Investigating uncertainties in zooplankton composition shifts under climate change scenarios in the Mediterranean Sea.

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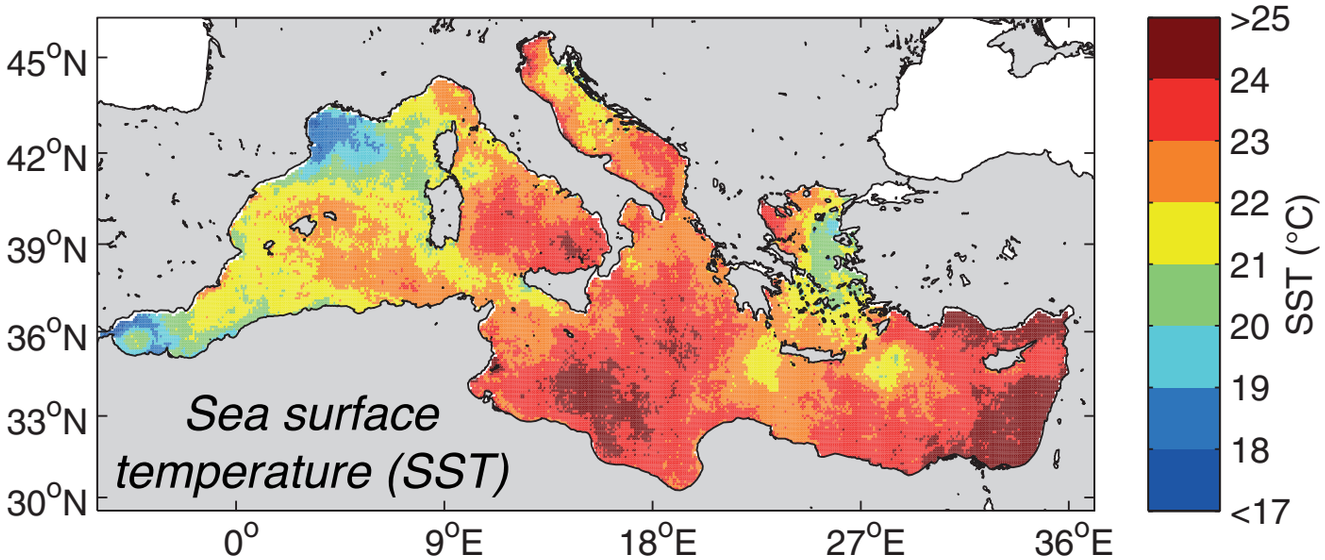
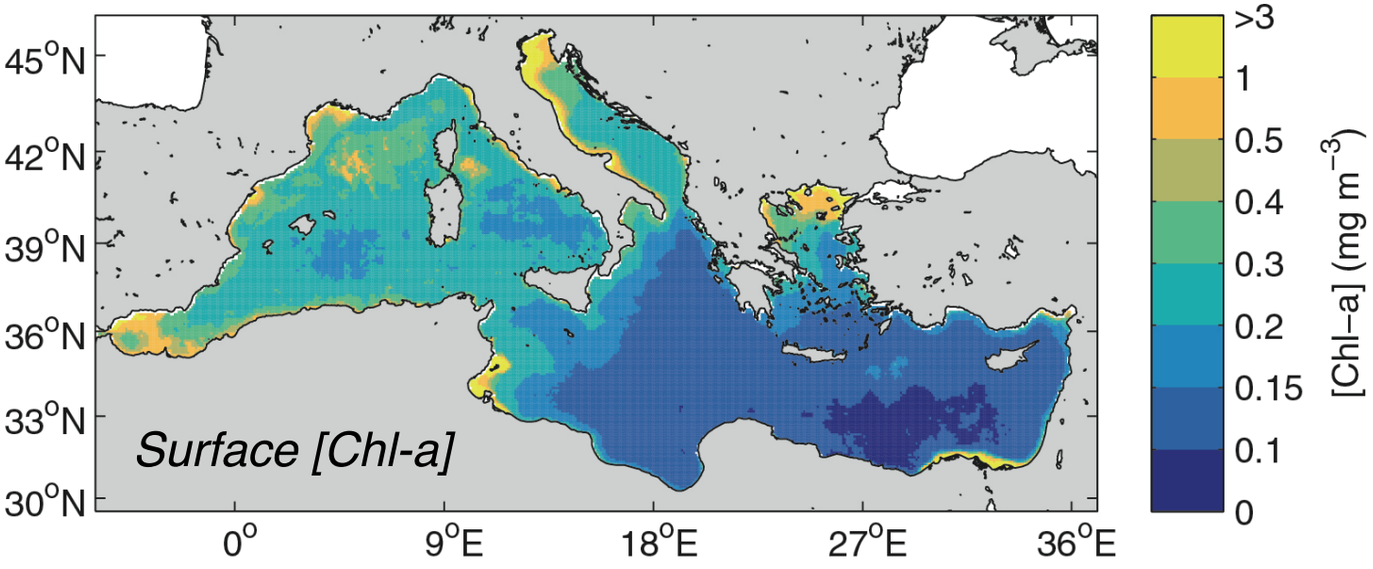
The Mediterranean Sea: a double hotspot !

