EARTH SCIENCE
APPLIED SCIENCES

EARTH SCIENCE APPLICATIONS WEEK 2022

Day 2: Climate & Water Resources

August 10, 2022

EARTH SCIENCE APPLICATIONS WEEK 2022

WELCOME!

DAY 2 – AUGUST 10th: CLIMATE & WATER RESOURCES

Event Attendance Guidelines

1. Please stay muted with cameras off
2. Post questions for speakers in the chat & they will be answered there

EARTH SCIENCE
APPLIED SCIENCES

CLIMATE & RESILIENCE APPLICATIONS

Dr. Allison Leidner
Program Manager
Climate Program

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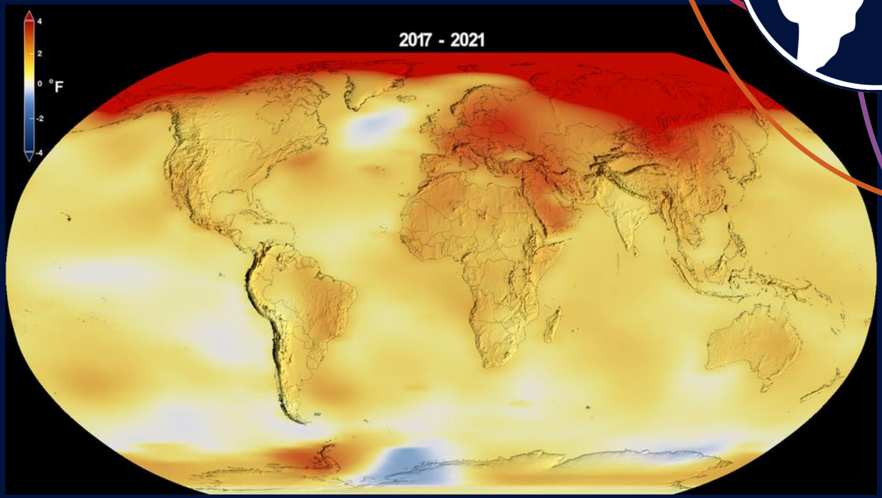
NASA & Climate

- NASA observations and models provide enormous insight into how and why climate is changing, as well as what this means for people around the world and how we can adapt
- Climate change will impact NASA facilities, assets, and operations
- NASA invests in advancing aeronautics research to reduce contributors to climate change



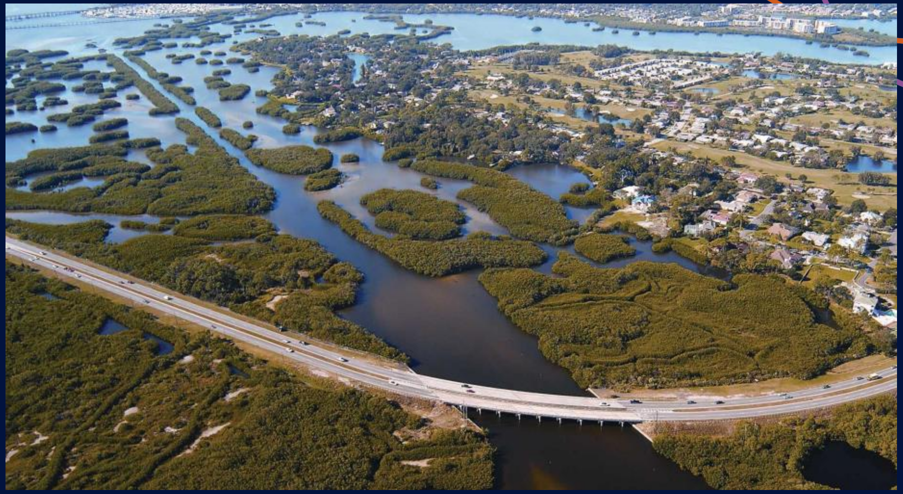
Global Temperature Anomalies: 1880-2021
https://svs.gsfc.nasa.gov/4964

Kennedy Space Center

Climate & Resilience

- A new applications area in Applied Sciences that is in development!

- Big picture: It will address uses of Earth science capabilities to inform policy analyses and business decisions related to climate factors; it will support public and private sector decision-making using Earth science data and models to reduce risks and build resilience in integrated human and natural systems



The Fourth National Climate Assessment Coastal Effects chapter highlighted the integrated socioeconomic and environmental impacts and consequences of a changing climate.

Where are we now?

- Understanding the programmatic landscape in the public and private sector

- Assessing climate information supply and demand to identify areas where NASA observations, models, and knowledge can make an impact

- Potential topics: infrastructure, coastal resilience, climate information systems, climate services, scenario development and analysis, greenhouse gases, energy infrastructure

NASA's Orbiting Carbon Observatory-2 (OCO-2) mission launched in 2014

SEMCOG's climate resilience work includes investigating the impacts of extreme precipitation in stormwater management and transportation planning

SERVIR-CArbon Pilot (S-CAP)

Emil A. Cherrington [1,2], Christine A. Evans [1,2], Africa I. Flores-Anderson [1,2], Eric R. Anderson [2], Ashutosh Limaye [2], Daniel E. Irwin [2]

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[2] SERVIR Science Coordination Office, NASA Marshall Space Flight Center

August 10, 2022

CONNECTING
SPACE TO **VILLAGE**

SERVIR is a partnership of NASA, USAID, and leading geospatial organizations in Asia, Africa, and Latin America.

- We work with countries and organizations in the use of free and open satellite data to build resilience to climate change and address its contributing causes.
- We co-develop innovative solutions through a network of regional hubs to improve sustainable resource management at local, national and regional scales.
- We build capacity to address critical challenges in **climate change**, **food security**, **water and related disasters**, **land use**, and **air quality**.

USAID FROM THE AMERICAN PEOPLE | NASA | SERVIR | ICRISAT | RCMRD | ICIMOD | adpc | ALLIANCE Bioversity CIAT

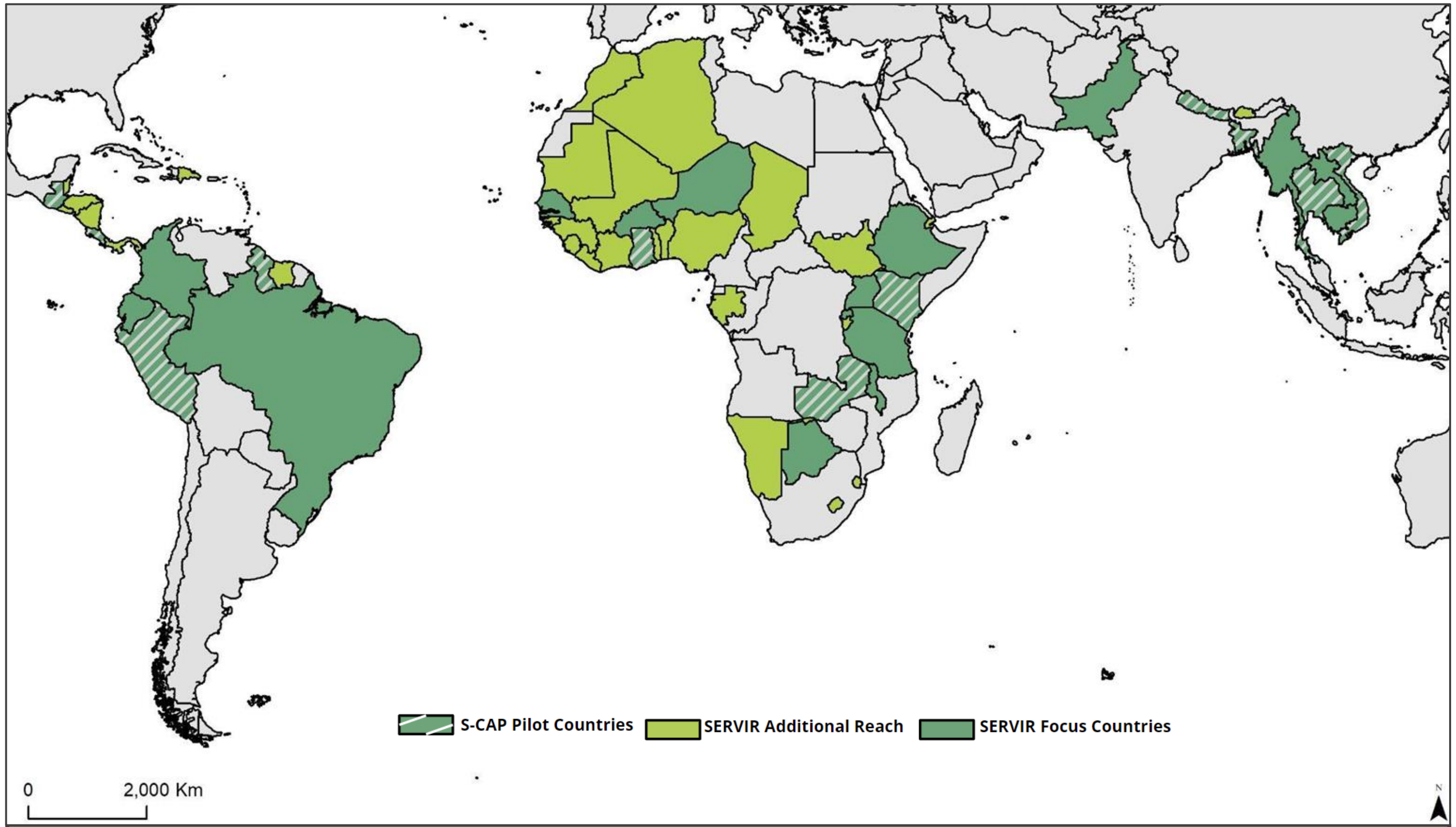
Highlights: SERVIR activities in LC monitoring

- Network est. in 2005, supporting land cover monitoring + other activities in 5 regions
- Partnership w/ regional centers of excellence, international orgs like FAO, private sector
- Scientific backstopping by NASA-funded Applied Science Team
- Focus on capacity development
  - SAR Handbook
  - Collect Earth Online (for reference data collection)
  - Emerging technologies
- Focus on services (leveraging service planning approach)
- Multiple services focusing on wall-to-wall mapping
- Ongoing global land cover change algorithm inter-comparison activity (Flores + Spera)

1. Background: S-CAP objectives

Strengthen the ability of the SERVIR network to integrate greenhouse gas (GHG) estimation into services & other activities

- **Development of transparent & replicable methodologies** for GHG estimation -> open science / demystification
- **Development of GHG estimates for pilot countries** -> ongoing SERVIR global land cover change algorithm inter-comparison
- **Integrate GHG estimation into SERVIR LC services**
- Collaboration w/ NASA CMS scientists -> strengthen SERVIR GHG monitoring capacities
- Devt. of training materials for GHG estimation



Pilot countries

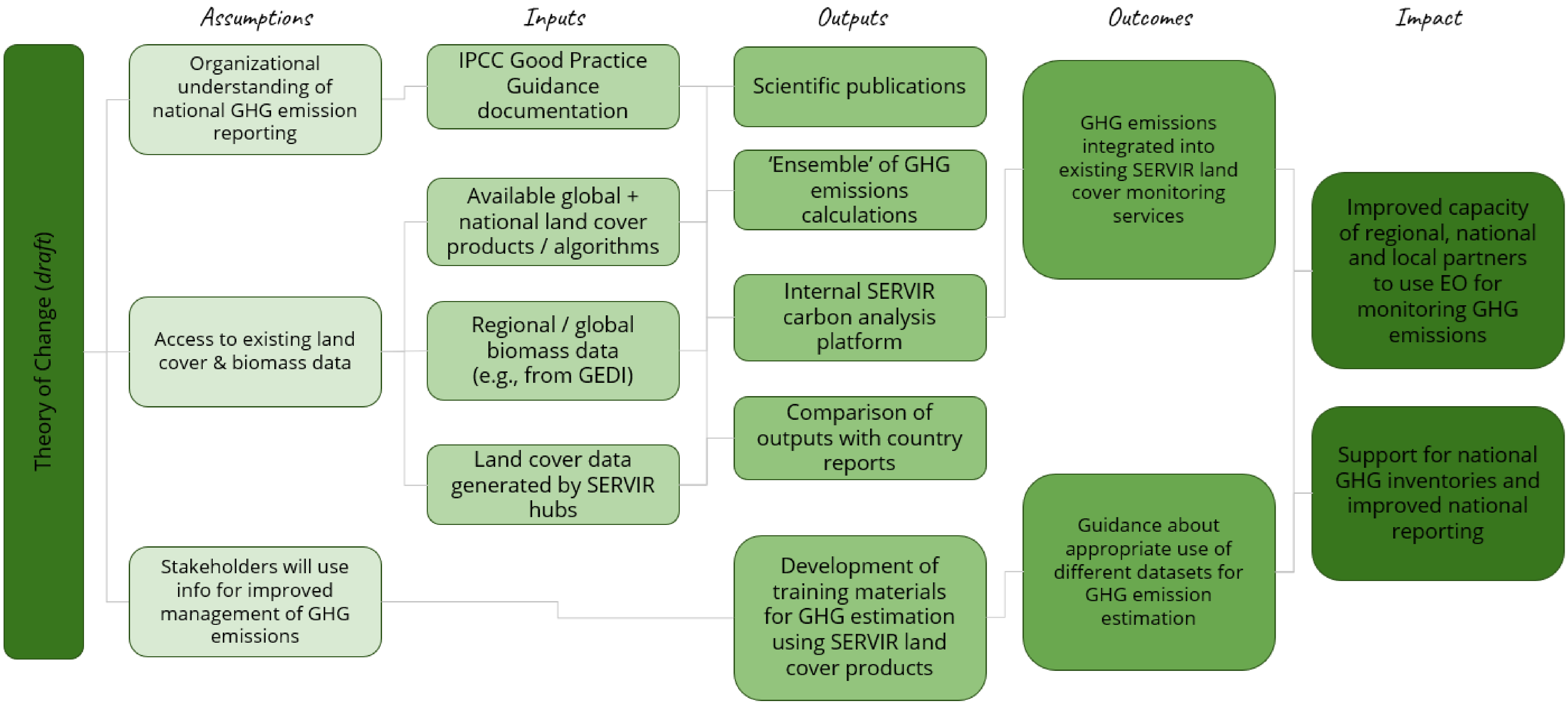
SERVIR-AMZ
- Guyana

SERVIR-WA
- Ghana

SERVIR-E&SA
- Zambia

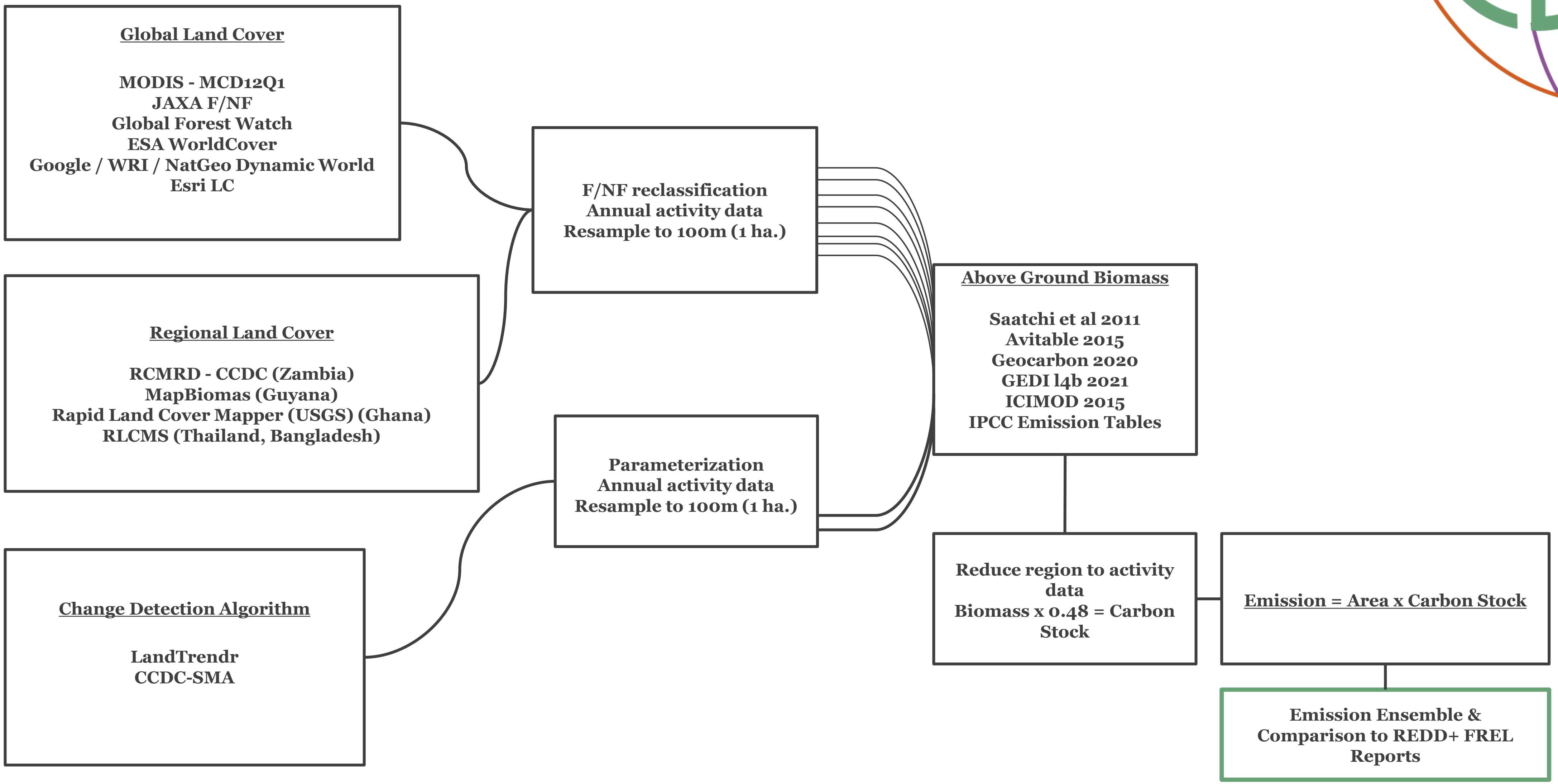
SERVIR-HKH
- Bangladesh

SERVIR-MKG
- Thailand



Theory of Change (draft)
Assumptions
Inputs
Outputs
Outcomes
Impact
Organizational understanding of national GHG emission reporting
Access to existing land cover & biomass data
Stakeholders will use info for improved management of GHG emissions
IPCC Good Practice Guidance documentation
Available global + national land cover products / algorithms
Regional / global biomass data (e.g., from GEDI)
Land cover data generated by SERVIR hubs
Scientific publications
'Ensemble' of GHG emissions calculations
Internal SERVIR carbon analysis platform
Comparison of outputs with country reports
Development of training materials for GHG estimation using SERVIR land cover products
GHG emissions integrated into existing SERVIR land cover monitoring services
Guidance about appropriate use of different datasets for GHG emission estimation
Improved capacity of regional, national and local partners to use EO for monitoring GHG emissions
Support for national GHG inventories and improved national reporting

