



Science Mission Directorate
Heliophysics Division

SPACE WEATHER COUNCIL



Earth Science Applications: Lessons Learned

Lawrence Friedl
Earth Science Division

22-23 Feb 2024

Earth. Science. Action.

Applications Lessons

Major Takeaways

Terms and Purposes

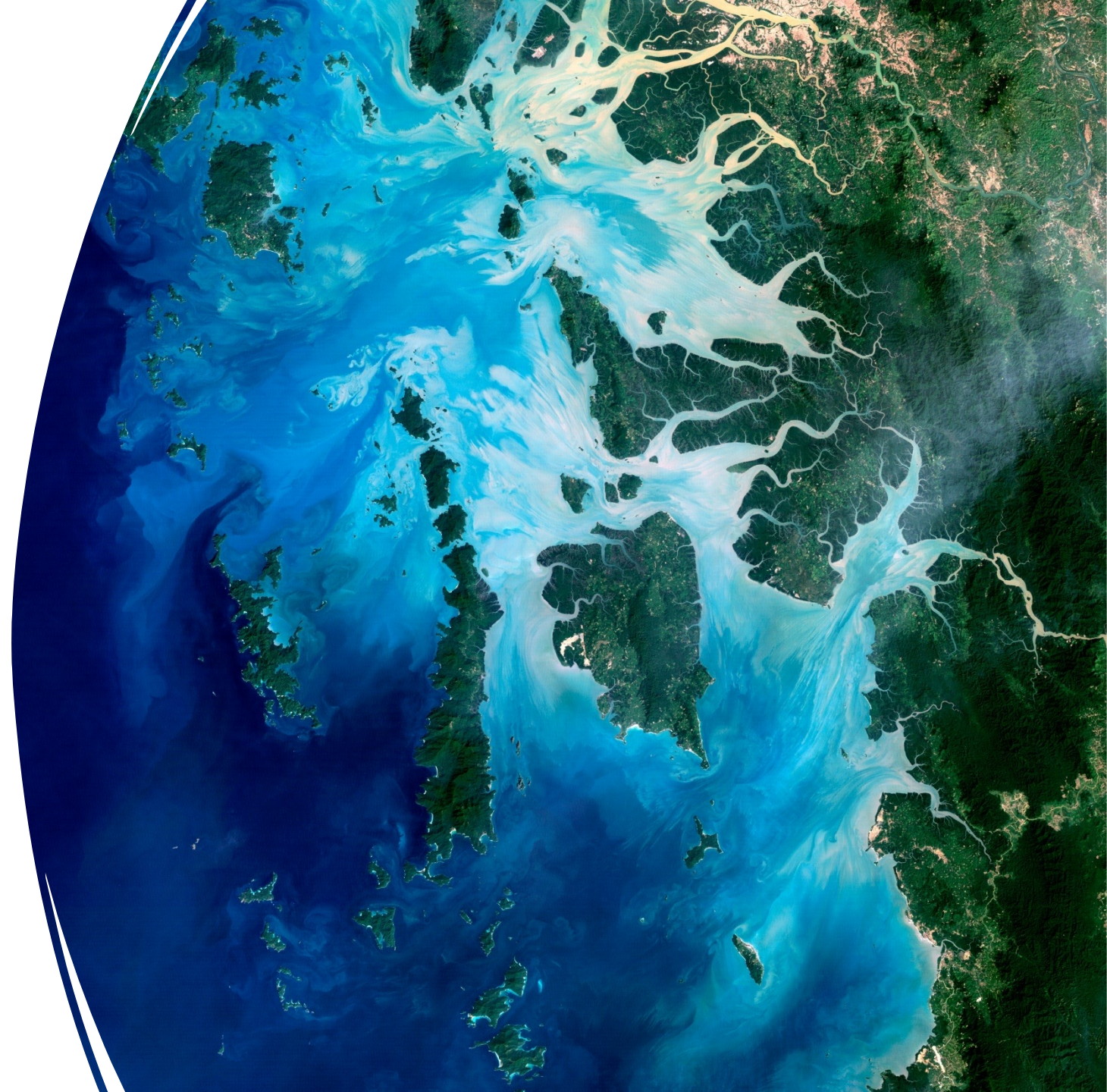
Engaging Users

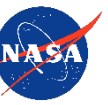
Programs and Projects

Missions and Applications

Community Capacity

Communications





- 1 Applications is interactive, hands-on, and relational much more than transactional
- 2 Apply the most appropriate science and not necessarily the latest or cutting-edge results
- 3 Experience, insight, and technical expertise exist in user communities – authentically appreciate that and engage them early and often

- 4 Don't ask "What Do You Need?"
Ask more leading questions for an exploratory conversation
- 5 Build in approaches to be flexible and agile and responsive



MAJOR TAKEAWAYS



6

Integrate applications specialists in science teams and enable user presence in science team meetings

7

Put attention toward building capacity and skills associated with community-engaged research

8

Go to where the managers and users meet and convene. Attend *their* meetings and engage in *their* associations to learn their language, concerns, and issues

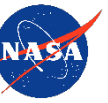
9

Ensure reward structures incentivize and recognize applications work accordingly

10

Leverage human-based narratives in communications





NASA Earth Science has defined science to include research, applied research, and applications with the emphasis based on the specific activity. Suggested differentiation ...

Research: Fundamental learning to explain phenomena and understand processes in the natural world



What role does soil moisture play in the water cycle?

Applied Research: Development of scientific knowledge directed to particular result and codification of knowledge in models and tools for predictive capabilities

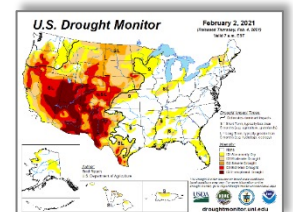


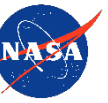
Development of groundwater and soil moisture drought indicator variables derived via GRACE-FO and other observations

Applications: Uses of data and information products to inform decisions and guide actions of organizations for policy, business, and management activities
aka, decision-support applications



Integration of GRACE-FO based indicators into the information flow and decision process for weekly production of the U.S. Drought Monitor





Earth: Applications Program

Technical and programmatic investments were to ...

Enable people & organizations to apply insights from Earth science to generate creative solutions to improve their decisions and actions

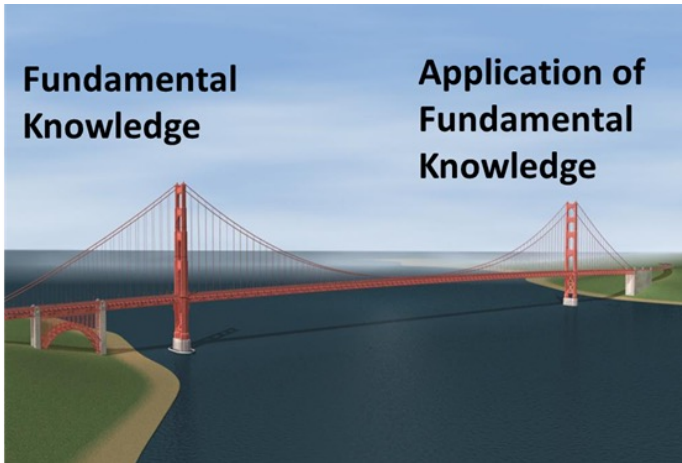
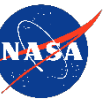
Lower the technical and institutional barriers to using Earth science information – lead to greater and broader use

Draw on connections with users to bring their feedback back into NASA to inform research, missions, data products, etc.

