Overview of Wetland Remote Sensing Technologies

Pete Kauhanen
San Francisco Estuary Institute
January 9th, 2023

San Francisco Estuary Institute (SFEI) - Wetland Mapping

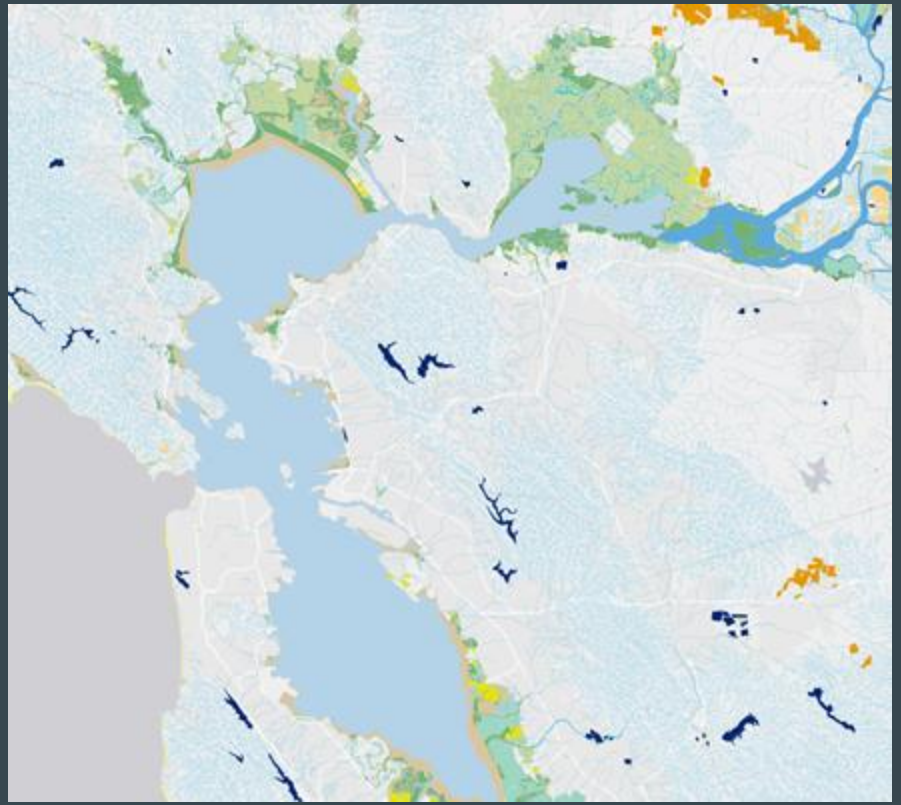
EcoAtlas (EcoAtlas.org)

- California Aquatic Resource Inventory (CARI)
  - Bay Area (BAARI)
  - Delta (DARI)
  - Santa Rosa (NCARI)
  - Tahoe (TARI)

Current Projects

- San Diego (SDARI)
- Russian River (RRARI)
- SF Baylands Mapping Update (BAARI +)

CRAM, other project based work, UAS surveys



Outline

- Remote Sensing Platforms
- Sensor Types
- Mapping Analyses/Products
- Software
- Existing Datasets and Resources

Image Credit: SFEI

Remote Sensing Platforms: What types of platforms are used for wetland mapping?

Image Credit: SFEI

Remote Sensing Platforms - relevant to wetlands

Satellites

- Largest spatial coverage (global)
- Lowest spatial resolution (~300m - 3m*)
- Dependable revisits time

Planes

- Medium spatial coverage (state/ county scale)
- High spatial resolution (~1m - 15cm*)
- Some national programs have dependable revisit times

UAS/drones

- Lowest spatial coverage (20 -1000 acres, project footprints)
- Highest spatial resolution (~ 5cm - 0.6cm*)
- More control over timing of collection

*Depends on the sensor and elevation flown

When should/shouldn't you use UAS?

UAS - Unoccupied Aerial Systems
Often there is a tendency to use drones because they are new and exciting!

