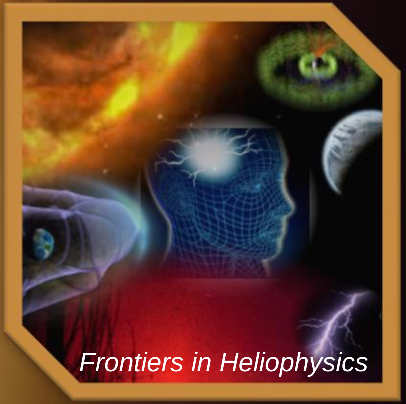

DRIVE Science Centers Briefing

HPAC

Janet Kozyra, Katya Verner
NASA HPD Program Scientists

Michael O'Rourke, Chet McCleskey
MSU Toolbox Dialogue Initiative

June 17, 2024

Fundamental Value of Research Centers

Integrative review of the literature investigating measures of team science success:

Benefits – Analysis of trends suggest:

- Major advances are produced by research teams
- Work is cited more often than that of individual researchers though both research modes are valuable
- Potentially greater scientific impact in the long term
- Cross-disciplinary diversity is assumed to lead to greater innovation

Challenges

- Discussed by the Toolbox Dialogue Initiative group in later slides
- Challenges may be acceptable if the outcomes accelerate knowledge

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1. Beth B. Tigges, Doriane Miller, Katherine M. Dudding, Joyce E. Balls-Berry, Elaine A. Borawski, Gaurav Dave, Nathaniel S. Hafer, Kim S. Kimminau, Rhonda G. Kost, Kimberly Littlefield, Jackilen Shannon, Usha Menon, and The Measures of Collaboration Workgroup of the Collaboration and Engagement Domain Task Force, National Center for Advancing Translational Sciences, National Institutes of Health

DRIVE Science Centers Origins & Vision

- First ever Heliophysics Science Centers
- High priority recommendation of the 2013 Solar and Space Physics Decadal Survey
- Part of an integrated multi-agency initiative, DRIVE (Diversify, Realize, Integrate, Venture, Educate)
- Address grand challenge topics poised for major advances
- Science that requires a research center for progress

Important Features:

- Support collaboration and deep knowledge integration – *human aspect of science teams*
- Competitive advantage in producing innovation
- Recommended in report by the National Academy of Sciences, *"Enhancing the Effectiveness of Team Science"*
- Activities included for broadening center contributions to community

DRIVE Centers Program Development Takes Into Account:

- NRC, *Solar and Space Physics: A Science for a Technological Society*, 2013
- NAS, *Enhancing the Effectiveness of Team Science*, 2015
- NAS, *Report Series: Committee on Solar and Space Physics: Heliophysics Science Centers.* CSSP, 2017 & 2018 discussion
- RFI Input from the Scientific Community, 2017
- 2017 HPAC Discussion & Individual Inputs
- 2017 – 2018 Discussions with NSF
- Research into 6 + other NASA & NSF Center Programs
- Discussions within NASA HPD
- Learning from the 2016 LWS FST Team Formation Activities
- Guided by recommendations from the NAS 2015 Team Science report

What are the Features of a DRIVE Science Center?

Potential for breakthrough science within its 5-year lifetime
Talented, diverse, multi/inter/trans-disciplinary, and fully integrated team; May include modelers, theoreticians, laboratory experimentalists, computer scientists, and observers
Empowered leadership that will define and manage all research tasks to realize the research center’s vision
Supportive infrastructure and management system
Creative, substantive activities in some of these areas aimed at: enhancing informal science education, STEM engagement & future workforce development, innovation, diversity, and/or public outreach (Broadening impacts)
Potential for impacts on other field(s) and/or benefits to society
Synergy or value-added rationale that justifies a center or institute-like approach

Phased Approach to Centers

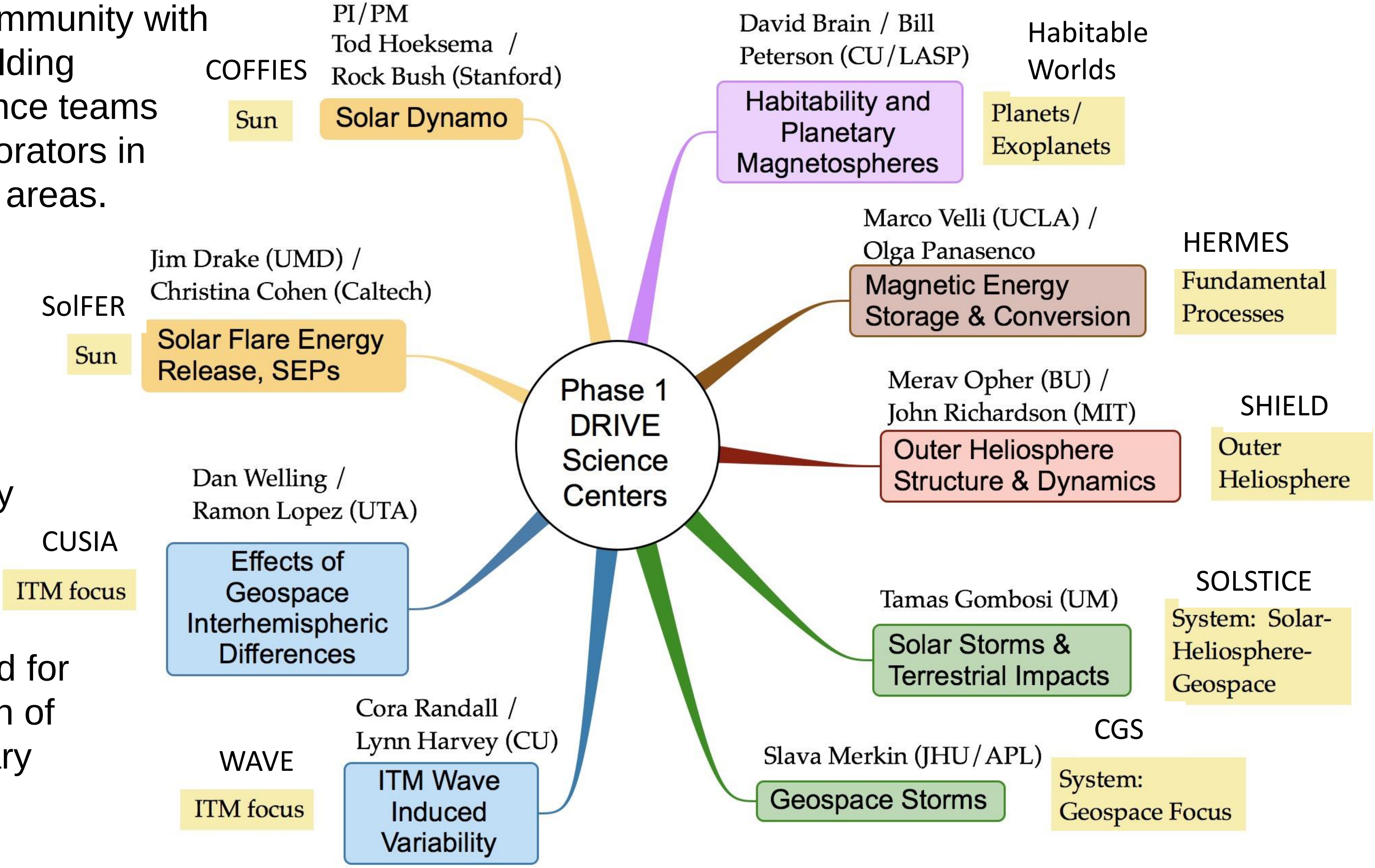
Phase I: $1.3 million over 2 years, to develop the team, build out the center's programs, and conduct critical research to demonstrate that the approach can be productive. Phase II proposal/critical review end of Year 2.

