

Gregory Cooke

ASTROPHYSICS · POSTDOCTORAL RESEARCHER

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Employment

Institute of Astronomy, University of Cambridge

Cambridge, UK

Research Associate in Exoplanetary Atmospheres

August 2023 - present

- My work centres on simulations of exoplanets in the sub-Neptune regime using one-dimensional (1D) and 3D photochemical models.
- I am exploring the chemical nature of exoplanet atmospheres, assuming different stellar hosts, and various initial conditions.
- I am a supervisor for the Stellar Structure and Evolution 3rd year undergraduate course.

Education

University of Leeds

Leeds, UK

PhD in Astrophysics; Thesis title: 3D simulations of oxygenated rocky planetary climates and observational predictions. Advisors: Professor Dan Marsh, Dr Catherine Walsh.

October 2019 - July 2023

- My thesis focused on simulating rocky worlds and understanding their climates, chemistry, and habitability. I use and modify the Community Earth System Model (CESM2), mostly the Whole Atmosphere Community Climate Model (WACCM6) configuration, to simulate paleoclimates and exoplanets.
- I simulated early Earth with a younger Sun and with varied atmospheric oxygen (O₂) concentrations.
- I used the Planetary Spectrum Generator (PSG) to determine how detectable specific planetary properties (e.g. chemical species such as ozone and oxygen; temporal variability) are using the next generation of telescopes (e.g. LUVOIR).
- I performed simulations for tidally locked M dwarf exoplanets (Proxima Centauri and TRAPPIST-1 systems) and predicted observations of these exoplanets.
- I found, for the first time, that it is possible for lethal surface concentrations of O₃ to build up on the surface of habitable zone exoplanets.
- My thesis received recognition for Research Excellence from the Dean of Postgraduate Research Studies.
- I was selected competitively as a Priestley Climate Scholar.

University of Manchester

Manchester, UK

MPhys in Physics (First-Class Honours: 81.4%)

October 2015 - June 2019

- Two MPhys projects:
 1. Investigating and defining habitability metrics for all known exoplanets.
 2. Designing an optimized telescope search for habitable exoplanets using the Besançon galactic model.
- Most optional courses taken were related to astrophysics (e.g. Astrophysical plasmas, General relativity, Exoplanets).

Funding

University of Leeds

Leeds, UK

STFC studentship

October 2019 - April 2023

- A 3.5-year STFC studentship (approximately worth £75,000).
- Funding for travel and funding for the conference fee to attend the 3rd Eddy Cross Disciplinary Symposium: Sun, Earth, Planet, Space, Atmosphere and Ocean, in Vail, Colorado, USA (total \$2,800).

Publications

Published:

- **Cooke G. J.**, Marsh DR, Walsh C, Black B, Lamarque J-F. 2022 A revised lower estimate of ozone columns during Earth's oxygenated history. R. Soc. Open Sci. 9: 211165. <https://doi.org/10.1098/rsos.211165>.
- **Cooke G. J.**, Marsh DR, Walsh C, Rugheimer S, Villanueva GL, Variability due to climate & chemistry in observations of oxygenated Earth-analogue exoplanets, Monthly Notices of the Royal Astronomical Society, 518(1), January 2023, pp. 206–219, <https://doi.org/10.1093/mnras/stac2604>
- Ji A., Kasting J. F., **Cooke G. J.**, et al., Comparison between ozone column depths & methane lifetimes computed by one- & three-dimensional models at different atmospheric O₂ levels. R. Soc. open sci. 10: 230056. <https://doi.org/10.1098/rsos.230056>
- Liu B., Marsh D. R., Walsh C., & **Cooke G. J.**, Higher Water Loss on Earth-like Exoplanets in Eccentric Orbits, Monthly Notices of the Royal Astronomical Society, June 2023, pp. 1491–1502, <https://doi.org/10.1093/mnras/stad1828>
- **Cooke G. J.** et al., 2023, Degenerate interpretations of O₃ spectral features in exoplanet atmosphere observations due to stellar UV uncertainties: a 3D case study with TRAPPIST-1e, The Astrophysical Journal, <https://iopscience.iop.org/article/10.3847/1538-4357/ad0381>.

Articles in review:

- **Cooke G. J.** et al., 2023, Lethal surface ozone concentrations are possible on habitable zone exoplanets, The Planetary Science Journal.
- Liu B., Marsh D. R., Walsh C., **Cooke G. J.**, & Sainsbury-Martinez F., Eccentric Orbits Enhance the Habitability of Earth-like Exoplanets.

