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/// 2019 ORAL ABSTRACTS

The influence of VOC mixing on the formation and properties of secondary organic aerosols

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Abstract Type: Oral

Secondary organic aerosols contribute to the particulate matter burden and have significant implications for air quality and climate. Both biogenic and anthropogenic volatile organic compounds include important secondary organic aerosol precursors. Through a recent international collaboration, we have shown that isoprene, carbon monoxide and methane can each suppress the instantaneous mass and the overall mass yield derived from monoterpenes in mixtures of atmospheric vapours through the reduction of the yield of low-volatility products that would otherwise form secondary organic aerosol. This contribution will discuss some of these findings and expand by presenting results from ongoing studies at the Manchester Photochemical Aerosol Chamber focusing on mixtures of biogenic and anthropogenic VOCs. We will present and discuss the influence of VOC mixing on the formation and properties of secondary organic aerosols.

Covariance of Storm hazards in the Atlantic Basin

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Abstract Type: Oral

The interannual variability of both the Atlantic hurricane season and the European winter windstorm season is influenced by large scale climate features. It is therefore reasonable to ask, are the two seasons related through climate teleconnection patterns? If so, how frequently does a strong season in one follow a strong season in the other? Answering these questions is not straightforward however, as reliable measures of seasonal activity such as best track data only cover the recent satellite era (1979 to present) over which statistical relationships are unreliable, making it difficult to assess the significance of any such connection. This issue is exacerbated by the fact that connections may occur on multiple timescales, from interannual to multidecadal. With the aim of addressing this problem, we use the latest ECMWF seasonal forecast product (SEAS5) to increase the number of ‘œobservations’ by including storms which were forecast by the multimember ensemble, but not subsequently observed in reality. This allows for a wide range of theoretically possible storm events over 1800 model years and a much larger sample size, increasing confidence in any relationship found between these extreme weather events and associated climate forcing.

Here we first verify that tracks of both tropical and extra-tropical cyclones within SEAS5 are an accurate representation of the climate system, with reference to best track data and reanalysis. The seasonal cycle, interannual variability and spatial variability are all shown to be well represented in both seasons. For tropical cyclones, a post processing step is required to remove some extra-tropical systems, the details of which are discussed. On establishing the viability of SEAS5 for this approach, the following hypotheses of covariability between the seasons are tested: 1) El Niño Southern Oscillation induced wind shear over the main development region (MDR) and simultaneous rossby wave influence on the North Atlantic Oscillation (NAO) 2) The positive phase of the Arctic Oscillation associated with high MDR wind shear and anomalous westerlies over Europe 3) Persistent Atlantic tripole sea surface temperature (SST) pattern, associated with anomalously low tropical SSTs and the positive NAO phase. For each hypothesis, we then build a climatology of model years which satisfy the criteria and examine the impact on windstorm track density of both Atlantic hurricanes and European winter windstorms.

Simulating the Climate Response to Atmospheric Oxygen Variability in the Phanerozoic

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Abstract Type: Oral

The amount of dioxygen (O2) in the atmosphere may have varied from as little as 10 % to as high as 35 % during the Phanerozoic eon (541 Ma – Present). These changes in the amount of O2 are large enough to have lead to changes in atmospheric mass, which may alter the radiative budget of the atmosphere, which could be a cause of the disagreement between climate model simulations and proxy reconstructions of past climates. Here we present the first fully 3D numerical model simulations to investigate the climate impacts of changes in O2 during different climate states using the HadGEM3-AO and HadCM3-BL models. We show that simulations with an increase in O2 content result in increased global mean surface air temperature under conditions of a pre-industrial Holocene climate state, in agreement with idealised 1D and 2D modeling studies. We demonstrate the mechanism behind the warming is complex and involves trade-off between a number of factors.

Case studies from past climates are investigated using HadCM3-BL which show that in the warmest climate states, increasing oxygen may lead to a temperature decrease, as the equilibrium climate sensitivity is lower. For the Maastrichtian (72.1–66.0 15 Ma), increasing oxygen content leads to a better agreement with proxy reconstructions of surface temperature at that time irrespective of the carbon dioxide content. For the Asselian (298.9–295.0 Ma), increasing oxygen content leads to a warmer global mean surface temperature and reduced carbon storage on land, suggesting that high oxygen content may have been a contributing factor in preventing a Snowball Earth during this period of the early Permian. These climate model simulations reconcile the surface temperature response to oxygen content changes across the hierarchy of model complexity and highlight the broad range of Earth system feedbacks that need to be accounted for when considering the climate response to changes in atmospheric oxygen content.

Gas and Aerosol measurements from the Manchester Time of Flight Chemical Ionisation Mass Spectrometer on the FAAM Bae 146 Research aircraft

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Abstract Type: Oral

The Filter Inlet for Gases and AEROsols (FIGAERO) coupled with the Aerodyne High Resolution (HR)-Time of flight (ToF)-Chemical ionisation mass spectrometer (CIMS) is a fairly novel technique that can provide quantitative trace gas and aerosol measurements as well as some fundamental properties of the measured aerosol. The FIGAERO ‘“ CIMS has now been used widely in chamber and ground based measurements and results from laboratory characterisation of the instrument as well as field work results from the Amazon Rainforest, Brazil and Beijing, China will be presented. As part of the recent NCAS project, the CIMS has also been certified and deployed on the FAAM Bae 146 Research aircraft for measurements of organics and their oxidation products, halogen species and other important species atmospherically and has been certified in three different configurations 1. Atmospheric pressure ionisation mode for detection of ambient ions 2. Trace gas chemical ionisation mode with various reagent ions for the detection of trace gasses and 3. FIGAERO for semi simultaneous detection of trace gasses and aerosol. Preliminary analysis of trace gas measurements from this platform will also be presented from the North Atlantic Troposphere during the NCAS funded ACSIS projects, focusing on trace gas halogen measurements made here.

High-resolution Weather Research and Forecasting (WRF) simulations of ice crystal icing events and the risk to aircraft

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Abstract Type: Oral

Commercial aircraft have commonly reported jet engine power loss and turbine engine damage while flying at high altitudes in and around areas of deep convection in tropical regions. Tropical convection is characterised by deep updraft cores which continually transport water vapour from the lower troposphere into high altitudes, thus producing localised regions of high ice water content (HIWC) and very high concentrations of ice crystals and mixed phase icing conditions. Flight through such environments can consequently lead to damage via ice accretion in the aircraft engine by ingested ice particles. However, understanding the occurrence of HIWC remains uncertain due to the typically coarse spatio-temporal resolution of current observational datasets. Here, we present two high-resolution (4km spatial resolution) case studies of high-altitude clouds and HIWC environments using an ice-crystal-icing-optimised version of the Weather Research and Forecasting (WRF) model. The model is validated against a series of observational datasets (weather stations, radiosondes, and geostationary- and polar-orbiting satellites) which show good model agreement spatially and temporally. The model simulations indicate that such events are associated with precipitation at the surface, low cloud top temperatures (<-30 oC), high ice water content between 6km ‘“ 12km elevation (> = 1.0 g m-3) and low reflectivity (typically < 30 dbZ). We identify HIWC conditions (> = 1.0 g m-3) and extreme HIWC potential (up to 4 g m-3) during both of these case studies, indicating that ice accretion would be a threat for flight through such environments. Characterising the occurrence and atmospheric processes leading to HIWC environments, and understanding the impact of such conditions on aircraft and turbine engines, is vital for safe flight operations at high altitudes.

Towards improved characterisation of the impact of chlorinated VSLSs on atmospheric chemistry and climate

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Abstract Type: Oral

The emissions of most long-lived halogenated ozone-depleting substances (ODSs) are now decreasing, owing to controls on their production introduced by Montreal Protocol and its amendments. However, short-lived halogenated compounds can also have substantial impact on atmospheric chemistry, including stratospheric ozone, particularly if emitted near climatological uplift regions. It has recently become evident that emissions of some chlorinated very short-lived species (VSLSs), such as chloroform (CHCl3) and dichloromethane (CH2Cl2), could be larger than previously believed and increasing, particularly in Asia. While these may exert a significant influence on atmospheric chemistry and climate, their impacts remain poorly characterised.
We address this issue using the UM-UKCA chemistry-climate model. We use a newly developed Double-Extended Stratospheric-Tropospheric (DEST) chemistry scheme, which includes emissions of all major chlorinated and brominated VSLSs alongside an extended treatment of long-lived ODSs. After assessing its performance, we show preliminary model results regarding the atmospheric impacts of chlorinated VSLSs over the recent past (2000-present), with a focus on stratospheric ozone and HCl trends. Finally, we introduce our future plans regarding examining the impacts of chlorinated VSLSs under a range of potential future emissions scenarios; the results of which will be directly relevant for the next WMO/UNEP assessment.