Phase II: $15 million over 5 years (up to 10 years possible with renewal) to conduct high-impact, transformative research that leads to innovation; integrated with early career and diversity elements, and informal science communication. Post-award oversight, possible renewal in Year 5 requires new/expanded science goals.

Seeding the community with expertise in building integrated science teams and with collaborators in other discipline areas.

Longer-term vision for building expertise to solve complex interdisciplinary science issues

Training ground for next generation of multi-disciplinary heliophysics researchers



Phase 1 DRIVE Science Centers

COFFIES
Sun
Solar Dynamo
PI/PM
Tod Hoeksema / Rock Bush (Stanford)

SolFER
Sun
Solar Flare Energy Release, SEPs
Jim Drake (UMD) / Christina Cohen (Caltech)

CUSIA
ITM focus
Effects of Geospace Interhemispheric Differences
Dan Welling / Ramon Lopez (UTA)

WAVE
ITM focus
ITM Wave Induced Variability
Cora Randall / Lynn Harvey (CU)

Habitable Worlds
Planets/ Exoplanets
Habitability and Planetary Magnetospheres
David Brain / Bill Peterson (CU/LASP)

HERMES
Fundamental Processes
Magnetic Energy Storage & Conversion
Marco Velli (UCLA) / Olga Panasenco

SHIELD
Outer Heliosphere
Outer Heliosphere Structure & Dynamics
Merav Opher (BU) / John Richardson (MIT)

SOLSTICE
System: Solar-Heliosphere-Geospace
Solar Storms & Terrestrial Impacts
Tamas Gombosi (UM)

CGS
System: Geospace Focus
Geospace Storms
Slava Merkin (JHU/APL)

Phase 2 DRIVE Science Center Selections

On March 17th, 2022, NASA selected three Phase 2 DRIVE Centers ($3M/YR for 5 Years):

COFFIES

Consequences of Flows and Fields in the Interior and Exterior of the Sun (COFFIES)

- Hoeksema / Stanford

CGS | CENTER FOR GEOSPACE STORMS

Center for Geospace Storms (CGS)

- Merkin / JHU / APL

SHIELD

Our Heliospheric Shield

- Opher / Boston University

DRIVE Science Centers Already Producing New Paradigms & Innovation

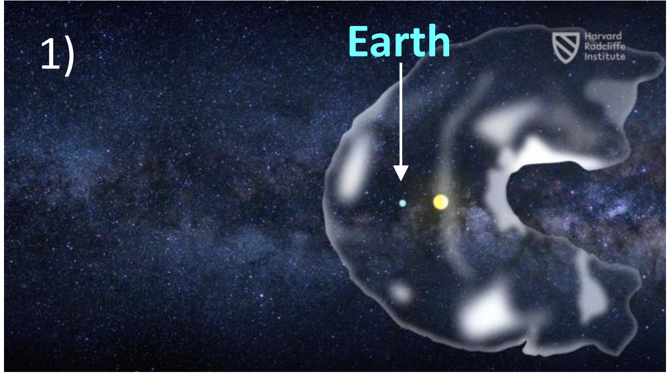
New HPD Frontier

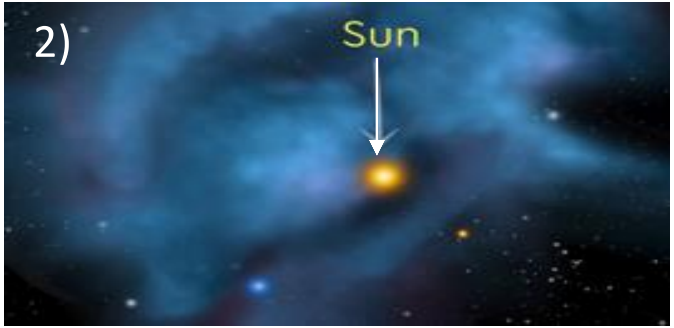
Connecting the location of the Sun and the heliosphere in the galaxy to extreme conditions on Earth

