ISIMIP
Inter-Sectoral Impact Model Intercomparison Project

PROCLIAS

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Book of abstracts

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Side events

Side event: FireMIP

1. The FLARE Workshop's Future Directions of Fire Science, and What it Means for Global Fire Modelling (Douglas Kelly).

Speaker: Douglas Kelly
Affiliation: UK Centre for Ecology & Hydrology

Abstract: Fire and wildfire events have come to epitomise our changing climate and environment, increasingly impacting people, ecosystems, policy and the wider Earth System. This is placing more and more demands on the fire science community to provide critical information needed to understand, mitigate, and adapt to their far-reaching consequences. The Fire, Land-use, and Climate Adaptation in a Rapid Evolving World (FLARE) initiative aims to bridge interdisciplinary gaps in fire science, including global fire modelling, and provide fire science a roadmap to meet this demand. Throughout the latter half of 2023, FLARE workshops and online engagement activities brought together fire scientists across various disciplines, including modelling, observations, physical and social scientists, policy, media and artists, and representatives of fire-prone communities, to facilitate these transdisciplinary discussions. Together, we identified three major challenges facing fire science:
* Fires' influence on carbon cycles
* The emergence of extreme fire events
* The profound impact of human activities and fire's role in society and policy
Global fire modelling is a crucial aspect of all three, but it cannot tackle them alone. We discuss the implications for our community, the gaps and weaknesses our models face when answering these challenges, and some exciting and novel advances we are making to integrate models with observations and other fire research disciplines - many coming from fireMIP. We would love feedback on the recommendations from FLARE. Through our interactive presentation, we will provide the opportunity to comment on how we can bring a more interdisciplinary approach to fire modelling. We would also like your thoughts on the best ways to continue engaging across fire science to meet the demands placed on us by fire's more prominent role in the world.

2. Enhanced future vegetation growth with elevated carbon dioxide concentrations could increase fire activity (Robert Allen)

Speaker: Robert Allen
Affiliation: University of California, Riverside

Abstract: Many regions of the planet have experienced an increase in fire activity in recent decades. Although such increases are consistent with warming and drying under continued climate change, the driving mechanisms remain uncertain. Here, we investigate the effects of increasing atmospheric carbon dioxide concentrations on future fire activity using seven Earth system models. Centered on the time of carbon dioxide doubling, the multi-model mean percent change in fire carbon emissions is 66.4+/-38.8% (versus 1850 carbon dioxide concentrations, under fixed 1850 land-use conditions). A substantial increase is associated with enhanced vegetation growth due to carbon dioxide biogeochemical impacts at 60.1+/-46.9%. In contrast, carbon dioxide radiative impacts, including warming and drying, yield a negligible response of fire carbon emissions at 1.7+/-9.4%. Although model representation of fire processes remains uncertain, our results show the importance of vegetation dynamics to future increases in fire activity under increasing carbon dioxide, with potentially important policy implications.

3. Equations for predicting Carbon Monoxide Emissions from Amazon Rainforest Fires (Sarah Gallup)

Speaker: Sarah Gallup
Affiliation: Colorado State University, USA

Abstract: Earth systems models (ESMs), which can simulate the complex feedbacks between climate and fires, struggle to predict fires well for tropical rainforests. This study provides equations that predict historic carbon monoxide emissions from Amazon rainforest fires for 2003-2018. We also include equations to convert the predicted emissions to burned area. Regressions of varying mathematical forms were fitted to one or both of two fire CO emission inventories. Equation accuracy was scored on r^2, bias of the mean prediction, and ratio of explained variances. We find that one equation is best for studying smoke consequences that scale approximately linearly with emissions, or for a fully coupled ESM with online meteorology. Compared to the deforestation fire equation in the Community Earth System Model, this equation's linear-scale accuracies are higher for both emissions and burned area. A second equation, more accurate when evaluated on a log scale, may better support studies of certain health or cloud process consequences of fires. The most accurate recommended equation requires that meteorology be known before emissions are calculated. For all three equations, both deforestation rates and meteorological variables are key groups of predictors. Predictions nevertheless fail to reproduce most of the variation in emissions. The highest linear r^2s for monthly and annual predictions are 0.29 and 0.40 respectively. The impossibility of matching both emission inventories simultaneously limits achievable fit. One key cause of the remaining unexplained variability appears to be noise inherent to pan-tropical data, especially meteorology.

Side event: FishMIP

1. Exploring Prince William Sound ecosystem under FishMIP Model Evaluation Protocol (Beatriz Dias)

Speaker: Beatriz Dias
Affiliation: University of Alaska, Fairbanks

Abstract: In Prince William Sound, Pacific herring has long been a critical forage species, that once supported both commercial and subsistence fisheries. However, in the last 50 years, the herring population has experienced significant changes, with a notable collapse in 1993. After 30 years the population has not recovered, with consistently low recruitment and biomass. The causes of the initial population collapse and lack of recovery are attributed to a combination of poor nutrition, infectious diseases, the effects of the 1989 Exxon Valdez oil spill, overfishing, and climate-related changes. Due to the ecological and societal importance of herring and the Prince William Sound ecosystem, we have joined FishMIP 3a protocol efforts to run historical climate simulations. We took the following steps: 1) built an Ecopath model to represent Prince William Sound marine ecosystem; 2) fit 33-year long times series of mortality, biomass, and landings for the fished functional groups in Ecosim, the dynamic portion of the mass balanced food web model; 3) developed double logistic curves of thermal envelopes for half of the 62 functional groups; and 4) developed the simulation set up with Sea Surface Temperature (GFDL-MOM6-COBALT2). Our aim in this exercise is to collaborate with the FishMIP Model Evaluation Protocol's goal to understand and reduce the uncertainty associated with FishMIP models through model evaluation under historical climate and fishing effort forcings.

2. BOATSv2: model development, evaluation and uncertainty (Kim Scherrer)

Speaker: Kim Scherrer
Affiliation: University of Bergen

Abstract: One of the current focus areas of Fish-MIP is to develop a common framework for model evaluation. In the global Fish-MIP model BOATS, recent developments (separate benthic-pelagic energy pathways; iron limitation of fish; spatially varying economic forcings) significantly increased the agreement between the simulated global fishing patterns and reality. These developments required a comprehensive model parametrization and evaluation process, including an estimate of model uncertainty. This presentation will describe the approach used to tune and evaluate BOATSv2, hopefully inspiring discussion about whether these approaches, or the insights from the process, can be of use for the Fish-MIP community. It will describe how uncertain parameters were handled during the model tuning and show how parameter uncertainty was addressed by confronting the model with a set of constraints from observations. While the approach might not be feasible for Fish-MIP models with larger numbers of parameters, the ranges of the parameter uncertainty in relation to other sources of uncertainty might still be informative. In addition, useful sources of evaluation data are highlighted.

ISIMIP Sector Meetings

Peat

1. Peatlands have the potential to emerge as significant contributors to future climate warming (Nitin Chaudhary)

Speaker: Nitin Chaudhary
Affiliation: Lund University

Abstract: Peatlands store a substantial amount of carbon in the terrestrial ecosystem. Peatlands are long-term sinks of organic carbon and a major natural source of atmospheric methane. The accumulation of carbon is a result of net primary production surpassing decomposition rates over millennia, whereas methane production is intricately linked to the anaerobic decomposition of carbon mass. These carbon-rich ecosystems are at risk of losing their carbon sink capacity and becoming a source of carbon dioxide and methane due to ongoing warming. In this study, we modelled the past and future trends of peatland carbon and methane fluxes and their influence on the climate system. We found that peatlands > 25 °N will remain a carbon sink and methane source under a low-warming scenario (RCP2.6) but they would shift from being not only a source of methane but also of carbon dioxide under a high-warming scenario (RCP8.5) by the mid-21st century leading to a strong radiative forcing (0.25 W m-2) by the end of the 23rd century. This underlines the potential warming feedback in which peatland radiative forcing on the climate system would shift from negative to positive in the future.

Biodiversity

1. Will land-use change continue to be the main driver for biodiversity loss in the future? (Edouard Davin)

Speaker: Edouard Davin
Affiliation: University of Bern

Abstract: In this study, we combine future climate scenarios and land-use pathways derived from integrated assessment modeling (IAM) to assess their impact on biodiversity. To this end, we use the global simulations with species distribution models and two climate scenarios following the ISIMIP2b simulation protocol and apply a land-use filter on the species occurrence probabilities to determine the implications for the world's amphibians, mammals and reptiles at a 0.5° resolution. The land use data used to include future projections of land-use change is the Land Use Harmonization dataset v2 (LUH2) which are matched with the IUCN Habitat and Classification schemes to refine the climate envelope and filter out regions where species cannot persist. Species richness loss is exacerbated if we combine climate and land use change, with greatest losses in Sub-Saharan Africa and Caribbean & Mesoamerica. In some areas, land use change reduces species richness losses, thus land use change can also mitigate biodiversity decline. Our findings therefore highlight the need to include both climate and land use change when assessing projected biodiversity impacts and suggest that land use decisions will be critical not only for climate change mitigation, but also to curb biodiversity loss.

