RMetS
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BOOK OF ABSTRACTS

CONTENT

Multi-Decadal Variations in Seasonal Forecasts

Matthew Wright (he/him), DPhil Student, University of Oxford

Session 1: Climate

Multiple studies have quantified the ability of global climate models (GCMs) to reliably predict seasonal climate forecasts, showing that seasonal ENSO forecast skill has undergone pronounced multidecadal variations over the 20th century. Forecast skill is high near the beginning of the century, and again near the end, but undergoes a period of low skill in the middle of the century. A similar trend is seen for other atmospheric signals, including the NAO and Pacific/North American Index (PNA). Since the variations in forecast skill do not correlate with the quality of available data, this variation is attributed to underlying climatic variability in the coupled atmosphere-ocean system. This work investigates the reasons for these variations in seasonal predictive skill seen throughout the 20th century.

Results examining the impact of the strength, spatial pattern, and temporal trends in the El-Nino Southern Oscillation on predictive skill are presented. In general, we find that stronger ENSO events are better predicted, and that the period of reduced seasonal predictive skill coincides with a period of low ENSO variability. However, eastern and central El Nino events do not seem to influence predictive skill. There is also a negative Pacific Decadal Oscillation (PDO) event in the middle of the century which may contribute to the change in skill. These results help understand how good current seasonal forecasting models are, how they could be improved, and how we can ensure they remain skilful into the future.

Simple Modelling of Marine Biomass Regeneration

Elisavet Baltas (she/her), PhD Student, Centre for Climate Repair, University of Cambridge

Session 1: Climate

Effective and large-scale atmospheric carbon capture is essential in limiting global warming to within 1.5 degrees Celsius as outlined by the Paris Agreement. The oceans make up two thirds of the Earth's surface and absorb approximately a quarter of anthropogenic emissions annually, therefore it is imperative to maximise their carbon sequestration ability through large scale Carbon Dioxide Removal (CDR). One technique that aims to improve the efficiency of oceanic carbon uptake is Marine Biomass Regeneration (MBR), otherwise known as Ocean Iron Fertilisation (OIF). MBR is grounded on evidence that introducing certain key nutrients to nutrient depleted areas of the ocean can enhance primary productivity and regenerate ocean biomass, which then acts as a carbon sink.

A two-dimensional carbon and heat cycling box model with meridional overturning circulation is extended, to include biological processes and nutrient cycling. This model has previously been used to carry out climate projections, by investigating the ocean's carbon and thermal response to annual anthropogenic emissions, but there has been no investigation on how the changing meridional overturning circulation impacts the biological carbon pump. A simple nutrient-phytoplankton-zooplankton (NPZ) biological model is introduced to model the impact of macronutrient concentrations on phytoplankton and zooplankton growth. Further to this, some basic parameterisations for iron cycling will be added. Using the extended model, it will be possible to undertake MBR experiments with different nutrient ratios and concentrations and investigate the impact these parameters have on the oceanic carbon and heat uptake and distribution from anthropogenic carbon emissions. The model also accounts for slower meridional overturning with increased ocean warming, which allows for the investigation of the effect of slower circulation on the biological carbon pump, primary productivity, and nutrient distribution.

Investigating the Value Added to Drought Projections by the CMIP5 Downscaled Models in the UKCP Convection-Permitting Ensemble

Matt Grant (he/him), Foundation Scientist, UK Met Office

Session 1: Climate

The UK Climate Projections (UKCP) are a climate analysis tool widely used by government, industry, and academia to investigate the projected changes to the UK climate over the coming decades. The latest release of UKCP, known as UKCP18, included the ground-breaking UKCP Local climate projections. These provided the first ever use of a convection-permitting model (CPM) with a national climate projections framework. UKCP Local was run on a 2.2km grid across the UK, resulting in climate simulations with a spatial resolution on a par with weather forecast models.

The driving model for UKCP Local, the UKCP Global (60 km) product featured a 15-member perturbed parameter ensemble (PPE-15), and 13 models sub selected from the 5th phase of the Coupled Model Intercomparison Project (CMIP5-13). Currently, the UKCP Local projections consist of 12 members of the PPE. To improve the information provided in the UKCP Local projections, 4 extra models from the CMIP5-13 have been downscaled to the Local projections' resolution. This extension to the Local projections provides a novel addition to UKCP, allowing users to investigate high resolution projections from models with a broader range of climate sensitivity. However, before the additional models can added to UKCP Local projections, several steps will need to be completed to understand the relationship between the PPE and CMIP5 models across the three UKCP resolutions (Global, Regional (12km) and Local).

This work is likely to focus on the analysis of impacts-based metrics (such as droughts) in both sets of models and investigating differences that might be found. This would include evaluating present day model performance and assessing uncertainty in future changes.

Response of Atmospheric Variability in the Northern Hemisphere Winter to Past Climate Conditions and Elevated CO2 Levels

Arthur Oldeman (he/him), PhD Candidate, Utrecht University, the Netherlands

Session 1: Climate

A specific feature where future climate projections fail to see a consistent response to increasing CO2 levels is Northern Hemisphere winter atmospheric dynamics and variability. This holds specifically for the Northern Annular Mode (NAM) and its regional expression, the North Atlantic Oscillation (NAO). The lack of consensus in future projections is caused in part due to the large internal variations of these modes of atmospheric variability compared to the response to elevated CO2.

The response of interannual and decadal climate variability to warm conditions can be isolated in climate simulations equilibrated at elevated CO2 concentrations. However, we cannot perform a future model-data comparison. Fortunately, we can turn to the past. The last time the Earth saw similar CO2 concentration as the present day was approximately 3 million years ago, in the mid-Pliocene epoch. The mid-Pliocene is often considered the 'best analog' to an equilibrated climate at present or near-future CO2 levels. However, can the mid-Pliocene be used to assess the response of Northern Hemisphere winter atmospheric variability, such as the NAO and NAM, to a warm climate?

To answer this question, we have performed a set of sensitivity experiments using a global coupled climate model (CESM1.0.5). We have performed sensitivity studies using a pre-industrial and a mid-Pliocene geography, as well as two levels of radiative forcing (280 ppm and 560 ppm), as a part of intercomparison project PlioMIP2. Our mid-Pliocene simulations generally compare well to proxy reconstructions of sea-surface temperature.

We consider the sea-level pressure (SLP) and zonal wind at 200 hPa using 200 years of January-mean data, and perform principal component analysis. In response to the mid-Pliocene boundary conditions (other than CO2), we find a large increase in the mean SLP along with a decreased variance over the North Pacific Ocean. This is accompanied with a weakened jet stream over the western North Pacific, as well as increased occurrence of a split jet condition over the eastern North Pacific. These findings are connected to a regime shift in the modes of atmospheric variability in the Northern Hemisphere, where the so-called North Pacific Oscillation (NPO) becomes the most dominant mode of variability. We do not see tendencies towards similar behavior in the CO2 doubling experiment indicating that the Pliocene boundary conditions are the main driver of the observed shits in variability. This suggests that the mid-Pliocene is not a good analog for a warm future climate when considering Northern hemisphere winter atmospheric variability.

Statistical Post-Processing of Cloud Base Height

Marcus Spelman (he/him), Scientist, Met Office

Session 2: Forecasting & Nowcasting

IMPROVER (Integrated Model post PROcessing and VERification) is a post-processing system run by the Met Office to produce gridded and site probabilistic forecasts on the UK and global domains.

IMPROVER blends model output from both deterministic and ensemble forecasts. Ensemble forecasts are produced by running the same model multiple times with perturbed initial conditions, thus better capturing the uncertainty and spread of the forecast. IMPROVER seeks to improve upon the output of these models by applying a range of calibration and post-processing techniques to correct for biases, spatiotemporal errors and assumptions within the original models. IMPROVER then blends these calibrated probabilistic forecasts from multiple models to create a single probabilistic forecast. This approach is aimed at fully exploiting the available ensemble forecasts.

This presentation will describe some of the post-processing methods used within IMPROVER and demonstrate how these steps can benefit a forecast, specifically looking at forecasts of cloud base height for scattered (3 oktas cloud cover) and broken cloud (5 oktas cloud cover). These variables are of particular interest to aviation meteorologists when producing terminal aerodrome forecasts.

Evaluating Optical Flow Methods for Storm Prediction in the Maritime Continent

Joey Smith (he/him), PhD Student, University of Leeds

Session 2: Forecasting & Nowcasting

The Maritime Continent (MC) regularly experiences powerful convective storms that produce intense rainfall. Often the intense rainfall leads to flooding and landslides and thus to widespread destruction. At short lead times (0-12 hours), numerical weather prediction (NWP) models show low skill in the MC for forecasting convective activity. Nowcasting aims to solve this issue by using alternative methods to NWP models to make more accurate and reliable predictions of convective activity from observations over this key timescale. Optical flow algorithms are one of the most effective nowcasting methods as they are able to accurately track clouds across observed image series and predict forward trajectories. Optical flow is generally applied to weather radar observations, however, the radar network over the MC is sparse and cannot penetrate the high mountainous regions. In this research, we present the results of applying the Lukas-Kanade optical flow algorithm to infrared satellite imagery to generate 1 – 6 hour lead time nowcasts of storms over the MC. For evaluation of the nowcasts, we present a novel adaption of the fractional skill score to quantify how nowcast skill varies spatially and temporally across the MC domain. Overall, the results show that the Lukas-Kanade algorithm has good skill, outperforming a persistence forecast for all lead times and showing skill up to 6 hours on a 50 km spatial scale. Low skill is observed over the mountainous regions in the early afternoon due to the algorithm's inability to predict convection initiation. Overnight, however, high skill is seen over the sea as the model is able to accurately predict the offshore propagation of storms. These results show that the Lukas-Kanade algorithm can effectively nowcast mature storms and, when analysed alongside skill maps, has potential to be used in an operational nowcasting system for the MC.

Operational Forecasting On-the-Fly

Laurents Marker (he/him), Software Developer, National Centre for Atmospheric Science

Session 2: Forecasting & Nowcasting

At the National Centre for Atmospheric Science (NCAS), a new operational forecasting project is under way. FORCE (Forecasting Operations for Research Campaigns and Experiments) will enable users to access bespoke forecasting and visualisation tools to enable better scientific planning and decision making for projects within the atmospheric science community. A particular focus is the support of operations at the Facility for Atmospheric Airborne Measurements (FAAM) and Atmospheric Measurement and Observation Facility (AMOF).

The development of a robust pipeline for the production and dissemination of on-the-day forecasting products requires a variety of methods and expertise from the fields of atmospheric science, computing and communications. In particular, product design and specification, high performance computing, atmospheric modelling, user interfacing, data post-processing, visualisation and archiving and web development. In this presentation we will discuss ongoing development, tools and methods for forecasting and plans for improvement and growth. We will display examples of our products and their applications in campaigns.

Interactive visualisation tools hosted online allow users to access the model outputs through an intuitive, purpose-built interface. The Weather Research and Forecasting (WRF) model and the Model for Predictions Across Scales (MPAS) provide our simulations and plots are produced on a computing cluster at the University of Leeds whilst the web server is hosted via the JASMIN system at the Rutherford Appleton Laboratory. Python data processing and graphical packages such as wrf-python and matplotlib provide the post-processing for model output with web design software such as the Django REST framework and MapBox GL being used to create a user-friendly platform.

CoastSafe: Early Warning System for the Rush-Portrane Coastline

Daniel O'Brien, Student, Maynooth University

Session 2: Forecasting & Nowcasting

This project aims to develop a coastal warning system for vulnerable beach dune systems in Rush-Portrane, Ireland by utilising specialised models and data collected by citizen scientists to provide early warnings of coastal hazards to local communities.

A study is being conducted in a region prone to coastal erosion and aims to improve the response of authorities and protection measures by providing accurate information. A combination of oceanographic and morphological modelling methods to predict a 'Safe Corridor Width' at a coastal location, was combined with crowdsourced data to create the system. This data is analysed and combined with other sources such as remote sensing to improve quality, and processed in software to generate relevant, high-resolution hazard forecasts.

The outcome of the CoastSafe project will demonstrate the feasibility of utilising traditional methods and citizen science initiatives for real-time hazard forecasting. The system's objective is to provide more accurate coastal forecasts with high temporal and spatial resolution and therefore help in mitigating major impacts to the local environment. Additionally, the system could provide valuable information for decision-makers, local authorities, and businesses, to help minimise the impacts of coastal erosion and reduce disruption to communities.

In conclusion, the real-time coastal forecasting system being developed will demonstrate the potential of combining modelling and citizen science methods to provide accurate and up-to-date hazard information, which can help improve public safety and reduce the impacts of coastal erosion.

Improving Vertical Detail in Simulated Temperature and Humidity Data Using Machine Learning

Joana Rodrigues (she/her), AI Aided Hybrid Modelling Scientist, Met Office

Session 3: Data Science

Low-level clouds are not properly resolved in weather and climate models and cloud fraction can sometimes be underestimated at those heights due to temperature inversions that occur at scales smaller than the vertical resolution of the models. Studies have shown that due to their strong shortwave radiation effect, the poor representation of low-level clouds in GCMs is one of the main sources of uncertainty in surface temperature predictions in global warming simulations. For that reason, increasing the vertical resolution in global models is vital, but unfortunately, still too computationally expensive. Machine Learning (ML) comes up as a more viable and affordable solution. In this project, we aim to build a Machine Learning model to improve the resolution of the Temperature and Specific Humidity vertical profiles by training it with radiosonde data, which has a much higher resolution than the forecast models. The ML model trained for this purpose is a Convolutional Neural Network with a U-Net architecture and the results so far are promising, with our model outperforming a cubic interpolation for both Temperature and Specific Humidity. When plotting cloud fraction from the model's predictions it was observed that for some cases the model is already improving the estimate of cloud fraction at low heights. So far, the model has shown great promise but there is still a lot that can be done to further improve it. In the future, if successful, it could also be applied to other similar applications.

Reducing the Overhead of Coupled Machine Learning Models Between Python and Fortran with an Application to Gravity Wave Parameterisations

Jack Atkinson (he/him), Research Software Engineer, Institute of Computing for Climate Science, University of Cambridge

Session 3: Data Science

Machine learning (ML) has recently been utilised to achieve higher computational and/or predictive performance in climate models. This is often through subgrid models (or parameterisations), with a neural network trained against observational data or a high-resolution dynamical model.

This approach typically results in the challenge of language interoperation: Python is the most popular language for building ML models due to libraries like PyTorch and TensorFlow, whilst Fortran is commonly used for climate and other geophysical models. Fortran and Python have different data models and so aligning the two languages requires some care. Interoperability libraries, such as forpy, that allow communication between the languages exist. This involves establishing native Python types that are accessible from Fortran and requires restructuring of data when exchanging information. In this work, we ask, is this method the best approach?

We present alternative approaches for TensorFlow and PyTorch that avoid direct use of Python and leverage the significant advantages of shared memory. To do this we have produced Fortran libraries that access the underlying ML codebase via an Application Programming Interface (API). For PyTorch this accesses a TorchScript model, whilst TensorFlow involves code-generation of a Fortran module.

We test these approaches in the context of atmospheric gravity waves; a key source of momentum transfer and driver of global circulation. Due to their range of spatial scales subgrid parameterisations are required in models. Recent work has shown that a data-driven ML model can replace physics-based schemes in climate models and successfully reproduce the Quasi-Biennial Oscillation - a key test for the effectiveness of parameterisations.

Early tests indicate speedup of around 3x when compared to the forpy approach, with further tests and comparisons between the approaches in progress. Our code libraries are open-source, supported, and well-documented, with examples to guide users with a wide variety of potential applications across geophysical modelling.

A Machine Learning Approach to Study Coastal Flooding Caused by Extreme Sea Level Changes

Alice Re (she/her/they/them), PhD Student, Interuniversity Department of Regional and Urban Studies and Planning (DIST), Politecnico and Università di Torino

Session 3: Data Science

Extreme sea levels and coastal flooding are projected to be among the most uncertain yet severe outcomes of climate change, due to a combination of hazard variability and high population and asset exposure in coastal areas. A wide spectrum of assessment methodologies for coastal flooding has been developed in research as a consequence of this. On one side of the spectrum, indicator-based methodologies favour ease of application, scalability and low computational requirements sometimes to the detriment of accuracy. On the other, methodologies such as numerical flood modelling are able to provide accurate depictions of the flood event while oftentimes entailing prohibitive runtime requirements and economic costs. In order to overcome some of these methodology limitations, the use of Machine Learning approaches for flood modelling is currently being explored in scientific literature. The ability to represent nonlinear interactions among different system components and diverse data types, coupled with the lower computational requirements and quicker runtimes make Machine Learning approaches suitable candidates to study flood events in the context of climate change adaptation. The aim of this research is to define and implement a Machine Learning-based approach to study the exposure to coastal inundation caused by extreme sea level changes, accounting for both data on the coastal flood hazard (i.e., climate variables related to the sea level in coastal areas) and data on the physical geographical features influencing the way the flood event might unfold locally. The creation of the database on the locally-relevant climatic and geographic flood triggering factors will be discussed; particular attention will be paid to data on recorded extreme events needed to train the model, and to the potential alternatives in the event of their paucity or absence. The choice of the specific algorithm, its possible outputs and main drawbacks will also be addressed.

