viCPCMW
Buenos Aires city, 2022 Sep. 7-9th

Convection-Permitting Climate Modeling Workshop

vi Convection-Permitting Climate Modelling Workshop

Abstracts book

Co-organized by 'Centro de Investigaciones del Mar y la Atmósfera' (CIMA)
'Departamento de Ciencias de la Atmósfera y los Océanos' (DCAO) &
'National Center for Atmospheric Research' (NCAR)

Buenos Aires, September 7-9th 2022

http://www.cima.fcen.uba.ar/cpcmw2022/

Location of the meeting

Universidad de Buenos Aires
Godoy Cruz 2290
C1425FQB, C.A. Buenos Aires
ARGENTINA https://www.uba.ar/

Organization

'Centro de Investigaciones del Mar y la Atmósfera' (CIMA)
'Departamento de Ciencias de la Atmósfera y los Océanos' (DCAO)
'National Center for Atmospheric Research' (NCAR)

Support

'Universidad de Buenos Aires' (UBA)
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'Consejo Nacional de Investigaciones Científicas y Técnicas' (FONCyT)
'Instituto Panamericano de Geografía e Historia' (IPGH)
'National Center for Atmospheric Research' (NCAR)
'The Global Energy and Water Exchanges', (GEWEX)
'Instituto Franco-Argentino sobre Estudios de Clima y sus Impactos. CNRS - IRD - CONICET - UBA' (IRL 3351 IFAECI)

Chair of Conference

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Roy Rasmussen *'National Center for Atmospheric Research'* (NCAR)
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All times are in local time (UTC - 3)

Programme and book of abstrcats automatically generated with *'Python to manage and plot netCDF'*, (PyNCplot, https://git.cima.fcen.uba.ar/lluis.fita/pyncplot/-/wikis/home)

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Book of Abstracts

C. A. Buenos Aires, 7-9th September 2022

http://www.cima.fcen.uba.ar/cpcmw2022/index.php, vi.cpcmw@cima.fcen.uba.ar

Schedule at local time (UTC -3)

Wednesday 7th

7:45-8:30 : *Bus leaves from Dazzler and Recoleta hotel*

8:00-8:30 : *Bus leaves from Sarum hotel*

08:30-09:00 : *welcome / registration*

09:00-09:30 : *welcome and introduction*

09:30-10:30: Discussion Panel 1. **How can CPM modeling contribute to climate services in South America?**

Chairs: *Maria Laura Bettolli*

09:30-09:45: Climate services in Southern South America: the Argentine National Meteorological Service Perspective

[1]**Lorena Ferreira**

[1]*National Weather Service (SMN), Argentina*

09:45-10:00: South America Climate Change Impacts and Risks. Results from IPCC AR6 WG2

[1]**Matilde Rusticucci**

[1]*DCAO, UBA-CONICET & LA of IPCC AR6 WG2 Chapter 12*

Central and South America are highly exposed, vulnerable and strongly impacted by climate change, a situation amplified by inequality, poverty, population. growth and high population density, land use change, soil degradation, and high dependence of national and local economies on natural resources for production of commodities.
Main observed and projected impacts and risks over the region assessed in the Central and South America chapter will be presented.

10:30-11:00 : *Coffee break*

11:00-12:30: Discussion Panel 2. **Best practices in constructing regional climate change information**

Chairs: *Roy Rasmussen*

11:00-11:10: Providing improved quantitative estimates of future changes in local weather extremes.

[1]**Elizabeth Kendon**

[1]*Met OFfice*

11:10-11:20: What is the best dynamical downscaling method to project future regional climate change?

[1]**Alex Hall**

[1]*UCLA*

11:20-11:30: Storyline simulations for informing decision making

[1]**Lai-yung Ruby Leung**

[1]*PNNL*

11:30-11:40: Constructing regional climate information relevant for risk assessments and

decision making: Insights from IPCC AR6 WGI

[1]**Anna Sörensson**
[1]*CIMA & CLA of IPCC AR6 WG1 Chapter 10*

The Working Group I of the International Panel of Climate Change released its report "Climate Change 2021: The Physical Science Basis" in August 2021. Compared to previous Working Group I assessment reports, this report has an increased focus in regional climate change information, and in particular, the Chapter 10 "Linking Global to Regional Climate Change" assesses the methodologies that is being used by the community in constructing regional climate information that is relevant for risk assessments and decision making. Chapter 10 finds that "Distilling regional climate information from multiple lines of evidence and taking the user context into account will increase the fitness, usefulness and relevance for decision-making and enhances the trust users will have in applying it (high confidence). This distillation process can draw upon multiple observational datasets, ensembles of different model types, process understanding, expert judgement and indigenous knowledge. Important elements of distillation include attribution studies, the characterization of possible outcomes associated with internal variability and a comprehensive assessment of observational, model and forcing uncertainties and possible contradictions using different analysis methods. Taking the values of the relevant actors into account when co-producing climate information, and translating this information into the broader user context, improves the usefulness and uptake of this information (high confidence)." This talk summarizes the main ideas of Chapter 10 with the purpose to let the audience reflect on whether and how the concepts of "multiple lines of evidence" and "co-production" can be useful for the convective-permitting modelling community

11:40-11:50: Some issues in constructing large-scale forcing for climate downscaling

[1]**Aiguo Dai**
[1]*U. Albany*

12:30-13:30 : *LUNCH*

13:30-14:30: Discussion Panel 3. Data archive and access challenges

Chairs: *Lluís Fita*

13:30-13:40: PRIMAVERA's use of the JASMIN super-data-cluster for the analysis of high-resolution multi-model climate datasets

[1]**Malcolm Roberts** and [1]**Bjorn Stevens**
[1]*Met OFfice*

The PRIMAVERA project was a European Union funded climate modelling project with the aim of producing a new generation of advanced and well-evaluated high-resolution global climate models and generating simulations and predictions of regional climate with unprecedented fidelity. Seven different climate models were run at supercomputer facilities across Europe, generating 1.6 pebibytes of output data. This data was analysed by partners from 20 institutes throughout Europe. Downloading this volume of data for analysis at each institute was not feasible and so the approach of taking the analysis to the data was used, using the JASMIN super-data-cluster. Here we describe JASMIN and how PRIMAVERA used this central analysis facility. As climate models increase in resolution and produce larger volumes of data we describe the benefits that other projects can gain from the use of a central analysis facility such as JASMIN.

13:40-13:50: ESGF, a Globally Distributed Software Infrastructure to Address the Challenges of Data Management, Access and Analysis for High Volume Climate Model Data

[1]**Philip Kershaw**
[1]*Head Centre for Environmental Data Analysis*

The Earth System Grid Federation is an internationally federated archive providing access to Earth science data. Sustained through a collaboration effort between research institutions across the world it was first established over ten years ago to support the distribution of the outputs from CMIP5. In the last two years a major effort has been undertaken to reappraise the overall architecture and re-engineer the underlying software taking into account the challenges around rising data volumes, opportunities presented by the use of cloud computing and new paradigms which combine data access and analysis through the use of web-based platforms. This has resulted in the development of a more modular system suitable for deployment on-premise and using public cloud. A complete node has been in operation on Amazon Web Services operated by US partners GFDL. In the European context, hybrid models are being explored with on-premise hosting of large data volumes, together with services for sub-setting and data reduction to facilitate use in Climate4Impact a web platform which utilises Jupyter notebooks and a data cache hosted on cloud. It is expected that the new US funded ESGF2 project will utilise similar approaches and other new innovations to support user communities with both data access and in-situ data analysis capabilities.

14:30-15:00: Keynote 4. What can we learn from weather forecasting?

Chairs: *Lluís Fita*

14:30-15:00: Kilometer-scale NWP: a challenge to glory

[1]**Linda Schlemmer**
[1]*DWD*

None

15:00-15:30 : *Coffee break*

15:30-16:30 Session 1: The added value of convection-permitting climate simulations

Chairs: *Andreas Prein*

15:30-15:45: Highlight findings from the WCRP CORDEX Flagship Pilot Study on Convection over Europe and Mediterranean (FPSCONV)

[1,2]**Stefan Sobolowski**, [3]**Erika Coppola** and [4]**the FPSCONV team**

[1]*NORCE Norwegian Research Centre*
[2]*the Bjerknes Centre for Climate Research*
[3]*The Abdus Salam International Centre for Theoretical Physics*
[4]*Multiple institutions*

For the past five years, dedicated teams of climate scientists have worked to build and analyze an ambitious multi-model ensemble of the present and future climate over the greater Alpine region at convection permitting scale. In this, the final year of the project, two important milestones will be reached. The first is that the data from the simulations will be released to the public. Interest in these simulations has been high and we look forward to others investigating the vast array of questions that can be addressed with such a dataset. The second milestone is a special issue in Climate Dynamics that represents the culmination of the scientific work of the FPSCONV team. This talk will focus the latter and presents the highlights from the special issue. These include but are not limited to: fine scale modulation of extreme heat waves; shifting convective and orographic precipitation intensities; feature tracking of present and future mesoscale storms; scale dependencies of climate change signals; higher confidence in future extreme rainfall projections at cp-scales. We also present the legacy of the project and our perspective on the future prospects of such endeavours. As the demands for robust adaptation planning increase the need for actionable fine scale climate information increases in proportion. Studies such as FPSCONV have important contributions to make but also face serious challenges that can hinder their effectiveness.

15:45-16:00: Improvements in simulating tropical-extratropical cloud bands over South America by using convective-permitting models.

[1]**Marcia T Zilli** and [1]**Neil C. G. Hart**

[1]*School of Geography and the Environment, University of Oxford*

Tropical-extratropical cloud bands are typical of the subtropical South American climate, occurring mainly during the rainy season and producing more than 60% of the season's precipitation. Thus, their correct representation in climate models is fundamental for the accuracy of simulated subtropical precipitation. Here, we investigate the representation of the tropical-extratropical cloud bands in two convective-permitting simulations. The first, produced by the UK Met Office, is a 10-year simulation with 4.5 km spatial resolution. The second model is a 20-years retrospective simulation produced by the NCAR Water System Program, using a WRF model with 4-km grid spacing. The cloud bands are identified using an objective detection algorithm applied to OLR, as described by Zilli et al. (2020). Characteristics of these cloud bands, including precipitation and circulation variables, are compared to ERA5 reanalysis. Previous analysis of a similar CPM model over Africa (CP4-Africa) identified an improvement in the convective activity during cloud band events due to improvements in the upper-level westerly winds over the subtropics (Hart et al. 2018). Over South America, Zilli et al. (in prep.) identified similar biases in CMIP-like simulations, resulting in biases in the cloud band events. By using CPMs simulations, we expect to identify improvements in the representation of the South American cloud band events similar to those identified over Africa.

16:00-16:15: Land surface processes on Convection-Permitting Climate Modelling

[1]**Jan Polcher**

[1]*LMD-IPSL, CNRS, Ecole Polytechnique*

Most km-scale models used to address climate questions will be configured over continents. It is thus important to determine if current land-surface models (LSM) are suitable to provide correct lower boundary conditions to the atmosphere at these resolutions.

LSMs have seen a rapid development in global Earth system models. At these resolutions models assumed implicitly that only vertical movements of water are relevant. Only water from local precipitation can evaporate within each grid box. The complexity of smaller scale surface processes are represented with tiling approaches to mimic the diversity at the surface. Using LSMs at km-scale begs the question if these basic assumptions are valid. Hill-slopes are not sub-grid any more and water transfers from ridge to valley need to be represented explicitly. In semi-arid regions the flow of water at the surface and shallow aquifers along slopes are critical for evaporation over the dry period. Humans have developed infrastructures to carry water over a few tens of km in order to satisfy demands. This water will then evaporate, especially over crops, at another location than where it fell as precipitation.

The LIAISE field campaign over Spain has documented how lateral water transfers at the landscape scale, natural and man made, affect evaporation and the atmospheric boundary layer. We will discuss how these observations can be used to test the ability of LSMs to represent surface energy balance contrasts at km-scales.