Considerations:

- Study area size
- Ensure the data you capture can and are needed to address your questions
- Constraints: (e.g. flight restrictions, access, and liability)
- Alternatives
  - Satellite
  - Plane based
  - Stationary cameras
  - Boots on the ground

Image Credit: SFEI

UAS - Products and Uses

Products:

- Video
- Imagery
- DEMs (photogrammetry)
- Point Clouds
- 3D models

Uses

- Before and after (restoration, disasters etc.)
- Virtual cross sections
- Counts (paired with ML or manual)
- Communication materials
  - 360 Panos, Fly-throughs, Maps

Image Credit: SFEI

Sensor Types:
What types of sensors are useful for wetland mapping?

Sensor Types

Passive

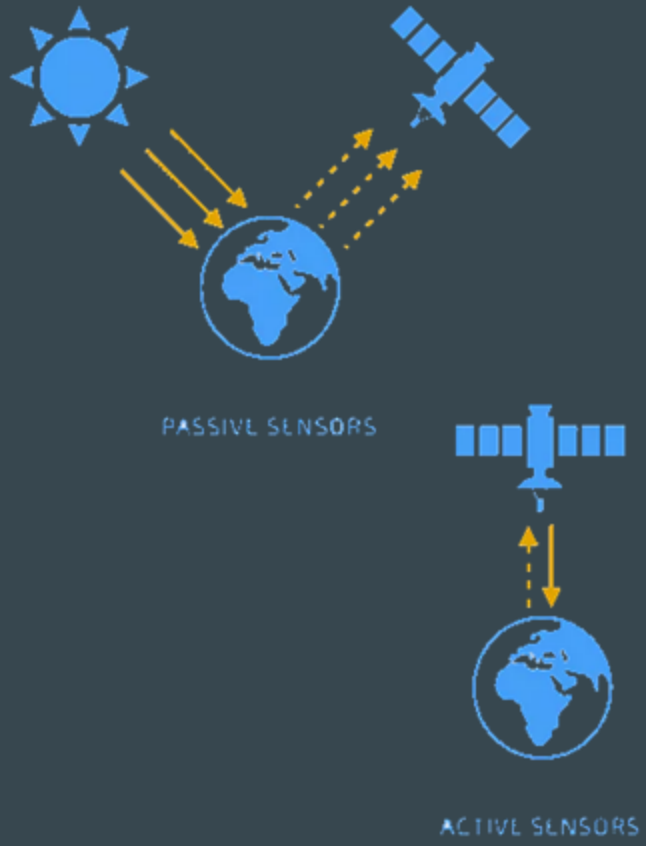
Detect natural energy (radiation - e.g. reflected sunlight)

- Optical Imagery
  - True color
  - 4 band - R, G, B, NIR (i.e. Multispectral)

Active

Emit own radiation and observes reflection/backscatter. Cloud cover and nighttime observations don’t obstruct

- LiDAR (Laser Imaging, Detection, and Ranging)
- SAR (Synthetic-aperture Radar)



Mapping Analyses/Products:

What types of products can be used?

How are wetlands mapped?

