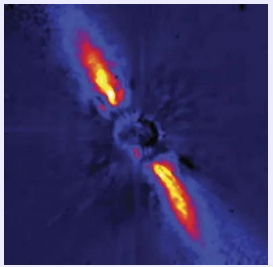
4.15.2022

Small Pieces of Our Solar System: Dust, Ice, Pluto, and More

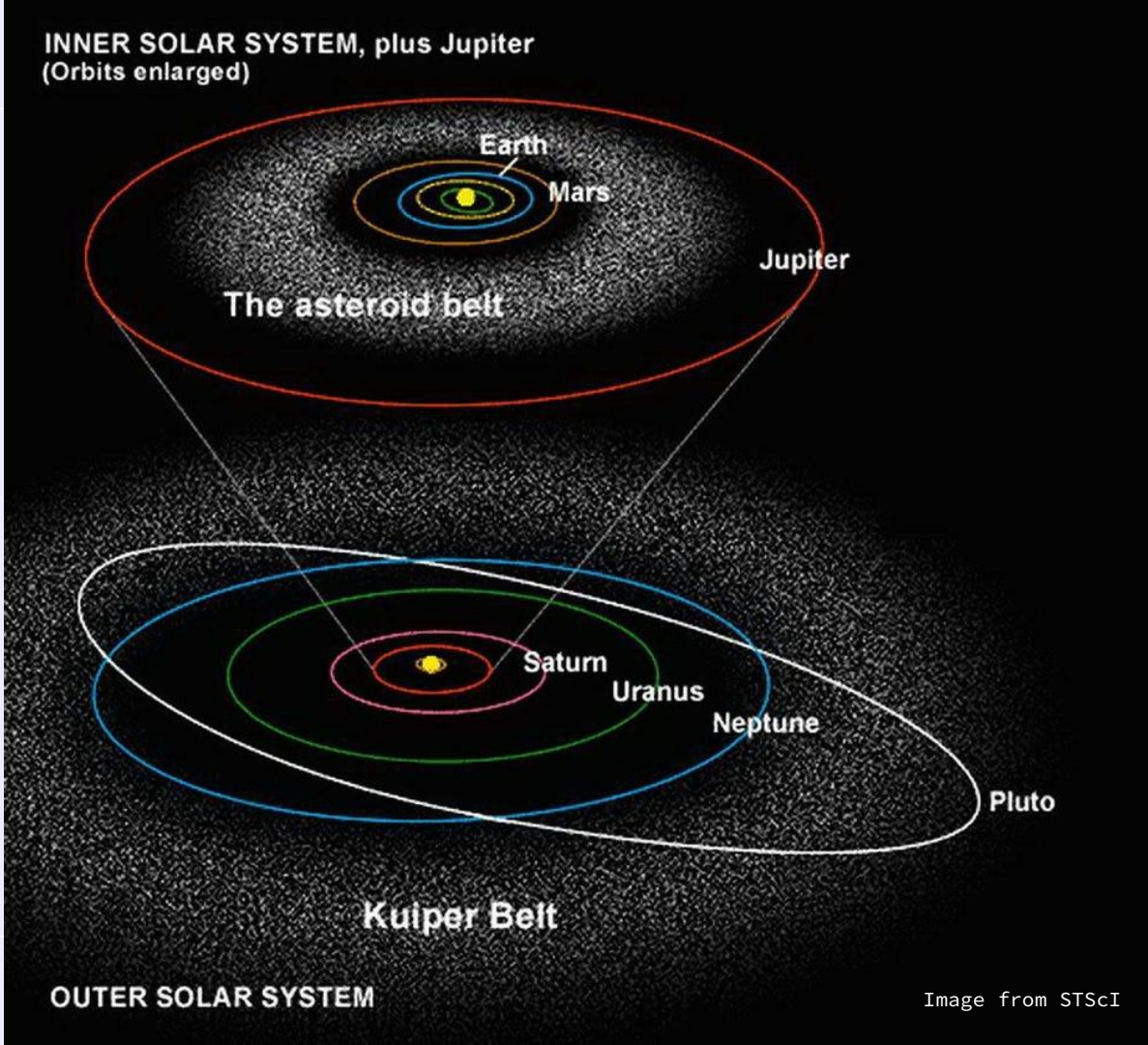


NASA ExoExplorers

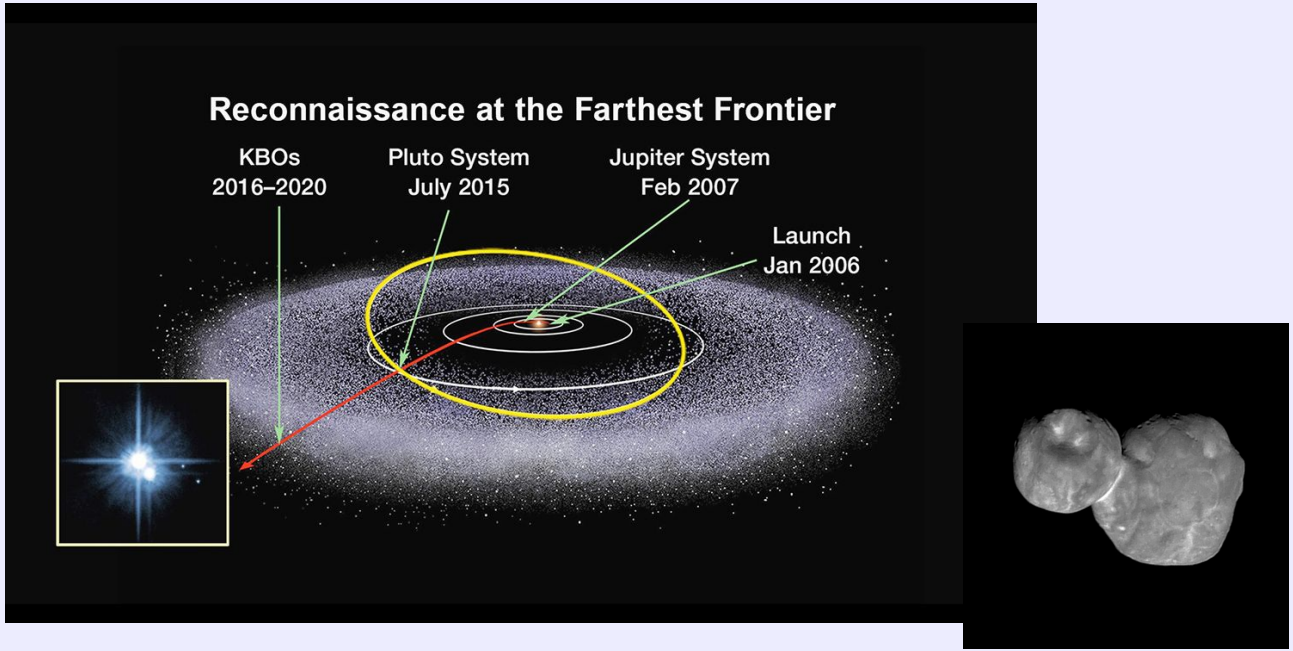
Briley Lewis, UCLA Physics & Astronomy

@briles_34

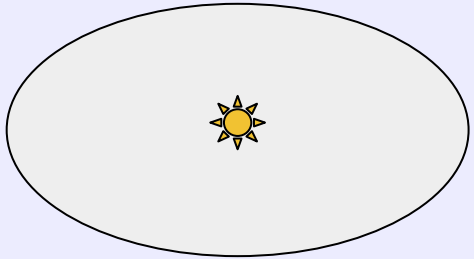
Small debris is all over our solar system



The Kuiper Belt = remnants of planet formation

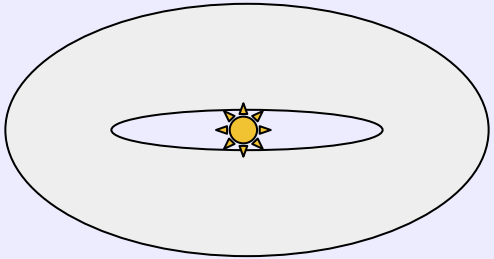


Debris disks, a.k.a. “Exo-Kuiper Belts”



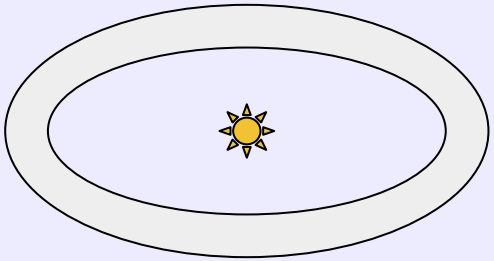
Protoplanetary/primordial disk — gas/dust, optically thick

