



COASTAL ATACAMA WATER RESOURCES

Improving Industry and Authority Response
to Indicators of Possible Harmful Algal
Blooms in Coastal Atacama Using Satellite
Image Processing Techniques

Celeste Delgado

Annika Hsi

Cody O'Ferrall

Anna Valcarcel



Virginia – Langley | Summer 2024



MEET THE TEAM



Cody O'Ferrall
(Team Lead)

Celeste Delgado

Annika Hsi

Anna Valcarcel

HARMFUL ALGAL BLOOMS

An event where certain algae proliferate rapidly, reaching levels that damage ecosystems and threaten human health.



COMMUNITY CONCERNS



**Negative
Ecological
Impact**



**Public
Health
Risks**



Compromises Aquaculture and Fishing

*Image credits (clockwise from left):
Aaron Carlson, Joko Apriyo Putro,,
Ekrem Canli*

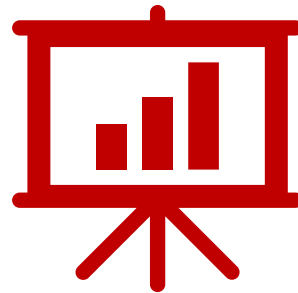
PROJECT OBJECTIVES

Indicator Assessment



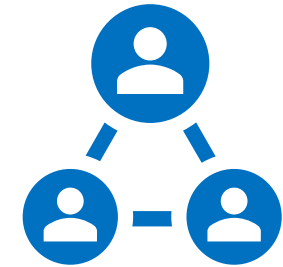
Assess feasibility for the use of chlorophyll-a, sea surface temperature, and turbidity as indicators of HABs

Trends



Quantify temporal trends of bloom events across multi-year, yearly, and seasonal timescales

Implications



Identify potential hotspots of algae activity to guide partners' water sampling and mitigation efforts

PARTNERS

**University of Atacama
(UDA)**

**Centro de
Información de
Recursos Naturales
(CIREN)**

Atacama Region

Washington D.C.

**Embassy of Chile,
Agricultural Office**

**Ministry of Health of
Chile (MINSAL)**



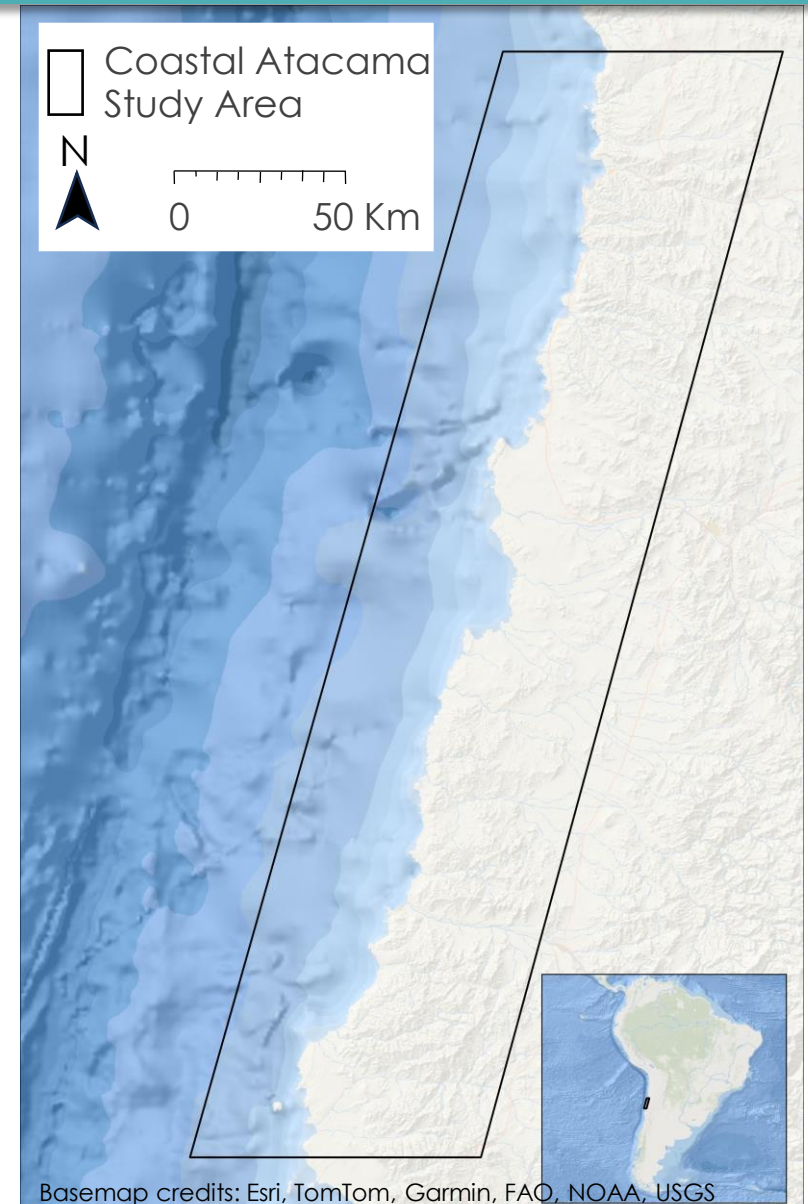
Basemap credits: Esri, Earthstar Geographics

STUDY AREA AND PERIOD

 Coastal Atacama Region, Chile

 30km offshore, 50km inland

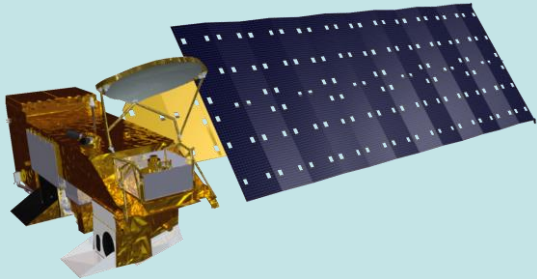
 June 2015 to June 2022



EARTH OBSERVATIONS

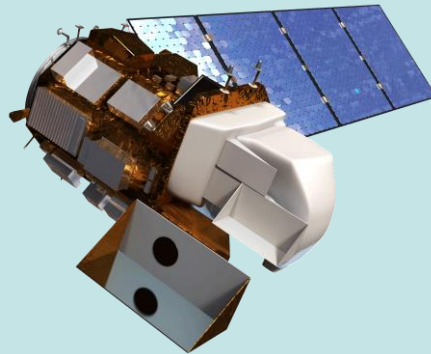
Aqua MODIS

- Chl-a
- Sea surface temperature
- Normalized Fluorescence Line Height (NFLH)