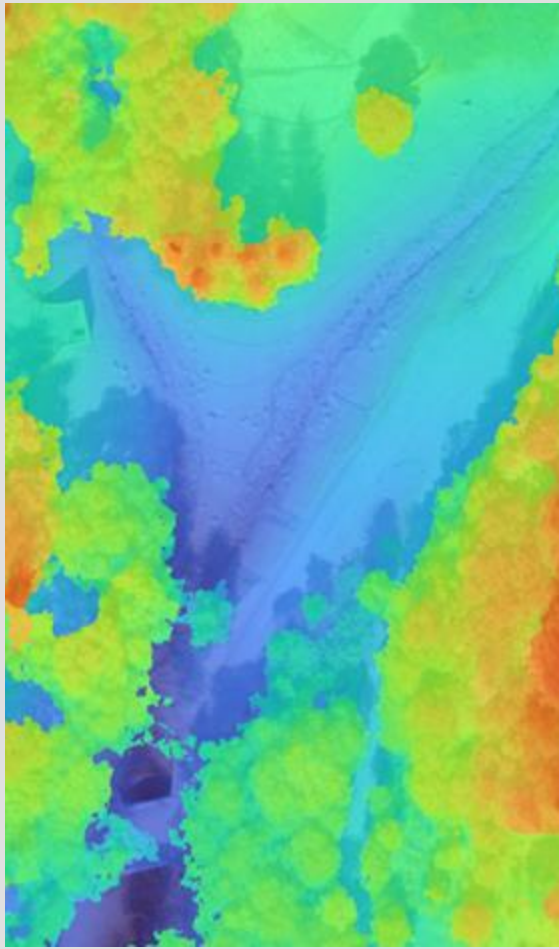
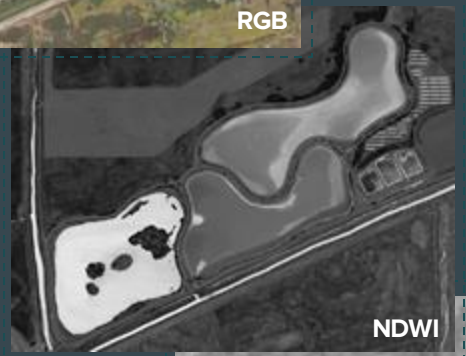
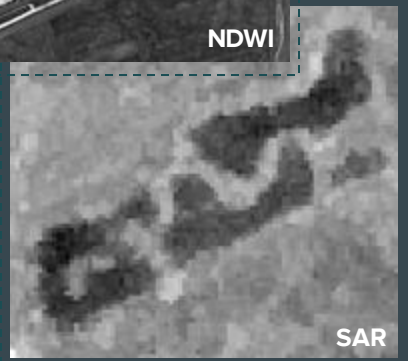


Image Credit: SFEI

Remote Sensing Data Products Used

- Imagery
  - True color imagery
  - 4 Band (Infrared) - false color
  - Indices
    - Normalised Difference Water Index (NDWI)
    - Normalised Difference Vegetation Index (NDVI)
- Elevation
  - Topographic Wetness Index (TWI)
  - Normalized Digital Surface Model (nDSM)
  - Roughness
- SAR (Radar)
  - Polarization





Mapping wetlands

Wetlands have characteristics that we can remotely detect:

- Hydrology / source of water / saturated soils
- Vegetation associated with wetlands / hydrophytes

We can use remote sensing to get clues and supporting evidence for where wetlands are on the landscape:

Source of water - topographic lows, or areas where water flows to them. Directly sensing open water