A Flexible Data and Knowledge-Driven Method for Identifying Climate Drivers to Predict Summer Conditions in Northeast China

Nathan Creaser (he/him), Scientific Software Engineer, Met Office

Session 3: Data Science

Northeast China is a globally important food production region. Working with the China Meteorological Administration, the Met Office have co-developed an annual climate service forecasting maize yield in the region aimed at helping regional planners manage risks to food security. As the current seasonal forecast models have limited skill in this region, the maize yield predictions are currently based on observed June-August temperature and precipitation. Therefore, we have developed a flexible and powerful method for generating skilful statistical forecasts of June-August temperature and precipitation, increasing the time available for decision makers to take appropriate action to adverse conditions. There are 5 main steps to our approach: 1) collecting a large set of potential predictors at monthly temporal resolution (e.g. ENSO, IOD, NAO indices) from the KNMI data explorer or calculated from ERA5 reanalysis. 2) Random Forest regression for feature selection. 3) Bayesian Networks to identify the subset of selected features that have the most explanatory power and to explore potential causal relationships between predictors and regional temperature and precipitation in Northeast China, incorporating knowledge of teleconnections. 4) Testing the physical plausibility of these links by mapping correlations between selected features and global meteorological variables. 5) Out-of-sample predictions using the optimal subset of predictors in Linear Regression models to forecast temperature and precipitation in each region. This approach is trained and tested for 1980-2016 and shows improved performance compared to current dynamical seasonal forecast models for Northeast China but could be applied anywhere in the world.

Investigating the Benefits of Using Reforecasts for Statistical Post-Processing of Weather Forecasts

Ben Hooper (he/him), Foundation Scientist, Met Office

Session 3: Data Science

Numerical Weather Prediction (NWP) is a method of forecasting which uses a set of physics equations to model the weather. Due to the inherently chaotic nature of the weather and model biases arising from uncertainty in the initial conditions, parameterisations in the equations, and numerical methods applied in solving the equations, such forecasts can be inaccurate. Post-processing of NWP forecasts can reduce these biases. Statistical post-processing, for example, utilises a historic record of forecasts and verifying observations to determine a relationship between them, before applying a corresponding correction to future forecasts to improve performance.

Forecast biases are dependent on the model used to generate them, so that statistical post-processing trained on forecasts from one model cannot be used to correct forecasts generated by another model. It is, however, desirable to train statistical post-processing schemes on a long dataset so that the model is exposed to a wide variety of weather types and even rarely occurring events are accounted for. Updates to the NWP model make the use of such a dataset challenging, because data from previous model versions are not representative of current model biases.

A possible solution to the desire for long training datasets is the production of reforecasts; retrospective forecasts generated using a fixed model version. By generating reforecasts, a dataset of forecasts and verifying observations can be created which is longer than would be available if only forecasts from the current model version were used. In practice, the production of reforecasts is computationally expensive and requires storing large volumes of data. This means that statistical post-processing trained on reforecasts must result in better forecasts than using a shorter training dataset of previous forecasts to be worthwhile. This presentation will compare the performance of different statistical post-processing methods using forecast or reforecast datasets for training.

Climate Modelling the Atmospheric and Environmental Effects of Hydrogen

Hannah Bryant (she/her), PhD Student, University of Edinburgh

Session 4: Air Quality and Atmospheric Chemistry

A shift in our energy production is crucial to the control of global warming. This will occur as fossil fuels are phased out, following legislation created to reach the targets set out in the Paris Agreement. One of the possible sources for a low carbon energy landscape is hydrogen. Whilst hydrogen represents a potential energy source, it carries the risk of leakage from the system. This leakage causes an associated increase in atmospheric hydrogen concentrations. Changes in atmospheric hydrogen have both chemical and radiative impacts; here we use a model to investigate the potential environmental effects of a hydrogen economy.

Estimates of hydrogen from current modelling studies disagree with observational measurements due to limited representations of important processes related to hydrogen within chemistry climate models and some budget terms remain highly uncertain. I am using the United Kingdom Chemistry and Aerosol model within the atmosphere only version of the UK Earth System Model to simulate the current atmospheric budget of hydrogen and to update the hydrogen Global Warming Potential. This involves the quantification of any indirect radiative effects due to the interaction between hydrogen and the radiatively active gases methane, ozone, and water vapour. Without suitable quantification of these effects, the consequences of a hydrogen economy remain uncertain. This work is part of the wider model inter-comparison project, HYDROGEN, with the Centre for International Climate Research.

3D Simulations of the Archean Earth Including Photochemical Haze Profiles

Mei Ting Mak (Martha, she/her), PhD Student, University of Exeter

Session 4: Air Quality and Atmospheric Chemistry

The first evidence for life on Earth dates back to the Archean (2.5-3.8 billion years ago). The atmosphere during the Archean was temperate and reducing, which suggests a low likelihood of oxygen-based metabolisms but a prevalence of methanogens instead. Since the Earth's atmosphere has spent most of its

time in the Archean, it is reasonable to expect that other Earth-like planets in the habitable zone to possess an Archean-like atmosphere, characterised by high concentration of CH_4. CH_4 as a greenhouse gas would warm up the planet but laboratory data have shown that when CH_4/CO_2 exceeds approximately 0.1, hydrocarbon haze would start forming which would cool down the planet due to its antigreenhouse effect. We therefore need a comprehensive study of haze when modelling CH_4 in the Archean or exoplanets.

By varying the CH_4/CO_2 ratio, we prescribe different profiles of haze into the Archean atmosphere within a 3D general circulation model (GCM) - the Met Office Unified Model. We find that the temperature profile is very sensitive to the prescribed haze profile. When $CH_4/CO_2 \approx 0.1$, the haze layer has no radiative impact on the atmosphere. When we increase CH_4/CO_2, the global mean surface temperature drops rapidly, therefore changing the global circulation. When CH_4/CO_2 goes beyond ≈ 0.2, the haze layer becomes saturated and the atmospheric structure does not vary much. We therefore conclude that the ratio of CH_4/CO_2 would be small for a temperate Archean climate. This study has important implications for the habitability of exoplanets, particularly for M-dwarf hosted planets where atmospheric methane absorption of the stellar radiation is larger.

New Pollen Forecasting System at the Met Office

Katie Coward (she/her), Foundation Scientist, The Met Office

Session 4: Air Quality and Atmospheric Chemistry

More than 10 million people in UK suffer from hay fever. The Met Office produces a pollen forecast which helps suffers manage their symptoms. The current forecast is produced manually using expert judgement for 16 regions. Over the last few years, work has been underway at the Met Office to produce a new pollen forecasting system which outputs pollen concentration on a 5 km grid. Utilizing the Met Office's 1.5 km weather model and atmospheric dispersion model, the new forecast requires no manual input. The new system is species specific, modelling the emission and dispersion of alder, hazel, birch, oak, grass, and nettle pollen. The pollen emissions consider many meteorological conditions including the accumulated temperature of the year so far, allowing species to be emitted during their season. Other factors include wind speed, humidity, and precipitation rate. Comparison of the output of the new pollen model with the existing forecast shows it produces comparable results with the benefits of being species specific, higher horizontal resolution and requiring no manual input.

Air pollution in the U.K.

Dimitra Gkouzouli (she/her), Research Lead, Six Degrees Edinburgh

Session 4: Air Quality and Atmospheric Chemistry

Contrary to popular belief, the United Kingdom (U.K.) air pollution crisis does not mainly stem from rising levels of air pollution, but from the impacts of air pollution. This report attempts to estimate the levels of ground-level air pollution, assess the impacts and review the relevant policies. We analysed data from 2020 by the Department of Environment and Rural (D.E.F.R.A.) and the National Atmospheric Emission Inventory (N.A.E.I.) using Python. We included the industrial processes into a broad industrial sector, to examine how legitimate is to focus the blame into individual responsibility. We innovate by naming the company sites that recorded highest annual emissions. We found out that the D.E.F.R.A.'s pollutant with the greatest number of zones exceeding limits is ozone, followed by nitrogen oxides. Both are greenhouse gasses (G.H.G.s) with no legally binding limits. Greatest annual overall pollution was found at South Whales, followed by The Greater London Urban Area. The cleaner air is found in Northeast Scotland. Industries cover the greatest responsibility of pollutant sources (37%), with agriculture (18%) succeeding. The sites that recorded highest annual limits, with descending order, were Wintershall (gas and oil), Wyman-Gordon Limited (forging for civil and military applications), YUASA BATTERY (UK) LTD (batteries manufacturer for commercial, industrial and defence applications), Px (TGPP) Limited (waste disposal management and energy storage) and Vion Food group (meat and plant-based alternatives). The annual nitrogen oxide offshore levels exceed those of Northern Ireland, Scotland and Whales all together, exposing the personnel into alarmingly high health risks. There are no data about U.K. Overseas Territories, Gibraltar, and Crown Dependencies. UK pollutant limits align with the WHO guidelines, but there is great uncertainty as to which legislation will cease after Brexit. Steps need to be taken to monitor more effectively and transparently air pollution, with a focus on vulnerable communities.

How Well are Aerosol-Cloud Interactions Represented in Climate Models?

George Jordan (he/him), Foundation Scientist, Met Office Hadley Centre

Session 4: Air Quality and Atmospheric Chemistry

Aerosols have a potentially large effect on climate, most notably through their interactions with clouds. These aerosol-cloud interactions are thought to cool the Earth via two mechanisms known as the first and second indirect effects. The former describes how aerosols act to produce more reflective cloud droplets which scatter more sunlight back to space, whilst the latter describes how aerosol-influenced clouds may retain more liquid water which increases cloud lifetimes and the duration in which they reflect incoming radiation. The magnitude of the combined cooling effect of the two mechanisms is highly uncertain partly due to models struggling to represent cloud responses to aerosol changes. As atmospheric aerosol concentrations continue to decrease it is important to address this uncertainty to better understand how much of this cooling effect we stand to lose. Large volcanic eruptions produce sulphur dioxide, which in turn produces aerosols, and so provide an opportunity to assess the model simulation of aerosol-cloud interactions. In this study, we use satellite and ground-based observations of the 2014-15 volcanic eruption in Holuhraun, Iceland to perform a multi-model assessment of 9 general circulation models. Preliminary results suggest that the models successfully replicate the first indirect effect, yet their ability to capture the second indirect effect differ markedly from one another. Moving forward, this study looks to quantify and compare the magnitude of the Holuhraun aerosol induced cooling across the models. This will provide an insight into whether a model's inability to simulate the second indirect effect alters the projected cooling. If found to do so, then this provides the wider climate modelling community a route to reduce the uncertainty of the magnitude of cooling from aerosol-cloud interactions.

Understanding Climate Drivers of Drought and Fire Multi-Hazards in Indonesian Borneo Using Climate Model and Seasonal Hindcast Ensembles

Timothy Lam (he/him), PhD Student, University of Exeter

Session 5: Tropics

Fires occurring over the peatlands in Indonesian Borneo accompanied by droughts have posed devastating impacts on human health, livelihoods, economy and the natural environment, and their prevention requires a comprehensive understanding of climate-associated risk. We want to strengthen the possibility of early warning triggers of drought, which is a strong predictor of the prevalence of fires, and evaluate the climate risk relevant to the formulation of long-term policies to eliminate fires. Although it is widely known that the droughts are often associated with El Niño events, the onset process of El Niño and thus the drought precursors and their possible changes under the future climate are not clearly understood. Here we use a causal network approach to quantify the strength of teleconnections to droughts at a seasonal timescale shown in (1) observational and reanalysis data (2) CMIP6 models and (3) seasonal hindcasts. We consider two drivers of JJA droughts identified through literature review and causal analysis, namely Niño 3.4 SST in JJA (abbreviated as ENSO) and SST anomaly over the eastern North Pacific to the east of the Hawaiian Islands (abbreviated as Pacific SST) in MAM. The observational and reanalysis data proves that the droughts are strongly linked to ENSO variability, with drier years corresponding to El Niño conditions, and droughts can be predicted with a lead time of three months based on their associations with Pacific SST, with higher SST preceding drier conditions. We find that some CMIP6 models are showing unrealistic amounts of JJA rainfall and underestimate drought risks in Indonesian Borneo and their teleconnections, owing to the underestimation of ENSO amplitude and overestimation of local convections. Under the SSP585 scenario, the CMIP6 multi-model ensembles show significant increase in both the maximum number of consecutive dry days in the Indonesian Borneo region in JJA ($p = 0.006$) and its linear association with Pacific SST in MAM ($p = 0.001$) from year 2061 – 2100 compared with the historical baseline. On the other hand, seasonal hindcast models are (1) overestimating the variability of maximum number of consecutive dry days, (2) showing varied skills in simulating the mean rainfall and drought indicators, and (3) underestimating the teleconnections to Borneo droughts, making it difficult to assess the likelihood of unprecedented drought and fire risk under El Niño conditions. Our study agrees with previous studies regarding the limited skill of fire risk prediction by state-of-the-art seasonal forecasting models, with their shortfalls caused by a lack of proper representation of relevant teleconnections.

Exploring the Compound Nature of Extreme Meteorological Events in Brazil Using an Events-Based Approach

Anna Bradley (she/her), Foundation Scientist – Climate Impacts Modelling, Met Office

Session 5: Tropics

Traditional approaches to analysing climate risk often focus on individual extreme events. However, these approaches can struggle to capture the full extent of the potential impact on lives and livelihoods as these events rarely happen in isolation. Increasingly, compound event analysis is being utilised to study events which are driven by multiple hazards, or result in multiple impacts, offering a more robust method to comprehensively assess risks.

This study uses an events-based approach to identify and analyse historical impactful meteorological events in Brazil. We perform a series of evaluations to diagnose the compound characteristics of each event. In collaboration with Brazilian partners through the Climate Science for Services Partnership initiative, events were identified through a variety of sources including published reports, media announcements and workshop surveys. By using ERA5 reanalysis data, we identified meteorological signals, such as the Wet Bulb Globe Temperature (a measure of human heat stress) and the Standardised Precipitation Index (a measure of precipitation conditions), with associated historical events. The spatial and temporal interactions between hazards were subsequently analysed to explore the extent to which they could have contributed to reported impacts. To assess how the frequency and severity of compound events may change under climate change, the impact indices were also calculated for CMIP6 models at different global warming levels.

We highlight how the characterisation of compound events improves the understanding of the risk of extreme meteorological events to society in a changing climate, and therefore informs the development of more effective climate adaptation strategies.

Sub-Saharan African Precipitation Responses to Aerosol Forcing

Catherine Toolan (she/her), PhD Student, University of Reading

Session 5: Tropics

My PhD project aims to examine the effects of future anthropogenic aerosol emissions on sub-Saharan African climate. Aerosols play an important role in climate response to anthropogenic emissions through their changes to global-mean effective radiative forcing, but their impacts are felt most strongly at a regional level. The project will investigate the effects of both local and remote aerosol emission changes on Eastern and Western sub-Saharan African climate, and the sensitivities to the geographical region and composition of the aerosol emissions, as well as the mechanisms behind these changes. In addition, the dependence of the aerosol forcing response on the representation of aerosol processes and the modelled internal variability will also be investigated.

This presentation will focus on the changes in behaviour of precipitation metrics over Africa in historical and Detection and Attribution Model Intercomparison Project (DAMIP) experiments under different forcings, for example aerosol-only forcing. Specifically, the presentation discusses the response of the West African monsoon and the East African rainy seasons associated with the interannual migration of the Inter-Tropical Convergence Zone to aerosol perturbations. The changes to West African monsoon onset and total precipitation are discussed, as well as changes in the interannual variability of monsoon behaviour.

