

Biodiversity Exposure FOREcasts (BEFORE): Anticipating Ecological Vulnerability to Global Change

Cory Merow

Mark Urban

Pep Serra-Diaz

Gonzalo Pinilla-Buitrage

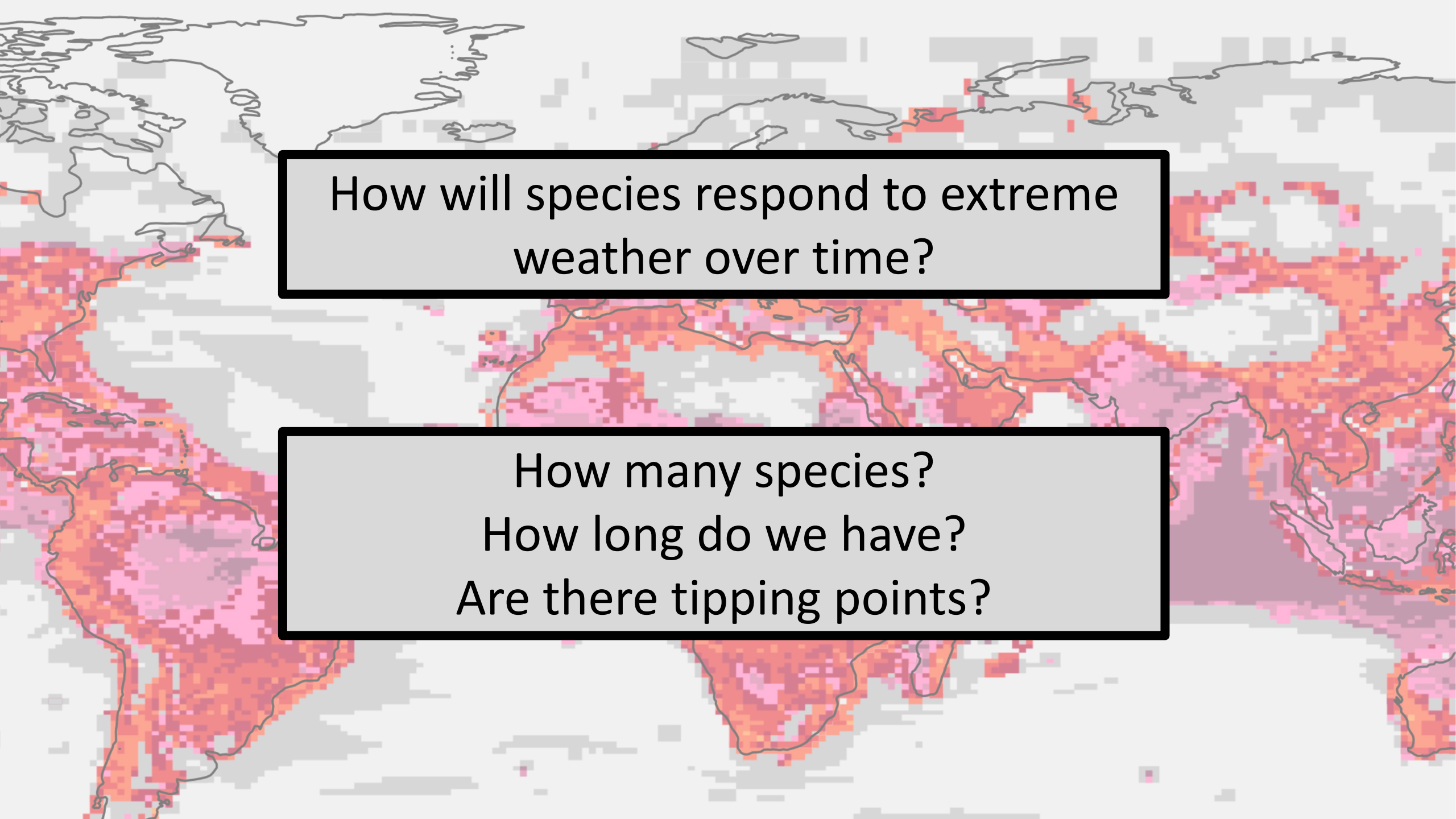
Ben Carlson

Brian Maitner