16:15-16:30: Cold pools, mesohighs, and severe wind gusts: opportunities to assess the South American climatology of intense convectively-induced surface features with a convection-permitting regional climate simulation.

[1]**Ernani de Lima Nascimento**

[1]*Departamento de Física, Universidade Federal de Santa Maria, Santa Maria - RS, Brasil.*

Convective storms are capable of producing a myriad of severe weather phenomena, among which heavy convective rainfall outstands as the main cause of Natural Disasters in countries like Brazil. However, other manifestations of extreme convective weather also deserve attention given their potential to pose a threat to important social and economic sectors. In this context, damage caused by localized severe wind gusts is not a rare occurrence in many portions of South America. The dynamics of convective wind gusts is tightly associated with the dynamics and thermodynamics of convectively-induced surface cold pools and mesohighs. In turn, the size, depth and intensity of cold pools and mesohighs accompanying deep convection are sensitive to cloud microphysics mechanisms that are not necessarily well represented in parameterization schemes available in convection-permitting models. Hence, the assessment of the skill of convection-permitting regional climate simulations in representing distinct types of extreme convective weather also can profit from local observations of cold pools, mesohighs and accompanying wind gusts. This study aims at comparing the observed statistics of surface wind gusts, cold pools and mesohighs associated with deep convection in southern Brazil from 2005 to 2015 with the respective simulated statistics obtained from the WRF-4km climate simulations made available by SAAG-NCAR for the same region and period.

16:30-17:30 : *Poster session (in venue hall)*

17:30-18:30 : *Ice breaker (in venue hall)*

18:45-19:30 : *Bus is leaving for hotels*

Thursday 8th

8:00-9:00 : *Bus leaves from Dazzler and Recoleta hotel*

8:30-9:00 : *Bus leaves from Sarum hotel*

09:00-10:30: Discussion Panel 5. What are unique topics that we have to simulate in CPM models that are not relevant in NWP

Chairs: *Stefan P. Sobolowski*

09:00-09:05: Ocean-Atmosphere Regional Climate Modeling Systems: Pros and Cons

[1]**Bodo Ahrens**

[1]*Goethe-Universitkät*

09:05-09:10: The Importance of Water Below Ground in Convection Permitting Models for Climate Simulations

[1]**Francina Dominguez**

[1]*U. Illinois*

Deep soil moisture exhibits longer timescales of variability than the overlying atmosphere, thus providing inertia and memory to the climate system. Groundwater systems experience a filtered and delayed response to precipitation. This in-turn implies that groundwater effects on soil moisture and vegetation may have a different timing and a different temporal scale than precipitation, providing a water source decoupled from the large temporal fluctuations characteristic of precipitation. The communication between the water below ground and the atmosphere is done primarily through plant roots. However, our current understanding of the effect of groundwater on the atmosphere relies on a very simple characterization of plant roots. In reality, roots are highly adaptive and can shift in space-time securing limiting resources. The importance of groundwater and roots on the overlying atmosphere increases with higher model resolution because, as models represent the details of local topography, groundwater flow begins to emerge in valleys. Current conceptualization of land-atmosphere interactions in numerical models used for climate projections requires an appropriate representation of groundwater and a representation of deep dynamic roots to access the slowest-varying moisture reservoir on land.

09:10-09:15: Modeling the impacts of Amazon deforestation on the Andes-Amazonas hydroclimatic connection

[1]**Jhan Carlo Espinoza** and [1]**Clémentine Junquas**

[1]*IRD*

09:15-09:20: Daytime convective development over land: the role of surface forcing

[1]**Wojtek Gabowsky**

[1]*NCAR*

Diurnal cycle of solar radiation over tropical and midlatitude summertime continents forces strong evolution

of atmospheric convection. As surface sensible and latent heat fluxes increase after sunrise, a dry convective boundary layer develops in the early morning hours. It proceeds with the formation of shallow convective clouds as the convective boundary layer deepens and may eventually lead to the transition from shallow to deep precipitating convection. Factors affecting shallow-to-deep convection transition have been studied in the past, but the early evolution of dry convection and how it affects development of shallow convection and eventual transition to deep convection attracted much less attention.
This presentation will discuss a set of large-eddy simulations that considers the impact of the surface flux Bowen ratio, the partitioning of the surface heat flux into sensible and latent components, on the development of dry and eventually moist convection. The key point is that the Bowen ratio affects the surface buoyancy flux and thus growth of dry convective boundary layer before the moist convection onset. This has a strong impact on the development and organization of shallow convection and eventual transition to deep convection. Details of the simulation results will be discussed.

09:20-09:25: Land and water usage: Humans create with their water usage contrasts at the surface which drive atmospheric processes at various scales

[1]**Jan Polcher**

[1]*LMD, IPSL, CNRS, IRD*

09:25-09:30: Recent glacier changes and their main climatic forcings across the Andes

[1]**Mariano Masiokas**

[1]*Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, IANIGLA, CCT CONICET Mendoza*

The Andes Cordillera extends for 8,000 km from ca. 11°N in northern Colombia and Venezuela to ca. 55°S in southern Chile and Argentina. Along this extensive latitudinal range, this region portrays an impressive variety of topographic and climatic conditions that result in extensive areas covered by seasonal snow, numerous tropical and extratropical glaciers, and many mountain permafrost landforms. This great variety of features makes the Andean cryosphere the most diverse on Earth. In this brief overview, we will discuss the recent, widespread glacier shrinkage and ice mass loss that has been documented throughout the Andes by numerous studies using remote sensing products and/or field measurements. We will also discuss recent assessments that have characterized the main topographic and climatic variables affecting the glacier distribution and mass balance changes in the Andes. These studies show contrasting influences of the different forcings affecting glacier behavior at different latitudes. Understanding these contrasting influences is relevant for the proper modeling and assessment of the glacier-climate relationships in different sectors of the Andes, and can provide a basic framework to better understand the impacts of climate change across the western portion of South America.

10:30-11:00 : *Coffee break*

11:00-12:30 Session 2: South American high resolution modeling research activities

Chairs: *Alejandro Martínez*

11:00-11:15: Regional climate modeling of the diurnal cycle of precipitation over an equatorial Andean glacier region (Antizana, Ecuador)

[1]**Clémentine Junquas**, [1]**M.B. Heredia**, [1]**T. Condom**, [1]**J.C. Ruiz-Hernandez**, [2]**L. Campozano**, [3]**J. Dudhia**, [1]**J.C. Espinoza**, [1]**M. Menegoz**, [1]**A. Rabatel** and [1]**J. E. Sicart**

[1]*Univ. Grenoble Alpes, IRD, CNRS, Grenoble INP, IGE, 38000 Grenoble, France*
[2]*Departamento de Ingeniería Civil y Ambiental, Escuela Politécnica Nacional, Quito, Ecuador*
[3]*NCAR National Center for Atmospheric Research, PO Box 3000, Boulder, CO 80307âĂŞ3000, USA*

A multi-experiment ensemble is performed using the WRF (Weather Research and Forecasting) model at high spatial resolution (1 km) over the Antizana region (Ecuador) during the year 2005. Our goal is to identify the model configurations that best represent atmospheric processes. The model is able to simulate the complex zonal gradient of precipitation between the wet Amazon and the drier inter-Andean region. The main precipitation biases are (i) an overestimation in the afternoon in the Antizana region related to local surface circulation patterns and (ii) a nighttime overestimation in the Andes-Amazon transition zone associated with the regional circulation. Changing the microphysics scheme and/or the cumulus scheme primarily affect nighttime processes, while changing the topography forcing and activating slope radiation and shading options mostly affects afternoon processes. For this study region and year, our results show that the best configurations require the activation of the cumulus scheme even at 1-km spatial resolutions, which improves the regional nighttime convection induced by the easterly regional flow on the Amazon-Andes transition region. Activating the cumulus scheme instead of using a convection-permitting parameterization also strengthens the daytime upward moisture transport through stronger thermally driven valley winds.

11:15-11:30: Influence of regional processes in convection over an inter-Andean valley in Colombia

[1]**Sebastián Gómez-Ríos**, [1]**K. Santiago Hernández**, [1]**Juan J. Henao**, [1]**Vanessa Robledo**, [1]**Alvaro Ramírez**, [2]**Jimmy Flórez**, [2]**Sara Lorduy**, [2]**David Ortega** and [1]**Angela M. Rendón**

[1]*Geolimna, Escuela Ambiental, Facultad de Ingeniería, Universidad de Antioquia, Medellín, Colombia*
[2]*Centro de Desarrollo Tecnológico Aeroespacial - CETAD, Fuerza Aérea de Colombia, Rionegro, Colombia*

The inter-Andean valley of the Magdalena River in Colombia has been recognized as a tropical region with intense convective activity, where along- and cross-valley dynamics create an atmospheric environment favorable for convection strengthening. However, the Magdalena Valley is not the only region with high convection in Northwestern South America. This is also a feature of some neighboring regions: the Maracaibo-Catatumbo region, the place with most lightning activity on Earth; the Colombian Pacific Coast, containing one of the rainiest places on Earth; the Caribbean flatlands, a reported hotspot for mesoscale convective systems in tropical America; and the Amazon and Colombian Savannas. This work aims to elucidate possible relationships between atmospheric processes in these regions and the convection over the Magdalena Valley using high-resolution simulations with the WRF model for one month between September and October 2019. Dynamic and thermodynamic patterns in the surrounding regions and the valley itself are assessed, along with diurnal-scale processes that could enhance or decrease convective activity over the valley. Findings suggest that mid-level heating and circulations in the Amazon-Savannas and Catatumbo-Maracaibo regions contributed to instability and enhancement of nocturnal convection in the valley. At the same time, low-level fluxes from the Caribbean and Pacific flatlands provide moisture for the generation of convective systems in the valley.

11:30-11:45: Predictability of a supercell using convection-permitting ensemble simulations in Argentina

[1]**Milagros Alvarez Imaz**, [2,3,4]**Paola Salio**, [1,5]**María Eugenia Dillon**, [3,4]**Lluís Fita** and [6]**Diego Saúl Carrió Carrió**

[1]*Servicio Meteorológico Nacional, Argentina*
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[4]*Instituto Franco-Argentino sobre Estudios del Clima y sus Impactos (UMI-3351 IFAECI/CNRS-CONICET-UBA), Argentina*
[5]*CONICET, Argentina*
[6]*University of Melbourne, Australia*

Sierras de Córdoba (SDC) is a mountain range located eastward to the Andes range strongly associated with the initiation and further upscale growth of deep moist convection. The location and timing of convective initiation (CI) over this region is strongly forced by the presence of moisture availability and large scale conditions as well as local mesoscale processes.
In order to analyze the predictability of the CI over SDC, six 20-member ensembles with the WRF model at convection-permitting resolution (3 km) were carried out to study a marginal supercell initiated at the SDC foothills. The experiments consisted of 24-h forecasts initialized on 00 UTC October 17, 2017, using 3-h frequency boundary conditions from 2 different global ensemble forecasting systems: the ECMWF model and the GEFS. They were built using 3 different microphysics parameterizations (WSM6, Thompson and Morrison) and 2 planetary boundary layer parameterizations (Yonsei University and Mellor Yamada Janjic). It is shown that the forecasted environment is favorable for supercell formation with the majority of the configurations. CI over the eastward side of SDC is strongly forced by the presence of instability and moisture availability as well as mesoscale circulations providing low level convergence. A strong easterly component of the wind, promoting the convergence of the wind over the mountains is noticeable in all members with convection development.

