MarineSDMs

Marine Species Distribution Models

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1 Introduction

```r
# remotes::install_github("debruine/glossary")
library(glossary)
glossary::glossary_path("glossary.yml")
glossary::glossary_popup("click")
glossary::glossary_persistent(TRUE)
# quarto publish gh-pages
```

1.1 Background

The best available global distributions are presently AquaMaps (Kaschner et al. 2006; Ready et al. 2010) with supplementation by IUCN RedList range maps[1]. We previously used this to calculate the Biodiversity goal of the Ocean Health Index across all Exclusive Economic Zones (EEZs) (Halpern et al. 2012) and beyond EEZs in the high seas (Visalli et al. 2020) with taxonomic groupings [based on (Tittensor et al. 2010): see gmbi (global marine biodiversity indicators)].

1.2 Goals

This book is meant to capture the overview and details of modeling species distributions in the marine environment for the purposes of advancing the status quo of global and U.S. national species distributions along the following dimensions:

1. **Space**
   The current AquaMaps distributions are 1/2º (~55 km at equator), whereas the best available global bathymetry is 1/240º (< 0.5 km).

2. **Time**
   The current AquaMaps distributions are based on static climatic averages over all seasons, which does not capture temporal dynamics: seasonally within a year, nor long-term climate change trends. This will necessitate sampling the environment contemporaneously

[1] IUCN RedList range maps: https://www.iucnredlist.org/resources/spatial-data-download

with species observations before fitting the model and predicting to different environmental snapshots.

3. **Environment**
   Other environmental variables besides the initial physiographic (depth) and oceanographic (temperature, chlorophyll, primary productivity and ice) may elicit an improved statistical fit, related to species' environmental niche. Some candidates include: temperature fronts, eddy kinetic energy, distance from shore, distance from shelf.

4. **Biology**
   Where sufficient observations exist, additional models should be developed highlighting differences between:

   - **Life stage**, e.g. larval vs adult.
   - **Gender** where varies, such as male sperm whales being more cosmopolitan.
   - **Subpopulations** for understanding metapopulation dynamics
   - **Behavior**, such as migrating, feeding or breeding.

By definition MBONMarine Biodiversity Observation Network; see MarineBON.org is a network, so this is inclusive of and meant for all participants.

1.3 Inspirations

- AquaMaps.org
  Lots of work. To be continued
- R package `dismo`: sdm.pdf -> `raster` sdm -> `terra` sdm
-