2. Methodology: Overview



3. Results: Global & Regional Remote Sensing data

Guyana

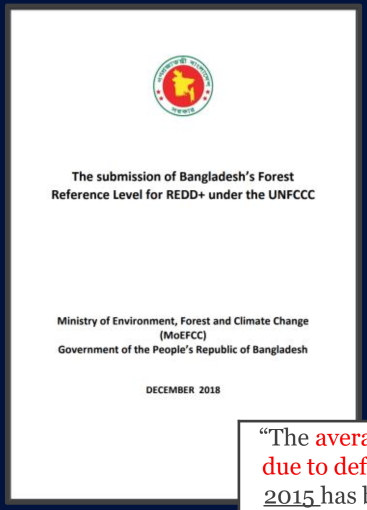
LC Dataset	AGB Dataset	Change in Forest Area (ha./yr)	Emissions = Area x AGB (per year)
MCD12Q1	IPCC Tier 1	21,924.83	5,392,192.69
JAXA F/NF	Saatchi 2011	37,705.40	2,426,659.22
GFW	Avitable 2015	8,011.96	2,392,852.87
MapBiomas	GeoCarbon 2020	15,334.04	3,457,519.98

Ghana

LC Dataset	AGB Dataset	Change in Forest Area (ha./yr)	Emissions = Area x AGB (per year)
MCD12Q1	IPCC Tier 1	36,677.75	4,165,242.66
JAXA F/NF	Saatchi 2011	60,680.63	1,500,607.58
GFW	Avitable 2015	33,545.45	921,829.09
USGS	GeoCarbon 2020	106,502.68	2,737,118.93

Thailand

LC Dataset	AGB Dataset	Change in Forest Area (ha./yr)	Emissions = Area x AGB (per year)
MCD12Q1	IPCC Tier 1	1,119,450.61	9,661,738.65
JAXA F/NF	Saatchi 2011	188,331.43	11,808,832.34
GFW	Avitable 2015	118,888.89	9,721,544.44
RLCMS	GeoCarbon 2020	102,641.35	4,985,203.83



"The average annual historical emissions due to deforestation in the period 2000-2015 has been estimated to be 819,854 t CO2e/year at the national scale"

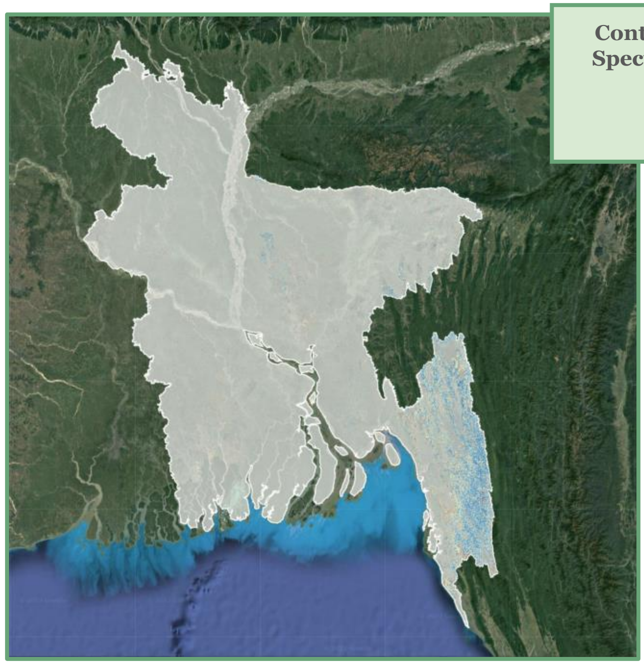
Bangladesh

LC Dataset	AGB Dataset	Change in Forest Area (ha./yr)	Emissions = Area x AGB (per year)
MCD12Q1	IPCC Tier 1	19,286.22	1,688,512.99
JAXA F/NF	Saatchi 2011	50,832.31	2,687,850.00
GFW	Avitable 2015	13,892.44	1,037,209.73
RLCMS	GeoCarbon 2020	10,051.61	831,067.32

Zambia

LC Dataset	AGB Dataset	Change in Forest Area (ha./yr)	Emissions = Area x AGB (per year)
MCD12Q1	IPCC Tier 1	98,035.05	7,974,249.61
JAXA F/NF	Saatchi 2011	183,029.00	5.836.135.91
GFW	Avitable 2015	92,000.00	2,416,840.00
RCMRD	GeoCarbon 2020	192,816.67	4,249,987.84

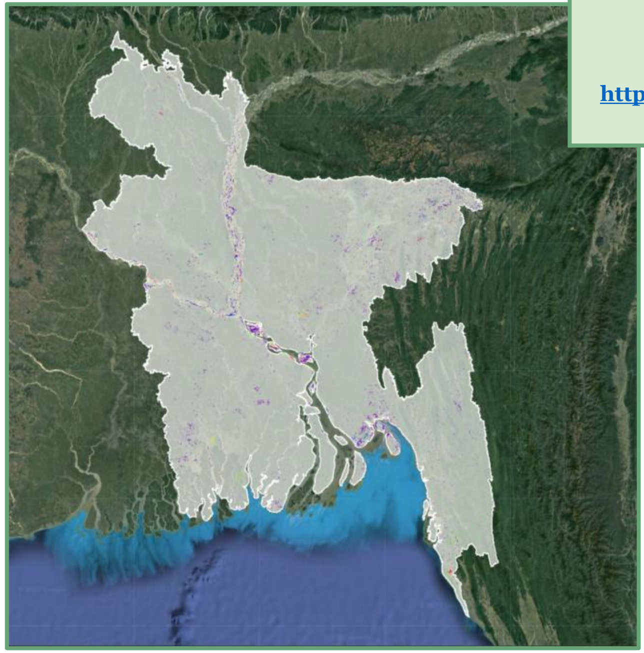
3. Results: Global LCC Intercomparison Project Algorithms - Bangladesh



Continuous Change Detection and Classification - Spectral Mixture Analysis (CCDC-SMA) algorithm
2000-2019
https://t.co/M3pVPLQPE1

Parameters

Threshold: 4450
Number of consec: 5
Start year: 2000
End year: 2019
Start day: 1
End day : 365
Forest mask: Hansen GFW - "treecover2000"
Deforestation mask: RLCMS 2019 non forest cover



LandTrendr spectral-temporal segmentation algorithm.
1990-2020
https://code.earthengine.google.com/?accept_repo=users/emaprlab/public

Parameters

Collection:
startYear = 1990
endYear = 2020
startDay = 01-01
endDay = 12-31

Landtrendr:
maxSegments: 6
spikeThreshold: 0.9
vertexCountOvershoot: 3
preventOneYearRecovery: true
recoveryThreshold: 0.25
pvalThreshold: 0.05
bestModelProportion: 0.75
minObservationsNeeded: 6

Change:
delta: loss
sort: greatest
year: start: 1990
end: 2020
mag: 100
dur: 4
preval: 300
mmu: 8

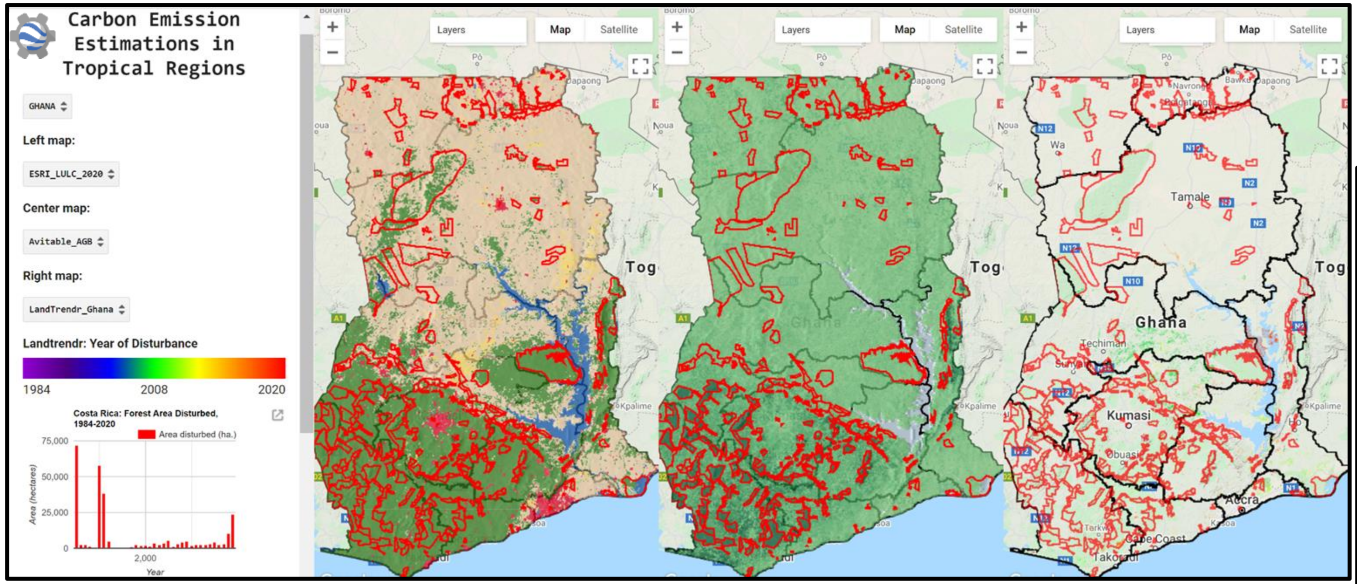
Change Algorithm	Change in area (ha/yr)	AGB dataset	Carbon stock	Emissions (tons CO_2e)
CCDC-SMA	60,767.18	Saatchi et al 2011	146.48	3,540,660.43
CCDC-SMA	60,767.18	Avitable 2015	45.48	8,901,176.32
CCDC-SMA	60,767.18	GeoCarbon 2020	117.73	2,763,691.28
LandTrendr	8,033.19	Saatchi et al 2011	130.91	1,051,624.47
LandTrendr	8,033.19	Avitable 2015	81.54	655,026.04
LandTrendr	8,033.19	GeoCarbon 2020	135.13	1,085,524.51

4. Implications: Policy Relevance

- Improved understanding of carbon dynamics (nationally, regionally)
- USG support for climate change mitigation activities

USAID's Global Climate Change program's Sustainable Landscapes goal "to assist countries to **reduce greenhouse gas emissions from deforestation and land degradation and to enhance sequestration of carbon** associated with sound land use and management"	Glasgow Leaders' Declaration (COP26) goal of global net zero deforestation by 2030: "**conserve forests and other terrestrial ecosystems and accelerate their restoration**"	SDG Target 15.2: "By 2020, promote the implementation of **sustainable management of all types of forests**, **halt deforestation**, restore degraded forests and substantially increase afforestation and reforestation globally"

5. Future activities: 2022-2023



Google Earth Engine App & Estimation Ensemble

Pilot Country	LC Dataset	AGB Dataset	Sample Period	Change in Forest Area (ha.)	Average Change in Forest Area (ha./year)	AGB Carbon Stock (tons CO2/ha.)	BGB Carbon Stock (tons CO2/ha.)	Total Biomass (AGB+BGB)	Multiplier (0.48)	Total Carbon Stock (Total Biomass X 0.48)	Multiplier (44/12)	Total CO2e (Carbon Stock X (44/12)	Carbon Emission (Total CO2e * Area)	Emissions = Area x AGB (whole sample period)	Emissions = Area x AGB (per year)
Costa Rica	MCD12Q1	FREL	2000-2014	395,358.29	26,357.22	300.148	68.82	368.97	0.48	177.11	3.666666667	649.39	256,740,612.94	118,666,000.03	7,911,066.67
Costa Rica	MCD12Q1	IPCC Tier 1	2000-2014	395,358.29	26,357.22	204.225	56.14	260.37	0.48	124.98	3.666666667	458.25	181,171,671.25	80,742,046.78	5,382,803.12
Costa Rica	MCD12Q1	Saatchi et al 2011	2000-2014	395,358.29	26,357.22	179.36	44.84	224.20	0.48	107.62	3.666666667	394.59	156,005,218.37	70,911,462.89	4,727,430.86
Costa Rica	LandTrendr	FREL	2000-2020	88,351.55	5,890.10	300.148	68.82	368.97	0.48	177.11	3.666666667	649.39	57,374,365.67	26,518,541.03	1,767,902.74
Costa Rica	LandTrendr	IPCC Tier 1	2000-2020	88,351.55	5,890.10	204.225	56.14	260.37	0.48	124.98	3.666666667	458.25	40,486,815.06	18,043,595.30	1,202,906.35
Costa Rica	LandTrendr	Saatchi et al 2011	2000-2020	88,351.55	5,890.10	118.84	29.71	148.55	0.48	71.30	3.666666667	261.45	23,099,336.04	10,499,698.20	699,979.88
Costa Rica	GFW code	FREL	2001-2014	192,099.89	13,721.42	300.148	68.82	368.97	0.48	177.11	3.666666667	649.39	124,747,209.69	57,658,397.78	4,118,456.98
Costa Rica	GFW code	IPCC Tier 1	2001-2014	192,099.89	13,721.42	204.225	56.14	260.37	0.48	124.98	3.666666667	458.25	88,029,159.87	39,231,600.04	2,802,257.15
Costa Rica	GFW code	Saatchi et al 2011	2001-2014	192,099.89	13,721.42	145.79	36.45	182.24	0.48	87.47	3.666666667	320.74	61,613,734.52	28,006,242.96	2,000,445.93
Costa Rica	JAXA F/NF	FREL	2007-2017	289,293.29	28,929.33	300.148	68.82	368.97	0.48	177.11	3.666666667	649.39	187,863,359.57	86,830,802.41	8,683,080.24
Costa Rica	JAXA F/NF	IPCC Tier 1	2007-2017	289,293.29	28,929.33	204.225	56.14	260.37	0.48	124.98	3.666666667	458.25	132,567,724.40	59,080,922.15	5,908,092.22
Costa Rica	JAXA F/NF	Saatchi et al 2011	2007-2017	289,293.29	28,929.33	160.39	40.10	200.49	0.48	96.23	3.666666667	352.86	102,079,451.72	46,399,750.78	4,639,975.08
Costa Rica	FREL	FREL	2000-2014	84,242.89	5,616.19	300.148	68.82	368.97	0.48	177.11	3.666666667	649.39	54,706,254.46	25,285,334.95	1,685,689.00
Costa Rica	FREL	IPCC Tier 1	2000-2014	84,242.89	5,616.19	204.225	56.14	260.37	0.48	124.98	3.666666667	458.25	38,604,034.77	17,204,504.21	1,146,966.95
Costa Rica	FREL	Saatchi et al 2011	2000-2014	84,242.89	5,616.19				0.48		3.666666667				
Costa Rica	CCDC-SMA	FREL	2007-2019	534,944.75	41,149.60	300.15	68.82	368.97	0.48	177.11	3.666666667	649.39	347,386,273.36	160,562,596.82	12,350,968.99
Costa Rica	CCDC-SMA	IPCC Tier 1	1987-2019	240,495.17	7,515.47	204.23	56.14	260.37	0.48	124.98	3.666666667	458.25	110,206,141.61	49,115,125.89	1,534,847.68
Costa Rica	CCDC-SMA	Saatchi et al 2011	1987-2019	240,495.17	7,515.47				0.48		3.666666667				
Peru	MCD12Q1	FREL	2001-2014	2,320,296.95	145,018.56	324.98	83.98	408.96	0.48	196.30	3.666666667	719.77	1,670,079,207.58	754,050,102.81	47,128,131.43
Peru	MCD12Q1	IPCC Tier 1	2001-2014	2,320,296.95	145,018.56	193.10	53.59	246.70	0.48	118.41	3.666666667	434.18	1,007,438,038.42	448,058,622.23	28,003,663.89
Peru	MCD12Q1	Saatchi et al 2011	2001-2014	2,320,296.95	145,018.56	205.53	51.38	256.91	0.48	123.32	3.666666667	452.17	1,049,159,390.69	476,890,632.13	29,805,664.51
Peru	LandTrendr	FREL	2000-2018	391,688.78	20,615.20	324.98	83.98	408.96	0.48	196.30	3.666666667	719.77	281,925,672.91	127,291,018.10	6,699,527.27
Peru	LandTrendr	IPCC Tier 1	2000-2018	391,688.78	20,615.20	193.10	53.59	246.70	0.48	118.41	3.666666667	434.18	170,065,375.11	75,636,669.21	3,980,877.33
Peru	LandTrendr	Saatchi et al 2011	2000-2018	391,688.78	20,615.20	176.47	44.12	220.59	0.48	105.88	3.666666667	388.23	152,066,899.87	69,121,318.12	3,637,964.11
Peru	GFW code	FREL	2000-2014	2,043,251.58	136,216.77	324.98	83.98	408.96	0.48	196.30	3.666666667	719.77	1,470,670,368.84	664,015,896.84	44,267,726.56
Peru	GFW code	IPCC Tier 1	2000-2014	2,043,251.58	136,216.77	193.10	53.59	246.70	0.48	118.41	3.666666667	434.18	887,149,103.36	394,560,052.14	26,304,003.54
Peru	GFW code	Saatchi et al 2011	2000-2014	2,043,251.58	136,216.77	197.54	49.39	246.93	0.48	118.52	3.666666667	434.59	887,972,615.48	403,623,916.13	26,908,261.14
Peru	JAXA F/NF	FREL	2007-2017	4,474,594.75	447,459.48	324.98	83.98	408.96	0.48	196.30	3.666666667	719.77	3,220,677,273.37	1,454,153,801.86	145,415,380.19
Peru	JAXA F/NF	IPCC Tier 1	2007-2017	4,474,594.75	447,459.48	193.10	53.59	246.70	0.48	118.41	3.666666667	434.18	1,942,801,742.54	864,062,144.60	86,406,214.46
Peru	JAXA F/NF	Saatchi et al 2011	2007-2017	4,474,594.75	447,459.48	176.25	44.06	220.31	0.48	105.75	3.666666667	387.75	1,735,024,114.31	788,647,324.69	78,864,732.47
Peru	FREL	FREL	2001-2014	1,712,284	122,306.00	324.98	83.98	408.96	0.48	196.30	3.666666667	719.77	1,232,449,969.77	556,458,054.32	39,747,003.88
Peru	FREL	IPCC Tier 1	2001-2014	1,712,284	122,306.00	193.10	53.59	246.70	0.48	118.41	3.666666667	434.18	743,447,960.05	330,648,889.54	23,617,777.82
Peru	FREL	Saatchi et al 2011	2001-2014	1,712,284	122,306.00				0.48		3.666666667				
Ghana	MCD12Q1	FREL	2001-2010	366,777.50	36,677.75	42.92	10.73	53.65	0.48	25.75	3.666666667	94.42	34,632,598.66	15,742,090.30	1,574,209.03
Ghana	MCD12Q1	IPCC Tier 1	2001-2010	366,777.50	36,677.75	215.12	62.10	277.23	0.48	133.07	3.666666667	487.92	178,956,988.54	78,902,713.88	7,890,271.39

- Technical Assessment Group (TAG)
- Integration of outputs into existing hub land cover services
- **Capacity development activities** with SERVIR hubs / devt. of training materials
- Collaboration with NASA DEVELOP
- Prototyping of S-CAP platform for integration of external LC, AGB data -> *Bring Your Own Data (BYOD)*
- Scientific publications

6. Summary: SERVIR-CArbon Pilot (S-CAP)

Why?

