Meeting report

On 11th January the RAS in London hosted a specialist discussion meeting entitled “Integrated Atmospheric and Space Science” which was organised by Prof. Mark Lester (University of Leicester), Dr Mervyn Freeman and Dr Tracy Moffat-Griffin (both from British Antarctic Survey). The rationale for this meeting was the awareness that continued progress in the areas of conventional meteorology and space weather will require an integrated approach; an understanding of the whole atmosphere (charged and neutral) from the ground to surface. This meeting aimed to bring together the UK space, atmosphere and meteorological communities to explore this new scientific frontier.

The meeting was divided into three speaker sessions (all speakers were invited): ‘top down effects’ which covered solar and space effects on the atmosphere, ‘bottom up effects’ which covered instrument and modelling studies of waves in the atmosphere and ionosphere and ‘Looking forward – extending the models’ which covered the planned extension to the Met Office Unified Model. There was also a poster session over the lunch break.

The morning session on top down effects was opened by Prof. Lesley Gray (University of Oxford) with a talk on the solar effects on climate. The talk provided a good overview of the evidence of the effects of the solar-cycle on the Earth’s climate system and discussed the mechanisms that responded to the variations in solar-cycle. The current understanding of the processes involved in these various mechanisms and how well we are able to represent them in climate models were also discussed.

The second talk of the session was by Dr. Annika Seppälä (Finnish Metrological Institute) on energetic particles - global analysis and models. She provided an overview of the effects of energetic particle precipitation (EPP), from both solar storms and the magnetosphere, on the atmosphere. She showed the impact that this ionisation has on chemistry (the production of NOx and HOx) and the related ozone depletion during the winter months in the Polar Regions. She also presented re-analysis data and modelling results which showed a link between surface temperatures and EPP chemistry changes higher up in the atmosphere, see Figure 1. It was proposed that dynamical coupling between the atmospheric layers were the mechanism for linking space weather effects to the polar climate.

The third talk of the session was by Dr David Newnham (British Antarctic Survey) on Energetic particles – vertical transport and mechanisms. This talk showed results from the ground-based microwave radiometer located in Antarctica, which is able to measure the concentrations of various chemical species in the mesosphere that are related to EPP events. Results from the period of solar minimum (2008-2009) showed that even during periods of low geomagnetic activity there is significant production of NOx, which then impacts on stratospheric ozone.

The fourth talk of the session was by Dr. Giles Harrison (Reading University) on global circuit coupling of space weather into the lower atmosphere. Dr. Harrison provided a clear explanation of the global atmospheric electric circuit and how it can propagate space weather effects (such as cosmic ray changes) down to the troposphere. He focussed on the influence of cloud layers on the global circuit, due to the conductivity of the air reducing in clouds, and possible links to lower atmospheric temperature changes.

The final talk of the morning session was by Dr. Mai Mai Lam (British Antarctic Survey) on the interplanetary magnetic fields influence on the surface climate. This talk reported a new result that there was a variation in the mid-latitude surface atmospheric pressure that corresponded to variations in the IMF (which influences the atmosphere via the global electric circuit). Previous work had assumed that this effect was only present at high latitudes. Their interpretation was that the polar effect is able to modify Rossby waves, and thereby alter weather patterns, at mid-latitudes.

The poster session was held between the morning and afternoon sessions in the RAS library. 11 posters on topics ranging from access to atmospheric and space weather datasets, studies done with their data, latest atmospheric modelling work and data re-analysis studies. Despite the space restrictions the poster session was busy and provided the opportunity for many enthusiastic discussions.

The first afternoon session on bottom up effects was opened by Dr Jack McConnell (York University, Canada) who gave a talk on the Canadian Ionosphere-Atmosphere Modelling System (CMAM-UAM). He outlined that they were looking to develop a whole atmosphere model so they could study the effects of lower atmosphere dynamics on the upper atmosphere and also the effect of space weather features such as energetic particles on the lower atmosphere. The first step to achieving the whole atmosphere model has been to couple the Canadian Middle Atmosphere Model (CMAM) and the ionospheric Upper Atmosphere Model (UAM). A case study of model results was shown where the effect of upward propagating waves (from the lower atmosphere) on ionospheric structure was examined. Comparisons were done with data from the IMAGE-FUV imager, looking at the longitudinal structure of the features. Analysis of the model results implied that the zonal difference in wave penetration to ionospheric altitudes modified the ionospheric electric current, which modified the emission seen in the imager data.

