Student and Early Career Conference

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BOOK OF ABSTRACTS

CONTENT

Extracting likely scenarios from high resolution ensemble forecasts in real-time

Kris Boykin, University of Reading

Session: Session 1: Weather Extremes

Currently, the Met Office produces a high-resolution ensemble forecast, MOGREPS-UK, which is intended to be used for forecasting local weather and high impact weather. However, each member produces large amounts of data that the forecaster cannot easily digest in real time and the ensemble mean and spread are also likely to smooth out significant features due to the position errors often being larger than the scale of the feature itself, such as a severe thunderstorm or strong wind event. The aim of this project is to determine distinct plausible scenarios within the members through different clustering techniques, such as K-means clustering, focusing on the finer features of interest and different weather impacts. Three different approaches will be explored including a top down approach, from global down to local patterns, a bottom up approach, focusing on weather variables at high resolution, and a method involving physical insight before further clustering and analysis. These groupings should be similar in terms of outcomes and should allow the forecaster to assign probabilities to each one. These probabilities can then be passed to users who can feed this information into risk-based decision making. Preliminary results will be presented using the near-surface temperature and humidity field across the UK to cluster high resolution forecasts.

Storm Dynamics Leading to Rare and Severe Hailstorms: Case Studies over Singapore

Isaac Tan, University of Leeds

Session: Session 1: Weather Extremes

Hail associated with intense thunderstorms is rare over Singapore and most of the equatorial tropics. Due to the warm climate all year round, hailstorms in Singapore only occur approximately once every few years. Between 2008 and 2018, there were only six reported cases of hail over different parts of Singapore. However, even rare hailstorms can cause damage to infrastructure, property, and crops, and are often accompanied by other hazards such as flooding from intense rainfall, and strong winds from cold downdrafts that reach the surface and spread horizontally. Additionally, hail occurrences are very localised and short-lived, posing challenges in accurate real-time detection and forecasting.

In this study, a combination of ground-based weather station, weather radar, and remote sensing observations, along with news reports of hail occurrences on 25 June 2013 and 30 January 2018 were used to analyse the dynamical and microphysical processes that contributed to the development of this rare phenomenon. Reanalysis data and upper-air soundings were also used to investigate the pre-convective conditions prior to each hail event. It was found that both hail events coincided with high amplitude, dry phases of the Madden Julian Oscillation (MJO), vertical wind shear, and dry intrusions at the mid-tropospheric levels. According to ground-based weather station data, the hailstorms were accompanied by heavy rain rates, strong winds, and sharp decreases in dry-bulb temperature (DBT). Using weather radar observations, the hail core was identified against the background intense rainfall by combining the reflectivity (Z) parameter with differential reflectivity (ZDR), specific differential phase (KDP), and radial velocity (V). Finally, there was a clear correlation between the hail core and lightning strikes density.

Using a hierarchical triangular mesh and feature tracking algorithm to track North Atlantic storms from the ERA5 reanalysis dataset

Erin Walker, University of Bristol

Session: Session 1: Weather Extremes

A large proportion of extreme weather events in Western Europe are a result of extratropical cyclones (ETC) travelling across the Atlantic Ocean. Dangerous ETCs bring with them many negative socio-economic impacts and are expected to change in the future as a result of climate change. A hierarchical triangular mesh and a feature-tracking algorithm created by Massey (2016) has been used to track North Atlantic ETCs from the ERA5 dataset, released by the European Centre for Medium-Range Weather Forecasts. Using the high-resolution mesh offers an improved method for tracking storms at higher latitudes, as it overcomes the issues included in tracking storms on a regular latitude-longitude grid. Storm tracks and densities will be compared with the results of ERA-Interim to provide a better insight into the recent storms hitting Western Europe. The aim is that this method will provide better estimates of North Atlantic ETC tracks for different climate change scenarios.

Thermals in deep convective updrafts

Liam Till, University of Reading

Session: Session 1: Weather Extremes

Convective storms are responsible for severe weather on short time scales and can become organised into larger longer lived systems. Forecasting the timing and size of storms is still a challenge for operational weather forecasts. Convection evolves through the vertical air motion feeding the storm. Understanding and representing the dynamics of this vertical motion is crucial to predicting the evolution of convective clouds. Previous research using observations and numerical simulations of shallow convection have shown that the vertical motion evolves through a series of successive thermals. Observations of thermals in deep convection are limited. Here, we have detected and tracked thermals in deep convective clouds observed using ground based radar in Southern England. Tracking utilises the fact that thermals are identified as features of variability in Doppler winds in the radar data. Using multiple cases, thermals are identified in consecutive scans and are found to be ascending throughout deep convective clouds. The relationship of thermals with the vertical motion is assessed in terms of the ascent depth, number of thermals per updraft and ascent rate. These properties can have implications for entrainment and microphysics in convective clouds. Further high-resolution radar observations using the Chilbolton radar will be carried out to further investigate this.

The Global Distribution and Interannual Variability of Severe Convective Storm Environments

Amethyst Annie Johnson

Session: Session 1: Weather Extremes

The large-scale environmental conditions for the formation of severe convective storms are generally well known. Such storms have been studied extensively over the United States, but these conditions have not been explored globally or over a long time period (e.g., decades). With the advent of global reanalyses and high-powered computers with large data-storage systems, we have the ability to begin to ask the question, “What is the distribution of the environments for convective storms over the globe?” and “What is the interannual variability of the environments for convective storms over the globe?” This research project aims to answer these two questions. To achieve this, over 3 billion datapoints from the European Centre for Medium-Range Weather Forecasts’ Interim reanalysis have been used to calculate the quantities that describe the environment of convective storms on a global scale, for a twice-daily period of 39 years. By reviewing previous studies, thresholds have been determined and applied to the data to produce a more complete understanding of where these environments lie. The aim is to present these results in map plots for the easy visualisation of hotspots, as well as density scatter plots with marked thresholds to demonstrate the year-on-year variation.

Impact of Air Pollution on Cognitive Function

Tom Faherty, University of Birmingham

Session: Session 2: Air Quality & Atmospheric Chemistry

The impact of pollution on human cognition is understudied despite other health impacts being well known (Pope & Dockery, 2006).

Exposure to air pollution causes Neuroinflammation through multiple processes (Calderón-Garcidueñas et al., 2008). The hippocampus, responsible for learning and memory, is particularly susceptible to inflammation changes (Farrar, Kilian, Ruff, Hill, & Pert, 1987) with rodent studies show a deficit in spatial memory after both induced Neuroinflammation and direct exposure to air pollution (Barrientos et al., 2009; Oppenheim et al., 2013). Recent evidence suggests that ability to distinguish emotions of others is compromised by increased brain inflammation levels (Balter et al., 2017), however this has not been tested with direct comparison to pollution exposure.

60 non-smoking, clinically normal participants will complete a study with a cognitive test for spatial memory (MemoryArena), social cognition (SocialGo), and executive function (Transfer learning), as well as providing details of recent air pollution exposure and inflammation levels using the Pollution Exposure and Lifestyle (PEL) questionnaire. In a mixed crossover design over two days, participants will be exposed to increased levels of PM due to a candle burning in the testing room prior to testing, or to ambient levels of PM when no candle manipulation is used (sham).

It is predicted that participants exposed to the candle manipulation will have a higher distance error on the MemoryArena task, make more errors & take longer to determine facial expressions on the SocialGo task, and take more trials to learn complex associations on the transfer learning task, compared to participants exposed to the sham condition. Results will be controlled for lifestyle impacts on neuroinflammation such as weight and recent sickness.

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Ozone Depletion Potentials of Chlorinated Very Short-Lived Substances

Tom Claxton, Lancaster University

Session: Session 2: Air Quality & Atmospheric Chemistry

Chloroform (CHCl3), dichloromethane (CH2Cl2), perchloroethylene (C2Cl4) and 1,2-dichloroethane (C2H4Cl2) are chlorinated Very Short-Lived Substances (Cl-VSLS) with a range of commercial/industrial applications. The sources of these substances are mainly anthropogenic, particularly for CH2Cl2, and observed surface mixing ratios of this Cl-VSLS have increased rapidly in recent years. Recent studies also highlight the increasing influence of Cl-VSLS on the stratospheric chlorine budget and therefore their possible role in ozone depletion.

