UN/SKAO Workshop on Dark and Quiet Skies for Science and Society 2025

Pitch Talk – Looking to the Future and Learning from Other Sectors

# Space Debris-Induced Night Sky Brightness:
## Quantifying Model Uncertainties and Observational Impacts

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# The Hidden Threat

Beyond satellite streaks: diffuse skyglow from space debris

## The Problem

Satellite fragmentation creates millions of sub-millimeter particles that collectively scatter sunlight, producing a measurable diffuse glow across the entire night sky.

**Current Impact (2024)**

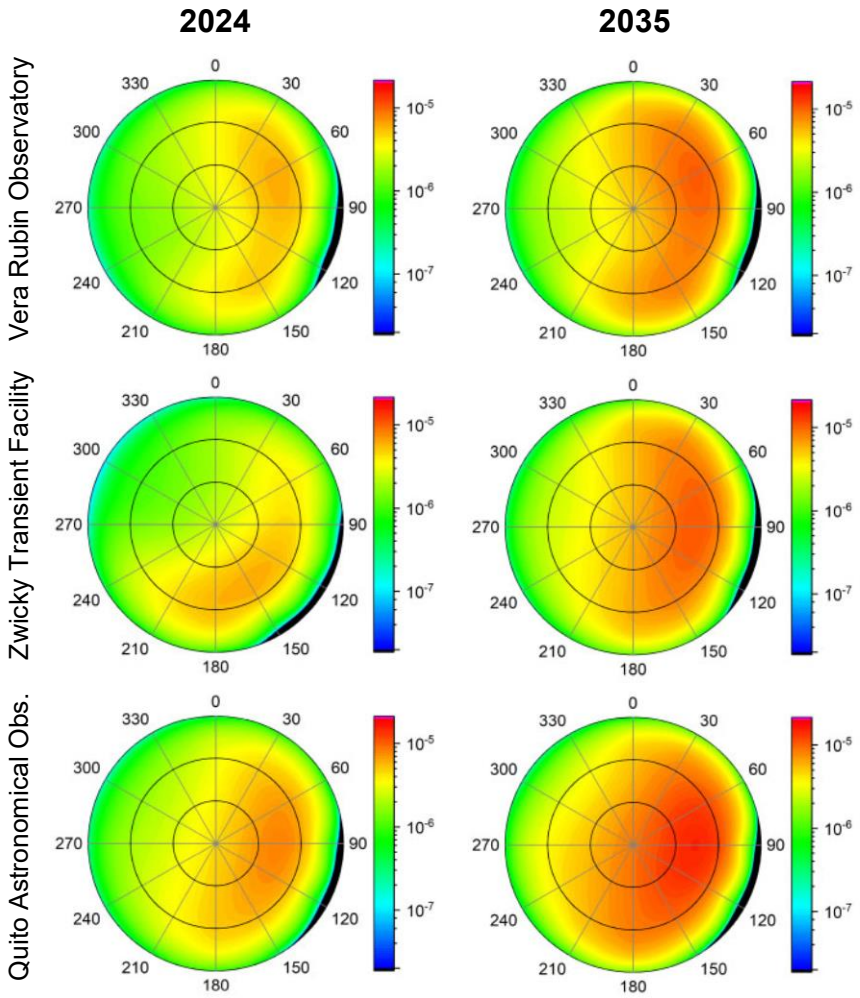
**3–8 µcd/m²**

Additional sky brightness from LEO debris

**Projected (2035)**

**Up to 19 µcd/m²**

Threefold increase over the decade




Kocifaj et al. (2025) MNRAS 541, L47–L51 | Wallner & Kocifaj (2025) A&A (in press)

# The Uncertainty Crisis

Order-of-magnitude disagreement between debris models

**100×** difference in predictions for particles <3mm

ESA MASTER vs NASA ORDEM debris models fundamentally disagree on small particle populations

## ESA MASTER

Semi-deterministic fragmentation model

**2024 NSB Contribution:**

**29.7–30.3**

mag/arcsec²

**2035 Projection:**

**28.7–29.5**

mag/arcsec²

**~3–8%** above natural levels

## NASA ORDEM

Bayesian + observational calibration

**2024 NSB Contribution:**

**26.2–26.8**

mag/arcsec²

**2035 Projection:**

**25.2–25.8**

mag/arcsec²

**~5–20%** above natural levels

**This uncertainty spans 25× in sky brightness—preventing informed policy decisions**

Lower magnitude values = brighter contribution | Natural V-band sky ~21.5 mag/arcsec² at dark sites

# Consequences & Solutions

Observational impacts and the path forward

### Signal-to-Noise Degradation

**7–20%**
decrease by 2035

For faint sources (27 mag/arcsec²) at 8-m class telescopes

### Required Exposure Increase

**8–34%**
longer observations

To maintain constant sensitivity—directly impacts survey efficiency

**Differential impact:** Large facilities observing faint sources most affected. Smaller telescopes with brighter sky-limited magnitudes relatively unaffected.

**11-year solar cycle modulation:** NSB varies 20–30% between solar maximum (enhanced atmospheric density → faster orbital decay) and minimum

### Required Action

To regulate debris accumulation effectively, we must:

- Resolve model uncertainties through enhanced tracking or in-situ measurements
- Establish international debris characterization standards
- Develop evidence-based policies for satellite design and end-of-life disposal

IAU threshold for observatory sites: 20 µcd/m² | VLT/FORS2 analysis for extended sources

# Contact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