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The UV surface habitability of Proxima *b*: first experiments revealing probable life survival to stellar flares

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Appendix A: The UV surface habitability of Proxima *b*: experiments revealing probable life survival to stellar flares

by X. C. Abrevaya, et al. 2019, MNRAS*

METHODS

Microorganisms and growth conditions

Pseudomonas aeruginosa ATCC 27853 was cultured in nutrient broth (8 g.l⁻¹ Difco nutrient broth, 5 g.l⁻¹ NaCl) at 37°C until the stationary growth phase. The cells were then harvested by centrifugation and the pellets were washed and resuspended with phosphate-buffered saline. A similar procedure was applied for *Haloferax volcanii* DS70, but cultured in Hv-YPC broth (Kauri,1990) at 30°C. The pellets were washed and resuspended in HV-saline solution (Abrevaya et al.,2011). The final concentration was approximately 8 x 10⁸ colony-forming units (CFU) per ml (optical density 0.3 at 650 nm) for both microorganisms.

Irradiation procedure

Experiments were conducted using germicidal lamps (Philips TUV 15W/G15 TB). As these the lamps emits almost monochromatically in the UVC range at 254 nm (with some small contributions at other wavelengths which can be considered negligible), the UVC fluence rate of 254 nm we used for the experiments was equivalent to the total flux calculated for the star in the UVC range (200-280 nm). It is important to note that even we do not cover the complete UVC range emitted by the star using this lamp, as nucleic acids absorb radiation around 260 nm, which is very close to the peak of emission of the lamp, the radiation emitted by the lamp is effective producing cellular damage and therefore this approach is a good approximation. The lamps were placed above suspensions of microorganisms at a suitable distance to obtain a fluence rate of 8.7 W m⁻² or 92 W m⁻² (measured using a ILT 77 Germicidal Radiometer), for the case of a simulation of a typical flare or a superflare, respectively. The microorganisms were exposed for different time intervals, giving different fluences, while maintained under slow magnetic agitation. The time ranges were from 5 to 4500 seconds for the flare, considering the typical distribution for the duration of flares described in Gershberg (2005), and from 5 to 420 seconds for the superflare, considering

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the peak of the superflare described in Howard et al. (2018). The control groups were non irradiated samples.

Photoreactivation procedure

Samples of *P. aeruginosa* previously irradiated at a fluence rate of 92 W m^{-2} were stirred with magnetic bars and exposed for 3 hours to visible light (Philips TLD 15 W 54 tube, fluence rate of 20 W m^{-2} , measured with an ILT 1400-A radiometer). The controls followed the same procedure in the dark. CFUs were obtained before and after the procedure.

Enumeration procedure

Aliquots of the irradiated suspensions of *P. aeruginosa* were diluted and spread on Nutrient Agar plates (Difco Nutrient Agar 23g.l^{-1} , NaCl 5g.l^{-1}). CFUs were counted after incubation at 37° C in the dark for 24 h. The same procedure was applied for *H. volcanii*, but the suspensions were diluted in HV-saline solution (see section "Microorganisms and grow conditions", above), plated on Hv-YPC broth with agar and incubated at 30° C in the dark for 15 days. The limit of detection (LOD) was 40 CFU per ml, considering that 10 CFU is the minimum amount to be counted in an agar plate inoculated with 0.25 ml of undiluted suspension.