Articles undergoing internal review:

- Bhongade A., Marsh D. R., Sainsbury-Martinez F., & **Cooke G. J.**, Asymmetries in the simulated ozone distribution on TRAPPIST-1e due to orography.

Articles in prep:

- Braam M. & **Cooke G. J.**, A chemistry-climate comparison for Proxima Centauri b simulations.
- **Cooke G. J.** et al., Oxygen's control on hydrogen escape in Earth-like atmospheres across FGKM dwarf stars.
- **Cooke G. J.** & Madhusudhan N., Atmospheric modelling of H₂ dominated atmospheres.

Contributed talks

Mar 2024	LCLU Annual Science Day , <i>Lethal surface ozone concentrations are possible on habitable zone exoplanets.</i>	Cambridge, UK
Jan 2024	Rocky Worlds III , <i>Lethal surface ozone concentrations are possible on habitable zone exoplanets.</i>	Zurich, Switzerland
Nov 2023	Habitable Worlds Observatory – UK community workshop , <i>3D simulations of exoplanet climates and observational predictions</i>	Leicester, UK
Jul 2022	Rocky Worlds II , <i>A revised lower estimate of ozone columns during Earth's oxygenated history.</i>	Oxford, UK
Jul 2022	ResCompLeedsCon2022 , <i>Simulations of tidally locked exoplanet atmospheres in 3D.</i>	Leeds, UK
Jun 2022	3rd Eddy Cross Disciplinary Symposium , <i>3D whole-atmosphere modelling of rocky exoplanet systems and synthetic telescope observations.</i>	CO, USA
Jun 2021	CESM Workshop , <i>Viewing the Earth and its exoplanet analogues through time.</i>	Virtual
Apr 2021	UK Exoplanet Meeting , <i>Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures.</i>	Virtual

Invited and internal seminars

Mar 2024	Invited, University of Oxford , <i>Ozone in habitable zone exoplanet atmospheres: observational ambiguities and lethality to life.</i>	Oxford, UK
Mar 2024	Invited, University of Leeds , <i>Ozone in habitable zone exoplanet atmospheres: observational ambiguities and lethality to life.</i>	Oxford, UK
Nov 2023	Internal, University of Cambridge , <i>Imposter syndrome.</i>	Cambridge, UK
Oct 2023	Internal, University of Cambridge , <i>3D simulations of oxygenated rocky exoplanet atmospheres and observational predictions.</i>	Cambridge, UK
Feb 2023	Invited, University of Edinburgh , <i>A revised lower estimate of ozone columns during Earth's oxygenated history.</i>	Edinburgh, UK
Oct 2022	Internal, University of Leeds , <i>Variability due to climate and chemistry in observations of oxygenated Earth-analogue exoplanets.</i>	Leeds, UK
May 2022	Invited, National Center for Atmospheric Research , <i>A revised lower estimate of ozone columns during Earth's oxygenated history.</i>	CO, USA
Mar 2022	Internal, University of Leeds , <i>A revised lower estimate of ozone columns during Earth's oxygenated history.</i>	Leeds, UK
May 2021	Invited, University of Cambridge , <i>Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures.</i>	Virtual
Oct 2020	Invited, National Center for Atmospheric Research , <i>Oxygen as a control over 2.4 billion years of atmospheric evolution.</i>	Virtual

Posters

Jun 2024	Exoplanets V , <i>Oxygen's control over hydrogen escape on Earth-like exoplanets.</i>	Lieden, NLD
Jun 2024	Exoplanets V , <i>Exploring the diversity of habitable exoplanets through photochemical and biogeochemical models.</i>	Leiden, NLD
Jun 2023	Exoclimes VI , <i>Characterising stellar UV to improve the interpretation of observations: a 3D case study with TRAPPIST-1 e.</i>	Exeter, UK
Sep 2022	UK Exoplanet Meeting , <i>Accurate UV stellar spectra measurements required to use O₃ as an indicator for O₂ abundance, virtual poster.</i>	Edinburgh, UK
May 2022	Exoplanets IV , <i>Variability due to climate in observations of oxygenated Earth-analogue exoplanets.</i>	LV, NV, USA
Jun-Jul 2021	European Astronomical Society Annual Meeting , <i>Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures.</i>	Virtual
Jun 2021	The Coupling, Energetics, and Dynamics of Atmospheric Regions workshop , <i>Atmospheric escape on oxygenated Earth-like exoplanet atmospheres.</i>	Virtual
Jul 2020	Exoplanets III , <i>Variable detectability of biosignatures on inhabited worlds.</i>	Virtual

Software experience

- I am an advanced user of Python for atmospheric data analysis, e.g., matplotlib, pandas, numpy, and xarray.
- I have used and modified the FORTRAN codes [Atmos](#) and [Photochem](#) which model planetary atmospheres in 1D.