Part I

Process

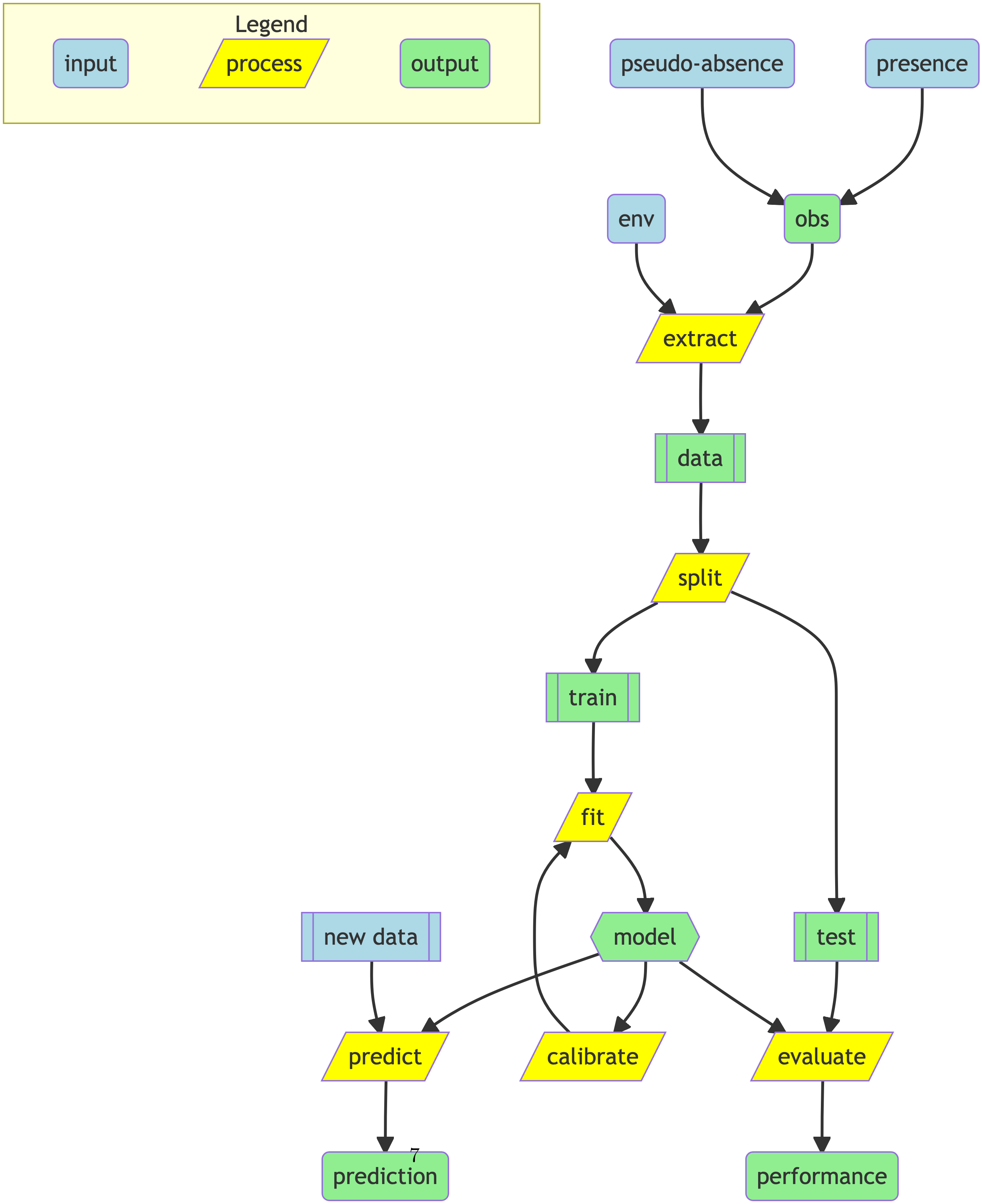

Figure 1.1: Diagram of SDM data preparation and model fitting.