The second talk was by Dr Andrew Orr (British Antarctic Survey) on modelling gravity wave induced stratospheric temperature fluctuations over the Antarctic Peninsula. Stratospheric temperature perturbations seen in satellite data have been linked to the formation of Polar Stratospheric Clouds (PSCs). These perturbations are thought to be caused largely by gravity wave activity. PSCs are important as they are linked to the loss of ozone. In this talk a modelling case study over the Antarctic Peninsula was presented. The Unified Model (UM) was used to try and reproduce temperature perturbations seen in satellite data. The Antarctic Peninsula is a mountainous region and generates lots of gravity waves (mountain waves). The results from the case study showed that the high resolution UM was able to realistically reproduce the magnitude, timing and location of the temperature fluctuations but that the low resolution version was unable to represent the structure and magnitude of the disturbances, see Figure 2. This highlights the need for a better representation of gravity waves in low resolution climate models in order to capture important effects like fine scale temperature perturbations and PSCs.

The final talk of the session was by Prof. Steve Milan on Medium-Scale Travelling Ionospheric Disturbances (MSTIDs) observed over the Antarctic Peninsula by HF radar. The HF radar was located in the Falkland Islands between May 2010 and April 2011 and its field of view covered the Drake Passage and Antarctic Peninsula, known regions of high gravity wave activity. Using the observations of ground backscatter from the radar they were able to identify MSTIDs which had scales consistent with medium-scale gravity waves. The MSTIDs were found to have a primary population of Northward propagating waves, which are associated with solar wind-magnetosphere-ionosphere coupling, and a smaller westward propagating population, thought to be associated with gravity waves from the mountains of South America/Antarctic Peninsula or those formed at the edge of the Polar Vortex.

The final session of the meeting was a detailed talk by Prof. David Jackson (Met. Office) on the thermosphere extension in the Met Office Unified Model (UM). Currently the UM is widely used for weather forecasting and climate studies and has an upper boundary of 85km. The motivation for expanding upwards is to improve capability for space weather forecasting and accurately represent space weather effects on the whole atmosphere. The need to understand the dynamical links between the lower atmosphere and thermosphere/ionosphere is also very important. He outlined plans for the expansion of the UM up to 600km in order to produce a model that represents the coupling between the layers in a self-consistent manner. The challenges in such an expansion were discussed highlighting the need to incorporate features such as non-LTE heating schemes and gravity wave drag, the issue of how to expand the chemistry side of the model was also discussed. He showed that work towards the goal of a whole atmosphere model was progressing well but that it was going to take a lot of research and development to get it right and the community working together is important.

The meeting was attended by over 50 people from all areas of the space weather, atmospheric and meteorology communities. There were many active discussions during the meeting breaks and lots of comments were made about how interesting the talks were and how much they learnt. Overall the meeting was hugely successful and we hope it has forged many new links between the different communities and highlighted the importance of an integrated approach to our research areas.