Create multipliers and stimulate demand for Earth Science



*Partnership and User-centric
Applying the most appropriate science*



Applications is sometimes depicted as a bridge for the transfer of data and knowledge from the research community to the user community.

This depiction tends to over-simplify the nature of the engagement – the interactions are often quite iterative among user communities and technical experts.



The development of applications can follow multiple pathways depending on the organizations involved and their level of familiarity, resources, motivations, and incentives.

Some users are very sophisticated and can navigate the applications development process smoothly, while others are not and need assistance to navigate their way.

The Neglected Heart of Science Policy: Reconciling supply of and demand for science. D.Sarewitz and R.Pielke Jr, *Envir. Science & Policy*, 2007.

DOI:10.1016/j.envsci.2006.10.001

Crossing the Valley of Death. Faisal Hossain et al., *BAMS*, August 2014.

DOI:10.1175/BAMS-D-13-00176.1

Earth Science information providing evidence for different types of decisions and actions:

- Planning, management, resource allocation, and response
Ex: Damage proxy maps after disasters to target deployment of supplies
- Monitoring and tracking impact
Ex: Monitoring crop conditions and examining impact of droughts
- Alert systems and forecasts
Ex: Early warnings of environmental conditions, such as harmful algae blooms in lakes





EXAMPLE MECHANISMS:

Individual Project Grants

Projects develop creative uses of Earth science

Projects are done with user organizations to support transition and adoption into their decision making

One- and Two-Step Solicitations

Agile Consortia

For key issues that have broad impact (e.g., agriculture, water management), multi-sector consortia exist. Approach allows flexibility in number, size, scope, and duration of projects



**NASA Harvest
Agriculture Consortium**

<https://nasaharvest.org/>



**Western Water
Applications Office**

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

Problem-Solving Teams

Team Members routinely interact with managers on the ground to collaborate on topics of emerging and urgent need; Both agility and responsiveness



**Health and Air
Quality Applied
Sciences Team**

<https://haqast.org/>



Trainings:

Applied Remote Sensing Training

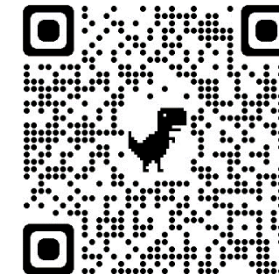
ARSET offers free, hands-on trainings for professionals. Courses span from Beginner to Advanced level trainings.

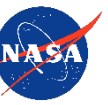


Feasibility Projects:

DEVELOP

Early career professionals gain experience applying geospatial data and tools through rapid prototypes with nonprofits, state & local governments, and others.





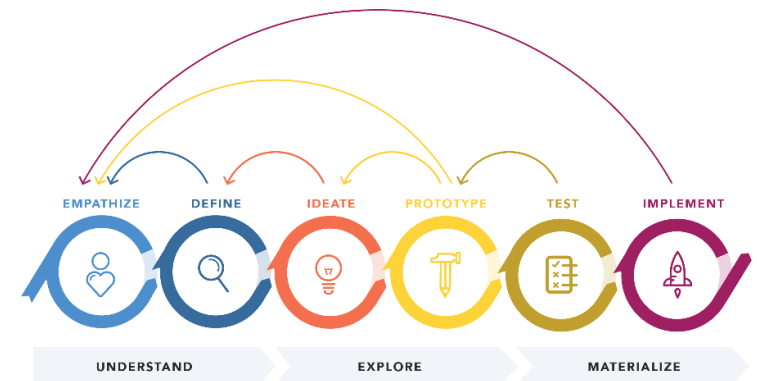
Developing applications begins with engaging with, and listening to, users and decision makers and their teams ...

Typical Topics and Questions:

- » Tell me about a day at your work
- » Where do you spend 80% of your time?
- » Tell us about a problem you haven't solved
- » What's a decision you'd like to be more certain about?
- » What keeps you up at night?
- » What's a decision you'd like to be more certain about?
- » What information don't you have that you wish you did?
- » If you had a magic wand, what you do (related to your work)?

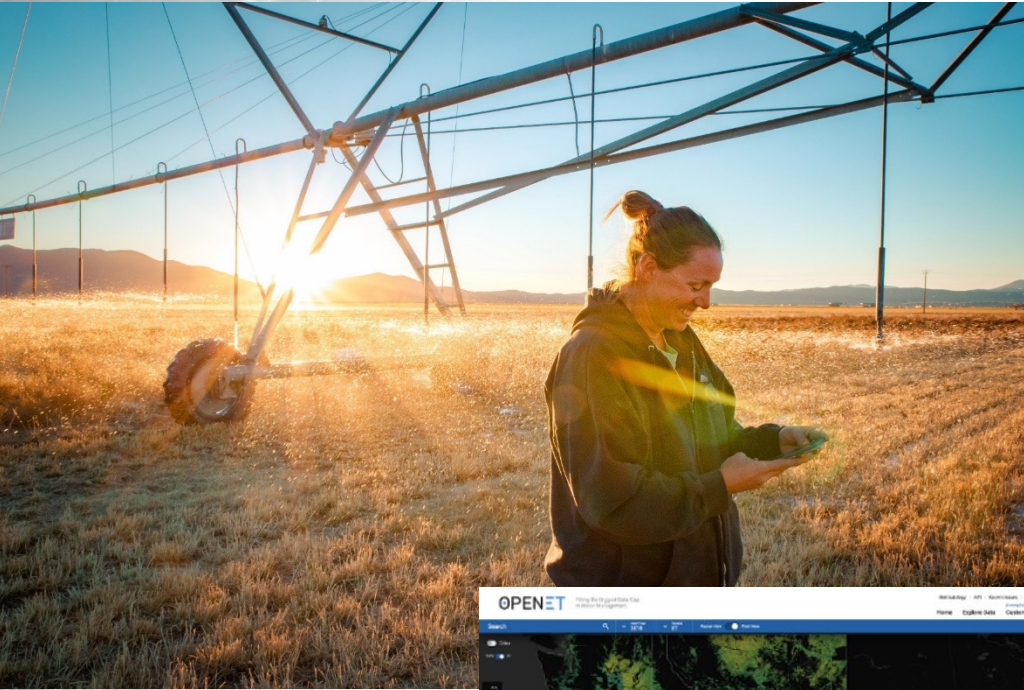


Design Thinking >>
illustrates the
process well



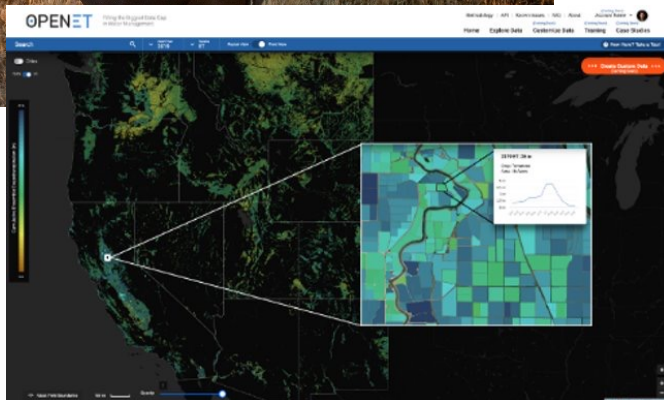
OPENET

Filling the Biggest Data Gap in Water Management in the Western US



Above: Nevada farmer Denise Moyle will use OpenET to plan irrigation of her alfalfa fields

