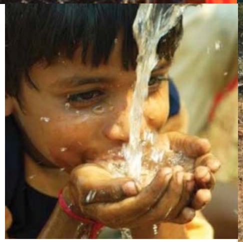
Science Mission Directorate
Heliophysics Division

# Space Weather Council




# *Earth Science Applications: Lessons Learned*


Lawrence Friedl
Earth Science Division


*22-23 Feb 2024*

# *Applications Lessons*

Major Takeaways

Terms and Purposes

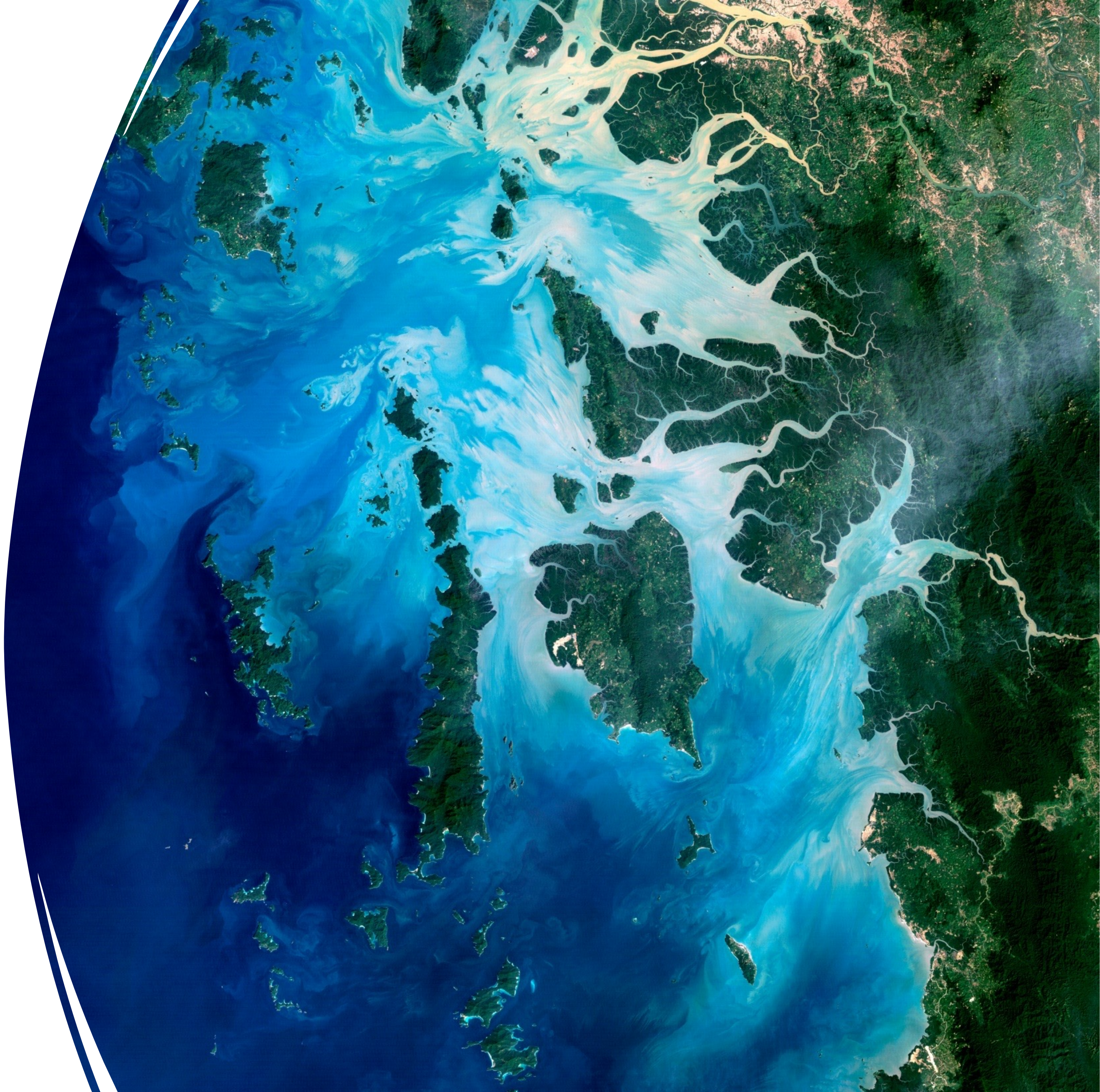
Engaging Users

Programs and Projects

Missions and Applications

Community Capacity

Communications



# Major Takeaways

NASA Science

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

# Terms & Purposes

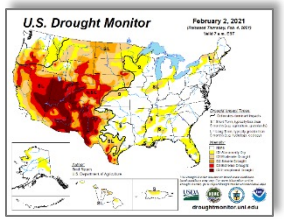


NASA Earth Science has defined science to include research, applied research, and applications with the emphasis based on the specific activity. Suggested differentiation …

