Understanding the Variability of Neutral Calcium in Mercury's Exosphere by Comparing MESSENGER Observations to Models

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MACH

MACH CENTER
DO HABITABLE WORLDS
REQUIRE MAGNETIC FIELDS?

LASP
Laboratory for Atmospheric and Space Physics
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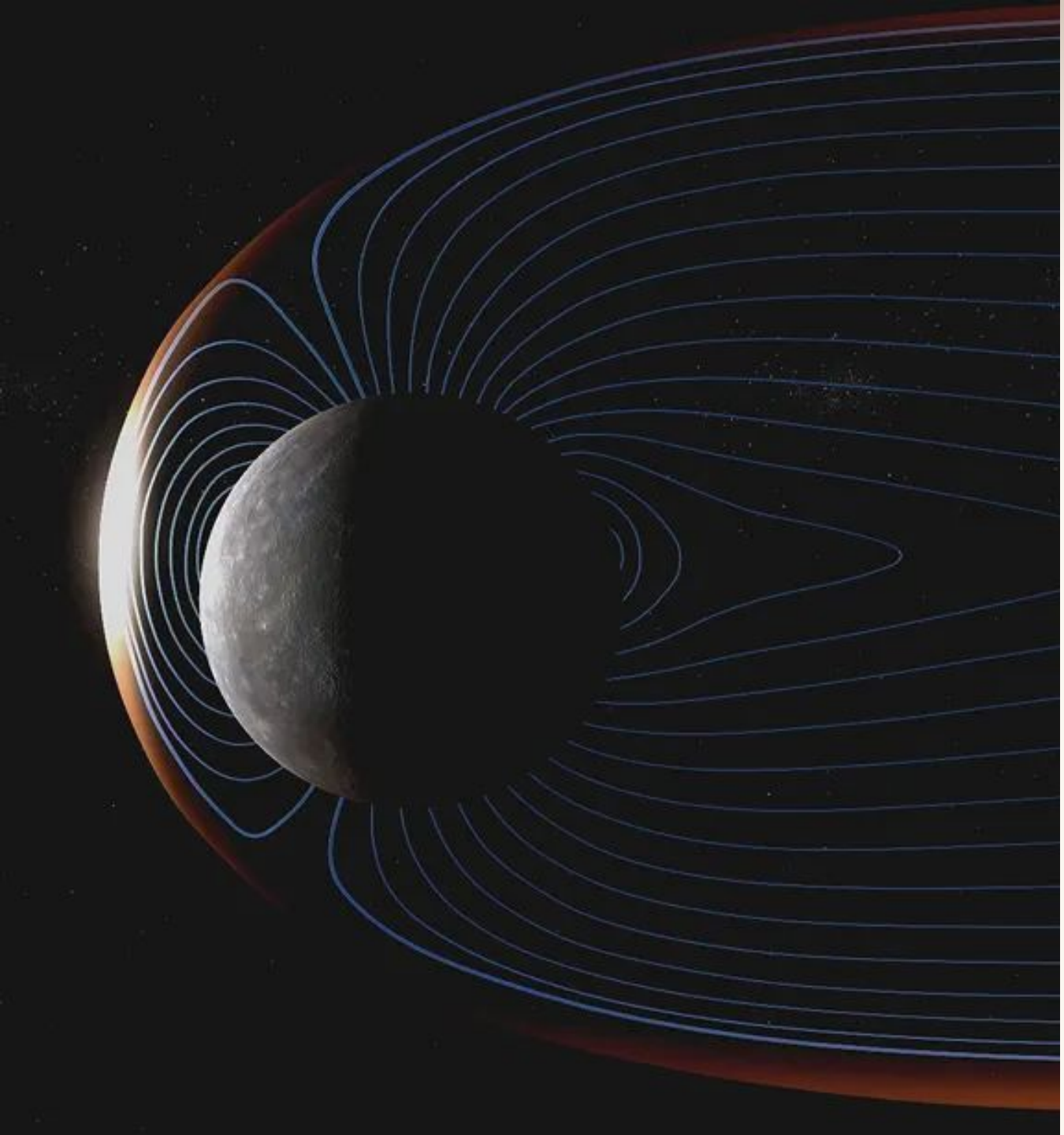
Mercury and MACH

- Surface-bounded exosphere
- Magnetosphere
- Isolate atmospheric loss processes (source processes for Mercury)
- Apply what we learn to other planets

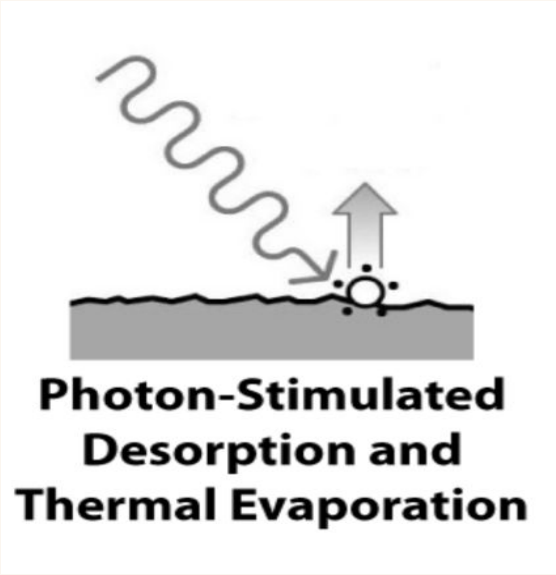


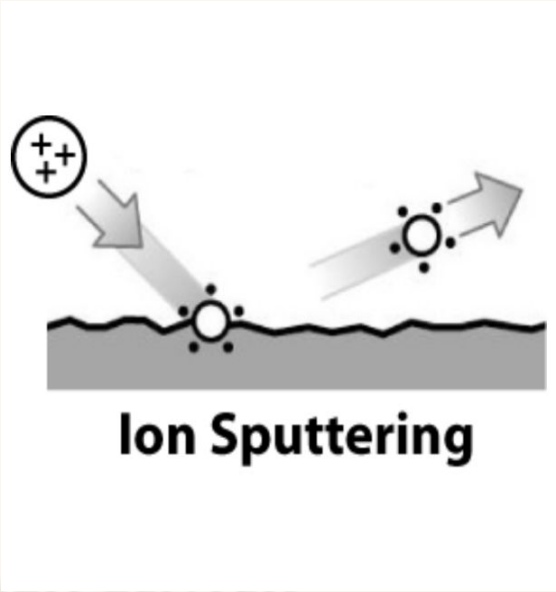
Mercury and MACH

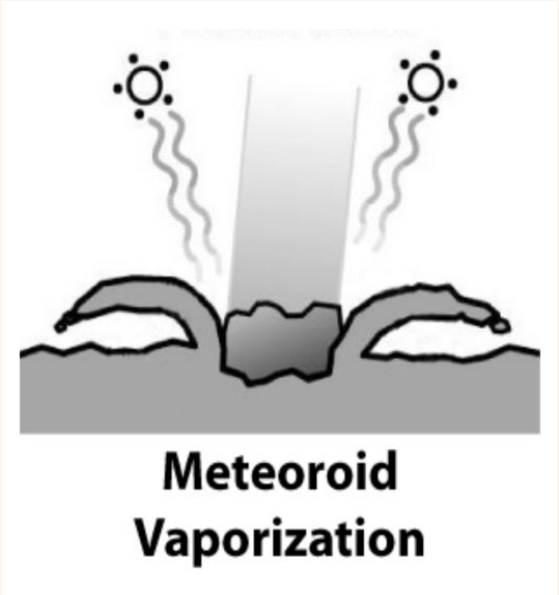
Water on Mercury?

- Close proximity to Sun
  - High influx of water comets
- 3:2 spin-orbit resonance
  - Permanently shadowed poles
- Water ice on the poles