Validation of TAMSAT-derived soil moisture using NDVI

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Abstract Type: Oral

Extreme weather events impact vegetation dynamics, with implications for the lives of people and wildlife. Across much of the African continent, vegetation dynamics are largely driven by water availability. In particular, soil moisture relates strongly with primary productivity and vegetation phenology. Monitoring and forecasting of soil moisture therefore provides the opportunity to predict vegetation dynamics. Subsequent identification of emerging hazards will enable policy makers, aid agencies, wildlife managers and farmers to mitigate potential negative impacts.

TAMSAT (Tropical Applications of Meteorology using SATellite data and ground-based observations) provides daily rainfall estimates for all of Africa from 1983 to the delayed present. Recent advances have used TAMSAT rainfall estimates to drive a JULES (Joint UK Land Environment Simulator) model, translating rainfall into daily estimates of soil moisture. In addition, forecasting of soil moisture is possible using the TAMSAT-ALERT (TAMSAT-AgricuLtural EaRly warning sysTem) framework. TAMSAT-ALERT uses historic observations of rainfall to determine current conditions, then forecasts likely soil moisture depending on possible weather futures derived from the climatology.

Here, TAMSAT-derived estimates of soil moisture are validated to determine the skill of this approach in predicting vegetation dynamics in Kenya. NDVI (Normalised Difference Vegetation Index) obtained from the GIMMS (Global Inventory Monitoring and Modelling System) project is used to monitor primary productivity and vegetation phenology. Results will inform the operational application of the TAMSAT-ALERT framework for forecasting soil moisture and vegetation dynamics.

Ammonia Trends and future research directions for the UK and globally

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Abstract Type: Oral

Ammonia is a global air pollutant which requires substantial research to address. In the UK the Clean Air Strategy proposes governmental actions that could substantially reduce UK ammonia emissions with potentially significant benefits for both vulnerable ecosystems and human health. The underpinning scientific evidence to support the process.

Low-emission technologies are likely to be adopted by agricultural industries and novel mitigation techniques applied across the UK landscape. Both long-term and intensive quantitative measurement of ammonia will be needed to understand the changes. This presentation will discuss methods applied at landscape scale and approaches to integrate traditional diffusive sampling with high resolution measurements. Results from recent and on-going ammonia measurements will be discussed.

Observations Of Highly Oxidised Molecules And New Particle Formation In Urban Atmospheres

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Abstract Type: Oral

New particle formation is one of the main sources of atmospheric particulate matter by number, with new particles having great impact on both human health and climate. Highly oxidised multifunctional organic molecules (HOMs) have been identified recently as key constituents in the growth, and sometimes, in initial formation of new particles due to their low vapour pressures. While there have been many studies of HOMs in atmospheric chambers, flow tubes and clean environments, analyses of data from polluted environments are scarce. Here, measurements of HOMs and inorganic acids measured with a Nitrate CI-APi-ToF, and particle size distributions down to small molecular clusters are presented alongside VOC and trace gas data from campaigns in both Beijing (China) and Barcelona (Spain). Many gas phase HOMs have been characterised and their temporal trends and behaviours analysed in the context of new particle formation. The HOMs identified have a comparable degree of oxidation to those seen in other, cleaner environments, likely due to an interplay between the higher temperatures facilitating rapid hydrogen abstractions and the higher concentrations of NOx and other RO2. terminators ending the autoxidation sequence more rapidly. Frequent NOx termination also leads to a high proportion of nitrogen-containing HOMs, likely with R-ONO2 functionality. Alkylbenzenes, monoterpenes, and isoprene are seen to be important precursor VOCs for HOMs in cities. Many of the C5 and C10 compounds derived from isoprene and monoterpenes have a slightly greater degree of average oxidation state of carbon compared to those from other precursors. Most HOMs in Beijing except for large dimers have daytime peaks, indicating the importance of OH. chemistry in the formation of HOMs, for example, O3 is often lower on the days with higher HOM concentrations, despite the capacity of ozone to both break the rigid ring structure and produce aldehyde functionalities with loosely bound protons favourable for intramolecular hydrogen abstraction in endocyclic alkenes like Î±-pinene and limonene. Similarly, VOC concentrations are often lower on the days with higher HOM concentrations, indicating that their concentrations are not limiting factors. The daytime peaks of HOMs coincide with the growth of freshly formed new particles, and their initial formation coincides with the peak in sulphuric acid vapours, suggesting that the nucleation process is sulphuric acid-dependent, with HOMs contributing to subsequent particle growth.

Structure, lifecycle and environmental conditions of Tibetan Plateau Vortices

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Abstract Type: Oral

The Tibetan Plateau (TP) and surrounding high mountains constitute an important forcing of the atmospheric circulation due to their height and extent, and thereby impact weather and climate in downstream regions of East Asia. Mesoscale Tibetan Plateau Vortices (TPVs) are one of the major precipitation-producing systems on the Tibetan Plateau. TPVs originate on the TP; the majority of TPVs remain on the TP throughout their lifetime, while a fraction moves east off the TP. These ‘œmoving-off’ TPVs can trigger extreme precipitation and severe flooding over large parts of eastern and southern China, for example in Sichuan province and the Yangtze River valley.

Due to their potentially severe impacts downstream of the TP, it is important to understand the conditions under which TPVs can move east off the TP. In the first part of this study, we examine the vertical and horizontal structure of TPVs moving off the TP in contrast to those that do not using reanalysis data and a high-resolution global climate model. We analyse storm centred composites of atmospheric fields for different stages in the cyclone lifecycle (e.g. genesis, maximum intensity, and maximum precipitation) and for different regions over and downstream of the TP, to account for the heterogeneous topography.
In the second part, we examine the influence of large-scale environmental conditions on the behaviour of TPVs. First results suggest that the strength and position of the subtropical westerly jet influences how far TPVs can travel eastwards and therefore appear to influence the occurrence frequency and annual cycle of moving-off TPVs.

Understanding the connection between the large-scale atmospheric conditions/ circulation and the behaviour and structure of the TPVs might enable us to improve forecasts of moving-off TPVs and the associated precipitation in the densely populated regions downstream of the TP.

An improved approach to land-surface initialisation in the Met Office Global Seasonal Forecasting System (GloSea)

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Abstract Type: Oral

The land surface is a crucial component in the climate system; the exchange of heat and moisture flux between the land and atmosphere has an important impact on near-surface temperatures and precipitation.

Here, we describe experiments to initialise the land surface (notably soil moisture) in the UK Met Office's (MO) state-of-the-art Global Seasonal Forecasting System (GloSea). GloSea employs a coupled atmosphere-ocean model, using MO's Unified Model and Nucleus for European Modelling of the Ocean. Land interactions are modelled using the Joint UK Land Environment Simulator (JULES).

Due to the challenge in obtaining consistent information for both the historical and real-time periods, we have to resort to using a climatology for both hindcasts and forecasts. Inconsistencies in the initialisation (and therefore the forecast/ hindcast model climatology) can result in a biased forecast. This work hopes to improve the current initialisation scheme.

Owing to the availability of real-time data, we investigate land-surface initialisation using the Japanese Reanalysis Project (JRA-55), provided by the Japanese Meteorological Agency. Our goal is to replace the existing climatology used for the forecasts with soil moisture calculated from the daily data. Hindcasts, as for our experiments, will be initialised using a time-series from a JULES reanalysis forced with the JRA-55 data.

We discuss the impact of the new initialisation scheme on standard skill scores, as well as case studies of the European and Russian heat-waves of 2003 and 2010.

Unsupervised classification of convective organisation with Deep Learning

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Abstract Type: Oral

The precise mechanisms driving different forms of convective organisation which arise both in nature and in simulations are currently unknown. With a tool to automatically classify regions into distinct forms of convective organisation it will be possible to produce a statistical description of the most likely large-scale and local environmental conditions (e.g. windshear, horizontal convergence) present in differently organised states. Using unsupervised learning of GOES-R and MODIS imagery, a machine learning model has been developed to automatically identifies regimes of convective organisation in satellite imagery. First results will be presented producing a map of the distribution of different forms of convective organisation, with the aim to later link these to the large-scale forcing and local conditions.

