UKFN SRV Report

Experimental investigation into the dynamics of eye formation in atmospheric vortices

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This SRV took place over an extended period during 2018 and involved a collaboration between myself (Cambridge University Engineering Department) and Professor Peter Read of Atmospheric, Oceanic and Planetary Physics (AOPP) at Oxford University. The objective of the visit was to perform laboratory experiments on rotating convection in an effort to replicate results seen in numerical simulations.

The problem of eye formation (the development of a central region of weak, recirculating flow) in atmospheric vortices is one with a number of proposed mechanisms, yet no broadly accepted theory at present. Recent work has shown that in numerical simulations of shallow, rotating convection it is possible to form an eye at the centre of a large vortex. An explanation for the mechanism by which this happens has been put forwards based on the generation of vorticity in the lower boundary layer. It was the aim of this SRV to design and perform a laboratory experiment to replicate the results of simulations that support this theory.

The first stage of the SRV involved a three day visit to AOPP to gain familiarity with the laboratory and facilities, and to discuss potential experimental designs. Following this, time was spent planning the experiment, selecting an appropriate tank, and sourcing some materials. Due to the time constraints it was also important during this period to develop a clear plan for the work to be performed and the parameter ranges to be investigated.

The main period of the work took place in the late summer of 2018 during which I spent two weeks in Oxford working at the AOPP laboratory. After setting up the experiment I performed various runs over a wide variety of parameters gathering data to be processed at a later date. I performed experiments using flourescein dye to examine qualitatively what was happening over a range of rotation and heating rates. Once some promising set-ups had been found these were followed up with particle imaging experiments using an LED sheet to observe the flow at different heights in the tank. One particular challenge of this work is that the parameter regime we were especially interested in is relatively weakly forced. This means that the temperature differences and rotation rates are quite small and difficult to control, and effects such as turbulence and any three dimensional asymmetries could easily affect the flow in a way that is not seen in numerical simulations. We briefly examined the effects of increasing the forcing and were able to observe the transition to other regimes, notably the presence of many individual vortical plumes. Following the SRV I am now analysing the data I gathered.

I am extremely thankful to UK Fluids for supporting me in this short research visit. In addition to being able perform experiments towards my PhD that would not have been possible in my own department, I have also been able to gain experience in experimental design and methods whilst learning new techniques such as PIV and dye/flourescein imaging. Another indirect advantage of the SRV was the fact that it allowed me to work collaboratively with another research group in a slightly different area,

learn about what they do and how they work. Particularly enjoyable was being invited to participate in group meetings during my stay, sharing my work with others and hearing about their research.

My thanks to Professor Peter Read for hosting and working with me during the visit, research student Cherry Qian for her assistance in the lab, the AOPP lab technicians, and of course the UK Fluids Network.

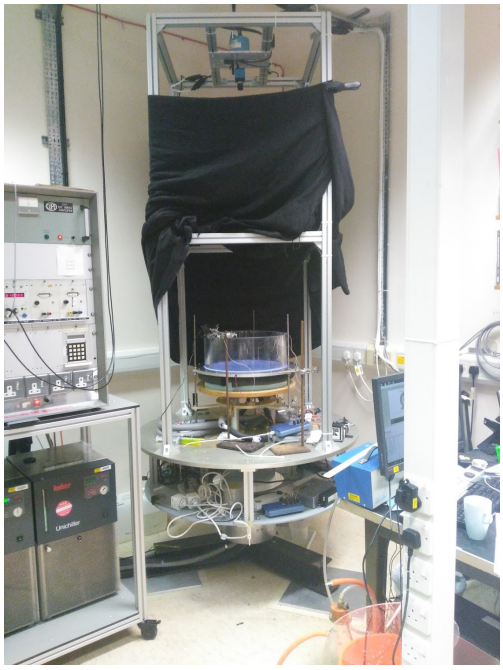
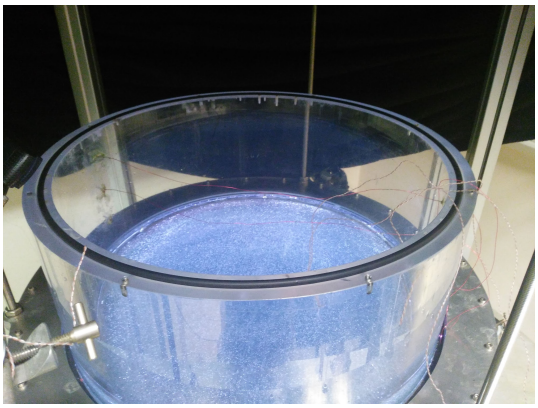
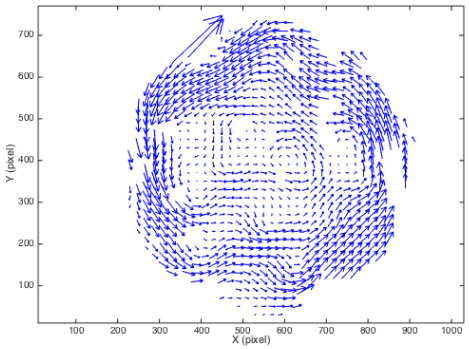


