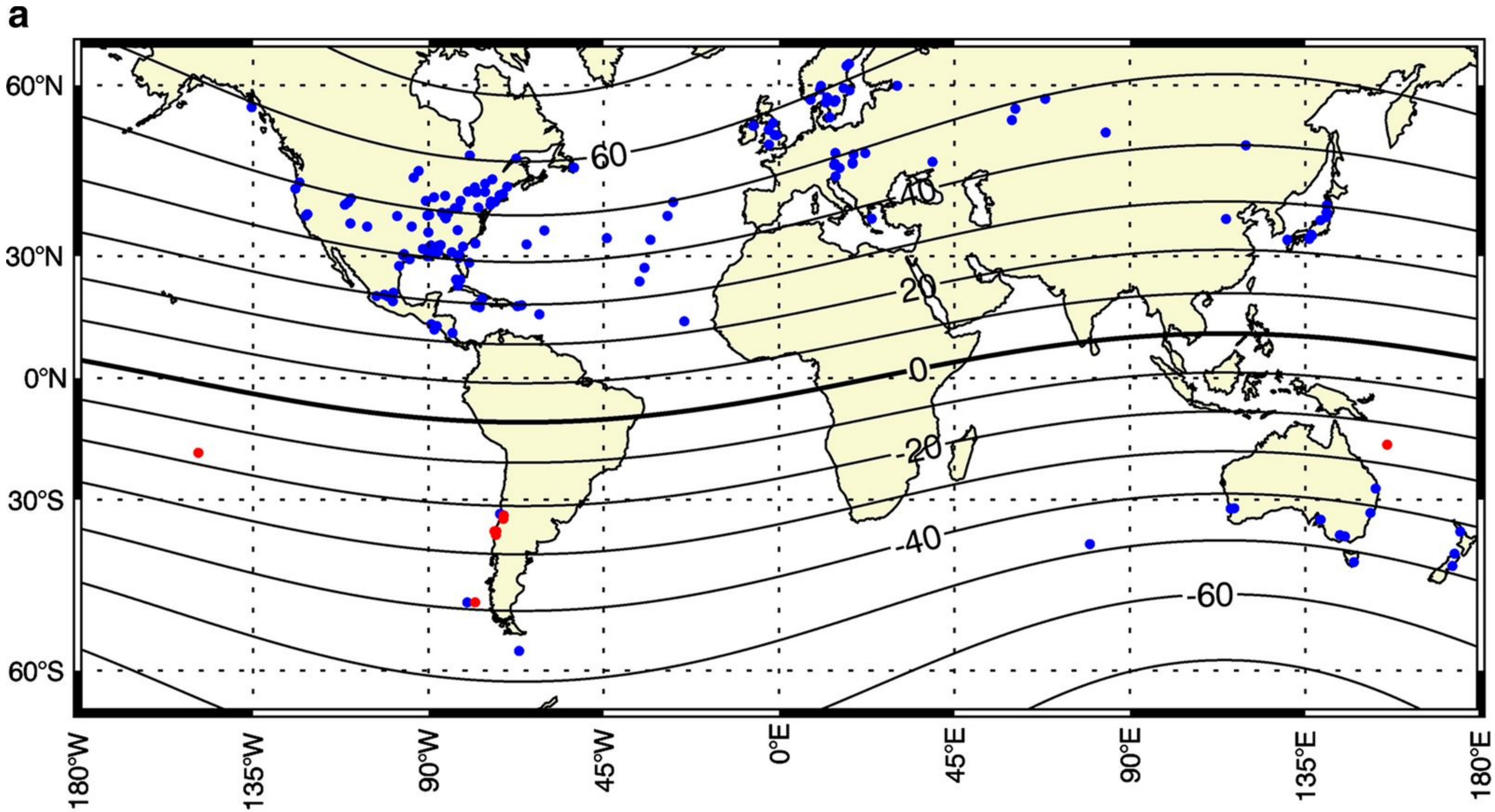
A Surge in Intensity: The Impact of Extreme Space Environments

Antígona Segura, Universidad Nacional Autónoma de México

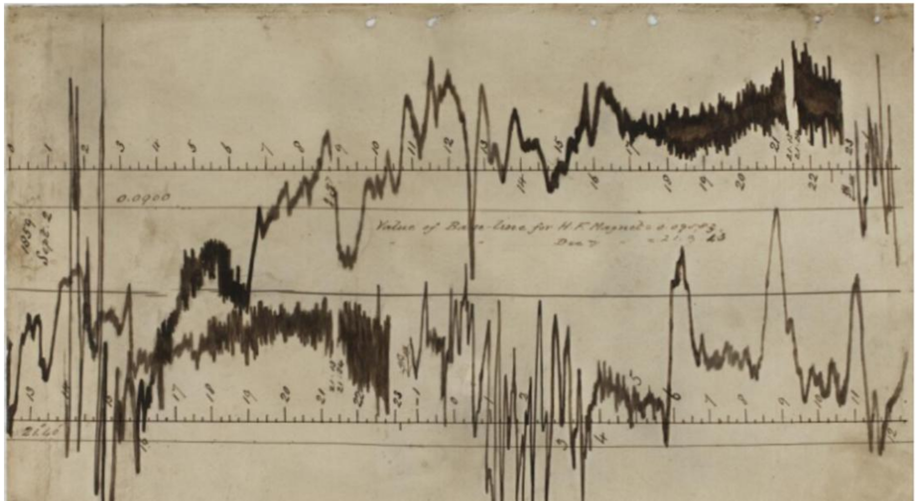

Credit: Professor Hirosi Ooguri
Source: Caltech Instagram
Images
Source National Geographic

1/2 September 1859



Hayakawa et al. 2020 Earth, Planets and Space

The Carrington event



Mandea and Petrovský, 2019, History of Geo- and Space Sciences

The Auroral Display in Boston.

Boston, Friday, Sept. 2.

There was another display of the Aurora last night, so brilliant that at about one o'clock ordinary print could be read by the light. The effect continued through this forenoon, considerably affecting the working of the telegraph lines. The auroral currents from east to west were so regular that the operators on the Eastern lines were able to hold communication and transmit messages over the line between this city and Portland, the usual batteries being discontinued from the wire. The same effects were exhibited upon the Cape Cod and other lines.

The New York Times
Published: September 3, 1859

On September 3, 1859, *The Boston Globe* reported:

> Yesterday there was a great magnetic storm which affected all the telegraph lines in the country. The telegraph lines in Boston were all interrupted for several hours, and some of them were so badly injured that they will not be repaired for several days. The storm also affected the magnetic compasses on ships, and some vessels lost their way.

Source: Briggs, 2023, EarthSky

On a curious Appearance seen in the Sun.
By R. Hodgson, Esq.

"While observing a group of solar spots on the 1st September, I was suddenly surprised at the appearance of a very brilliant star of light, much brighter than the sun's surface, most dazzling to the protected eye, illuminating the upper edges of the adjacent spots and streaks, not unlike in effect the edging of the clouds at sunset; the rays extended in all directions; and the centre might be compared to the dazzling brilliancy of the bright star *α Lyræ* when seen in a large telescope with low power. It lasted for some five minutes, and disappeared instantaneously about 11.25 A.M. Telescope used, an equatoreal refractor 6 inches aperture, carried by clockwork; power, a single convex lens, 100, with a pale neutral-tint sunglass; the whole aperture was used with a diagonal reflector.

