSC)	Oversees implementation of the Delta Plan; sets policy direction; tracks progress and promotes coordination across agencies. Provides science funding and policy support but does **not implement field control measures**.
California Department of Fish and Wildlife (CDFW)	Leads **on-the-ground species monitoring**, **enforcement**, and **habitat protection**. Its Invasive Species Program helps prevent, detect, and manage non-native species impacts.
Interagency Ecological Program (IEP)	A **science consortium** (including CDFW and DWR) that conducts long-term ecological monitoring and targeted research to inform adaptive management, including studies on IAV trends, impacts, and ecosystem effects.
Department of Water Resources (DWR)	Supports IAV management through **restoration projects**, **water operations**, and coordination with the Division of Boating and Waterways (DBW), which carries out much of the direct IAV treatment (e.g., herbicide spraying). Also contributes to long-term monitoring and modeling.

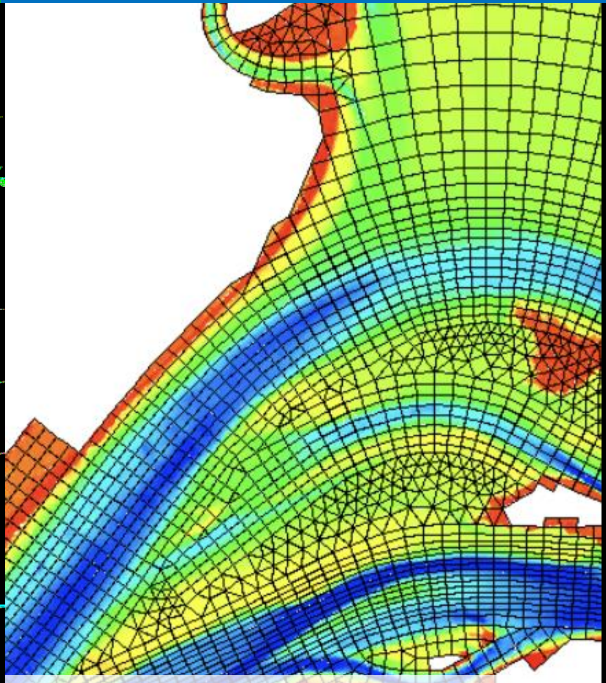
Goal 1: Operationalize S2 Class Mapper



Goal 2: SDMs to Assess IAV Responses to Management Actions

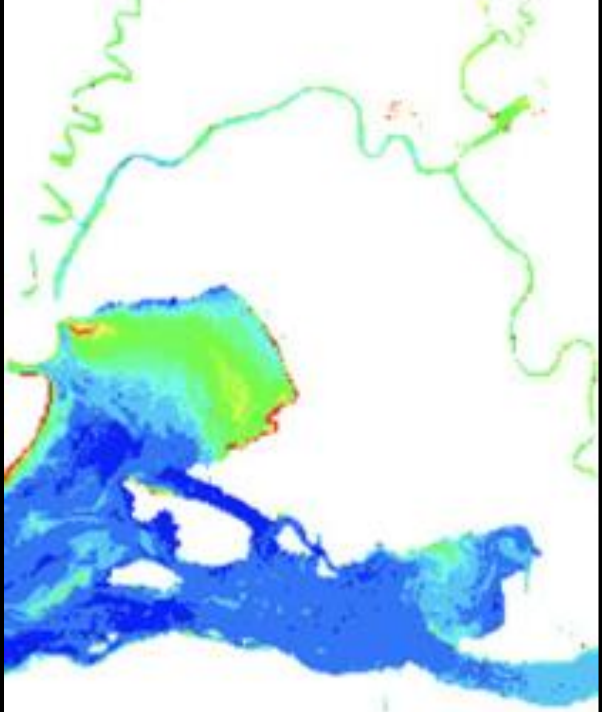
Response Variable	Environmental Predictors		



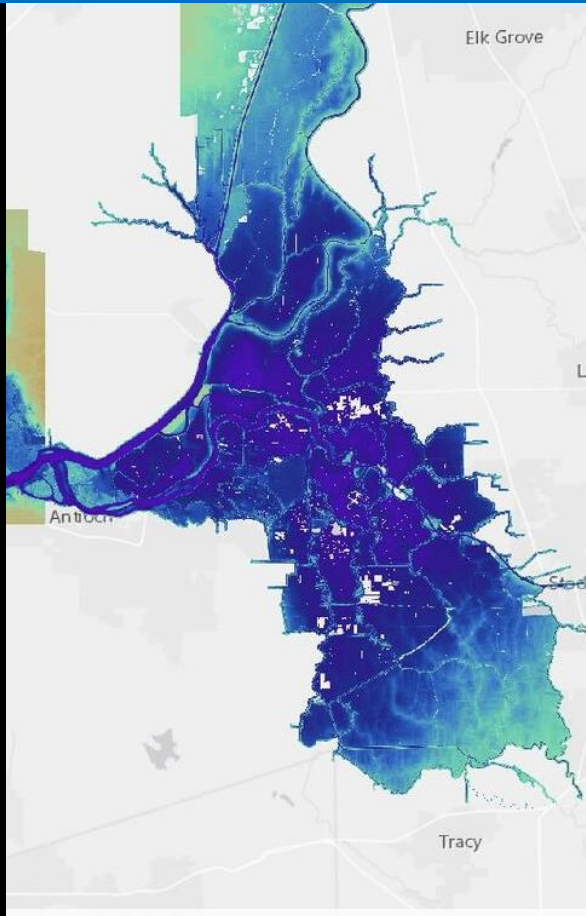


UnTRIM 3D Hydrodynamic Model

- Depth
- Salinity
- Velocity (Speed)



Turbidity



Single Beam Bathymetry