11:45-12:00: The impact of convective permitting resolution in a coupled regional ocean-atmosphere model of the Eastern Tropical Pacific

[1]**Chiara De Falco**, [1]**Priscilla Mooney** and [1]**Jerry Tjiputra**

[1]*NORCE Norwegian Research Institute and Bjerknes Centre for Climate Research*

Resolving processes at the convective scales is of key importance to decreasing model biases and can be of remarkable value to resolve the local dynamics. Simulations at these scales typically improve model representation of precipitation intensity and pattern, small scale wind variability and direction, as well as better resolving topographic interactions. An improved representation of the atmospheric circulation would also enhance the performance of air-sea interactions with the consequent impact on the oceanic models. In this study, we use the Coupled-Ocean-Atmosphere-Wave-Sediment Transport (COAWST) Modeling System to simulate the eastern tropical Pacific circulation and biogeochemistry, with a particular focus on Central America. This area is particularly sensitive to convective processes, which influence the behavior of the Intertropical Convergence Zone. The model includes an atmospheric component, the Weather Research and Forecast Model (WRF), and an oceanic component, the Regional Ocean Modeling System (ROMS), at 20 and 4 km resolution. Comparing the results of these two sets of simulations, we uncover the key role of convective permitting resolution in decreasing important biases. We focused on evaluating the improvement of crucial variables for marine ecosystems, such as SST and pCO_2, of which, more reliable future projections, are critical to predicting changes in reef fish distribution and the subsequent cascading effects on biodiversity and people well-being.

12:00-12:15: Impact of using precipitation from convection permitting models on the simulated Uruguay River streamflow

[1,2,3]**Moira Doyle**, [4]**Gonzalo Díaz**, [1,2,3]**María Laura Bettolli**, [1,2,3]**Silvina A. Solman**, [4]**Laura Chavez**, [1,5,2]**Rocío Balmaceda Huarte**, [6]**Josefina Blazquez**, [7]**Rosmeri Porfirio da Rocha**, [8]**Marta Llopart** and [9]**J. Milovac**

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Precipitation is a key input to hydrological models used to simulate streamflow conditions. However it is also an important source of uncertainty, particularly when numerical climate model outputs are used. Global Climate Models have shown difficulties in representing the correct combination of frequency and intensity of precipitation, particularly for extreme events. Increasing resolution in atmospheric models highly improves the representation of processes leading to precipitation events, hence directly impacting on simulated streamflow. Regional Climate Model (RCM) simulations using convection-permitting resolution (below ∼4 km grid spacing) have shown to better capture precipitation extremes in other parts of the world. At present several projects are currently running convection permitting RCMs over South America. The available RCM outputs at standard and convection permitting resolutions from the CORDEX Flagship Pilot Study in South America and the NCAR SAAG high resolution simulations over South America are used to force the macroscale hydrological Variable Infiltration Capacity (VIC) model and simulate streamflow at 7 closing points of the Uruguay River. Streamflow outputs at 7 gauge stations over the basin are analyzed with special focus on the impact of precipitation amount and occurrence. The sensitivity of streamflow to precipitation uncertainty and to the use of convective permitting simulations when compared with lower resolution simulations is also evaluated.

12:15-12:30: Evaluating Extreme Precipitation Forecasts using Convective-Permitting Modeling in Tarapacá Region, Chile

[1]**Lourdes Mendoza Fierro**, [1]**Christopher L. Castro**, [1]**Hsin-I Chang**, [1]**Rodrigo Valdés-Pineda** and [1]**Christoforus Bayu Risanto**

[1]*Department of Hydrology and Atmospheric Sciences. The University of Arizona*

During the last decade, Tarapacá Region in northern Chile has experienced extreme precipitation events causing flash flooding, landslides, and associated adverse socioeconomic impacts. Events that are likely to worsen in the future due to an increase of the intensity and frequency of convective storms driven by global warming and the consequent climatic changes. In this research, the Weather Research and Forecasting (WRF) model is used at a convective-permitting resolution to design an ensemble-based, short-range forecast for probabilistic weather forecasts in Tarapacá Region. All ensemble members from the Global Ensemble Forecast System (GEFS) are used to establish initial and lateral boundary conditions for different extreme weather precipitation events between 2012 and 2021. Preliminary simulation results show a significant improvement in total precipitation, as compared to the driving global forecast model and satellite observations. They also provide a comparative advantage over the steep terrain of the Andes Mountains satellite observations which substantially underestimate precipitation. WRF simulation results are primarily used to improve streamflow simulations using a set of hydrologic models. The final combination of climate and hydrologic simulations is used to establish hybrid evaluation metrics for the development of comprehensive data assimilation, paradigm to be operationally implemented in the Tarapacá Region.

12:30-13:30 : *LUNCH*

13:30-14:15: Keynote 6. Kilometer-resolution climate modelling over the tropical and sub-tropical Atlantic

Chairs: *Roy Rasmussen*

13:30-14:15: Kilometer-resolution climate modelling over the tropical and sub-tropical Atlantic

[1]**Christopher Schär**, [1]**Christoph Heim**, [2]**Nikolina Ban**, [1]**Jacopo Canton**, [1]**Laureline Hentgen**, [1]**David Leutwyler**, [1]**Shuchang Liu**, [3]**Silje L. Sørland**, [1]**Abraham Alavez Torres** and [1]**Christian Zeman**

[1]*Institute for Atmospheric and Climate Science, ETH Zürich, Switzerland*
[2]*Institute for Atmospheric and Cryospheric Sciences, University of Innsbruck, Austria*
[3]*NORCE Norwegian Research Centre, Norway*

In the last decade, kilometer-resolution regional climate models have seen a multitude of promising applications related to convective precipitation in a changing climate. Studies have in particular considered extreme events, such as heavy precipitation, flash floods, severe weather (with hail, lightning and wind gusts), as well as organized convective systems (e.g. hurricanes, medicanes and mesoscale convective complexes). However, regarding the representation of tropical clouds, the systematic application of km-resolution climate models has only just started. Here we present a project dedicated to the study of tropical and subtropical cloud feedbacks over the Atlantic. The main motivation is to improve the representation of cloud feedbacks, to assess their role in a changing climate, and to constrain current estimates in climate projections and climate sensitivity. We are working with horizontal resolutions between 550 m and 4.4 km on a range of different computational domains. The largest domain covers a large fraction of the Atlantic (9100x6800 km at a horizontal resolution of 3.3 km). Our work includes multi-year current and future climate simulations using the pseudo-global warming (PGW) approach, the exploitation of a systematic model calibration procedure to constrain uncertain model parameters, validation against a range of in-situ, remote-sensing and reanalysis data sets, as well as convergence studies using different resolutions. The presentation will provide an overview of these activities, with the goal to assess the potential of the approach.

14:15-15:00 **Session 3: Towards global convection-permitting modelling**

Chairs: *Ruby L. Leung*

14:15-14:30: Towards a convection-permitting global configuration of the Met Office Unified Model

[1]**Lorenzo Tomassini**, [1]**Martin Willett**, [1]**Alistair Sellar**, [1]**Adrian Lock**, [1]**David Walters**, [1]**Claudio Sanchez**, [1]**Julian Heming**, [2]**Charmaine Franklin** and [3]**Catherine Senior**

[1]*Met Office, Exeter, United Kingdom*
[2]*Bureau of Meteorology, Melbourne, Australia*
[3]*Met Office/Hadley Centre, Exeter, United Kingdom*

A first exploration of convection-permitting global modelling at the Met Office in the context of the current modelling system, the Met Office Unified Model, is presented. All simulations were performed at global N2560 (nominal 5km) resolution. The model resolution thus resides in the convective grey zone where the grid length approaches the scale of turbulence and convection, and contributions from both resolved and subgrid fluxes are non-negligible.
A case study approach has been taken in which testbed cases have been defined and the model has been evaluated against observations. The main finding is that the configurations which include scale-aware turbulence and a carefully reduced and simplified mass-flux convection scheme overall outperform both the reference model with parameterised convection as well as a configuration in which the subgrid convection parameterisation is switched off completely.
The development of global convection-permitting models is more than just an incremental enhancement in resolution. Such models allow for, at least partly, resolving fundamental new turbulent and convective phenomena in the atmosphere. In the presented work, however, the focus is on developing an appropriate tool for emerging new scientific endeavours, and on better understanding the strengths, limitations, and sensitivities of this tool. An outlook including further model development steps and a road map towards convection-permitting global climate modelling is given.

14:30-14:45: Towards a Python-Based Performance-Portable Finite-Volume Dynamical Core for Numerical Weather Prediction

[1]**Stefano Ubbiali**, [2]**Till Ehrengruber**, [2]**Enrique González Paredes**, [1]**Nicolai Krieger**, [3]**Christian Kühnlein**, [1]**Lukas Papritz**, [2]**Hannes Vogt** and [1]**Heini Wernli**

[1]*Institute for Atmospheric and Climate Science, ETH Zurich*
[2]*Swiss National Supercomputing Centre*
[3]*European Centre for Medium-Range Weather Forecasts*

We present recent progress in the development of a Python implementation of the next-generation finite-volume non-hydrostatic dynamical core option IFS-FVM at ECMWF and its member state partners. The main driver behind the IFS-FVM development is the suitability of the non-oscillatory finite-volume numerical schemes for convective-scale resolutions and increasing multi-level parallelism. Starting from the original Fortran code targeting CPU-based systems, sustainable implementation with respect to emerging and future heterogeneous computing platforms is addressed by a profound software redesign for IFS-FVM that leverages the GT4Py framework. The user-facing part of GT4Py consists of a domain-specific language embedded in Python which allows to express stencil-based computations in a hardware-agnostic fashion. By exploiting automatic code generation techniques, the internal toolchain of GT4Py converts the high-level definition of the stencil kernel into optimized code targeting specific computer architectures. This separation of concerns between domain scientists and performance specialists not only enables performance portability, but also improves the readability and maintainability of the application code. We report on the numerical and scientific activity which accompanied the implementation of a limited-area version of the IFS-FVM on Cartesian grids. Ongoing work towards the global model on unstructured meshes and aspects of the physical parametrizations are discussed.

14:45-15:00: Advantages of global storm resolving models in representing seasonal characteristics of tropical precipitation

[1]**Hans Segura**, [1]**Cathy Hohenegger**, [1]**Christian Wengel** and [1]**Bjorn Stevens**

[1]*Max Planck Institute for Meteorology*

In this work, we use one year of simulation of the global storm resolving model ICON coupled with the ocean with a resolution of 5km to analyze the different characteristics of the seasonal variability of precipitation in the tropics. We use the SAL (structure, amplitude, and location) method to identify and characterize the monsoon systems over land and the tropical rainbelts over the ocean. Regarding the tropical rainbelt, we select five ocean regions, namely the Atlantic, the eastern Pacific, the central-western Pacific, the southern Pacific, and the Indian ocean. Monsoon regions considered in this study are South America, Africa, India, and Southeast Asia. We also use the climatology of IMERG (2001-2020) to have a reference point of comparison. Tracking the areas of high values of monthly precipitation over land, we demonstrate that ICON can adequately reproduce the seasonal changes in the structure and location of monsoon systems in South America, Africa, and SE. Asia. A similar conclusion is reached when analyzing the tropical rainbelt in the eastern Pacific and the Atlantic. For instance, ICON can reproduce the area increase in the Eastern Pacific and Atlantic rainbelts during their northward migration. However, we observe some issues in the zonal migration of the rainbelts in the central and western Pacific and the Indian ocean. Thus, these results confirm that by resolving convection explicitly, important characteristics of tropical precipitation can be represented.

15:00-16:00 : *Poster session & Coffee break (in venue hall)*

16:00-16:45: Discussion Panel 7. **What are some of the unique contributions that the CPM community can make to the next IPCC report?**

Chairs: *Alex Hall*

16:00-16:10: The Sixth Assessment Report of the IPCC: gaps and opportunities for the next cycle

[1]**Paola A. Arias**

[1]*U. Antioquia & LA of IPCC AR6 WG1 Chp 8*

16:10-16:20: Convection-permitting models in IPCC reports: a parallel with Regional Climate Models?

[1,2]**Alejandro Di Luca**

[1]*Centre Étude et simulation du climat à l'échelle régionale (ESCER)U. du Québec à Montréal*

[2]*Département des Sciences de la Terre et de l'atmosphère, Université du Québec à Montréal, Montréal, Canada*

In this presentation, I will briefly discuss what the main contributions to the latest Sixth Assessment Report (AR6) by the Intergovernmental Panel on Climate Change (IPCC) are from studies involving convection-permitting climate models. I will then go on to discuss how convection-permitting modelling might contribute to future IPCC cycles by tracing a parallel with the use of traditional regional climate models in IPCC reports.

