Gregory Cooke

Astrophysics · Postdoctoral researcher

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Employment

Institute of Astronomy, University of Cambridge — *Cambridge, UK*

Research Associate - Hycean Worlds. PI: Nikku Madhusudhan. 2nd advisor: Emily Mitchell — *October 2024 - present*

- I am simulating the atmosphere and oceanic environments of Hycean World exoplanets. If they exist, these planets will have a habitable ocean underneath a hydrogen-rich atmosphere and will be conducive to atmospheric characterisation with JWST.
- The major component of this work includes the development of new ecological models, inspired by Earth, but applied to exoplanetary environments such as hycean worlds.

Research Associate in Exoplanetary Atmospheres. PI: Nikku Madhusudhan — *August 2023 - September 2024*

- My work centred on simulations of exoplanets in the sub-Neptune regime using one-dimensional (1D) and 3D photochemical models.
- I explored the chemical nature of habitable exoplanet atmospheres, assuming various planetary conditions.
- I supervised 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 used and modified the Community Earth System Model (CESM2), mostly the Whole Atmosphere Community Climate Model (WACCM6) configuration.
- I simulated early Earth with a younger Sun and with varied atmospheric oxygen (O_2) 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 O_3 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).

Awards and Funding

STFC — *Cambridge, UK*

DiRAC computer time — *Waiting for decision*

- 5.1 M CPUh on DiAL3 to use ROCKE-3D and WACCM6 to simulate early Earth climates under different conditions.
- If awarded, this would be enough computer time for simulations that would results in three publications on Earth's paleoclimates and then one paper on possible exoplanet observations.

Royal Astronomical Society — *Cambridge, UK*

Education & Outreach Small Grants Scheme — *Awarded October 2025*

- £5,000 for IncludeHer UK project.

University of Leeds — *Leeds, UK*

Research excellence in doctoral thesis — *October 2019 - April 2023*

- Award to reflect outstanding achievement in the thesis and oral examination at a level significantly above what would be expected for the award of a doctoral degree, including major contributions to the field through interdisciplinary work.

Conference funding — *June 2022*

- 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:

- Madhusudhan N., Constantinou S., Holmberg M. & **Cooke G. J.**, Exploring the Sub-Neptune Frontier with JWST, 2025, **10.1073/pnas.2416194122.**
- **Cooke G. J.** *et al*., The Oxygen Valve on Hydrogen Escape Since the Great Oxidation Event, 2025, **10.5194/egusphere-2025-1133**

- Sainsbury-Martinez F., Walsh C., & **Cooke G. J.**, 2025, The Response of Planetary Atmospheres to the Impact of Icy Comets I: Tidally-Locked exo-Earths, **10.3847/1538-4357/ad96ad/meta**
- Bhongade A., Marsh D. R., Sainsbury-Martinez F., & **Cooke G. J.**, 2024, Asymmetries in the simulated ozone distribution on TRAPPIST-1e due to orography. **10.3847/1538-4357/ad8f2f**
- **Cooke G. J.** & Madhusudhan N., Considerations for Photochemical Modeling of Possible Hycean Worlds, 2024, **10.3847/1538-4357/ad8cda**
- Sainsbury-Martinez F., Walsh C., **Cooke G. J.**, & Marsh D. R., How Land-Mass Distribution Influences The Atmospheric Dynamics of Tidally Locked Terrestrial Exoplanets. **10.3847/1538-4357/ad6d5b**
- **Cooke G. J.**, Marsh DR, Walsh C, & Sainsbury-Martinez F, 2024, Lethal surface ozone concentrations are possible on habitable zone exoplanets, The Planetary Science Journal, **10.3847/PSJ/ad53c3**.
- Liu B., Marsh D. R., Walsh C., **Cooke G. J.**, & Sainsbury-Martinez F., July 2024, Eccentric Orbits Enhance the Habitability of Earth-like Exoplanets, Monthly Notices of the Royal Astronomical Society, **10.1093/mnras/stae1758**
- **Cooke G. J.**, Marsh DR, Walsh C, & Youngblood A, 2023, Degenerate interpretations of O_3 spectral features in exoplanet atmosphere observations due to stellar UV uncertainties: a 3D case study with TRAPPIST-1e, The Astrophysical Journal, **10.3847/1538-4357/ad0381**.
- Liu B., Marsh D. R., Walsh C., & **Cooke G. J.**, June 2023, Higher Water Loss on Earth-like Exoplanets in Eccentric Orbits, Monthly Notices of the Royal Astronomical Society, pp. 1491–1502, **10.1093/mnras/stad1828**.
- 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 O_2 levels. R. Soc. open sci. 10: 230056. **10.1098/rsos.230056**.
- **Cooke G. J.**, Marsh DR, Walsh C, Rugheimer S, & Villanueva GL, January 2023, Variability due to climate & chemistry in observations of oxygenated Earth-analogue exoplanets, Monthly Notices of the Royal Astronomical Society, 518(1), pp. 206–219, **10.1093/mnras/stac2604**.
- **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. **10.1098/rsos.211165**.