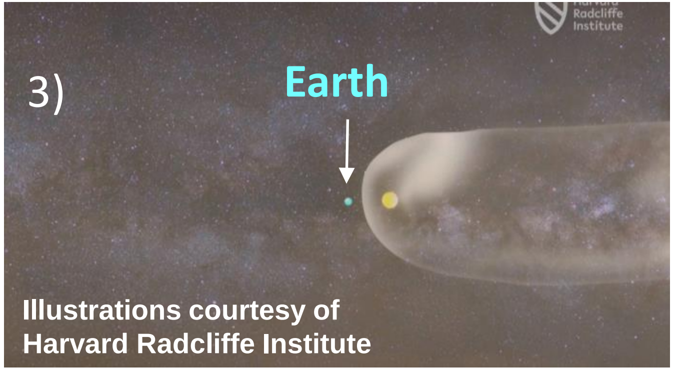
---

Launch of a new interdisciplinary science area!

- Almost certainly had a substantial impact on our planet and its climate:
  - Cold temperatures
  - Increase in hydrogen in the atmosphere
  - Enhanced radiation
- May help to explain a range of phenomena, like ice ages, diversification of species, & the extinction of dinosaurs.
- Peak in Iron-60 2-3 Myr ago seen at Earth
- Joining research in heliophysics with, astrophysics, terrestrial climate, biodiversity, and fossil records in deep-sea sediments, crust, and lunar samples





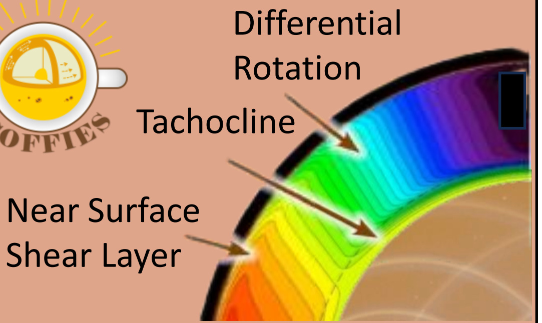


Illustrations courtesy of Harvard Radcliffe Institute

1) The Earth and Sun within the present-day “croissant-shaped” heliosphere
2) Two to three million years ago, the Sun entered a dense cold molecular cloud that would have dramatically compressed the heliosphere.
3) The SHIELD “Heliosphere Twin” model, indicates the Earth would have been outside the protection of the compressed heliosphere, leaving it exposed to the ISM and the contents of the cloud, including plutonium-244 and radioactive iron-60
4) Paper associating a second peak in iron-60 at Earth with another dense cloud encounter 7 Myrs ago, just accepted in ApJ

A possible direct exposure of the Earth to the cold dense interstellar medium 2-3 Myr ago. M Opher*, A Loeb, J Peek, Nature Astronomy, 2024. doi.org/10.1038/s41550-024-02279-8

The Solar Cycle is the Consequence of Fields & Flows

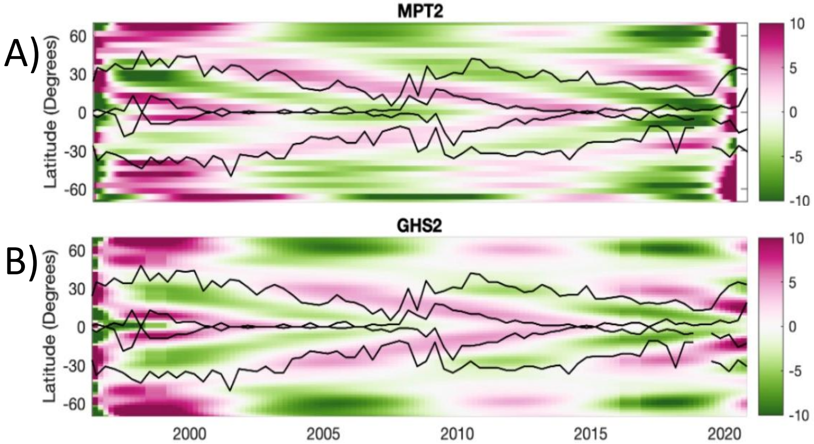


Fundamental Questions About the Sun’s Activity Cycle

- Thin shear layers at the top and bottom of the Convection Zone (CZ) can amplify magnetic fields.
- The deeper Tachocline & CZ [4,5,6] typically get most attention as the seat of the solar dynamo and the source of active region flux.
- Recently attention has focused on the Near Surface Shear Layer (NSSL) in the outer 5% of the Sun. Vasil+[9] suggests the solar cycle might reside near the surface – though that is controversial..

Near Surface Shear Layer Results Enabled by COFFIES Cross-Disciplinary Teams - Investigating some of the most difficult mysteries about how the Sun’s dynamo operates

- COFFIES Team harmonized Zonal Flow accelerations measured with tracking in photosphere and near-surface helioseismology over 2.5 solar cycles [3,8]
- First principles NSSL simulations match observations [2]
- The NSSL has 3 zones [7] The shear across the NSSL varies on global scales on time scales of several months [1]



Acceleration of EW flows from 1996-2022

Measured with Very Different techniques [3]
A): Magnetic Tracking
B): Helioseismology

All papers have COFFIES leads except [9]; Each COFFIES-led paper has contributions from multiple science disciplines; 3 led by post docs [3, 4, 5].

1. **Bogart+: 2023ApJ...950L..21B**
2. **Kitiashvili+: 2023MNRAS.518..504K**
3. **Mahajan+: 2024SoPh..299...38M**
4. **Manek+: 2022ApJ...929..162M**
5. **Matilsky+: 2024ApJ...962..189M**
6. **Pipin+: 2023ApJ...949....7P**
7. **Rabello Soares+: 2024ApJ...967..143R**
8. **Upton+: 2024SoPh, in prep.**
9. **Vasil+: 2024Natur.629..769V**

New discoveries:

CGS as a center brings together the interdisciplinary expertise to connect regions with models from the outer reaches of the magnetosphere to the surface of the Earth for the 1st time.