16:45-17:30 Session 4: Event-based storyline approaches to climate change

Chairs: *Alex Hall*

16:45-17:00: Sensitivity of convective precipitation to warming in the extratropical Andes

[1,2,3]**Miguel Lagos-Zúñiga**, [4,1]**Deniz Bozkurt** and [5,1]**Roberto Rondanelli**

[1]*Center for Climate and Resilience Research, University of Chile*

[2]*Advanced Mining Technology Center, University of Chile*

[3]*Civil Engineering Department, University of Chile*

[4]*Meteorology Department, University of Valparaiso*

[5]*Geophysical Department, University of Chile*

Deep convective activity in the extratropical Andes is intense during austral summer and can produce severe precipitation events that may induce localized flooding and landslides due to the relatively high temperatures and zero-isotherm lifting. Summer precipitation events are commonly triggered by high water vapor availability and enhanced instability due to surface warming and(or) cooling in the mid-to-upper tropospheric levels. In this study, we aim to explore the sensitivity of convective precipitation to warmer sea surface and air temperatures for the two historical events: i) a Cut Off Low event (COL, February 2017), and ii) an Atmospheric River + COL (January 2019). Both cases are analyzed in the region between 30-35°S along the Andes. We use the Weather Research and Forecasting Model (WRF) at a convective permitting 3 km horizontal resolution to obtain dynamically downscaled high-resolution simulations. We first obtain a control simulation using GFS initial and boundary conditions. We evaluate control simulations through surface and upper-air observations. The warmer conditions are evaluated with three warmer SST and/or troposphere conditions with modified forcings through a pseudo-global warming experiment based on CMIP6 simulations (SSP5-8.5 scenario). We explore precipitation sensitivities in magnitude and affected areas to analyze the potential enhanced risk of summer precipitation events due to warmer conditions.

17:00-17:15: Examining the Effect of Climate Change on Arctic Cyclone Behavior in a Regional Climate Framework

[1,2]**Chelsea Parker**, [3]**Priscilla Mooney**, [4]**Melinda Webster** and [1]**Linette Boisvert**

[1]*NASA Goddard Space Flight Center*

[2]*ESSIC University of Maryland*

[3]*NORCE, Bjerknes Centre for Climate Research*

[4]*University of Alaska Fairbanks*

Cyclones are synoptic weather events that transport heat and moisture into the Arctic, and have complex impacts on sea ice, marine ecosystems, and socioeconomic activities. However, the effect of a changing climate on Arctic cyclone behavior remains a topic of active research. This study uses high resolution (4km), Weather Research and Forecasting (WRF) model regional simulations of cyclone events and downscaled global climate reconstructions and projections from the Climate Model Intercomparison Project (CMIP6) to examine how recent and future climatic changes alter spring cyclone behavior. Results from this pseudo global warming, event-based storyline framework suggest that recent climate change has not yet had an appreciable effect on Arctic cyclone characteristics during early spring. However, the convection-permitting simulations show that future sea ice loss and increasing surface temperatures by the year 2100 drive large increases in the near-surface temperature gradient, sensible and latent heat fluxes from the surface to the atmosphere, and deep convection during cyclone events. The future climate alters cyclone trajectories and increases and prolongs cyclone intensity, with significantly augmented wind speeds, temperatures, and precipitation rates. The increasing extreme nature of weather events such as Arctic cyclones has important implications for atmosphere-ice-ocean interactions in the new Arctic.

17:15-17:30: Contributions of CPM to evaluate the impact of historical warming on recent extreme events in Japan

[1]**Hiroaki Kawase**
[1]*JMA*

None

17:45-18:30 : *Bus is leaving for hotels*

19:30-20:00 : *Appointment for walking to the 'Gala dinner'*

20:00-22:00 : *'Gala dinner'*

22:30-22:45 : *Bus is leaving for hotels*

Friday 9th

8:00-9:00 : *Bus leaves from Dazzler and Recoleta hotel*

8:30-9:00 : *Bus leaves from Sarum hotel*

9:00-10:00: Discussion Panel 8. CP and impact studies and policy making

Chairs: *Anna Sörensson*

09:00-09:10: Performing Convection Permitting simulations to address policy makers questions

[1]**Jason P. Evans**
[1]*UNSW ARC CCRC*

Policy makers want projections that help them make decisions. Many of these decisions are aimed at managing risks of various kinds. While, in my experience, policy makers always want higher resolution images (projections) because the extra detail makes them "feel better", there are many questions that require kilometre or better resolution to address at all. Questions around city planning require resolving differences in urban landscape and topography within a city. Guidelines for building infrastructure that can handle future hydrological extremes such as urban flash flooding requires projections with high resolution in both space and time. In this talk I will show a couple of examples of convection permitting simulations performed to address questions raised by policy makers.

09:10-09:20: Regional Information for Society (RIfS): a roadmap for policy-relevant climate research

[1]**Silvina A. Solman**
[1]*CIMA, CORDEX SAT & GEWEX RifS*

09:20-09:30: Making Modeling Responsive to Stakeholder Needs: Recommendations for Fruitful Coproduction

[1]**Monica Morrisson**
[1]*NCAR*

09:30-09:40: Developing capacity for southern countries to engage in convection permitting modelling

[1]**Chris Lennard**
[1]*CSAG/UCT & LA of ICC AR6 WG2 Chp 9*

Convection permitting modelling is computationally expensive in terms of CPU and storage. This is particularly true for long simulations and large domains e.g., transient CMIP6 downscalings at the continental or large country scale.
Most developing countries do not have hardware infrastructure capable of running such simulations, human capacity to maintain and administer such infrastructure nor can work with the large datasets resulting from

these simulations. Therefore, most CPM programmes are conducted by northern institutions that (justifiably) address their own research interests.
However, the IPCC AR6 shows that countries most vulnerable to climate change are southern nations, many of which are in convective climate regimes. Convection resolving modeling will therefore very likely contribute to a better understanding of climate risk in these regions, particularly from extreme rainfall and wind.
Unfortunately, with very few southern research centers having the capacity to run these types of simulation (in terms of compute infrastructure, sysadmin support and big data analysis), and the focus of northern centers on their research interests, the added value CPM brings to risk assessment and adaptation planning may not materialize in these regions for years.
How then can we capacitate southern countries to engage in CPM and how can the added value of CPM inform climate resilient development pathways in these countries? How can northern and southern research groups collaborate?
During this interactive session we will try to address some of these questions, so please bring your ideas to the discussion...

10:00-10:30 Session 5: Mechanisms of extreme events by using very high resolution model

Chairs: *Andreas Prein*

10:00-10:15: Future Mesoscale Convective System Rainfall Related to Changes in Convective and Stratiform Structure

[1]**Erin M. Dougherty**, [1]**Andreas F. Prein**, [1]**Ethan D. Gutmann** and [1]**Andrew J. Newman**

[1]*National Center for Atmospheric Research*

Mesoscale convective systems (MCSs) are responsible for a majority of warm-season flash flood events in the central U.S. Given their high impact, it is critical to understand how MCSs will change in a future climate. This study identifies 8 flood-producing MCS cases and perturbs them with an ensemble of climate change signals in order to analyze the variability in future MCS rainfall. Future MCS area average rainfall increases by 95–120%, with maximum hourly rain rates varying from 19–63% among all cases. The MCS reflectivity structure is classified into convective and stratiform structures, with both components showing systematic changes in a future climate. These structural changes in MCS convective and stratiform elements are related to future changes in rainfall amounts, highlighting which regions of the MCS dominate the changes in area-average and maximum rainfall amounts. The results from this study not only highlight which MCS elements contribute most to future rainfall changes, but also distinguish these changes by MCS archetypes, which is necessary to understand the impact of convective storms on future flood impacts in the Central U.S.

10:15-10:30: A Mesoscale Convective System over the tropical Andes: role of the Orinoco Low-level Jet and PBL schemes

[1]**J. Alejandro Martinez**, [2]**Paola A. Arias**, [3]**Francina Dominguez** and [4]**Andreas F. Prein**

[1]*Escuela Ambiental, Universidad de Antioquia, Medellín, Colombia*
[2]*Grupo de Ingeniería y Gestión Ambiental (GIGA), Escuela Ambiental, Universidad de Antioquia, Medellín, Colombia*
[3]*University of Illinois, Department of Atmospheric Sciences*
[4]*National Center for Atmospheric Research (NCAR), Boulder, CO, USA*

Mesoscale Convective Systems (MCSs) that form over the northwestern Amazon can affect the tropical Andes, contributing to precipitation over important human settlements and ecosystems in the region. We investigate a MCS event over the Andes-Amazon transition region that was preceded by a strengthened Orinoco Low-Level Jet (OLLJ). We explore the role of the OLLJ and the flow in the vicinity of the Andes on the size and movement of the MCS over the Andes, via sensitivity experiments with different grid spacings (12, 4 and 1.3km) and different boundary layer (PBL) schemes. We find that the OLLJ event helped with the moisture transport and provided lines of low-level convergence. The PBL scheme is critical in the organization and movement of the MCS near and over the Andes. PBL schemes with stronger flow are also associated with stronger gradients, since the Andes provide blocking in all cases. Therefore simulations with stronger flow exhibited stronger convergence areas, with larger and more organized simulated MCSs that moved further over the Andes, with cloudiness patterns more similar in size and trajectory to the observed event. This suggests that the PBL scheme strongly modulates moisture transport and convergence within the OLLJ, affecting the simulation of MCSs. Additional simulations comparing the statistics of size and passage of MCSs over the Andes originating in the northwestern Amazon region could help to better predict severe weather events over parts of the Andes.

10:30-11:00 : *Coffee break*

11:00-12:30 Session 6: South America coordinated scientific efforts

Chairs: *Lluís Fita*

11:00-11:15: WRCP - GEWEX

[1,2]**Peter J. van Oevelen**

[1]*International GEWEX Project Office*
[2]*George Mason University*

None

11:15-11:30: ANDEX

[1,2,3]**Mariano Masiokas**

[1]*Instituto Argentino de Nivologíia, Glaciología y Ciencias Ambientales (IANIGLA)*
[2]*CCT-CONICET-Mendoza*
[3]*CNRS UMI-3351 IFAECI, Mendoza, Argentina*

None

11:30-11:45: NCAR SAAG

[1]**Roy Rasmussen**

[1]*National Center for Atmospheric Research (NCAR)*

None

11:45-12:00: CORDEX FPS South America

[1,2,3]**María Laura Bettolli**

[1]*Departamento de Ciencias de la Atmósfera y los Océanos, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires (DCAO-FCEN-UBA), Buenos Aires, Argentina*
[2]*Institut Franco-Argentin d'Estudes sur le Climat et ses Impacts, Unité Mixte Internationale (UMI-IFAECI/CNRS-CONICET-UBA), Buenos Aires, Argentina*
[3]*Centro de Investigaciones del Mar y La Atmósfera (CIMA), CONICET-UBA, Buenos Aires, Argentina*

no abstract provided

12:00-12:15: RELAMPAGO – CACTI

[1]**Kristen Rasmussen**

[1]

None

12:15-12:30: Discussion

[1]**Alex Hall**

[1]

Summary & short presenteations of the outcomes of the discussions within each groupd

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12:30-13:30 : *LUNCH*

13:30-14:30 : *Breakout group*

14:30-15:00 : *Coffee break*

15:00-15:45 : *Report breakout group*

15:45-16:00 : *7th workshop announcement & End of Workshop*

16:15-17:00 : *Bus is leaving for hotels*

End of conference

List of posters

Session 1: The added value of convection-permitting climate simulations

P.1.1: Morning Soil Moisture Heterogeneity is Strongly Linked to Daytime Convection over Subtropical South America

[1]**Divyansh Chug**, [1]**Francina Dominguez**, [2]**Christopher Taylor**, [2]**Cornelia Klein** and [3]**TBD**

[1]*University of Illinois Urbana Champaign*
[2]*United Kingdom Center for Ecology and Hydrology*
[3]*TBD*

How does surface heterogeneity, specifically mesoscale gradients in soil moisture (SM), affect convective initiation (CI) over Subtropical South America (SSA)? Recent work has shown that mesoscale circulations induced by soil moisture heterogeneity can lead to convective initiation preferentially over "dry patches" and thus, exert a sub-daily negative feedback. Using satellite data from various infrared and microwave sensors, we track nascent convective clouds and quantify the underlying, antecedent, soil moisture characteristics over different eco-regions of subtropical South America (10S-40S). We find that convection initiates preferentially over strong negative (positive) along-wind gradients of surface temperature (soil moisture) associated with spatially warmer (drier) soil patches, over regions with lower topographic complexity and moderate background wind speed. This work presents the first observed link between mesoscale soil moisture heterogeneity and convection over the South American continent. Further proposed research will investigate the effect of SM heterogeneity on CI over SSA using output from the 20-year convection-permitting Weather Research and Forecasting (WRF) model simulations run by the NCAR South America Affinity Group (SAAG), and subsequently perform multi-day SM homogenization runs under a range of synoptic conditions to test whether heterogeneous SM conditions lead to diurnally earlier onset and increased frequency of daytime convection.