A three-dimensional chemical transport model (TOMCAT/SLIMCAT) has been used to evaluate the ozone depletion potential (ODP) of these Cl-VSLS and investigate sensitivity to emission location/season. This was done in two stages: the first used unit emissions from five industrially significant regions to determine the injection into the stratosphere of Cl-VSLS, in addition to their product gases HCl and phosgene; the second used these injections as perturbations to investigate the changes in stratospheric column ozone due to these Cl-VSLS, to calculate ODPs.

The seasonal dependence of the ODPs is small but ODPs vary by a factor of 2-3 depending on the continent of emission: 0.0146-0.0255 (CHCl3), 0.0102-0.0202 (CH2Cl2), 0.006-0.0182 (C2Cl4) and 0.0032-0.0109 (C2H4Cl2). Asian emissions produce the largest ODPs owing to proximity to the tropics and efficient troposphere-to-stratosphere transport of air originating from industrialised East Asia. With Asian emissions hypothesised to increase in the last decade, the potential for greater ozone depletion is higher. The Cl-VSLS ODPs are generally small but the upper ends of the CHCl3 and CH2Cl2 ranges are comparable to the mean ODP of methyl chloride (0.02), a longer-lived ozone-depleting substance.

Air Quality and Climate Impact of Charcoal Use in Africa

Alfred S. Bockarie, University of Birmingham

Session: Session 2: Air Quality & Atmospheric Chemistry

Demand for charcoal in Africa is growing at a rate of 7 % per year, due to unavailable and unaffordable energy alternatives. Its production and use, including plastic burning in low-income households to initiate combustion, release large quantities of trace gases and aerosols that impact air quality and climate. Here we develop an inventory of emissions of reactive trace gases and aerosols to assess the impact of the production, use, and transport of charcoal in Africa in 2014 on air quality and climate. We combine open access datasets of land cover, population density and demographics, road network and United Nations energy statistics for African countries to map charcoal production to production zones 5-10 km from major roadways, transport by unregulated trucks to urban centres, and use in urban households. We estimate that 208 Tg of fuelwood is used to produce charcoal (24 % of annual biomass burned from intense seasonal open fires in Africa) and 1277 tonnes of plastic is burned. Emissions from charcoal are highest in East and West Africa where most of the charcoal is produced and in densely populated urban areas where charcoal is consumed. Total annual emissions are 0.03 Tg BC, 0.07 Tg OC, 15 Tg CO, 0.07 Tg NOx, 1.9 Tg CH4 and 0.02 Gg HCl. The inventory is developed for 2014, but can be estimated for other years using urban population as a predictor for annual trends in charcoal emissions. Finally, we apply the inventory to the GEOS-Chem chemical transport model to estimate the contribution of charcoal production, transport, and use in Africa to regional air pollution (fine particles and ozone) and global climate.

Megacity Carbon Emissions from Atmospheric Observations

Daniel Hoare, University of Bristol

Session: Session 2: Air Quality & Atmospheric Chemistry

The Intergovernmental Panel on Climate Change's Special Report on 1.5ºC Warming highlights the need for rapid reduction in greenhouse gasses such as carbon dioxide and methane. Cities and urban areas are some of the largest and most concentrated emitters, but city governments have opportunities to reduce emissions not present at the national level. For these reasons, urban areas are key to ensuring that the negative impacts of climate change are avoided.

Atmospheric concentrations of greenhouse gases are tracked through ground-based sites located across the world, and the UK government uses a national network of these sites to estimate its carbon emissions each year through inverse modelling. This work will utilise a new, dense network of atmospheric observations throughout the megacity London to infer and track emission rates using a Bayesian framework. The data from this network will be combined with space-based measurements from the latest generation of satellites to further constrain emission estimates.

In order to successfully infer emissions at the urban scale, the chemical transport model will be improved to take advantage of high-resolution meteorology and use new turbulence parametrisation to handle effects such as increased surface roughness and the urban heat island. It is expected that local pollution events will occur at scales finer than the high-resolution meteorology can resolve, and this must be mitigated using careful site selection and data filtering to allow the Bayesian model to infer emissions correctly. These results can then be used to verify both emission reductions and emission inventories produced by the Greater London Authority.

Assessment of aerosols characteristics over Indian mega city using satellite and ground based instrument measurements

Kanika Taneja, Jamia Millia Islamia

Session: Session 2: Air Quality & Atmospheric Chemistry

In order to understand the effect of aerosols on climate, it is essential to know their optical properties as well as spatial and temporal variability. The present study is focused on the megacity Delhi and its surrounding areas which are the most polluted urban regions in the world. The spatial and temporal heterogeneities of aerosol distribution can be well determined by satellites on global scale, whereas regional scale studies with satellite retrievals reveal uncertainties. With this purpose in consideration, ground-based instruments have been developed to validate the satellite data. So far, MODIS-derived aerosol properties over land and ocean have been validated by Aerosol Robotic Network (AERONET) stations worldwide. But discrepancies still remain in understanding the aerosol properties in many parts of the world, especially over the Indian sub-continent due to the absence of sufficient numbers of ground-based aerosol monitoring stations. the satellite data is statistically verified and validated with the ground based sky radiometer instrument installed at New Delhi. The statistical parameters for comparing the MODIS with SKYNET data like R value (0.571), RMSE (0.330), and Bias (0.760) were found to be highest for the year 2011. It is observed that MODIS data tends to overestimate SKYNET data during winter months of December and January in all the years. Finally, the relationship between land-use structure and satellite retrieved AOD has been analyzed for the first time over Delhi and the impacts of topography on the aerosol distribution has been discussed.

Global Sources of Gravity Waves: Ray-Tracing AIRS Measurements on the Global Scale

Jon Perrett, University of Bath

Session: Session 3: Atmospheric Dynamics

Gravity Waves (GW's) deposit energy and momentum throughout the atmosphere, and play an important role in influencing the dynamics of the atmosphere. They can be generated by winds flowing over mountains, storms, and other atmospheric processes. Measuring their global sources and sinks is vital for developing the next generation of weather forecasting models, and to further our understanding of atmospheric dynamics.

Using a 3-D Stockwell Transform-based method, we analyse a month of wave measurements derived from global high-resolution data from the Atmospheric Infrared Sounder (AIRS). We ray-trace these data using the Gravity wave Regional Or Global RAy Tracer (GROGRAT), with background wind and temperature taken from the ERA5 reanalyses dataset (ECMWF Reanalysis 5).

Our results allow us to identify key wave sources and sinks at the global scale. In particular, the number of waves that we trace facilitates the quantification of subtropical and southern hemispheric mountain wave momentum budgets with unprecedented accuracy.

Vertical Structures of Precipitation Microphysics and Latent Heat from the Global Precipitation Measurement Mission Core Observatory

Daniel Watters, University of Leicester

Session: Session 3: Atmospheric Dynamics

Satellite observations provide the potential to improve our understanding of precipitation. For the past 5 years, the Global Precipitation Measurement Mission Core Observatory has provided three-dimensional precipitation measurements over the tropics and mid-latitudes. The dual-frequency precipitation radar on-board is the first of its kind in space, and enables investigation of the microphysical processes of precipitation. Furthermore, radar precipitation observations provide estimates of the latent heat released into and absorbed by the atmosphere. This research investigates the vertical structures of microphysics and latent heat inferred from radar measurements for different types of precipitation (convective, stratiform, shallow, isolated, etc.) across different regions of the global ocean. Furthermore, convective-stratiform ratios are determined for different oceanic regions; the ratio is 0.80 over the Atlantic Inter-Tropical Convergence Zone and 0.14 over the northern Atlantic Ocean. With such results, there is the possibility to evaluate precipitation models. In particular, comparison of the radar-derived vertical structures of latent heat and microphysics with simulations will aid in identifying model inaccuracies on the local scale. Representation of latent heat flux within simulations of the global energy budget may improve as a result.