~2-10 Myr



Transitional disk — gaps start forming

~1-2 Myr



Debris disks — optically thin, mostly dust (can be replenished by collisions)

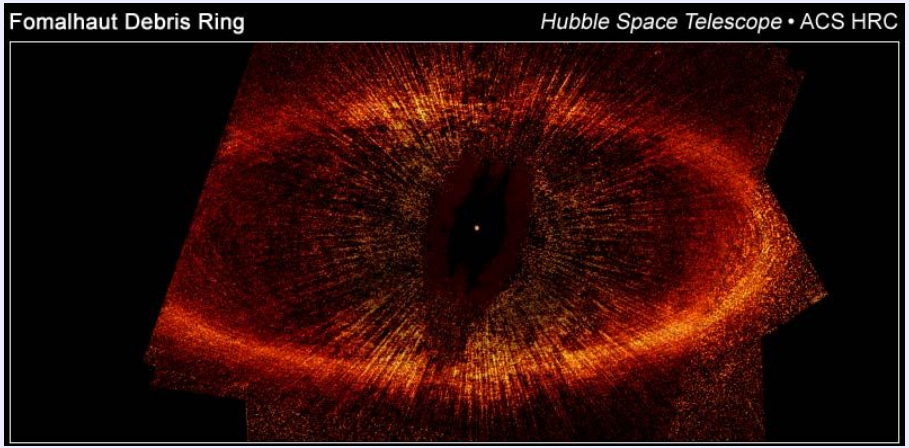
>5 Myr

Wyatt 2008

Debris disks are...

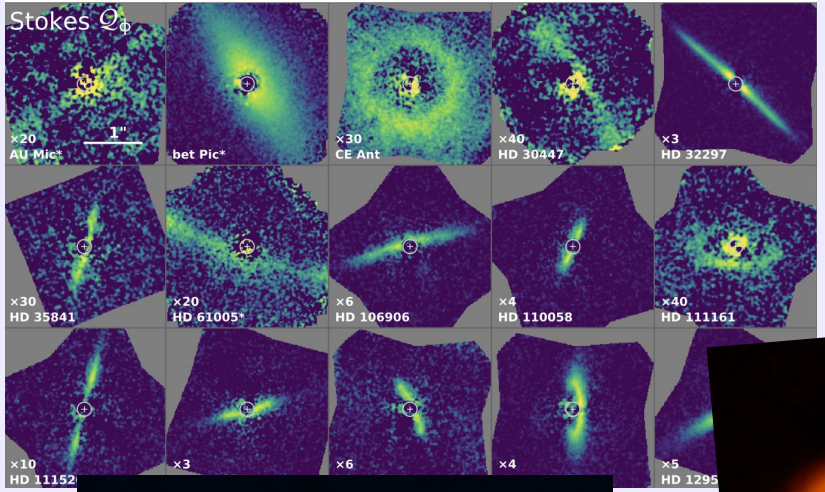
Rings of dust around young(-ish) stars

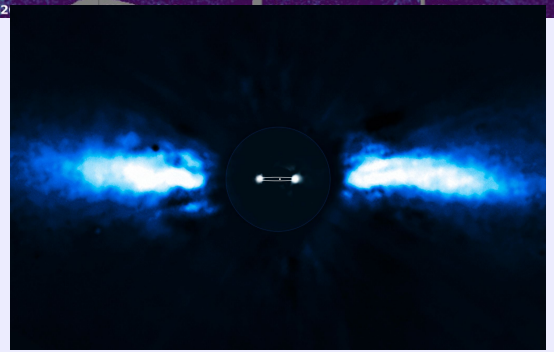
Key to understanding *how* different system architectures are created!

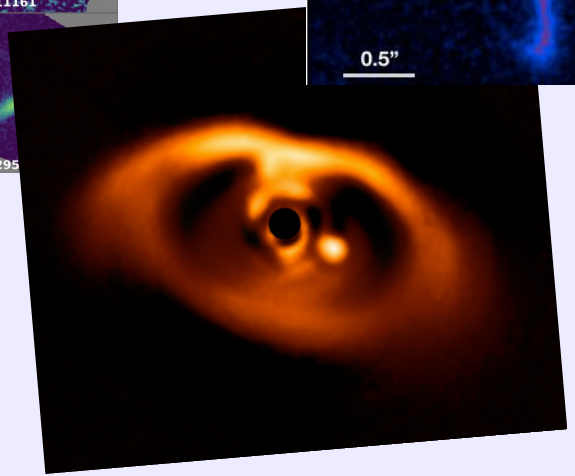


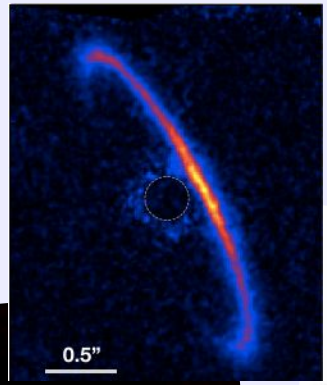
Wyatt 2008; NASA/ESA/Kalas et al.

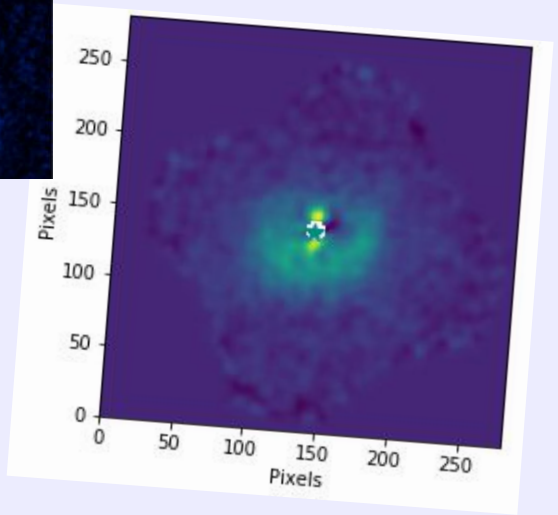
High-contrast imaging has resolved many examples