"The phenomenon was of too short duration to admit of a micrometrical drawing, but an eye-sketch was taken, from which the enlarged diagram* has been made; and from a photograph taken at Kew the previous day, the size of the group appears to have been about $2^m\ 8^s$, or (say) 60,000 miles.

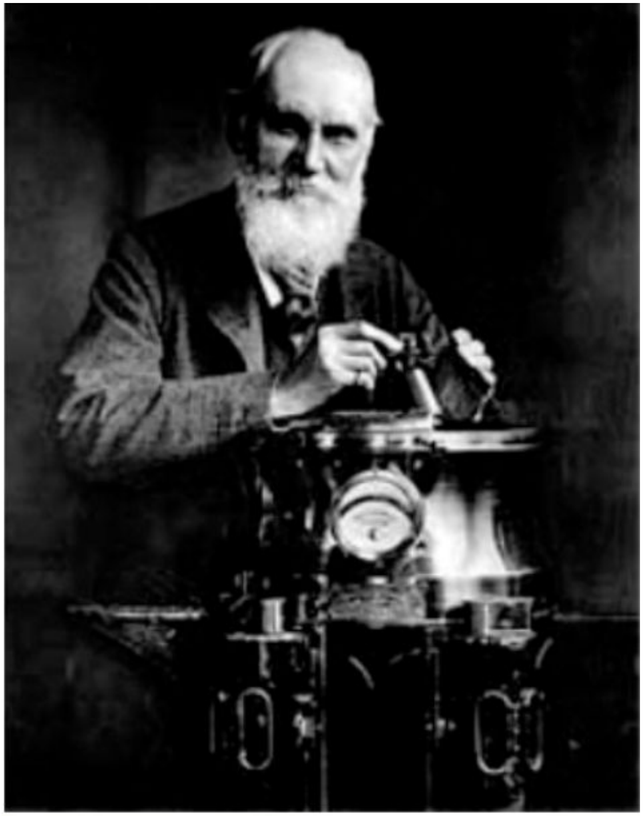
"The magnetic instruments at Kew were simultaneously disturbed to a great extent.

"*Nov.* 11, 1859."

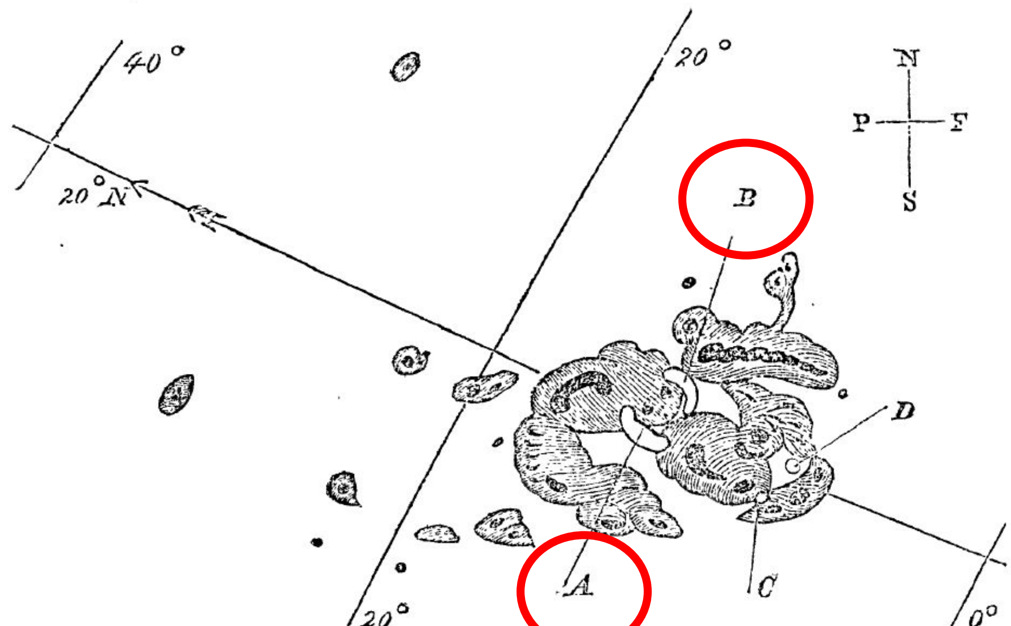
Monthly Notices of the Royal Academy of Science, 1859

Description of a Singular Appearance seen in the Sun on September 1, 1859. By R. C. Carrington, Esq.

While engaged in the forenoon of Thursday, Sept. 1, in taking my customary observation of the forms and positions of the solar spots, an appearance was witnessed which I believe to be exceedingly rare. The image of the sun's disk was, as usual with me, projected on to a plate of glass coated with distemper of a pale straw colour, and at a distance and under a power which presented a picture of about 11 inches diameter. I had secured diagrams of all the groups and detached spots, and was engaged at the time in counting from a chronometer and recording the contacts of the spots with the cross wires used in the observation, when within the area of the great north group (the size of which had previously excited general remark), two patches of intensely bright and white light broke out, in the positions indicated in the appended diagram by the letters A and B, and of the forms of the spaces left white. My



Richard Carrington



Monthly Notices of the Royal Academy of Science, 1859

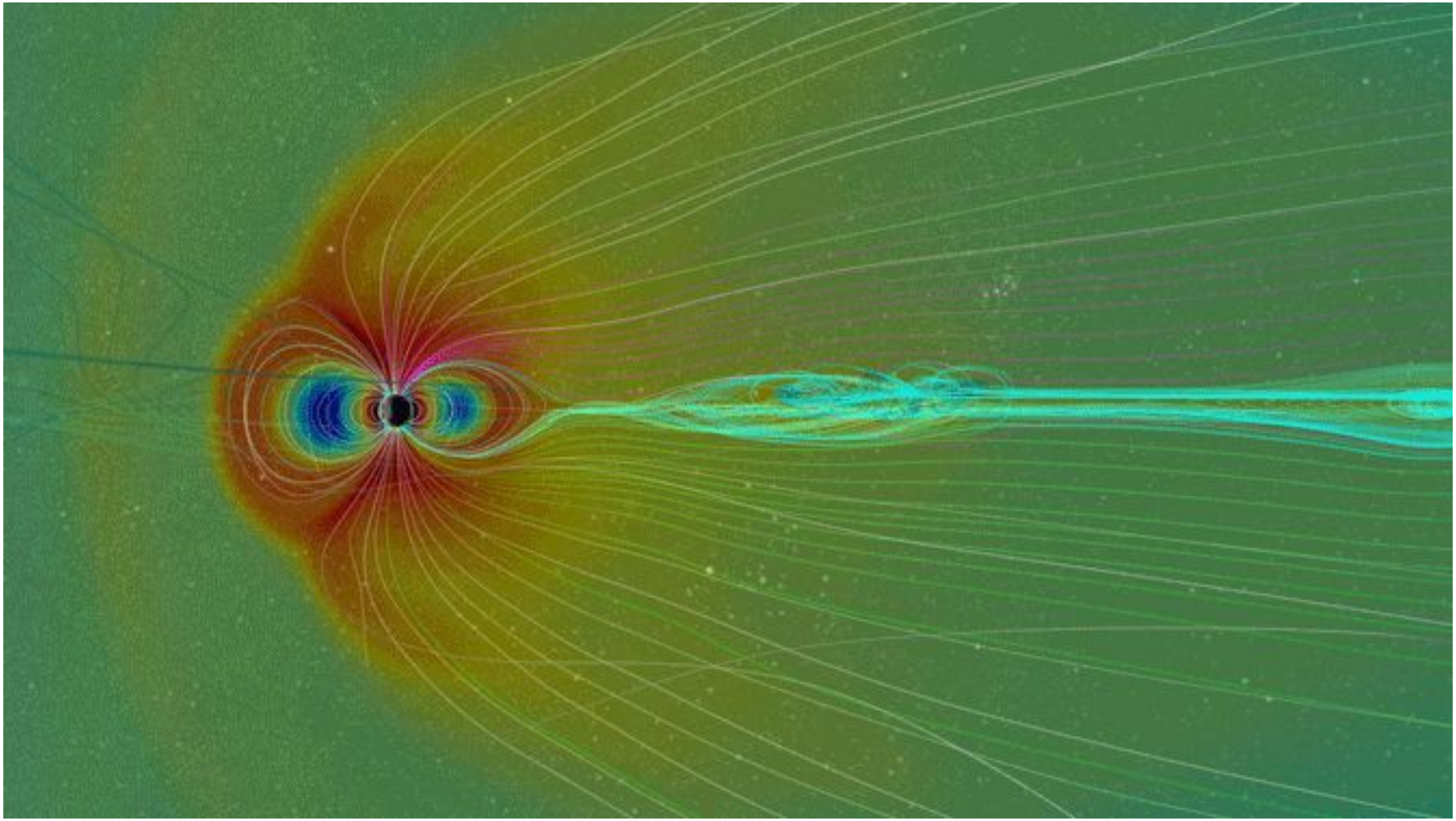
A CME heading straight for Earth on Oct. 28, 2003.
Image credit: SOHO.

