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Projecting wildfire occurrence at regional scale from Land Use/Cover and climate change scenarios

Lara Vilar (1), Etel Tafur-García (1), Marta Yebra (2,3), Sixto Herrera (4), Joaquín Bedia (4), Javier Martínez-Vega (1), and M.Pilar Martín (1)

(1) Institute of Economics, Geography and Demography (IEGD-CCHS), Spanish National Research Council (CSIC), Madrid, Spain (lara.vilar@cchs.csic.es), (2) Fenner School of Environment and Society, The Australian National University, Acton, ACT, Australia, (3) Bushfire and Natural Hazards Cooperative Research Centre, Melbourne, Australia, (4) Santander Meteorology Group, Dept. of Applied Mathematics and Computer Science, University of Cantabria, Santander, Spain

This work aims to project wildfire occurrence at regional scale by combining information derived from future Land Use/Cover change (LUCC) and climate scenarios in Madrid region (Spain). Generalized Linear Models have been used to obtain a historical wildfire occurrence model for the 2000-2010 period at 1x1km grid cell resolution. Land Use/Cover (LUC) interfaces: Wildland Urban Interface (WUI), Agricultural-Forest interface (AFI) and Grassland-Forest interface (GFI) have been derived and used as input drivers related to human-caused wildfire ignitions along with other variables such as orientation, precipitation, temperature and fuel moisture content (FMC). Wildfire presence-absence observations were obtained from available ignition points coordinates in the study site and used as the response variable in the model. A future LUC scenario by 2050 was run up by using Land Change Modeler (LCM). LCM transition susceptibility maps were calculated by neural networks and Markov chain matrices were used to determine the quantity of change. The model was calibrated with the observed LUCC between 1998 and 2008 derived from the ESA-CCI maps reclassified in eight classes. The obtained transition potentials and calibration rates were used to simulate LUC maps for the year 2015. Real 2015 map was used to assess model performance. Overall agreement between real and modelled maps was >90%. The trend scenario was run using drivers of change and restrictions to generate the LUC map for the year 2050, obtaining the future interfaces (WUI, AFI, GFI) from this map. Average projected precipitation and temperature for the 2050s were obtained from the regional climate change projections for Spain developed under the PNACC (http://escenarios.adaptecca.es). These projections considered both dynamical and statistical downscaling to obtain regional projections at 12x12 km, approximately, the spatial resolution from the IPCC-AR5 (CMIP5) global projections. In order to obtain the final resolution ($\sim$1 km) of the climate indicators, the climate change signal ($\sim$12 km), defined as the difference between the future and historical periods (delta), was added to the observed climatology ($\sim$1km), obtaining the future climatology at 1km (Bedia et al., 2013). Note that this is the simplest bias calibration method which assumes that the bias of the models disappeared when considering those deltas. FMC predictions for 2050 were obtained by using reflectance estimates for three LC vegetation types (grass, shrub, forest), the 2050 LUC map and the inversion of radiative transfer model following Yebra et al. (2018) methodology. Predictive reflectance models were calibrated using historical MODIS data for invariant LC pixels and climate variables. The approach was first tested for 2015 and validated using the real 2015 FMC map.
Wildfire occurrence prediction was finally obtained by applying the historical wildfire occurrence model to 2050 data.

Bedia, J., Herrera, S., Gutiérrez, J.M., 2013. Dangers of using global bioclimatic datasets for ecological niche modeling. Limitations for future climate projections. Global and Planetary Change 107, 1-12.
Yebra, M., Quan, X., Riaño, D., Rozas Larraondo, P., van Dijk, A.I.J.M., Cary, G.J., 2018. A fuel moisture content and flammability monitoring methodology for continental Australia based on optical remote sensing. Remote Sensing of Environment 212, 260-272.

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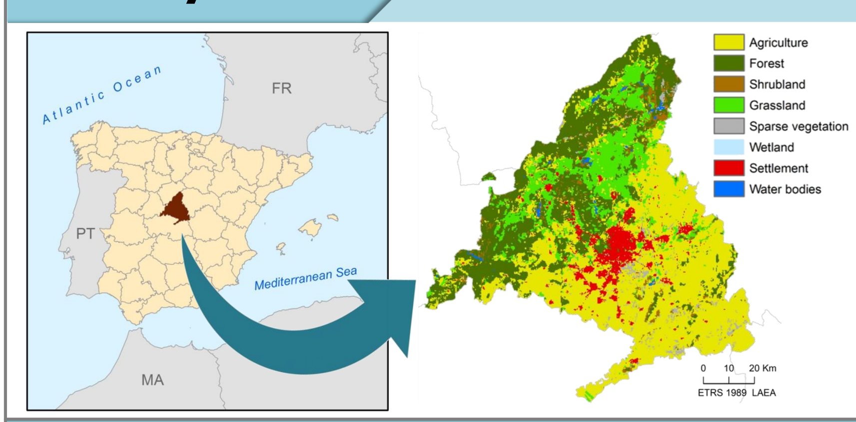
lara.vilar@cchs.csic.es