Source Processes: Mercury

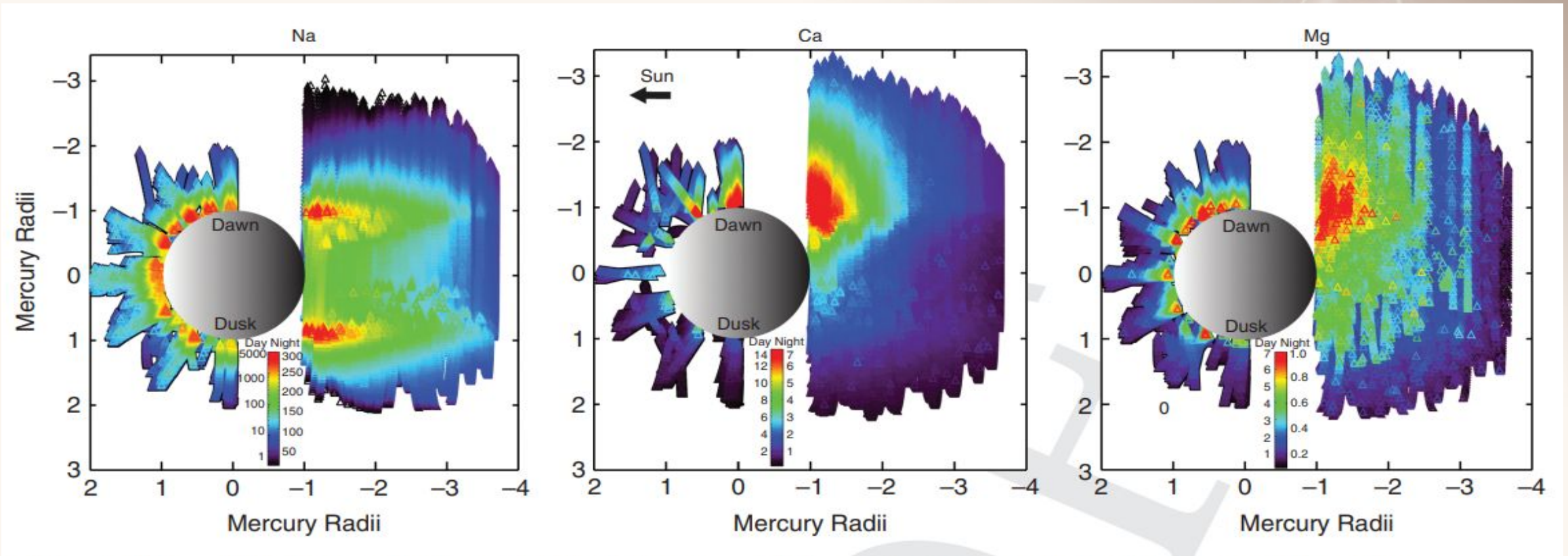




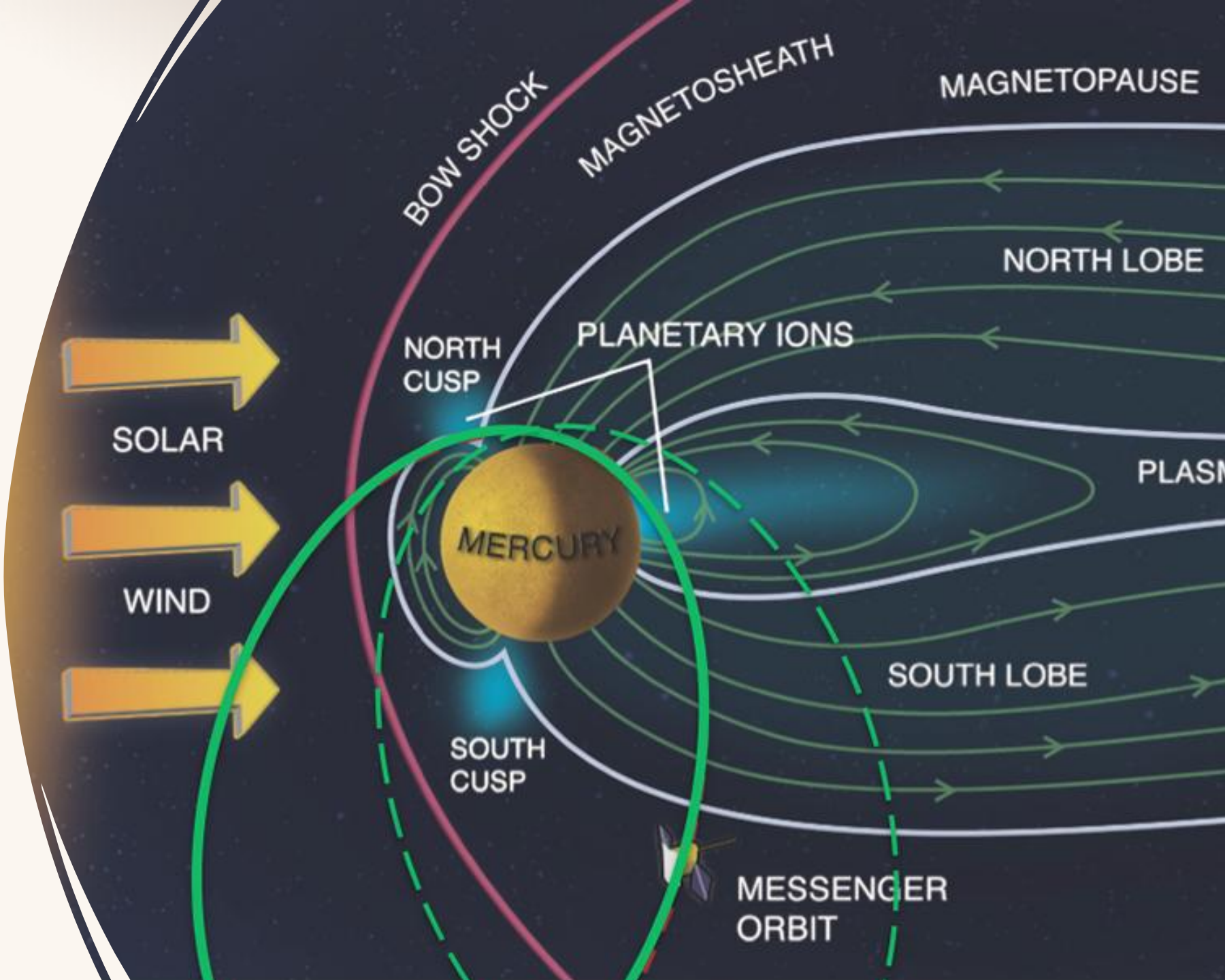


- Photon-Stimulated Desorption
  - Sunlight breaks the bonds that holds the surface together
- Sputtering
  - Solar wind ions colliding with the surface
- Impact vaporization
  - Meteoroids colliding with the surface releasing species, can followed by photon-dissociation

