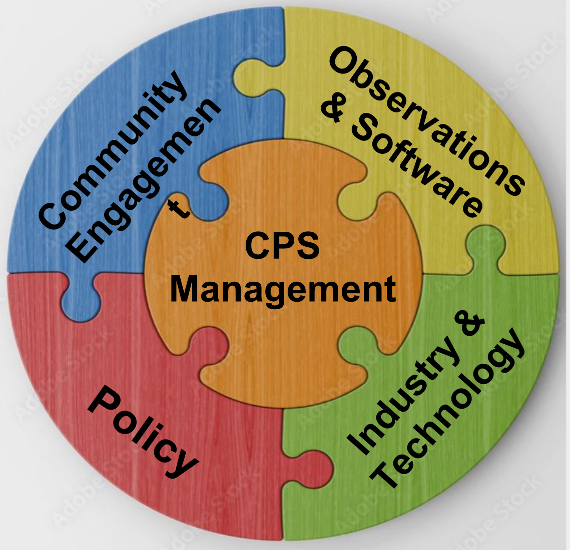
A mitigation tool to forecast satellite passes & brightness for optical telescopes worldwide

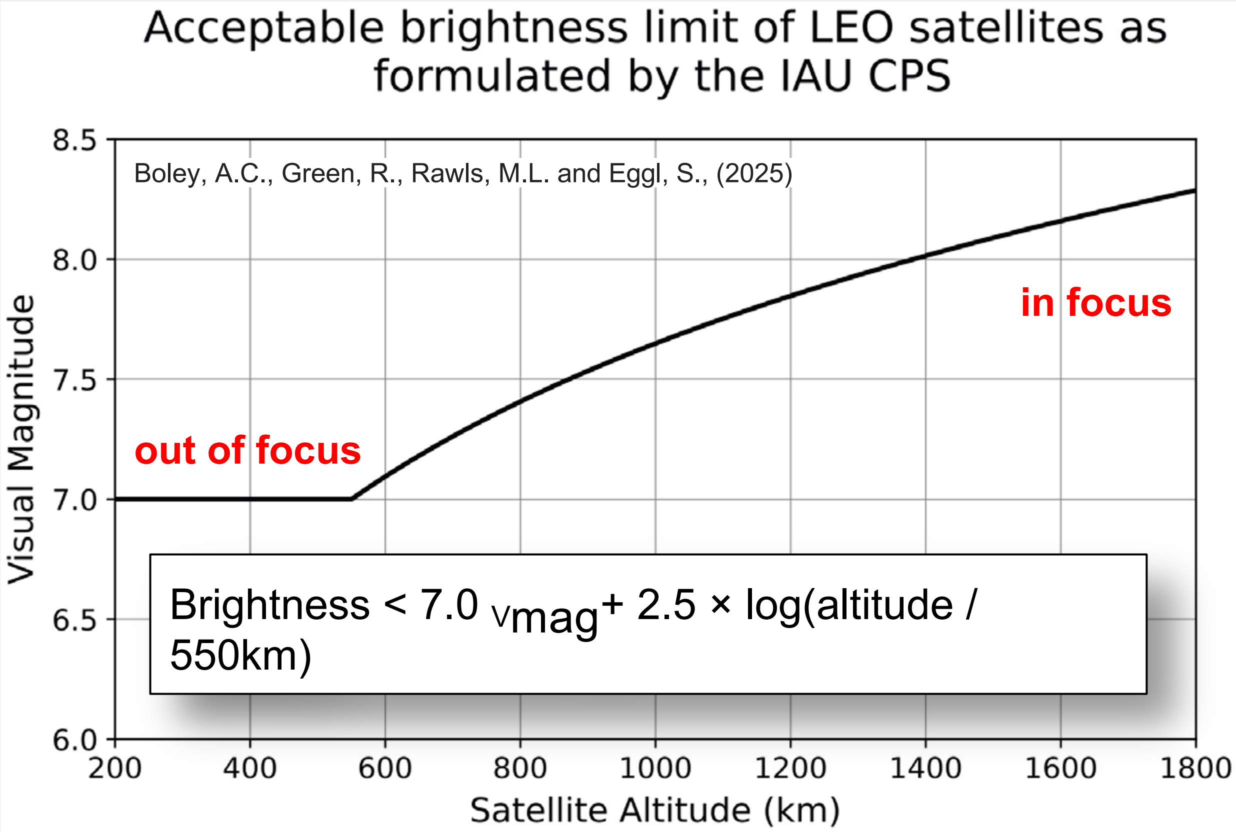
Connie Walker, a Director of the Center for the Protection of D&QS (CPS)
with Michelle Dadighat, Software Engineer for CPS, &
Siegfried Eggl & Meredith Rawls, CPS SatHub Co-Leads

