International Mistral workshop – Climate Change impacts in the Mediterranean region

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Likelihood of changes in forest species suitability, distribution and diversity under future climate: the case of Southern Europe

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- ✓ To quantificate and map the species' range shifts due to develope effective plans to conserve biodiversity
- ✓ To investigate the impacts of Climate Change on the distribution of some European forest species in terms of spatial ranges
- ✓ To focalize the analysis on the Mediterranean Basin
- ✓ To formulate hypotheses on future changes in forests composition and diversity
- ✓ To assess the uncertainty in future projections due to variability in GCMs' outputs

"…all approaches to conservation of biodiversity seek an answer to the question of where species were, are or will be." (Yalcin & Leroux, 2017)

Aims

Study area (some numbers)

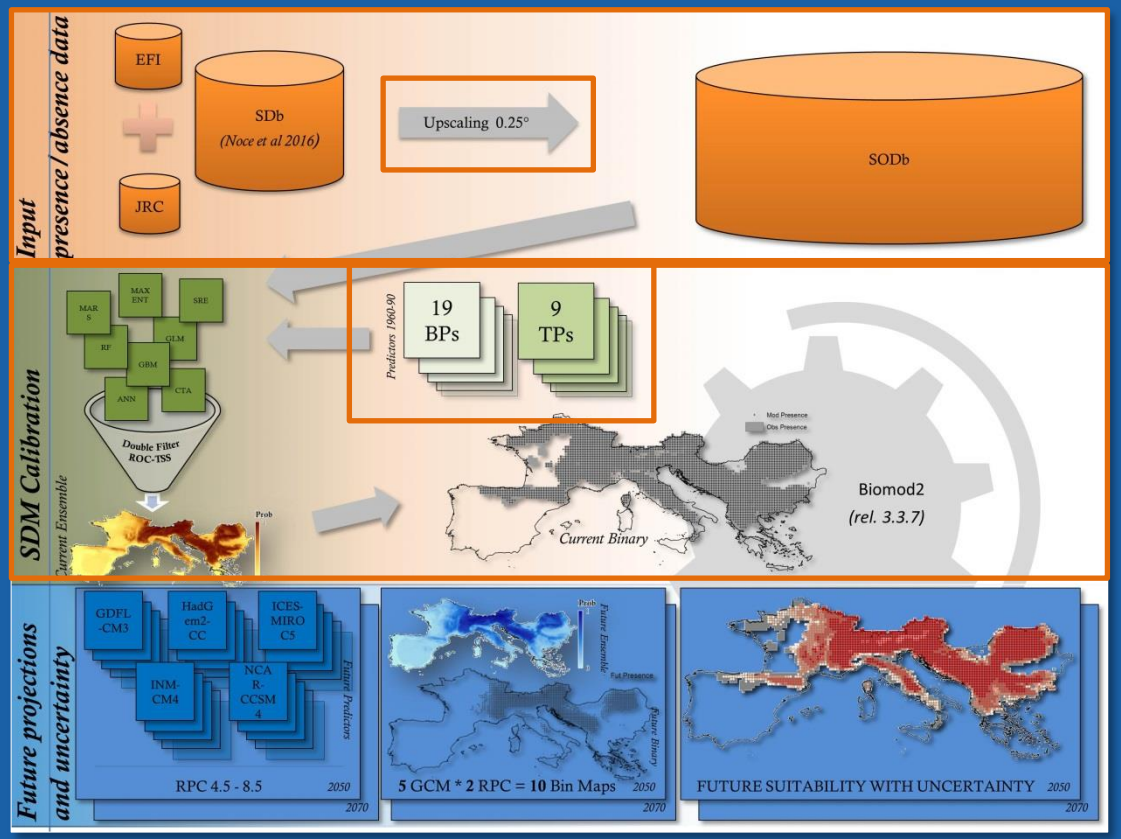
- ✓ 18 countries: Albania, Andorra, Austria, Bosnia and Herzegovina, Bulgaria, Croatia, France, Greece, Italy, Republic of Macedonia, Montenegro, Portugal, Romania, San Marino, Serbia, Slovenia, Spain, and Switzerland. 4 Main biogeographical regions (EEA,2015)
- ✓ Total surface approx 2.34 million km^2
- ✓ About 30% of it is covered by forest (FAO, 2014).
- ✓ 44% of forests is included into protected areas
  www.protectedplanet.net

- ✓ 59% of the forestland domain is occupied by broadleaved species, 25% by coniferous, and 16% by mixed forests. CORINE 2012
- ✓ Analysis grid 0.25° (4219 sample sites)

