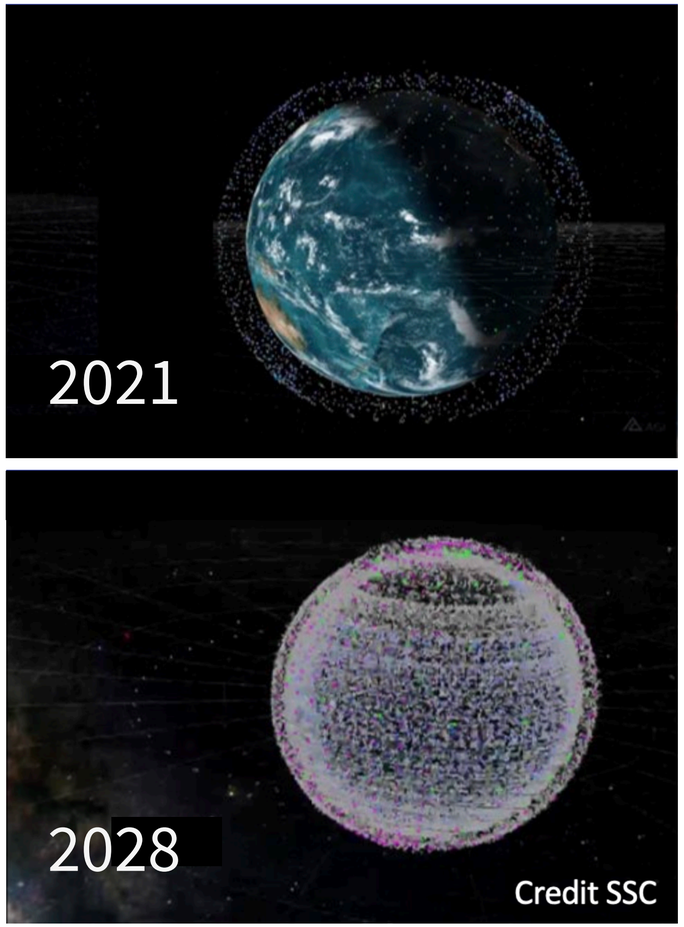
@merrdiff

@mrawls

Overview of Satellite Streaks in Rubin and Beyond

Meredith Rawls | Rubin PCW Satellite Constellations | August 9, 2022

This is a new era for Earth's orbital space environment



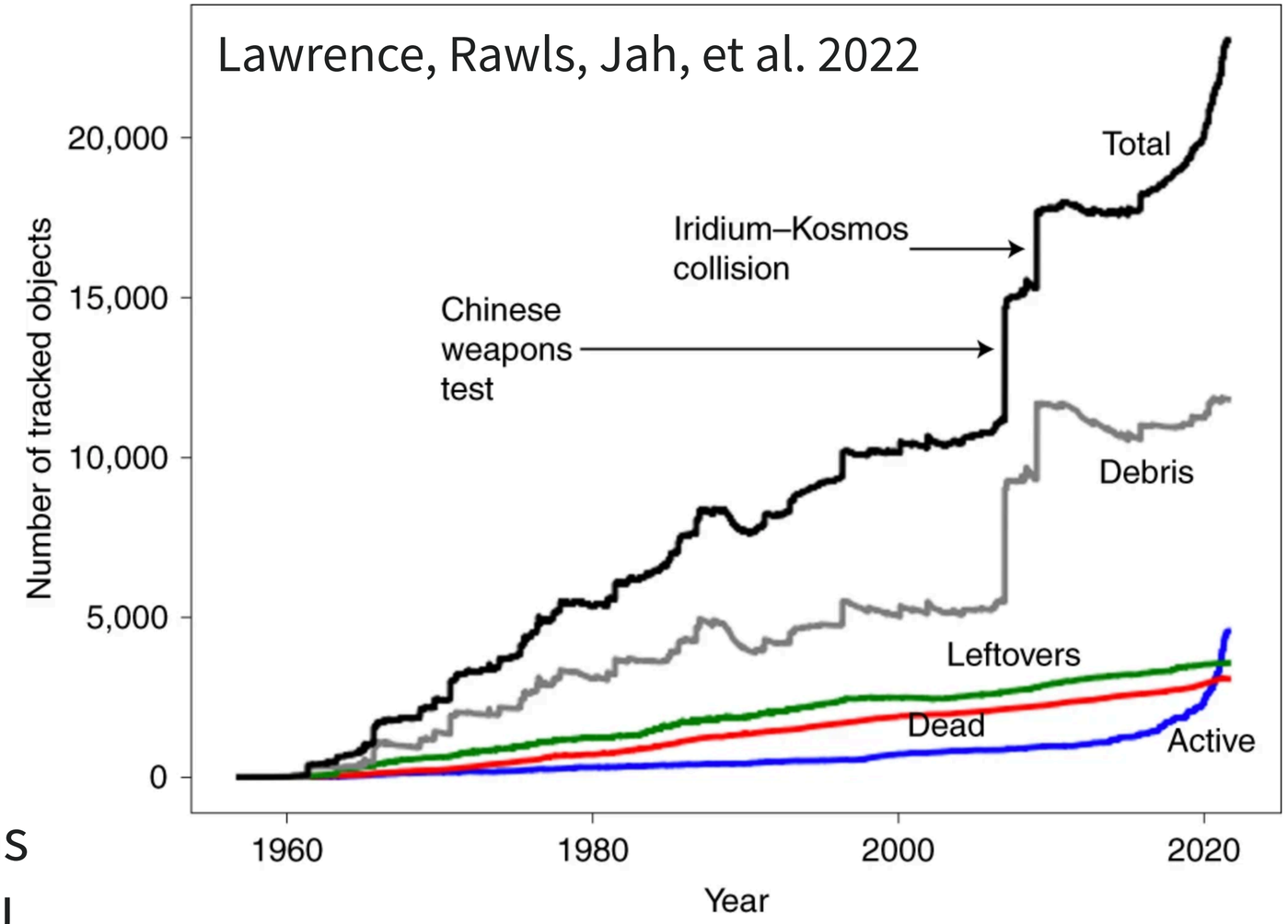
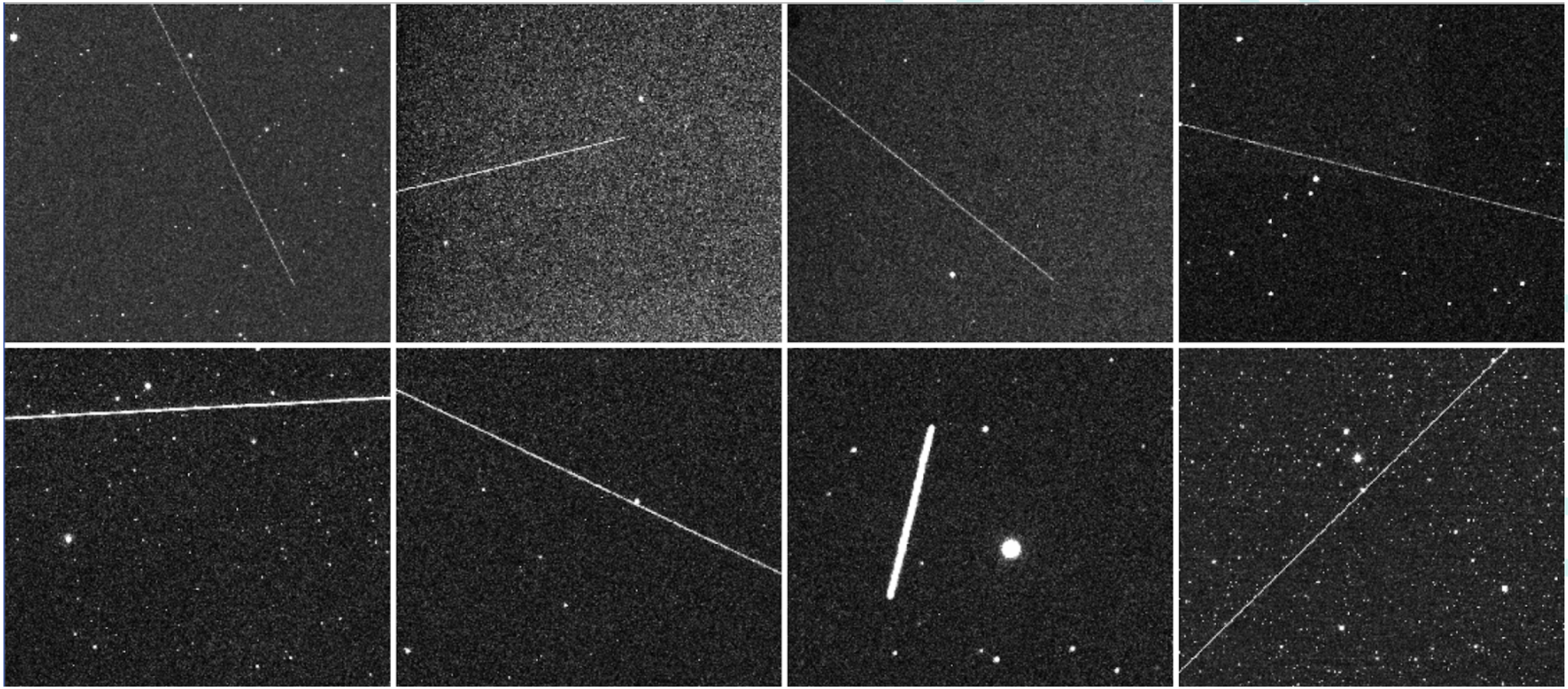


