Uranus Stellar Occultation Observation Campaign Updates from the 2024-11-12 and 2025-04-08 Events

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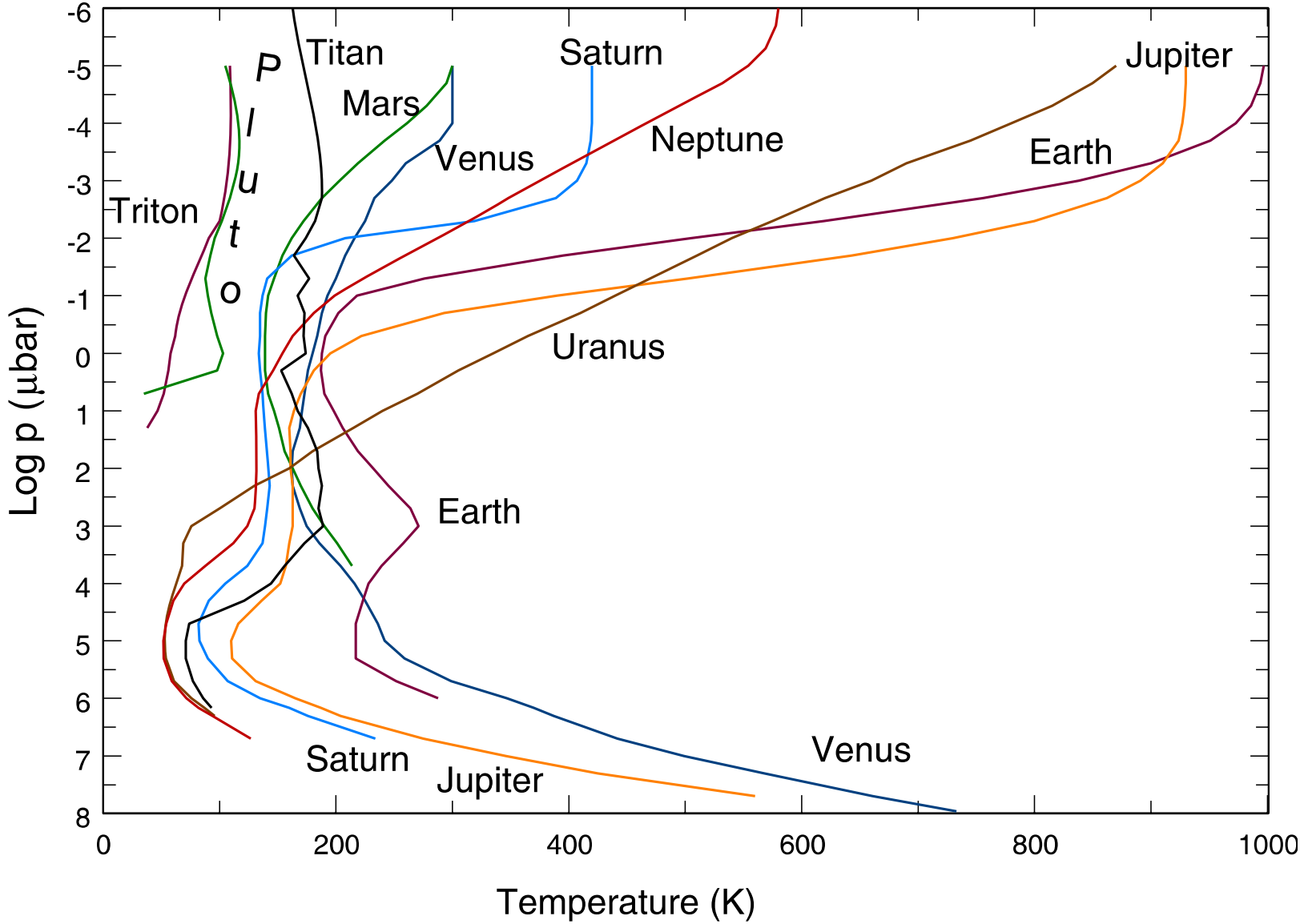
Background: Uranus' Atmosphere

- Voyager 2 measured Uranus to have a cold stratosphere and hot thermosphere.
- Uranus' thermal structure is unlike those of other giant planets.
- Its unexplained hot thermosphere is part of the "giant planet energy crisis"

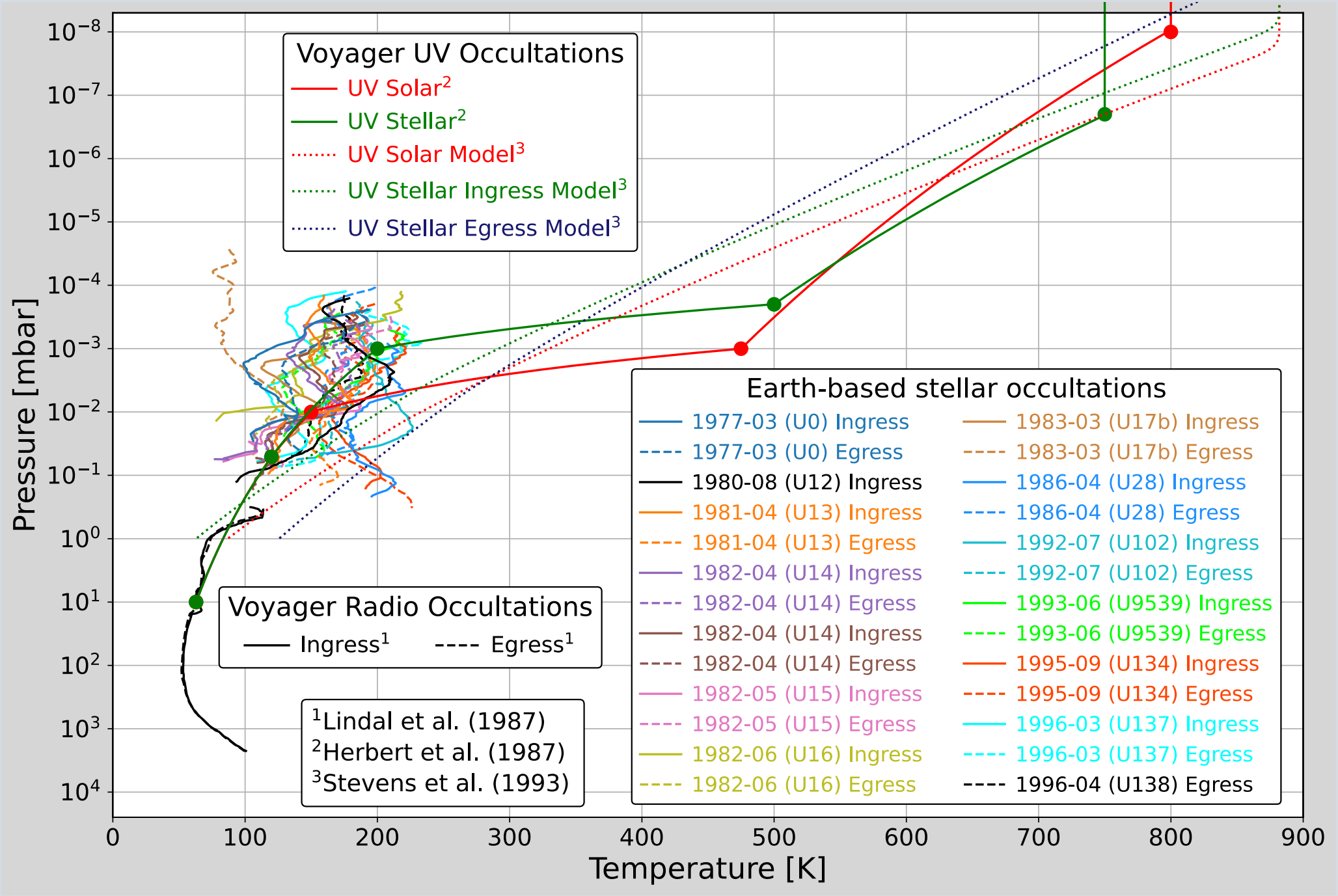


Mueller-Wodarg et al. (2008)

Different measurements of Uranus' thermal structure strongly disagree.