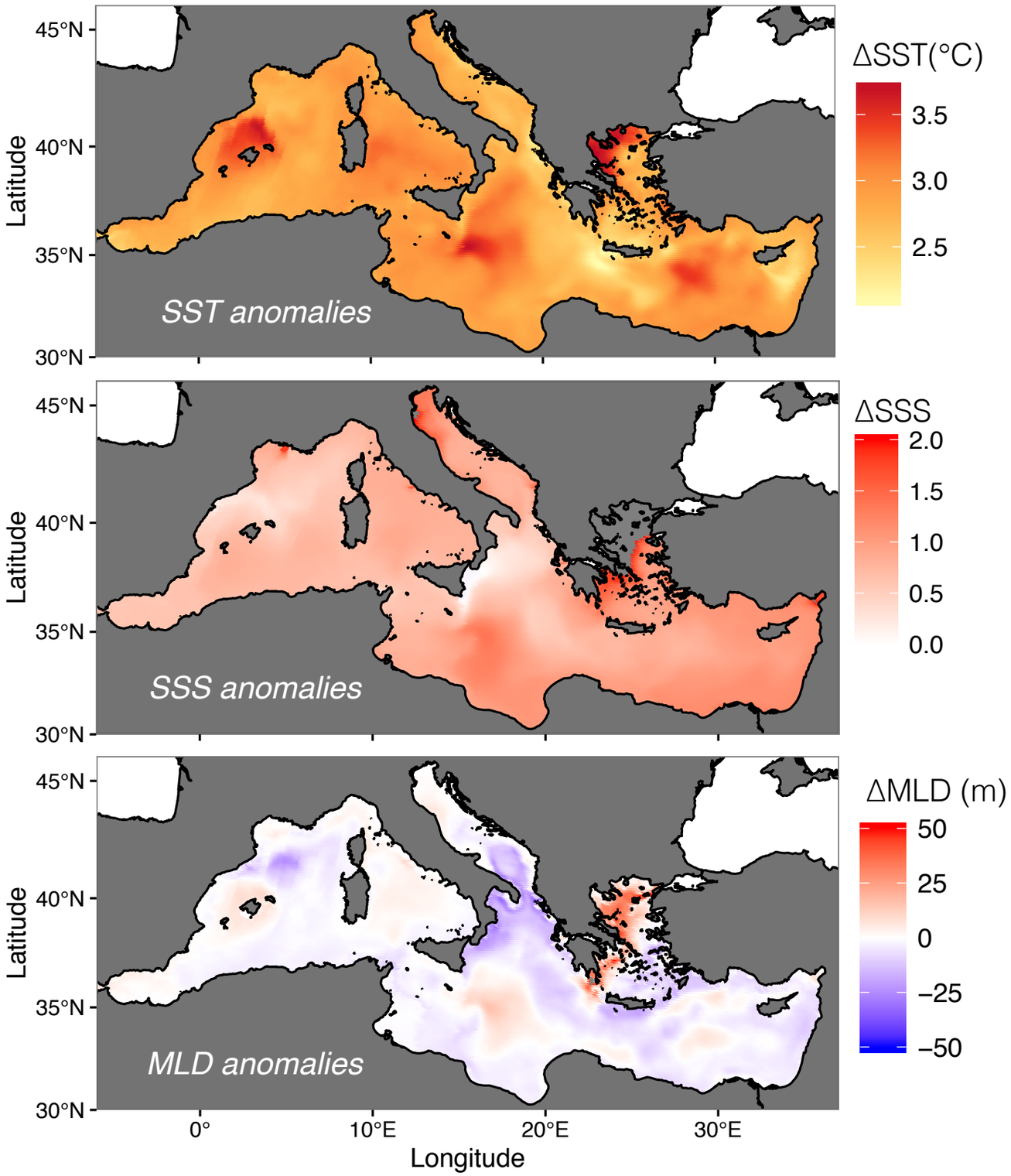


- Largest semi-enclosed sea.
- Presents its **own thermohaline** water mass **circulation.**
- **Strong NorthWest-SouthEast gradients** in SST, salinity or primary production.



- Combination of **spatial location** and **variety of conditions** enabled the emergence of a **biodiversity hotspot** (Myers et al. 2000).
- But also a **climate change hotspot** (Giorgi 2006)!

Annual climatology (year 2015) of SST and surface [Chl-a] measured by MODIS Aqua (http://oceancolor.gsfc.nasa.gov).
Maps given par Dr. Nicolas Mayot.

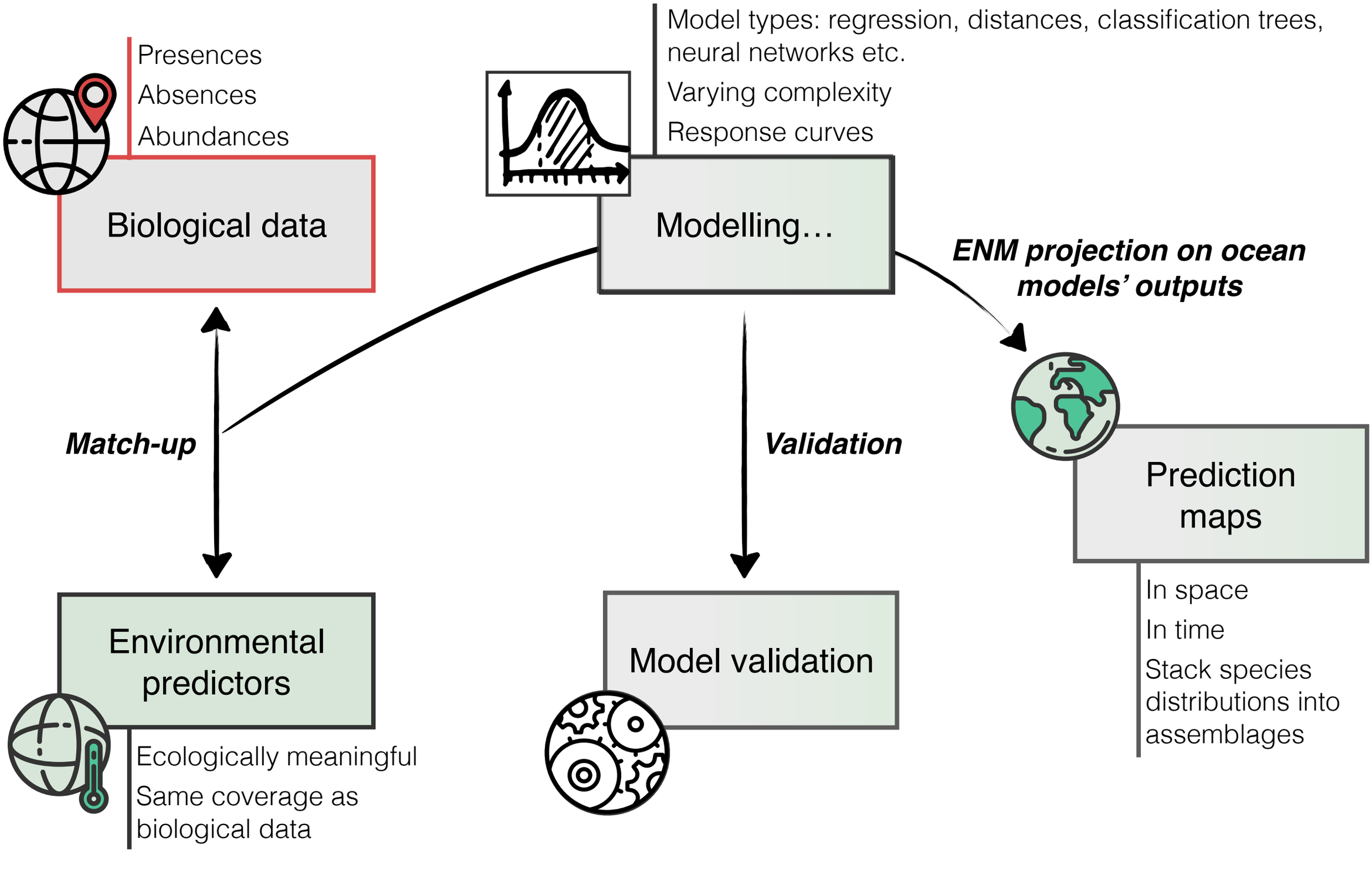


Climate change effects in the Mediterranean Sea ?

- Strong **temperature** and **salinity increase**.
- **Increased stratification** and **weakening** of the **thermohaline circulation**.
- Impacts on primary production? Next to unknown…
- Impacts on diversity and community composition ? Poorly understood…
- PhD theses of F. Ben Rais Lasram, C. Albouy, T. Hattab for impacts on fish diversity.
- Nothing yet for the basis of the food-web: the **plankton**!

Date from Adloff et al. (2015) - Anomalies calculated between the 2069-2098 period and the present (WOA2013), according to a A2 scenario.

