

# Gregory Cooke

ASTROPHYSICS · PHD STUDENT

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## Education

### University of Leeds

Leeds, UK

**PhD in Astrophysics; Thesis title: 3D simulations of rocky exoplanets and future observations.**

October 2019 - present

**Advisors: Professor Dan Marsh, Dr Catherine Walsh.**

- My thesis focuses 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 (O<sub>2</sub>) 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 am performing simulations for tidally-locked M dwarf exoplanets (Proxima Centauri and TRAPPIST-1 systems) and will predict observations of these exoplanets.
- 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 - present

- 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.

## Publications

#### Published:

- Cooke GJ, 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 GJ, Marsh DR, Walsh C, Rugheimer S, Villanueva GL, Variability due to climate and chemistry in observations of oxygenated Earth-analogue exoplanets, *Monthly Notices of the Royal Astronomical Society*, 2022;, stac2604, <https://doi.org/10.1093/mnras/stac2604>

#### Articles undergoing internal review:

- Cooke et al., The O<sub>3</sub>-O<sub>2</sub> relationship on M dwarf terrestrial atmospheres: critical dependence on the stellar UV flux.
- Ji et al., Comparison between ozone column depths and methane lifetimes computed by 1-D and 3-D Models at different atmospheric O<sub>2</sub> levels.

## Contributed talks

Apr 2021	<b>UK Exoplanet Meeting</b> , <i>Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures.</i>	Virtual
Jun 2021	<b>CESM Workshop</b> , <i>Viewing the Earth and its exoplanet analogues through time.</i>	Virtual
Jun 2022	<b>3rd Eddy Cross Disciplinary Symposium</b> , <i>3D whole-atmosphere modelling of rocky exoplanet systems and synthetic telescope observations</i> , Vail, Colorado, USA, June 2022.	CO, USA
Jul 2022	<b>ResCompLeedsCon2022</b> , <i>Simulations of tidally locked exoplanet atmospheres in 3D.</i>	Leeds, UK
Jul 2022	<b>Rocky Worlds II</b> , <i>A revised lower estimate of ozone columns during Earth's oxygenated history.</i>	Oxford, UK

## Invited and internal seminars

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

Oct 2022	<b>Internal, University of Leeds</b> , <i>Variability due to climate and chemistry in observations of oxygenated Earth-analogue exoplanets.</i>	Leeds, UK
TBC	<b>Invited, University of Exeter</b> , <i>A revised lower estimate of ozone columns during Earth's oxygenated history.</i>	Exeter, UK

## Posters

Jul 2020	<b>Exoplanets III</b> , <i>Variable detectability of biosignatures on inhabited worlds.</i>	Virtual
Jun 2021	<b>The Coupling, Energetics, and Dynamics of Atmospheric Regions workshop</b> , <i>Atmospheric escape on oxygenated Earth-like exoplanet atmospheres.</i>	Virtual
Jun-Jul 2021	<b>European Astronomical Society Annual Meeting</b> , <i>Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet biosignatures.</i>	Virtual
May 2022	<b>Exoplanets IV</b> , <i>Variability due to climate in observations of oxygenated Earth-analogue exoplanets.</i>	NV, USA
Sep 2022	<b>UK Exoplanet Meeting</b> , <i>Accurate UV stellar spectra measurements required to use <math>O_3</math> as an indicator for <math>O_2</math> abundance</i> , <a href="#">virtual poster</a> .	Edinburgh, UK

## Software experience

- I have used and developed an open-source 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).
- Advanced user of Python for atmospheric data analysis, e.g., matplotlib, pandas, numpy, and xarray.
- Developing open-source 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 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.

## Teaching

### 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.

### 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.

## 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

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- [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).
- [Live YouTube talk](#) for the University of Leeds Be Curious festival on planet habitability (2021).
- TikTok Video summarizing my research for COP 26 and how it is important for understanding our planet (2021).
- I have written a number of astronomy news articles for the astronomy magazine [Popular Astronomy](#).
- [Everything Astronomy](#) virtual session for Xavier Space Solutions (February 2022).
- Invited talk at Bradford Astronomical Society (April 2023).