Earth-based stellar occultations: ~200 K at 10^{-3}–10^{-4} mbar

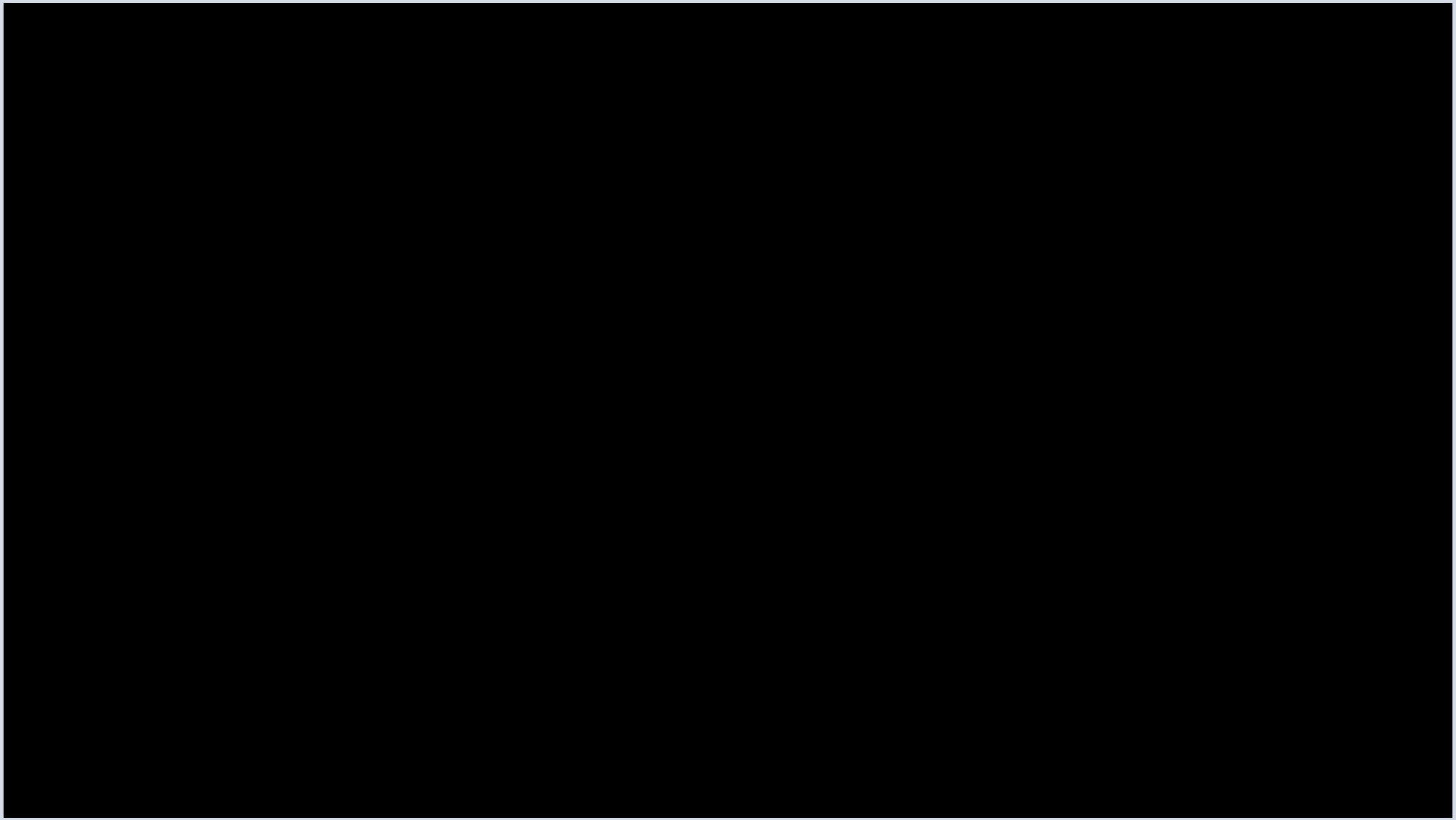
Voyager 2: ~500 K at 10^{-3}–10^{-4} mbar



Saunders et al. (2024)

Background: Earth-Based Stellar Occultations

Occurs when a solar system object passes in front of a distant star.