How to predict climate change impacts on Biodiversity ? ENMs.



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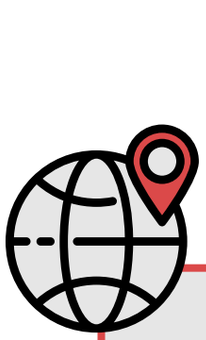


Presences
Absences
Abundances

Biological d

Model types: regression, distances, classification trees, neural networks etc.
Varying complexity
Response curves

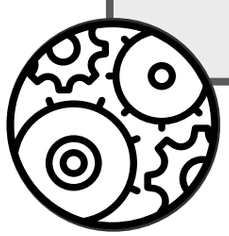
UNCERTAINTIES ????

Match-up

Environmental predictors

Ecologically meaningful
Same coverage as biological data

Model validation



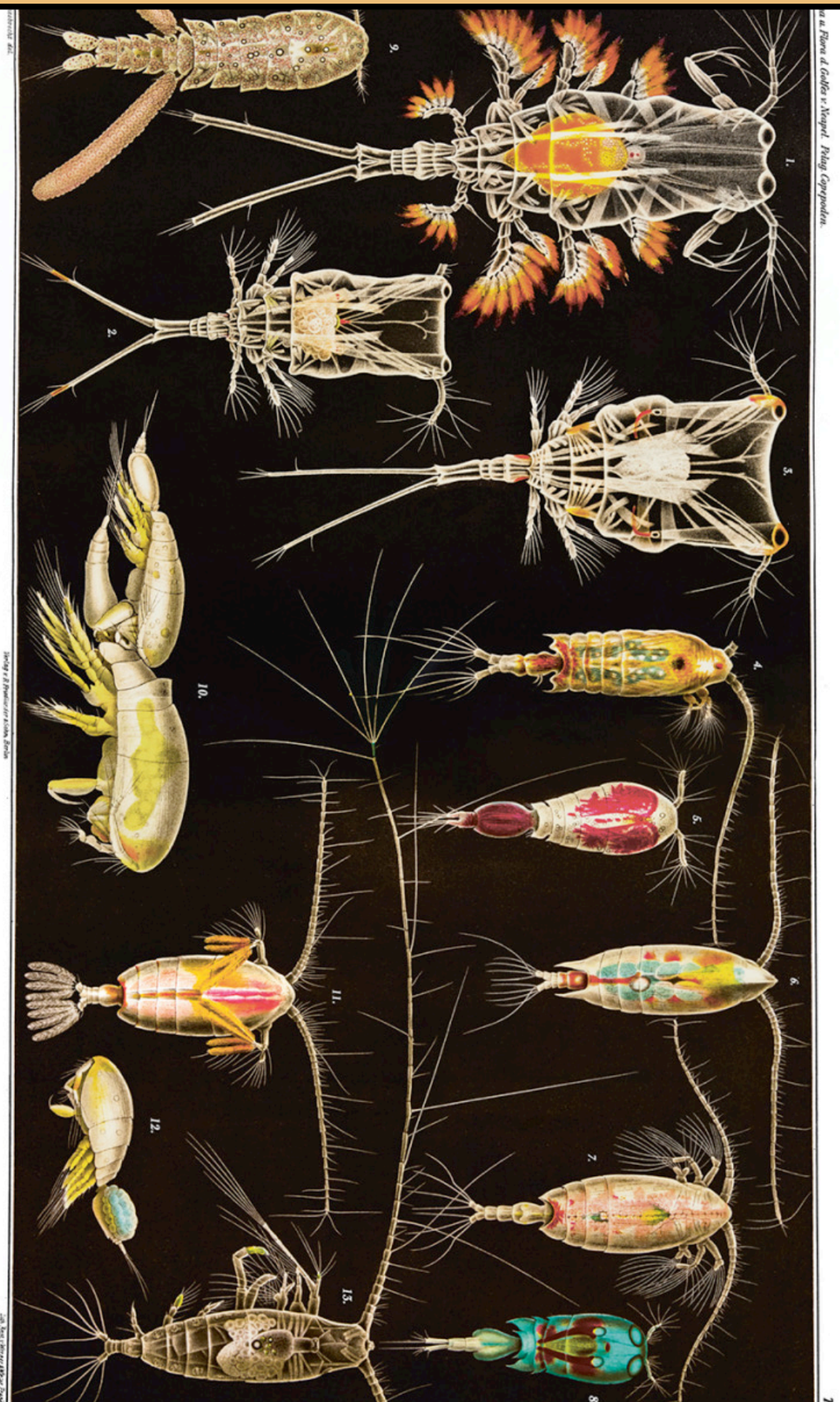
Prediction maps

In space
In time
Stack species distributions into assemblages

- Predict climate change impact on zooplankton distribution and diversity through Environmental Niche Models (ENMs).

- Quantify the relative contributions of the uncertainty sources to the variability across predictions.

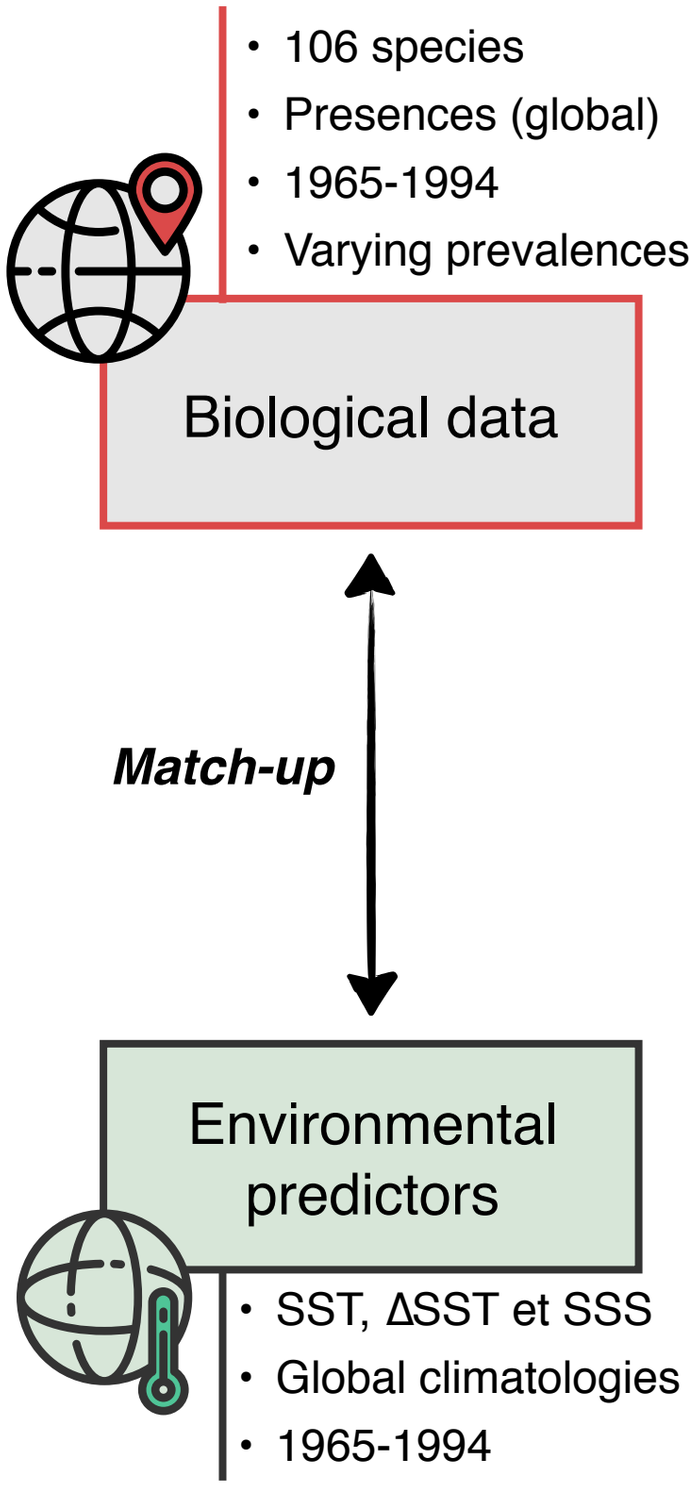
- Later: use the predictions to estimate the impact of climate change on zooplankton functional diversity (not presented here).