Methods

Input Data and Calibration phase

- ✓ Occurence database (30 arcsec) for 10 forest categories was created merging 2 European datasets: the European Forest Institute (EFI) 'Tree species maps for Europe' (Brus et al., 2012) and the Joint Research Center (JRC) 'Novel Maps for Forest Tree Species in Europe' (Köble and Seufert, 2001)
- ✓ Database (SDb), has been upscaled to 0.25°
- ✓ 8 SDMs (Species Distribution Models) considered for Ensemble Forecasting (Biomod2 Package)
- ✓ 28 environmental predictors (19 Bioclimatic - 9 Topographic) both for calibration phase and future projections



Methods

Future projections

- ✓ 5 bias corrected CMIP5 GCMs (GDFL-CM3, HadGem2-CC, MIROC5, INM-CM4.0 CSSM4)
- ✓ 2 RCP (4.5-8.5)

- ✓ 10 probability maps for each f.category were converted in 10 binary maps of future suitability for mid term (2050) and long term (2070). These were combined in an ensemble suitability map with associated a likelihood flag based on consensus among projections (IPCC approach)

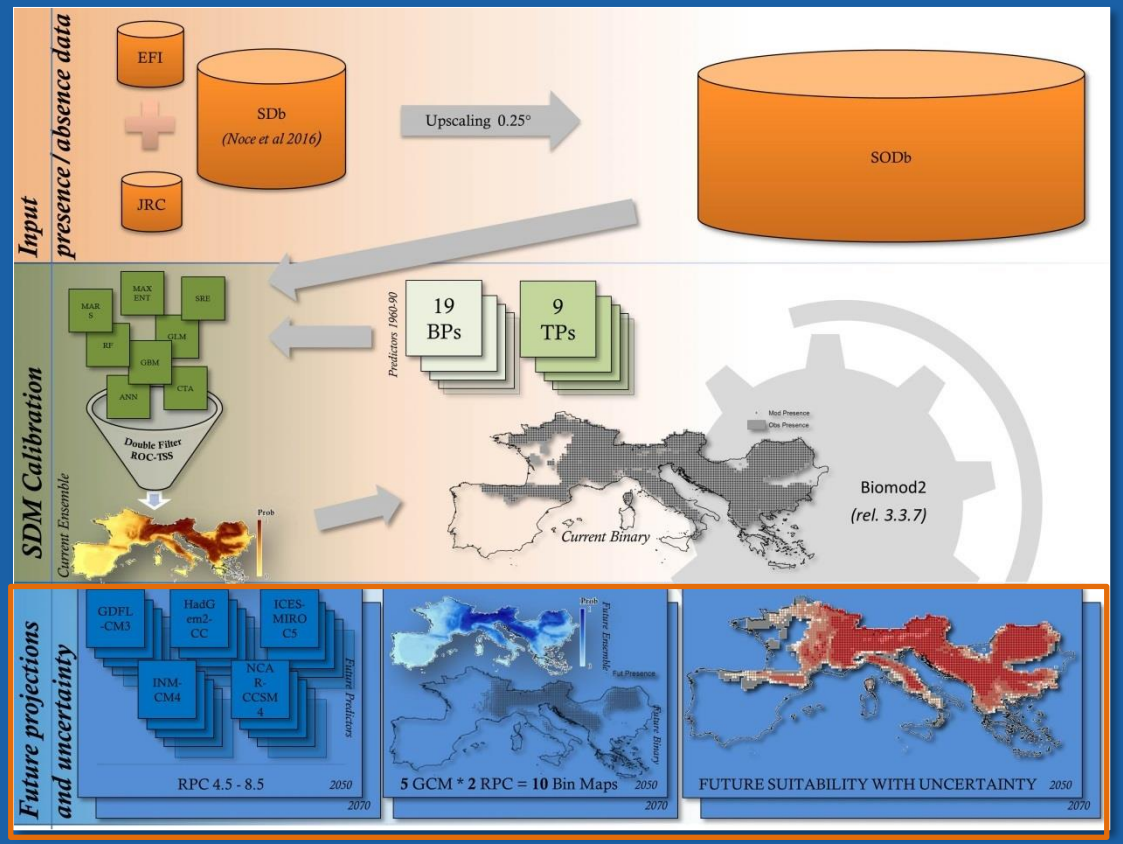


TABLE 3 Likelihood scale (based on IPCC AR5 guidance note Mastrandrea et al., 2011)

Term	Number of predicted suitability
Extremely unlikely	1
Unlikely	2–3
About as likely as not	4–6
Likely	7–8
Extremely likely	9–10

(Noce *et al*, 2017)

Methods

Cascade Ensemble System (CES)

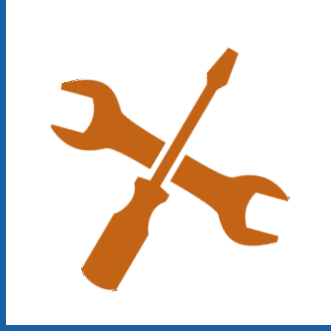
Why use SDMs?