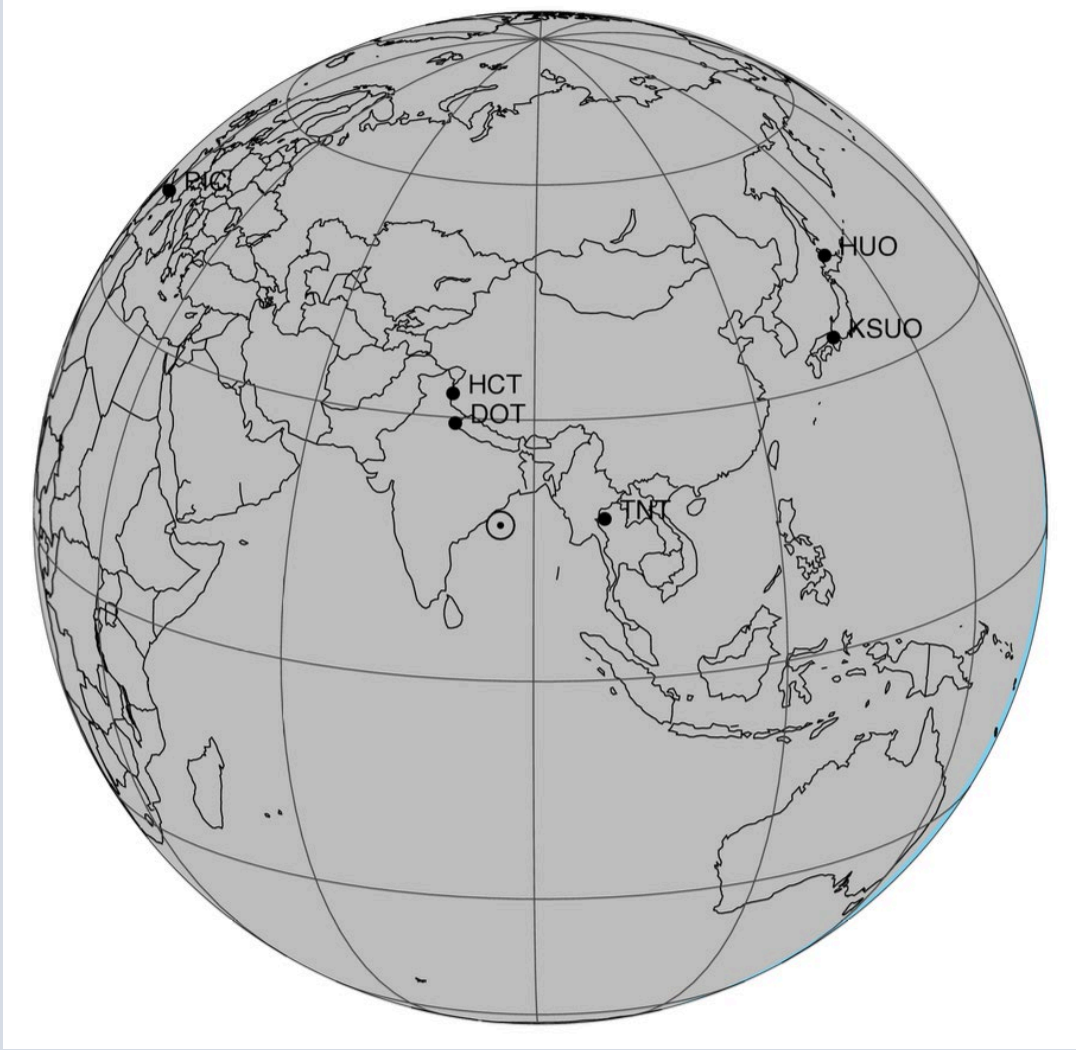
Credit: NASA Langley Research Center

Motivations for Observing Uranus Occultations

- Science Objectives:
    1. Measure an accurate temperature profile of the middle atmosphere of Uranus in the 2020s. Build a 1-D model based on these results.
    2. Determine how stratospheric temperatures have changed since 1996.
    3. Detect and characterize waves in the middle atmosphere to better understand energy transport and the energy crisis.
    4. Detect rings and ring material. Use these to improve Uranus' ephemeris.
- Technology Objective:
    1. Produce high resolution density profiles that can improve the case for aerocapture for the Uranus Orbiter and Probe (UOP) mission.

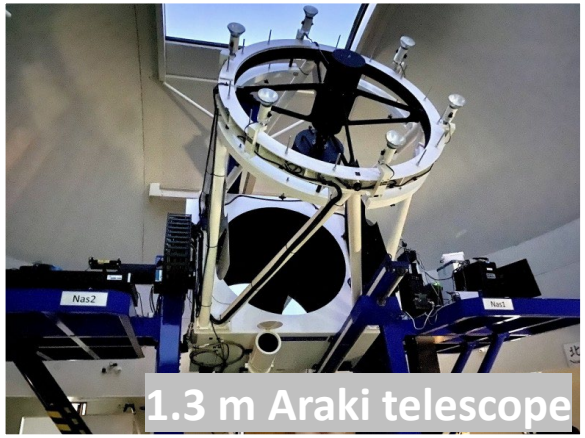
2024-11-12 Uranus Occultation Campaign

- Star magnitudes: G=12.8, K=11.2
- Occultation speed: 23.3 km/s
- Best visible from Asia
- Observed from 5 telescopes:
  - 2.4-m Thai National Observatory
  - 1.3-m Kyoto Sangyo University Observatory
  - 1.6-m Hokkaido University
  - 2.4-m Himalayan Chandra Observatory (India)
  - 3.6-m Devasthal Optical Telescope (India)



Details of November 2024 Japanese observations

Kyoto Sangyo University



Major Specifications

Optics	Ritchey–Chrétien
Foci	Cassegrain, Nasmyth x 2
Diameter of Primary Mirror	1.3 m
Focal Ratio	f/10.0

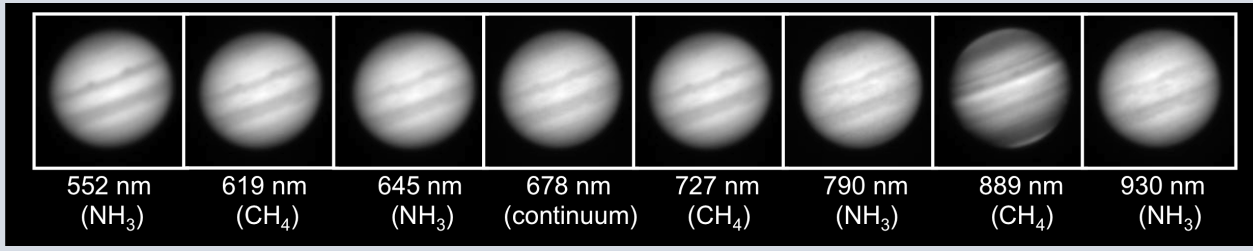
CMOS camera (ZWO ASI1600MM-Cool) + CH4 band filter (20 nm width) is attached to the eyepiece port.

Hokkaido University

Major Specifications

Optics	Ritchey–Chrétien
Foci	Cassegrain, Nasmyth x 2
Diameter of Primary Mirror	1.6 m
Focal Ratio	f/12.0

Instrument at the Cassegrain focus :
Multi-Spectral Imager (Watanabe et al., 2012) 360-1050 nm



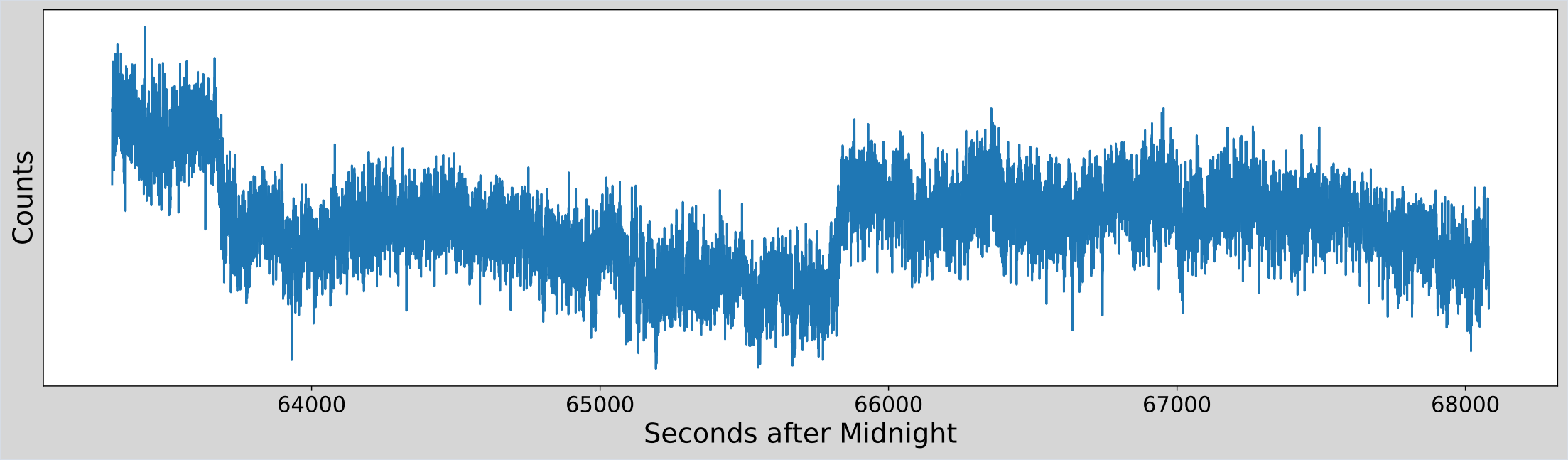
2024-11-12 Uranus Occultation Campaign

Major results:

- Indian telescopes detected multiple ring occultations; anticipate some atmospheric measurements as well.
  - Ring occultations allowed improvements to Uranus ephemeris and future occultation timings.
  - **~300 km improvement in Uranus position accuracy: as a result, 2025 occultation predictions improved from ~10 second to ~1 second accuracy.**
  - Japanese and Thai telescopes were able to observe part of the occultation (Thai telescope had technical issues, and Japanese weather conditions were not ideal).