Right: Screenshot of OpenET platform



An operational system of freely-available NASA Earth data on evapotranspiration (ET) now in the hands of farmers and water resource managers

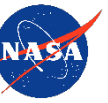
Also supports incentive-driven conservation programs and demand management in the Colorado River Basin and groundwater management in California

Provides data services from the Landsat, USDA, or



<https://etdata.org/>

- daily, monthly and annual timesteps



Maximize benefits by enhancing the missions' applications value in three ways

Direct Use

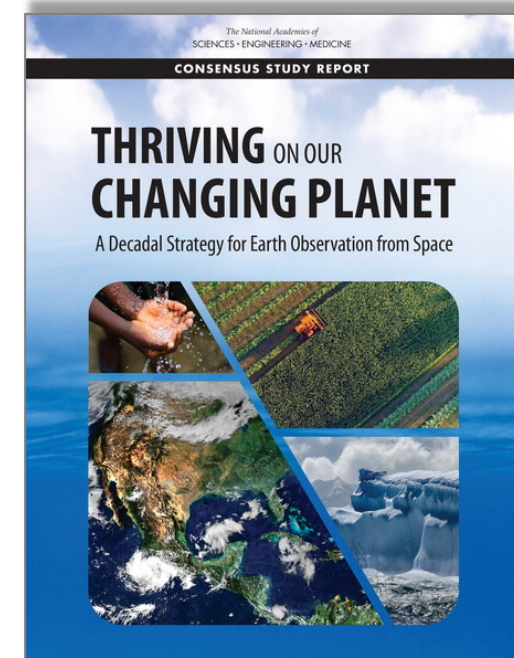
Accelerate uses of data & info. products to improve decisions for societal and economic benefits; Gather feedback from less-traditional audiences for ESD; Increase direct ROI from the mission

Research Results

Increase awareness and familiarity with research pursuits of the missions & researchers; Increase user communities' anticipation of research results

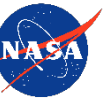
Advocacy

Broaden the range of communities and organizations interested in the missions and potential voices to support them



2017 Earth Decadal

“To its credit, NASA has increasingly integrated applications into flight programs and research, with results that have been embraced by both the science and applications communities.”



Maximize benefits by enhancing the missions' applications value in three ways

Direct Use

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Research Results

Increase awareness and familiarity with research pursuits of the missions & researchers; Increase user communities' anticipation of research results

Advocacy

Broaden the range of communities and organizations interested in the missions and potential voices to support them

Program Applications Lead (PAL)

Ensures the applications activities of the mission remain viable and true to strategic objectives during development of the mission

Earth Science Applications Directive

Establishes the guidelines for implementing a Project Applications Program for a mission

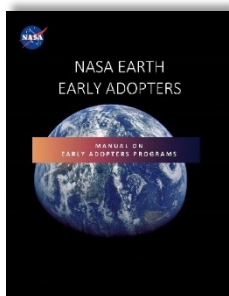


Community Assessment Reports

In Pre-Phase A, the CAR serves to characterize the potential applications communities for a mission; CAR serves as a reference throughout lifecycle

Early Adopters Program

Helping potential users work with proxy data prior to mission launch; Users provide feedback to improve data products





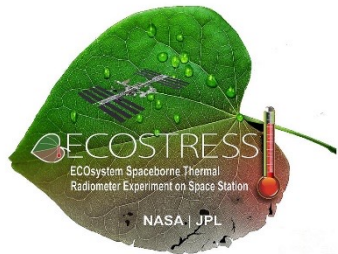
Sample of Early Adopters

Based on engagement with Early Adopters ...



SMAP EA Video

National Snow and Ice Data Center DAAC added an additional format (KML) for SMAP products based on specific Early Adopter comments and requests



DAAC resolved issues with gap filling, data volume handling, and data format. Project addressed concerns EAs raised about cloud mask, cold bias, and geolocation



SWOT decided to reduce data latency for SWOT products from 45 days to less than 3 days, enabling short-latency oceanographic and hydrologic applications



PACE

Persona: A human-centered design method used to create memorable, actionable, and distinct representations of different user types and their unique needs.