Variability, trends and sensitivity to aerosol forcing of historical climate extremes in a novel single-model ensemble

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Abstract Type: Oral

The role of anthropogenic aerosol forcing in driving historical climate variations is currently a topic of ongoing scientific debate, owing to large uncertainties in the magnitude of historical forcing due to anthropogenic aerosol. The computational cost of running climate model simulations has steadily declined in recent years, making it possible to run a large number of ensemble members to investigate the roles of internal variability and aerosol forcing in shaping surface climate variability.

Here, we present results from a novel historical ensemble of simulations conducted with the HadGEM3-GC3.1 climate model for the period 1850-2014. In this ensemble, the anthropogenic aerosol emissions are scaled to sample a wide range in historical aerosol forcing. Multiple ensemble members sampling different ocean initial conditions are run for each scaling factor to enable the differences between the forced responses to be reliably estimated. As expected, a wide range of historical global mean temperature changes are simulated, depending on the aerosol scaling factors. For trends in temperature extremes, both the magnitude of internal variability and the sensitivity to aerosol forcing are highly dependent on the region and season. We discuss the relative importance of forcing vs. internal variability for different regions and seasons, and explore the mechanisms for these differences.

Attribution of 2012 extreme climate events: does air-sea interaction matter?

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Abstract Type: Oral

In 2012 extreme anomalous climate conditions occurred around the globe. Large areas of North America experienced anomalous hot summer, with large precipitation deficits inducing severe drought. Over Europe, the summer of 2012 was marked by strongly precipitation anomalies with the U.K. experiencing its wettest summer since 1912 while Spain suffered severe drought. What has caused these extreme climate conditions in various regions in 2012? This study compares attribution conclusions for 2012 climate anomalies relative to a baseline period (1964-1981) based on two sets of parallel experiments with different ocean model configurations (ocean mixed layer model and no interactive ocean) to assess whether the attribution statements for climate anomalies in this year are sensitive to air-sea interaction.

Modelling results indicate that attribution conclusions for large scale surface air temperature (SAT) changes in both boreal winter and summer are generally robust and not sensitive to air-sea interaction. This is especial true over South Europe, Eurasia, North America, South America, and North Africa. Results also indicate a role of changing anthropogenic forcing in increased precipitation over North Europe and Sahel, and reduced precipitation over North America and Amazon in boreal summer and an insensitivity of these changes to air-sea interaction. However, attribution of circulation and precipitation changes for some other regions indicates a sensitivity to air-sea interaction. With air-sea interaction model results show a positive NAO-like circulation response in the Atlantic sector in boreal winter and weak changes in the East Asian summer monsoon and precipitation over East Asia. Without air-sea interaction, results show some different responses over these two regions. Comparison with observed changes indicates that the coupled simulations generally agree better with observations, demonstrating that the atmospheric general circulation models (AGCMs) based attribution method has limitations and may lead to erroneous attribution conclusions for regional circulation and precipitation.

Isoprene measurements in an oak-dominated forest during the 2018 heatwave in the UK

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Abstract Type: Oral

Global change over the next decades, and in particular increasing temperatures, are expected to profoundly affect the emissions of isoprene, one of the largest biogenic emissions on the planet (estimated 300-700 TgC/year, cf. ~500 TgC/year from methane). A better understanding of how isoprene emissions will change in the near future is crucial for an accurate characterisation of the composition and oxidising capacity of the lower atmosphere, which ultimately affect air quality and climate. In particular, an improved description of the canopy-to-atmosphere exchange for isoprene is highly desirable, along with the characterisation of emission changes in response to extreme events such as droughts and heatwaves, both of which are predicted to become more frequent.

In this work we describe the deployment of the iDirac, an autonomous, custom-built portable gas chromatograph with photo-ionisation detection (GC-PID) to measure isoprene concentrations in Wytham Woods (UK) in summer 2018. Wytham Woods is Oxford University's research forest and is dominated by European oaks (Quercus robur), one of the strongest isoprene emitters in mid-latitude/temperate regions. Taking advantage of the treetop walkway available onsite, isoprene abundances were measured continuously at four heights within, below and above the canopy during the whole 2018 growth season (May-Oct). A number of meteorological variables (temperature, relative humidity, photosynthetically active radiation (PAR) and wind) were also measured at various heights across the canopy. These continuous observations were complemented with occasional leaf gas exchange measurement and whole air samples, as well as with satellite retrievals of normalised difference vegetation index (NDVI) and photochemical reflectance index (PRI) for the area.

The measurement period overlapped with a long and uninterrupted heatwave in the UK (22/06/18-08/08/18), characterised by unusually high temperatures and virtually no rainfall. Our observations show a strong correlation of isoprene with temperature and PAR for most of the summer, with daily peak isoprene concentrations during the early heatwave higher than those before and after the heatwave by up to a factor of 5. In particular, the isoprene response to temperature during the heatwave was different to that before and after the heatwave. The lack of precipitation during the heatwave allows an assessment of the effects of prolonged drought on isoprene emissions, using NDVI and PRI as an indicator of ecosystem health. Further analysis of the data from this measurement campaign will be discussed, along with modelling approaches and the wider implications of future scenarios with more frequent heatwaves.

Transport resilience to weather in Rio de Janeiro, Brazil

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Abstract Type: Oral

Urban transport systems are fundamental in modern society to access work, education, healthcare and other amenities. In megacities, the high demand for transport means that even minor or short-lived disruption to transport systems caused by extreme weather can impact a large number of people. However, there are few transport resilience and climate change adaption studies from the Global South where the majority of current and future megacities are located, and where socio-economic challenges such as poverty and poor infrastructure services makes these cities particularly susceptible to extreme weather events. This study provides a unique perspective on transport resilience to weather and climate from Rio de Janeiro derived from interviews with local transport operators, civil servants and academics undertaken in 2017. Rio de Janeiro has a population of 12 million inhabitants and in recent years, mega-events such as FIFA World Cup, 2014 and Olympic Games, 2016, have led to significant public and private sector investment in the three mass transport-systems; rail, metro and bus rapid transit (BRT). Despite this, all transport systems are impacted by urban flooding, typically occurring during the summer, which can inundate the tracks, roads, stations and platforms, and/or prevent customers from reaching the stations. On the BRT system, hot temperatures cause air-conditioning failures, over-heating engines, and heat-related deformation of the road surface. The Centre of Operations (COR), which integrates datasets and personnel including municipal and state civil servants, and private transport operators, has previously coordinated the municipal response to extreme weather and produced a municipal Climate Change Adaptation Strategy. However, the transport operators have no climate change adaption plans, nor a legal requirement to produce them, commenting, ‘œtalking about extreme weather is not a culture we have here in Brazil’. The study provides five recommendations to improve transport resilience; (i) quantify the impact of weather on the transport systems; (ii) undertake a climate change risk assessment for transport; (iii) continue operational integration of transport systems; (iv) improve integration of transport systems at strategic planning level; and, (v) uphold strong leadership from the COR. Strong leadership is particularly important given the multiple spheres (federal, state, municipal) of governance responsible for transport, the current political uncertainty, and the ongoing Operation Car Wash (Lava jato) corruption scandal linked to major infrastructure investments. These recommendations will be relevant to stakeholders in other urban areas, and we call for more perspectives from the Global South.

Tropical waves and high impact weather in SE Asia

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Abstract Type: Oral

Equatorially trapped waves, such as Kelvin Waves, Equatorial Rossby Waves and Westward-moving Mixed Rossby-Gravity (WMRG) Waves, play a major role in organizing tropical convection on synoptic to sub-seasonal timescales. These waves have the potential to provide an important source of predictability for high impact weather in South East (SE) Asia and the tropics more widely. To accurately forecast high impact weather events Numerical Weather Prediction (NWP) models must be able to represent the weather systems that organize deep convection, and the relationships between these weather systems and convection. Methods have been developed to identify equatorial wave activity in both observations and forecasts. Using this approach the observed statistical relationship between equatorial waves, heavy precipitation and high impact weather events in Southeast Asia is examined, as well as the role of equatorial waves in high impact weather forecasts. High impact weather in SE Asia is linked to all three types of waves that are included in analysis; Kelvin, Rossby and WMRG waves. In observations, precipitation in SE Asia is increased as high amplitude waves propagate through SE Asia. In particular, heavy precipitation can be up to four times more likely to occur during a high amplitude wave in regions of SE Asia, including Malaysia, Indonesia and the Philippines. Analysis also examines the representation of these relationships in the UK Met Office global and regional NWP models, consequently providing information on the skill of associated high impact weather forecasts.