**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*



# Terms & Purposes



**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

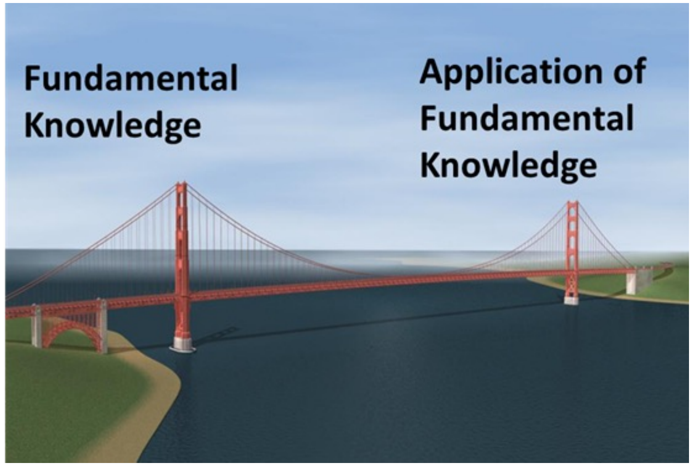
Draw on connections with users to bring their feedback back into NASA to inform research, missions, data products, etc.

Create multipliers and stimulate demand for Earth Science


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

# Terms & Purposes

NASA 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

# Programs & Projects

NASA Science

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

# Programs & Projects



*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 Consortiums

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

HAQAST

**Health and Air Quality Applied Sciences Team**

https://haqast.org/

# Programs & Projects



### 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.

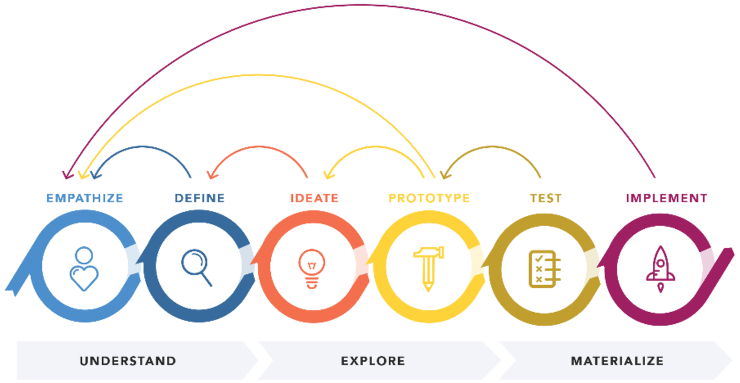
# Engaging Users

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


Typical Topics and Questions:

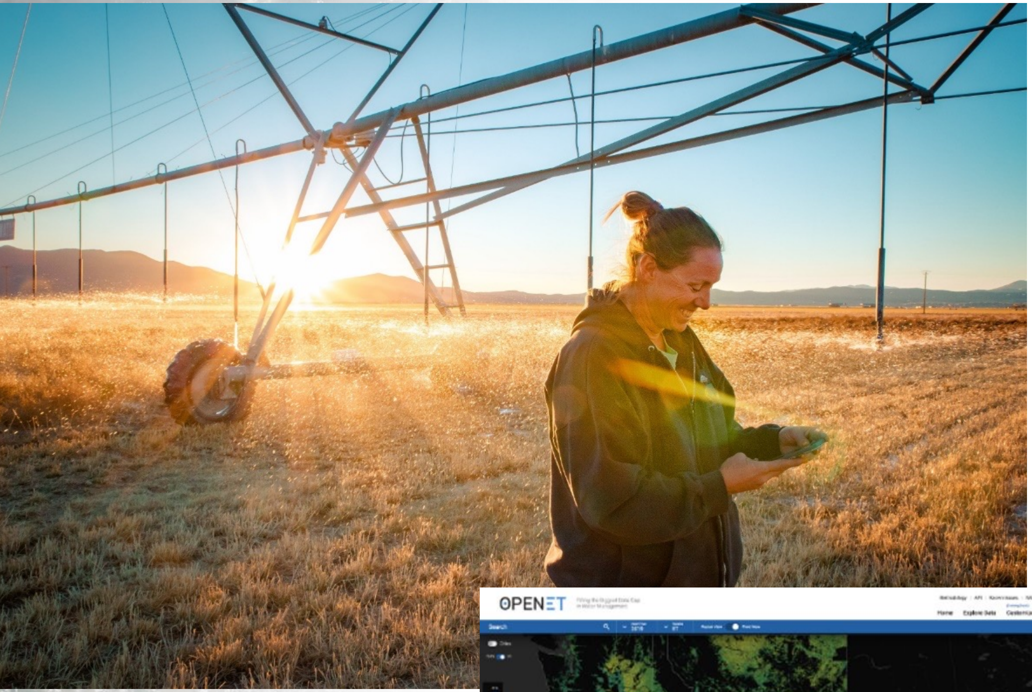
» Tell me about a day at your work
» Where do you spend 80% of your time?
» Tell us about a problem you haven't solved
» What's a decision you'd like to be more certain about?
» What keeps you up at night?
» What's a decision you'd like to be more certain about?
» What information don't you have that 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

