NASA Astrobiology Program Update

David Grinspoon
Senior Scientist for Astrobiology Strategy

Astrophysics Advisory Committee

October 19, 2023

Please allow me to introduce myself…

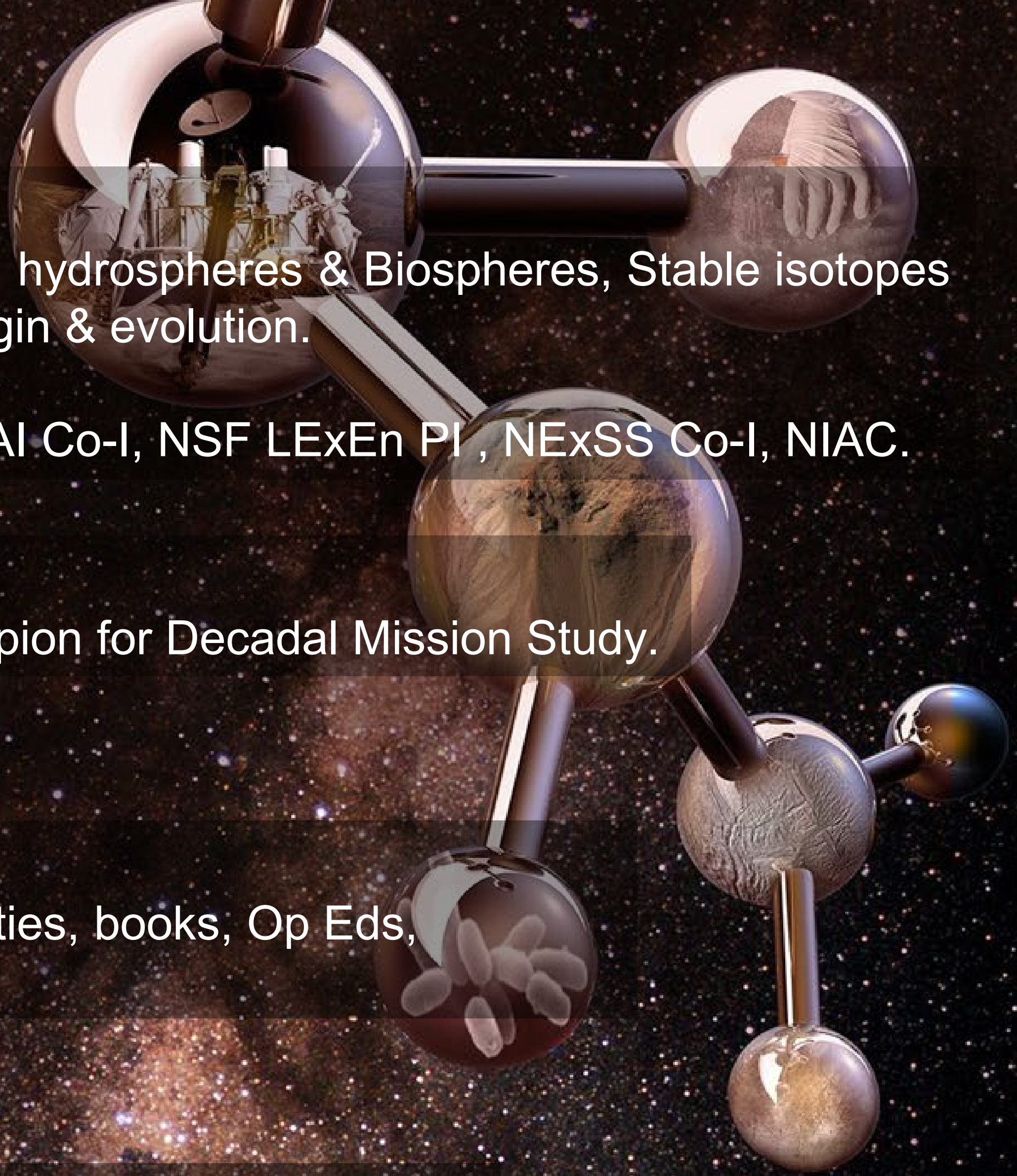
Science:
Evolution of Terrestrial Planetary Atmospheres, Climates, Surfaces, hydrospheres & Biospheres, Stable isotopes in nebulas & atmospheres, large impacts, icy moon atmosphere origin & evolution.

PI & Co-I: Exobiology & several other NASA research programs, NAI Co-I, NSF LExEn PI , NExSS Co-I, NIAC.

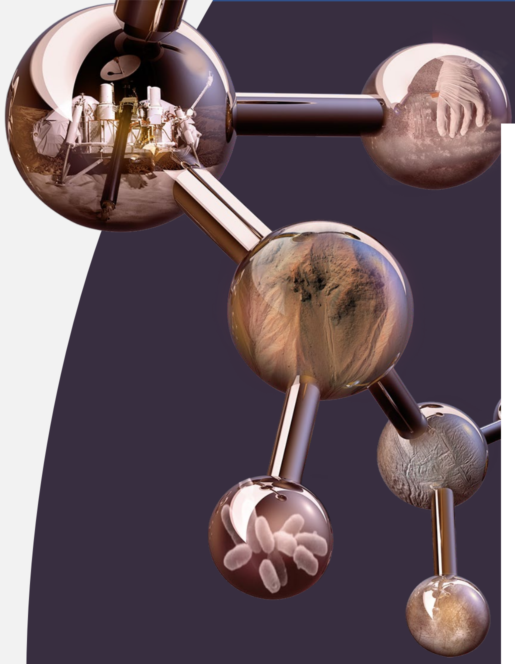
Missions:
Venus Express IDS, MSL RAD Co-I, DAVINCI Co-I, Science Champion for Decadal Mission Study.

