Annual report 2024 for Flagship Pilot Study Dynamical downscaling experiments and hydrological modelling for Canada and Mexico.

Status and progress during the year including scientific highlights (and images if possible), end to end perspective and participants engaged in the project

Progress.

1. During September 2024, José Antonio Salinas visited ICTP (International Centre for Theoretical Physics, Trieste, Italy) as Senior Associate increasing collaboration with the group that developed the RegCM5 model, analyzing ten years of simulations of the Caribbean and Gulf of Mexico carried out at the ICTP, for evaluation, contributing to applying the best configuration of the RegCM5 model.
2. The 2nd Workshop of the Flagship Pilot Study (FPS) "Dynamical Downscaling Experiments and Hydrological Modelling for Canada and Mexico" was held at the *Centro del Cambio Global y la Sustentabilidad (CCGS)* in Villahermosa, Tabasco, Mexico, on November 12-13, 2024.
   This Workshop focused on share dynamical downscaling experiments experiences for North America—encompassing Mexico, the United States, and Canada—using two of the CMIP6 Earth System Models (ESMs) identified as having the best performance for these regions. Additionally, in the Workshop some results were presented related to the statistical downscaling of CMIP6 models, particularly for southern and southeastern Mexico (Andrade-Velázquez & Montero-Martínez, 2023a, 2023b; Andrade-Velázquez et al., in press). The objectives of the workshop include providing an update on the project's current status and outlining the activities necessary to complete it. An open session with local stakeholders was also presented. In the event, presentations from participants and interactive discussions among the three key groups: dynamical downscaling, statistical downscaling, and hydrology, identifying great opportunities for open dialogue, focusing on internal communication, project milestones, and strategies for achieving them. Information on data, software, and products.
3. Collaboration between Universidad Veracruzana and ETS (Quebec University), focused on integrating and analyzing uncertainty sources to improve flood projection accuracy and contribute to developing climate change adaptation strategies in hydrology. Four main uncertainty sources were identified: Climate Models, Post-Processing Techniques, Hydrological Models, Probability Distributions.
4. Evaluation of three Statistical Downscaling techniques using Neural Networks in Northwestern Mexico, a region characterized by high temperatures, precipitation variability, prolonged droughts, scarce water resources, and exposure to tropical cyclones. Key findings: The LSBC method showed good results in Pearson correlation and standard deviation (SD) for temperature and precipitation. The RNN LSTM method tends to underestimate variability but improves Pearson correlation and RMSE in all models, performing particularly well with MIROC6. The GLM method overestimates variability in three models but performs well for CNRM. For temperature, GLM stands out in correlation, SD, and RMSE across all models.
5. Dynamic Downscaling with Convective Permitting Using WRF: Progress in a Tropical Convection Case Study in Mexico using the Weather Research and Forecasting (WRF) system in a case study on tropical convection, highlighting that dynamic downscaling faces significant challenges in processes such as radiation, cumulus parameterization, turbulence, cloud microphysics, and land cover.
   He also outlined the next steps to advance towards creating high-precision models for studying tropical convection in Mexico: Evaluate and validate the dynamic downscaling methodology at resolutions of 20 km and 4 km using WRF, based on ERA5 data and CMIP6 models. Incorporate bias corrections (e.g., sea surface temperature, SST) and Pseudo Global Warming (PGW) methodologies.
6. Generation of Climate Change Scenarios for Southern-Southeastern Mexico focuses on creating future projections for Southern Mexico using statistical downscaling techniques. The main findings are: SSP4-6.0 scenario was identified as suitable for future projections, supported by statistical analyses (Andrade-Velázquez et al., 2021). SSP2-4.5 and SSP4-6.0 scenarios were determined as viable options, while SSP5-8.5 was considered less favorable due to its environmental implications. Bias correction improved model accuracy, reducing errors by 50% in the southern region and by 15-25% in the southeastern region. Regarding model performance, CNRM-ESM2-1 was preferred for the southern region, while IPSL-CM6A-LR, MIROC6, and MRI-ESM2-0 were more suitable for the southeastern region.

Activities 2024.