University of Connecticut

Eversource Energy Center and

Ecology and Evolutionary Biology

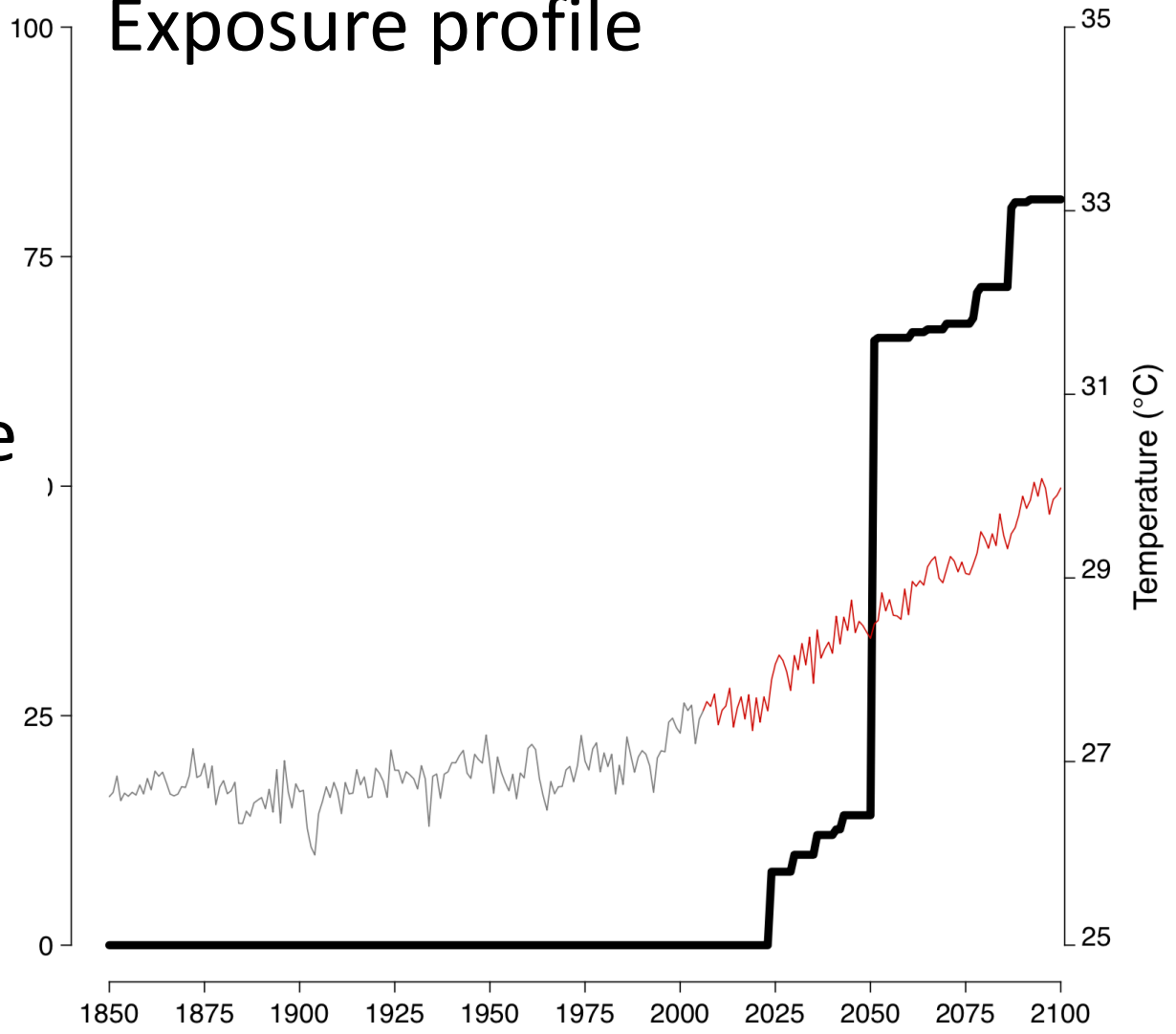


How will species respond to extreme weather over time?

How many species?
How long do we have?
Are there tipping points?