2 Prep Data

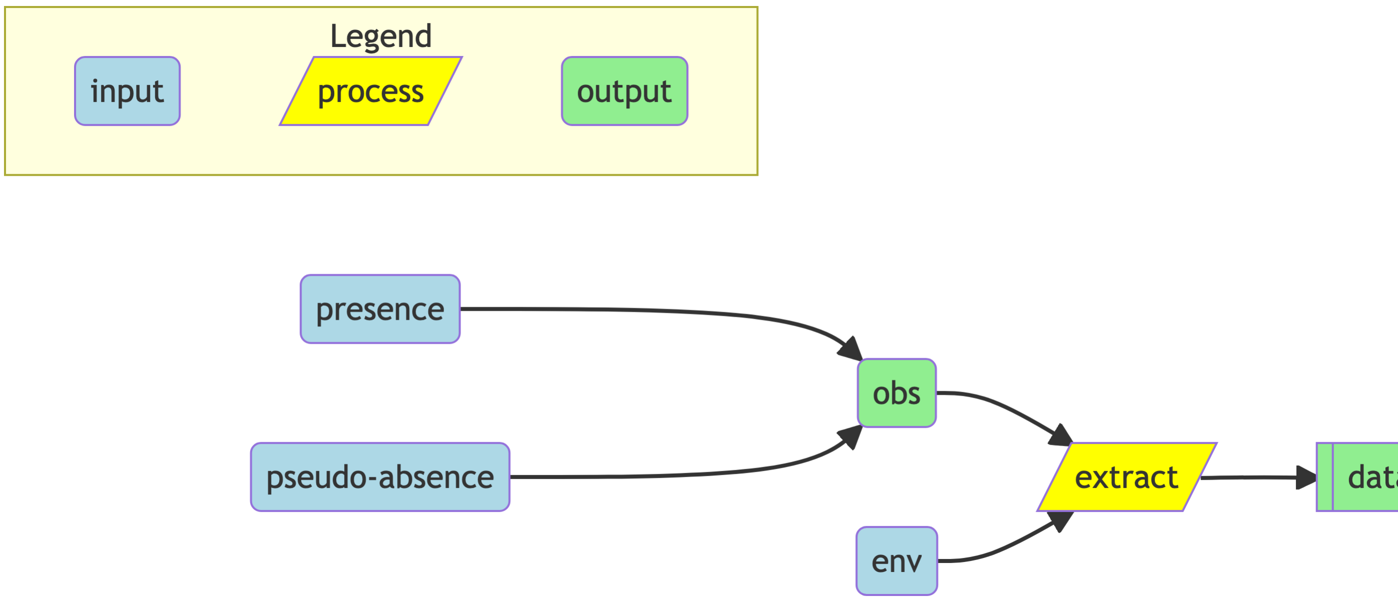

Figure 2.1: Diagram of SDM data preparation for model fitting.

- **obs**
  observations: occurrences from OBIS; masked by FAO regions defined by AquaMaps (Skyttner 2020)
  - **presence**
    OBIS: species occurrence
  - **absence**
    OBIS not-species, but same family
- **env**
  environment
- **tbl**
  table of observations (presence and absence) with environmental values

2.0.1 Environmental Predictors

2.0.2 Physiographic

- `depth`
  Bathymetric Depth
- `d2coast`
  Distance to Coast
- `d2shelf`
  Distance to Shelf

2.0.3 Time Varying

- `vgpm`
  Vertically integrated primary Productivity model

2.0.3.1 Depth & Time Varying

- Temperature
- Salinity

3 Model

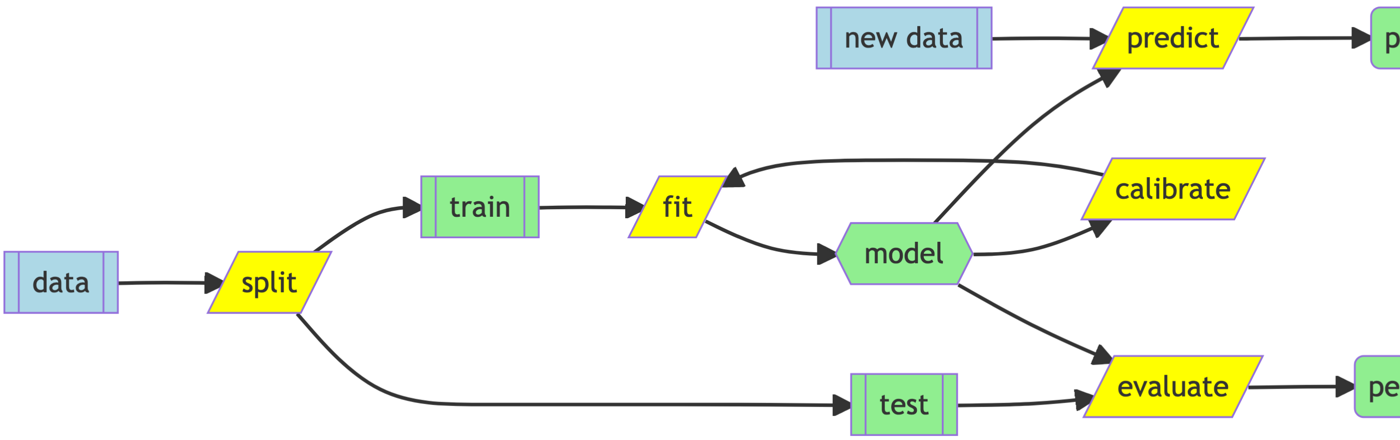

Figure 3.1: Diagram of SDM Modeling processes.