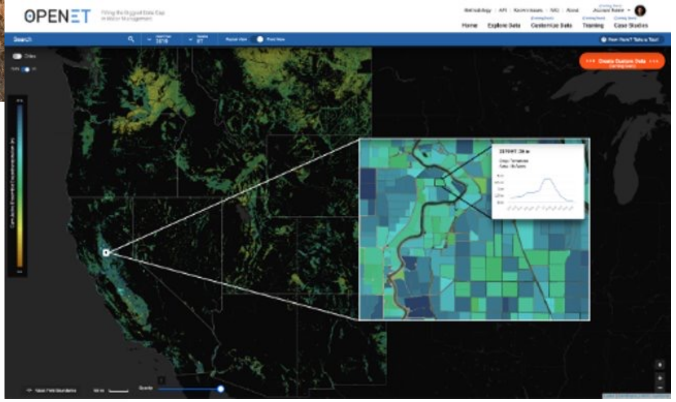


An operational system of freely-available NASA Earth data on evapotranspiration (ET) now in the hands of farmers and water resource managers

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

Provid[illegible] dat[illegible] primarily from the Landsat [illegible]

• daily, monthly and annual timesteps




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

Right: Screenshot of OpenET platform

https://etdata.org/

# Missions



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

**Direct Use**

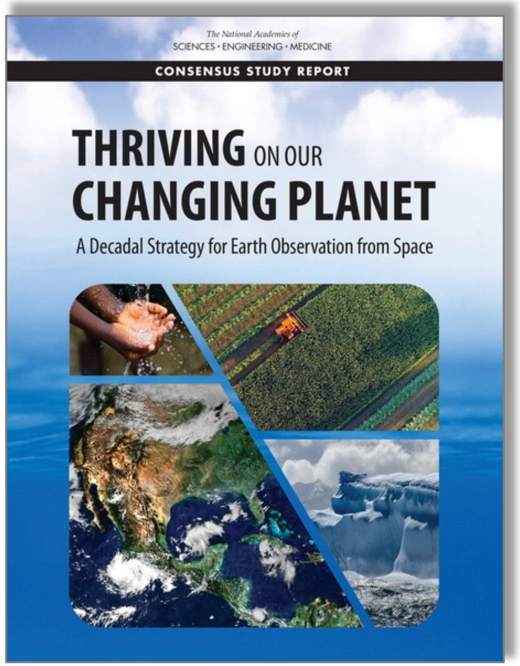
Accelerate uses of data & info. products to improve decisions for societal and economic benefits; Gather feedback from less-traditional audiences for ESD; Increase direct ROI from the mission

**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."

*p. 61*

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## *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*

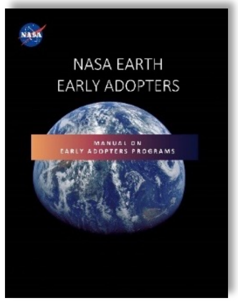
Establishes the guidelines for implementing a Project Applications Program for a mission


## *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



# Missions



| *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.

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 about their users *explicit*.

# COMMUNITY CAPACITY



## 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

# Community Capacity




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.