P.1.2: Fine-scale climate projections: What additional spatial detail is provided by a convection-permitting model?

[1]**Dave Rowell** and [1]**Ségolène Berthou**
[1]*Met Office Hadley Centre, Exeter, UK*

Convection-permitting models promise much in response to the demand for increased localisation of future climate information: greater resolution of influential land surface characteristics, improved representation of convective storms (including feedbacks onto larger-scales), and unprecedented resolution of user-relevant data. In practice, however, the gap between models' computational and effective resolution must be recognised. Nevertheless, where surface forcing is strongly heterogeneous, one can argue that usable information may persist close to the grid-scale. Here we analyse a 4.5km resolution projection for Africa, asking whether and where fine-scale projection detail is robust at sub-25km scales, focussing on rainfall. Statistically significant detail is most frequent in regions of high topographic variability, for both seasonal means and daily extremes. Lake coastal features have smaller but significant impacts on projection detail, whereas ocean coastlines and urban conurbations have little or no detectable impact. The amplitude of this sub-25km projection detail can be similar to that of the local climatology in mountainous regions, so potentially beneficial for improved localisation of future climate information. In flatter regions distant from coasts, spatial heterogeneity can be explained by sampling variability, and the robustness of climate projection information can be substantially enhanced by spatial aggregation to circa 25km scales.

P.1.3: The 2012 North American Derecho: A testbed for evaluating regional and global climate modeling systems at cloud-resolving scales

[1]**Weiran Liu**, [1]**Paul Ullrich**, [2]**Jianfeng Li**, [3]**Colin Zarzycki**, [4]**Peter Caldwell**, [2]**Lai-yung Ruby Leung** and [2]**Yun Qian**
[1]*Department of Land, Air, and Water Resources, University of California-Davis, Davis, CA, USA*
[2]*Pacific Northwest National Laboratory, Richland, WA, USA*
[3]*Department of Meteorology and Atmospheric Science, Pennsylvania State University, University Park, PA, USA*
[4]*Lawrence Livermore National Lab, Livermore, CA, USA*

In this study, we develop a testbed that can be used to evaluate the representation of severe storm events in regional and global climate models at cloud resolving scales. The simulated case is an exceptional progressive derecho occurring from 29-30 June 2012. The evaluation is performed by focusing on four essential parameters: precipitation, composite radar reflectivity, outgoing longwave radiation, and wind speed, and separately addressing errors in timing and pattern.
The testbed is applied to intercompare regional and regionally-refined global climate models. Specifically, we investigate WRF at 4km, and the regionally refined model (RRM) using the Simple Cloud-Resolving E3SM Atmosphere Model (SCREAM). Tests address RRM grid spacing (6.5-1.625km), differences between hydrostatic and nonhydrostatic dynamics cores, low-resolution and high-resolution model configurations, initialization time, and source for the initial conditions. As the RRM grid spacing decreases, model performance improves significantly. Results are highly sensitive to the initial conditions; simulations initialized with the Rapid Refresh show best model performance. Despite a two-hour delay in the feature timing, SCREAM better represents the echo shape and the intense wind gusts. Both WRF and SCREAM overestimate the rainfall intensity and underestimate the precipitating area.

P.1.4: Investigating the added value of the Convection Permitting Model CNRM-AROME over the Island of Corsica

[1]**Virginia Edith CORTES-HERNANDEZ**, [2]**Philippe LUCAS-PICHER**, [3]**Erwan BRISSON**, [1]**Gilles BELLON**, [1]**Cécile Caillaud** and [1]**Antoinette Alias**
[1]*METEO FRANCE*
[2]*Département des sciences de la Terre et de l'atmosphère, Université du Québec*
[3]*Cervest*

For the Mediterranean region, recent studies have shown the added value of Convection Permitting Models (CPMs) when compared to Regional Climate Models (RCMs), in particular for extreme precipitation. However, the added value is yet to be determined for mediterranean islands, where the complex orography, coastal line, and the specific island atmospheric processes are especially important to simulate climatic conditions. For these reasons, Islands are ideal testbeds to explore the potential of using CPMs.
The objective of this study is to investigate the added value of the 2.5 km resolution CPM CNRM-AROME for the mountainous Mediterranean island of Corsica. For that, hourly simulated data from: a) the 12 km resolution RCM ALADIN (following the EURO-CORDEX protocol), and two simulations of the CPM CNRM-AROME over two different domains, b) the pan-Alpine domain (following the CORDEX FPS Convection project) and c) the northwestern European domain (defined through the EUCP H2020 project) are compared with 17 hourly weather station data across Corsica for the 2000-2018 period. Preliminary results show an improvement of the simulated distribution of hourly precipitation of CPM simulations when compared to the RCM simulation. These results can be attributed, not only to the better simulation of convective processes by the CPMs, but also to a better representation of the complex orography of Corsica.

P.1.5: What added value of CNRM-AROME convection-permitting regional climate model compared to CNRM-ALADIN regional climate model for urban climate

studies ? Evaluation over Paris area (France)

[1]**Aude LEMONSU**, [1]**Cécile Caillaud**, [1]**Antoinette Alias**, [1]**Yann SEITY**, [1]**Sébastien RIETTE**, [1]**Benjamin LE ROY**, [1]**Yohanna MICHAU** and [1]**Philippe LUCAS-PICHER**

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Convection-permitting regional climate models (CP-RCM) are promising tools for urban studies, due to fine horizontal resolution, more accurate land use mapping and better resolved local-scale processes. Especially, some CP-RCMs run urban-canopy models (UCM) inline to deal with surface-atmosphere exchanges in cities and to explicit interactions between urban and regional climate.
The focus here is on the French CP-RCM CNRM-AROME which is running with a 2.5-km horizontal resolution and coupled to the TEB UCM. CNRM-AROME was applied on a domain restricted to the northern half of France for analyzing its performances in simulating urban climate of Paris region. This choice was motivated both by the urban context, since the Paris metropolitan area is the largest and most populated in France, and by the availability of gridded long-term observations to conduct a climatological-scale evaluation of the simulation and of urban effects. In this study, attention was also paid to the possible added-value of CNRM-AROME compared to the CNRM-ALADIN RCM, which has a coarser resolution of 12.5 km and describes the urban areas as rocky surfaces with high roughness.
Some systematic biases were noted, especially for precipitation, that currently motivate investigations for improving physical and dynamic parameterisations. Nonetheless, the results showed that the CP-RCM better captures intensity and spatial variability of urban heat islands, and maps of heatwave warnings over the region.

P.1.6: Analyses of added value for heavy rain fall and strong wind in convection-permitting climate simulations over Germany

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The overall progressing climate change affects processes on all horizontal scales, from the global to the local scale. For the local climate, the impact of climate change is more heterogeneous due to small-scale features.
In the project “BMDV - Network of experts: Adapting transport infrastructure to climate change and extreme weather events”, we address the needs of our project partners for high spatial and temporal resolved climate model data by performing convection-permitting climate simulations with the regional climate model COSMO-CLM 5.0. The domain is centred over Germany on a 3 km grid. The simulations were dynamically downscaled from MIROC-MIROC5 GCM data and they were performed for 30-year time slices (historical from 1971-2000, future from 2031-2060 and 2071-2100 with scenario RCP 8.5). An additional evaluation run (“HoKliSim-De”) was performed for the time range of 1971 to 2019, driven by ERA-40 with a two-way nesting for 1971 to 1978 and with direct downscaling of ERA5 from 1979 onwards.
For our analyses, we use observation data with daily and hourly resolution. A focus of our analyses is the quantification of the added value from the high resolution in comparison to the forcing model data concerning extreme events like heavy rain fall and strong winds. Further analyses of return levels for extreme precipitation using the peak-over-threshold method have also been performed. Results of these analyses will be presented.

P.1.7: Precipitation frequency in Med-CORDEX and EURO-CORDEX ensembles from 0.44° to convection-permitting resolution: Impact of model resolution and convection representation

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Our goal is to better understand what explains the weaker frequency of precipitation in the CP ensemble by assessing the triggering process of precipitation in the MED & EURO-CORDEX and the CORDEX FPS "Convective Phenomena over Europe and the Mediterranean" ensembles available over Europe. We focus on the statistical relationship between tropospheric temperature, humidity and precipitation. The results show that all model ensembles capture the temperature dependence of the critical value of IWV (IWVcv), above which an increase in precipitation frequency occurs, but the differences between the models in terms of the value of IWVcv, and the probability of its being exceeded, can be large at higher temperatures. The lower frequency of precipitation in CP simulations is not only explained by higher temperatures but also by a higher IWVcv and a lower probability to exceed it. The spread between models in simulating IWVcv and the probability of exceeding IWVcv is reduced over land with explicit convection, especially at high temperatures, when the influence of the representation of entrainment in models impacts more. To analyse further the impact of resolution versus convection representation, we used a small ensemble of three models, each one with a group of three simulations: with and without parametrized deep convection at 0.11° of resolution and without parametrisation of deep convection at 3km resolution.

P.1.8: A preliminary assessment of convection-permitting simulations over southeastern South America performed with the WRF model

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A two-member ensemble of convection permitting simulations using the Weather Research and Forecasting model (WRF) has been performed over an area covering subtropical South America (from 70oW to 50oW and from 34oS to 17oS). The simulations span a 6-month period covering a warm season from October 2015 to March 2016. The 2015-2016 warm season was identified a one of the wettest seasons on record over the region. For performing these simulations, the WRF model was driven directly by the ERA-Interim reanalysis. Additionally, a 20-km resolution simulation performed with the WRF model driven by ERA-Interim reanalysis is used for evaluation purposes. Simulations are compared against three satellite-based precipitation observations which provide 3-hourly precipitation data at roughly 0.1ox0.1o (lat-lon) spatial resolution. The variety of observational data allows including the observational uncertainty of precipitation in the region. The analysis is focused on evaluating several features of the 3-hourly simulated precipitation with emphasis on extremes. The diurnal cycle of heavy precipitation and the diurnal cycle of the frequency of heavy precipitation over several subregions within the domain is also assessed. Additionally, the empirical distribution of the 3-hourly precipitation is assessed. The analysis allows identifying the major differences and benefits of convection-permitting simulations vs a lower resolution simulation in which deep convection is parameterized.

