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# Supplementary Material

## Cross-regional modelling of fire occurrence in the Alps and the Mediterranean Basin

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**Table S1:** Full list of the variables that were used in the study.

| Variable | Description | Category |
|---|---|---|
| **BIO 1** | Annual mean temperature | Temperature |
| **BIO 2** | Mean diurnal range | Temperature |
| **BIO 3** | Isothermality (BIO2/BIO7) (* 100) | Temperature |
| **BIO 4** | Temperature seasonality | Temperature |
| **BIO 5** | Max temperature of warmest month | Temperature |
| **BIO 6** | Min Temperature of coldest month | Temperature |
| **BIO 7** | Temperature annual range (BIO5-BIO6) | Temperature |
| **BIO 8** | Mean temperature of wettest quarter | Temperature |
| **BIO 9** | Mean temperature of driest quarter | Temperature |
| **BIO 10** | Mean temperature of warmest quarter | Temperature |
| **BIO 11** | Mean temperature of coldest quarter | Temperature |
| **BIO 12** | Annual precipitation | Precipitation |
| **BIO 13** | Precipitation of wettest month | Precipitation |
| **BIO 14** | Precipitation of driest month | Precipitation |
| **BIO 15** | Precipitation seasonality (Coefficient of variation) | Precipitation |
| **BIO 16** | Precipitation of wettest quarter | Precipitation |
| **BIO 17** | Precipitation of driest quarter | Precipitation |
| **BIO 18** | Precipitation of warmest quarter | Precipitation |
| **BIO 19** | Precipitation of coldest quarter | Precipitation |
| **Road network** | Road line density | Anthropogenic |
| **Human settlement** | Percentage built up area (0-100 %) | Anthropogenic |
| **Land cover** | Categorical land cover data | Anthropogenic |
| **Tree cover density** | Tree cover density (0-100 %) | Forest |
| **Forest type** | Categorical forest type data (broadleaved or coniferous) | Forest |
| **Aspect** | Direction that a slope faces | Topography |
| **Slope** | (°) | Topography |

