Agile Collaboration: Citizen Science as a Transdisciplinary Approach to Heliophysics

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Motivation

Solving Grand Challenges in Heliophysics requires novel techniques and methods...

Macro trends:

- Heliophysics missions are generating increasing amounts of data.
- Groundbreaking science often requires analyzing large volumes of data, and the amount of data to process can be overwhelming.

Opportunities:

- Data collected by the general public may be integrated into the space weather research-to-operations-to-research (R2O2R) framework (e.g., using Aurorasaurus aurora sightings to refine the OVATION Prime model (see Kosar+ (2018)).

This solar maximum is an opportunity to connect and engage with the public.

Acute need:

- We need accurate education of space physics concepts around solar maximum. Does the general public know why Heliophysics is important or how space weather impacts them?

What is citizen science?

"Organized research in which members of the public engage in the processes of scientific investigations by asking questions, collecting data, and/or interpreting results (Citizen Science Central)"

Principles of Citizen Science

- Generates new knowledge or understanding.
- Has a genuine scientific outcome.
- Citizen scientists participate in the scientific process.
- Citizen scientists receive feedback and reciprocity.
- Engages the public and democratizes science.
- Citizen scientists are acknowledged.
- Projects and programs are evaluated.

STEVE
Figure from Nishimura+ (2023).

Agile Collaborators

Citizen scientists are agile collaborators. Agility, in the science context, is the extent to which a person, group or people, technology, or project can work efficiently, pivot, and adapt. **Aurora chasers are agile collaborators.**

Aurora chasers... create scientifically-valuable data

- Data quality depends on the quality of the project's design.
- The quality of directly-sourced data (e.g., aurora photos) depends on who produces them. However, aurora chasers already value the scientific capabilities of their photos.
- The capabilities of consumer off-the-shelf (COTS) cameras rivals scientific-grade instrumentation in some scenarios.

Examples of creating scientific impact:

- High spatial and temporal resolution-recording of auroral phenomena (e.g., Nishimura+ (2023)).
- Comparisons between auroral structures seen from space (e.g., VIIRS, MAAX, CINEMA) and the ground. See the comparison to the right.

The same mesoscale auroral forms can be seen in satellite imagery (top) and citizen science imagery (bottom). Image Credit: Donna Lach

Aurora chasers... have both contributory and experiential expertise

Contributory expertise:

- Those with contributory expertise may be experts in other fields. These preexisting skillsets can be leveraged in collaborations with scientists.

Experiential expertise:

- Aurora chasers have a deep understanding of auroral behavior and patterns gained through experience in the field.
- Most aurora chasers have seen the aurora more times than auroral scientists have...

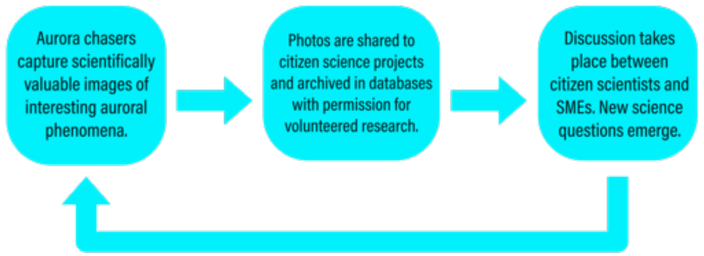
Integrating a variety of scientific backgrounds and stakeholder perspectives to solve scintific problems is called transdisciplinary science!

Vincent Ledvina and Justin Anderson aurora chasing in Churchilll, MB.

Aurora chasers... link SMEs with the general public

- Cultivating relationships between scientists and citizen scientists brings awareness to Sun-society issues and helps inspire public interest in STEM.
- Citizen scientists in online aurora chasing communities directly communicate with subject matter experts (SMEs), facilitating a positive feedback loop that encourages scientific discussions and more targeted observations.

INFORMATION FLOW IN AURORA CHASING COMMUNITIES

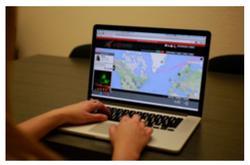


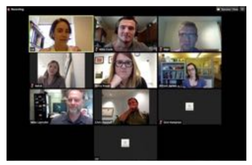
Aurorasaurus

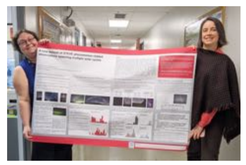
- Crowdsourced aurora sightings on aurorasaurus.org.
- Provides more accurate predictions of auroral visibility.

Facilitating agile collaboration

- Ambassador network connects citizen scientists with SMEs.
- Project design leverages aurora chasers' inherent agility.
- Educational content teaches participants the science and how to use the platform.
- Project iterates and adapts to changing technologies and user needs.





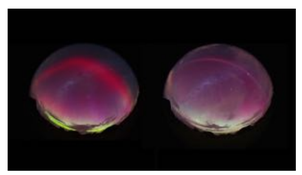


Recent Discoveries by Aurora Chasers

STEVE

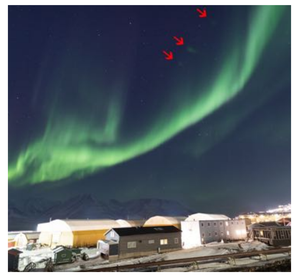
- "Backronym" - stands for Strong Thermal Emission Velocity Enhancement.
- White/mauve broadband emission with accompanying green picket fence features.
- First observed by Carl Størmer and others in 1911 on photographic film.
- Modern-day scientists thought it to be a proton arc and subvisual, but in 2018, citizen scientists (mainly in the Alberta Aurora Chasers) shared photos of this proton arc and named it STEVE.

Størmer called STEVE a "feeble homogenous arc of great altitude." Figure from MacDonald+ (2020).



SAR Arc turning into STEVE
Figure from Martinis+ (2021).

RAGDA; Credit: Malle Einaste



FAEs; Credit: Sophie Cordon

"Friends" of STEVE

- The discovery of STEVE led to renewed interest into other rare auroral phenomena and subsequent citizen science investigations.
- Red Aurora with Green Diffuse Arc (RAGDA) was named by Finnish observers and is associated with proton aurora.
- Stable Auroral Red (SAR) arcs may be a precursor to STEVE and tend to occur under similar circumstances and environments.

Dunes

- Modification of a "dune shelf" made of diffuse aurora by gravity waves in the mesopause.
- Discovered by Finnish citizen scientists in 2020.

Fragmented Auroral Emissions (FAEs)

- Relatively unknown phenomenon with only a handful of observations.
- Appearance similar to the streaks seen in STEVE's picket fence.

RAGDA; Credit: Malle Einaste

I would like to acknowledge the Space Weather Workshop for granting me student travel funding to attend this conference and present these views.