P.1.9: Trends of convective event climatology in the Arabian Peninsula and forecast opportunity at S2S time scale

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Severe weather associated with organized convective systems is becoming more intense globally and is also observed in the Arabian Peninsula (AP). The extreme rainfall-associated flooding in low soil infiltration region like the AP often lead to significant social and economic losses within a very short period. Improving forecast capability at sub-seasonal to seasonal (S2S) timescale can potentially assist disaster risk mitigation, and water resource management.
A series of S2S regional climate model reforecasts were completed using the Weather Research and Forecasting Model (WRF) at convective-permitting resolution (4 km) for the AP. We dynamically downscale 20 years of winter season from the European Centre of Medium-range Weather Forecasts (ECMWF) S2S reforecast product. WRF simulations were initialized weekly with 1-month simulation duration between November and April.
Methods designed to evaluate the S2S forecast skills considers the probability of detection of precipitation, determining the rate of forecast agreements between ensemble members. We evaluated the WRF ensembles against satellite based Global Precipitation Mission (GPM) and 4-km reanalysis data from the King Abdullah University of Science and Technology (KAUST-RA). The WRF S2S downscaled reforecasts significantly improved from the driving ECMWF reforecast climatology. Our WRF results also produced reasonable winter precipitation climatology over the AP across various forecast lead times.

Session 2: Mechanisms of extreme events by using very high resolution model

P.2.1: Changes in Mediterranean convective storms under climate change conditions

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The Mediterranean is a climate change hotspot due to its potential vulnerability to changes, but large uncertainties still exist in future projections of rainfall. It is thus urgent to better understand the sources of uncertainty and the mechanisms that may alter precipitation in the region. This is particularly true for extremes, since large parts of the region gather most of their total annual precipitation from a few intense events, for which trends have proven difficult to detect. Here, we use a convection-permitting model (2-km) over the western Mediterranean to study possible changes in convective rainstorms. We completed two decade-long experiments: one for present climate (2011-2020) and another where end-of-the-century climate anomalies were added to present climate conditions (Pseudo Global Warming). This setup allows us to quantify the thermodynamic and large-scale dynamic climate change impacts on convective storms in the western

Mediterranean.
Using a storm-tracking algorithm, we identify convective systems producing high rainfall rates and measure a range of characteristics. This provides a complete description of convective rainstorms and help us determine which features may be most affected by climate change. Our experiments suggest a future strengthening of short-lived extreme rainfall events. We link changes in convective storm features to heavy rainfall intensification with focus on late summer and early fall, when the most damaging episodes tend to occur.

P.2.2: Fall Mediterranean Heavy Precipitation Events as seen by a large ensemble of CP-RCM future projections

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The northwestern Mediterranean is affected by Heavy Precipitation Events (HPE), occurring mainly in autumn. With rainfall accumulations greater than 100 mm recorded often within just a few hours, these extreme events lead to devastating flash floods and landslides that may cause widespread destruction and even fatalities. Improving the projection the future evolution of these high-impact weather events is therefore highly policy-relevant.
The rainfall extremes involved in Mediterranean HPE are essentially produced through small-scale to mesoscale convective motions, leading to short-duration precipitation extremes. Convection-Permitting Regional Climate Models (CPRCM) have shown a step-change in the quality of reproducing these short-duration precipitation extremes (Ban et al. 2021) and especially fall Mediterranean HPEs (Caillaud et al. 2021) with respect to lower-resolution climate models. Moreover, this good behavior of CPRCMs allows us to go beyond the basic Eulerian statistical approach and to set up an object-oriented Lagrangian approach in order to explore the spatial and temporal connections that may exist within a given event. The object-oriented approach is applied to the CPRCM ensemble of the CORDEX Flagship Pilot Study on Convection (∼15 models). After a model evaluation that demonstrates the ability of the ensemble to represent Mediterranean HPE' characteristics, the same approach is applied to investigate the projected changes at the end of the 21st century.

P.2.3: Mechanisms behind the occurrence of convective systems in Northwestern South America: results from a cloud-resolving simulation

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Numerical Weather Prediction models are an essential tool to advance our understanding of convective systems. Here we use the WRF model to investigate the atmospheric mechanisms behind the occurrence of convective systems in Northwestern South America. Our analyses are based on a cloud-resolving (4km) simulation between September and October 2019 and focus on six regions identified by previous studies as convection hotspots. We used a tracking and identification algorithm to assess the model performance against satellite data and select relevant convective systems based on their area, lifetime, and rainfall intensity. Dynamic and thermodynamic patterns in the atmospheric environment are studied in different stages of the convective events, and diurnal patterns during days with strong convection are investigated. Results reveal dynamics and thermodynamic mechanisms behind the genesis, evolution, and âĂŇâĂŇdecaying of convective systems, which vary with the region. First, in the Colombian Savannas and Amazon, convection evolution depends on diurnal heating patterns and dynamics in large-scale features such as low-level jets. Second, intra-valley differential heating and dynamics play a key role in convection in the Andean region. Third, in coastal regions, convective initiation and propagation relate to sea-land breezes and interaction with the inland topography.

P.2.4: Mesoscale Convective Systems in the Colombian Caribbean: Insights from ConvectionPermitting simulations

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Mesoscale Convective Systems (MCSs) have an important role in tropical hydrometeorology and in the occurrence of extreme weather events, especially near the Andes. The Colombian Caribbean (CC) is surrounded by the Caribbean Sea and the Andes, and it has been recognized as a region where MCSs are frequent; however processes associated with their Convective Initiation (CI) are not fully documented. Convection-Permitting (CP) simulations present the opportunity of resolving mesoscale aspects associated with CI in complex terrain. This work presents the diagnosis of two MCS events in the CC. Mesoscale conditions were analyzed with the Weather Research and Forecasting (WRF) model at CP resolutions. Both events initiated near the Andes and decayed over the sea, presented low pressure zones over the CC, with an Easterly Wave influencing one of the events. WRF indicated that one event presented southerly winds channeled within the Andes, reaching high speeds and providing convergence lines over the CC. In the second case, the convergence lines were formed by northward winds from the Andes foothills, a sea breeze and low-level inland flow. The latter accelerated at night probably due to the reduction in drag from the reduced surface warming and its effect on the turbulent flux of momentum. This study might contribute to understanding the mechanisms behind the formation of MCSs, and the skills of CP simulation for representing such mechanisms, in a complex tropical region as the CC.

P.2.5: Convection in future winter storms over Northern Europe

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Precipitation within storms (extratropical cyclones) is very likely to increase towards the end of the century. We investigate hourly precipitation changes in end-of-century winter storms with the first km-scale model ensemble covering northwest Europe and the Baltic region, allowing an explicit representation of convection and slantwise convection. High resolution models agree that moderate and heavy precipitation in the warm sector of storms are responsible for mean precipitation increases. In the most pessimistic model, future winter storms have similar warm sector precipitation rates as current autumn storm, with more Convective Available Potential Energy (CAPE) and Convective Inhibition (CIN). CPMs give more confidence in changes in the warm sector, but the future mean hourly changes are similar to that given by RCMs (apart from one model). Mean changes are driven by temperature increase (with little relative humidity changes) and storm dynamical intensity (more uncertain).

P.2.6: Analysis of model WRF sensibility on extreme events in the mountains of Rio de Janeiro

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The South Atlantic Convergence Zone (SACZ) is described as the meteorological phenomenon that most impacts the rainfall region in the southeastern and central-west regions of Brazil on the late Spring and Summer. Furthermore, these events usually cause great impacts due to their intense precipitation rate and accumulation. In this way, their prediction is of paramount importance. This prediction is made using global models, such as European Centre for Medium-Range Weather Forecasts (ECMWF) and Global Forecast System (GFS) , and regional models such as Weather Research and Forecasting (WRF). Thus, model improvements and their performance evaluation is useful and should be considered. This work aims to evaluate the impact of different initial conditions for the WRF model using high-resolution simulations for a severe precipitation event in the Rio de Janeiro State. The event occured during SACZ periord in February of 2022. The simulations start on February 11, 2022 at 00Z and end on February 18, 2022 at 00Z using the ERA5 reanalysis data as the first initial condition and the prediction data from the GFS model in order to observe the impacts and difficulties of forecasting data in identifying such extreme events.

P.2.7: Characterization of the thermodynamic environment of extreme precipitation events in southeastern South America

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Southeastern South America (SESA) is characterized as one of the regions with the highest frequency of occurrence of intense storms associated with deep convection. These events induce extreme precipitation events and produce most of the warm season rainfall generating significant damage (floods, intense winds, hail) and have a high impact on economic and social activities. Considering that the occurrence of extreme events in SESA is associated with the occurrence of certain thermodynamic patterns, in this work we used a set of convection-permitting regional climate models to explore their ability to reproduce the thermodynamic environment that triggers deep convection in SESA. The characterization of the thermodynamic environment was obtained from the simulation outputs of three models (WRF-CIMA, WRF-UCAN, REGCM4-USP) belonging to the Flagship Pilot Study in southeastern South America (FPS-SESA) for two spatial resolutions, 4 and 20 km (Bettolli et. al 2021 and Lavin-Gullon et al 2021). From the data, the spatial distribution of the equivalent potential temperature at the 850 hPa level and the vertical gradient between 850 hPa and 600 hPa were analyzed.

P.2.8: The Importance of Grid Spacing in Simulating Organized Convective Storms

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Mesoscale Convective Systems (MCSs) provide a majority of precipitation in the tropics and some mid-latitude regions. They also cause a significant amount of flooding and other hazards in the regions they occur.
Simulating MCSs is challenging due to the complex interaction between processes that range from synoptic scales to microscales. Here we use the Weather Research and Forecasting (WRF) model to simulate well observed MCSs in the central U.S. and the Amazon basin with model grid spacings ranging from hydrostatic scales (12 km) to turbulence resolving scales (125 m). We evaluate these simulations with a range of observations from the U.S. Department of Energy (DOE) Atmospheric Radiation Measurement (ARM) sites, satellite data, and in-situ measurements. The goal is to understand how MCS characteristics change with model grid spacing, to detect systematic model biases, and to identify efficient model settings that allow to simulate MCSs reliabely in weather and climate models.

Session 3: Event-based storyline approaches to climate change

P.3.1: The influence of in the moisture transport from the Amazon Forest to the South America continent

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Changes in the atmospheric circulation, water budget, and heat fluxes are developing to the increase of Amazon deforestation and global warming in the South American continent. Therefore, the work objective is to evaluate how the Amazon deforestation process may impact the moisture transport and the water budget in the Brazilian southeastern (S/SE) region in a 2o C warmer world (SWL2 approach) during the austral autumn. Using the Brazilian Atmospheric Model (CPTEC-BAM1.2 - $\sim$ 200 km and 28 levels) was possible to simulate the total conversion from the tropical forest (D00) to the pastureland (D100). The atmospheric model was driven by the IPSL-CM5A-LR Sea Surface Temperature (SST) condition. The vertically integrated moisture flux (from surface up to 500 hPa) from the Amazon Forest (represented by a domain ranging from 10oS up to 3oN and from 75oW up to 50oW) to the S/SE region (20oS up to 27oS and from 53oW up to 45oW) was computed. As a result, there was an intensification of the influx from the Atlantic Ocean (+20.7 kg m-1 s-1) to the Amazon region. Furthermore, the result indicated a decrease in the moisture transport to the S/SE (-15.4 kg m-1 s-1). In addition, changes in the Walker cell (an increase in the subsidence movement – +2.5 Pa/s), low-level jet pattern (+3 m/s), and a decrease in the jet stream velocity (-4 m/s) were essential drivers which modulated the incoming of moisture in the S/SE regions.

P.3.2: The climatology of the Orinoco low-level jet in CMIP5/CMIP6 models

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The Orinoco low-level jet (OLLJ) plays an essential role in atmospheric moisture transport from the tropical Atlantic and the Orinoco basin to the northern Amazon. Although various studies have assessed its main features, the representation of the OLLJ by General Circulation Models (GCMs) has not been evaluated yet. This study focuses on the GCMs of the Fifth and Sixth phases of the Coupled Model Intercomparison Project (CMIP5 and CMIP6) in terms of their representation of the OLLJ. We use data from the historical experiment during 1979-2005 for CMIP5 and 1979-2014 for CMIP6, while ERA5 is used as the reference database. The annual cycle is characterized with zonal and meridional wind, and sea-level pressure (SLP), near-surface air temperature, and surface sensible heat flux (SSHF) are used to link the performance of the models with the simulation of patterns that modulate the jet activation. Our results suggest contrasting skills among CMIP5 models, while CMIP6 models show an improved performance. An accurate simulation of the SLP and temperature gradients between the ocean and the northern South America landmass does not seem to influence the representation of the OLLJ, particularly in CMIP6. Besides, links between changes in the jet intensity and regional gradients of SSHF, air temperature, and SLP tend to be represented by GCMs. This study reinforces the usefulness of GCMs in understanding regional climate, allowing the analysis of climate variability at different scales.