Knowing Meteors, Knowing U: Using Meteor Radar to Investigate Horizontal Winds, Waves and Tides in the Mesosphere

Shaun Dempsey, University of Bath

Session: Session 3: Atmospheric Dynamics

The dynamics of the middle atmosphere are strongly affected by gravity waves. These waves play an important role in the transfer of momentum and energy between the lower and middle atmosphere. The waves can be generated by winds blowing over mountains, jet stream instabilities, storms or in-situ secondary excitation. The momentum fluxes of gravity waves largely drive the zonal and meridional winds in the planetary-scale circulation of the mesosphere.

Global Circulation Models (GCM) under represent gravity-wave momentum flux and variance near 60o S leading to the so-called cold pole problem. Further, there is a need to specify mesospheric gravity wave fluxes to constrain GCMs that are extended to the mesopause and above. There is thus a need to measure gravity wave fluxes at these latitudes and heights. Here we measure the winds and gravity waves of the mesosphere using a meteor radar on the isolated, mountainous island of South Georgia in the Southern Atlantic (54o S, 36o W).

The observations reveal a rich field of background winds, planetary waves, tides and gravity waves. The background winds show strong zonal wind shears in summer accompanied by an equatorward flow. Statistical measurements of the gravity-wave field reveal a strong seasonal cycle with a winter maximum in variance superimposed on which is significant short-term variability. We consider the causes for both the seasonal cycle and short-term variability in terms of filtering by background winds and the variability of gravity-wave sources.

Antarctic Atmospheric Waves and Tides in Airglow

Anna Clark, British Antartic Survey

Session: Session 3: Atmospheric Dynamics

One of the main science priorities for Antarctica is to understand the global impacts of processes that happen in the Antarctic atmosphere.

The mesosphere and lower thermosphere (MLT), at altitudes between 50km and 120km, is a highly dynamic region that couples the lower atmosphere with the upper atmosphere.

The dynamics of the MLT region are strongly affected by thermally forced atmospheric tides, global scale planetary waves and upward propagating small-scale gravity waves. These waves play an important role in the transfer of momentum and energy between layers of the atmosphere.

Using an airglow spectrometer to measure hydroxyl airglow emissions near the mesopause, it is possible to determine the properties of atmospheric waves and tides by analysing how the temperature of the mesosphere varies over time.

By drawing on sixteen years of observational data from the Halley and Rothera stations in Antarctica, we will show the long-term variations in planetary waves, atmospheric tides and gravity waves. Additionally, we will extract other contributors to the observed temperature variation, such as the solar cycle.

Large-Eddy Simulation of Wind Flow around a Small Forest

Ed Bannister, University of Birmingham

Session: Session 3: Atmospheric Dynamics

Forests affect our weather and climate in a variety of ways. Unfortunately, eddy covariance, the current standard technique for measuring forest-atmosphere interactions, deals badly with heterogeneous landscapes – e.g. those containing transitions from forest to pasture. This matters because forests are becoming increasingly fragmented. For example, 70% of the world's forest area is now less than one kilometre from the nearest edge. How does this fragmentation affect forest-atmosphere interactions?

To help answer this question, we used large eddy-simulation (LES) to investigate wind dynamics over a small forest. We approximated the site of the Birmingham Institute of Forest Research free-air carbon dioxide enrichment facility (BIFoR FACE), an oak-dominated woodland with average tree height of around 25m.

We found clear patterns of behaviour around the forest. Notably, the wind slows and deflects upwards when it hits the forest. The tree crowns experience high gusts and momentum transfer. The tops of the trees four to ten tree heights downwind of the forest edge experience very strong gusts. The air above the forest is highly turbulent.

These results complement previous studies performed on smaller domains. LES models of this type show excellent qualitative and quantitative agreement between studies. We will extend our study by using meteorological data from BIFoR FACE to investigate the coupling of flow dynamics and scalar fields, including carbon dioxide and heat.

How will tropical cyclone activity in the North Atlantic change in a warmer world?

Emily Vosper, University of Bristol

Session: Session 4: Climate

"Tropical cyclones are among the most destructive natural disasters affecting humanity, in both social and economic terms. The damage caused by Hurricane Katrina in 2005, for example, was estimated to be over $100bn, whilst secondary events such as storm surges and flooding can claim hundreds of thousands of lives in extreme cases. Since a large proportion of the world's coastal communities are affected by these systems, small island states being particularly vulnerable, it is critical that we develop an understanding of whether tropical cyclone activity will change as a result of a warming climate – and if so, how – such that these states can be informed when preparing for the impacts of climate change.

The influence of a climate warming by 1.5oC and 2.0oC from the pre-industrial average on tropical cyclones in the North Atlantic basin is explored using a dynamical downscaling approach applied to future projection simulations from five global circulation models (GCMs). These simulations are taken from the Half a degree Additional warming, Prognosis and Projected Impacts (HAPPI) super-ensembles, which comprise of bias-corrected climate model output for the present day, 1.5oC and 2oC warmer worlds. The dynamical downscaling technique, developed by Kerry Emanuel, uses certain thermodynamic and kinematic quantities from the GCMs and applies them to a downscaled tropical cyclone model to produce highly resolved tropical cyclones with a realistic intensity spectrum. As the model is driven by large-scale thermodynamic and dynamic conditions the results will provide useful insights into the impacts of large-scale climate conditions on tropical cyclone activity in the North Atlantic region.

Consensus of future projections based on theory and high-resolution models indicate that a warming climate will likely cause the global frequency of tropical cyclones to either decrease or remain the same, concurrent with a greater likelihood of stronger storms with higher mean maximum wind speeds and rainfall rates. According to the fifth report by the International Panel on Climate Change (IPCC), it is virtually certain that the strongest tropical cyclones in the North Atlantic have become more frequent and more intense since the 1970s. However, confidence remains low for projections of tropical cyclones activity in this region due to the small number of basin-scale studies and the variance of the published projections."

Impact of Atmospheric resolution on ocean heat transport into the Arctic

Sally Woodhouse, University of Reading

Session: Session 4: Climate

Recent trends in the Arctic show that this region is extremely sensitive to climate change with surface temperatures increasing at 2-4 times the global average and a corresponding large decrease in sea ice extent. However, CMIP5 models have a large uncertainty in their representation of the current Arctic climate, such as sea-ice extent, and thus, in the projected decrease of sea-ice.

In this study the impact of atmospheric resolution on the Arctic climate and energy transports into the Arctic is evaluated in a coupled climate model (HadGEM3-GC2) using three different atmospheric resolutions (N96: 140km, N216: 60km, and N512: 25km). The ocean model is kept at the same resolution, ¼ degree NEMO, a state-of-the art model that will be used within the CMIP6 program.

It is found that in the higher resolution experiment (N512) the Arctic is warmer and has a correspondingly smaller sea ice extent. This is linked to a substantial increase (e.g. 0.045PW at 65N) in the total energy being transported into the Arctic, between the N96 and N512 experiments. This increase is dominated by an increase in the energy transported by the ocean. The ocean heat transport (OHT) through the four ocean gateways (Davis, Fram, Barents Sea Opening and Bering Straits) in the high resolution atmosphere experiment gives a better agreement with recent observational estimates than the lower resolution experiments (N96: 0.09PW, N512:0.15PW). The large changes in the OHT show that the ocean model is highly sensitive to the applied atmospheric forcing and therefore sensitive to the resolution of the atmospheric model. This sensitivity could lead to important feedbacks on the atmospheric model.

How changes in the atmosphere, between the different resolutions, drives the changes in the OHT will be presented. The impact that these heat transports have on the representation of the Arctic climate will be discussed.

Land Surface Temperature Climate Change Initiative: Requirements for Climate Science

Freya Aldred, Met Office

Session: Session 4: Climate

The Land Surface Temperature (LST) CCI project is funded by the European Space Agency (ESA) as part of the Agency's 2019 Climate Change Initiative (CCI) Programme. It aims to deliver a significant improvement on the capability of current satellite LST data records to meet the challenging Global Climate Observing System (GCOS) requirements for climate applications and realise the full potential of long-term LST data for climate science.