CGS innovations in modeling enable investigation of events from:

- Ionospheric impacts of the 15 Jan 2022 **Tonga Volcano eruption** [*Wu et al.. JGR, 2023*]
- To the rare formation of **Alfven wings** in the 24 April 2023 superstorm [*Burkholder et al., GRL, 2024*]
- Now to the **extreme penetration electric fields** during the 10-11 May 2024 superstorm and their impacts. [https://cgs.jhuapl.edu/Resources/May-10-12-Geospace-Storm.php]

CGS collaborates widely with the Helio community and raises the overall capabilities for cutting-edge research (ex: Alfven wings above).

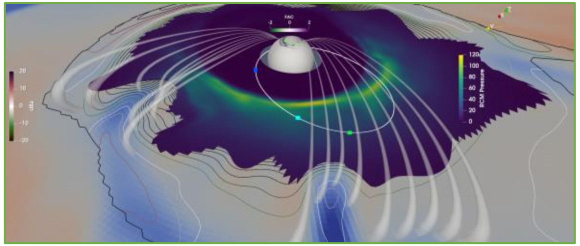
Innovations in Space Weather Modeling:

- Developing a mesoscale-resolving, data-augmented, seamlessly-coupled, Multiscale Atmosphere Geospace Environment (MAGE) model. Enables holistic modeling whereby geospace regions interact & influence each other in complex, non-linear ways.

Interdisciplinary Geospace-Atmosphere System Science Team:

- Outer magnetosphere, inner magnetosphere, plasmasphere, ionosphere, atmosphere, modeling, data analysis, software infrastructure

Plasma sheet bubbles critical to the buildup and evolution of the stormtime ring current



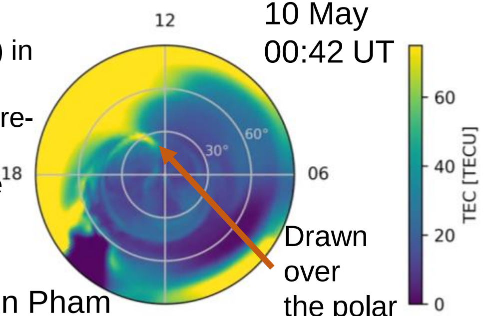
Sciola et al., (2023), JGR Space Phys

- MAGE simulation shows that plasma sheet bubbles contribute at least half of the total buildup of ring current energy during the March 17, 2013 storm
- The contribution of plasma sheet bubbles to ring current buildup is a major outstanding question with global geospace consequences.

MAGE modeling of the 10-11 May 2024 Superstorm: Faster than real-time.

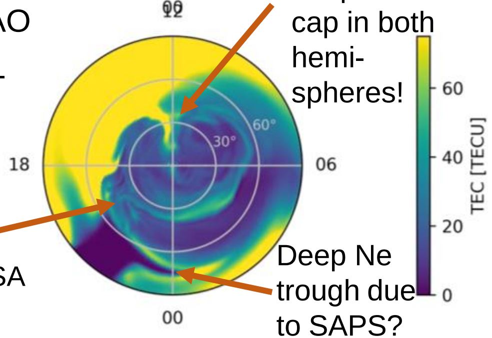
Total electron content (TEC) in fully coupled magnetosphere-ionosphere-thermosphere simulation (MAGE).

10 May
00:42 UT



Drawn over the polar cap in both hemi-spheres!