Spatial Distribution

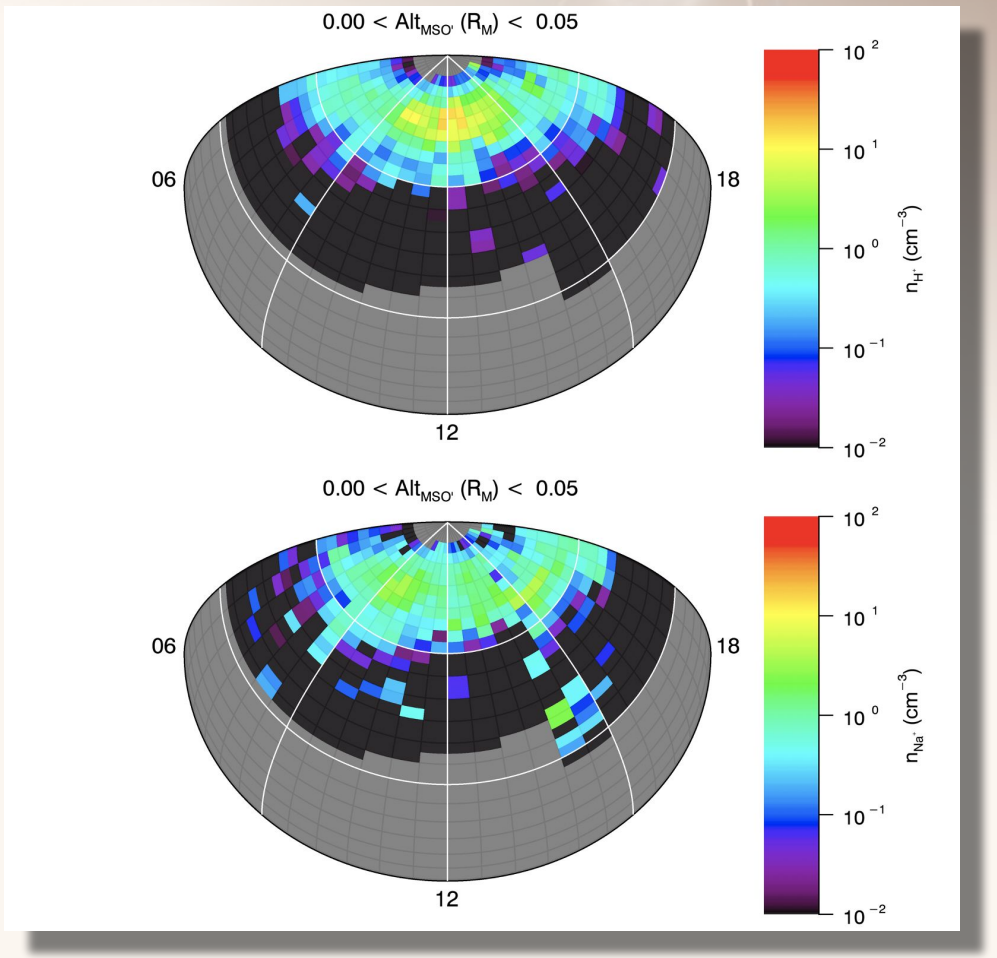


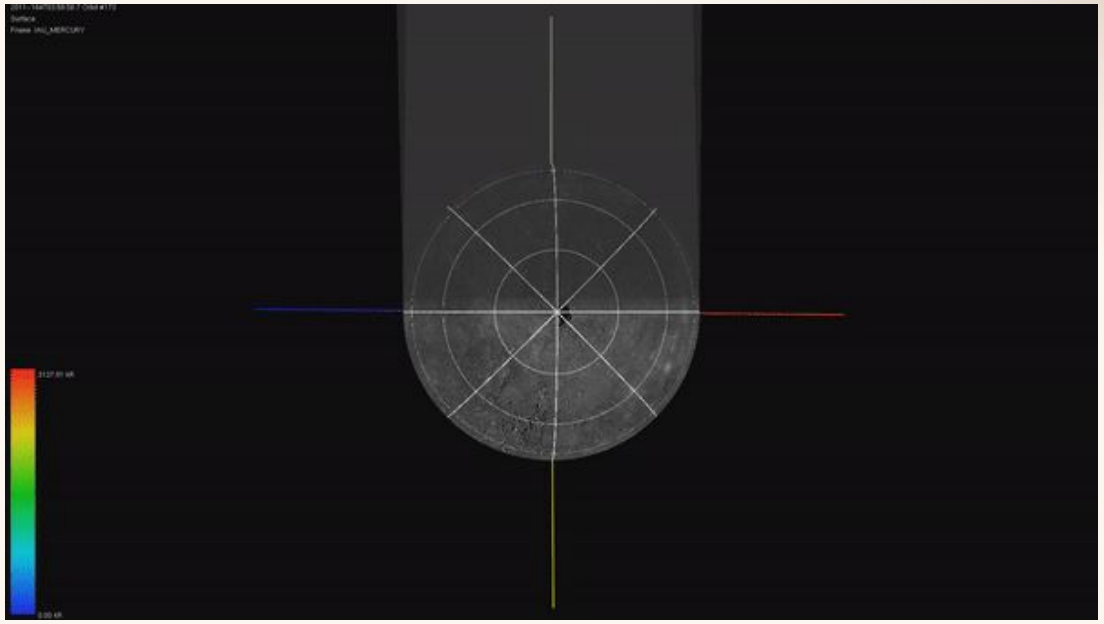
Mercury's Magnetosphere

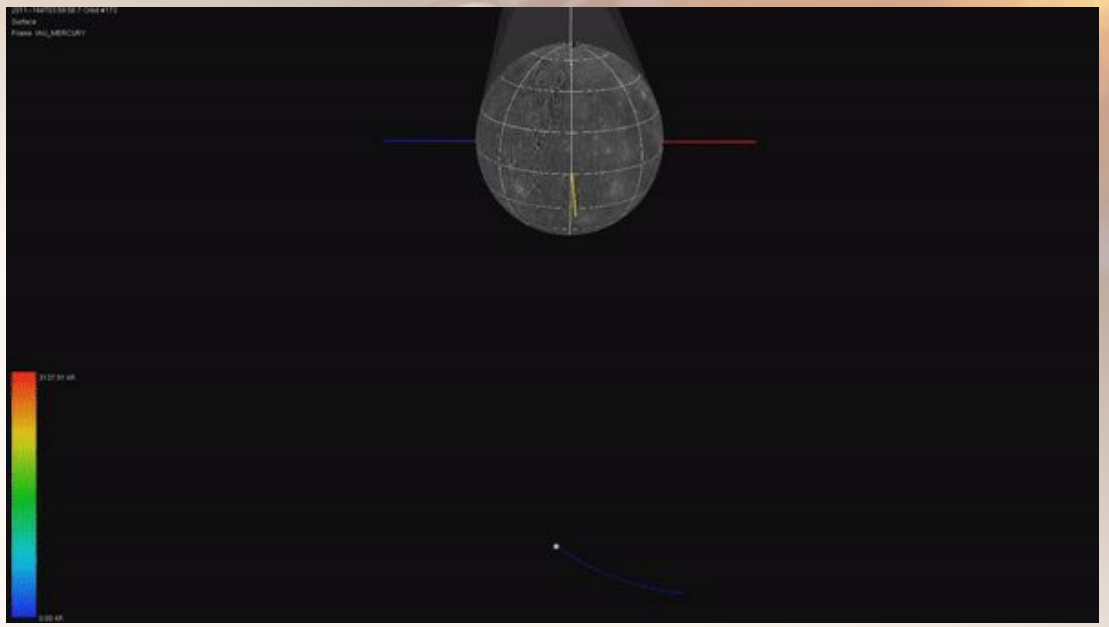


Mercury's Magnetosphere: FIPS

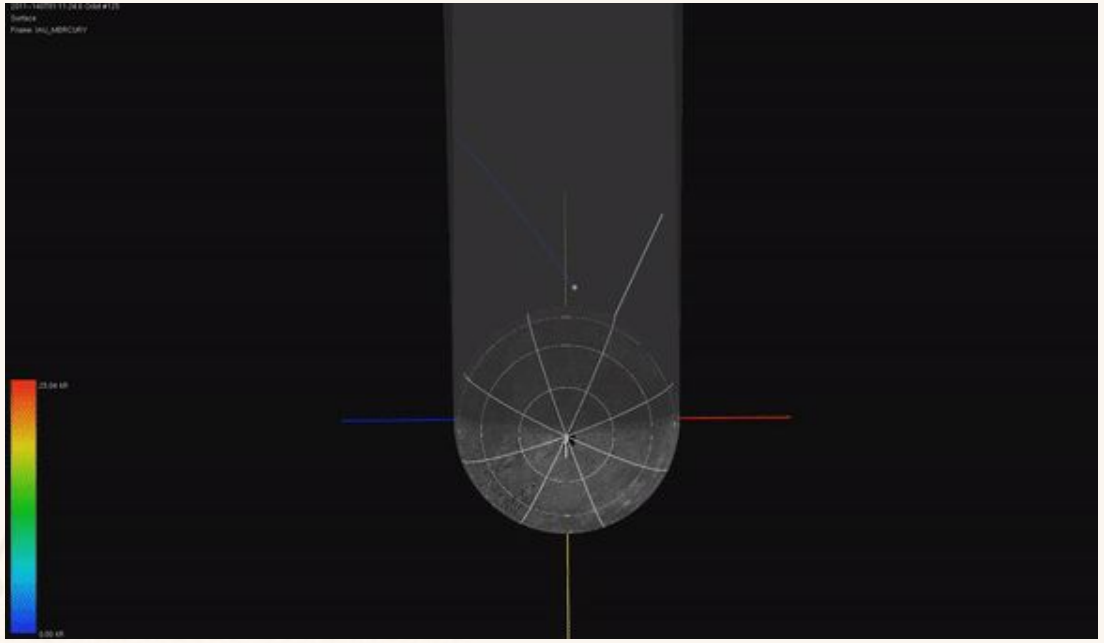
- (From FIPS) Mercury's cusp
- Fast Imaging Plasma Spectrometer
  - Measures mass per charge, the energy per charge, and incident angles for particles entering the sensor.