Landsat 8 OLI

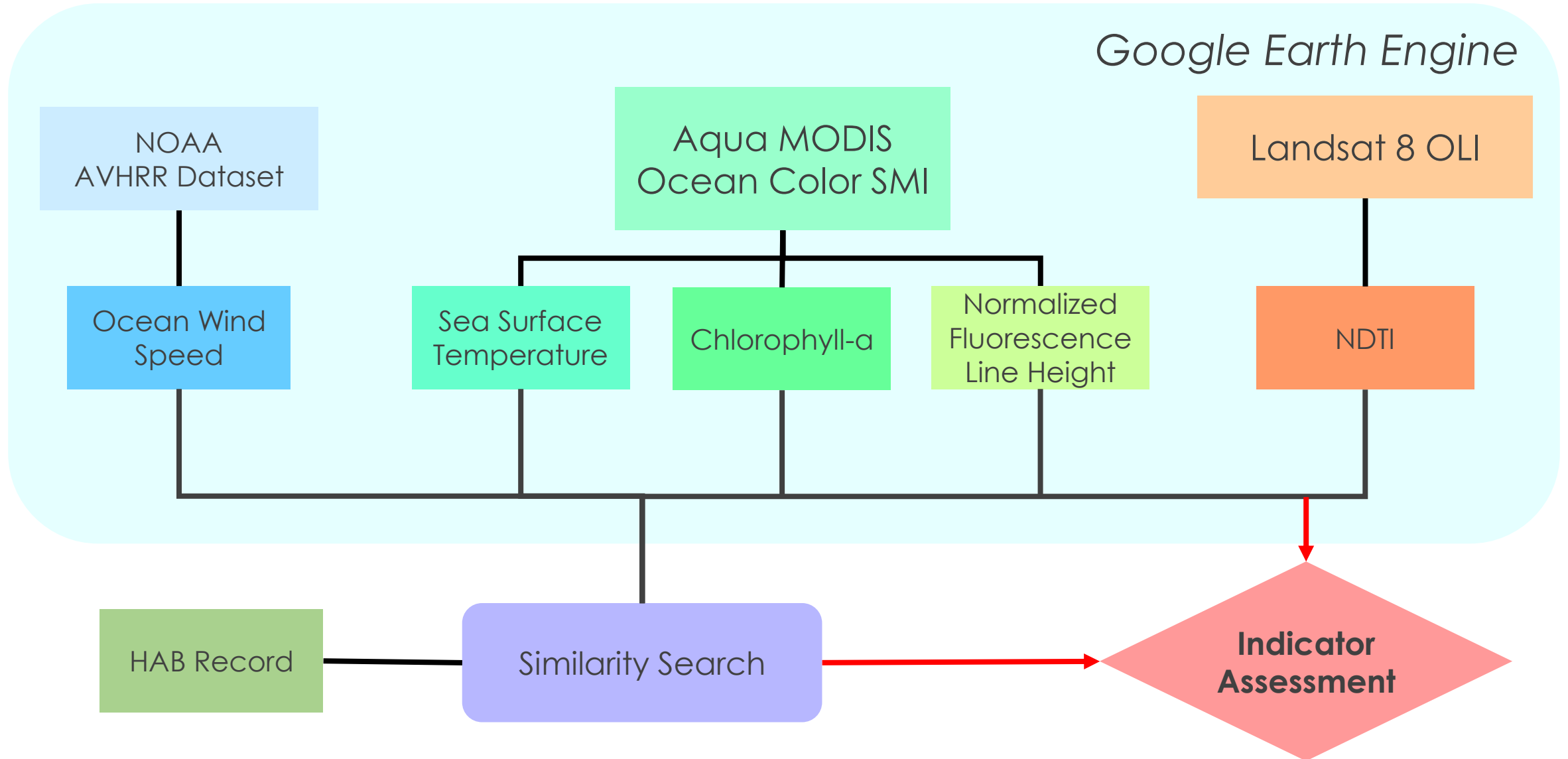
- NDTI (turbidity)