Pros

- ✓ Have a predominant spatial component (needed for range shift predictions)
- ✓ Are less data (predictors – presence/absence data) demanding
- ✓ Have a multi scale approach (from local to global)
- ✓ Can be complementary to Process Based Models
- ✓ Are not species specific
- ✓ Can be automatically grouped and processed (*Ensemble forecasting*)
- ✓ … …

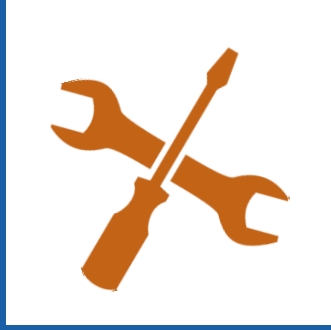
Cons

- ✓ Are based on several and uncertain assumptions (i.e. relationship between predictors and presence/absence unchanged in future)
- ✓ Results depend widely on environmental predictors
- ✓ Can suffer of collinearity among predictors
- ✓ Do not routinely consider relevant population and dispersal dynamics or intraspecific variation in climatic tolerances
- ✓ … …



Methods

Forest species



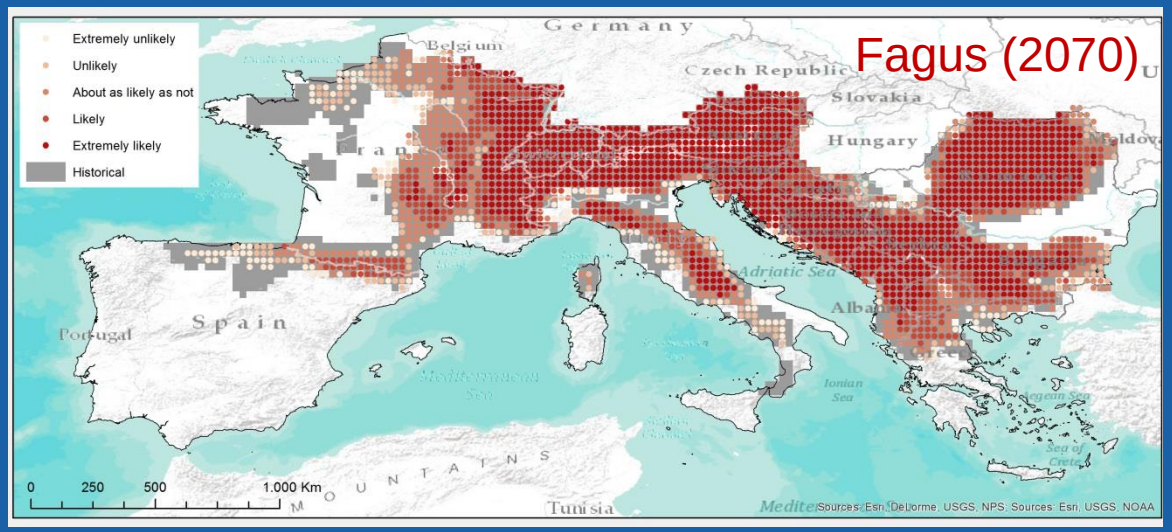
Species	Category Name
Abies alba Mill., *Abies cephalonica* Loudon	Abies
Betula pendula Roth, *Betula pubescens* Ehrhart	Betula
Fagus sylvatica L.	Fagus
Larix decidua Mill.	Larix
Picea abies (L.) H.Karst.	Picea
Pinus pinaster Aiton	PinusPin
Pinus sylvestris L.	PinusSylv
Quercus robur L., *Quercus petraea* (Mattuschka) Liebl.	QuercusRP
Other *Quercus* not included in QuercusRP (Mediterranean Oaks)	QuercusSP