Articles in review:

- Pica-Ciamarra L., Madhusudhan N., **Cooke G. J.**, *et al*., 2025, A Systematic Search for Trace Molecules in Exoplanet K2-18 b. **Preprint here.**
- Sarkar S., Madhusudhan N., Holmberg M., Rigby F., Moses J., & **Cooke G. J.**, ApJ Letters.

Articles in prep:

- Braam M. & **Cooke G. J.**, A chemistry-climate comparison for Proxima Centauri b simulations.
- **Cooke G. J.**, Madhusudhan N., & Mitchell. E, Title to be confirmed.
- **Cooke G. J.** & Madhusudhan N., *et al*. Title to be confirmed.
- **Cooke G. J.** *et al*. IncludeHer UK analysis, Title to be confirmed.
- Sainsbury-Martinez F., **Cooke G. J.**, Walsh C., The Response of Planetary Atmospheres to the Impact of Icy Comets III: Atmospheric Escape, submission planned for ApJ.
- Kumar A. & **Cooke G. J.**, Title to be confirmed, submission planned for JGR Atmospheres.

Contributed talks

Mar 2025	**UK Exoplanet Meeting,** *A chemistry intercomparison for Proxima Centauri b atmospheric simulations.*	*Leeds, UK*
Mar 2024	**LCLU Annual Science Day,** *Lethal surface ozone concentrations are possible on habitable zone exoplanets.*	*Cambridge, UK*
Jan 2024	**Rocky Worlds III,** *Lethal surface ozone concentrations are possible on habitable zone exoplanets.*	*Zurich, Switzerland*
Nov 2023	**Habitable Worlds Observatory – UK community workshop,** *3D simulations of exoplanet climates and observational predictions*	*Leicester, UK*
Jul 2022	**Rocky Worlds II,** *A revised lower estimate of ozone columns during Earth's oxygenated history.*	*Oxford, UK*
Jul 2022	**ResCompLeedsCon2022,** *Simulations of tidally locked exoplanet atmospheres in 3D.*	*Leeds, UK*
Jun 2022	**3rd Eddy Cross Disciplinary Symposium,** *3D whole-atmosphere modelling of rocky exoplanet systems and synthetic telescope observations*.	*CO, USA*
Jun 2021	**CESM Workshop,** *Viewing the Earth and its exoplanet analogues through time.*	***Virtual***
Apr 2021	**UK Exoplanet Meeting,** *Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures.*	***Virtual***

Invited and internal seminars

Apr 2025	**Invited, MPIA Heidelberg,** *Considerations for Photochemical Modeling of Possible Hycean Worlds*.	*Virtual*
Nov 2024	**Invited, University of Leeds,** *Considerations for Photochemical Modeling of Possible Hycean Worlds*.	*Leeds, UK*
Mar 2024	**Invited, University of Oxford,** *Ozone in habitable zone exoplanet atmospheres: observational ambiguities and lethality to life*.	*Oxford, UK*
Mar 2024	**Invited, University of Leeds,** *Ozone in habitable zone exoplanet atmospheres: observational ambiguities and lethality to life*.	*Leeds, UK*
Nov 2023	**Internal, University of Cambridge,** *Imposter syndrome*.	*Cambridge, UK*
Oct 2023	**Internal, University of Cambridge,** *3D simulations of oxygenated rocky exoplanet atmospheres and observational predictions*.	*Cambridge, UK*
Feb 2023	**Invited, University of Edinburgh,** *A revised lower estimate of ozone columns during Earth's oxygenated history*.	*Edinburgh, UK*
Oct 2022	**Internal, University of Leeds,** *Variability due to climate and chemistry in observations of oxygenated Earth-analogue exoplanets*.	*Leeds, UK*