<p>This is Mike</p> <p>Occupation: Remote Sensing Sci</p>  <p>Bio/ Backstory: Mike is a remote sensing scientist at the US Volcano Observatory. He develops advanced satellite measurements of ash and SO2, ground imaging, and ground-based laser observation. Mike enjoys camping and fishing.</p>	<p>This is Sam</p> <p>Occupation: Post-doctoral Rese</p>  <p>Bio/ Backstory: Sam is a first-year post-doctoral researcher at the University of California, San Diego. She focuses on the burden of disease, addressing how demographics, weather, and ambient air quality affect health. In her free time, she enjoys drawing and justice.</p>	<p>This is Angela</p> <p>Occupation: Senior Scientist/M</p>  <p>Bio/ Backstory: Angela is a Senior Scientist at the European Centre for Medium-Range Weather Forecasts (ECMWF). She holds degrees in Meteorology. She is interested in aerosol and cloud interactions.</p>	<p>This is Anne</p> <p>Occupation: Air Quality Scienti</p>  <p>Bio/ Backstory: Anne works as a staff scientist for Arizona's Center for Air Quality and Environmental Health. She supports the enactment of an Implementation Plan for air pollution strategy. She is interested in air quality and health. She enjoys travel and photography.</p>	<p>This is Rachel</p> <p>Occupation: Citizen Science Dir</p>  <p>Bio/ Backstory: Rachel is the Director of the citizen science organization consisting of citizens, environmental professionals and academics working together to improve air quality and health. She enjoys travel and photography.</p>	<p>This is Ryan</p> <p>Occupation: Air Quality Speciali</p>  <p>Bio/ Backstory: Ryan is an air quality specialist and Air Resource Service where he monitors air quality before, during, and after wildfires. He communicates the impact of air quality on human health and the environment.</p>	<p>This is Gabe</p> <p>Occupation: CEO and Lead E</p>  <p>Bio/ Backstory: Gabe is the CEO of Solar Kings, a solar energy company based in Kelowna, BC. The company provides commercial site assessments to gauge the potential of solar energy.</p>	<p>This is Gloria</p> <p>Occupation: Ministry of Environ</p>  <p>Bio/ Backstory: Gloria is a scientist at the Ministry of Environment and Climate Change Canada. She works on wildfire and volcanic eruptions. She utilizes satellite data to monitor and assess the impact of these events.</p>	<p>This is Daniel</p> <p>Occupation: Staff Scientist</p>  <p>Bio/ Backstory: Daniel is a staff scientist studying clouds and aircraft remote sensing. He contributes to NASA's working on the operational cloud optical and microphysics data collection.</p>	<p>This is John</p> <p>Occupation: Climate Risk Data Manager</p>  <p>Age: 37 Location: McLean, VA</p> <p>Bio/ Backstory: John is a climate risk data manager at Freddie Mac, a large financial lending institution. He works across the Climate Risk Team to identify, measure, monitor, control and report climate-related risks. He models climate risk and reports on the impact of climate change on the financial system.</p>
<p>This is Tom</p> <p>Occupation: Water Quality Manag</p>  <p>Bio/ Backstory: Tom has worked at Florida DEP for 25 years. He has a masters in Marine Biology at the University of Florida. He focuses on the environment and recreational fishing. He is focused on Gulf Coast water quality, focusing on blooms, fecal coliforms, and associated recreation. Tom plans to retire in the next 5-7 yrs.</p>	<p>This is Julie</p> <p>Occupation: Post-doctoral Researc</p>  <p>Bio/ Backstory: Julie is a first-year post-doctoral researcher at the University of California, San Diego. She researches new ideas to study the role of organic matter in a variety of waters using remote sensing techniques. She has a background in environmental engineering, and physics. In her free time, she enjoys yoga and kayaking.</p>	<p>This is Feng</p> <p>Occupation: Senior Scientist</p>  <p>Bio/ Backstory: Feng is a Senior Scientist at IGB-Berlin. He holds a Ph.D. in Ecology. His research focuses on conservation of populations, biodiversity patterns of species, and anthropogenic changes will influence food web community structure. In his free time, Feng plays tennis.</p>	<p>This is Astrid</p> <p>Occupation: Senior Staff Scienti</p>  <p>Bio/ Backstory: Astrid works as an engineer for a medium-sized environmental consulting firm. Before joining the private sector, she served as a Senior Scientist at the Center for Environmental Engineering. Astrid is part of a team that works on water quality and air quality.</p>	<p>This is Jake</p> <p>Occupation: Research Techn</p>  <p>Bio/ Backstory: Jake works at the Gulf of Maine Research Institute. His work looks at how changing climate patterns impact the zooplankton community in the Gulf of Maine. He also works alongside the Center for Environmental Engineering to build software tools for connecting and analyzing data from the GOM region. Jake is an avid homebrewer.</p>	<p>This is Claire</p> <p>Occupation: Citizen Science D</p>  <p>Bio/ Backstory: Claire leads NOAA's National Phytoplankton Community-based network of citizen-scientists and Hubs. She trains groups of citizen-scientists on how to collect field samples, report data to the NOAA HAB Monitoring System, and manage the data in an online database. In her free time, she enjoys fishing and spending time with her family.</p>	<p>This is John</p> <p>Occupation: Naval Researcher</p>  <p>Bio/ Backstory: John is a researcher at the Office of Naval Research. He works on water resour monitoring and prediction for water resour operations planning. His models inform military operations planning, including prediction of turbidity and depth of the thermocline. He shares information with the fishing community and with policy-makers.</p>	<p>This is Elena</p> <p>Occupation: Ministry of Env</p>  <p>Bio/ Backstory: Elena is a scientist at the Ministry of Environment and Climate Change Canada. She works on satellite data to produce maps on sea surface temperature, current speed and direction, and depth of the thermocline. She shares information with the fishing community and with policy-makers. In her free time, she enjoys swimming.</p>	<p>This is Krystal</p> <p>Occupation: Principal Air Quality Consultan</p>  <p>Age: 43 Location: Melbourne, Australia</p> <p>Bio/ Backstory: Krystal is an air quality consultant at an environmental consulting firm where she provides expertise on environmental assessments, geochemical modeling, greenhouse gas and air emissions inventories, air dispersion modeling, regulatory permitting, and climate change mitigation and adaptation strategies for sectors such as mining, oil and gas, manufacturing, or infrastructure. In particular, she reports on air quality impacts of mining operations, including tracking dust and toxic emissions.</p>	



This is Julie

Occupation: **Post-doctoral Researcher**

Age: **28**

Location: **San Diego, CA**

Water Resources
Ecological Forecasting

Goals

- Acquire/assimilate remotely sensed data to support her modeling work & research
- Develop combined satellite modeling approach to evaluate the role of particulate organic carbon (POC) in oligotrophic gyres

Technical Characteristics

Remote Sensing Knowledge:

Computing Power:

Machine Learning & Classification:

Data Pre-processing Ability:

Pain Points / Frustrations

- Limited resources for processing in situ and satellite data
- Insufficient data coverage to capture underlying drivers of POC variability
- Bridging the gap between satellite data, model data, and in situ data
- Available data is often not high enough quality to produce useful

Ideal Experience / Must Have

- Reliable, accurate data with per pixel uncertainty
- Data interoperability: data format should be accessible and readable by various programming software/languages
- Products in different processing levels, allowing her to test atm correction and algorithms

Bio/ Backstory:

Julie is a first-year post-doctoral researcher at UC San Diego. Her research explores new ideas to study dissolved organic matter (DOM) using remote sensing and data mining techniques. She enjoys modeling, experimentation, and cooking, yoga, and kayaking.

This is Tom

Occupation: **Water Quality Manager**

Age: **59**

Location: **Tampa, FL**

Water Resources
Ecological Forecasting

Goals

- Provide accurate, up-to-date info. on coastal HAB and bacteria conditions.
- Effectively coordinate with other teams/managers on the conditions & risks

Technical Characteristics

Remote Sensing Knowledge:

Computing Power:

Machine Learning & Classification:

Data Pre-processing Ability:

Pain Points / Frustrations

- Limited computing/processing resources for processing satellite data
- Coastal cloud inference reducing data consistency, reliability, and dependability
- Difficulty communicating risk conditions to citizens and decision-makers

Ideal Experience / Must Have

- Easy source of information to convey risk & safety about beach & recreational conditions
- Free, and/or cheap, access to data for multiple locations
- Routine data notifications
- Data that is delivered routinely, daily would be ideally for management (low latency products)

Bio/ Backstory:

Tom has worked at Florida DEP for 25yrs. He has a masters in Marine Biology and is passionate about the environment and recreational fishing. Most of his work is focused on Gulf Coast water quality, focusing on harmful algal blooms, fecal coliforms, and associated recreation. Tom plans to retire in the next 5-7yrs.

This is John

Occupation: **Naval Researcher**

Age: **50**

Location: **Arlington, VA**

Water Resources
Ecological Forecasting

Goals

- Develop high spatial resolution datasets and models
- Connect data and models to practical military applications, working alongside operations planning staff

Technical Characteristics

Remote Sensing Knowledge:

Computing Power:

Machine Learning & Classification:

Data Pre-processing Ability:

Pain Points / Frustrations

- Cross mission data/cross agency collaboration
- Poor spatial resolution in coastal zones
- Low data latency, data isn't timely enough for military applications
- Data download, data is often not in an easy-to-use format
- Data management and server resources; limited funding for storing & processing large datasets
- Dust impact on Lidar measurements

Ideal Experience / Must Have

- Mapped data with "coastal" configuration with all the needed quality flags applied
- Consistency between the file formats, grids; data that can "talk" to each other
- Manageable data volume & file size that doesn't require high-computing power machines
- Confidence in data products (cross-sector/cross-agency uncertainties)
- Higher spatial resolution for coastal environments
- Easy source of information to convey/communicate to managers

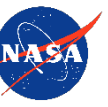
Bio/ Backstory:

John is a researcher at the Office of Naval Research working in turbid waters monitoring and prediction for water resource management and US Navy operations planning. His models inform military applications along coastal areas, including prediction of turbidity for use of Lidar and other technologies in operations planning. In his free time, John enjoys boating with his family.