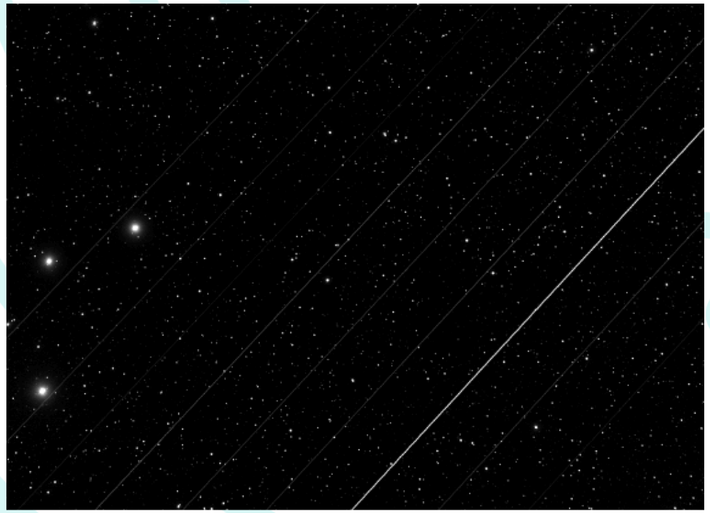
Illustration based on applications filed with the US FCC and the ITU

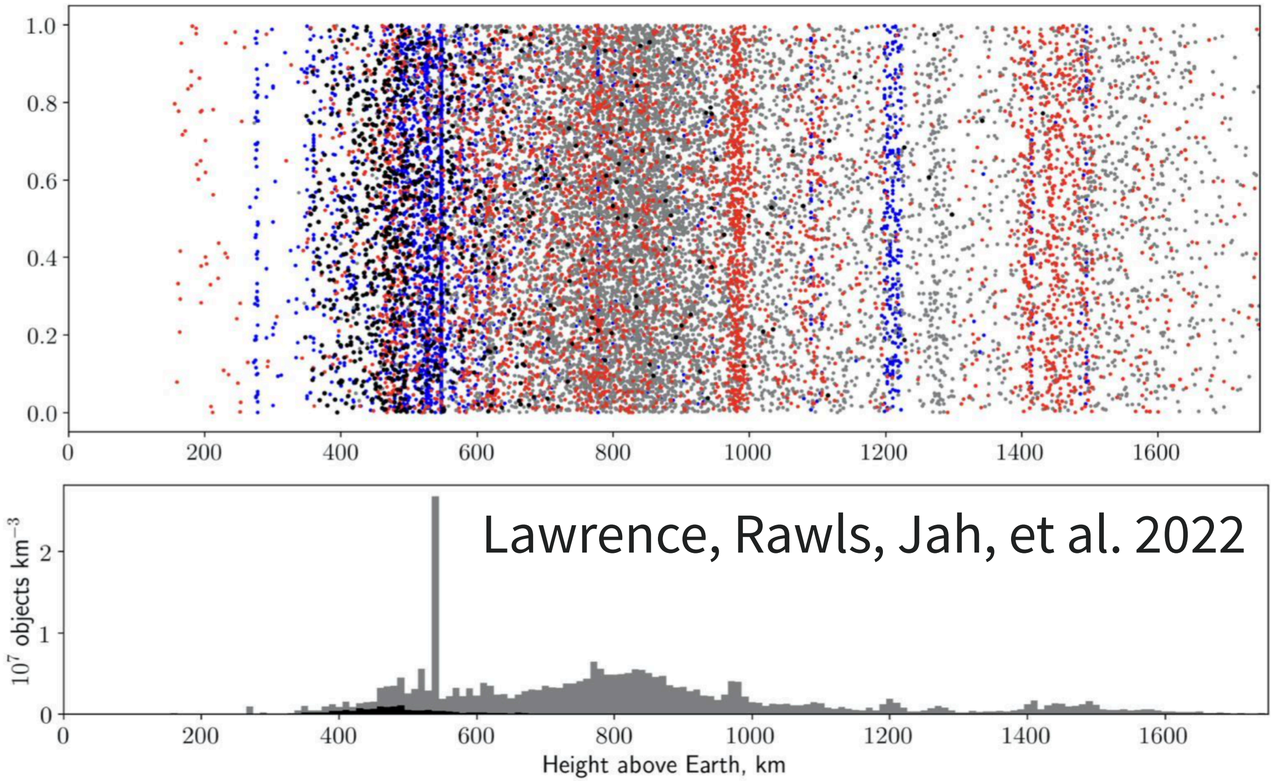
A handful of recent satellite photobombs