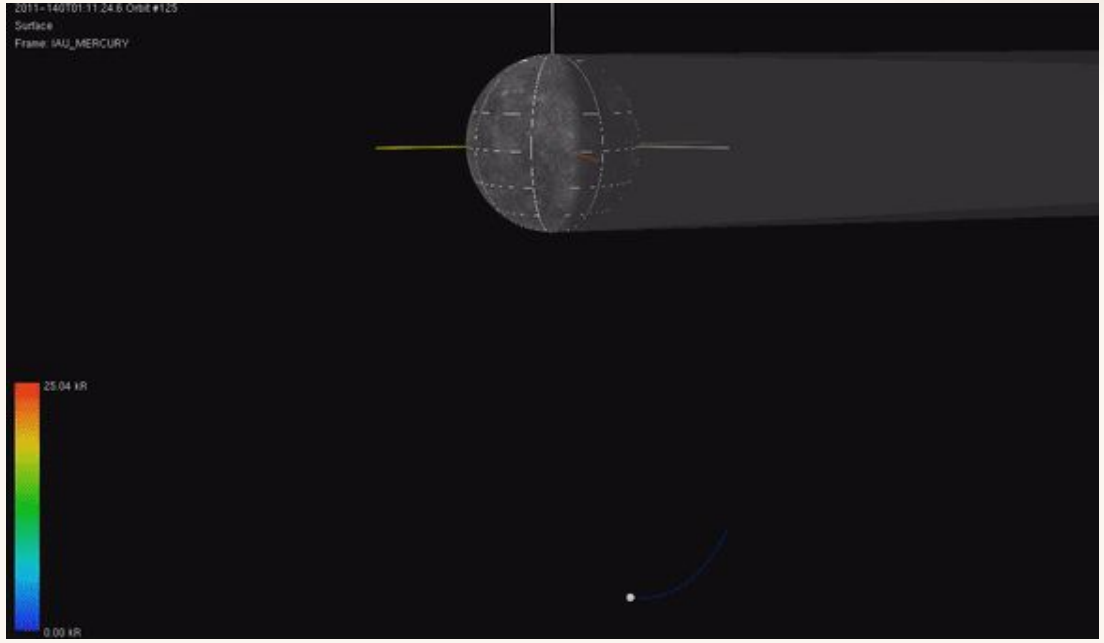






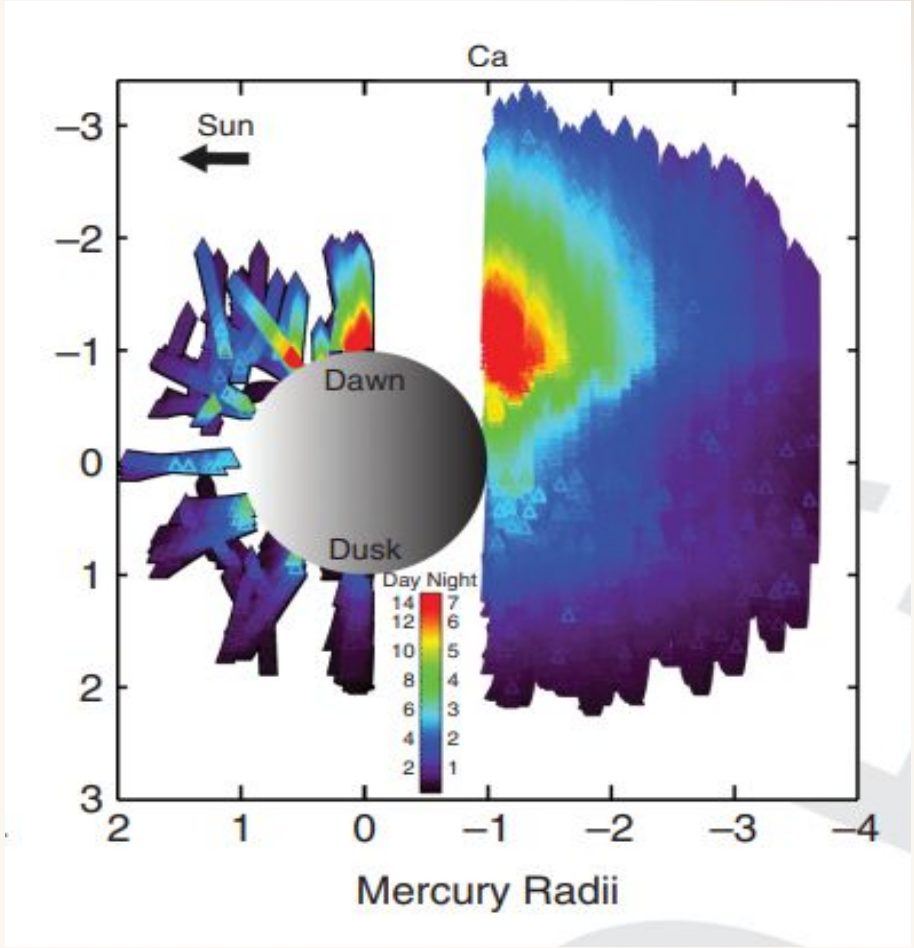
Dayside limb scans

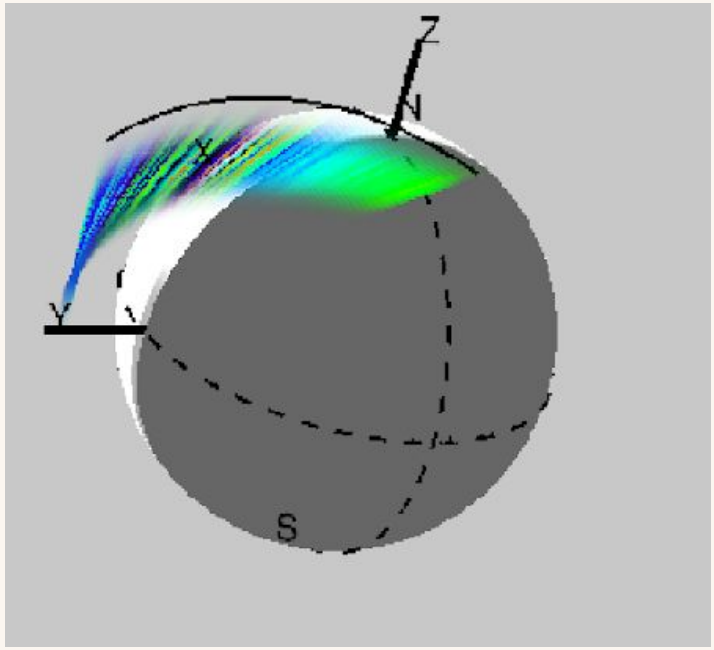


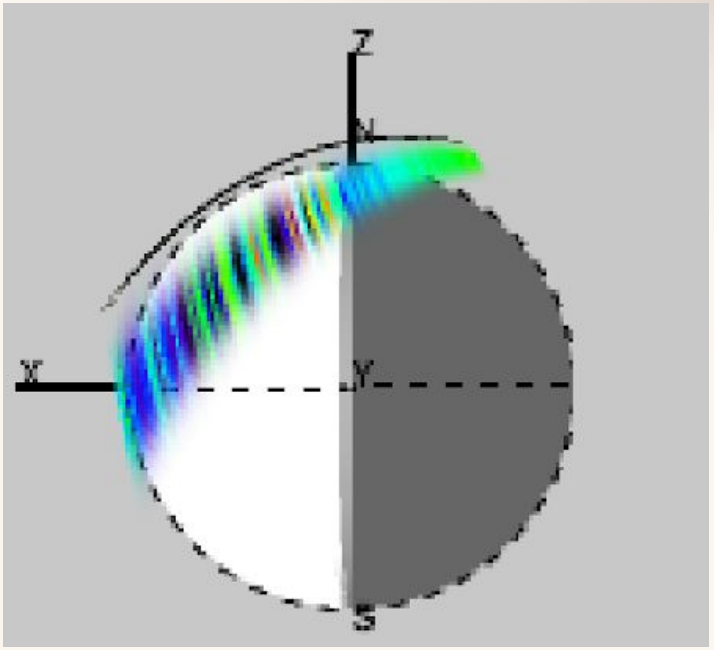


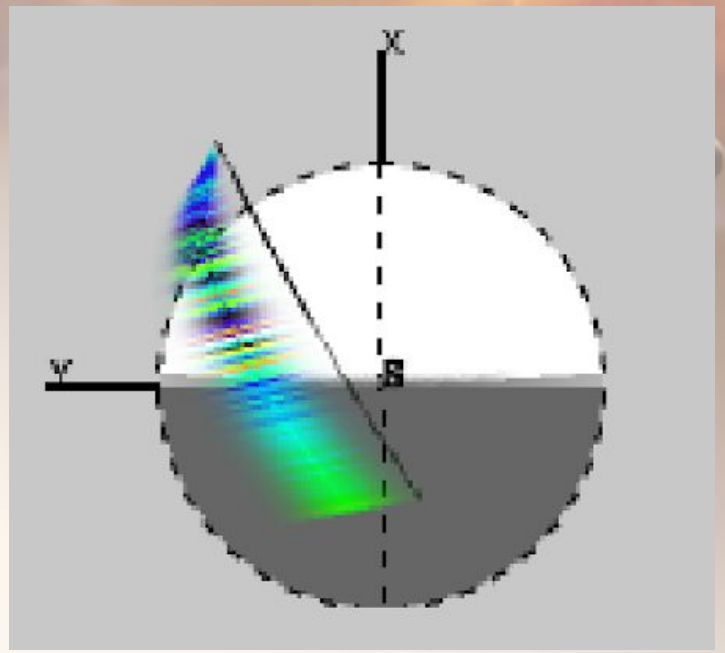
Nightside tail sweeps

Calcium Spatial Distribution





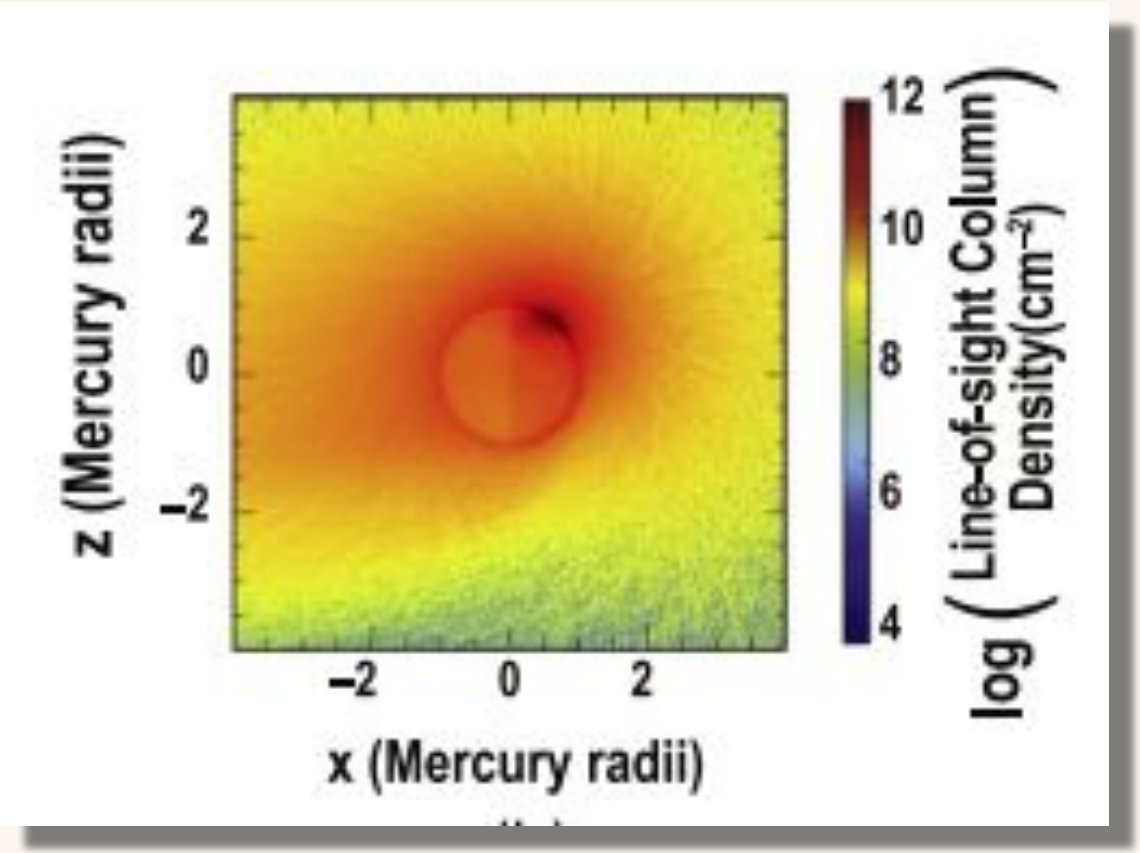




Mercury: A case study

How do we explain the observed enhancement of calcium over the dusk northern pole of the planet?