- CC mitigation: Countries need to monitor + report on CO_2 / GHG emissions
- Simple transition from LC data to GHG emission estimation
- Support Hubs' integration in REDD+ reporting
- Quantifying uncertainty

Who?

- SERVIR global network
  - SCO, Hubs, Applied Sci. Team, Technical Assessment Group (Duncanson, Ogle, Olofsson)
  - 1 pilot country per SERVIR region
- Linkages w/ SilvaCarbon

What?

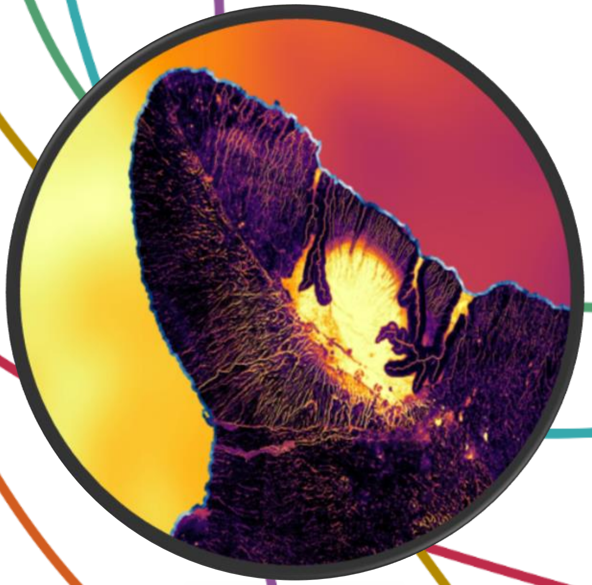
- Capacity building activities w/ Hubs
- GHG estimates for pilot countries
- Hub integration of GHG emission estimates into their LC services
- Internal SERVIR prototype platform

How?

- Analysis of existing data, incl. LC outputs from Hub services
- Analysis of data from IPCC's Emission Factor Database
- Application of methodologies consistent w/ IPCC's Good Practice Guidance

Hawaii Climate

Utilizing Earth Observations to Model Probable Wetland Extents, Model Sea-Level Rise Inundation Risk, and Assess Impacts on Historic Hawaiian Lands



TEAM: Connor Racette, Ian Lee, Lisa Tanh, Matilda Anokye

ADVISORS: Dr. Roberta Martin, Dr. Jiwei Li, Dr. David Hondula, Ryan Hammock

EARTH SCIENCE
APPLICATIONS WEEK 2022

Project Partners & Objectives

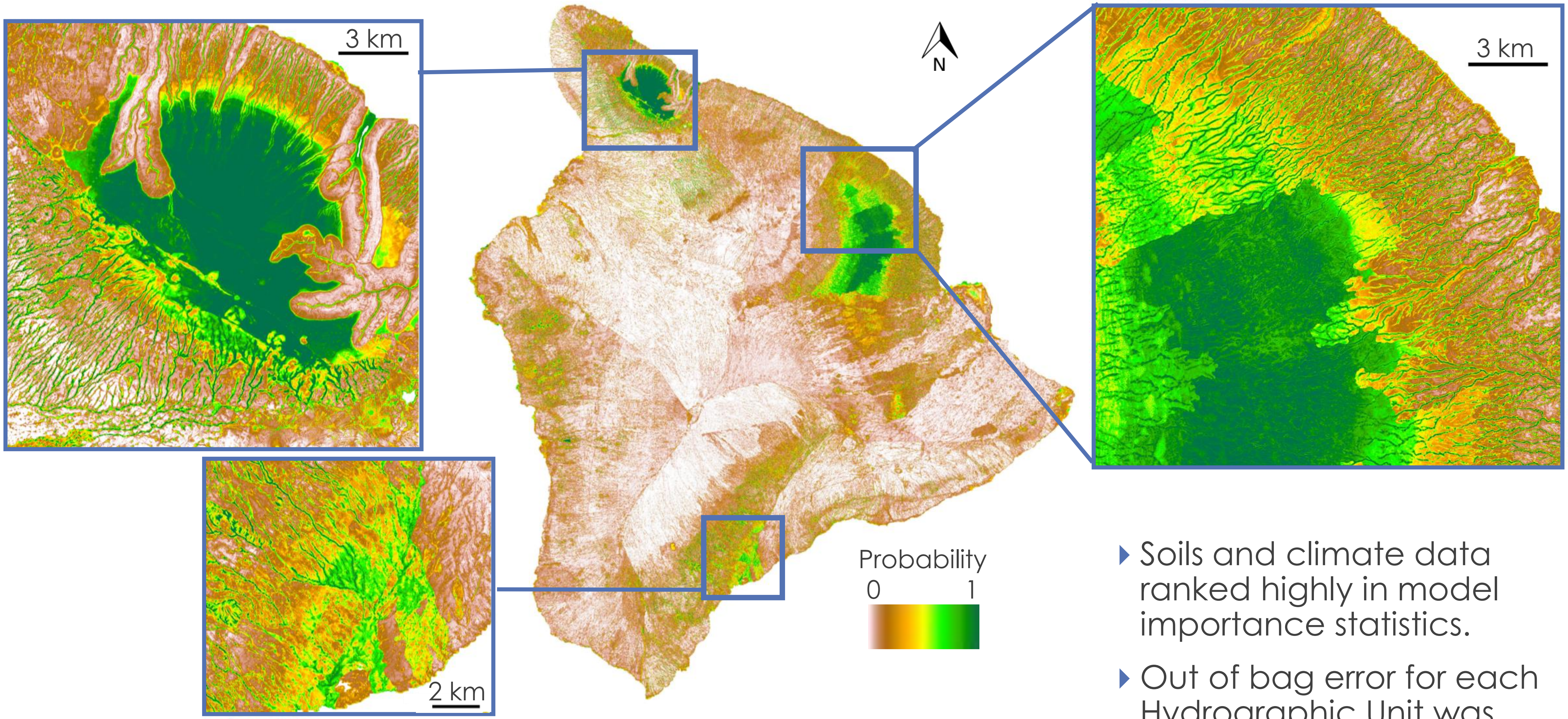
- **County of Hawaii**, *Planning Department*
- **State of Hawaii**, *Department of Land and Natural Resources*
- **Arizona State University**, *Center for Global Discovery and Conservation Science*

Create a wetlands extent map

Model short-term flood inundation

Provide insight on sea level rise risk

Wetland Extent Map

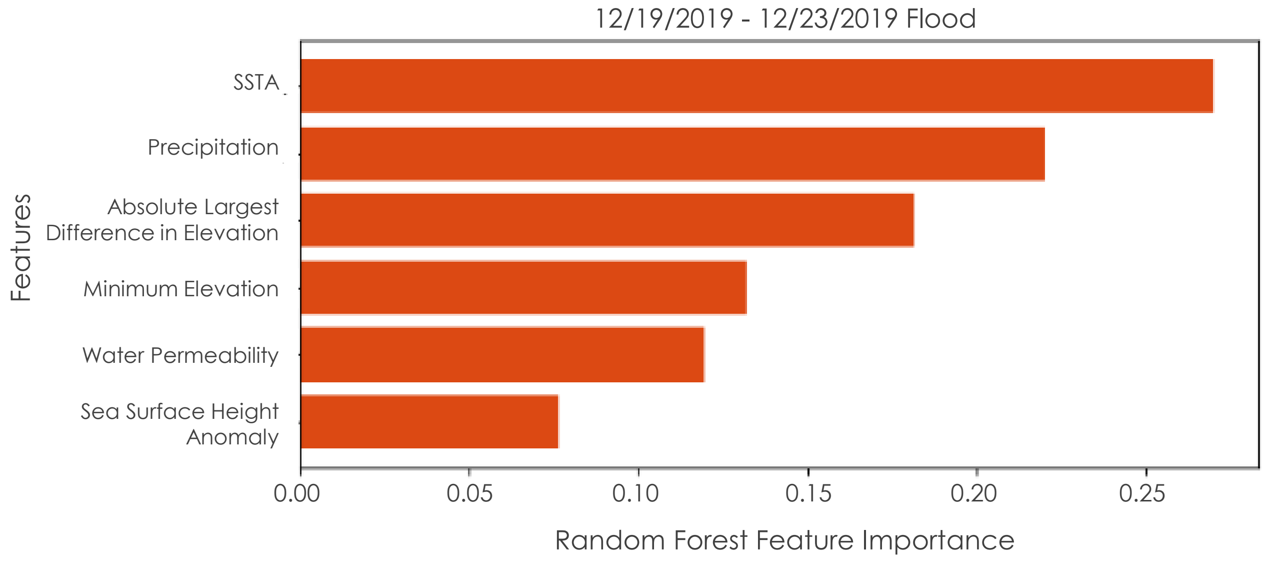


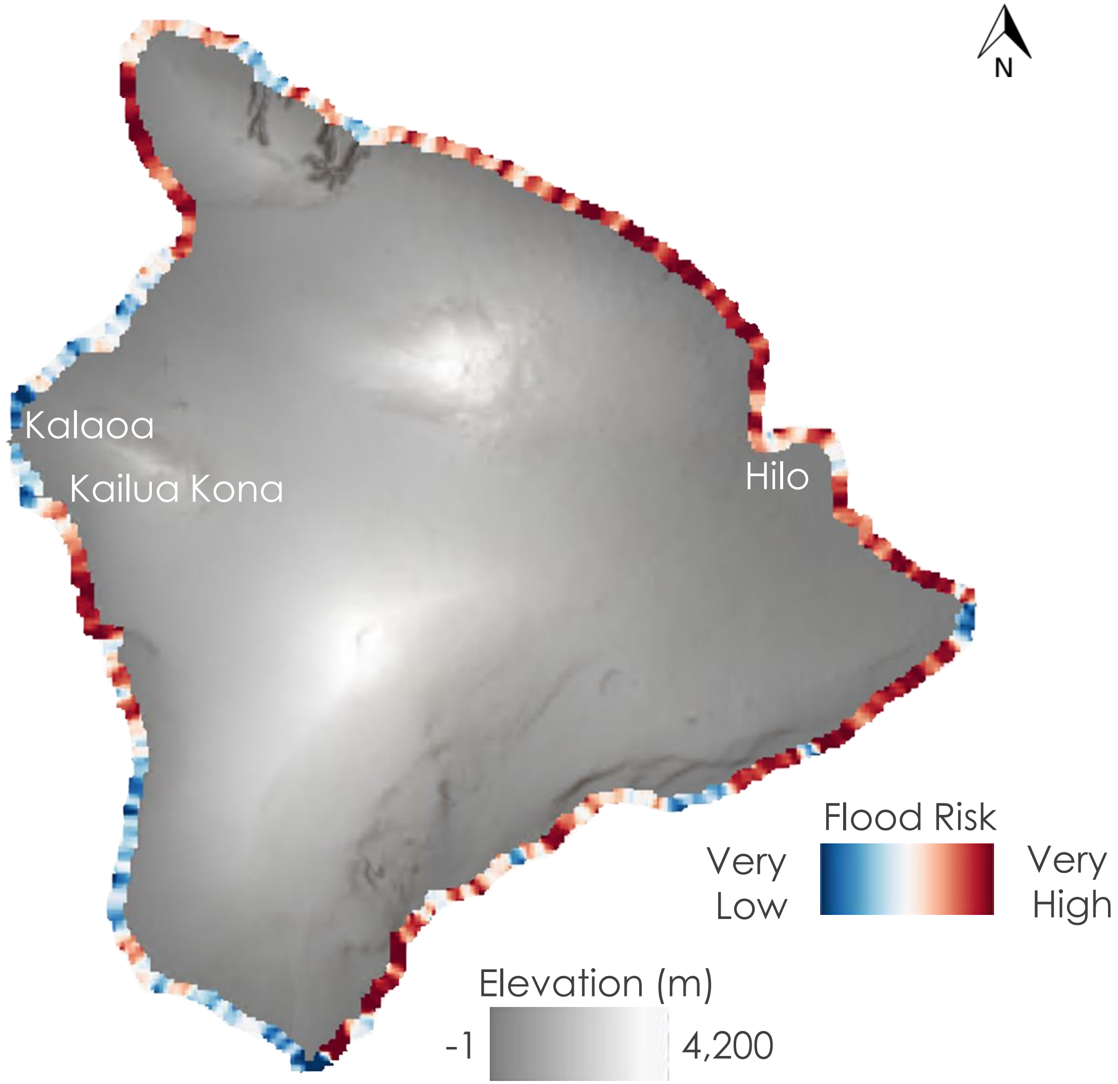
- Soils and climate data ranked highly in model importance statistics.
- Out of bag error for each Hydrographic Unit was under 10%

Wetland Intrinsic Potential tool: Miller, D., and Halabisky, M. (2019)

Sea Level Inundation Model

- Intra-event accuracy: ~90%
- Results consistently rank sea surface temperature anomaly (SSTA) and precipitation as high importance features
- Feasibility study showing the possibility of using RF and important features for flood prediction

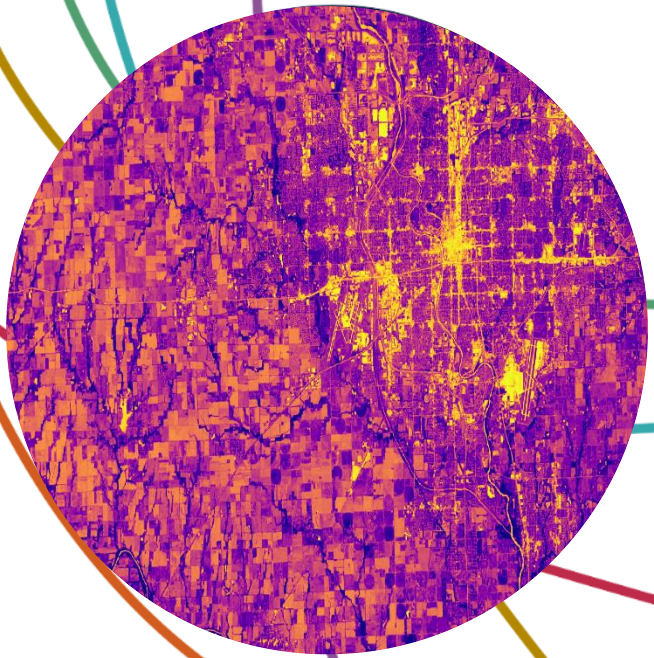




Base map: Esri, NASA, NGA, USGS

Wichita Climate

Using Satellite Data to Identify Neighborhoods Vulnerable to Extreme Heat for Equitable Climate Mitigation and Planning



TEAM: Melisa Ashbaugh, Brooke Laird, Muskaan Khemani, Sadie Murray

ADVISORS: Lauren Childs-Gleason, Dr. Kenton Ross

CLIMATE ADAPTATION THROUGH THE LENS OF ENVIRONMENTAL JUSTICE

Community Concerns

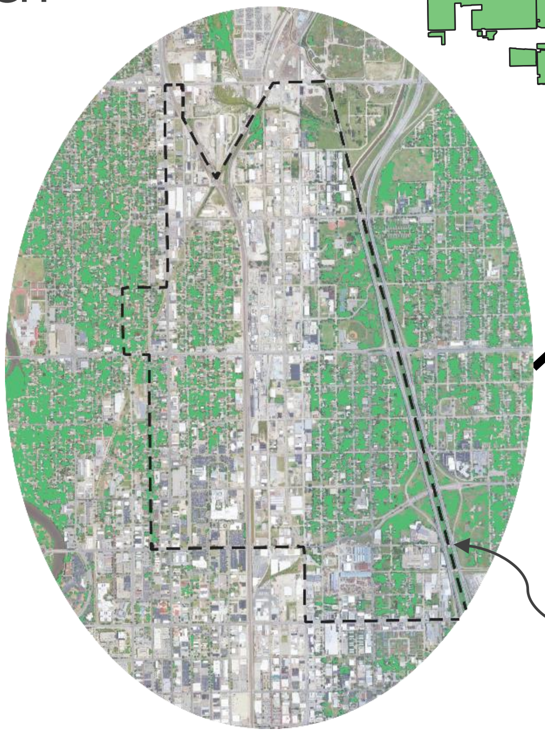
- Balancing economic vitality and environmental quality
- Continuing tree loss
- More extreme weather events