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

# Community Capacity

NASA Science

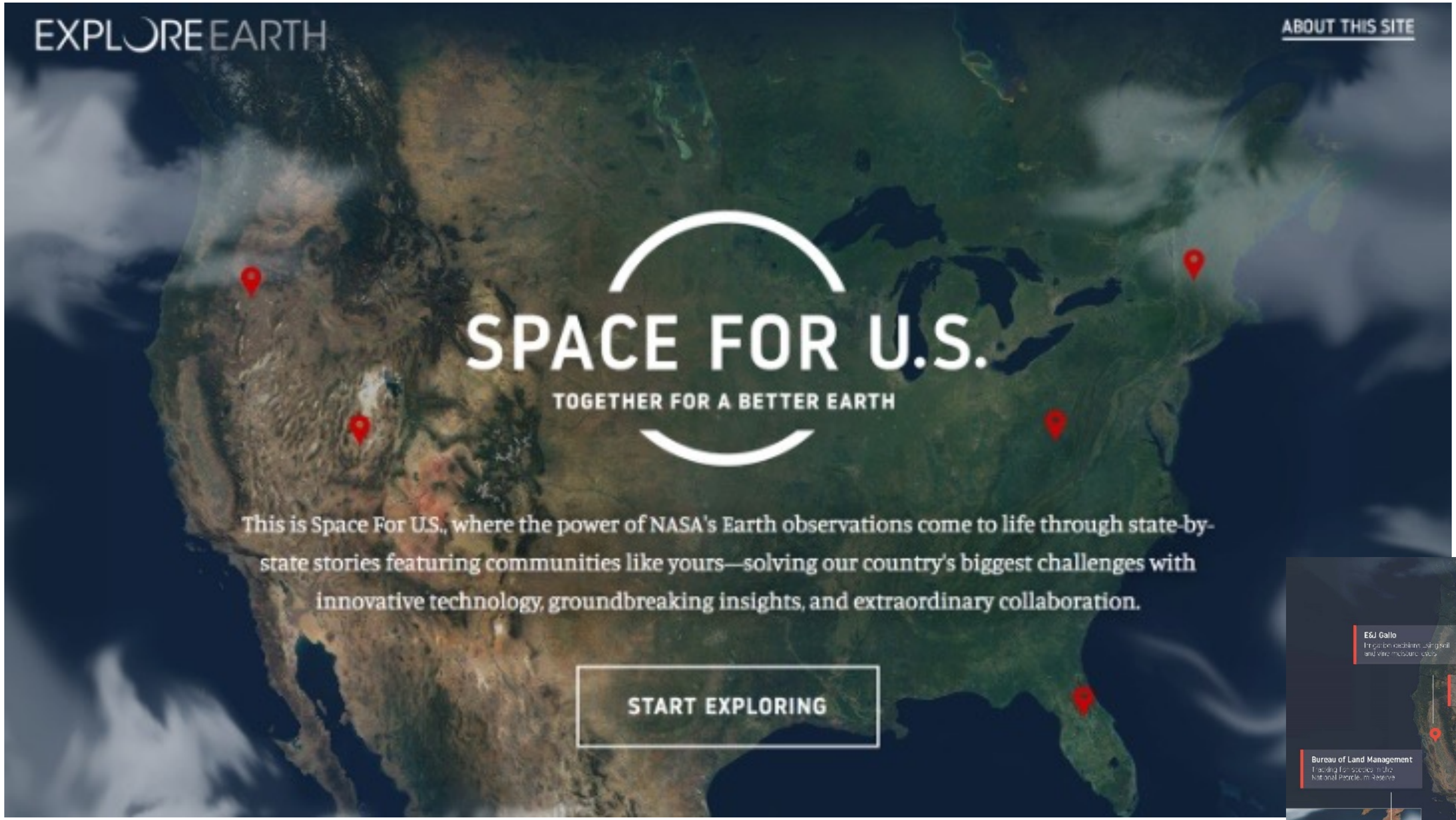
| Mode | Objective | Origin of research question | Type of relationship | Stakeholder involvement | Stakeholder representation |
|---|---|---|---|---|---|
| Contractual | Test applicability of new technology or knowledge | Researchers | Unidirectional flow of information from researchers to stakeholders | 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*

# Communications

NASA Science




nasa.gov/spaceforus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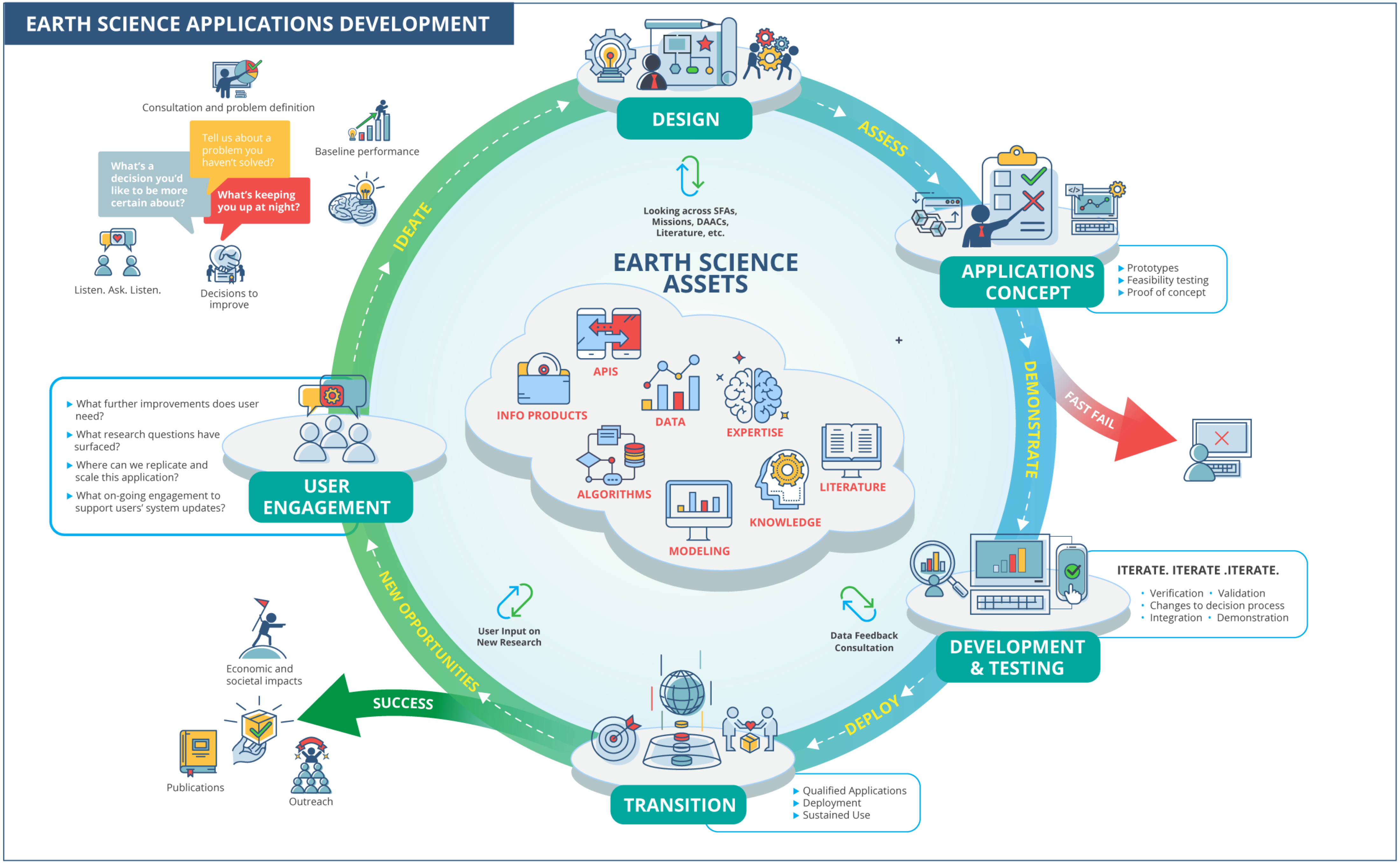