Halloween Storms

“59% of NASA’s Earth and space science satellites were affected in one way or another.” Phillips, 2021

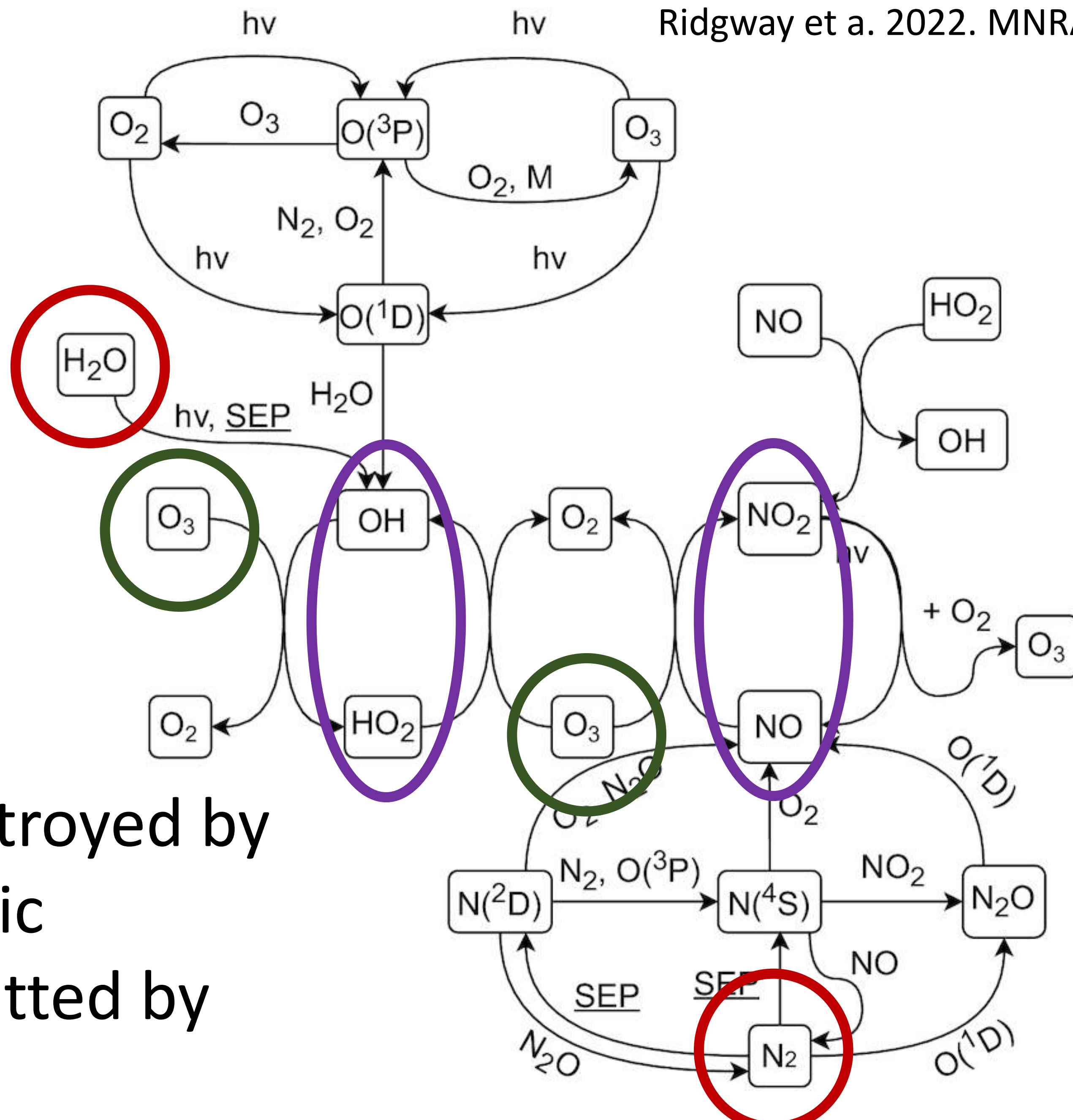
https://spaceweatherarchive.com/

1859: the Carrington event



NASA's Goddard Space Flight Center

Ridgway et a. 2022. MNRAS



