Day 2: Climate & Water Resources

August 10, 2022
Event Attendance Guidelines

1. Please stay muted with cameras off
2. Post questions for speakers in the chat & they will be answered there
CLIMATE & RESILIENCE APPLICATIONS
Dr. Allison Leidner
Program Manager
Climate Program
Allison.K.Leidner@NASA.gov
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
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)


1 Earth System Science Center, University of Alabama Huntsville
2 SERVIR Science Coordination Office, NASA Marshall Space Flight Center

August 10, 2022
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.
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

<table>
<thead>
<tr>
<th>SERVIR-AMZ</th>
<th>SERVIR-E&amp;SA</th>
<th>SERVIR-MKG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guyana</td>
<td>Zambia</td>
<td>Thailand</td>
</tr>
<tr>
<td>SERVIR-WA</td>
<td>SERVIR-HKH</td>
<td></td>
</tr>
<tr>
<td>Ghana</td>
<td>Bangladesh</td>
<td></td>
</tr>
</tbody>
</table>
2. Methodology: Overview

**Global Land Cover**
- MODIS - MCD12Q1
- JAXA F/NF
- Global Forest Watch
- ESA WorldCover
- Google / WRI / NatGeo Dynamic World
- Esri LC

**Regional Land Cover**
- RCMRD - CCDC (Zambia)
- MapBiomas (Guyana)
- Rapid Land Cover Mapper (USGS) (Ghana)
- RLCMS (Thailand, Bangladesh)

**Change Detection Algorithm**
- LandTrendr
- CCDC-SMA

**F/NF reclassification**
- Annual activity data
- Resample to 100m (1 ha.)

**Parameterization**
- Annual activity data
- Resample to 100m (1 ha.)

**Above Ground Biomass**
- Saatchi et al 2011
- Avitable 2015
- Geocarbon 2020
- GEDI L4b 2021
- ICIMOD 2015
- IPCC Emission Tables

**Reduce region to activity data**
- Biomass x 0.48 = Carbon Stock

**Emission**
- Area x Carbon Stock

**Emission Ensemble & Comparison to REDD+ FREL Reports**
### 3. Results: Global & Regional Remote Sensing data

<table>
<thead>
<tr>
<th>Country</th>
<th>LC Dataset</th>
<th>AGB Dataset</th>
<th>Change in Forest Area (ha./yr)</th>
<th>Emissions = Area x AGB (per year)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Guyana</strong></td>
<td>MCD12Q1</td>
<td>IPCC Tier 1</td>
<td>21,924.83</td>
<td>5,392,192.69</td>
</tr>
<tr>
<td></td>
<td>JAXA F/NF</td>
<td>Saatchi 2011</td>
<td>37,705.40</td>
<td>2,426,659.22</td>
</tr>
<tr>
<td></td>
<td>GFW</td>
<td>Avitable 2015</td>
<td>8,011.96</td>
<td>2,392,852.87</td>
</tr>
<tr>
<td></td>
<td>MapBiomas</td>
<td>GeoCarbon 2020</td>
<td>15,334.04</td>
<td>3,457,519.98</td>
</tr>
<tr>
<td><strong>Ghana</strong></td>
<td>MCD12Q1</td>
<td>IPCC Tier 1</td>
<td>36,677.75</td>
<td>4,165,242.66</td>
</tr>
<tr>
<td></td>
<td>JAXA F/NF</td>
<td>Saatchi 2011</td>
<td>60,680.63</td>
<td>1,500,607.58</td>
</tr>
<tr>
<td></td>
<td>GFW</td>
<td>Avitable 2015</td>
<td>33,545.45</td>
<td>921,829.09</td>
</tr>
<tr>
<td></td>
<td>USGS</td>
<td>GeoCarbon 2020</td>
<td>106,502.68</td>
<td>2,737,118.93</td>
</tr>
<tr>
<td><strong>Thailand</strong></td>
<td>MCD12Q1</td>
<td>IPCC Tier 1</td>
<td>1,119,450.61</td>
<td>9,661,738.65</td>
</tr>
<tr>
<td></td>
<td>JAXA F/NF</td>
<td>Saatchi 2011</td>
<td>188,331.43</td>
<td>11,808,832.34</td>
</tr>
<tr>
<td></td>
<td>GFW</td>
<td>Avitable 2015</td>
<td>118,888.89</td>
<td>9,721,544.44</td>
</tr>
<tr>
<td></td>
<td>RLCMS</td>
<td>GeoCarbon 2020</td>
<td>102,641.35</td>
<td>4,985,203.83</td>
</tr>
<tr>
<td><strong>Bangladesh</strong></td>
<td>MCD12Q1</td>
<td>IPCC Tier 1</td>
<td>19,286.22</td>
<td>1,688,512.99</td>
</tr>
<tr>
<td></td>
<td>JAXA F/NF</td>
<td>Saatchi 2011</td>
<td>50,832.31</td>
<td>2,687,850.00</td>
</tr>
<tr>
<td></td>
<td>GFW</td>
<td>Avitable 2015</td>
<td>13,892.44</td>
<td>1,037,209.73</td>
</tr>
<tr>
<td></td>
<td>RLCMS</td>
<td>GeoCarbon 2020</td>
<td>10,051.61</td>
<td>831,067.32</td>
</tr>
<tr>
<td><strong>Zambia</strong></td>
<td>MCD12Q1</td>
<td>IPCC Tier 1</td>
<td>98,035.05</td>
<td>7,974,249.61</td>
</tr>
<tr>
<td></td>
<td>JAXA F/NF</td>
<td>Saatchi 2011</td>
<td>183,029.00</td>
<td>5,836,135.91</td>
</tr>
<tr>
<td></td>
<td>GFW</td>
<td>Avitable 2015</td>
<td>92,000.00</td>
<td>2,416,840.00</td>
</tr>
<tr>
<td></td>
<td>RLCMS</td>
<td>GeoCarbon 2020</td>
<td>192,816.67</td>
<td>4,249,987.84</td>
</tr>
</tbody>
</table>