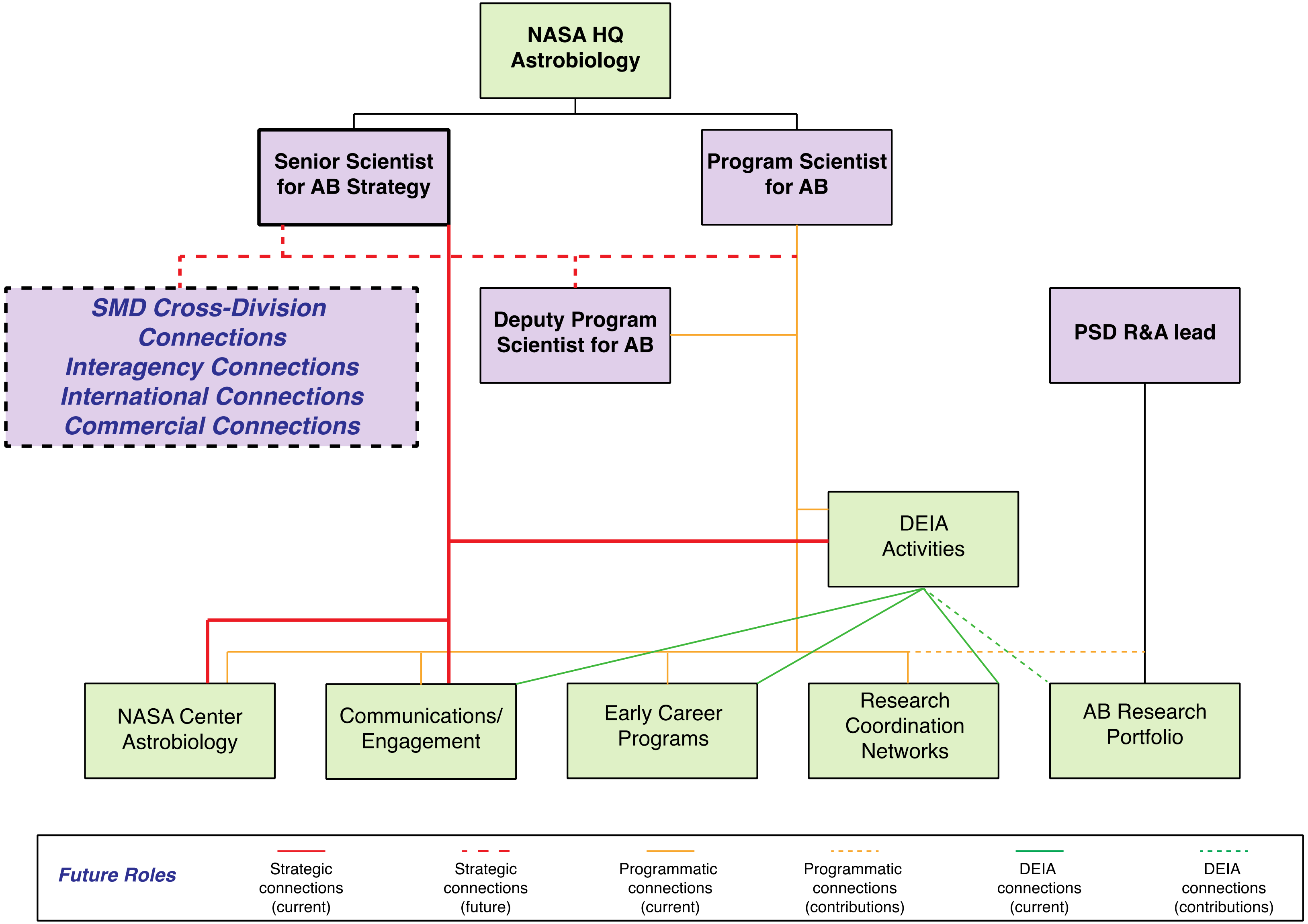
Education & Outreach:
Curator of Astrobiology at DMNS, Taught Astrobiology at 4 universities, books, Op Eds, magazine writing, podcasts, planetarium shows, online courses,

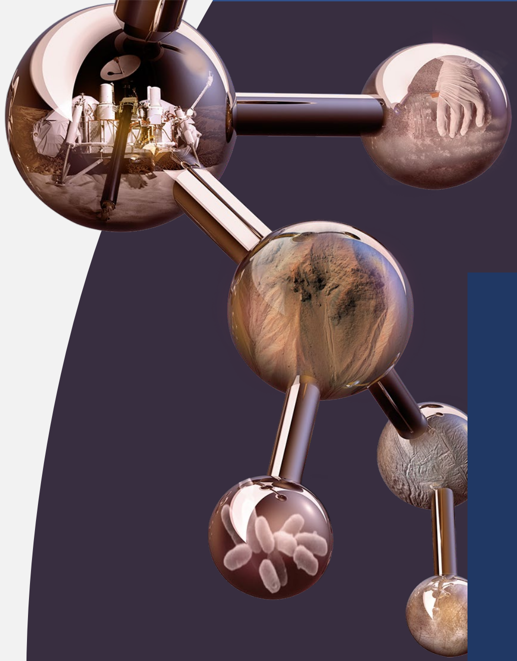
Other:
Inaugural Blumberg Chair, NASA SDTs, SSES, Decadal Panels, White Paper author, etc.



New NASA Astrobiology Org Chart:







Senior Scientist for Astrobiology Strategy

This is a new position.

New leadership roles:

SSAS (David Grinspoon):

"Up and out"

Expand the astrobiology program within NASA and beyond.

Program Scientist for Astrobiology (Lindsay Hays)

"Down and in"

Deputy Program Scientist for Astrobiology (Becky McCauley Rench)

An exciting time for Astrobiology!

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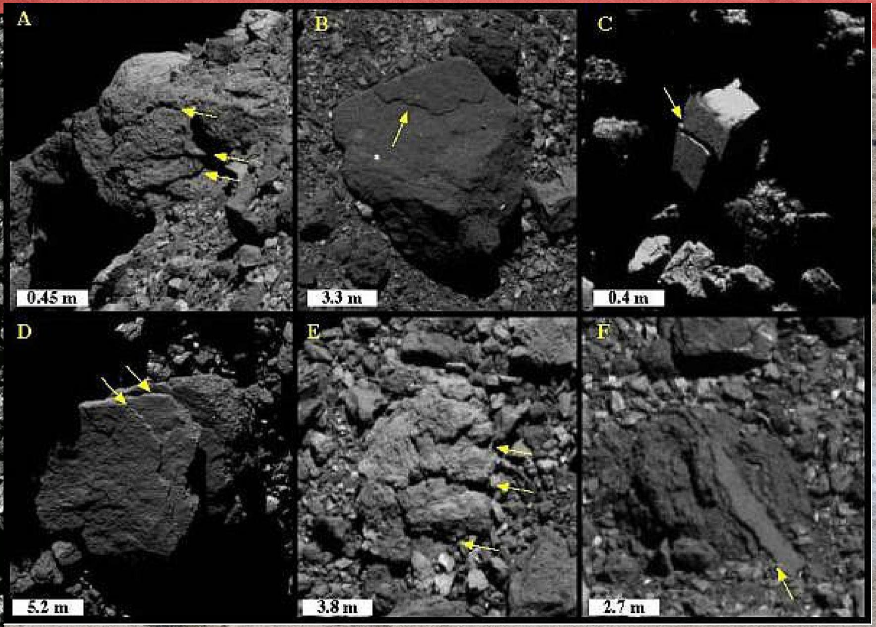

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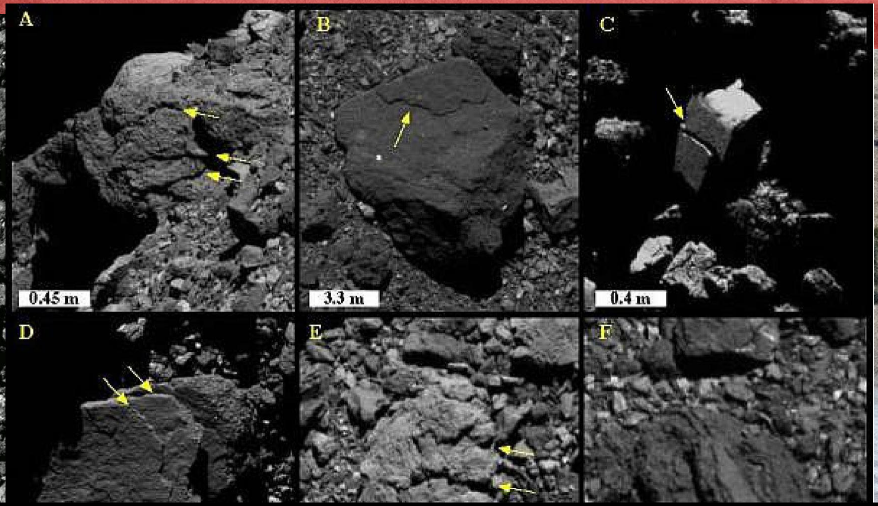