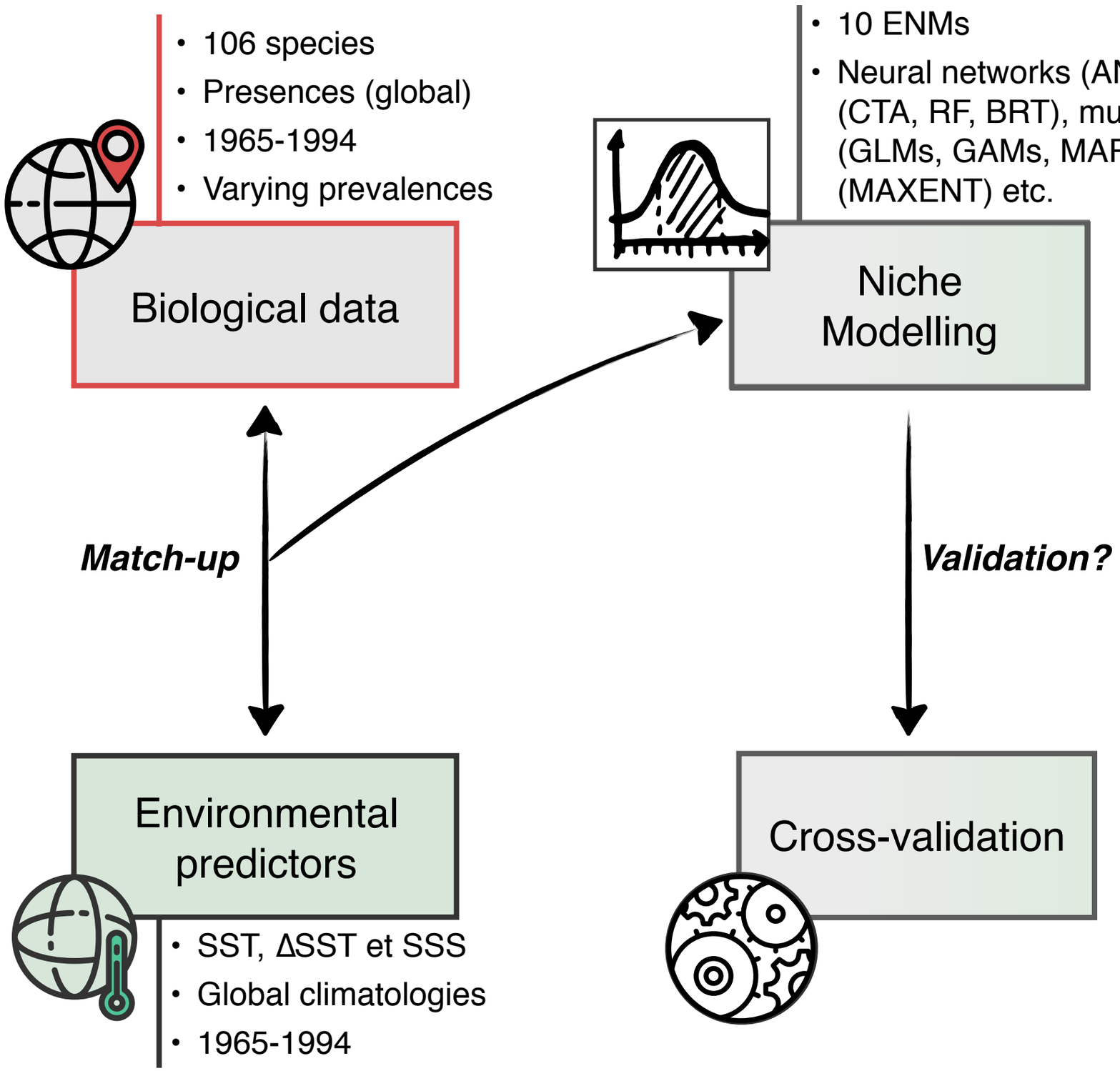


Wilhem Giesbrecht, 1892,
« Systematik und Faunistik der pelagischen Copepoden des Golfes von Neapel »

Planktonic Copepoda

- Potentially the **most abundant group** of Metazoans in the Oceans.
- Very important for the **biological carbon pump** and **transfer of energy** in the trophic web.
- **Great variety** of forms (< 1mm to > 2 cm), of **trophisms**, and **life strategies**.
- Largely **dominate the biomass and diversity** of the zooplankton in the Mediterranean Sea.
- Most studied group in the zooplankton…so the one with relatively high data quantity.


• 106 species
• Presences (global)
• 1965-1994
• Varying prevalences (n of presences)
Biological data
Match-up
Environmental predictors
• SST, ΔSST et SSS
• Global climatologies
• 1965-1994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Biological data
• 10 ENMs
• Neural networks (ANN), Classif. trees (CTA, RF, BRT), multiple regression (GLMs, GAMs, MARS), Max. entropy (MAXENT) etc.
Niche Modelling
Match-up
Validation?
Environmental predictors
• SST, ΔSST et SSS
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Cross-validation

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Niche Modelling

ENMs projections on NEMOMED8 anomalies

Match-up

Environmental predictors

- SST, ΔSST et SSS
- Global climatologies
- 1965-1994

Validation?