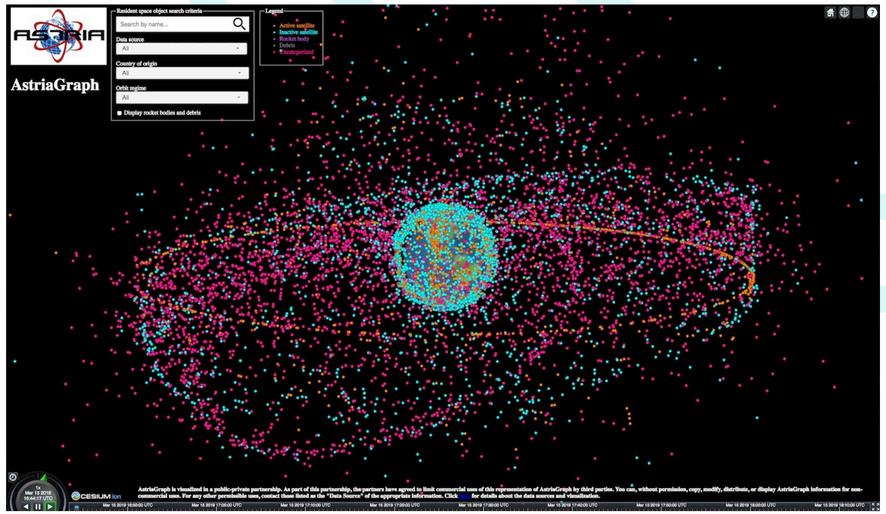
Hugely increasing rate of new commercial satellites

- Most prevalent near twilight, but some **illuminated all night long**
- Impacts are worst for large wide-field ground-based facilities
- New satellites launching and old ones de-orbiting





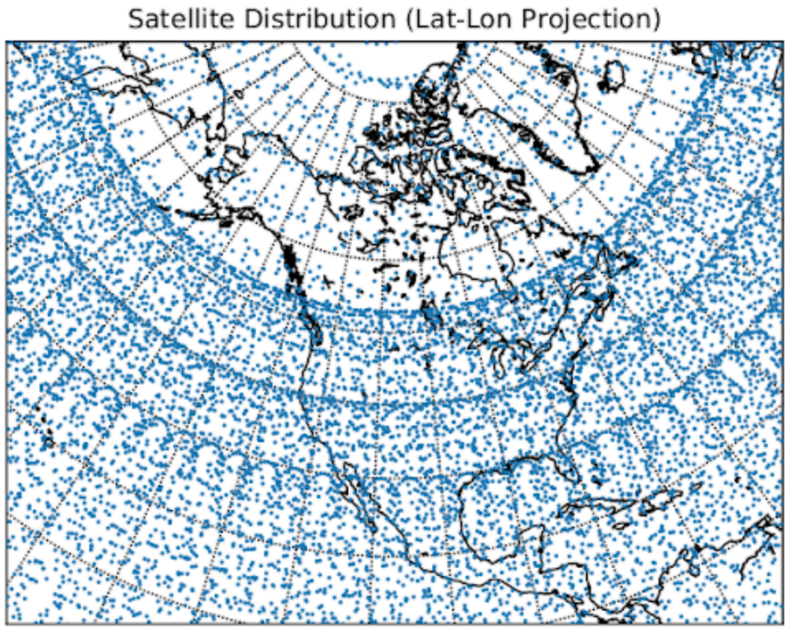
Lawrence, Rawls, Jah, et al. 2022



Orbital space is a human environment in need of preservation

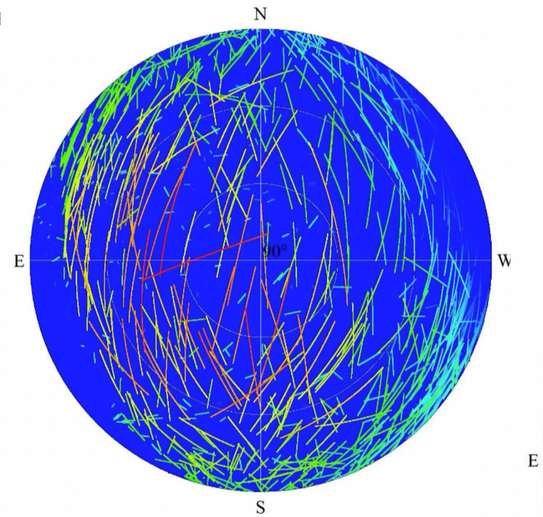
- We rely on the orbital space environment by looking through it and working within it
- Cumulative effects — a critical framework
- Beyond impacts to astronomy, we must consider impact on the public access to the sky, collision impacts on space operations, atmospheric pollution, ground and airspace collisions, animal and plant ecosystems, and space weather issues

The case for space environmentalism
Lawrence, Rawls, Jah, et al. 2022
Nature Astronomy



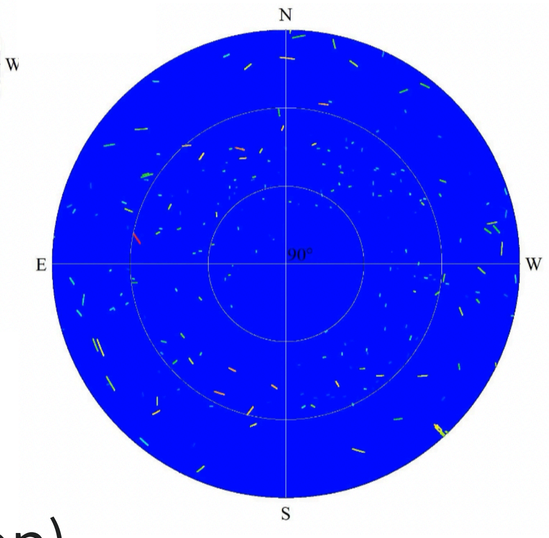
Lawler et al. 2021

Rubin's potential for discovery is also its vulnerability to LEO satellites

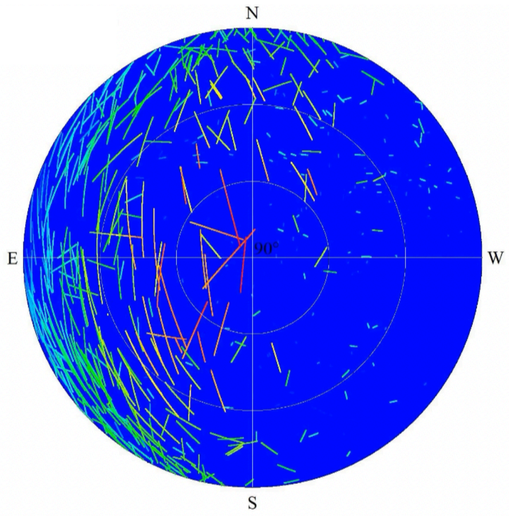


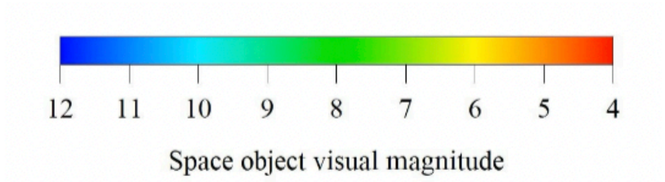
Evening twilight from Rubin site (July 2020 sat pop)