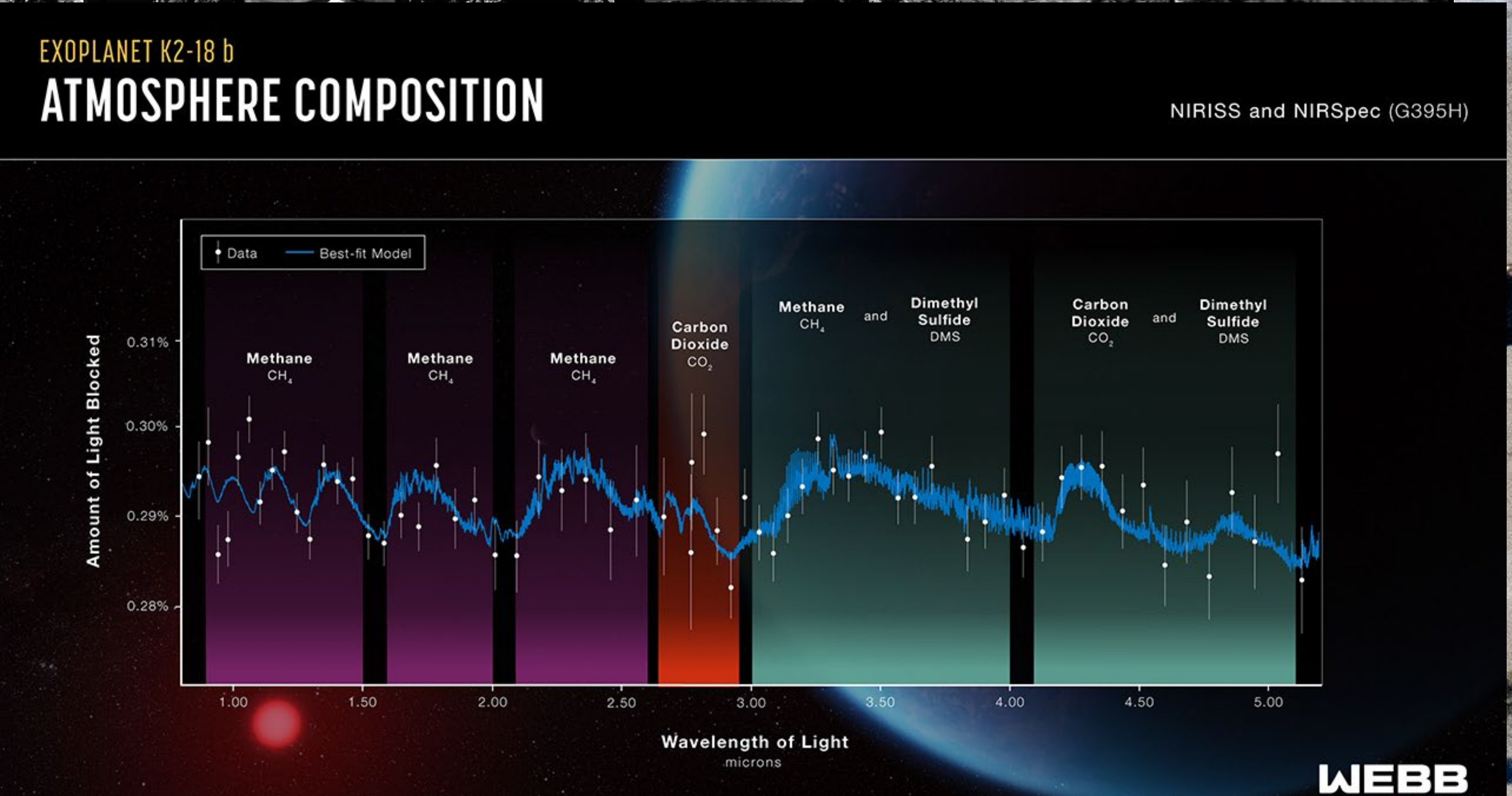

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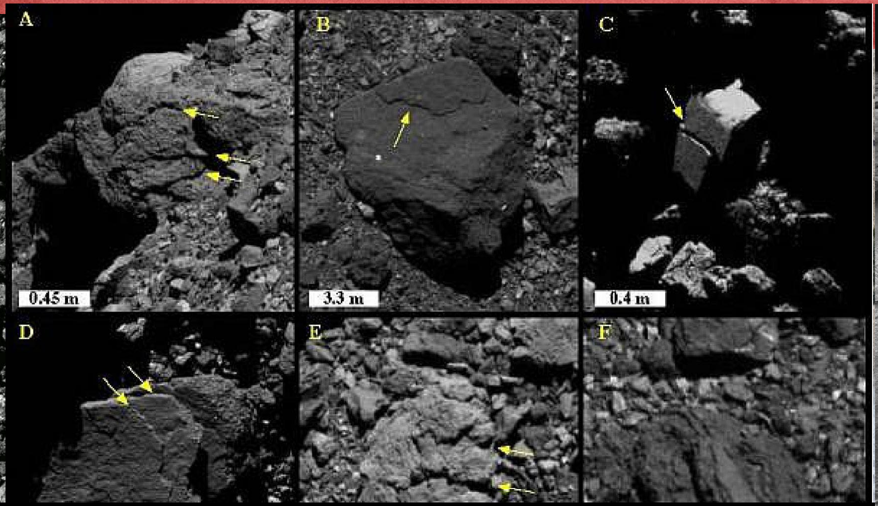