IAU Center for the Protection of the Dark & Quiet Sky from Satellite Constellation Interference (CPS)

- Research the impact of satellite constellations
- Collect, produce & disseminate information
- Bring together different communities
- ~500 members from 57 countries
- 4 Hubs including SatHub (Observations & Software)
- **SatHub**
  - Software tools for observation planning, predictions, and processing affected data
  - Brightness modeling
  - International observing network & campaigns
- **Industry Hub**
- **Policy Hub**
- **Community Engagement Hub**



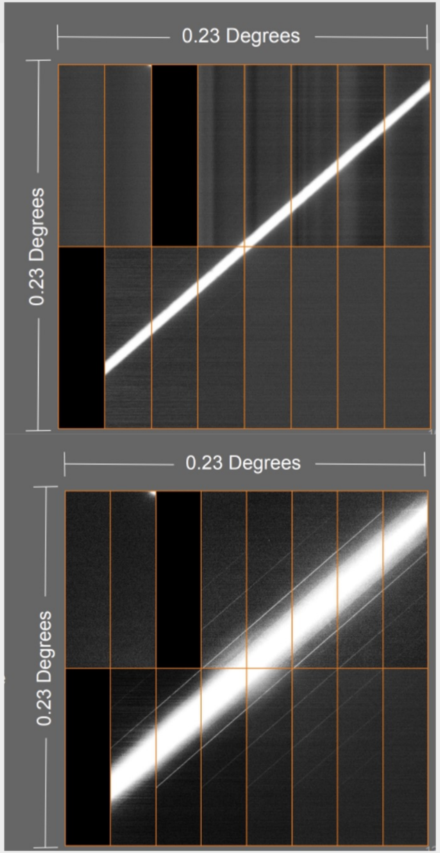
Rubin Observatory Detector Response (Tyson/UCDavis)



Brightness < 7.0 $_{\mathrm{V}}$mag + 2.5 × log(altitude / 550km)