Middle of night



Nearing sunrise

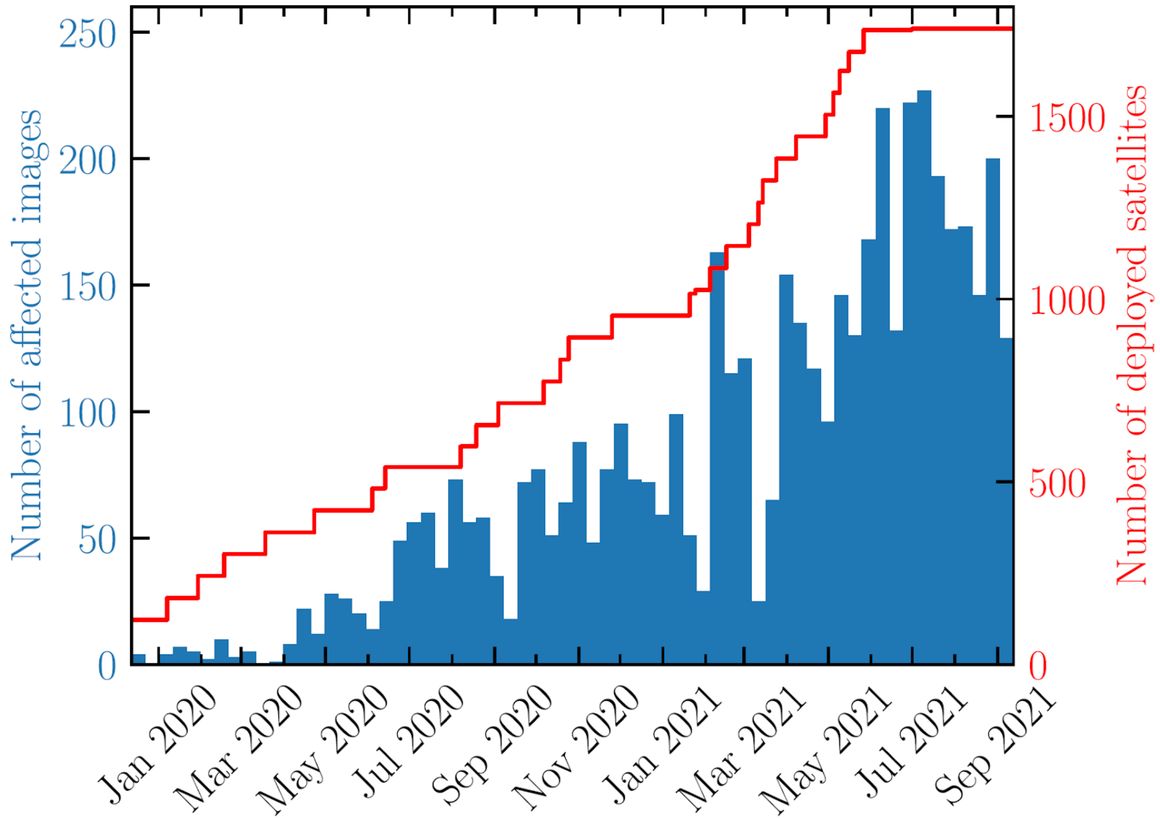




Simulation: Moriba Jah

- Wide field of view
- Sensitive to faint things
- Looking for "bumps in the night"
- Imaging subtle cosmic structures

Current impacts on the Zwicky Transient Facility (kind of a mini Rubin)



"Despite the increase in satellite streaks observed during the analyzed period, the current science operations of ZTF are not **yet** strongly affected."

Mroz et al. 2022

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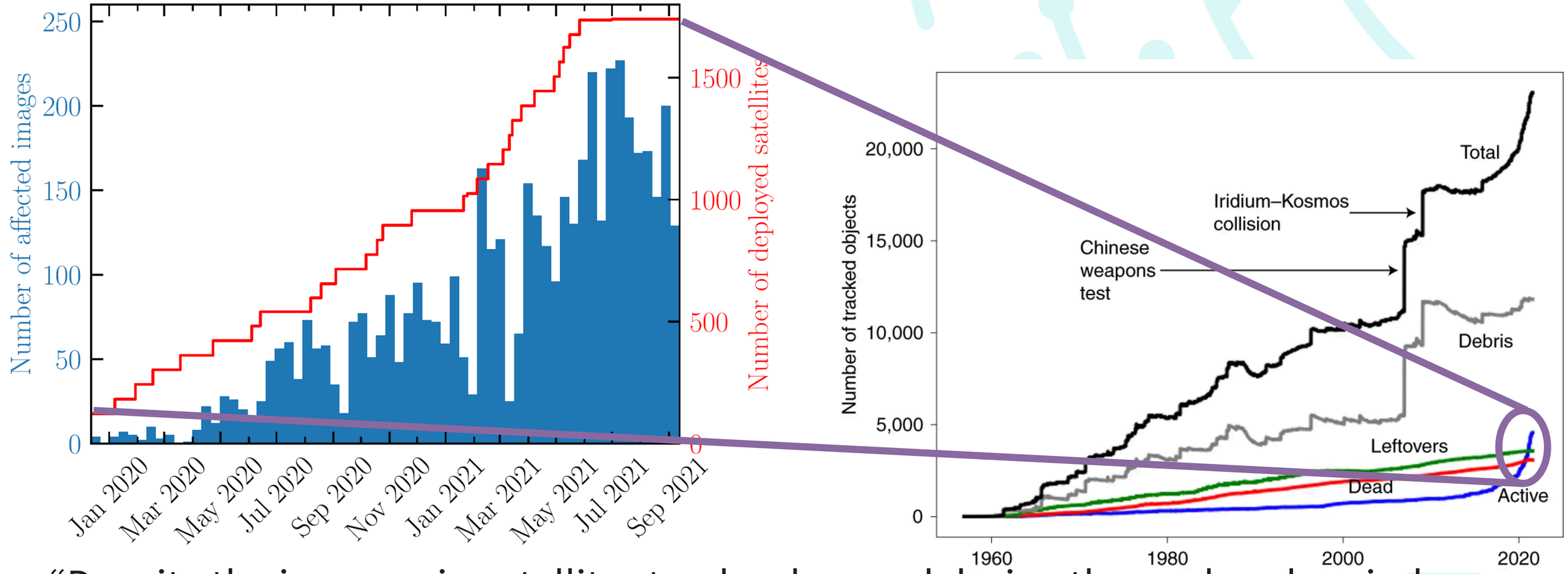