Measurement and modelling of physico-chemical properties and atmospheric behaviour of automotive diesel particles

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Abstract Type: Oral

In the FASTER study, particulate and gaseous emissions were sampled from a light duty automotive diesel engine prior to extensive chemical characterisation and determination of physical properties, and the resultant data used to predict aerosol behaviour within a neighbourhood-scale numerical model. Sampling from the engine was conducted in different operating modes and with different diesel fuels and lubricants. Particles and vapour were collected for subsequent chemical characterisation by two dimensional gas chromatography with time-of-flight mass spectrometric detection, allowing identification of both individual and groups of compounds. Size fractionated samples were collected by impaction, and electrical mobility size distributions were also measured. The vapour pressures of key components (n-alkanes) were measured in the laboratory and used in a numerical simulation of evaporation/ condensation processes as a function of particle composition and size. In a parallel activity, air samples were collected in the atmosphere of London alongside measurements of particle size distributions, total number counts and black carbon. The results were used to set the boundary conditions for a WRF-Large Eddy Simulation model of a small area of central London in which the composition and size distribution of diesel exhaust particles were simulated.

Managing Air for Green Inner Cities

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Abstract Type: Oral

Increasing urbanisation coupled to current building design and city planning practices place unsustainable pressures on energy resources, leading to increased urban pollution and heat islands. The result is a cycle of increased demand for air conditioning and, in turn, increased emissions of heat, greenhouse gases and other pollutants. The MAGIC project (2016-2022) aims to break this cycle by creating a system that models external conditions and their impact on the indoor environment and encourages the use of natural ventilation, thereby dramatically reducing energy demand and emissions from the built environment.

This challenge can be summarised quite simply: a system to be applied to short term management and long term planning must be able to predict outdoor and indoor environmental conditions in some detail, both in space and time, and respond properly to changes in the built environment, traffic flows, meteorology, etc. and will only be used if it runs quickly and operates effectively on relatively modest computational resources. This is now a practical proposition and its attainment the goal of the MAGIC project.

Research in the EnFlo wind tunnel is designed to provide detailed insight that can guide development of the final system and support interpretation of the results from monitoring data taken both within test buildings and in their surrounding environments. Recent wind tunnel work will be presented and set in the context of the project as a whole. This includes detailed studies of the sensitivity of flow and dispersion behaviour to the extent and detail of the urban area being modelled, and basic investigations of the correlations between building surface pressures, local wind fields and pollutant concentrations. Plans for further work will be discussed, including simulation in stable and unstable boundary layers.

Volcanic impacts on large-scale climate modes in a multi-model ensemble

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Other Authors:
Abstract Type: Oral

Large volcanic eruptions in the tropics have global impacts, but have been found to especially affect the North Atlantic climate system in the first few winters after the eruption. This is primarily through the North Atlantic Oscillation and its climate impacts, but the tropical Pacific is also thought to contribute to changes over the North Atlantic. Since 1960, a period when the earth system has been relatively well observed, there have been three major eruptions: Agung (1963), El Chichon (1982) and Pinatubo (1991). These are mid-sized eruptions compared to earlier eruptions, but they are large enough to have impacts on climate over several seasons. In this work, we use five state-of-the-art decadal prediction systems to investigate the climate response to these recent volcanic eruptions. We compare forecasts started before each respective eruption with identical forecasts that have no volcanic aerosols. We focus on the mechanisms in each model that lead (or not) to responses in large-scale climate modes such as the NAO and El NiÑo. We find that models are able to reproduce many of the volcanic impacts seen in observations.

Reconstruction of the Southern Annular Mode from ships' logbooks and other historical observations

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Abstract Type: Oral

We use historical pressure and wind data from land stations, and ships' logbooks, to reconstruct past variability in the Southern Annular Mode (SAM) with a focus on the inter-war period. The Southern Annular Mode is the major mode of circulation variability in the extratropical Southern Hemisphere, representing changes in the strength and location of the Southern Hemisphere storm tracks. In recent decades the SAM has moved to its positive phase (stronger and more poleward storm tracks) due to stratospheric ozone depletion. Extending the record back in time is important to put these human-induced changes into a longer-term context. Existing instrumental-based SAM reconstructions are based on teleconnections between mid and high latitudes, and contain very little high latitude data prior to the mid-20th century when regular meteorological measurements started at Antarctic stations. Our reconstructions use newly-rescued pressure data from the project ACRE Antarctica (from both ships' logbooks and land stations), combined with pressure and wind data from ships' logbooks from the ICOADS (International Comprehensive Ocean-Atmosphere Data Set) dataset, to reconstruct past variability in the SAM. We will then use these reconstructions, and the rescued observations, to evaluate the Twentieth Century Reanalysis at high southern latitudes, and to evaluate the influence on the quality of the Reanalysis of assimilation of new observations.

Modelling the impacts of ongoing East Asian CFC emissions on ozone recovery

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Abstract Type: Oral

The Montreal Protocol (MP) was agreed as a response to the unambiguous detection of ozone depletion driven by halogen compounds, and is regarded as the most successful environmental treaty to date. However, recent observations indicate that compliance with the Protocol may not be complete, with studies identifying a new source of CFC-11 in East Asia. This new source of CFC-11 will have an impact on the timing of ozone recovery, depending on the duration and magnitude of the emissions.

Using the UM-UKCA model, the immediate and future impact of recent emissions of CFC-11 is explored. A baseline scenario following the WMO2014 recommendations for lower boundary CFC mixing ratios is performed, from which separate integrations are initialised in 2012 and run to 2100 following different scenarios for CFC-11 (and CFC-12) emissions. A range of assumptions are made about the magnitude and duration of additional CFC production, the direct emissions into the atmosphere and the effect on the banks. Using these scenarios, potential future changes to stratospheric chlorine loadings and ozone mixing ratios are examined in order to determine the impact on ozone recovery if rapid action is not taken to curb these recent emissions.

State of the UK Climate 2018

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Abstract Type: Oral

The Met Office National Climate Information Centre (NCIC) produces an annual State of the UK Climate publication each year from 2014. This provides an accessible and up-to-date assessment of UK trends, variations and extremes based on the most up to date observational datasets of climate quality. The reports presents summary statistics for the year against 1981-2010 and 1961-1990 averages and examine trends and variability in national climate series. From 2017, the reports are published in the International Journal of Climatology as a special supplement.

The 2018 report makes use of a new UK climate gridded dataset, HadUK-Grid. This dataset is at an improved 1km resolution and makes use of recently digitized data sources enabling monthly temperature to extend back to 1884 and monthly rainfall to 1862. This annual report is produced by NCIC as a key climate monitoring product for the Met Office Public Weather Service, Hadley Centre Climate Programme and UK Climate Projectons (UKCP18) project. We provide a summary of State of the UK Climate 2018 report including the production process and key findings, and an overview of the HadUK-Grid gridded dataset and ClimateGrid software on which it is based.

An analysis of the UKESM1 CMIP6 historical ensemble

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Abstract Type: Oral

A sixteen member ensemble of CMIP6 historical simulations has been made using the 1st UK Earth system model (UKESM1). The ensemble uses a set of initial conditions that samples decadal to centennial internal variability in the UKESM1 CMIP6 pre-industrial control simulation (piControl). We present an overview of the main results from these simulations, including analysis of the simulated historical evolution of surface temperature, ocean heat uptake, sea ice and carbon exchanges between the atmosphere and both ocean and land reservoirs. A particular focus is placed on the Southern ocean, a region observations indicate has played a key role in the global marine uptake of both heat and carbon over recent decades. We evaluate the coupled Southern Ocean mean state simulated by UKESM1, including representation of the meridional overturning ocean circulation, the Antarctic circumpolar current (ACC) and associated atmospheric winds and relate these to model-simulated meridional density and pressure gradients in the ocean and atmosphere.

