WORKSHOP

Previsão Numérica em Portugal 2021

Numerical Weather Prediction in Portugal 2021

Surface-Atmosphere Interactions

BOOK OF ABSTRACTS

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ORAL PRESENTATIONS

Session 01 – Surface-atmosphere interaction & modelling

Alqueva lake impact on a regional climate: a typical meteorological study

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This work summarizes a study done during the ALOP project (Alentejo observational and prediction systems) which aimed at the impact of the Alqueva on regional weather regimes. The study implied two identical numerical atmospheric simulations that differed in only one way: the presence of the Alqueva reservoir in the surface data. Thus, comparing the results of these simulations made it possible to retrieve a raw impact of the young reservoir on weather and estimate its reach. A Typical Meteorological Year (TMY) was chosen for a time span. A TMY is a set of 12 consecutive months where each of them represents typical climate conditions in the region of interest, therefore, 12 months can represent a year similar to a hypothetical “average” year. The work shows how the Alqueva changed thermal regimes in nearby territories, lake breeze conditions, and changes in fog formation.

Improvement of Meso-NH solar radiation simulations with Artificial Neural Networks

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Numerical Weather Prediction models tend to show some errors when solar radiation is concerned mainly due to difficulties in correctly simulating clouds and the usage of monthlymean aerosol climatology. This is especially evident in the case of direct normal and diffuse horizontal irradiation while global horizontal irradiation predictions show a small bias compared with ground-based measurements. This work presents a method based on artificial neural networks for the improvement of the solar radiation prediction given by the mesoscale atmospheric model, Meso-NH, taking into consideration aerosol data from the Copernicus Atmospheric Monitoring System and typical meteorological data. This allows for a more accurate assessment of the solar resource which is crucial for solar radiation related applications such as planning and design of solar energy systems.

Hail climatology in Portugal and some insights into the regional dynamical drivers

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This study presents a hail climatology in mainland Portugal based on a network of 15 meteorological stations and over the period of 1971–2009 (39 years). For this purpose, three hail sub-classes based on the SYNOP codes are used, i.e., small hail, hail without thunder and

hail with thunder. Additionally, hail occurrences are also related to thunderstorm, convection and precipitation days. The analysis reveals that hail events are more frequent in northern Portugal during winter and spring, with a maximum in April. Furthermore, both thunderstorm and convection events present a maximum in April–May and a secondary peak in October, which is often related to convective storms without hailfall at the ground, since no clear autumnal maximum can be found in the hail frequency, mostly in the case of small hail and hail without thunder. Temperatures in October are commonly higher than in February–April, which may lead to high-freezing level heights that hamper hailfall at the ground. The dynamical processes governing hail occurrence are also assessed through eight three-dimensional weather types. The atmospheric conditions connected to Western European Trough, Blocking and Scandinavian Trough explain approximately 75% of the hail occurrences in Portugal. Hail events are generally favoured either by extra-tropical depressions, with cold front passages over Portugal, or by upper-level troughs/lows over western Iberia, mainly in the period from December to May. These conditions favour atmospheric instability, herein diagnosed using both the convective available potential energy and the total-totals index.

Land-atmosphere coupling during extreme heat events in the LUCAS experiment

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Land-atmosphere energy and water exchanges are fundamentally linked to soil-moisture. The distribution of the planets' biomes hinges on the surface-atmosphere coupling since soil moisture and temperature feedbacks have a strong influence on plant transpiration and photosynthesis. Land use/land cover changes (LUC) modify locally land surface properties that control the land-atmosphere mass, energy, and momentum exchanges. The impact of these changes depends on the scale and nature of land cover modifications and is very difficult to quantify. However, large inconsistencies in the LUC impacts are observed between models, highlighting the need for common LUC across a large ensemble of models. The Flagship Pilot Study LUCAS (Land Use & Climate Across Scales) provides a coordinated

effort to study LUC using an ensemble of regional climate models (RCMs). In the first phase of the project 3 experiments were performed for continental Europe: EVAL (current climate); GRASS (trees replaced by grassland) and FOREST (grasses and shrubs replaced by trees). An analysis of the energy and moisture balance for the three experiments is performed, focusing on the relationship between the fluxes partitioning, heat waves and droughts. To better asses the link between extreme temperatures and soil moisture or evapotranspiration, a new coupling metric for short time scales is proposed, the Latent Heat Flux-Temperature Coupling Magnitude (LETCM). This new metric is computed for a specific period, considering the positive temperature extremes and the negative latent heat flux extremes. Areas with positive magnitude values imply higher temperature anomaly, due to a negative latent heat flux anomaly. This new metric only considers periods of strong coupling, with positive signals in areas of high temperatures and evaporative stress, allowing for the detection of events that are extreme for energy and water cycle. The analysis focuses on the three experiments revealing that the number, amplitude and spatial distribution of compound extreme heat and drought is highly model dependant. The impact of afforestation or deforestation is not consistent across models.

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Response of the surface climate to different land surface models: WRF sensitivity to groundwater options

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Four simulations with the WRF model differing in land surface models and options were investigated as a sensitivity study over the European domain. These experiments span from 2004-2006 with a one-month spin-up and were performed at 0.11º horizontal resolution with 50 vertical levels, following the CORDEX guidelines. The lateral boundary conditions were driven by ERA5 reanalysis from European Centre for Medium-Range Weather Forecasts. For the first experiment, the Noah land surface model was used. For the remaining simulations, the Noah-MP (multi-physics) land surface model was used with different runoff and groundwater options: (1) original surface and subsurface runoff (free drainage), (2) TOPMODEL with groundwater and (3) Miguez-Macho & Fan groundwater scheme. These experiments allow the analysis of the sensitivity of different land surface options and to understand how the representation of land surface processes impacts on the atmosphere properties. This study focusses on the investigation of land-atmosphere feedbacks trough the analysis of the soil moisture – temperature and soil moisture – precipitation interactions, latent and sensible heat fluxes, and moisture fluxes. The land energy and water balances are also explored.