SUPPLEMENTARY FIGURES

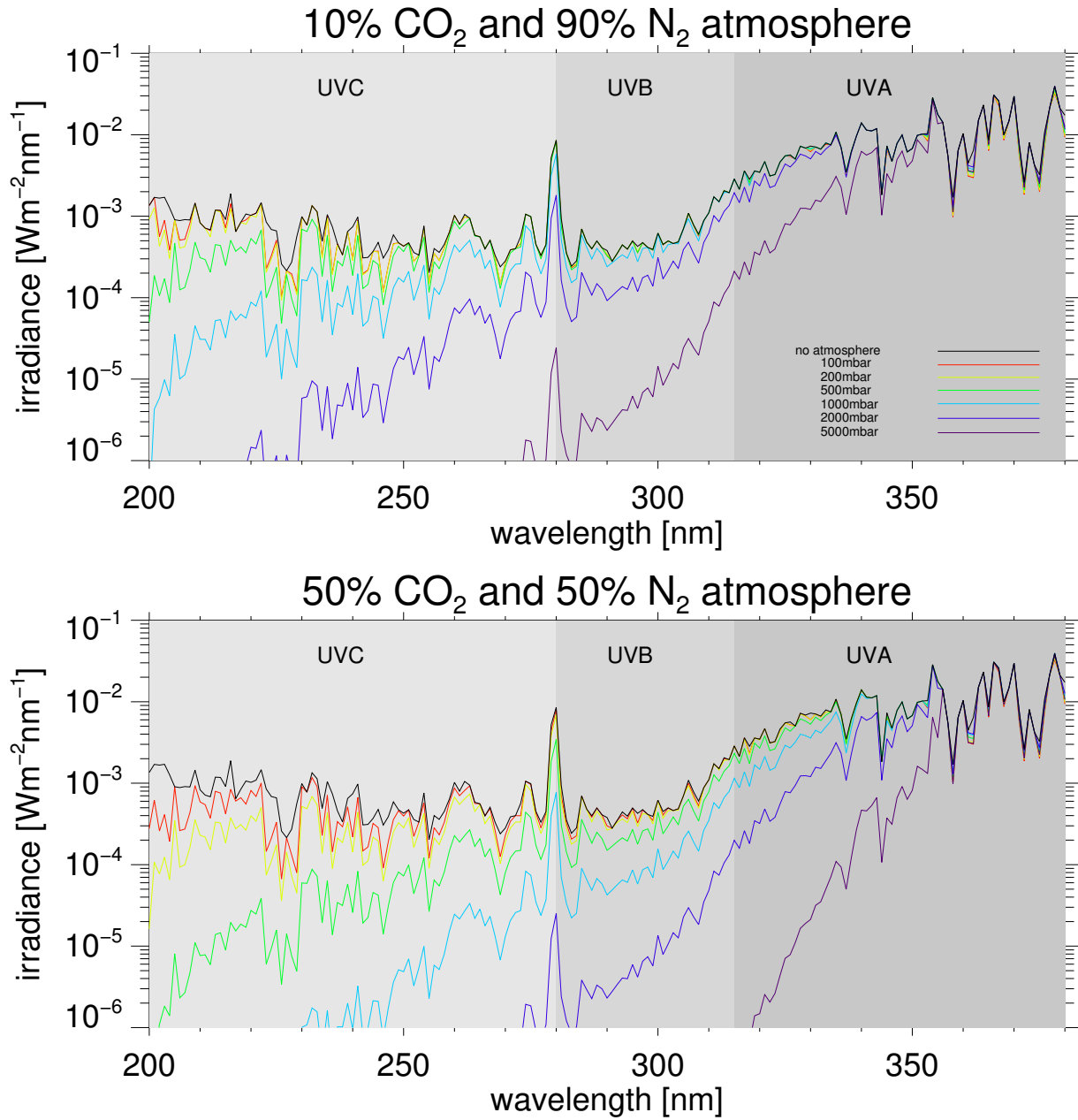


Figure A1. UVR in the 200–380 nm wavelength range reaching the planetary surface for atmospheric compositions 10%CO₂/90%N₂ and 50%CO₂/50%N₂ and different pressures. UVA (315–400 nm), UVB (280–315 nm) and UVC (200–280 nm) bands are indicated by the gray shaded areas.