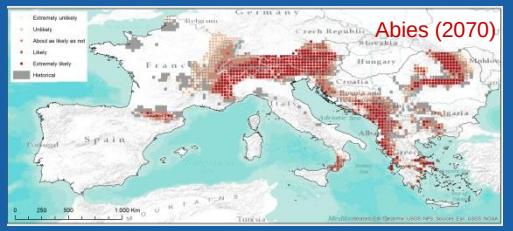
Good cover of total Mediterranean forest diversity

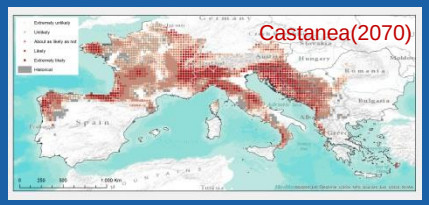
Methods

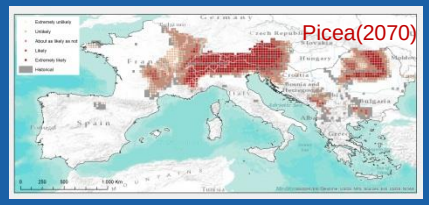
Suitability maps

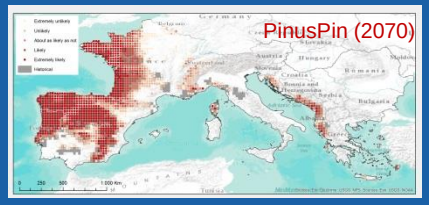
2 Suitability (mid-long term) maps for each f. category flagged with likelihood scale