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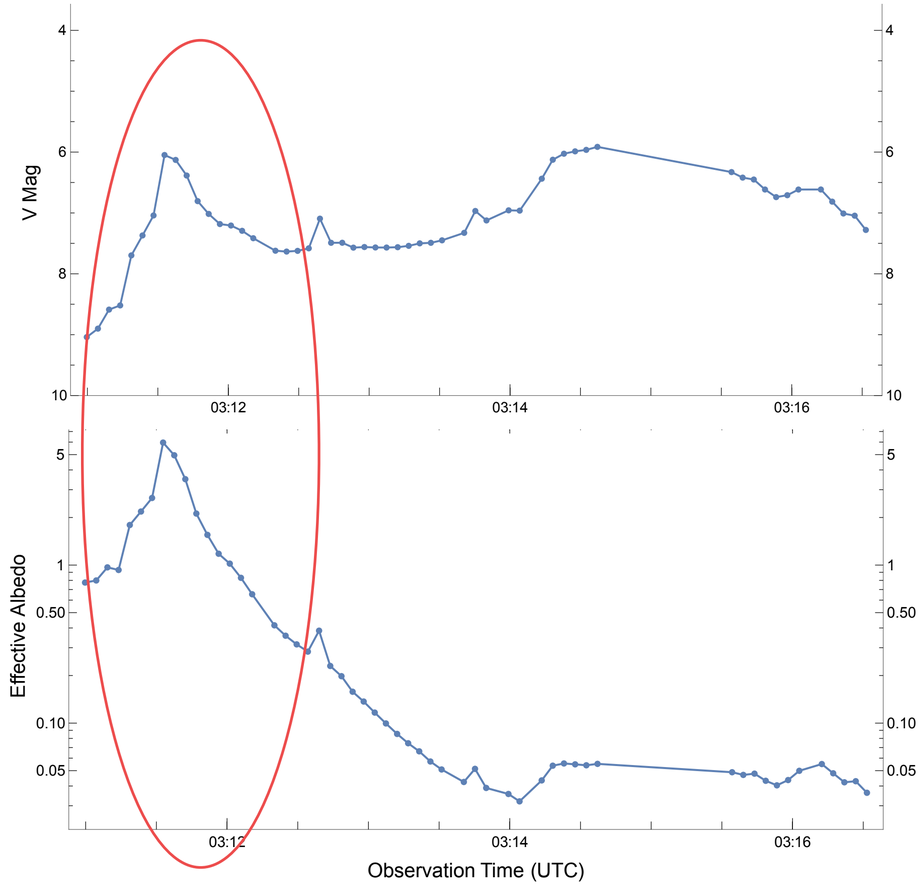
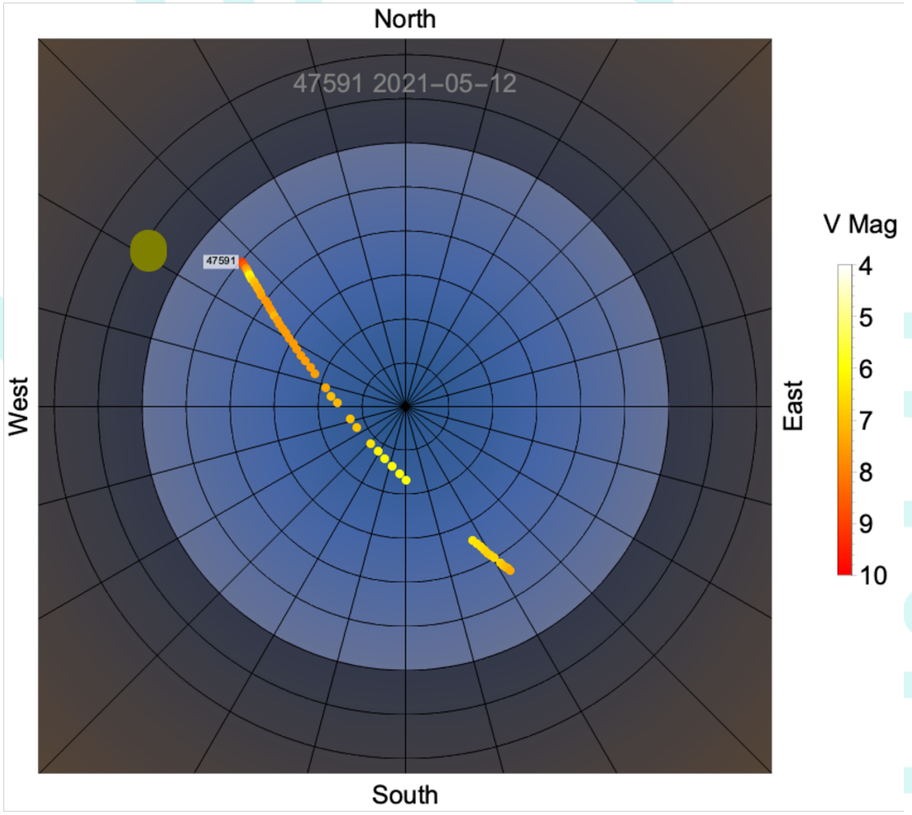
Mroz et al. 2022

Routine maneuvers can manifest as glints

- Many Starlinks exhibit a characteristic flare at low Solar elongation
- Increase in effective albedo indicates specular (mirror-like) reflection