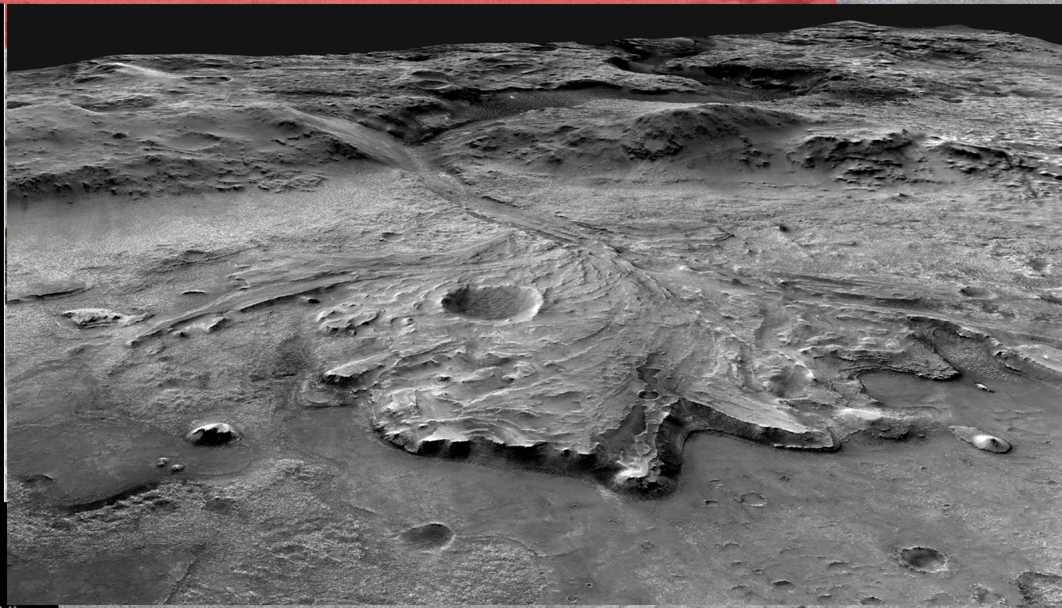

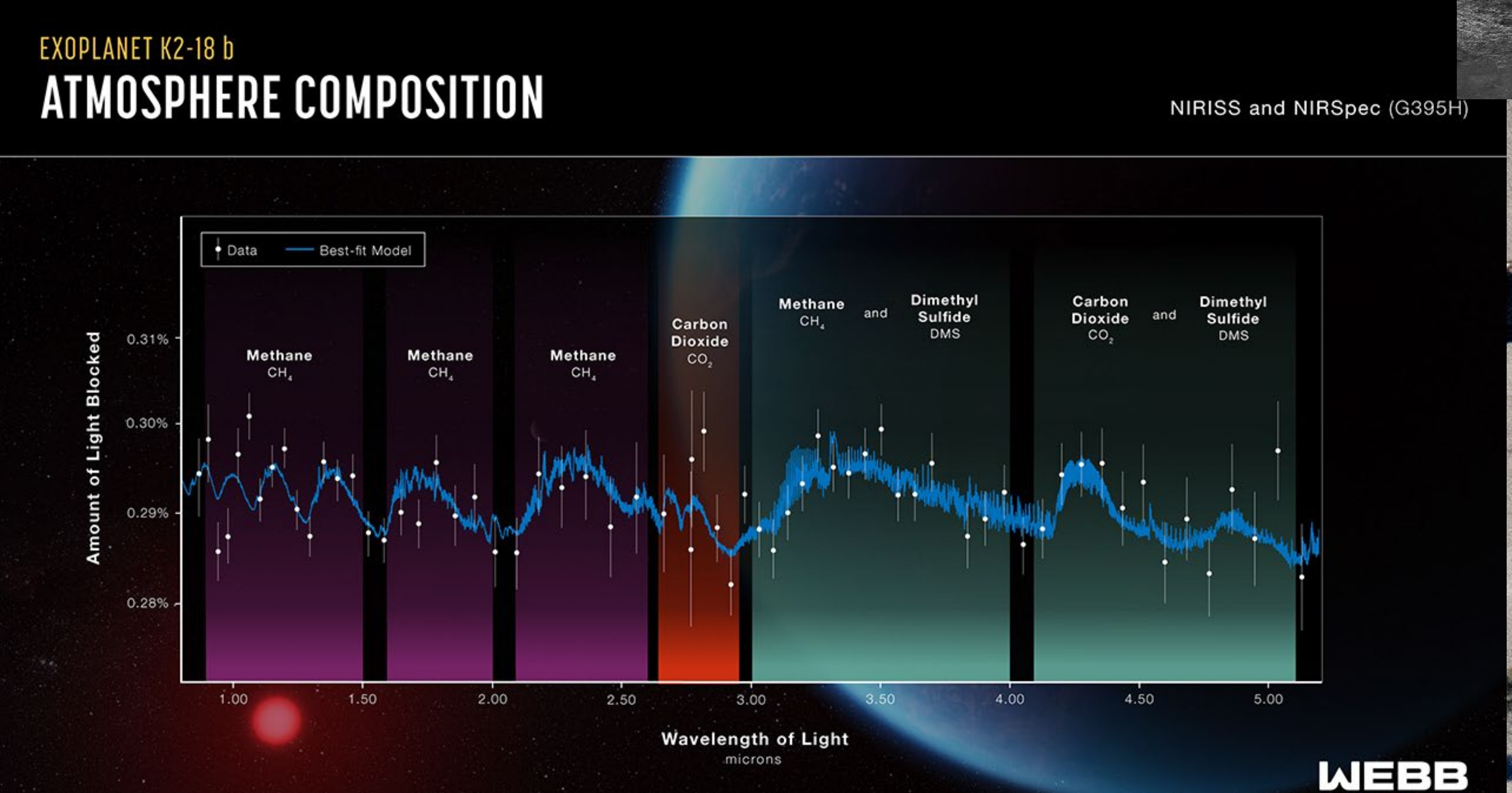

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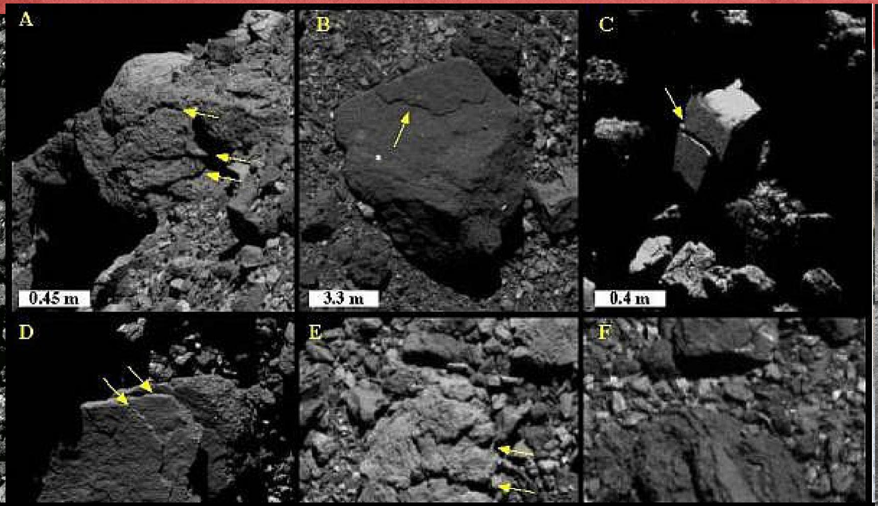