May 2022	**Invited, National Center for Atmospheric Research,** *A revised lower estimate of ozone columns during Earth's oxygenated history*.	*CO, USA*
Mar 2022	**Internal, University of Leeds,** *A revised lower estimate of ozone columns during Earth's oxygenated history*.	*Leeds, UK*
May 2021	**Invited, University of Cambridge,** *Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures*.	*Virtual*
Oct 2020	**Invited, National Center for Atmospheric Research,** *Oxygen as a control over 2.4 billion years of atmospheric evolution*.	*Virtual*

Posters

Jan 2026	**Rocky Worlds IV,** *Ecological modelling of ocean worlds*. **Poster to be placed here once complete**.	*Gronningen, NED*
Jul 2025	**Exoclimes VII,** *Hydrocarbons in sub-Neptune atmospheres*. **Poster PDF here**.	*Montréal, CAN*
Sep 2024	**Origins Federation Conference 2024,** *Is K2-18 b a mini-Neptune or a Hycean World?* **Poster PDF here**.	*Cambridge, UK*
Jun 2024	**Exoplanets V,** *Oxygen's control over hydrogen escape on Earth-like exoplanets*. **Poster PDF here**.	*Lieden, NL*
Jun 2024	**Exoplanets V,** *Is K2-18 b a mini-Neptune or a Hycean World?* **Poster PDF here**	*Leiden, NL*
Jun 2023	**Exoclimes VI,** *Characterising stellar UV to improve the interpretation of observations: a 3D case study with TRAPPIST-1 e*. **Poster PDF here**.	*Exeter, UK*
Sep 2022	**UK Exoplanet Meeting,** *Accurate UV stellar spectra measurements required to use O_3 as an indicator for O_2 abundance*. **Virtual poster**.	*Edinburgh, UK*
May 2022	**Exoplanets IV,** *Variability due to climate in observations of oxygenated Earth-analogue exoplanets*.	*LV, NV, USA*
Jun-Jul 2021	**European Astronomical Society Annual Meeting,** *Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures*. **Poster PDF here**	***Virtual***
Jun 2021	**The Coupling, Energetics, and Dynamics of Atmospheric Regions workshop,** *Atmospheric escape on oxygenated Earth-like exoplanet atmospheres*.	*Virtual*
Jul 2020	**Exoplanets III,** *Variable detectability of biosignatures on inhabited worlds*.	*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 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 H_2O and CO_2).
- 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

Part III Masters project *October 2025 - present*

- Supervising a fourth year (part III) student. The project is open ended but revolves around simulating different hycean candidates and exploring important atmospheric parameters.

Part III Masters project *October 2024 - June 2025*

- Supervised a fourth year (part III) student. The project was on simulating several different hycean candidates assuming they are either uninhabited or inhabited.

Supervisor Stellar Dynamics and Structure of Galaxies *October 2024 - present*

- Supervised the third year (Part II) Stellar Dynamics and Structure of Galaxies course delivered by Vasily Belokurov.
- Supervised two student groups of two students.

Supervisor Stars and Stellar Evolution *October 2023 - January 2024*

- 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.

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.

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

Academic journal reviews *2023 - present*

- Scientific reports
- The Astrophysical Journal
- Communications earth & environment
- JGR atmospheres

Institute of Astronomy, University of Cambridge *Cambridge, UK*

Women's Network co-chair *January 2025 - present*

- International Women's Day (IWD) Outreach event
- Organised IWD departmental event
- Organised monthly meetings for the women's network

Work-life balance EDI chair *October 2024 - present*

- I arranged and chaired the work-life balance equality diversity and inclusivity (EDI) group.
- I arranged meetings and social events to help improve the work-life balance of students and postdoctoral researchers at the Institute of Astronomy.
- Attended institute meetings on EDI in order to improve the ethos of the workplace.

First year PhD journal club *October 2024 - May 2025*

- I organized the journal club for the first year PhD cohort of 12 students.
- I chaired the meetings and facilitated discussion on recent and important papers in different astronomical fields.

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 *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

- International Women's Day outreach activities for year 8 students (March 2025).
- Invited talk at Bradford Astronomical Society (November 2024).
- 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).