RMetS Virtual Student & Early Career Scientists Conference 2020

Tuesday 30 June 2020 | 9.30-11.00
Session 7 – Dynamics and Meteorological Applications

Dynamics

Comparison of the prediction of Indian monsoon low-pressure systems by Subseasonal-to-Seasonal prediction models

Akshay Deoras, University of Reading, PhD student

Monsoon low-pressure systems are important synoptic-scale tropical disturbances which contribute about half of the summer season precipitation in India. These weather systems modulate the intra-seasonal rainfall variability and trigger high-impact flooding leading to significant damage. Many features of monsoon low-pressure systems have been explored in recent decades. However, equivalent attempts have not been made to understand the potential for their predictability on the sub-seasonal to seasonal time scale, which is important for long-term planning. This project analyses the prediction of Indian monsoon low-pressure systems by the eleven models of the Subseasonal-to-Seasonal (S2S) prediction project. Using a feature-tracking algorithm, monsoon low-pressure systems are identified in the eleven S2S models during a common re-forecast period of 1999-2010. The identified systems are then compared with the ERA-Interim reanalysis dataset. Forecast verification statistics are produced for the position and intensity of monsoon low-pressure systems which suggest large differences between different S2S models. The ensemble spread-error relationship is also explored to ascertain the reliability of S2S models in predicting these weather systems. These results, along with the future work on the examination of large-scale factors modulating the interannual variation in the frequency of monsoon low-pressure systems, envisage the possibility of improved forecasts.

Climatology of mesoscale convective systems in Southern West Africa

Michael Baidu
University of Leeds, PhD Researcher

Mesoscale Convective Systems (MCSs) and their associated winds are one of the most devastating high impact weather systems in Southern West Africa (SWA). These systems are not well understood and poorly predicted. The (thermo-) dynamic environment of different types of MCSs in SWA are compared to storms from the neighbouring sub-regions, such as the Sahel. The storms are classified based on their lifetimes and speeds in order to investigate what controls the lifetime, speed and rain-rates of MCSs in the different sub-regions. The storm categories are: short-lived-slow moving, long-lived-fast moving, and long-lived-moderate-speed storms. The (thermo-) dynamics of the different categories are investigated by analysing the relationship between the associated wind shear, brightness temperature, Convective Available Potential Energy (CAPE) and Convective Inhibition (CIN). SWA storms are larger and associated with high CAPE but lower CIN compared to their Sahelian counterparts, which are smaller, deeper, have colder brightness temperatures, and are associated with higher CAPE and CIN values. The frequency of Sahelian storms is highest in July, August and September (JAS) while that of SWA storms peaks in May and September. Short-lived-slow-moving storms are mostly found over the oceans. These storms are shallower and smaller, have warmer brightness temperatures, weaker shear and lower rain-rates compared to the long-lived-fast moving storms which are the dominant

storm type over land. The speed of the MCSs are controlled by their steering level winds but also modified by vertical wind shear. Larger MCSs propagate faster than smaller storms, but are not necessarily associated with the highest rain-rates. The highest rain-rates are associated with long-lived MCSs that move at an average speed of 12 ms-1. These storms are mostly found in the Sahel and North Atlantic. They have higher vertical wind shear values but are not always associated with the coldest brightness temperatures. The results suggest that higher wind shear leads to faster and deeper (colder brightness temperatures) storms with higher rain-rates and larger storm size. Contrary, the storms in the North Atlantic have higher rain-rates but lower vertical wind shear, warmer brightness temperatures, smaller sizes and move at relatively slow speed. This may be attributed to the higher thermal inertial and moisture availability over the ocean.