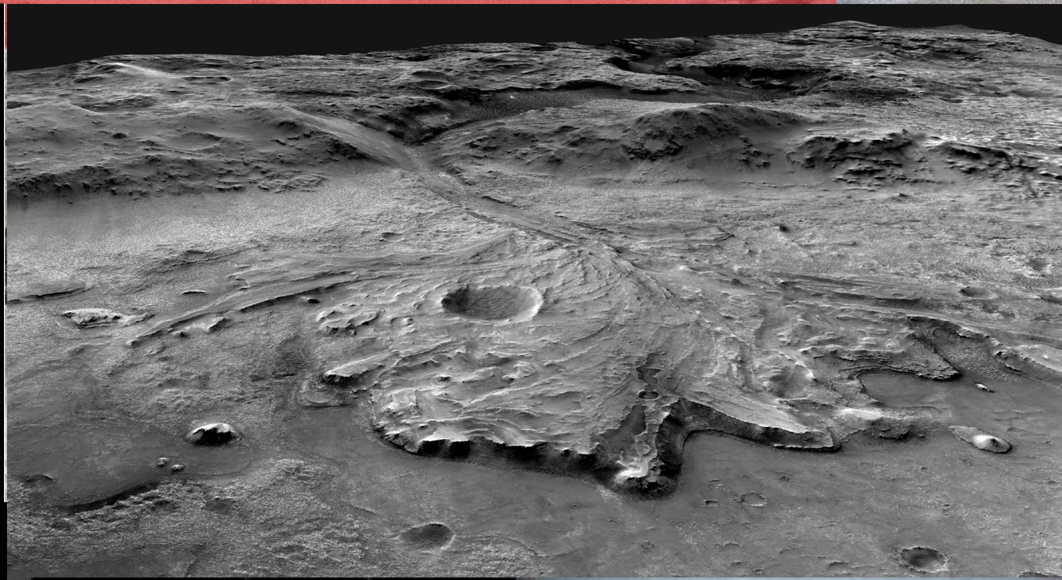
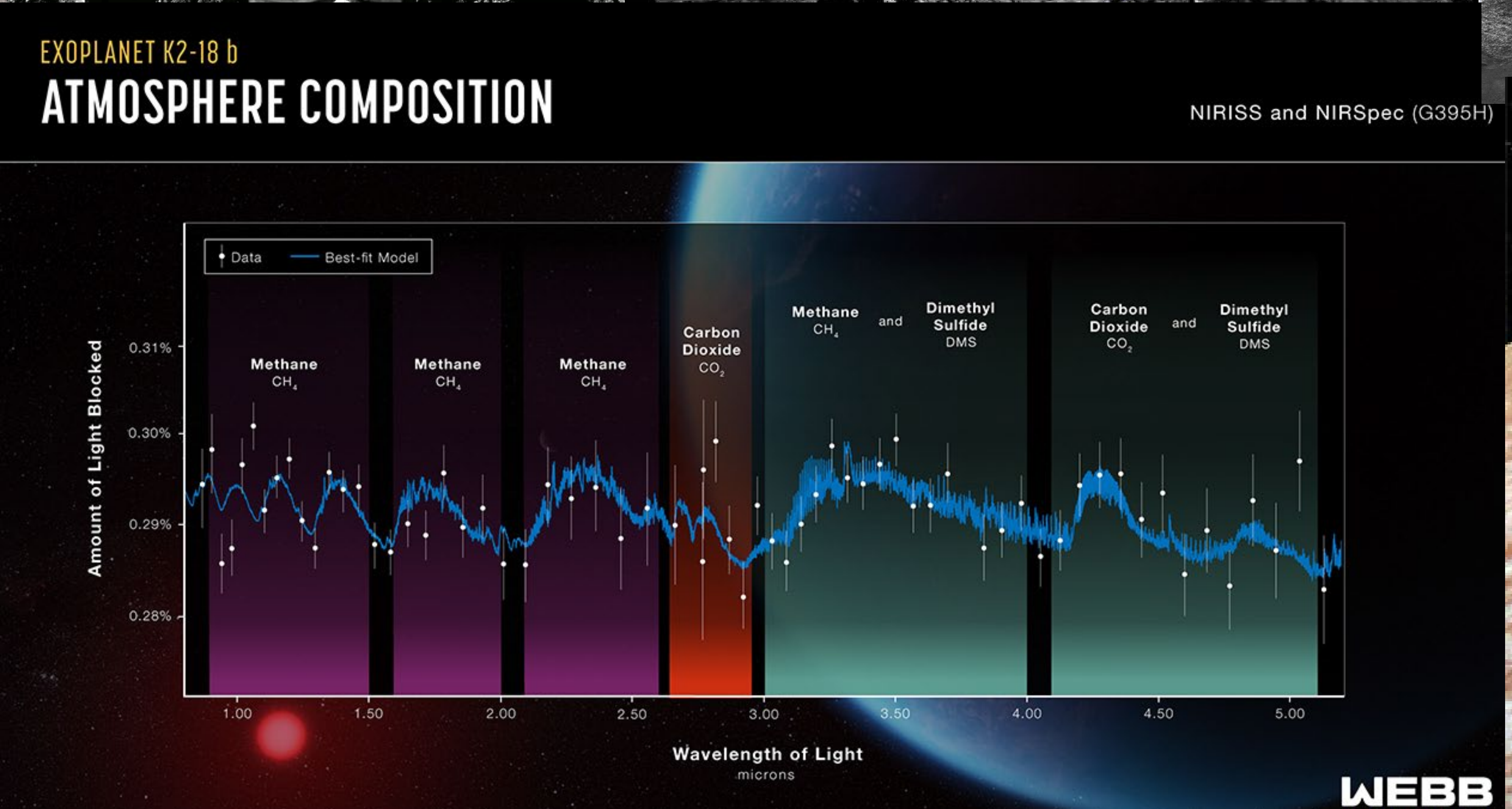
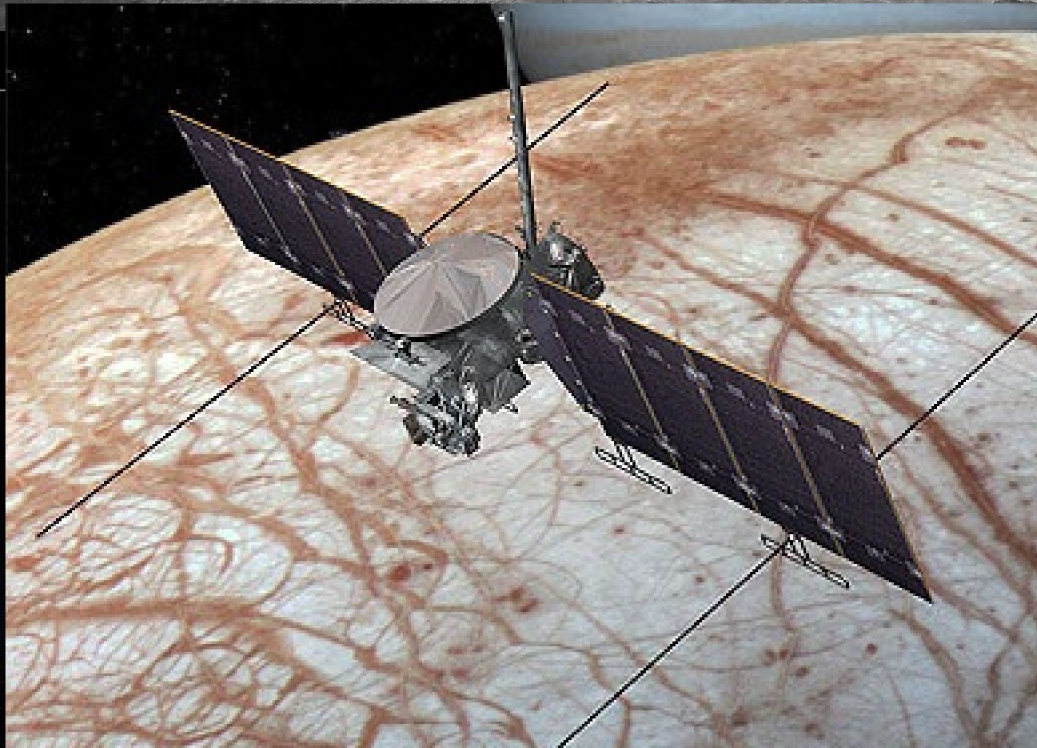
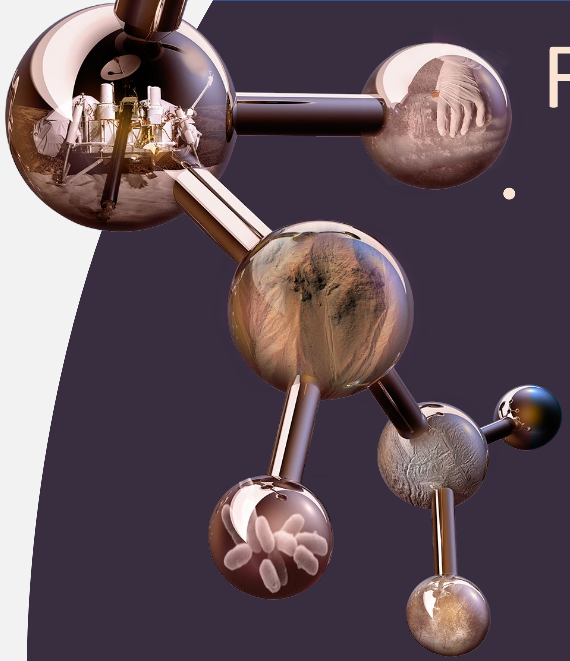