A Lagrangian View to the Evolution of Convective Updrafts

Thomas J. Hutton, PhD Student, University of Exeter

Session 6: Modelling

Fires occurring over the peatlands in Indonesian Borneo accompanied by droughts have posed devastating impacts on human health, livelihoods, economy and the natural environment, and their prevention requires a comprehensive understanding of climate-associated risk. We want to strengthen the possibility of early warning triggers of drought, which is a strong predictor of the prevalence of fires, and evaluate the climate risk relevant to the formulation of long-term policies to eliminate fires. Although it is widely known that the droughts are often associated with El Niño events, the onset process of El Niño and thus the drought precursors and their possible changes under the future climate are not clearly understood. Here we use a causal network approach to quantify the strength of teleconnections to droughts at a seasonal timescale shown in (1) observational and reanalysis data (2) CMIP6 models and (3) seasonal hindcasts. We consider two drivers of JJA droughts identified through literature review and causal analysis, namely Niño 3.4 SST in JJA (abbreviated as ENSO) and SST anomaly over the eastern North Pacific to the east of the Hawaiian Islands (abbreviated as Pacific SST) in MAM. The observational and reanalysis data proves that the droughts are strongly linked to ENSO variability, with drier years corresponding to El Niño conditions, and droughts can be predicted with a lead time of three months based on their associations with Pacific SST, with higher SST preceding drier conditions. We find that some CMIP6 models are showing unrealistic amounts of JJA rainfall and underestimate drought risks in Indonesian Borneo and their teleconnections, owing to the underestimation of ENSO amplitude and overestimation of local convections. Under the SSP585 scenario, the CMIP6 multi-model ensembles show significant increase in both the maximum number of consecutive dry days in the Indonesian Borneo region in JJA ($p = 0.006$) and its linear association with Pacific SST in MAM ($p = 0.001$) from year 2061 – 2100 compared with the historical baseline. On the other hand, seasonal hindcast models are (1) overestimating the variability of maximum number of consecutive dry days, (2) showing varied skills in simulating the mean rainfall and drought indicators, and (3) underestimating the teleconnections to Borneo droughts, making it difficult to assess the likelihood of unprecedented drought and fire risk under El Niño conditions. Our study agrees with previous studies regarding the limited skill of fire risk prediction by state-of-the-art seasonal forecasting models, with their shortfalls caused by a lack of proper representation of relevant teleconnections.

On Alleviating Semi-Annual Oscillation Wind Biases in Climate Models

Aleena M J (she/her), DPhil Student, University of Oxford

Session 6: Modelling

The representation of the semi-annual oscillation (SAO) in models shows up a common easterly bias of several tens of m/s compared to observations. These biases are likely a response to deficiencies in eastward wave forcing or the position and timing of the climatological summer time jet and Brewer-Dobson circulation (Smith et al 2019). This motivates further analysis of the energetics of the upper stratosphere within models and a more detailed comparison with reanalyses to see where these differences are coming from. In this study, ERA5, ERA-interim and MERRA2 reanalysis data are used to analyse the contributions of different forcing terms (from the transformed Eulerian mean momentum equation) within the SAO. A first comparison is made between WACCM from CMIP6 and reanalysis data. Analyses show that lack of strong resolved waves and parameterised gravity waves, along with weakened BDC above 1hPa might be the major model deficiencies. A further analysis is on progress to identify likely improvements, including improved convective gravity wave parametrisation, vertical resolution and whether the tropical stratosphere circulation biases are sensitive to these.

Stochastic Data Adapted AMOC Box Models.

Ruth Chapman (she/her), Phd Researcher, University of Exeter and Met Office

Session 6: Modelling

The Atlantic Meridional overturning Circulation (AMOC) is responsible for the comparatively temperate climate found in Western Europe, and its previous collapse thought to have triggered glacial periods seen in the paleoclimate data. This is a system that has multiple stable states- referred to as ‘on’ when the circulation is strong as in the current climate, and ‘off’ when it is much weaker. The AMOC has tipping points between these states. Tipping points occur when a rapid shift in dynamics happens in response to a relatively small change in a parameter. Making future projections of the AMOC response to the climate is essential for avoiding any anthropogenic caused tipping, but it is computationally expensive to calculate the full hysteresis for different scenarios. This work looks at a conceptual five box model of the AMOC which is easy to understand and cheap to implement. Previous work has considered bifurcation and rate-dependent tipping. This current work looks to estimate a realistic amount of noise from various General Circulation Model data sets and apply this to the model. We compare the covariance of the salinity data for a variety of CMIP6 models, and we compare the amount of noise covariance found in each data set, and how this can be input back into the box model. We perform some analysis to suggest where in the model the largest noise sources should be found.

Dynamically Calculating Mixing Lengths in Shallow Cumulus Convection

Alanna Power (she/her), PhD Student, University of Reading

Session 6: Modelling

Advances in computational power have enabled numerical weather prediction models to run with kilometer scale grids. Such models only partially resolve the dominant turbulent structures in the boundary layer (BL), and therefore unresolved turbulence still needs to be parametrized. However, current parametrization schemes are only valid when the turbulence is completely subgrid (unresolved). The “in-between” regime where turbulence is only partially resolved is known as the grey zone. It occurs when the length scales of the dominant turbulent structures are of the same order as the grid spacing. As the BL over land is on the order of a kilometer in height during the day, kilometer scale NWP models are firmly in the grey zone.

When modelling BLs, large eddy simulations (LES) can be employed as they use high resolution grids which can resolve turbulence down to very small scales (on the order of tens of meters). In this study, the LES model uses the Smagorinsky subgrid scheme, which is a viscosity based dissipation model that prevents a build-up of energy at the smallest scales. Kinematic viscosity depends on a mixing length, while scalar viscosity is related to kinematic viscosity via a Prandtl number. Standard LES models fix these parameters to constants. However, previous research shows that these parameter values vary widely in the grey zone, and setting parameters to constants may cause excessive energy dissipation.

Flow dependent values for the mixing lengths were determined by applying the dynamic Smagorinsky model to data from cloudy-topped BL cases. As this method requires substantial computational power, the resulting flow dependent fields were analysed to investigate if functional relationships between parameters and the flow could be found. Such relationships could be used as grey zone adaptions to more accurately represent the flow without high computational expense, while also avoiding the use of fixed constants.

How Will City Temperatures Respond to Changes in Climate?

Sarah Berk (she/her), PhD Researcher, University of East Anglia

Session 7: Applications

As centres of human activity, cities contain over half the world's population and this proportion is projected to increase to around 70 percent in 2050. The urban heat island (UHI) is a well observed phenomenon, where temperature in a city is warmer than the surrounding rural area. The properties of the UHI are influenced by both the climate and the morphology of the city. It follows therefore, that a changing climate is expected to result in consequences for characteristics of the UHI.

Modelling the future climate of cities remains a challenge as resolution of global climate models is too coarse to capture the scale of a city, and regional climate models are computationally expensive. In order to address these issues, statistical models can be used. Focusing on cities in the tropics and subtropics and those with a population of less than one million, this research explores the relationship between the UHI effect and climate. Satellite data, with global coverage, is used to quantify the SUHI of the chosen cities and statistical models fitted to the current observations using predictive variables based on climate. The model shows promising performance for the majority of cities in the dataset and results are discussed.

Multivariate Compound Cold Events in the UK

Kanzis Mattu (she/her), PhD Candidate, University of Strathclyde

Session 7: Applications

Despite climate change, extreme cold events still occur in the UK which incur costly damages and disruptions across several industries. The winter of 2010-11 brought widespread snowfall to the UK resulting in pressure on many core services including emergency and local councils. The transport industry was severely affected with heavy snowfall causing disruption to road, rail and air travel. More recently, the cold spell in December 2022 saw prolonged periods of air temperatures below freezing resulting in extensive ground frost and icy conditions across the UK. The impacts of these cold events have been amplified by the compounding effect of another meteorological variable, may that be dry or wet and windy conditions. Therefore, these cold events could be classified as multivariate compound events. The subsequent socio-economic impacts differ depending on the nature of the cold event (cold-wet-windy or cold-dry). Using meteorological observation data (HadGrid UK), this study aims to identify and classify cold-wet-windy and cold-dry events in the UK from 1884 to present. This research looks to identify the regions of the UK most susceptible to these events and predict how trends will evolve when considering climate change. Recognition of cold events as multivariate compound events will benefit future studies that consider the differing impacts of cold-wet-windy and cold-dry events in the UK.

The Future of Surface Transport Forecasting at the Met Office

Alice Lake (she/her), Scientist – Post-processing Applications, Met Office

Session 7: Applications

For more than 35 years the Met Office has been delivering key road weather information to infrastructure decision-makers across the United Kingdom, allowing them to anticipate and react to road weather hazards and thus reduce risk to members of the public. Currently, these are generated using a bespoke surface energy exchange scheme which takes forecast outputs from numerical weather prediction (NWP) models and produces deterministic predictions of the state - for example, dry, damp, or icy - of the road surface.

However, despite significant increases in forecasting capabilities over the past decades, certain meteorological conditions remain difficult to precisely forecast. A small error in the predicted location of a cloud, or the timing of a rain shower, can have a significant impact on the predicted road surface state. Therefore, the Met Office is currently developing a new Surface Transport Forecasting (STF) system designed to make use of NWP ensemble output, allowing us to move towards probabilistic, risk-based forecasting.

The new STF post-processing system is centred on the Joint UK Land Environment System (JULES), a community model used as the land-surface component of the Met Office Unified Model (UM), but which can also be used – as we do here – as a stand-alone land-surface model. Since JULES was originally developed to describe soil-vegetation-atmosphere interactions, we have had to make several modifications to the physics of the model to allow us to use it for the bespoke purpose of generating site-specific surface transport forecasts.

In this talk, I will detail the science development we have undertaken to develop an STF model within JULES. I will describe how we are using output from the Met Office regional ensemble model MOGREPS-UK to allow us to generate probabilistic forecasts. Finally, I will discuss how this work will allow us to support the future of surface transport forecasting, particularly the emerging Connected and Autonomous Vehicle sector.

Using Expired Weather Forecasts to Supply up to 10 000 Years of Weather Data

Petr Dolezal (he/him), PhD Candidate, AI for the research of Environmental Risk (AI4ER), University of Cambridge

Session 7: Applications

When modelling possible future renewable electricity systems, a strong focus needs to be directed to the input weather variables driving any such system. Since we cannot know the exact weather in any slightly distant future, a probabilistic approach is usually chosen, modelling the system over many possible scenarios, typically all of the past recorded weather data available. However, this narrows the range of situations considered to about 40 years, placing fundamental limits on the analysis, e.g. of rare, extreme scenarios.

In my work, I explore the possibility of using past expired ensemble forecasts from the European Centre for Medium-Range Weather Forecasts to drastically increase the number of scenarios considered to up to 10 000 years of data. These ensemble forecasts are physical models that are regularly initialized from the same slightly perturbed snapshot, but due to the chaotic nature of weather, their predictions diverge from each other. The later stages of their predictions are thus entirely independent predictions of what the weather could have been, including the correct spatial correlations. I analyze the data from the operational archive of ECMWF to assess their suitability for modelling renewable systems of the future and demonstrate how this wealth of additional weather scenarios can enable the utilization of otherwise heavily data-dependent machine learning techniques in energy modelling.

Intercomparison of Observations from Citizen Weather Station Networks and Applications

Chris Squires (he/him), Foundation Scientist, Met Office

Session 8: Observations

The growing prevalence of Citizen Weather Station observation networks represents an opportunity to obtain widespread and relatively low-cost meteorological observations which can be used in forecasting, numerical weather predication and nowcasting applications. In this study we analysed one year (2020) of data from three networks (Davis, Netatmo and Met Office Weather Observations Website WOW) in the UK to determine the spatial distribution, data availability and data quality. The data were compared against the Met Office 1.5 km UK Variable numerical weather prediction model background, Met Office automatic weather station data and World Meteorological Organisation criteria for spatial resolution of observations. We found that the citizen weather station networks represented a significant increase in the number and spatial density of observation sites when compared against traditional observation networks. Netatmo has over 8,800 sites, mainly located in urban areas; Davis has approx. 1,200 sites largely in rural areas and WOW almost 2,000 sites equally split between urban and rural locations. In comparison to Met Office UKV model background data the WOW network bias was smaller than that of Netatmo for all variables except pressure. Davis temperature and relative humidity measurements exhibited slightly smaller biases on average, with WOW biases lower for the remaining pressure and wind variables. Wind data from all three networks significant underestimation and large standard deviation compared to the model data, mainly due to exposure issues. Numerous studies have demonstrated effective QC techniques to remove gross errors and correct biases from crowd-sourced observations. This paper presents results of the analysis undertaken using data from 2020, including the diurnal and seasonal biases and specific data quality issues.

Characterising Ice Particle Size Distributions Using In Situ Observations

Rosie May Mammatt (she/her), PhD Student, University of Reading

Session 8: Observations

Clouds cause uncertainties in numerical weather prediction due to a lack of understanding about their microphysics. This is due to uncertainties in the representations of Particles Size Distributions (PSDs) in models. This issue has a subsequent impact in climate models, where clouds still produce some of the largest uncertainties due to a lack of understanding about how cloud microphysics will change. In this study, data collected during the Parameterizing Ice Clouds using Airborne obServationS and triple-frequency dOppler radar data (PICASSO) field campaign has been analysed. To collect these data, the Facility for Airborne Atmospheric Measurements (FAAM) research aircraft made several flights through clouds of different species and performed straight and level runs at different altitudes. Due to the difference in altitudes, the temperature varies which affects the ice crystal habit (shape) and the ratio of ice to liquid water in the cloud. The aircraft measured PSDs on each run, using correction techniques to mitigate the effect of shattering crystals. Comparison with measurements of the liquid and ice water contents and particle images, also taken by the aircraft, allows the determination of the microphysical regime of the cloud. This information will be used to characterise microphysical regimes in clouds and determine a more accurate representation of the PSDs, which could be implemented in models in improve the accuracy of predictions.

Exploring Climate Conditions on Mount Everest's Upper Slopes Using in-situ Observations and Model Outputs

Lorenzo Minola (he/him), Postdoctoral Research Fellow, University of Gothenburg (Sweden)

Session 8: Observations

Mountains cover 25% of Earth's land surface and with their snow and glaciers act as water reservoirs for more than a billion people worldwide. As climate is generally warming at high altitudes more rapidly than the global mean, these "water towers" are extremely vulnerable to the accelerated melt of their ice stores. Unfortunately, the extreme environment at really high mountains challenges the data collection for water-resource monitoring. The result is that observations of climate variables from automatic weather stations have been biased toward lower and more accessible elevations. Thus, the lack of high-altitude observations has limited the understanding of how the mountain stores of frozen water are likely to respond to climate change. This problem is especially evident in the High-Mountain Asia region, where only a few in-situ measuring stations have been installed above 5.000 m, an elevation above which most of the glaciers are found. To overcome the absence of weather monitoring at the highest mountain elevations, a network of 6 automatic weather stations has been deployed on the southern flanks of Mount Everest during the National Geographic and Rolex perpetual Planet Expedition in April and May 2019. This study comprehensively analyses for the first time the climatology of various observed climate variables (e.g., temperature, wind, humidity, etc.) on the upper reaches of Mount Everest. In addition, as reanalyses and simulations of climate models have been widely used when observations were not accessible, this study further investigates the capability of such datasets in simulating the climate here by comparison with the observations. The outcomes of this study are used for the assessment of the thermal comfort of alpine equipment (e.g., mountain boots) in laboratory testing.

Weather Forecast Verification with Crowd-Sourced Data

Matthew Spurrier (he/him), Verification Scientist (Professional Placement), Met Office

Session 8: Observations

Weather forecast verification is a vital component of developing new and improving existing weather models. The Met Office Weather Observations Website (WOW) has been in place for 10 years collecting crowdsourced observations from around the country. Currently, Met Office Public Weather Service (PWS) forecasts that appear on the Met Office website and app are verified against a set of around 120 official weather observing sites around the country.

Although these are reasonably well distributed, they do not give the same degree of fine detail as the WOW observations. Successfully harnessing this could vastly improve verification resolution, hence facilitating effective high-resolution forecasts, including more specificity to where users live, and highly localised natural hazards.

Promising early results will be presented from verification of Met Office PWS forecasts against WOW observations, for UK surface air temperature. The higher level of detail available compared to the existing verification, the ability to successfully implement data quality control, and the completeness of relevant data fields, will be investigated via case studies. Hence, the usefulness of crowdsourcing as a verification data source is to be determined.