2. Comprehensive Expansion: Advancements in Downscaling Algorithms Beyond Temperature and Precipitation for the CHELSA Dataset (Dirk Nikolaus Karger)

Speaker: Dirk Nikolaus Karger
Affiliation: Swiss Federal Research Institute WSL

Abstract: The current iteration of the CHELSA-W5E5 dataset, utilized in ISIMIP3a, encompasses essential climate variables such as precipitation rates, air temperature, and shortwave solar radiation. However, numerous impact models demand a broader spectrum of data beyond these primary variables. In response, we have devised terrain-based downscaling algorithms to incorporate additional critical variables widely used in climate studies, including relative humidity, longwave solar radiation, wind speed, surface air pressure, and total cloud cover. This presentation illuminates the efficacy of these newly developed downscaling algorithms in comparison to observational data, demonstrating their potential integration within the ISIMIP framework. Our findings reveal that kilometer-scale, daily climate variables, derived from our downscaling algorithms, consistently outperform interpolation-based methodologies. Furthermore, we showcase that these algorithms yield results comparable to those achieved through dynamical downscaling employing numerical climate models. This research contributes valuable insights into enhancing the completeness of climate datasets, ensuring a more comprehensive representation of environmental conditions for diverse applications.

3. GEO BON EcoCode - pushing towards (regional) biodiversity model intercomparisons including process-explicit models (Damaris Zurell)

Speaker: Damaris Zurell
Affiliation: University of Potsdam

Abstract: Time is running out to limit further devastating losses of biodiversity. Addressing the biodiversity crisis requires accurate predictions about which species and ecosystems are most at risk to ensure efficient use of limited conservation and management resources. Yet, our understanding and predictive capacity of ongoing biodiversity dynamics remains limited. Part of the problem could be the sheer complexity of nature and the human-mediated impacts, but also limited data and limited availability of flexible and easily modified mechanistic models. Current applications are heavily biased towards correlative models and towards the population and species level. Existing mechanistic models cannot not easily be reconfigured for other species or systems, omit key biological processes, and cannot accommodate feedback with Earth system dynamics. To fill these gaps, we envision an adaptable, accessible, and universal biodiversity modelling platform that is able to forecast essential biodiversity variables, from the gene to the ecosystem level. Wider usage of mechanistic biodiversity models should be further facilitated by a toolbox with easier-to-use methods for data integration and model validation, and best practice guidelines. To address these needs and coordinate efforts, a new working group on biodiversity modelling and knowledge-to-action hub are being launched within the Group on Earth Observations Biodiversity Observation Network (GEO BON). In the presentation, I outline the working group goals and activities and how they could support ISIMIP's mission.

Water quality

4. Future global water scarcity including quality under climate and socioeconomic change (Edward Jones)

Speaker: Edward Jones
Affiliation: Utrecht University

Abstract: Inadequate availability of clean water presents systemic risks to human health, food production, energy generation and ecosystem functioning. While future alterations to water demands and availability are widely projected to exacerbate water scarcity, the impact of changing water quality is largely unknown. Leveraging a newly-developed global surface water quality model (DynQual) which is coupled to a global hydrological model (PCR-GLOBWB2), we make the first projections of future global water scarcity including both water quantity and quality aspects.
We consider three combined RCP-SSP scenarios (SSP1-RCP2.6, SSP3-RCP7.0 and SSP5-RCP8.5), each of which simulated with bias-corrected CMIP6 climate input from five GCMs provided within ISIMIP3b, to encompass a range of possible future conditions and to capture uncertainty inherent in the climatological (GCM) projections. Simulated monthly sectoral water demands (domestic, industrial, livestock and irrigation), water availability (e.g. discharge) and water quality (total dissolved solids, biological oxygen demand and fecal coliform) for 2005-2100 are used as basis for quantifying clean water scarcity, which we express in terms of population exposure.
We find that 55% of the global population (~3.8 billion people) are currently exposed to clean water scarcity at least one month per year, increasing to 56 – 66% by the end of the century based on different plausible scenarios for climate change and socioeconomic development. Increases in exposure are largest in developing countries – particularly in Sub-Saharan Africa – driven by a combination of water quantity and quality. Strong reductions in both human water use and pollution are therefore necessary to minimise the impact of future water scarcity on humans and the environment.

5. Mapping hotspots for present and future water pollution in Africa using SDG indicator 6:3.2 (Maria Theresa Nakkazi)

Speaker: Maria Theresa Nakkazi
Affiliation: Vrije Universiteit, Brussel

Abstract: Efficient monitoring and reporting of Sustainable Development Goal (SDG) indicator 6.3.2 is essential for assessing progress toward good ambient water quality. However, data limitations, particularly in developing regions such as Africa, hinder accurate assessment of water quality in lakes and rivers. This study addresses this challenge by employing modelling to map progress of the SDG indicator 6.3.2 for Africa. We utilized model simulations from two water quality models; DynQual and SWAT+ to generate water quality indexes (WQIs) using four core parameter groups at level I reporting namely salinity (Total Dissolved solids), nitrogen (Total Nitrogen), phosphorus (Total Phosphorus) and oxygen (Biological Oxygen Demand). Model simulations were compared to national target values to derive country-level WQIs. For historical analysis, WQIs were calculated for the last decade (2010-2019), allowing for hotspot identification and comparison with previous reports. Additionally, we intend to compute WQIs under different future scenarios to assess whether established water quality thresholds would be met in 2030, 2050, or 2100. This study's robust methodology for SDG mapping significantly enhances our understanding of both past and future water quality dynamics in Africa, contributing to the achievement of SDG 6 and broader environmental sustainability objectives across the continent.

Agriculture

1. Validation of ISIMIP 3 crop simulations (Cornelia Auer)

Speaker: Cornelia Auer
Affiliation: Potsdam Institute of Climate Impact Research Centre

Abstract: The understanding of potential impacts on crop yields and altered resource availability under climate change is essential. However, recent modelling results from AgMIP show strong divergence in globally projected crop yields. In this paper we deliver a validation of crop yield simulations against historic benchmark data from the FAO. Based on multivariate regression we analyze how well global gridded crop models reproduce historic crop yields in various global regions. We find that especially low producing countries suffer from higher model disagreements. Our analysis further systematically identifies which model characteristics influence performance most for specific regions. Based on our statistical analysis we provide and evaluate an ensemble projector with regionally varying model weights according to the assessed historical model performance in each region. These insights can help to improve future model efforts and support policy makers better in planning for adaptation in specific regions.

Forests (TG2.5)

1. Ecosystem dynamics in arid conditions should be increasingly considered in vegetation model`s evaluation and improvement: The case of model iLand in Spanish pine forests (Agnish Kumar Das)

Speaker: Agnish Kumar Das
Affiliation: Czech University of Life Sciences, Prague, Czech Republic

Abstract: Forest mortality from drought, wildfires, windthrows, insect outbreaks and diseases increase globally and affects ecosystem functioning and the provision of ecosystem services. Dynamic Ecosystem Models have become essential tools for assessing forest development under changing environmental conditions. Nonetheless, models' capacity to simulate the emerging dynamics, including the climatically intensified tree mortality and new disturbance interactions, remains limited. Here, we investigated the capability of a process-oriented ecosystem model iLand to simulate the development of *Pinus sylvestris* stands, including the drought-induced mortality, near the xeric limit of species distribution, a context where the model had not been previously applied. Five simulation plots designed based on 55 Spanish forest inventory plots distributed within an elevation range 645-1,364 m a.s.l. were simulated with iLand from 2007 to 2015. iLand is an individual-based climatically sensitive forest model with an explicit water cycle. The stress-related mortality is driven by the carbohydrate status of a tree that depends on the net primary productivity, the biomass in the reserve pool, and the turnover rate for fine roots, foliage, and the reserve pool. We found that the simulated stand increment aligned with the pattern of the observed increments. In the simulations, the driest sites failed to regenerate, contrasting with the real conditions where a regeneration cohort was present. Both simulated and observed stand mortality were associated with the occurrence of dry conditions. However, contrary to the observed mortality, the simulated mortality was more strongly associated with the stand density. These findings suggest that the progressive aridification of European forest landscapes presents a new challenge for appraising ecosystem dynamics using simulation models. Testing the models against forest monitoring data and ecosystem experiments from the species rear edge conditions, and improving model parameters accordingly, should receive an increased attention in future research endeavors.

2. Testing robustness and plausibility of Biome-BGCMuSo simulations at a large scale (Katarina Merganicova)

Speaker: Katarina Merganicova
Affiliation: 1. Department of Biodiversity of Ecosystems and Landscape, Institute of Landscape Ecology, Slovak Academy of Sciences, Slovakia
2. University of Life Sciences Prague, Faculty of Forestry and Wood Sciences, Czech Republic

Abstract: A permanent development of models requires their repeated testing to ensure that feasible results are obtained in applications. We evaluated the robustness and plausibility of the new Biome-BGCMuSo across environmental space using a set of 87 forest research plots located within 5 European countries (Poland, the Czech Republic, Slovakia, Hungary, Croatia). The analysis was based on the comparison of trends along elevational, soil, and climatic gradients revealed in the simulated output with those reported in literature and derived empirical data acquired from field observations. Although we primarily focused on carbon stocks in stem, litter and soil, we examined also other variables describing carbon cycle, e.g. carbon stocks in roots, foliage, or coarse woody debris, as well as some carbon fluxes, particularly heterotrophic respiration. The responses of simulated outputs to environmental characteristics were examined using Spearman correlations, linear and quadratic regressions and generalised additive models. All analyses were performed in the R environment. The results confirmed that the model simulations were robust and plausible in the tested region spanning from the Adriatic to the Baltic Sea. Most examined variables followed the trends derived in empirical studies confirming that the new version of Biome-BGCMuSo is capable of accurately simulating beech forest ecosystems in Central Europe and can be used for comprehensive large-scale experiments.