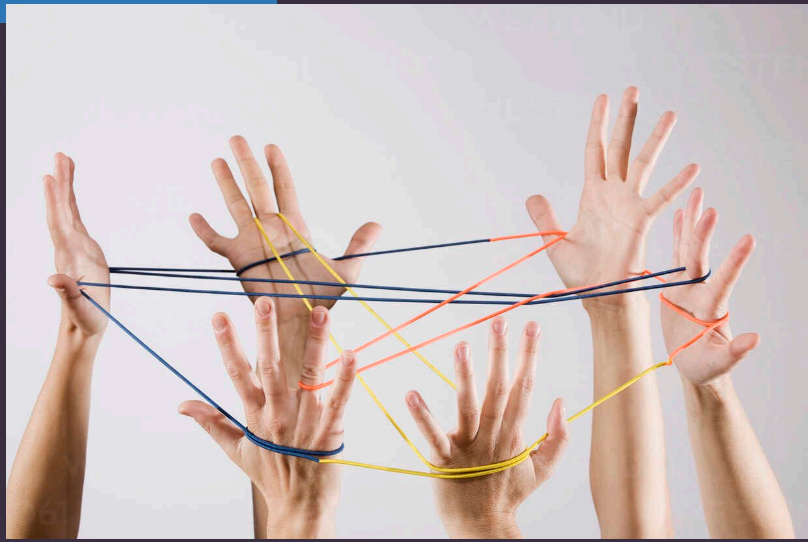


Future Directions:

(1/2)

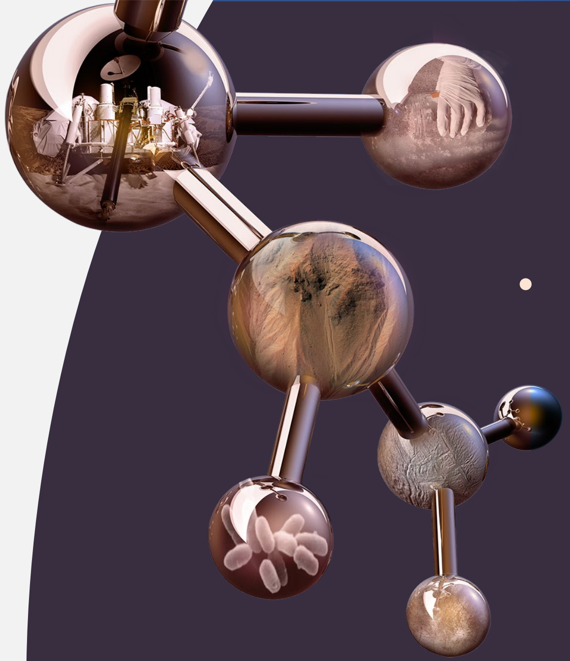
- Increased cross-divisional & cross-directorate activity in Astrobiology at NASA.

The current divisional structure within the Science Mission Directorate largely predates the discovery of exoplanets and significant placement of the search for life as a cross-cutting theme for NASA science.



Goal: Raise visibility of astrobio program, increase connectivity. Look to bolster existing activities with new models for support of interdisciplinary, cross-divisional research projects.

- Interagency programs. (NSF, USGS, NIH…)
- Revitalized international connections & collaborations.
- Public/private partnerships.
- Role in missions.



Future Directions:

(2/2)

- Post discovery planning/imagining
  – communication.
  -- science.

If we succeed in “finding life” that is not the end but a new beginning for Astrobiology.
Comparative planetology -> comparative biospheres, biochemistries, etc.
What would that science look like?

- Astrobiology & global sustainability/Anthropocene/
  future of ife/technosignatures

- Transformative potential of new technologies: AI,
  machine learning, networked smallsats…

- Ethical issues in fieldwork, exploration

Example of Inter-Divisional Research Potential:

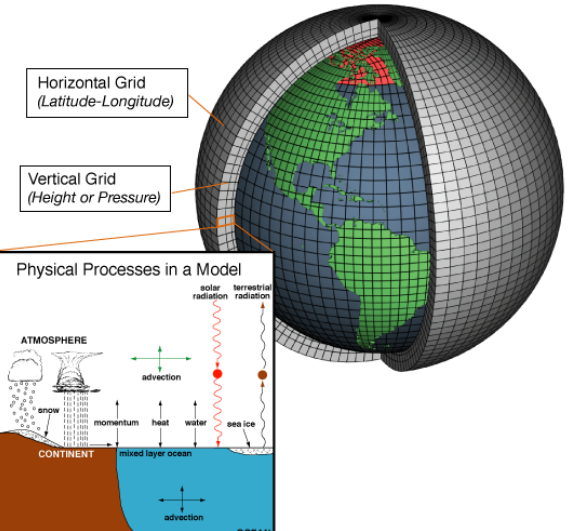
Was Venus the first habitable world of our solar system?