Method: The Monte Carlo Model



(Rosemary M. Killen *et al* 2022 *Planet. Sci. J.* 3 139)

Initial Conditions → Vector Calculations → Model Radiance

Packets represent atoms

- Species
- Initial **v**
- Forces
- Source processes

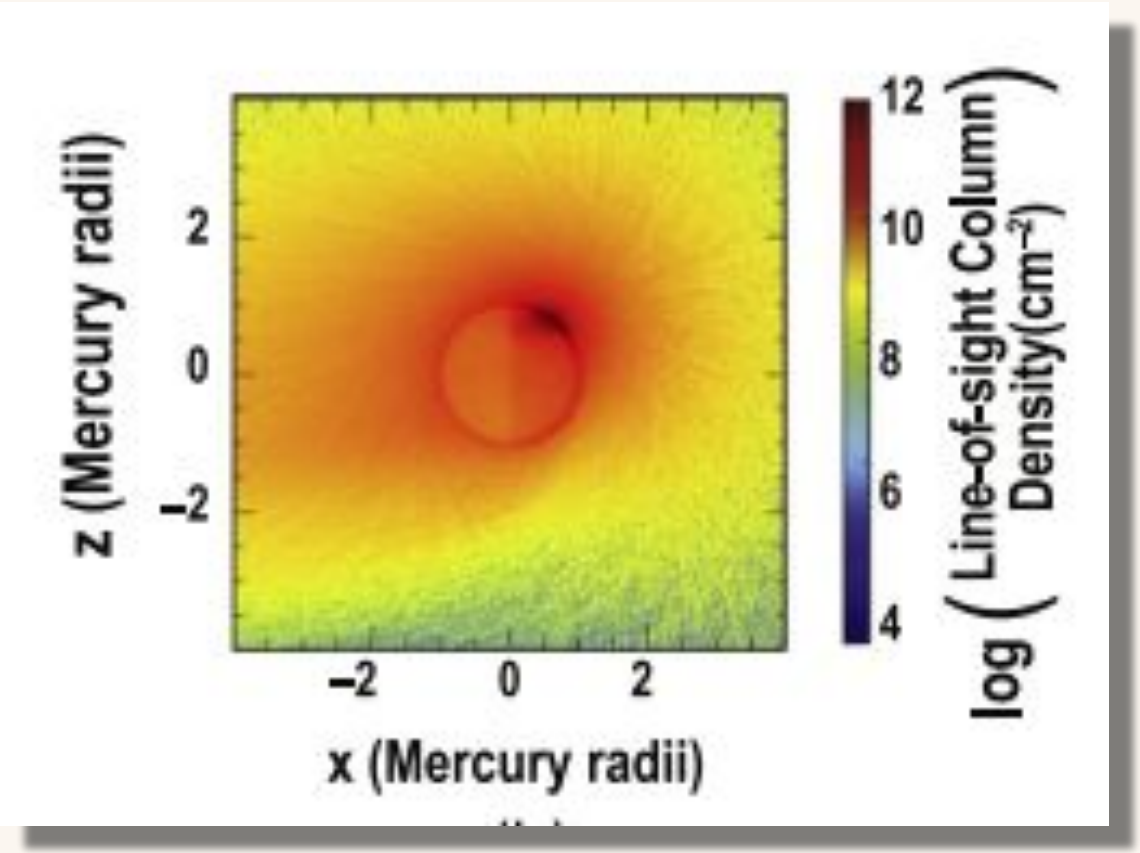
Trajectory of packets calculated

- 5th order Runge-Kutta integration
- Velocity and position

Radiance of model calculated

- Can plot against other instrument measurements

Method: Calcium at the Cusp



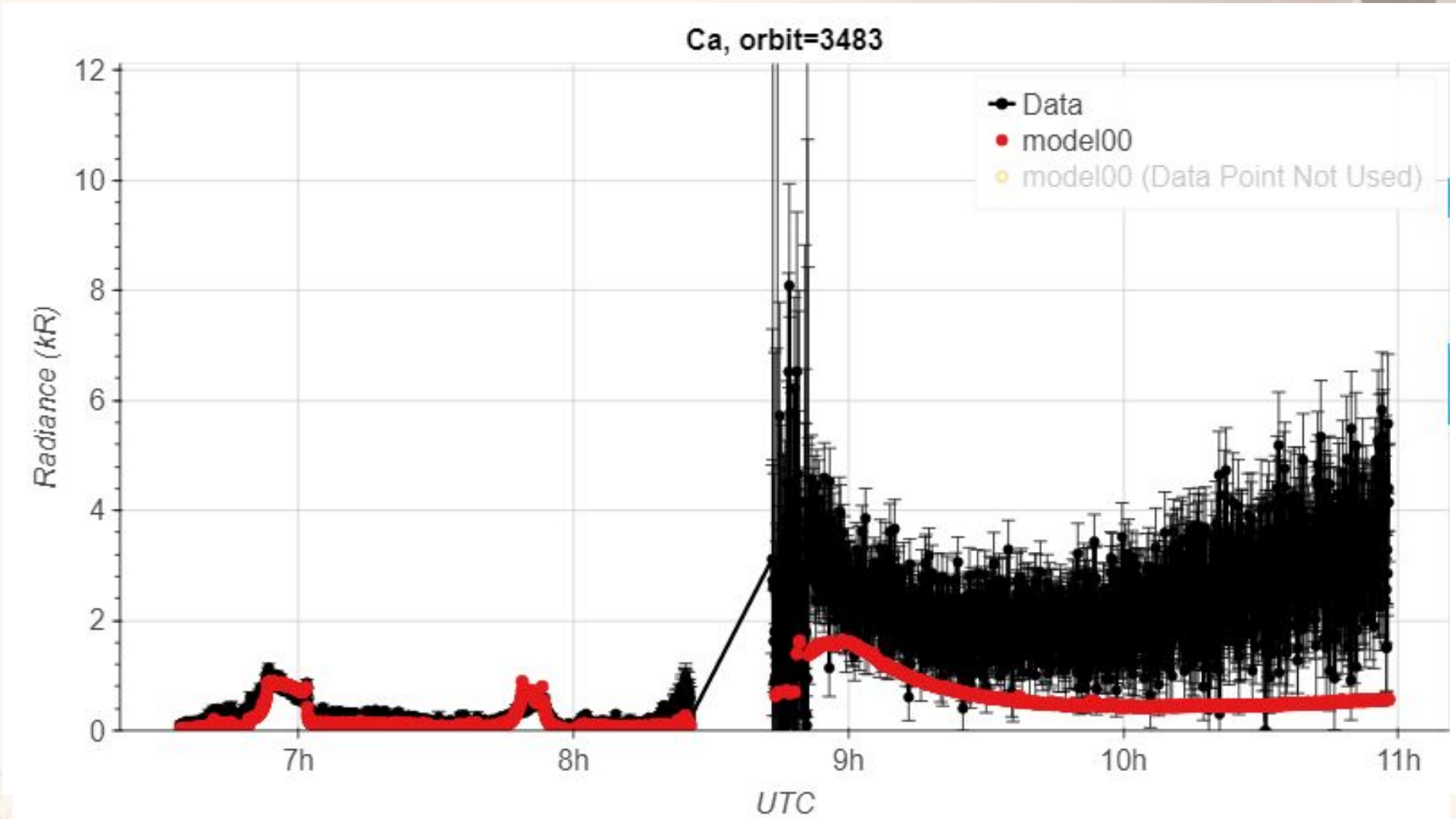
(Rosemary M. Killen *et al* 2022 *Planet. Sci. J.* 3 139)

Initial Conditions

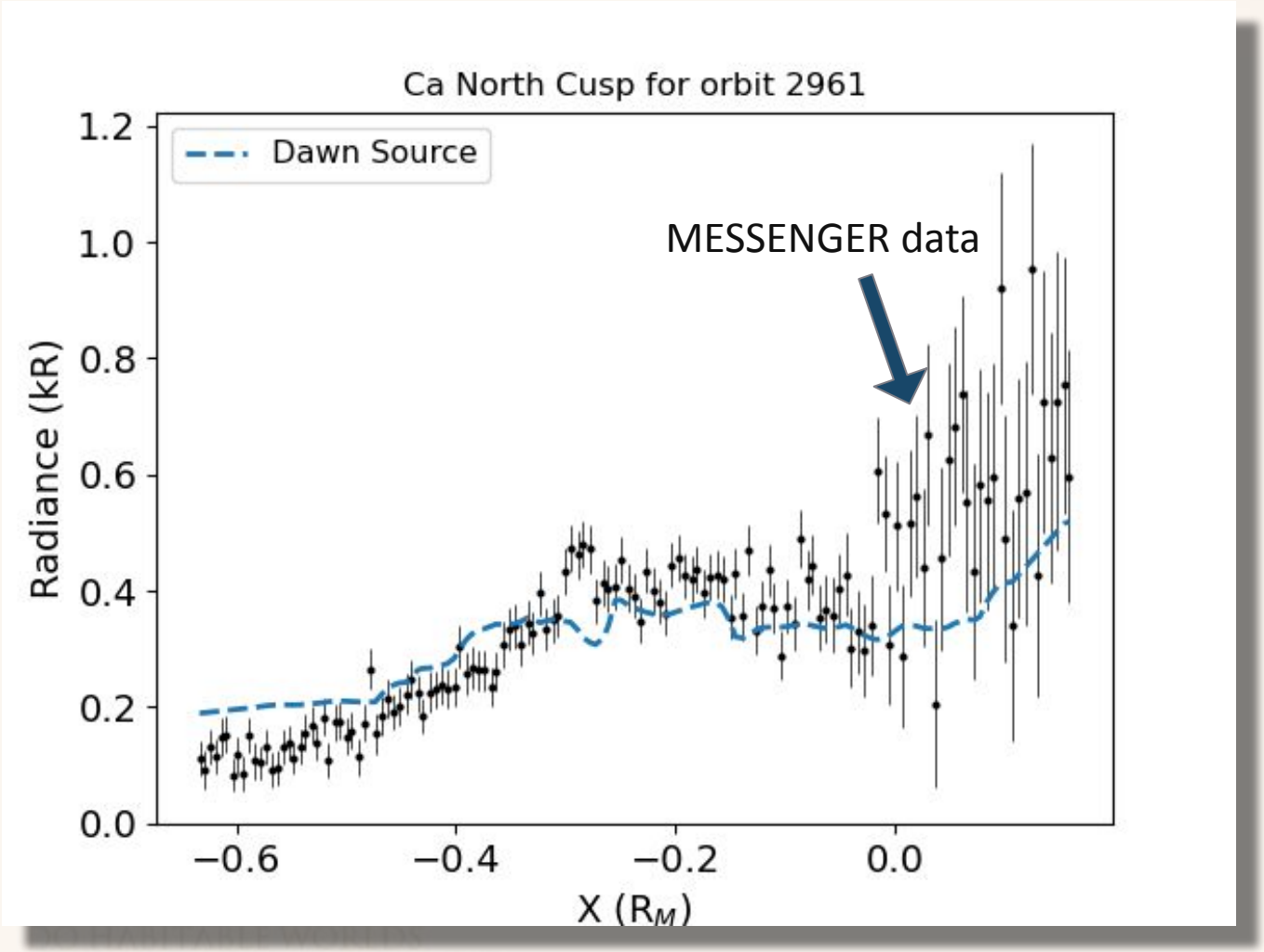
Assumptions for dawn source

- Gravity and radiation pressure
- Sticking coefficient
- Maxwellian speed distribution
- Surface spot spatial distribution
- Temperature of 60,000 K