Results from the Thai National Telescope

- Low S/N (< 10)

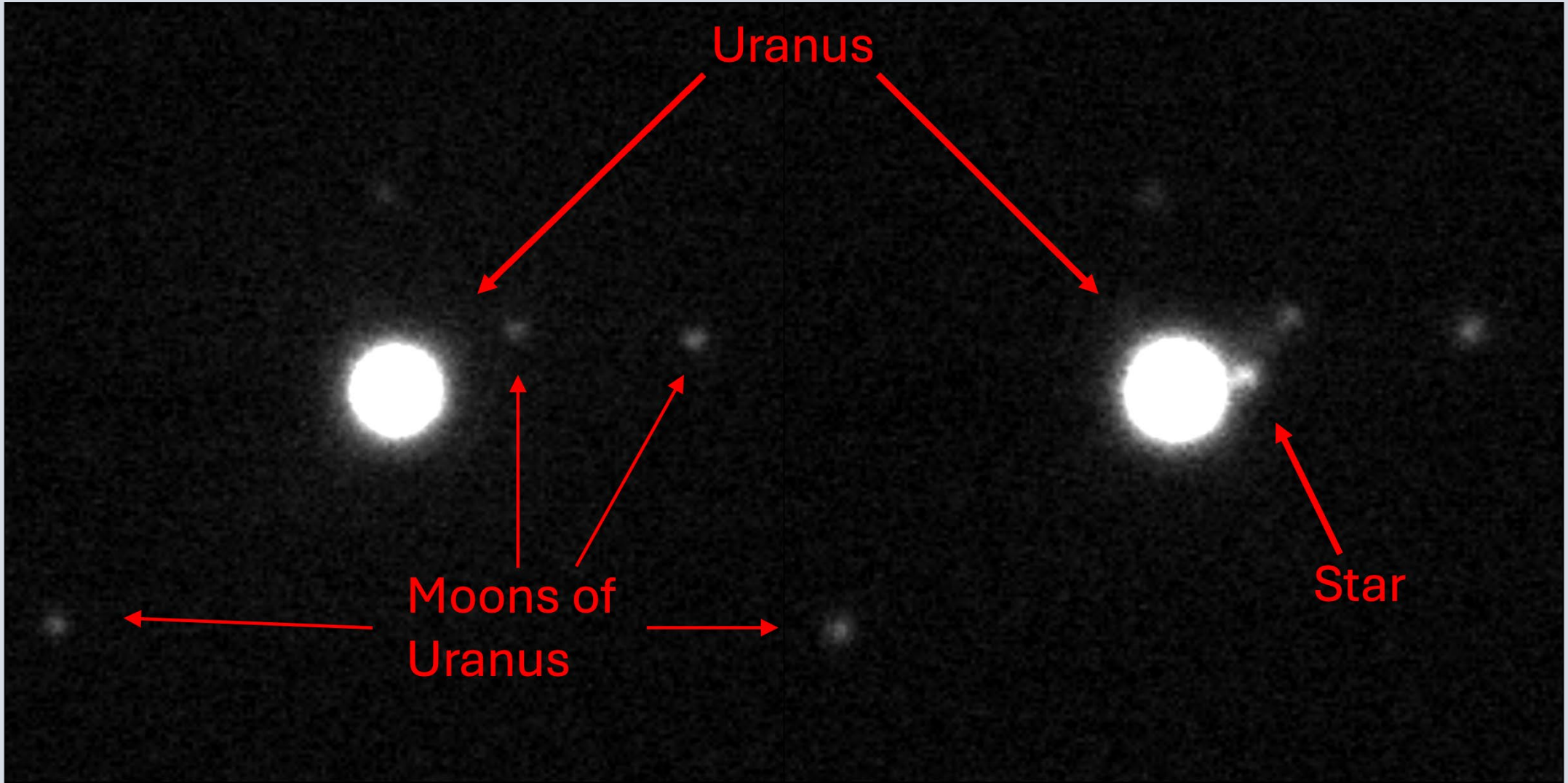


Initial light curve. Atmospheric occultation is visible, but no ring occultations were detected

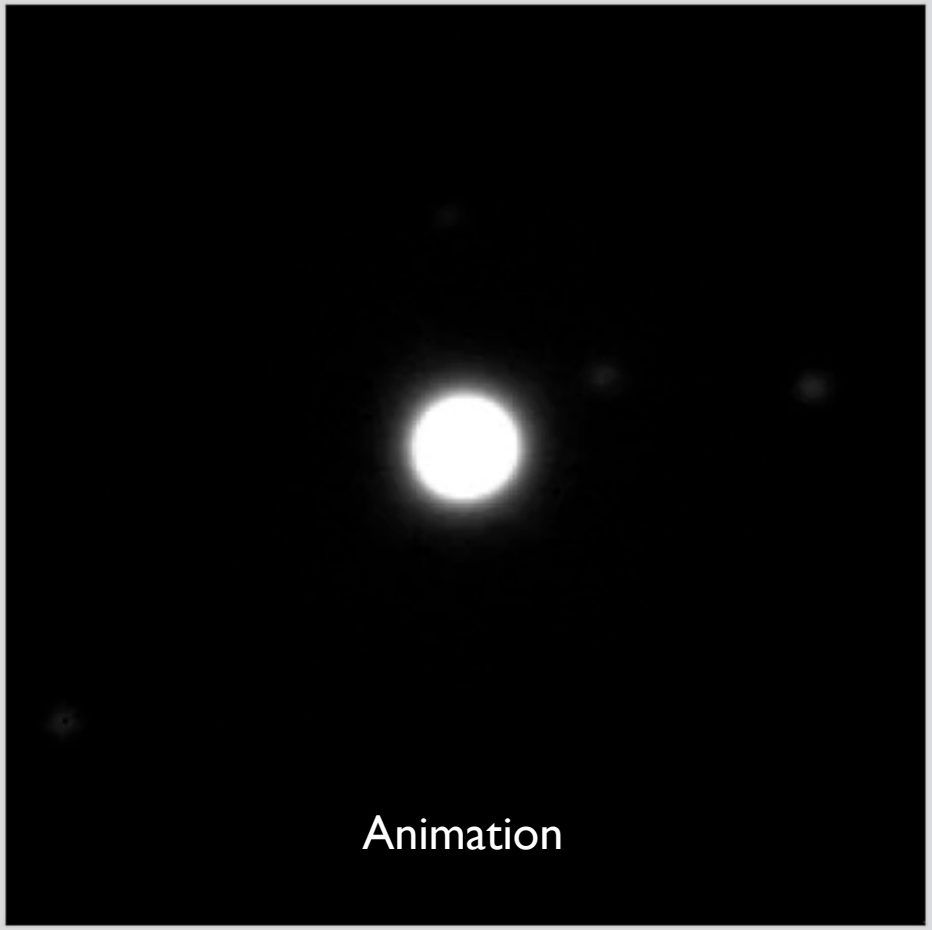
Results from Hokkaido University Observatory