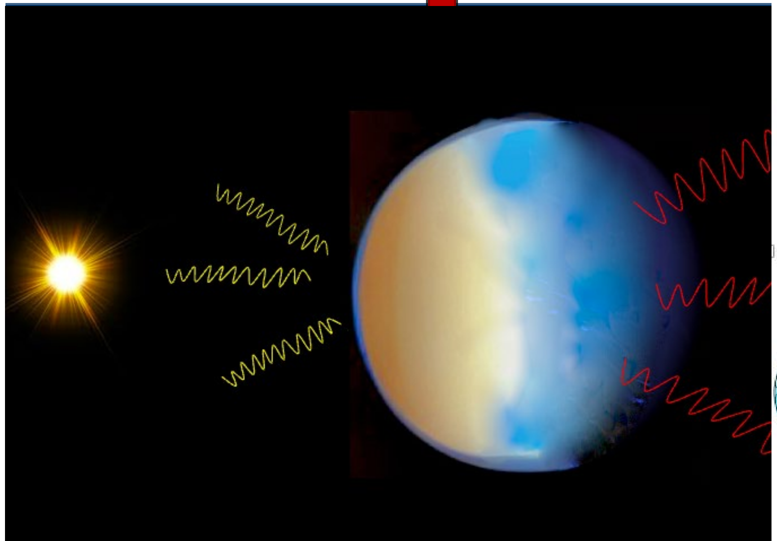
M. J. Way[1,2], Anthony D. Del Genio[1], Nancy Y. Kiang[1], Linda E. Sohl[1,3], David H. Grinspoon[4], Igor Aleinov[1,3], Maxwell Kelley[1], and Thomas Clune[5]

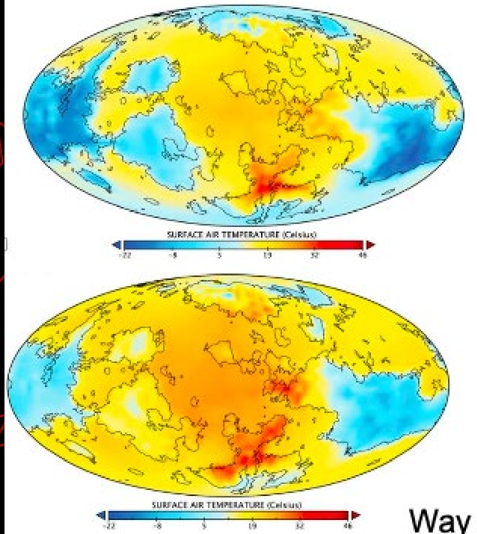
[1]NASA Goddard Institute for Space Studies, New York, New York, USA, [2]Department of Astronomy and Space Physics, Uppsala University, Uppsala, Sweden, [3]Center for Climate Systems Research, Columbia University, New York, New York, USA, [4]Planetary Science Institute, Tucson, Arizona, USA, [5]Global Modeling and Assimilation Office, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA

Abstract Present-day Venus is an inhospitable place with surface temperatures approaching 750 K and an atmosphere 90 times as thick as Earth's. Billions of years ago the picture may have been very different. We have created a suite of 3-D climate simulations using topographic data from the Magellan mission, solar spectral irradiance estimates for 2.9 and 0.715 Gya, present-day Venus orbital parameters, an ocean volume consistent with current theory, and an atmospheric composition estimated for early Venus. Using these parameters we find that such a world could have had moderate temperatures if Venus had a prograde rotation period slower than ~16 Earth days, despite an incident solar flux 46–70% higher than Earth receives. At its current rotation period, Venus's climate could have remained habitable until at least 0.715 Gya. These results demonstrate the role rotation and topography play in understanding the climatic history of Venus-like exoplanets discovered in the present epoch.

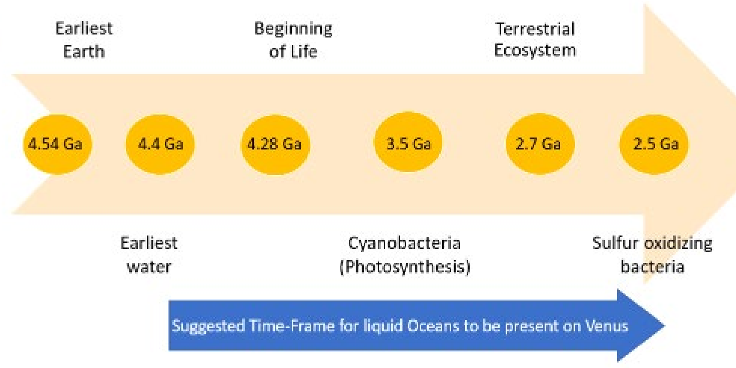
- Tools from Earth Science
- Data from Planetary & Helio
- Tested with future planetary missions
- Results relevant for Exoplanets, future space telescopes, etc.