**Table S2:** Variable contributions of individual variables.

| | Model | Resolution | Category | Variable Name | Value contribution | | Model | Resolution | Category | Variable name | Value contribution |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | AU | Coarse | Temperature | bio01 | 44.5 | 1 | AU | Fine | Forest | tcoverd | 37.9 |
| 2 | AU | Coarse | Anthropogenic | roadnet | 44.2 | 2 | AU | Fine | Temperature | bio1 | 27.7 |
| 3 | AU | Coarse | Temperature | bio06 | 5.8 | 3 | AU | Fine | Anthropogenic | roadnet | 18.7 |
| 4 | AU | Coarse | Topography | slope | 3.1 | 4 | AU | Fine | Topography | aspect | 6.4 |
| 5 | AU | Coarse | Forest | tcoverd | 2.3 | 5 | AU | Fine | Forest | fty | 4.6 |
| | | | | | | 6 | AU | Fine | Anthropogenic | landcover | 2.7 |
| | | | | | | 7 | AU | Fine | Temperature | bio3 | 1.0 |
| | | | | | | 8 | AU | Fine | Precipitation | bio15 | 1.0 |
| 1 | CH | Coarse | Forest | tcoverd | 36.2 | 1 | CH | Fine | Forest | tcoverd | 46.3 |
| 2 | CH | Coarse | Temperature | bio01 | 30.8 | 2 | CH | Fine | Temperature | bio1 | 32.0 |
| 3 | CH | Coarse | Precipitation | bio15 | 7.6 | 3 | CH | Fine | Precipitation | bio15 | 6.6 |
| 4 | CH | Coarse | Anthropogenic | roadnet | 6.6 | 4 | CH | Fine | Anthropogenic | roadnet | 3.5 |
| 5 | CH | Coarse | Temperature | bio08 | 5.0 | 5 | CH | Fine | Topography | aspect | 3.3 |
| 6 | CH | Coarse | Temperature | bio07 | 4.6 | 6 | CH | Fine | Anthropogenic | landcover | 2.5 |
| 7 | CH | Coarse | Topography | aspect | 3.3 | 7 | CH | Fine | Precipitation | bio18 | 2.4 |
| 8 | CH | Coarse | Precipitation | bio18 | 2.0 | 8 | CH | Fine | Anthropogenic | settl | 1.4 |
| 9 | CH | Coarse | Temperature | bio09 | 2.0 | 9 | CH | Fine | Temperature | bio7 | 1.1 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | CH | Coarse | Precipitation | bio17 | 1.0 | 10 | CH | Fine | Precipitation | bio19 | 0.8 |
| 11 | CH | Coarse | Anthropogenic | landcover | 0.7 | | | | | | |
| 12 | CH | Coarse | Forest | fty | 0.1 | | | | | | |
| | | | | | | | | | | | |
| 1 | CR | Coarse | Temperature | bio08 | 42.6 | 1 | CR | Fine | Temperature | bio8 | 41.4 |
| 2 | CR | Coarse | Temperature | bio09 | 23.4 | 2 | CR | Fine | Forest | tcoverd | 21.5 |
| 3 | CR | Coarse | Forest | tcoverd | 17.2 | 3 | CR | Fine | Temperature | bio9 | 19.8 |
| 4 | CR | Coarse | Anthropogenic | roadnet | 9.5 | 4 | CR | Fine | Anthropogenic | roadnet | 8.8 |
| 5 | CR | Coarse | Temperature | bio07 | 2.1 | 5 | CR | Fine | Anthropogenic | landcover | 1.9 |
| 6 | CR | Coarse | Topography | slope | 1.6 | 6 | CR | Fine | Temperature | bio3 | 1.8 |
| 7 | CR | Coarse | Anthropogenic | landcover | 1.5 | 7 | CR | Fine | Precipitation | bio19 | 1.4 |
| 8 | CR | Coarse | Precipitation | bio19 | 1.3 | 8 | CR | Fine | Temperature | bio7 | 1.4 |
| 9 | CR | Coarse | Precipitation | bio12 | 0.4 | 9 | CR | Fine | Topography | slope | 1.2 |
| 10 | CR | Coarse | Forest | fty | 0.3 | 10 | CR | Fine | Precipitation | bio13 | 0.7 |
| | | | | | | 11 | CR | Fine | Anthropogenic | settl | 0.1 |
| | | | | | | | | | | | |
| 1 | SPA | Coarse | Anthropogenic | roadnet | 38.4 | 1 | SPA | Fine | Anthropogenic | roadnet | 38.3 |
| 2 | SPA | Coarse | Temperature | bio01 | 34.0 | 2 | SPA | Fine | Temperature | bio1 | 29.9 |
| 3 | SPA | Coarse | Forest | tcoverd | 11.4 | 3 | SPA | Fine | Temperature | bio3 | 6.2 |
| 4 | SPA | Coarse | Precipitation | bio12 | 5.6 | 4 | SPA | Fine | Forest | tcoverd | 5.8 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | SPA | Coarse | Precipitation | bio13 | 5.1 | 5 | SPA | Fine | Precipitation | bio12 | 5.7 |
| 6 | SPA | Coarse | Temperature | bio03 | 2.3 | 6 | SPA | Fine | Anthropogenic | landcover | 5.5 |
| 7 | SPA | Coarse | Anthropogenic | landcover | 2.2 | 7 | SPA | Fine | Precipitation | bio13 | 5.2 |
| 8 | SPA | Coarse | Anthropogenic | settl | 0.9 | 8 | SPA | Fine | Topography | slope | 2.8 |
| | | | | | | 9 | SPA | Fine | Anthropogenic | settl | 0.6 |
| | | | | | | | | | | | |
| 1 | TR | Coarse | Precipitation | bio19 | 42.8 | 1 | TR | Fine | Forest | tcoverd | 28.4 |
| 2 | TR | Coarse | Forest | tcoverd | 20.2 | 2 | TR | Fine | Temperature | bio8 | 24.1 |
| 3 | TR | Coarse | Anthropogenic | roadnet | 14.7 | 3 | TR | Fine | Anthropogenic | roadnet | 18.1 |
| 4 | TR | Coarse | Temperature | bio10 | 11.1 | 4 | TR | Fine | Precipitation | bio12 | 12.2 |
| 5 | TR | Coarse | Temperature | bio02 | 4.8 | 5 | TR | Fine | Topography | slope | 5.9 |
| 6 | TR | Coarse | Anthropogenic | landcover | 3.3 | 6 | TR | Fine | Anthropogenic | landcover | 5.6 |
| 7 | TR | Coarse | Temperature | bio04 | 2.3 | 7 | TR | Fine | Temperature | bio2 | 4.2 |
| 8 | TR | Coarse | Forest | fty | 0.7 | 8 | TR | Fine | Forest | fty | 1.5 |

**Study Regions**

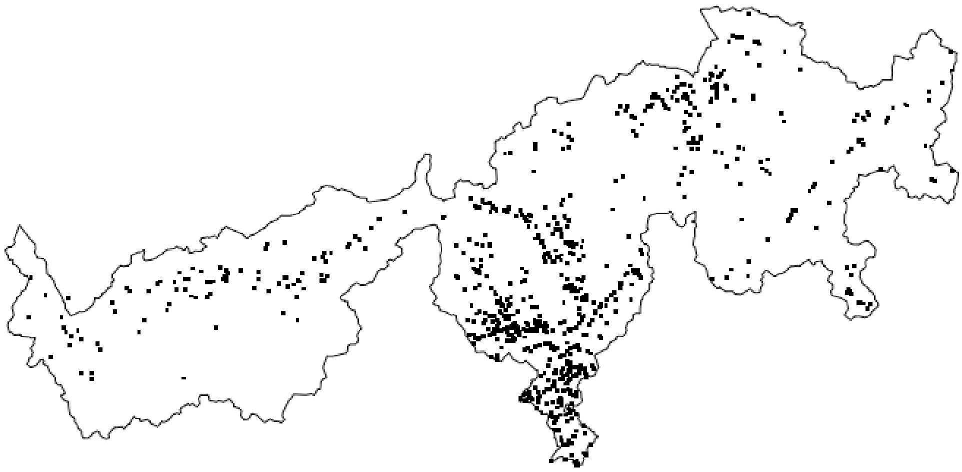

**Fig. S1:** Fire locations in Southern Switzerland (Central and Southern Alps).

## Central and Southern Alps of Switzerland

This study region is located in central and southern Alps and contains three cantons of Switzerland: Valais, Ticino and Grisons, covering 15 141 $km^2$. It exhibits highly diverse climate conditions from a very dry continental climate in Valais to warm and humid conditions in Ticino.