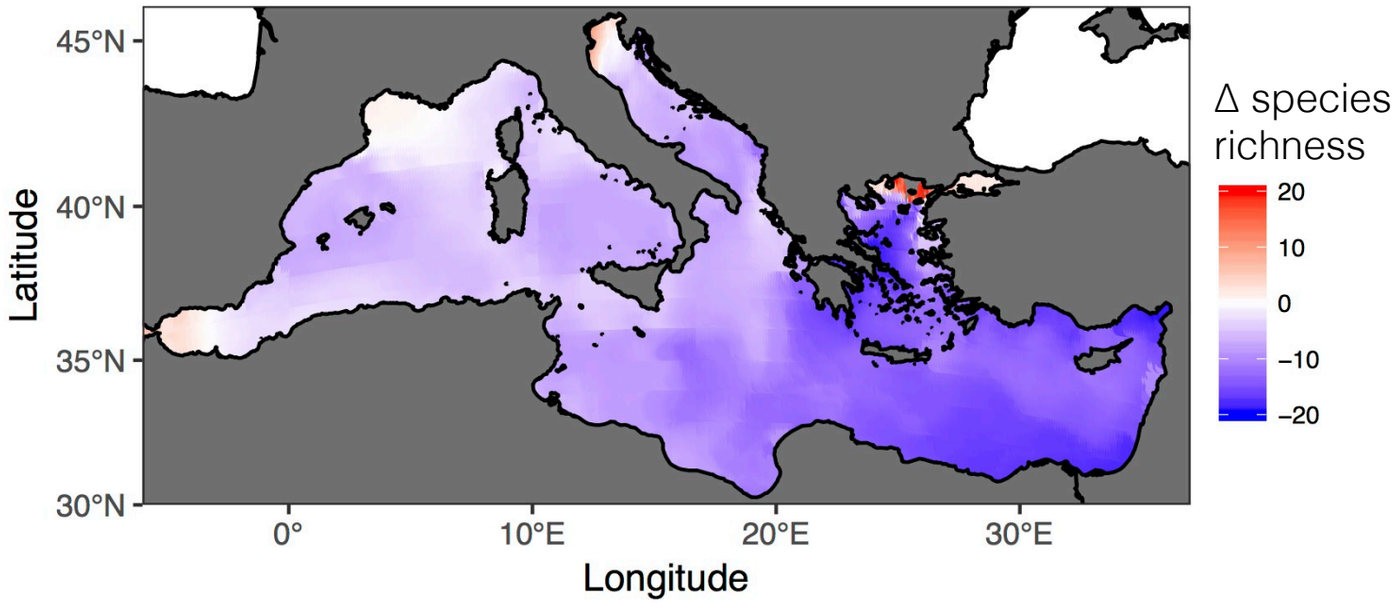
Cross-validation

Prediction in the Mediterranean

- **3 scenarios**
- Different **forcings**
- **Present** & **future**
- **10 ENMs**
- **Assemblages**.

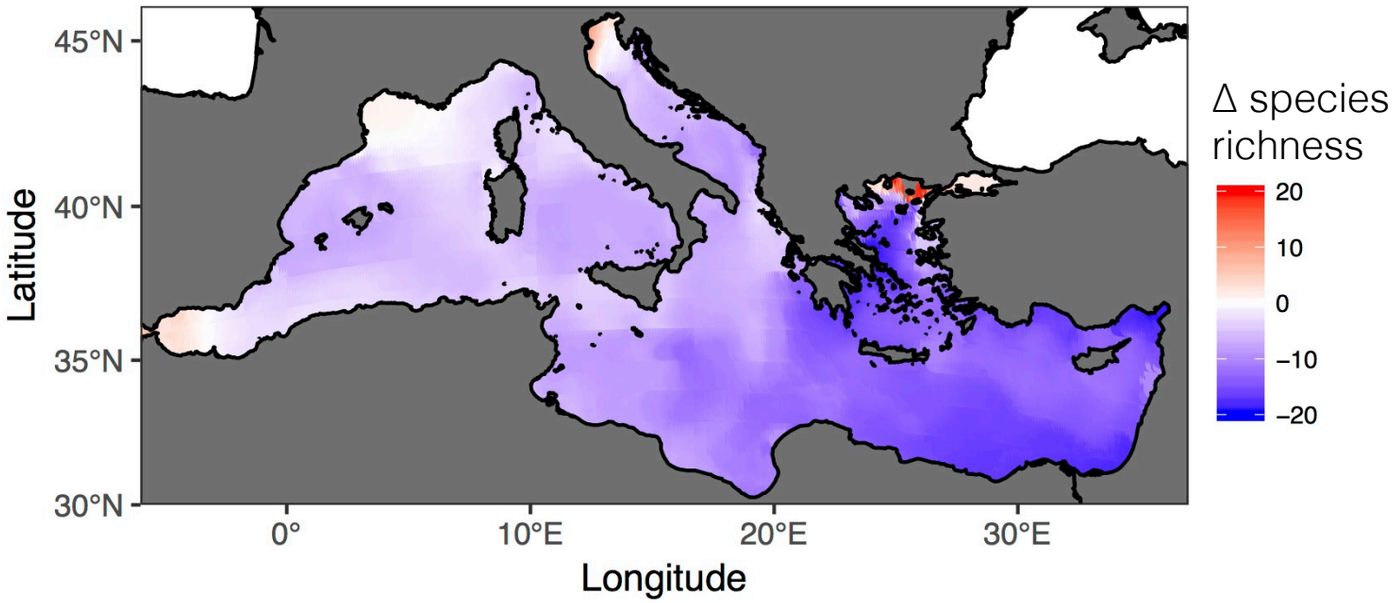
2 067 000 projections

Average projection of diversity changes



- Relatively **low decrease** in richness all over the basin. **Higher** losses in the **Eastern basin**.
- Slight **richness increase** in the **coldest** and **freshest** areas**.**
- Impact on composition ? Turn-over or nestedness ?