Accurate knowledge of LST plays a key role in describing the physics of land-surface processes at regional and global scales as they combine information on both the surface-atmosphere interactions and energy fluxes within the Earth Climate System. LST provides a metric of surface state when combined with vegetation parameters and soil moisture, and is one of the drivers of vegetation phenology. Furthermore, LST is an independent temperature data set for quantifying climate change complementary to the near-surface air temperature Essential Climate Variable (ECV) based on in situ measurements and reanalyses.

The project will use data from a variety of satellites to provide an accurate view of temperatures across land surfaces globally over the past 20 to 25 years. This will involve developing innovative techniques to merge data from different satellites into combined long-term satellite records for climate.

Understanding requirements within the climate science community for LST data and the impact of making dataset developments provides the first step to producing a valuable set of products. Requirements are collected through a short hand completed questionnaire, a comprehensive questionnaire hosted online and interviews held with members of the climate research group. This presentation will provide an overview of the LST CCI project and why LST data is important for climate research, and an insight into the requirement gathering process.

Stochastic Weather Generators and the Köppen Classification System

Sarah Wilson-Kemsley, University of East Anglia

Session: Session 4: Climate

Stochastic weather generators are statistical tools used for generating realistic, synthetic time series of weather under current or future climate conditions. Modelling precipitation accurately is of particular importance as many weather generators condition other climatic variables on precipitation status. Input parameters of these generators are calculated using past observations. Subsequently, these input parameters will be perturbed to represent weather characteristics under a changed climate.

As such, stochastic weather generators following a Markovian approach are of particular interest as their input parameters (wet and dry transition probabilities) are believed to be simpler to perturb. From initial investigation, it appears that different climate regimes may be best described by different orders of Markov chain. The accuracy of generated precipitation sequences will be assessed globally across five basic climate regimes – tropical, humid, dry, continental and cold (using the Köppen climate classification system) – to determine which order of Markov chain best suits each regime. First, second and third order two-state Markov chains will be used in this comparison.

Using weather sensitivity analysis to predict business performance

Hannah Brown, Met Office

Session: Session 5: Met Applications

For many businesses, the weather is a strong driver of performance. Ultimately, the goal for any corporate decision-maker is to understand the key influences on their business performance (e.g. ‘sales volume’ or ‘service provision’) in sufficient detail to enable them to predict it. In this presentation I will introduce the concepts behind an assessment tool designed for organisations wanting to identify these links, so that they may subsequently be used to predict future changes. By combining data collected by businesses with historical Met Office weather data, the service uses a set of pre-defined statistical analysis methods to quantify their sensitivities. This analysis is fast, flexible and low cost, to facilitate the ease of incorporation of meteorological effects within the corporate decision-making process. The weather sensitivity analysis conducted includes both correlation/regression analysis and weather pattern analysis, providing results suitable for subsequent operational application within a real-time forecast system. A demonstration of this tool will be provided using bike hire data collected under the Santander Cycles scheme, published by Transport for London, wherein it is shown that 74% of the variability in the journeys undertaken may be explained by a simple statistical model.

Weatherproofing for a smarter, resilient and more sustainable agri-sector

Joanna Raymond, Umiversity of East Anglia

Session: Session 5: Met Applications

Over the last 1-2 decades, the UK has been one of many countries observing plateaus in key crop yields. This is despite innovation in farming practice, such as the adoption of precision agriculture, and advanced plant breeding programmes. The agricultural industry also continues to witness strong impacts on crop yields due to interannual weather variability. Evidently, crop varieties more resilient to weather and climate variability need to be identified and further developed. In this project, we seek to quantify the specific impact of weather variables on yields with a focus on process understanding. We use crop modelling to understand which crop traits are best suited to projected future UK climate, and highlight novel breeding targets for growers. Given that the UK imports almost half of its food each year, the focus of this project also extends to international supply chains.

Work to date has included analysis of long-term records of UK soil temperature data, to provide growers with updated guidance on optimum planting dates. In addition to showing the findings from these analyses, I will present an overview of my project and the expected outcomes.

Understanding the thermodynamic and dynamic contributions to future changes in European heatwaves

Helen Pearce, University of Birmingham

Session: Session 5: Met Applications

Constraining regional climate change projections is one of the most pressing challenges in climate science, in particular with regard to extreme weather events such as heatwaves. Drivers behind changes in heatwaves are often separated into thermodynamic and dynamic mechanisms. The thermodynamic component can be thought of as a simple shift in the mean of a regional temperature distribution, which makes heatwaves more likely in a warming world. Dynamic effects express themselves primarily in the shape of the temperature distribution, for example due to a higher or lower frequency of occurrence of certain large-scale weather patterns. Here, different methods to separate out the dynamic and thermodynamic effects on European heatwaves are compared. We first show the effect of a mean shift in the European temperature distribution for different climate model simulations from the Coupled Model Intercomparison Project phase 5 (CMIP5). Afterwards, we demonstrate how characteristic states of the atmosphere over Europe can be identified using self-organizing maps, a form of large-scale cluster analysis that produces a set representative nodes. These nodes resemble typical weather regimes and we apply this type of analysis to centennial sea level pressure and geopotential height anomaly datasets from the CMIP5 archive. In particular, we isolate anthropogenic effects on the dynamical component by comparing the distribution of atmospheric states for long-term preindustrial time-slice simulations to historical and RCP8.5 simulations. We also discuss the model-dependence of these results.

Key Controls on Surface Transport Weather Forecasting

Rose Webster, Met Office

Session: Session 5: Met Applications

The Met Office provides important surface transport forecast data to commercial customers and to critical national infrastructure networks, including road, rail and runways. Surface transport forecasts provide essential routine guidance for safety-critical decisions, such as winter road gritting.

The Met Office Road Surface Temperature (MORST) model is the numerical physics model used for surface transport forecasting. It is an atmospherically driven surface exchange scheme, using Numerical Weather Prediction (NWP) forecast parameters and observation data as inputs and modelling water and heat fluxes at specific road, rail and runway sites. This includes factoring in site-specific features, such as traffic, shading (blocking of direct shortwave radiation) and surface construction.

The aim of this study was to review MORST through a multi-parameter experiment, testing its output sensitivity to key input variables. To do this, the model was run repeatedly with varying levels of traffic volume at 18 different sites during wet, dry, marginal-freezing and radiative cooling weather control scenarios.

Results found MORST output to be most sensitive to traffic volume during the hours of 10:00 until 16:00, with a spread in forecast surface temperature of up to 10℃. This effect is explained by sensible heat transfer, caused by air mixing induced by vehicle motion. A spread of up to 5℃ was also observed during the early hours of the morning, between 04:00-08:00 and is particularly significant due to the likelihood of reaching the minimum temperature in the diurnal cycle, causing potential impact on customer decision-making for winter risk mitigation in marginal sub-zero conditions.

In this presentation, I will outline these findings and discuss consequential impacts on surface transport forecast users.

Following the Forecast: The Communication of the Met Office's 3-Month Outlook

Chris Manktelow, University of Exeter

Session: Session 5: Met Applications

The 3-month outlook produced by the Met Office provides an indication of possible future temperature and precipitation conditions over the whole of the UK. It is potentially useful to contingency planners in government, business and industry, who can use the outlook to assess and manage seasonal weather-related risks. However, the 3-month outlook is a probabilistic forecast and is inherently uncertain. This makes the message of the 3-month outlook difficult to interpret and communicate. Existing social scientific research also suggests that different social groups often have different ways of judging the credibility and usability of seasonal forecasts, which further complicates the communication process. This research project will therefore aim to understand how the 3-month outlook is understood, interpreted and communicated by following it from its point of production to its point of use. Interviews with Met Office staff and users of the 3-month outlook, observations of stakeholder briefings and the textual analysis of relevant documents will be used to produce a detailed, qualitative account of the communication process. This will highlight how the message of the 3-month outlook changes as it is interpreted. It will also draw attention to the different views that people have on the purpose, credibility and usability of the 3-month outlook. The results of this research project will be relevant to anyone interested improving the communication of uncertainty in climate science and meteorology.