EARTH SCIENCE APPLICATIONS DEVELOPMENT
Consultation and problem definition
Baseline performance
Tell us about a problem you haven't solved?
What's a decision you'd like to be more certain about?
What's keeping you up at night?
Listen. Ask. Listen.
Decisions to improve
IDEATE
DESIGN
ASSESS
Looking across SFAs, Missions, DAACs, Literature, etc.
EARTH SCIENCE ASSETS
APIS
INFO PRODUCTS
DATA
EXPERTISE
ALGORITHMS
LITERATURE
KNOWLEDGE
MODELING
APPLICATIONS CONCEPT
Prototypes
Feasibility testing
Proof of concept
DEMONSTRATE
FAST FAIL
What further improvements does user need?
What research questions have surfaced?
Where can we replicate and scale this application?
What on-going engagement to support users' system updates?
USER ENGAGEMENT
ITERATE. ITERATE .ITERATE.
Verification • Validation
Changes to decision process
Integration • Demonstration
DEVELOPMENT & TESTING
User Input on New Research
Data Feedback Consultation
NEW OPPORTUNITIES
DEPLOY
Economic and societal impacts
SUCCESS
Publications
Outreach
TRANSITION
Qualified Applications
Deployment
Sustained Use

# Major Takeaways



1. Applications is interactive, hands-on, and relational much more than transactional
2. Apply the most appropriate science not necessarily the latest or cutting-edge results
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4. Don't ask "What Do You Need?" Ask more leading questions for an exploratory conversation
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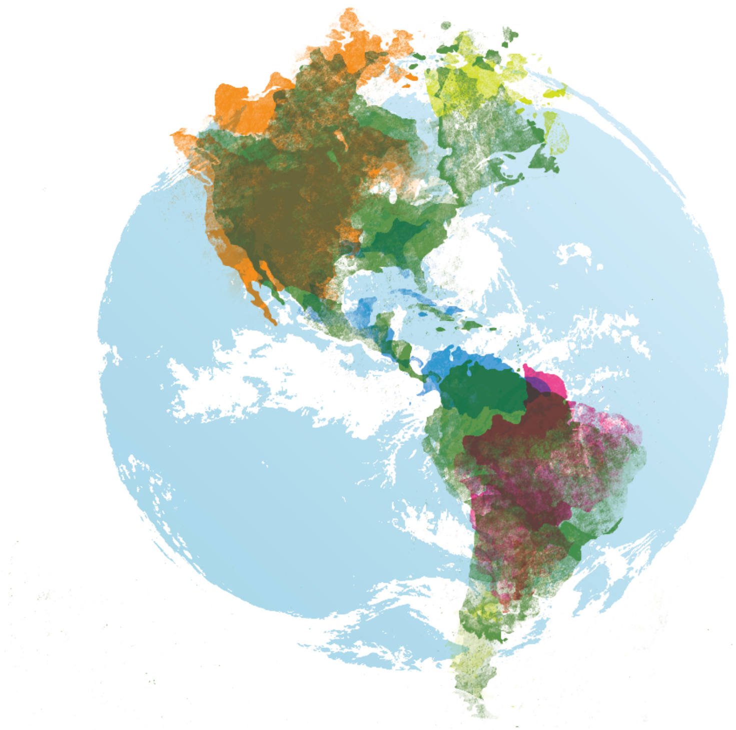