Dawn Source as a Source Process



Dawn Source as a Source Process



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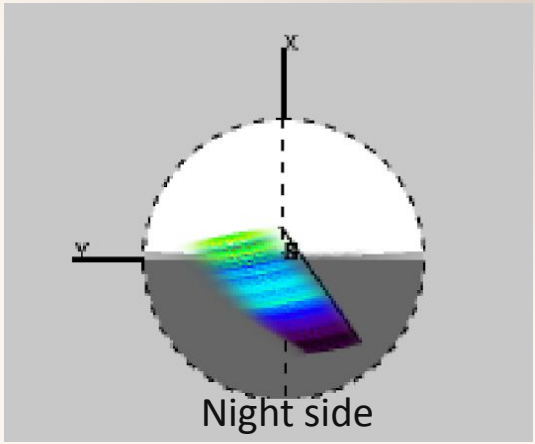
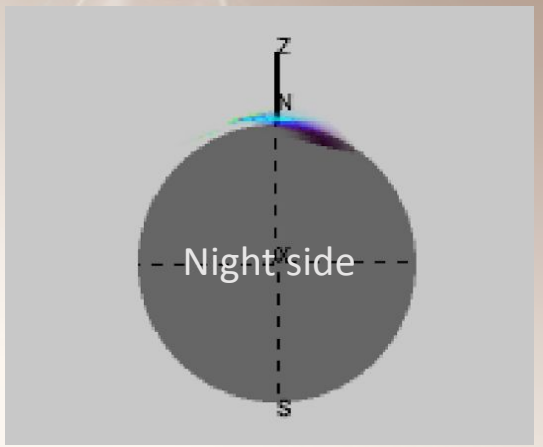
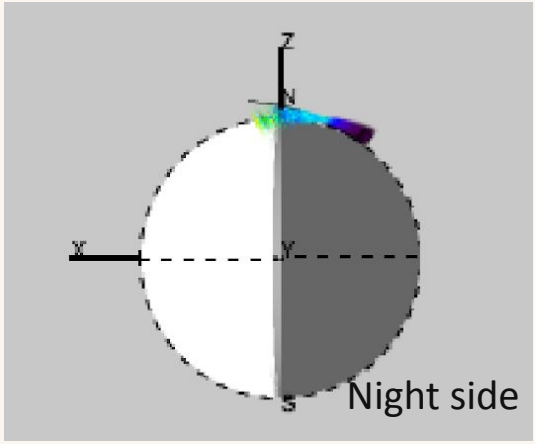
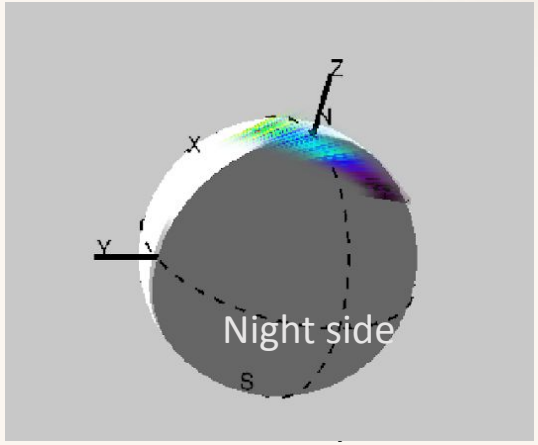
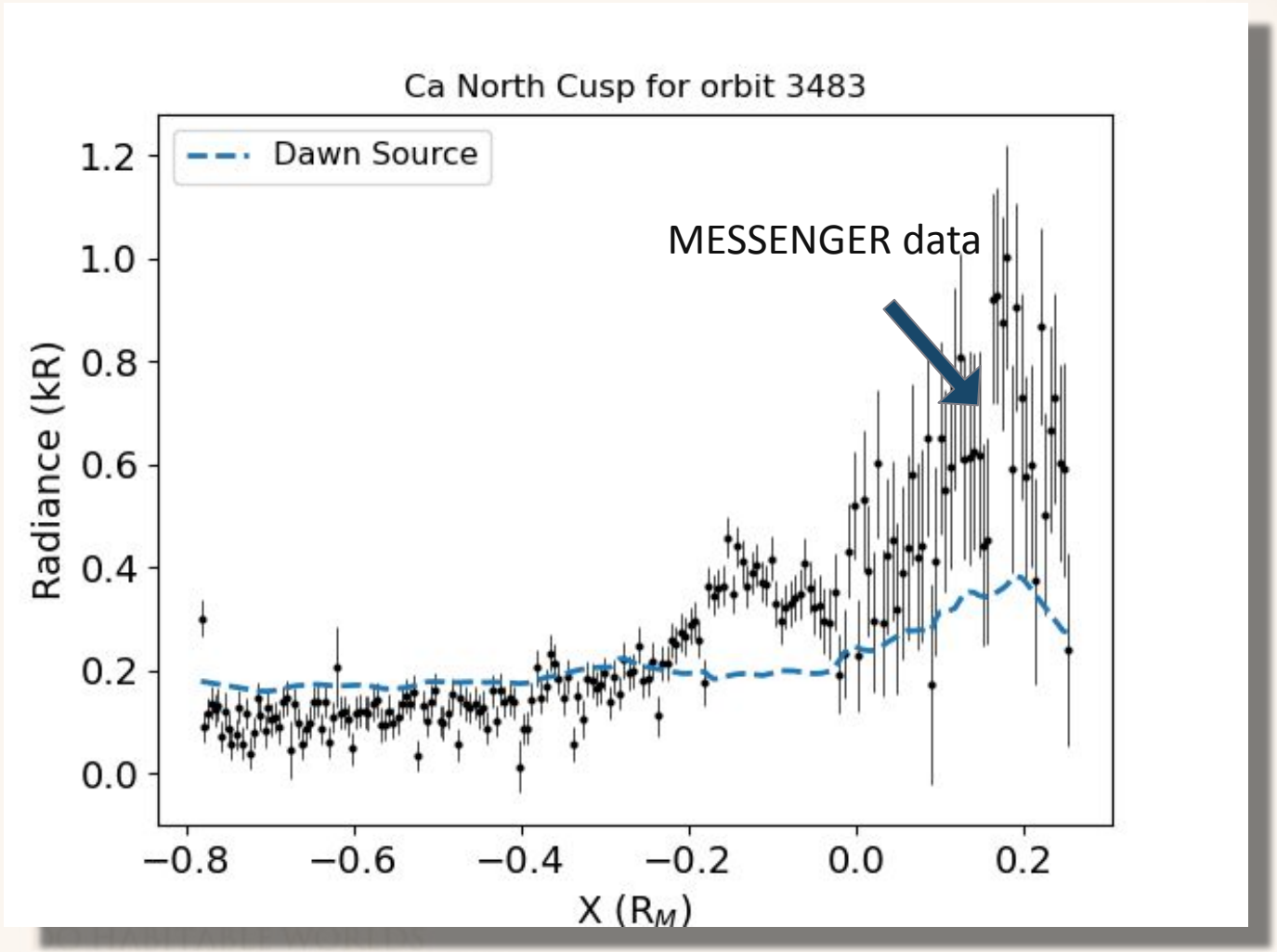