Vegetation - spectral signature of chlorophyll or healthy vegetation

True Color Imagery

Red (red), Blue (blue), Green (green) bands

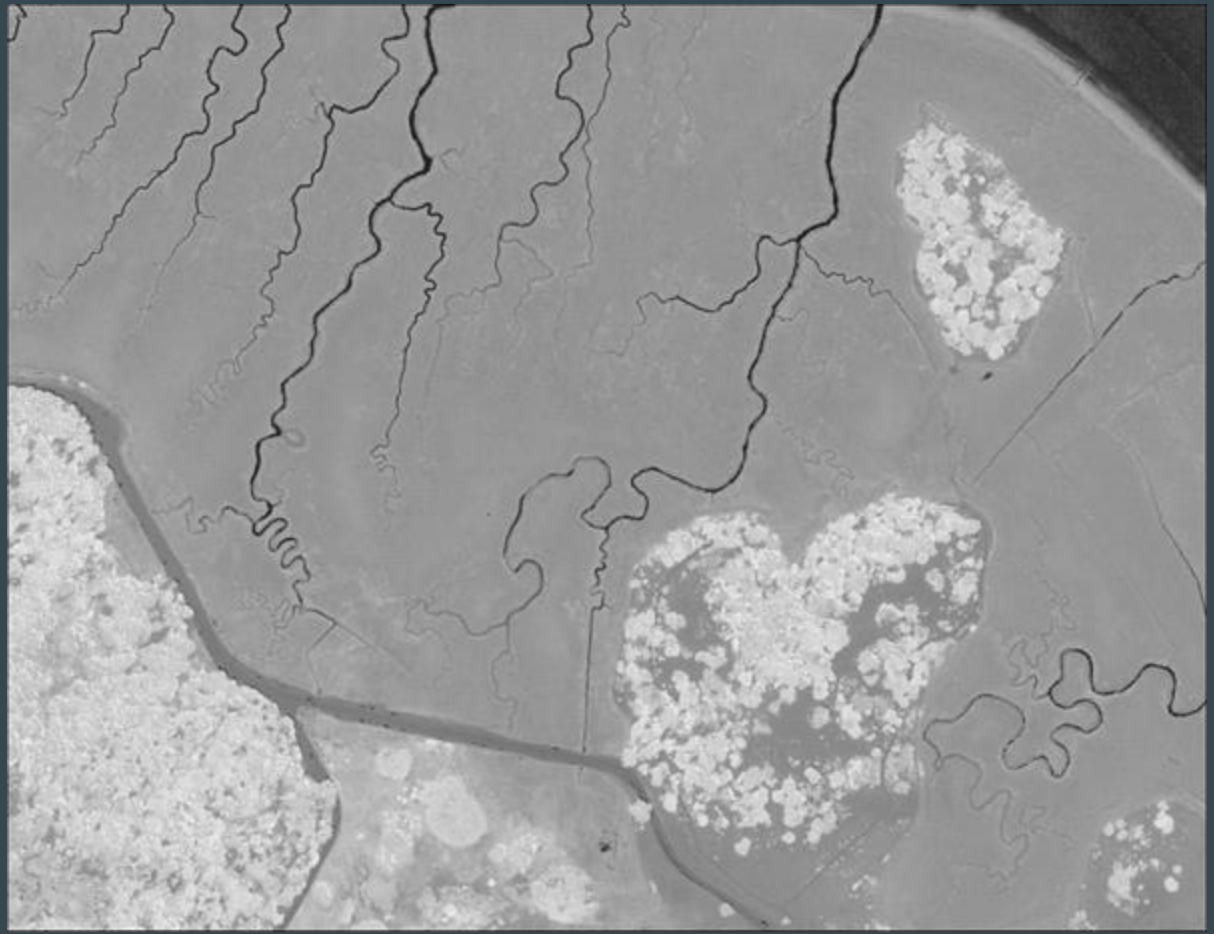
NIR Composite