- I have used and developed an open-source 3D climate model (CESM2-WACCM6). I have read Fortran-90 code to understand how certain calculations in WACCM6 are made. I modified the Fortran-90 code to set up different planetary conditions (e.g. altered upper boundary conditions, tidally locked the model, and implemented absorption in the Schumann–Runge bands for H₂O and CO₂).
- I have developed Python code in Jupyter Notebook to analyse vast amounts of climate data that can switch between different types of plots and datasets. I developed the Stellar Wind and Irradiance Module (SWIM), a flexible notebook for multi-model use that downloads Mega-MUSCLES stellar spectra and scales the exoplanet to any exoplanet chosen by the user.
- I used and developed a pipeline to convert WACCM6 output to interact with the Planetary Spectrum Generator (PSG). I used new methods (where I swapped particular atmospheric components) to analyse the results for the WACCM6 oxygenated scenarios.
- Coding experience in C++ during my master's degree. The final project was to design a chess game using C++.

Teaching

University of Cambridge

Cambridge, UK

Supervisor Stars and Stellar Evolution

October 2023 - present

- Supervised the third year (part II) Stars and Stellar Evolution lecture course delivered by Max Pettini.
- Supervised student groups between the sizes of 1-3 students.

University of Leeds

Leeds, UK

Introductory python course

September 2022

- Introduction to Python lesson during a Community Earth System Model (CESM) tutorial.
- I demonstrated data visualisation using Xarray, Matplotlib, and Cartopy in functions combined with IPyWidgets in a Jupyter notebook.

University of Leeds

Leeds, UK

Lab demonstrating

October 2019 - May 2022

- I taught experiments in the Phys 10001 undergraduate laboratory to 1st year students including: the determination of Planck's constant; measurement of Earth's magnetic field, spectrometer measurement of sodium lines; the viscosity of glycerine; and electrical circuits.
- I marked lab workbooks and formal reports on several of these experiments.

University of Leeds

Leeds, UK

Informal MPhys student supervision

October 2021 - March 2022

- I aided B. Butcher to produce and analyse transmission spectra of Jupiter-sized exoplanets.
- I helped I. Willis analyse WACCM data and produce figures using Python.

Organisation and citizenship

University of Leeds

Leeds, UK

Internal seminars chair

January 2020 – October 2022

- I arranged and chaired internal seminars for the University of Leeds Astrophysics group.
- I organised and led weekly informal science sessions where members of the group get together to discuss their current work.
- I led a journal club that ran every three weeks.

University of Leeds Priestley scholars

Leeds, UK

Priestley Climate Scholar

January 2020 – December 2021

- I attended multiple seminars on interdisciplinary topics relating to climate change, including transport, climate finance, climate modelling, and climate justice.
- I co-organised a seminar on climate finance, as well as a monthly journal club focussed on climate science topics.

University of Manchester Men's Hockey Club

Manchester, UK

Treasurer

May 2017 - May 2018

- I was elected out from a club of approximately 80 members.
- I managed ~£20,000 in financial transactions between the club, club members, the Athletic Union, and several different organisations.

Public engagement and press

- Invited talk at Bradford Astronomical Society (2024, TBC).
- Public talk on *Jill Tarter and the Search for ExtraTerrestrial Intelligence* (March 2024).
- Public talk on *A Brief History of Women in Astronomy* for International Women's Day (March 2024).
- Invited talk at Sidney Sussex Wilson-Walker Natural Sciences Society (March 2024).
- Invited talk at Harrogate Astronomical Society (February 2024).
- Public talk at the Institute of Astronomy, University of Cambridge, *Exoplanet Atmospheres* (November 2023). [YouTube](#).
- Invited talk at Wakefield and District Astronomical Society (July 2023).
- Invited talk at Bradford Astronomical Society (April 2023).
- [Everything Astronomy](#) virtual session for Xavier Space Solutions (February 2022).
- I have written a number of astronomy news articles for the astronomy magazine [Popular Astronomy](#).
- TikTok Video summarizing my research for COP 26 and how it is important for understanding our planet (2021).
- [Live YouTube talk](#) for the University of Leeds Be Curious festival on planet habitability (2021).
- [Priestley Scholar Twitter spotlight](#). I was retweeted by the Priestley Scholar Twitter account for a whole day as I tweeted about my research and scientific interests (2021).