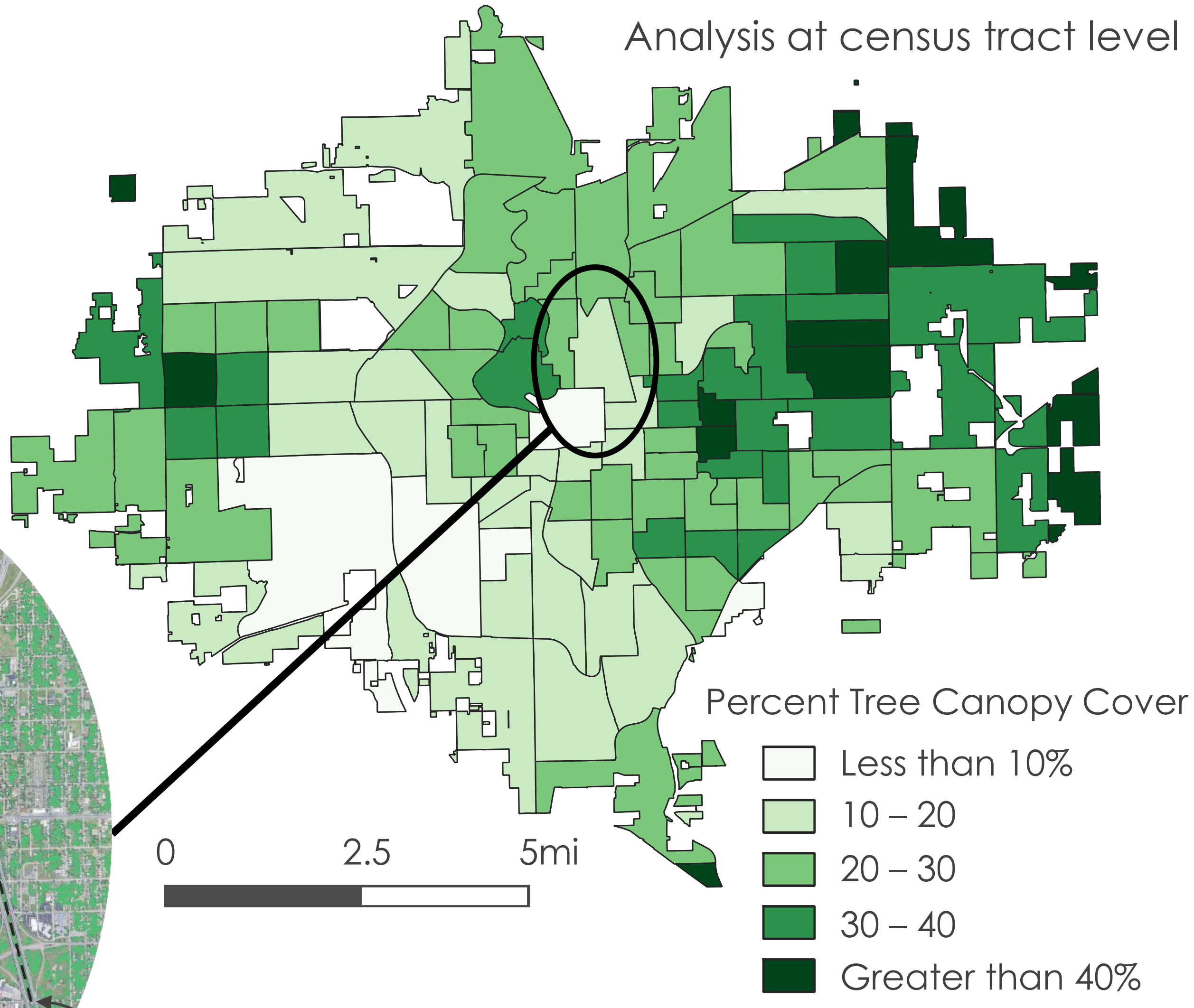
Government Goals

- Develop a Climate Adaptation and Mitigation Plan
- Explore using this research to support future grant applications

TREE CANOPY

- Unequal distribution of tree canopy
- Areas of highest heat exposure have the least canopy cover
- Classified 20% more trees than the NLCD

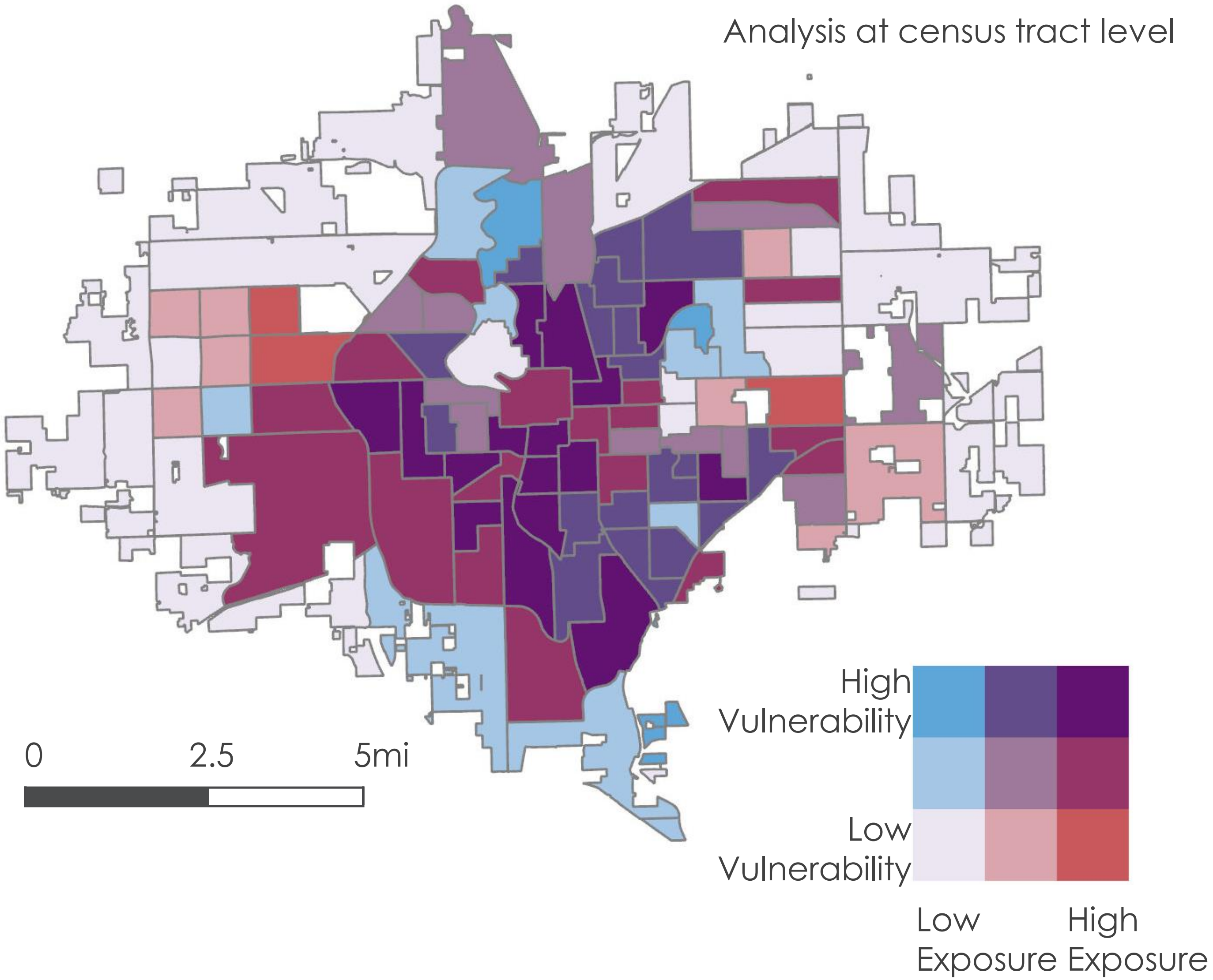




HEAT RISK INDICES

- We identified 17 high risk census tracts
  - 82% are also identified as disadvantaged by CEJST

- Spatial Trends
  - High risk tracts circle the city center
  - SW tracts have high exposure tracts with medium vulnerability
  - Eastern tracts have medium exposure and high vulnerability



WATER RESOURCES & WESTERN WATER APPLICATIONS OFFICE INTRODUCTION

Sarah Brennan
Deputy Program Manager
on behalf of Dr. Brad Doorn, Program Manager
Water Resources Program

NASA Water Data

- Precipitation
- Snow Cover
- Groundwater
- Soil Moisture
- Water Quality Indicators

Why Does NASA have a water resources application area?

NASA Satellite Data → Sustained use of NASA data in resource management decisions.

What drives us…

"The work with GRAPEX has dramatically improved our ability to accurately schedule irrigation...Once we implement the findings of GRAPEX across our entire vineyard acreage, we will reduce the amount of water we apply for irrigation by up to 25%, and that's a very, very big number."

Nick Dokoozlian, vice president of viticulture, chemistry and enology at Gallo, worked with a project supported by Water Resources application area.

“These new data deliver localized moisture readings – this is what matters to the farmer.”

Zhengwei Yang, U.S. Department of Agriculture National Agricultural Statistics Service

“Together we are working to help take watershed models that were developed by NASA and USGS to understand how water is flowing on the landscape and then use these models to quantify pollution or the nutrients in that water… In analyzing this information, we can pinpoint areas on the landscape to focus our efforts on and develop different strategies of controlling sources of pollution.”

Marcus Beck, Tampa Bay Estuary Program

"We value the partnership with NASA and the ability of their remote-sensing resources to integrate data over large spatial scales, which is useful for assessing drought impacts."

Jeanine Jones, Interstate Water Resources Manager, California Department of Water Resources

A second scenario, one developed without satellite data showed that there would likely be a 7-day delay in public health warnings, resulting in increased healthcare costs, lost work hours and other economic impacts. Their conclusion was that the satellite early warning saved the community about $370,000

How?
Through user-centered collaboration

- Relationship development
- User/partner/community identified needs
- Collaboratively matching capabilities and building out applications

Local Resource Managers and Decision makers

NC Department of Health and Human Services

CAP Central Arizona Project

Department of Water Resources State of California

Office of the State Engineer Interstate Stream Commission

Transportation & Public Facilities State of Alaska

Federal and international

República de Angola

Mekong River Commission MRC For Sustainable Development

USDA

United States Environmental Protection Agency

USGS

República del Perú

Non-profit and private sector

The Nature Conservancy

EDF Environmental Defense Fund

TBEP Tampa Bay Estuary Program Partnership for a Healthy Bay

American Water Works Association *Dedicated to the World's Most Important Resource*

American Water Resources Association

DRI

Walton Family Foundation

The Pillars of the NASA Applied Sciences Water Resources Program

Portfolio of Applied Research Projects

Western Water Applications Office (WWAO)

Partnership Engagement and Program Activities

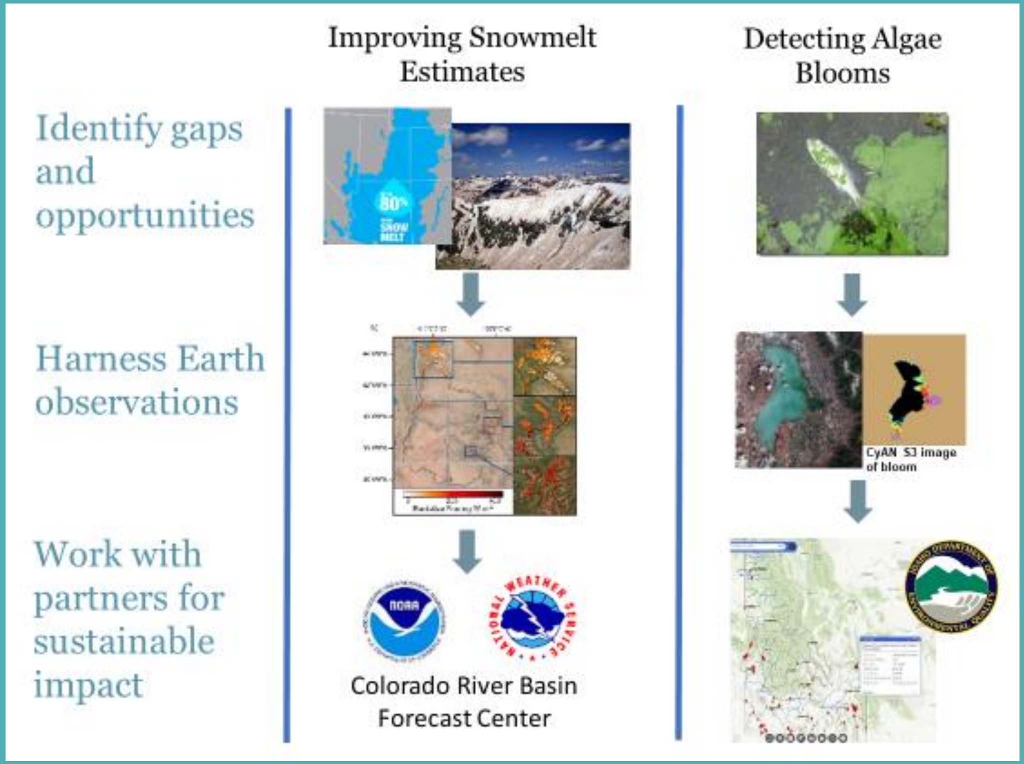
The Pillars of the NASA Applied Sciences Water Resources Program

Portfolio of Applied Research Projects

Western Water Applications Office (WWAO)

Partnership Engagement and Program Activities

Enabling and Supporting the use of Earth Science



Grants provided through NASA ROSES

Awarded 30 new funded projects in 2021 including topic areas such as:

- water quality
- surface water
- seasonal to subseasonal forecasting
- AI integration

The Pillars of the
NASA Applied Sciences Water Resources Program

Portfolio of Applied Research Projects

Western Water Applications Office (WWAO)

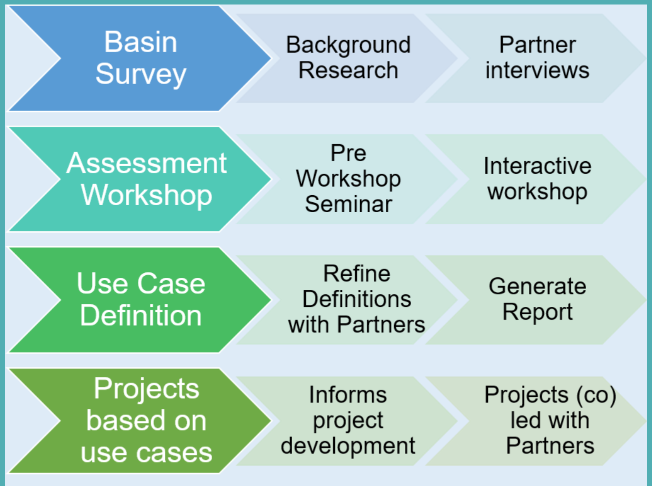
Partnership Engagement and Program Activities

WWAO's mission is to **improve how water is managed by getting NASA data, technology and tools into the hands of western water managers.**

To achieve this, WWAO:

- **Identifies Water Needs** that NASA can address
- **Makes Connections** between stakeholders and NASA to address needs
- **Transitions** water applications into operations for sustainable and long-term impact

https://wwao.jpl.nasa.gov/



Above: WWAO's Needs Assessment workflow

River Basin Needs Assessments Completed:

- Columbia River Basin
- Missouri River Basin
- Colorado River Basin Needs
- Rio Grande River Basin

The Pillars of the
NASA Applied Sciences Water Resources Program

Portfolio of Applied Research Projects

Western Water Applications Office (WWAO)

Partnership Engagement and Program Activities

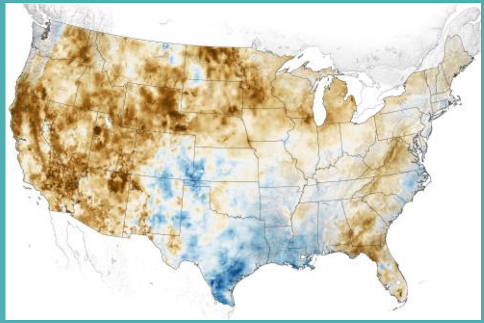
DROUGHT

Communicating the ways NASA Strengthens Our **Resilience to Drought**

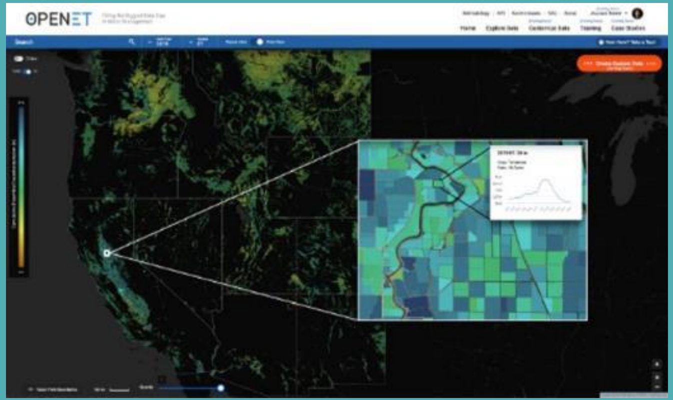
- Improves drought monitoring including forecasts and early warning
- Supports drought management and scenario planning
- Improves water supply Forecasts
- Informs efficient water use practices

RESEARCH TO OPERATIONS

"These satellite-derived vegetation condition indices and soil moisture condition maps …contribute extensively to operations and research on various issues, including agricultural sustainability and extreme weather events, such as flooding and drought." **-** Rick Mueller, USDA NASS Spatial Analysis Research Lead



Above Screenshot of CropCASMA: https://nassgeo.csiss.gmu.edu/CropCASMA/



"OpenET allows planning for agricultural water needs in a way that just wasn't possible before." **-** E. Joaquin Esquivel, Chair of the California State Water Resources Control Board

Left: Screenshot of OpenET platform *https://openetdata.org*

The Pillars of the
NASA Applied Sciences Water Resources Program

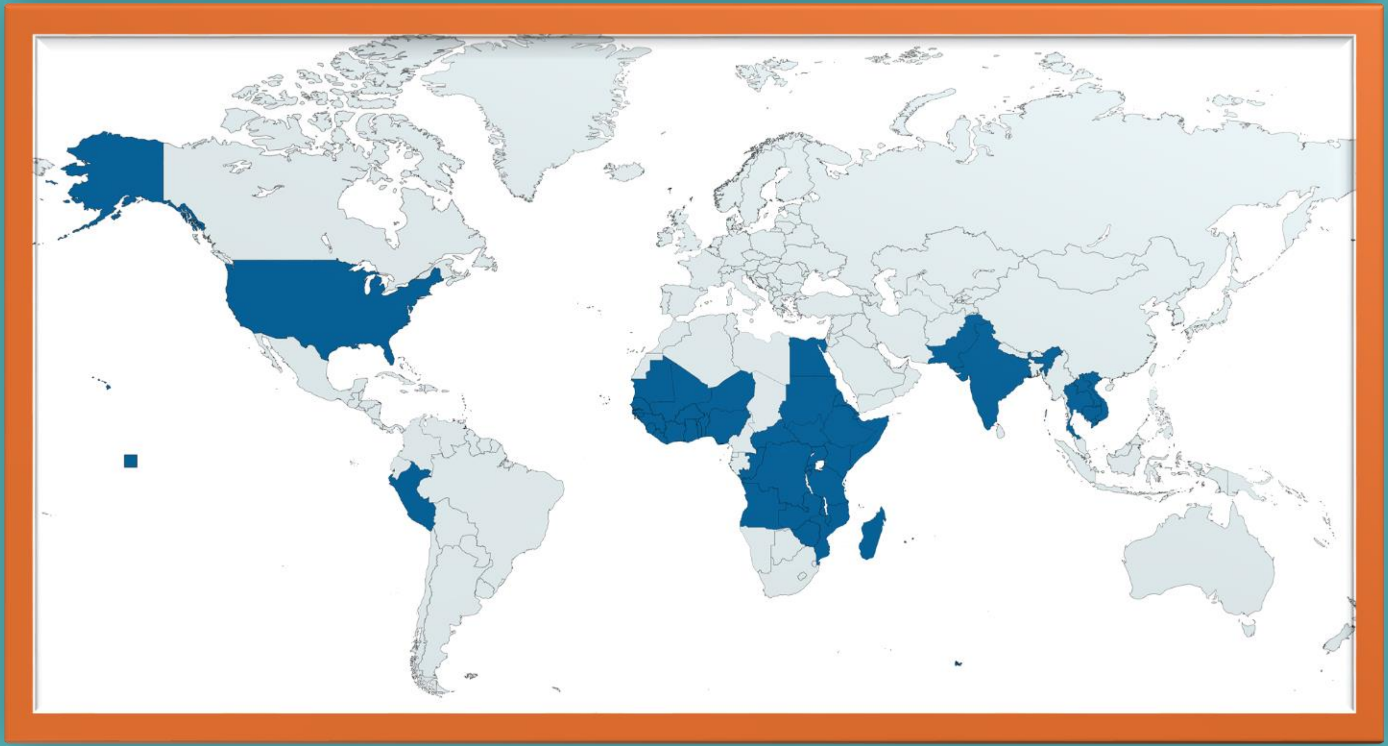
Portfolio of Applied Research Projects

Western Water Applications Office (WWAO)

Partnership Engagement and Program Activities

<u>Three foci for the upcoming year:</u>

- International Water Strategy (Next presentation!)
  - International community needs
  - U.S. Department of State
  - White House Global Water Security Strategy
- Private Sector Engagement
- Water Quality Engagement



GET INVOLVED!