Abstract

This work aims to project wildfire occurrence at regional scale by combining information derived from **future Land Use/Cover change** (LUCC) and **climate scenarios** in Madrid region (Spain). Generalized Linear Models have been used to obtain a historical wildfire occurrence model for the 2000-2010 period at 1x1km grid cell resolution. **Land Use/Cover (LUC) interfaces**: Wildland Urban Interface (**WUI**), Forest-Agricultural interface (**FAI**) and Forest-Grassland interface (**FGI**) have been derived and used as input drivers related to human-caused wildfire ignitions along with other variables such as orientation, **precipitation**, **maximum temperature** and live fuel moisture content (**LFMC**). A future **LUC scenario** by **2050** was run up by using **Land Change Modeler** (LCM). LCM transition susceptibility maps were calculated by neural networks and Markov chain matrices were used to determine the quantity of change. The model was calibrated with the observed LUCC between 1998 and 2008. Real 2015 map was used to assess model performance. **Overall agreement** between real and modeled maps was **>90%**. The trend scenario was run using drivers of change and restrictions to generate the LUC map for the year 2050, obtaining the **future interfaces** (WUI, FAI, FGI) from this map. Average **projected precipitation** and **temperature** for the 2050s for Spain were obtained from the **regional climate model RACMO22E**, from the **KNMI**, driven by the global climate model EC-EARTH and considering the two future experiments RCP4.5 and RCP8.5, which has been developed under the European branch of the CORDEX initiative (http://www.cordex.org/), Euro-CORDEX, at 12x12 km approximately. In order to obtain the final resolution (1 km) of the climate indicators, the climate change signal (12 km), defined as the **difference between the future and historical periods** (delta), was added to the observed climatology (1km), obtaining the future climatology at 1km (Bedia et al., 2013). Note that this is the simplest bias calibration method which assumes a linear bias of the models which disappears when considering those deltas. LFMC from year 2005 was used for 2050 wildfire estimation as it was the most similar to 2050 in terms of climatic conditions. **Wildfire occurrence prediction** was finally obtained by applying the historical wildfire occurrence model to 2050 . Generally speaking future wildfire occurrence will increase in the study site.

Study site



T: 12-14ºC P: 400-1000 mm

25% mixed shrubland trees, deciduous forest, 14% grass

Highly populated

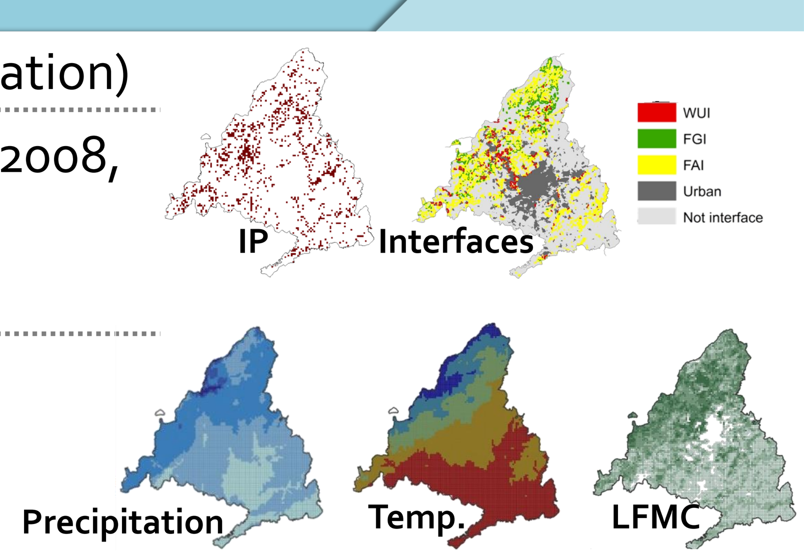
1000 fire events (2001-2010), 11379 burned ha, 22% accidents