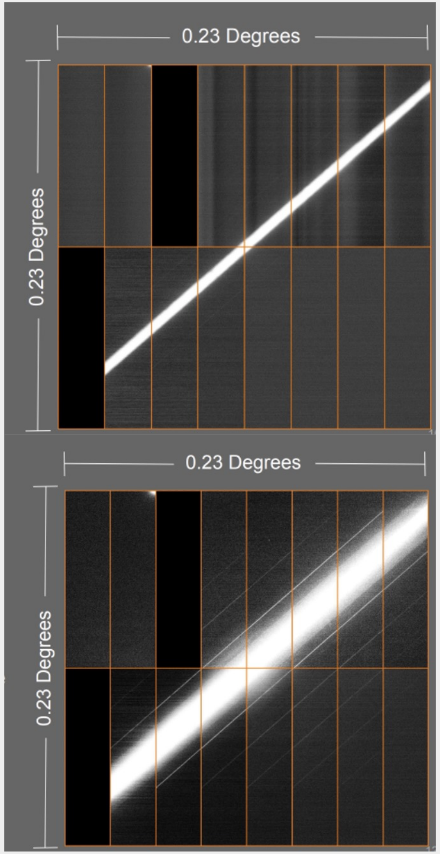
IAU recommendation

First Gen Starlink

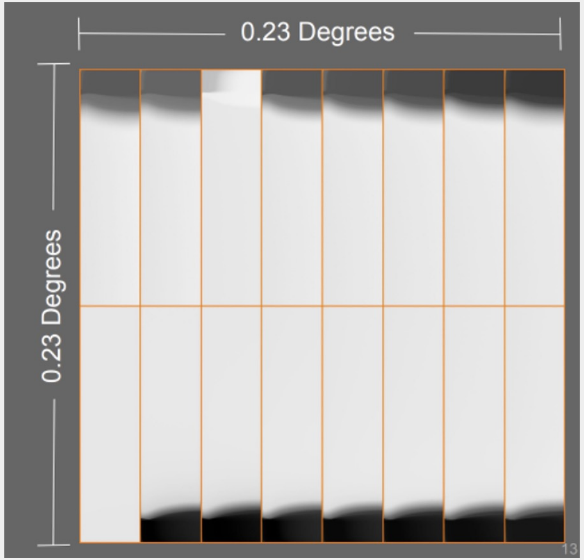


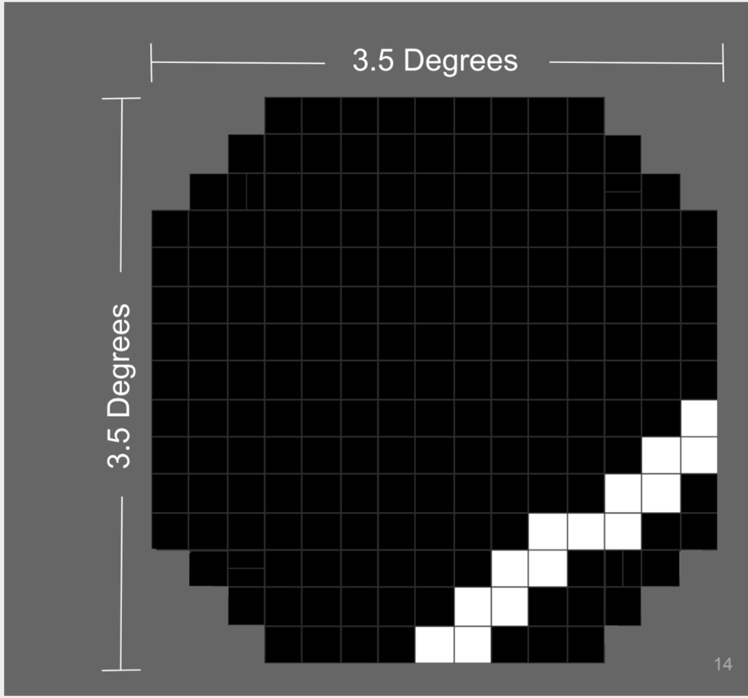
Rubin Observatory Detector Response (Tyson/UCDavis)

IAU recommendation



First Gen Starlink





BlueWalker 3

$64m^2$ - up to 0mag,

15th brightest object in the night sky

BlueBirds 1-5 launched in 2024

IAU NOIRLab SKAO

SatChecker Field of View Prediction Service

Michelle Dadighat (NOIRLab), Nayan Jangid (UIUC)

satchecker.readthedocs.io/en/latest/fov.html

SatChecker

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- Release History
- Acknowledgements

/ Field of View (FOV) Endpoints — View page source

Field of View (FOV) Endpoints

The FOV API provides two main endpoints for checking satellite positions relative to a field of view or horizon.

Satellite passes Through FOV

`GET /satellite-passes/`

Get satellites that pass through a specified field of view during a time period. The field of view is defined by a center RA and Dec and a radius, both in degrees.

Either a start time or observation mid point time can be provided, but one must be specified.

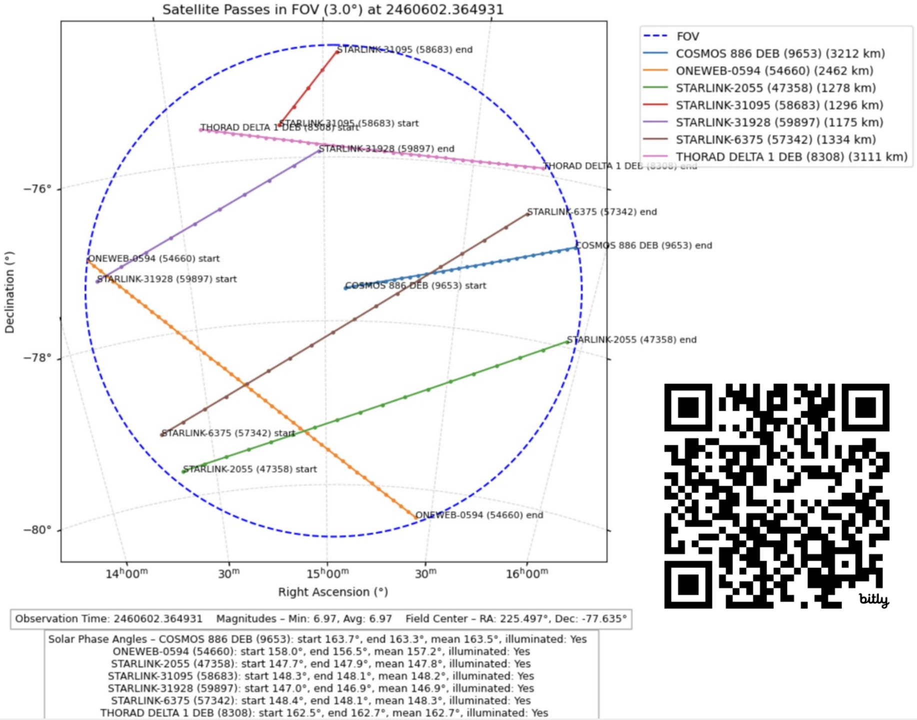
Query Parameters:

- **latitude** – (*required*) – Observer's latitude in degrees
- **longitude** – (*required*) – Observer's longitude in degrees
- **elevation** – (*required*) – Observer's elevation in meters
- **site** – (*optional*) – Site name (e.g. 'greenwich') - if provided, latitude, longitude, and elevation can't be used; see astropy site names for a list of valid site names
- **start_time_jd** – (*optional*) – Julian Date for start of observation window
- **mid_obs_time_jd** – (*optional*) – Julian Date for middle of observation window
- **duration** – (*required*) – Duration to check in seconds
- **ra** – (*required*) – Right Ascension of FOV center in degrees
- **dec** – (*required*) – Declination of FOV center in degrees
- **fov_radius** – (*required*) – Radius of circular FOV in degrees
- **group_by** – (*optional*) – How to group results ("satellite" or "time"). Default is "time" for chronological order

Example Request

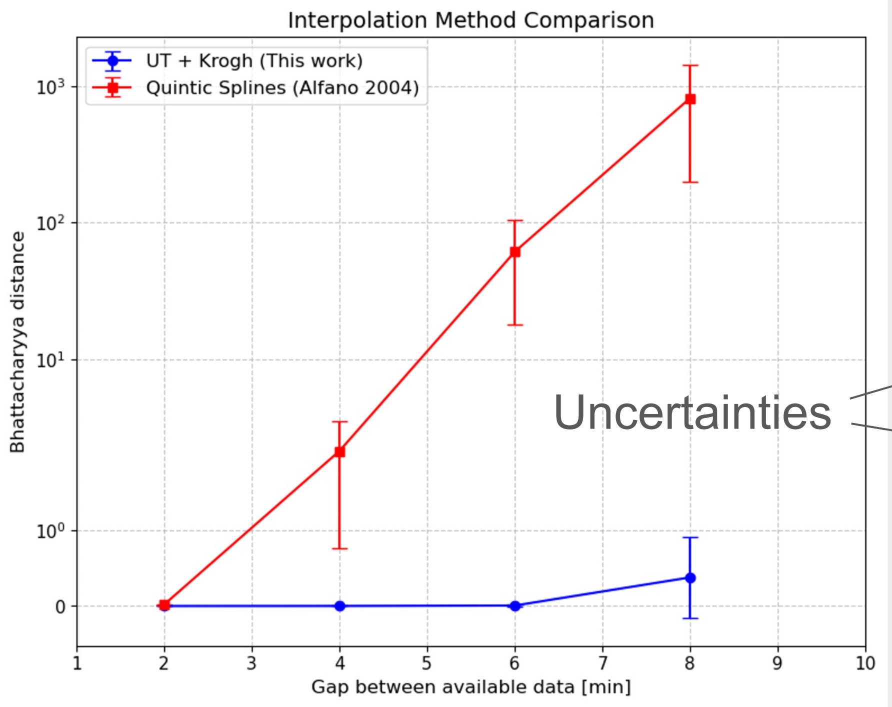
Browser | Python | Bash | Powershell

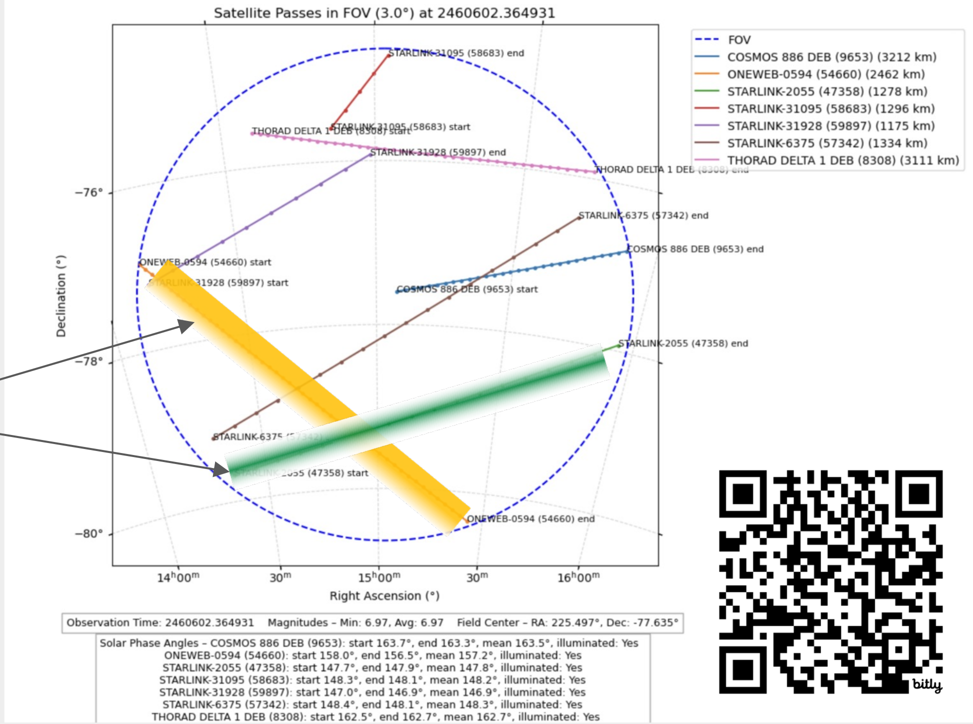
https://satchecker.cps.iau.org/fov/satellite-passes/?latitude=33&longitude=-117&elevation=100&start_time_jd=2460623.394780&duration=2&ra=157.5&dec=20&fov_radius=3&group_by=satellite



bitly

SatChecker Field of View Prediction Service





Improved Orbit Covariance Interpolation
Jangid & Eggl (submitted)

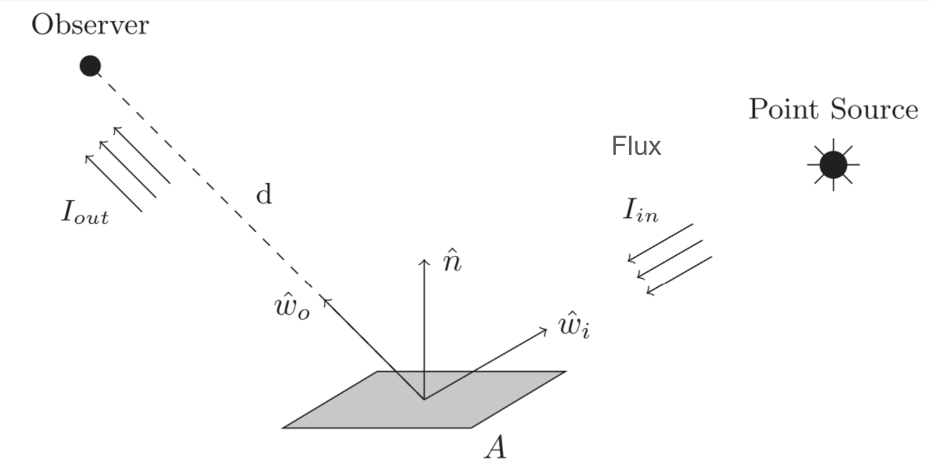
Michelle Dadighat (NOIRLab), Nayan Jangid (UIUC)