Ozone is destroyed by high energetic particles emitted by the Sun

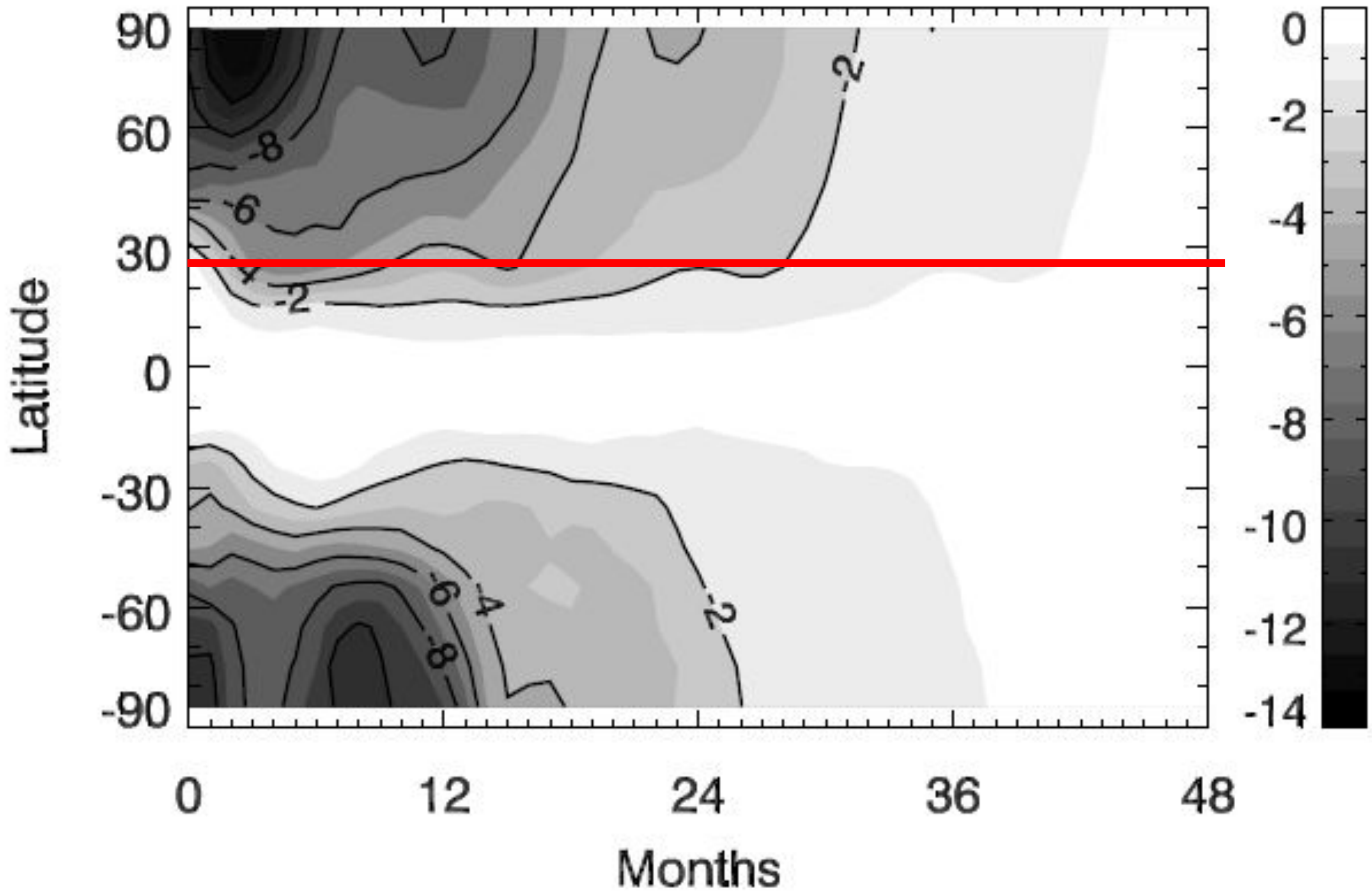
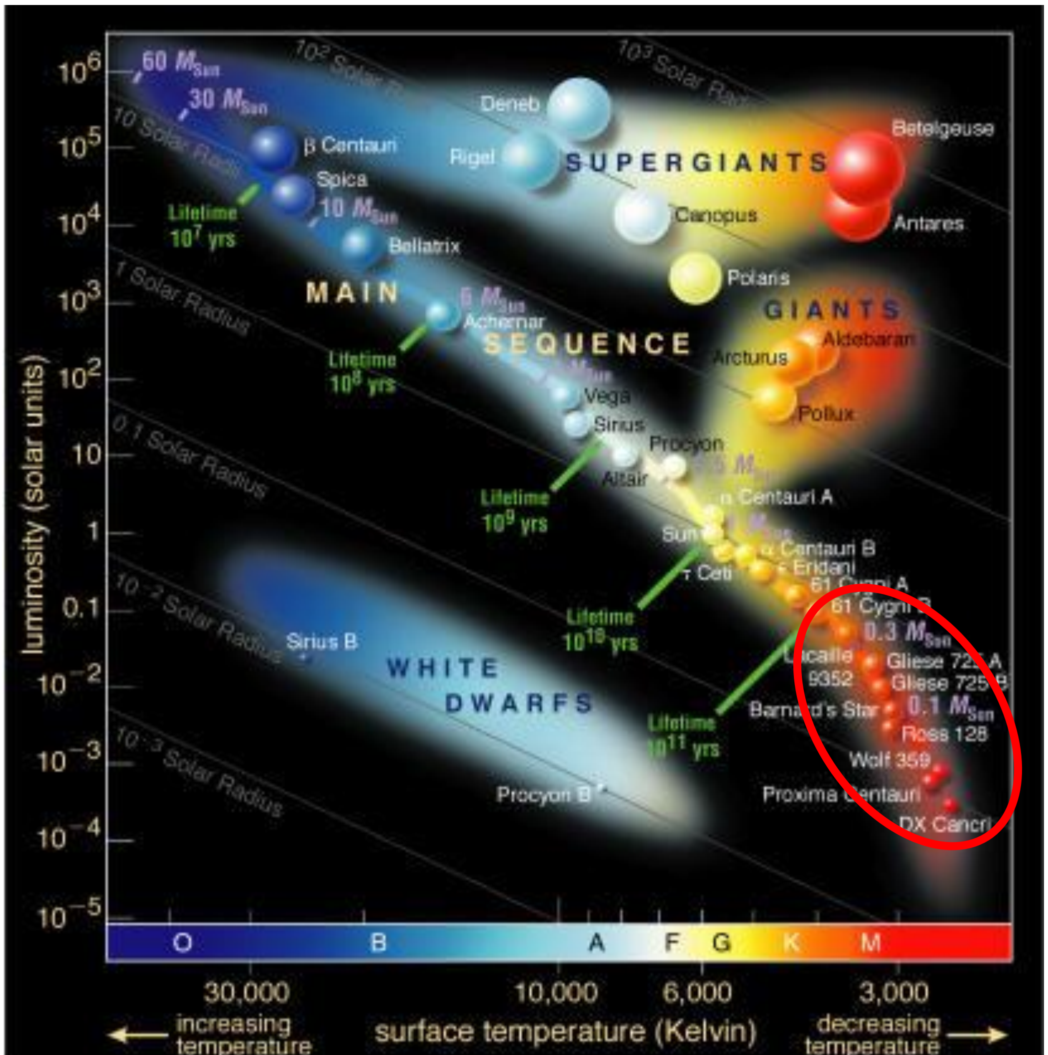


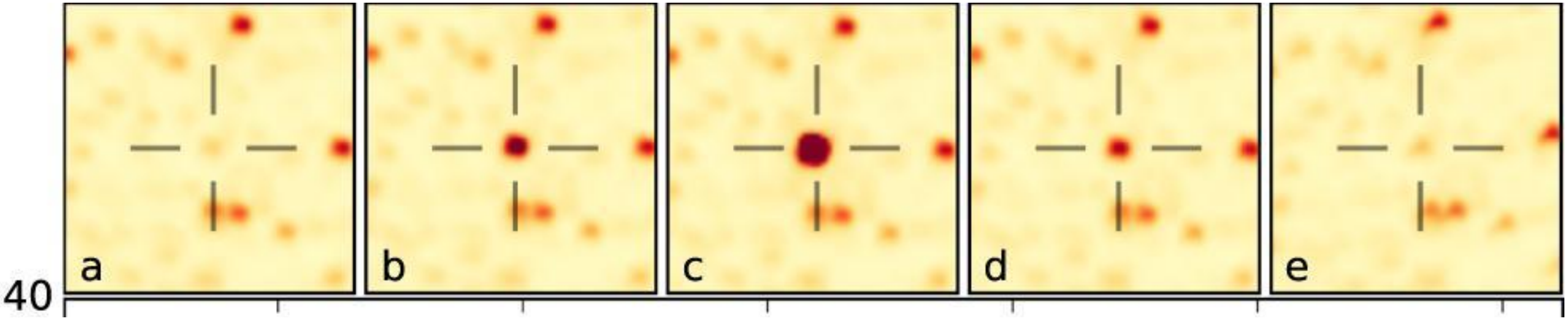
Figure 5. Percent difference in column O_3 between perturbed and unperturbed runs for the first four years after the SPE.