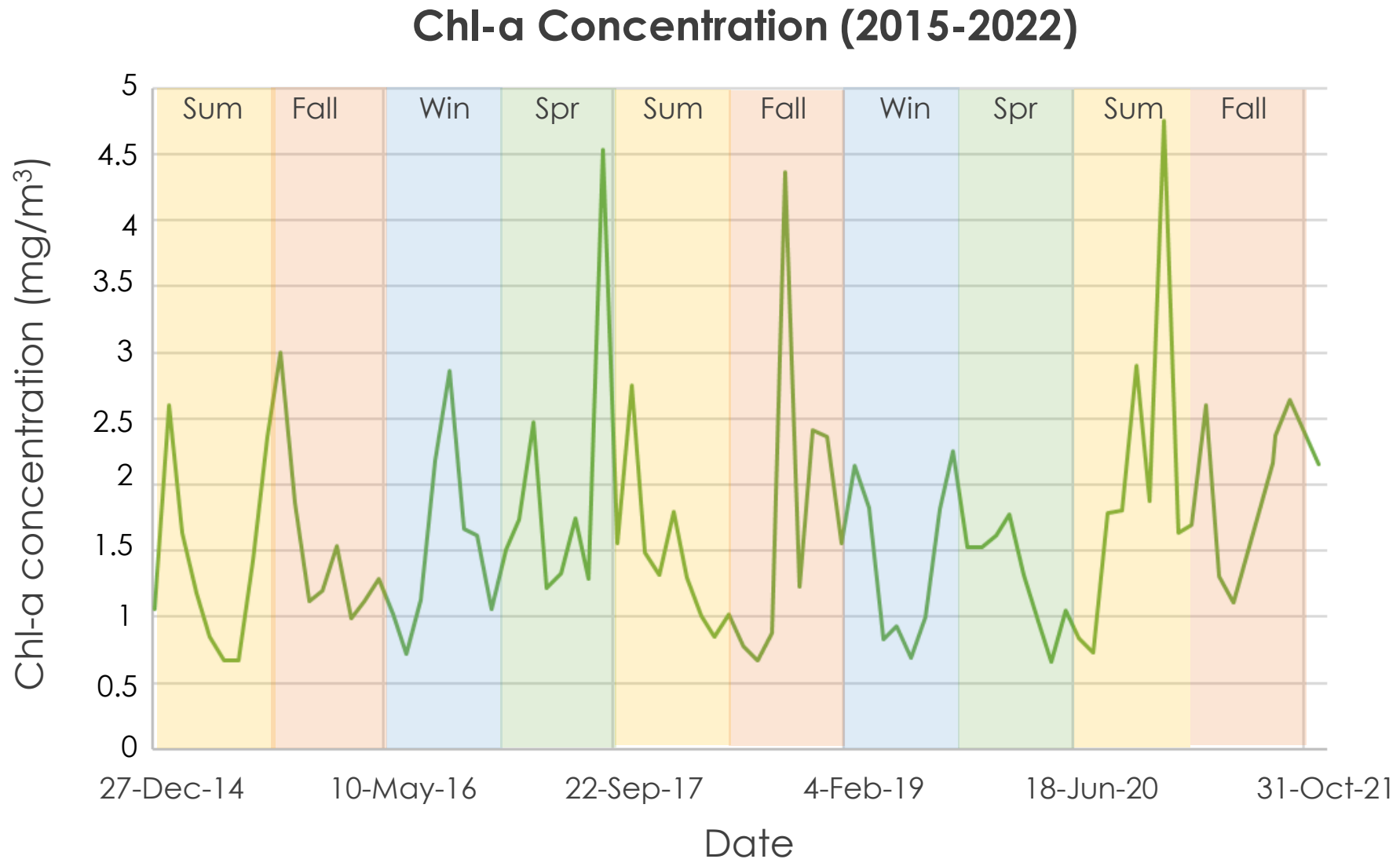
NOAA AVHRR Dataset

- Ocean wind speed

METHODOLOGY

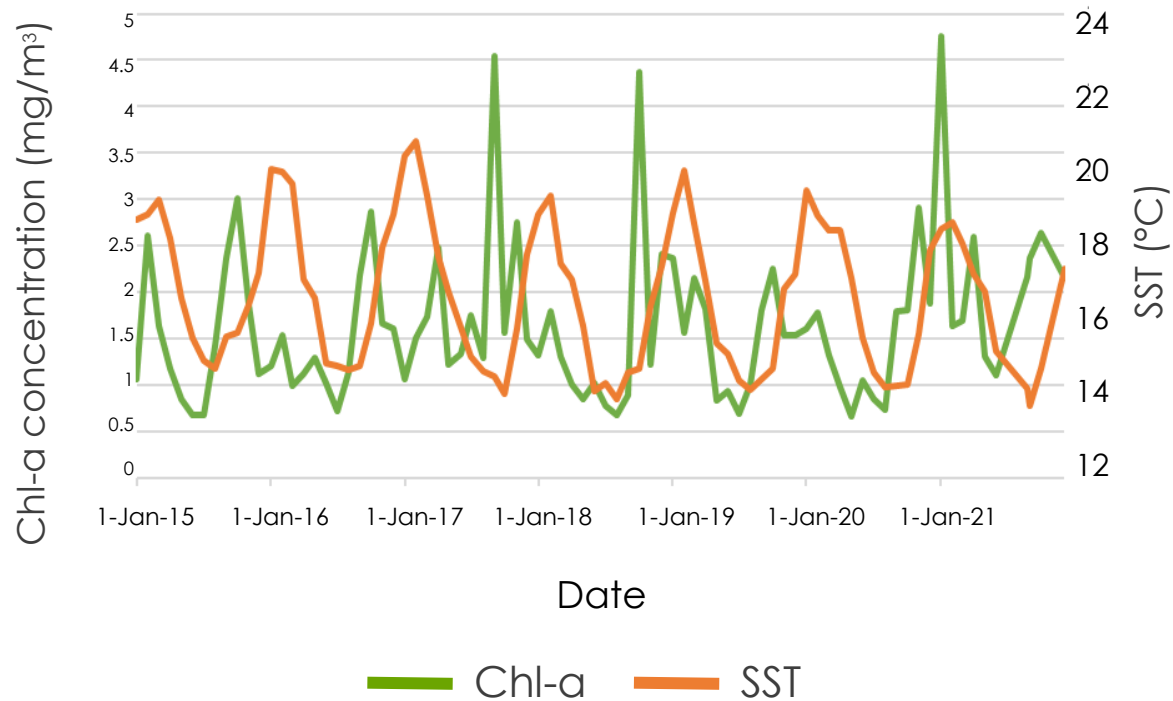


RESULTS – Chlorophyll-a (Aqua MODIS)

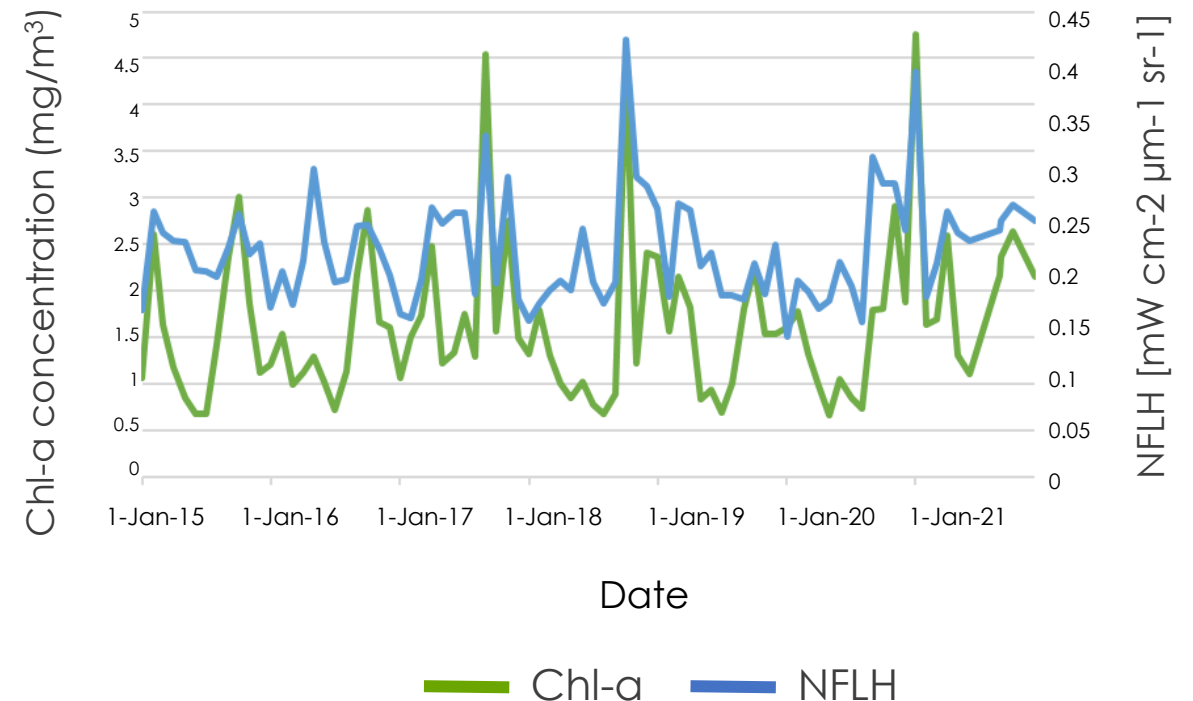


RESULTS – Chlorophyll-a (Aqua MODIS)