Work by Kevin Pham @ NCAR/HAO

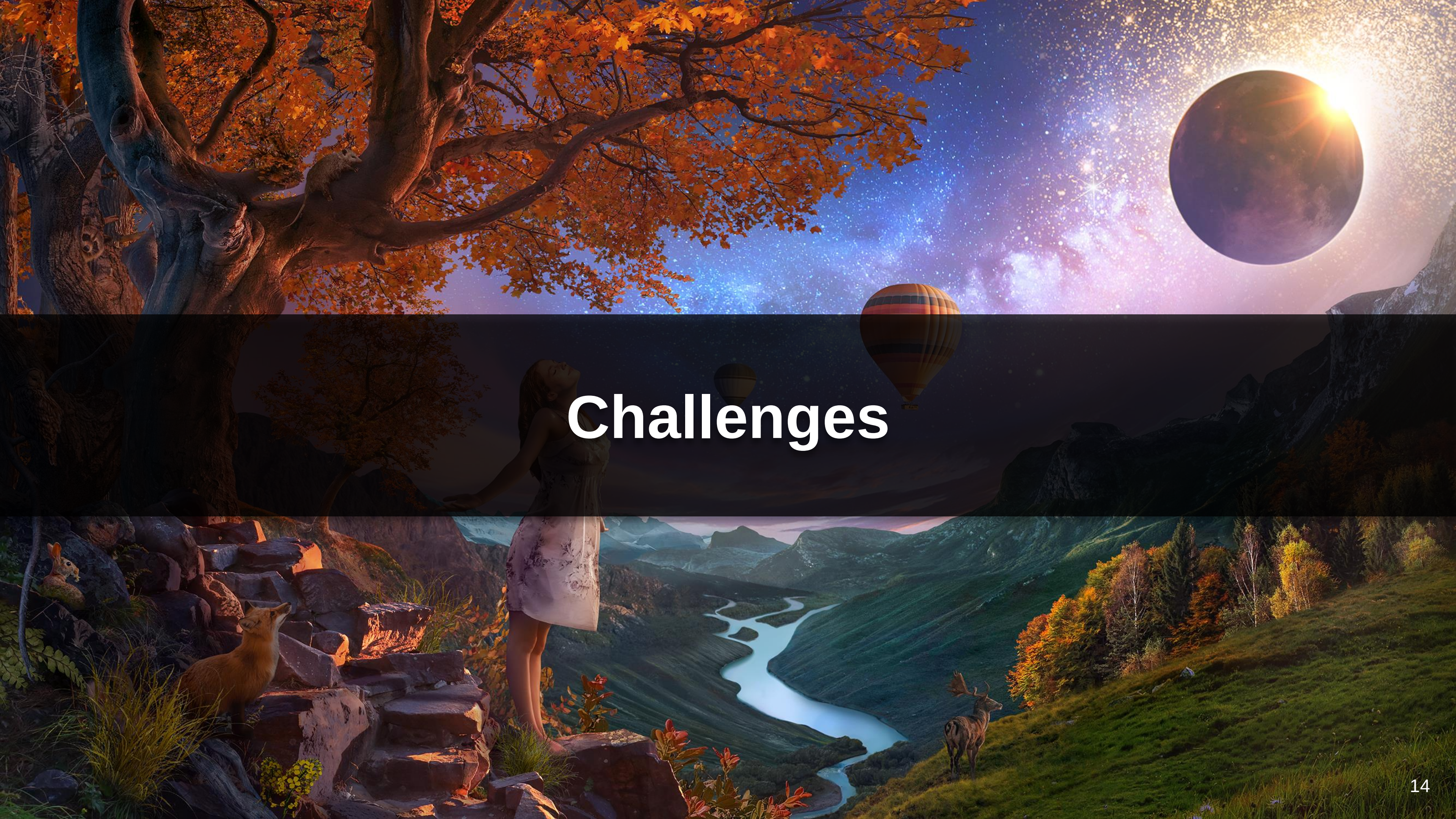


Low- and mid-latitude Ne enhancement possibly merging with the auroral oval? (cf. NASA GOLD)

Deep Ne trough due to SAPS?

Successful Centers

The Heliophysics DRIVE Science Center Program funded these centers, enabling them to produce groundbreaking paradigm shifts and innovations that will change the nature of heliophysics.



Challenges

Program Challenges

- Building and optimizing science teams
- Providing resources needed for science centers to develop
- Identifying measures of success that take into account all aspects of the DSCs

Chet McCleskey and Michael O'Rourke with the MSU Toolbox Dialogue Initiative will talk about these challenges and how to meet some of them next

Toolbox Dialogue Initiative Center

The Toolbox Dialogue Initiative (TDI) is:

A research and outreach initiative based in the Toolbox Dialogue Center at Michigan State University

Workshops:

Information Gathering

Instrument Development

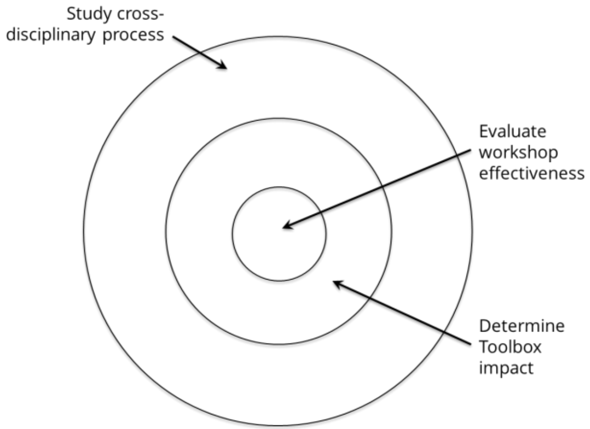
WORKSHOP

Instrument/ Dialogue/ Co-creation

Report

Reflection

Research:



Study cross-disciplinary process

Evaluate workshop effectiveness

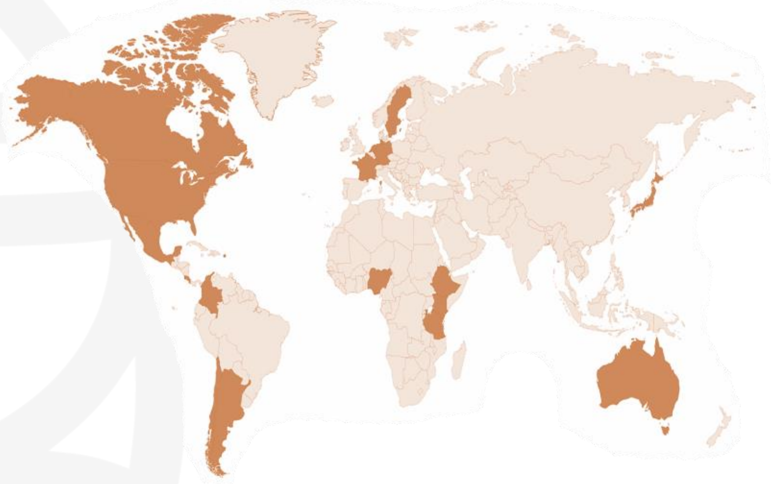
Determine Toolbox impact

Toolbox Dialogue Initiative Center

TOOLBOX
DIALOGUE INITIATIVE ™

550+ workshops around the world

21 U.S. states and territories, 16 countries



NSF
European Commission
NOAA
NASA
Pacific Northwest NATIONAL LABORATORY
PURDUE UNIVERSITY
SCRiM
UNIVERSITY OF GEORGIA
NW CSC Northwest Climate Science Center
MICHIGAN STATE UNIVERSITY
AgBioResearch

TBM

PRACTICE TOOLS

How to talk to strangers: facilitating knowledge sharing within translational health teams with the Toolbox dialogue method

Lynn M Schnapp, MD,[1] Liela Rotschy, MA,[2] Troy E Hall, PhD,[3] Stephen Crowley, PhD,[4] Michael O'Rourke, PhD[5]