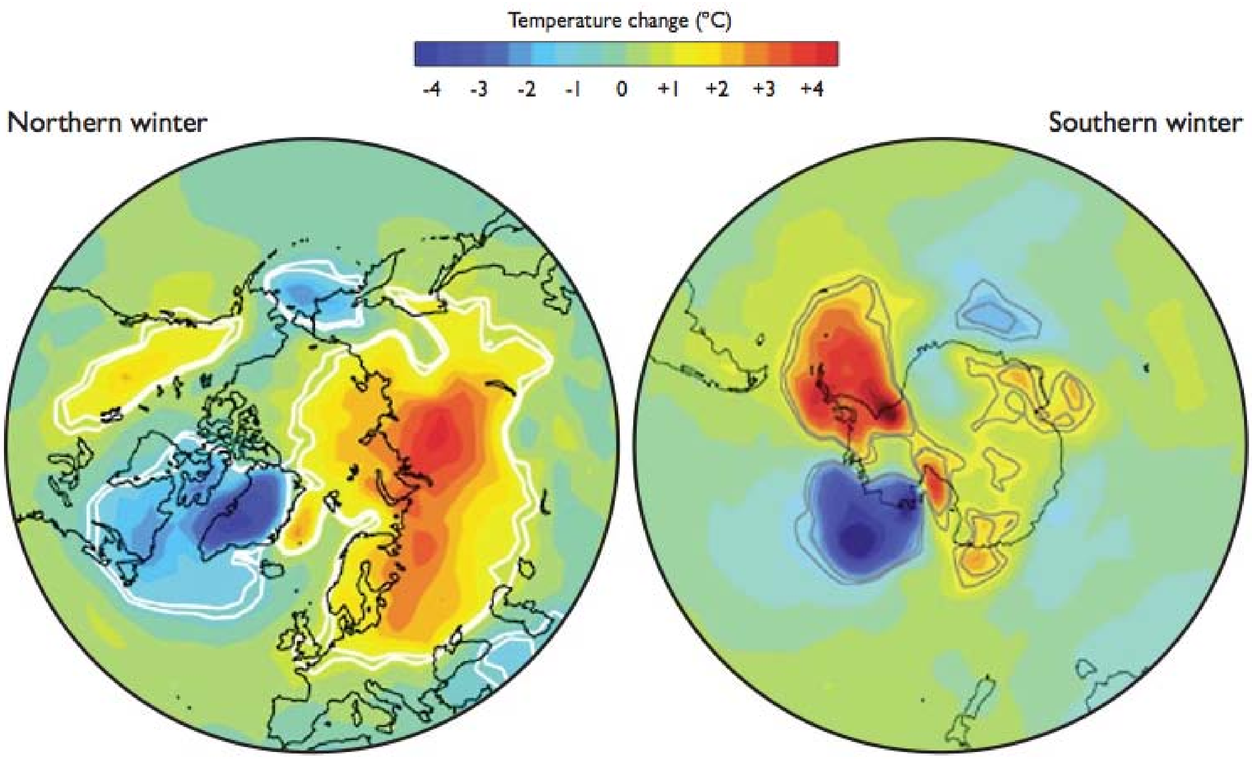
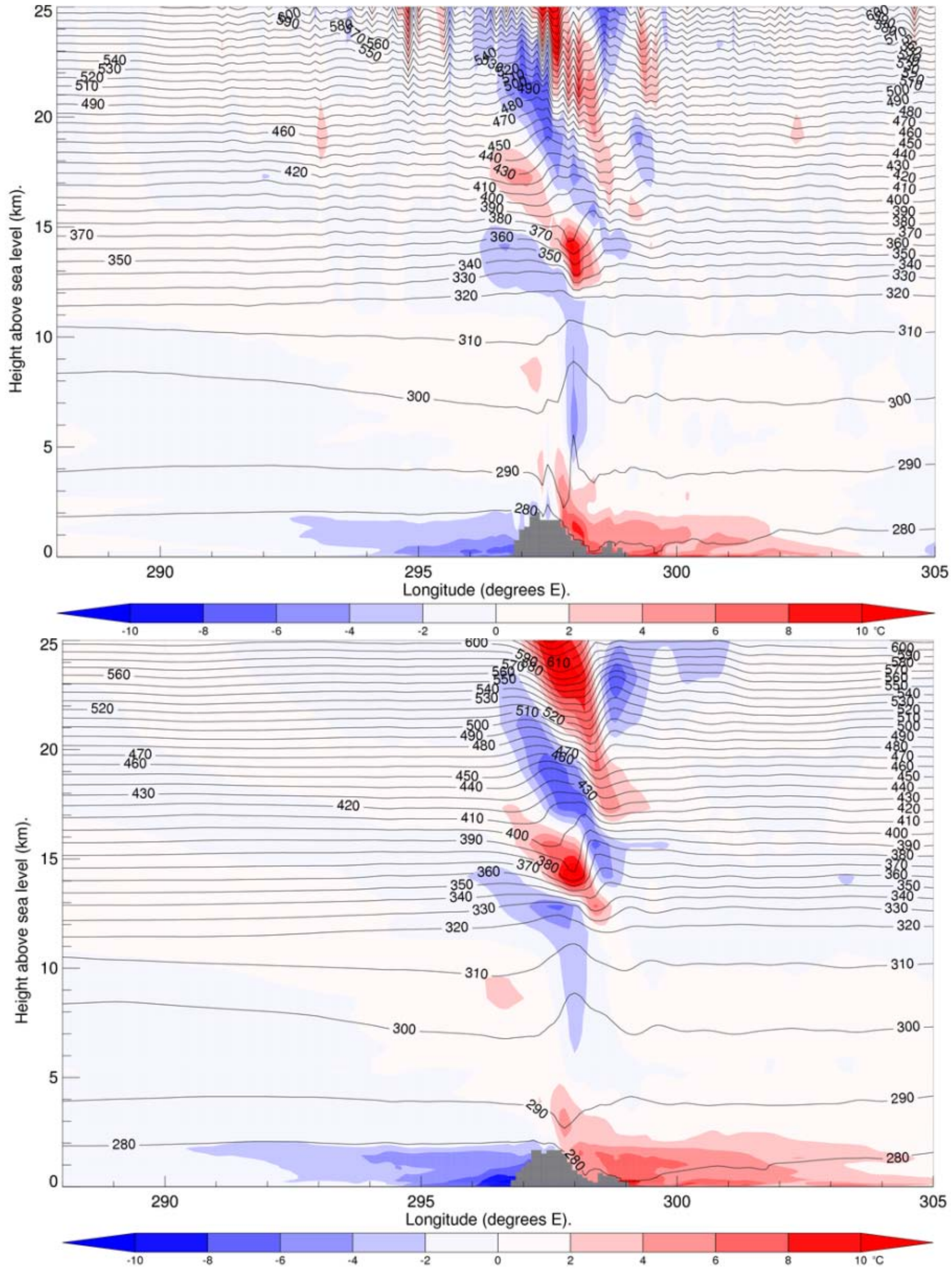