4 Mosaic

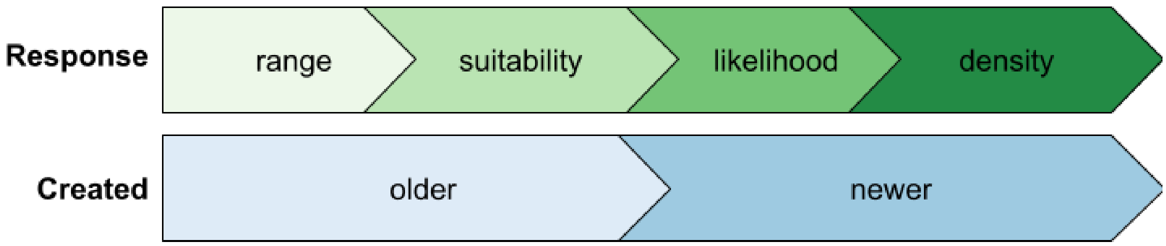

Figure 4.1: Hierarchy of preferred model outputs based on response type and age.

This is illustrated well by Figure 4.1.

5 Software

5.1 R

Most packages have not yet migrated from using the deprecated `raster` R package to the new `terra` package, except for `biomod2` (ref?).

- `eks`
  Tidy and Geospatial Kernel Smoothing
  for spatially filtering outlier observations
- test

5.2 Python

- Xarray
  Xarray makes working with labelled multi-dimensional arrays in Python simple, efficient, and fun!

5.3 Google Earth Engine

- XEE
  XEE is a new Python package for Earth Engine that provides a set of functions to facilitate the use of Earth Engine API. It is designed to be used in Jupyter notebooks and Google Colab. Documentation

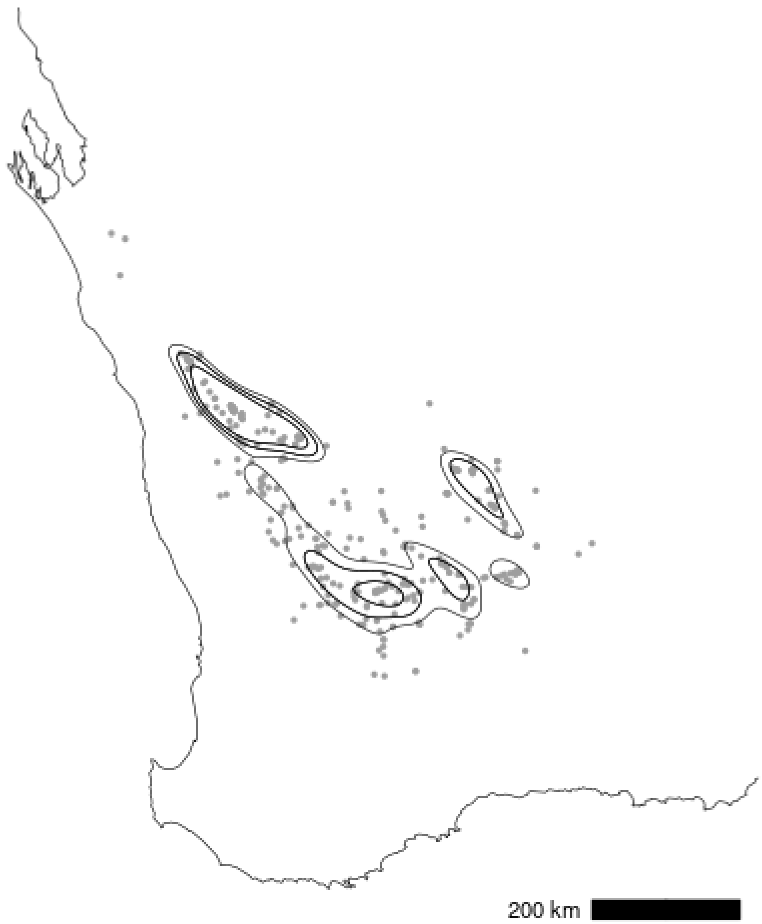

Figure 5.1: Source: Kernel density estimates for tidy and geospatial data in the eks package