Near infrared (red), Green (blue), red (green) bands

NDVI

Normalized Difference Vegetation Index

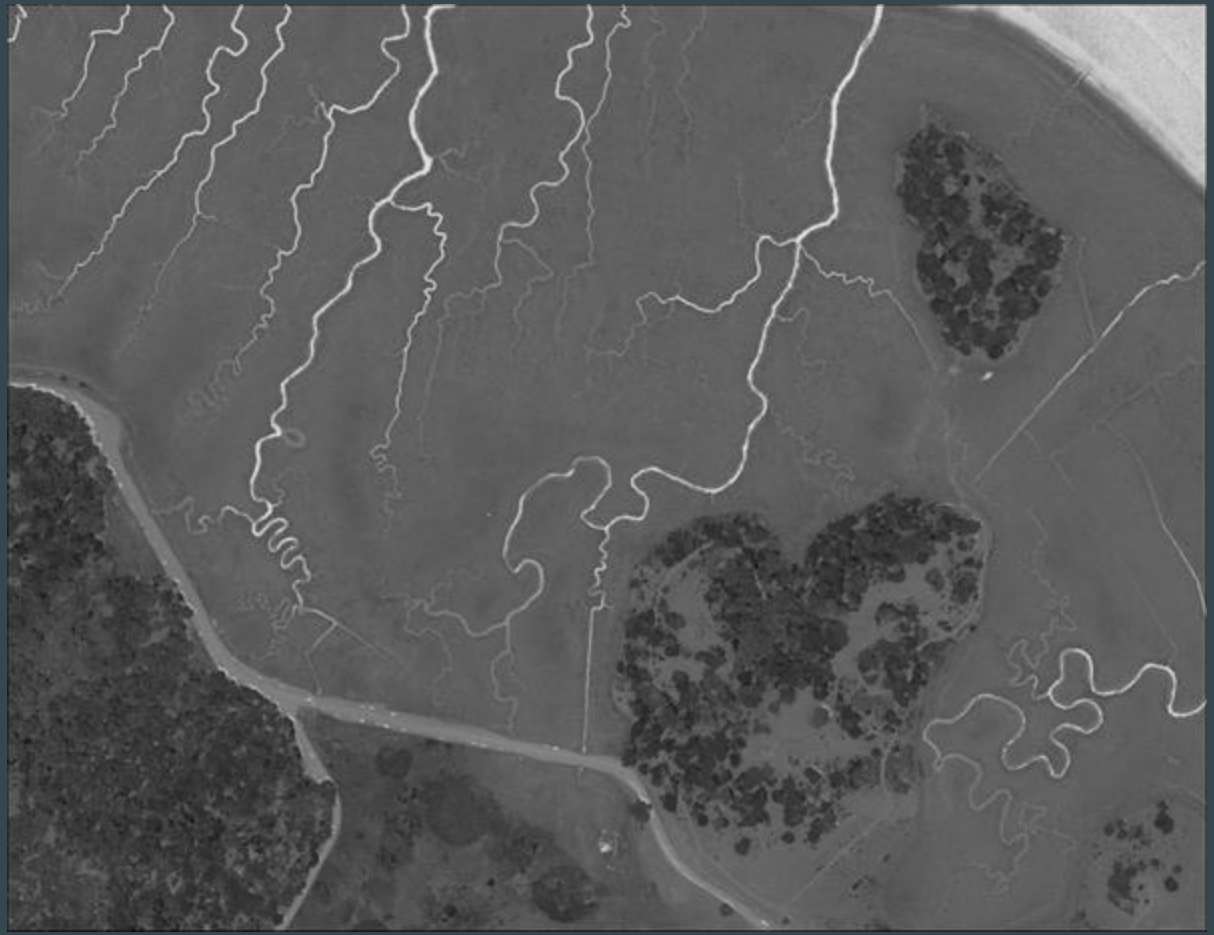
Areas with higher chlorophyll levels typically have a higher value