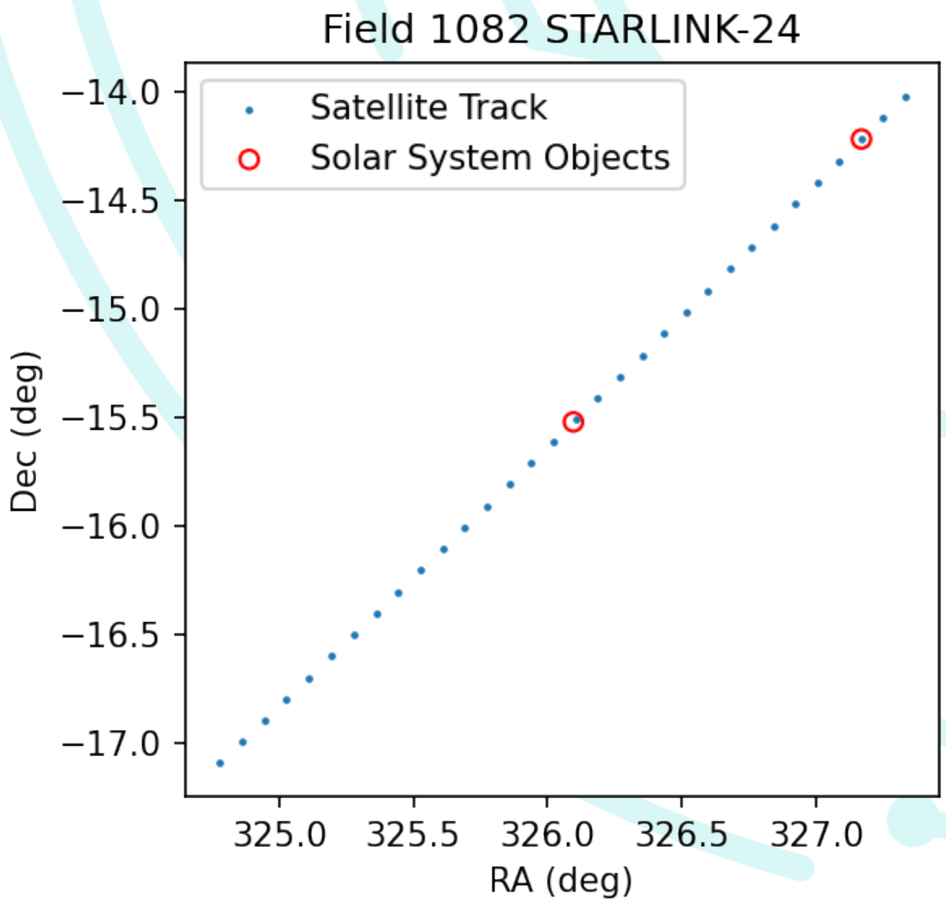
Starlink-1996 has a visor, but reorients for maneuvers every ~3 days



Credit: H. Krantz, U of AZ Steward Obs

Impact on Rubin Solar System Discoveries

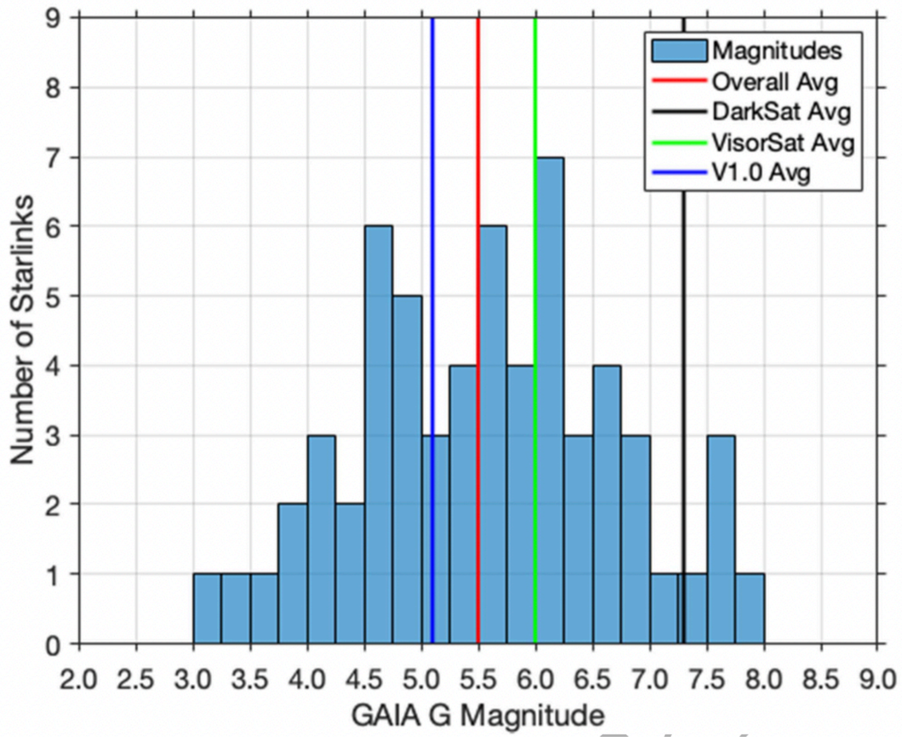
- New Solar System Object discoveries require at least six detections over three nights
- If one observation is missed due to a streak, the object can be lost entirely
- Near-Earth asteroids have particularly short discovery windows



Credit: Siegfried Eggl, with students Valery Balbin-Sepulveda, David Roman Garcia, Anthony Rihani, and Sanjana Srivastava

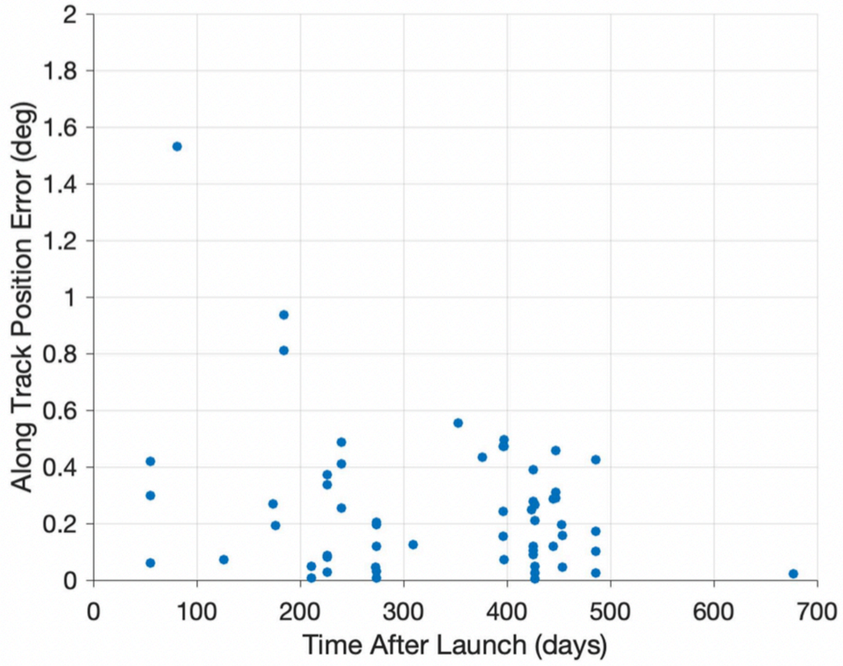
Isn't SpaceX making their satellites darker and proactively sharing satellite positions and trajectories?