On the influence of pre- and in-seasonal meteorological conditions on grass pollen interannual variations in the UK

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Abstract Type: Oral

Up to 30% of the UK population are sensitized to grass pollen. Therefore, grass pollen is considered the most allergenic pollen type in the UK. Estimating the grass pollen season severity and interannual variation is a key task in aerobiological studies. The season severity is quantified using the Seasonal Pollen Integral (SPIn) - the integral over time of daily pollen concentration. This severity is tightly connected to personal exposure and the symptoms among hay fever sufferers. Recent studies suggest that the SPIn interannual variation is related to variation in pre- and in-seasonal meteorological conditions at the specific region. Here, we investigate whether the SPIn interannual variation can be explained by variation in pre-seasonal precipitation and in-seasonal air temperatures in the UK. Seven UK pollen observation sites have been chosen in the study: Worcester, Plymouth, Isle of Wight, Belfast, York, Islington (London) and Ipswich. The pollen observations cover the 1996-2018 grass pollen seasons, where we include those years without substantial gaps in the daily time series, thereby providing 116 pollen seasons to be included in the study. Maximum daily air temperature and precipitation data have been taken from the global summary of the day meteorological dataset. The SPIn, temperature and precipitation data have been transformed to interannual variations relatively mean value at each pollen observation site. The transformed time series have been analysed by looking for correlation between variations in pre-seasonal precipitation, in-seasonal air temperature and SPIn. The results show positive and significant correlation between pre-seasonal precipitation and SPIn variations ($R = 0.35$, p-value < 0.001) at the selected sites. Station-wise, the correlation is positive and significant at Worcester ($R = 0.54$, p-value < 0.01) and Ipswich ($R = 0.81$, p-value < 0.05). Correlation between in-seasonal air temperature and SPIn variations is also positive and significant ($R = 0.33$, p-value < 0.001) at the sites. Station-wise, the correlation coefficient is positive and significant at Worcester, Plymouth and Islington ($R = 0.51, 0.50, 0.59$, respectively p-value < 0.05). The study indicates that the SPIn variation is not a regional scale phenomenon in the UK. Instead, it appears to be related to local environmental effects. It is also shown that the pre- and in-seasonal meteorological conditions are statistically correlated with the SPIn, which may be explained by the fact that governing processes affecting the SPIn are related to both pollen production (pre-season) and atmospheric conditions (in-season).

ENSO modulation of MJO teleconnection to the North Atlantic & Europe and implications for subseasonal predictability

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Abstract Type: Oral

The Madden-Julian Oscillation (MJO), an organized eastward propagating source of enhanced convection, acts as a Rossby wave source and as a global tropical driver of subseasonal predictability. An example pathway leads this source of predictability out of the tropics to the North Atlantic / European (NAE) region, known as a teleconnection, via the jet stream and stratosphere. Through this teleconnection the MJO can influence regimes of large-scale weather patterns, including the North Atlantic Oscillation (NAO). The aim of this study is to investigate the dependence of the MJO - NAE teleconnections on the interannual variations in the background state associated with the El NiÑo Southern Oscillation (ENSO). We use the Cassou (2008) framework to show that these teleconnections from the MJO to the NAE weather and jet regimes are strongly dependent on the phase of ENSO. For example, during El NiÑo years the MJO to NAO+ teleconnection is strongly enhanced and persists throughout more MJO phases, dominating the climatological mean picture, whilst during La NiÑa this teleconnection to the NAO+ is weak and short-lived. Further NAE regime transitions and in situ development also become clearer via this perspective separated by ENSO background state. We also discuss the seasonal mean response to ENSO in the NAE region through rectification of these subseasonal teleconnections onto the seasonal mean. The dependence on the background state has strong implications for subseasonal predictability, including implications for interannual variations in subseasonal predictive skill and also the need for models to get the background state correct in order to correctly represent these teleconnections.

Potential benefits of cool roofs in reducing heat-related mortality during heatwaves in a European city

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Heatwaves are associated with a range of adverse health effects, which can lead to an increase in emergency hospitalisations and increased mortality. In towns and cities, air temperatures are often higher than in surrounding rural areas, particularly at night. This Urban Heat Island (UHI) effect can exacerbate health impacts associated with heat exposure. The UHI is often amplified during summer heatwave periods, and heatwaves are likely to become more frequent, intense, and longer, due to climate change.
Birmingham in the West Midlands is a highly urbanised area with a distinct UHI. Recent work suggests that up to half of heat-related mortality in the West Midlands during the 2003 heatwave could be attributed to the UHI. High temperatures and excess-mortality also occurred in July 2006 in this region.
Actions or interventions to reduce the intensity of the UHI could potentially reduce heat-risk. Retrofitting of buildings, for example installing cool (reflective) roofs, or interventions such as increasing urban vegetation, are possible ways to reduce the UHI, and thus reduce population exposure to heat.
In this study we use a regional weather model (WRF) with detailed representation of urban areas (Noah-LSM and BEP urban sub-model) to study the UHI across the West Midlands. We present results of the impact of interventions such as cool roofs and greenspace on reducing exposure to high ambient temperatures for a summer season, and two heatwave periods.
Our modelling suggests that during heatwaves, cool roofs could reduce mean UHI intensity by up to 23%, and reduce heat-related mortality attributed to the UHI by 25%. Results show targeting the most urbanised areas could contribute more than half of this reduction during heatwaves, and modifying half of all industrial/commercial urban areas could have the same impact as modifying buildings in all high-intensity residential areas. We also explore sensitivity to different exposure-metrics used for health impact assessments.
The research was part funded by the National Institute for Health Research Health Protection Research Unit (NIHR HPRU) in Environmental Change and Health at the London School of Hygiene and Tropical Medicine in partnership with Public Health England (PHE), and in collaboration with the University of Exeter, University College London, and the Met Office. The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR, the Department of Health or Public Health England. We acknowledge funding from NERC (grant number NE/R01440X/1) for CH.

Aerosol sources in Delhi drived from eddy-covariance flux measurements and concentration analysis

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Abstract Type: Oral

The WHO ranks Delhi amongst one of the most polluted cities globally, with significant impacts on life expectancy and the economy. Much of the air quality problems are related to high concentrations of particulate matter (PM). In order to target emission abatement measures most cost effectively it is important to understand the sources contributing to the PM. For this reason, two Aerodyne Aerosol Mass Spectrometers (AMS) were operated at two contrasting sites in Delhi: the first was located on the edge of Old Delhi overlooking densely populated areas and traffic arteries. The second instrument was situated in a more affluent area of New Delhi, characterised by residential buildings, institutes and significant greenspace. In addition to measuring concentrations, the instruments were operated in a mode that allows local fluxes to be derived via the micrometeorological eddy-covariance technique. Positive matrix factorisation (PMF) was applied to analyse the factors that contribute to the organic aerosol mass, both for concentrations and fluxes. Whilst the concentration measurements provide a more regional assessment, the flux measurements quantify the sources within the flux footprint, within 1 km or so of the measurement locations. At the Old Delhi site all components detectable by the AMS showed net emission. By contrast, at the New Delhi site, ammonium, nitrate and chloride were transported downwards, either due to deposition to vegetation or, more likely, due to the contribution of evaporation of volatile ammonium compounds below the measurement height. At this site, total organic mass flux was bi-directional. Application of PMF to the fluxes revealed that this net flux was composed of hydrocarbon organic like organ aerosol (HOA) which was emitted and secondary oxidised organic aerosol (OOA) factors which showed deposition. At both sites the PMF flux results show that the organic aerosol flux was dominated by HOA. By contrast, concentrations were dominated by OOA, although primary aerosol factors made a larger relative contribution than in other megacities.

Machine learning parameterizations for ozone in climate sensitivitysimulations

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Abstract Type: Oral

Ozone is an important feedback factor in climate simulations [1-5]. However, interactive atmospheric chemistry schemes needed for calculating changes in ozone are computationally expensive. Climate modellers therefore often use climatological ozone fields, which are neither consistent with the actual climate state simulated by each model nor with the specific climate change scenario. We suggest a novel method using a machine learning regression algorithm to model ozone in pre-industrial and abrupt 4xCO2 climate sensitivity simulations [6]. Using the atmospheric temperature field as the only input, the regression reliably predicts three-dimensional ozone distributions. In particular, the representation of stratospheric ozone variability is much improved compared with a fixed climatology. Our method requires training data covering only a fraction of the usual length of simulations and, as we show here, is transferable between generations of the UK Met Office's climate model. Our method thus promises to be an important stepping stone towards a range of new computationally efficient methods to consider ozone changes in long climate simulations.

UKESM1: An assessment of the pre-industrial to present-day anthropogenic forcing and its attribution to different forcing agents

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Abstract Type: Oral

A quantitative understanding of the role of different forcing agents in both historical and future climate change remains a key motivation and scientific question for the forthcoming 6th Coupled Model Intercomparison Project (CMIP6). Fundamental to this question is the impact of physical and chemical perturbations due to anthropogenic activities on the Earth's radiative balance. In this work, effective radiative forcings (ERFs) are quantified for different anthropogenic forcing agents with the UK's Earth System Model, UKESM1. By using a single modelling framework and adopting the protocol from the Radiative Forcing Model Intercomparison Project (RFMIP), pre-industrial to present-day ERFs are calculated consistently for all anthropogenic climate forcers. The forcing agents considered here are the long-lived well-mixed greenhouse gases (GHGs), stratospheric and tropospheric ozone (O3), aerosols, and land use change. In particular, additional UKESM1 simulations are used to attribute the methane ERF, as an example, to forcing by methane, tropospheric and stratospheric O3, aerosols, and stratospheric water vapour. Results show that the O3 forcing attributable to methane is close to zero, due to changes in stratospheric and tropospheric O3 offsetting each other. However, the pre-industrial to present-day change in methane gives rise to a positive aerosol forcing through aerosol-cloud interactions by changing the relative contributions of the different sulphur dioxide oxidation pathways and the aerosol size distribution.

