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Department of Physics UROP (Summer 2019), Imperial College London

UROP Title: Assessing Future Jet Stream Responses in CMIP5 and CMIP6 Global Climate Models

How I came to do a UROP and the application process

As many other students within the department, my UROP journey started by emailing several members of academic staff. In particular, I had always wanted to study climate change in more depth, so I contacted several researchers working within the Atmospheric Physics group. I was delighted, therefore, when Dr Paulo Ceppi of the Grantham Institute (and Department of Physics) at Imperial agreed to supervise me for the summer, and to support my UROP application. After a couple of discussions, we decided to centre the project around some of Dr Ceppi's previous research which investigated the response of the midlatitude jet streams to greenhouse gas forcing in, what were at the time, the most advanced climate models at our disposal: The Coupled Model Intercomparison Project Phase 5 (CMIP5). We promptly submitted the application and proposal, and we were both delighted to find out a few months later that we had been accepted for funding by the EPSRC.

My motivation, preparation, and the UROP Itself

Broadly, my motivations to pursue a UROP were to study climate change, particularly to understand how we predict changes to the Earth's atmosphere in response to anthropogenic forcing, and to develop my skills as a researcher. However, I entered the summer having just finished the second year of the MSci Physics course, which meant that I hadn't yet studied atmospheric physics or climate change in a formal capacity. Aware of this, I took time before the project to study several aspects of the subject using textbooks, and a couple of papers recommended by Dr Ceppi.

As is often the case in research, the first few weeks of the project were a little rocky, during this time we encountered several teething problems. However, from the start we shared a highly effective working relationship, and once I had swapped from using python to R (the latter of which facilitated a much more efficient manipulation of the data files we used), our work really picked up pace and I was able to repeat several analyses and results from previous papers by the midpoint of the project. As someone who learns through actively doing things, encountering these problems early on enabled me to quickly broaden my knowledge of the subject, and to experience first-hand the challenges of research.

Towards the end of the project, data from the next generation of models, CMIP6, was being released. Excited to repeat our analysis with these new models, we shifted our focus to CMIP6 for the last two weeks, and continued to work on this research after the UROP. At the end of the summer I particularly enjoyed writing up our results, creating the document which then served as a starting point for our eventual publication.

Outcomes of our research

As more CMIP6 data was released, we eventually had a reasonable sample size to work with, in turn allowing us to identify new and exciting trends in the data, notably that increased model resolution in the newest models is likely contributing to more realistic projections for future climate change in the Southern Hemisphere. Ultimately, this work led to a publication: 'Role of the Mean State for the Southern Hemispheric Jet Stream Response to CO2 Forcing in CMIP6 Models', published in the high-impact Environmental Research Letters journal in May 2020. Perhaps the highlight of all of this, our paper was recently cited in chapter four of the UN IPCC Sixth Assessment Report (Working Group One: The Physical Science Basis), released in August 2021. To be able to contribute research to a body of work as vital for the planet as this, albeit in a very minor way, is an incredible honour.

Skills, experiences gained and influence on my career

I was able to develop my skills as a researcher, for example in writing code for data analysis, and more generally working with a more open-ended research problem than would normally be encountered at the undergraduate level. In particular, working on an academic paper was very challenging; this was not a standard of working that I had ever encountered before. Being able to adapt language for this purpose, and to produce plots and figures to a publishable standard are vital skills that I have developed from this, and will certainly take forward throughout my career. This project has served as my biggest motivation to study for a PhD in the field of climate dynamics, which I am now starting at Yale University in the United States. Finally then, I would highly recommend that students at Imperial, regardless of year of study get involved in the UROP programme. The Department of Physics' broad range of research and expertise means that everyone can make the most of this opportunity.

Acknowledgements

Finally, I want to again thank Dr Paulo Ceppi for hosting me over the summer, and for every success that has come from this project. Also to Dr Giuseppe Zappa of the ISAC, Italy, for his input on our paper.

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