Ray-Tracing Satellite Observations of Gravity Waves

Phoebe Noble (she/her), PhD Student, University of Bath

Session 8: Observations

Analogous to ocean waves, there are perturbations in our atmosphere known as gravity waves. Although small-scale, gravity waves are key drivers of atmospheric circulation. Understanding their sources and propagation is key to improving weather and climate models.

Gravity waves have a variety of different sources including wind flow over mountains, convection and jet stream instabilities. Yet when working with observations of gravity waves we can only make informed guesses of their sources. In this work we use GROGRAT to backwards ray trace stratospheric observations of gravity waves to learn more about their origins.

We use observations of temperatures in the stratosphere observed by the AIRS (Atmospheric InfraRed Sounder) instrument on NASA's Aqua satellite. Observed gravity waves are then backwards ray traced through the ERA5 atmosphere. The significance in this work lies in the volume: we ray trace 21 years (2002-2022) of AIRS data globally, representing by far the largest such observational dataset ever reverse ray-traced.

By investigating the lowest traceable altitude of these rays, we can attribute the gravity waves to their sources (orographic gravity waves will originate near the surface whilst convective waves will have a higher origin). We can also investigate the horizontal propagation of orographic gravity waves from specific mountain ranges and how this changes seasonally. This work aims to answer the question: "Where do gravity waves observed in the stratosphere come from?"

How the Met Office Took TikTok by Storm

Emma Lawrence (she/her), Content Production Co-ordinator, Met Office

Session 9: Applications

TikTok. More than a short-lived craze?

Although famous for its dance videos, other types of content have become just as relevant and viral. At first glance it may not seem a place for traditional brands – but we proved this wrong.

At the Met Office, we are constantly finding innovative ways to communicate our science to reach new audiences. Publishing around the clock across multiple social platforms, we keep an eye on new trends and technology. We have been monitoring TikTok since launch and it continues to top the list of most downloaded non-gaming apps used predominantly by 18-24-year olds.

Initially, whilst struggling to see a fit with our brand, we started experimenting. We created a channel in December 2019 to develop some test content and in January 2020 had published four videos getting just over 4.5k views.

The goal posts shifted in April 2020 when TikTok announced they were investing in new verticals, including fashion, cooking …and educational content. Our purposes became more closely aligned.

Educational content became an important category on TikTok, actively being promoted using #LearnOnTikTok. The channel quickly grew beyond all expectations, allowing the Met Office to reach 5.4 million people during a week of stormy weather in February 2022.

We saw anecdotal evidence of young people taking action based on our advice, with users commenting that they were going to keep their rabbit safe or tell their mum to tie down the trampoline.

For us, and many others, TikTok offers opportunities far beyond dance videos. It has become a place to engage with younger audiences when it really matters, and communicate important warnings to drive action during severe weather. It's changing the face of social media altogether and how people expect to receive information across all of their digital platforms. It is influencing culture…

Projections of the Future Heat Health Burden Under Climate, Socioeconomic and Demographic Change

Rebecca Cole (she/her), PhD Student, London School of Hygiene and Tropical Medicine

Session 9: Applications

Under climate change periods of extreme heat are projected to increase in frequency, duration and intensity and summers are generally set to become warmer. Higher ambient temperatures are linked to morbidity and mortality. A large body of literature aims to estimate the future heat health burden to inform policy interventions.

Older adults and those with existing health conditions are most vulnerable to the impacts of heat and across much of the world global warming is being accompanied with population growth and aging. In a review of the literature, we found only 25% of studies estimating the heat health burden considered the effect of aging and a third of (radiative concentration pathways)RCP-(shared socioeconomic pathways)SSP pairings considered in such studies where unfeasible. Neglecting these effects was found to lead to an underestimation of the heat health burden of 64% on average across studies when compared to the same warming with no population effect. Underestimation of the future burden could impede action and lead to under preparedness.

This work aimed to project the heat health burden under detailed future scenarios informed by the recently published UK-SSP data which provides quantitative projections of several socioeconomic indicators at regional levels across the UK. Observations of these indicators are used to fit a regression model to existing risk coefficients and the model is then used to predict risk coefficients under the projected indicators for each scenario from the UK-SSP data. Weather data from the UKCP18 projections is used to estimate the deaths attributable to heat under population change, socio-economic development, and climate changes. These new estimates of the heat health burden will be discussed.

Characterization of heat waves and human health on the north coast of Peru

Wil Laura (he/him), Meteorologist and Graduate Student, University of Liverpool

Session 9: Applications

Heat waves are among the most dangerous natural hazards. More than 166 000 people worldwide died as a result of heat waves in the last 20 years. In developing countries, heat waves can have the most negative health effects, thus it is imperative to discover more insights about the relationship between heat waves and health in these regions. The purpose of this study was to examine the characteristics of heat waves that affect health along Peru's north coast. A relative risk methodology on general mortality across 30 definitions of heat waves was employed to establish which definition was most relevant in five communities with deaths and meteorological records during the 2003-2017 period. Then, using reanalysis data from 1981 to 2017, a machine learning technique known as self-organized maps was used to discover the frequent synoptic patterns during the occurrence of heat waves. It was found that when the maximum air temperature exceeds the 95th percentile threshold for at least two days, there is an increased risk of death by heat waves. During the warmer months of the year, these events can happen one to two times, and they usually last three days. There are two common synoptic patterns: the first depicts a localised warming of the air under the influence of surface northerly winds, and the second depicts a regional warming on a synoptic scale linked to El Niño events. These insights will be helpful in creating an accurate health-focused heat warning system. In addition, the increase in the frequency of these events over the last decade emphasises the importance of developing policies regarding natural hazards and public health planning.

How Public Sector Organisations are Adapting to Climate Change: A Scottish Case Study

Emma L Yule (she/her), PhD Researcher & Tutor, University of Edinburgh

Session 9: Applications

As global temperatures rise, many forms of extreme events are set to become more intense and increase in frequency. Risk assessment underpins effective adaptation decision-making helping to reduce the impacts of such extreme events. This research examines how risk assessments for adaptation are being conducted by the public sector in Scotland from planning to implementation. Some key challenges faced by the public sector in Scotland that are leading to a lack of progress in the adaptation space as noted in a recent UK Climate Change Committee report, “Is Scotland climate ready? – 2022 Report to Scottish Parliament” are presented. The key research questions considered are: “What tools, frameworks, data and knowledge are currently being used to conduct risk assessments for adaptation?”; “What kind of tools, frameworks, knowledge and data may be helpful for decision makers in this space?” and “What challenges and barriers exist for public sector bodies when setting out to complete a risk assessment for adaptation?” This research presents where the key challenges lie when accessing, interpreting and using information to complete risk assessments for adaptation by report analysis and through conducting semi-structured interviews with practitioners. By setting out the challenges currently facing the public sector in Scotland, as well as discussing potential solutions, this study can help bridge the gap between climate science and decision-makers by making it clearer what the requirements are for future tools, models and data to help accelerate adaptation action and how it is reported on and evaluated.

An Analysis of the Daily Variation in the LLJ at BBM, Algeria and Comparison to ERA5

Alice Reynolds (she/her), Student, School of Geography and the Environment, University of Oxford

Poster Board Number: 1
In Person

Understanding mineral aerosol emissions (also known as dust) is important due to their direct, semi-direct and indirect impacts on local and global climate. As a result of these impacts, the correct modelling of dust emissions is important for our understand of climate. Observational data is key to our understanding of dust emissions as well as the evaluation of models. This research uses wind speed data from the June 2011 Fennec project at Bordj Badji Mokhtar (BBM), Algeria to analyse the characteristics of the low-level jet (LLJ) - the second most important source of dust at the BBM. This data is then compared to wind speed data from ERA5 to evaluate how well ERA5 compares to observed wind speeds. Temperature data from ERA5 was also analysed to aid the evaluation of ERA5. Overall, significant variation of the LLJ was found between days. For those day which were previously categorised as having LLJ activity, there was variation in the how well the profiles compared to what would be expected for a day with LLJ activity. This variation was generally captured by ERA5 although a consistent underestimation of wind speeds by ERA5 was also seen. Additionally, ERA5 could not replicate the turbulence seen in the early afternoon in observations.

Ground-Truthing of the ICESat-2 Atmospheric Backscatter Data

Andrew Martin (he/him), PhD Student, University of Leeds

Poster Board Number: 2
In Person

Studies have shown that the radiative effects of clouds over the Greenland Ice Sheet lead to increased radiative forcing at the surface, and have shown that this effect is likely to increase in magnitude in a warming climate. Higher radiative forcings can increase the rate of ice sheet mass loss, resulting in global sea level rise. Small changes in cloud occurrence can result in large energy imbalances at the surface. As such, monitoring the presence of clouds and the conditions that promote them is important to understanding how the polar regions will evolve. This study will look to ground-truth the ICESat-2 ATL09 atmospheric data product by comparing the lidar backscatter profiles with those taken from the ground at the Summit Camp, Greenland, and Rothera, Antarctica. This work will pave the way for a climatology of polar clouds detected by ICESat-2 since its launch in 2018, which will add to our knowledge of polar clouds and the conditions under which they form.

Trends and Regional Variation in Upper Tropospheric Humidity

Thea Stevens (she/her), PhD Student, University of Reading

Poster Board Number: 3
In Person

Water vapour dynamics increase the magnitude of climate change in response to anthropogenic warming resulting in a major positive feedback. This is determined as the moisture holding capacity of the atmosphere is expected to increase with rising temperatures which, as water vapour is a greenhouse gas, causes greater absorption of longwave and shortwave radiation by the atmosphere. Model simulations show that this feedback is the most powerful feedback in the climate system, with the capacity to more than double the sensitivity of the surface temperature to anthropogenic forcing. The upper troposphere plays a particularly important part of this mechanism, with studies suggesting that a large portion of this feedback results from this region.

Despite the importance and the physically well understood thermodynamics of upper tropospheric humidity, there remains uncertainty in the ability of models to simulate variability correctly. Therefore, the aim of this work is to understand the main climatology, variability and trends in upper tropospheric humidity and to provide a direct comparison with model simulations. Here we will evaluate satellite dataset quality and quantify the variability of atmospheric humidity in space and time. To do this, the agreement between different satellite and other observational datasets will be investigated. Then, with the use of the Radiative Transfer for TOVS (Television infrared observation satellite Operational Vertical Sounder) model, ERA5 outputs of upper tropospheric humidity will be investigated to understand how well this variable is simulated and how much of its variability is captured. This work will provide a direct comparison of observational and model upper tropospheric humidity.

Future Changes in East African Long Rains and Indo-Pacific Warming

Thea Stevens (she/her), PhD Student, University of Reading

Poster Board Number: 4
In Person

East Africa has an arid climate with a bi-modal annual precipitation cycle. The long-rains, occurring during March April and May, provides a great amount of precipitation in the region and therefore has a large societal impact on local populations. Since the 1980s, observational data shows a decrease in precipitation totals during this rainfall season. However, in contradiction to this observed drying, CMIP6 models projects a wetting trend in response to anthropogenic warming. This contradiction has become known as the ‘East African rainfall paradox’.

One of the main reasons behind observed rainfall decrease is suggested to be the warming of the Indo-Pacific Ocean potentially due to anthropogenic global warming. Here, we analyse the uncertainty in future long-rains precipitation evolution in 38 CMIP6 models and investigate its connection to changes in Indo-Pacific sea surface temperature (SST) through a storyline approach. We find that though all models tend to show a positive change in long-rains in the future over East Africa, there is a sensitivity to the SST warming over the Indo-Pacific Ocean. The models with higher Indo-Pacific warming show a lesser increase in rainfall over East Africa. This indicates that the decline in the observed east African long rains over the last decades may not be entirely a “paradox”. Rather our results from multiple coupled climate models support a potential role of the recent Indo-Pacific warming to East Africa long rains decline under anthropogenic climate change

Application of Stochastic Partial Differential Equations to the Problem of Radar Nowcasting

Viv Atureta (she/her), Postgraduate Research Associate, University of Exeter

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Poster Board Number: 5
In Person

In this work, we develop spatio-temporal statistical models for nowcasting precipitation using weather radar observations. The dynamics of the system are captured by the advection-diffusion equation. We show that this partial differential equation (PDE) coupled with a forward-time centered-space (FTCS) discretization scheme gives rise to a vector autoregressive (VAR) process. We introduce some randomness into the PDE, by defining spatially correlated errors via a Gaussian Process.

With the VAR(1) model we aim to estimate parameters like the advection velocity, diffusion, dampening, and spatial dependence parameters like correlation length and variance, using a few past radar images up to the present. The estimated parameters are encoded in a propagation matrix (D) in our VAR(1) model and used to advect the last radar image forward for a few time steps to make predictions about where we expect to see rain and when.

The principal focus in the proposed model is in achieving computational efficiency using sparse matrices in the estimation of the advection-diffusion and the covariance function parameters. Simulation studies are used to explore the efficiency of the method. The nowcasts will be evaluated with lead times from 15 minutes to 6 hours and we aim to compare this with UK precipitation events available from the Met Office Nimrod data.

Decadal Modulation of El Niño-Southern Oscillation by Atlantic Multidecadal Variability

Arundhati Kalyan (she/her), Postgraduate Researcher/PhD Student,
School of Earth and Environment, University of Leeds

Poster Board Number: 6
In Person

Coupled ocean-atmosphere interactions give rise to distinct low-frequency patterns of climate variability in the Earth's ocean basins. These naturally occurring climatic modes mutually interact and remotely modulate one another's properties and meteorological impacts. For instance, the El Niño-Southern Oscillation (ENSO), which varies interannually in the tropical Pacific, is known to be influenced by sea surface temperature (SST) changes in the Atlantic and Indian Oceans.

Our study aims to investigate the effect of Atlantic Multidecadal Variability (AMV) on ENSO on seasonal to decadal timescales. The AMV is a multidecadal basin-scale pattern of alternating anomalously warm and cool SSTs in the North Atlantic Ocean. Previous studies have shown using observations and idealized SST-restoring experiments that the AMV alters the tropical Pacific mean climate and therefore contributes to multidecadal ENSO variability. The AMV acts to modify the strength of the Walker circulation and the trade winds in the tropical Pacific as well as the thermocline feedback in the upper ocean that causes ENSO events to grow or decay.

Building on these idealized studies, we attempt to examine the AMV–ENSO relationship in large Earth System Model ensembles that allow us to realistically sample uncertainties arising from both internal variability and external forcing. We use historical simulations (run over the period 1850–2014) from the CMIP6 model archive. For each ensemble member, we compute an AMV index over the simulation period by detrending area-weighted mean SST anomalies relative to climatology over the North Atlantic. AMV impacts are evaluated by compositing El Niño and La Niña events over each AMV phase, and then calculating the differences relative to the mean AMV+ and AMV– states.

The outcomes of our study could potentially improve the long-range forecasting skill for ENSO and its regional teleconnections, and further our understanding of future changes in ENSO characteristics.

High Resolution Simulations of European Air Quality in 2050 Following Different Shared Socioeconomic Pathways

Connor Clayton (he/him), PhD Student, University of Leeds

Poster Board Number: 7
In Person

Air quality co-benefits are expected to occur alongside climate change mitigation, although different patterns of socioeconomic development could impact on whether these co-benefits materialise and how. To factor in socioeconomic development, much of the literature simulating future climate uses the integrated Shared Socioeconomic Pathways, designed for use with the CMIP6 model ensemble. Studies using SSPs for modelling air quality largely used global climate or earth system models that have a course horizontal resolution and use less detailed chemistry schemes than more specialised models. This may affect how effectively they model air quality at regional and sub-regional scales.

We use a detailed atmospheric chemistry model (WRF-Chem v 4.2) at 30km horizontal resolution to simulate 2050 air quality with emissions from three different integrated SSPs (SSP1-2.6, SSP2-4.5, SSP3-7.0) and compare these with a 2014 control simulation. We show that the scenarios with greater emphasis on environmental sustainability overall have significantly improved air quality compared to those that do not, however some scenarios show notable spatial heterogeneity in PM2.5 and O3 change, where air quality can worsen in localised areas.