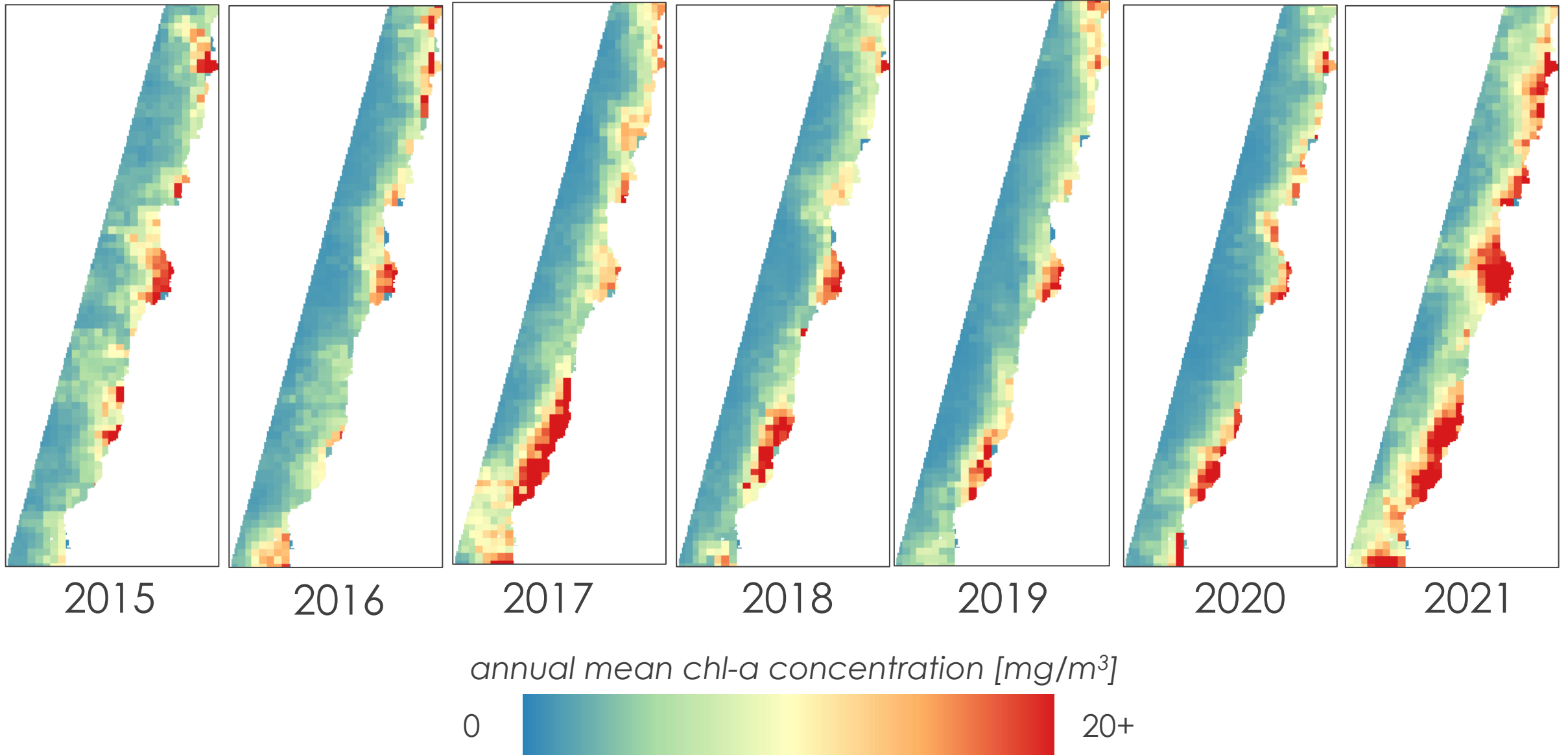
Chl-a Concentration and Sea Surface Temperature (2015-2022)



Chl-a Concentration and Normalized Fluorescence Line Height (2015-2022)



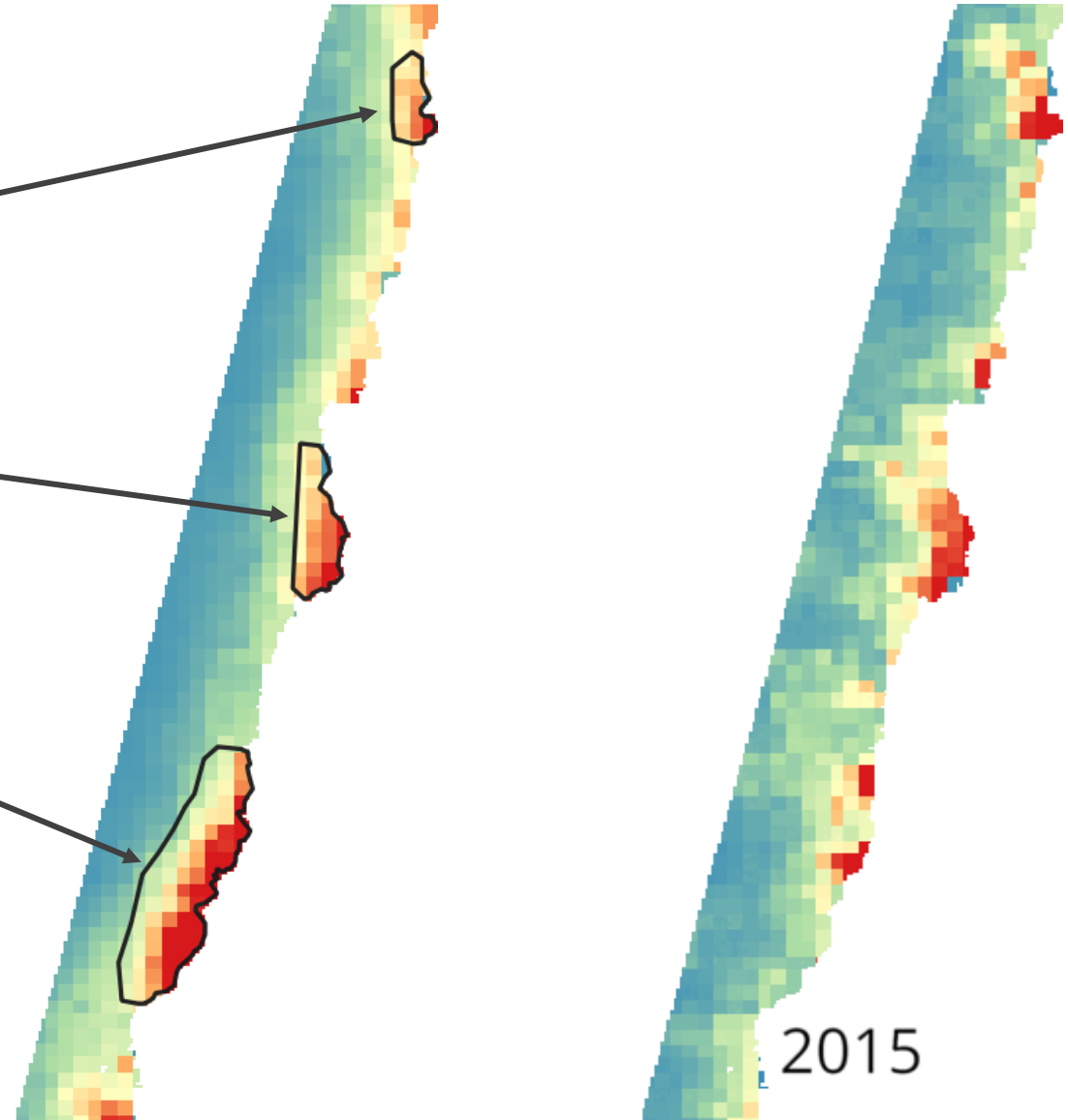
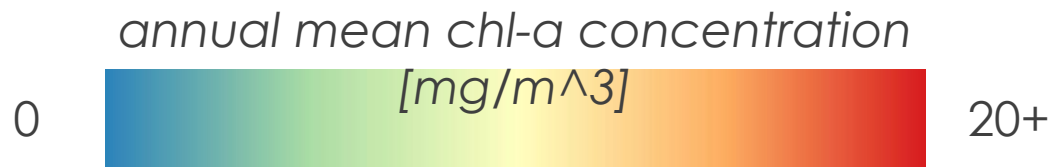
RESULTS – Chlorophyll-a (Aqua MODIS)