Thomas et al. 2003. Geophys. Res Lett.

Main sequence M stars: M dwarfs a.k.a. red dwarfs



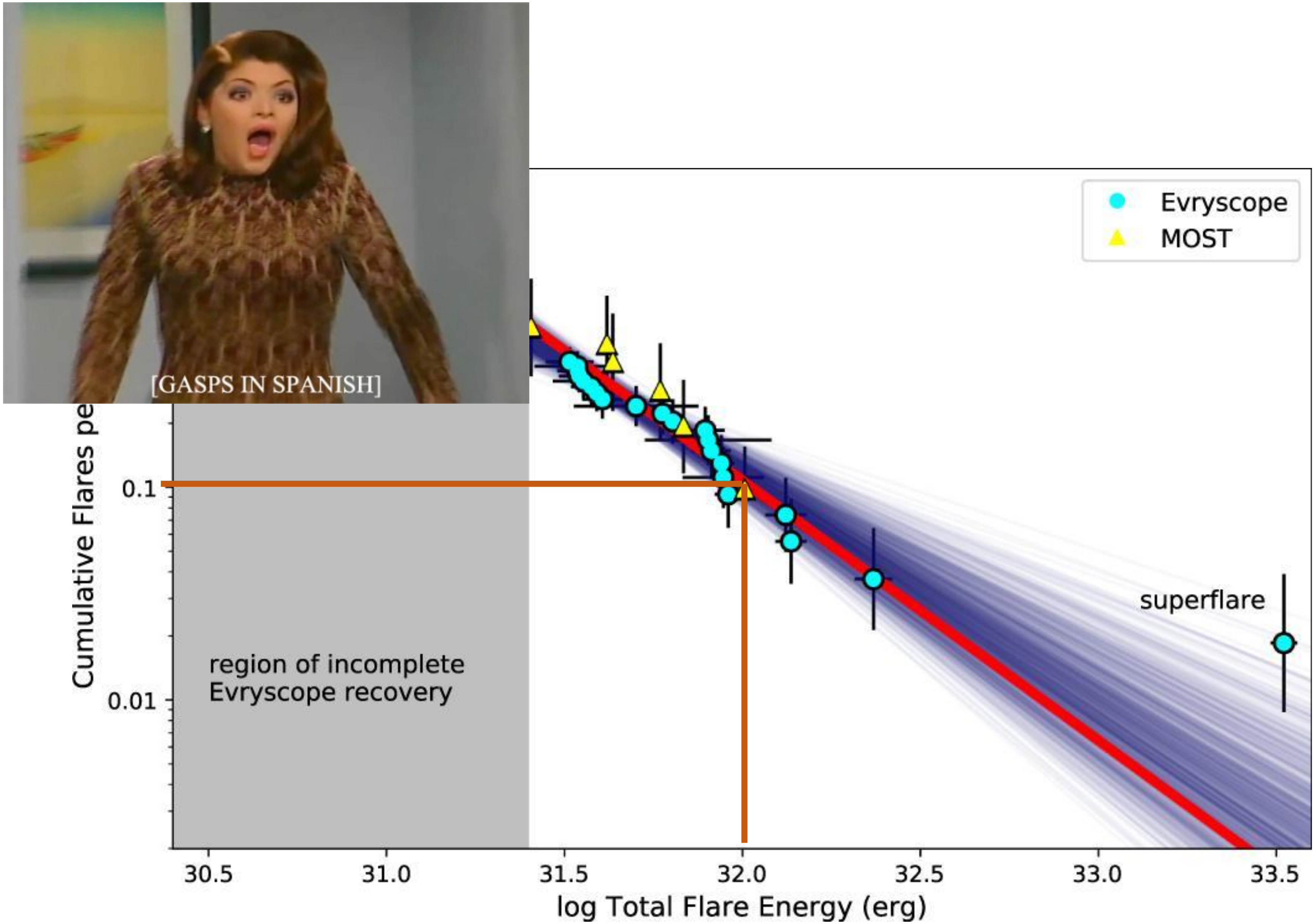
- Masses: 0.06-0.6 Solar masses.
- Luminosities: 0.6-10^{-4} Solar luminosity.
- 73% of the stars in the solar neighborhood: Many of them to search for habitable planets.
- Most likely targets for characterization of potentially habitable planets.