During Occultation

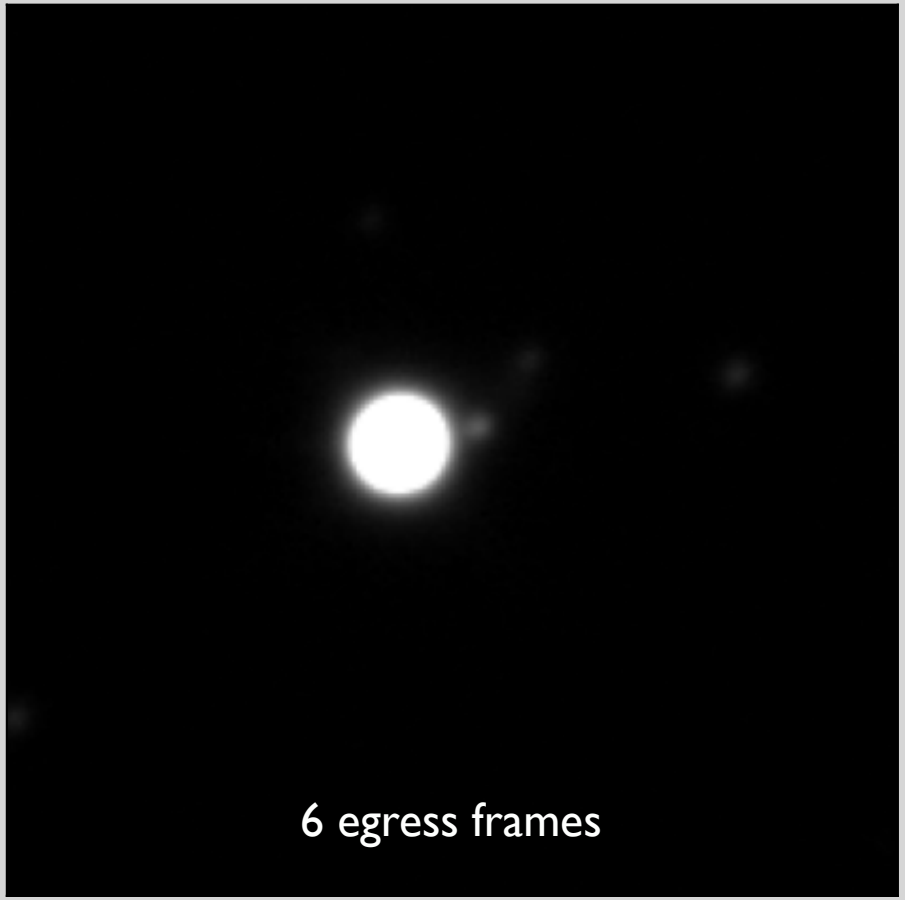
After Occultation



Results from Hokkaido University Observatory



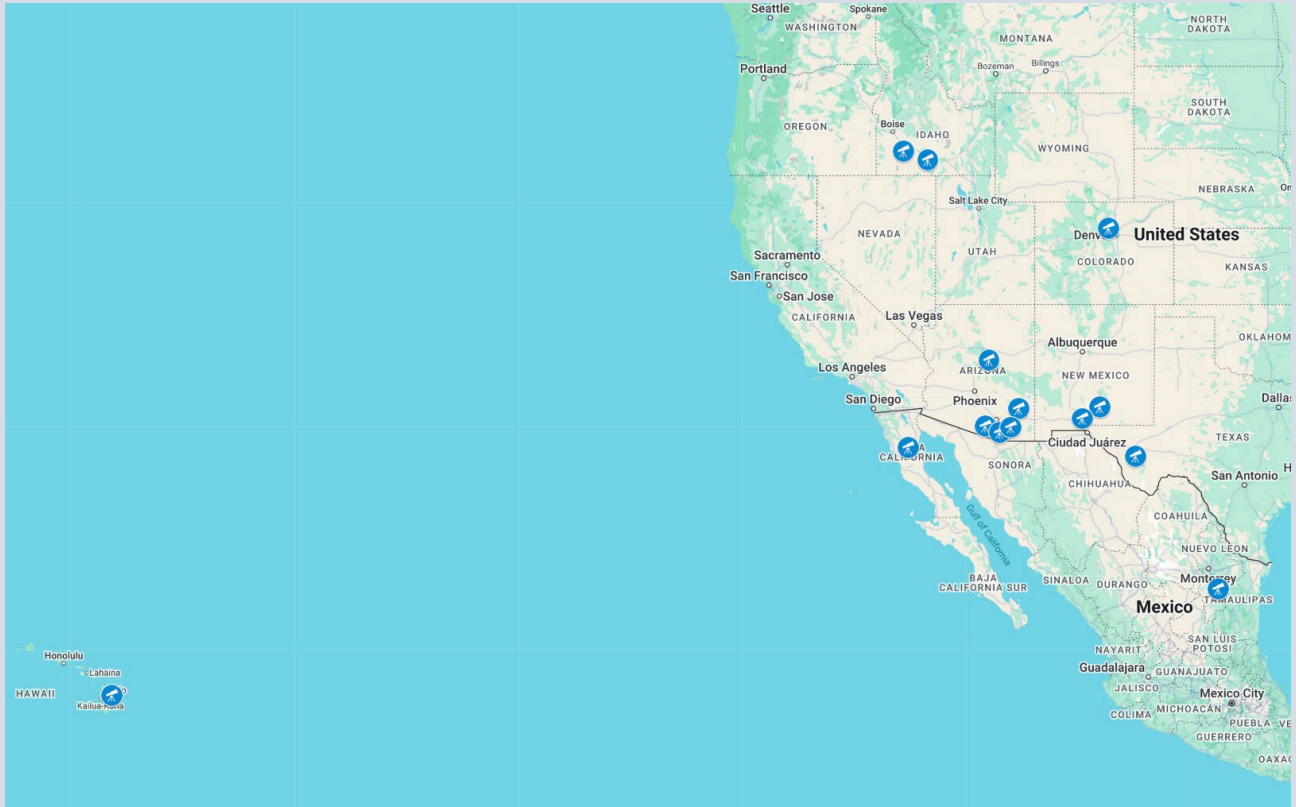
Animation

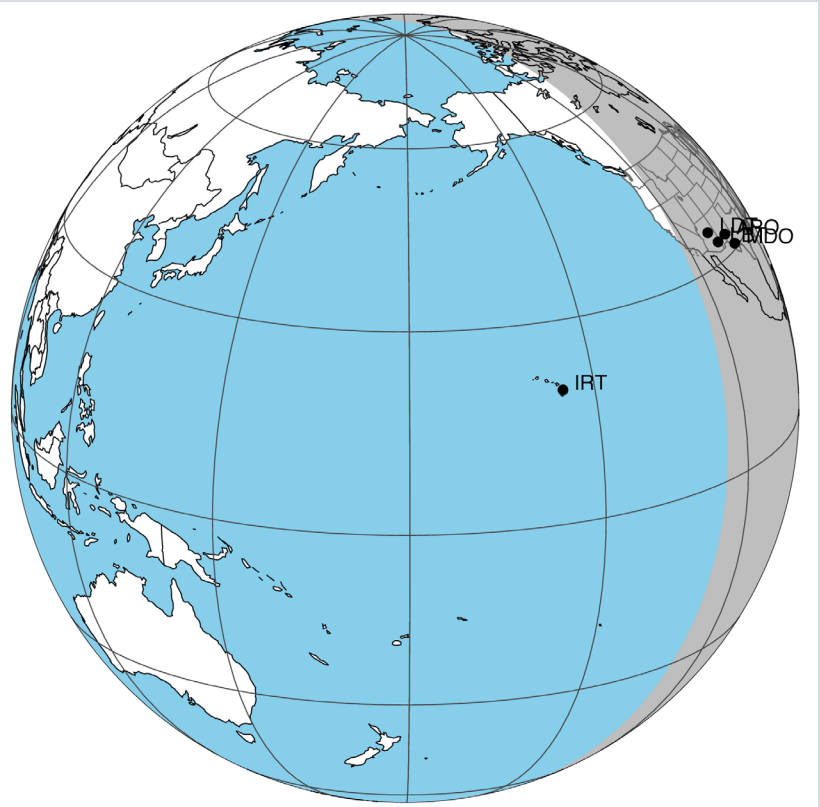


6 egress frames

2025-04-08 Uranus Occultation Campaign

- Predictions improved from 2024 occultation: accurate to within 1 second.
- Challenging geometry: right after sunset and low elevation