Geo-referenced fire data for the period 2000-2016 were obtained from the swiss forest fire database Swissfire (www.wsl.ch/swissfire) of the Swiss Federal Institute for Forest, Snow and Landscape Research WSL (Pezzatti *et al.* 2010). The dataset had 831 fires. This region is the most fire prone part of Switzerland (Zumbrunnen et al., 2012) and has fires all year round with two major peaks in March-April and July and August. Among the three cantons, Ticino has much higher fire activity than Valais and Grisons. De Angelis *et al.* (2015) splitted the fires into "winter fires" (non-vegetative season, from December to April), stating that most of them are of anthropogenic origin, and "summer fires" (vegetative season, from May to November), consisting of fires of both natural and anthropogenic origin.

**Fig. S2:** Fire locations in Carinthia, Austria.

### CARINTHIA

Carinthia is located in the southern part of Austria and covers 9 536 km$^2$. The region experiences a climate with high summer temperatures and cold winters; it also experiences high number of thunderstorms (Grima 2011). Vegetation is mostly dominated by alpine coniferous (*Picea abies*, *Abies alba*, *Pinus slyvestris*, *Larix decidua*) or beech forests (*Fagus sylvatica*) (Grima 2011).

Fire data for the years 2000-2017 were obtained from the forest fire database of Austria (Vacik *et al.* 2011). In total, there were 491 fires in the dataset. Most of them occurred in the period of March to September. Carinthia experiences a high number of lightning strikes, and as a result nearly a quarter of the fires are lightning-induced (Vacik *et al.* 2011).

VALENCIA

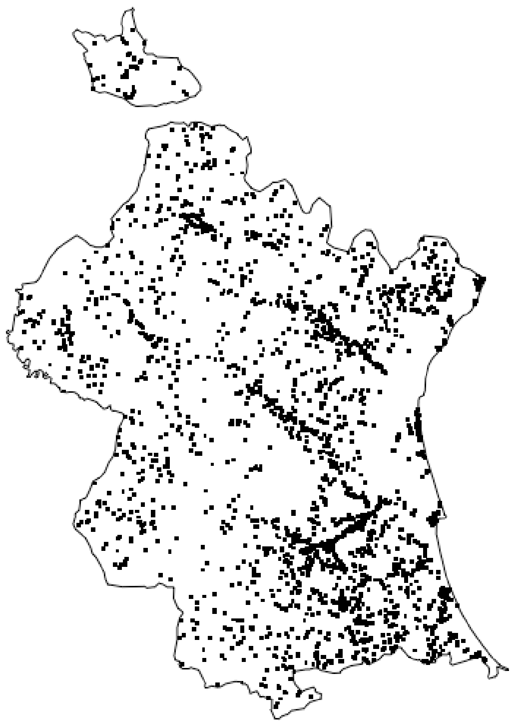

**Fig. S3:** Fire locations in Valencia, Spain.

The region of Valencia locates in eastern Spain along the Mediterranean coast. Area has Mediterranean-type climate with hot and dry summers and mild winters. Vegetation is mainly dominated by evergreen shrublands (*Quercus coccifera*) and pine woodlands (*Pinus halepensis*).

Fire data were gathered by the Regional Government of Valencia for the period 2001-2014. The fire regime of the region is strongly influenced by land-use changes), but for the period considered here, climate (drought) is also very relevant (Pausas 2004, Pausas & Fernández-Muñoz 2012). Ignitions are largely anthropogenic. In total, there were 2 688 fires in the region, most of them occurred during summer (June to August).

## SOUTHWESTERN TURKEY

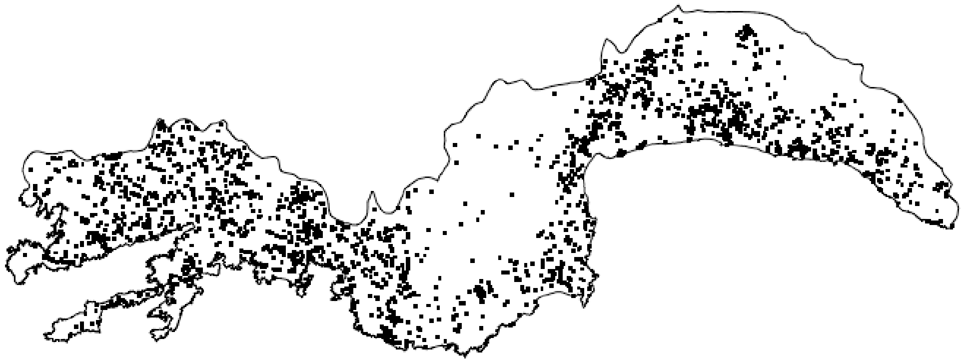

**Fig. S4:** Fire locations in Southwestern Turkey.

The study region covers 32 831 km$^2$ along the southwestern coast of Turkey. The climate is typical Mediterranean with hot and dry summers and rainy and mild winters. The vegetation of the low elevation levels of the study region is dominated by *Pinus brutia* forests and Mediterranean shrublands. Dominant tree species of forests changes to *Pinus nigra* and *Cedrus libani* with the increasing elevation and distance to coast (Atalay et al. 2014). We obtained fire ignition data from the General Directory of Forestry of Turkey ('OGM'). Fire statistics go back to 2000, but since we needed geo-referenced data, we were only able to use data for the period 2013-2017. Total number of fires was 2 512 for this period with a peak in the summer-drought period (June to September). The region has an intense anthropogenic pressure, especially in low elevations, but the climate is still the main driver of the fire activity in the area (Bekar, 2016).