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On the added value of the EURO-CORDEX multi-model ensemble simulations over the Iberian Peninsula

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In the recent years, due to a large increase in computational resources, Regional Climate Model simulations with increasing domains, resolutions, and spanning larger temporal periods have emerged. A good example is the 12 Km resolution from the Coordinated Regional Climate Downscaling Experiment for the European domain (EURO-CORDEX). However, these simulations are computationally demanding, not always revealing a clear added value. In this study, a recently proposed Distribution Added Value (DAV) metric is considered to assess the gains or losses of the precipitation, max and min temperature, taken from the high-resolution EURO-CORDEX Hindcast (1989-2008) and Historical (1971-2005) simulations, against their respective lower-resolutions counterparts: Era-Interim reanalysis or Coupled Model Intercomparison Project Phase 5 Global Circulation Models. To this end, a new observational gridded dataset at 0.1º covering the entire Iberian Peninsula (Iberia01) is used as reference. The Iberia01 thus constitutes an unprecedent opportunity in assessing the performance of EURO-CORDEX runs, since both datasets have similar resolutions. This assessment can be performed for the entire domain, returning a representative value, or spatially, allowing a regional overview, while at the same time either considering the whole PDF or in parts, such as those related to the extremes. In general, most Hindcast models reveal gains above 15% for precipitation, while for the extremes, values above 20% are reached. As for the Historical models, although most pairs display gains, some do reveal losses, sometimes around -5% or stronger. However, the spatialization of the DAV is clear in revealing a spread out significant added value for precipitation throughout the domain, particularly on the extremes. On the other hand, the gains for max temperature are more relevant in comparison to min temperature. These results for min temperature might be partially owed to known problems derived from the snow- albedo-atmosphere feedback around 0 ºC. For more local scales, areas near the coast always reveal significant added value in comparison with the interior, which in turn displays detrimental effects around -30%. As for temperature extremes, a similar range is observed. Finally, in an effort to assess the differences between coast and the interior, and also the effect of orography, the DAVs metric is also computed at different height levels.

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Assessing marine climate change in the North Atlantic

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An improved understanding of the present and future marine climatology is necessary for numerous activities, such as operation of offshore structures, optimization of ship routes and the evaluation of wave energy resources. To produce global wave information, the WW3 wave model was forced with wind and ice-cover data from an RCP8.5 EC-Earth system integration for two 30-year time slices. The first covering the periods from 1980 to 2009 represents the present climate and the second, covering the periods from 2070-2099, represents the climate in the end of the 21st century. Descriptive empirical statistics of wind and wave parameters are obtained for different 30-year time slices, for the North Atlantic Ocean. Regarding wind, magnitude and direction will be used. For wave, significant wave height of total sea, mean wave period, peak period, mean wave direction and energy will be investigated. Changes from present to future climate are evaluated, regarding both mean and extreme events. Maps of these empirical statistics are presented. The long-term monthly joint distribution of significant wave heights and peak periods is generated. Changes from present to future climate are assessed, comparing the empirical statistics between time slices.

Modeling the Iberian Current System

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A high-resolution simulation of the Iberian Margin is being developed using the Regional Ocean Modeling System (ROMS). It covers the entire Iberian Margin, at a resolution of ~1.8km and 60 vertical levels, with enhanced resolution near the surface. This simulation uses a larger domain and an embedded child domain running simultaneously and exchanging information between each other at every model time-step. Along the larger domain open boundaries it was applied an adaptive nudging towards monthly averages of the Mercator-Ocean global reanalysis GLORYS2V4. The atmospheric forcing was created using ERA5 ECMWF atmospheric reanalysis, every 4-hours. The simulation includes monthly averages of river discharges of the main Iberian rivers, obtained from simulations with the hydrodynamic model CaMa-Flood driven by runoff generated by the land surface model CHTESSEL. The simulation spans the period of 2002 to 2008, and will be extended to the present. In this presentation the model results are compared with other products and possible improvements are discussed.

Session 02 – Surface observations applications

Uncertainty in different precipitation products in the case of two atmospheric river events

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One of the World Climate Research Programme Grand Challenges is to evaluate whether existing observations are enough to underpin the assessment of weather and climate extremes. In this study, we focus on extreme associated with atmospheric rivers (ARs). ARs are characterized by intense moisture transport usually from the tropics to the extra-tropics. They can either be beneficial, providing critical water supply, or hazardous, when excessive precipitation accumulation leads to floods. Here, we examine the uncertainty in gridded precipitation products included in the Frequent Rainfall Observations on GridS (FROGS) database during two atmospheric river events in distinct Mediterranean climates: one in California, USA, and another in Portugal. FROGS is composed of gridded daily-precipitation products on a common 1° × 1° grid to facilitate intercomparison and assessment exercises. The database includes satellite, ground-based and reanalysis (RE) products. Results show that the precipitation products based on satellite data, individually or combined with other products, perform least well in capturing daily precipitation totals over land during both cases studied here. The RE and the gauge-based products show the best agreement with local ground stations. As expected, there is an overall underestimation of precipitation by the different products. For the Portuguese AR, the multi-product ensembles reveal mean absolute percentage errors between −25% and −60%. For the western US case, the range is from −60% to −100%.

Applications of remotely sensed Land Surface Temperature Products

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The Satellite Application Facility on Land Surface Analysis (LSA-SAF) has been providing remotely sensed land surface information since 2004, relying on measurements from instruments on the EUMETSAT satellites. In particular, the imager on the Meteosat Second Generation (MSG) provides data every 15 min with 3 km resolution at nadir, which are used to determine the Land Surface Temperature for every clear-sky pixels within the field of view, which encompasses Europe, Africa and part of South America. Similar retrievals are performed with geostationary sensors covering the Americas (GOES-16), the Middle East (MSG IODC mission) and Asia/Australia (Himawari-8), which are used together with the MSG 0° mission to produce the Copernicus Global Land (CGL) LST, which is also produced at IPMA.
The number of applications of these datasets has been growing, especially given its ever-increasing timespan. In this work we illustrate some of these applications, including:

- The study of biophysical recovery of wildfire scars;
- Characterization of heatwaves, in terms of their extension, magnitude and duration

- Study of the evolution of the Land-Sea contrast along the West Iberian coast
- The use of LST to tune surface schemes in NWP

These applications demonstrate the usefulness of these datasets to monitor the land surface as a whole, and their time span allows the rapid determination of robust anomalies that can be used in decision-making processes. The potential to improve NWP models was also demonstrated, as it was shown that the mismatches between model and satellite skin temperatures can only be alleviated with a correct representation of the land surface.