3. Reconciling climate-smart forestry in Europe with constraints on forest protection and timber demand (Konstantin Gregor)

Speaker: Konstantin Gregor
Affiliation: Technical University, Munich

Abstract: Forests are vital for climate change mitigation, yet they also provide timber and numerous other ecosystem services. Furthermore, they require adaptation to ongoing climate change. Climate-smart forestry aims to combine mitigation, adaptation, and the provision of ecosystem services. Developing strategies for climate-smart forestry in Europe is a complex undertaking. This complexity is further complicated by external constraints, such as the desire to strictly protect 10% of the land area, as postulated by the EU Biodiversity Strategy for 2030 and the EU Forest Strategy for 2030. On the other hand, increasing wood demand poses additional constraints on timber production. Here, we present a methodology how these demands could be reconciled in the development of European strategies and what the impacts on the forest landscape would be.

PROCLIAS TG3.11: Heat warning catalogue

1. Changes in heat-mortality over time: Are countries adapting to heat fast enough? (Samuel Lüthi)

Speaker: Samuel Lüthi
Affiliation: ETH Zurich

Abstract: The risk of heat mortality is ever-increasing with the rapidly changing climate. However, several studies that project future levels of heat mortality have been criticized as being over-pessimistic, as these studies don't reflect communities' ability to adapt to heat. Adaptation to heat is highly complex and complicated by the changing climate and other mega-trends such as ageing societies or urbanization. In this project, we thus want to assess past trends of heat mortality across locations, by disentangling the trends into the three underlying drivers - climatic change, population change and adaptation. Concretely, we model the relationship between daily temperature and mortality using a well-established approach in climate change epidemiology. The relationship expresses the change in mortality risk at specific temperature values against an optimum temperature (the so-called temperature of minimum mortality, MMT). We model this relationship for discrete three-year intervals for more than 500 locations across the globe. In a second stage, we apply a longitudinal multivariate random-effect meta-regression to evaluate changes in heat-related mortality risks and account for time, local warming and changes in populations structure as predictors with country and city as random effects. By utilizing this setup, we are able to examine how heat mortality levels in communities have changed over time. Our findings show that despite adaptation, heat-related deaths are increasing in many countries. However, the extent and effectiveness of adaptation differ greatly among countries and regions. While changes in population dynamics, such as ageing societies and general health trends, have a lesser impact on overall mortality levels compared to the effects of climate change and adaptation, they can still have a significant influence on the outcomes observed.

2. Assessing the effects of the heat health warning system on mortality in 15 German cities: A difference-in-differences approach (Veronika Huber)

Speaker: Veronika Huber
Affiliation: Ludwig Maximilian University of München

Abstract: The background of the study is that the heatwaves pose significant risks to human health, and implementing heat health warning 15 systems (HHWS) has been widely adopted as a preventive measure. However, the effectiveness of the German HHWS, implemented in 2005, in reducing mortality during heat episodes across different cities has scarcely been researched. This study aims to assess the effect of HHWS on mortality during heat episodes in 15 major cities in Germany and explore city-specific factors influencing the effectiveness of heat alerts. Methods used in the study are daily all-cause mortality data during the warm-season months (May-September) from 1993 to 2020 were linked with heat alert data and meteorological information. A difference-in-differences (DID) approach was employed to estimate the city-specific effects of heat alerts on mortality. In the second-stage meta-regression models were used to pool the city-specific estimates and examine the heterogeneity across cities. The analysis revealed a significant but small protective effect of heat alerts on mortality across all cities studied (DID estimate = -0.16, 95% confidence interval: -0.29 to -0.04). However, substantial variation in the city-specific effects was observed, with some cities exhibiting significant reductions in mortality during heat episodes after the HHWS implementation while others showed no significant effect. City-specific factors, such as population size, population density, and the presence of blue and green urban areas, were found to influence the impact of heat alerts on mortality. The conclusion of the study is that the implementation of HHWS in Germany has led to a decrease in mortality during heat episodes in the studied cities. However, the effectiveness of heat alerts varied significantly across the cities, suggesting the importance of considering city-specific factors. Understanding these factors can help improve the effectiveness of HHWS and tailor interventions to address the specific needs of different urban areas.

Opening session

1. Keynote speech on ‘Impact assessments and scenarios in the Seventh IPCC Assessment Cycle: overview of current discussions’ (Bart van den Hurk)

Speaker: Bart van den Hurk
Affiliation: Deltares

Abstract: Just a few days after the IPCC scoping meeting of the Special Report on Climate Change and cities we will reflect on the ambitions of the current 7th IPCC Assessment cycle. A clearly articulated ambition to be not only policy relevant but also be explicitly oriented at the solutions to existing climate challenges implies a relatively strong involvement of practitioners into the scoping and assessment process. It also calls for an assessment of scientific studies that document the prospects, limitations, enabling conditions, barriers and trade-offs of climate policies, both in the domains of mitigation and adaptation. In addition, the current cycle plans to update the 1994 IPCC guideline on climate impacts and adaptation, including a coverage of relevant indicators and metrics.

It is clear that the impact modelling research community has a lot to offer to the upcoming IPCC assessments. We will elaborate on the potential implications of the chosen emphasis during this cycle.

2. WG1: Automatic quality check / quality assessment of impact model output (Hannes Müller Schmied, Jochen Klar)

Speakers: Hannes Müller Schmied(1,2), Jochen Klar(3), Matthias Büchner(3), Gerbrand Koren(4)

Affiliations:
1. Goethe-University Frankfurt
2. Senckenberg SBiK-F Frankfurt
3. Potsdam Institute for Climate Impact Research, Potsdam,
4. Copernicus Institute of Sustainable Development, Utrecht

Abstract: Process-based impact models are frequently used for a range of applications and are valuable for simulating environmental processes in a changing world. Model Intercomparison Projects like the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP, www.isimip.org) act as an umbrella for various sectors (e.g. water, agriculture, health) and numerous modelling teams that are following a common modeling protocol that enables model intercomparison and (cross-) sectoral multi-model impact assessments. However, such assessments require reliable model outputs which can be evaluated from two perspectives.

First, a quality control (QC) check ensures that simulated files follow the formal standards defined in the modelling protocol and includes plausibility checks. For example, structural consistency, format conventions and correct metadata entries can be assessed. Also, in cases where the range of a specific variable exceeds plausibility limits (e.g. unrealistically high precipitation rates), such a tool can facilitate error checking. The tool can be used even before upload, which is particularly helpful with the high data volume we encounter in ISIMIP. It helps avoiding the loss of valuable research time on analysis of incorrect or incomplete data.

Second, a quality assessment (QA) tool compares model output to already existing model outputs, observational data or sectorial benchmark models. This is not only important to find errors in the data during the publication process, but can also be used for model development and improvement as it can highlight benefits and limitations of models for e.g., specific model configurations. It is also able to identify models that are best suited for specific regions and research questions.

Within the EU COST-Action “Process-based models for climate impact attribution across sectors“ (PROCLIAS), the aim is to establish a QC/QA workflow for the ISIMIP models. This presentation provides experiences gained with the already operationally implemented QC tool and the state of development of the QA tool. This presentation also calls for an exchange of ideas and a continuation of the efforts beyond PROCLIAS.

ISIMIP3a results (“from too dry to too wet”)

1. The fingerprint of climate change in crop losses during recent heatwaves and droughts (Jonas Jägermeyr)

Speaker: Jonas Jägermeyr
Affiliation: Columbia University/NASA

Abstract: The climate change signal in crop losses associated with historical extreme weather events such as heatwaves and droughts remains unclear. Here we leverage latest crop model ensemble simulations from AgMIP’s global gridded crop model initiative (GGCMI) to evaluate yield losses during heatwave and drought events recorded in the EMDAT disaster database. A new counterfactual weather product based on the W5E5 reanalysis is used in conjunction with the factual W5E5 product to isolate the climate change contribution to these losses simulated by an ensemble of at least 6 state-of-the-art process-based crop models. Preliminary results indicate that management adaptation and higher atmospheric CO2 concentrations contribute to increasing average crop yields in many world regions. However, despite positive yield trends, normalized crop losses during droughts and especially during heatwaves become more severe over time compared with the counterfactual simulations assuming a weather forcing without climate change. This study provides new quantitative evidence that climate change exacerbates the adverse impacts of extreme weather events in global agriculture.