Observational Uncertainty in Recent Temperature Changes over Africa from Multiple Observational Products

Dan Green (he/him), Postgraduate Teacher and PhD Student, University of Bristol

Poster Board Number: 8
In Person

Accurate representations of our climate is important for understanding past change and for providing observational constraints. These can be used to ensure plausible and credible projections of temperature and extreme heat are used to inform adaptation and mitigation policies. However, our understanding of observed climate at a pan-African scale is limited. This study examines the consistency between 4 observation based datasets, in the representation of trends of mean temperature and hot days, and the return periods of the most extreme annual events, using gridpoint and regional domain averages. All regions of Africa saw robust evidence of warming in annual mean maximum temperature. However, there was uncertainty in the magnitude of warming between datasets, in addition to the spatial representation of the areas experiencing the largest changes. With increasing temporal resolution (seasonal-monthly), the uncertainty in the sign and magnitude of trends increased at gridpoint and regional domain spatial scales. The frequency and intensity of hot days has been shown to be increasing for nearly all African regions, with the largest uncertainty in the sign and magnitude of these trends seen at gridpoint scale. These seemingly occur where there are a lack of surface observations. Examining the return periods of the hottest annual temperatures, there was no agreement in the magnitude of a 1/5 year event for regional domains. This study finds that the choice of dataset influences the representation of absolute temperature and the characteristics of extreme heat events. Studies examining future change should seek to account for this uncertainty through the use of multiple observational datasets, in order to help mitigate against misleading representations of past and future climate.

The use of Crowdsourced Observations to Build Climate Grids and Assess Urban Heat Hazard

Matthew Fry (he/him), Scientist – Observation Network Design, Met Office

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Poster Board Number: 9
In Person

Urban heat hazards pose a significant risk to human health and wellbeing. Traditional methods for determining standard hazard metrics, such as the number of tropical nights (minimum temperature > 20 degrees), rely on observations from a limited number of weather stations which are often located outside the urban core. Crowdsourced observations have the potential to provide the necessary increases in observation density for improving the representation of urban climatology. In this pilot project, basic quality control procedures are applied to observations from WOW, Davis, Netatmo, and Met Office sites around Manchester (UK), and site records of daily minimum and maximum temperatures are built. These are interpolated onto a set of daily observed grids of temperature for Manchester at 1km resolution for summer (JJA) 2020, thus yielding a crowdsourced alternative to HadUK-Grid. A comparison is then made between the number of tropical nights given by the two grids, which will give insights into the potential for crowdsourced observations to improve gridded observations, a standard urban heat hazard metric, future projections of that metric, and so influence public policy decisions related to extreme heat.

Mixed Layer Heat Budget Analysis in the Eastern Equatorial Indian Ocean during the Positive Indian Ocean Dipole Events in 2018 and 2019

Aparna Anitha Reghunathan (she/her), PhD Student, School of Environmental Sciences, University of East Anglia

Poster Board Number: 10
In Person

The Indian Ocean hosted a strong positive Indian Ocean Dipole (pIOD) event in 2019–2020, and a weak event in 2018–2019, such as the magnitude of the cold sea surface temperature anomaly (SSTA) during June-December in the former case is a factor of two higher (~ − 1.5 °C) than the latter (~ − 0.75 °C) at the western periphery of the eastern IOD zone at 5° S, 95° E. The plausible mechanisms responsible for this difference in the SSTA between these two events are examined using the mixed layer heat budget estimate using the moored buoy measurements. It is found that the enhanced cooling during June-December in 2019–2020 is determined primarily by the anomalous cooling due to the vertical processes associated with the combined effect of the anomalous thin barrier layer (BL), shallow thermocline, weak near surface stratification, and strong wind speed induced vertical mixing, and secondarily by the enhancement in the latent heat flux (LHF) loss from the ocean. Conversely, the magnitude of cooling due to the vertical processes is much smaller in 2018–2019 due to the near-climatological states such as a thick BL, deep thermocline, and weak wind speed. During these events, the warming tendency by the horizontal advection dampens the cooling tendency associated with the vertical processes and LHF. These characteristics are distinct from the past study that suggested that the horizontal advection was responsible for the cool SSTA at the exact location during an extreme pIOD event in 2006–2007.

Earth System Impacts of a Climate Overshoot Scenario

Selena Zhang (she/her), MPhil Student, University of Cambridge

Poster Board Number: 11
In Person

Overshoot scenarios describe climate pathways where global surface temperature exceeds a certain threshold in the middle of the century due to insufficient decarbonization but is then brought down by the end of the century through deployment of negative emissions technologies (NETs). These pathways have not yet been comprehensively studied although current rates of greenhouse gas emissions and technological innovation suggest scenarios such as these are a possible future realization. Overshooting temperature has the potential to trigger positive feedbacks and hysteresis in the climate system that would be avoided by staying under a temperature threshold, e.g. 1.5 ºC above pre-industrial levels, throughout the century. The U.K. Earth System Model (UKESM1) was used to simulate an ensemble of a possible overshoot scenario, with mid-century temperatures reaching up to 1.9 ºC above pre-industrial levels, as well as a no-overshoot control ensemble to determine the climate impacts of a parabolic temperature trend over the 21st century. Through analysis of these runs, we find significant hysteresis in sea ice volume and regional temperature, especially at the North Pole, despite average global surface temperature returning to 1.4 ºC above pre-industrial levels by 2100. Preliminary results also highlight changes to precipitation, net primary productivity, and other factors with direct relevance to human populations that will be further studied.

The Hybrid Tangent Linear Model – A Novel Approach to Forecast Model Linearisation in 4D-Var Data Assimilation

Tom Hill (he/him), Foundation Scientist in Data Assimilation, Met Office (UK)

Poster Board Number: 12
In Person

Data assimilation is the process of optimally combining a model with observations to best represent the state of a dynamical system. It is used to provide initial conditions for operational forecasts produced by numerical weather prediction (NWP) models. 4D-Var, a variational data assimilation method, is used for global forecasts at leading centres such as the Met Office. A challenging aspect of 4D-Var, regarding software maintenance, computational cost, and accurately representing physical processes, is differentiating the NWP model to form the tangent linear model (TLM), and coding this.

It was suggested that an ensemble of model runs could be used to construct the TLM through linear regression (a local ensemble TLM), and this was shown to improve the linearisation of parameterised physics and reduce software maintenance needs. However, to perform well, this method requires a prohibitively computationally expensive ensemble size. This led to the idea of using a coded TLM for the model's dynamical core but adjusting it using an ensemble to account for the remaining physics: a so-called hybrid TLM. This requires a far smaller ensemble and has been shown to outperform both other methods in one study.

Work began recently to implement this method in the Joint Effort for Data Assimilation Integration (JEDI), a model-agnostic data assimilation system being developed by the Joint Center for Satellite Data Assimilation and partners. Software tests with a modified quasi-geostrophic model have been successful. Work is currently under way to assess whether a hybrid TLM can provide significant benefits to a cycling 4D-Var forecast system for this simple model. Additionally, any model providing a JEDI interface will be able to use the method, which the Met Office plans to do with the LFRic model as part of its next-generation data assimilation programme. This poster will present ongoing work on each of these aspects.

Numerical Investigation of High Impact Foehn Storm in February 1925 using WRF and PALM Mode

Renuka Prakash Shastri (she/her), PhD Student, University of Bern, Switzerland

Poster Board Number: 13
In Person

One of the most hazardous windstorms was observed on 15th February 1925 in Switzerland. The storm is categorized as a 'High impact Foehn Storm' that affected all foehn regions of (German-)Switzerland, all communities, stables, and houses were partially or completely damaged in the canton of Glarus. In the previous work, by Stucki et al. 2015 the WRF downscaling (from 20CRv2 with a 220 km grid width of 3 km) was done for this storm. The wind speeds remained in the valleys below the expected values. The question arose whether with LES high gust peaks also would occur at the bottom of the valley. It motivates to verify the ability of the PArallelized Large-eddy simulation Model (PALM) to simulate the Wind Field intensity. This storm was analyzed by the PALMv6.0 and Weather Research and Forecasting Model (WRFv4.1.2). In the first stage, WRFv4.1.2 was downscaled to a resolution of 1x1 km2 by using the "Twentieth Century Reanalysis" (20CRv3) as a boundary condition. Three nested domains with resolutions 25km, 5 km, and 1 km were set up for the simulation experiment. The second stage involves downscaling of PALMv6.0 to a resolution of 20 meters by using the output of WRFv4.1.2 as a boundary condition. The simulation shows a strong wind field between Netstal and Näfels. Peak gusts of 40 m/s and more hit the valley floor south of Näfels. A vertical section in the main valley in the south-north direction shows strong turbulence fields reaching the ground with velocities of 30 to 40 m/s and more. In total, the simulation shows good agreement with the damage described and the simulated peak gusts easily reach the measured maxima of extreme storms.

How Well Do Forecast Models Represent Liquid and Ice Phases in Clouds?

Matt Evans (he/him), Cloud & Aerosol Research, Met Office

Poster Board Number: 14
In Person

Arctic Cold Air Outbreaks (ACAOs) transport cold, dry air from the Arctic southwards to the mid-latitudes and contain extensive regions of mixed-phase boundary layer clouds, which are poorly represented in current weather and climate models. The current generation of Met Office models struggle to maintain enough supercooled liquid water in these cloud regimes and detailed in-situ measurements are required to confront the simulations.

During a three-week period in March 2022, the Facility for Airborne Atmospheric Measurements (FAAM) BAe146 aircraft was used to collect in-situ measurements of cloud, aerosol and boundary layer conditions in ACAOs. Measurements from eight case-studies were taken from the Arctic sea ice edge to northern Scandinavia. Co-ordinated observations were also taken with other aircraft: SAFIRE ATR42, DLR HALO and POLAR5/6. The HALO aircraft focused on taking high altitude (remote) measurements whilst the other aircraft were offset horizontally: to gather more upstream and downstream data, or to aid spatial coverage.

In this analysis, the amount of ice and liquid present and the spatial distribution of ice in different mixed-phase cloud regimes will be a primary focus. By understanding these properties, one can then investigate how ice depletes the liquid from the clouds through processes such as deposition (growth of ice from vapour) and riming (ice growth through collisions with liquid). The observations will ultimately be combined with modelling, from regional NWP and global models, to improve the physical understanding and simulation of mixed-phase cloud processes.

Decadal Climate Forecasting for the Energy-Sector

Ben Hutchins (he/him), PhD Student, Department of Meteorology, University of Reading

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Poster Board Number: 15
In Person

The rapid deployment of renewable energy technologies, such as wind turbines and solar photovoltaics, is changing power systems around the world. As these renewables are dependent on meteorological variables, such as wind speed and incoming solar radiation, power systems are becoming increasingly sensitive to climate variability. This makes it more challenging for power system operators to maintain a secure balance between electricity-demand and supply. Of particular concern are low-wind-cold-snap events, which cause sustained reductions in wind power generation during periods of high demand. Understanding the frequency and magnitude of such events is important for long-term operation and future planning of the power system.

Decadal climate forecasting can be useful for assessing how power systems may be impacted by climate variability over the next 1-10 years. Recent developments in the field have shown surprising skill in retrospective decadal forecasts of the North Atlantic Oscillation, a major influence on weather conditions over western Europe. This project will explore how this skill can be leveraged to provide skillful decadal forecasts for energy-sector relevant variables, such as mean production from renewables or mean demand for power, using models from the Decadal Climate Prediction Project. The predictive ability of these will be evaluated using retrospective forecasts (hindcasts) to compare model output with reanalysis data. Preliminary results for decadal forecasts of demand (from temperature) and wind power generation will be shown.

The implication is that decadal forecasts might be useful for power system operators to inform the operation and management of the energy system from a season to several years ahead. These forecasts may provide a useful tool for forecasting energy-system stress events, such as low wind years, or identifying optimal “pathways” for the integration of infrastructure over the course of several years.

Tracking Storms and Extreme Rainfall over South America in km-Scale Simulations of Present and Future Climate

Harriet Gilmour (she/her), PhD Student, University of Exeter

Poster Board Number: 16
In Person

Ranging from large, organised mesoscale convective systems above the Amazon to extratropical cyclones across Argentina, South America is highly vulnerable to high-impact storms and extreme precipitation. Future warming will likely bring changes to storm characteristics and precipitation extremes across the region. However, the coarse horizontal resolution of current global climate models fails to explicitly resolve convective processes, making any future changes uncertain. Here, cutting-edge ten year-long convection-permitting simulations over South America, run by the UK Met Office, are used to assess the representation of convective storms in both present and future climate simulations. These kilometer-scale simulations will be compared with satellite observations and coarser global climate models using storm tracking algorithms to assess storm representation. These algorithms provide useful statistics on storm characteristics, such as spatial frequency, velocity, precipitation rate, size and speed. Based on existing literature for African and European domains, we expect the convective-permitting simulations to better represent present day storms and associated precipitation compared with the current generation of coarser-resolution global climate models. Since these convective systems play a crucial role in South American climate, more realistic representation would be key to providing improved projections of extreme rainfall with future climate change. In turn, this may help policymakers across South America to reduce the vulnerability of the population to storm-related natural disasters in a changing climate.

Extreme Event Attribution for a Midlatitude Cyclone using Medium-Range Forecasts

Shirin Ermis (she/her), Doctoral Researcher, University of Oxford, AOPP

Poster Board Number: 17
In Person

Extreme events such as storms are difficult to predict more than a week in advance. Additionally, the climate change signal in variables such as wind speed and precipitation is low compared to the noise of weather which further complicates the attribution of a single event to climate change. The damage done by mid-latitude storms, however, makes it imperative to study how they change with climate change.

The mid-latitude cyclone Eunice hit the South of the UK on February 18, 2022 and caused the first red weather warning ever issued in London by the UK Met Office. Here, we assess changes to Eunice due to anthropogenic forcing. The ECMWF ensemble prediction system is used as its initialised numerical models show skill in the prediction of the storm. Using perturbed initial conditions in the greenhouse gases and 3D ocean temperatures, we create counterfactual scenarios for storm Eunice for a pre-industrial climate and for an increased CO2 climate for three initialisation dates (eight, four, and two days before the event).

Distributions of wind gusts between pre-industrial, current, and future climates are compared by initialisation date. We also compare storm tracks qualitatively in the three experiments using a storm tracking algorithm.

We note that atmospheric conditions are currently left unchanged in the counterfactual simulations, possibly impacting the skill of the simulations in these experiments. Here, further work is needed to create realistic initial conditions. For the skill of seasonal simulations atmospheric initial conditions play a much lesser role so that the storminess in these simulations could be contrasted to conditioned event-specific results from medium-range simulations.

Assessment and Optimisation of Carbon Monoxide Measurements at the FAAM Airborne Laboratory

Eve Grant (she/her), MChem Placement Student, FAAM

Poster Board Number: 18
In Person

Carbon monoxide is a key trace gas, emitted from incomplete combustion and the oxidation of NMHC's and CH4, with an atmospheric lifetime of approximately 1-2 months. Its role as a precursor to the formation of more atmospherically taxing pollutants makes it an important species to measure. Airborne in situ measurements allow the assessment of pollutants over large geographical ranges, going to places where there may be poor insitu data. Due to the lifetime of CO, we can assess the extent of plume age using the aircraft, looking at ΔO3/CO ratios from three atmospheric environments; clean air, polluted continental and in shipping. Laboratory linearisation of the CO system with three highly accurate surveillance standards highlighted an interference (+8ppb offset) that was seen within previous measurements. This may be due to a water interference, which will be investigated through a humidity experiment. Analysis of three working standards used for the calibration of the inhouse FGGA were analysed during these linearisation's to deduce their CO concentrations. Calibrations with one of these and a high CO working standard are proposed as a new way of inflight calibration, which should cover a large enough range to generate a linearisation. The CO system has a data acquisition of 1Hz, and in the future will be brough inline with 10Hz insitu measurements undertaken on the chemistry gas-phase payload aboard the aircraft. Comparison with CO2 10Hz data should show the increased precision of data and hopefully reduce the lag times, which can then be upgraded on the CO system, producing faster insitu data for FAAM.

Conclusion of the future work should assess the nature of the interference within the system along with the necessary upgrades to the system.

Developing Tailored Rainfall Information Packs for UK Cities

Rebecca Sawyer (she/her), Applied Scientist (Foundation Scientist), Met Office

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Poster Board Number: 19
In Person

Cities in the UK are impacted by a range of weather events and climate hazards including extreme heat, heavy rainfall, and sea level rise. Cities are particularly vulnerable to intense rainfall as they have hard surfaces and less green spaces meaning less rainwater gets absorbed and therefore more rain passes into the drainage network. This can overwhelm the drainage system, leading to flooding. Indeed, the Met Office climate projections show that within this century climate change will cause an increasing trend in winter precipitation totals and an increase in the intensity of heavy summer rainfall events. These extreme rainfall events will lead to increasing risks in cities from flash flooding.