A Google earth Engine application to retrieve high resolution Land Surface Temperature from Landsat imagery

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Land surface temperature (LST) is widely recognized as an important variable for the description and understanding of surface processes. The temperature of the interface between the soil and the atmosphere is a crucial element of the surface energy balance, determining radiation loss and being closely linked to the partitioning between latent and sensible heat fluxes. As such, satellite-derived LST is being increasingly used in various applications related to the assessment of land surface conditions, including the assessment and improvement of land surface schemes in numerical weather prediction models, in the estimation of evapotranspiration, and in the monitoring of plant water stress or drought extent.

The Landsat series of satellites have the potential to provide LST estimates at high spatial resolution that are particularly appropriate for local and small-scale studies. Numerous LST algorithms for the Landsat series have been proposed. While most algorithms are simple to implement, they require users to provide the necessary input data and calibration coefficients, which are generally not readily available. Some datasets are available online, however, they generally require users to be able to handle large volumes of data. Google Earth Engine (GEE) is an online platform created to allow remote sensing users to easily perform big data analyses without the need for computation resources. All Landsat Level-1 and 2 data are directly available to GEE, including top-of-atmosphere (TOA) and surface reflectance (SR) data. However, until now high resolution LST datasets from Landsat have been unavailable in GEE.

Here we describe a methodology for deriving LST from the Landsat series of satellites (i.e. Landsat 4, 5, 7 and 8) which is fully implemented in GEE. We provide a code repository with all the GEE scripts necessary to compute LSTs from Landsat data. The repository allows users to perform any data analysis they require within GEE without the need to store data locally. The LST is computed using the Statistical Mono-Window (SMW) algorithm developed by the Climate Monitoring Satellite Application Facility (CM-SAF). Besides Landsat data, the LST production code makes use of two other datasets available within GEE: atmospheric data from re-analyses of the National Center for Environmental Prediction (NCEP) and National Center for Atmospheric Research (NCAR) and surface emissivity from the Advanced Spaceborne Thermal Emission and Reflection Radiometer Global Emissivity Database (ASTER GED) developed by the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory (JPL).

Local AROME surface Data Assimilation: status and plans

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IPMA maintains in operations a local version of the convection-permiting model AROME (Piet et al. 2018) which is initialised by downscaling of the forecasts of the global model ARPEGE. The local version of AROME is executed over three different geographical areas. Efforts are being developed in order to provide the AROME initial model state of atmospheric small-scale information, through the assimilation of locally available observations from the operational Iberian surface network. The method, by Optimal Interpolation, is computationally cheap, which makes this a popular scheme in many operational centers worldwide. The present communication aims at providing the status and plans on the mentioned surface Data Assimilation scheme to the local AROME.

Termonia, P., Fischer, C., Bazile, E., Bouyssel, F., Brožková, R., Bénard, P., Bochenek, B., Degrauwe, D., Derková, M., El Khatib, R., Hamdi, R., Mašek, J., Pottier, P., Pristov, N., Seity, Y., Smolíková, P., Španiel, O., Tudor, M., Wang, Y., Wittmann, C., and Joly, A.: The ALADIN System and its canonical model configurations AROME CY41T1 and ALARO CY40T1, Geosci. Model Dev., 11, 257–281, https://doi.org/10.5194/gmd-11-257-2018, 2018.

On the convergence of reanalysis produced by different data assimilation streams: a case study with NASA-GMAO MERRA-2 reanalysis system

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Due to the enormous computational costs of producing reanalyses, it has become common practice to split the reanalysis production into multiple, parallel computational streams that usually include some year-long periods of overlap to account for the necessary spin-up integration period of each stream and foster continuity between successive streams. A fundamental assumption underlying the use of parallel NWP-DAS computational streams is that they will eventually converge to a common atmospheric state in a relatively short period of time. This important expectation of convergence has very limited investigation, and this study presents a more in depth analysis on this question.

Differences between reanalyses valid at the same times but produced by different streams were determined using overlapping periods from NASA's GMAO MERRA-2 reanalysis. By the end of the overlapped periods, the monthly mean of the differences between the streams are small, as desired. However, the standard deviations of these differences were shown to be a large fraction (40 to 60%) of the estimated standard deviations of typical analysis errors. It was also shown that the streams do not appear to be converging as it was expected in terms of standard deviations of the differences, since little variation is seen between the beginning and the end of the spin-up period. This occurs although the overlapping streams use the same observations, numerical weather prediction and data assimilation models, and assimilation algorithm, differing only in the background information applied at the beginning of each overlapping period.

Session 03 – Land modelling

Serão os ciclones de origem tropical um risco para Portugal?

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Desde o final do século XX, o nordeste do Atlântico Norte tem vindo a apresentar um aparente aumento de ciclones com características tropicais. O interesse da comunidade científica nestas tempestades deve-se à ideia de que a ocorrência de ciclones tropicais é altamente improvável nas latitudes médias, devido ao ambiente hostil caracterizado por valores relativamente baixos da temperatura da superfície do mar e elevado efeito de corte do vento (wind shear). No entanto, a formação de ciclones subtropicais (com características híbridas entre sistemas tropicais e extratropicais) torna a ocorrência dos ciclones tropicais, nestas latitudes, mais plausível, pois através de um processo denominado por transição tropical, um ciclone subtropical pode transformar-se num sistema com características tropicais. Estes sistemas híbridos formam-se através da ocorrência de instabilidade baroclínica, que compensa a falta de energia de águas quentes necessária para manter sistemas tropicais. Importa então perceber as razões que poderão estar na base desta modificação fundamental do clima da região nordeste do Atlântico Norte, que tem permitido a ocorrência de sistemas híbridos de origem tropical e subtropical. Com base na literatura disponível sobre o assunto, foram identificados três fatores essenciais para a manutenção deste tipo de tempestades: 1) temperatura da superfície do mar, 2) o efeito de corte do vento, medido entre os níveis baixos e os níveis altos da troposfera (wind shear), e 3) a taxa de variação da temperatura (o gradiente adiabático ou ‘lapse rate’) entre a baixa e a média troposfera (1000-500 hPa).