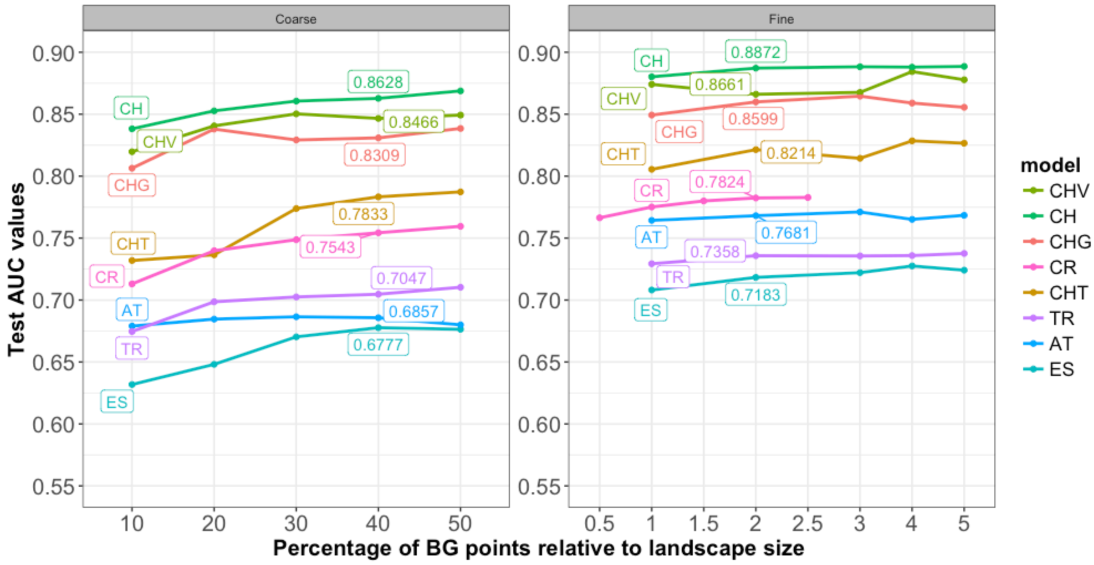


**Fig. S5:** Effect of the number of background (BG) points used in Maxent on model performance (AUC). CR = cross-regional; AT = Austria; ES = Spain; TR = Turkey; CH = Switzerland, CHV = Valais, CHG = Graubünden, CHT= Ticino.

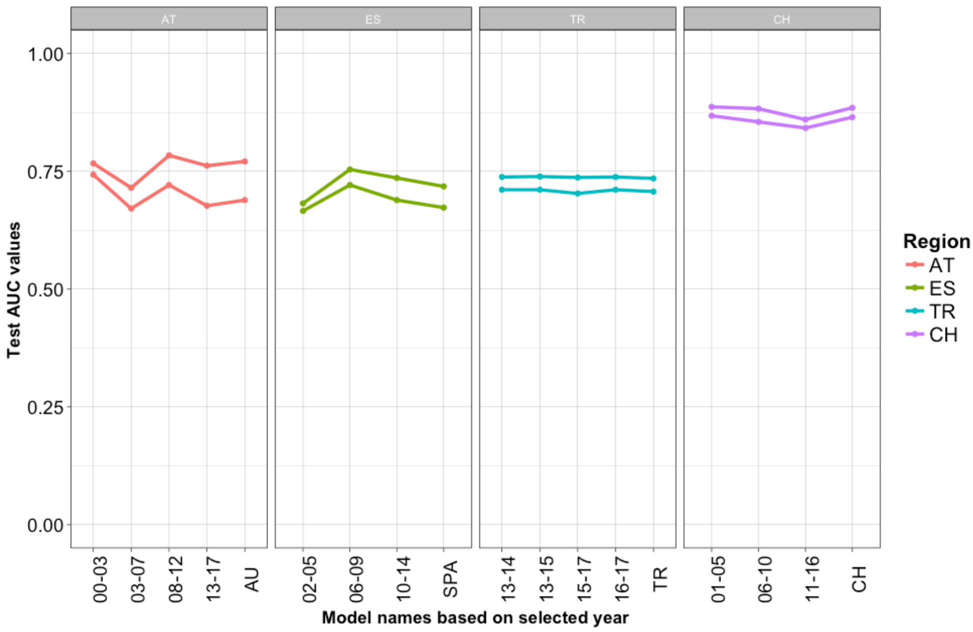


**Fig. S6:** The effect of using different periods of the predictor variables on model performance. CR = cross-regional; AT = Austria; ES = Spain; TR = Turkey; CH = Switzerland.