Session 4: South American high resolution modeling research activities

P.4.1: ASSESSING PBL PARAMETERIZATION SCHEMES PERFORMANCE OVER THE CENTRAL AMAZON BASIN DURING GOAMAZON2014/5

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The modeling of the boundary layer was performed using the WRF model, with a domain of 3 one-way interacting nested grids. The results from the inner domain (1 km) for different PBL schemes (nonlocal (ACM2, MRF, SH, YSU, QNSE-EDMF) and local (BouLac, GBM, MYNN2.5, MYNN3, MYJ, UW)) were analyzed against in situ observations. The PBL heights (PBLH) were compared with ceilometer measurements. Short-term forecasts (72-h) were conducted (with a 12 h spin-up) for 4 cases: rainy and dry seasons for a typical (2014) and ENSO-influenced (2015) years. The statistical analysis was performed separately for daytime and nighttime due to the pronounced diurnal variation, which revealed that the PBLH is better predicted during daytime. The local schemes (MYNN2.5, MYNN3, MYJ) give reasonable estimates for the convective boundary layer and non-local scheme (SH) for stable conditions. The diagnosed PBLH spatial fields for nighttime (02 Local Time) and daytime (14 LT) were investigated. The PBLH spatial fields revealed that nonlocal PBL schemes are influenced by the hydrography, while local PBL schemes were not. In general, the local MYNN2.5 and MYNN3 and the nonlocal QNSE-EDMF schemes predicted a deeper PBLH. Nonlocal schemes (ACM2 and MRF) depict the hydrography in their PBLH distribution with higher PBLH over the land (>1500 m) and lower over the water bodies (<800 m) during the daytime. The same typical values for nighttime are 100-200 m over the continent and 50-100 m over the water.

P.4.2: Convection-permitting climate simulations for South America: a land-surface perspective (with insights from Europe and Africa)

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Convection-permitting models have been shown to improve the precipitation intensity distribution compared with observations by decreasing the amount of light precipitation and increasing the amount of heavy precipitation. As convection-permitting models are increasingly applied at climate timescales, it is becoming more important to understand the behaviour of the land surface within these models. The Met Office now has CPM climate simulations of at least 10 years in length for several regions including South America in which the effect of the shift in the precipitation intensity distribution on land surface interactions and in particular hydrology, can be explored. We introduce the South American CPM simulations, indicating the areas of added value. We also highlight the common themes that emerge from these and related experiments for Africa, and report on sensitivity tests for Europe, in which different land surface setups are compared. We find consistent differences in the relative contribution of soil evaporation and canopy evaporation to total evaporation in CPM simulations compared to those with parametrised convection, which we attribute to the shift in precipitation intensity distribution. This has implications for the amount of rainfall partitioned into runoff and feedbacks from soil moisture to the surface energy budget and precipitation. Furthermore, our results have implications for the land surface scheme in future CPM climate simulations.

P.4.3: Convective-Scale Impacts of Deforestation on Amazonian Rainfall (CIDAR)

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Deforestation in the Amazon has a great impact on the coupling between the land and atmosphere at scales ranging from local to global climate. It may locally outweigh impacts from global climate change and has been identified as a potential trigger for a tipping point. Despite this, the overall effects of deforestation on rainfall remain unknown; land-use change influences rainfall through a combination of storm-scale to continental-scale processes that until recently have been impossible to capture in a single model due to computational expense. Here we present results from convection-permitting (CP) simulations using the Tropical configuration of the Met Office Unified Model. Our domain covers the majority of South America and includes a series of land-use sensitivity runs making use of socioeconomic deforestation scenarios to 2050. The high-resolution (4km), continental-scale simulations present a real opportunity to address the uncertainty in Amazonian water budget within a single model. We will show initial results on the CP representation of local convective storms, mesoscale convective systems and large-scale circulations, and how these are influenced by land-use change; this will include evaluation of the simulated rainfall characteristics at a range of spatial and temporal scales.

P.4.4: Evaluating the impact of WRF-3DVAR assimilation for weather forecasting in the Ander: The case of the Antisana glacier in Ecuador

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The topographic complexity, coupled with insufficiently monitored atmospheric processes, the lack of knowledge of optimal sub-grid parameterizations, and the sensitivity of models to initial conditions, make weather forecasting for water resource management and risk assessment difficult. Data assimilation either from synoptic, radiosonde, or satellite data is used to improve the initial conditions for running regional weather models. This study evaluated the performance of the WRF model using three assimilation scenarios: radiosondes, weather stations, and both over the Antisana glacier in the northeastern Andes, which supplies drinking water to the south of Ecuador's capital, Quito. The scenarios were compared with forecasts without assimilation schemes, and observations from weather stations in the glacier area. Forecasts were evaluated from 1-3 days, for two time periods in November 2019, and January 2020. The results shown that the forecasts with assimilation were not accurate in November, the variables' behavior is mostly irregular and does not reflect the conditions of the area. In January, assimilation produced a positive impact on temperature forecasts, and it managed to reduce the underestimation of accumulated precipitation, but still shows drawbacks in short-term events. A simple synoptic analysis revealed that January forecasts gave better results because winds have more synoptic characteristics, and they have fewer local influences than those shown in November.

P.4.5: Improved representation of Amazon precipitation by organized convection in storm-resolving simulations

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In this study we investigate whether a better representation of precipitation in the Amazon basin is related to the representation of organized convective systems (OCS). In addition to satellite data, we use ensemble simulations of the ICON-NWP model at 2.5km and 5km storm-resolving resolutions with explicit convection (E-CON) and at 40km coarse resolution, with parameterized convection (P-CON). The main improvements in the representation of Amazon precipitation by E-CON are the distribution of precipitation intensity and spatial distribution in the diurnal cycle. By isolating precipitation from the OCS, it is shown that its representation is essential for those characteristics of Amazon precipitation. E-CON ensembles are able to capture the OCS and mainly its diurnal cycle, but its frequency is reduced compared to observations. The simulated and observed OCSs are then classified into 6 clusters that distinguish nocturnal and diurnal OCSs. In addition, we analyzed the environmental conditions of these clusters. The nocturnal clusters are associated with strong low-level easterly winds, possibly related to the Amazonian low-level jet. The diurnal clusters are rather influenced by surface processes, such as cold pools, which contribute to their propagation. The limited simulation of OCS could be related to deficiencies in the representation of these mechanisms, especially for the diurnal OCS that accounted for a smaller fraction of the total OCS compared to observations.

P.4.6: Effects of the regional-local circulation on precipitation development in the tropical Andes (Rio Santa Basin).

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The Cordillera Blanca (central Andes of Peru) represents the largest concentration of tropical glaciers in the world. The atmospheric processes related to precipitations are still scarcely studied in this region. The main objective of this study is to understand the atmospheric processes of interaction between local and regional scales controlling the diurnal cycle of precipitation over the Santa River basin located between the Cordillera Blanca and the Cordillera Negra. The rainy season (December–March) of 2012–2013 is chosen to perform simulations with the WRF (Weather Research and Forecasting) model, with two domains at 6 km (WRF-6 km) and 2 km (WRF-2 km) horizontal resolutions, forced by ERA5. WRF-2 km precipitation shows a clear improvement over WRF-6 km in terms of the daily mean and diurnal cycle, compared to in situ observations. WRF-2 km shows that the moisture from the Pacific Ocean is a key process modulating the diurnal cycle of precipitation over the Santa River basin in interaction with moisture fluxes from the Amazon basin. In particular, a channeling thermally orographic flow is described as controlling the afternoon precipitation along the Santa valley.

P.4.7: New Leaf Area Index data for CORDEX FPS-SESA simulations

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As resolution in climate modeling increases towards kilometer-scale, there is a need to consider static data for climate factors such as land surface characteristics with increased details and accuracy. Leaf area index (LAI) is an important quantity in land surface modeling that characterizes phenology, accounting for the one-sided green leaf area per unit ground surface area. LAI affects net land surface radiation by modulating albedo and energy partitioning between latent and sensible heat flux. Phenology also has a direct influence on intercepting precipitation, evapotranspiration and runoff.

LAI in the Weather Research and Forecasting (WRF) model can be obtained from a lookup table, depending on the land use category, or from LAI maps based on the MODIS satellite-derived climatology. More complex land surface models in WRF include a dynamic vegetation model that calculates LAI. Over Europe, LAI taken from the lookup table or default map input

in WRF are shown to be considerably low for some land use categories, especially for croplands which cover an extensive area of the European continent. Therefore we prepared a new static data set for WRF based on the 15-year SPOT satellite-derived climatology. SPOT is a high resolution Earth imaging satellite system operated by the French Space agency.
In this work we introduce this updated LAI data set for WRF and show some initial results of model sensitivity to LAI for the convection permitting CORDEX FPS-SESA simulations.

P.4.8: An Evaluation of High-Resolution Model Simulation Variations of Orographic Precipitation and Snowpack in the Southern Andes

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Orographic precipitation and snowpack are important for water resources and hydrometeorological disasters in the Andes Mountain range. Improved understanding of orographic precipitation and snowpack in a warming climate is needed to provide a foundation for understanding future hydroclimate change over the Andes. The goal of this research is to evaluate how well variations in high-resolution regional climate simulations agree with observations of (1) orographic precipitation and (2) snowpack over the southern Andes (35-55deg S). We use ERA-5-forced Weather Research and Forecasting (WRF) simulations with 4-km grid spacing that were run for 2000-2015 over South America by the NCAR-led South America Affinity Group (SAAG). The fine grid spacing of the SAAG-WRF simulations allows better resolution of the complex terrain. Precipitation results are compared to rain gauge observations from national networks in Argentina and Chile to examine how well each captures orographic effects on precipitation patterns and intensity. The Andean Snow Reanalysis (ASR) byâĂŕCortés and Margulis (2017) provides probabilistic estimates of snow variables over the complex Andean terrain where in situ data are scarce. SAAG-WRF SWE are compared to ASR to assess spatiotemporal variations. Important biases will be assessed if they exist, and analysis may lead to better representation of orographic precipitation and snow cover over the Southern Andes.

P.4.9: The CORDEX FPS-SESA Ensemble convection-permitting simulations: Achievements, challenges and future developments

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With focus on extreme rainfall events in Southeastern South America (SESA), the FPS-SESA initiative seeks (1) to promote inter-institutional collaboration and further networking to study multi-scale processes and interactions that result in extreme precipitation events and (2) to develop actionable climate information from statistical and dynamical downscaling based on co-production with the impact and user community. During the first phase of the CORDEX FPS, short-term event-based simulations and 6-months simulations were performed with four convection permitting models following a protocol specifically designed for the preliminary ensemble. The results from this preliminary ensemble allowed identifying the benefits of convection-permitting simulations. However, discussions among members of the FPS dedicated to assessing the impact of extreme events on agriculture and on the hydrology of the Uruguay basin, revealed the need of enlarging both the domain and the temporal span of the simulations. This will allow to evaluate the extent to which driving the impact models with outputs from convection permitting models allows capturing the impact of wet and dry conditions on crop production over southeastern Brazil and on the runoff variability of the Uruguay river basin. Therefore, a new version of the ensemble convection permitting modelling protocol was designed. The presentation will focus on the latest results from this new convection permitting ensemble.