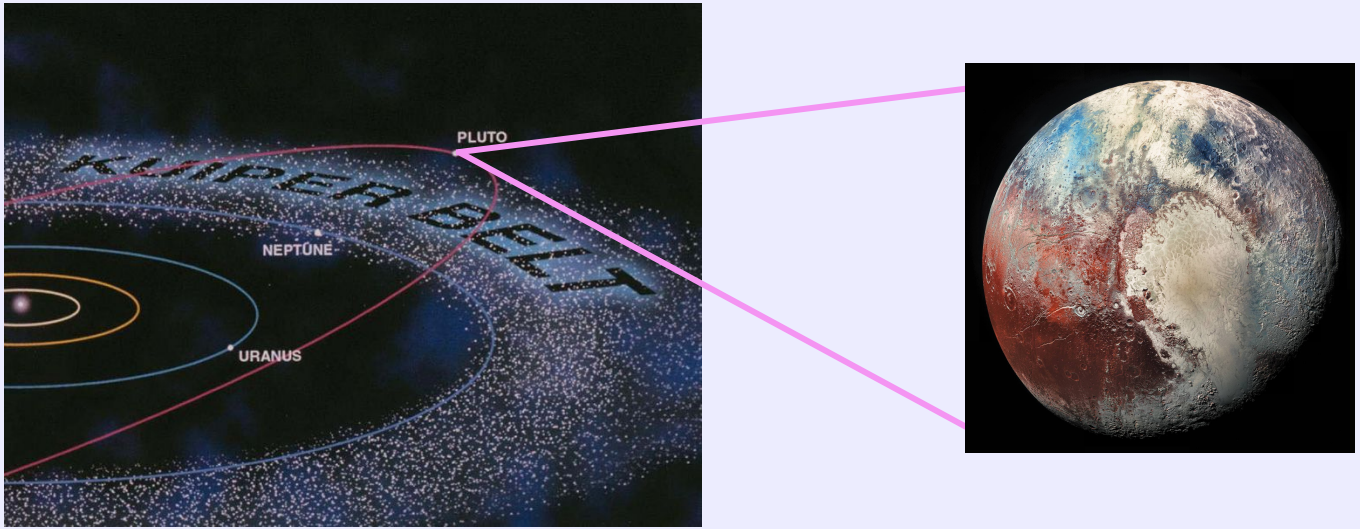






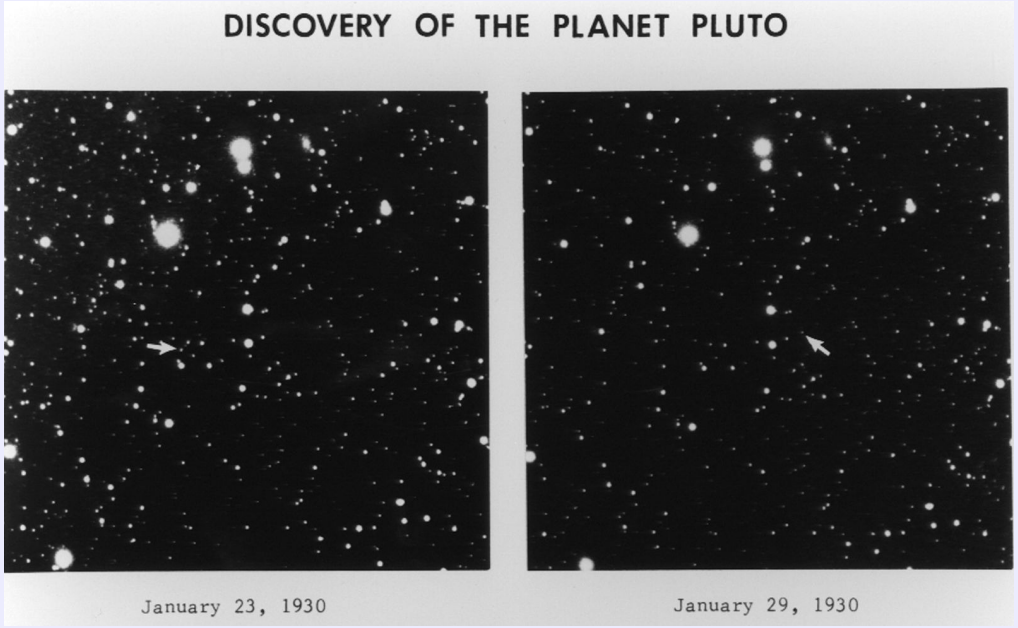
Esposito et al.; ESO/Lagrange; Muller et al.; Arriaga et al.; Lewis et al. in prep