NDWI

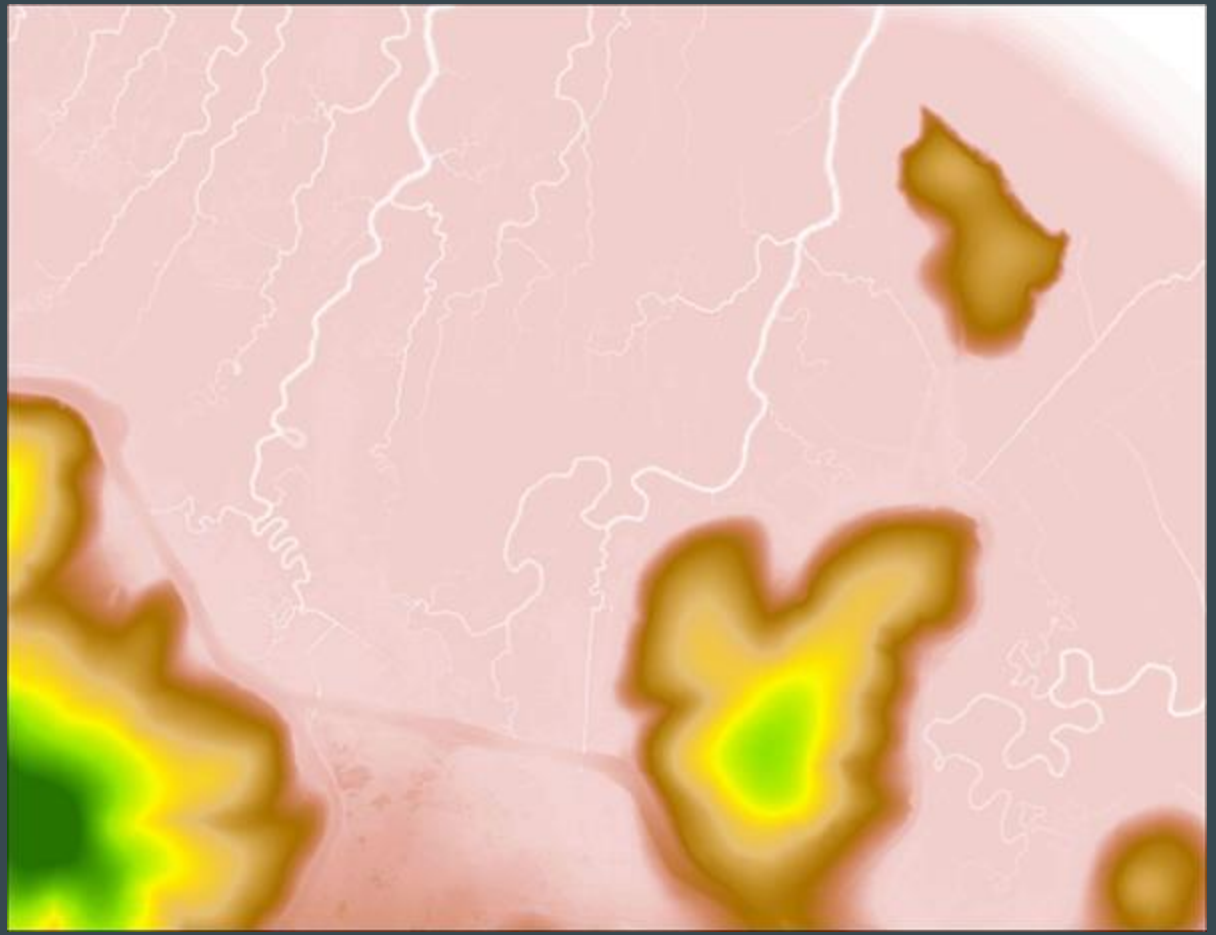
Normalized Difference Water Index

Areas that have spectral signatures of water and wet areas have a higher values



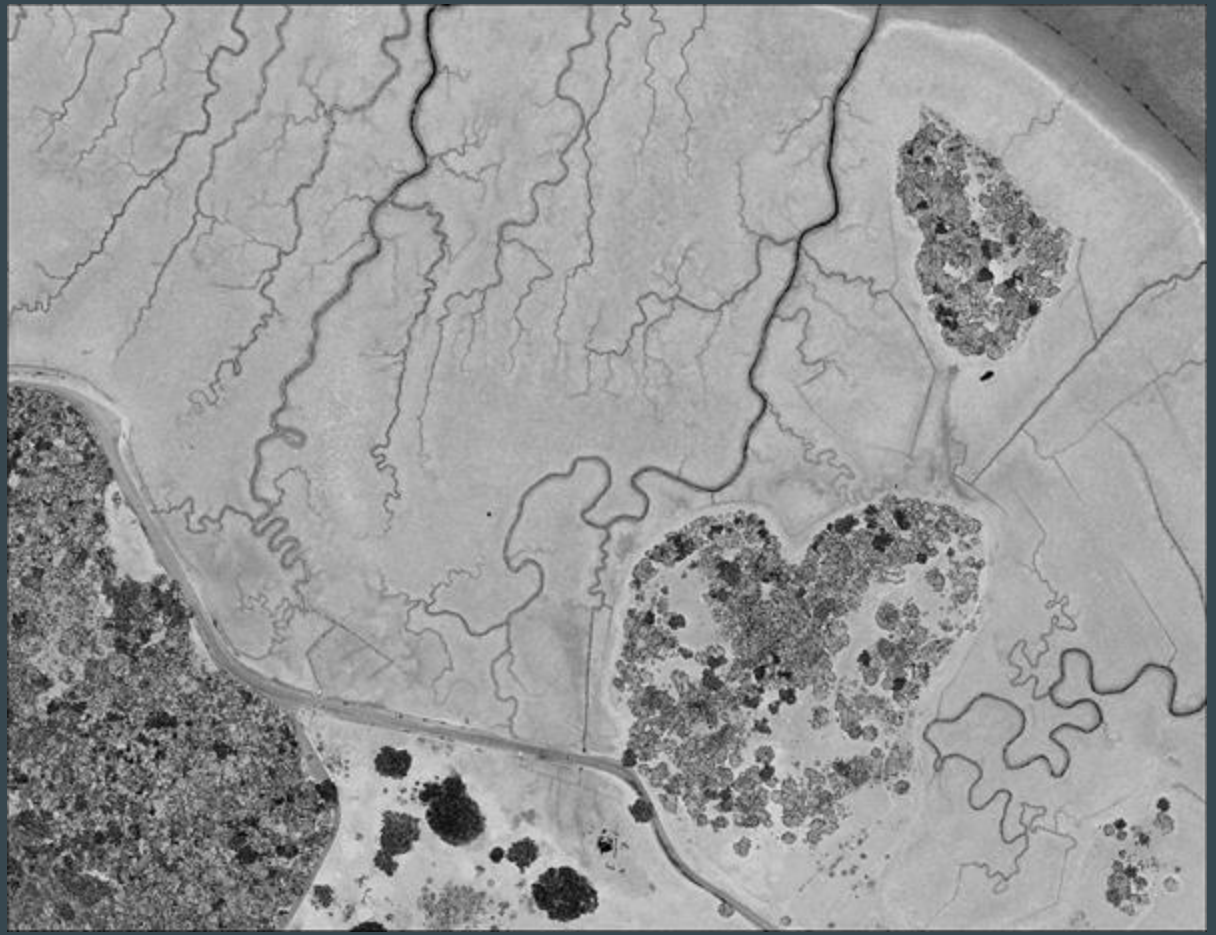
DEM (LiDAR)

Digital Elevation Model



LiDAR Intensity

Return Strength of laser beam



Wetland Mapping Analysis

- Heads up digitizing
  - Historically approach
