M2 stage ISEM Spring 2026: University of Montpellier

Modeling biodiversity exposure to future climate change scenarios (Modélisation de l'exposition de la biodiversité aux scénarios de changement climatique futurs)

Responsables du stage

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Keywords:

Ecologie, changements climatique, vulnérabilité, exposure, biodiversité, macroécologie

Thesis detailed overview/ Problématique:

Future climate change is predicted to expose a large number of species to environmental conditions outside their observed historical limits, potentially affecting their survival. This includes exposure to not only changing mean temperatures and precipitation but also more variability and extreme events. Exposures can occur in multiple aspects of different environmental variables simultaneously or at different times; thus, identifying which aspects of climate change are likely to cause exposure first, which cause the most prevalent exposure across regions and species, and which may cause exposure occurring simultaneously, is a critical component of understanding the vulnerability of biodiversity to climate change. Previous work has shown that due to clustered warming tolerances for species, the expansion of exposure to maximum temperature is likely to be abrupt; however, less is known about the comparative response of other aspects of climate change. These exposure patterns are also dependent on the trajectory of climate warming- the Shared Socioeconomic Pathways (SSPs) present possible scenarios of warming over the coming century based on mitigation pathways. This thesis aims to assess temporal dynamics of climate exposure for biodiversity worldwide based on these SSP scenarios. The primary aim is to compare relative impacts of different aspects of future climate change on global biodiversity by comparing the timing, extent, and abruptness of exposure. This study will help isolate the importance of different factors in determining where future conditions are likely to be stressful, and which species are most exposed.

Objective:

This thesis will study the projected temporal dynamics of future climate exposure of global terrestrial and freshwater biodiversity by using a database of historical species climate limits and comparing them to future conditions based on different SSPs.

Context:

Climate change vulnerability for a species comprises its intrinsic sensitivity to climate change over its current range, its projected exposure to novel environmental conditions, and its

adaptive capacity to evolve or disperse to new areas (Foden et al., 2013). This project focuses on the exposure aspect of vulnerability, specifically assessing the extent to which species will experience conditions exceeding their historical limits. Previous work on future temperature and heatwave exposure (Trisos et al., 2020; Murali et al., 2023) has shown that that the expansion of exposure risk for a single species assemblage (and for species over their geographic range) is globally widespread and highly abrupt, with sharp increases beyond a threshold amount of warming. However, it is critical to compare risks associated with changes in different variables to generate conditions beyond historical limits of biodiversity, and to identify the extent of abruptness across different variables in space and time. Though the clustered nature of inferred tolerances suggests abruptness as a hallmark of exposure (Williamson et al., 2025), historical constraints on rare events such as heatwaves versus more naturally variable aspects such as rainfall may lead to different abruptness patterns and therefore different patterns of risk. The value of this project will be to identify broad-scale drivers of exposure, compare trends, and identify sources of variation arising across space and taxa. Thus, this will highlight regions and species at maximum climate exposure risk, and the timescales at which this risk will be expanding (Pigot et al., 2023). The use of different SSPs representing climate change pathways (van Vuuren et al., 2011) will also permit the comparison of exposure patterns in different future states, identifying where warming mitigation and conservation may be the most effective.

Déroulement du stage (acquisition de données, modélisation, résultats attendus etc.) :

The project is structured around two axes - (1) using local climate limits from future projections to model patterns and properties of exposure in different variables; and (2) integrating these projections into a cohesive comparative study of abruptness, spatial extent, and timing of exposure across each variable. To do this we will use the ClimLimits database produced by the group for historical species climate limits, as well as publicly available SSP projections from the ISIMIP3b project, and perform statistical analysis primarily in R. The internship will be located at the ISEM in the BioDicee team (https://biodicee.edu.umontpellier.fr, UMR5554, Montpellier). The earliest start is in February 2027. We welcome students from Ecology/Evolution masters with a strong interest in biodiversity science and conservation, or students with a statistical background interested in ecology/evolution.

Méthodes, techniques, outils à utiliser :

Analyse et manipulation de données empiriques, statistiques, modélisation.

Profile*

The stage will be carried out in English. Statistical modeling and scientific programming, and skills in data management and analysis are welcome. Prior experience handling climate rasters is helpful but not necessary.

Référence(s) (publication(s) de l'équipe d'accueil illustrant le contexte général du sujet) :

Girish, K. S., Dakos, V., & Jacquet, C. (2026). ClimLimits: a global database of multivariate realized climate limits for animal species. *bioRxiv*, 2026-07.

Références *

Foden, W. B., Butchart, S. H., Stuart, S. N., Vié, J. C., Akçakaya, H. R., Angulo, A., ... & Mace, G. M. (2013). Identifying the world's most climate change vulnerable species: a systematic trait-based assessment of all birds, amphibians and corals. *PloS one*, *8*(6), e65427.

Trisos, C. H., Merow, C., & Pigot, A. L. (2020). The projected timing of abrupt ecological disruption from climate change. *Nature*, *580*(7804), 496-501.

Murali, G., Iwamura, T., Meiri, S., & Roll, U. (2023). Future temperature extremes threaten land vertebrates. *Nature*, *615*(7952), 461-467.

Pigot, A. L., Merow, C., Wilson, A., & Trisos, C. H. (2023). Abrupt expansion of climate change risks for species globally. *Nature Ecology & Evolution*, *7*(7), 1060-1071.

Williamson, J., Lu, M., Camus, M. F., Gregory, R. D., Maclean, I. M., Rocha, J. C., ... & Pigot, A. L. (2025). Clustered warming tolerances and the nonlinear risks of biodiversity loss on a warming planet. *Philosophical Transactions of the Royal Society B: Biological Sciences*, *380*(1917), 20230321.

Van Vuuren, D. P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., ... & Rose, S. K. (2011). The representative concentration pathways: an overview. *Climatic change*, *109*(1), 5.