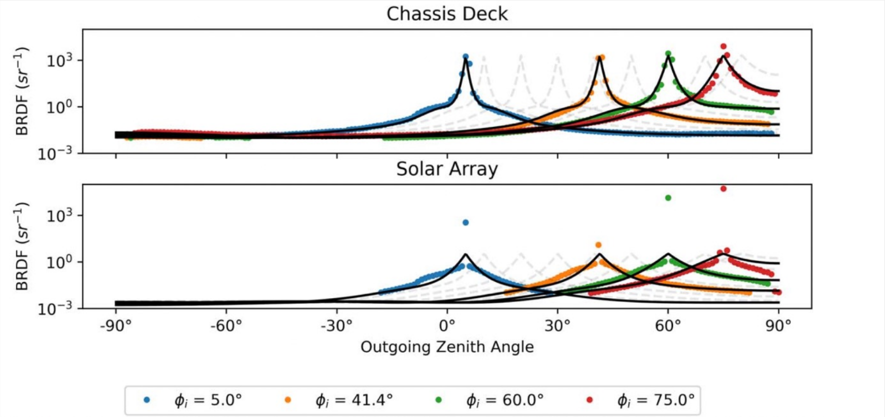
Satellite Brightness Modeling

$$\mathrm{BRDF} = f_r(\hat{w}_i, \hat{w}_o) \equiv \frac{1}{\cos(\phi_o)\cos(\phi_i)L_i}\frac{\partial L_o}{\partial \hat{w}_i}.$$

L… Radiance

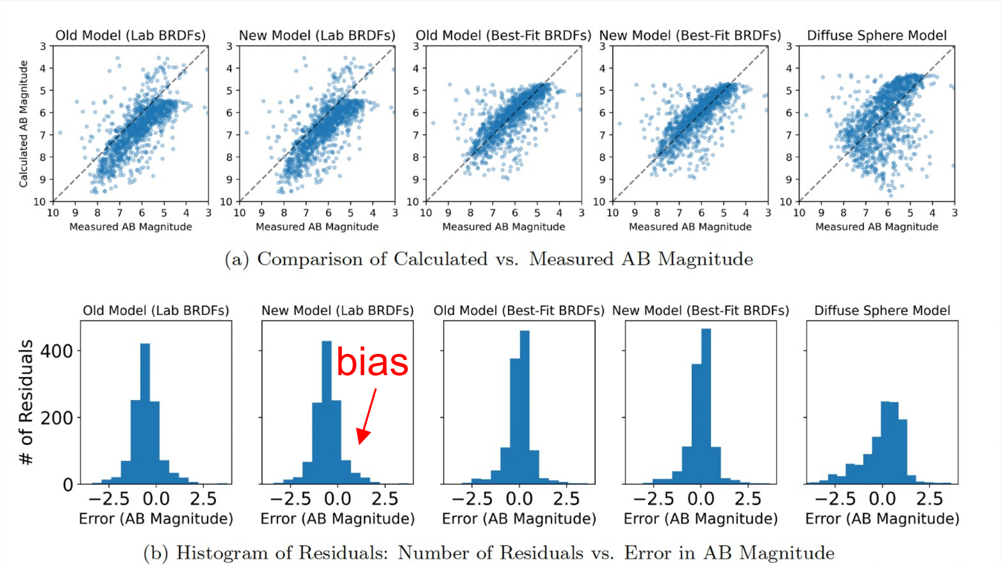
Lab Bidirectional Reflectance Distribution Function For Starlink satellites (v1)





Fankhauser+ (2023), Jangid & Eggl (in prep)

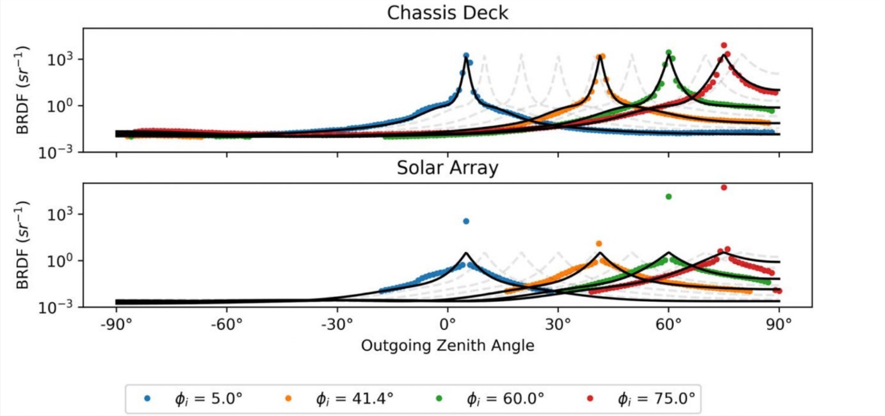
Satellite Brightness Modeling



(a) Comparison of Calculated vs. Measured AB Magnitude

(b) Histogram of Residuals: Number of Residuals vs. Error in AB Magnitude

Lab Bidirectional Reflectance Distribution Function For Starlink satellites (v1)