Sensing social impacts of global weather events using social media

Michelle Spruce, University of Exeter

Session: Session 5: Met Applications

The social impacts of extreme weather events across the world can be difficult to assess and quantify. At present, news reports about extreme weather events are manually processed to assess the scale of the impact. However these news reports can often be hard to find and time consuming to review. Here we consider the use of social media, in particular Twitter data, to automate the detection, location and evaluation of the social impacts of 'high impact' weather events relating to heavy rainfall, heatwave and 'coldwave' events across the world.

We develop a pipeline for automatically processing large volumes of social media data, applying text filters and interring geographic locations. This pipeline greatly increases the volume and relevance of the data set. The data is extensively validated using a community impact database of weather events that have resulted in societal impacts, collated by the Met Office. Early analysis has found good correlation between social media 'events' and the Met Office impact database. We also find good global coverage, particularly for countries with more Twitter users. Within the social media data we also find some high impact weather events not picked up by the current Met Office method of impact detection. Using this approach we can start to develop a framework for including social media data in weather impact data collection and impact-based evaluation.

The method provides a new way to collect global forecast validation data for extreme weather events, as well as a way to bring together information on social impacts of weather at a global scale.

Carve your niche

Kathryn Chalk

Poster Board Number: 1

Getting your foot in the door into a big organisation is one thing, but how do you make sure you are not just another number once you've landed your first job in your dream organisation. On paper, my role as an Operations Officer in the Flood Forecasting Centre (FFC) includes admin tasks such as updating procedures, fixing IT faults and writing up minutes.

In this presentation, I share how I have used this role in a joint partnership between the Met Office and the Environment Agency to my advantage to carve my own niche through networking and shadowing and creating my own personal project in communicating surf forecasts.

By working 9-5 surrounded by hydrometeorologists, broadcast meteorologists and oceanographers, I have gained contacts and learnt various skill sets to benefit the FFC and my personal career goal in broadcast meteorology. To develop my meteorology and passion for surfing further, outside of work I present surf forecasts for the South West on a YouTube channel, communicating surf forecasts in a weather broadcast style.

The results have shown that networking opens up a wide array of opportunities in personal development for example becoming a surf commentator; bringing different teams together in a large organisation and continuous learning to benefits to my career in the future.

Assessing the efficacy of autumn-winter air quality policies in Jing-Jin-Ji

Gongda Lu, University of Birmingham

Poster Board Number: 2

Assessing the efficacy of autumn-winter air quality policies in Jing-Jin-Ji

The Jing-Jin-Ji (JJJ) region in the North China Plain suffers poor air quality and frequent haze events in autumn and winter, due to high anthropogenic emissions and unfavourable meteorology. In October 2017 to March 2018 the government implemented aggressive emission controls to achieve a 10-25% decrease in PM2.5 (mass concentrations of fine particles with aerodynamic diameter < 2.5 μm). The emission controls targeted heavy industries, vehicles, and burning of coal in homes and thermal power plants. Here we estimate decline in air pollutant concentrations in JJJ using surface measurements from the China National Environmental Monitoring Network (CNEMN) and satellite observations from multiple publicly available datasets and interpret emission changes with the GEOS-Chem chemical transport model. We find that CNEMN PM2.5 is consistent with observations from the US Embassy in Beijing (r = 0.98) and observations from the Atmospheric Pollution and Human Health in a Chinese Megacity (APHH) campaign (r = 0.97-0.98). We estimate decline in CNEMN PM2.5, SO2, and NO2 concentrations from autumn-winter 2016/2017 to autumn-winter 2017/2018 in JJJ of 27, 37, 14 %, respectively. Preliminary results suggest that the satellite observations only weakly reproduce (r < 0.40) the change observed in the surface measurements. Next steps include detailed analysis of the satellite observations and estimates of emission trends using GEOS-Chem nested over China.

Climate Changes of Ice Thickness on the Northern Caspian

Zhanar Naurozbayeva

Poster Board Number: 3

As it is known the Caspian Sea treats partially freezing seas. In its northeast part, as well as on all Northern Caspian Sea the powerful, steady ice cover differing in big dynamism annually is established. It interferes with normal navigation, promotes destruction of coastal hydraulic engineering constructions. Ice conditions have impact not only on many sea branches of economy, but also on an ecological situation in the region, for example, shift of terms of the ice phenomena has impact on biological cycles in ecosystems that is reflected in turn to fish capacity. Therefore, identification of changes of ice conditions in connection with climate change was an objective of this research. As the region of research the northeast part, adjoining coast of Kazakhstan as here the ice situation, peculiar for every year, which depends on features of the atmospheric processes developing over the sea, degrees of anomalies of thermal conditions during late autumn and in the winter is formed is chosen. As this area is located in a zone of the greatest continentally of climate, the cold period happens longer here and its most part is covered with motionless ice at this time.

The climatic changes in the maximum ice thickness at seven measurement points in the water area of the Northern Caspian and at one point in the Volga delta are analyzed. Influencing meteorological factors are established on the basis of the constructed dependences between the maximum ice thickness and air temperature. It is obtained that the maximum thickness of ice decreases at all stations, but to a greater extent in the northeast, to a lesser extent in the northwest, and at the south station it already reaches critical values at which ice does not form in same years. The main reason is a decrease in the sum of negative air temperatures over the cold period and an increase in temperature in March, while the temperature in the other months of the cold period of the year has not changed much.

Developing a Relative Humidity Correction for Low Cost Sensors Measuring Ambient Particulate Matter

Andrea Di Antonio, University of Cambridge

Poster Board Number: 4

There is increasing concern about the health impacts of ambient Particulate Matter (PM) exposure. Recent studies have shown portable low-cost devices (e.g., optical particle counters, OPCs) can be utilised to determine the spatial-temporal characteristic of ambient Particulate Matter. However, the application of these devices under ambient conditions can be affected by high relative humidity (RH) events. Reference instruments are usually equipped with drying systems which remove water from particles before measurement, making them independent of ambient relative humidity. Many low-cost sensors do not include such drying processes, with the result that particle sizes can be overestimated at high relative humidity, resulting in higher estimation of Particulate Matter values relative to reference measurements. Here, we show how, by exploiting the measured particle size distribution information, a correction can be derived which accounts for the relative humidity effects on the number concentration measurements of OPCs to ensure the correct Particulate Matter values are calculated. The application of the correction algorithm results in a significant improvement, with the overestimation of low-cost Particulate Matter measurements reduced, in a case study, from a factor of ~5 before correction to 1.05 after correction. We conclude that a correction based on particle size distribution not only properly accounts for relative humidity effects and enables low-cost optical Particulate Matter sensors to provide reliable ambient Particulate Matter measurements, but also retains fundamental information on particle composition, opening to the possibility of characterising particle chemical composition using low-cost sensors.

Quantifying sectoral-level methane fluxes in a Bayesian inversion using co-emitted tracers

Alice Ramsden, University of Bristol

Poster Board Number: 5

Atmospheric methane is the second most influential greenhouse gas and contributes largely to climate change by increasing the radiative forcing in the lower atmosphere. Methane has a range of both natural and anthropogenic sources; it is emitted by wetlands and livestock, during biomass burning and in the extraction, refinement and use of fossil fuels. Concentrations of atmospheric methane are rising, with the largest contribution from the tropics. It is important that we can accurately measure and quantify emissions from different sources of methane in order to create the most effective climate change mitigation strategies.

Bayesian inverse modelling is a commonly used method for quantifying methane fluxes both regionally and globally. This statistical method uses observations of atmospheric mole fractions (from satellites and ground stations) to infer methane emissions through use of an atmospheric chemical transport model. My work aims to improve on an inverse modelling technique developed at the University of Bristol by including measured mole fractions of co-emitted gases and their emission ratio to methane. As some sources emit different ratios of trace gases, these co-emitted tracers allow us to apportion methane emissions to different sources. However, there are uncertainties and spatial and temporal variability in tracer emission ratios. I aim to quantify the effect of these uncertainties on sectoral methane emission quantification by building this uncertainty into the inversion process.

This improved method will be used to study biomass burning in Sub-Saharan Africa where there are very few accurate greenhouse gas inventories and, due to the landscape and biome types, it is difficult to determine methane emissions' sources based only on their location.