2. Attribution clarifies the complex impacts of climate change on vegetation biomass change. (Akihiko Ito)

Speaker: Akihiko Ito
Affiliation: National Institute for Environmental Studies, Japan

Abstract: Vegetation biomass represents biospheric structure and functions including carbon storage and depends on environmental factors and socioeconomic development. However, the mechanisms underlying vegetation biomass change are not fully elucidated, due to the complexity and heterogeneity of the involved processes. We attribute changes in global vegetation biomass to impacts of major driving forces, elevated CO_2 level, land-use, and climatic change, based on experimental multi-model ensemble simulations with state-of-the-art vegetation models. At the global scale, historical (1901–2019) vegetation biomass change was mostly explained by increasing CO_2 and land-use, mainly in the tropics; the impact of climatic change was minor. A counterfactual experiment with detrended forcing data revealed that regional differences concealed climate impacts globally. Northern vegetation biomass was enhanced by warming, while tropical vegetation biomass was suppressed. These dynamics were further complicated by changes in wildfire. The divergent nature of impacts attributable to climate change may be attenuated by further warming.

3. Impacts of observed climate change on northern peatland hydrology: first results from the ISIMIP peatland sector (Michel Bechtold)

Speaker: Michel Bechtold
Affiliation: Department of Earth and Environmental Sciences, KU Leuven

Abstract: Over the last two decades, peatland-specific processes were included in several global land surface models. Implementations were realized in very different ways which originates from the constraints given by the existing model structure into which the adaptations for peatlands were integrated but also from modeler choices dealing with challenges in modeling peatland ecosystems. The peatland sector in ISIMIP offers a new platform to systematically compare the existing global peatland models, to learn about the performance of the different approaches, and to analyze their responses in climate change scenario simulations. In this presentation, we will provide preliminary results of an evaluation of the hydrological variables of the first model outputs in the peat sector. In the first part, model performance will be assessed with available hydrological ground truth data from peatlands, in particular groundwater levels. In the second part, output from scenario simulations will be used to analyze the impact of past climate change on peatland hydrology.

4. Changing flood processes under future climate scenarios (Lina Stein)

Speaker: Lina Stein
Affiliation: University of Potsdam

Abstract: Climate and anthropogenic change increasingly affect flood magnitude, frequency, and timing. However, the variability of drivers, catchments and flood generating processes means these changes are not the same everywhere. Future snowmelt floods will likely be more constrained towards more Northern regions and higher elevations, while extreme rain floods might become more severe in warmer parts of the world. Studying diverse and changing flood processes at the global scale provides a rich database both within and across catchments. While changing flood patterns (e.g. magnitude, frequency, timing…) have been studied, much less is known about changing flood processes. This is a critical knowledge gap given that the most extreme floods are often caused by processes different from the dominantly occurring process in a catchment. These events can reach unexpected and threatening magnitudes or timings. We propose to apply an existing global flood classification method (Stein et al, 2020, HP) to the (daily) outcomes of several global hydrological models within the ISIMIP3 framework. Flood events will be classified as caused by snowmelt, rain-snow, intense short or long rainfall, excess rainfall or other possible causes. Our hypothesis is that the combination of different climate projections and global hydrological models allows for a robust evaluation of future flood generating processes and extreme events.

5. Towards validating reservoir operations in global hydrological models using satellite remote sensing – A case study in the CONUS (Naota Hanasaki)

Speaker: Naota Hanasaki
Affiliation: National Institute for Environmental Studies

Abstract: There has been less validation of reservoir operation simulations by global hydrological models, primarily because of limited observational data. However, recent advancements in satellite remote sensing have facilitated the collection of data regarding water surface area and elevation, thereby providing the ability to validate reservoir storage. In this study, we sought to establish a methodology for validation and intercomparison of reservoir storage within global hydrological model simulations using satellite-derived data. Accordingly, we chose two satellite-derived reservoir operation products to create monthly time series storage data for seven reservoirs in the contiguous United States (CONUS) , with access to long-term ground truth data. We assessed two global hydrological models that participated in the Inter Sectoral Model Intercomparison Project (ISIMIP) Phase 3 project, H08 and WaterGAP2, with three distinct forcing datasets: GSWP3-W5E5 (GW), CR20v3-W5E5 (CW), and CR20v3-ERA5 (CE). The results indicated that WaterGAP2 generally outperforms H08; the CW forcing dataset demonstrated superior results compared with GW and CE; the DAHITI showed better consistency with ground observations than GRSAD if temporal coverage is sufficient. Overall, our study emphasizes the potential uses of satellite remote sensing data in reservoir operations validation. The results highlight the relative performances of different hydrological models and forcing datasets, yielding insights concerning future advancements in reservoir simulation studies.

Poster Session

1. Examining the contribution of human induced climate change on global soil moisture drought characteristics (Aristeidis Koutroulis)

Presenters : Aristeidis Koutroulis, Manolis Grillakis and ISIMIP Global Water Sector Coordinators and Modellers
Affiliation: Technical University of Crete

Abstract: Drought is generally considered a slow process natural hazard. However, the faster onset and strength of recent events have received great attention. Climate change and human activities can both play a role in altering the characteristics of droughts, including their speed of development and intensity. Climate change can, for example, indirectly impact droughts by changing the amount and distribution of precipitation, while human activities, such as land management, can directly alter the water content of the soil. In this study, we use outputs of the ISIMIP Global Water models driven by the counterfactual stationary ISIMIP3a climate dataset, a hypothetical climate without climate change, and transient land use changes based on observations. We use soil moisture as a water deficit indicator and a framework for calculating the hydrological drought propagation speed to define drought characteristics. We compare results against those calculated from historical runs with climate-related forcing based on observations (factual) to examine historical imposed long-term changes attributed to human-induced climate change. Our results show that climate change could significantly impact the speed of development and intensity of droughts. Some regions like South America rainforest, Europe and South Australia are simulated as hot spots of more fierce droughts, while others (e.g. East African mountains) may have faced milder droughts as a result of climate change. These changes can have important consequences for the productivity of agricultural lands, the health of ecosystems, and the availability of water for human use. Future climate change highlights the implications of faster droughts on risk management and challenges the research of drought hazard prediction.

2. Graphical representation of global water models participating in the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP2b) (Hannes Müller Schmied)

Presenter: Hannes Müller Schmied(1,2), Laura Müller(1), Simon Gosling (3) and ISIMIP2b model diagram team
Affiliation: 1. Goethe-University Frankfurt
2. Senckenberg SBiK-F Frankfurt
3. University of Nottingham

Abstract: Numerical models are simplified representations of the real world at a finite level of complexity, which means they are not exhaustive in the number of processes they include. Global water models are used to simulate the global water cycle and their outputs are used to estimate important natural and societal issues, including water availability, flood risk, and ecological functioning. Whilst global water modelling is an area of science that has developed over several decades, and individual model-specific descriptions exist for some models, there has to date been no attempt to visualize how several models work, using a standardized visualization framework. Here, we address this gap, by presenting a set of visualizations of several global water models participating in the Inter-Sectoral Impact Model Intercomparison Project phase 2b. The diagrams were co-produced between a graphics designer and in total 16 modelling teams, based on extensive discussions and pragmatic decision-making that balanced the need for accuracy and detail against the need for effective visualization. The model diagrams are based on a standardized "ideal" global water model that represents what is theoretically possible to model with the current generation of state-of-the-art global water models. Model-specific diagrams are then copies of the "ideal" model diagram, with individual processes either included or greyed out. As well as serving an educational purpose, we envisage that the diagrams will help researchers in and outside of the global water model community to select the right model(s) for specific applications, stimulate a community learning process, and identify missing components to help direct future model developments.

3. Thirsty sectors: a layered model for managing scarce water resources (Ioan Sabin Taranu)

Speaker: Ioan Sabin Taranu
Affiliation: Vrije Universiteit Brussels

Abstract: Global water scarcity presents a significant challenge for sustainable resource management. With the increasing demand for water across various sectors and growing impacts of climate change, there is a need for better modelling tools to support efficient water allocation applications, especially in water scarce regions. At the same time, current Global Hydrological and Land Surface Models (GHMs/LSMs) ignore or oversimplify the representation of sectoral competition when water supply is limited, without accounting for regional environmental, economic, social, political and technological factors. In this poster, we introduce a novel modelling framework designed to capture the sectoral competition when water is scarce. Our approach is based on integrating together existing data on sectoral demands, water availability, socio-economic drivers, and national/subnational statistics to infer better ways of allocating water, when limited, between various sectors. This ongoing project seeks to enhance the understanding of competitive water use among sectors, with the ultimate goal of influencing advancements in GHMs/LSMs to more effectively reflect human water management practices. A key objective is to develop this model as a standalone tool, offering potential utility for water managers and policymakers. This tool is designed to aid in optimizing water usage and fostering sustainable development, addressing a critical need in contemporary water resource management.