The Kuiper Belt's largest inhabitant: Pluto



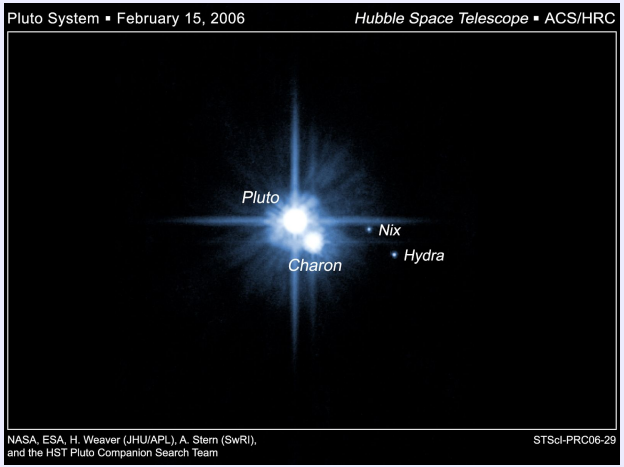
NASA/New Horizons

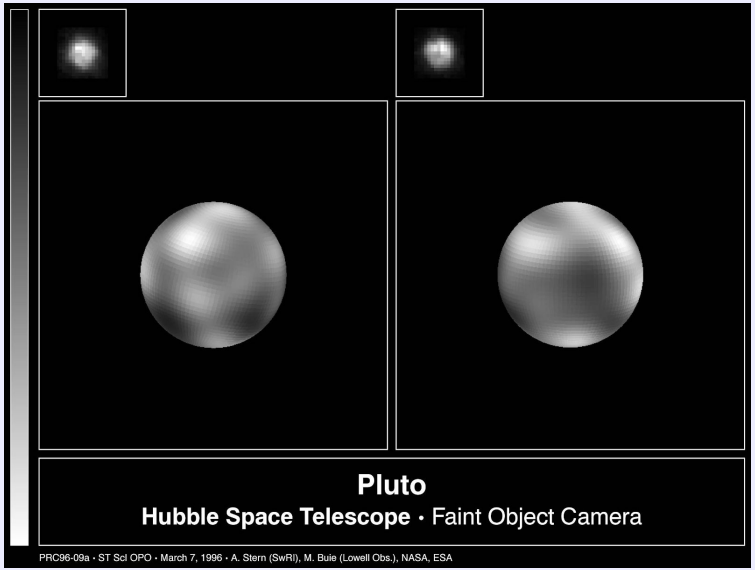
Pluto, Before *New Horizons*



Tombaugh / Lowell Observatory

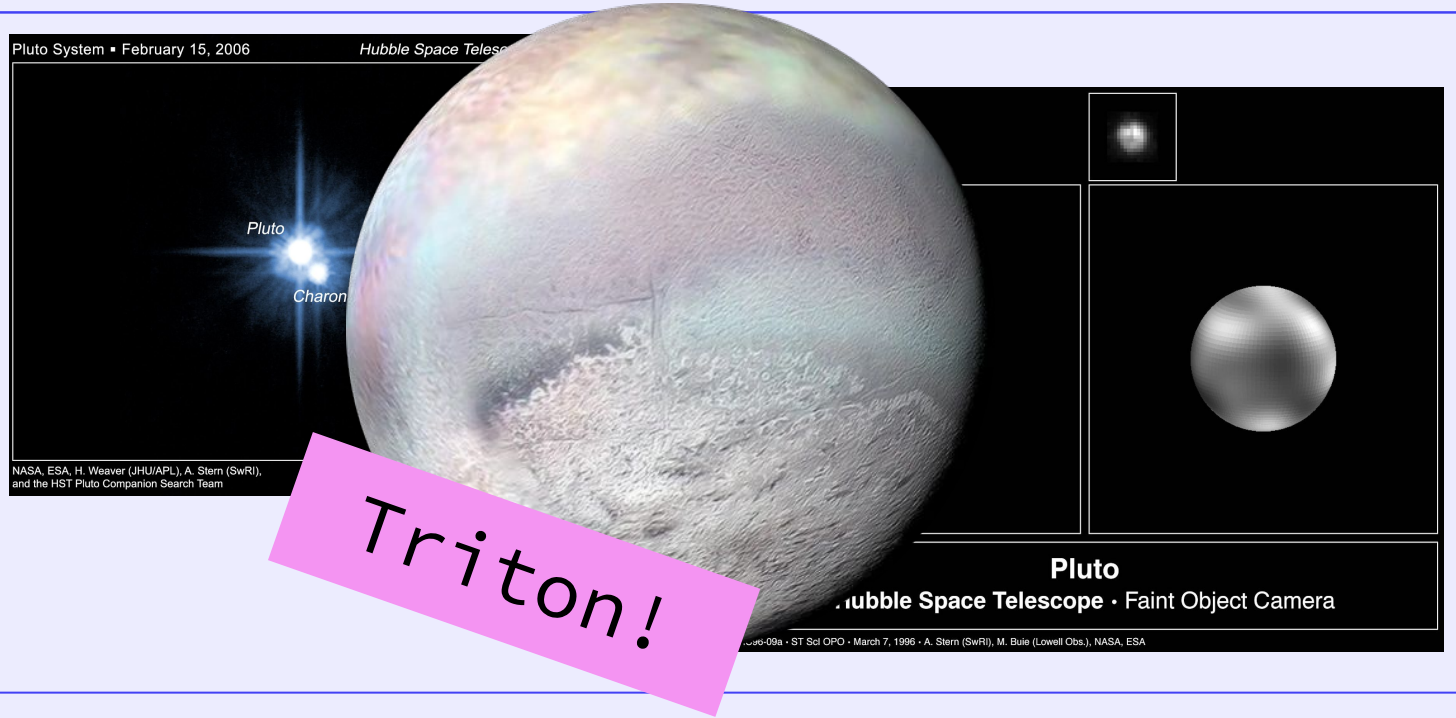
Pluto, Before *New Horizons*





NASA, ESA, H. Weaver, A. Stern

Pluto, Before *New Horizons*



NASA, ESA, H. Weaver, A. Stern / Voyager 2

Part 01

PLUTO

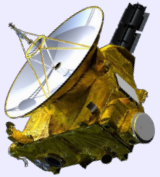
and New Horizons

Image from S. Sagynbayeva

Part 01

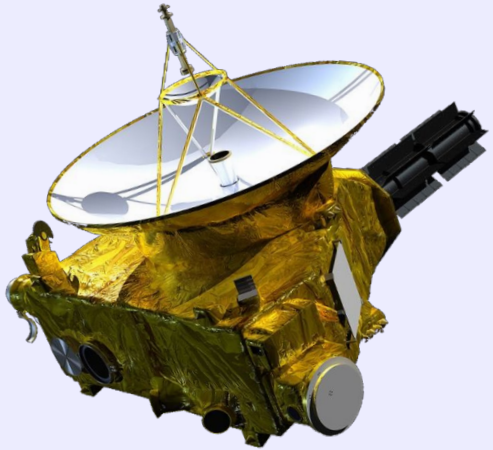
PLUTO

and New Horizons



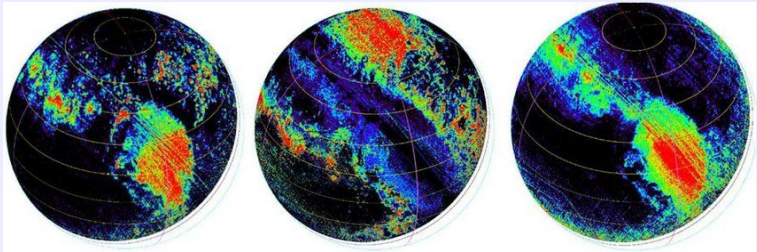
New Horizons was *revolutionary*

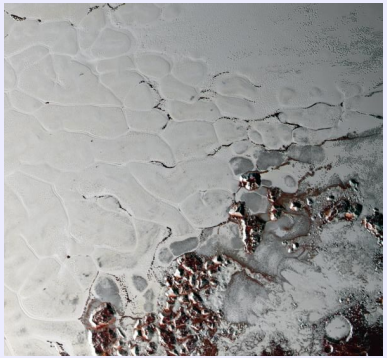
- Flyby of Pluto system in 2015
- First detailed information on a Kuiper Belt Object! (Now we've got 2 — MU69)
- Multiple instruments: images, spectra, dust counting, and more



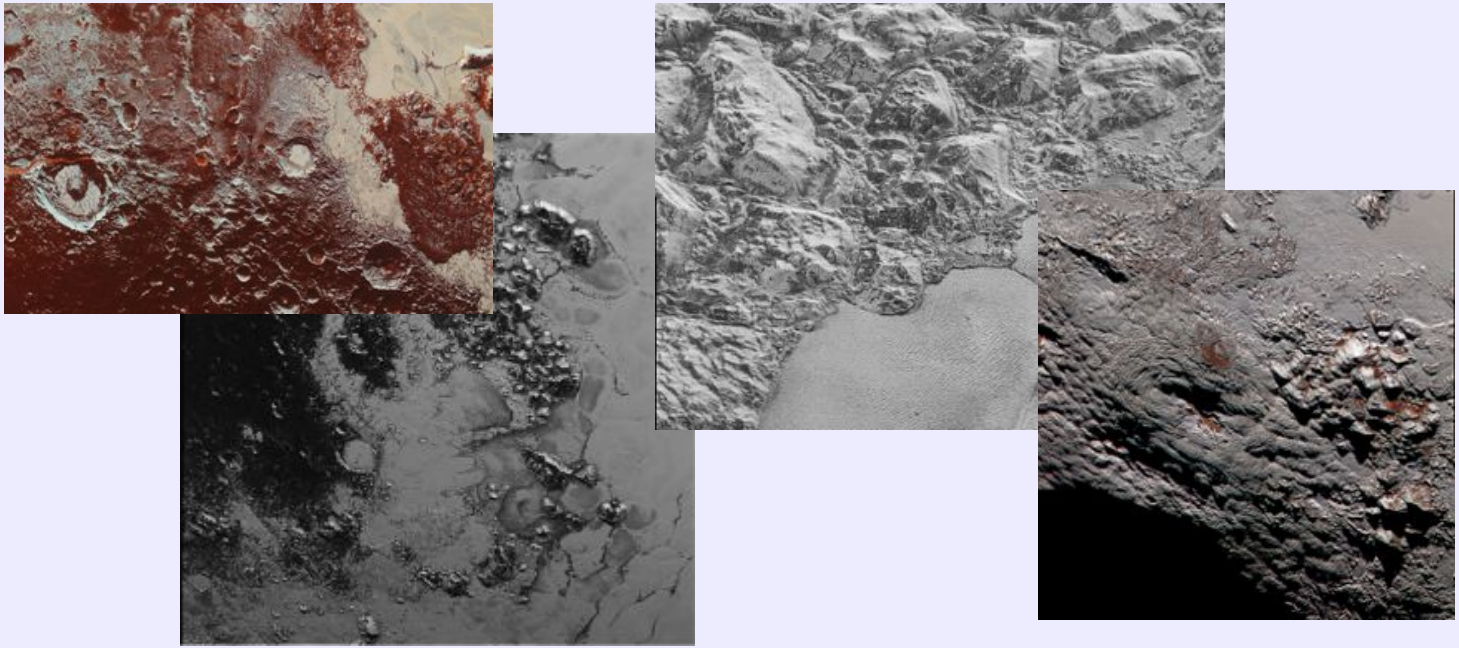
NH gathered images + spectra

- **LEISA** — Linear Etalon Imaging Spectral Array (1.25-2.5 micron, R~240, 6-7 km/pix)
  - Spectral info -> composition!
- **MVIC** — Multispectral Imaging Camera, even higher resolution image data sets!
  - Other maps, like albedo and elevation!