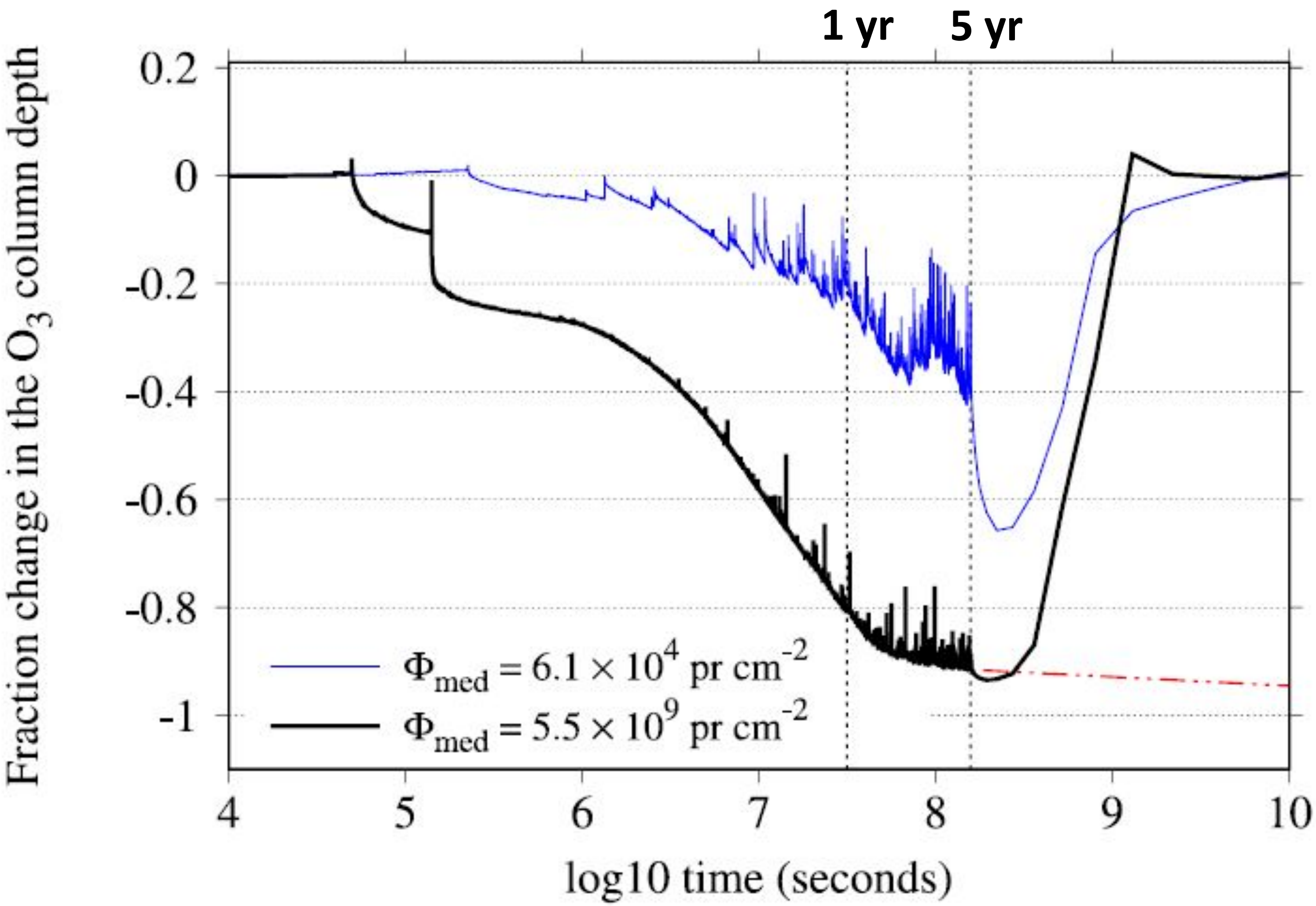
Proxima Centauri

March 2016

Optical flux increased by a factor of ~68



Howard et al. 2018 Astrophys. Journal Lett.

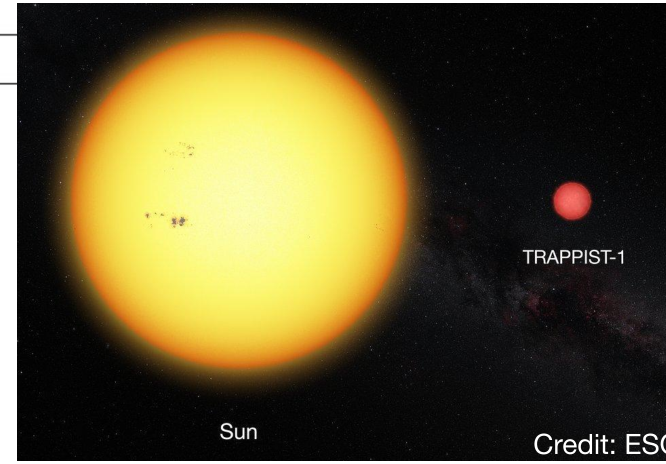


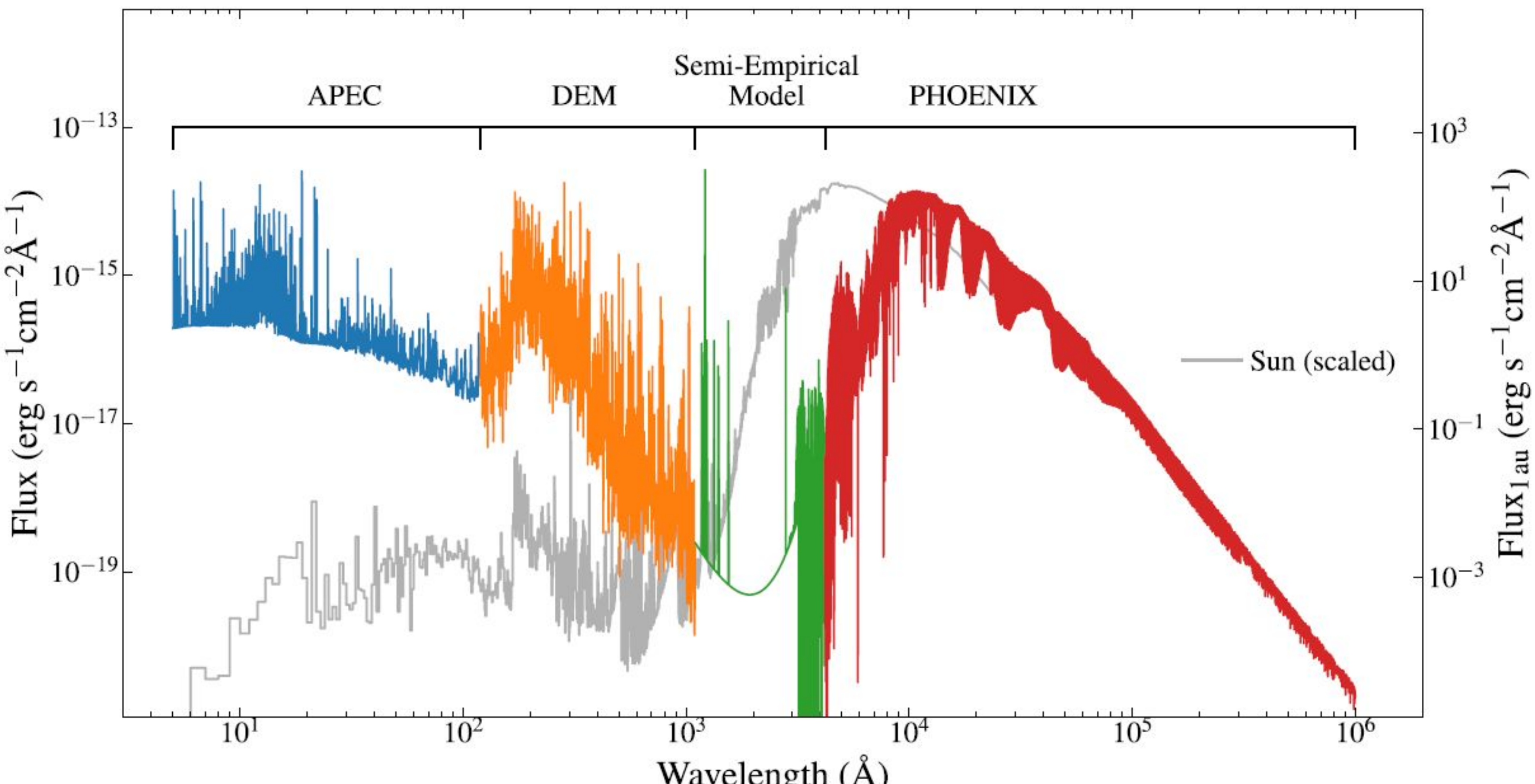
Ozone layer would be destroyed increasing 100 times the ultraviolet radiation at the surface

Howard et al. 2018 Astrophys. Journal Lett.

