Science Utilizing Data from Spire Global as part of the NASA Commercial SmallSat Data Acquisition (CSDA) Program

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Pre-CSDA Background

In November 2017, NASA initiated a pilot activity investigating the utility of commercial small satellite data for NASA research and applied science activities

- Evaluation performed to assess data in their ability to augment or complement existing NASA observations

Initial evaluation focused on three vendors

- Spire Global (GNSS Science)
- DigitalGlobe (Imagery)
- Planet (Imagery)

Pilot activity ended in early 2020

- Final report and project summaries available via CSDA webpage
  - https://earthdata.nasa.gov/csda

CSDA: Program Background

Out of the pilot, the CSDA was created as a follow-on to the pilot with these objectives:

- Establish a continuous and repeatable process to onramp new commercial data vendors and evaluate data for its potential to advance NASA's Earth science research and applications activities.
- Enable sustained use of purchased data for broader use and dissemination by NASA scientific community.
- Ensure long-term data preservation through establishment of data management processes and systems to support rapid evaluation; access and distribution of purchased data; and long-term access to purchased data for scientific reproducibility.
- Coordinate evaluation and scientific use with the European Space Agency (ESA) as part of the Joint Program Planning Group activities for data from commercial third-party missions.

As a results of the pilot, NASA entered into purchase agreements for "sustained use" from two of the pilot vendors

- *Spire Global*
- Planet

Sustained Purchase of Spire Data

As part of the initial sustained purchase agreement with Spire, NASA agreent o

- Purchase Spire's Earth Science data catalog for an 18 month period beginning on 1 Nov 2019
- Receive data deliveries on a 30-day latency

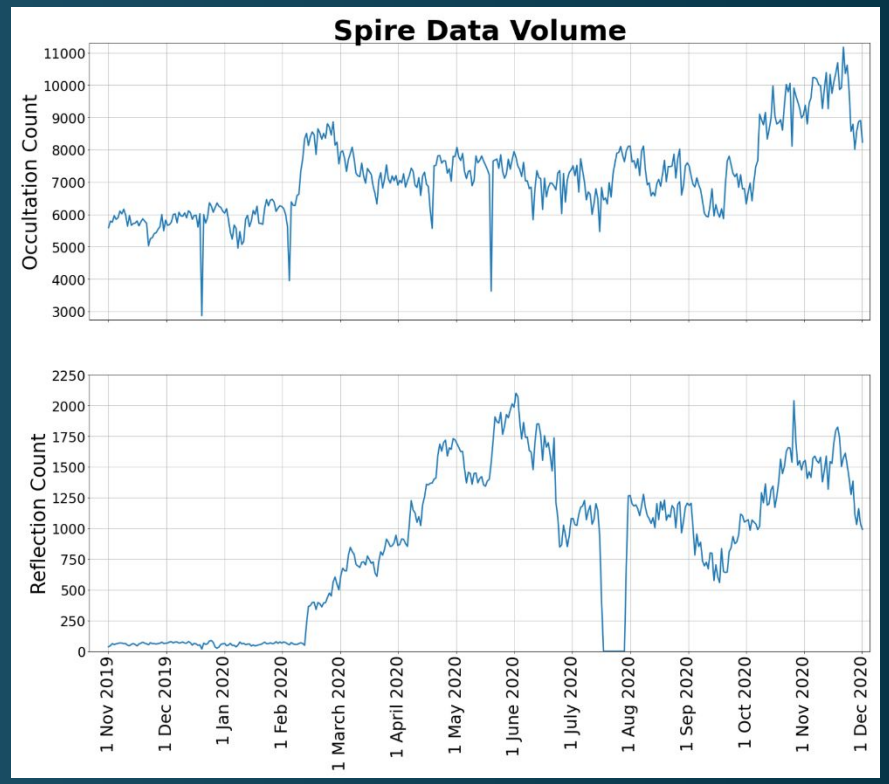
The data holdings, including those acquired during the pilot, are shown to the right