ENGAGE

ACCESS

DRIVE

GET INVOLVED!

ENGAGE

ACCESS

DRIVE

WITH OUR COMMUNITY

- Stay connected:
  - WRP listserv: : https://lists.nasa.gov/mailman/listinfo/nasa-water-resources
  - WWAO newsletter: https://wwao.jpl.nasa.gov/subscribe/
- Support, encourage, and bring in new voices to the discussion – especially early career scientists, social scientists, and local and regional community members!
- Advertise, communicate, and become advocates for your own work and each other's work!
- Attend sessions, events, and team meetings!

GET INVOLVED!

ENGAGE

ACCESS AND UTILIZE

DRIVE

Access NASA Data

- NASA Earth Data
- Earth Information System: Freshwater

Resources

- ARSET
- Applied Sciences Guidebook
- Water and Agricultural Pathfinder

Examples of open Tools and Applications supported by WRP and WWAO:

- CropCASMA - access to high-resolution data to map soil moisture and crop vegetation conditions across the US
- CyAN – web and app based tool that provides daily, weekly, and true-color satellite data on potential harmful algal blooms
- Global Water Monitor - satellite data products relevant to lakes, reservoirs, river channels, wetlands and global mean sea level
- Open ET - easily accessible satellite-based estimates of evapotranspiration (ET) at the field scale
- Soil moisture on GEE - Global soil moisture data provides soil moisture information across the globe at 10-km spatial resolution.

GET INVOLVED!

ENGAGE ACCESS DRIVE THE FUTURE

Provide feedback

- Submit a Water Management Need on WWAO website.
- Contact us via the Applied Sciences website

Lead research

- Identify NASA Grant Opportunities
- Be an Early Adopter

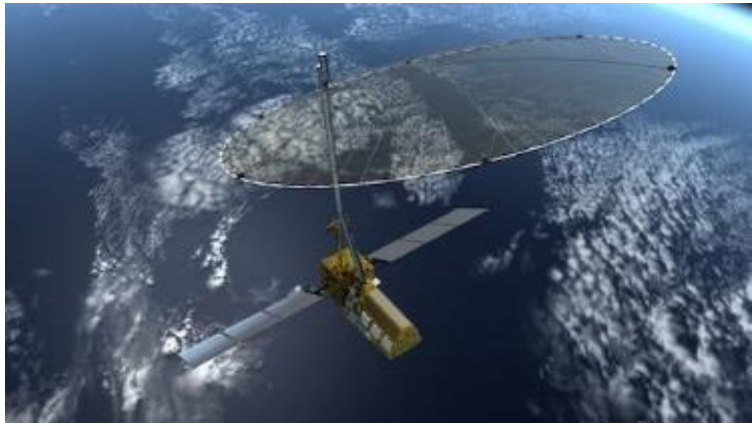
Contribute to the conversations:

- AGU, Pecora, AMS, World Water Week, AWWA meetings, AWRA meetings

IN THE NEXT DECADE NASA IS LEADING AN OUTPOURING OF FRESHWATER INFORMATION FROM SPACE

NASA-ISRO SAR (NISAR)

Launch Target: 2023

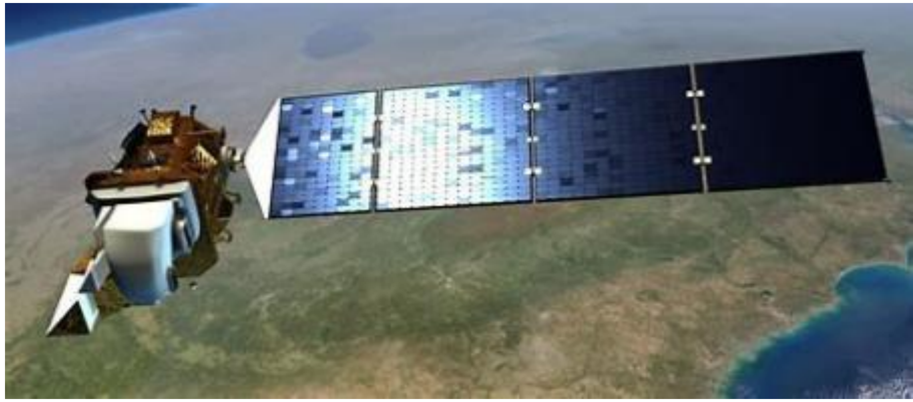


Surface Water and Ocean Topography (SWOT)

Launch Target : November 2022

Landsat 9

Launched: September 27, 2021



Up Next!

- 3:20pm: NASA's International Water Strategy - *Dr. John Bolten & Perry Oddo*
- 3:30pm: Project Highlight: California's Groundwater Future: Relating Subsidence & Consumption in the Central Valley - *Dr. Kyra Adams*
- 3:40pm: Feasibility Study Snapshot: Yampa Water Resources - *Erin Weitzel*
- 3:45pm: Feasibility Study Snapshot: Puget Sound Water Resources - *Sofia Fall*
- 3:50pm: Mission Highlight: Plankton, Aerosol, Cloud, ocean Ecosystem (PACE) - *Natasha Sadoff*
- 3:55pm: Closing Remarks - Lawrence Friedl

NASA Earth

Water Resources Leadership

Brad Doorn

Christine Lee

John Bolten

Sarah Brennan

Indrani Graczyk

Forrest Melton

Stephanie Granger

Thank You!

For further questions, please contact:

- Bradley.doorn@nasa.gov, Program Manager, Water Resources Application Area
- Sarah.Brennan@nasa.gov, Deputy Program Manager, Water Resources Application Area

Water Resources Program
International Water Strategy

John D. Bolten, Perry Oddo, and Aarti Arora

Meet the Team!

John Bolten

Perry Oddo

Aarti Arora

Motivation

ipcc
INTERGOVERNMENTAL PANEL ON climate change

Climate Change 2022

Impacts, Adaptation and Vulnerability

Complex, Compound and Cascading Risks

Weather and climate extremes are causing **economic and societal impacts** across national boundaries through supply-chains, markets, and natural resource flows, with **increasing transboundary risks projected across the water, energy and food sectors** (high confidence)

The Washington Post

Harris calls water security a foreign policy priority

Suman Naishadham and Michael Phillis | Jun 1, 2022

Workshop Report and Recommended Path Forward

Transboundary Water: Improving Methodologies and Developing Integrated Tools to Support Water Security

Dialogue toward a future framework for Federal coordination and integrated analysis capabilities in support of global water security

Raha Hakimdavar, Danielle Woo
Green, Corey Hummel, Thomas

Key Findings

Many **existing science and technology capabilities are available** to address operational information needs of decision makers regarding transboundary water management, **but are often disjointed and not directly connected to end-user communities**.

The National Academies of | SCIENCES ENGINEERING MEDICINE | THE NATIONAL ACADEMIES PRESS

TABLE S.1 Science and Applications Priorities for the Decade 2017-2027

Science and Applications Area	Science and Applications Questions Addressed by MOST IMPORTANT Objectives
Coupling of the Water and Energy Cycles	How do anthropogenic changes in climate, land use, water use, and water storage interact and modify the water and energy cycles locally, regionally and globally and what are the short- and long-term consequences?

How is NASA addressing water needs?

NASA Applied Sciences Strategic Plan

EARTH SCIENCE APPLIED SCIENCES

1. Applications using **Earth System knowledge are in high demand domestically and internationally** and are prominent within NASA, the Earth science community and beyond.
2. A vibrant, diverse, and **growing community** exists with the skills to use, assess value, and communicate the importance of Earth science information on a societal and personal level.
3. **High-quality applications that incorporate Earth science** spark innovations in the economy, environmental sustainability, and public services.

Decadal Survey for Earth Observations

NATIONAL ACADEMIES

H1. Coupling the Water and Energy Cycles
How is the water cycle changing?

H2. Prediction of Change
What are anthropogenic changes and what are the consequences?

H3. Freshwater Resources
How does water cycle changes affect availability/ biogeochemical cycles?

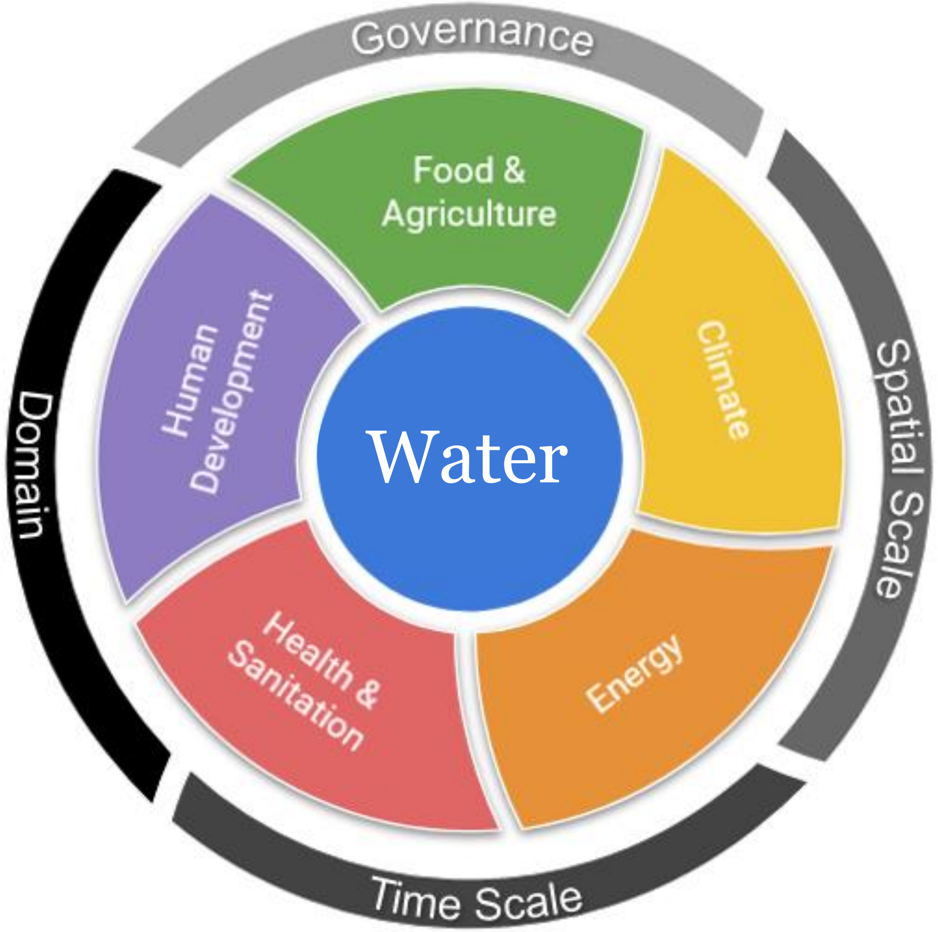
H4. Hazards, Extremes, and Sea Level Rise
How to predict/ prepare/ mitigate extreme events?

U.S. Global Water Strategy

USAID FROM THE AMERICAN PEOPLE

- Increasing sustainable access to safe drinking water/sanitation services, adopting key hygiene behaviors
- Encouraging the sound management and protection of freshwater resources
- Promoting cooperation on shared waters
- Strengthening water-sector governance, financing, and institutions

Water Research Nexus



Global Themes

- *Governance*
  - Transboundary Rights
  - Sovereignty / Conflicts
  - Economics
- *Spatial Scale*
  - Global / Regional / National
  - Local / Community
  - Individual
- *Time Scale*
  - Daily fluctuations vs. decadal trends
  - Quantity through time
- Domain
  - Surface Water
  - Groundwater
  - Precipitation

Strategic Vision

Mission Statement:

To facilitate international water management through applied research, capacity building, and improved coordination between NASA, its partners, and stakeholders.

Vision:

To support sustainable and scalable engagements across all sectors of the water community, using NASA's unparalleled capacity to monitor, model, and forecast the global hydrological system.

Goals:

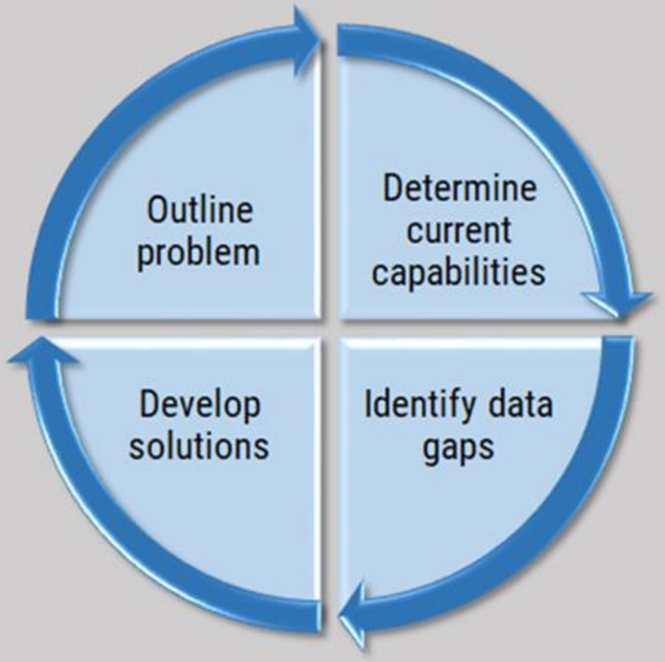
To establish a unified strategy that more efficiently pairs emerging water needs with NASA science capabilities. We aim to accomplish this by building strategic interagency partnerships, seeking out diverse funding opportunities, utilizing state-of-the-art technologies, and observing best practices for knowledge sharing.

This International Water Strategy seeks to establish water metrics for availability, quality, sustainability, accessibility, and resiliency. In doing so,
we also recognize the position water holds at the nexus of Food & Agriculture, Climate, Energy, Health & Sanitation, and Human Development.

Strategic Engagement Framework

Understand User Needs

Work with partners through iterative process to understand their specific problems and capabilities to determine best management practices



Leverage Partnerships

Identify linkages with capabilities within the Applied Sciences and through interagency cooperation to craft solutions

Develop Solutions

Formulate coordinated response according to user capabilities and stakeholder needs. Examples could be:

1. Existing tools and software that can be repurposed with minimal adjustment
2. Operational models that can be tailored to address specific needs of project partners
3. Fully-customized software built to specification for new problems

Thinking Outside the Box

1 Global Water Needs

- What are relevant laws / policies?
- What capabilities can NASA provide?

2 Engagement Criteria

- Do engagements align with ASP Strategic Plan goals?
- Do they bring value to USG priorities?

3 Capturing Impact

- How can engagement inform NASA programs and missions?
- What are best metrics for assessing impact?