$$\log(\mathrm{BRDF}) = \sum_{k=0}^{n} \left\{ \sum_{i=0}^{m} b_{ik} \delta^i + \frac{1}{2} \sum_{i=l_1}^{l_2} c_{ik} \log(1 + q^i \delta^2) \right\} \nu^k,$$

$$\delta^2 = \|\boldsymbol{\rho} - \boldsymbol{\rho}_0\|^2 \qquad \nu = \boldsymbol{\rho} \cdot \boldsymbol{\rho}_0.$$

$$\mathrm{BRDF} = \frac{K_d}{\pi} + K_s \frac{n+2}{2\pi} (\hat{w}_r \cdot \hat{w}_o)^n.$$

Fankhauser, Tyson & Askari (2023), Jangid & Eggl (in prep)

The Satellite Constellation Observation Repository

SatChecker

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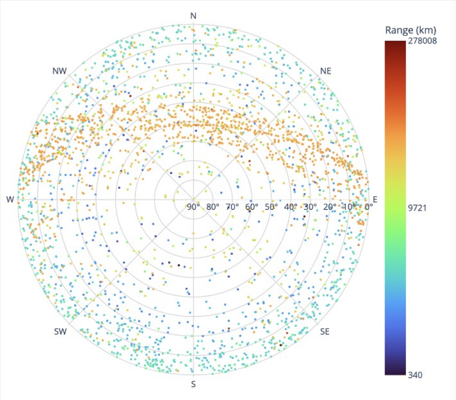
/ API Examples — View page source

API Examples

Here are a few examples of how to use the API:

Get all visible passes of STARLINK-1600 at a given location for the specified time range:
https://satchecker.cps.iau.org/ephemeris/name-jdstep/?name=STARLINK-1600&latitude=40.1106&longitude=-88.2073&elevation=222&startjd=2460000.1&stopjd=2460010.1&stepjd=0.5

Get any passes (visible or not) of STARLINK-1600 at a given location for the specified time range:
https://satchecker.cps.iau.org/ephemeris/name-jdstep/?name=STARLINK-1600&latitude=40.1106&longitude=-88.2073&elevation=222&startjd=2460000.1&stopjd=2460000.3&stepjd=0.1&min_altitude=-90



Satellite Constellation Observation Repository

← Back to Satellites Page

Satellite Details

ACS 3

NORAD ID: 59588
COSPAR ID: 2024-077B
View other objects from this launch
RCS Size: LARGE
Object Type: PAYLOAD
Launch Date: 2024-04-23
Decay Date: N/A

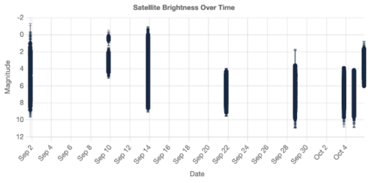
Observation Summary

Number of Observations: 24463
Average Magnitude: 5.34926
Most Recent Observation: Oct. 5, 2024
First Observation: Sept. 1, 2024

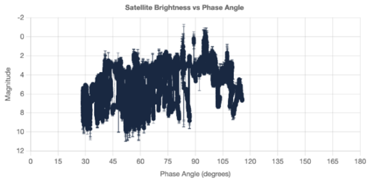
Date added (UTC)	Date observed (UTC)	Mag	Filter	Latitude (deg)	Longitude (deg)	Altitude (m)	Obs. mode	Observer ORCID
Nov. 07, 2024 01:19 PM	Oct. 05, 2024 08:08 PM	3.2	CLEAR	52.154	4.4909	8	CCD	0000-0001-6659-9253
Nov. 07, 2024 01:19 PM	Oct. 05, 2024 08:08 PM	3.2	CLEAR	52.154	4.4909	8	CCD	0000-0001-6659-9253
Nov. 07, 2024 01:19 PM	Oct. 05, 2024 08:08 PM	3.2	CLEAR	52.154	4.4909	8	CCD	0000-0001-6659-9253
Nov. 07, 2024 01:19 PM	Oct. 05, 2024 08:08 PM	3.2	CLEAR	52.154	4.4909	8	CCD	0000-0001-6659-9253
Nov. 07, 2024 01:19 PM	Oct. 05, 2024 08:08 PM	3.28	CLEAR	52.154	4.4909	8	CCD	0000-0001-6659-9253