Pluto’s geology is varied



Images from NASA/SwRI

Topographic extremes -5 to 5 km

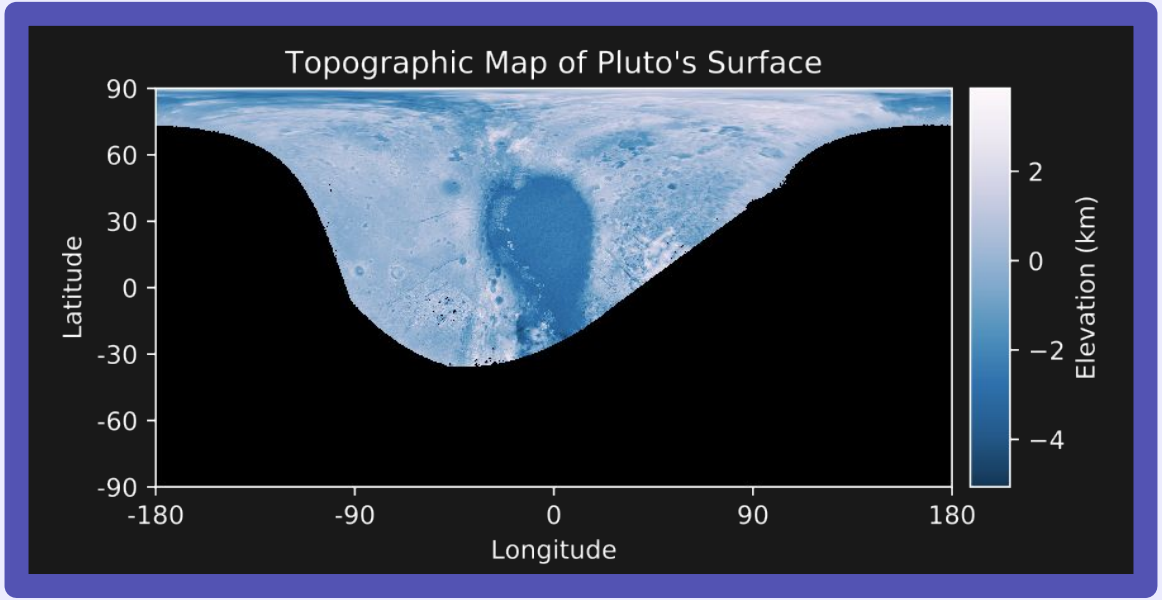


Image adapted from Schenk et al. 2018

Orienting ourselves on this map

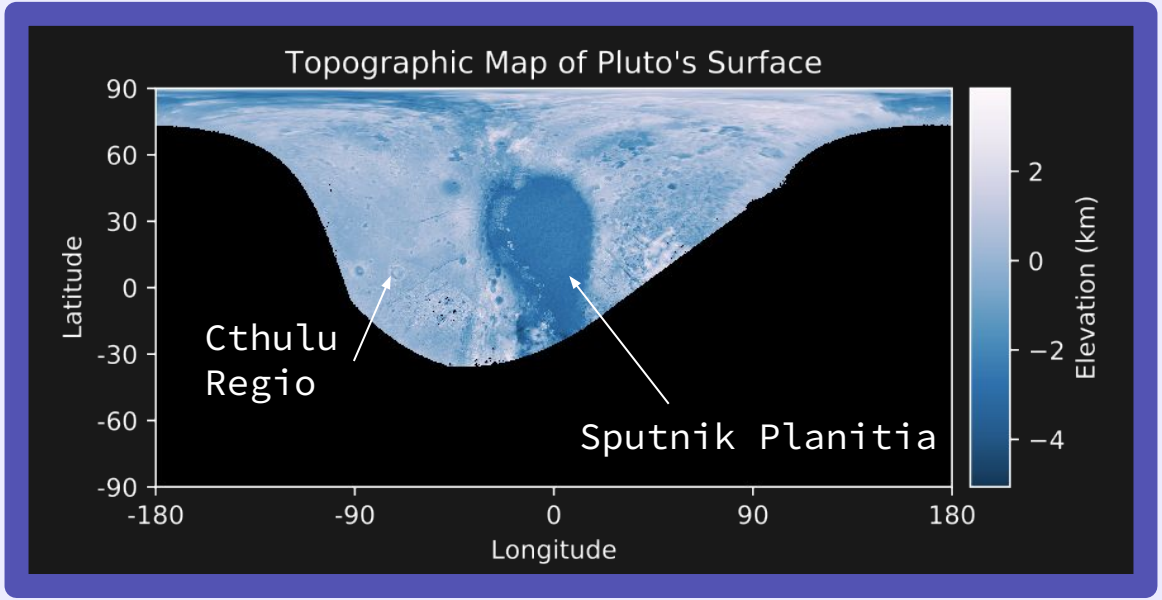
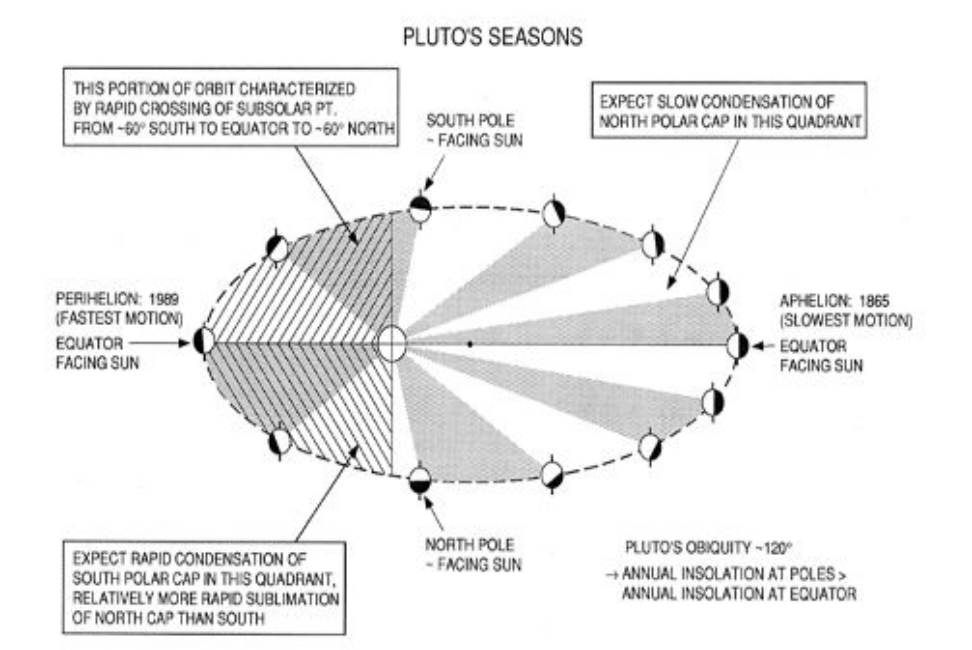


Image adapted from Schenk et al. 2018

Pluto is moving into Northern Summer

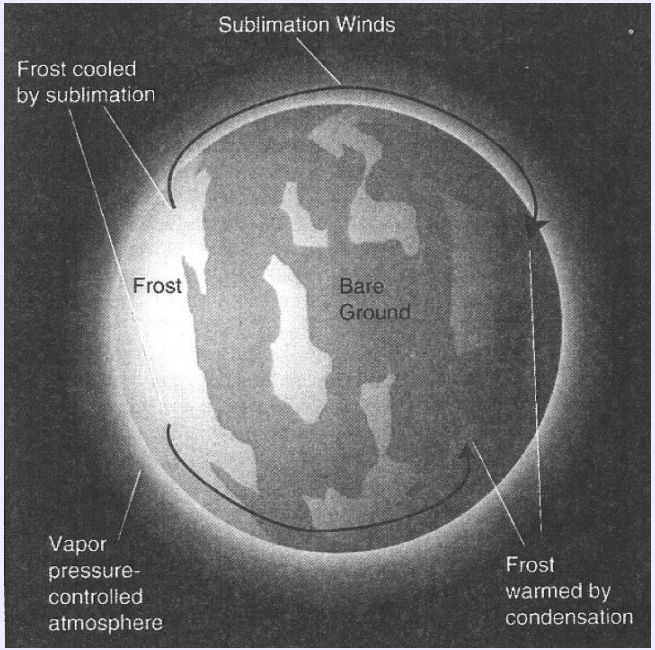


1 Pluto orbit = 248 Earth years

Passed equinox and perihelion in ~1989 (moving from Northern spring to Northern summer)

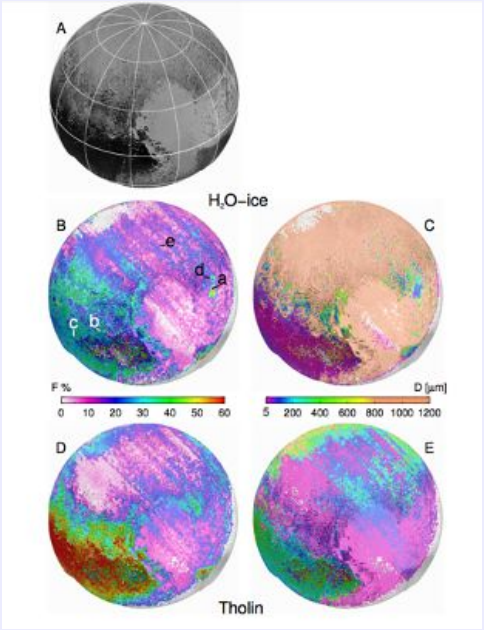
Hansen et al. 2013

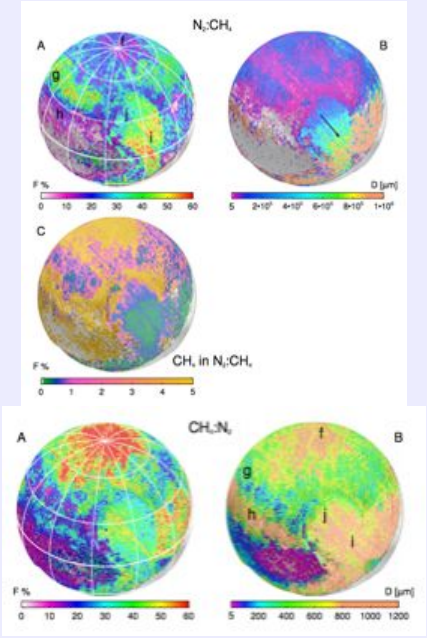
Pluto's ice transport is driven by sublimation