Assessing external and internal sources of Atlantic Multidecadal Variability using models, proxy data and early instrumental indices

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Abstract Type: Oral

Atlantic Multidecadal Variability (AMV) of North Atlantic sea surface temperature exhibits an important influence on the climate of surrounding continents. It remains unclear, however, the extent to which AMV is due to internal climate variability (e.g. ocean circulation variability) or changes in external forcing (e.g. volcanic/ anthropogenic aerosols or greenhouse gases). Here, the sources of AMV are examined over a 340-year period using proxy indices, early instrumental data, and the Last Millennium Ensemble (LME) simulation. The proxy AMV closely follows the accumulated atmospheric forcing from the instrumental North Atlantic Oscillation (NAO) reconstruction ($r=0.65$) - an ``internal" source of AMV which can occur in the absence of external forcing. This provides strong observational evidence that much of the AMV is generated through the oceanic response to atmospheric circulation forcing, as previously demonstrated in targeted modelling studies.
The ensemble mean AMV in the LME reveals a substantial externally-forced component, which exhibits a modest but significant correlation with the proxy AMV (i.e. $r = 0.37$), implying that at least 13% of the AMV is externally-forced. In the LME simulations, however, the AMV response to accumulated NAO forcing is weaker than in the proxy/observational datasets - possibly related to the decadal NAO variability, which is substantially weaker in the LME than in observations. The externally-forced component of the proxy AMV is also related to the accumulated NAO forcing, indicating that the external forcing is influencing the AMV through different mechanistic pathways: via changes in radiative forcing in the LME and via changes in atmospheric circulation in the observational/proxy record.

Development, amplification and decay of European summer weather patterns linked to spring North Atlantic sea surface temperatures

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Abstract Type: Oral

A recent study has provided evidence that spring extratropical North Atlantic sea surface temperature (SST) gradients influence a specific pattern of summer atmospheric circulation, the summer East Atlantic (SEA) pattern. It was shown that a statistical model based on an index of the spring SST gradient was able to predict the SEA pattern with considerable skill (r=0.67).
Here, we investigate the physical mechanisms behind this relationship in both observations and coupled climate models. This includes the mechanisms responsible for the development, amplification, and decay of the SEA pattern.
A key result is that the observed SEA pattern amplification from July to August appears to be driven by positive feedback between the atmospheric circulation and SST involving anomalous surface fluxes. These surface fluxes include short wave radiation associated with changes in cloud cover.
The model representation of this relationship is assessed with the HadGEM3-GC2 global coupled climate model. The model is shown to reproduce some aspects of the observed relationship but the magnitude of the summer relationship is half the size of the observations. The analysis suggests that the weaker model signal could be a consequence of the misrepresentation of the physical processes associated with the observed positive feedback between the SEA pattern and SST in July and August.

Atmospheric Boundary Layer, stagnation events and Particular Matter connections over the Atacama Desert

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Abstract Type: Oral

The Atacama Desert in northern Chile plays a significant role in the economic development of the country, which is the largest producer of copper worldwide. The Desert spans vast areas of complex topography under the effect of both a persistent temperature inversion layer and the South Pacific Anticyclone. The Air Stagnation Index (ASI) was computed for the Atacama Desert (16ÂºS-32ÂºS) from outcomes of three Regional Climate Models forced by the IRA-Interim reanalysis throughout the evaluation experiment (1980-2015); UCAN-WRF341I (res 0,4 deg), RegCM-SAM44 (res 0,4 deg) and RegCM-CL09 (res 0,09 deg). Additionally, the daily-basis Ventilation Coefficient (VC) based on surface wind speeds and the Planetary Boundary Layer Height (PBLH), inferred from the observed Temperature Inversion Layer Height (TILH), was computed for five desert locations in the Antofagasta Region. This area was selected as it presents both high levels of PM10-PM2.5 and high frequencies of stagnant episodes. TILH was calculated from radio sounding observational data, and PM-wind time series were obtained from Chile's National Air Quality Information System (SINCA). A set of logistic statistic models comprising ASI and VC were fit to analyse the significance of stagnation and ventilation on PM events (daily mean > 80 ugm-3) at the five sites selected. Modelled ASI index suggests higher frequencies of stagnant days at lower latitudes where stagnation is present at least during the half of the year leading to a quasi-permanent stagnant condition given mainly by the extreme stable atmosphere along the coast and almost null precipitations. Although the three regional climate models consistently reproduced vast stagnant areas, the finest model (RegCM-CL09) suggests higher frequencies than the coarser ones, reaching until 270 stagnant days/year in some locations in the northern Atacama. In the Antofagasta Region, a response of extreme PM events to ASI index is observed. The above is supported by the high significance of both VC and wind speed at 500 hPa consistently observed in the logistic models (Area Under ROC Curve > 0.8) suggesting synoptic connections with PM events. Under the RCP4.5 Climate Change scenario, modelling outcomes suggest an increasing frequency of stagnant events in some areas of Northern Atacama. Also, a decreasing trend of the boundary layer thickness is projected at lower latitudes. Further research based on a coupled climate-chemical modelling approach is proposed.

Understanding the Signal-to-Noise Paradox with Nonlinear Dynamics

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Abstract Type: Oral

Using a simple Markov Chain model of circulation regime behaviour in the North Atlantic region, we show that the Signal-to-Noise paradox identified in seasonal forecasts by Eade et al (2014) can be understood in terms of a nonlinear model error whereby the model basins of attraction are too shallow, with weak persistence characteristics, compared with reality. This model may also help understand interdecadal variability in this signal-to-noise diagnostic as identified by Weisheimer et al (2018). Both increased resolution and stochastic parametrisation should help mitigate this model error.

The study of topographic changes of the middle levels of the atmosphere and its effect on the heat increase in the Middle East

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Abstract Type: Oral

The Middle East region being located in the world's dry belt is among the vast and strategic parts of the world, whose water resources, agriculture and vegetation are gradually deteriorating. Since most environmental characteristics are directly or indirectly explained in relation to topographic changes of atmospheric pressure levels (500 HPa), the study of the main causes of climate change in the Middle East region is of particular importance. For this purpose, first, the altitude data of contour 500 hpa of the atmosphere and the temperatures of January and February for the past half-century (1968-2017) for a range of studies with dimensions of 25-77.5 degrees longitude and of 10-45 degrees latitude were taken and summarized from the NCEP/NCAR. Using factor analysis and clustering, homogeneous regions were identified. The temperature trend and the significance test of its changes were performed using the Mann-Kendall statistical and graphic method. Using the correlation and multiple regressions, the equation governing the status of the process of temperature changes in each of the Middle East countries was calculated and analyzed. Eventually, Using GIS, the results of climate change were prepared and analyzed in form of illustrative maps.
The results of the study showed that over the past half century, both the western wind wave has been displaced by 2.5 degrees to higher geographic latitudes, and the frequency and the trough axis of the western winds ridge affecting the Middle East region have changed. Following these changes, isothermal lines of all Middle Eastern countries rose by 1.5 to 2.5 centigrade during the winter rainfall. From south to north-east of the region, the isothermal lines have moved from 250 to 150 kilometers to higher latitudes respectively. The most significant increase in temperature was in February, and in southern Iran, Iraq and Syria, temperatures have risen more than other regions.

Analysis of tropospheric NO2, HCHO, HONO and O3 from three years of remote and urban MAX-DOAS measurements in Australasia

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Abstract Type: Oral

Tropospheric ozone chemistry is integrally linked to nitrogen oxides (NOx) and volatile organic compounds (VOC) in a complex, non-linear fashion, underpinning the lower atmosphere's self-cleansing capability. Understanding such oxidative processes is crucial for pollution and greenhouse gas chemistry and local aerosol formation. Multi-axis differential optical absorption spectroscopy (MAX-DOAS) is ideally suited to studying the tropospheric oxidative cycle as it can provide vertically resolved information on a number of key species including nitrogen dioxide (NO2), formaldehyde (HCHO), nitrous acid (HONO) and ozone (O3). This study compares results from MAX-DOAS measurements, ongoing since 2016, at an urban site in Melbourne, Australia and a rural site at Lauder, New Zealand. NO2 and HCHO are consistently retrieved both at Lauder and Melbourne, while HONO is observed above the MAX-DOAS detection limit only in Melbourne. NO2 and HCHO are typically 10 times higher in Melbourne than at Lauder. Using the ratio of HCHO to NO2 (Rfn) as an indicator of tropospheric ozone formation regime, Lauder consistently exhibits NOx-limited conditions (Rfn >; 0.5). Ozone formation in Melbourne is also typically NOx-limited however is strongly seasonally-dependent, tending towards VOC-limited in winter (0.05 < Rfn < 1.0). This analysis of tropospheric ozone formation conditions is made in conjunction with the first attempts to retrieve Southern Hemisphere tropospheric ozone profiles entirely from MAX-DOAS measurements.