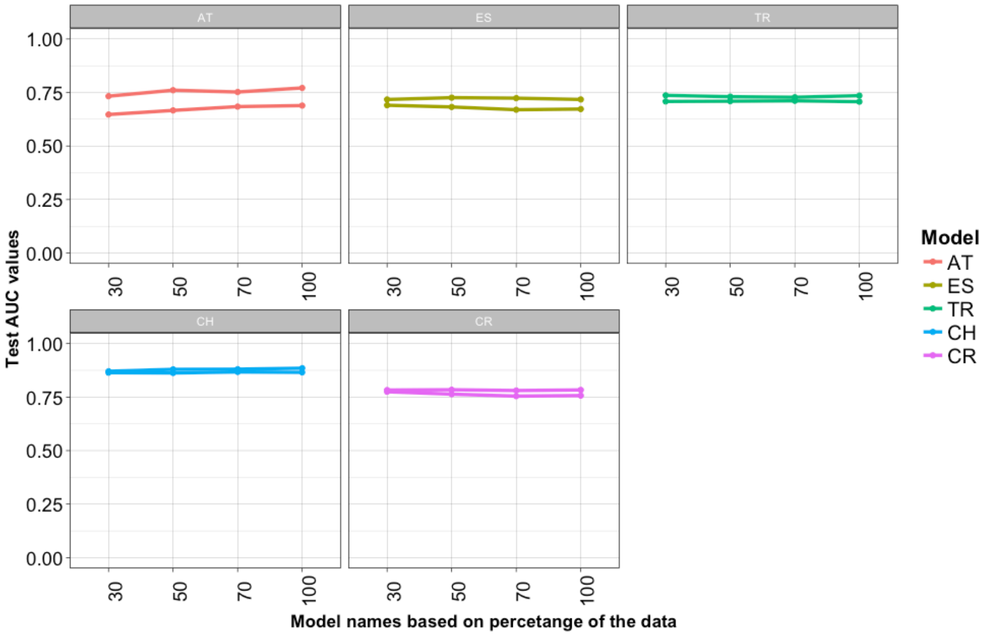


**Fig. S7:** The effect of sample size on model performance. CR = cross-regional; AT = Austria; ES = Spain; TR = Turkey; CH = Switzerland.

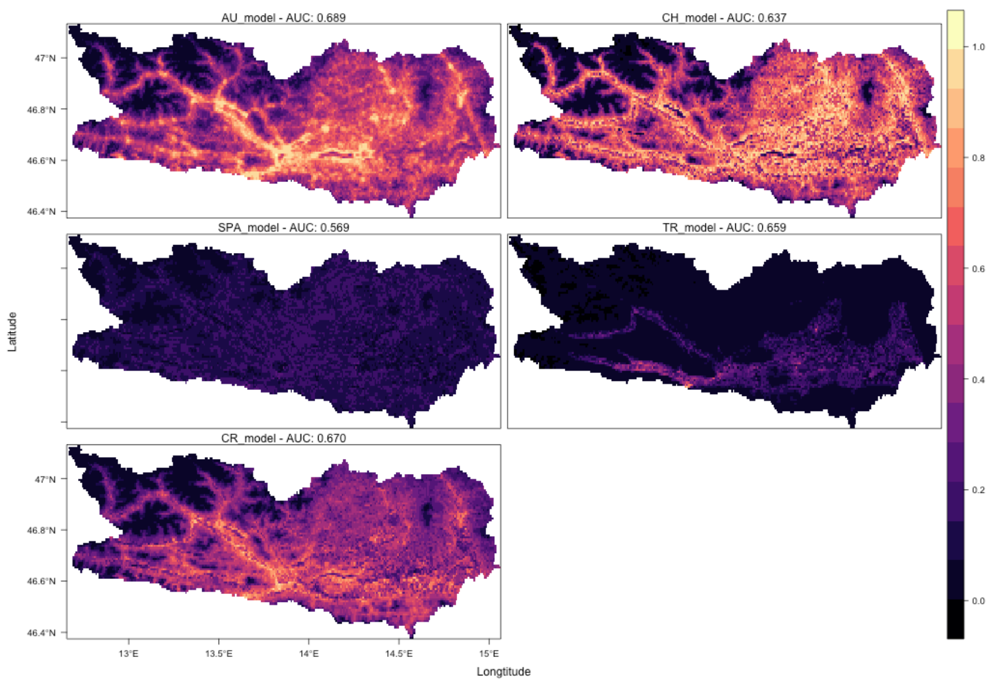


**Fig. S8:** Predicted fire occurrence maps for Carinthia (Austria) using the coarse resolution models of the other regions.

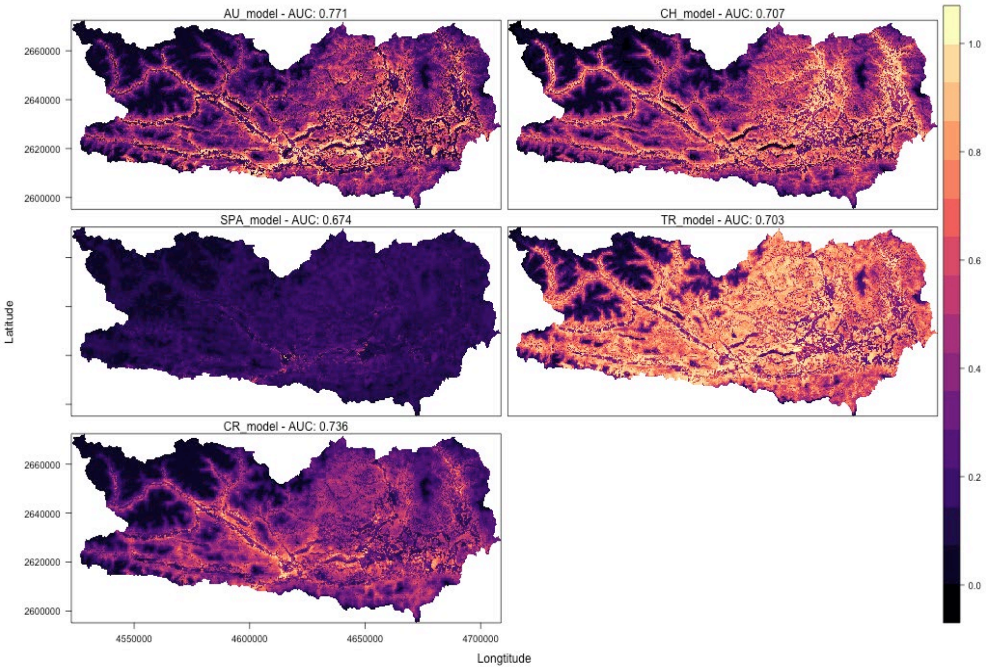


**Fig. S9:** Predicted fire occurrence maps for Carinthia (Austria) using the fine resolution models of the other regions.