Monitoring and forecasting the regional water cycle with the Terrestrial Systems Modelling Platform (TSMP): Overview and first evaluation results

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The Terrestrial Systems Modelling Platform (TSMP, https://www.terrsysmp.org) is a scale-consistent, highly modular, massively parallel, physics-based integrated, coupled regional Earth system model. In its current production mode TSMP features the Consortium for Small-scale Modeling (COSMO) atmospheric model, the Community Land Model (CLM), and the hydrologic model ParFlow, linked through the OASIS3-MCT coupler. Driven by ECMWF forecasts, a monitoring and forecasting setup (TSMP-M) provides daily 10-day deterministic forecasts of the terrestrial hydrological cycle from regional to continental scales for a 12.5-km pan-European domain and a smaller convection-permitting km-resolution domain over North-Rhine Westphalia, Germany. The unique TSMP-M provides all states and fluxes from groundwater to the top of the atmosphere. Here we present an overview of TSMP-M and an evaluation of its performance as a monitoring system against observations.

Revising ECMWF land cover and vegetation: impact in offline and coupled atmosphere simulation

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IPMA

In this study, we show that limitations in the representation of land cover and vegetation seasonality in the European Centre for Medium-Range Weather Forecasting (ECMWF) model are partially responsible for large biases (up to ∼10°C, either positive or negative depending on the region) on the simulated daily maximum land surface temperature (LST) with respect to satellite Earth Observations (EOs) products from the Land Surface Analysis Satellite Application Facility.

Subsequently, we updated the ECMWF model's land cover characterization leveraging on state-of-the-art EOs—the European Space Agency Climate Change Initiative land cover data set and the Copernicus Global Land Services leaf area index. Additionally, we tested a clumping parameterization, introducing seasonality to the effective low vegetation coverage. The updates reduced the overall daily maximum LST bias and unbiased root-mean-squared errors.

Session 04 – Physiographic effects & wildfire behaviour

The role of orography and SST on shaping coastal surface wind, in the Canary upwelling ecosystem

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OOM – IDL

The accurate simulation of the surface wind over the ocean is an important issue when forcing an oceanic model since the coastal wind shape will strongly influence the mesoscale eddy activity and, subsequently, the net primary production, which is particularly important in coastal upwelling regions where about 20% of the world fish-catchments occurs.

Coastal orography, coastline orientation and air-sea interaction can shape coastal SST and wind, leading to an intense weakening of the wind close to the coast, the so-called wind drop-off. This is especially true in coastal upwelling regions where an intense SST front can affect the coastal wind vertical structure.

Here, it is analyzed the wind drop-off in the Canary upwelling ecosystem, with remote sensed satellite data and with numerical simulated data retrieved from a high resolution (3 km) ocean-atmosphere 2-way coupled numerical simulation. More precisely, it is shown the strong dependence of the wind drop-off spatial variability on the coastal orography, and the progressive importance of wind-sst coupling with the increasing distance to the coast, that contrasts with the decreasing relevance of coastal orography in the surface wind, with the increasing distance to the coast.

Additionally, as the studied domain also comprises the Madeira and Canary Archipelagos, it will be shown the disruptive effect of the islands in wind-sst coupling. In fact, nearby the islands the atmospheric flow is essentially controlled by orography, which gives origin to the frequently observed intense jets (tip-jets) near its flanks, that contrast with the weak winds usually observed in the island’s wakes.

Estudo de eventos meteorológicos extremos com base na modelação da atmosfera e das suas interações com a superfície

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Neste trabalho são apresentados exemplos da utilização de modelação atmosférica com o modelo Meso-NH no estudo de diferentes fenómenos meteorológicos extremos e da importância das interações superfície-atmosfera. Num investiga-se o papel da circulação atmosférica no transporte de grandes quantidades de poeiras do deserto do Saara para Portugal em fevereiro de 2017. As simulações incluindo a emissão de poeiras foram realizadas sobre um domínio horizontal de 3000 × 3600 km e com resolução de 10 km. A modelação numérica permitiu verificar que o episódio foi governado por uma variedade de interações entre a superfície e a dinâmica atmosférica durante vários dias. Os ventos intensos próximos à superfície foram o principal fator para a mobilização das poeiras. Além disso, um sistema de baixa pressão de latitudes médias foi fundamental para a longa duração do evento, bem como para o transporte das poeiras do Saara para Portugal. No segundo exemplo, testa-se a capacidade do atual esquema elétrico do Meso-NH (CELLS) prever a probabilidade de ocorrência de descargas elétricas suscetíveis de originarem de incêndios florestais. O desafio é diagnosticar as descargas elétricas do tipo nuvem-solo (CG) com resolução espacial de 1 km em zonas com combustível e condições de humidade propícias à ocorrência de incêndios florestais. Como caso de estudo foi considerada a tarde de 17 de junho de 2017. O ambiente de trovoada seca configurou um cenário ideal para ignição natural e evolução de alguns incêndios. O incêndio florestal de Pedrógão Grande ocorreu neste período. A distribuição espacial de raios CG simulados apresentou boa concordância com as descargas detetadas pela rede nacional de deteção de raios, confirmando as potencialidade da aplicação do esquema elétrico na previsão da probabilidade de ignição de incêndios florestais por descargas atmosféricas.

Estudo das condições atmosféricas associadas a incêndios florestais na Ilha da Madeira

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Compreender os efeitos da atmosfera e da topografia na propagação do fogo em contextos específicos é fundamental para apoiar estratégias de prevenção e supressão de incêndios. Neste estudo, as condições atmosféricas associadas a incêndios florestais históricos que ocorreram na Ilha da Madeira são analisados a partir de modelação atmosférica. O modelo Meso-NH foi usado para identificar o ambiente de mesoscala durante três eventos de incêndios florestais. O modelo foi configurado em dois domínios aninhados, um domínio com resolução de 2.5 km e um domínio menor com 500 m. O estudo apresenta uma análise sobre os fatores que favoreceram a evolução dos grandes incêndios ocorridos na Madeira em agosto

de 2010, julho de 2012 e agosto de 2016. Estes incêndios foram selecionados por se caracterizarem pela sua grande dimensão que se expandiu em um curto período de tempo, ameaçando pessoas e propriedades nas áreas de interface urbano-florestal. As simulações de alta resolução foram capazes de indicar as regiões favoráveis a incêndios, nomeadamente aquelas afectadas por maiores temperaturas, menores valores de humidade relativa e por ventos muito fortes, o que se mostrou estar associado com a geometria da ilha e dos efeitos orográficos criados devido à interação da ilha com o escoamento atmosférico. O estudo destaca que o terreno local produz efeitos orográficos que aumentam o perigo de incêndio na encosta sul durante as condições atmosféricas típicas do verão.