To help stakeholders, decision makers and the public to become more aware of how climate change and extreme rainfall will affect their areas, the Met Office are developing Rainfall Packs (factsheets). These will provide information on how extreme rainfall events in selected cities may change in this century due to climate change, the impacts and how to build resilience to extreme rainfall. They are designed in a way to communicate complex scientific findings and uncertainties in relation to rainfall, in a simplistic way. I will present on the approach taken to develop one of these packs for Hull, including the information gathering and user engagement stages.

Seasonal Rainfall Trends and Drought Characteristics over Northern Uganda

Joan Badebye (she/her), Student/Graduate Trainee, University of Reading/ Uganda National Meteorological Authority

Poster Board Number: 20
In Person

Climate variability is associated with frequent extreme events such as floods and droughts with devastating impacts on agriculture, health, water resources, and disaster risk management among other socioeconomic sectors. The main objective was to examine recent patterns in the seasonal rainfall trends and drought characteristics over Northern Uganda. The Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) monthly rainfall dataset was obtained from the IGAD Climate Prediction and Applications Centre (ICPAC) website for the period of 1981-2016. This data was extracted using the GeoClim software tool and temporal seasonal rainfall trends plus temporal SPI graphs were generated from the R package. The rainfall trends, average rainfall, change in average rainfall, Standardised Precipitation Index (SPI), and anomaly tools in Geoclim software were used to spatialize the rainfall over northern Uganda. The Normalized Difference Vegetation Index (NDVI) maps for the years 2009, 2006, and 2014.

The results indicated seasonal rainfall disparities in sub-regions of northern Uganda in time and spatially. The SPI's indicated evidence of drought conditions in the region. The vegetation conditions based on NDVI indicated some linkage with rainfall conditions with significant time. In conclusion, frequent droughts in the regions may lead to water stress, crop failures, the death of animals, migrations, and conflicts among communities.

Impact of Ocean Resolution on the Simulation of ENSO and its Teleconnections

Ned Williams (he/him), PhD Researcher, University of Exeter

Poster Board Number: 21
In Person

The El Niño-Southern Oscillation (ENSO) influences climate on a global scale and is a source of long-range predictability. Accurate modelling of the impact of ENSO requires accurate representation of teleconnections as well as of ENSO itself. We consider a set of CMIP6 models and assess the effect of increasing model resolution on ENSO and its boreal winter teleconnections. The spatial structure, strength and asymmetry of both ENSO and its teleconnection to the extratropical North Pacific are considered. We find evidence of an improved El Niño teleconnection in high resolution models, but this effect is weaker for La Niña. We aim to establish whether ocean or atmospheric resolution is the primary driver of resolution-based trends, and we evaluate the relevance of mean state biases on these trends.

Can we Improve Short-Range Plume Dispersal Modelling for Fire Related Emergency Response Operations?

Nicola Stebbing (she/her), Foundation Scientist, Met Office

Poster Board Number: 22
In Person

Large fires that produce plumes of smoke and other contaminants can cause harm to both people and the environment. To support emergency responders in understanding the effect pollutants could have, the Met Office Environmental Monitoring and Response Centre (EMARC) provides dedicated weather advice and air pollution forecasts in the form of CHEmical METeorological (CHEMET) reports. Forecasts of the plume's expected location are produced using the Numerical Atmospheric-dispersion Modelling Environment (NAME), which simulates the transport and dispersion of pollutants by numerical weather prediction data. During major fires, CHEMETs can be supported by on the ground air quality monitoring to confirm the presence of elevated concentrations of contaminants. We use air concentration measurements from multiple events to evaluate the operational set-up of NAME used to create CHEMETs and consider whether improvements can be made by altering the model set-up. In particular, we look at changing the vertical extent of the model output that is used to indicate the location of the plume and any pollutants at the surface and investigate the use of three schemes that are designed to improve the representation of short-range dispersal dynamics: the near-source velocity memory scheme, the plume-rise scheme, and the urban scheme. We find that in many cases changing the vertical extent of the output appears to affect the model air concentrations more than changing the schemes used, but when analysed statistically the use of certain scheme combinations simulates plumes that better compare to the observations.

The Role of Ozone in S2S Weather Prediction

Meryl Anil (she/her), PhD Student, University of Reading

Poster Board Number: 23
In Person

Sub-seasonal to seasonal (S2S) weather prediction involves predictions made in advance of two weeks to less than a season. Being able to accurately generate predictions in this time range can have crucial impacts in numerous areas, such as the mitigation of natural disasters to the impact on the agricultural industry. Additionally, this is the time range that bridges the gap between weather and climate prediction, maybe one day leading to seamless weather/climate prediction. The stratosphere has shown to be a source of predictability for numerical weather prediction (NWP) on the S2S timescale, and ozone is a key player in this area of atmosphere. Our expectation is therefore that through better representation of ozone and its interactions with the climate system, we can take advantage of this increased predictability and thereby work towards improving S2S weather prediction. To explore this, experiments with a new ozone parameterisation scheme, the Hybrid Linear Ozone scheme with interactive ozone are analysed. The aim of this project is to determine the impact interactive ozone has on forecasts and to provide insight into the physical mechanisms behind those impacts. Understanding the importance of a prognostic ozone scheme combined with interactive ozone for NWP should help inform decisions on incorporating this into operational systems.

Indian Ocean Systematic Biases in the Met Office Global Coupled Model

Hannah Ellis (she/her), Scientist – Global Coupled Modelling, Met Office

Poster Board Number: 24
In Person

The Indian Ocean is a region of significant climatic importance due to its role in modulating regional and global climate patterns. Therefore, accurate simulations of the Indian Ocean in climate models are crucial for better understanding the region's dynamics and its associated teleconnections. Analysis of the Met Office Global Coupled model reveals a number of biases in the Indian Ocean, common to other models. The prominent cold sea surface temperature (SST) bias seen in the eastern Indian Ocean is of particular interest as this can have a significant impact on the forecast skill of the Asian-Australian monsoon and extreme weather events such as droughts and tropical cyclones. Various hypotheses for the sources of error are being investigated, including air-sea interactions, ocean circulation and mixing processes, and the role of the Indonesian Throughflow. We introduce several metrics to monitor the biases of the Indian Ocean and the potential factors contributing to them. These metrics will form a useful tool for evaluating and improving the performance of future Global Coupled model releases.

The Impact of Rotation Rate on Clouds

Daniel A. Williams (he/him), PhD Student, University of Exeter

Poster Board Number: 25
In Person

Whilst we are very familiar with the distribution of clouds that we observe on Earth, we understand less about where clouds may be found on other terrestrial planets. Clouds have also been observed on Venus, Mars and Titan, and a growing number of exoplanets, however the possible connection between planetary rotation rate and cloud distribution has not been explored until now. Using the modelling framework Isca with a comprehensive radiation scheme and a simple cloud model, we develop a set of models to sweep through the parameter space to investigate if the planetary cloud distribution varies with rotation rate, and whether this impacts on planetary albedo. We also investiage if the addition of clouds compared to a clear-sky model has any influence on the seasonality of the climate. Our initial results suggest that cloud distribution has a strong dependence on the atmospheric dynamics driven by rotation rate, but that the albedo follows a non-monotonic behaviour throughout the parameter space. We also find that the presence of clouds has an effect on the seasonal behaviour of certain dynamical variables. These results will likely have relevance in the understanding of observations of other planets, as we seek to understand and decypher climates that are not as familiar to us as our own.

Utilizing the Integration of MODIS and Landsat Data to Ascertain the Land Surface Temperature (LST): A Novel Approach for Dhake Megacity

Nigar Sultana Parvin (she/her), Doctoral Researcher, University of Birmingham

Poster Board Number: 26
In Person

This study intends to assess the use of multi-temporal and multi-spectral satellite imagery for Urban Heat Island (UHI) vulnerability of Dhaka city from 2011 to 2022. The selected years correspond the respective Censuses. To properly understand the seasonal changes in the study area and ensure frequent monitoring, we estimated UHI for Dhaka's Winter to Summer transitional period (Jan – May) for 2011 and 2022, respectively. Application of one or two satellite imagery for a month/year is not enough to figure out the average Land surface temperature (LST). To measure an average LST of Dhaka city, we used more than three satellite imagery for each month. Landsat's 30m imagery is sufficient for assessing local scale variations of LST within Dhaka. However, it is not possible to obtain more than three Landsat imagery in each month. So, the study demonstrated the utility of fusing Moderate Resolution Imaging Spectroradiometer (MODIS), and Landsat 5 and 9 to obtain imagery with both high spatial and temporal resolutions necessary for accurate UHI estimation. We employed Spatial and Temporal Adaptive Reflectance Fusion Model (STARFM). This Fusion algorithm produced synthetic Landsat imagery which has been applied along with the actual Landsat images to calculate the LST of Dhaka for the respective years. UHI map of the period for 2011 and 2022 has been developed in ArcGIS 10.7 and those UHI maps have illustrated different results than of using only Landsat or MODIS. Ground climate datasets about Dhaka city provided the surface air temperatures for comparison and accuracy assessment.

Exploiting Grid Orthogonality: Solver Optimisation in New Met Office Regional Models

Benjamin Buchenau (he/him), Placement Student, Met Office, University of Edinburgh

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Poster Board Number: 27
In Person

The Met Office is currently developing a new model infrastructure called LFRic that is designed to make model code more flexible and scalable with regards to new supercomputing hardware. Part of LFRic is the new dynamical core GungHo, which simulates atmospheric dynamics using a mixed finite-element, finite-volume, semi-implicit discretisation of the governing fluid flow equations.

In its regional (also called limited-area or LAM) configuration, GungHo uses a rotated-pole latitude-longitude mesh, which, in contrast to the global cubed-sphere mesh, is orthogonal. Here, we explore a potential avenue for exploiting that orthogonality in order to speed up the solution of the large system of linear equations that needs to be solved several times on each GungHo time step.

This linear system is challenging to solve. However, the grid orthogonality in the LAM reduces the amount of coupling between grid cells, which simplifies the problem. This poses the question whether the LAM solver can converge using just the approximate pressure Schur complement solve, that usually acts as a preconditioner to the solve of the full mixed system of equations.

We run a series of idealised tests to isolate the effect that approximations made during the construction of the pressure Schur complement operator have on the stability and the accuracy of the model, as well as to assess the magnitude of the speed-up gained. Those approximations, which are made regardless of the orthogonality of the grid, affect the handling of Coriolis and orography terms. In addition to potentially helping speed up the LAM, results from this work might inform more general improvements to the GungHo solver in the future.

Seasonal Forecasting of the Physical Marine Environment of the European North West Shelf

Jamie Atkins (he/him), PhD Student, University of Exeter

Poster Board Number: 28
In Person

The European North West shelf seas (NWS) support economic and environmental interests of several adjacent populous countries. Forecasts of physical marine variables on the NWS for upcoming months – an important decision-making timescale – would be useful for many industries. However, currently there is no operational seasonal forecasting product deemed sufficient for capturing the high variability associated with shallow, dynamic shelf waters. Here, we identify the dominant sources of seasonal predictability on the shelf and quantify the extent to which empirical persistence relationships can produce skilful seasonal forecasts of the NWS at the lowest level complexity. We find that relatively skilful forecasts of the typically well-mixed Winter and Spring seasons are achievable via persistence methods at a one-month lead time. In addition, incorporating observed climate modes of variability, such as the North Atlantic Oscillation (NAO), can significantly boost persistence for some locations and seasons, but this is dependent on the strength of the climate mode index. However, even where high persistence skill is demonstrated, there are sizeable regions exhibiting poor predictability and skilful persistence forecasts are typically limited to ≈ one-month lead times. Summer and Autumn forecasts are generally less skilful owing largely to the effects of seasonal stratification which emphasises the influence of atmospheric variability on sea surface conditions. As such, we also begin incorporating knowledge of future atmospheric conditions to forecasting strategies. We assess the ability of an existing global coupled ocean-atmosphere seasonal forecasting system to exceed persistence skill and highlight areas where additional downscaling efforts may be needed.

Enhanced Climatology of Large Hail in the UK: Radar-derived diurnal cycle and storm mode

Henry Wells (he/him), Doctoral Researcher, Department of Geography and Environment, Loughborough University

Poster Board Number: 29
In Person

Large hail, with a diameter of at least 20 mm, is a hazard associated with severe convective storms (SCS) that can cause significant damage. Understanding of atmospheric environments conducive to large hail is underpinned by catalogues of past events. Because of the small footprint of hail events, these often rely on crowdsourced reports. In the UK, the relative rarity of large hail and low public awareness of SCS hazards makes obtaining a complete set of reports difficult, and in many cases the precise time of the hail is not recorded. In this study, the two major databases of UK large hail reports are merged for the first time. Composite radar reflectivity data are used to verify and enhance 260 reports since 2006. Time of the hail and the basic storm mode (isolated, clustered or linear) are visually estimated from animations. Compared to the UK's most severe historic hailstorms (1800–2004), our quality controlled climatology of all sizes of large hail shows a diurnal cycle with a slightly broader peak. Around 55% of large hail events are associated with isolated cells, while 34% have supercellular characteristics, a much lower proportion than found in the USA. The full event set (1979–2022), comprising over 850 reports, is used to update the seasonal, spatial and size distributions of large hail in the UK. We intend that this hail event set forms part of a multi-hazard analysis of UK SCS, also including tornadoes and extreme rainfall, and its relationship to background atmospheric conditions. The effect of climate change on UK SCS will be investigated through past and future trends in these background conditions.

Probabilistic Machine Learning for Predicting Atmospheric Convection

Greta Miller (she/her), PhD Student, Department of Physics, University of Oxford

Poster Board Number: 30
In Person

Realistically representing atmospheric convection is important for accurate numerical weather and climate simulations. However, parameterizing where and when convection occurs is a well-known source of model uncertainty. In this study, we develop a probabilistic machine learning model that predicts the probability of the onset of deep convection. The model uses observed large-scale atmospheric variables from the Atmospheric Radiation Measurement constrained variational analysis dataset, and the model is used to understand which mechanisms driving the initiation of convection are most important. In future work, the model will be used to evaluate convection initiation in high-resolution convection-permitting models.

Suitability of Entraining Parcel Models for Parameterisation of Convection

Jure Zgubic (he/him), PhD Student, University of Cambridge

Poster Board Number: 31
In Person

Despite advances in both understanding of the Earth's climate and improvements in computational resources, climate models remain prone to significant uncertainties. A major contributor to this issue is the representation of atmospheric convection-convection is a complex process that spans a variety of temporal and spatial scales which forces climate models to rely on a technique called parameterisation to represent its behaviour. An indispensable part of modern convective parameterisations are entraining parcel models which represent a rising parcel of air within a grid cell column. While the need for their improvement has been long acknowledged, no single comprehensively superior scheme has emerged so far, making further research necessary. This work evaluates the theoretical framework and compares entraining parcel schemes in two models: CoMorph (Met Office's new bulk mass-flux scheme) and the spectral Convective Cloud Field Model to a "ground truth" high resolution simulation of a shallow convection event. Even though the two schemes adopt distinct theoretical approaches and triggering mechanisms, the respective assumptions in their derivations are suitable for representation of convection. The results of the two schemes could be improved by relaxing some of the theoretical assumptions and introducing more complex features. Early work on model results in idealised environments has shown that CoMorph produces stronger convection in given conditions, but both models were found to be highly adaptable and tunable. We now aim to use non-idealised true environmental profiles to investigate the differences in the strength of convective responses, sensitivity to initial conditions and vertical parcel behaviour. This will uncover the extent to which entraining parcels are suitable for representation of convection and how to improve their performance.

Using a High-Resolution Climate Model (CP4A) - For wind power projections in Tanzania

Alexander Chamberlain-Clay (he/him), Scientific Software Engineer, Met Office

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Poster Board Number: 32
In Person

For the CSSP-China project in the Met Office, we have downscaled HadGEM2-ES climate model at 12km and 4km resolution. In order in better compare model performance with reality, we needed to run the regional climate models driven by reanalysis products to replicate the observed weather. This is needed to better inform users about model performance when using CSSP-China climate data for urban climate services in China.