Figure 1: Experimental setup on the rotating table.

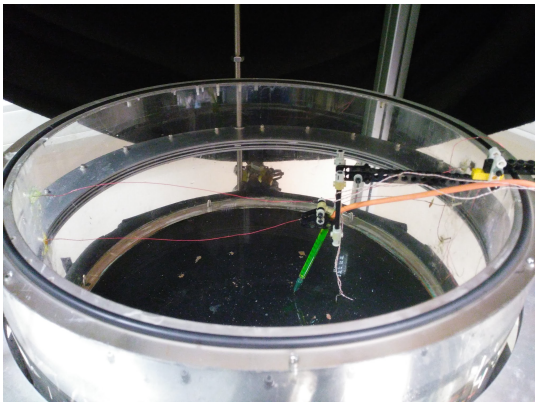


(a) Tank with PIV seeding

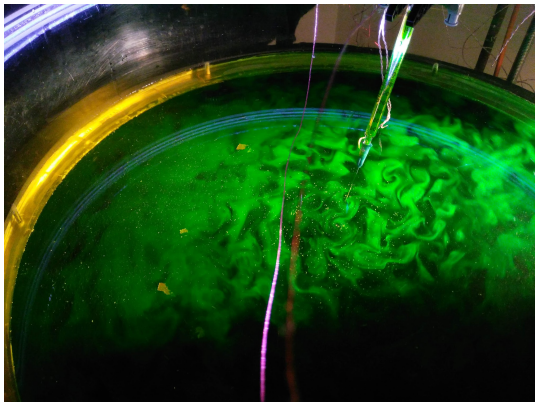


(b) Example of PIV data from experiments

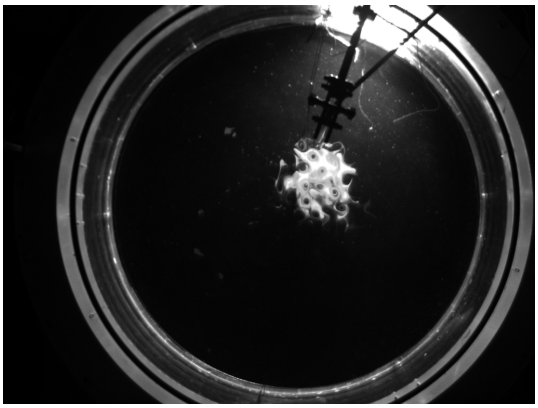
Figure 2: Images from the PIV experiments



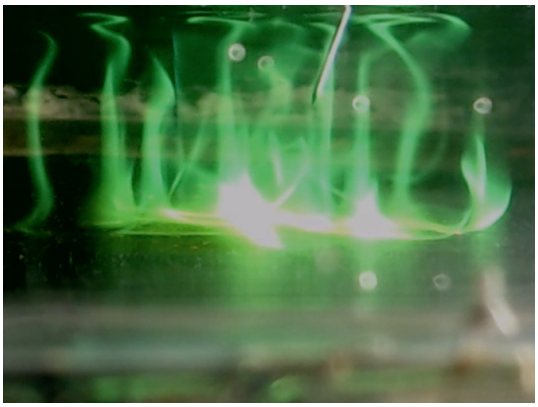
(a) Tank with hypodermic setup



(b) Flourescein in tank



(c) Formation of vortical convection cells



(d) Vortical convection cells from side

Figure 3: Images from the flourescein experiments