- ✓ Implementation of a regional numerical simulation strategy: the Pseudo Global Warming (PGW) approach, which involves directly imposing large-scale changes on a control simulation with real conditions, modifying boundary conditions in regional grids. This technique studies how projected large-scale changes could affect local conditions. A case study on the energy relationship between atmospheric disturbances (easterly waves and tropical cyclones) and the Caribbean low-level jet was developed. Results showed that during active tropical cyclone years (1980, 1988, 1995, 1996, 1998, 2004, 2005, 2007, 2008, and 2017), the jet is less intense, and disturbance kinetic energy is higher. Conversely, in inactive years, tropical cyclones and disturbance kinetic energy decrease, while the jet becomes stronger.
- ✓ Study comparing six climate models from the CMIP6 experiment with ERA5 Reanalysis to assess their accuracy in the annual cycle of precipitation, maximum temperature, and minimum temperature in four Mexican subregions, compared to their CMIP5 versions. Key findings include: IPSL-CM6A-LR, MRI-ESM2.0, and NorESM1-M showed better capacity for reproducing the annual precipitation cycle in all four subregions. CNRM-CM6-1 improved representation of the annual maximum temperature cycle in all subregions. MIROC6 best reproduced the annual minimum temperature cycle in all four subregions. Although MRI-ESM2.0 only improved in three of four subregions, all selected CMIP6 models showed advances in reproducing precipitation cycles in southeastern Mexico. The results indicate CMIP6 models are useful for climate change impact studies in Mexico, though accuracy varies by region and climate variable analyzed.

Summary of each workshop/activity held during the year

Title, date, short description, location, website, links	Responsible person/-s	Funder
2nd Workshop of the Flagship Pilot Study (FPS) "Dynamical Downscaling Experiments and Hydrological Modelling for Canada and Mexico" was held at the Centro del Cambio Global y la Sustentabilidad (CCGS) in Villahermosa, Tabasco, Mexico, on November 12-13, 2024.	Antonio Salinas/ Mercedes Andrade-Velázquez	CORDEX

Related publications during the year

Title, journal and link to publication	Author/-s	Date
Análisis sobre las proyecciones de cambio climático en México. *Tlamati Sabiduría* 2024*, 18*, 7-22. Available (in Spanish only) from: https://tlamati.uagro.mx/images/Archivos/Tlamati_Vol_18_2024/Montero-Martinez_y_Andrade-Velazquez_2024.pdf	Montero-Martínez M.J., Andrade-Velázquez M.	2024
Evaluación del desempeño de los modelos climáticos globales (GCMS) del CMIP5 y CMIP6 en México. In *Memorias de la V Edición del Seminario Diáspora Hídrica*, p. 32, IMTA, BUAP, UNAM, UNESCO. Available (in Spanish only) from: https://www.imta.gob.mx/gobmx/DOI/libros/2024/Memorias-Diaspora-Hidrica-2024.pdf https://doi.org/10.24850/b-imta-2024-14	Ordoñez-Sánchez, A., Montero-Martínez M.J., Andrade-Velázquez M.	13 September 2024
Reducción de escala estadística aplicando escalado lineal y redes neuronales en la Región Noroeste de México. In Memorias de la V Edición del Seminario Diáspora Hídrica, p. 71, IMTA, BUAP, UNAM, UNESCO. Available (in Spanish only) from: https://www.imta.gob.mx/gobmx/DOI/libros/2024/Memorias-Diaspora-Hidrica-2024.pdf https://doi.org/10.24850/b-imta-2024-14	Rodríguez-Torres, S., Montero-Martínez M.J., Andrade-Velázquez M.	13 September 2024
Influencia de las oscilaciones climáticas AMO, PDO y ENSO en los patrones de precipitación en México: caso Sureste. Teoría y Praxis 33 · 2024: 41-49. DOI 10.22403/UQROOMX/TyP33/05 http://www.teoriaypraxis.uqroo.mx/doctos/numero33/41-49_Andrade,Montero.pdf	Andrade-Velázquez, M., Montero-Martínez, M. J.	15 December 2024

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To Aileen Rojas Valencia, Geophysical engineering student.

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Please remember to inform IPOC about news, calls, activities or other information that can be shared with the community during the year! We want to show your work at the website and on social media.

If more space is needed just add rows in the table.
The report is due the 15th of February each year and should be sent to ipoc@cordex.org.