Representation of the Indian Ocean Walker Circulation in Climate Models and Links to Kenyan Rainfall

James King, University of Oxford

Poster Board Number: 6

Climate change projections over East Africa are of great importance, but global climate models involved in Coupled Model Intercomparison Project 5 (CMIP5) display significant biases in their representation of key rainy seasons, which call into question the reliability of such projections. In this study, we investigate the links between models' representation of rainfall over Kenya during the Long and Short Rains and the zonal Walker Circulation. Models with stronger descent over Kenya are generally drier, and there is a strong correlation in the Short Rains between the magnitude of model error in Kenyan rainfall and in mid-to-upper tropospheric omega. The overturning circulation is largely absent in models with strong wet biases over Kenya during the Short Rains, while in the Long Rains, dry biased models tend to overestimate the strength of the descending limb of the circulation over Kenya. The results add to recent work on the impacts of climate model biases in this region, demonstrating that the Walker Circulation should be a focus for future model improvement, and a consideration when assessing the reliability of climate projections over East Africa.

Satellite Land Surface Temperature Data for an Urban Heat Climate Service

Freya Aldred, Met Office

Poster Board Number: 7

Anthropogenic climate change is leading to more frequent and extreme weather events such as heat waves. This can be further exacerbated by the Urban Heat Island (UHI) effect, and with rapid urbanization found in countries like China, an increasing proportion of the population may be exposed to extreme heat-stress events without access to the resources they need. There are two routes to action this problem: heat response plans which target vulnerable populations at the time of events with local aid in the community; and environmental design strategies which direct long term urban construction to reduce heat absorption and retention. Both of these strategies require an understanding of the distribution of persistent ‘hot spots’ within urbanised areas.

The use of satellite retrieved Land Surface Temperature (LST) to analyse the UHI effect is investigated, including methods to determine the areas most affected by extreme heat. This is put into the context of potential climate services, and how they could benefit residents in large and developing cities. Four case study cities in China are investigated: Xi’an, Shanghai, Beijing and Guangzhou. LSTs from NASA's MODIS instrument on board the Aqua satellite are used, due to the twice daily, 1km coverage of this instrument, and an overpass time close to the hottest part of the day. ESA's CCI Land Cover product for years 2003 - 2014 is also used to enable analysis by land use type. Methods for spatial and temporal analysis are investigated, with initial spatial analysis showing that LST correlates well with land use as expected, and that there is a condensed hot spot in the centre of the cities which is more pronounced at night. City regions are further analysed for pixel anomalies against the urban background, and to identify temporal variations in LST.

Performance of a low-cost sensor system for air pollution monitoring

Jinghua Li, University of Chester

Poster Board Number: 8

Conventional air pollution monitoring is based on a sparse network of limited stationary sites equipped with accurate but expensive and complex instruments, therefore, it is impractical to provide fine-grained information. With growing concerns of health issues that related to air pollution and the rapid development of sensor technologies, commercial Low-cost sensors (LCSs) for air pollution monitoring are thriving. However, the data qualities and performances of them can be substandard, which means that to be considered an indicative tool for air pollution monitoring, they may require calibration and validation.

The aim of this project is to prototype, calibrate and evaluate a system with commercially available PM and NOx LCSs based on Arduino. Once calibration completed in a dynamic exposure chamber under controlled laboratory conditions, the prototype will be evaluated at diverse micro-environments. Data are validated with a machine-learning approach to improve the reliability of LCSs and enhance their performances in both laboratory and field tests. The prototype with “built-in-self-correct-model” will then be deployed on drones and Heli-kites to measure vertical profile of air pollutants. Ultimately, air pollutants and meteorological parameters are measured during a rocket launch.

The Use of Clumped Isotopologues to Understanding Global Methane Flux

Eunchong Chung, University of Edinburgh

Poster Board Number: 9

Methane is the second most important anthropogenic greenhouse gas. Precise quantification of the methane budget is required to develop effective mitigation plans to minimise our impact on climate. Competing hypothesis on the budget can explain the current rise in atmospheric methane exist. We explore how doubly-substituted clumped isotopologues, 13CH3D and 12CH2D2, can reduce the current uncertainties in budget estimation if we are to measure them in the ambient air, complementing our knowledge on source signatures.

On seasonal and sub-seasonal forecasting of the Indian monsoon low pressure systems

Akshay Deoras

Poster Board Number: 10

Monsoon low pressure systems are among the main components of the Indian Monsoon. They contribute about half of the summer season precipitation in India and modulate the intra-seasonal rainfall variability. The resultant flooding and drought episodes have significant socio-economic implications since agriculture is mainly rainfed. Many features of monsoon low pressure systems have been explored in recent decades. However, equivalent attempts have not been made to understand the potential for predictability of monsoon low pressure systems on the sub-seasonal to seasonal time scale, which is important for farmers, governments and disaster management organisations in long-term planning. This PhD project focuses on understanding the structure, representation, forecast skill and lead time of monsoon low pressure systems in the Subseasonal-to-Seasonal (S2S) database. Using a feature-tracking algorithm, monsoon low pressure systems are identified in one of the eleven S2S models during a common re-forecast period of 1999-2010. The identified systems are then compared with ERA-Interim reanalysis. Many interesting statistical and observational aspects related to monsoon low pressure systems are revealed. These results, along with the future work, envisage the possibility of improved seasonal forecasts of monsoon rainfall, thereby benefitting society.

Evaluation of meteorological drought using the Standardized Precipitation Index (SPI) in the High Ziz river Basin, Morocco

Khadija Diana

Poster Board Number: 11

One of the adverse impacts of climate change is drought, and the complex nature of the latter makes them one of the most important climate hazards. Drought indices are generally used as a tool for monitoring changes in meteorological, hydrological, agricultural and economic conditions. In this study, our database of meteorological drought events concern the High Ziz river Basin, central High Atlas, Morocco. The application of drought index is useful for drought assessment to consider adaptation and mitigation methods when dealing with climate change. By figuring out the level and duration of the drought and the precipitation trend at different times, we could address the climate variability and change over a specific area. In order to analyze drought in the study area, we used two different approaches to address the change in climate, particularly in precipitation, to assess both the climate variability and change over the years and the change within the year using different timescales (monthly, seasonally and annually) from 1971 to 2017. In the first approach, precipitation data were used in longer time scales, annually and more than a one-year period. For this purpose, a change in the Standardized Precipitation Index (SPI) was considered to quantify the rainfall deficit for multiple timescales. For the second approach, the trend analysis was applied for precipitation in different time scales within the year using the Mann-Kendall (M-K) test in different time scales within the year, to analyze the trend. The results showed that the study area has no significant trend in annual rainfall; however, in terms of seasonal rainfall, the magnitude during summer showed a positive significant trend in three stations. Significant negative and positive trends in monthly rainfall were observed in April and August only, respectively.

Environments conducive for severe convective winds in Europe

George Pacey

Poster Board Number: 12

Each year severe convective storms in Europe cause damage to businesses and personal property and can cause fatalities. For example, a convective windstorm event in Poland in 2017 brought down tens of thousands of trees, resulting in 6 fatalities. Between 1950 and 2000, research on such European windstorms was relatively scarce. The European Severe Weather Database (ESWD) became operational in 2006 to collect and provide detailed and quality-controlled information on severe convective storms across Europe, and in turn, has enabled further understanding of the environments favourable for such events.

Other hazardous convective weather, such as hail and tornadoes, have attracted increasing interest in recent years in Europe, whereas non-tornadic severe winds, which usually originate from the storm's downdraft, remain relatively unexplored. In this study, radiosonde data within a defined distance and time of the severe convective windstorm are analysed to infer information about the storm environment. Furthermore, this information will be combined with the OPERA European radar dataset to produce a climatology of storm morphologies, something that is not thought to have been done before in published literature.

ESWD data shows 11,356 reports of severe convective winds occurring between 2000–2018, with 84% reports in summertime, over half occurring between 1500–2100 local solar time, and the highest density in central Europe, particularly in Poland. Preliminary radiosonde analyses show that severe convective winds occur when both 0–1-km and 500–700-hPa lapse rates are steep, and when most unstable convective available potential energy and 0–6-km wind shear are large. The next stages of research will evaluate the synoptic environments and storm morphologies of severe convective wind events.