- Attempted from 18 observatories in the US and Medico: 14 had success



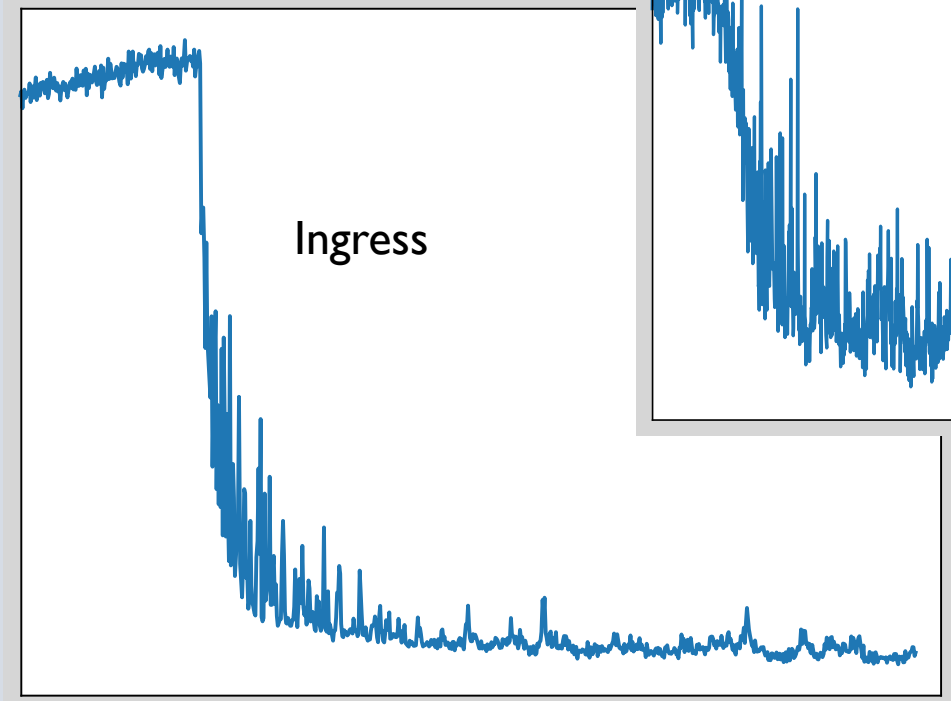


Animation of occultation from the Lowell Discovery Telescope, 890nm methane absorption filter.

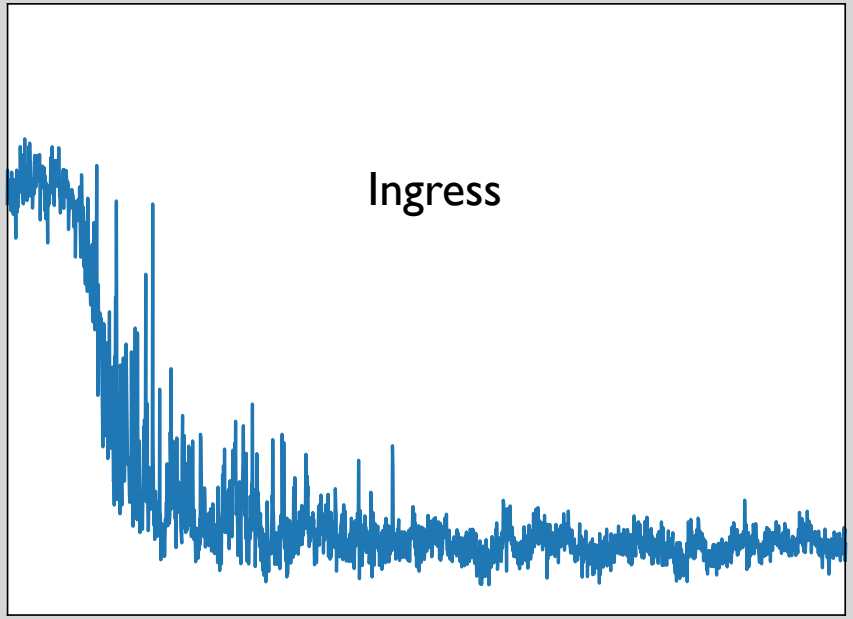
Credit: William Saunders, Stephen Levine

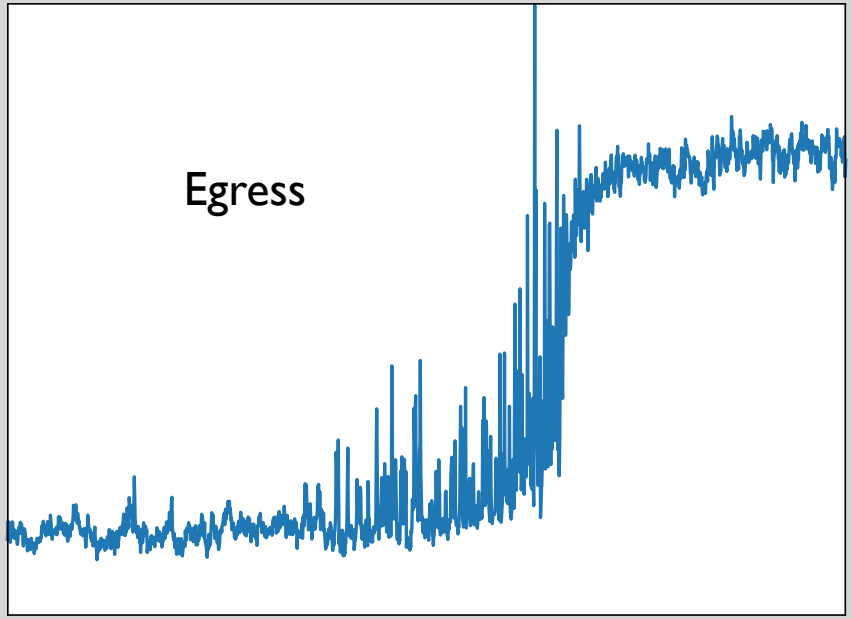
2025-04-08 Uranus Occultation Campaign

- Data extraction and analysis is ongoing.