Average projection of diversity changes



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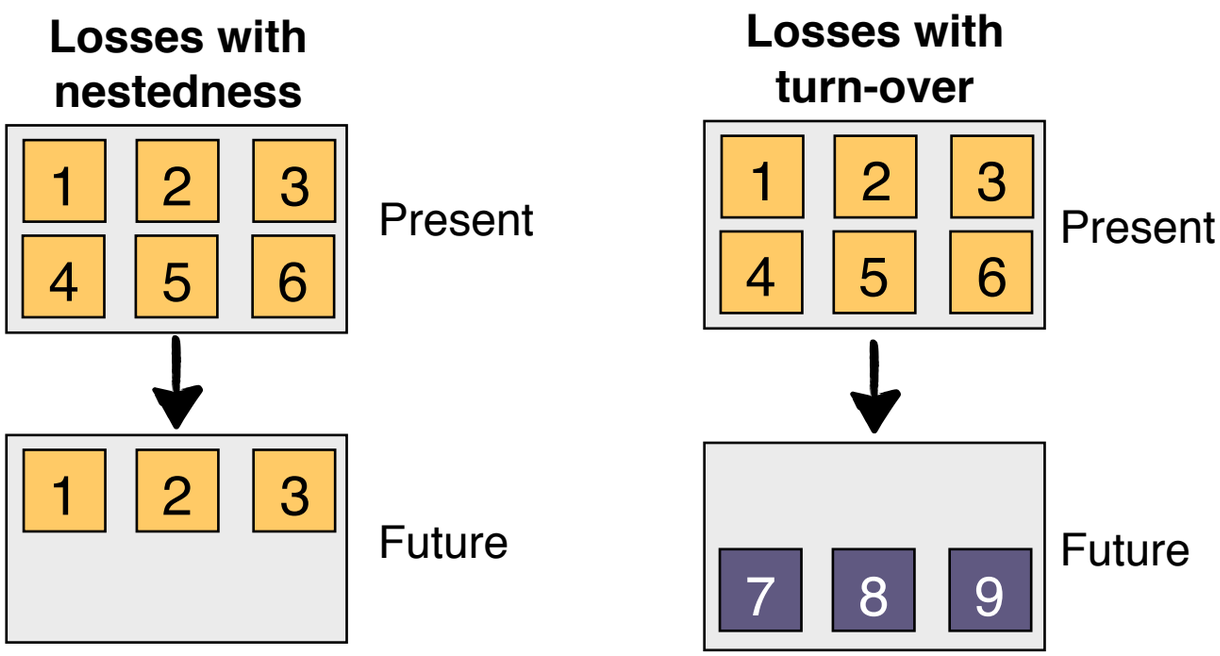
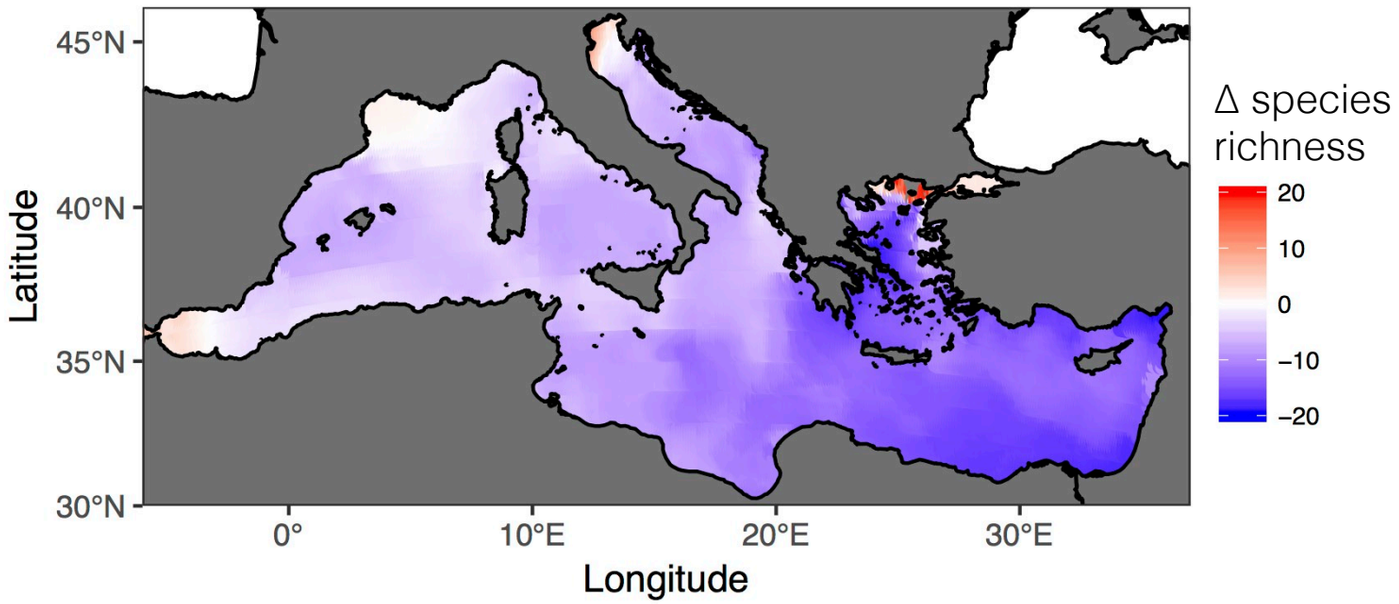


(Numbers = different species)