4. Assessing the impact of climate change on erosion processes near bridges over rivers – data and methodological challenges (Kristina Potocki & Martina Lacko)

Speaker: Kristina Potočki, Martina Lacko
Affiliation: University of Zagreb Faculty of Civil Engineering

Abstract: The increasing intensity and frequency of extreme climate events are associated with an increase in flood events and, consequently, with changes in hydraulic and geomorphological processes in rivers. The variability of discharges can lead to increased erosion of the riverbed and scouring near bridges, compromising infrastructure safety. Possible methodological approaches to modeling scour near bridges under the influence of hydrological and meteorological parameters are presented and an overview of the challenges of incorporating different climate change scenarios and data availability is given. The R3PEAT ("Remote Real-Time Riprap Protection Erosion Assessment on large rivers") project, funded by the Croatian Science Foundation, will investigate the influences of these hydrological processes on riverbed erosion near bridges on rivers in Croatia.

5. Global warming is projected to lead to increased freshwater growth potential and changes in pace of life in Atlantic salmon Salmo salar (Adrian Rinaldo)

Speaker: Adrian Rinaldo
Affiliation: University College Cork, Marine Institute

Abstract: Global warming has been implicated in widespread demographic changes in Atlantic salmon Salmo salar populations, but projections of life-history responses to future climate change are lacking. Here, we first exploit multiple decades of climate and biological data from the Burrishoole catchment in the west of Ireland to model statistical relationships between atmospheric variables, water temperature, and freshwater growth of juvenile Atlantic salmon. We then use this information to project potential changes in juvenile growth and life-history scheduling under three shared socioeconomic pathway and representative concentration pathway scenarios from 1961 to 2100, based on an ensemble of five climate models. Historical water temperatures were well predicted with a recurrent neural network, using observation-based atmospheric forcing data. Length-at-age was in turn also well predicted by cumulative growing degree days calculated from these water temperatures. Most juveniles in the Burrishoole population migrated to sea as 2-year-old smolts, but our future projections indicate that the system should start producing a greater proportion of 1-year-old smolts, as increasingly more juveniles cross a size-based threshold in their first summer for smoltification the following spring. Those failing to cross the size-based threshold will instead become 2-year-old smolts, but at a larger length relative to 2-year-old smolts observed currently, owing to greater overall freshwater growth opportunity. These changes in age- and size-at-seaward migration could have cascading effects on age- and size-at-maturity and reproductive output. Consequently, the seemingly small changes that our results demonstrate have the potential to cause significant shifts in population dynamics over the full life cycle. This workflow is highly applicable across the range of the Atlantic salmon, as well as to other anadromous species, as it uses op enly accessible climate data and a length-at-age model with minimal input requirements, fostering improved general understanding of phenotypic and demographic responses to climate change and management implications.

6. How multi-sectoral climate-related risks could cumulate and affect livestock in West Africa (Audrey Brouillet)

Speaker: Audrey Brouillet
Affiliation: ESPACE-DEV, Univ Montpellier, IRD, Univ Guyane, Univ Reunion, Univ Antilles, Univ Avignon, Maison de la Télédétection, 500 rue Jean-François Breton, F-34093 Montpellier, Cedex, France

Abstract: A large range of climate change impacts is expected during the twenty-first century in vulnerable regions such as West Africa, where local populations largely rely on livestock systems as their main food production and income source. As climate change threatens livestock systems in various ways, here we assess how regional livestock could be exposed to cumulated climate-related stressors in the future. Using the world's largest multi-model climate impacts simulations database ISIMIP, we find that a large part of West Africa will experience at least 5–6 cumulated multiple climate stressors before the 2030s, including amplified severe heat stress conditions and flood risks. Consequently, about 30% of the current total regional livestock could be exposed to these cumulated stressors, with sheep and goat as the most affected species (~40%). The related publication brings new quantifications that may help policy makers to prioritize decisions regarding each sectoral impact, and that could prepare local populations to face multiple climate-related impacts.

7. Biosphere destabilization in ISIMIP3b scenarios (Fabian Stenzel)

Speaker: Fabian Stenzel
Affiliation: Potsdam Institute of Climate Impact Research Centre

Abstract: Biosphere integrity is a key planetary health indicator often missing from future scenario analyses, not least because its complexity makes it hard to compute. We have developed and applied two complementary indicators (https://doi.org/10.5194/egusphere-2023-2503) that assess human pressure on biomass production (based on Human Appropriation of NPP) and the corresponding risk of ecosystem degradation (based on the ecosystem change metric Gamma). They are based on simulations with the dynamic global vegetation model LPJmL and enable mapping of current spatial patterns of these anthropogenic biosphere modifications and appropriations. Results indicate that large regions globally show biomass modification and extraction of over 25% of the preindustrial potential natural net primary production. The human appropriation, together with climate change, leads to drastic alterations in key ecosystem variables, suggesting a high risk for ecosystem destabilization. We now apply our indicators to future scenario runs based on ISIMIP3b inputs. We see strong differences in biosphere integrity between socioeconomic pathways, especially in regions with increasing land use intensity, deforestation, management, and climate impacts. Potentially regions with a high risk for Ecosystem destabilization can be identified when comparing ssp585soc with ssp126soc or the current state.

8. Climate change impact on wireless communications (Louis-Francois Pau)

Speaker: Louis-François Pau
Affiliation: CBS, Erasmus University, Upgötva

Abstract: Climate research has almost not looked at the implications of climate change upon key infrastructures which human lives and cross-sectoral operations rely upon. This paper reports on research on climate change impacts on wireless communications (5G, 6G and satcoms) which sustain human communications and operations , including climate impact mitigation systems. Gases in the Earth's atmosphere can absorb and attenuate electromagnetic waves in specific frequency ranges. This absorption is due to the rotational and vibrational modes of gas molecules, that the absorption of electromagnetic waves by water vapor varies with frequency, temperature, and concentration of water vapor in the atmosphere. The absorption characteristics are typically represented by absorption coefficients or specific absorption lines associated with different vibrational or rotational modes of water molecules. Because of the interplay between internationally regulated spectrum bands, atmospheric propagation characteristics, and the climate change induced changes in humidity, atmospheric currents, & chemical air composition mix, there is a significant change in the spectrum efficiency and power levels of Next Generation Node B (gNodeB) radio base stations that allow mobile phones to connect to 3G, 4G and 5G mobile networks. They exploit Orthogonal Frequency Division Multiple Access (OFDMA) and are part of NG-RAN (Next Generation Radio Access Network). Thus the climate change drives altogether changes in communications coverage, radio network power consumption, as well as aggregated end user user equipment (UE) power consumption , at a time where wireless data flows and data rates are surpassing fixed networks and IEEE 802.11x (WiFi). As wireless communications and propagation rely on highly non-linear phenomena, and climate change models must in a first approximation be regionalized to link to by traffic density estimates , this research relies on extensive computing .It has direct impact on gNodeB cell density, real estate via network planning, systems design, regulations (energy, communications), emissions and ultimately also on the feasibility of some climate adaptation systems. The paper will report the methodology, models, and some of the results obtained. A consortium has been assembled for a large EU project on this subject starting in Fall of 2024.

9. Unveiling the Value of Cultural Forest Services: Overcoming Analytical Challenges for Informed Policy Decisions (Melania Michetti)

Speaker: Melania Michetti
Affiliation: ENEA -Italian National Agency for New Technologies, Energy and Sustainable Economic Development

Abstract: A growing body of literature focuses on assessing the significance of cultural services offered by forests. However, the majority of analyses often yields results that lack proper contextualization within the comprehensive array of forest ecosystem services. Firstly, many analyses treat cultural services as a singular dimension, leading to an underrepresentation of potential trade-offs between cultural services and provisioning or regulation services. Additionally, these studies lack the exploration of trade-offs occurring within the broader category of cultural services itself. Lastly, most analyses exclusively consider values associated with the current state forest ecosystems, disregarding future directions in forest management and/or conditions due to environmental changes. A preliminary and precise analysis of the concept of cultural services and their components can address the aforementioned shortcomings and convey more nuanced and appropriate messages for policymakers. In this regard, stakeholder engagement becomes a crucial step in accurately defining the framework for economic evaluation. We present a successful stakeholder engagement plan developed within the ForestNavigator project (https://www.forestnavigator.eu/) and demonstrate how the derived outcomes may inform the design of a Stated Preference Approach. By employing this survey-based method, we assess individuals' preferences and values regarding cultural services, in addition to regulation and provisioning, across four EU case studies. In doing so, we encompass various scenarios with varying levels of policy ambition and different forest management that allow capturing trade-offs. The survey results will aid in understanding people's willingness to financially support private forest owners. Lacking this support, private owners would shoulder the entire economic burden of providing a more balanced spectrum of ecosystem services, while sustaining future forest resilience as mandated by EU policy targets. The attainment of policy objectives will be streamlined and more feasible through the engaged participation of the entire community in a collaborative effort.