Exposure profile

% of species
in assemblage
exposed



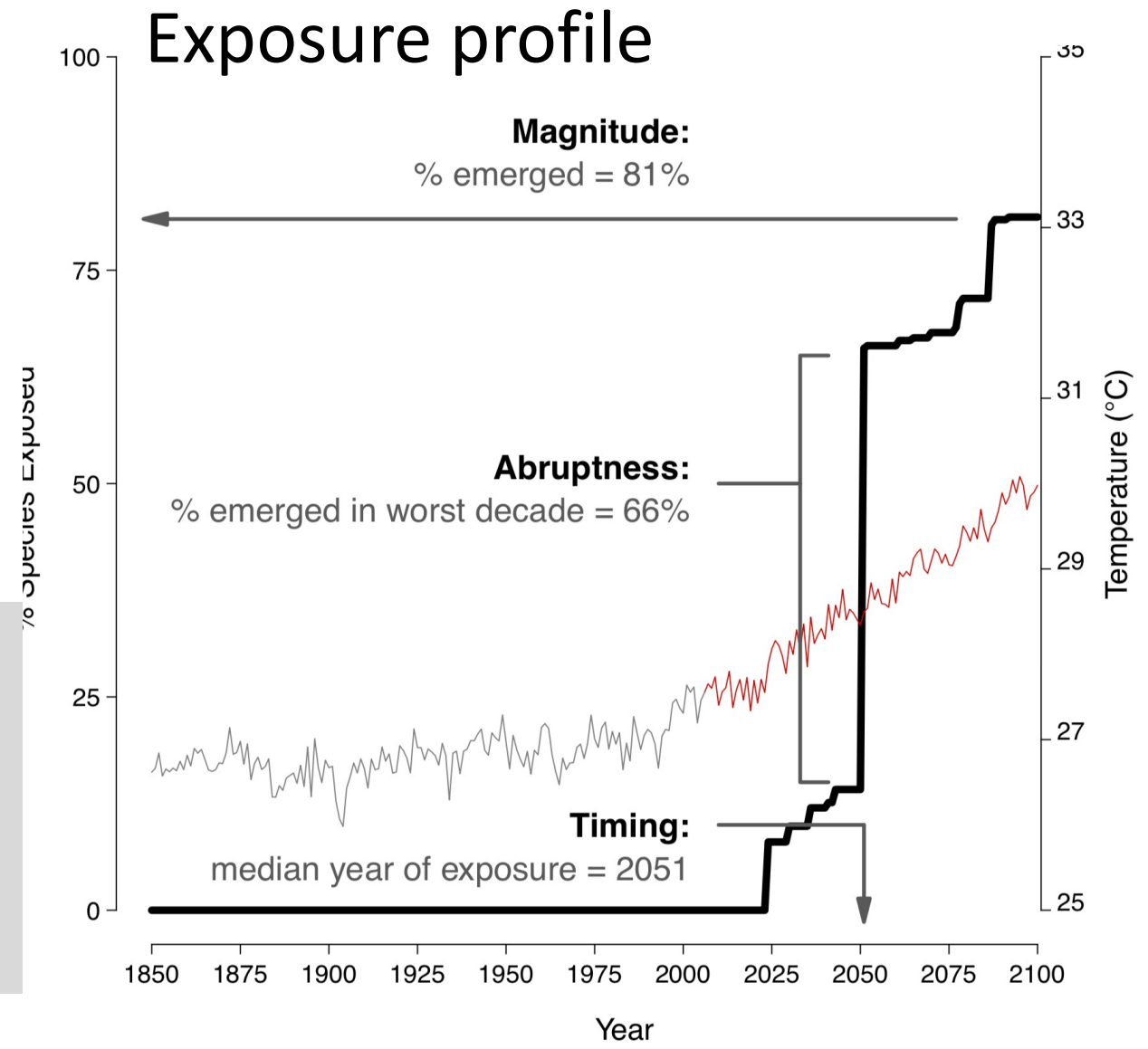
Year

Temperature (°C)