Some Current International & Interagency Activities

WATER RESOURCES

GEO GLOWS
GLOBAL WATER SUSTAINABILITY

CIC
Cuenca del Plata

MEKONG - U.S. PARTNERSHIP

eis

HARVEST


AXIOS

May 13, 2022 - World

Exclusive: 21 federal agencies monitoring Ukraine war's environmental toll

Andrew Freedman, author of Axios Generate


U.S. Government
Global Water Strategy

SERVIR

Water Resources Program

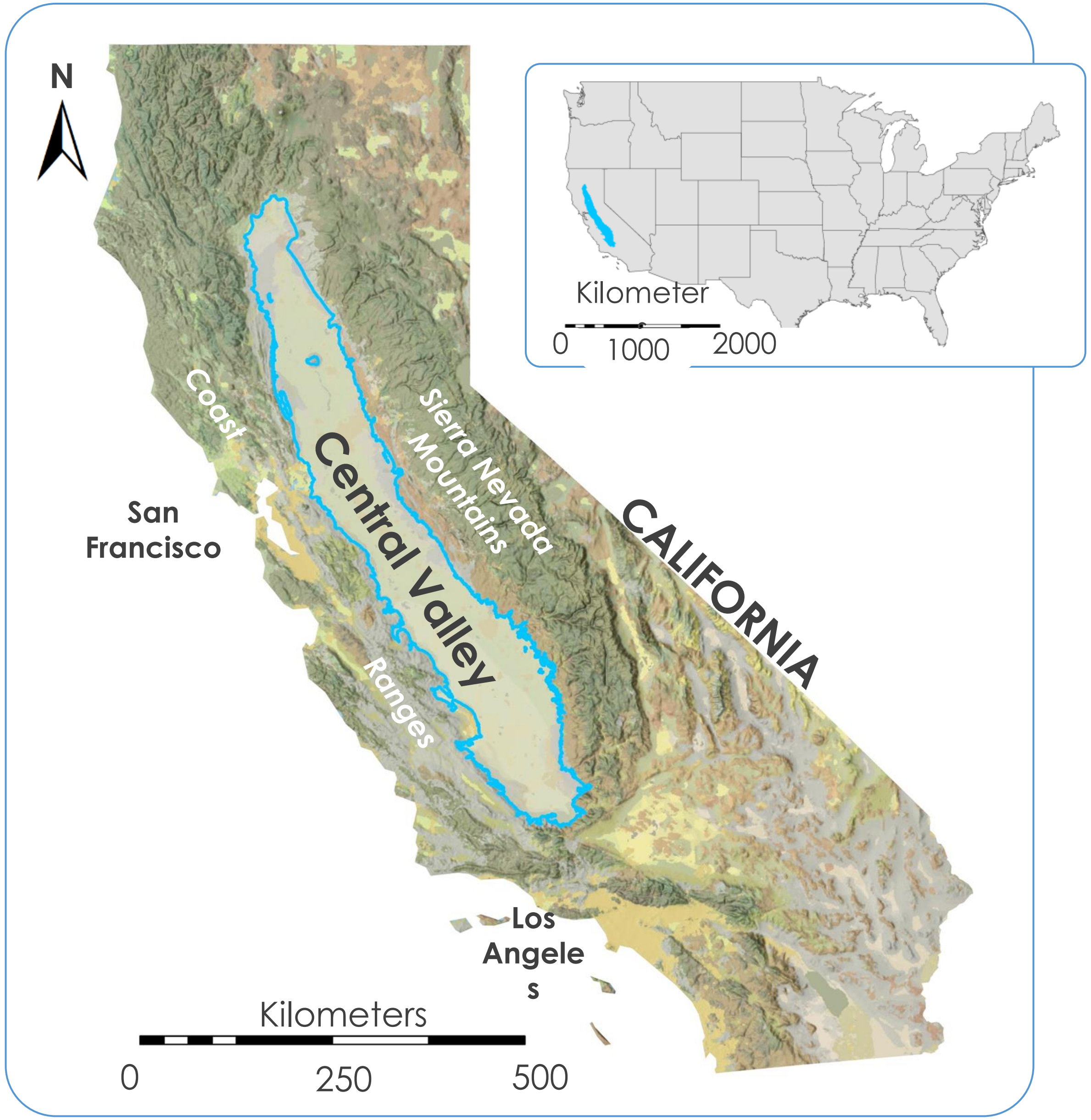
International Water Strategy

California’s Groundwater Future: Relating Subsidence and Consumption in the Central Valley

Dr. Kyra Adams (Kim)
PI: JT Reager
JPL Water & Ecosystems Group

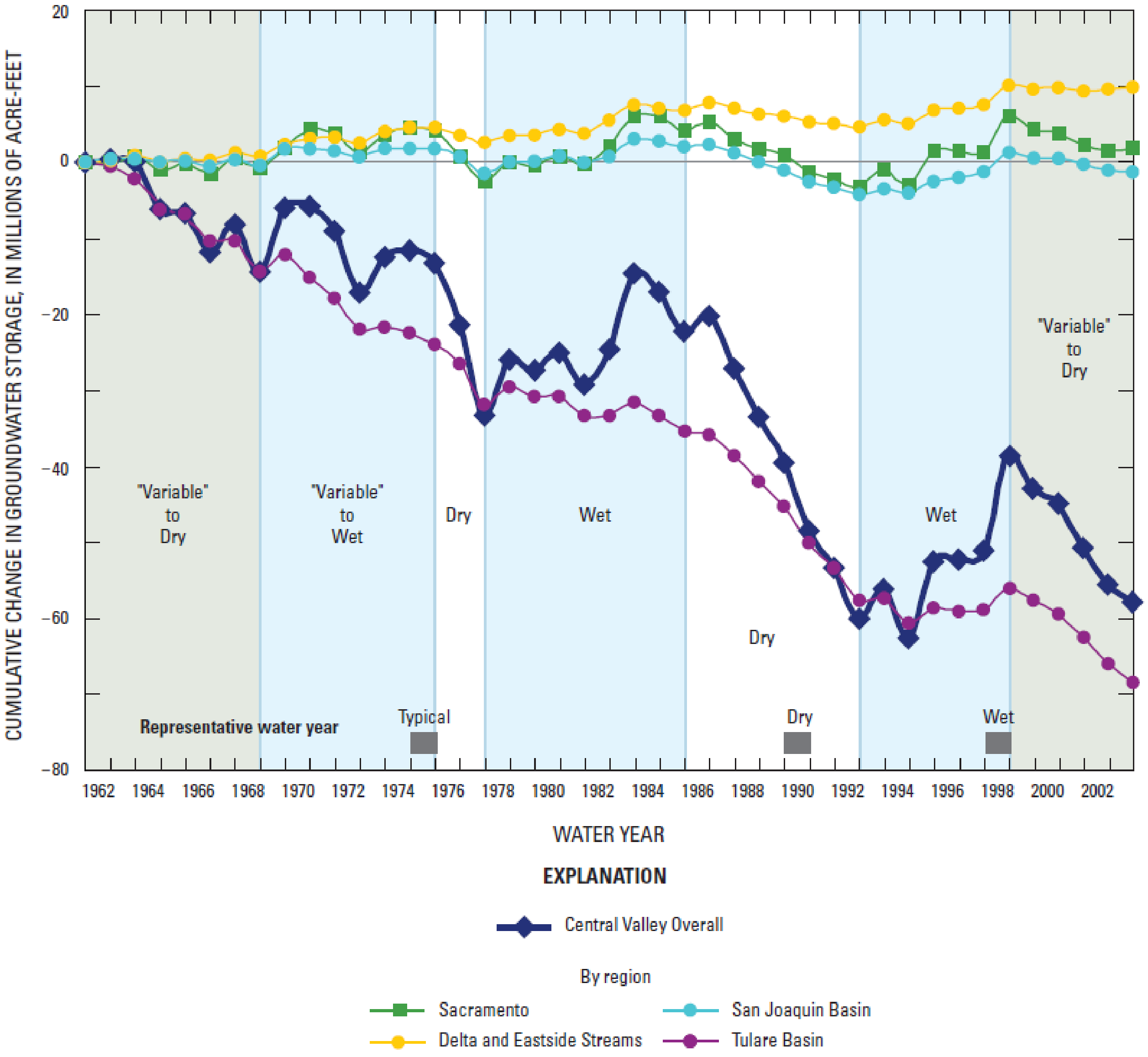
EARTH SCIENCE
APPLICATIONS WEEK 2022

Central Valley Aquifer System

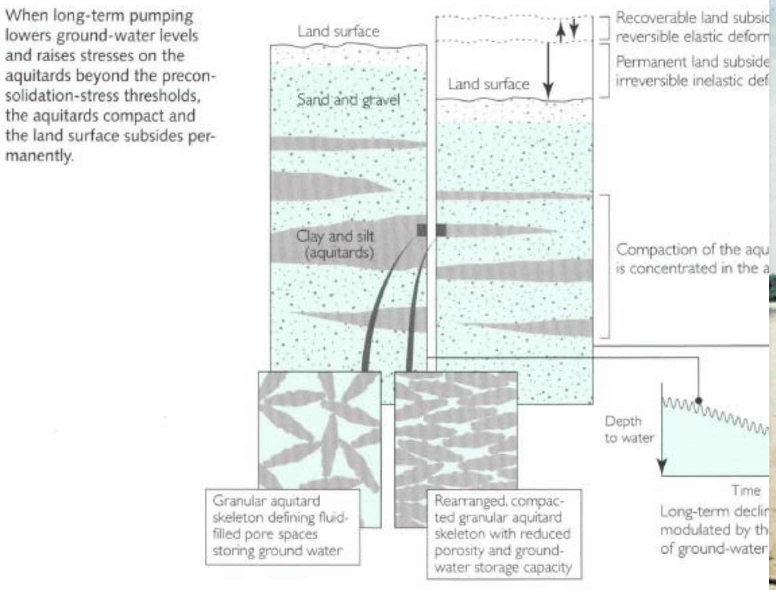


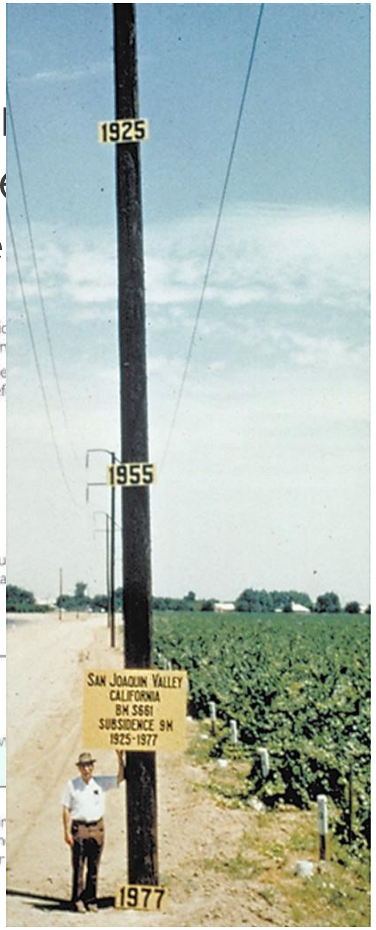
- **California's Central Valley**
  - **Area**: 20,000 square miles
  - **Population**:
    - 6.5 million (2018)
  - **California**:
    - 11% of the state's total land area
    - Supplies 60-75% of the state's water
  - **Agriculture**:
    - $20 billion in crops annually
    - 250 different crops
    - ~50% of United State's nuts, fruits, and vegetables

Groundwater depletion and subsidence

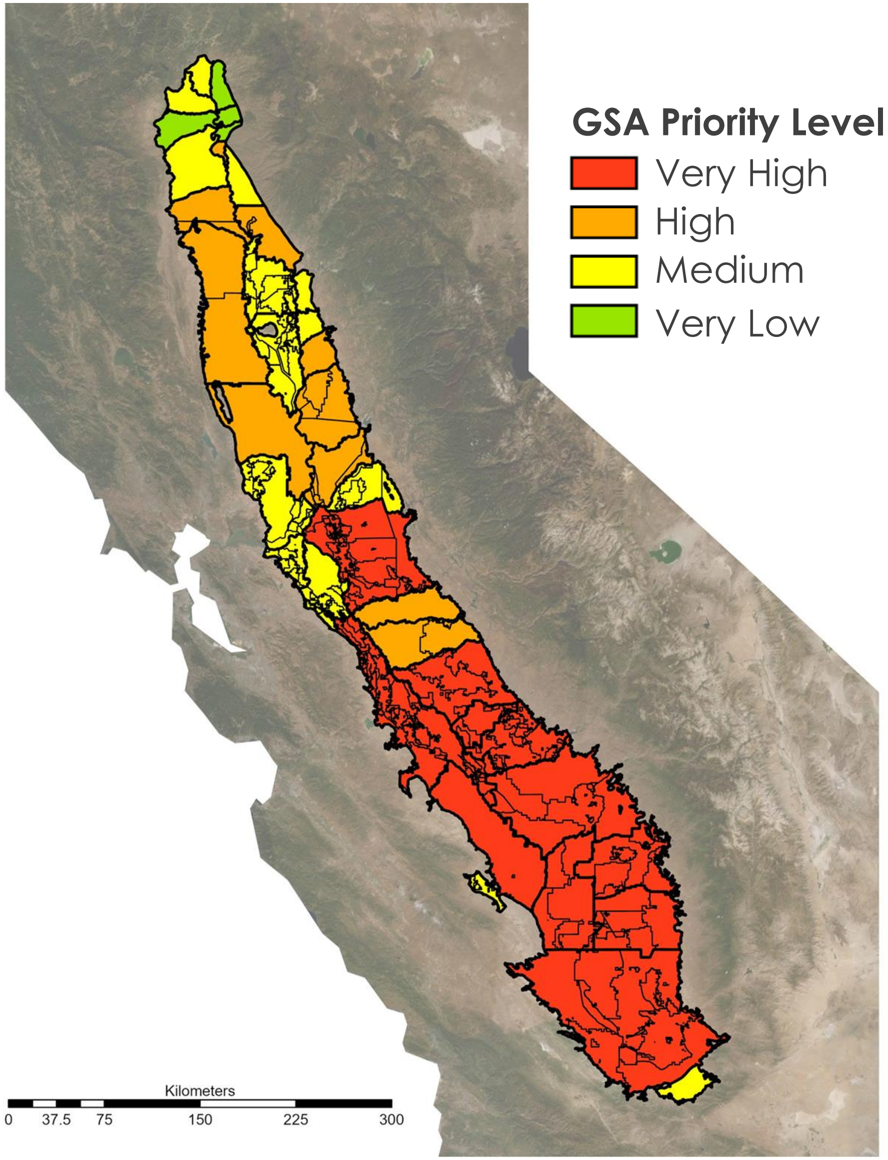


- **Groundwater Depletion**
  - **1920-2013:** ~ 125 million acre-feet of groundwater drained (1/3 Lake Erie)
  - Groundwater depletio to rearrangement of ge matrix and subsidence





SGMA Legal framework



Sustainable Groundwater Management Act (2014)

- **Groundwater Sustainability Agencies (GSAs):**
  - Mandated to institute mgmt. plans that halt overdraft and avoid subsidence by **2020-2022**
  - **In-situ data availability** is inconsistent

Can remotely-sensed datasets be used for depletion-subsidence assessments?

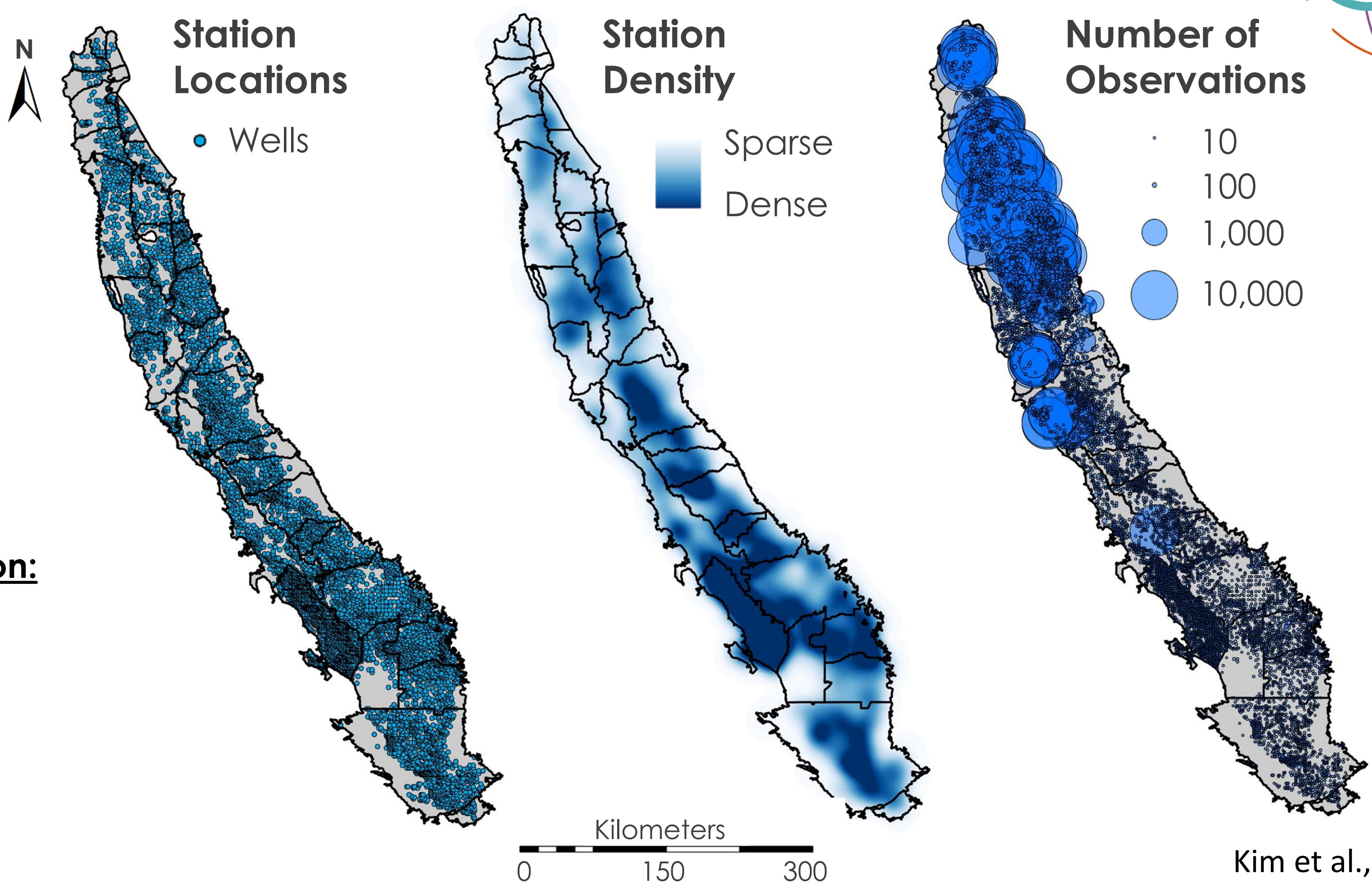
In situ well data availability

In-Situ:
Wells

Total Well Stations
7,706

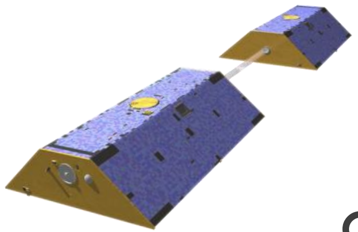
Total Observations
642,736

Number of Observations/Station:
Mean: 83.4
St. Dev: 501.06
Maximum: 13,949
Median: 11
Minimum: 1.00