**EARTH.**
**SCIENCE.**
**ACTION.**

# NASA
# Earth Science

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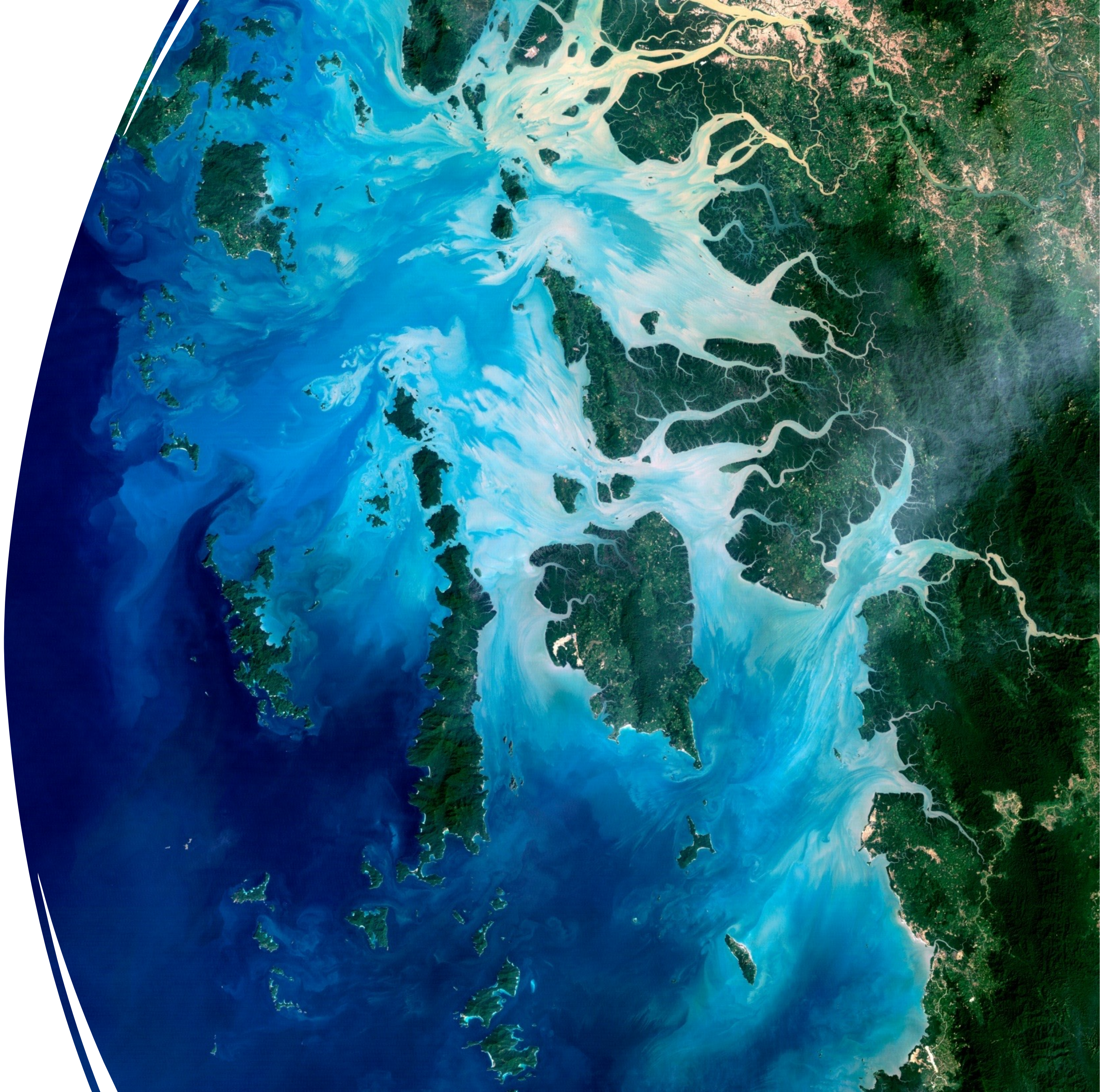
– NASA Heliophysics –

## Space Weather Council

# Earth Science Applications Lessons

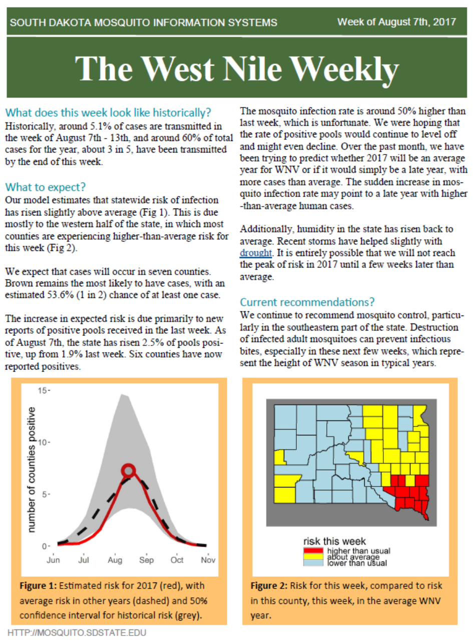
# *Additional & Reference Materials*



Creating Tools
*(e.g. OpenET)*

Creating Spaces
*(e.g. HAQAST)*

Creating Capacity
*(e.g. ARSET)*



SOUTH DAKOTA MOSQUITO INFORMATION SYSTEMS — Week of August 7th, 2017

# 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.

The mosquito infection rate is around 50% higher than last week, which is unfortunate. We were hoping that the rate of positive pools would continue to level off and might even decline. Over the past month, we have been trying to predict whether 2017 will be an average year for WNV or if it would simply be a late year, with more cases than average. The sudden increase in mosquito infection rate may point to a late year with higher-than-average human cases.