- Yes, and astronomers appreciate this work and the example it sets!
- But… they're still not dark enough, typical astrometric errors are > 0.1 deg, other operators exist, and **all operator mitigations are entirely voluntary**



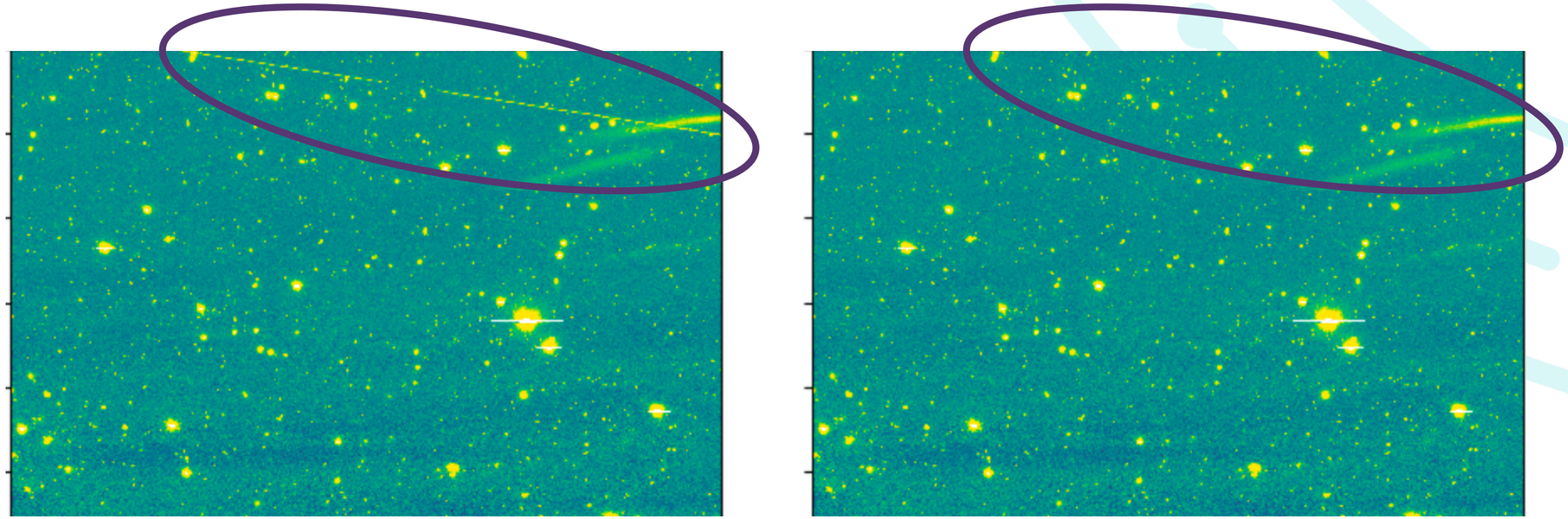
Just released:
Halferty et al. 2022

61 Starlinks observed over 16 months



Can’t we fix most streaks with clever software?

- Severity depends strongly on the (growing) satellite population and your science
- Streaks tend to be brighter in redder bands; majority of twilight exposures will have a streak
- Visual (V) mag ~ 7 or fainter would make most streaks easier to mask in coadds
- You will find surprise satellites in Rubin data products despite our best efforts

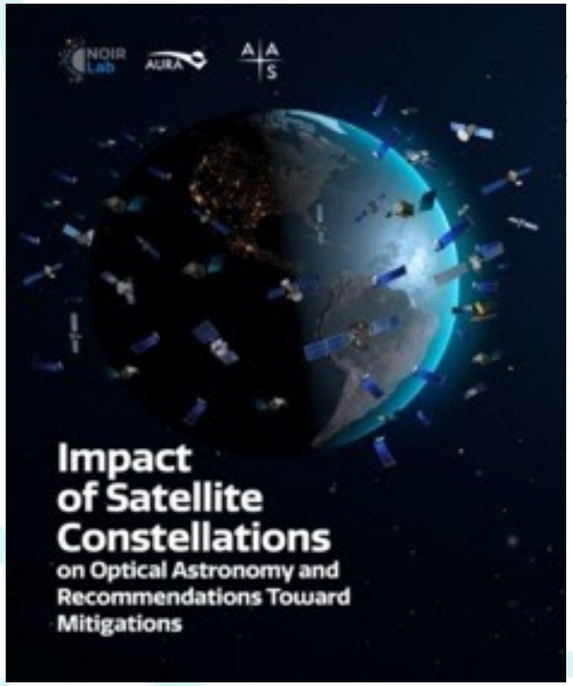


Figures courtesy Clare Saunders

What else can we do about this problem?

- Launch fewer satellites to lower altitudes
- Design satellites with darkening mitigations for all orbit phases
- Operators and regulators must consider aggregate impacts
- Foster coordination agreements for orbital space and night sky users (e.g., NASA, NSF, operators)
- Encourage international collaboration among US agencies, UN COPUOS, the IAU, and numerous other stakeholders
- Continued/improved financial support for mitigation efforts
- Consider applying environmental laws to low Earth orbit
- Mitigation of harm to astronomy should be a requirement of licensing

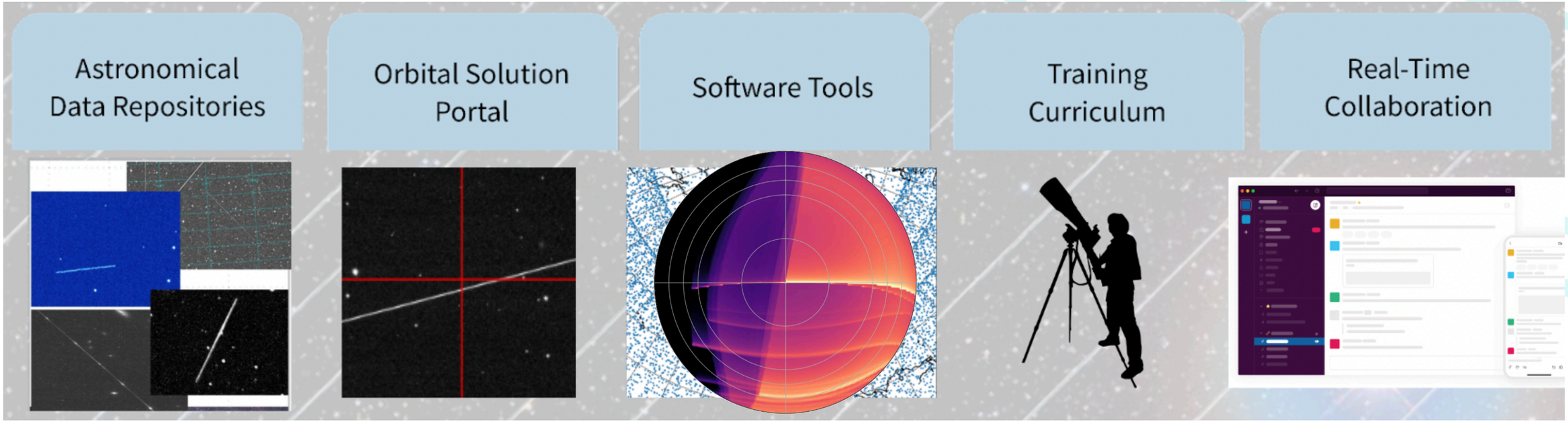
Credit: AAS LPRISD "leave behind" doc



Join me at SatHub to help!