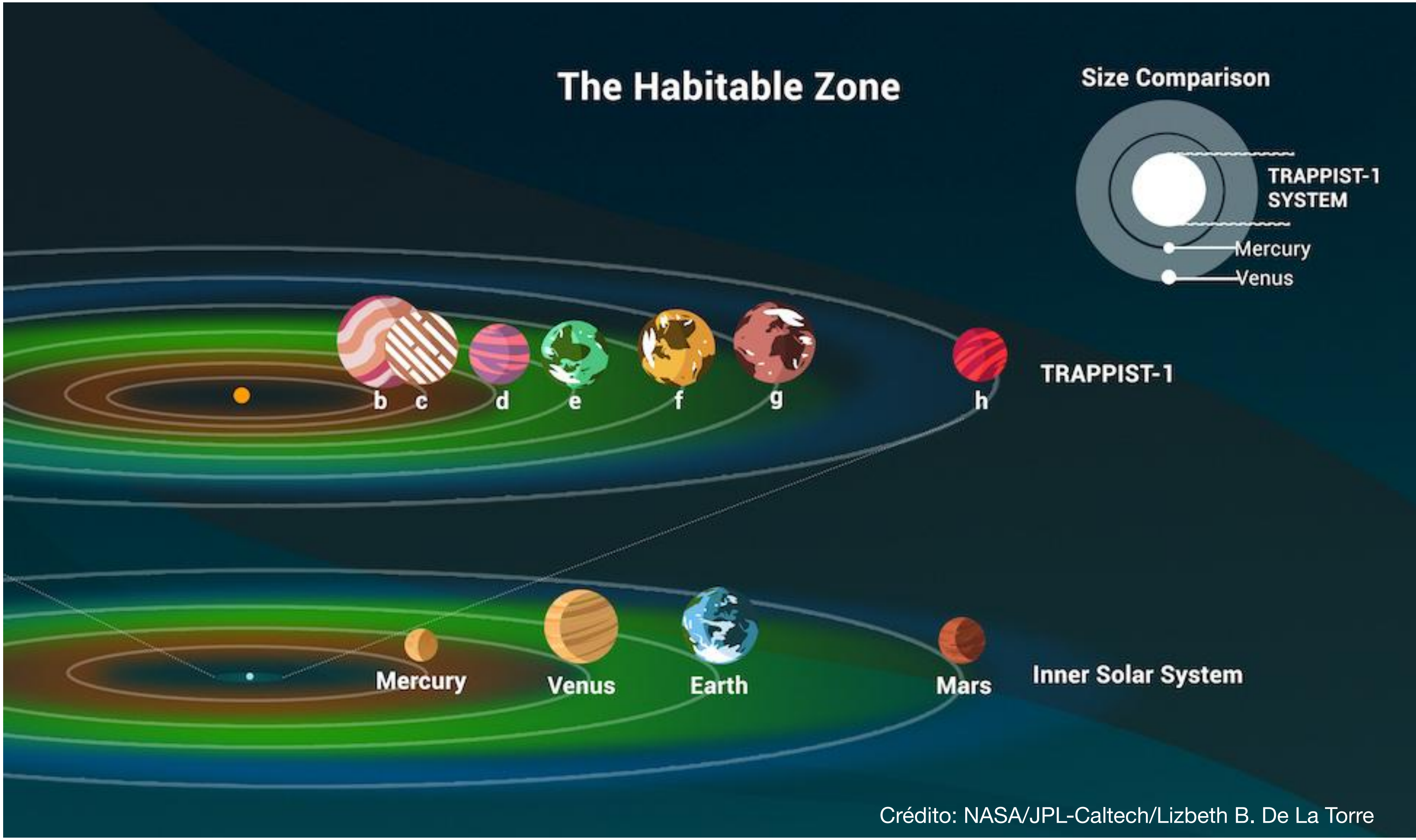
Table 1 | Updated properties of the TRAPPIST-1 planetary system

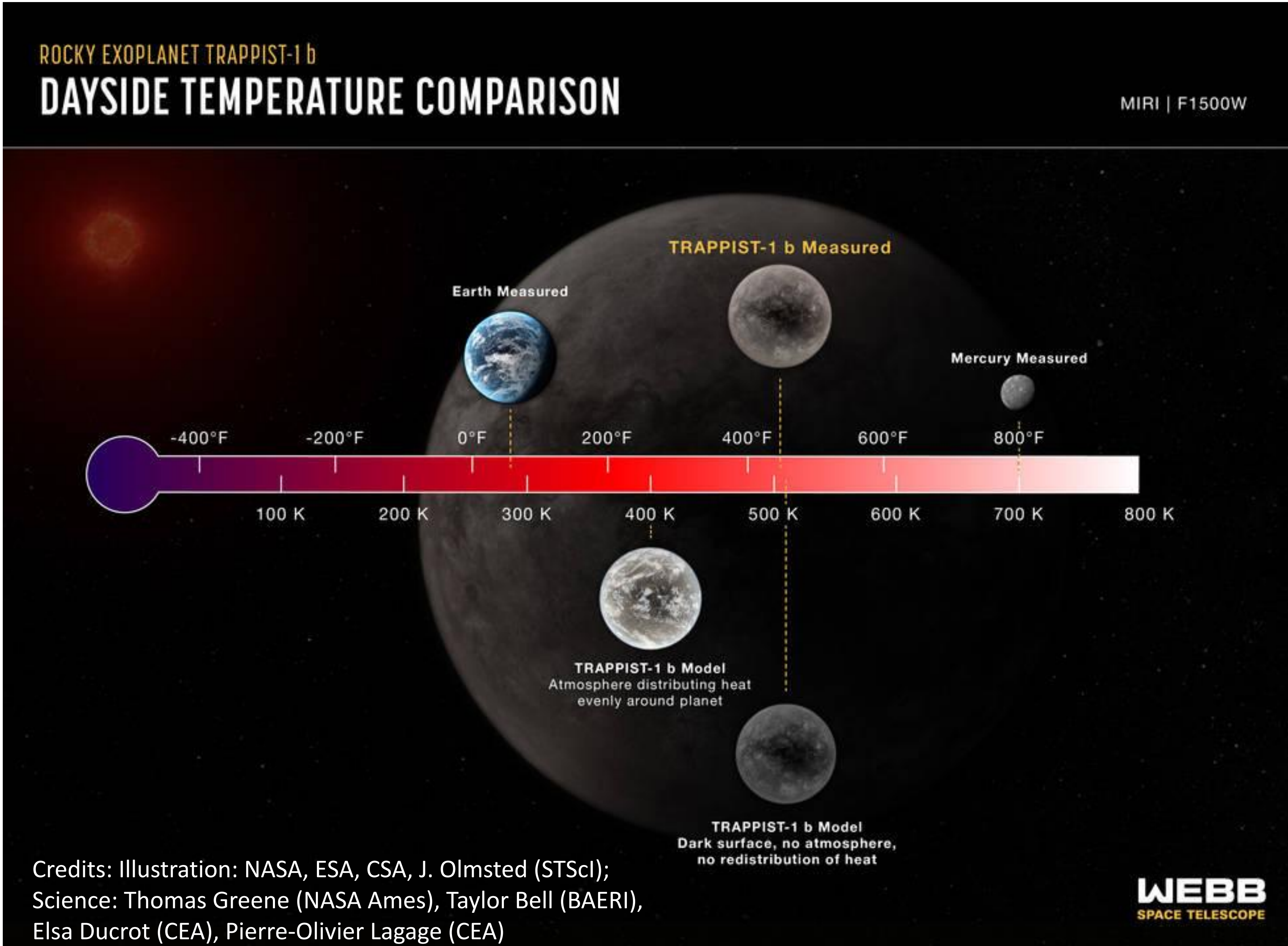
Parameter	Value
Star	**TRAPPIST-1 = 2MASS J23062928−0502285**
Magnitudes[1]	$V = 18.8, R = 16.6, I = 14.0, J = 11.4, K = 10.3$
Distance (pc)[1]	12.1 ± 0.4
Mass, $M_\star$ ($M_\odot$)†	0.0802 ± 0.0073
Radius, $R_\star$ ($R_\odot$)†	0.117 ± 0.0036
Density, $\rho_\star$ ($\rho_\odot$)	$50.7^{+1.2}_{-2.2}$
Luminosity, $L_\star$ ($L_\odot$)†	0.000524 ± 0.000034
Effective temperature, T_{eff} (K)†	$2{,}559 \pm 50$