6 Organize

6.1 Partners

- ***Confirmed***
  - **AquaMaps**
    distribution maps for over 33,500 species of fishes, marine mammals and invertebrates
    contacts:
    * Gabriel Reygondeau (g.reygondeau@oceans.ubc.ca)
  - **DisMAP**
    Distribution Mapping and Analysis Portal
    contacts:
    * Melissa Karp (melissa.karp@noaa.gov)
    * Roger Griffis (roger.b.griffis@noaa.gov)
  - **MBON**
    Marine Biodiversity Observation Network
    contacts:
    * Ben Best
    * Tylar Murray
    * Dan Otis
    * Frank Muller-Karger
  - **OBIS**
    Ocean Biodiversity Information System
    contacts:
    * Candido Principe De Souza, Silas (s.principe@unesco.org)
    * Ward Appeltans (w.appeltans@unesco.org)
- ***Proposed***

- **FishGLOB**
  fish biodiversity under global change (global bottom trawl)
  contacts:
    - Malin Pinsky
- **MGEL**
  Marine Geospatial Ecology Lab, Duke
  contacts:
    - Jason Roberts
    - Patrick Halpin
- **PMEL**
  Pacific Marine Environmental Lab, NOAA
  contacts:
    - Heather Welch
    - Elliot Hazen

6.2 Portal

- Candidate website:
  MarineSpeciesMaps.org (BDB registered domain)
  - similar to:
    - MarineRegions.org
      spatial authority
    - MarineSpecies.org
      taxonomic authority

6.3 Timeline

6.3.1 Meetings

- **2024-01-23**
  Marine Biodiversity Summit in DC
  (organized by Gabrielle, Emmett)
- **2024-03-21**
  SDM meeting in New Orleans
  (organized by BDB; so far AquaMaps)

6.3.2 Sequence

1.

References

Halpern, Benjamin S., Catherine Longo, Darren Hardy, Karen L. McLeod, Jameal F. Samhouri, Steven K. Katona, Kristin Kleisner, et al. 2012. "An Index to Assess the Health and Benefits of the Global Ocean." *Nature*. https://doi.org/10.1038/nature11397.

Kaschner, K., R. Watson, A. W. Trites, and D. Pauly. 2006. "Mapping World-Wide Distributions of Marine Mammal Species Using a Relative Environmental Suitability (RES) Model." *Marine Ecology Progress Series* 316 (July): 285–310. https://doi.org/10.3354/meps316285.

Ready, Jonathan, Kristin Kaschner, Andy B. South, Paul D. Eastwood, Tony Rees, Josephine Rius, Eli Agbayani, Sven Kullander, and Rainer Froese. 2010. "Predicting the Distributions of Marine Organisms at the Global Scale." *Ecological Modelling* 221 (3): 467–78. https://doi.org/10.1016/j.ecolmodel.2009.10.025.

Skyttner, Markus. 2020. "Aquamapsdata: Curated Data from AquaMaps.org." https://github.com/raquamaps/aquamapsdata.

Tittensor, Derek P., Camilo Mora, Walter Jetz, Heike K. Lotze, Daniel Ricard, Edward Vanden Berghe, and Boris Worm. 2010. "Global Patterns and Predictors of Marine Biodiversity Across Taxa." *Nature* 466 (7310): 1098–1101. https://doi.org/10.1038/nature09329.

Visalli, Morgan E., Benjamin D. Best, Reniel B. Cabral, William W. L. Cheung, Nichola A. Clark, Cristina Garilao, Kristin Kaschner, et al. 2020. "Data-Driven Approach for Highlighting Priority Areas for Protection in Marine Areas Beyond National Jurisdiction." *Marine Policy*, March, 103927. https://doi.org/10.1016/j.marpol.2020.103927.

A Glossary

```
glossary::glossary_table(as_kable=F) |>
  knitr::kable("pipe", escape = F, row.names = F)
```

Part II

Explorations

AquaMaps Downscaled