Data wildfire occurrence model

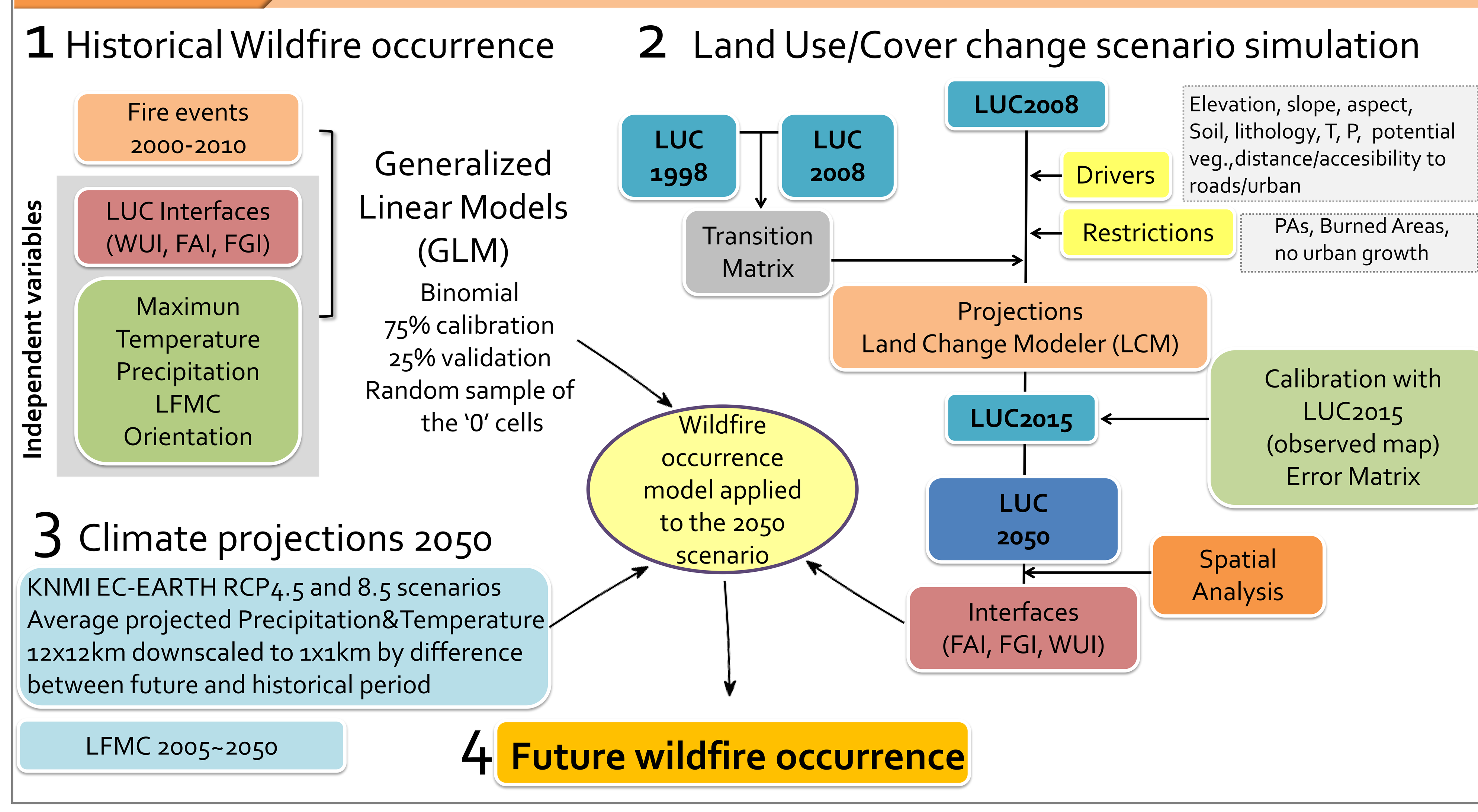
Fire ignition points (x, y location)