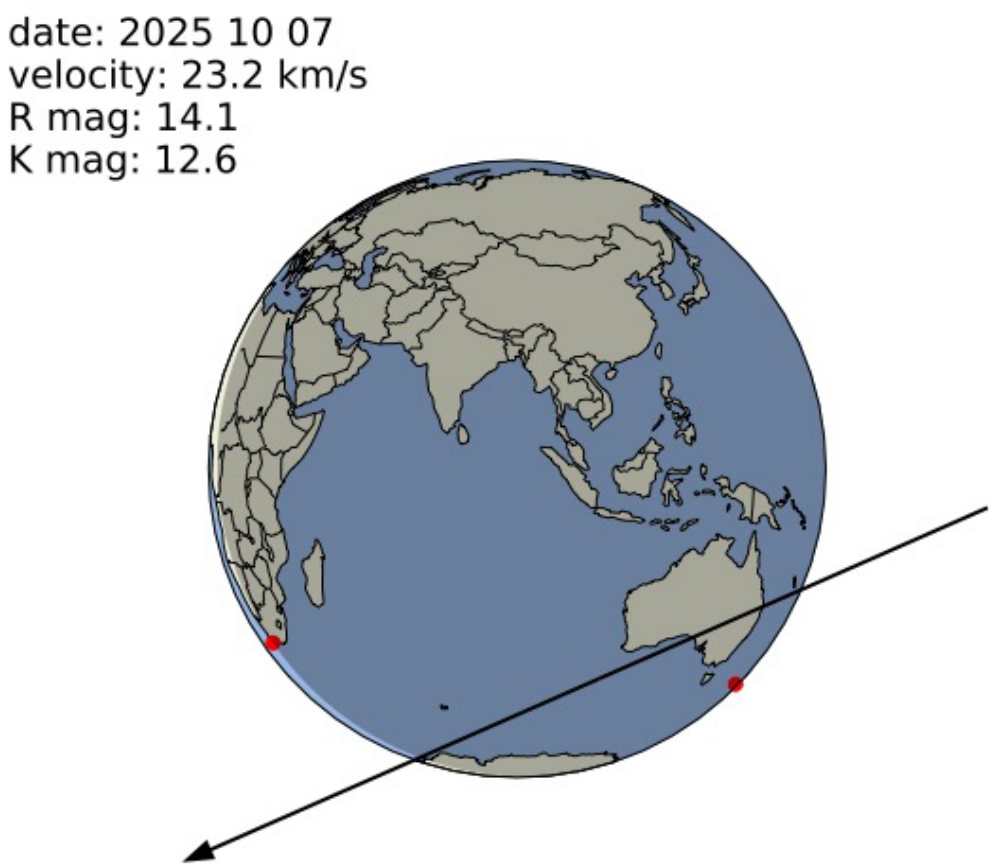
Large Binocular Telescope 1 (8.2-m; Arizona)



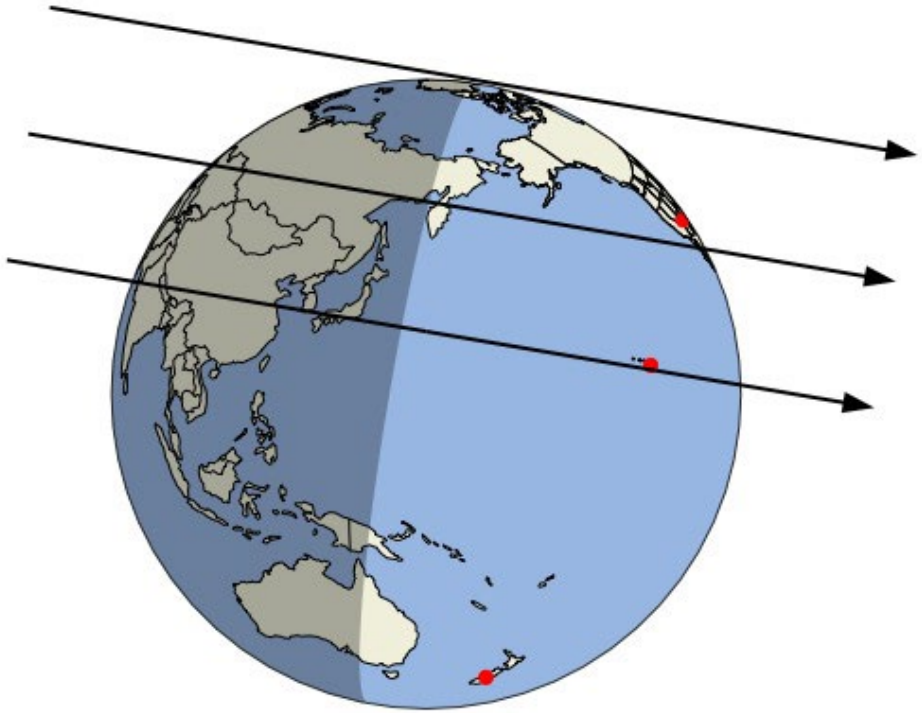


Lowell Discovery Telescope (4.3-m; Arizona)

Call for observatory participations in observing Upcoming Occultations in October 2025