P.4.10: Developing a Real-Time Operational Short-range to Sub-seasonal Forecast System to Improve Planning and Mitigation Activities of Extreme Hydroclimatological Events in the Tarapacá Region, Chile

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Convective storms in northern Chile are generally related to the South American monsoon that develops during the Altiplano Winter. Scientific evidence indicates that convective precipitation from monsoon events have become more frequent and intense during the last decades and will keep this pattern in the future. Due to its location (Andes mountains), there are favorable conditions for occurrence of flash floods that impacts downstream where all cities are located, as it happened in this region on March 24-26, 2015. Current regional Hydrometric Monitoring Network managed by the Regional Directorate of Water Resources of Tarapacá Region has deficiencies in the temporal and spatial representation of convective storm events due to the low observational site density. In this regard, our research focuses on the construction, calibration, and validation of a real-time and operational Hydrometeorological Forecasting System to provide weather and hydrological short-range to sub-seasonal forecasts in the Tarapacá Region. We apply high-resolution convective-permitting modeling schemes to represent convective-scale processes with multiple ensemble realizations. These forecasts are used to establish hybrid evaluation metrics for the development of comprehensive data assimilation assessments, which will be operationally implemented in the region to inform stakeholders and decision makers about the socioeconomic risk and anticipate planning and mitigation activities at the regional scale.

Session 6: Co-production of climate impact information based on convective permitting models and observations

P.6.1: Impact of urbanization on precipitation: a multi-site observation-modelization analysis over the United States of America.

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Understanding how cities impact precipitation can help to manage the water resources and the risks generated by intense rainfall. Thus, numerous articles aim to investigate the potential effect of urban areas on precipitation. In a recent review of literature (Lalonde-Le Pajolec et al., submitted), we noticed that a consensus on the increase of precipitation induced by cities is found when models are used while it is not true when radar data are analyzed. In this study, we analyze the urban impact on precipitation on a country scale, in 38 cities in the United States of America for 11 years (2002-2012) using the same methodology for all cities and both observation (STAGE-IV) and model (convective-permitting WRF simulation performed at NCAR; Liu et al., 2017) datasets at the same resolution (4km). We examine the hourly precipitation spatial distribution following multiple methodologies (according to wind directions and land uses). Then, we investigate the variation of the results over our city set following four parameters: the urban sprawl, the altitude gradient, the roughness, and the proximity to large water surfaces (lakes, oceans). Our conclusions obtained with the simulation (which does not include an urban scheme but represents cities as rocks) and with radar observations will be analyzed in a second step to assess how much the simulation can reproduce the effects of cities at this resolution, without specific parametrization.

P.6.2: The Climate Response of Heavy Precipitation Events over the Alps and in the Mediterranean

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In the Alps and Mediterranean region convective storms are influenced by both, the presence of a large area of sea water and complex orography, and can cause hazardous flash floods. We here study heavy precipitation events (HPEs) by using the CORDEX-FPSCONV convection permitting regional climate model ensemble and a tracking algorithm.
We investigate the climate change response of characteristic HPE properties describing their propagation, scale, intensity and severity: by year 2100 HPEs travel by $>10\%$ farther, they last longer by $>5\%$, their area increases by $>15\%$ and their rainfall volume by $>35\%$. Their maximum precipitation rate by about 13% and an estimate of severity is found increased by $>20\%$.
Eventually we resolve the response for specific storm categories, geographical regions and seasons: changes are greatest for landfalling HPEs, and for those affected by orography. North of the alps, a region not renowned for severe weather, the occurrence frequency of HPEs is found to double in wintertime, accompanied by a strong increase in their rainfall volume of $>50\%$. Changes in rainfall volume, intensity and severity are greater in fall and winter than in summer.
For the whole domain changes of characteristic HPE properties scale with surface warming at rates smaller than suggested by the Clausius-Clapeyron feedback, likely due to limited moisture supply in dry summers. However, we also show that changes in such a complex domain show strong local and seasonal variability.

Session 7: Relation between climate modeling - impact studies - policy makers

communities

P.7.1: The need for Regional Climate Modelling for Brazil

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Climate models have been used as a critical tool for improving our understanding and predictability of climate in several socio-ecological studies. Despite models producing simulations of current and past large-scale climates that agree with observations, they may not always represent the patterns of variation in regional and local scale features, particularly for Brazil, as a continental country with regional climate diversity. Simulations of the climate at convection-permitting resolution (at kilometer-scale) are emerging as a promising tool to produce a better-detailed representation of regional climate and its extremes. New cutting-edge climate simulations have recently been completed over South America using a Met Office high-resolution convection-permitting climate model as part of the CSSP-Brazil project. Here, we present a perspective on the potential need of the regional modelling frameworks for Brazil. The work begins with a general overview of the current state of knowledge on future projections that are available via the GCM and RCM models. The presentation also shows preliminary results on how the CPM performs in representing the main features of daily precipitation over Brazilian regions. These unique simulations are expected to provide Brazilian climate scientists with improved understanding of many impact-relevant aspects of climate such as rainfall variability and extremes.

P.7.2: Identifying end-user needs and opportunities provided by convection-permitting simulations in the Amazon Basin

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It is now well established that convection-permitting simulations provide a step-change improvement in the representation of precipitation, including diurnal variability, extremes, and its coupling with land-surface conditions. The computation cost of these simulations, however, come at the expense of limited domains, shorter simulation lengths and more limited sampling of future scenarios and uncertainties. Day-to-day variability in precipitation is a key metric to end-users across a range of sectors, and so improvements from convection-permitting simulations could be very valuable to a range of stakeholders. There is a need, however, to communicate these opportunities to end users and better understand their data needs and constraints, to ensure that these modelling advances are accessible to relevant stakeholders. Here we will present the outcomes of a virtual stakeholder workshop taking place in June 2022 as part of the UK-funded Convective-Scale Impacts of Deforestation on Amazonian Rainfall (CIDAR) project. The workshop will bring together different stakeholders in the Brazilian Amazon, including local authorities, government bodies for research and protection of the Amazon, civil defence, fires and health, and indigenous leaders. The aims will be to determine climate-data needs required for decision-making, including at what spatial and temporal scales, with a focus on understanding possible impacts of deforestation using convection-permitting models.

P.7.3: Analysis of extreme hydrological events in the Uruguay River basin

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During the periods October 2009-March 2010 and October 2015 - March 2016 several extreme precipitation events occurred in southeastern South America and impacted on the Uruguay River streamflow. Within the framework of the Flagship Pilot study in southeastern South America endorsed by CORDEX, statistical and dynamical simulations were performed for these particular periods. These extreme events are analyzed based on precipitation outputs from regional climate models (RCMs) and empirical statistical downscaling

(ESD) in comparison to weather station observations within the Uruguay River basin. Model outputs and observations are also used to force the macroscale hydrological Variable Infiltration Capacity (VIC) model to study the impact on river flows. Correlations are significant between observation and model simulated streamflow though with considerable spread. The 85th, 90th and 95th percentiles are calculated to determine the wet events and the 5th, 10th and 15th percentiles for the extremely dry events for each of the models and the observed data. Results indicate differences between the percentile values from model outputs and observations, and also on the date associated with each of the selected events. There are less differences in the dates associated with the 95th percentile in wet extreme cases and in general the degree of coincidence is smaller with RCMs. Streamflow results for extremely high and low percentiles show smaller differences than precipitation.

P.7.4: Effects of climate change on drought events on the Salar de Atacama

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Andean wetlands support a unique biological diversity with a high level of endemism. The Salar de Atacama (SA) is in an arid zone of Chile, where surface water and rainfall are scarce, considering the climate projections for the region, it is necessary to generate climate information at a local scale.
Projections of minimum (Tn), maximum temperature (Tx) and precipitation (pp) were made through statistical downscaling using 13 GCM under the RCP4.5 and RCP8.5 scenarios for the medium future (2046 - 2065), whose results were used to estimate potential evapotranspiration (PET) using Hargreaves and Samani equation. Standardized Precipitation Index (SPI) was estimated to analyze drought events.
Results indicate increases of Tn and Tx of up to 4°C (6°C) for the mean future according to RCP4.5 (RCP8.5) with respect to the historical period (1980 - 2005), in turn, the Tx presented increases of up to 2°C for both scenarios. The pp projections indicated increases in the Altiplano zone and decreases for the rest of the area exceeding 80% towards the coast.
The models used project increases in the ETP for the Peine, Linzor, Chiu-Chiu and El Loa Calama Ad stations. close to the SA, in addition to increases in the intensity of drought events with respect to the observed period (1980 - 2020) according to SPI-6 and SPI-12.
Considering drought estimates for the future, it is important to integrate future changes in land use planning, water management and adaptation plans.

Session 8: Benefits of convection-permitting climate modeled data for impacts assessments and policy making

P.8.1: Using a high-resolution regional climate model for studying urban climate evolution in cities of northwestern Europe

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Nowadays, cities account for nearly half of the world's population. Given the major environmental, economic, and health issues there identified, it is essential to better understand and evaluate precisely the expected impacts of climate change on urban areas and populations.
The latest advances in regional climate modeling allow simulations to be performed over longer time periods with finer horizontal resolutions of up to few kilometers. The scientific community emphasizes the considerable improvements linked to the use of these Convection-Permitting Models (CPMs), especially for the representation of small-scale phenomena, as well as for extreme weather events such as heat waves. Also, CPMs offer a very interesting modeling framework for urban studies, in particular through the explicit coupling with devoted urban parameterization.
In this study, the French weather forecasting model AROME adapted to climate simulations (CPM CNRM-AROME) and coupled to the Town Energy Balance model is used at 2.5 km resolution. Simulations were carried out over a large northwestern European domain as part of the EUropean Climate Prediction system (EUCP) project over an historical period (1996-2005) and mid- and longterm future periods (2041-2050 and 2090-2099) using the RCP8.5 scenario. This study aims to investigate the urban climate evolution in northwestern Europe cities (including urban heat island) in interaction with regional climate change, and to assess the impacts on populations.

P.8.2: Convection-Permitting Model Simulation based on Local Climate Zones (LCZs) for winter in Istanbul

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High resolution simulations at kilometre scales from convection-permitting models (CPMs) provide new avenues for studying the dynamics of urban regions that do not use deep convection parameterisation schemes. As a pilot investigation, a sensitive study was performed to explore the relationships between the thermal conditions and urban surface representation based on 11 types of Local Climate Zones (LCZs) in Istanbul during a winter week. Three surface schemes were considered. They are the single-layer Urban Canopy Model (UCM), the Building Environment Parameterization (BEP), and the Building Energy Model (BEM). Compared to the IMERG data, the performance of three surface schemes is comparable, although the overall BEM model performance is slightly better than the other two schemes based on correlations and root mean square errors.

The outputs of three different schemes all show that the relative positions of default land use classes are not different when the LCZ classes are introduced into simulations. Therefore, additional land use definitions based on LCZs only provide refined spatial details by redistributing energy within the area. Based on the relative positions between LCZ types, compact midrise zones (LCZ 2) have a higher temperature than open midrise zones (LCZ 5). From these pilot results, new experiments for different seasons are designed to explore how to use different regional configurations of LCZ types to promote thermal comfort and climate change resilience.

P.8.3: First assessment of long-term RegCM4 convection permitting simulations over the center-southeast of South America

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New developments in the Regional Climate Model version have been implemented in the last three years allowing the model to solve the processes in the scale of convection. In the context of the CORDEX FPS-SESA initiative (Flagship Pilot Studies-Southeastern South America) that established a collaborative network to study extreme precipitation events and its impacts, a long-term simulation for impact studies on agriculture and hydrology was required. In this study we analyze a long-term simulation, from June 2018 to 2020, using RegCM4 at convective permitting resolution (4 km of horizontal grid spacing). The simulation domain covers from center to southeast ($\sim$ 15o to 35oS) of South America and it was forced by ERA5 reanalysis. In this first assessment we compare the simulated monthly climatology with both fine resolution gridded data (MSWEP with 0.1o) and with selected local stations. Additionally, we assess the ability of long-term convective permitting simulation to capture long dry and wet periods since these kinds of events have great impacts in both hydrology and agriculture.

Contributions