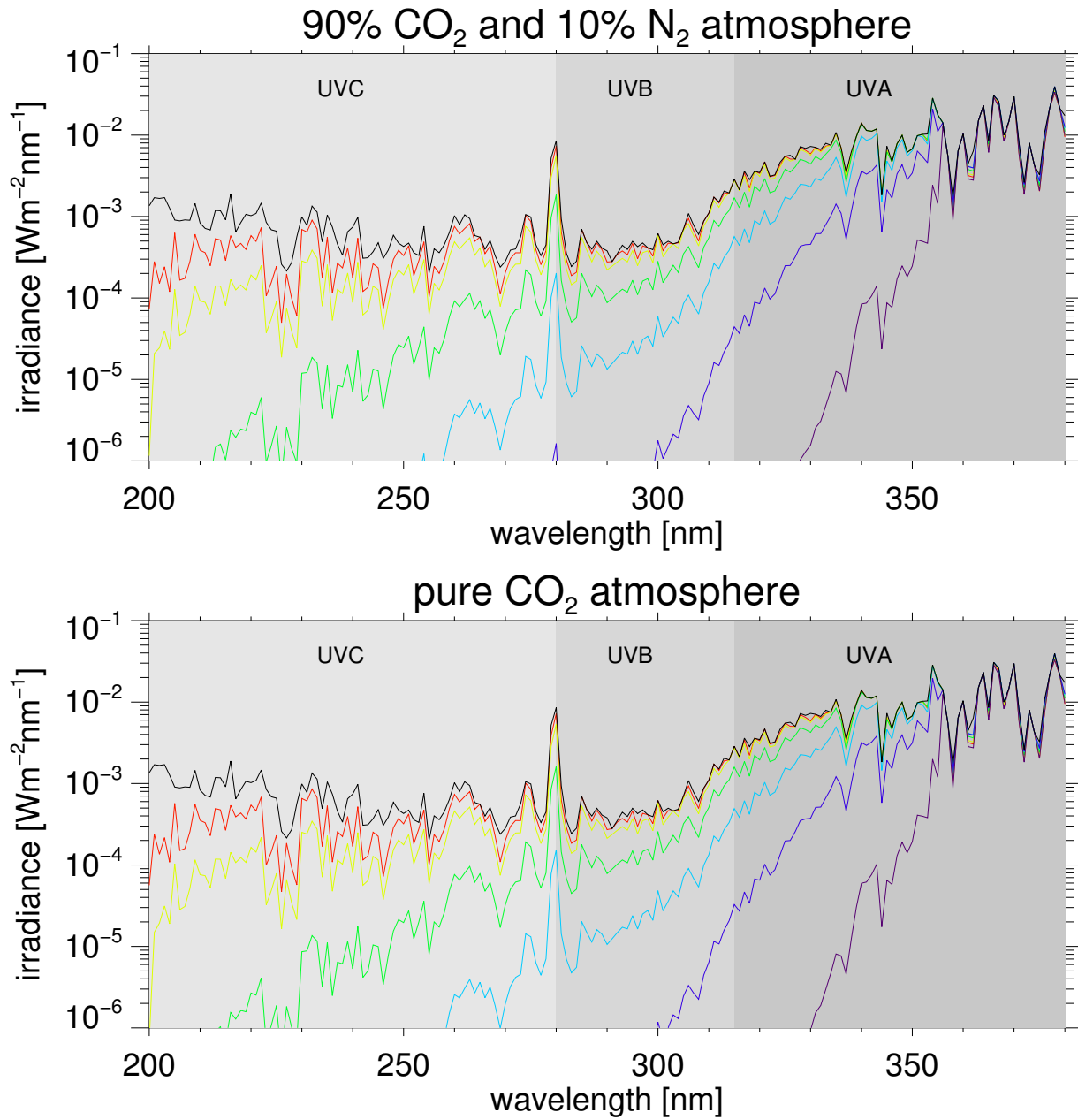


Figure A2. Same as figure A1 but for atmospheric compositions 90%CO₂/10%N₂ and 100%CO₂/0% N₂.