Additionally, humidity in the state has risen back to average. Recent storms have helped slightly with drought. It is entirely possible that we will not reach the peak of risk in 2017 until a few weeks later than average.

### 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.

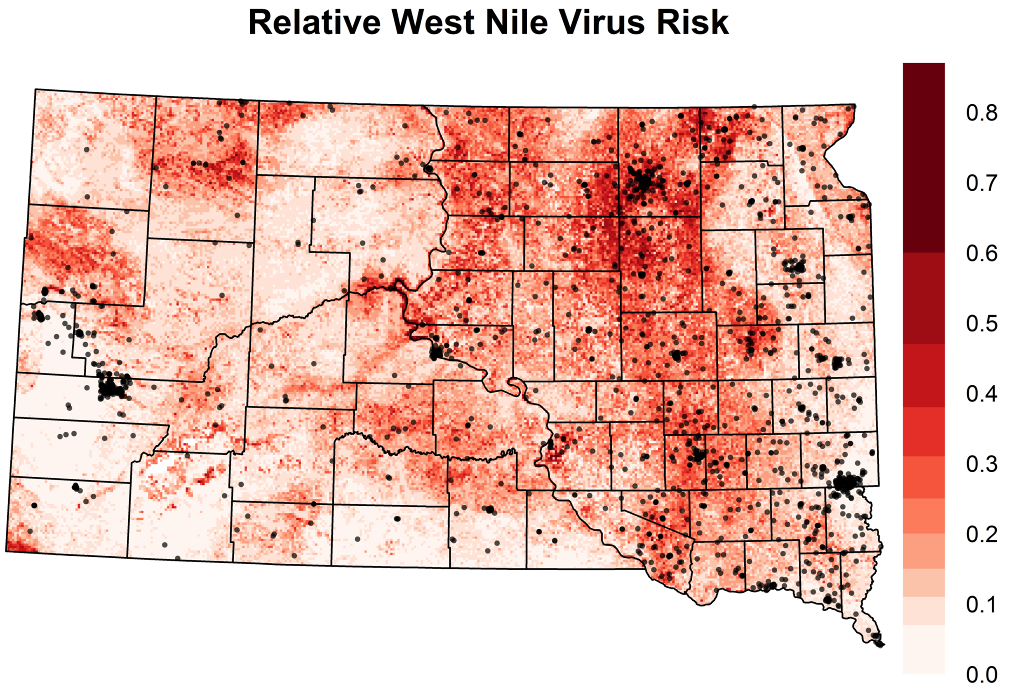


**Figure 1:** Estimated risk for 2017 (red), with average risk in other years (dashed) and 50% confidence interval for historical risk (grey).



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

HTTP://MOSQUITO.SDSTATE.EDU



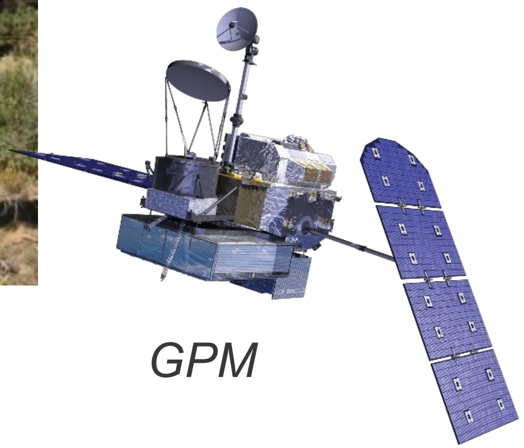

SOUTH DAKOTA DEPARTMENT OF HEALTH

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

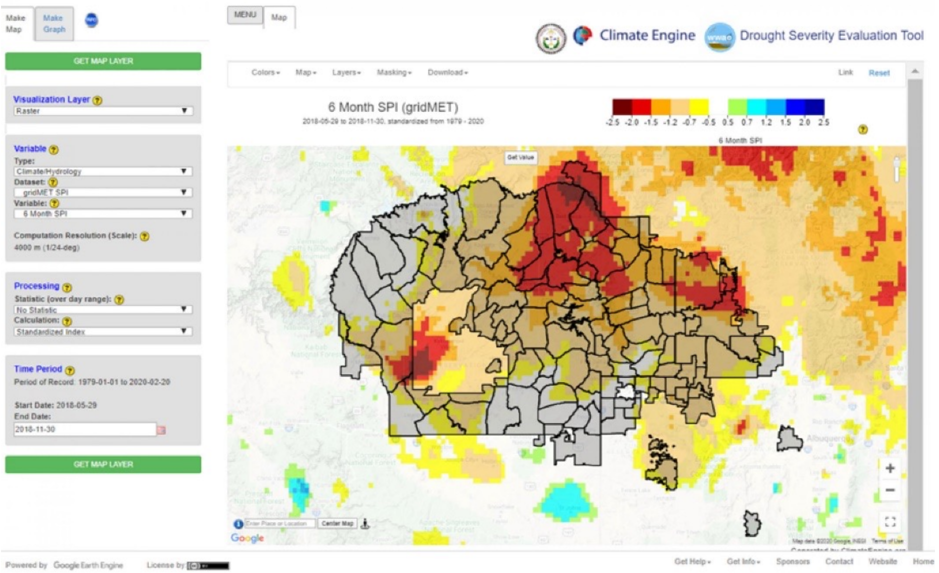
South Dakota has the highest per-capita incidence of mosquito-borne West Nile Virus. The SD Department of Health worked with an Applied Sciences team to apply Earth science data and models for risks maps