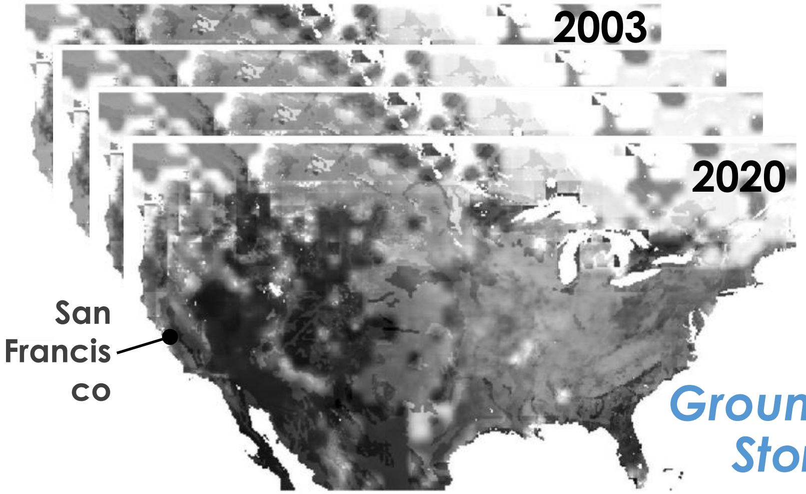
Kim et al., 2020

Integrating remotely-sensed datasets

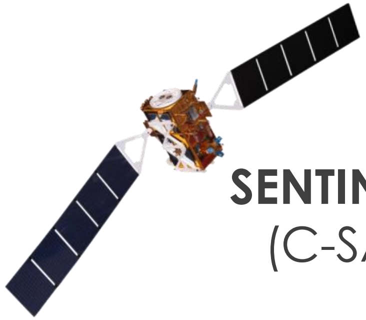


GRACE &
GRACE-FO

GRACE: Gravity **R**ecovery **A**nd **C**limate **E**xperiment



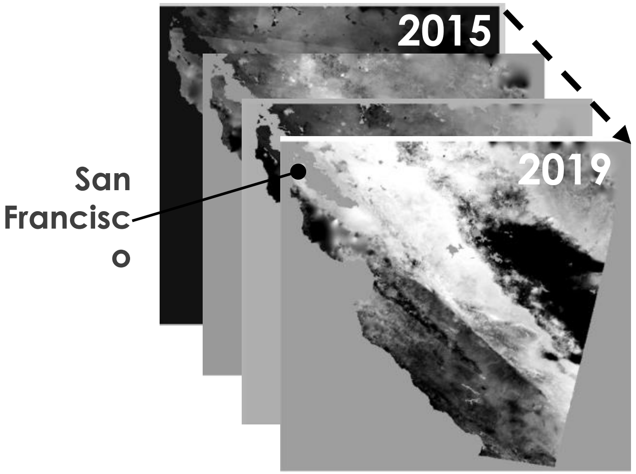
Groundwater Storage



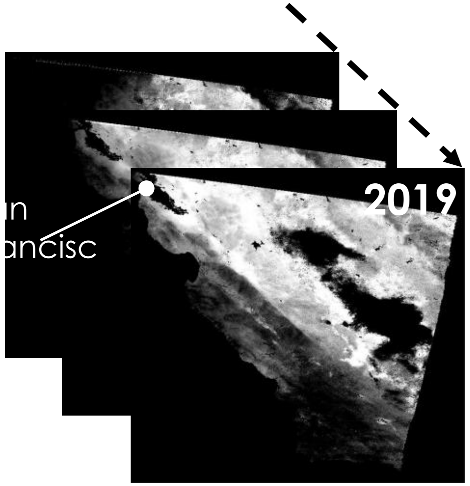
SENTINEL-1
(C-SAR)

ALOS-2
(PALSAR-2)

InSAR: Interferometric **S**ynthetic **A**perture **R**adar



Subsidence

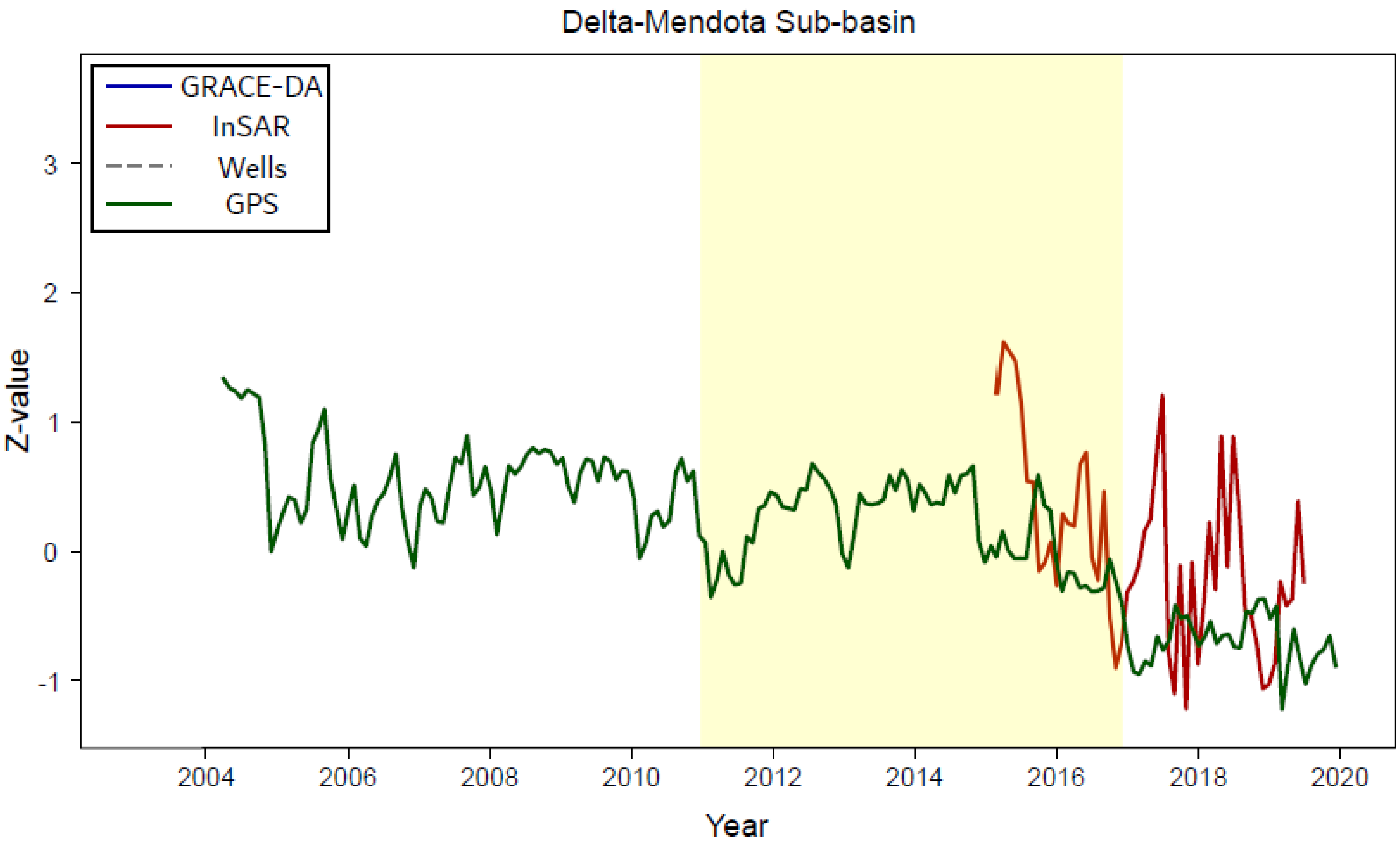


Subsidence

Use Data-Assimilated GRACE/GRACE-FO (1/8 degree, ~12.5 km)

Calculated z-values by sub-basin for all datasets (remove seasonal signals and normalize using st.dev)

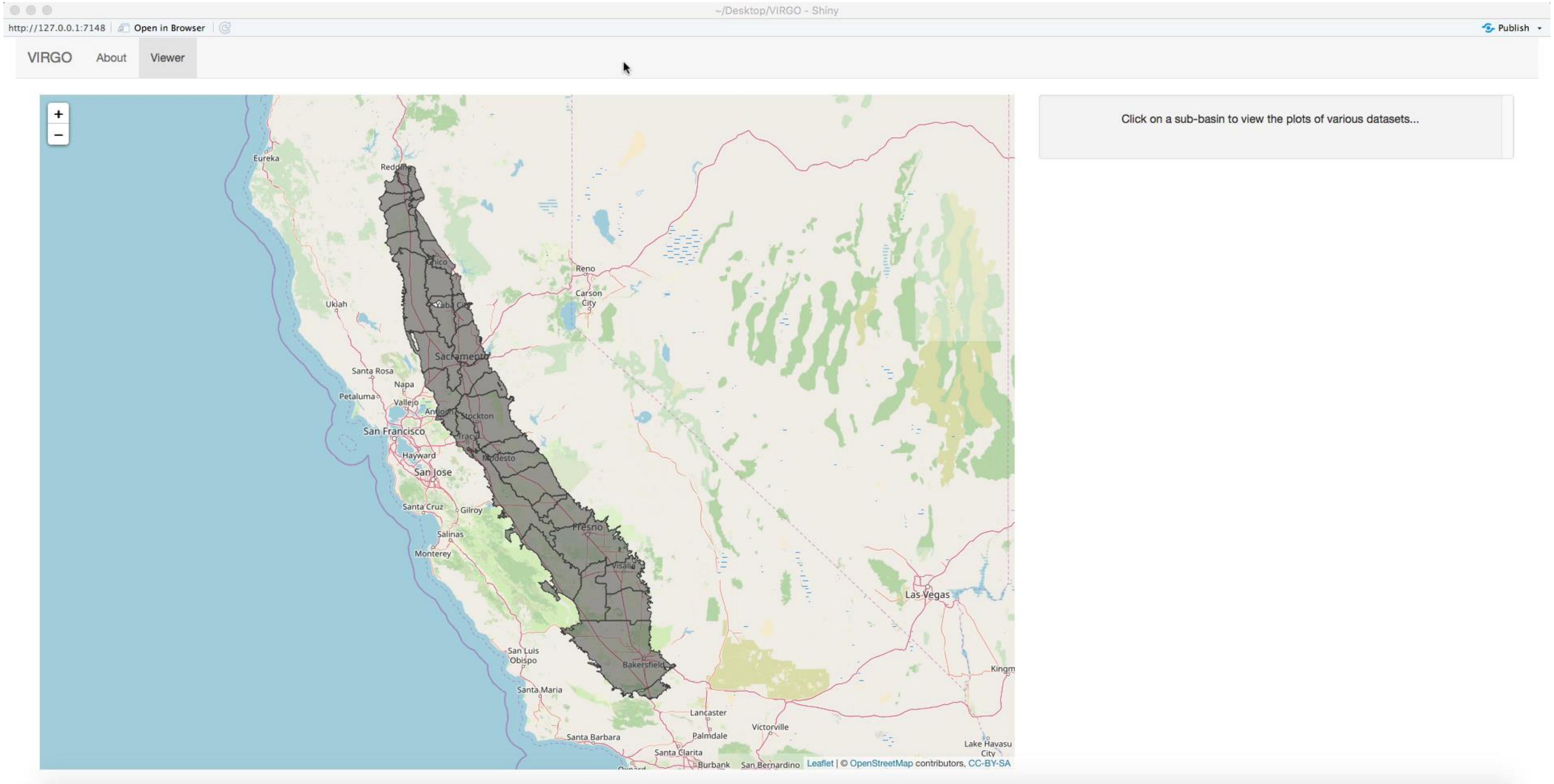
Sub-basin scale analyses



- GRACE-DA and well signals correlated well
- Elastic & inelastic subsidence captured by both GPS and InSAR
- **Limits**: Interpretation of GPS and geologic information

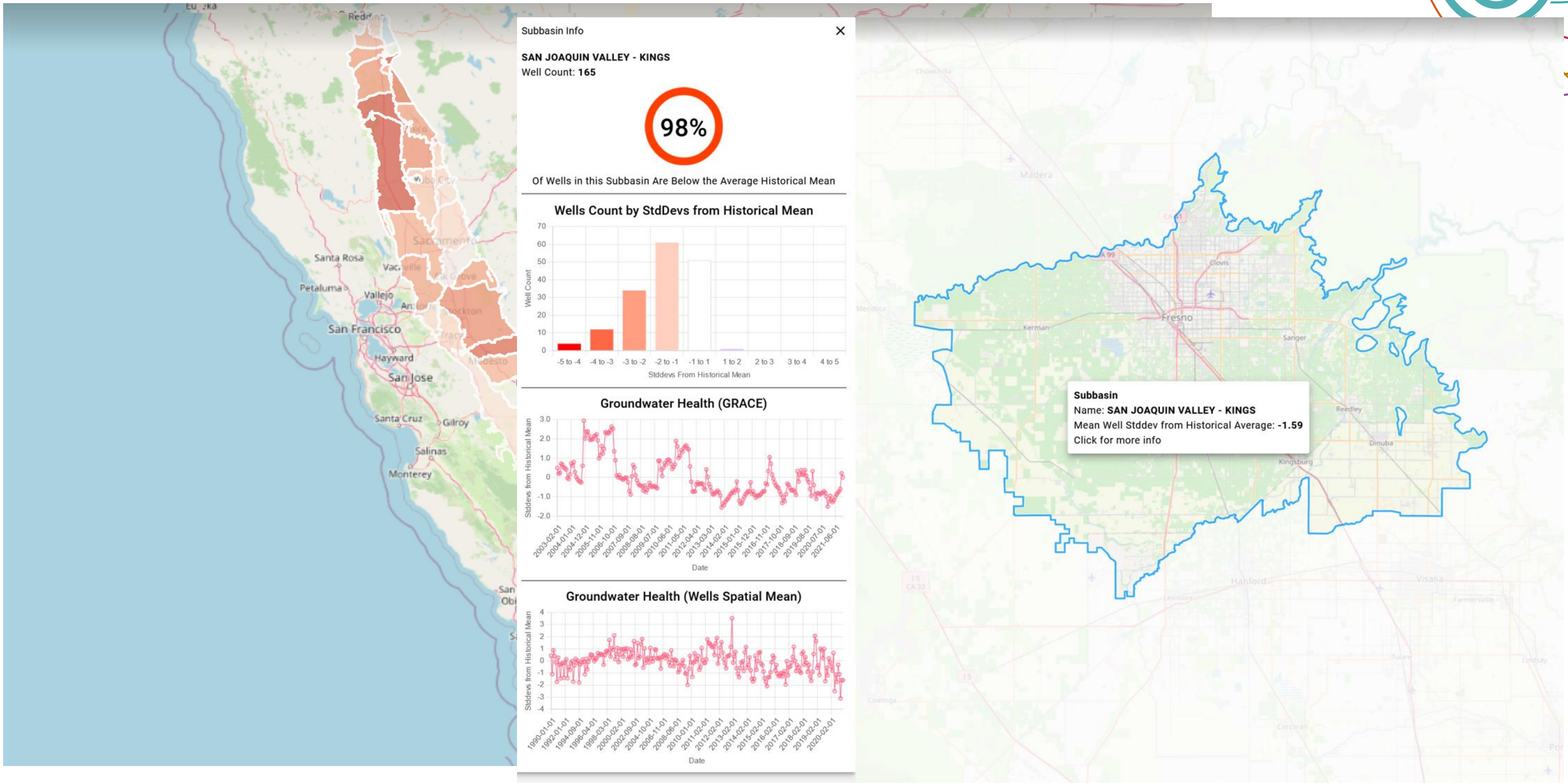
Kim et al., 2020 JAWRA
Vasco et al., 2022 Nature Sci Reports

VIRGO: **V**isualization of **I**n-situ and **R**emotely-sensed **G**roundwater **O**bservations



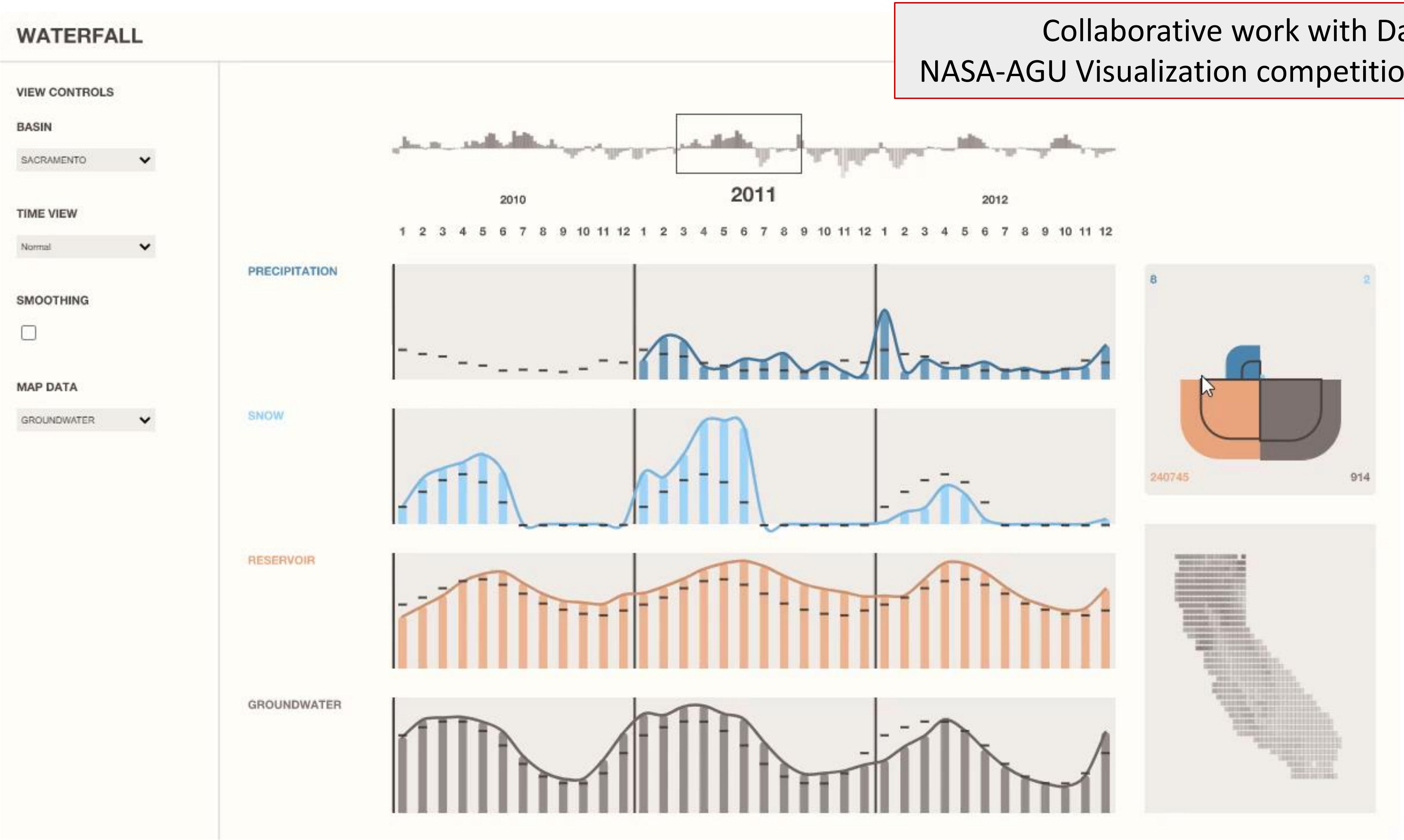
James Kitchens & DEVELOP 2020 team

VIRGO updates

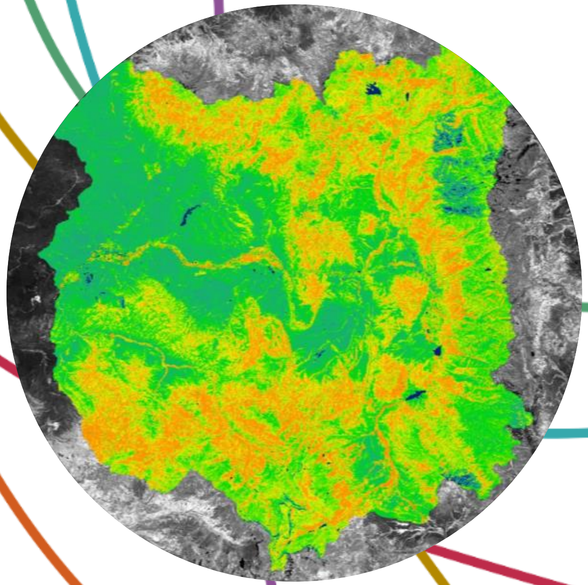


Waterfall – an artistic visualization tool

Collaborative work with Data2Discovery
NASA-AGU Visualization competition Grand Prize