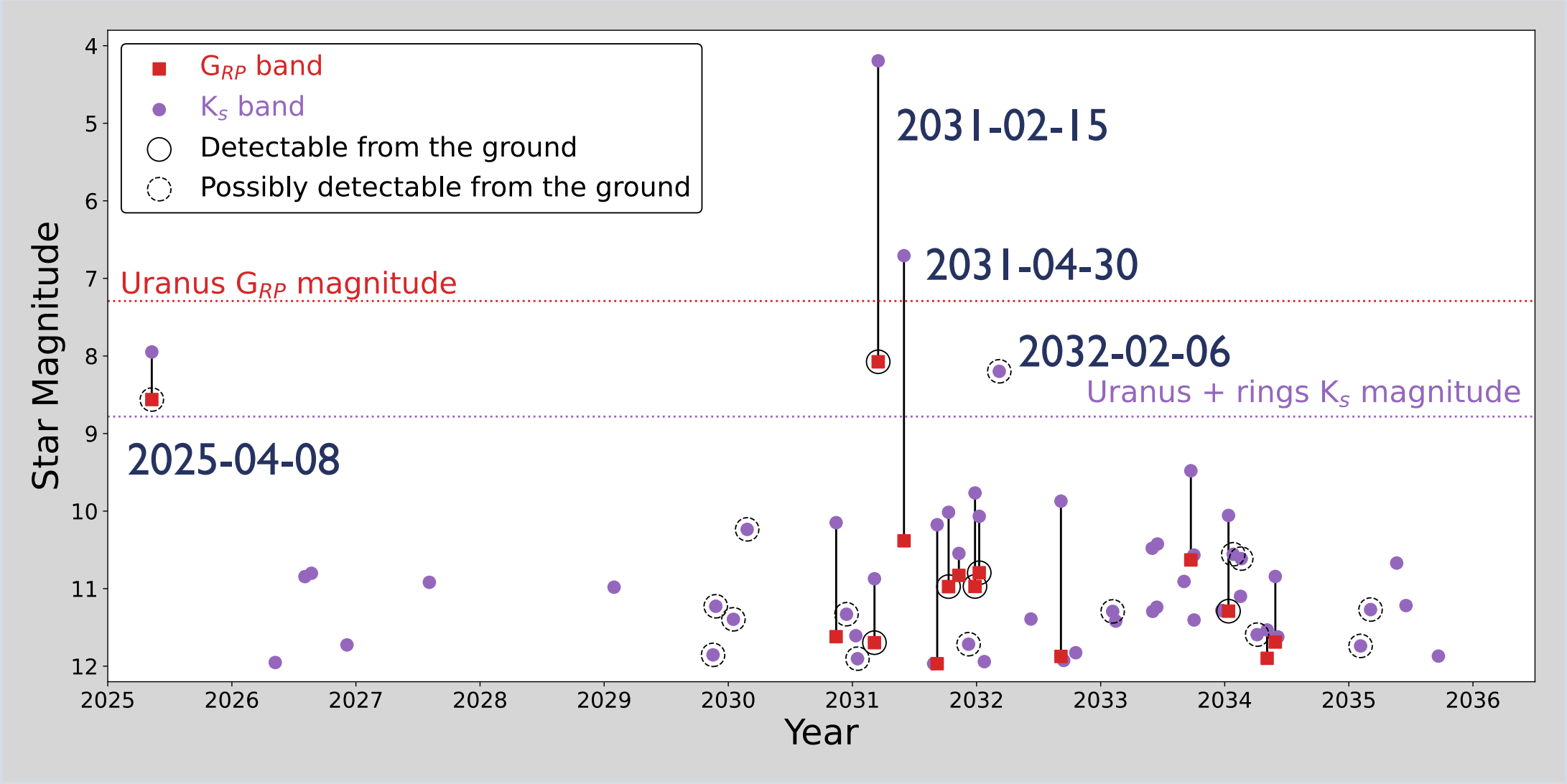


Neptune: October 7, 2025

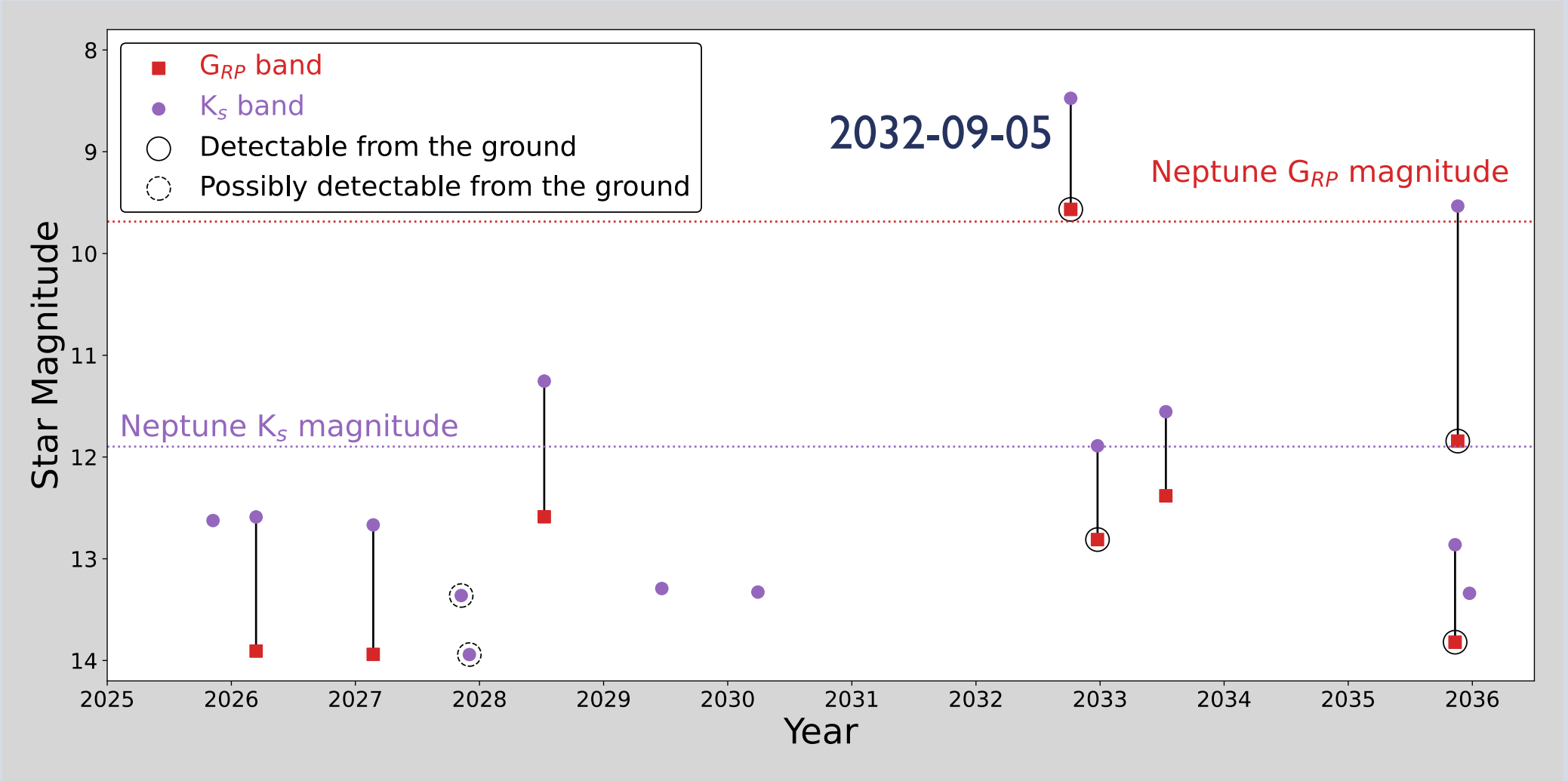


Callisto: October 10, 2025

Future Uranus Occultations



Future Neptune Occultations



Anticipated Results

- New temperature-pressure profiles for Uranus.
- Measurements of how the stratosphere has changed in the past few decades.
- Detection of wave activity.
- Improvement of Uranus' ephemeris from ring occultations.
- Stronger case for observing future occultations from an airborne or space-based platform.

Stay tuned as we make progress in our analysis!