Identification of Summer Monsoon Onset over Nepal by using Satellite-Derived OLR (Outgoing Long-wave Radiation) Data

Sanjib Adhikari

Poster Board Number: 13

Monsoon onset is considered as the beginning of the rainy season or simply the monsoon (summer) season in Nepal and India. Above 80% of annual rainfall in Nepal occurs during summer monsoon from June to September. The date of monsoon onset is an important event in Nepal because socio-economic life is dominated by agricultural sector. Therefore, the early prediction of monsoon onset date will benefit the agriculture and other monsoon related sectors. The Meteorological Forecasting Division (MFD) of Department of Hydrology and Meteorology (DHM) makes an official prediction of monsoon onset in Nepal using a subjective method. In this study, satellite-derived Outgoing Long-wave Radiation (OLR) data from March to June is analyzed for the study of monsoon progression towards Nepal. Rainfall amount is compared with the OLR data which depicts higher correlation in the southern part of Eastern and Central Nepal than in the northern parts. Two main convective episodes are observed, consequent to the significant drops in OLR by about 10 Wm-2 from 22 March to 1 May & drops in OLR by more than 20 Wm−2 from 10 May to 10 June. The correlation between these two characteristic falls and onset date announced by MFD is evaluated to predict new onset dates over the region. The predicted onset date is found to be 13 of June in average. The study highlights the potential application of the remote sensed satellite-derived OLR method for the prediction of onset of summer monsoon in about three weeks ahead. However, there is significant disagreement between monsoon onset dates predicted by this method and dates announced by MFD.

Relation between SOI and monsoon onset shows the earlier monsoon onset date in El-Nino years. Higher temporal consistency is observed for the earlier onset date predicted from May fall of OLR than that announced by MFD and predicted from March fall of OLR for El-Nino years. For the normal years, delay in monsoon onset date is found. Higher temporal consistency is observed for the delayed onset date predicted from March and May fall of OLR than that announced by MFD. Focusing on the La-Nina years, onset dates aren’t found to be consistently advanced or delayed.

Assessment of CMIP6 Simulations of the American Monsoon System

Jorge L Garcia-Franco

Poster Board Number: 14

A new suite of CMIP6 simulations (UKESM and HadGEM3) are assessed for their representation of precipitation and circulation regimes in the Americas, including: The North and South American Monsoon Systems and the Central-American Mid-Summer Drought.

Surface observations and re-analyses data are used to evaluate the performance of these new simulations in representing American tropical climate.

Biases in surface climatologies (e.g. temperature and precipitation) are identified to highlight statistically robust model-observation differences.

These biases are examined by analyzing the main large-scale and local drivers associated with these seasonal precipitation regimes.

Particular emphasis is placed on the simulated land-sea temperature contrasts, moisture availability, large-scale low-level circulation and local convective potential.

Different measures of these circulation drivers are then compared between simulations and observations.

Understanding the physical mechanisms accounting for the spatial and temporal biases between state-of-the-art climate models and observations is key for improving model projections and provides a framework for tackling outstanding questions of subtropical climate variability in the Americas.

The impact of atmosphere, wave, ocean coupling on extreme surface wind forecasts

Emanuele Silvio Gentile, University of Reading

Poster Board Number: 15

Localized extreme winds are an important meteorological hazard. Starting from storm Helene, September 2018, a number of case studies will be performed to gain a physical understanding of extreme winds and gusts. Experiments will be performed with the newly developed Met Office UK Environmental Prediction (UKEP) model system, which represents the feedbacks that exist between land, ocean and atmosphere. The aim is to determine whether, and if so how, coupling can improve the predictions of the atmosphere and particularly extreme surface winds. Here analysis of Helene with the Met Office's operational (uncoupled) convection-permitting UKV model is presented to demonstrate the suitability of this storm as a case study for the UKEP experiments.

Identifying and characterising specific humidity biases in models

Jake Bland

Poster Board Number: 16

Lower stratospheric moisture influences Rossby wave evolution through radiative induced temperature changes. Therefore misrepresentation of moisture in models can lead to forecast errors, which can propagate downstream and affect future system development. Characterising this misrepresentation is the first step to determining this impact. Here the moisture error in operational Met Office model analyses and forecasts is evaluated using radiosonde data for the period of the North Atlantic Waveguide and Downstream impacts EXperiment (NAWDEX) field campaign. A mean moist bias exists in the lower stratosphere associated with a temperature bias which increases with lead time. These biases are stronger in troughs than in ridges.

Cold-Air Outbreaks over the Subpolar Seas

Chris Barrell, University of East Anglia

Poster Board Number: 17

Over the subpolar seas cold-air outbreaks are common and regularly affect UK winter weather. They are important within the climate system influencing sea-ice formation and driving ocean convection, playing a significant role in creating dense water masses that feed into the Atlantic Meridional Overturning Circulation, a key component of global ocean circulation. As a result, it is very important that cold-air outbreaks are accurately represented in models for operational to seasonal weather forecasting and climate projections.

This project focuses on the investigation of cold-air outbreaks using a number of case studies gathered from aircraft and ship-based field campaigns, such as the Iceland Greenland Seas Project. The overarching aim of this research is to contribute to the improvement of how CAOs are simulated in numerical weather prediction models.

Initial findings will be presented from comparing in-situ observations to forecasts made by the Met Office atmosphere-only global operational forecast model and a coupled model in development that features ocean-atmosphere interaction. This investigation seeks to test the hypothesis that ocean-atmosphere interaction in the coupled model will result in better forecasting skill for near-surface meteorology than the operational model.

The role of interactive chemistry in modelling Sudden Stratospheric Warming events

Oscar Dimdore-Miles

Poster Board Number: 18

Sudden Stratospheric Warming events (SSWs) are rapid disruptions of the Northern Hemisphere (NH) winter stratospheric polar vortex and represent the largest source of inter-annual variability in the NH winter stratosphere. They have been linked to winter surface climate anomalies such as cold snaps over North America and Eurasia. Representing these events accurately in large scale GCMs is key to developing a greater understanding of them and their role in stratosphere-troposphere coupling as well as improving predictability of winter surface climate. A key component of a GCM is its representation of atmospheric chemistry which is normally prescribed by observations. However, a small fraction of CMIP6 models calculate chemical fields interactively by coupling an atmospheric chemistry model to radiation and dynamical components, incurring substantial computational cost.

This work evaluates the impact of interactive chemistry when modelling SSW events. 500 year pre-industrial control runs from the MetOffice HadGEMGC3.1 model which prescribes chemical fields and UKESM1 which calculates trace gas concentration interactively are utilised. We find that both models overestimate the occurrence of SSW events in early winter (November) compared to reanalysis. This is due to a weak early winter vortex and overactive upper tropospheric planetary wave activity. Over the whole season - The Earth System Model appears to suppress warmings while the model with prescribed physics overestimates their occurrence compared to reanalysis. There also appears little significant difference between the models' representation of stratosphere-troposphere coupling as assesed by the North Atlantic Oscillation and Northern Annular Mode at a lag of 0-90 days after events. These preliminary results suggest that interactive chemistry does not improve a GCM's representation of SSWs, however further work examining potential chemical feedbacks associated with events is required to make a comprehensive evaluation.

Can global atmospheric chemistry models simulate ozone air quality in China?

Ayesha Tandon, University of Exeter

Poster Board Number: 19

Surface level ozone has detrimental effects on ecosystem health, crop growth and climate change. For example, surface ozone concentrations of 45 ppbv have been estimated to cause a 13% reduction in crop yields, which has serious implications for food security under global change and concomitant increases in global population and food demand. The accurate simulation of surface ozone concentrations in China is crucial to enable the informed development of effective mitigation strategies that protect ecosystem and crop health.

Here, we evaluate surface ozone simulations in 8 state-of-the-science global atmospheric chemistry models against ozone measurements from the Ministry of Environmental Protection of China. The models include 6 models from the Coupled-Chemistry Model including the HadGEM3-ES model from the Met Office Hadley Centre, and results from the GEOS-Chem model at 2 different horizontal spatial resolutions.