Spencer et al. 1997

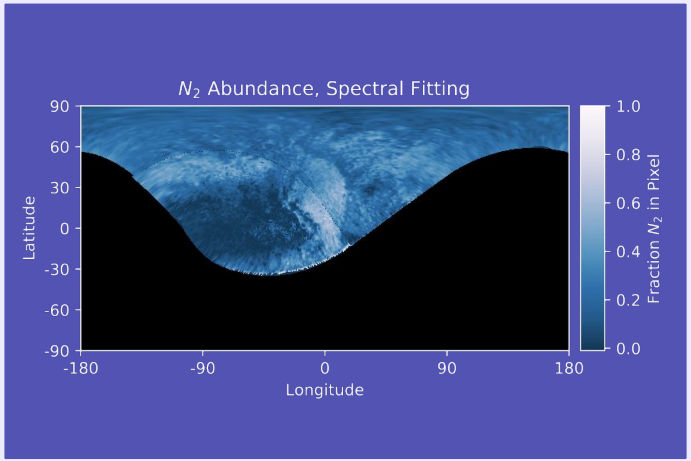
4 main components: H_2O, CH_4, N_2, CO





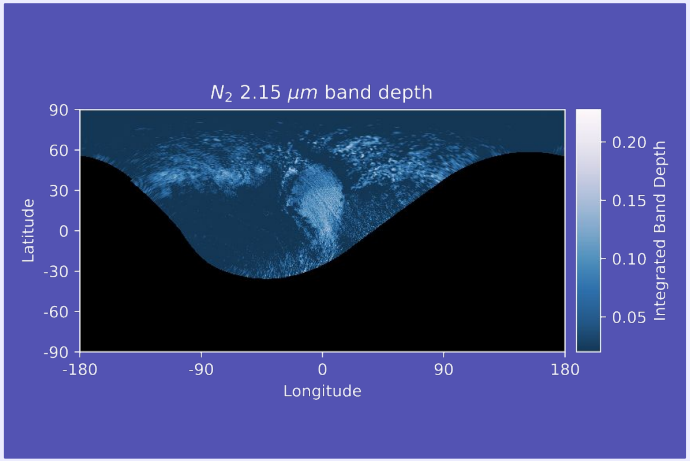
Protopapa et al. 2017

2 methods of mapping composition



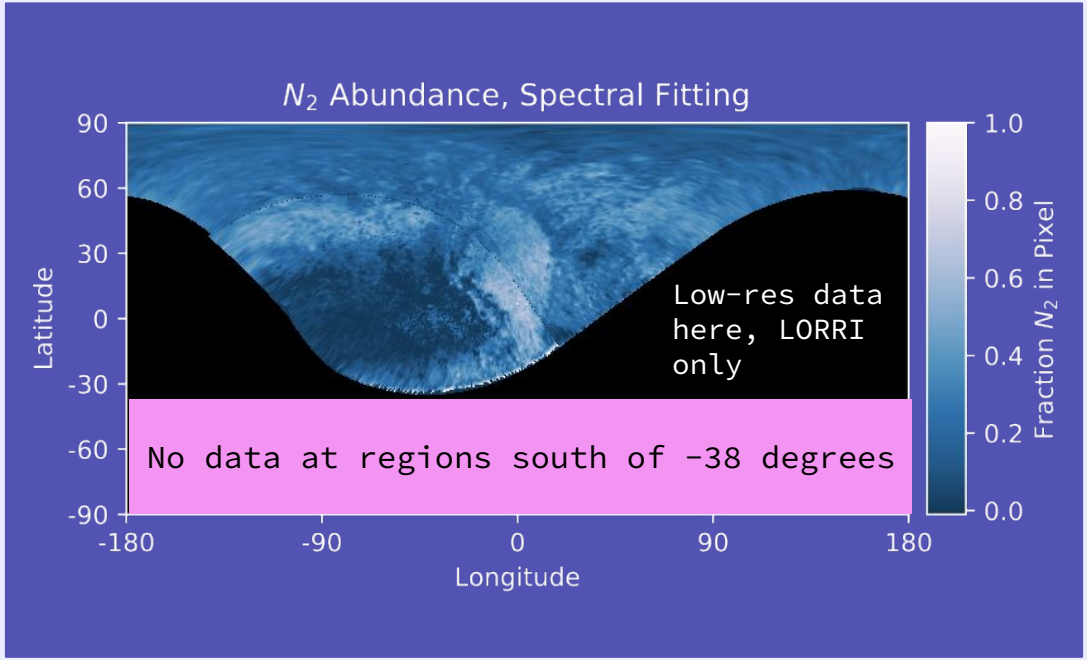
Spectral fitting (Hapke Modeling)

Integrated band depth measurements



Protopapa et al. 2017; Schmitt et al. 2017; Lewis et al. 2021

Missing coverage on half of globe



Protopapa et al. 2017; Lewis et al. 2021

Goal = Relate N_2 (mapped by New Horizons) to geology, topography, and global trends

Why? To get a detailed snapshot of Pluto's seasonal/climatic state, informing both model predictions & historical climate studies

Conclusion #1: Ice moves to low places

- Frost at lower elevation feels higher atmospheric pressure
- Must maintain vapor pressure equilibrium
- Preferentially deposits at low elevation because of pressure differential

A different way of moving ice!

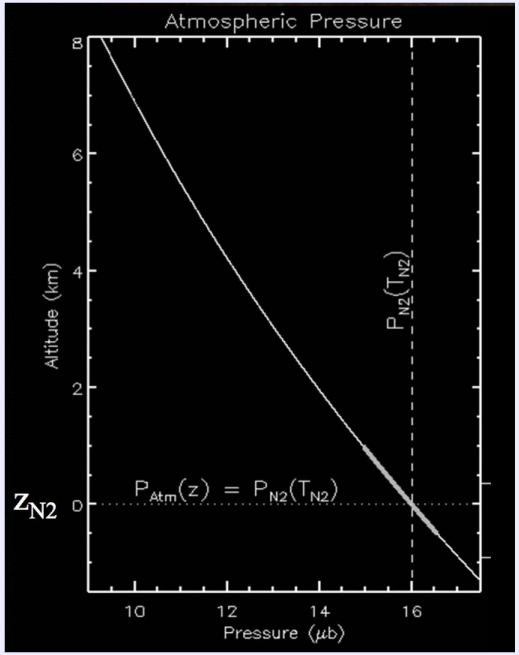
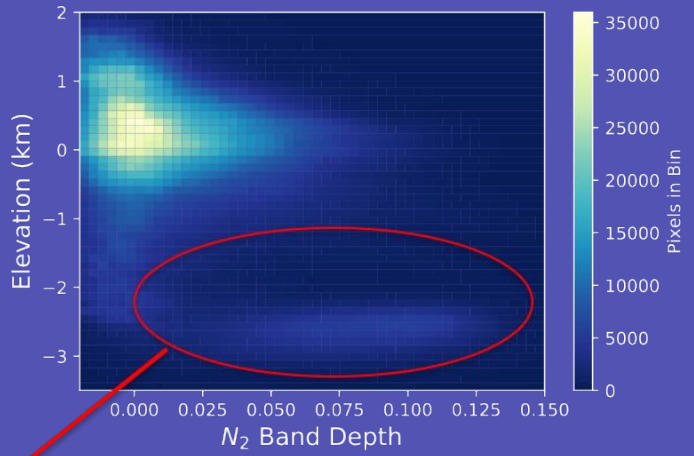
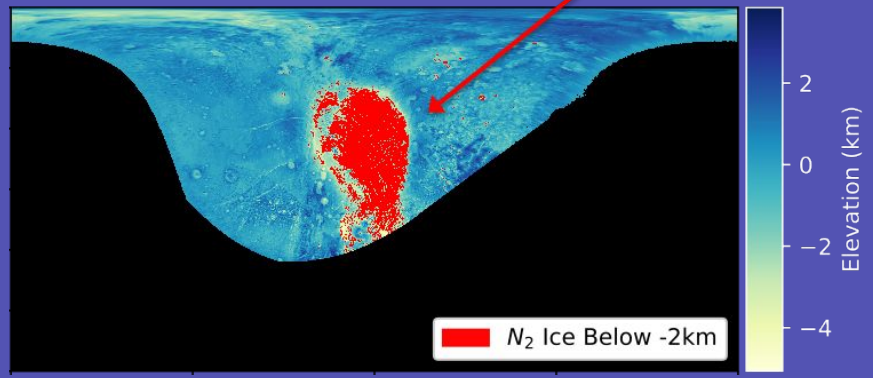


Figure from Stansberry et al. in prep; Lewis et al. 2021

We see evidence of this transport in the current ice distribution!