RESULTS – Chlorophyll-a (Aqua MODIS)

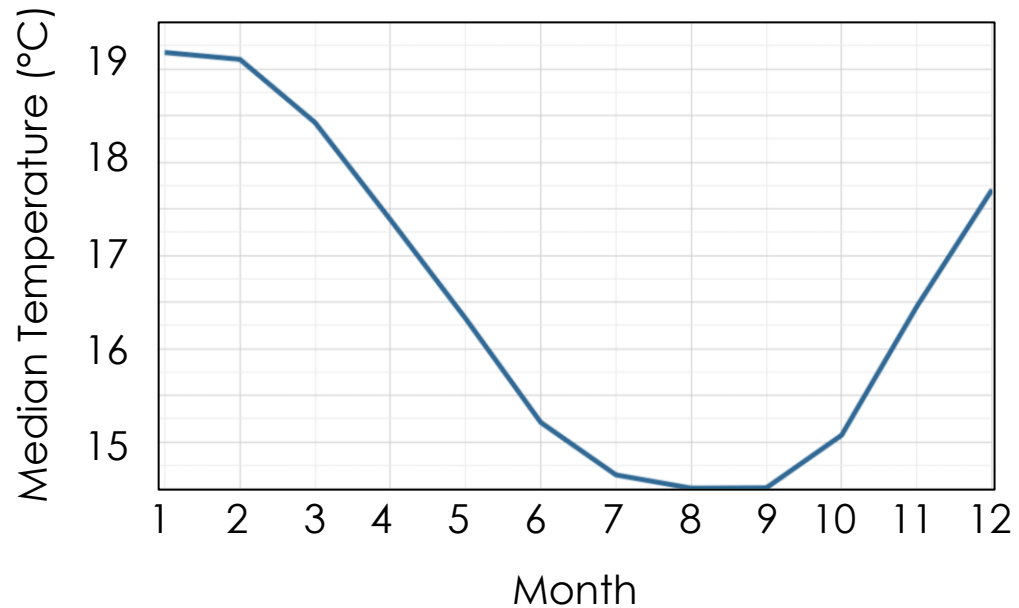
Hotspot Locations:

- Chañaral
- Bahía Inglesa
- Huasco

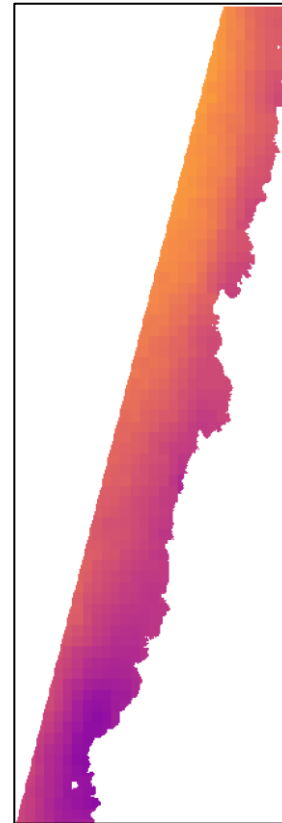


RESULTS – SST (Aqua MODIS)

Monthly Median Sea Surface Temperature
2011-2021



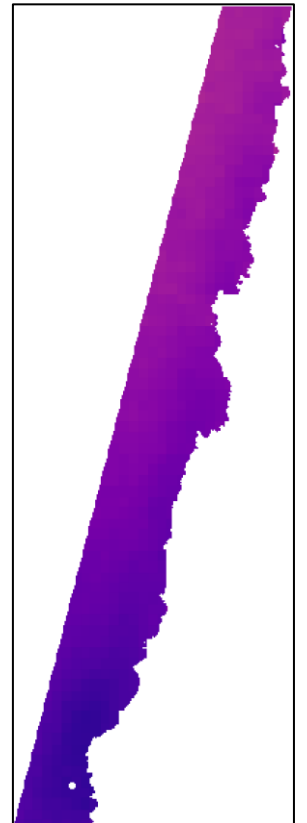
January (Summer)



April (Fall)



July (Winter)



October (Spring)