ESA CCI-Land Cover 1998, 2008, 2015, 2005 and derived LUC Interfaces

Climate
Life Fuel Moisture Content
Orientation



Methods

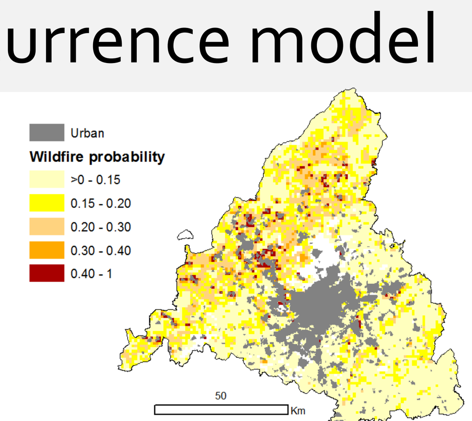


Results and discussion

Historical wildfire occurrence model

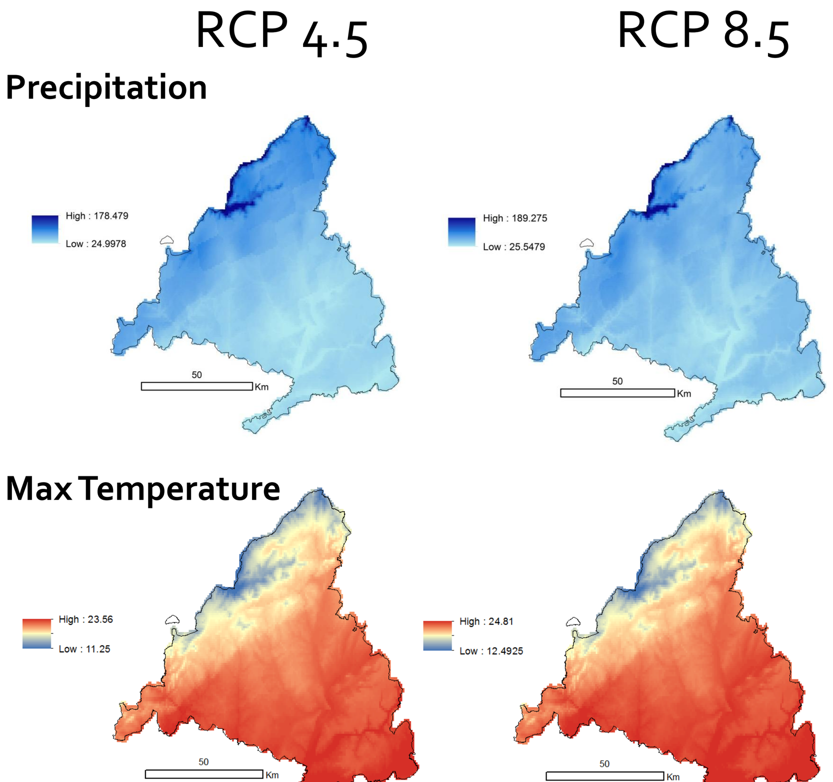
	Estimated coefficients	p-value
(Intercept)	-5.524	1.44e-07 ***
FAI	0.661	3.89e-05 ***
WUI	3.093	6.62e-14 ***
T max	0.122	0.00104 **
LFMC	0.024	7.27e-09 ***