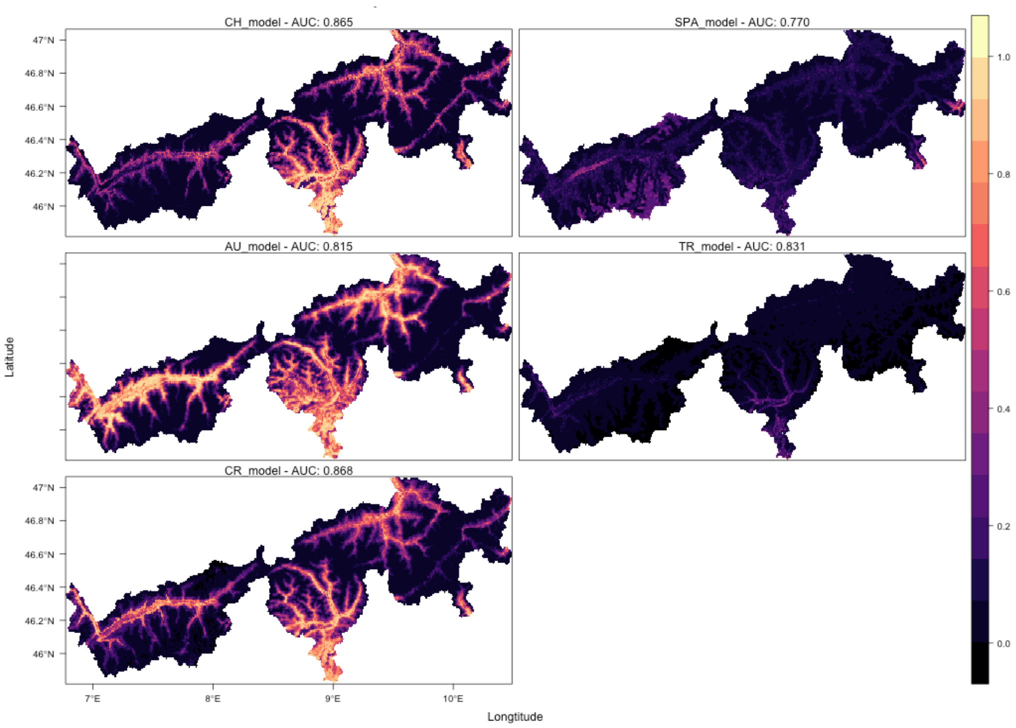


**Fig. S10:** Predicted fire occurrence maps for Southern Switzerland using the coarse resolution models of the other regions.

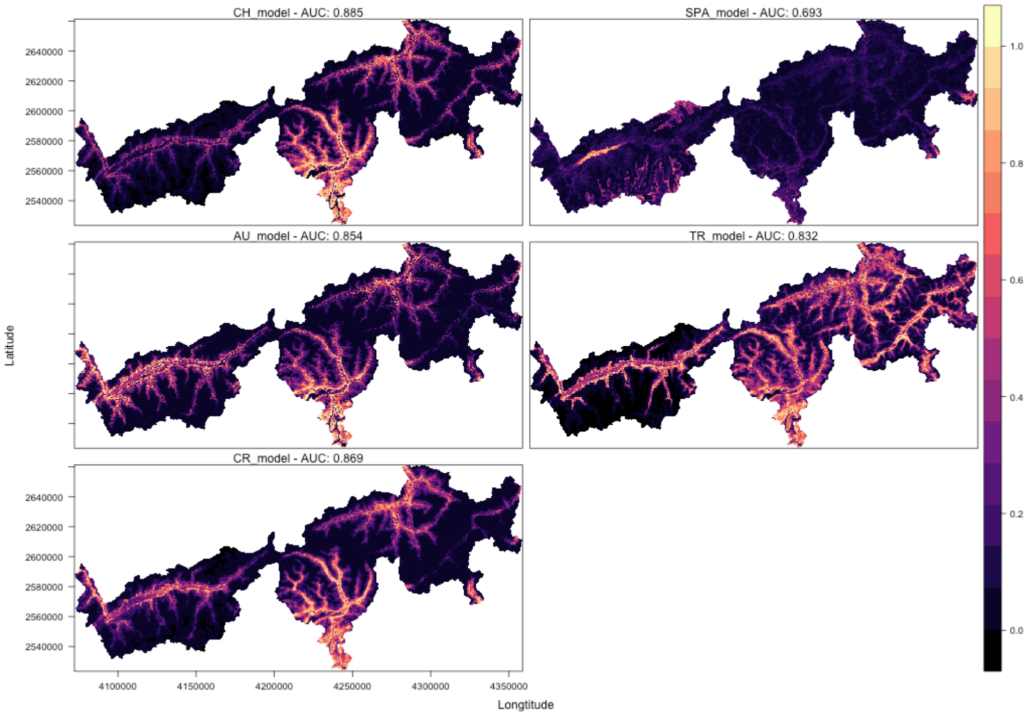


**Fig. S11:** Predicted fire occurrence maps for Southern Switzerland using the fine resolution models of the other regions.