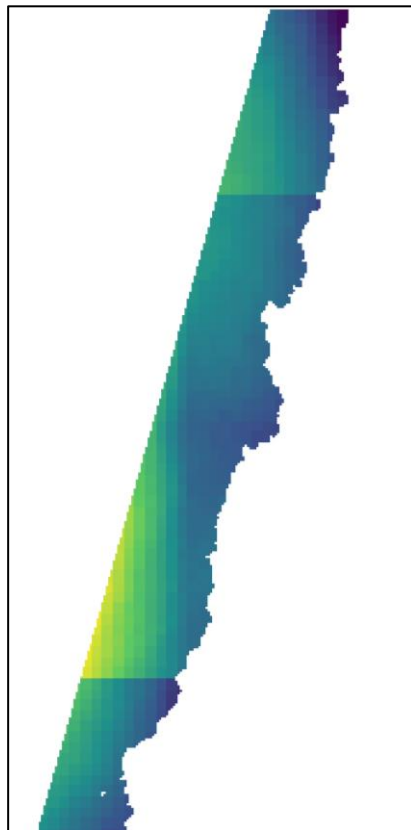
13°C



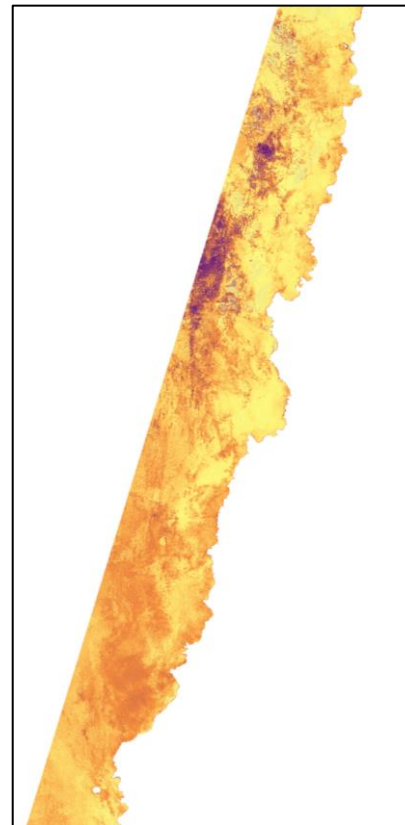
21°C

RESULTS – NDTI, NFLH, WIND SPEED

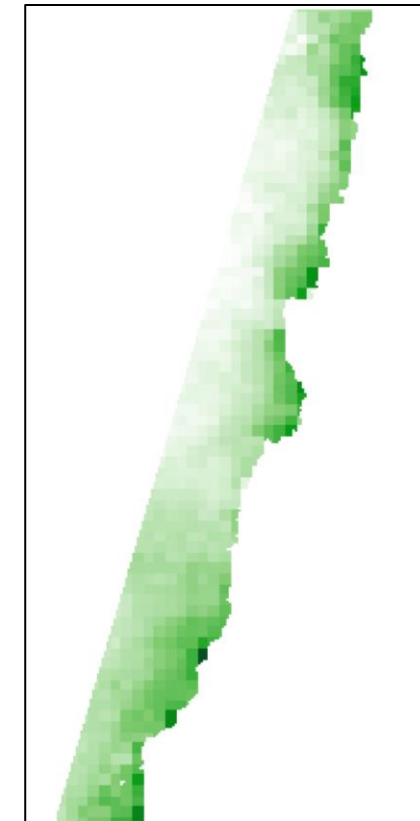
Average Spring Values (2015-2022)



Wind Speed (m/s)



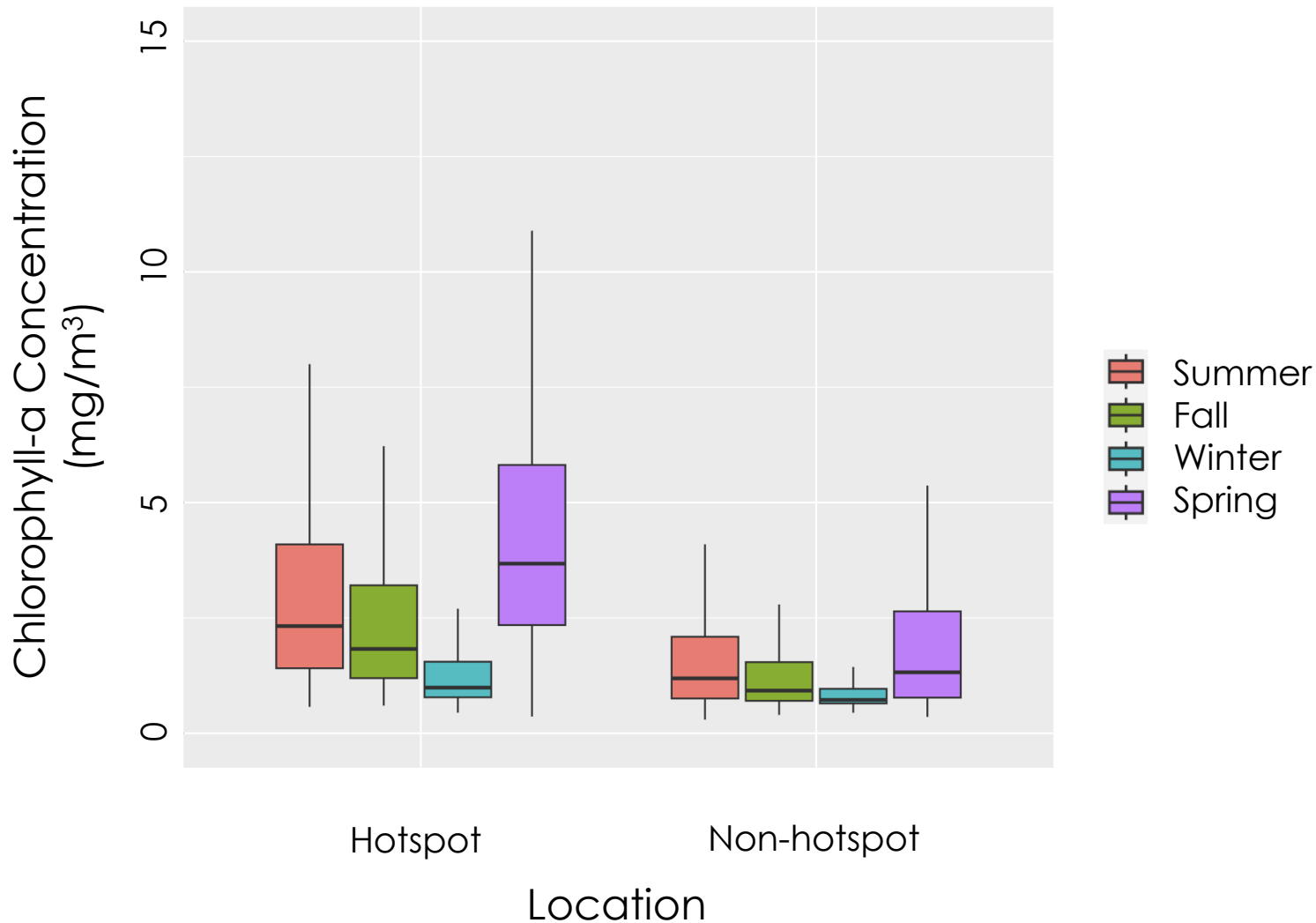
Normalized Difference
Turbidity Index (NDTI)



Natural Fluorescence
Line Height (NFLH)