For this purpose, I developed the capacity to run the existing downscaling model with ERA5 boundary data rather than global climate models. This capacity is deployable for any region on the globe, and available to all Met Office scientists and partners. A technical description of the model configuration and Initial results of the analysis on model performance will be presented

Comparing Gravity Waves Sampled from a Kilometre-Scale IFS run to AIRS Satellite Observations

Emily Lear (she/her), PhD Student, University of Bath

Poster Board Number: 33
In Person

Gravity waves are small-scale atmospheric waves which transport energy and momentum. These waves impact the large scale circulation and increasing our understanding of them is therefore important to support improvements to weather and climate models. This presentation focusses on gravity waves in the stratosphere using data from a high resolution run of the European Centre for Medium-Range Weather Forecasts (ECMWF) Integrated Forecasting System (IFS) operated at a kilometre-scale spatial resolution, the Atmospheric Infrared Sounder (AIRS) on NASA's Aqua satellite and the ECMWF ERA5 reanalysis. For this comparison, the IFS run and ERA5 are resampled using the AIRS observational filter. Data are examined during the first 2 weeks of November, as the high resolution model was initialised on the 1st of this month. Wave properties were found using the 2D+1 S-Transform, a spectral analysis technique, which has been previously applied to AIRS data. Asia and surrounding regions are investigated, because preliminary studies of AIRS data suggested strong gravity wave activity in this region during this time period. Gravity waves can also be seen in the high resolution model and ERA5 data at similar times and locations as those in the observations. Higher amplitude gravity waves can be seen in nighttime AIRS data compared to the resampled models. The horizontal wavelengths in the data sets are generally similar in areas of peak gravity wave activity for nighttime data. Weather models are advancing rapidly and kilometre scales, such as the experimental IFS run, could become operational in the next decade. At these grid scales, gravity waves must be resolved instead of parameterized so the models need to be tested to see if they do this correctly. This work provides information on how a cutting edge model resolves gravity waves compared to observations.

Multivariate Skill and Spread in the Energy Sector

Emma Patmore, Meteorologist, Lake Street Consulting Ltd

Poster Board Number: 34
In Person

It is commonly accepted by meteorologists that the spread of forecast ensemble members can provide an indication of the potential error the forecast may hold. In an ideal scenario, the average root mean square error (RMSE) for each timestep would be equal to the average ensemble spread at each time point, indicating that the spread is able to capture the likely error. In scenarios where the spread is less than/more than the error, the possibility of a more extreme solution could potentially be under/over estimated by decision makers.

First, we take temperature forecasts and calculate the RMSE and ensemble spread for the UK. Using this information, it can be estimated whether at each timestep the error is (on average) well captured by the ensemble spread, or if in actuality the spread is over/under dispersed.

We then consider the multivariate situation found in most applied applications, namely residual energy demand (demand not offset by renewables). Using these details, an estimate of the impact of the forecast spread failing to capture the error can be calculated. This will outline the importance of understanding, and communicating, the uncertainties and volatility you are likely to come across as a forecaster.

Nowcasting of Convective Thunderstorms using 3D Radar Cell Tracking

Andrew McNaughton (he/him), Foundation Scientist, Met Office

Poster Board Number: 35
In Person

Post-processing is a powerful tool for improving the accuracy and skill of Numerical Weather Prediction (NWP) model outputs, however, post-processing is only able to amplify skill in a forecast if there is already some level of underlying skill to begin with. Visibility forecasting, and specifically the forecasting and modelling of low visibility (<1000m) conditions is one such variable currently modelled by the Met Office's Unified Model (UM) for which there is limited skill in the raw model output. The current visibility physics scheme utilised in the UM, 'VISBTY', is known to produce poor verification scores, and exhibits notable numerical instability at visibilities of ~<1000m, a key threshold for aviation and other applications, where fog begins to form. A new physics scheme, 'VERA' (Visibility Employing Realistic Aerosols) has been implemented experimentally as part of the UM and aims to improve the skill of visibility forecasts using more sophisticated physics to model aerosols in the atmosphere. This work looks at the impacts on verification scores and forecast skill when both the current (VISBTY) and newly implemented (VERA) visibility schemes are used as inputs into the Met Office's next generation post-processing system IMPROVER (Integrated Model post-PROcessing and VERification). Qualitative comparisons are made between the two visibility schemes for specific case studies, in addition to discussion of quantitative verification of a longer multi-month trial of continuous archived model output data, using observations as truth.

A Novel Method for Identifying Gravity Waves from Satellite Observations

Peter Berthelemy (he/him), PhD Student, University of Bath

Poster Board Number: 36
In Person

Gravity waves are vital to mesospheric dynamics, models looking at this altitude are not as good as those at lower altitudes due to limited observations and historic lack of need to know. Next generation models are intended to be used from surface to Sun, so we need to understand this region to be able to build decent models around here. The mesosphere is necessary to be understood as it is a key coupling region in the vertical between the lower neutral atmosphere where we live, and the charged upper atmosphere that interacts with the solar wind..

Here we are developing a new way to exploit airglow imagers. These imagers have been deployed for decades around the world, and passively sense dynamics in the airglow layers, which are localised in the mesosphere. Such a method will allow us to analyse the long time series provided by these imagers, giving access to both their climatological dynamic state and also how they have varied over recent years.

In this poster I will describe my progress towards this goal and plans to apply my new techniques to addressing the fundamental scientific problems in this domain.

Detection and Attribution of Climate Change in UK Hazards and their Impacts

Regan Mudhar, PhD Student, University of Exeter

Poster Board Number: 37
In Person

I will present findings from a comprehensive review of the detection and attribution of climate change in the UK, conducted to inform the Climate Change Committee's upcoming UK Climate Change Risk Assessment. The first part of the review covers the detection and attribution of weather and climate changes relevant to specific Climate Impact Drivers, based on recent and past events within the UK's observation record. The second covers societal, infrastructural, economic, and biodiversity impacts associated with these. I will highlight where there are notable gaps and whether they can be closed with existing data or techniques, particularly when the impacts are critical for UK risk.

The Seasonal Teleconnections of the Indian Ocean Dipole to the North Atlantic Region

Tim Hempel (he/him), PhD Student, University of Oxford

Poster Board Number: 38
In Person

The Indian Ocean Dipole (IOD) is a major source of seasonal climate variability in the Indian Ocean. This dipole has strong impacts on the Indian Ocean region and through teleconnections can influence the seasonal climate of remote regions like the North Pacific and North Atlantic. A prominent example of this teleconnection from the IOD occurred in the winter 2019/2020, where the IOD was in a positive state. This influenced the state and predictability of the Northern Hemisphere extratropics. Thus, a good understanding of the mechanism that transports information from the Indian Ocean to the North Atlantic is desirable. In this contribution we investigate the special teleconnection of the winter 2019/2020 and analyse the transport mechanism.

In model experiments with the OpenIFS from ECMWF we show that the NAO in the winter 2019/2020 is influenced by the IOD and analyse the teleconnection mechanisms. We use hindcast ensemble model experiments of the DJF season 2019/2020 to analyse the behaviour of the IOD and its impact on the NAO. In the uncoupled OpenIFS the Sea Surface Temperature (SST) boundary conditions are perturbed in regions of importance to the NAO (like the ENSO region and the Indian Ocean). With these perturbations we identify the relative importance of individual ocean regions to the state of the NAO in the winter of 2019/2020.

We contrast the experiments with the perturbed SST conditions to the operational ECMWF System5 forecast and ERA5 reanalysis. Experiments with the 2019/2020 SST's in the Indian Ocean (with other boundary conditions set to climatology) reproduce many of the observed atmospheric 2019/2020 features. In contrast, experiments with SST's in the Pacific show very different patterns to the observed 2019/2020 ones.

We identify eddy-mean-flow interactions as a mechanism that connects and transports information from the Indian Ocean to the North Atlantic. With Hoskins E-Vectors we show that anomalous eddy activity during IOD events impacts the position and strength of the Northern Hemisphere extratropical jet. This interaction provides a teleconnection mechanism in addition to the Rossby-wavetrain discussed in other studies.

Extreme Temperature Indices Based on Satellite Land Surface Temperature Data

Josh Blannin (he/him), Foundation Climate Observation Scientist, Met Office Hadley Centre

Poster Board Number: 39
In Person

A greater frequency of extreme temperature events, such as heatwaves, is one of the likely impacts of climate change. The 2-metre air temperature (T2m) is frequently used across climate studies, especially when considering heat related mortality, but quantifying these values requires setting-up and maintaining measurement stations across the globe. The choice of station sites can be influenced by aspects such as geography, economics, and geopolitics, resulting in an uneven distribution of stations around the world. A possible solution to this is to utilise remote sensing, such as satellites. Low earth orbiting satellites image the entire surface of the Earth within a couple of days and can have greater spatial resolution and more homogeneous coverage than station-based monitoring systems. However, satellites are not able to record the T2m, but can acquire the land surface temperature (LST) by measuring electromagnetic radiation emitted from the Earth's surface, particularly at infrared (IR) and microwave (MW) wavelengths. The European Space Agency Climate Change Initiative land surface temperature project (LST_cci) is dedicated to measuring LST using a variety of sensors and produces climate quality LST datasets.

This work examines the potential of using LST to monitor temperature extremes. We use China as a case study in conjunction with the Climate Science for Services Partnership (CSSP) programme and make use of data from the LST_cci to compare LST and T2m extremes. For a range of temperature extremes indices (given by the Expert Team on Sector Specific Climate Indices; https://climpact-sci.org/indices/), we hope to find LST thresholds that are triggered in similar proportions to the current T2m thresholds. This would give merit to using LST for monitoring global temperature extremes, and would provide greater resolution and coverage than T2m station measurements.

The Characteristics of Trapped Lee Waves over the UK

Hette Houtman (he/him), PhD Student, University of Reading

Poster Board Number: 40
In Person

Orographic gravity waves, which are generated by the restoring force of gravity when stably stratified atmospheres flow over mountains, may exert frictional forces on the atmosphere and thus influence atmospheric circulation. While the effects of these waves may be large-scale, the mountains causing them are often of a smaller scale than can be resolved by most weather and climate models. Parametrisations are therefore necessary to approximate their effects on atmospheric circulation. Vertically propagating orographic gravity waves often are parametrised, but trapped lee waves, their horizontally propagating counterparts which occur at low levels, are often not. To nonetheless encapsulate some of the effects of trapped lee waves in weather and climate models, other atmospheric effects such as turbulent mixing may be overestimated, but this causes inaccuracies in other model predictions, such as the boundary layer height and low-level jet speed. The existence of trapped lee waves is often identified by the formation of stationary cloud bands in satellite imagery.

The aim of this project is to determine the effects of trapped lee wave drag on the atmosphere through theory, simulations, and observations and to contribute to the development of a new trapped lee wave drag parametrisation for the Met Office Unified Model. As a first step towards this project goal, Met Office convection-permitting model outputs for known cases of trapped lee waves are examined to determine the atmospheric conditions under which trapped lee waves commonly occur over the British Isles.

Does the Application of Shelf-Sea Model S2P3 Refine SST Estimates for Impact Assessments?

Joshua Wiggs (he/him), Scientific Software Engineer, Met Office

Poster Board Number: 41
In Person

An understanding of our changing climate can be obtained through the use of computational modelling, allowing for insights into climatic futures across the globe. Combining projections from a range of climate models allows for an understanding of the uncertainty related to the predictions, with the Coupled Model Intercomparison Project (CMIP) facilitating this on an international level and standardising the output formats of members. This enables the creation of community tools & projects such as the Earth System Model Evaluation Tool (ESMValTool) & the Coordinated Regional Climate Downscaling Experiment (CORDEX), adding value to the cutting-edge results & datasets produced by CMIP. CORDEX downscales global climate model outputs (able to provide predictions on spatial scales of approximately 1000x1000km) to particular regions of interest, empowering them to make decisions protecting them from the impacts of future climatic changes. Greater levels of fidelity provided in predictions allows for more targeted changes to be made in order to protect the most important assets within a region. Additionally, it is recognised that urbanised population centres, such as cities, will be impacted by climatic changes in ways not captured by larger scale models, highlighting the importance of obtaining high resolution results over urban environments. We will demonstrate how results obtained using downscaled & regional climatological models over developing countries can generate usable climate information. Further, we will discuss how this information can assist in the identification of adaptation options & strategies incorporating knowledge of uncertainties determined by using an ensemble of models.

A Framework for Understanding the Correlation between Aggregated Losses of Compound Events

Toby P Jones (he/him), PhD Student, University of Exeter

Poster Board Number: 42
In Person

The risk from individual natural hazards (such as extratropical cyclones) can be large, but the aggregate loss over yearly timescales is significantly greater. For example, the three major European windstorms in February 2022 caused more than €3.5 billion of insured losses due to wind damage.

This study proposes a random sum modelling framework for understanding the correlation between aggregate risks that occur from compound events. By considering the frequency and intensities of compound events to random variables, the framework provides an expression for correlation between two aggregate losses from compound events.

The framework shows that this correlation will generally increase monotonically towards one as the dispersion (clustering) of the number of events increases. Under certain conditions, the correlation will always monotonically increase with dispersion.

The framework has been illustrated by applying it to annual sums from 1980-2020 using wind speed and precipitation as proxy measures for insured loss. This is calculated from ERA5 reanalysis data which includes 39587 storm events and covers the European region and Atlantic Ocean (from 30°N 100°W to 75°N 40°E).

The framework performs well, capturing the general behaviour of the correlation, with large positive correlation over the N. Atlantic Ocean and weaker correlations over European land regions.

Using Infographics to Communicate Climate Information

Hannah Griffith (she/her), Climate Scientist, Met Office

Poster Board Number: 43
In Person

Communicating climate science to a range of audiences can be difficult and can result in some audiences becoming unintentionally excluded due to a lack of prior knowledge or technical understanding. Climate information is often presented in formats unsuitable for audiences with non-technical backgrounds or prior knowledge, by using technical terms and jargon. This can result in key messages being restricted to certain audiences, limiting the reach to the wider community.

In my work, I have produced infographics to help overcome this issue. These infographics present information in a visual and non-technical way whilst maintaining scientific integrity. Presenting climate information in this way facilitates engagement with a wider audience, including those from non-technical backgrounds or with no prior knowledge. Three examples have been provided, covering a range of climate topics and include infographics used to accompany more technical reports as well as standalone infographics.

The infographics were received positively with feedback praising their high value in extending the reach of projects or pieces of work to wider audiences. Feedback on infographics accompanying more technical projects mentioned how they provided an entry point for those from non-technical backgrounds to access and understand the key findings. Feedback for standalone infographics mentioned how they provide an optimal way to present required information in a concise and engaging way.

Infographics are an excellent communication tool for climate science. The success of using infographics in this field has highlighted the need to use more in the future, especially to accompany more technical work. This enables a wider audience to understand climate science, thereby increasing the impact of climate research.

Understanding the Influence of Arctic Weather Systems on Predictive Skill Across Mid-Latitudes

Doug Wood (he/him), PhD Student, University of Reading

Poster Board Number: 44
In Person

Weather systems in the Arctic can interact with the planetary-scale waves that impact the poleward displacement of the upper-level jet stream, thereby influencing the weather in the populated mid-latitude regions of the northern hemisphere. By understanding the uncertainty associated with Arctic weather systems, and under which situations this impacts mid-latitude forecast predictability, there may be opportunities to improve medium-range forecasts. It can also be used to assess whether there is a changing influence of the Arctic on mid-latitude forecast predictability due to climate change.

Recent work on the mid-latitudes has highlighted that predictability is flow-dependent with a significantly larger forecast uncertainty when some weather systems, especially those involved in moist processes, are present. The approach assessed atmospheric uncertainty using a diagnostic based on the initial growth in the variance of geopotential height across members of an ensemble.

Here, the same approach has been applied to the Arctic region poleward of the jet stream with the initial studies focused on July 2022, coinciding with an Arctic cyclone aircraft-based field campaign centred on Svalbard. The results show that regions of uncertainty growth in the Arctic can be tracked over several days with some features moving equatorwards into the mid-latitude regions. The largest growth rates are often associated with low values of mean sea level pressure and large gradients in geopotential and potential vorticity, indicating that moist processes in the Arctic may also be an underlying cause of poor forecast predictability.

This work demonstrates an approach for understanding the impact of Arctic weather on predictive skill in the mid-latitudes that can be used to support improvements in numerical weather predictions.