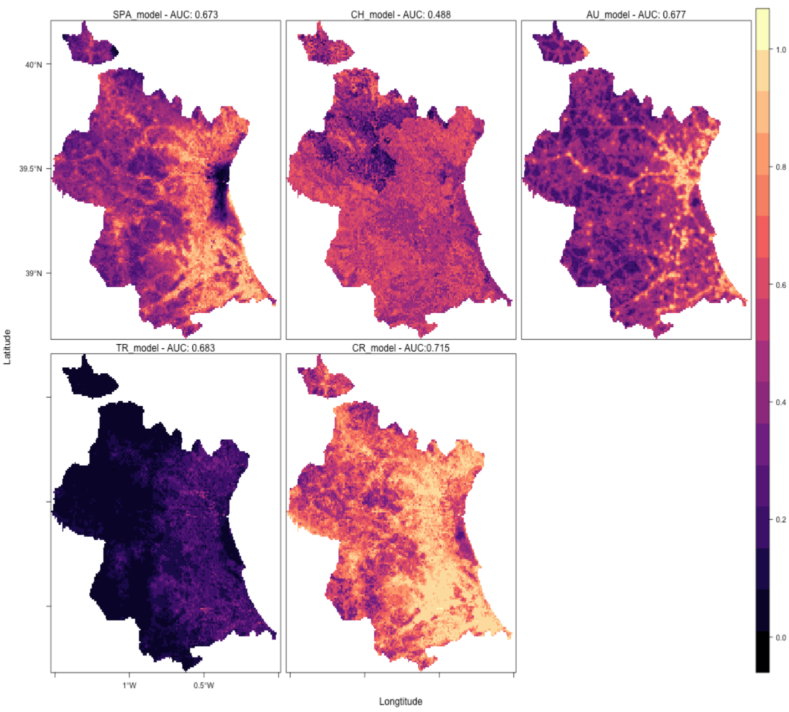


**Fig. S12:** Predicted fire occurrence maps for Valencia (Spain) using the coarse resolution models of the other regions.