Dawn Source as a Source Process



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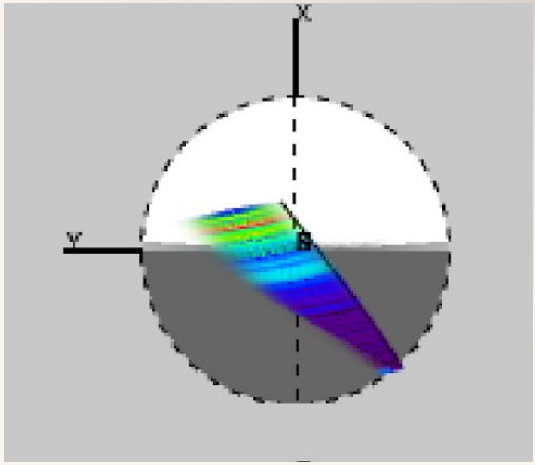
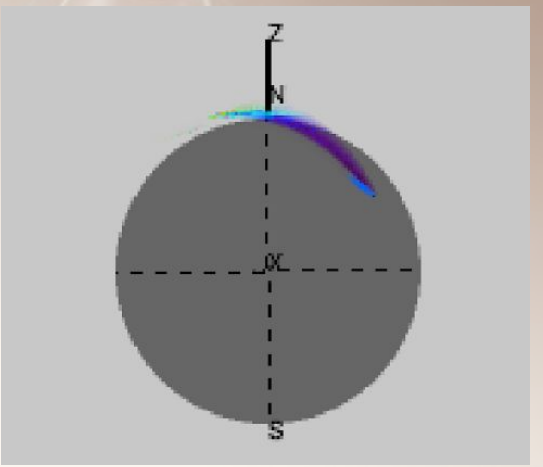
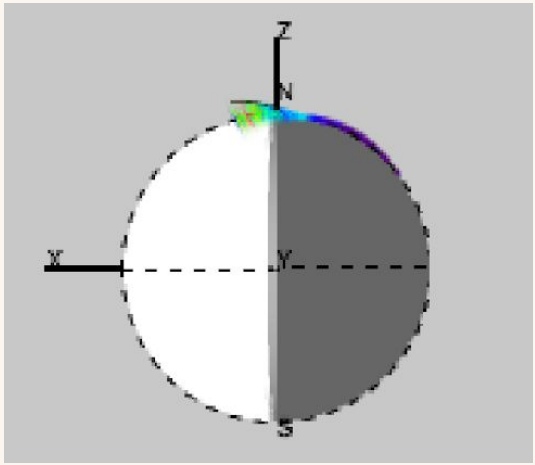
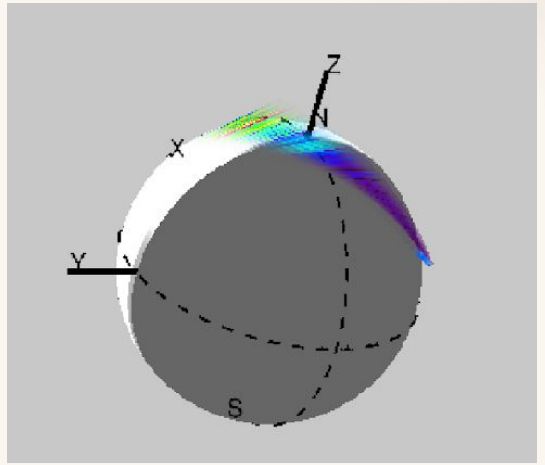
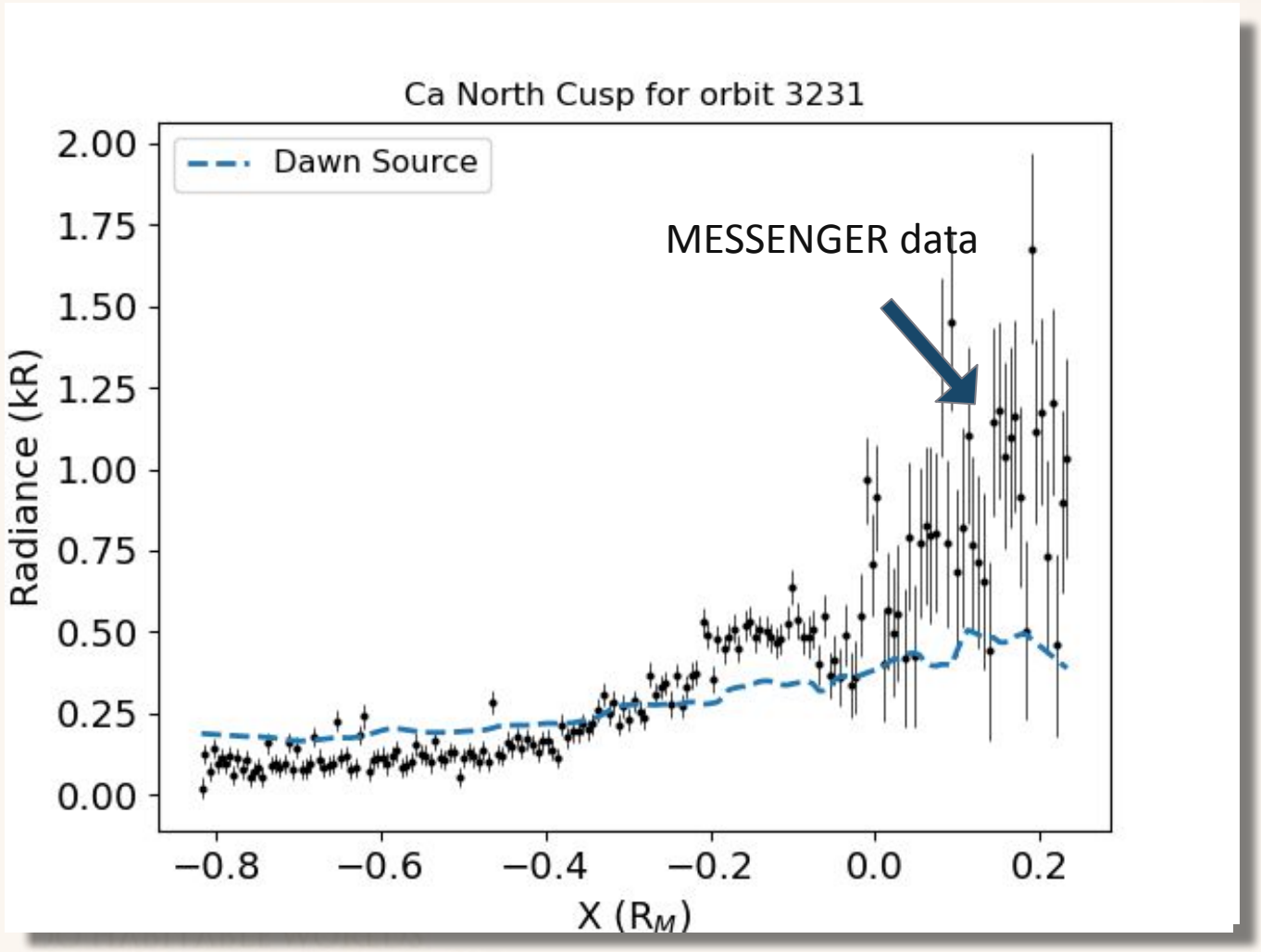








Dawn Source as a Source Process



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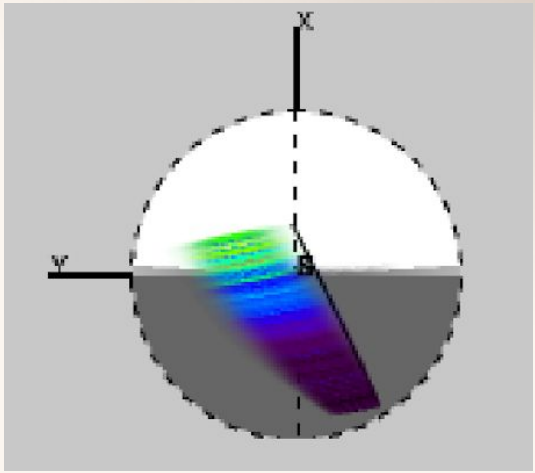
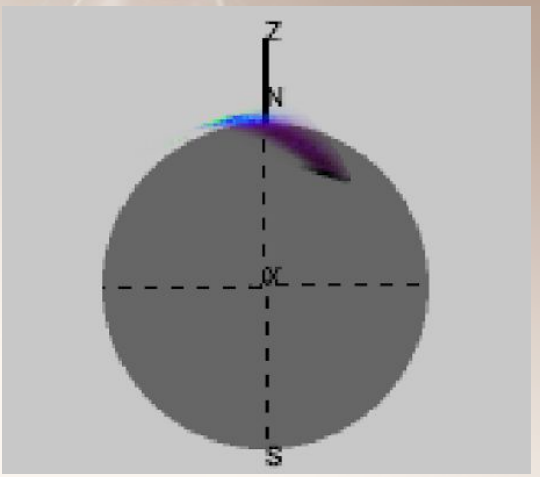
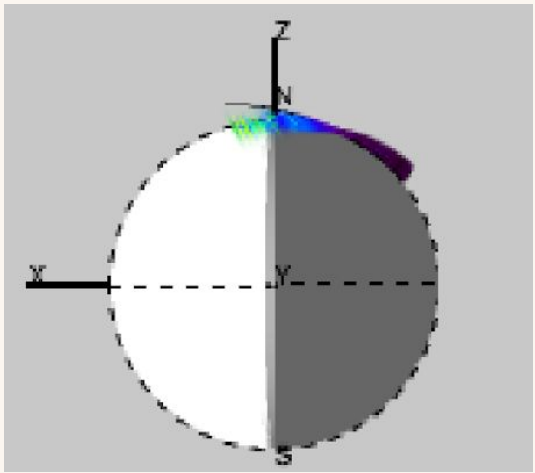
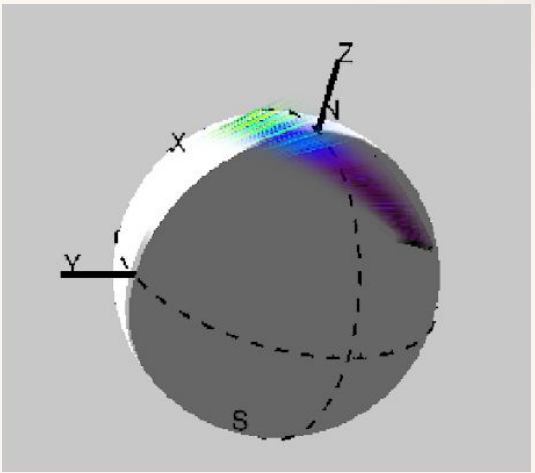
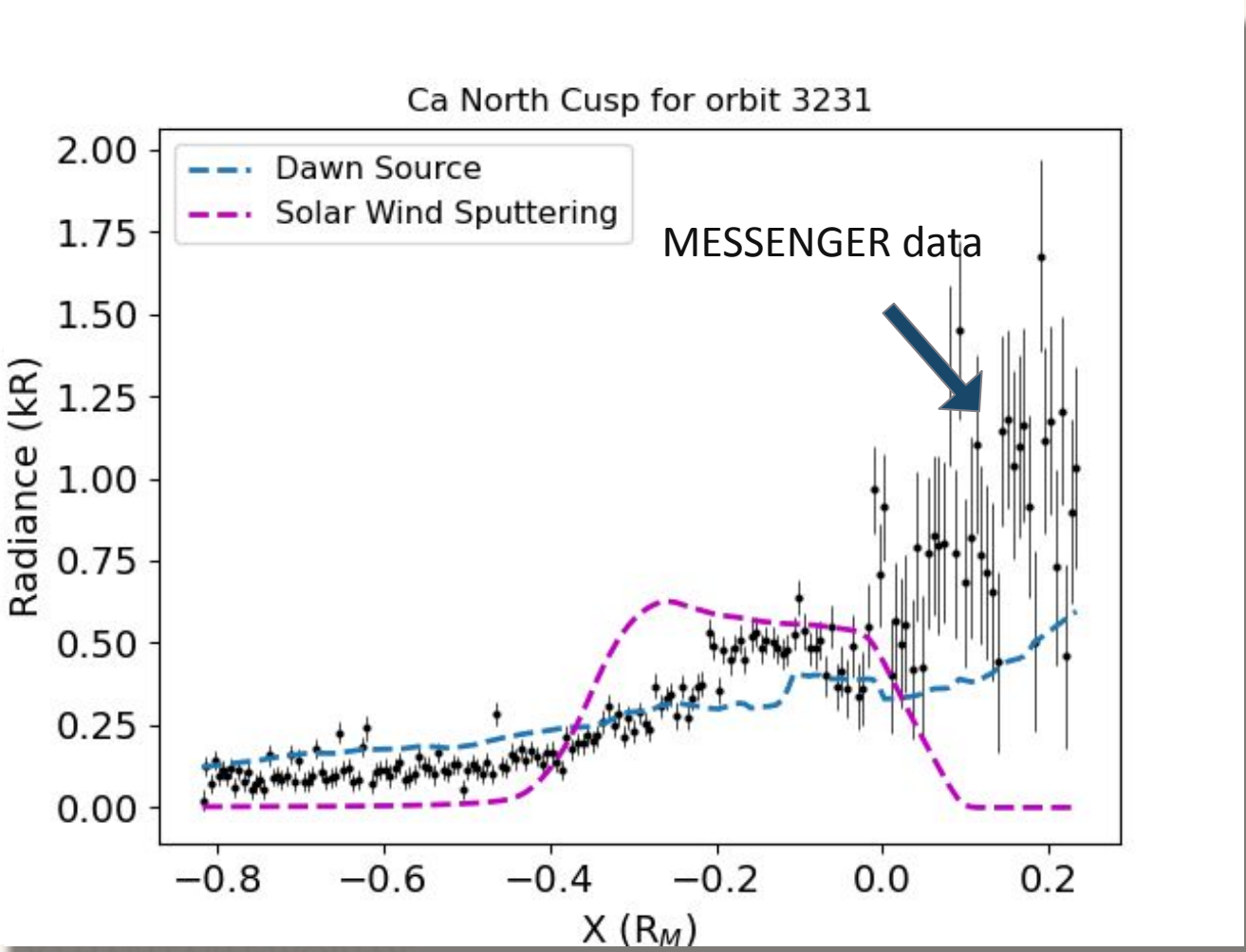