Exploring Trends in UK River Flow: An approximate Bayesian approach for Detection and Analysis

Tommy Irons (he/him), PhD Student, University of Exeter

Poster Board Number: 45
In Person

The detection of trends in annual maximum river flow values allows for the prediction of future events, and therefore helps with preparative and preventative measures taking place. In this work, a spatio-temporal Generalised Extreme Value (GEV) distribution is fitted at various river gauging stations in the UK on annual maximum river flow data from the National River Flow Archive (NRFA). For inference, a penalised likelihood estimation and a Bayesian hierarchical modelling framework are used, with a spatial prior on the GEV parameters. The GEV location parameter is relaxed to be a linear function in time, so trends in extreme river flows can be found. Cross-validation is used to compare the predictive skill of models with different trend parameterisations and spatial priors, including the stochastic partial differential equation approach implemented in the R-INLA package. The effects of the spatial priors on the GEV parameters are evaluated and compared to the inferred modal point estimates. An analysis of the sensitivity of inferred GEV parameters and flood trends to choices of prior distributions and parameterisations is included. Comparisons of the trend results presented here and trends previously reported in the literature are presented, and the cross validation results allow us to make recommendations about suitable spatiotemporal GEV models for flood prediction.

The Pliocene as an Analogue for our Warmer Future

Lauren Burton (she/her), Postgraduate Researcher, University of Leeds

Poster Board Number: 46
In Person

The Pliocene, specifically the mid-Piacenzian Warm Period (~3.3-3.0 Ma), is widely referred to as a potential analogue for future climate within the palaeoclimate community. The Pliocene is well placed to be a palaeoclimate analogue given that it is the most recent period of sustained warmth above pre-Industrial levels, and that the atmospheric CO2 concentration is similar-to-modern at ~400 ppmv.

Results from the Pliocene Model Intercomparison Project (PlioMIP) highlight similarities in large-scale features of Pliocene climate to the future: global mean surface air temperature is ~3°C warmer and global mean total precipitation is ~7% higher than pre-Industrial.

However, it is also important to consider how analogous other factors are, such as the drivers of those changes in climate. Using the outputs from a subset of models in PlioMIP2, we show that less-analogous forcings, such as changes to ice sheets and orography, are responsible for 44% of surface air temperature and sea surface temperature change in the Pliocene, and 49% of precipitation change. These forcings must be taken into consideration, and affect how comparable the climate of the Pliocene is to our warmer future.

We discuss the implications of these results, and consider what it means for the Pliocene to be a “palaeoclimate analogue”.

Summer Compound Heatwaves over China: Projected Changes at Different Global Warming Levels and Related Physical Processes

Mingming Zhang (she/her), PhD Student, University of Reading

Poster Board Number: 47
In Person

Heatwaves (HWs) are weather events characterized by extreme hot surface air temperature anomalies that persist for several days, and thus leading to devastating impacts on society. Previous studies suggested that the Compound HWs will be the most frequent type that populations are exposed to after 2030 in the Northern Hemisphere. However, a limited number of studies have discussed the future changes of Compound HWs over China and they are mainly based on a fixed future time period. Considering the increasingly importance of the future projections at the target global warming levels (GWLs), this study aims to assess the changes in frequency, intensity and duration of Compound HWs in summer over China at various GWLs under the SSP3-7.0 and SSP5-8.5. In this study, Compound HWs are identified when the daily maximum and minimum temperature exceed the baseline 90th percentile for at least three consecutive days. The results indicate that China would face a future with projected frequency increase, intensity enhancement and duration extension of HWs. The magnitudes of these changes are primarily dependent on GWLs, but they are not very sensitive to the scenarios. Overall, seasonal mean warming dominates the changes in HW properties over China at the different GWLs. The seasonal mean warming in summer across China is related to the increases of longwave radiation and the increase of shortwave radiation (under the SSP5-8.5) over eastern China. Changes of shortwave radiation tend to play a weaker role for surface warming under the SSP3-7.0 than those under the SSP5-8.5, which is related to increased aerosol changes under the SSP3-7.0. Our results provide important context for the development of mitigation and adaption decisions to reduce the adverse impacts of HWs on society.

The Roles of Anthropogenic Forcings on the Decadal Changes of Summer Heatwaves over China

Mingming Zhang (she/her), PhD Student, University of Reading

Poster Board Number: 48
In Person

In recent decades, heatwaves (HWs) are becoming more frequent and severe over China, which can lead to severe damage to society. According to the occurrence time and different impacts, HWs can be divided into Compound HWs (hot in both day and night), Daytime HWs and Nighttime HWs. Compound HWs and Nighttime HWs increased significantly in frequency, duration, intensity and areal extent during 1961-2010. This study aims to investigate the role of changes in external forcing on the decadal changes of these three types of summer HWs over China in observations using CMIP6 multi-model ensembles and quantify the relative roles of changes in greenhouse gas forcing (GHG) and anthropogenic aerosol forcing (AA). Results suggest that the significant increases in frequency, intensity and duration over the entire China in Compound HWs and Nighttime HWs in observations are predominantly explained by changes in external forcing in which changes in GHG play a dominant role. AA makes a positive (negative) contribution over the northern (southern) part of China. The decadal changes in climatological seasonal mean state of physical processes are further discussed to explain the decadal changes of HWs. The increase of GHG concentrations and GHG change induced increases of water vapor in the atmosphere lead to the increase of surface longwave radiation, which is associated with the increase of Compound HWs and Nighttime HWs across China. In response to AA changes, the shortwave radiation decreases significantly over the Southwest China, which contributes to the decrease of Compound HWs and Daytime HWs while changes of HWs over northern China mainly result from AA induced circulation changes.

The Signal To Noise Paradox: Assessing Climate Models' Ability To Accurately Predict Atmospheric Circulation Variability

Frankie Cottrell (she/her), Student, University of Exeter

Poster Board Number: 49
In Person

Some aspects of climate variability on seasonal to multidecadal timescales are predictable. This predictable component is underestimated in extratropical seasonal forecasts, limiting their use for climate services and pointing to untapped potential predictability. Models appear better at predicting the real world than themselves, which has become known as the signal-to-noise paradox (SNP). The root cause of the SNP remains a mystery. Here, we examine a large multi-model ensemble (n=460) of 'amip' experiments – atmosphere-only simulations with prescribed observed SST and sea ice from 1979-2014.

The ensemble-mean winter sea level pressure is significantly correlated with observed variability over the North Atlantic and North Pacific. We assess the ratio of predictable components (RPC). Ideally, the RPC should be 1, as the observations and model should contain the same proportion of predictable variance. The spatial pattern of RPC in winter sea level pressure bears close resemblance to that seen in seasonal forecasts, for example, with an RPC significantly above one over the North Atlantic. The North Atlantic Oscillation index has an RPC of ~1.8 (implying the real world has twice the predictable signal of the models).

Our results confirm that the SNP exists in uninitialised simulations, and therefore in the absence of SST (and sea ice) biases. To gain further insight into the cases of the SNP, we stratify the ensemble by horizontal resolution. Higher resolution models show greater correlation between modelled and observed NAO than lower resolution models, and the SNP emerges more clearly.

Video-Based Convolutional Neural Networks for Rainfall Forecasting

Andy Barnes (he/him), Lecturer in Artificial Intelligence, University of Bath

Poster Board Number: 50
In Person

Monthly variations in rainfall often lead to extreme events causing substantial damage to society. This damage is often caused by droughts and floods. Current sub-seasonal rainfall forecasts are based on large ensemble models using complex numerical predictions which require large amounts of computing power. Despite this, they often fail to capture the extreme events. In this study daily mean sea-level pressure (MSLP) and 2m air temperature (2AT) forecast images across the North Atlantic are used to produce regional, monthly rainfall forecasts for Great Britain. For each month 28 MSLP and 2AT images are derived from the MetOffice GloSEAS5 daily forecasts. The target rainfall is derived from the CEH-GEAR (Centre of Ecology and Hydrology Gridded Estimates of Areal Rainfall) and is used as the benchmark to be aimed for. Three types of convolutional neural networks (CNN) are trialled at combining the image sets into a regional rainfall forecast. These architectures are named slow-fusion, early-fusion and single frame. For each of the three architectures a CNN is developed independently for each region. The CNNs are then evaluated against derived monthly precipitation forecasts from the MetOffice's GloSEAS5 model. The results show that all three CNN architectures outperform the derived forecasts with the early-fusion and slow-fusion models performing the best, with root mean-squared errors of 11.2mm and 8.16mm respectively. The worst performing forecasts were given by the MetOffice derivations and the single frame CNN with RMSEs of 43.8mm and 33.3mm respectively. Errors across all models are highest in the western regions of Great Britain and lowest in the east. Similarly errors are also higher in the winter months (December, January and February). However, across these high-error months and regions the slow-fusion and early-fusion models consistently have errors less than 50% that of the MetOffice derivations.

ADS-B Interferometry: A New Source of Humidity Observations

Ollie Lewis (he/him), PhD Student, Met Office & University of Exeter

Poster Board Number: 51
In Person

Detailed measurements of water vapour in the lower atmosphere are currently difficult and expensive to obtain. For this reason, there is interest in the development of low-cost, high-volume opportunistic technologies to acquire measurements of atmospheric humidity. We propose the use of radio interferometry to measure the angle of refraction of Automatic Dependent Surveillance-Broadcast (ADS-B) routinely broadcast by commercial aircraft. Variations in atmospheric refraction are strongly influenced by changes in humidity, and atmospheric refractivity has proved to be an ideal substitute in numerical weather prediction models. By combining the angle of refraction measurements of multiple aircraft radio broadcasts, a detailed profile of atmospheric humidity can be constructed. In regions of suitable air traffic density such as the UK, there is the potential to obtain millions of humidity observations every day, orders of magnitude greater than what current refractivity observation technologies can deliver. Significant developments have been made in improving the quality of the data obtained using a prototype ADS-B interferometer installed at the Met Office-owned Clee Hill radar tower. If fully realised, this novel technology could complement existing humidity observation methods and improve the quality of weather forecasts in the UK and beyond.

Analysing the Influence of Environmental Conditions on Air Temperature Measurements

Natali Giselle Aranda (she/her), PhD Student, Politecnico di Torino

Poster Board Number: 52
In Person

In ground-based meteorological observations, the characteristics of the observing site and physical variables affect the measurements results, introducing errors and affecting the overall measurement uncertainty. Although the World Meteorological Organization has assigned an estimated uncertainty according to the characteristics of the field and instrumental quality, little is known about the uncertainty contribution due to the environmental effects. With the aim of exploring the behaviour of the air thermometers exposed to ambient conditions, the dispersion of the air temperature was evaluated, with respect to other meteorological parameters. For this purpose, the records every 10 seconds of 6 identical thermometers in identical solar shields, a hygrometer and a wind sensor installed at the Istituto Nationale di Ricerca Metrologica field, were analysed. The dispersion of the air temperature was calculated as the difference in the lecture of each thermometer and the mean (considering the 6 thermometers). For the 2-year analysed period the dominant winds were calms and light air, and the study was focused on the measurements recorded under these characteristics. Statistics tests were performed, revealing the influence of the humidity on the dispersion of the air temperature: the higher the humidity, the lower the dispersion. Moreover, the seasonality was also reflected. In summer, when the relative humidity ranged between 50 % and 75%, the standard deviation of the air temperature was 0.07 °C but in winter, for the same threshold of humidity, the standard deviation of the air temperature was 0.14 °C. This is a first approach to estimate the air temperature uncertainty due to the humidity effect, in presence of low wind. In this way, future research will be performed to investigate the effect of other meteorological variables in the dispersion of the air temperature, like solar radiation.

The Impact on Forecast Skill for Post-Processed Met Office Visibility Forecasts when Using a New Underlying Visibility Physics Model, VERA

Will Luscombe (he/him), Foundation Scientist, Met Office

Poster Board Number: 53
In Person

Post-processing is a powerful tool for improving the accuracy and skill of Numerical Weather Prediction (NWP) model outputs, however, post-processing is only able to amplify skill in a forecast if there is already some level of underlying skill to begin with. Visibility forecasting, and specifically the forecasting and modelling of low visibility.

Sensitivity of Ocean Model Simulations in the Adriatic Sea to ERA-Interim and ERA5 Reanalyses

Javad Babagolimatikolaei, PhD Student, University of Manchester

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Virtual

The horizontal grid spacing of the ERA-Interim reanalyses is approximately 80 km on 60 levels, as compared to ERA5, which is 30 km on 137 levels. The question remains as to how much using ERA5 as atmospheric forcing can improve ocean modeling compared to using ERA-Interim. We select the Adriatic Sea to address this question. For 7 years (2012–2018), the ROMS ocean model was run in two scenarios, one with ERA5 and the other with ERA-Interim. Otherwise, both model configurations were identical, and observational data and satellite imagery were used to verify the model simulations.

Both model simulations underestimate the sea surface temperature in general, especially during cold seasons, but using ERA5 shows roughly 0.1–0.3°C better results on average for temperature than when using ERA-Interim, compared to observations. Also, using ERA5 shows about 0.2 PSU better simulations of salinity than when using ERA-Interim, when compared to observations.

Although there are some differences between the two simulations, both simulations indicate that the current surface water circulation speed ranges from 25 to 45 cm/s. The Adriatic Sea circulation is composed of three gyres. The southern gyre is stronger in the ERA5 scenario, with an average speed of 35 cm/s during the winter, which is 5 cm/s higher than the ERA-Interim scenario. In the summer, there are no remarkable changes in all basins, but for spring and autumn the current speed of ERA-Interim reanalyses is 10–20% stronger in the northern basin. The vertical structure of the simulation using ERA5 also shows the mixed layer 4–5 m higher (and closer to the observations) than the simulation using ERA-Interim. Overall, the simulation using ERA5 leads to better results, demonstrating the importance of improvements in atmospheric modeling on improving ocean models.

Understanding the Dynamic and Energetic Association between ITCZ Migration and Cloud Bias in Climate Models over Tropical Africa

Tomviezibe Cephas Dombo (he/him), PhD Scholar, Indian Institute of Technology, Delhi

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Virtual

Tropical Africa is home to millions of Africans whose socio-economic and agricultural life depend on the summer monsoon rainfall variability. The projection of monsoon precipitation using simulations from Coupled Model Intercomparison Project Phase 6 (CMIP6) requires evaluation. Hence, we first evaluate the representation of historical rainfall in these models compared to observations, then investigate the likely causes of stagnation in ITCZ location by models. The results show considerable southward bias in the location of precipitation and ITCZ over the region from June to September. The stagnation in the seasonal migration of precipitation could be attributed to biases in low cloud simulation in CMIP6 models. Other underlying dynamics and energetics contributing to these biases are investigated.

Enhancing Smallholder Farmers' Resilience through Effective Climate Communication Channels in Rwanda: A Case Study of Ruhango District

Alexis Nzeyimana, Observation Supervisor, Rwanda Meteorology Agency

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Virtual

Globally climate change has been a major constraint towards achieving food security. Therefore, adaptation to climate change is imperative to reduce farmers' vulnerability. The production and provision of climate information services (CIS) in Rwanda has increased, but their accessibility and utilization in decision-making have been limited. One approach to enhance resilience among the smallholder farmers is to provide them with timely, accurate and reliable climate information services through effective communication channels. This study investigated, among others, the Climate Information and Services (CIS) communication channels accessed by the smallholder farmers in Ruhango district of Rwanda; the farmers' social-economic characteristics which influence the accessibility of those channels and the factors inhibiting the use of the available climate information services effectively in decision-making. Also, this study assessed the available adaptation practices applied by the smallholder farmers to tackle the impacts of climate change experienced in their area. A total of 159 smallholder farmers were interviewed by using the Survey CTO computer software application installed in Tablets; while Key Informant Interviews (KIIs) tool was used to gather information from forecasting and extension officers. The results showed that while 92.5% of the respondents were aware about Rwanda Meteorology Agency, majority (91.2%) accessed of only the daily weather forecasts and radio was the main dissemination channel followed by mobile phone. Family size was only the socio-economic characteristic established to be statistically significant in influencing the accessibility to communication channels. Among the smallholder farmers that accessed CIS, only 11.9% used it. While all the respondents (100%) were confirmed that "the Climate has changed. Only anti-erosion practices were reported to be dominant (53.5%) applied as adaptation practice. Majority (88.1%) of smallholder farmers who did not use the CIS said it is due from "lack of trust based on untimely and unreliable climate information received in previous years. To enhance smallholder farmers', trust in CIS, the providers should ensure that the information is accurate and promotion of farmer promoters' groups to ensure the flow of CIS and discussion among local farmers would increase the access and use of climate information services. The study recommended the provision of accurate, timely and reliable climate information services to smallholder farmers should be the priority of climate information and services' providers.