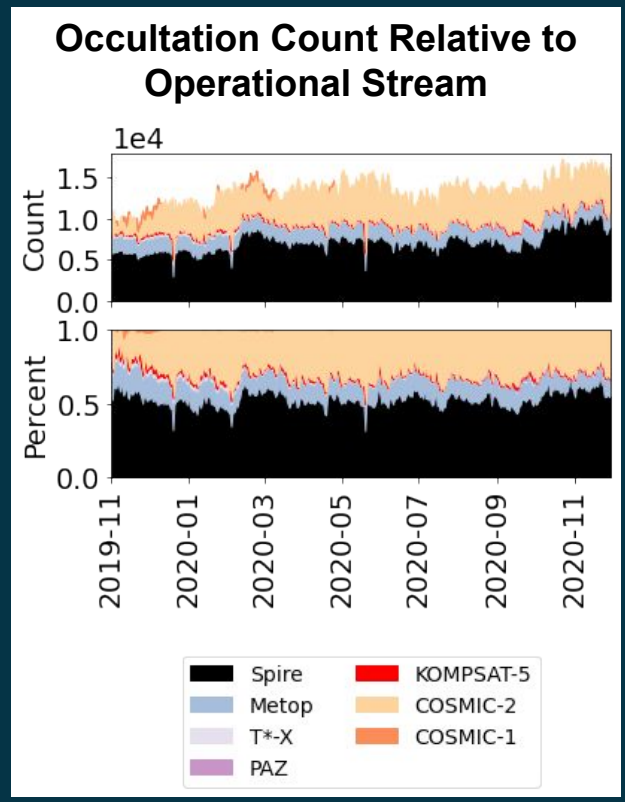
Additionally, NASA is acquiring additional datasets from Spire for evaluation and future integration into the data catalog

- L2 Grazing Angle Reflectometry
  - Sea ice, altimetry
- L1 & L2 Bistatic Radar
  - Wind Speed, Soil Moisture

Product Class	Dates	Product Level	Short Name	Format
GNSS Radio Occultation	24 Sept - 9 Dec 2018	L1A	opnGns	Binary
	14 Dec 2018 - 8 Mar 2019	L1B	atmPhs	NetCDF
	1 Nov 2019 - onward	L2	atmPrf	NetCDF
			bfrPrf	BUFR
GNSS Grazing Angle Reflectometry	9 Jan - 18 Apr 2019	L1A	grzObs	NetCDF
	1 Nov 2019 - 17 July 2020			
	30 July 2020 - onward	L1B	grzRfl	NetCDF
Satellite Precise Orbital Determination (POD) and Satellite Attitude	24 Sept 2018 - 18 Apr 2019	L1A	leoAtt	ASCII
	1 Nov 2019 - onward		telAtt	CSV
			podObs	RINEX
			leoOrb	SP3
Total Electron Content	1 Nov 2019 - onward	L1B	podTec	NetCDF
Scintillation	1 Nov 2019 - onward	L1B	scnLv1	NetCDF
Ionospheric Profiles	1 Nov 2019 - onward	L2	ionPrf	NetCDF
Magnetometer	1 Nov 2019 - onward	L1A	magObs	CSV
Raw Intermediate Frequency	17, 20, 21 June 2020	L0	rocRIF	Binary
	8 Sept 2020			

Sustained Purchase of Spire Data

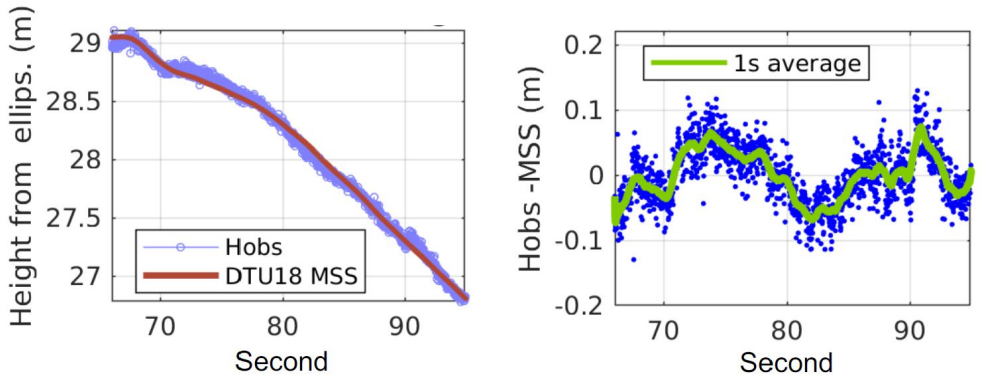




Data volume of the Spire data RO (left, top), as well as its relative contribution to the operational RO data streams used in DA (right). Also shown is the grazing angle reflectometry data volume (left, bottom)