Modelação atmosférica associada a um incêndio florestal: caso de estudo de Vila de Rei

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O comportamento de um incêndio florestal resulta da combinação de alguns fatores que influenciam a propagação do fogo, tais como as condições de superfície e atmosféricas do local. Neste estudo analisou-se as condições atmosféricas associadas ao incêndio que ocorreu no concelho de Vila de Rei, situado na zona Centro de Portugal Continental. Este incêndio florestal, que iniciou no dia 20 de julho de 2019 às 14h50m ardeu uma área total estimada em 9249 hectares num período de pouco mais de 12 horas. O trabalho é baseado no estudo da atmosfera a partir do modelo Meso-NH, o qual foi inicializado com as análises do Centro Europeu (ECMWF). A simulação foi configurada com dois domínios aninhados, um numa resolução horizontal de 2500 m (150x200 pontos de grelha), e um domínio interno de 500 m (200x250 pontos de grelha). Neste trabalho, a grelha vertical foi configurada com 50 níveis calculados automaticamente pelo modelo e seguindo a topografia. A integração do modelo foi efetuada utilizando as parametrizações standard do modelo, as quais estão preparadas para representar os principais processos físicos que ocorrem na atmosfera. O esquema da turbulência a 1D no domínio maior, e a 3D no domínio menor. A convecção profunda foi calculada explicitamente, enquanto que a convecção rasa foi parametrizada somente no domínio maior (EDKF). Também foi utilizada uma parametrização da microfísica das nuvens capaz de representar cinco tipos de hidrometeoros (ICE3). Com a simulação numérica obteve-se outputs de cada hora, começando às 06h do dia 20 de julho no domínio maior e a partir das 12h também para o domínio menor. Os resultados demonstram que no dia 20, a temperatura máxima do ar aos 2 metros esteve ao redor dos 30ºC e a humidade relativa mínima do ar aos 2 metros ao redor dos 40%. Ao longo da tarde e da noite, o vento predominou de Noroeste, com velocidades médias entre os 4.5 e os 6 m/s e com rajadas de vento até aos 12 m/s. Deste modo, o vento foi o principal causador do aumento da área ardida num curto espaço de tempo.

Session 05 – Urban effects & Air quality

Forecasting atmospheric pollutants over Portugal

Carla Gama
Universidade de Aveiro

Air quality models are important tools to understand the behavior of pollutants in the atmosphere, especially the relationship between emissions, atmospheric transport, chemistry and deposition. Since 2007, the Portuguese Air Quality Forecast system runs operationally at the University of Aveiro, aiming to deliver timely to the population information on forecast pollution levels in areas of significant public exposure. This information allows the adoption of preventive measures particularly important for individuals sensitive to air pollution.

When simulating air quality, numerical models are forced by meteorological simulations and are fed with chemical boundary conditions and primary pollutant emissions. In this presentation, the Portuguese Air Quality Forecast system will be presented, including its performance in forecasting the main atmospheric pollutants over Portugal: particulate matter and ozone. The main processes affecting concentrations of these two pollutants within the boundary layer will be assessed, and the sources of uncertainty will be explored. As we will see, in air quality forecasting, meteorology is the “good fellow” in terms of uncertainties in input data.

Study of Urban Heat Islands Using Different Urban Canopy Models and Identification Methods

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This work aims to compare the performance of the single#(SLUCM) and multilayer (BEP-Building effect parameterization) urban canopy models (UCMs) coupled with the Weather Research and Forecasting model (WRF), along with the application of two urban heat island (UHI) identification methods. The identification methods are: (1) the “classic method”, based on the temperature difference between urban and rural areas; (2) the “local method” based on the temperature difference at each urban location when the model land use is considered urban, and when it is replaced by the dominant rural land use category of the urban surroundings. The study is performed as a case study for the city of Lisbon, Portugal, during the record-breaking August 2003 heatwave event. Two main differences were found in the UHI intensity (UHII) and spatial distribution between the identification methods: a reduction by half in the UHII during nighttime when using the local method; and a dipole signal in the daytime and nighttime UHI spatial pattern when using the classic method, associated with the sheltering effect provided by the high topography in the northern part of the city, that reduces the advective cooling in the lower areas under prevalent northern wind conditions. These results highlight the importance of using the local method in UHI modeling studies to fully isolate urban canopy and regional geographic contributions to the UHII and distribution. Considerable improvements were obtained in the near#surface temperature representation by

coupling WRF with the UCMs but better with SLUCM. The nighttime UHII over the most densely urbanized areas is lower in BEP, which can be linked to its larger nocturnal turbulent kinetic energy (TKE) near the surface and negative sensible heat (SH) fluxes. The latter may be associated with the lower surface skin temperature found in BEP, possibly owing to larger turbulent SH fluxes near the surface. Due to its higher urban TKE, BEP significantly overestimates the planetary boundary layer height compared with SLUCM and observations from soundings. The comparison with a previous study for the city of Lisbon shows that BEP model simulation results heavily rely on the number and distribution of vertical levels within the urban canopy.

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AI for metropolitan scale urban climate: an approach for predicting sub-kilometric near-surface air temperature

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CoLAB +ATLANTIC

As climate change prospects point towards the pressing need for local-scale adaptation measures, heat exposure becomes a key aspect in determining the health of the urban environment (European Environment Agency (EEA), 2005; Hallegatte and Corfee-Morlot, 2011; Hatvani-Kovacs et al., 2016). In addition, many northern hemisphere metropolitan areas are characterized by an ageing population which may lead to an increased community-level sensitivity to heat extremes (EUROSTAT, 2017; United Nations, 2014) – that is the case in many European Functional Urban Areas (FUAs), including in the Greater Lisbon (hereinafter Lisbon) area. Lisbon has a track record of regular exposure to severe heatwaves (HW) (Espírito Santo et al., 2014; Sousa et al., 2019), and regional climate change prospects refer that HW frequency, duration and severity will likely continue to increase in the upcoming decades (Fischer and Schär, 2010; Giorgi et al., 2004; Hewitson et al., 2014; Lionello et al., 2014; Russo et al., 2015). Accordingly, there is a pressing need to downscale the available near-surface air temperature information up to a sub-kilometric scale, to facilitate the identification of short-term critical areas of the metropolitan region, where acclimatization measures and public health actions should be prioritized, especially during HW events (Baklanov et al., 2018; European Environment Agency (EEA), 2005; Hallegatte and Corfee-Morlot, 2011; Matzarakis and Endler, 2010).