Trisos, Merow and Pigot, *Nature*, 2020

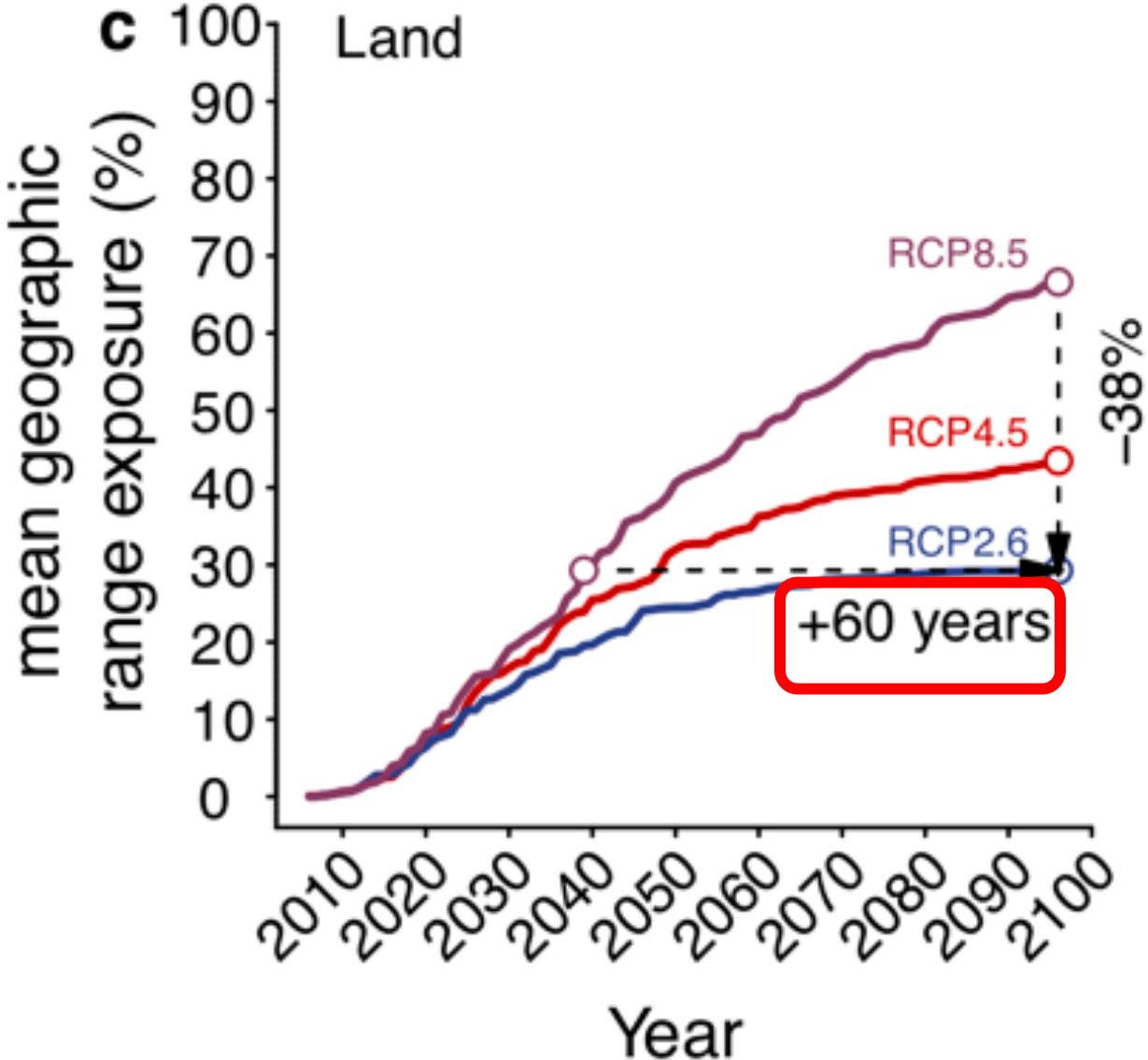
% of species
in assemblage
exposed

OR
% of a single
species range
exposed



Trisos, Merow and Pigot, *Nature*, 2020

Background: How long do we have?



Trisos, Merow and Pigot,
Nature, 2020

A world map with a heatmap overlay. The colors range from light pink to dark red, indicating varying levels of intensity or density across the globe. The text is centered over the map.