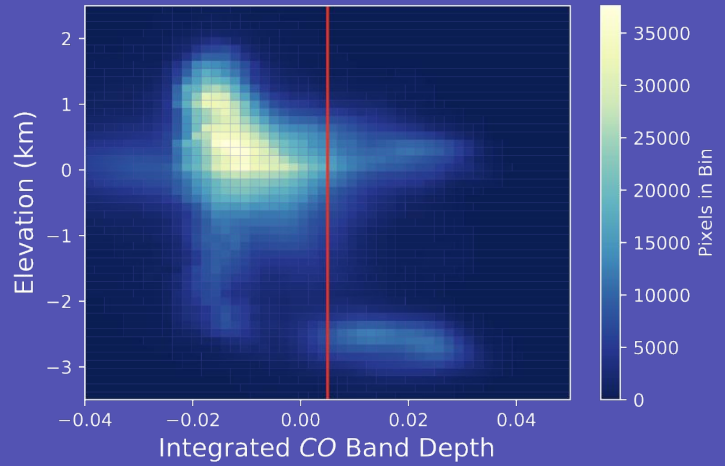


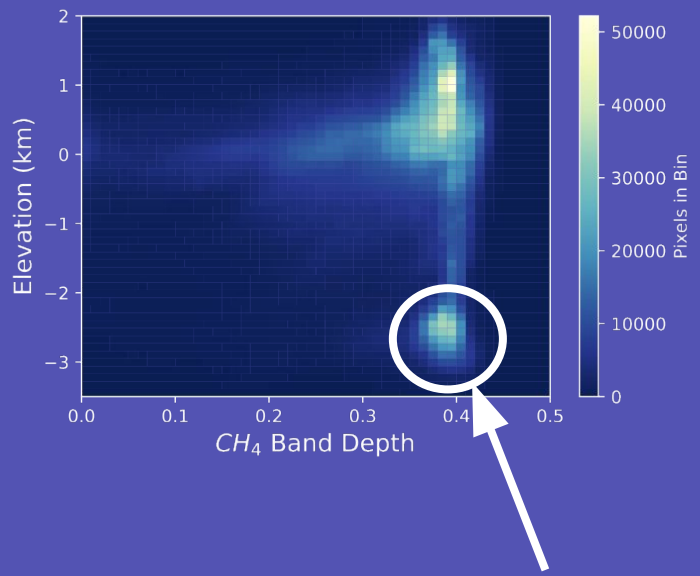


"Topographic" transport could have filled Sputnik Planitia

Lewis et al. 2021

Other ices on Pluto like methane and CO also trace this distribution.

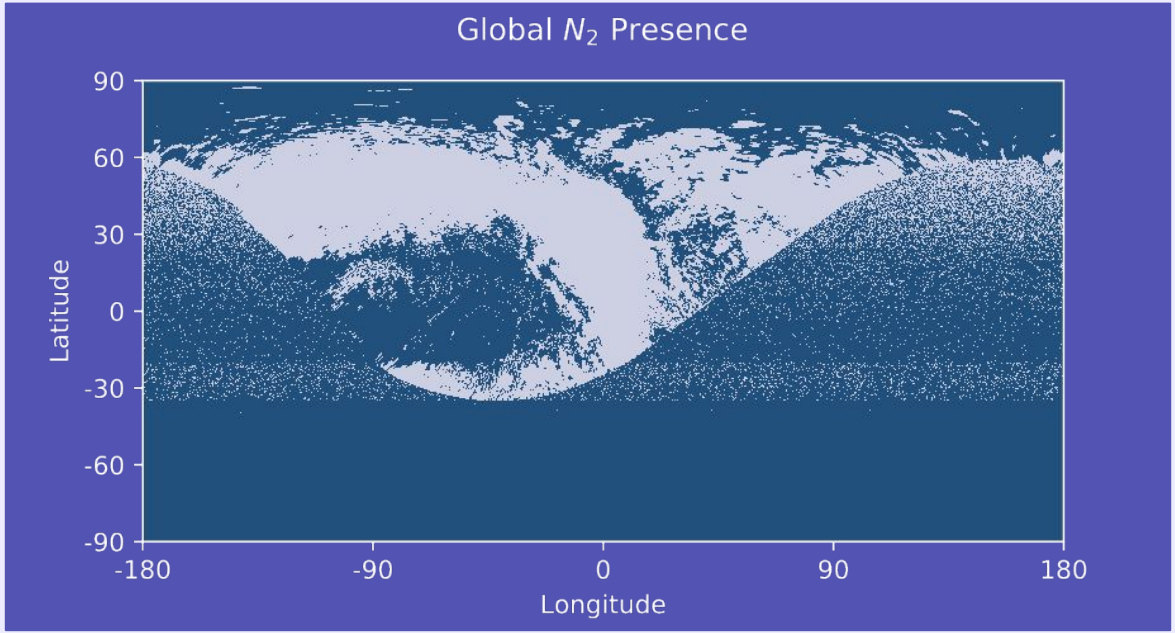




In fact, some of the methane *follows* the nitrogen!

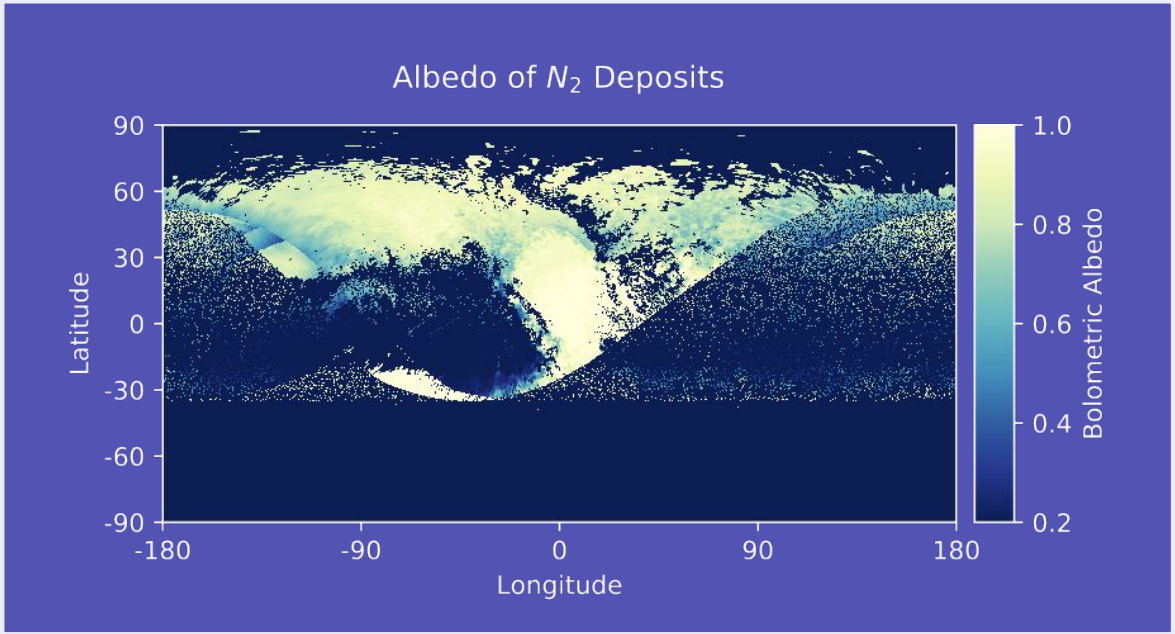
Lewis et al. 2021

Conclusion #2: Latitudinal trends match climate models



Lewis et al. 2021

Conclusion #3: Pluto is “Triton-Like”



Albedo
~0.8

Emissivity
0.5-0.9

Lewis et al. 2021; Adapted from Buratti et al. 2017

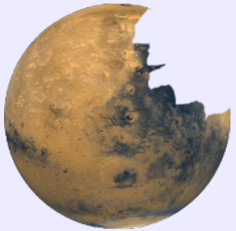
Looking to the future...

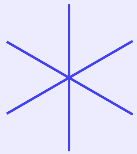
- People are proposing missions to return to Pluto! (Buie et al. 2021)
- *JWST* observations of both KBOs and Debris Disks (PIs Stansberry, Chen, Lellouch, Hinkley, and many more)
  - Looking at KBO composition (including Pluto)
  - Measuring solid-state reflectance spectra of debris disks
- Improvements in tech for ground-based high-contrast imaging (AO, GPI 2.0, data processing, ELTs, and more) (Guyon 2018, Chilcote et al. 2018, Lewis et al. in prep)

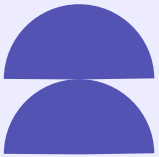
Part 02

WRITING

in Physics & Astro







“Writing is not a special language owned by the English teacher. Writing is thinking on paper...Writing, demystified, is just another way for scientists to transmit what they know.”

—William Zinsser, author

How do astronomers learn to write?

You tell me!

In the chat, tell us how you learned to write about science.

How do astronomers learn to write?