10. Education and capacity building on climate change and planetary health for healthcare professionals in global context (Muhammed Asaduzzaman)

Speaker: Muhammed Asaduzzaman
Affiliation: University of Oslo

Abstract: As the name demonstrates, Planetary Health (PH) has a strong mission to deal with the environmental threats to public health in both cities and rural settings which needs to be discussed in a more organized and sustainable way within the global public health and healthcare disciplines. PH should be considered a cardinal component of the global academic framework for healthcare professionals (HCPs). Therefore, there should be a knowledge base for clinicians, particularly in planetary well-being along with wider inclusion of students, trainees and professionals from all disciplines in HCPs. We conducted a scoping review to identify potential resources describing PH education and existing education programs for HCPs. We searched MEDLINE through PubMed, Scopus, and Web of Science with the search term "Planetary Health" AND "Education" for published documents written in English from the year 2000 to 25th April 2022. We initially retrieved 470 articles and screened those articles. Following exclusion of the duplicates and independent dual screening of the titles and abstracts, we scrutinized 33 articles from which full-text evaluation and data extraction was conducted. Most of the PH education initiatives have been focused on nursing and medical curricula. However, PH modules in undergraduate, doctoral, and post-doctoral programs are few, while several modules are available in graduate programs, mostly in global north. The majority of the available PH courses and discussions of curriculum development, have emerged from high-income countries. We observed a visible resource inequity in global south, lack of a universal PH module for HCPs and minimal inclusion of allied health disciplines (e.g. healthcare workers, physiotherapists, pharmacists) in the learning process. Considering water and food insecurity, loss of biodiversity and sea level rise due to climate change, Africa, South Asia, and Small Island Developing States are the most climate vulnerable regions. Therefore, these regions need to be prioritized in capacity building for climate education as well as in clinical practice due to the high burden of climate related illness. We recommend a dedicated network of motivated HCPs and regional hubs with an agenda to ensure a comprehensive, and inclusive PH education curriculum and practice.

11. Routing climate model runoff from CMIP6 to project future changes in global river discharge (Pauline Seubert)

Speaker: Pauline Seubert
Affiliation: ETH Zürich

Abstract: Modelling discharge along river networks is crucial for climate impact studies that investigate effects of hydrological extreme events, which are expected to change in frequency and magnitude because of anthropogenic climate change. Global climate models (GCMs), however, focus on runoff at the grid cell level and generally address runoff routing externally. To overcome this limitation, global hydrology models (GHMs), which are designed to resolve the terrestrial water balance, are fed with atmospheric data from GCMs. Although this approach profits from the additional detail of GHMs, only a limited number of GCM projections can typically be considered which potentially underestimates the substantial spread imposed by GCM uncertainty and internal climate variability. To bridge this gap, we route daily runoff from several models of the Coupled Model Intercomparison Project (CMIP6) archive along the river network using the multiscale routing model mRM. Internally, mRM derives the river network by means of upscaling from high-resolution morphological data making it adjustable on a range of spatial scales. We evaluate the fidelity of this modelling chain carefully considering its underlying assumptions and the mismatch in spatial scale and resolution between GCMs and routing model. We use the new global discharge projections to explore future changes in mean and extreme river flow and their link to anthropogenic climate change in light of the model uncertainty from the CMIP6 archive.

12. The effect of extreme weather on coastal ecosystems and their services (Sarah Hülsen)

Speaker: Sarah Hülsen
Affiliation: Institute for Environmental Decisions, ETH Zürich

Abstract: Coastal ecosystems, including coral reefs, seagrass beds, mangroves, and salt marshes, are vital components of the planet providing a multitude of benefits to human societies, such as protection from extreme weather like tropical cyclones (TC). In a first study, we found that up to 21% of people exposed to TCs are within the protection distance of coastal ecosystems, down from 23% thirty years ago due to ecosystem loss. Furthermore, until 2050 climate change will likely increase the average number of people impacted annually by tropical cyclones predominantly in areas unprotected by coastal ecosystems, causing a further decline in coastal protection. At the same time, while ecosystem provide protection, they are themselves affected by the extreme weather and are sensitive to changes in their occurrence frequency. In a second study, we analysed the effect of extreme heatwaves at sea-bed level and found that upper mesophotic coral reefs (30-60m) may be more threatened than shallow coral reefs. This is in agreement with recent research and counters a previous hypothesis that deep-sea water might be refugia for coral reefs in a changing climate. In a third study, we analysed the relationship between global coastal ecosystems, described as ecoregions, and TC occurrence regimes. The change in TC frequency between 1980-2020 and 2018-2050 might lead to a transformation of a combined 9.4% of the surface of terrestrial coastal ecosystems. This could result in a shift in species composition that alters the overall structure and function of the affected ecosystems, potentially reducing their ability to provide essential services. Our studies exemplify some aspects of the complex relation between ecosystems, societies and the climate. These learning might help shape future mitigation and adaptation strategies by considering the long-term effects of changing extreme weather patterns on ecosystems.

13. Vary me a river: investigating the impacts of climate variability on hydropower and electricity systems planning in Switzerland (Yann Yasser Haddad)

Speaker: Yann Yasser Haddad
Affiliation: ETH Zürich

Abstract: Clean and renewable energy systems play a pivotal role in climate change mitigation strategies. Nevertheless, climate change constitutes a threat to current and future supply of clean energy. In this study, we investigate how climate variability affects hydropower production and electricity systems planning in Switzerland. As the “water tower of Europe”, Switzerland encompasses a wide range of hydro-climatological conditions and showcases a high share of hydropower in its energy mix, making it a relevant case study. Focusing on all hydropower plants with a capacity > 300 kW, we used daily runoff simulations from the PREVAH model, at 500 m resolution spanning 1991-2022, to estimate water availability and hydropower production for each power plant. The climate-impacted hydropower production time series are then given as input to Nexus-e, an integrated electricity systems modeling framework. This enables us to model the future state of the electricity system in Switzerland while considering climate variability. Our method provides an accurate estimation of national hydropower generation and its variations. The integration of climate informed inputs into Nexus-e yields strong impacts on simulated investments in renewable energy and economic indicators such as power prices and imports/exports. Notably, in case of a projected decrease in hydropower generation due to increased drought occurrence, an increase in wind turbine and alpine PV capacity is needed to meet electricity demand. This scenario poses several societal and political questions regarding the implementation of a resilient energy system for Switzerland in the context of increasing changes in the climate system and pressure on ecosystems and biodiversity.

14. Assessing the Risk and Impact of Fire Weather under Different Climate Change Scenarios (Yi-Ling Hwong)

Speaker: Yi-Ling Hwong
Affiliation: IIASA - International Institute for Applied Systems Analysis

Abstract: Anthropogenic climate change is causing fire events to become increasingly frequent and intense, with uncertain but significant impact on human population, biodiversity and ecosystems worldwide. It is therefore important to better understand both the present and projected fire activities and their associated impacts, in order to design better mitigation and adaptation strategies for these hazardous events. Our focus is on fire weather as a key driver for fire events, with fire weather characterised by compound dry, hot and windy weather conditions. We calculated the fire weather index (FWI) using the methods of Quilcaille et al. (2023) and simulation outputs of five earth system models (ESMs) from the ISIMIP (3b) project. Four annual indicators are computed: (1) maximum value of the FWI, (2) number of days with extreme fire weather, (3) length of the fire season, and (4) seasonal mean of the FWI. These indicators are calculated for the five ESMs at different global warming levels (1.2°C, 1.5°C, 2.0°C, 2.5°C, 3.0°C, and 3.5°C) and in combination with three shared socioeconomic pathways (SSPs). This work results in a rich dataset of annual fire danger indicators at different global warming levels and 0.5° x 0.5° resolution. Here we present a comparative analysis of increased fire weather possibility and the exposure of different land cover classes (e.g., croplands, natural forest, etc.), densely-populated regions and economic damages under different climate change scenarios. We characterise risk at the country level, incorporating governance indicators to determine capacity to manage and respond.

15. Climate impacts on crop losses: Using satellite data and spatial models to foster food security (Shannon de Roos)

Speaker: Shannon de Roos
Affiliation: Vrije Universiteit Brussel (VUB)

Abstract: Humanity faces significant challenges regarding global food insecurity, and climate extremes aggravates this risk through their impact on crop failure. Understanding the climatic drivers of crop failure, monitoring crop growth, and implementing early warning systems is therefore of crucial importance. The recent surge in satellite-based crop products now creates a unique opportunity to improve global-scale crop and climate models. In turn, these enhanced modeling systems can serve as a tool to add value to historical and new satellite missions. The combined use of long-term satellite data, crop models and Earth system models allows to investigate the main drivers of crop failures caused by climate extremes and helps to project crop failures in future climate simulations. CropWaves will harness these opportunities by using historical and new satellite data to (i) enhance the representation of crop phenology and agricultural management in the crop model AquaCrop and the Earth system model CESM, (ii) assimilate satellite-based soil moisture and vegetation information into both modeling systems, (iii) constrain long-term coarse-scale crop simulations in order to uncover the impacts as well as atmospheric, oceanic and land-based drivers of recent crop failures, (iv) constrain fine-scale crop simulations in support of early warning of crop losses, (v) enable improved future climate projections of crop growth and failure under a suite of climate and socio-economic scenarios.