RESULTS – COMBINING FINDINGS

Seasonal Chlorophyll by Location

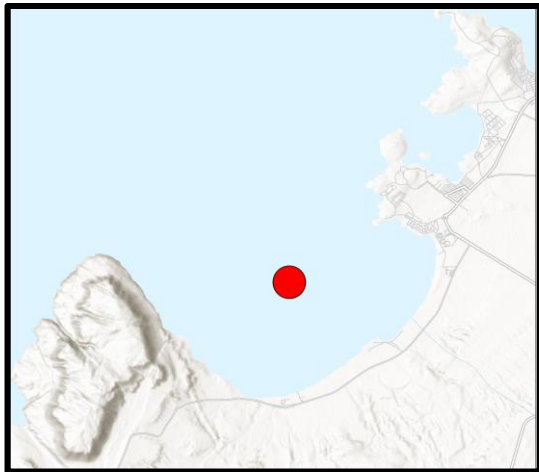


- Chlorophyll was significantly **higher in the hotspots** than in surrounding areas (*Welch Test: $p < 1e-7$*)
- Chlorophyll was significantly **higher during the spring** than in the winter (*Welch Test: $p < 1e-7$*)

METHODOLOGY – SIMILARITY SEARCH

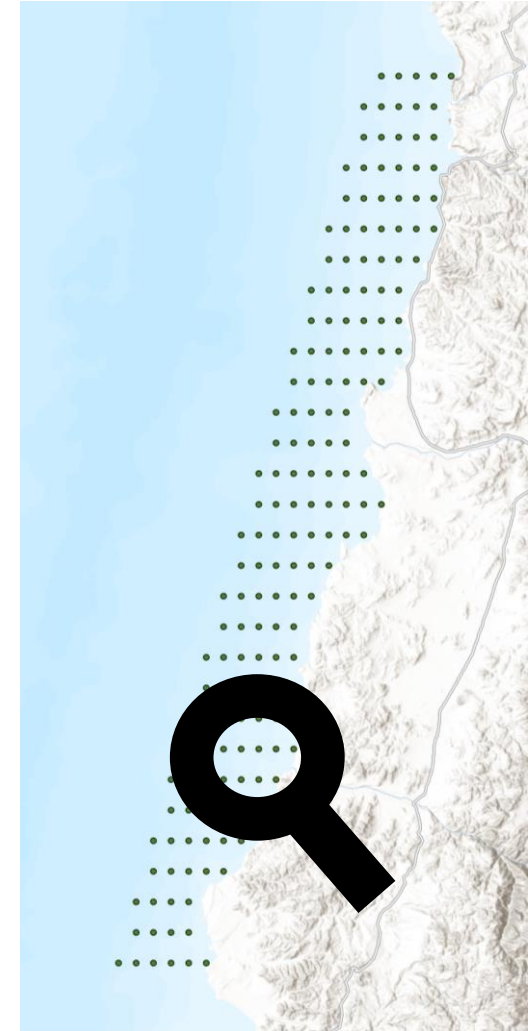
Similarity Search

- Searches the study area to find regions **most similar** to the points where HABs have occurred
- Searched the seasonal averages of indicators to identify seasonal trends