- First year composition classes in undergrad — assuming skills will transfer
- One-on-one mentorship and “on-the-job” practice
- One-off workshops or conference sessions
- Feedback from peers
- **Few astronomers report structured learning for writing within the discipline**

Why writing in physics/astro classes

- Scientists need to communicate well
  - for the public!
  - for other scientists!
- Better research paper writing = more accessible field, serving DEI goals *and* furthering science
- Writing can help improve understanding (writing-to-learn)

Why writing in physics/astro classes

- Scientists need to communicate well
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- Better research paper writing = more accessible field, serving DEI goals *and* furthering science
- Writing can help improve understanding (writing-to-learn)

Writing well *in a discipline* is a learned and practiced skill, and we should treat it that way

How writing in physics/astro classes

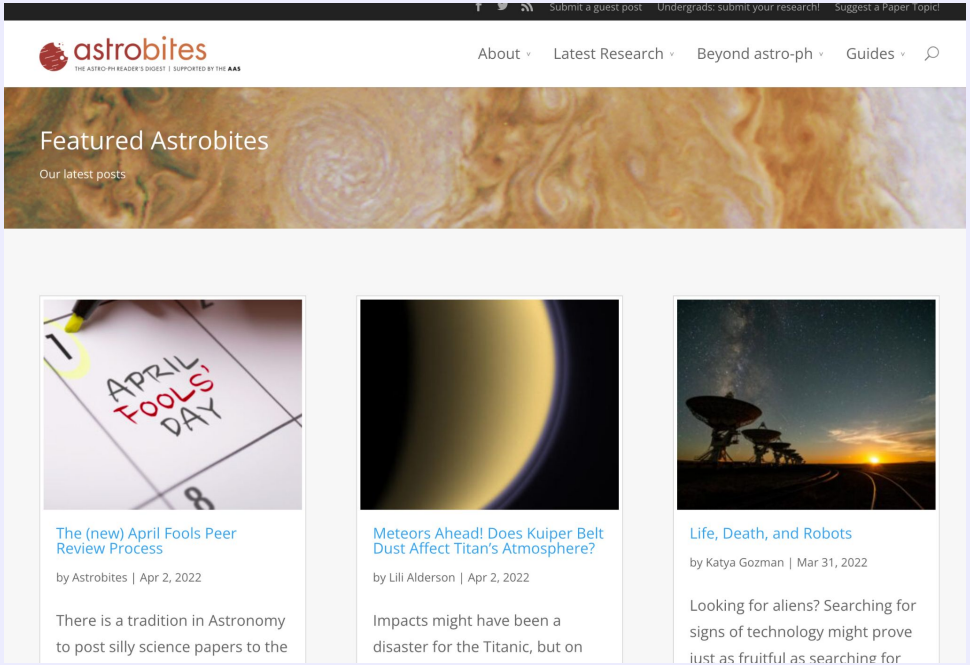
- Incorporate it into your existing curricula / courses! [e.g. quick writes, writing-to-learn, small assignments]
- More structured guidance + real-world tasks in lab classes
- Dedicated science communication and technical writing courses
- ...and more!

Writing in intro science courses

- Writing can also be useful in introductory / non-major courses
- Building science literacy
- Increasing confidence to engage with scientific research
- **Currently investigating how practicing writing about science influences student attitudes towards science in my class**

Lewis, Kennison, et al. in prep

Astrobites as a model for science writing education



Khullar et al. 2019, Lewis et al. in prep

Astrobites as a model for science writing education

150+ authors

Khullar et al. 2019, Lewis et al. in prep

Astrobites as a model for science writing education

150+ authors

3000+ articles

Khullar et al. 2019, Lewis et al. in prep

Astrobites as a model for science writing education

150+ authors

600k+ yearly views

3000+ articles

Khullar et al. 2019, Lewis et al. in prep

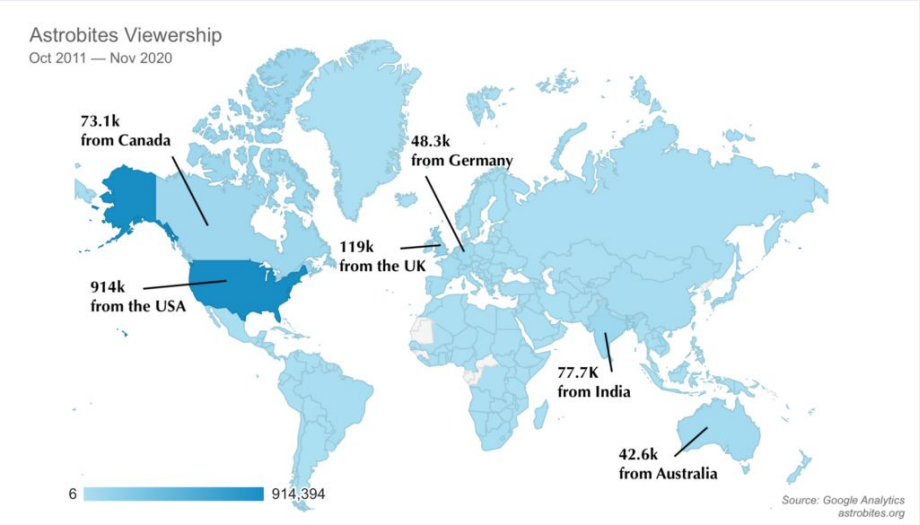
Astrobites as a model for science writing education

150+ authors

600k+ yearly views

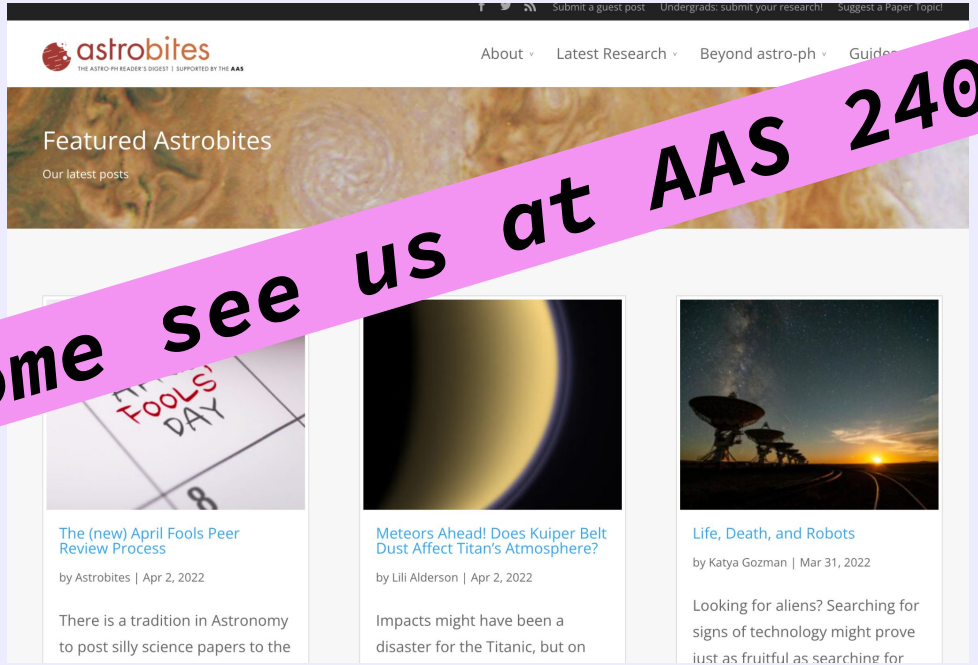
3000+ articles

Worldwide readership



Khullar et al. 2019, Lewis et al. in prep

Astrobites as a model for science writing education



Khullar et al. 2019, Lewis et al. in prep

Conclusions

Pluto is geologically active, interesting, and great place for in-depth study of the outer solar system.

Observations of both our own solar system's small bodies and debris disks can provide **complementary** insight into planet formation.

Writing is a key part of the skill set of a modern astronomer, and should be taught as such.

4.15.2022

THANK YOU

Any questions?

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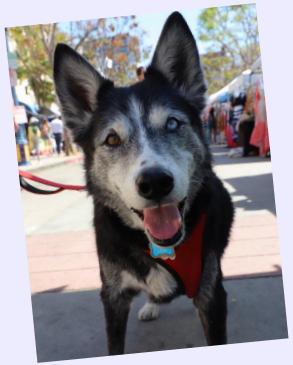

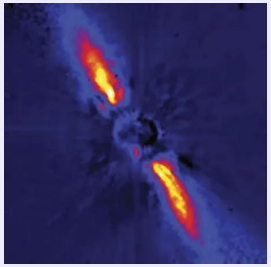

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Briley Lewis