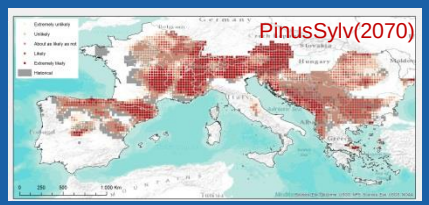


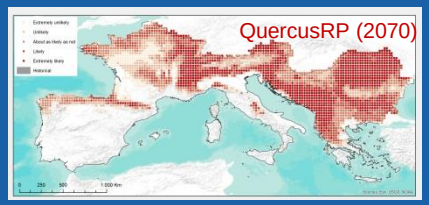






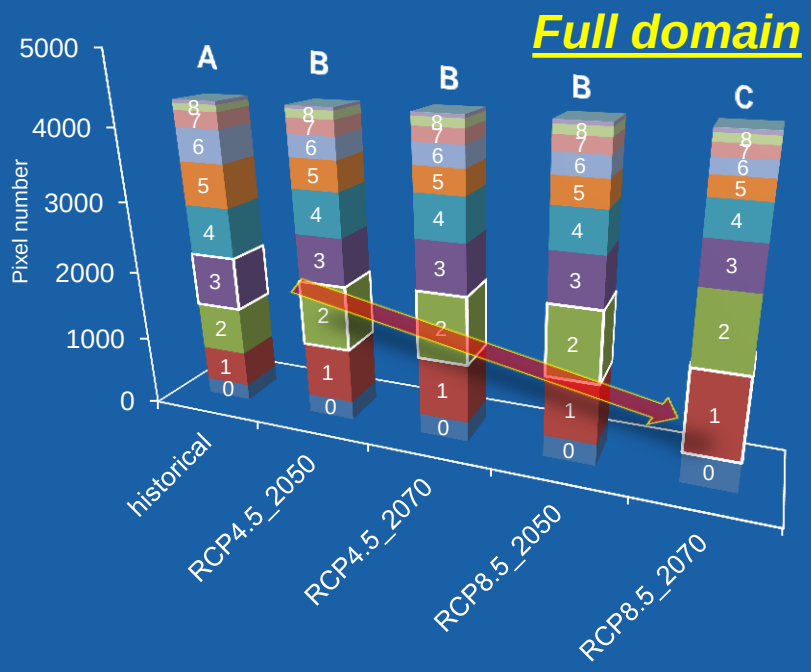


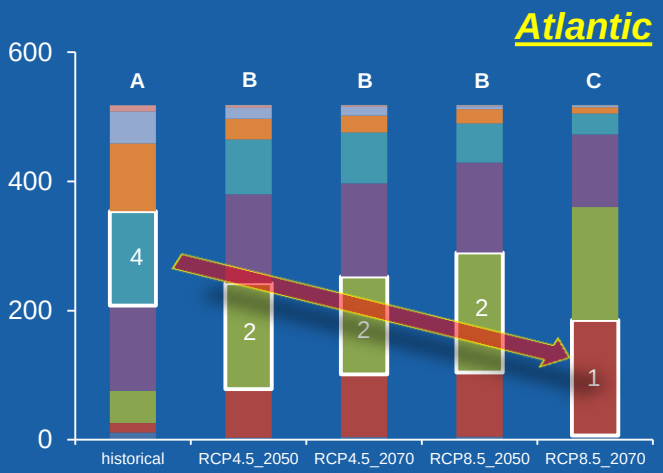


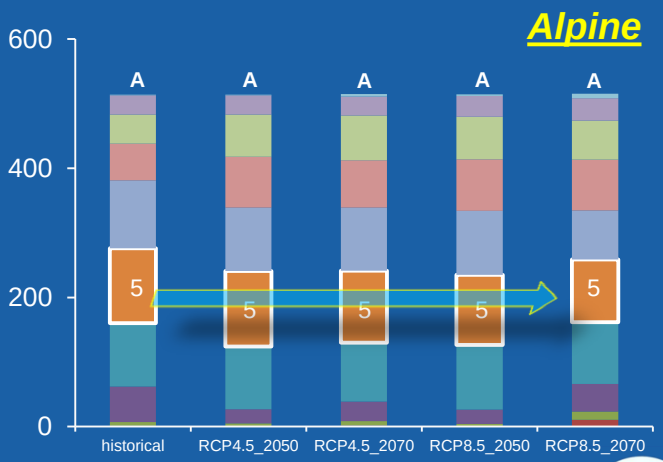


Results

Forest Diversity







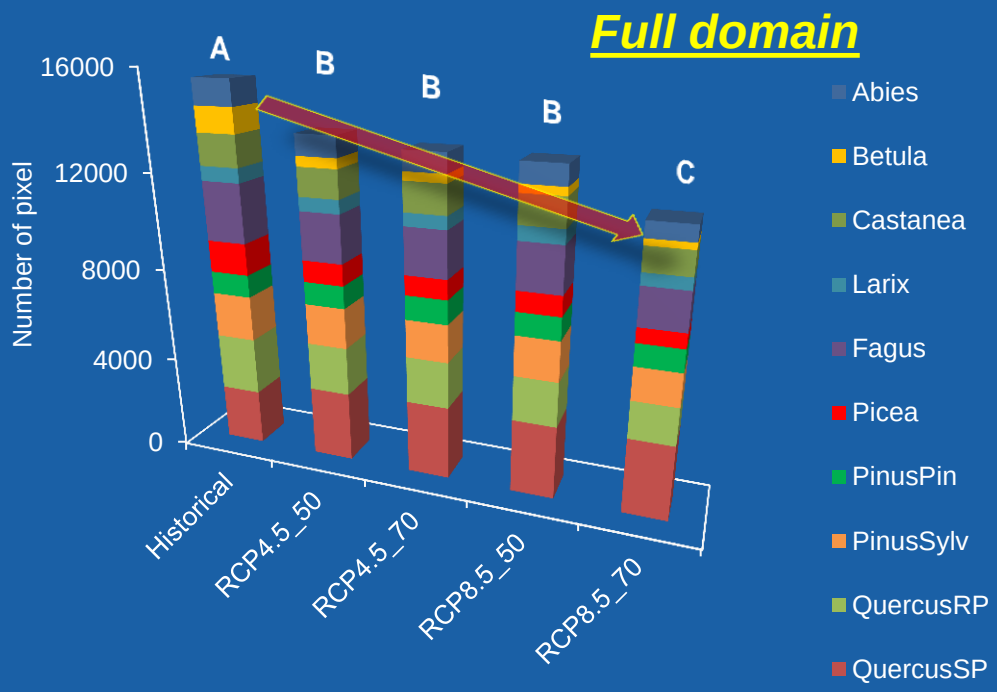
Most frequent combination of f. categories

Number of potential f. categories in the same area unit (pixel)

Different capital letters mean that distributions are significantly different at the 99.9% level (*p*-value < .001)

Results

Forest Distribution



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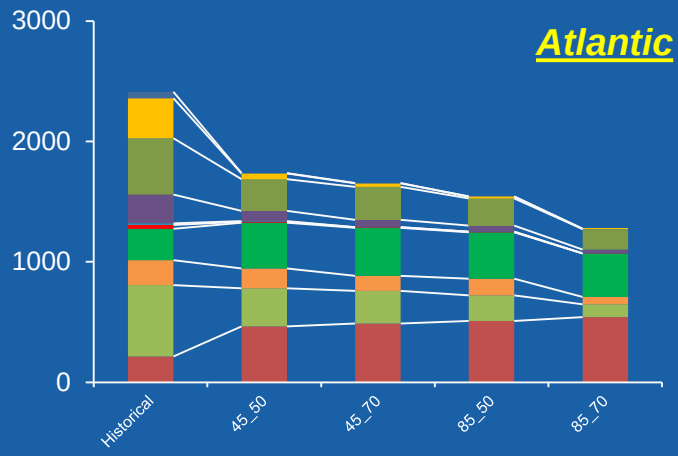