NASA Science Utilizing Spire Data

Ice and Water from Grazing Angle Reflectometry



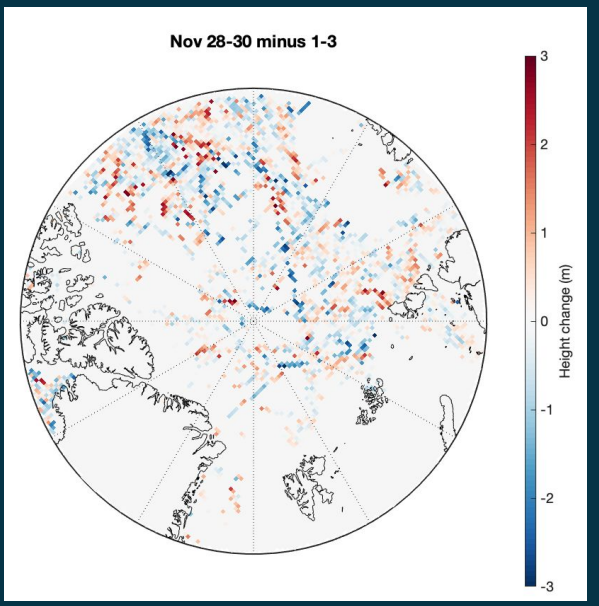
The retrieved (left, blue) and mean (left, red) sea surface height. The difference of the two (right, blue) illustrates the SSH variability seen in the observations

- *Accuracy of < 10 cm^{-1}, and the precision was ~2.5 cm over 1 sec intervals*

(S. Nerem, U. of Colorado)

Assessment of altimetry product shows signals in 30-day sea ice height change

- Below the 90-day repeat cycle of IceSat-2

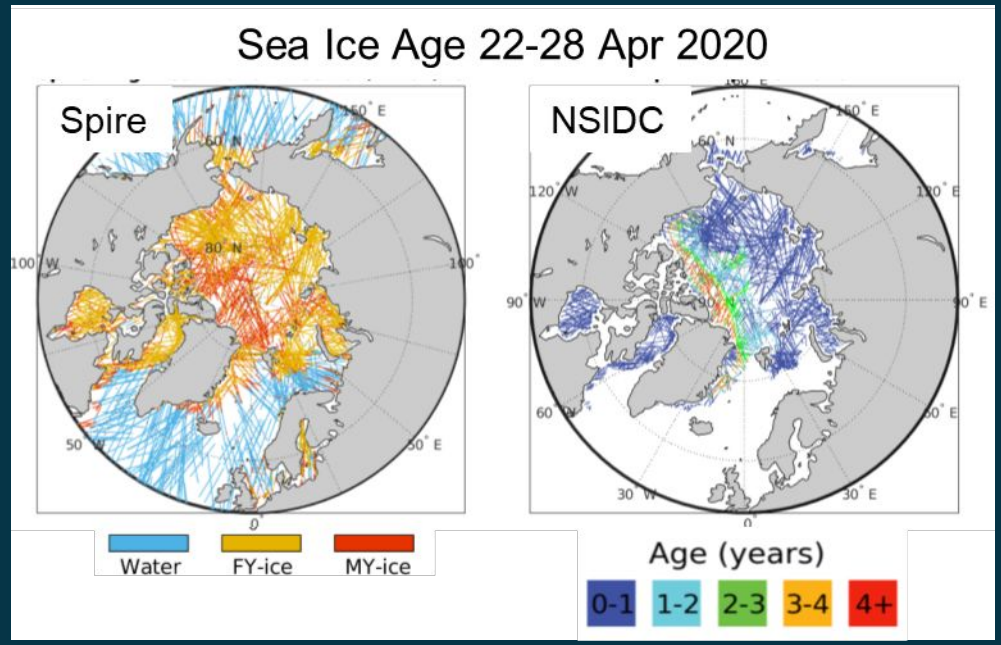


(L. Andrews, NASA/GSFC)

Ice and Water from Grazing Angle Reflectometry

Comparison between Spire Sea Ice product (left) and NSIDC product (right)