Showing 1 to 5 of 24463 rows 5 rows per page ‹ 1 2 3 4 5 ... 4893 ›

Download observation data



Reset Chart



Reset Chart Use Data Range

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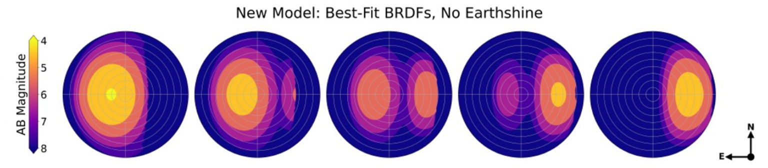
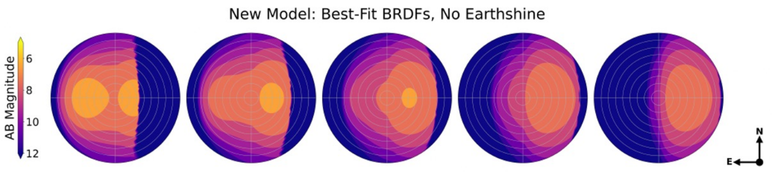
Satellite Brightness Modeling

OneWeb-0187



(a) New Phong Model: Brightness for various Sun Altitude

All OneWeb Data



(b) New Phong Model: Brightness for various Sun Altitude

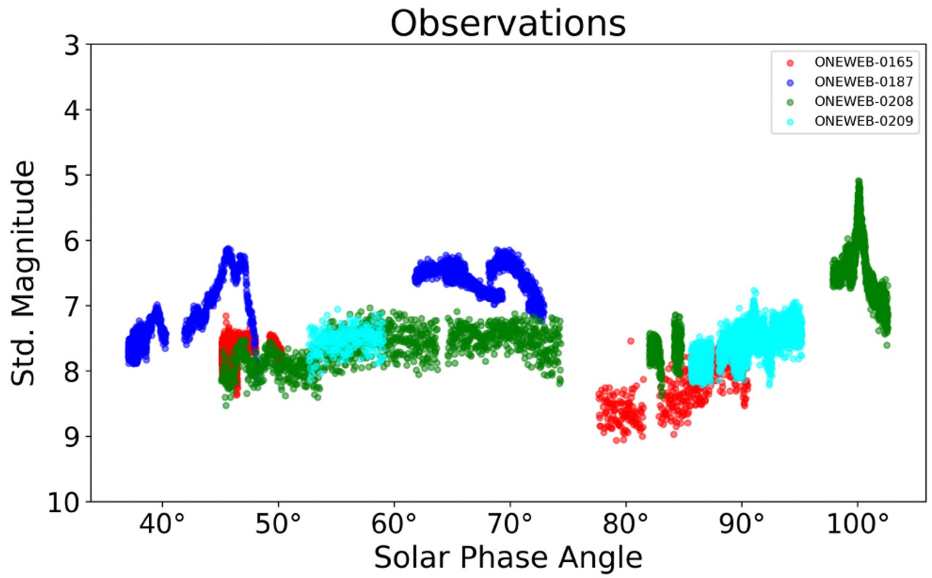


Figure 15. Brightness vs solar Angle for Data

$$\mathrm{BRDF} = \frac{K_d}{\pi} + K_s \frac{n+2}{2\pi} (\hat{w}_r \cdot \hat{w}_o)^n.$$

Limited coverage (phase angle, but also latitude / one ground station) can lead to different BRDF predictions

Jangid & Eggl (in prep)

Contact Information

IAU CPS **Co-Director**
Connie Walker
connie.walker@cps.iau.org

IAU CPS **SatHub**
sathub@cps.iau.org

Interested in joining? See:
IAU CPS **Website**
cps.iau.org

IAU CPS **Policy Hub**
policy@cps.iau.org

IAU CPS **Industry & Tech Hub**
industry-tech@cps.iau.org

IAU CPS **Community Engagement Hub**
community-engage@cps.iau.org