Abstract

Translational behavioral medicine involves experts from different disciplines and professions interacting to solve complex problems. Coordinating this expertise can be frustrated by the partially tacit nature of expertise and by the various ways in which it manifests in different communities. We describe a method—the Toolbox dialogue method—for addressing these challenges by means of a structured dialogue among team members concerning their respective approaches to complex problems. The Toolbox dialogue method consists of a philosophically grounded questionnaire—the "Toolbox"—deployed in workshops by collaborators from different disciplines and professions. The Health Science Toolbox was modified from an extensively utilized questionnaire designed for Science–Technology–Engineering–Mathematics (STEM) research and has been piloted with translational medicine teams. Eighty-five percent of participants in STEM workshops indicated a positive impact on awareness of the knowledge, opinions, or scientific approach of teammates. In the Health Science Toolbox, 35 % of questionnaire responses changed substantially from pre- to post-worksh demonstrating impact of the workshops. The T dialogue method is a relatively brief workshop that can have a positive impact on mutual unde within translational medicine teams.

KEYWORDS

Toolbox dialogue method, Science of team Philosophy, Teamwork, Interdisciplinary co

BACKGROUND

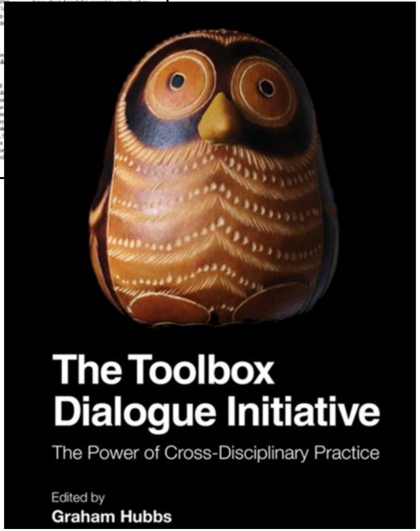
Implications

Practice: Structured philosophical dialogue about fundamental assumptions concerning collaborative research and practice in translational behavioral medicine can facilitate negotiation of key conceptual challenges.

Policy: Methods for improving aspects of team science such as collective understanding should be made available to collaborative projects in the translational health sciences.

Research: The method described in this article supports the identification and analysis of a team's collaborative dynamic.

If left unspoken, such differences can manifest as misunderstanding, disagreement, and ultimately, failure to achieve project objectives. We have developed the Toolbox method to identify and articulate these differences through structured dia-



The Toolbox Dialogue Initiative
The Power of Cross-Disciplinary Practice

Edited by
Graham Hubbs

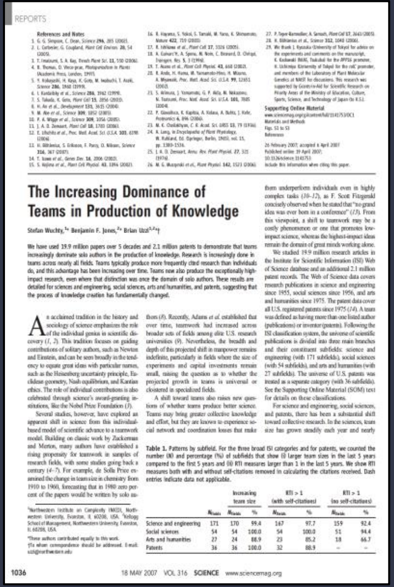
Building and Optimizing Science Teams

Teams and research

I. Grand challenges and other complex problems require complex responses

II. Interdisciplinary teams of experts allow for a variety of perspectives and disciplinary inputs to shape how problems are conceived and contribute to the solutions

III. In science, teams dominate knowledge production[*]



REPORTS

The Increasing Dominance of Teams in Production of Knowledge

Stefan Wuchty,[1*] Benjamin F. Jones,[2*] Brian Uzzi[1,2*†]

We have used 19.9 million papers over 5 decades and 2.1 million patents to demonstrate that teams increasingly dominate solo authors in the production of knowledge. Research is increasingly done in teams across nearly all fields. Teams typically produce more frequently cited research than individuals do, and this advantage has been increasing over time. Teams now also produce the exceptionally high-impact research, even where that distinction was once the domain of solo authors. These results are detailed for sciences and engineering, social sciences, arts and humanities, and patents, suggesting that the process of knowledge creation has fundamentally changed.

An acclaimed tradition in the history and sociology of science emphasizes the role of the individual genius in scientific discovery (1, 2). This tradition focuses on guiding contributions of solitary authors, such as Newton and Einstein, and can be seen broadly in the tendency to equate great ideas with particular names, such as the Heisenberg uncertainty principle, Euclidean geometry, Nash equilibrium, and Kantian ethics. The role of individual contributions is also celebrated through science's award-granting institutions, like the Nobel Prize Foundation (3).

Several studies, however, have explored an apparent shift in science from this individual-based model of scientific advance to a teamwork model. Building on classic work by Zuckerman and Merton, many authors have established a rising propensity for teamwork in samples of research fields, with some studies going back a century (4–7). For example, de Solla Price examined the change in team size in chemistry from 1910 to 1960, forecasting that in 1980 zero percent of the papers would be written by solo authors (8). Recently, Adams et al. established that over time, teamwork had increased across broader sets of fields among elite U.S. research universities (9). Nevertheless, the breadth and depth of this projected shift in manpower remains indefinite, particularly in fields where the size of experiments and capital investments remain small, raising the question as to whether the projected growth in teams is universal or cloistered in specialized fields.

A shift toward teams also raises new questions of whether teams produce better science. Teams may bring greater collective knowledge and effort, but they are known to experience social network and coordination losses that make them underperform individuals even in highly complex tasks (10–12), as F. Scott Fitzgerald concisely observed when he stated that "no grand idea was ever born in a conference" (13). From this viewpoint, a shift to teamwork may be a costly phenomenon or one that promotes low-impact science, whereas the highest-impact ideas remain the domain of great minds working alone.