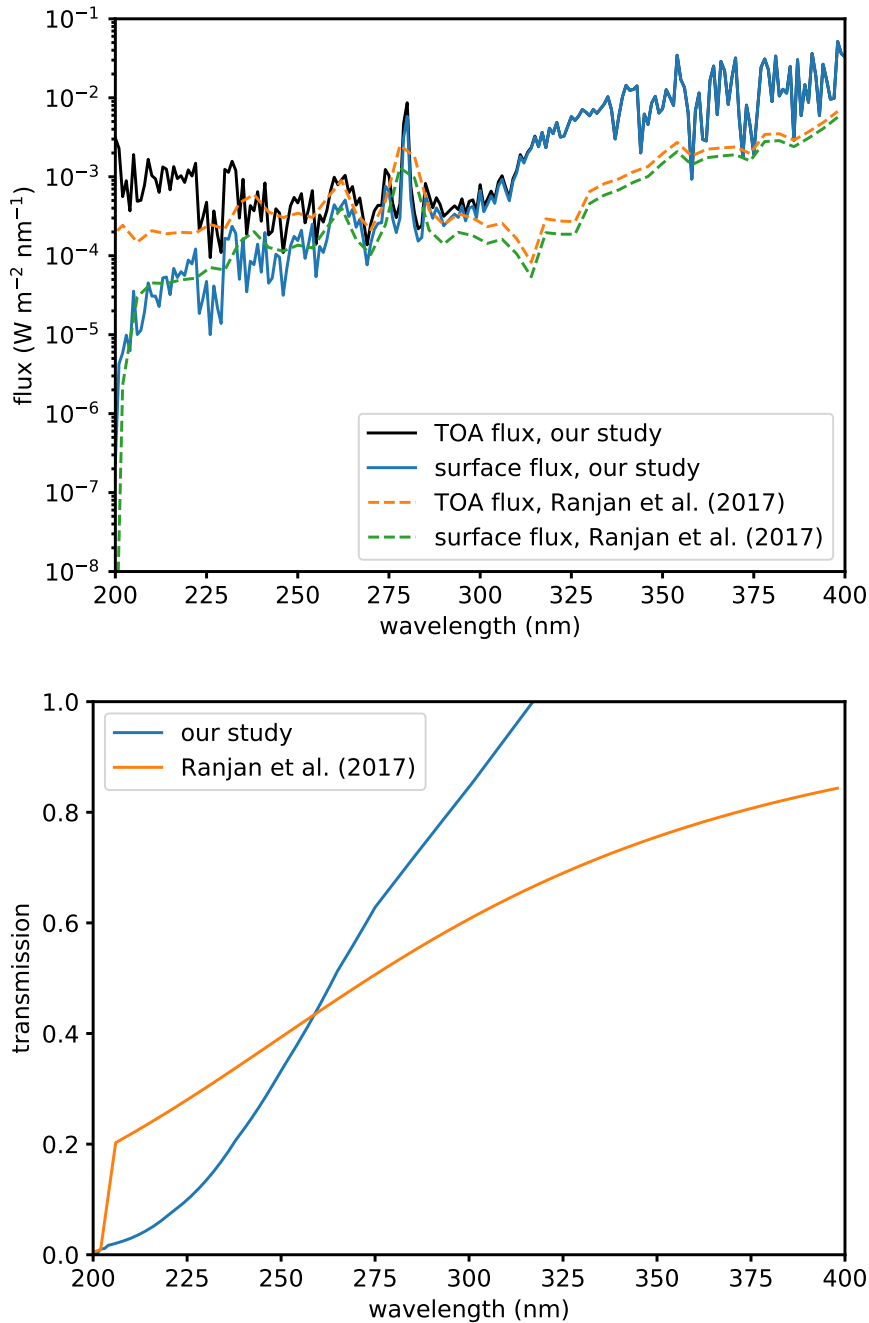


Figure B. Upper panel: Comparison of TOA and surface fluxes from Ranjan et al. (2017) and our study. We use the stellar spectrum from Meadows et al. (2018). Ranjan et al. (2017) adopted the spectrum from MUSCLES (<https://cos.colorado.edu/~kevinf/muscles.html>), which is lower in the UV range by a factor of five. The surface fluxes were both calculated for a 1 bar atmosphere composed of 90%N₂ and 10%CO₂. Note that we scale the Ranjan spectra from their adopted orbital distance of 0.042 AU to ours. To create the figure we use the data made available at <https://github.com/sukritranjan/ranjanwordsworthsasselov2017b>, which were slightly updated since the publication of Ranjan et al. (2017). Lower panel: Comparison of the atmospheric transmission (surface flux divided by TOA flux) between Ranjan et al. (2017) and our study. The transmission of our atmosphere model is lower at smaller wavelengths (approximately the UVC range), but higher for larger wavelengths.

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