Average projection of diversity changes



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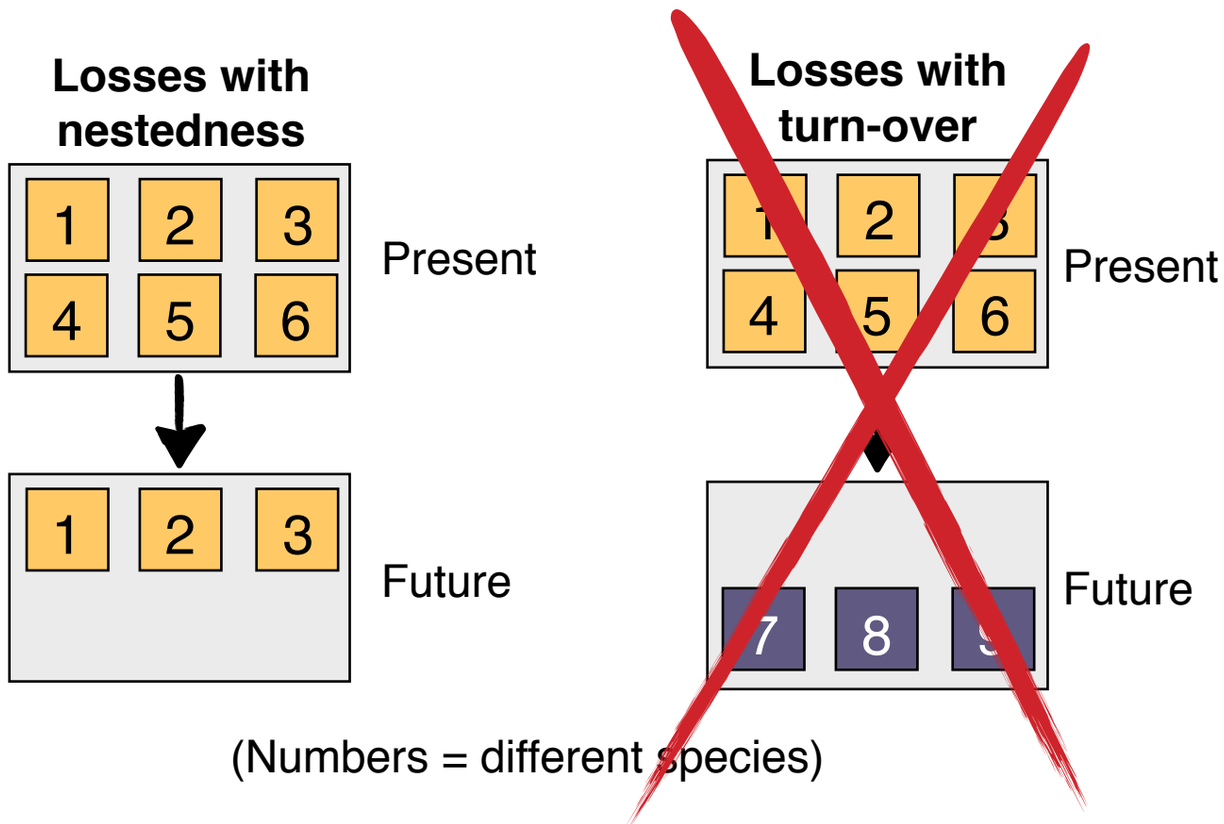
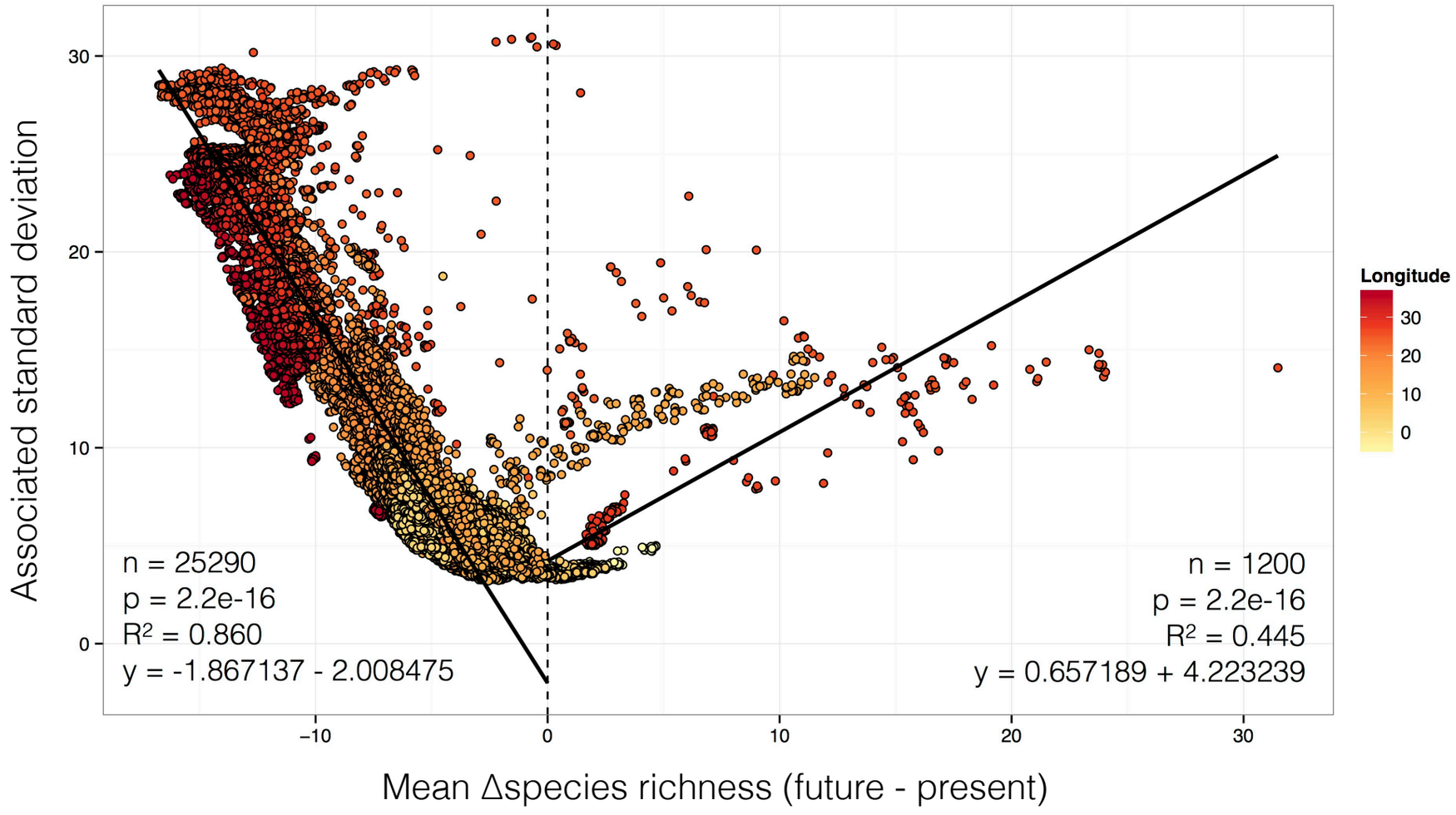


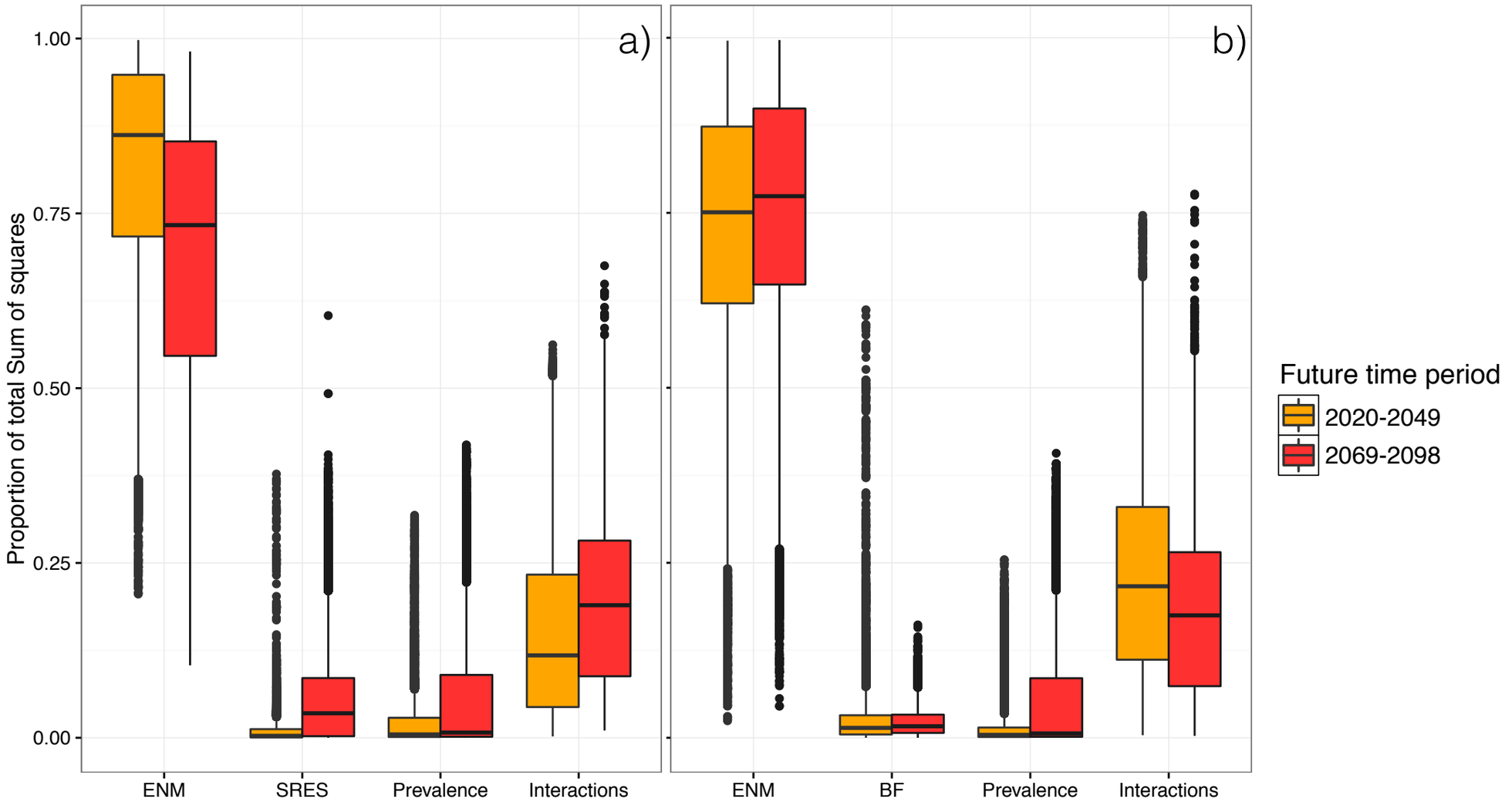
- **Dissimilarity dominated by richness decrease with nestedness** (lost species are not replaced).
- Related to the habitat reduction of the species of Atlantic affiliation/ origin.