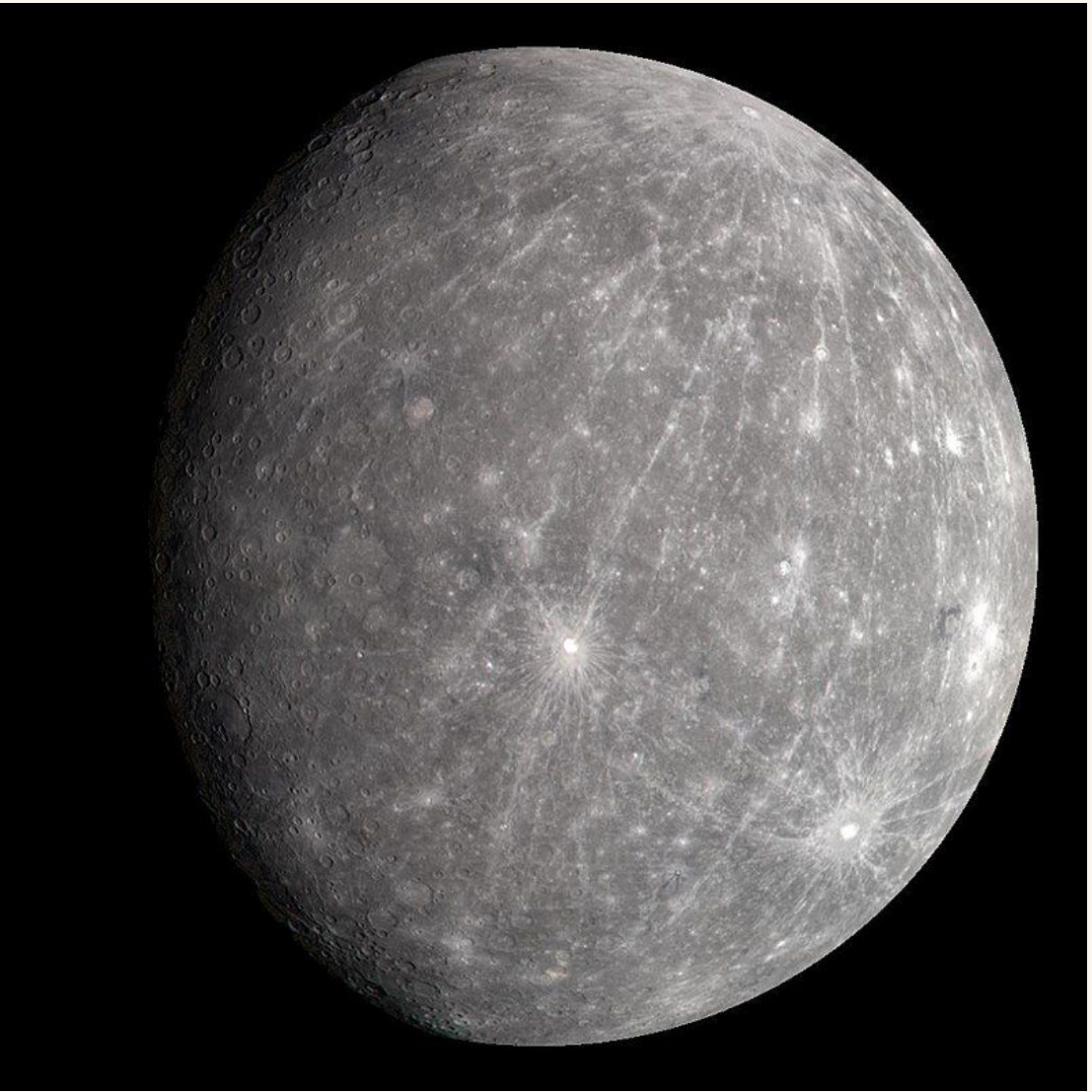


Solar Wind Sputtering as a Source Process



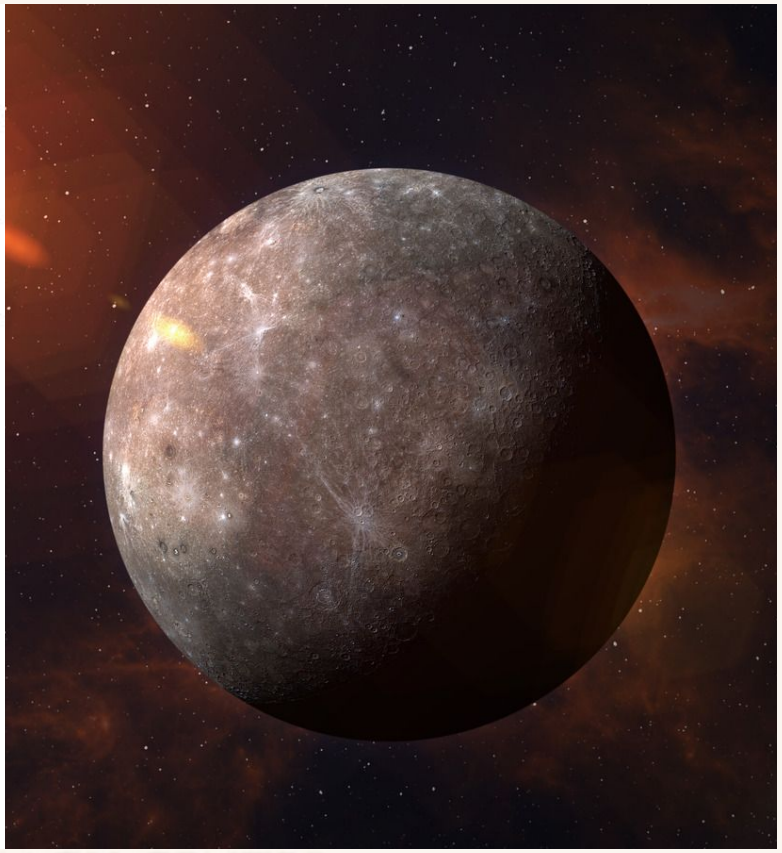
- Dawn source scaled to match UVVS data
- Solar wind sputtering spike before the pole
- Both sources don't account for the calcium enhancement

Next Steps



- Run a new routine with refined sputtering parameters
- Apply model to other species
- BepiColombo
- Magnetic cusp and solar wind sputtering?

Summary: Insights on Atmospheres, Magnetic Fields and Habitability



Atmospheric loss

- Ion sputtering (solar wind): So close to the Sun yet we see minimal influence
- Other planets like Mercury but with Atmosphere?

Magnetic Fields

Magnetic fields drive ion sputtering, so researching more about sputtering at Mercury will tell us about the atmosphere-magnetic field connection

Acknowledgments

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Dr. David Brain

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