AUC 0.74
Sensitivity 33%
Omision error 66%

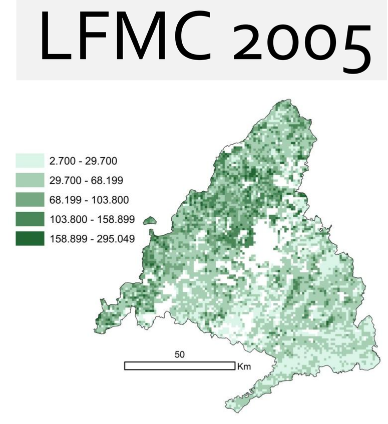


Precipitation & Max. temperature KNMI 2050

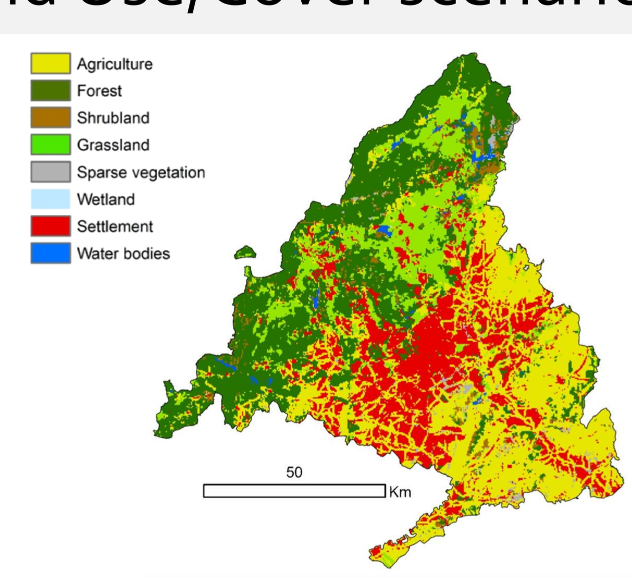
RCP 4.5 RCP 8.5



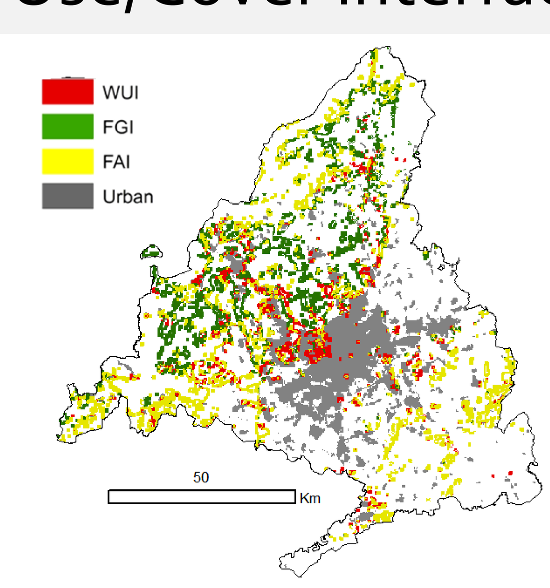
LFMC 2005



Land Use/Cover scenario 2050

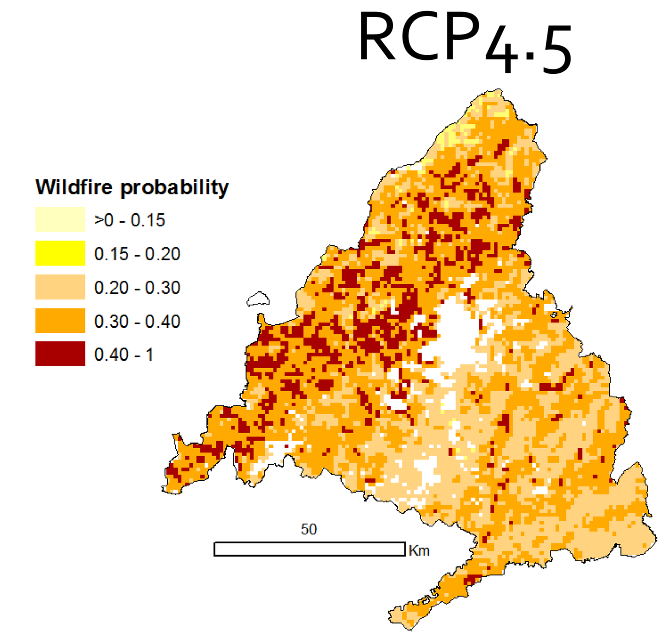


Land Use/Cover Interfaces 2050

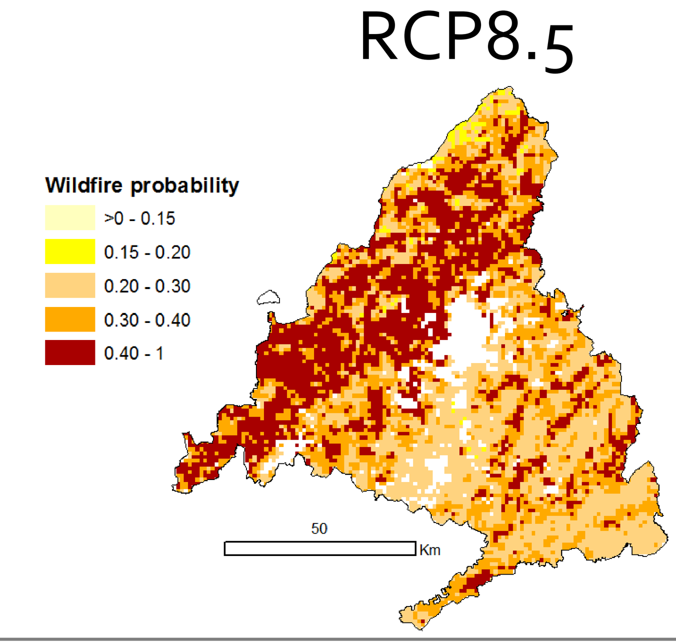


Future wildfire occurrence probability 2050

RCP4.5



RCP8.5



Conclusions

- Indicators of human-related ignition potential as the **LUC Interfaces** is a key issue to estimate wildfire occurrence in Mediterranean areas
- Biophysical variables improved **wildfire occurrence explanation**
- LUC **2050** scenario showed and **increase in urban areas** which leaded to an increment of **WUI**
- **Future wildfire** occurrence probability **increased** in both 4.5 and 8.5 RCP scenarios, more significantly in **RCP 8.5**
- The **north-west** regions have higher probability of wildfire occurrence using the historical wildfire model and under the projected climatic conditions

References

Bedia, J., Herrera, S., Gutiérrez, J.M., 2013. Dangers of using global bioclimatic datasets for ecological niche modeling. Limitations for future climate projections. Global and Planetary Change 107, 1-12.
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Acknowledgements

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