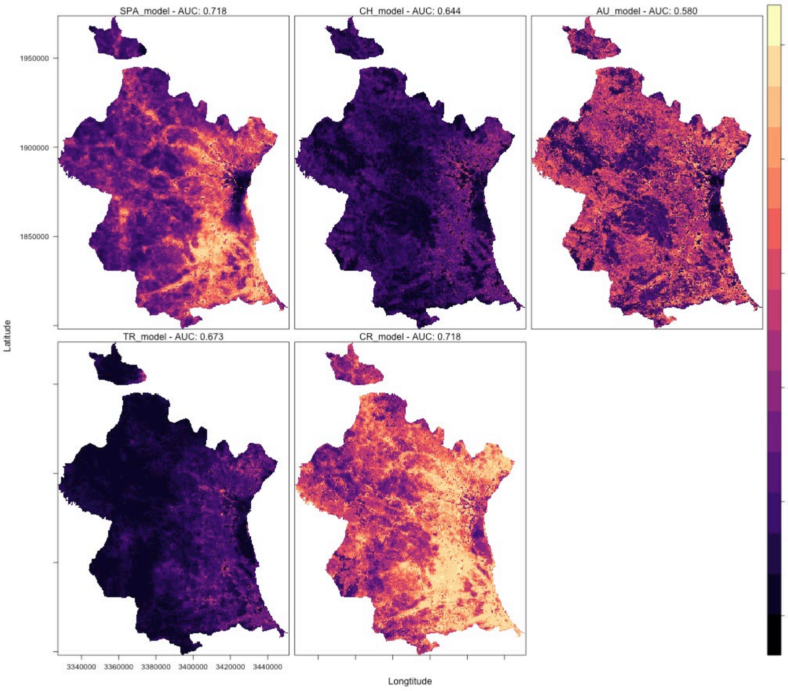


**Fig. S13:** Predicted fire occurrence maps for Valencia (Spain) using the fine resolution models of the other regions.

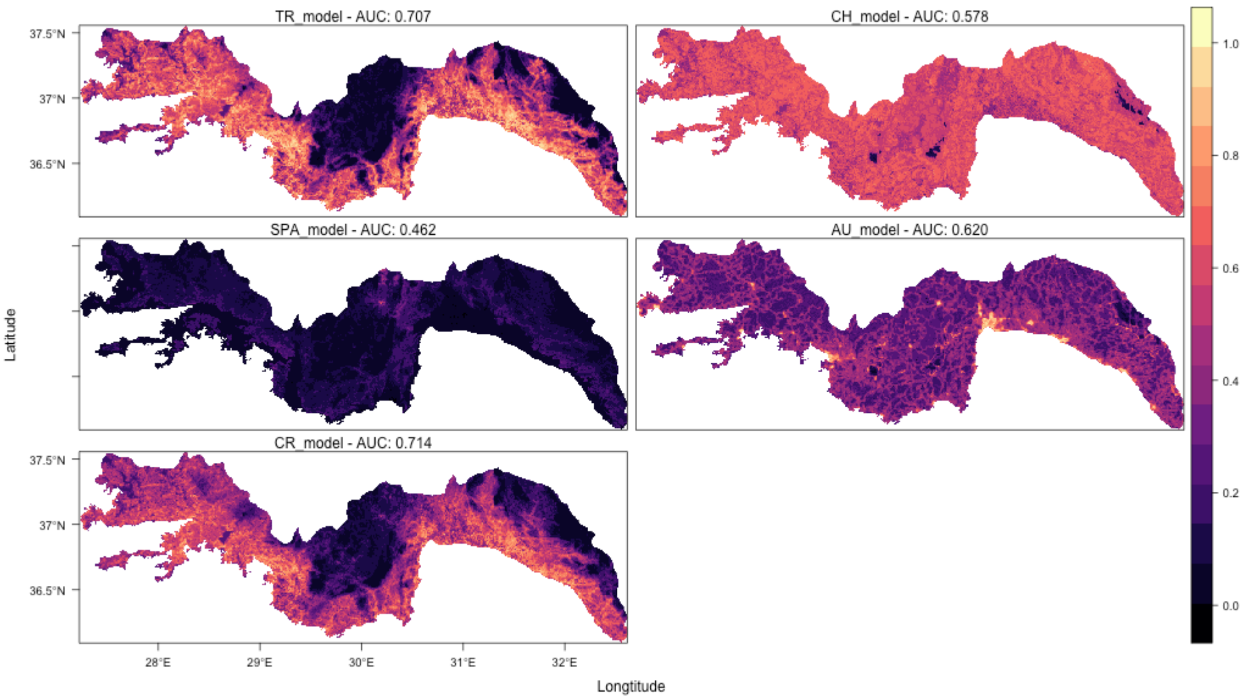


**Fig. S14:** Predicted fire occurrence maps for Southwestern Turkey using the coarse resolution models of the other regions.

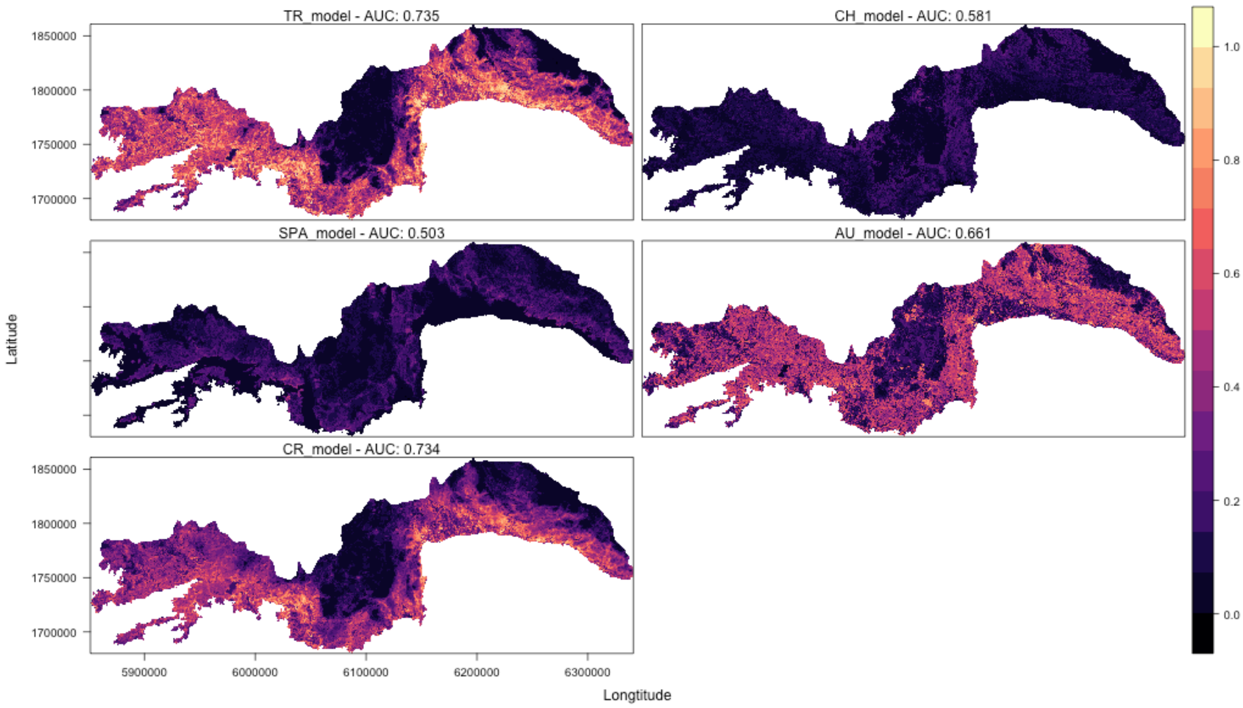


**Fig. S15:** Predicted fire occurrence maps for Southwestern Turkey using the fine resolution models of the other regions.

## References

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<eref>Grima N (2011) Forest fire hazard mapping in Carinthia (Southern Austria). M.Sc. Thesis, University of Natural Resources and Applied Life Sciences (BOKU), Vienna. Available at http://bit.ly/2EwTETb [Verified March 2020]</eref>

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<jrn>Zumbrunnen T, Menéndez P, Bugmann H, Conedera M, Gimmi U, Bürgi M (2012) Human impacts on fire occurrence: a case study of hundred years of forest fires in a dry alpine valley in Switzerland. *Regional Environmental Change* **12**, 935–949 doi:10.1007/s10113-012-0307-4.</jrn>