Personas helped the PACE Applications team prioritize products, services, and activities.

PACE used community brainstorming activities to "get to know" each persona.

Developing a diverse set of PACE user personas helped make the PACE team's *implicit* assumptions and about their users *explicit*.



Developing Applications and Enabling Transitions is Hands-On Work



It involves building relationships with the organizations which may adopt using the data



It takes time to build the relationships, especially for the successful adoption of the application



The skills required to *develop* an application may be different from the skills required to *transition* the application successfully to a partner



An online resource with practical tips and guidance on how to develop applications with impact

Platform with interactive, multimedia content

Lessons and practical tips from decades of work in engaging with organizations to apply Earth science in their planning, decision processes, and actions

<https://appliedsciences.nasa.gov/guidebook/>

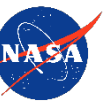


VIEW GUIDEBOOK

Key features:

- *Success factors & characteristics of successful projects*
- *Types of “users” and “decisions” plus concrete examples*
- *Practical advice and nuts & bolts guidance*
- *Cases illustrating typical pathways*



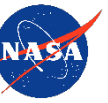


Co-Production of knowledge:

The process of producing usable (aka, actionable) science through collaboration between scientists and those who use science to make policy and management decisions.

- frame research questions
- decide how to answer the questions
- analyze the findings

Research on the outcomes of collaborations between scientists and decision makers has shown that when knowledge is co-produced it is more likely to be accepted and used by decision makers.



Mode	Objective	Origin of research question	Type of relationship	Stakeholder involvement	Stakeholder representation
Contractual	Test applicability of new technology or knowledge	Researchers	Unidirectional flow of information from researchers to stakeholders	Primarily as passive recipient of new knowledge or technology	Views and opinions of stakeholders are not emphasized
Consultative	Use research to solve real-world problems	Stakeholders or researchers	Researchers consult with stakeholders, diagnose the problem, and try to find a solution	At specific stages of research such as problem definition, research design, diffusion of findings.	Stakeholder views primarily filtered through third party (e.g., social scientists)
Collaborative	Learn from stakeholders to guide applied research	Stakeholders	Stakeholders and researchers are partners	Continuous with emphasis on specific activities, depending on joint diagnosis of the problem	Stakeholders themselves, local representatives, trained research team members
Collegial	Understand and strengthen local research and development capacity	Stakeholders	Researchers actively encourage local research and development capacity	Variable, but ongoing	Stakeholders themselves

Source: A.M. Meadow et al, *Weather, Climate, and Society*, 2015

Note: The paper presents approaches to deliberate co-production



EXPLORE EARTH

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SPACE FOR U.S.

TOGETHER FOR A BETTER EARTH

This is Space For U.S., where the power of NASA's Earth observations come to life through state-by-state stories featuring communities like yours—solving our country's biggest challenges with innovative technology, groundbreaking insights, and extraordinary collaboration.