- Data sampled to reflection points
- Ice edges well depicted, based on coherency of reflections
- Spire capable of detecting first-year and multi-year ice, on a weekly timescale, that is consistent w/ NSIDC product



(J. Morton, U. of Colorado)

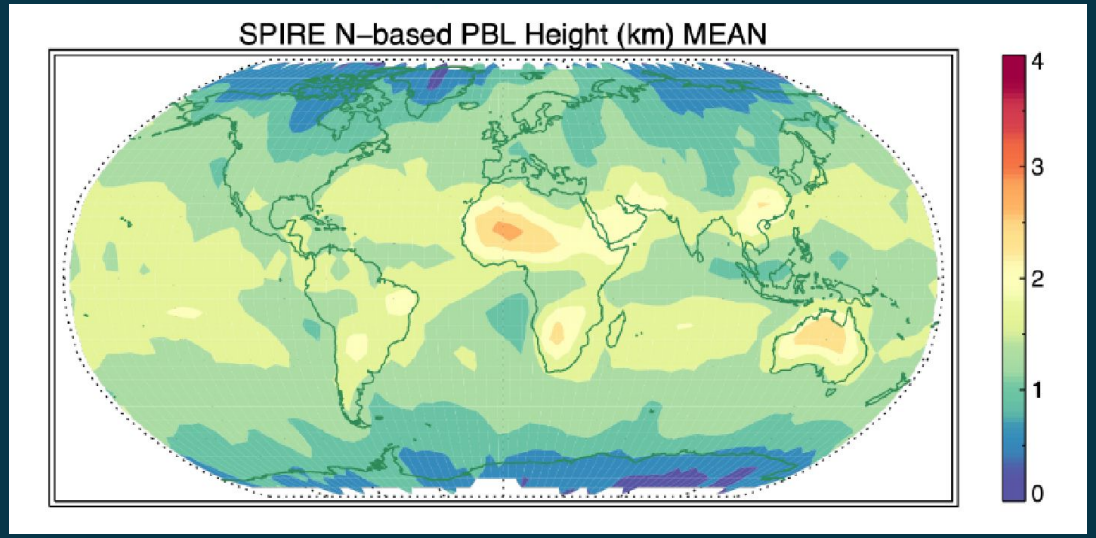
Detecting the PBL via Radio Occultation

Spire data were capable of detecting the height of the Planetary Boundary Layer (PBL)

- PBL height corresponds to sharp refractivity gradients
- The penetration depths of the observations were noted to exceed those of previous observations.

Potentially important role for radio occultation in the context of the PBL Decadal Survey Incubation-Class observable

- PBL science won't be tackled by a single observable



(W. Schreiner; Z. Zeng, UCAR)

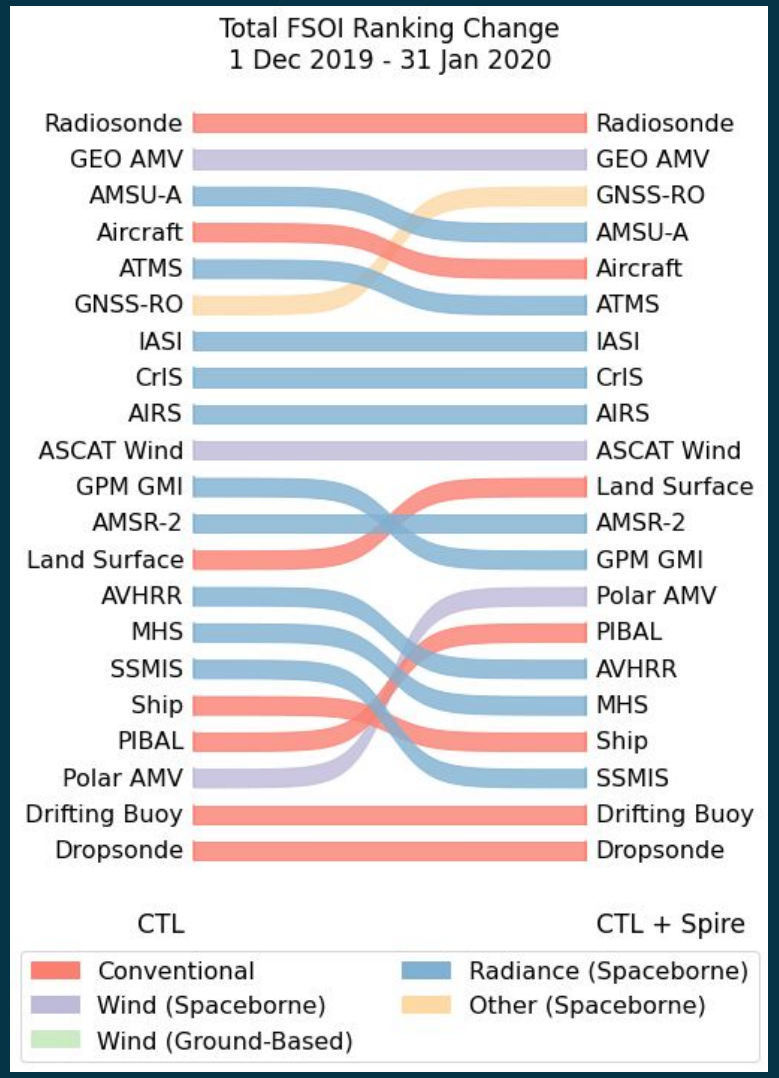
Quantifying the Role of Commercial RO Data on Numerical Weather Prediction