Uncertainty sources



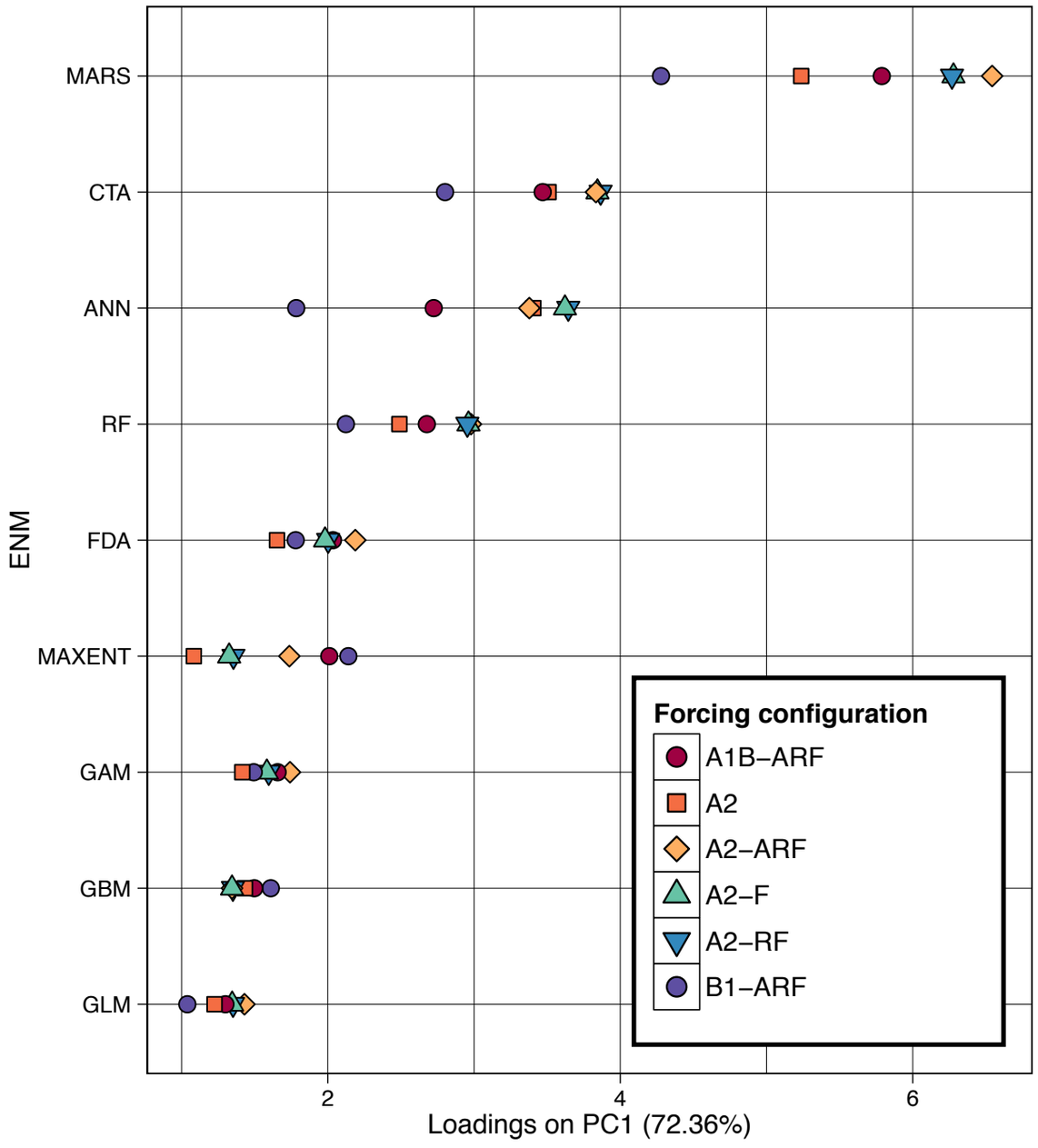
- **The greater** the predicted diversity changes, **the more variable/ uncertain** !
- **ANOVAs** to **quantify the relative contributions** of the **uncertainty factors** (ENM choice, climate model forcings, emission scenarios and species prevalence)

Uncertainty sources



- **Niche model choice** remains the **main source of uncertainty** in diversity predictions, before the choice of **the emission scenario**, the number of species occurrences (prevalence) and the circulation model's **boundary forcings** !
- **Interactions** between ENM type and scenarios are significant too.
- **Circulation model choice ??** Potentially important and remains to be tested !

Loadings of P/psA ENMs predictions on a PCA



- **Major dichotomy** between **P/psA ENMs** and the **SRE** (presence only).
- Here, P/psA **ENMs are ranked according to degree of predicted decreases** in richness and **variability** of predictions **across scenarios** (spread of the PC loadings).
- **Related to ENM type** (trees, boosting, regression-based…).

- Future temperature and salinity increase may translate in a **decrease in copepod species richness** in the whole Mediterranean Sea.
- The **most affected species** are those of **Atlantic origin**, contrary to the species that are mainly affiliated to more tropical conditions (« ***tropicalisation of the plankton*** » ?).
- **No « *cul-de-sac* » effect** predicted for copepods…

- The most affected species are **not functionally unique** ! (Benedetti et *al*., in prep.)
- **Beware**: our projections do not account for the possibility that **Red Sea and Indian Ocean species may spread to the Mediterranean**…(so turn-over is likely underestimated).
- **Uncertainties** across predictions are **driven by the choice of the niche model**. Changing the emission scenario or the circulation model's boundary forcings generates a lot less variability in comparison.
- Main differences between ENMs are related to input data (presence only vs. presence/pseudo-absence) and algorithm type.

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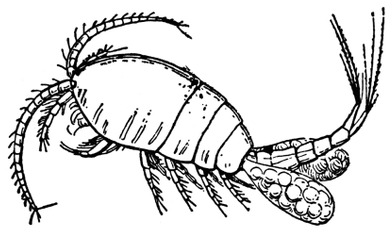
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