Figure 1: Northern and Southern hemisphere wintertime (Dec-Feb, Jun-Aug) differences in Surface Air Temperature due to Energetic Particle Precipitation (High EPP - Low EPP) from ERA-40 meteorological reanalysis data. For the NH years when a major SSW occurred during the winter are excluded. The contours represent the 90% and 95% confidence levels. From Seppälä et al. (2009).



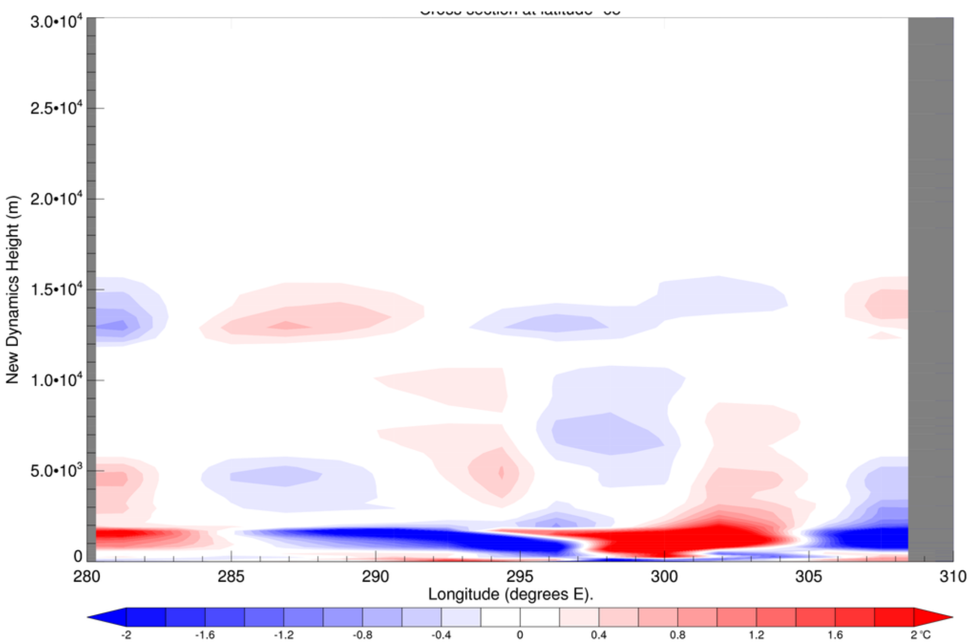


Figure 2: Vertical cross-sections of potential temperature (contours) and gravity-wave-induced temperature disturbance (shading) above the Antarctic Peninsula at a latitude of 65S for 03 UTC 7 August 2011 (during which strong westerly flow crossed the Peninsula) from forecasts of the UK MetOffice Unified Model run as a limited area mesoscale model (top two plots, 1.5 and 4 km horizontal resolution repectively) and as a climate model (bottom, N96 (~135 km) horizontal resolution, ensemble mean of thirteen runs). Note the different temperature scale between the top and bottom plots.