HAB Event Data Point

Chl-a
SST
NFLH
NDTI
Wind
Speed



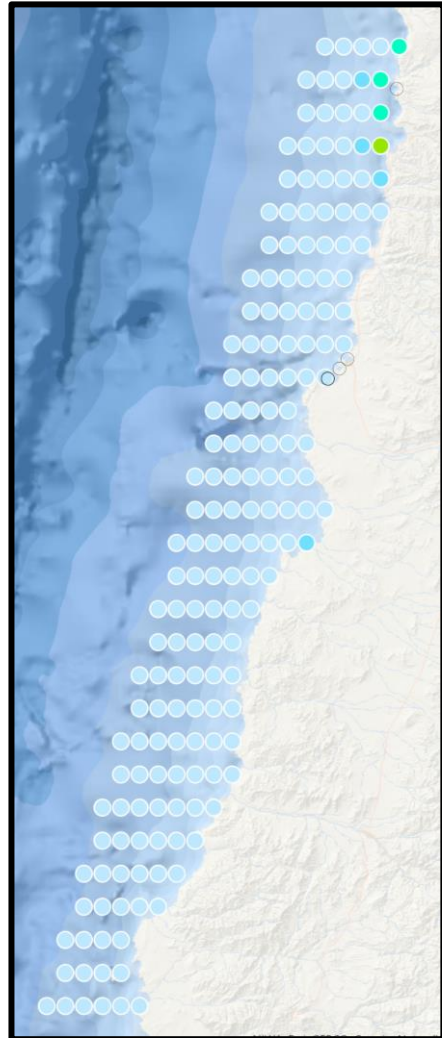
Areas to Search

RESULTS – SIMILARITY SEARCH

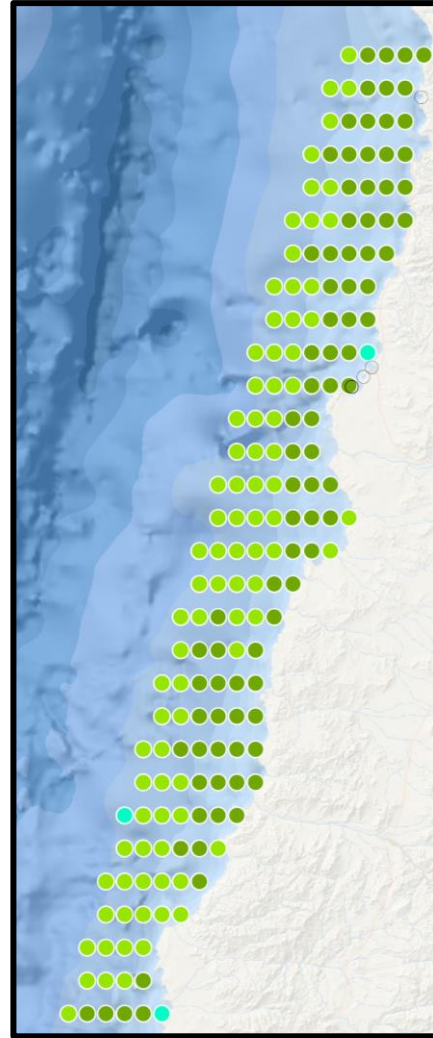
Greatest
Concern



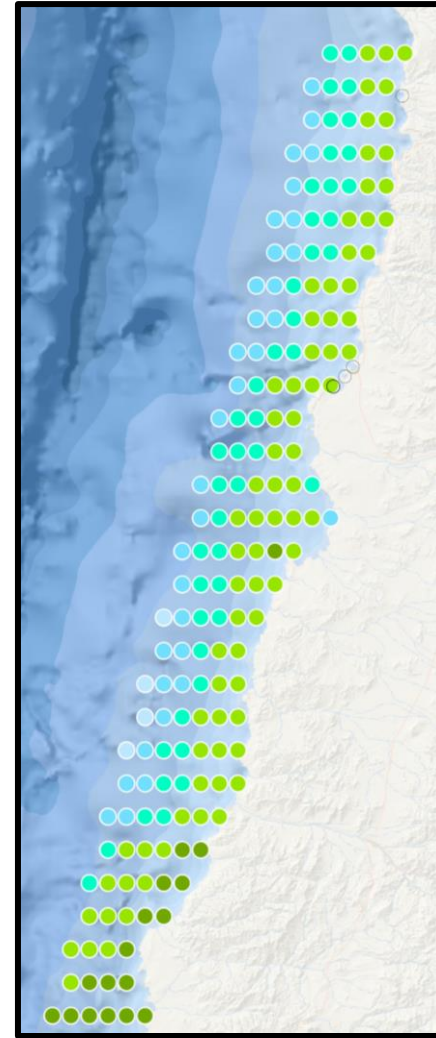
Least
Concern



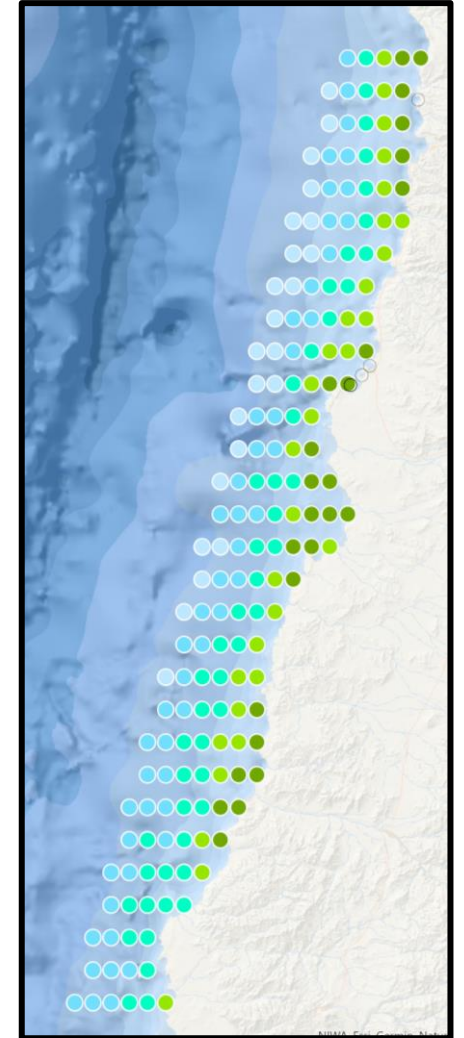
Winter



Spring



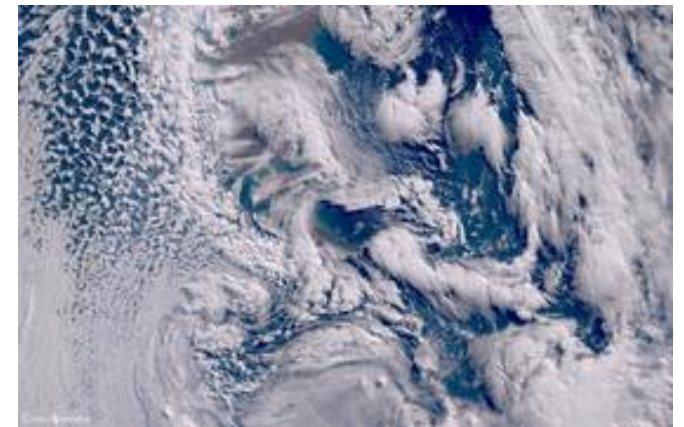
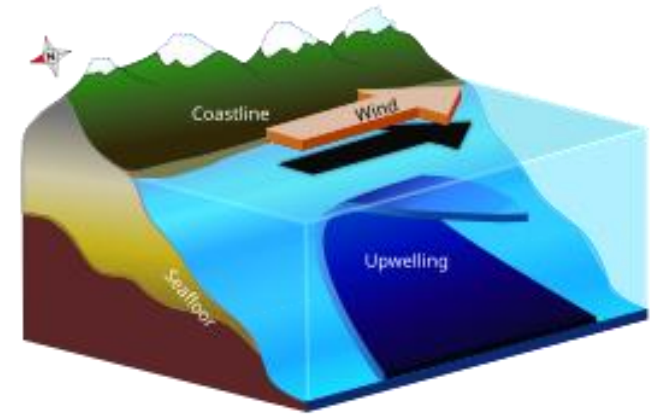
Summer



Fall

ERRORS AND UNCERTAINTIES

- Multiple contributing variables made it difficult to pinpoint direct causes of HABs
 - Coastal Upwelling
 - El Niño Southern Oscillation (ENSO)
 - Land Use effects and change
- Extensive cloud coverage throughout much of the year caused gaps in data
 - Cloud filtering/masking
- Limited literature and resources on recent HAB events in Northern Chile



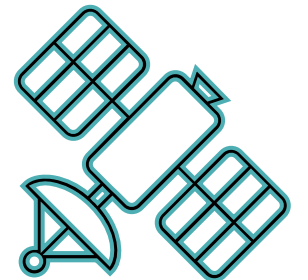
Attribution: Contains modified Copernicus Sentinel data 2020.

Image credits:
Lichtspiel (top), Monja Šebela and
Marko Repše (bottom)

FEASIBILITY AND PARTNER IMPLEMENTATION

Using satellite data from **Aqua MODIS**, **Landsat 8**, and **NOAA AVHRR** to monitor HABs in Atacama is **feasible**.

- Analysis of the historical, yearly, and seasonal trends of introduced parameters will aid in future HAB prediction
- Similarity search results demonstrate areas and times most likely to have a harmful algal bloom
- In-situ sampling in three hot spot regions, particularly during spring months



CONCLUSIONS AND NEXT STEPS

Summary

- **Aqua MODIS** - Ocean Color SMI bands beneficial to calculate Chl-a, SST, and NFLH
- **Landsat 8 OLI:**
 - Benefits long-term turbidity monitoring
 - 16-day revisit cycle can yield delayed detection
 - Cloud removal leave gaps in data
- Further **in-situ monitoring** in river outlets by Chañaral, Bahía Inglesa, and Huasco

Acknowledgments

- Partners:
 - Dr. Alejandro Murillo (University of Atacama)
 - Noelia Tastets (CIREN)
 - Carlos Patricio Calvo Cortés-Monroy (CIREN)
 - Andrea Rivera (MINSAL)
 - Fernando Vasquez (Embassy of Chile, Agricultural Office)
 - Andrés Matías Sarabia Méndez (Embassy of Chile, Agricultural Office)
- Science Advisors:
 - Dr. Xia Cai (NASA LaRC)
 - Dr. Xiaomei Lu (NASA LaRC)
 - Dr. Kenton Ross (NASA LaRC)
- Project Lead:
 - Olivia Landry (Virginia – Langley)