Long range predictability of climate, atmospheric angular momentum and the length of day

Main Author: Prof Adam Scaife
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Affiliation: Met Office Hadley Centre
Abstract Type: Oral

We use decadal climate predictions, initialised with the concurrent state of the climate, to show that year to year variations in total angular momentum of the atmosphere are predictable out to to more than a year ahead. This in turn provides predictability of the length of day out to the same range due to the well established relationship between atmospheric angular momentum and Earth's rotation rate. The source of this predictability appears to be largely attributable to the El Nino Southern Oscillation and the level of predictability varies non-monotonically with lead time: it has clear peaks in winter and clear troughs in summer following the start of the prediction. We also outline some further questions raised by this analysis.

First results from the UKESM1 CMIP6 scenarioMIP ensemble of future projections.

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Abstract Type: Oral

A five-member ensemble of UKESM1 future projections, covering the period 2015 to 2100, has been run following the CMIP6 scenarioMIP experiment protocol and forcing data. We present initial results from five scenarioMIP shared socioeconomic pathways (SSPs), including one designed as a scenario to limit the global mean surface temperature increase at 2100 to less than 1.5°C above pre-industrial values. We present the temporal evolution of UKESM1 in key climate variables, such as surface temperature, precipitation and carbon uptake, sampled across the scenarios.

An overview of Atmospheric Pollution and Human Health in a Chinese Megacity research program (APHH-Beijing)

Main Author: Dr Zongbo Shi
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Abstract Type: Oral

APHH-Beijing (Atmospheric Pollution and Human Health in a Chinese Megacity) is an international collaborative project to examine the emissions, processes and health effects of air pollution in Beijing. This presentation provides an overview of APHH-Beijing programme as a whole including its four research themes: (1) sources and emissions of urban atmospheric pollution; (2) processes affecting urban atmospheric pollution; (3) exposure science and impacts on health; and (4) interventions and solutions to reduce health impacts. It will then introduce the two cross-theme intensive field campaigns in Beijing including the meteorological and air quality conditions, which put the campaign observations in the context of long-term climatology. It will also highlights some of the scientific outputs from this programme.

An extension of the online atmospheric model WRF-Chem with bioaerosols at the species level

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Abstract Type: Oral

Background: Bioaerosols are a complex mixture in the atmosphere consisting of bacteria, pollen, spores, debris etc.. Pollen and spores receive considerable attention due to their effect on human health and vegetation but many bioaeraerosols play an important role in the atmosphere. These bioaerosols can potentially be analysed with numerical models. Furthermore it has been proposed that bioaerosols have a profound impact on meteorology and climate by affecting meteorology, e.g. in relation to the radiation or the hydrological cycle. Currently, there is very limited possibility to analyse a large range of specific bioaerosols in relation to all the main questions using numerical models. This stand in contrast with a revolution that is currently happening in relation to the detection of bioaerosols. A generic approach within a so-called online atmospheric model is therefore needed.

Method: We have extended the WRF-Chem model with a scheme for bioaerosols, that may be detected using either optical microscopes and molecular genetics. The scheme has been developed by modifying both the preprocessing part of WRF-Chem and several sub-modules. This includes the GOCART scheme, biological growth models and an emission model. Furthermore, a number of surface data sets have been prepared, which enable simulations over large domains while also maintaining the flexibility found within the WRF/WRF-Chem model package. This links to important aspects of the geographical setup such as grid resolution and choice of physical parameterisations. Here we present the model design and model results for two important bioaerosols. The model results cover atmospheric transport of pollen from birch trees and the invasive plant ragweed, both important aeroallergens relevant for human health.

Results: Model results over the UK with birch pollen and particulate matter show that the model is able to simulate plumes of bioaerosols arriving in the UK from the South during the beginning of the birch pollen season. The model simulations also demonstrate, that when applying the feedback mechanism in WRF-Chem, during episodes with elevated particulate matter and dust, there can be a statistical significant feedback from radiation on pollen concentration. Model simulations with ragweed pollen over Europe show considerable skill in relation to simulation of the exposure to ragweed pollen both within the main source regions as well as in regions away from the main emission areas.

Conclusion: An extension to WRF-Chem has been developed with the specific aim to enable simulations of bioaerosols and their impact on human health and the overall environment. Model results are promising and the aspect of extending WRF-Chem enables a number of new uses of WRF-Chem in relation to research, scenarios and forecasting.

UKESM-hybrid: focusing resolution where it's most needed

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Abstract Type: Oral

An Earth system model contains numerous scientific components. Some, such as the core dynamics and moist parameterizations, are known to benefit from higher model resolution, others, such as aerosols and chemistry are computationally expensive but there is less evidence of a direct performance benefit from increased model resolution. We describe development of a UKESM hybrid resolution model, where we interactively apply one model resolution to the simulation of physical and dynamical atmospheric processes and another, coarser resolution, to atmospheric aerosols and chemistry. Specifically we run two atmospheric models concurrently: with the higher resolution model simulating only atmospheric physical and dynamical processes, which we call Senior (Snr); and the lower resolution model simulating all processes, including atmospheric chemistry and aerosols, referred to as Junior (Jnr). The physical atmosphere simulated by the Snr model controls the evolution of the physical atmosphere in Jnr, where aerosol and chemistry processes are calculated. These fields are then passed back to the Snr model to influence evolution of the physical atmosphere in the Snr model. In this way we retain the benefits of high model resolution for simulating physical and dynamical atmospheric processes, while also retaining the forcing from detailed simulation of aerosol and chemistry processes, but carried out at a lower resolution and thus significantly reduced computational cost.

Thus far the hybrid configuration, UKESM-hybrid (N216-N96 ORCA025), consists of a N216 Snr Unified Model atmosphere (UM), a N96 Jnr UM and an ORCA025 (0.25° resolution) physical ocean (NEMO-ORCA). Ocean biogeochemistry (simulated by the MEDUSA model) has been disabled in this configuration to improve the computational speed of the ocean (a hybrid approach to ocean biogeochemistry will be considered later). Chemistry and aerosols currently slow the UM by a factor of ~3 (200% slower). Hence, both chemistry and aerosol are removed from the Snr N216 UM and are only simulated in Jnr. Coupling between all models components is done through the OASIS3-MCT coupler at each model hour, directly after the aerosol and chemistry calculations are made in Jnr. This means the 48 3D UKCA fields Snr requires from Jnr are available for coupling at the earliest opportunity. These fields are re-gridded from the Jnr grid to the Snr grid using OASIS. To constrain the physical atmosphere in Jnr to follow Snr, a number of dynamical core fields are passed from Snr to Jnr, with re-gridding also performed by the coupler. These fields overwrite the equivalent native variables in Jnr.
For the UKESM configuration without MEDUSA, UKESM-hybrid (N216-N96 ORCA025) is around 65% faster than the full UKESM N216 ORCA025, while results indicate both the simulated physical climate, as well as simulated aerosol and chemistry fields,from the two models are quite similar.

Climate science needs to take risk assessment much more seriously

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Abstract Type: Oral

For decision makers, climate change is a problem in risk assessment and risk management. It is, therefore, surprising that the needs and lessons of risk assessment have not featured more centrally in the consideration of priorities for physical climate science research, or in the Working Group I contributions to the major Assessment Reports of the Intergovernmental Panel on Climate Change. This presentation will discuss the reasons, which include a widespread view that the job of physical climate science is to provide predictions and projections - with a focus on likelihood rather than risk - and that risk assessment is a job for others. This view is incorrect. There is an urgent need for physical climate science to take the needs of risk assessment much more seriously. The challenge of meeting this need has important implications for priorities in climate research, climate modelling and climate assessments.

