Improved understanding of water vapour's role in the weather and climate system

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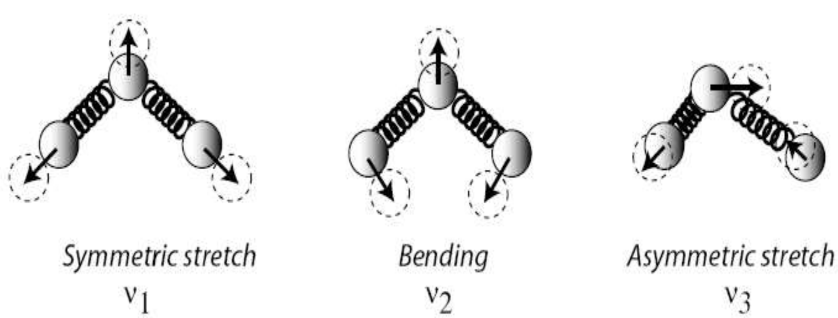
Water vapour is the most important radiatively-active gas in the Earth's atmosphere. It is a strong absorber of thermal infrared and solar radiation across wide regions of the electromagnetic spectrum. It acts as a greenhouse gas, acting to keep the surface much warmer than it otherwise would be. Its infrared emission acts to continuously cool the atmosphere, which profoundly influences the nature of the atmospheric circulation. The concentration of water vapour also increases with atmospheric temperature, and because of this, it acts as a positive feedback, amplifying the warming due to, for example, increases in carbon dioxide concentrations. In addition, the effect of climate change on precipitation has also been shown to be sensitive to important details on how water vapour absorbs infrared radiation.

The overall role of water vapour has been understood for some years, but important gaps in understanding exist in the way water vapour absorbs infrared radiation. Recent developments indicate a significant change in this understanding. In addition, representing the complex processes by which water vapour plays its role is a major challenge in computer codes used in weather forecasting and climate prediction, because of the necessity to represent these processes in a computationally efficient manner. The aim of this project it to quantify the impact of both changes in understanding and improvements in the representation of water vapour's radiative properties. This will be applied to both shorter timescales (one week to one year), relevant to weather forecasts, and longer timescales relevant to climate change. The student would also work to quantify the importance of remaining uncertainties.

Via a strong collaboration with the European Centre for Medium-Range Weather Forecasts (ECWMF), the student will learn to perform experiments with one of the world's leading weather forecast models, and to design experiments aimed at diagnosing the impact of changes in our understanding of the nature of water vapour's infrared absorption properties. Depending on the interests of the student, the emphasis can be either on processes relevant to weather forecasting or those more relevant to climate prediction, or some combination of these.



Although water has a relatively simple structure, its role in emitting and absorbing infrared radiation is complex because it has three distinct (and interacting) modes of vibration (shown here) and three distinct (and interacting) modes of rotation. This presents a challenge in how these processes are represented in computationally-fast radiative transfer models that are needed in weather and climate prediction. One component of its absorbing properties, called the continuum, is particularly uncertain, from both a theoretical and observational perspectives; the impact of improved understanding in this area on weather and climate prediction will be one major focus of the project. Figure taken from G. Petty *A First Course in Atmospheric Radiation* (Sundog Publishing)

Training opportunities:

The project would involve several placements to ECMWF (at its Reading site, about 3 km from campus, and due to move on to the campus in the next 3 years) amounting to 3 to 6 months. These would provide the student with invaluable experience of working in an operational research environment, building both team-working skills and the technical skills of modifying and running a large and complex model on a supercomputer and analyzing the large datasets produced.

Student profile:

This project would be suitable for students with a degree in physics, mathematics or a closely related environmental or physical science, including physical chemistry

https://research.reading.ac.uk/scenario/