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_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 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 (total $2,800).

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, 518(1), January 2023, pp. 206–219, **https://doi.org/10.1093/mnras/stac2604**

Submitted articles:

- Ji A, Cooke GJ, et al., Comparison between ozone column depths and methane lifetimes computed by 1-D and 3-D Models at different atmospheric O_2 levels.
- Liu B., Marsh D. R., Walsh C., and Cooke G. J., Higher Water Loss on Earth-like Exoplanets in Eccentric Orbits.

Articles undergoing internal review:

- Cooke GJ et al., The O_3-O_2 relationship on M dwarf terrestrial atmospheres: critical dependence on the stellar UV flux.

Contributed talks

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

Invited and internal seminars

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

May 2022	**Invited, National Center for Atmospheric Research,** *A revised lower estimate of ozone columns during Earth's oxygenated history.*	*CO, USA*
Oct 2022	**Internal, University of Leeds,** *Variability due to climate and chemistry in observations of oxygenated Earth-analogue exoplanets.*	*Leeds, UK*
Feb 2023	**Invited, University of Edinburgh,** *A revised lower estimate of ozone columns during Earth's oxygenated history.*	*Edinburgh, UK*
TBC	**Invited, University of Exeter,** *A revised lower estimate of ozone columns during Earth's oxygenated history.*	*Exeter, UK*

Posters

Jul 2020	**Exoplanets III,** *Variable detectability of biosignatures on inhabited worlds.*	*Virtual*
Jun 2021	**The Coupling, Energetics, and Dynamics of Atmospheric Regions workshop,** *Atmospheric escape on oxygenated Earth-like exoplanet atmospheres.*	*Virtual*
Jun-Jul 2021	**European Astronomical Society Annual Meeting,** *Oxygen's 2.4 billion year control on Earth's atmosphere with consequences for exoplanet bisoignatures.*	***Virtual***
May 2022	**Exoplanets IV,** *Variability due to climate in observations of oxygenated Earth-analogue exoplanets.*	*NV, USA*
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*

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, and implemented absorption in the Schumann–Runge bands for H_2O and CO_2).
- I am an advanced user of Python for atmospheric data analysis, e.g., matplotlib, pandas, numpy, and xarray.
- 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 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

- **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).
- Invited talk at Wakefield and District Astronomical Society (May 2023).