Numeric Weather Prediction (NWP) models are the staple of weather prediction, not only at the regional or global scales but also to assess local-scale processes (e.g., Bhati and Mohan, 2015; Li et al., 2019; Masson et al., 2019). Nevertheless, operational sub-kilometric NWP models are a demanding effort, and metropolitan or municipal authorities typically lack the necessary infrastructure or expertise to deploy their implementation and ensure its

operation (Oke et al., 2017). As an alternative, artificial intelligence (AI) techniques are now providing different empirical approaches to overcome these constraints, with promising results achieved in several cities (Levermore and Parkinson, 2019, 2017; Lowry, 1977; Oke et al., 2017; Oliveira et al., 2021; Schultz et al., 2021).

In this study, such a Machine Learning (ML) empirical approach is developed, providing a straightforward tool for the local authorities to (i) identify the short-term critical areas of the Greater Lisbon area; (ii) prioritize public health measures, especially during HW events; and (iii) test the efficiency of land use/land cover (LULC)-related acclimatization measures.

While in a previous study (Oliveira et al., 2021) the first step towards this aim was conducted, by establishing a machine-learning approach to correlate the regional background (i.e., non-urban) air temperatures with those registered at the city centre, its methods (hierarchical linear regression), multivariate time series (predictors and response variable), spatial coverage (city-scale only), and temporal granularity (daily time step) were limited, hence a broader metropolitan-level coverage was still lacking.

In this study, those methods are revisited, by developing an ensemble of data-driven algorithms to (i) adjust the summer near-surface air temperature forecasts from an operational NWP (AROME) (provided by the Portuguese Institute for Sea and Atmosphere, I. P. (IPMA)) to observational data (i.e., reducing its mean absolute error); and (ii) downscale the spatial level of detail, from a 2,5x2,5km pixel size (AROME) up to a 250x250m grid (ML grid). Following on previous findings, the methodology observes the rationale by Lowry (1977) which states that a given weather/climate ground truth measurement (here, near-surface air temperature, T_air) results from the sum of three components - the regional/synoptic-scale processes (R_air), the natural landscape topological contribution (L_air), and the local disturbances introduced by the man-made LULC changes (U_air).

Equation: $T_{air} = R_{air} + L_{air} + U_{air}$ Eq. 1

Where: T_{air} is the air temperature at time t and place x
R_{air} is the contribution of regional weather, in the absence of landscape/urban effects
L_{air} is the contribution of landscape features
U_{air} is the contribution of the urban presence

Accordingly, in-situ air temperature observations from the summer of 2020 (from June through September, JJAS) are considered the response variable in the ML models – these are retrieved from both official and citizen-owned stations, and subject to a two-fold quality control routine, to ensure appropriate outliers' removal. For the regional contribution component, R_air, several NWP-based inputs are retrieved from the AROME model, namely near-surface air temperature, T2m, mean surface level pressure, MSLP, wind speed and direction, Ws and Wdir, and relative humidity (RH). Topoclimate-scale effects, L_air, include elevation (DEM), exposure to prevailing winds (TOPEX - alternative TOPEX layers are introduced in the model, by octant, and in each hour, only one is selected as predictor according to the corresponding prevailing regional wind direction), proximity to the coast. At the local level (U_air component), LULC effects are introduced through the percentage of tree coverage, (TCD), imperviousness degree, IMD, and via the Local Climate Zones (LCZ)-based

Bowen-ratio classification (i.e., the ratio between latent and sensible heat flux components). While ML models are non-deterministic, i.e., they are statistical by nature, these input variables are all well-documented proxies of the physical processes involved. Three alternative ML algorithms are tested, and their results are compared – a linear mixed-effects model (LMM), a random forest (RF) and a neural network approach (NN).

Results from both ML models are shown to accurately predict T2m at the local scale, with a mean absolute error (MAE) reduced from the original 2.0 C (AROME forecasts versus in-situ observations) up to 0.5 C (RF model), i.e., improving the overall agreement by circa 75%. From the RF variables and LMM coefficient estimates, regional T2m forecasted values correspond to the most significant variable, explaining approximately 90% of the total T_air variance - this was expected due to the overall greater relative importance of synoptic patterns to the local T_air order of magnitude. Locally, the remaining circa 10% variance is adjusted mostly according to the Bowen ratio LULC classification which functions as a proxy for the known daily cycle of the energy balance components – i.e., during the day, the storage heat flux component is greater in artificial surfaces, compared with vegetation land cover, while the latent heat flux component is much lower; these differences contribute to a positive nocturnal T_air anomaly, in the urban context, where the 'excess' stored heat during the day is emitted to the nocturnal atmosphere, whereas in rural/natural settings the nocturnal air temperature cooling rate is faster (Oke, 1988, 1987, 1982; Oke et al., 2017). Predictions on a 250x250m grid also reveal well known spatial patterns of the T_air, such as the diurnal coastal distance effect, with greater T_air values inland compared to the coastal areas, whereas during the night the spatial thermal amplitude is reduced. Other significant spatial patterns of landscape-related effects include the T_air increase in topographically sheltered areas, compared to windward slopes, as well as the tree coverage contribution for a relative T_air reduction.

While the model estimates are inherently location-specific, this approach can be efficiently replicated in other locations with similar biogeographic conditions and available data. Future work will involve expanding the training and testing data to a full year time series, to test the models' ability to withhold their results during the winter season. Additional steps will also include validation of the models' performance through official weather stations, provided their information becomes available. Going forward, the authors aim to fully deploy the downscaling ML models within a framework of metropolitan-level operational services, to inform decision-makers on the spatial patterns of temperature-dependent risks.