PROCLIAS highlights from WG's 1-4

1. WG1: ISIMIP3a high-resolution sensitivity experiments (Johanna Malle)

Speaker: Johanna T. Malle/ Dirk Nikolaus Karger
Affiliation: Swiss Federal Institute for Forest Snow and Landscape Research WSL

Abstract: To date, we have not been able to quantify the benefits of high spatial resolution climate data for climate change impact models. While high spatial resolution in climate models seems generally desirable for a better representation of atmospheric processes, we do not yet know how a higher spatial resolution affects our ability to model potential implications of climate change. In this study we will present outcomes of the ISIMIP3a high-resolution sensitivity experiments: Modeling groups from various ISIMIP sectors (regional forests, biomes, labour, food security and nutrition, regional water, lakes) have performed simulations at resolutions spanning from 30arcsec to 1800arcsec. We evaluate the performance of the models at the respective resolutions in a process-based manner, using in-situ observations. Results of this study contribute to our understanding of the effects of spatial scale in climate change impact models and will help inform decisions with regards to resolution requirements for ISIMIP4.

2. WG2: Developments and challenges in attributing climate change impacts (Sabine Undorf)

Speaker: Sabine Undorf
Affiliation: Potsdam Institute of Cliamte Impact Research

Abstract: Identifying and quantifying the impacts of climate change already being observed is of interest to society and science alike. Attribution studies to that effect are multiplying, increasingly engaging expertise from relevant scientific disciplines as diverse as ecosystem science and economics while still leaving gaps. These studies rely on a variety of different data and methods and differ widely in research scope and focus; even the terminology is debated. As a result, it becomes increasingly difficult to see which questions are (not) addressed by different attribution studies, and, inversely, what data and methods should best be used in new studies on underattributed regions/hazards/impacts. This lack of clarity hinders progress in climate impact attribution.

Here, we offer a collective contribution from many climate impact attribution experts to help overcome these obstacles. In particular, we will aim to shed light on the contemporary state of attribution science by mapping existing studies to the causal chain, or spectrum, spanning all the way from anthropogenic emissions, ensuing changes in atmospheric composition, changes in climate and weather, in the physical world, and in the biosphere and industry, to society. We will note that the literature has drawn different lines within this spectrum, for example, between studies that link observed changes/events in a ‘climate-related system’ to anthropogenic climate forcing, and those that link from the observed changes in climate to ‘changes in natural, human or managed systems’ (IPCC, 2022). We will suggest that this split is increasingly artificial and that the methodological differences resulting in attribution to anthropogenic or observed climate change are one approximation among many others, such as attribution to greenhouse gas forcing or combined anthropogenic forcing, the appropriateness of which depends on the specific research aims.

We will then highlight three main components of attribution studies, including the breadth of types of observations and models and their respective peculiarities for the different parts of the climate/impact spectrum, and how to generate counterfactual data, and climate counterfactuals in particular. We will then discuss key choices made in attribution studies, such as the choice of analytical framework, of counterfactual generation, of how many, and which, links within the causal spectrum are covered, and we will mention factors influencing this choice and their implications for uncertainty propagation. We will then look at the various possible societal uses of attribution studies and how they map onto these methodological choices, namely awareness raising to motivate action; risk management and adaptation; Loss and Damage; and climate litigation, and present characteristics of attribution studies facilitating these uses as well as potential risks.

3. WG3: Understanding multiple climate risks (Simon Gosling)

Speaker: Simon Gosling
Affiliation: University of Nottingham

Abstract: This talk will highlight some of the main research outcomes from WG3 of PROCLIAS, discussing advances in understanding of multiple climate risks that have emerged from the group's activities, across sectors that include labour, human health, water availability and water quality.

4. WG4: Stakeholder Engagement for Climate Impact Attribution Studies: Opportunities, Challenges, and Pathways to Impact (Albert Nkwasa)

Speaker: Albert Nkwasa
Affiliation: Water Security Research Group, Biodiversity and Natural Resources Program, International Institute for Applied Systems Analysis (IIASA), Austria

Abstract: Stakeholder engagement has gained importance in climate science over the past decade. Stakeholder actions have considerable influence on societal development, hence we see an increasing importance to engage stakeholders in scientific projects through a variety of engagement methods ranging from advisory functions to co-development processes to ensure relevant outputs for stakeholder needs. In this perspective piece, we outline where stakeholder engagement in climate impact attribution can be useful, which challenges arise, and how such stakeholder engagement can become impactful. The benefits of stakeholder engagement in attribution science include ensuring relevance, enhancing technical quality leveraging diverse knowledge sources, fostering collaboration, and facilitating dissemination of findings. However, engaging stakeholders in climate impact attribution studies could face challenges in consensus-building, potential delays, and resource constraints, which may hinder successful involvement. Moreover, the complexity of attribution research, uneven distribution of knowledge, and political implications pose additional barriers, especially when dealing with conflicting agendas and vested interests. Despite these challenges, proactive stakeholder involvement is needed but requires early involvement, adequate resources, and effective communication of scientific uncertainties. Citizen science is identified as a promising avenue that could bridge the divide between attribution science and its significance within local communities especially in low- and middle-income countries. In conclusion, integrating stakeholders into attribution studies is crucial for producing policy-relevant outputs, and sustained dialogue and comprehensive reporting of stakeholder processes are vital for ensuring transparency and real-world impact.
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Cross-sectoral presentations

1. Temporal Dynamics of Internal Mobility in Response to Climate Extremes: A Global Analysis (2000-2019) (Kristina Petrova)

Speaker: Kristina Petrova
Affiliation: Potsdam Institute of Climate Impact Research Centre

Abstract: This study presents a novel approach to understanding the impact of climate extremes on human mobility by examining not only the occurrence of such events but also the dynamics of mobility across different time windows. Utilizing the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) climate data and the recently released geo-located sub-national net migration data provided by Niva et al. 2023, we assess the influence of various climate-related events, including droughts, floods, crop failures, and tropical cyclones, on human mobility. We delve into both recent and historical shocks, which allows us to explore the potential delayed effects of climate extremes, providing insights into population responses to environmental stressors over short, medium, and long-term periods We also aim to capture the shifts in net migration at a granular level, particularly in areas with pre-existing migration trends—whether as origins or destinations. This enables us to understand how extreme events can alter or restrict established migration patterns and systems. Finally, we consider the cumulative impact of natural hazards occurring in succession. These temporal aspects and tipping points are crucial in understanding the resilience and adaptability of communities in the face of climate change. Our findings reveal significant variations in mobility responses depending on the nature and delayed impacts of climate extremes.

2. Regional economic climate impacts in Europe: preliminary results from the TRACE (PESETA 5) project (Ignazio Mongelli, Juan-Carlos Ciscar)

Speaker: Ignazio Mongelli, Juan-Carlos Ciscar
Affiliation: JRC, European Commission

Abstract: The presentation will have two parts. The first part will introduce the main features of the new regional economic model to assess climate impacts in Europe, a simple growth model with technological and spatial spillovers. In a second part, preliminary economic results from the PESETA 5 project will be discussed, including labour productivity, droughts and coasts.

3. Climate impact emulation and integration to IAMs (Edward Byers, Michaela Werning)

Speaker: Edward Byers, Michaela Werning
Affiliation: IIASA

Abstract: Reconciling how the risks and impacts of climate change are presented alongside the mitigation pathways has long been a challenge, particularly in the IPCC with the topics of risk and vulnerability lying in WG2 whilst mitigation in WG3. Here we demonstrate a recently-released python software package (RIME), that takes the global mean surface air temperature trajectory, and calculates a range of climate impacts and exposure indicators (25+) in gridded spatial and tabular formats. The Rapid Impact Model Emulator uses global warming levels time-sampling approaches and can be used on indicators that have been prepared at global warming levels. We use a new database of climate impact indicators at various global warming levels (1.2 - 3.5°C) with indicators that include a variety of temperature and precipitation extremes, heatwaves, drought intensity, hydrological variability, and water stress. Building on previous work (Byers et al. 2018), we have developed a bi-variate impact score that includes statistics on the absolute level of impact (e.g. low or high precipitation) and the relative change under global warming compared to the historical baseline (e.g. a large change from low to high precipitation), and that allows the comparison of impacts from different indicators, even for an audience without a scientific background. The resulting global maps of absolute hazard, relative change, and impact scores at a high spatial resolution of 0.5° x 0.5° are hosted online (www.climate-solutions-explorer.eu) and presented alongside national dashboards presenting information on avoided impacts by mitigating to 1.5°C. Using a database of such indicators (Werning et al 2023.), that draws heavily on the ISIMIP data products, including outputs of global climate and hydrological models and a fire weather index, we show how batches of climate indicators can be quickly provided in seconds as outputs for new IAM scenarios. The presentation will illustrate the importance and value of both ISIMIP data and better WG2-3 integration, and will provide suggestions for further climate impact emulation research that helps bridge the two communities.