We studied 19.9 million research articles in the Institute for Scientific Information (ISI) Web of Science database and an additional 2.1 million patent records. The Web of Science data covers research publications in science and engineering since 1955, social sciences since 1956, and arts and humanities since 1975. The patent data cover all U.S. registered patents since 1975 (14). A team was defined as having more than one listed author (publications) or inventor (patents). Following the ISI classification system, the universe of scientific publications is divided into three main branches and their constituent subfields: science and engineering (with 171 subfields), social sciences (with 54 subfields), and arts and humanities (with 27 subfields). The universe of U.S. patents was treated as a separate category (with 36 subfields). See the Supporting Online Material (SOM) text for details on these classifications.

For science and engineering, social sciences, and patents, there has been a substantial shift toward collective research. In the sciences, team size has grown steadily each year and nearly

Table 1. Patterns by subfield. For the three broad ISI categories and for patents, we counted the number (N) and percentage (%) of subfields that show (i) larger team sizes in the last 5 years compared to the first 5 years and (ii) RTI measures larger than 1 in the last 5 years. We show RTI measures both with and without self-citations removed in calculating the citations received. Dash entries indicate data not applicable.

		Increasing team size		RTI > 1 (with self-citations)		RTI > 1 (no self-citations)	
	N_{total}	N_{fields}	%	N_{fields}	%	N_{fields}	%
Science and engineering	171	170	99.4	167	97.7	159	92.4
Social sciences	54	54	100.0	54	100.0	51	94.4
Arts and humanities	27	24	88.9	23	85.2	18	66.7
Patents	36	36	100.0	32	88.9	–	–

[1] Northwestern Institute on Complexity (NICO), Northwestern University, Evanston, IL 60208, USA. [2] Kellogg School of Management, Northwestern University, Evanston, IL 60208, USA.

[*] These authors contributed equally to this work.

[†] To whom correspondence should be addressed. E-mail: uzzi@northwestern.edu

Teams and innovation

I. Teams with diverse expertise, knowledge, and perspectives have more conceptual resources

II. These diverse resources allow for more nuanced understanding of the problem and potential solutions

III. To properly harness those resources teams need a culture of open communication and perspective-taking[#]

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[*] Wuchty, S., et al. (2007). The increasing dominance of teams in production of knowledge. *Science* 316: 1036-1039.

[#] van Knippenberg, D. (2017). Team Innovation. Annual Review of Organizational Psychology and Organizational Behavior. 4:211–233.

Building and Optimizing Science Teams

TOOLBOX DIALOGUE INITIATIVE ™

The neurological and psychological underpinnings of team science

I. Psychological safety is critical to team functioning*
   A. Studies are connecting what we know about brains to team functioning
      1. Lack of psychological safety leads to cortisol increase and 'fight or flight' response severely inhibiting collaborative capacity
      2. Presence of psychological safety leads to increase in oxytocin levels associated with interpersonal bonding and better collaboration

II. Expert level training changes brain structure#
   A. Affects what people take as salient in a given situation/problem space
   B. Neuroplasticity leads to practice effects for not only domain expertise but reflexivity needed to appreciate others' perspectives

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* Bonnstetter, R.J., Gosselin, D. (2023). What's the Brain Got to Do with It? In "D. Gosselin (ed.), A Practical Guide for Developing Cross-Disciplinary Collaboration Skills. Springer.

\# Gosselin, D. (2023). Introduction to Crossdisciplinary Collaboration: Definitions, Systems, and the Brain. In "D. Gosselin (ed.), A Practical Guide for Developing Cross-Disciplinary Collaboration Skills. Springer.

Building and Optimizing Science Teams

Teams, centers, & agencies

I. Scholarship on teams shows not only their great potential for long term impact but also their challenges*

II. Agencies are recognizing the importance of these teams, and creating programs aimed at providing resources
   A. CTSA (NIH)
   B. STC (NSF)
   C. DRIVE Science Centers (NASA)

NASA leadership

I. On the mission side, NASA has been a leader in funding research on teams for decades

II. On the science side, they are also demonstrating leadership through the DRIVE Science Centers
   A. Recognize that you can be proactive in addressing team challenges
   B. Provide resources to support capacity building in teams

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*Beth B. Tigges, Doriane Miller, Katherine M. Dudding, Joyce E. Balls-Berry, Elaine A. Borawski, Gaurav Dave, Nathaniel S. Hafer, Kim S. Kimminau, Rhonda G. Kost, Kimberly Littlefield, Jackilen Shannon, Usha Menon, and The Measures of Collaboration Workgroup of the Collaboration and Engagement Domain Task Force, National Center for Advancing Translational Sciences, National Institutes of Health

Building and Optimizing Science Teams

Interdisciplinary team challenges

I. Diversity of expertise is key, but integrating it without washing out differences is a challenge

II. Integration requires translation across technical languages, coordination of values, reconciliation of different beliefs*, creating a conducive team culture

III. Different skills and management styles are needed to facilitate this integration

One communication challenge in particular

I. Collaborators from different cultures (e.g., disciplines, institutions) can struggle to communicate because they can understand problems differently#

II. The Problem of Unacknowledged Differences: You are different from one another, but you don't necessarily know how, and we tend to assume we're more alike than we are@

---

* O'Rourke, M., et al. (2016). On the nature of cross-disciplinary integration: A philosophical framework. SHPBBS, 56: 62–70.

NAS (2004). *Facilitating interdisciplinary research*. Washington, DC: National Academies Press.

@ Ross, L., et al. (1977). The "false consensus effect": An egocentric bias in social perception and attribution processes. *J. of Exp. Soc.l Psych*. 13(3): 279–301.