Spire data was shown to have a positive benefit on the GEOS Atmospheric Data Assimilation system

- Even on top of COSMIC-2, the data still improved tropical skills
- Largest impacts seen in Southern Hemisphere
- This is for a period ~6000 occ./day; receiving > 10000 occ./day in recent months

The figure shows that via the FSOI metric, RO has a larger global impact on reducing short-term forecast skill than any single passive radiance observing system

(W. McCarty, NASA/GSFC)



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More data assimilation results Thursday @ 8:50 AM EDT

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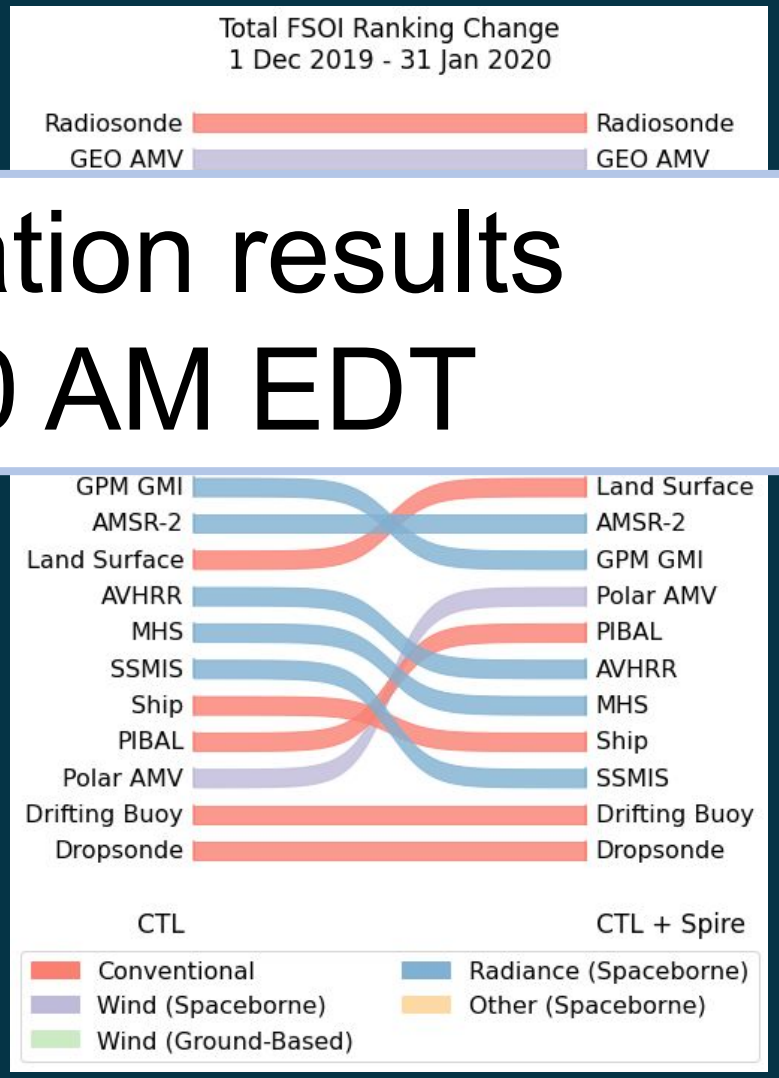
(W. McCarty, NASA/GSFC)