Keywords: Air temperature downscaling; artificial intelligence/machine learning for climate; local climate; Functional Urban Areas (FUAs); metropolitan regions adaptation to climate change.

Urban Heat Islands: Importance of temporal dimension and rural land cover

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Earth's population is still growing. The percentage of the population living in urban regions

was only 30% in 1950, increasing to 55% in 2018. It is projected that 68% of the population will live in urban areas by 2050. As so many people live in urban environments, the topic of urban climate affecting quality of life and public health is of great importance. Several studies found that urban heat stress negatively affects population living in more urbanized regions.

The urban heat island effect occurs when an urban area is warmer than its surroundings. Usually, it is computed as the difference in temperature of the rural region relative to the urban core region. The present work focuses on the surface urban heat island, hereafter mentioned as UHI and uses Land Surface Temperature (LST) data. Data is retrieved through the Meteosat Second Generation geostationary satellite with 3 km at nadir, every 15 minutes.

Paris, Madrid and Milan were chosen as case studies to evaluate how the UHI varies along the day/year and how does the rural land cover affect the heat island intensity. We found diurnal and seasonal variability of UHI between cities, as a result of different climates. Within each city, UHI varies depending on the type of rural land cover considered. Our results stress the importance of temporal resolution, as the UHI can behave differently during the day and night and also throughout the year, making temporal resolution a key factor when analyzing this phenomenon. Future land use and land cover changes may affect the UHI intensity by changing the surface temperature in rural areas.

In summary, it is important to take into account the time of day and time of year when interpreting UHI intensity, as well as the climate in which the city is located. Another important factor to consider is the rural land cover associated with the city, as the same type of land cover may behave differently in distinct climates.

POSTER PRESENTATIONS

Precipitable Water Vapor Derived from GNSS data in Angola.

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For accurate weather predictions, a good estimate for the amount of water content in the atmosphere is essential. This information is provided by several techniques like radio sondes that measure this parameter at various heights. However, most of them are very limited spatially and temporarily or suffer from measurement specific constraints. To complement these techniques, precipitable water vapour (PWV) can be measured by GNSS networks. PWV can be derived from the delay in the GNSS signal when it passes through the troposphere, when the temperature and pressure are also known at the station location.

In the framework of SUGGEST-AFRICA, we are implementing a system to use the national GNSS stations for the automatic computation of PWV in Angola. In five of the stations, SUGGEST-AFRICA is also funding the installation of weather stations to obtain the pressure and temperature. When there are no nearby meteo stations, we will use values from

global/regional models.

In this presentation, we describe the system to be implemented in order to obtain the PWV from GNSS+T+P in an automatic manner. We also present preliminary results for the variation of PWV in Angola over time.

This study is supported by SUGGEST-AFRICA, funded by Fundação Aga Khan and FCT. It uses computational resources provided by C4G — Collaboratory for Geosciences (PINFRA/22151/2016). It is also supported by project FCT/UIDB/50019/2020 – IDL funded by FCT.

Precipitable Water Vapor Derived from GNSS data in Nigeria.

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For accurate weather predictions, a good estimate for the amount of water content in the atmosphere is essential. This information is provided by several techniques like radio sondes that measure this parameter at various heights. However, most of them are very limited spatially and temporarily or suffer from measurement specific constraints. To complement these techniques, precipitable water vapour (PWV) can be measured by GNSS networks. PWV can be derived from the delay in the GNSS signal when it passes through the troposphere, when the temperature and pressure are also known at the station location.

In the framework of SUGGEST-AFRICA, we are implementing a system to use the national GNSS stations for the automatic computation of PWV in Nigeria. In five of the stations, SUGGEST-AFRICA is also funding the installation of weather stations to obtain the pressure and temperature. When there are no nearby meteo stations, we will use values from global/regional models.

In this presentation, we describe the system to be implemented in order to obtain the PWV from GNSS+T+P in an automatic manner. We also present preliminary results for the variation of PWV in Nigeria over time.

This study is supported by SUGGEST-AFRICA, funded by Fundação Aga Khan and FCT. It uses computational resources provided by C4G — Collaboratory for Geosciences (PINFRA/22151/2016). It is also supported by project FCT/UIDB/50019/2020 – IDL funded by FCT.

Precipitable Water Vapor Derived from GNSS data in Mozambique.

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(4) Centro Nacional de Cartografia e Deteção Remota (CENACARTA), Maputo, Mozambique

For accurate weather predictions, a good estimate for the amount of water content in the

atmosphere is essential. This information is provided by several techniques like radio sondes that measure this parameter at various heights. However, most of them are very limited spatially and temporarily or suffer from measurement specific constraints. To complement these techniques, precipitable water vapour (PWV) can be measured by GNSS networks. PWV can be derived from the delay in the GNSS signal when it passes through the troposphere, when the temperature and pressure are also known at the station location.

In the framework of SUGGEST-AFRICA, we are implementing a system to use the national GNSS stations for the automatic computation of PWV in Mozambique. In five of the stations, SUGGEST-AFRICA is also funding the installation of weather stations to obtain the pressure and temperature. When there are no nearby meteo stations, we will use values from global/regional models.

In this presentation, we describe the system to be implemented in order to obtain the PWV from GNSS+T+P in an automatic manner. We also present preliminary results for the variation of PWV in Mozambique over time.

This study is supported by SUGGEST-AFRICA, funded by Fundação Aga Khan and FCT. It uses computational resources provided by C4G — Collaboratory for Geosciences (PINFRA/22151/2016). It is also supported by project FCT/UIDB/50019/2020 – IDL funded by FCT.

Interação oceano-atmosfera - Análise de eventos extremos conjuntos

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As ondas de calor têm vindo a aumentar na sua frequência, duração e intensidade durante as últimas décadas, causando impactos severos nos ecossistemas terrestres e marinhos. É de esperar que, como consequência da atividade antropogénica, estes fenómenos continuem a aumentar a nível global.

Neste estudo, são analisados os eventos extremos registados tanto no oceano como na atmosfera, entre os anos 1979 e 2020, no domínio entre 20ºN e 55ºN de latitude e 40ºW e 15ºE de longitude, com base em registos de temperatura na superfície do mar e na atmosfera, a 2 metros do nível médio do mar.