TRAPPIST-1 system





Credits: Illustration: NASA, ESA, CSA, J. Olmsted (STScI);
Science: Thomas Greene (NASA Ames), Taylor Bell (BAERI),
Elsa Ducrot (CEA), Pierre-Olivier Lagage (CEA)

Article

No thick carbon dioxide atmosphere on the rocky exoplanet TRAPPIST-1 c

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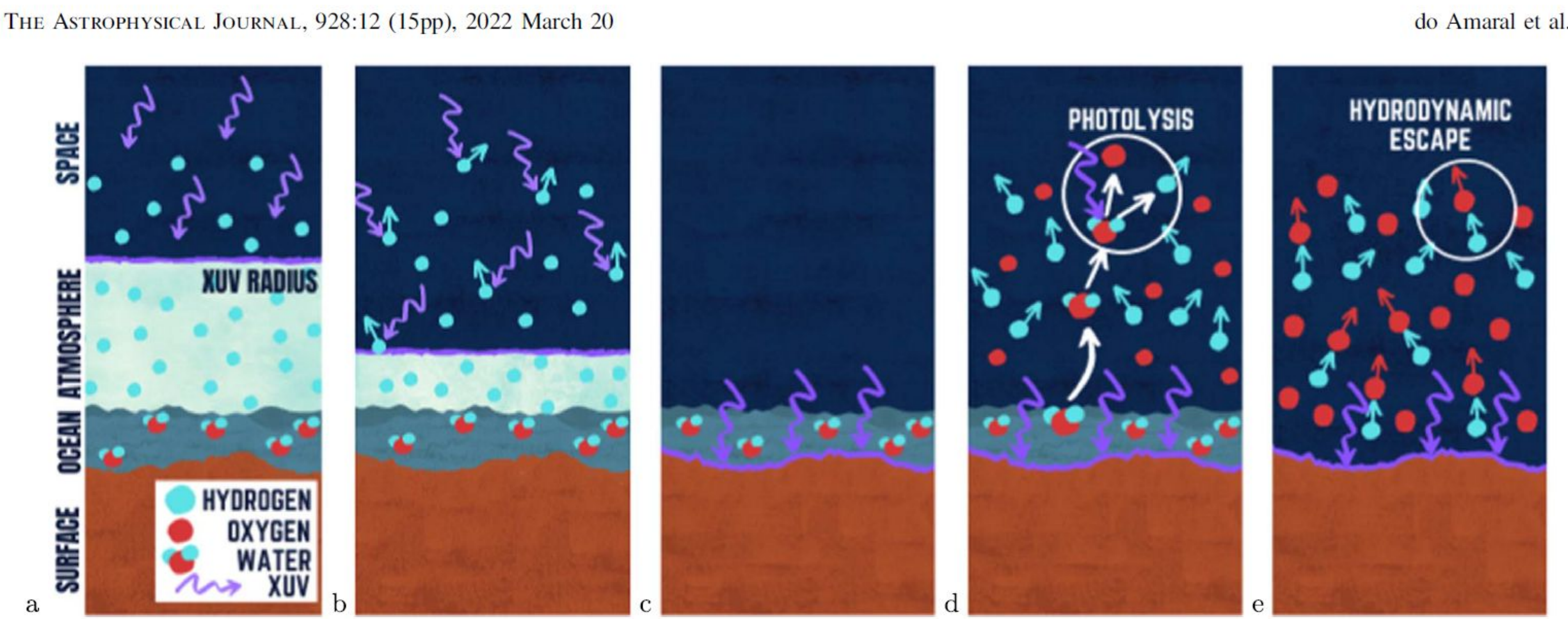
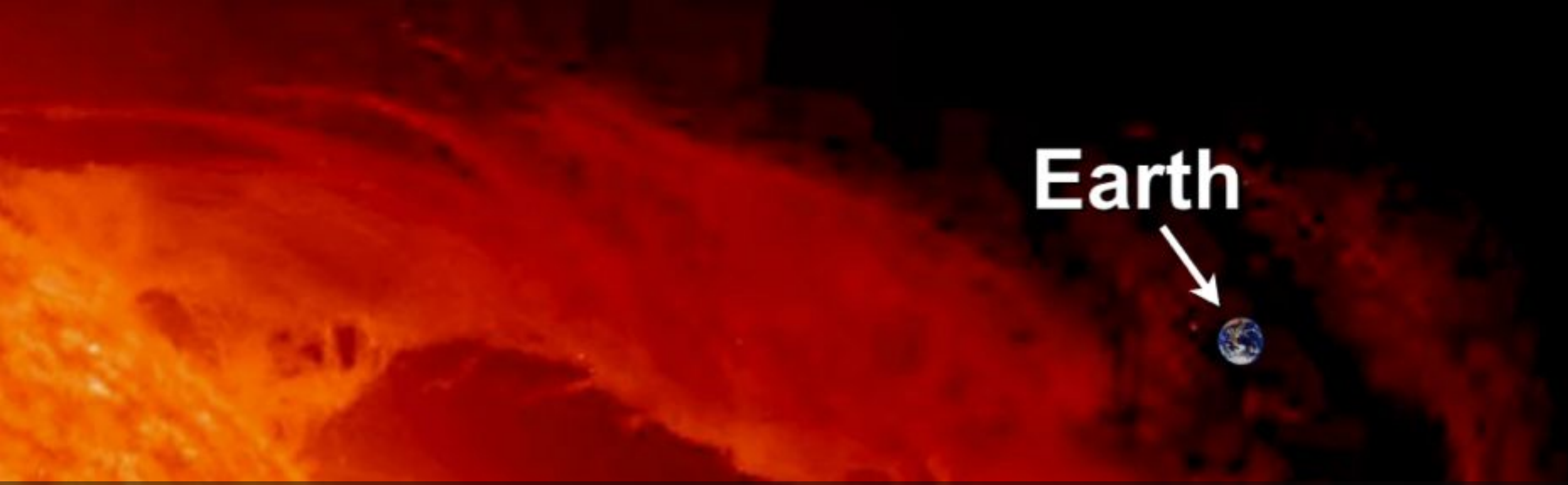
Seven rocky planets orbit the nearby dwarf star TRAPPIST-1, providing a unique opportunity to search for atmospheres on small planets outside the Solar System[1]. Thanks to the recent launch of the James Webb Space Telescope (JWST), possible atmospheric constituents such as carbon dioxide (CO_2) are now detectable[2,3]. Recent

Shaping new atmospheres

O_2 rich atmospheres
(Luger and Barnes, 2015)





Space weather around M dwarfs may be less dramatic than originally predicted.

Numerical models and future observations would provide clues about the effects of extreme space weather environments.