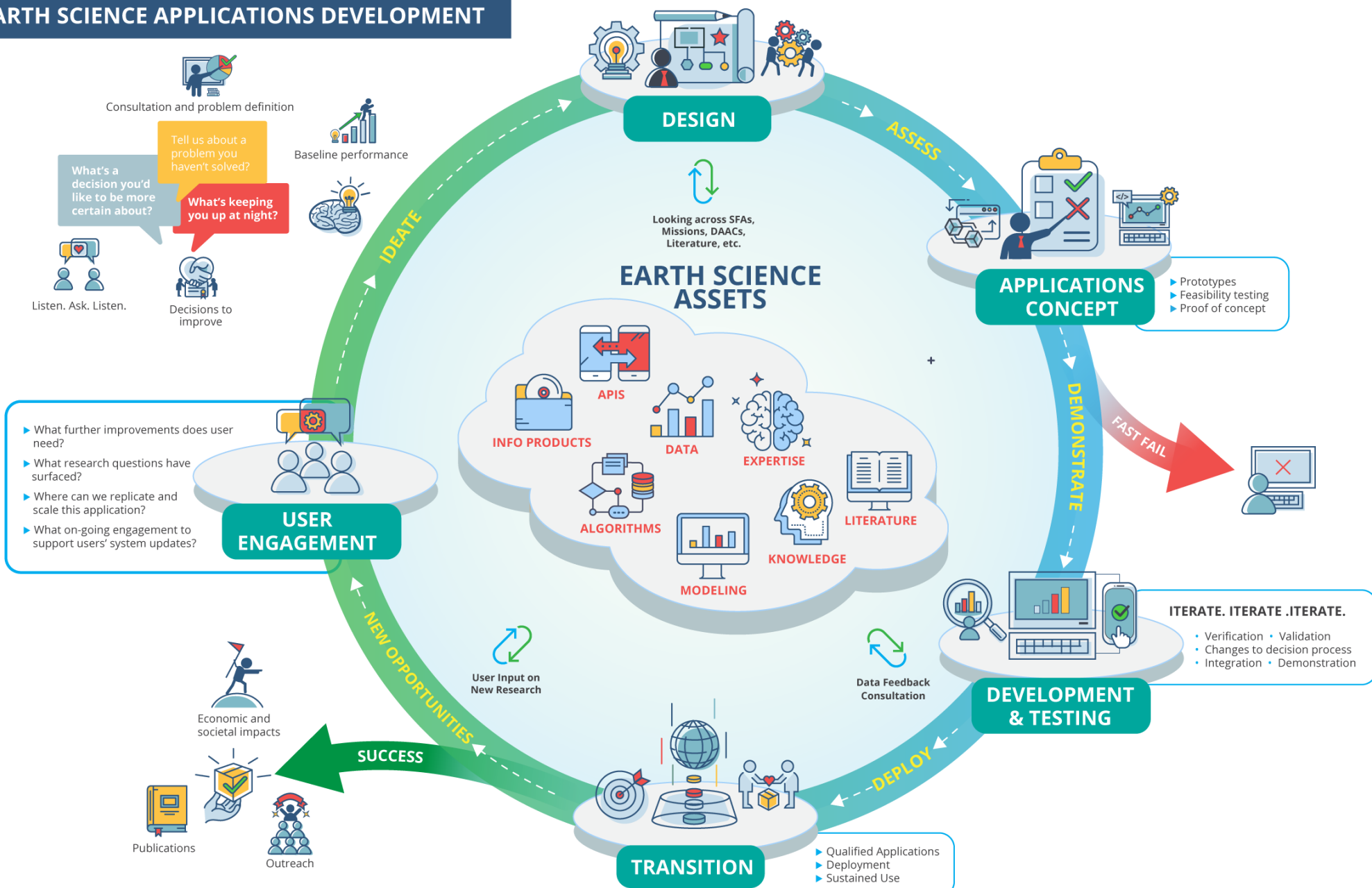
START EXPLORING

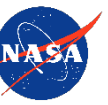
nasa.gov/spaceforum





EARTH SCIENCE APPLICATIONS DEVELOPMENT





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2. Apply the most appropriate science not necessarily the latest or cutting-edge results
3. Experience, insight, and technical expertise exist in user communities – authentically appreciate that and engage them early and often
4. Don't ask "What Do You Need?" Ask more leading questions for an exploratory conversation
5. Build in approaches to be flexible and agile and responsive
6. Integrate applications specialists in science teams and enable user presence in science team meetings
7. Put attention toward building capacity and skills associated with community-engaged research
8. Go to where the managers and users meet and convene. Attend *their* meetings and engage in *their* associations to learn their language, concerns, and issues.
9. Ensure reward structures incentivize and recognize applications work accordingly
10. Leverage human-based narratives in communications



NASA Earth Science

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**EARTH.
SCIENCE.
ACTION.**

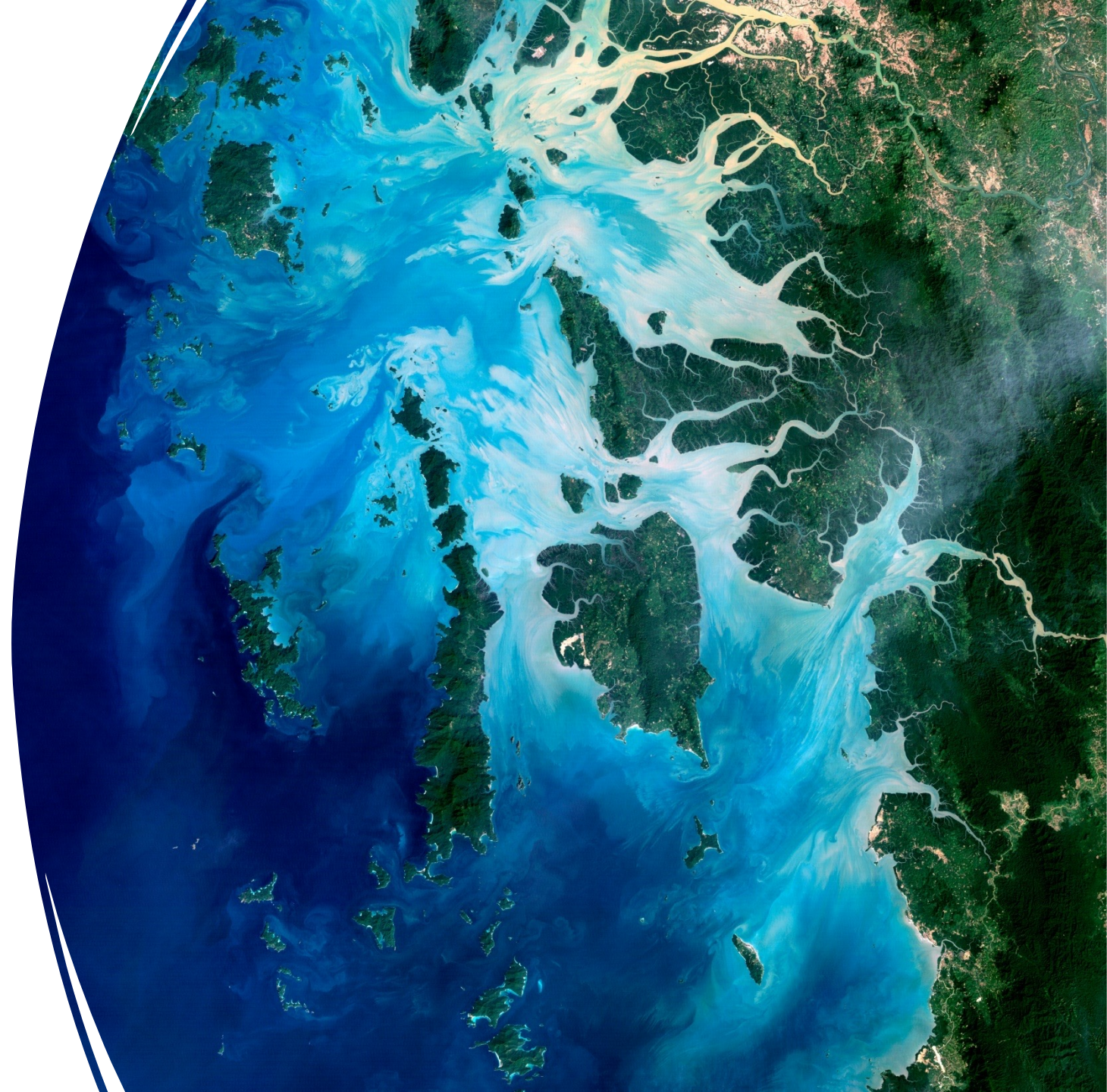


– NASA HELIOPHYSICS –

SPACE WEATHER COUNCIL

Earth Science Applications Lessons

Additional & Reference Materials





Creating Tools
(e.g. *OpenET*)

Creating Spaces
(e.g. *HAQAST*)



Creating Capacity
(e.g. *ARSET*)

The West Nile Weekly

What does this week look like historically?
Historically, around 5.1% of cases are transmitted in the week of August 7th - 13th, and around 60% of total cases for the year, about 3 in 5, have been transmitted by the end of this week.

What to expect?
Our model estimates that statewide risk of infection has risen slightly above average (Fig 1). This is due mostly to the western half of the state, in which most counties are experiencing higher-than-average risk for this week (Fig 2).

We expect that cases will occur in seven counties. Brown remains the most likely to have cases, with an estimated 53.6% (1 in 2) chance of at least one case.

The increase in expected risk is due primarily to new reports of positive pools received in the last week. As of August 7th, the state has risen 2.5% of pools positive, up from 1.9% last week. Six counties have now reported positives.

Current recommendations?
We continue to recommend mosquito control, particularly in the southeastern part of the state. Destruction of infected adult mosquitoes can prevent infectious bites, especially in these next few weeks, which represent the height of WNV season in typical years.



Early-Warning System for West Nile Virus Disease in South Dakota

South Dakota has the highest per-capita incidence of mosquito-borne West Nile Virus. The SD Department of Health worked with an Applied Sciences team to apply Earth science data and models for risks maps

WNV forecasting and risk mapping tools improve the effectiveness of mosquito surveillance and control in the main transmission season by helping to target limited resources more effectively

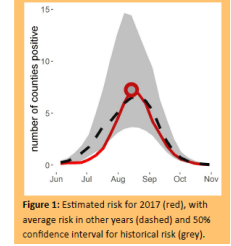


Figure 1: Estimated risk for 2017 (red), with average risk in other years (dashed) and 50% confidence interval for historical risk (grey).