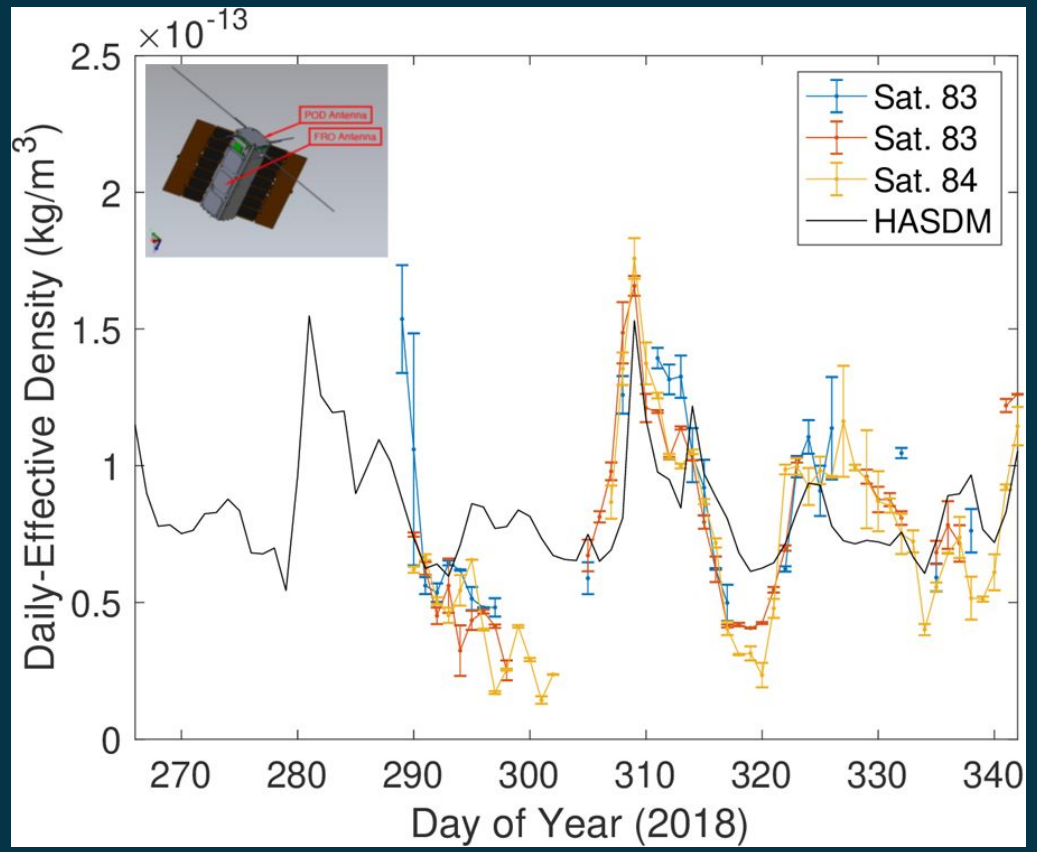


Thermospheric Density via POD

Spire POD measurements could determine the day-to-day variability of thermospheric density at flight level

- Feedback to Spire resulted in an improved product (telAtt):
- Higher-rate attitude data (0.1 Hz vs. 1 Hz)
- Satellite attitude both in all modes of operation

Inverted thermospheric density consistent satellite-to-satellite, matching trends forecasted in USAF High Accuracy Satellite Drag Model (HASDM)



(E. Sutton, U. of Colorado)

Distributing Spire Data for CSDAP

Data is currently available to NASA-funded researchers

- Via the Smallsat Data Explorer (SDX)
  - https://earthdata.nasa.gov/esds/csdap/sdx (requires EarthData login)
- Data being mirrored at NASA Center for Climate Simulation (NCCS)
  - Accessible on both discover and ADAPT systems

The SDX tool is good for discovery, but suboptimal for large data acquisitions

- Reach out to the data management team (via CSDA website) and Project Scientist (me, will.mccarty@nasa.gov)
- We don't want data access to hold your research up

Perennially looking for more users. Please reach out!

- CSDA falls under earth science, but we have a lot of space weather products!

https://earthdata.nasa.gov/csda/