Building and Optimizing Science Teams

TDI response in general

I. Create communication and integrative practices that bring experts from different domains together
   A. Practice with reflexivity and perspective taking
   B. Experience dialogue as an integrative practice
   C. Alert participants to issues they will face and provided them with tips and practice in addressing those issues

TDI response in particular

I. Facilitate structured dialogue-based workshops that address the Problem of Unacknowledged Differences*

II. Facilitate capacity building workshops for

III. Provide follow-up consultation that prepares participants to take advantage of team science resources, e.g., collaboration agreements, customized mini-interventions

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* Hubbs, G., et al. (Eds.). (2020). *The Toolbox Dialogue Initiative: The Power of Cross-Disciplinary Practice*. Boca Raton, FL: CRC Press.

Providing Resources to Science Centers

General challenges for agencies

I. Adjust expectations and success conditions to reflect the complexity of center-based science

II. Develop funding mechanisms and resources that enhance center synergy

III. Support capacity building within the centers so that they can harness their differences in pursuit of scientific innovation

Specific challenges for agencies

I. Develop mechanisms to support integrated, team-based science
    A. Funding mechanisms
    B. Post-award support

II. Adjust evaluation metrics and approaches
    A. Different success criteria
    B. Different evaluation methods

Providing Resources to Science Centers

Addressing these challenges

I. Buy-in is critical

II. Emphasize ‘process’ from the start

III. Consistent messaging from NASA helps

IV. NASA’s culture of teamwork is deeply embedded, but teamwork and team science are not necessarily the same

  A. Dialogue between NASA and Center leaders regarding resources and evaluation criteria

TDI Center’s role

I. TDI Center has been a partner with the DRIVE Science Center Program from the start and worked with the Phase I centers

II. Activities:

  A. Deliver Toolbox workshop at NASA DSC Kick-off meeting

  B. Develop capacity building workshops and content for DSCs

  C. Provide ongoing consultation and recommendations for the DSCs

Identifying Measures of Success

Success can look different for centers

I. Publications and funded proposals are critical, of course

II. Centers are complex and combine many people and perspectives that can spark groundbreaking innovations and paradigm shifts

III. Centers can also change how science is *practiced*, and that is one goal of the DRIVE Science Center Program

TDI Center’s role

I. Work with NASA and the Phase II centers to identify measures of success related both to scientific research and practice

II. We have identified five measures that pertain to both scientific research and practice

III. We can support Phase II DRIVE Science Centers in pursuing these objectives

Identifying Measures of Success

TOOLBOX DIALOGUE INITIATIVE ™

1. Transformative scientific advances:

   Making scientific progress that could not be achieved within the framework of the standard research program?

   - Papers leveraging the Center-wide collaboration, cross-disciplinary topics and authors
   - Papers in high-impact journals
   - Invited presentations, especially at community-wide or international conferences
   - Citations & other impact measures

2. Empowering the scientific community:

   Enabling scientific advances by the community beyond the Center team and lifetime?

   - Tangible outcomes/ deliverables with community-wide reach
   - Publications using Center outcomes by external 1st authors
   - Contribution of DSC outcomes to formulation of new NASA missions

3. Impacts beyond the scientific community:

   Making impacts outside the scientific community?

   - Innovations: Development of new methodologies, tools, or technologies.
   - Effects of broadening impacts activities

Identifying Measures of Success

4. Heliophysics workforce development:

   Is the Center contributing to the development of the Heliophysics workforce of the future?

   - Publications by early-career scientists
   - Contributions to training the next generation of scientists; Mentoring; Subsequent career trajectories.

5. Center effectiveness:

   Does the Center's approach to team science maximize its impact?

   - Diversity of team members' expertise; Level of integration
   - Ability to sustain collaboration, maintain productivity, adapt to changes
   - Strength, number, density of & diversity in collaborations; No. of cross-disciplinary collaborations

Looking Ahead

I. There is no one formula to rule them all
    A. All teams are different, but share family resemblances
    B. Dialogical engagement and other best practices serve as a foundation
II. Practice makes permanent
    A. Processes help create culture and that culture spreads
III. Science benefits from these programs
    A. Scientists' experiences travel with them and impact future work, training, and thus discoveries

Future Plans

Next Steps

- Increase public awareness about the exciting research going on within the interdisciplinary DSCs
- 1st Site Visits for Phase II DSCs in late 2024 and early 2025
    - Form a site visit team and create a charter
    - Identify measures of success appropriate to an interdisciplinary center
- Refine Phase I solicitation based on lessons learned from:
    - MSU Toolbox Dialogue Initiative (TDI) team
    - DSC Directors
    - HPD Program Scientists
- Design and implementation of Phase I pre-proposal workshop
- Plan for solicitation of new Phase I DSCs in 2025

Next Steps – Broad Impact

- Many layers of communication (DSCs, research community, broader community)
- Collaboration between DSCs
  - Visualization
  - HBY
  - Inclusion, Diversity, Equity, and Accessibility Activities
  - Open Science, Software, & Data

Resources:

- https://shielddrivecenter.com/
- https://cgs.jhuapl.edu
- https://coffies.stanford.edu

Celestial spectators come out for KIPAC's solar eclipse viewing party

Read next:
Melinda French Gates is the 2024 Commencement speaker at Stanford

Future Vision for DSCs

Robust program of multiple 2-year Phase I and 5-year Phase II Centers

Exciting progress on complex Heliophysics frontier science topics

Continuous seeding of the community with experience in high-functioning interdisciplinary teams

Development of relationships with researchers in other discipline areas – source of innovation

Investment in Phase I & II teams’ experience and refinement of frontier science issues leveraged into other research opportunities (NASA, NSF, NOAA, AFRL, etc.)

Increase in diversity/culture of inclusion, STEM engagement, workforce development, contributions to science literacy

Innovations that benefit science and society

Thank You! Questions?