Tides of the polar mesosphere-lower-thermosphere: Observations and model comparisons
Shaun Dempsey
University of Bath, PhD Student
The dynamics of the stratosphere and mesosphere are dominated by waves and tides of large amplitude. These waves and tides play a critical role in the transfer of energy and momentum between atmospheric layers and they are able to propagate from the surface way into the thermosphere. In the mesosphere/lower-thermosphere (MLT) region, the dynamics are dominated by solar atmospheric tides, with wind amplitudes reaching upwards of 60 m/s. As Global Circulation Models (GCMs) aim to raise their upper limit, they need to be capable of reproducing these tides to ensure that their representation of the middle and upper atmosphere is accurate. However, GCMs still fail to accurately represent these key features of the MLT. Therefore, there exists a critical need to accurately measure these tides. Here we present results comparing tides measured above the Antarctic Peninsula at the British Antarctic Survey Base at Rothera (68S, 68W) with the Extended Canadian Middle Atmosphere Model (eCMAM) and the Whole Atmosphere Community Climate Model (WACCM). We find there are large amplitude tides present throughout the year, the biggest being the 12-hour and 24-hour tides. The amplitude, phase and vertical wavelength all vary throughout the year and we find that the amplitude generally increases dramatically with height. Comparing these observations to the models reveals very significant differences with some seasons showing particularly poor predictions. We consider possible mechanisms for these differences including gravity wave momentum fluxes. By comparing these models to a “ground truth” we can determine their ability to predict the MLT accurately.

Can we wave goodbye to parameterisations?
Timothy Banyard
University of Bath, PhD Student
Direct observations of wind speeds in the upper-troposphere and lower-stratosphere (UTLS) are very difficult to obtain. This is a problem of critical importance for the study of atmospheric gravity waves, which form an integral part of the general circulation. Advancements in our understanding of gravity waves are vital for ensuring continued progress in the development of weather and climate models. For example, these waves play an important role in generating the instabilities that are responsible for severe turbulence experienced by aircraft. Improved parameterisation schemes have proven to be particularly effective in forecasting this; however, as model resolutions increase, there is the potential to

enhance forecast skill further by resolving gravity waves explicitly. Here, we study 25 years of commercial aircraft data from the IAGOS observing system and exciting new data from ESA’s ADM-Aeolus satellite. This allows us to investigate gravity waves in the UTLS region with unprecedented precision. The advantage of high-resolution wind measurements such as these is particularly pronounced at the tropopause, where the sharpness of the change in temperature gradient provides a unique challenge in observing gravity waves. We present a range of case studies of gravity wave activity in these datasets, and explore the far-reaching impacts of an improved UTLS gravity wave representation on overall model accuracy.

Meteorological Applications

Using aircraft accidents and incidents to evaluate the skill of clear-air turbulence diagnostics
Mark Prosser, University of Reading, PhD student
Clear air turbulence (CAT) is already a sizeable problem for the aviation industry.
It costs them 100s of millions of dollars as well as hospitalising passengers and crew each year. Being invisible and hard to forecast CAT is difficult to avoid. CAT is likely to worsen under climate change and in order to effectively prepare for it, the industry needs an accurate picture of how it is likely to evolve into the future. As climate models cannot explicitly simulate CAT, diagnostics are applied to model output to diagnose it.
But there are many diagnostics and they do not necessarily agree on the location and severity of the CAT. Just which ones are more/less skilled when it comes to aviation-affecting CAT? In order to investigate this, 20 real-world CAT events from the last decade were identified. 21 CAT diagnostics were then applied to these events' nearest grid-point in the ERA5 reanalysis dataset and then compared with their probability distributions. Higher/lower percentile diagnostics would indicate greater/lesser skill. Work is ongoing but early indications are that the 21 CAT diagnostics as a whole do possess skill with some being more skilled than others. Knowing accurately which diagnostics are more/less skilled would reduce diagnostic uncertainty thereby clarifying the future picture of aviation-affecting CAT. Such information would be invaluable in helping the aviation industry make good decisions now to prepare now for the future climate.

User-defined regimes: improving forecasts of good drying weather for farmers in Oxfordshire
Alicia Gleeson, Lake Street Consulting Ltd, Meteorologist
"Periods of consecutive dry days (dry spells) are vital for agriculture: in winter to drill winter wheat, in autumn for harvest, in summer months for the production of hay/haylage, and in spring for the spreading of fertilisers. The ability to forecast a dry spell early would provide valuable information, enabling increased crop production, decreased costs, and potentially decreased waste of weed killers and fertiliser.
We discuss what defines a dry spell, identify historic dry spells in Oxfordshire from the ERA5 land reanalysis data, then look to see if there is a correlation with larger scale atmospheric patterns using principal component analysis. Included in the results is a discussion of the robustness of the results, of the implications for forecasting dry spells going forward, and about how to communicate the forecasts to farmers.