Malika Khurana, Noah Deutsch



Yampa Water Resources

Monitoring Water Quality and Evaluating Potential Drivers of Algae Blooms in the Upper Yampa River Watershed

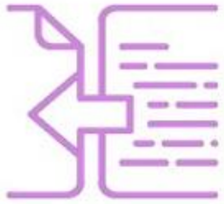
TEAM: Erin Weitzel, Samrin Sauda, Ethan Gates, Morgan Guttman

ADVISORS: Dr. Paul Evangelista, Dr. Catherine Jarnevich, Dr. Tony Vorster, Christopher Choi, Peder Engelstad, Nick Young, Sarah Hettema

EARTH SCIENCE
APPLICATIONS WEEK 2022

Objectives

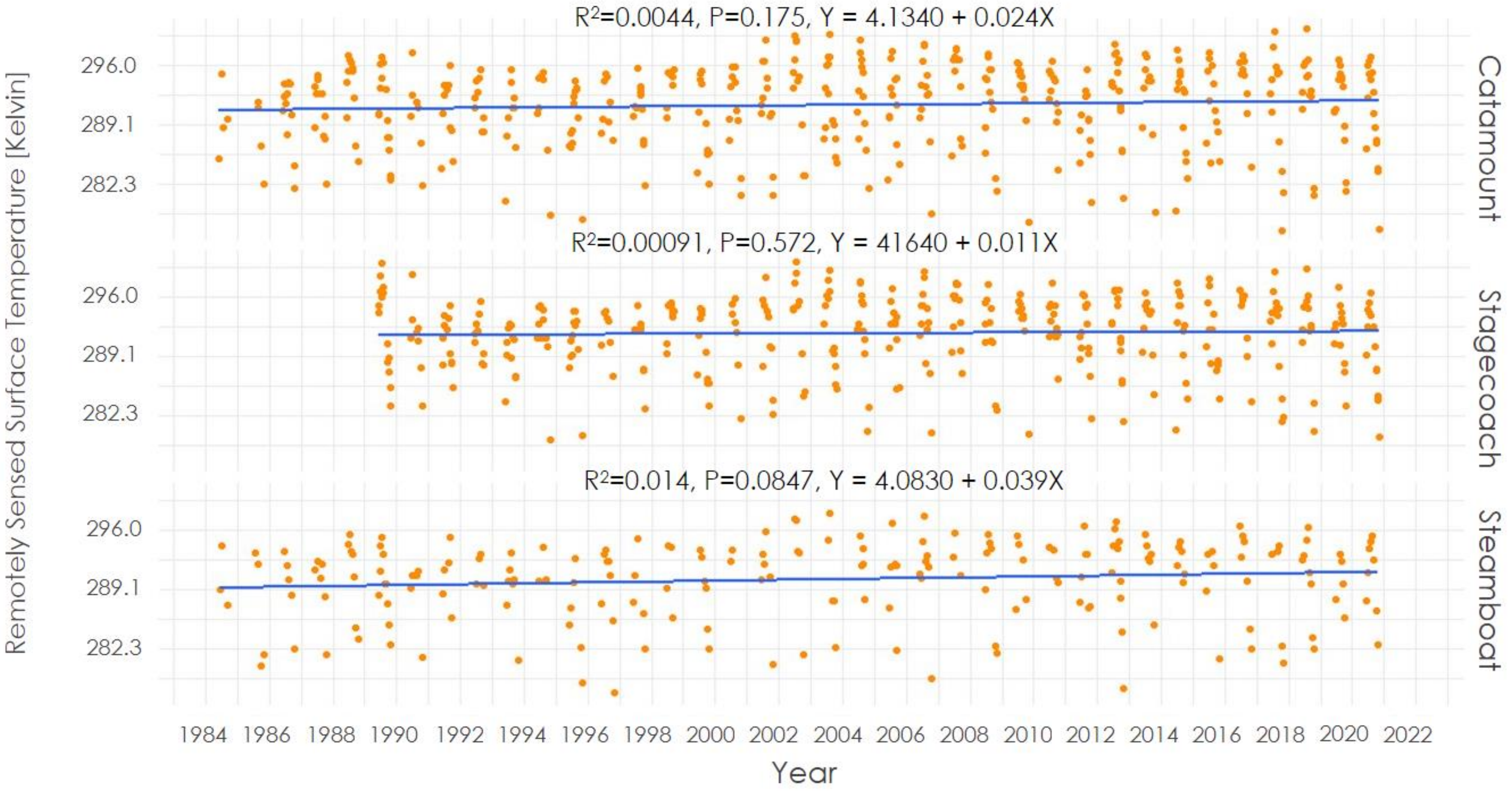
Analyze trends in water quality over time and fill historical data gaps



Assess viability of remote sensing to monitor water quality in the UYRB

Image Credit: The Noun Project

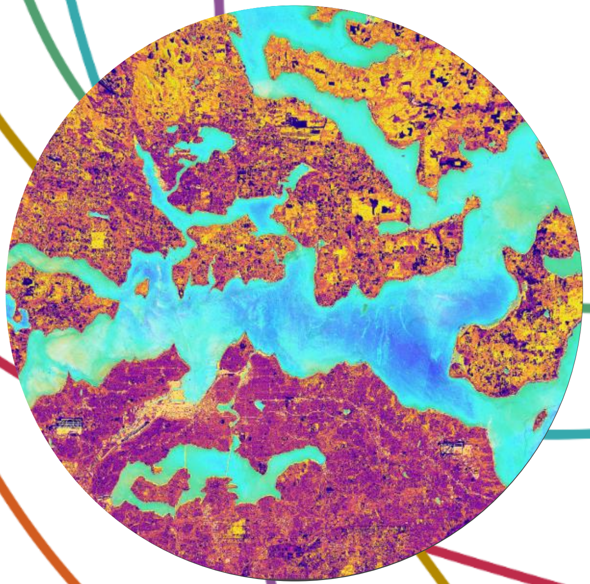
Results – Surface Temperature



Conclusions

- **Fill historical data gaps**
  - Constructed time series plots of lake color and temperature from 1984 to 2021 for 9 waterbodies of interest and maps for 3 lakes of interest
- **Assess viability of remote sensing to monitor water quality**
  - Lack of significant evaluation data makes it difficult to assess viability of using remote sensing to monitor water quality
  - Strong correlation between remotely sensed temperature and in-situ temperature
- **Analyze trends in water quality over time**
  - Mixed trends were found among the 3 lakes for the AVW, BWAI, and green band timeseries

Puget Sound Water Resources



Using Earth Observations to Map Bull Kelp in the Puget Sound, Washington, to Support Conservation and Restoration

TEAM: Sofia Fall, Mike Hitchner, Lily Oliver, Lyndsay Zemanek

ADVISORS: Peder Engelsted, Nicholas Young, Dr. Tony Vorster, Brian Woodward, Dr. Paul Evangelista, Dr. Catherine Jarnevich, Sarah Hettema

EARTH SCIENCE
APPLICATIONS WEEK 2022

Project Background

Decline of bull kelp in Puget Sound

Threats to ecological and cultural services

Gaps in local research on bull kelp abundance

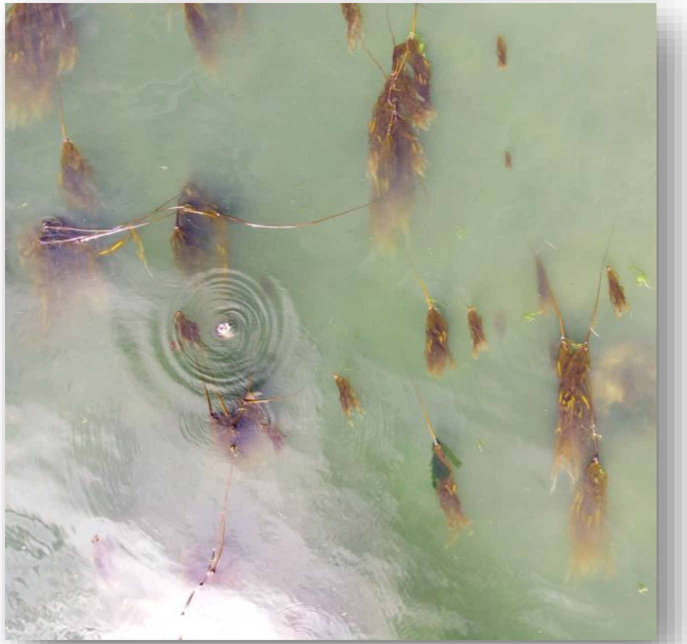


Image Credits: Hannah Gabrielson, Jennifer Stock/NOAA, Mike Hitchner

Remote Sensing as a Kelp Canopy Monitoring Tool

Is remote sensing a feasible and effective tool for monitoring changes in bull kelp canopy extent over time in the central Puget Sound?

Image Credit: Mike Hitchner

Takeaways

The rigid timing of Landsat 8 and Sentinel-2 imagery acquisition time is an important limitation on mapping bull kelp.

Higher resolution sensors and more frequent revisit times can help overcome many of the limitations of remotely sensing kelp extent.

While there are limitations, remote sensing can help support the monitoring of kelp, particularly when combined with field and aerial surveys.

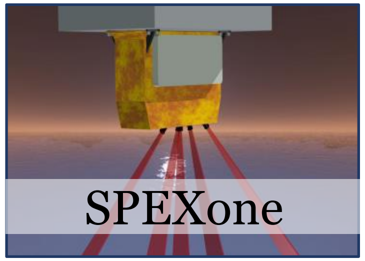
The PACE Mission and Applications Program

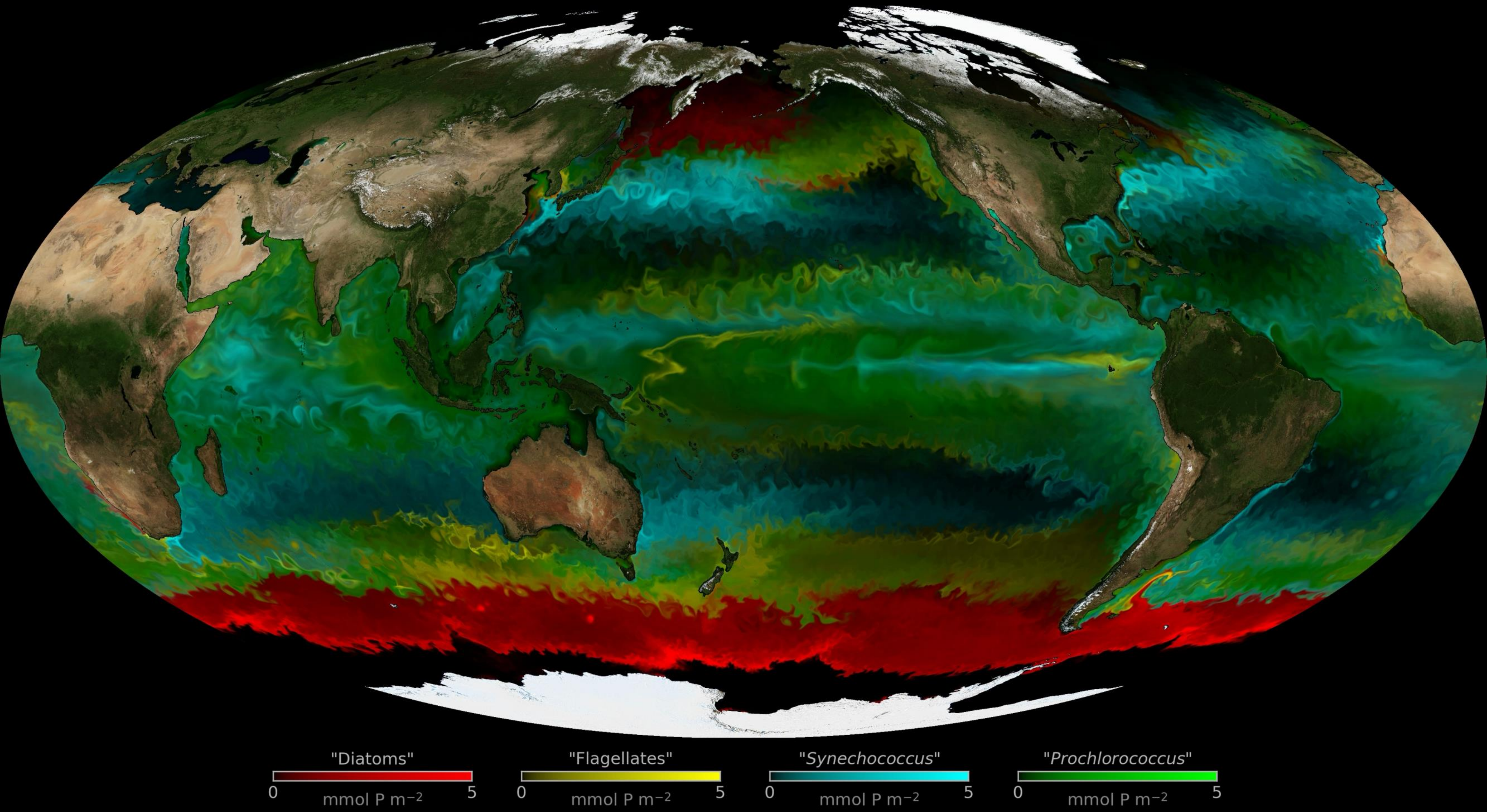
Natasha Sadoff and Erin Urquhart

NASA Goddard Space Flight Center

The PACE Observatory

- PACE is NASA’s next great investment in hyperspectral earth imagery and multi-angle polarimetry. *PACE is going to extend ocean biological, ecological, & biogeochemical data records, as well as cloud & aerosol data records.*
- Launch date: January 2024
- 3-year design life; 10-year propellant
- Hyperspectral imager: Ocean Color Instrument (OCI)
  - Spectral resolution: UV to SWIR (340-890 nm every 2.5 nm, with 940, 1038, 1250, 1378, 1615, 2130, & 2250 nm)
  - Temporal resolution: 2 days
  - Spatial resolution: 1-km2 at nadir
- Two multi-angle polarimeters
  - HARP-2: wide swath, hyper-angular, 4 bands across the VIS & NIR
  - SPEXone: narrow swath, hyperspectral (UV-NIR), 5 viewing angles

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PACE & Applied Science Objectives

PACE will support water resource management areas related to water supply, demand, and quality through the provision of data on ocean productivity, ocean change, land-ocean exchange, ocean-atmosphere exchange, ocean environment and ecosystems, algal blooms, and human impacts.

PACE Early Adopters: Pre-Launch Water Applications

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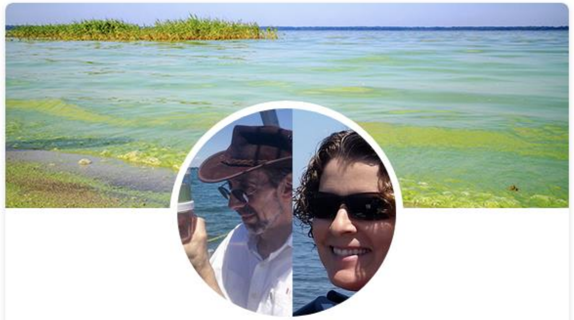
Clarissa Anderson

Applying PACE products to the California Harmful Algae Risk Mapping (C-HARM) System

Marjorie Friedrichs

Water clarity and particle size from hyperspectral remote sensing reflectance in the Chesapeake Bay



Richard Stumpf

Discriminating algal blooms in turbid coastal, estuarine and large lake environments

Get Involved

- Register for the 2022 PACE Applications Workshop (virtual, September 14-15)
- Apply to the PACE Early Adopter (EA) Program
  - Test out PACE simulated data alongside PACE Project Science and Science & Application Team members
- Join the PACE Community of Practice (CoP) to stay in touch and receive the PACE Community Newsletter
- Apply for future PACE Solicitations
  - PACE science data product validation and performance assessment (release ~Sep 2022)
  - Next Science & Application Team - develop new algorithms and/or applications (release ~Feb 2023)
  - Future applications-focused solicitations post-launch!

Register here:

INSIDE THE ISSUE

NASA PACE Community Newsletter / June 2022/ Issue 1

WELCOME

"We came all this way to explore the moon, and the most important thing is that we discovered the earth" – ***Apollo 8 astronaut William Anders***

Beyond its well-known space program, NASA hosts a fleet of Earth-observing satellites that monitor our home planet. Up next is PACE – NASA's latest investment in the combined study of sea, land, and sky. With its uniquely advanced and complementary instrument payload, PACE will usher in an era of unprecedented Earth science. And, despite the challenges the mission has faced, all systems are "go" as we approach our January 2024 launch date.

On behalf of the mission, we're excited to have you along for the ride.

- Jeremy Werdell
PACE Project Scientist

PACE Community of Practice

The PACE community includes a global group of applied scientists, researchers, decision-makers, members of the public, and other stakeholders. What does this diverse group have in common? An interest in applying PACE data from the ocean, atmosphere or land to benefit their own target audiences. The PACE Applications team has recently ramped up efforts to grow this community – now formalized through the new PACE Community of Practice (CoP).

The CoP includes anyone interested in the use of PACE products before and after launch, including for individual research, applications, or model development. PACE Early Adopters (EA) as well as PACE Science and Application Team (SAT) members are included. We want the CoP to be a place of networking, information sharing, and collaboration – a place to foster new partnerships and generate new interdisciplinary knowledge. Members of the CoP will hear about our PACE Applications events; PACE observatory updates; simulated, proxy, calibration and validation data; and have access to lessons learned throughout the community. We will offer opportunities for engagement, networking, and sharing – and we're open to your feedback on additional ideas to build bridges and expand this community.

We hope you will join us, share your work, meet PACE peers, and contribute to this exciting new community.

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Learn more about PACE EAs and the CoP on the PACE Applications Website:

Erin Urquhart & Natasha Sadoff
PACE-applications@oceancolor.gsfc.nasa.gov
https://pace.gsfc.nasa.gov

EARTH SCIENCE APPLICATIONS WEEK 2022

THANK YOU!

JOIN US TOMORROW 1-4PM EDT

SLIDES & RECORDINGS WILL BE POSTED BY AUG 31st