Os resultados mostram que parece existir um padrão semelhante entre ambos os sistemas no número anual de eventos e respetivas durações médias, tanto no domínio espacial como no domínio temporal. As tendências de evolução destas propriedades são positivas, observando-se uma grande variabilidade interanual.

Existem ondas de calor marinhas na ZEE de Portugal?

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Instituição FCUL/IDL

A ocorrência de ondas de calor marinhas (MHW) tem vindo a aumentar por todo o globo, resultando em impactos severos nos ecossistemas e em diversas atividades económicas. Neste

estudo são analisadas a ocorrência e as características dos eventos de MHW numa região coincidente com a Zona Económica Exclusiva (ZEE) de Portugal para o período 1982-2019, com base em registos observacionais da Temperatura da Superfície do Mar (TSM). Os resultados mostram que os eventos ocorrem com uma frequência média de ~2 eventos por ano, com duração média de 14 dias. As intensidades máximas excedem os 5º C em várias zonas do domínio, sendo identificadas intensidades cumulativas elevadas junto à costa Oeste de Portugal e no Arquipélago dos Açores. Serão apresentados também dois eventos que ilustram a co-ocorrência de anomalias positivas na TSM e temperatura do ar.

MODELING AND ASSIMILATION OF ATMOSPHERIC AEROSOLS OVER SÃO PAULO - BRAZIL WITH THE REGIONAL CHEMISTRY TRANSPORT EURAD-INVERSE MODEL ON HIGH-RESOLUTION.

Ediclê de Souza Fernandes Duarte
Universidade de Évora

A high-resolution air quality study over the Metropolitan Area of São Paulo (MASP), Brazil is presented using the EURopean Air Pollution Dispersion - Inverse Model (EURAD-IM) for a highly detailed simulation of the air pollution plume interactions. In these first case studies on particulate matter (PM2.5 and PM10) modeled data are evaluated with observational in-situ data from 24 surface stations from the Environmental Company of the State of São Paulo (CETESB) and a Lidar. The two presented case studies, focusing on July 10-13 and October 22-25, 2016, show how different meteorological conditions affect the transport of pollution plumes over the MASP originating from (i) central South America, associated to biomass burning activities, (ii) from the interior of the state of São Paulo (SP), (iii) the metropolitan region of Rio de Janeiro (RMRJ) 429 km apart, including transportation in the opposite direction, (iv) the port and city of Santos, as well as Campinas and contrary direction. Three simulations were carried out, the first using the emissions inventory of EDGAR v4.3.2, the second replacing the category of land transport emissions with data from the Vehicle Emissions Model (VEIN) with high spatial resolution and the third using the three-dimensional variational data assimilation technique (3D-VAR) for PM2.5. The performance of the model varied from excellent to good agreement with the observations varying within the standard deviations and elucidated the role of long-range transport of particulate matter from central South America and local transport within the state of SP, affecting the air quality at MASP. For the period from July 10-13, the results of PM10 and PM2.5 in the simulations without assimilation for the domain with 1 km x 1 km resolution underestimated the observations, and the bias varied between 8 - 41%. For MASP center, EURAD-IM performed better using VEIN emissions. The second case study in October revealed that air pollution plumes from the MASP and MARJ interact with each other, through two possible routes: via the Vale do Paraíba or via the ocean between the coast of Rio de Janeiro and São Paulo. EURAD-IM 3D-Var scheme was adapted and used in the MASP for first time. The assimilation significantly reduced errors, which improved the subsequent performance of PM2.5 during July 10-13.

Influência do acoplamento terra-atmosfera durante a onda de calor do verão de 2015

Sara Caetano

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Durante os últimos 20 anos, a Europa tem sido palco do paradigma dos verões extremamente quentes, que estão na origem de fenómenos severos de seca meteorológica. Simulações de clima futuro antecipam a ocorrência de ondas de calor mais frequentes, mais intensas e mais duradouras, com um incremento de frequência entre 5 a 10 vezes nos próximos 40 anos (Barriopedro et al. 2011). Assim, e dada a rapidez com que os eventos estão a ocorrer, é necessário aliar à monitorização contínua das condições extremas do verão europeu as necessárias avaliações dos novos extremos aparentes.

Nos últimos anos têm sido desenvolvidos vários índices climáticos para quantificar a duração e severidade das ondas de calor com base em mínimos noturnos ou máximos diurnos de temperatura. O presente estudo utiliza o Índice de Magnitude de Onda de Calor (HWMI) para o ano de 2015 (Russo et al, 2015), que tem em conta tanto a magnitude como a duração das ondas de calor. O principal objetivo deste trabalho é estudar o impacto do acoplamento solo-atmosfera na intensidade, duração e frequência de ocorrência das ondas de calor e a seca de 2015, utilizando simulações de clima regional. Para isso, combinam-se índices da excecionalidade dos fluxos de água e energia, temperatura e precipitação (Careto et al, 2018). Pretende-se ainda estender este tipo de diagnósticos para a utilização em dados de deteção remota (LST da LSA-SAF; Trigo et al, 2011), dado o seu potencial de identificação dessas situações extremas em tempo quase real.

The influence of the East African Rift System low-level jets on rainfall over SW Africa

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SW Africa is identified as a climate change hotspot mainly due to its vulnerability to intense droughts and flash flood events, very high weather-dependent agriculture and difficulties on the adaptation process to a changing climate. Most of the available atmosphere humidity across the subcontinent results from a strong advection of water vapor from the Indian Ocean, essentially during austral summer. This humidity flux from the Indian Ocean crosses a very large orographic feature in the eastern side of the subcontinent, named East African Rift System (EARS), inducing low level air jets (LLJs) within the river valleys, enhancing humidity fluxes to South/Central Africa regions. In this work, 2 LLJs were investigated (Limpopo and Zambezi River valley jets), as well as its correlation with rainfall over SW Africa (Angola/Namibia regions), using monthly averaged ERA5-reanalysis data from 1980 to 2020 and weather stations data retrieved from the Southern African Science Service Centre for Climate Change and Adaptive Land Management (SASSCAL). During this study, it was found that Limpopo and Zambezi valleys LLJs play a very important role on rainfall over SW Africa. Limpopo is more relevant in DJF (December, January and February) and Zambezi becomes the main source of moisture during March and April, however, globally, Zambezi jet represents the most important mechanism of advection of humidity to Southern Angola and Northern Namibia.

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