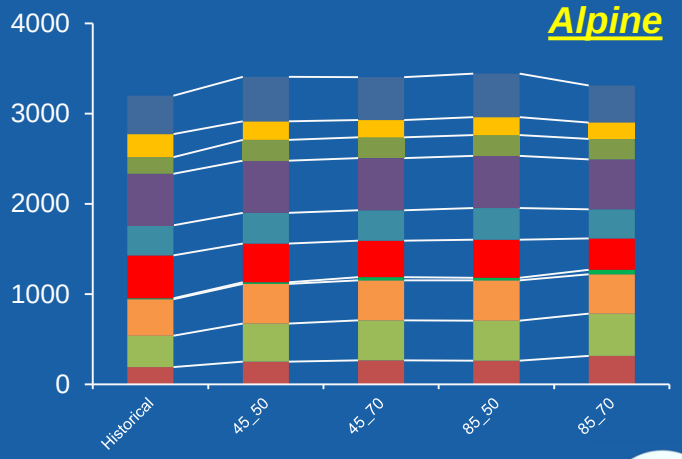

Results

Premises

- ✓ Analyzed forest categories represent a significant portion of species in Southern Europe but they neither cover the totality of current forest diversity
- ✓ To interpret the suitability as an indicator of forest presence/absence, species migration should be considered free from ties and constrains (i.e. the high degree of fragmentation of habitats peculiar of Mediterranean region)
- ✓ SDMs don’t take into consideration the competitive and dispersal capabilities of the species
- ✓ Our work does not consider the spreading of alien forest species

Discussion

Main expected impacts

- ✓ *Minor or no impacts on the historical distribution while new areas become suitable*

  PinusPin gains favorable conditions in Northern France, Western Alps Pyrenees (high level of uncertainty). QuercusSP's suitability appears extremely spreading in both northward and eastward directions (France and Western Romania)

- ✓ *Negative impacts on some portions of historical distribution and, in some cases, with suitability gain for others*

  Abies show its potential disappearing in France and Apennines, but suitability can increase across the Dinaric Alps and the Carpathians (eastward shifting). Noticeable impacts on QuercusRP in the Western side of its range (France). Fagus' suitability will be seriously threatened, decreasing in great part of Western and Southern edges of its historical distribution (clear examples in the Central and Southern Apennines); eastward shifting of the range

Discussion

Main expected impacts

- ✓ *Negative impacts on the most part of historical distribution*

Suitability for Betula will be guaranteed only in few areas (the Western, Central, and Dinaric Alps), strong reduction in the remaining range particularly in France. Likewise, especially long-term negative impacts on Castanea are significant and largely widespread. Also Picea's distribution could be negatively impacted on the medium and long term in the peripheral regions of the range.

- ✓ Atlantic bioregion seems to be the most exposed to CC in terms of forest diversity and distribution

- ✓ Considering the whole area, the impacts of both 4.5 and 8.5 RPCs are evident and the trends shown in mid term projections are confirmed and amplify over the long term

Discussion

- ✓ The *cascade ensemble system* allowed to treat both SDMs and climatic projections' uncertainty, providing more robust information about potential future changes in forest habitats under changing conditions

- ✓ Climate change is likely to led to *significant modifications* in the future, affecting forests with different degrees of magnitude across species and with various levels of uncertainty

- ✓ For most forest categories the new future conditions create a *less suitable environment*, meanwhile some (high-resilient) will find more suitable conditions in previously unsuitable locations

- ✓ A *strong decrease in local endemic species diversity* is projected in most of the area, with Alpine region showing the potentiality to become a refuge for species migration

Conclusion

Ref. Noce S, Collalti A, Santini M. Likelihood of changes in forest species suitability, distribution, and diversity under future climate: The case of Southern Europe. Ecology and Evolution 2017;00:1–18. https://doi.org/10.1002/ece3.3427

All maps contribute to ESRI Living Atlas of the World

http://arcg.is/1mKLi8

Thanks for your attention!!

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Contacts box