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

Landsat 9



GPM




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

# Navajo Nation Enhancing their Water Management

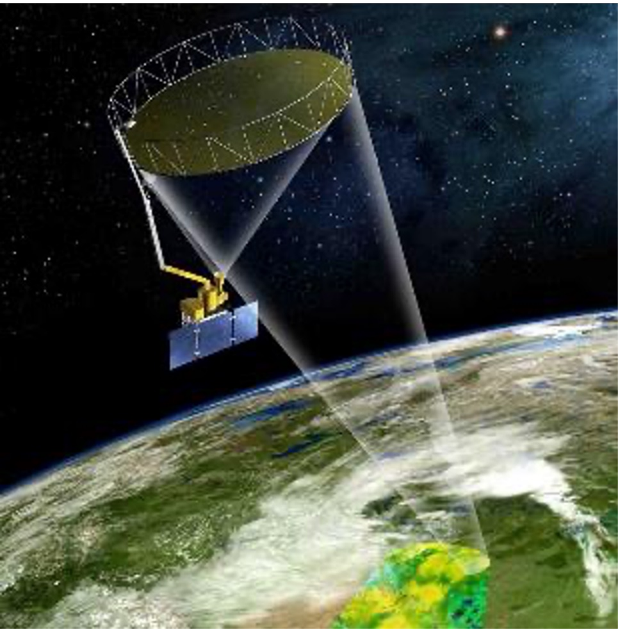
The Navajo Nation augments their sparse and limited ground-based measurements with Earth science data and drought monitoring tools

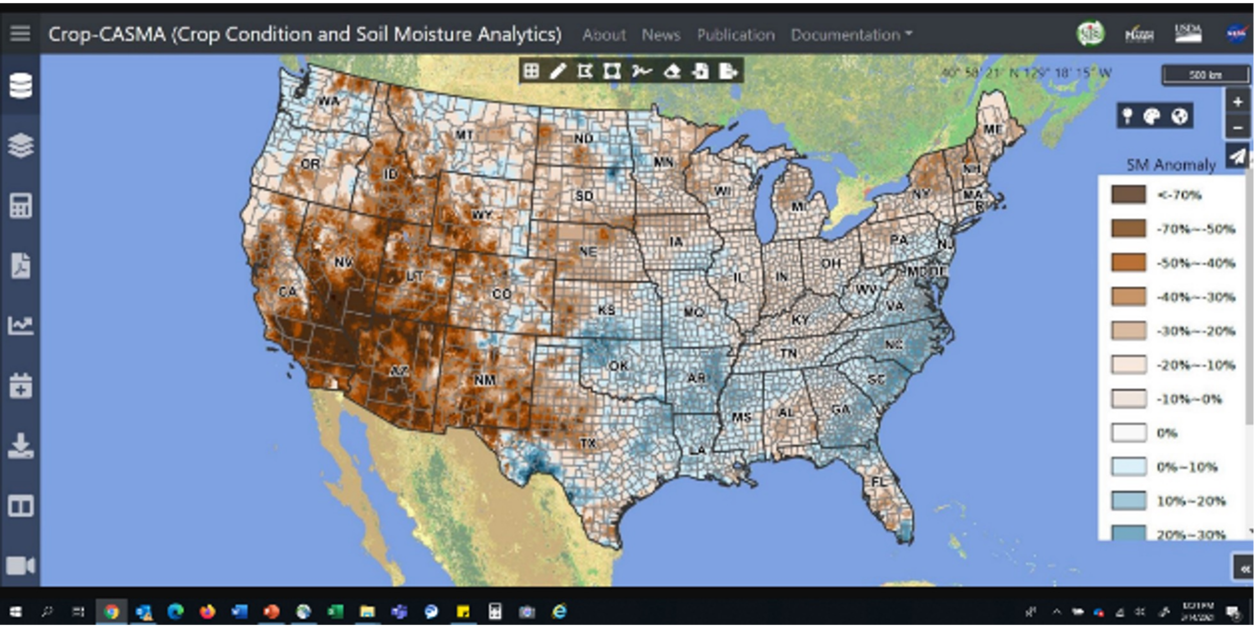
*Drought Severity Evaluation Tool is operational at Navajo Dept. of Water Resources*

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.

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