Coupled interactive fire-atmospheric chemistry model

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Abstract Type: Oral

Fires constitute a key process in the Earth system (ES), being driven by climate as well as affecting the climate by changing the atmospheric composition and having an impact on the terrestrial carbon cycle. However, global modelling studies on the effects of fires on atmospheric composition, radiative forcing and climate have been very limited to date. The aim of this work is the development and application of a fully coupled vegetation-fire-chemistry-climate ES model and the use of this to quantify the impacts of fire variability on atmospheric composition-climate interactions in present and future worlds. The models used in this framework are JULES for the land surface, INFERNO to represent fires, the UM for the atmosphere and UKCA for atmospheric chemistry and aerosols. Preliminary results show an acceptable performance of the fire-atmosphere coupling when compared to its standalone version. For the period between 1997 and 2009, the coupled model is able to reproduce observed present day global climate fire burnt area. However, both coupled and standalone demonstrate spatial skill but not temporal skill; the experiments tend to overestimate the amount of burnt area during the low fire season (February to May). Since emissions from fires are calculated based on burnt area, the differences in burnt area are also reflected in the total emissions. This work presents an assessment of the effects of interactive fire coupling has on atmospheric chemistry and climate.

Interaction of Convective Organisation with Monsoon Precipitation, Atmosphere, Surface and Sea: the 2016 INCOMPASS field campaign in India

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Abstract Type: Oral

The INCOMPASS field campaign combines airborne and ground measurements of the 2016 Indian monsoon. The monsoon supplies the majority of water in South Asia but forecasting from days to the season ahead is limited by large, rapidly developing errors in model parametrizations. The lack of detailed observations prevents thorough understanding of the interaction between monsoon circulation and the land surface: a process governed by boundary-layer and convective-cloud dynamics.

INCOMPASS used the UK Facility for Airborne Atmospheric Measurements (FAAM) BAe-146 aircraft for the first project of this scale in India, to accrue almost 100 hours of observations in June and July 2016. Flights from Lucknow in the northern plains sampled the contrast in surface and boundary layer structures between dry desert air in the west and the humid environment over the northern Bay of Bengal, during pre-monsoon and monsoon conditions. Flights from Bengaluru in southern India measured contrasts from the Arabian Sea, over the Western Ghats mountains, the rain shadow of southeast India and the southern Bay of Bengal. Flight planning was aided by forecasts from bespoke 4 km convection-permitting models at the Met Office and India's NCMRWF.

On the ground, INCOMPASS installed eddy-covariance flux towers to provide detailed measurements of surface fluxes and their modulation by diurnal and seasonal cycles. These data will be used to better quantify the coupling between the atmosphere and land surface.

Here we describe emerging results from the INCOMPASS field campaign and associated modelling work and implications for monsoon prediction.

Airmass analysis of the processes driving the progression of the 2016 Indian summer monsoon

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The Indian summer monsoon is a vital source of water and a cause of severe impacts for more than a billion people in the Indian subcontinent. The INCOMPASS project investigates the mechanisms driving its onset and progression through an observational field campaign supplemented by high-resolution convection-permitting numerical simulations for the 2016 season.

These simulations show that the progression of the monsoon over northern India in June 2016 is a non-steady process, modulated by the interaction between moist low-level south-westerly flow from the Arabian Sea and an overrunning north-westerly incursion of dry air from Central Asia. The balance between these two airstreams controls the development of convection and it is closely influenced by mid-latitude dynamics and by the associated, via southward PV-streamers propagation, formation of cyclonic vortices in the region.

Particular focus has been devoted to the use of Lagrangian trajectories to characterise the evolution of the aforementioned airstreams. The trajectories confirm that the interaction between them is a primary driver of the general moistening of the troposphere associated with the monsoon progression. The trajectories also highlight the effects of diabatic processes on the airstreams, stressing the importance of local evaporation from the Arabian Sea in addition to moisture transport from remote sources.

In summary, this combined Eulerian and Lagrangian analysis highlights the non-steady nature of monsoon progression over northern India, driven by the interaction of different air masses and influenced by a synergy of factors on different scales, such as higher-latitude dynamics, transient weather systems and local diabatic processes.

Seasonal forecasts of the 20th Century

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Abstract Type: Oral

Forecasts of seasonal climate anomalies using physically-based global circulation models are routinely made at many operational meteorological centres around the world. A crucial component of any seasonal forecast system are the retrospective forecasts, or hindcasts, from past years which are used to estimate skill and to calibrate the forecasts. Hindcasts are usually produced over a period of approx. 20 years. However, recent studies found that seasonal forecast skill can undergo pronounced variations at multi-decadal time scales. These results imply that relatively short hindcasts are not adequate for estimating the performance of seasonal forecasts and that small hindcast sample sizes can lead to skill estimates that are not robust.

Here we present results from new and unprecedented 110-year-long seasonal hindcasts based on simulations with ECMWF's coupled atmosphere-ocean-sea-ice model over the period 1901 to 2010. Initial data come from the coupled reanalysis CERA-20C. It is shown that the model performance for the recent period is in good agreement with those of operational models. Consistent with previous findings based on atmosphere-only hindcasts using prescribed SSTs, a drop in forecast skill during the middle of the 20th Century is found for a range of atmospheric fields including large-scale indices such as the North Atlantic Oscillation and the Pacific/North American pattern.

We would also like to advertise a new online dissemination platform for our hindcasts and sensitivity experiments, and invite the wider scientific community to explore their outputs.

Quantifying the effect of Asian circulation biases on the climate responseto aerosol forcing

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Abstract Type: Oral

Asian climate, and the summer monsoon in particular, represents one of the long-standing biases in climate models. Such dynamical biases can affect a model's ability to represent observed changes in Asian climate in response to changes in aerosol emissions. However, the accumulation and distribution of aerosol can be very diverse across models, even when the same emissions are prescribed. This can make inter-model differences that arise for other reasons, such as differences in the model representation of the atmospheric circulation, difficult to identify.
We use Easy Aerosol experiments to isolate the impact of background circulation on the simulated response to aerosol forcing. These experiments, performed with six atmosphere-only models, use idealised representations of aerosol forcing, which removes the effect of different aerosol distributions on simulated responses. The only differences between the model simulations are the model dynamics. Exploiting this, we identify systematic relationships between each model's circulation biases, such as the position of the ITCZ or in the strength of the Asian summer monsoon, and its simulated responses to aerosol forcing.

This quantification of how mean-state uncertainty translates into dynamical response uncertainty will aid the understanding of the role of model biases in climate projections, and offers the potential for reducing uncertainty in projections of Asian climate via observational constraint.

Increased shear in the North Atlantic upper-level jet stream over the past four decades

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Earth's equator-to-pole temperature gradient drives westerly mid-latitude jet streams through thermal wind balance. In the upper atmosphere, anthropogenic climate change is strengthening this gradient by cooling the polar lower stratosphere and warming the tropical upper troposphere, acting to strengthen the upper-level jet stream. In contrast, in the lower atmosphere, Arctic amplification of global warming is weakening the meridional temperature gradient, acting to weaken the upper-level jet stream. Therefore, upper-level trends in the speed of the jet stream represent a closely balanced tug-of-war between two competing effects. Here we isolate one of the competing effects, by studying the upper-level shear instead of the upper-level speed. We use three different reanalysis datasets to show that, while the zonal wind speed in the North Atlantic polar jet stream at 250 hPa has not significantly changed since the start of the observational satellite era in 1979, the vertical shear has increased by 16%. We further show that this trend is attributable to the thermal wind response to the enhanced upper-level meridional temperature gradient. The increased shear is consistent with the intensification of clear-air turbulence expected from climate change, which will affect aviation in the busy transatlantic flight corridor. We conclude that the impacts of climate change on the upper-level jet stream are being partly obscured by the traditional focus on speed rather than shear.

The utility of seasonal forecast information for drought risk assessments

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Abstract Type: Oral

Millions of livelihoods in Sub-Saharan Africa (SSA) depend on rain-fed agriculture and are therefore vulnerable to droughts (deficit rainfall) resulting in poor harvests, crop failure and subsequent food insecurity. However, recent improvements in early warning systems and weather forecasts are increasing the potential to foresee drought events and inform preparedness actions to minimise adverse impacts. By combining historical and present-day observations, TAMSAT-ALERT (Tropical Applications of Meteorology using SATellite data and ground-based observations, AgriculturaL EaRly warning sysTem) is a drought monitoring and decision support tool which can skilfully anticipate drought risk 1-2 months in advance. Here we investigate the added-value of incorporating seasonal meteorological forecast information into TAMSAT-ALERT. Specifically, we assess the impact and implications of the complex spatial variability of seasonal rainfall across SSA on the use of forecast information for rainfall monitoring and integration within drought-risk assessments. This highlights the importance of understanding the relevance and skill of meteorological forecasts for anticipating drought risk at local community-relevant scales.