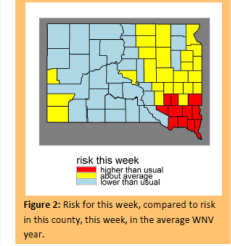
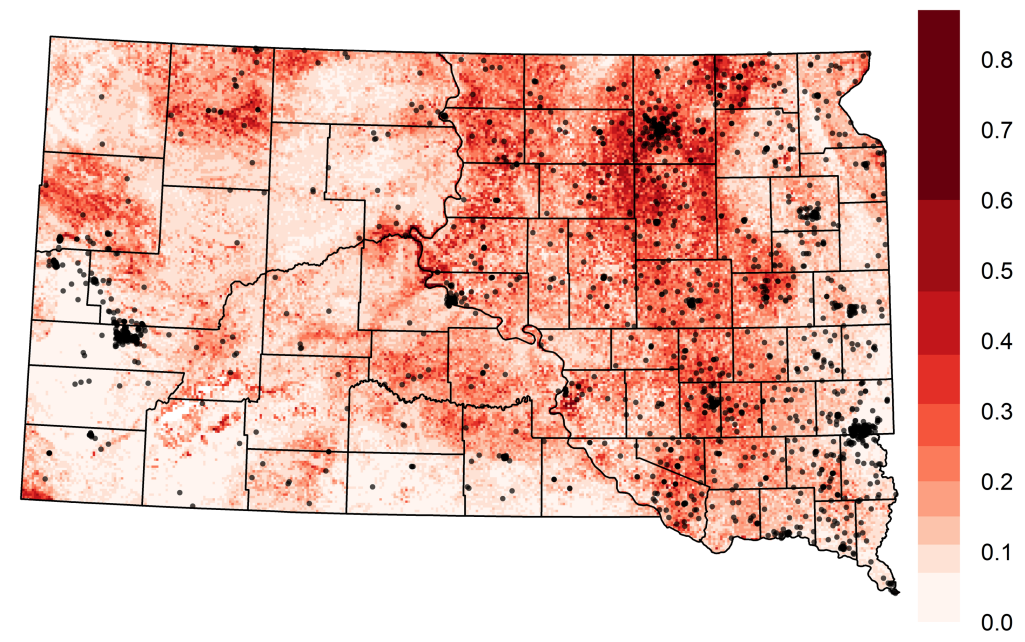
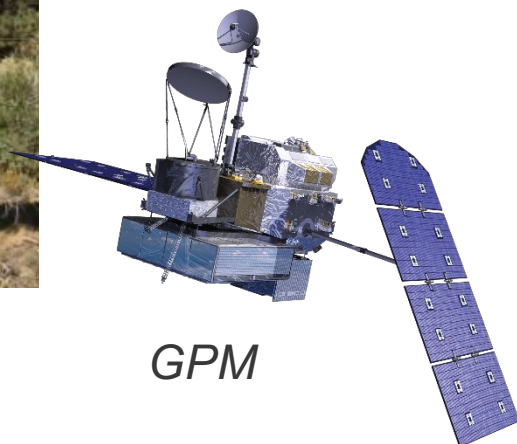


Figure 2: Risk for this week, compared to risk in this county, this week, in the average WNV year.

Relative West Nile Virus Risk

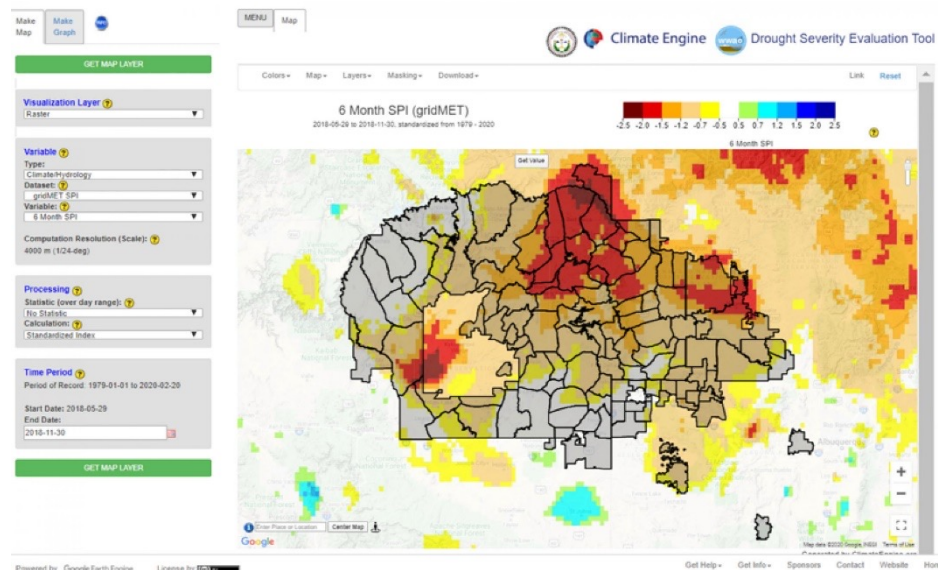




GPM



Landsat 9



*Outlook across the Navajo Nation:
Warmer colors representing drought conditions.*

Navajo Nation Enhancing their Water Management

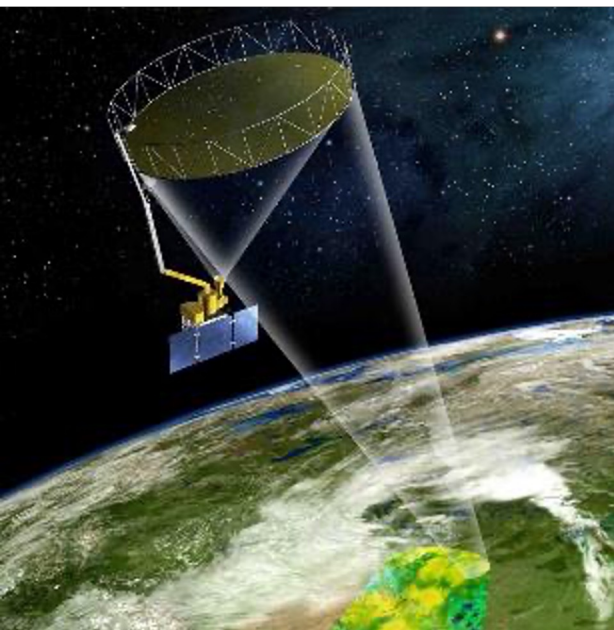
The Navajo Nation augments their sparse and limited ground-based measurements with Earth science data and drought monitoring tools

Drought Severity Evaluation Tool is operational at Navajo Dept. of Water Resources

The Navajo Nation uses the tool in allocating water resources and drought relief funds across their 110 chapters in more efficient and equitable ways

Data & Info:

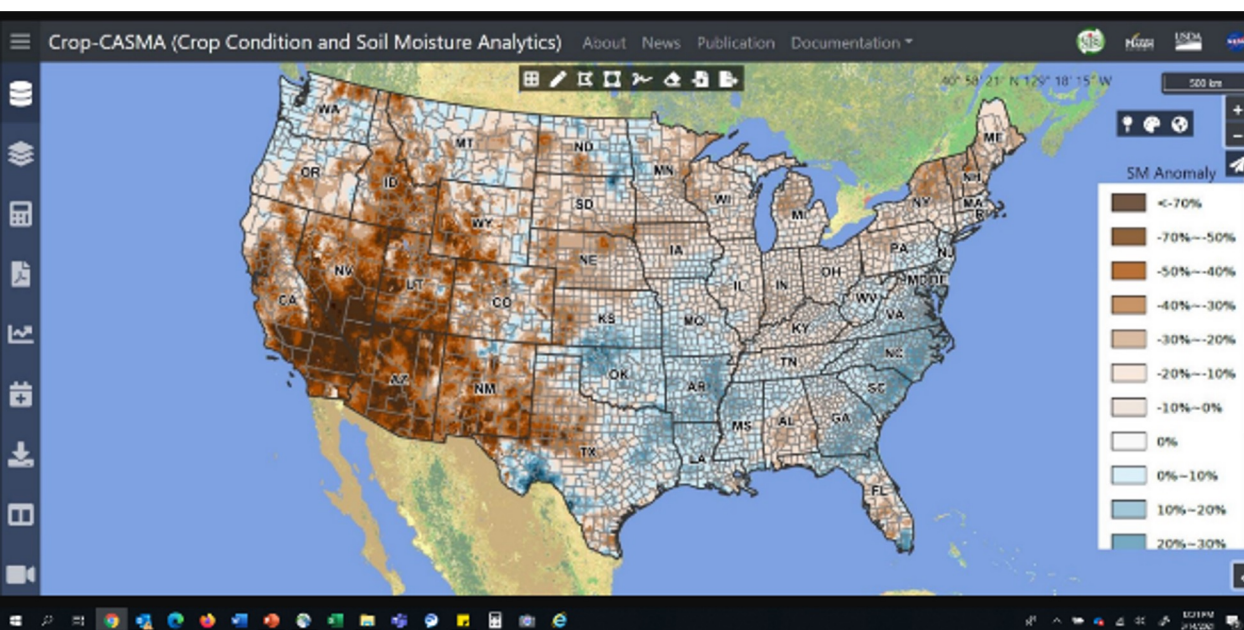
GPM CHIRPS Landsat Rain Gauges Models

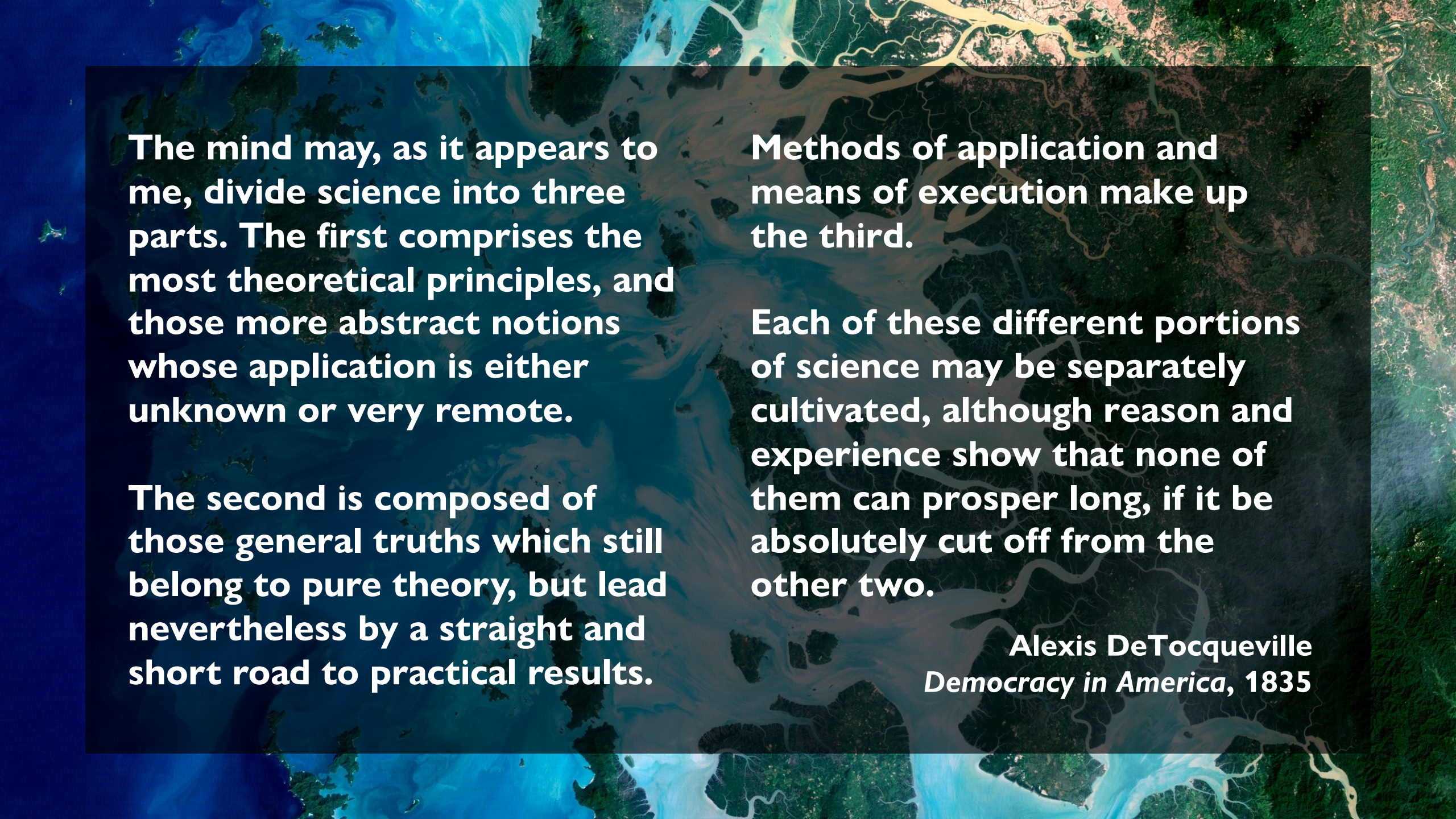


Soil Moisture Data in Hands of Farmers

Farmers looking for help on where their fields need water and where they can conserve have a new tool, using data from NASA's SMAP satellite. USDA's Crop Condition and Soil Moisture Analytics tool helps people grasp the impact of extreme events like flooding and drought and identify conditions that might prevent planning.

Example Use: USDA's weekly Crop Progress Reports, which give information to help make plans for when to plant crops, track crop health and growing progress, and forecast agricultural yields.



An aerial photograph of a river delta, showing a complex network of channels and distributaries. The water is a mix of blue and brown, and the surrounding land is green. A dark semi-transparent rectangular box is overlaid on the image, containing white text.

The mind may, as it appears to me, divide science into three parts. The first comprises the most theoretical principles, and those more abstract notions whose application is either unknown or very remote.

The second is composed of those general truths which still belong to pure theory, but lead nevertheless by a straight and short road to practical results.

Methods of application and means of execution make up the third.

Each of these different portions of science may be separately cultivated, although reason and experience show that none of them can prosper long, if it be absolutely cut off from the other two.

Alexis DeTocqueville
Democracy in America, 1835