- Image Analysis
  - **Pixel based image analysis**
    - Pixels in a raster are the unit being classified
  - **Object based image analysis (OBIA)**
    - Segmentation - create objects/polygons to classify

- Classification
  - Machine Learning
  - Rule Based

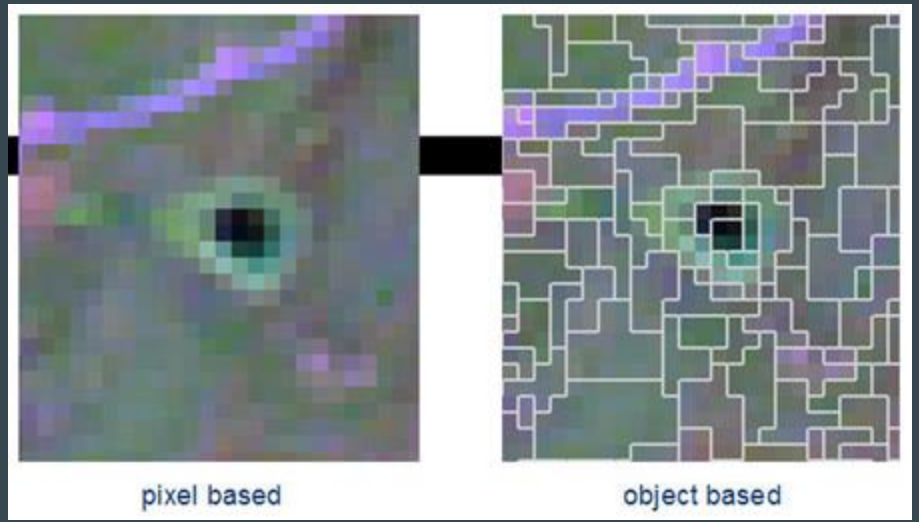


Image from Government of British Columbia (www2.gov.bc.ca)