Analyses of correlation (R2), point-for-point accuracy (normalised mean bias), and spatial variability were carried out for monthly averages between 2013-2017 at up to 1497 urban sites across China. All models simulate urban surface ozone concentrations in the summer, autumn, and winter seasons with reasonable accuracy, but were consistently unable to predict surface ozone concentrations in spring. Generally, the models overpredict surface ozone concentration. HadGEM3-ES over-predicts in summer and under-predicts in winter.

Furthermore, the spatial accuracy of the models was tested by analysing four highly polluted urban regions in China. This analysis, focussing on the GEOS-Chem and HadGEM3-ES models, demonstrated the limitations in model ability to capture spatial variability.

Understanding the thermodynamic and dynamic contributions to future changes in European heatwaves

Carl Thomas,

Poster Board Number: 20

Constraining regional climate change projections is one of the most pressing challenges in climate science, in particular with regard to extreme weather events such as heatwaves. Drivers behind changes in heatwaves are often separated into thermodynamic and dynamic mechanisms. The thermodynamic component can be thought of as a simple shift in the mean of a regional temperature distribution, which makes heatwaves more likely in a warming world. Dynamic effects express themselves primarily in the shape of the temperature distribution, for example due to a higher or lower frequency of occurrence of certain large-scale weather patterns. Here, different methods to separate out the dynamic and thermodynamic effects on European heatwaves are compared. We first show the effect of a mean shift in the European temperature distribution for different climate model simulations from the Coupled Model Intercomparison Project phase 5 (CMIP5). Afterwards, we demonstrate how characteristic states of the atmosphere over Europe can be identified using self-organizing maps, a form of large-scale cluster analysis that produces a set representative nodes. These nodes resemble typical weather regimes and we apply this type of analysis to centennial sea level pressure and geopotential height anomaly datasets from the CMIP5 archive. In particular, we isolate anthropogenic effects on the dynamical component by comparing the distribution of atmospheric states for long-term preindustrial time-slice simulations to historical and RCP8.5 simulations. We also discuss the model-dependence of these results.

Stochastic Weather Generators and the Köppen Classification System

Sarah Wilson-Kemsley, University of East Anglia

Poster Board Number: 21

Stochastic weather generators are statistical tools used for generating realistic, synthetic time series of weather under current or future climate conditions. Modelling precipitation accurately is of particular importance as many weather generators condition other climatic variables on precipitation status. Input parameters of these generators are calculated using past observations. Subsequently, these input parameters will be perturbed to represent weather characteristics under a changed climate.

As such, stochastic weather generators following a Markovian approach are of particular interest as their input parameters (wet and dry transition probabilities) are believed to be simpler to perturb. From initial investigation, it appears that different climate regimes may be best described by different orders of Markov chain. The accuracy of generated precipitation sequences will be assessed globally across five basic climate regimes – tropical, humid, dry, continental and cold (using the Köppen climate classification system) – to determine which order of Markov chain best suits each regime. First, second and third order two-state Markov chains will be used in this comparison.

The impact of perturbations to tropical aerosols and their precursors on local and remote climates.

Chris Wells

Poster Board Number: 22

Aerosols are a relevant climate forcer, but their historical effect has the largest uncertainty of any forcing, and so their mechanisms and impact must be better understood. Due to their short lifetime, aerosols have large impacts near their emission region, but they also have effects on the climate in remote locations. In recent years, studies have investigated the impacts of regional aerosols on global and regional climate, and the mechanisms that lead to remote responses to such forcings. However, there has been little work on the influence of emissions from the tropics, as the aforementioned studies typically focused only on emissions from the northern mid-latitudes. This work uses the new Met Office UKESM1 Earth System Model to investigate the effect of large perturbations to tropical aerosol and aerosol precursor emissions. In one experiment, SO2 emissions were multiplied by a factor of 10 between 30S-30N. Another experiment applied the same perturbation to Biomass Burning OC and BC, and a third entirely removed Biomass Burning OC and BC in the tropics. These are compared to a control run with continued present-day emissions, and impacts on temperature, precipitation, radiation fluxes, and circulation are investigated, both in the emission regions and remotely.

Overview of the CEDA Archive

Kate Winfield

Poster Board Number: 23

The Centre for Environmental Data Analysis (CEDA) hosts a data archive on JASMIN, holding vast heterogeneous data from sources including aircraft campaigns, satellites, pollution, automatic weather stations, climate models, etc. The CEDA archive currently holds 6 PB data, in 200 million of files from across the globe. This poster will explore a small selection of the data in the CEDA archive

Understanding the Global Sources and Sinks of Atmospheric Carbonyl Sulfide in Order to Provide Insights into Carbon Cycle Processes

Michael Peter Cartwright, University of Leicester

Poster Board Number: 24

The challenge in precisely quantifying the sources and sinks of atmospheric carbon dioxide (CO2) is that the CO2 taken up by plants during photosynthesis cannot be distinguished from the CO2 released by plants and micro-organisms during respiration. It has been shown that carbonyl sulfide (OCS) can be used as a proxy for photosynthesis. The relationship between vegetative flux of OCS and CO2 has been quantified for various species of plants and ecosystems, the results of which have been used in observing the relationship on a continental scale. The aim of this project is to both quantify the location and magnitude of the sources and sinks of atmospheric OCS, and to use these data to infer photosynthetic uptake of CO2 by vegetation on a global scale.

The Infrared Atmospheric Sounding Interferometer (IASI), onboard each of the MetOp satellites, measures top-of-atmosphere radiances from which OCS total columns can be retrieved. In order to assess the information content from an IASI OCS retrieval, we have performed retrievals from simulated IASI spectra, generated by the Reference Forward Model (RFM), using the University of Leicester IASI retrieval Scheme (ULIRS); an optimal estimation retrieval scheme, originally utilising 30 equidistant pressure levels and a floating pressure grid. Using IASI spectra from October 2006 to the present day a 12-year on-going global satellite dataset of atmospheric OCS will be generated and validated against existing satellite, ground and aircraft based measurements.

Finally, the 3D chemical transport model TOMCAT is being adapted to include emissions of OCS, carbon disulphide (CS2) and dimethyl sulfide (C2H6S), as well as sinks of OCS to provide a detailed representation of OCS chemistry. The outlook of this project is for TOMCAT to be used in conjunction with IASI measurements to invert the vegetative OCS flux, in order to provide insights into carbon cycle processes.

Monsoon Studies Over Indian Subcontinent Using a network of Ground Based GNSS receiversMonsoon Studies Over Indian Subcontinent Using a network of Ground Based GNSS receivers

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Poster Board Number: 25

The onset of SWM is the most anxiously awaited weather for singularity in the Indian subcontinent as it heralds the rainy season and marks the end of the hot summer. India Meteorological Department (IMD) is the nodal agency to declare onset and withdrawal of south west monsoon. Using highly temporal resolution total Column Integrated Precipitable water vapour (IPWV) estimated from ground based GNSS receiver over a station is used to study the monsoon .In our studied, It has been observed that build up of IPWV content is an indicator of the state of monsoon and can potentially be included in operational criteria for declaring onset/ withdrawal of South West Monsoon.

In the present work we have shown the variation of total column of Integrated Precipitable Water Vapor (IPWV) during the Onset/withdrawal of South West Monsoon season and presented daily mean to study SWM season over Indian subcontinent. Superposed epoch analysis of IPWV variation for 15 days period was carried out with respect to arrival/withdrawal date of south west monsoon.

Air Quality Assessment and Numerical Simulation of Aerosols in South-East Asia Region

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Poster Board Number: 26

Using Weather Research and Forecasting model coupled with chemistry (WRF-Chem), we simulated the concentrations of aerosol such as particulate matter during peak period of the haze event in the region in June 2013. The model evaluation included meteorological parameters that are relevant to air quality such as wind speed, atmospheric temperature. The WRF-Chem simulation was further validated by comparing the result to observed particulate matter levels - PM2.5 and PM10, in Singapore and Brunei Darussalam, respectively. These evaluations show that the model correctly captured the PM levels and meteorological parameters in the period, though with a slight lag and underestimation of PM level in Brunei. A more accurate biomass burning inventory would enhance the simulation results.