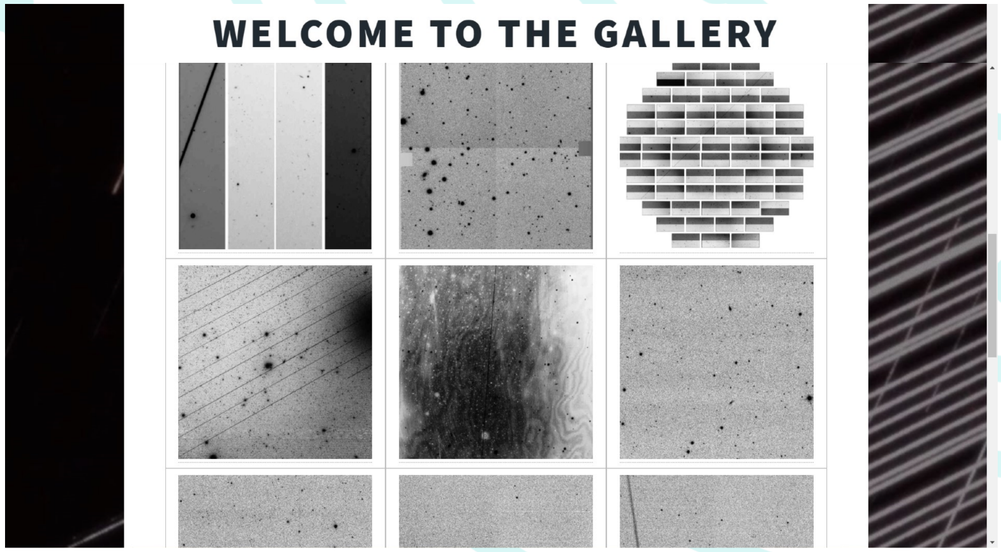
- Part of the new IAU Centre for the Protection of the Dark and Quiet Sky from Satellite Constellation Interference (CPS)
- Aims to be a **one-stop shop** for training, outreach, and collection & analysis of satellite observations

cps.iau.org



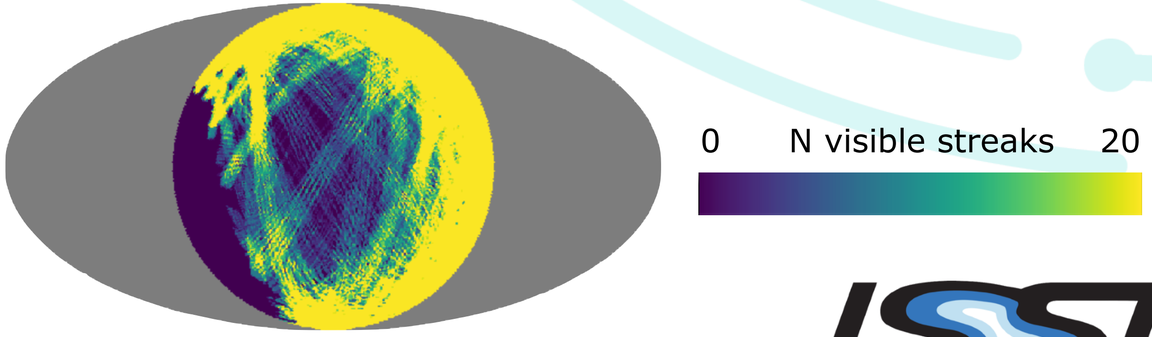
A sampling of projects in the works

- **Trailblazer**: enabling quantitative studies of streaks from satellites in images over time
- We are in “soft launch” beta mode — try uploading your FITS files at **trailblazer.dirac.dev**!



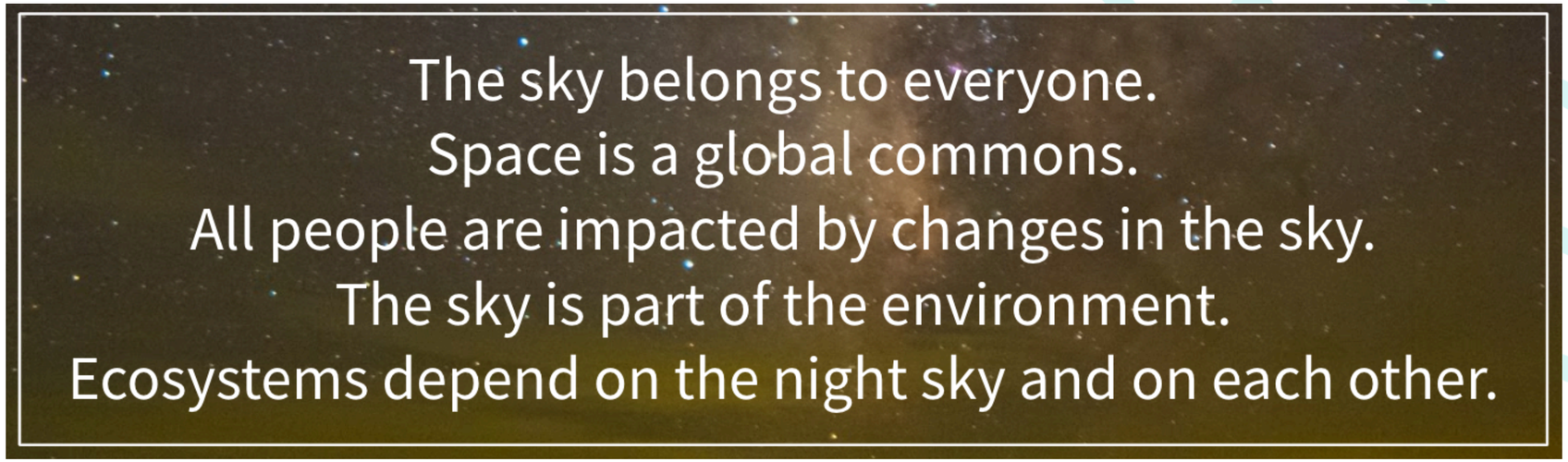
- **Satmetrics**: quantifying streaks in images
- UW eScience “Data Science for Social Good”

- **Scheduler dodging**: investigating the utility of dodging some satellites with the Rubin scheduler (Alina Hu had a poster yesterday!)
- Dodging is not worth the survey depth tradeoff



The future of the sky is on the cusp of changing

- This story is far larger than “astronomy vs. satellite internet”
- Billions of investor dollars are fueling an exponential rise in launches of preliminary hardware
- Astronomers have minimal funding and a handful of folks working on mitigation studies
- Haven’t even gone into radio astronomy or impacts on groups beyond astronomy…!



J. Lowenthal, A. Venkatesan, & SATCON2 Community Engagement Working Group