Importance of Validation Data

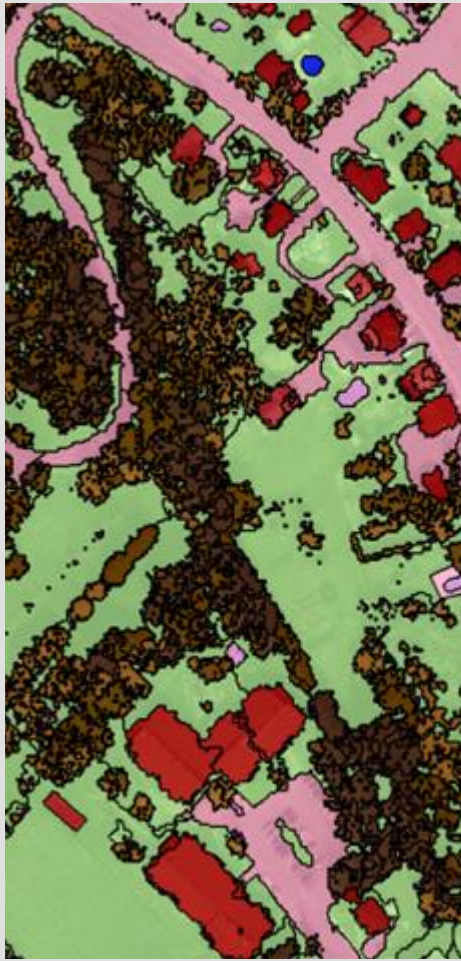
High quality validation data is extremely important for training classification models and for accuracy assessments of final mapping products

Validation Data

- Collection
  - Field data
  - Remotely sensed at higher resolution
- Classification used should be the same for validation as for mapping product
- Opportunity for wider scale participatory science.

Software:

What types of software is used for mapping wetlands?



Software for Mapping Wetlands

- Proprietary
  - ESRI - ArcGIS Pro
  - Trimble - eCognition
- Open Source
  - QGIS
  - *Python library*
  - *R libraries*
- Other
  - Google Earth Engine

Available Datasets:
What data is available and relevant to mapping wetlands?

coast.noaa.gov

Public Existing Databases

- Mapped Wetlands and Aquatic Features
  - NWI - National Wetland Inventory - USFWS
  - NHD - National Hydrography Dataset - USGS
  - CARI - California Aquatic Resource Inventory - SFEI
- Imagery
  - NAIP - airborne (1m - 60cm, 4 band) (National Agriculture Imagery Program - USDA)
  - Sentinel - spacebone (10m - 60m 13 spectral bands)
  - Landsat - spacebone (30m visible and NIR, 15m panchromatic)
- LiDAR
  - Various collections - USGS - The National Map, NOAA - Digital Coast
- SAR
  - Sentinel + others - NASA (Earthdata or ASF Alaska), ESA (Copernicus Hub)

Public Remote Sensing Data Sources

- Google Earth Engine
  - Access to a wide range of datasets for use
- USGS
  - The National Map (Elevation data + NHD +)
  - Earth Explorer (Imagery)
  - GloVis (Imagery)
- NOAA - Digital Coast
- NASA - Earthdata
- ESA - Copernicus Open Access Hub

Image Credit: SFEI

Questions?

Pete Kauhanen - GIS Manager
San Francisco Estuary Institute
petek@sfei.org

Image Credit: SFEI