"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"
### 3. Results: Global LCC Intercomparison Project Algorithms - Bangladesh

<table>
<thead>
<tr>
<th>Change Algorithm</th>
<th>Change in area (ha/yr)</th>
<th>AGB dataset</th>
<th>Carbon stock</th>
<th>Emissions (tons CO₂e)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CCDC-SMA</td>
<td>60,767.18</td>
<td>Saatchi et al 2011</td>
<td>146.48</td>
<td>3,540,660.43</td>
</tr>
<tr>
<td>CCDC-SMA</td>
<td>60,767.18</td>
<td>Avitable 2015</td>
<td>45.48</td>
<td>8,901,176.32</td>
</tr>
<tr>
<td>CCDC-SMA</td>
<td>60,767.18</td>
<td>GeoCarbon 2020</td>
<td>117.73</td>
<td>2,763,691.28</td>
</tr>
<tr>
<td>LandTrendr</td>
<td>8,033.19</td>
<td>Saatchi et al 2011</td>
<td>130.91</td>
<td>1,051,624.47</td>
</tr>
<tr>
<td>LandTrendr</td>
<td>8,033.19</td>
<td>Avitable 2015</td>
<td>81.54</td>
<td>655,026.04</td>
</tr>
<tr>
<td>LandTrendr</td>
<td>8,033.19</td>
<td>GeoCarbon 2020</td>
<td>135.13</td>
<td>1,085,524.51</td>
</tr>
</tbody>
</table>

**Continuous Change Detection and Classification - Spectral Mixture Analysis (CCDC-SMA) algorithm 2000-2019**
https://t.co/MjgYPLQPE1

**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**

**Change Algorithm**
- Continuous Change Detection and Classification - Spectral Mixture Analysis (CCDC-SMA) algorithm 2000-2019
- LandTrendr spectral-temporal segmentation algorithm.
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

- 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-CAarbon Pilot (S-CAP)

**Why?**
- CC mitigation: Countries need to monitor + report on CO₂ / 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
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%

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
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

Image Credit: City of Wichita
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
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

Federal and international

Non-profit and private sector

[Logos of various organizations]
The Pillars of the NASA Applied Sciences Water Resources Program

- Portfolio of Applied Research Projects
- Western Water Applications Office (WWAOS)
- 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

Western Water Applications Office (WWAO)

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

River Basin Needs Assessments Completed:

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

Above: WWAO's Needs Assessment workflow

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

“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](https://openetdata.org)

Above Screenshot of CropCASMA: [https://nassgeo.csiss.gmu.edu/CropCASMA/](https://nassgeo.csiss.gmu.edu/CropCASMA/)
Three foci for the upcoming year:

- 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 WITH OUR COMMUNITY

ACCESS

• Stay connected:
  ➢ WRP listserv: https://lists.nasa.gov/mailman/listinfo/nasa-water-resources
  ➢ WWAO newsletter: https://wwao.jpl.nasa.gov/subscribe/

DRIVE

• 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

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

ACCESS

DRIVE THE FUTURE
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
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
How do anthropogenic changes in climate, land use, water use, and natural resource flows, with increasing transboundary risks projected across the water, energy and food sectors (high confidence) locally, regionally and globally and what are the short- and long-term consequences?

Motivation

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).

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.
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

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.

How is NASA addressing water needs?
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
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

- Outline problem
- Determine current capabilities
- Develop solutions
- Identify data gaps

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

- Capacity Building
- Disasters
- Agriculture
- Water Resources
- Ecological Forecasting
- Wildland Fires
- Health & Air Quality

**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 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
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 depletion leads to rearrangement of geologic matrix and subsidence

When long-term pumping lowers ground water levels and raises stresses on the aquifers beyond the preconsolidation-stress thresholds, the aquifers compact and the land surface subsides permanently.
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

<table>
<thead>
<tr>
<th>Dense</th>
<th>Sparse</th>
</tr>
</thead>
</table>

**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

**Integrating remotely-sensed datasets**

**GRACE & GRACE-FO**

**GRACE**: Gravity Recovery And Climate Experiment

**GRACE & GRACE-FO**

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

**SENTEL-1**

**InSAR**: Interferometric Synthetic Aperture Radar

**ALOS-2**

**Grasity Recovery and Climate Experiment (GRACE)**

**GRACE & GRACE-FO**

**Subsidence 2015 - 2019**

**GRACE**: Gravty Recovery And Climate Experiment

**GRACE & GRACE-FO**

**Subsidence**

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

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

**GRACE**: Gravty Recovery And Climate Experiment

**GRACE & GRACE-FO**

**Subsidence 2015 - 2019**

**GRACE**: Gravty Recovery And Climate Experiment

**GRACE & GRACE-FO**

**Subsidence**

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

**Calculates 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: Visualization of In-situ and Remotely-sensed Groundwater Observations

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
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

\[ R^2=0.0044, \, P=0.175, \, Y = 4.1340 + 0.024X \]

\[ R^2=0.00091, \, P=0.572, \, Y = 41640 + 0.011X \]

\[ R^2=0.014, \, P=0.0847, \, Y = 4.0830 + 0.039X \]
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


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
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?
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
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

Eliza Bond
Coastal and marine mammal

Dan York
Aquaculture
Applying sustainable aquaculture

Marina Michalke
Near real-time distribution plan for America: Monitoring applications

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!

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