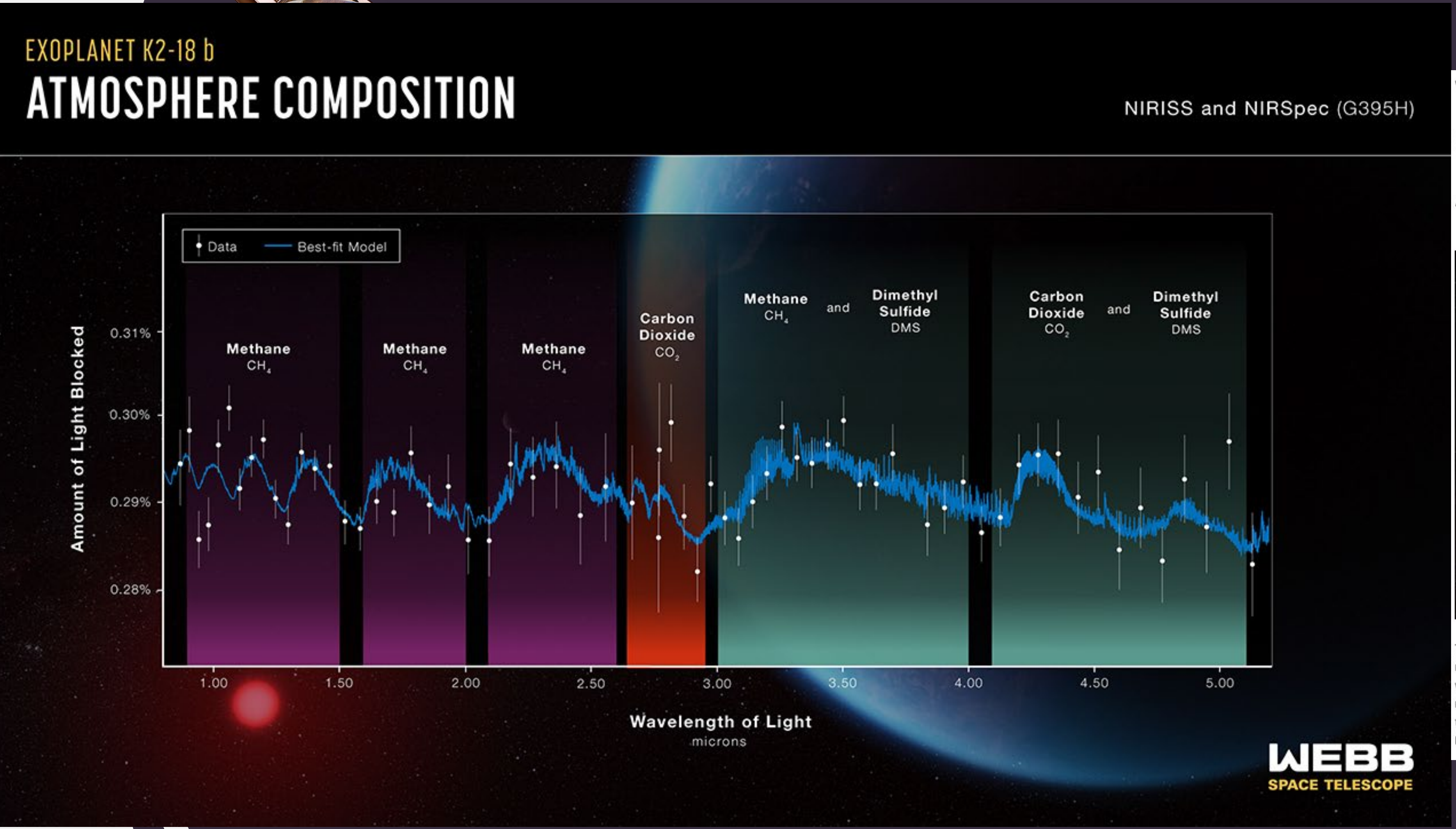


Way et al. 2016

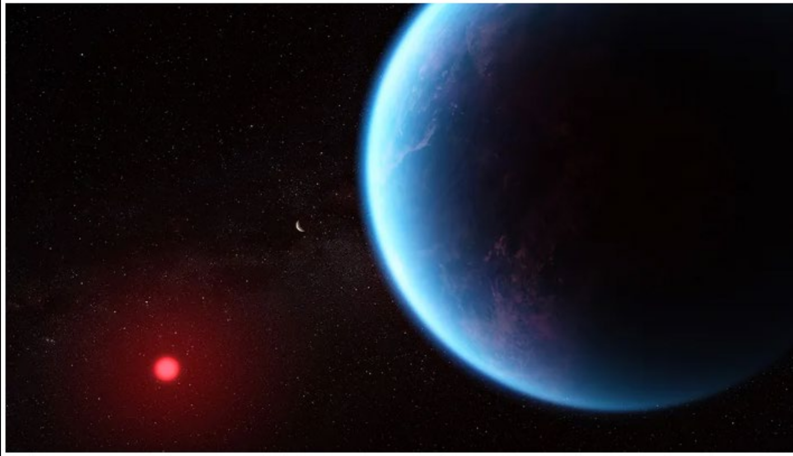


Neira et al. 2018

Communication Challenges



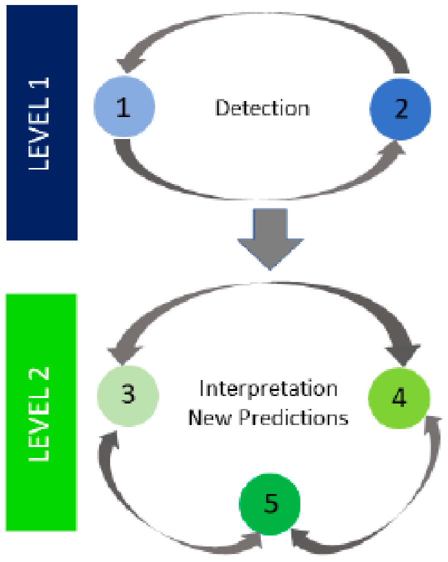
Webb Discovers Methane, Carbon Dioxide in Atmosphere of K2-18 b



This artist's concept shows what exoplanet K2-18 b could look like based on science data. K2-18 b, an exoplanet 8.6 times as massive as Earth, orbits the cool dwarf star K2-18 in the habitable zone and lies 120 light-years from Earth. A new investigation with NASA's James Webb Space Telescope into K2-18 b has revealed the presence of carbon-bearing molecules including methane and carbon dioxide. The abundance of methane and carbon dioxide, and shortage of ammonia, support the hypothesis that there may be a water ocean underneath a hydrogen-rich atmosphere in K2-18 b.

Illustration: NASA, CSA, ESA, J. Olmsted (STScI), Science: N. Madhusudhan (Cambridge University)

Standards of Evidence



Question 1: Have you detected an authentic signal?
Have you authenticated your signal, and is it statistically significant? Have you ruled out artifacts from the measurement, pre-processing and/or analysis process that might mimic a real signal?

Question 2: Have you adequately identified the signal?
Have you adequately ruled out other potential sources for this signal? For example, have you ruled out contamination in the environment, or other real phenomena that could produce a similar signal?

Question 3: Are there abiotic sources for your detection?
Is it likely that there is a current or past environmental process, other than life, that could be producing this signal? Have you ruled out these potential false positives for the biosignature?

Question 4: Is it likely that life would produce this expression in this environment?

Given what we know about the likely environment that an organism is operating in, or would have operated in, does it make physical and chemical sense that life would produce this potential biosignature?

Question 5: Are there independent lines of evidence to support a biological (or non-biological) explanation?
Are there other measurements that provide additional evidence, or allow you to predict and execute follow-on experiments, that will help discriminate between the life or non-life hypotheses?

CDSLU: Communicating Discoveries in the Search for Life in the Universe

Overview

If astrobiologists discover evidence of life beyond the Earth, how should these findings be shared with the public? Which communication strategies and techniques would best support public understanding of findings that are likely to be complex and highly specialized? Astrobiology faces a fundamental tension between the implications of finding evidence of biology or biological processes elsewhere in the universe, and explaining how observations or experiments used to accumulate that evidence will be subject to uncertainty and controversy. How might scientists and science communicators navigate this tension and communicate effectively about this uniquely compelling but challenging research?

This virtual workshop organized by NASA's Astrobiology Program (NAP) will bring together astrobiologists, science journalists, science communicators, and science content creators for a series of presentations, conversations, and activities aimed at building a greater shared understanding of the challenges and opportunities for each group that such an event might present. By creating a space to exchange perspectives, experiences, professional realities, and foster relationships between scientists and science communicators we hope to explore mutually-beneficial and socially responsible paths towards communicating the discovery of extraterrestrial life.

Summary

This virtual workshop will bring together the astrobiology and science communication communities to exchange perspectives about the potential discovery of life beyond Earth. Through a series of presentations, conversations, and activities the workshop will explore mutually-beneficial and socially responsible paths towards communicating the discovery of extraterrestrial life and creating a lasting community of shared interest.

Virtual Workshop Session Details

- Week 1
  February 5, 7, 9, 2024
- Week 2
  February 12, 14, 16, 2024
- *12:00 pm - 4:00 pm ET each day*

Application Deadline

November 15, 2023 by End of Day

Astrobiology Strategy 2025

We are starting to plan an activity to formulate a new Astrobiology Strategy

A decade since the previous one.

Much has happened :
-New Decadal Survey.
-Concrete evidence of habitable early environments on Mars,
-Dragonfly selection,
-Exoplanets (discovery that Trappist-1 has multiple planets in potentially HZ)
-Tremendous progress in understanding biology and environmental evolution of early Earth.

Include post-discovery science strategy?

Worth looking more than 10 years ahead?
20 years from now: Hopefully, samples back from many targets, HWO will be operating, perhaps we'll be planning a fleet of next generation telescopes, perhaps we'll have found multiple biosignatures (or not).
What laboratory & analytical techniques might we have access to?
What will our science look like?