RMetS Virtual Student & Early Career Scientists Conference 2020

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Session 2 – Air Quality and Modelling

Air Quality

A new Met Office kilometre-scale air quality model for the UK

Dr Benjamin Drummond
Met Office, Scientist

Exposure to air pollution has a significant impact on human health and can have Detrimental effects on biodiversity and the wider environment. One mitigating action for the former is to provide a forecast of air quality over the coming days allowing those who are most vulnerable to act and limit potential effects during episodes of heightened pollution. The Met Office provides the UK national air quality forecast using a numerical model that currently operates on a 12 km x 12 km grid. This scale is much larger than the typical distances that pollutant concentrations vary in the atmosphere (e.g. from individual large emitters like power stations or major road networks) and is significantly coarser than the current UK weather prediction model that operates on the kilometre-scale. We are upgrading the Met Office air quality model to use a 2.2 km x 2.2 km or 1.5 km x 1.5 km grid. This will better represent atmospheric processes (e.g. convection, surface deposition), benefit from emissions datasets that are available at higher resolution, better resolve pollutant concentration gradients in the rural and urban background environment and provide boundary conditions to very high-resolution urban air quality models. I will present preliminary results from this new kilometre-scale, convection-permitting air quality model and compare it with the existing 12 km x 12 km model. A UK-wide kilometre scale air quality model will bridge the gap between the regional (i.e. Europe-wide) and urban (i.e. individual cities) scales. Results from this study will infor development of the next generation Met Office national air quality forecast model.

DOMestic Energy Systems and Technologies InCubator (DOMESTIC) and indoor air quality of the built environment

Jinghua Li
University of Chester, Researcher

Two foci of DOMESTIC are improving energy efficiency and improving indoor air quality in the context of the net-zero climate agenda. There is an urgency for affordable energy delivery and clean growth, and indoor air quality has become a critical issue, with household air pollution ranking the 9th largest global burden of disease risk. Existing literature presents different aspects on indoor air quality of the built environment, i.e. smart homes; indoor air monitoring; the relationship between indoor and outdoor pollutants. However, few studies can be found on demonstration, assessment and development energy system technologies in a domestic context. DOMESTIC aims to fill this gap by providing facilities to evaluate different energy options and domestic technologies with real-time monitoring of energy consumption and selected indoor air pollutants. The main component of DOMESTIC is a converted 20ft shipping container modelled on a simplified domestic environment. It is designed

with low-carbon technologies and a versatile approach allowing technologies to retro-fitted. Once launched in July 2020, DOMESTIC may provide scientific evidence to allow market growth for innovations (i.e. air cleaning technologies, low-carbon technologies, local/microgeneration of energy); engaging academic and industry with potential research and commercial opportunities.

Modelling

Statistical methods to quantify and visualise the complex behaviour of clouds in the climate system
Rachel Sansom
University of Leeds, PGR (2nd year)
Much modelling work has been done to understand cloud responses to the aerosol semi-direct effect and indirect effects from aerosol-cloud interactions. Large uncertainty in cloud responses persist because there is limited understanding of how these effects, and those from other environmental changes, interact with each other in a buffered system. To understand all possible cloud responses to changes in their surroundings would require an impossible number of computer simulations.
This work develops a statistical method for studying complex cloud behaviours. Gaussian process emulation is a Bayesian method that approximates aspects of a complex model from select training data obtained by running the model over a range of values for each uncertain input parameter. The emulator interpolates between these known points to make predictions for the untried combinations as well as providing a Gaussian error surrounding each predicted point. Here, we show how emulation of a Large-Eddy Simulation model (the Met Office/Natural Environment Research Council Cloud Model) can be used to understand the key processes in warm, shallow cloud responses to aerosol and environmental changes. We show results from an observational stratocumulus case exploring how three environmental and aerosol related parameters affect cloud behaviour. We show how a well-designed ensemble is far superior to one-at-a-time perturbations for exploring cloud responses to multiple drivers.

Internal Atlantic Multidecadal Variability in HadGEM3-GC3.1 at resolutions
Wah Kin Michael Lai
University of Reading, PhD student
The North Atlantic has been observed to undergo decades of cool and warm phases on top of the global warming trend. This is referred to as Atlantic Multidecadal Variability (AMV). AMV has been linked to significant climate impacts, such as African rainfall. A physical understanding of the AMV will be crucial for predicting how the climate in these regions may change in the coming decades.
AMV has been linked to natural variations in ocean circulation, particularly the Atlantic Meridional Overturning Circulation (AMOC). However, it has also been suggested that external forcing from volcanic or anthropogenic aerosols may significantly impact the AMV. Although, the large inter-model spread in simulated AMV means there is currently no consensus on the mechanisms linking external forcing and AMV. Before trying to assess the influence of external forcing on AMV it

is necessary to understand the mechanisms driving internal AMV in models. We have characterised AMV, and identified its leading internal drivers, in the Met Office HadGEM3-GC3.1 climate model using a 500-year preindustrial control simulation. We also tested the sensitivity to resolution by comparing simulations at N96 and N216. In HadGEM3-GC3.1, AMV has an amplitude of ~0.2K, and a period between ~60years (N216) and ~80years (N96). The AMOC is a key driver of internal AMV, led by changes in Labrador Sea density. An NAO-like sea level pressure signal leading the AMV by 10 years suggests that the atmosphere is also important. However, there are differences in the atmospheric signal between the resolutions. The results presented here will be compared to forced scenarios to isolate the mechanisms related to forced variability. A key question next will be whether external forcing affects AMV through circulation changes or directly through radiative effects.

The Influence of anthropogenic aerosols on the Aleutian low
William Dow
University of Leeds, PhD student
There is an incomplete understanding of the mechanisms that govern the Pacific Decadal Oscillation (PDO), a major mode of climate variability that plays a key role in the evolution of global climate on decadal time-scales. Recent research has suggested that regional anthropogenic aerosol (AA) emissions could modulate the behaviour of the PDO, including the transition to a negative PDO phase starting in the late 1990s (Smith et al., 2016). However, other studies have questioned whether this connection is robust (Oudar et al., 2018). East Asia is a region of particular focus, where AA emissions having increased in recent decades (Bartlett et al., 2017). Here we combine analysis of an ensemble of coupled climate models running idealised AA perturbation experiments and a steady-state primitive equation model (LUMA) forced by diabatic heating anomalies to examine whether AA emissions influence the behaviour of the Aleutian low - a climate feature closely associated with the PDO - and if so, test the posited teleconnection mechanisms proposed by Smith et al. (2016). We further compare the response of the Aleutian low to well-mixed greenhouse gases to examine if AAs and GHGs influence the Aleutian low in a similar manner.