4. Global emergence of unprecedented exposure to climate extremes (Wim Thiery)

Speaker: Wim Thiery
Affiliation: VUB

Abstract: Climate extremes such as heatwaves, river floods, droughts, crop failures, as well as aspects of wildfires and tropical cyclones are increasingly attributable to anthropogenic climate change. Yet how this translates into unprecedented levels of extreme event exposure in one's lifetime remains unclear. Here we show that many of today's youth will experience unprecedented exposure to extremes during their lifetimes. For each event type above, the share people facing unprecedented lifetime exposure is projected to at least double from 1960 to 2020 birth cohorts under current mitigation policies aligned with a global warming pathway reaching 2.7 °C above pre-industrial temperatures by 2100. In a 1.5 °C pathway, 47% of people born in 2020 will experience unprecedented lifetime exposure to heatwaves. If global warming reaches 3.5 °C by 2100, this rises to 93% of this birth cohort. For the same cohort and warming pathway, 29% will live with unprecedented exposure to crop failures and 15% to river floods. Likewise, for tropical cyclones, when limiting cohort estimates to regions experiencing this geographically constrained event, this fraction nearly doubles from 10 to 19%. Our results overall call for deep and sustained greenhouse gas emissions reductions to lower the burden of climate change on young generations.

ISIMIP 3b results

1. Exposure of Europe's critical transport infrastructure to climate extremes (Cristina Deidda)

Speaker: Cristina Deidda
Affiliation: VUB

Abstract: As climate change intensifies, its impacts are evident across society. Extreme events like floods, heatwaves, and storms pose a significant threat to the Trans-European Transport Network (TEN-T), resulting in infrastructure damages, economic losses, and health issues. Future projections indicate an elevated risk of coastal flooding for seaports and ports, along with heightened exposure of railways and roads to extreme temperatures. This escalating risk underscores the imperative for implementing effective adaptation measures to enhance the resilience of the entire transport network. Our analysis focuses on assessing the exposure of all modes within the European Core Network (airports, seaports, railways, roads, inland water) to climate-related extreme events using ISIMIP data. We examine the specific challenges and impacts of weather-climate hazards on each transport mode, while also investigating the increasing exposure across different Representative Concentration Pathway (RCP) scenarios. The study is based on ISIMIP2b data!

2. Estimating Flood Risk under Global Warming: An Approach from the Insurance Industry (Giulia Giani)

Speaker: Giulia Giani
Affiliation: Gallagher Re

Abstract: The (re)insurance sector has established methods and tools to assess historical and current risk for several weather driven hazards in many geographical regions. Using those same methods to estimate risk under global warming is fraught with challenges as one may expect complex changes to all four risk components (hazard, exposure, vulnerability, and disaster response capability). Nevertheless, despite much uncertainty about how weather hazards may change under climate change, the insurance sector is increasingly expected to include risk estimates for future-looking business strategies. Supervisors (across different regulatory domains) are currently working with the insurance sector to better understand the transmission channels for climate risk and provide guidance on how to meaningfully estimate future risk due to weather driven hazards. To encourage discussion and transparency on methodology used to assess risk for insurance purposes (such as developing underwriting layers, or portfolio management) we demonstrate a recent approach developed by the global (re)insurance broker Gallagher Re to estimate risk of future floods aligned, and therefore comparable, with current flood risk estimates. We demonstrate the approach adopted for fluvial flooding which makes use of the Aqueduct flood hazard maps, derived using the ISIMIP streamflow projections. We also discuss how challenges (such as those detailed above) were addressed to derive a methodology that can be deployed globally, given access to robust and credible projections of extreme streamflow.

3. The regularity of climate-related extreme events under global warming (Karim Zantout)

Speaker: Karim Zantout
Affiliation: Potsdam Institute for Climate Impact Research

Abstract: Climate variability gives rise to many different kinds of extreme impact events, including heat waves, crop failures, or wildfires. The frequency and magnitude of such events are changing under global warming. However, it is less known to what extent such events occur with some regularity, and whether this regularity is also changing as a result of climate change. Here, we present a novel method to systematically study the time-autocorrelation of these extreme impact events, that is, whether they occur with a certain regularity. In studies of climate change impacts, different types of events are often studied in isolation, but in reality they interact. We use ensembles of global biophysical impact simulations from the Inter-Sectoral Impact Model Intercomparison Project (ISIMIP) driven with climate models to assess current conditions and projections. The time series analysis is based on a discrete Fourier transformation that accounts for the stochastic fluctuations from the climate model. Our results show that some climate impacts, such as crop failure, indeed exhibit a dominant frequency of recurrence; and also, that these regularity patterns change over time due to anthropogenic climate forcing.

4. Children disproportionately exposed to attributable heatwaves in low-latitude low-income countries (Rosa Pietroiusti)

Speaker: Rosa Pietroiusti
Affiliation: Vrije Universiteit Brussel

Abstract: Heatwaves are increasing in frequency, intensity, and duration, and represent the category of extreme event that is most easily attributable to anthropogenic warming. Yet how the spatiotemporal patterns of attribution outcomes link to population dynamics and demographic patterns is still poorly understood. Here we investigate whether children and young people are already being affected by a disproportionately greater number of attributable hot and hot-humid extremes, especially in the Global South. Using observations, reanalysis, and simulations of temperature and humidity changes available through the ISIMIP3a, ISIMIP3b and CMIP6 projects, in combination with demographic data, we investigate whether heat stress and temperature extremes emerge more clearly and consistently from the noise across low-income countries in lower latitudes, which have some of the youngest populations. We test the sensitivity of our findings to different definitions of a hot and hot-humid extreme and suggest possibilities to increase the impact-relevance of our framework, for example by accounting for health or educational impacts specific to the youngest populations, in future research. Our findings could have implications for children and young people seeking redress from climate harms, for example through climate lawsuits.

5. Can we understand the variability in flood-induced displacement using process-based global flood modelling? (Sandra Zimmerman)

Speaker: Sandra Zimmerman
Affiliation: Potsdam Institute of Climate Impact Research Centre

Abstract: Every year, disasters force millions of people around the world to leave their homes. Disaster-induced displacement often causes humanitarian hardship and incurs substantial costs on vulnerable, low-income societies in the Global South. With anthropogenic climate change increasing the intensity and number of extreme events in many regions of the world, understanding and being able to project disaster-induced displacement becomes increasingly important. Floods are among the main causes of disaster-induced displacements. However, the causes of variability in flood displacement over time and space are not well understood. Therefore, it is not known to what extent climate change has already affected displacement in the past, and it is difficult to produce reliable estimates of future displacement risk. In our study, we address the question how much of the observed variability can be explained on the basis of process-based flood hazard modeling. We use the output of state-of-the-art global hydrological models forced with observational climate and direct human forcings to derive flood extents by the global hydrodynamic model CaMa-Flood. We first assess how well modelled flood hazard can explain annual variations in past displacement as recorded by the Internal Displacement Monitoring Center at a global as well as national scale, before also accounting for differential vulnerabilities of communities by applying spatially-disaggregated vulnerability factors derived from the comparison of simulated number of people affected by flooding to observational displacement data. We hence provide a comprehensive assessment of the explanatory power of the process-based fluvial flood hazard component in terms of displacement.

6. Global change impacts on ecosystems and food: bridging the land-sea divide (Julia Blanchard)

Speaker: Julia Blanchard
Affiliation: Institute for Marine & Antarctic Studies, University of Tasmania

Abstract: All food production systems are linked through highly connected global social-ecological systems. However, marine and terrestrial systems are often treated separately in studies addressing the impacts of global change on future human food security and nutrition. Because separation risks missing key interactions and trade-offs that may threaten continued provision to meet demand there have been recent calls for improved integration. As a step towards this, we focus on the nexus of ecosystems, food and climate change. Using results from the ISIMIP 3 simulations, we illustrate how combining potential impacts across sectors on land and sea can help improve knowledge of cumulative impacts on potential food supply and stability, using fed aquaculture as a case study. We recommend further ways that integration of sectoral models (e.g. fisheries, agriculture, aquaculture, rivers, biodiversity) and scenarios could help inform the nexus of food-biodiversity-climate change.

PROCLIAS TG2.1: State of the art and ways forward for impact attribution

1. How do ISIMIP3a observation-based factual and counterfactual climates compare with ISIMIP3b GCM-based climate baselines ? (Mel Thanatcha Brehon)

Speaker: Mel Thanatcha Brehon
Affiliation: Vrije Universiteit Brussel (VUB)

Abstract: As an effort to attribute the realized impacts of climate change in a system, the ISIMIP3a protocol proposes using a counterfactual climate derived from observational factual climate data. This study examines long-term changes in climate between 1901 and 2014 using factual and counterfactual climate data from ISIMIP3a along with climate simulations from the Coupled Model Intercomparison Project Phase 6 provided by ISIMIP3b. By calculating the differences in multi-year averages over the first and last 30 years of the period, we quantify the long-term changes in large-scale temperature mean and extremes, as well as in precipitation means over the Congo River basin. This research also assesses the contributions of climate change to long-term change in river discharge means and extremes from WaterGAP simulations under both ISIMIP3 frameworks. Our analysis reveals a contribution of climate change to a 39 % decrease in annual river discharge means at the outlet under ISIMIP3a compared to a contribution of anthropogenic climate change to a 4% decrease under ISIMIP3b. Despite close averages over the end (1985-2014), diverging river discharge magnitudes are found over the beginning of the period (1901-1930). Our results also reveal contrasting long-term changes in large-scale temperature extremes between factuals and a long-term weakening of these extremes in the ISIMIP3a counterfactual. Overall, our findings initiate an exploration of ISIMIP3a climate data and call for further research on the treatment of climate extremes by ATTRICI.