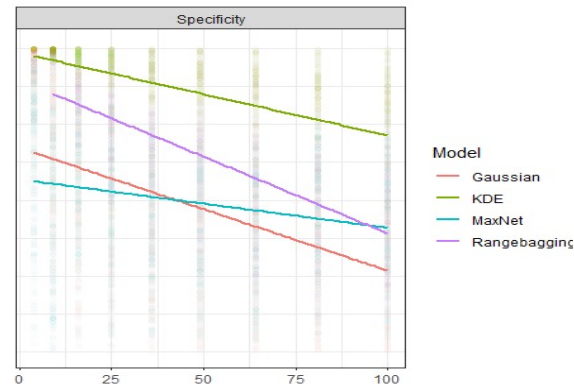
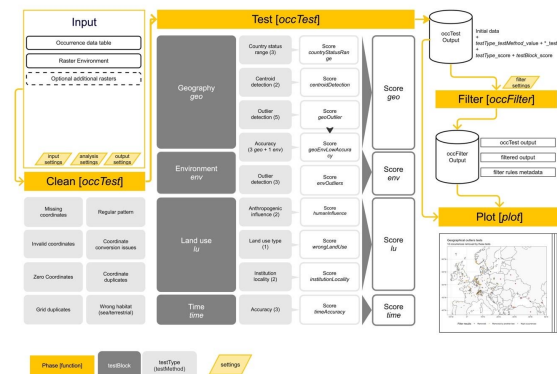
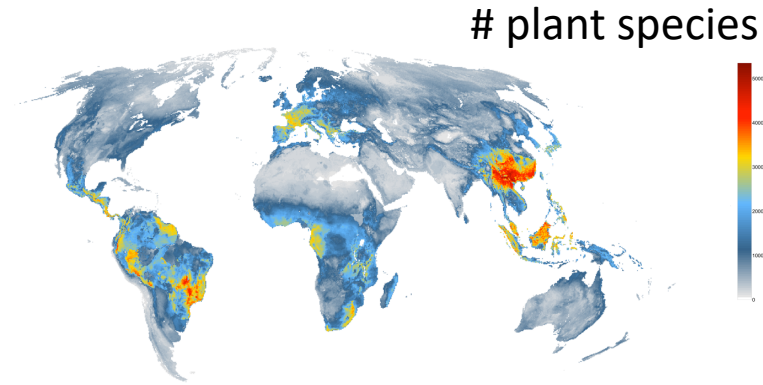
New Results:
all the ingredients of a
forecasting pipeline

Inputs

1. Data:
Global Plant Species Richness
(~300k species)

2. Data Cleaning:
R package occTest

3. New Modeling Algorithms:
R Package pbsdm



BOEN

Pep Serra-Diaz



Brian Maitner

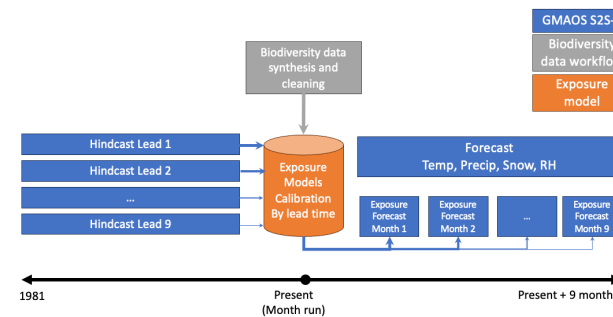
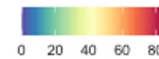
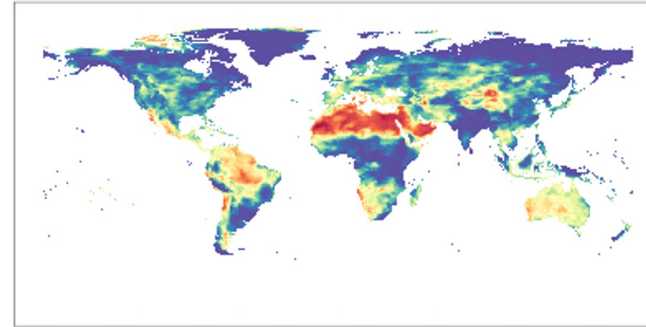


Inputs

4. New Environmental Layers: Droughts
Severity, Intensity, Duration, Frequency

5. New Environmental Layers: S2S
Seasonal to subseasonal
(9 Month) forecasts

Extreme Droughts
through 2100



Pep Serra-Diaz



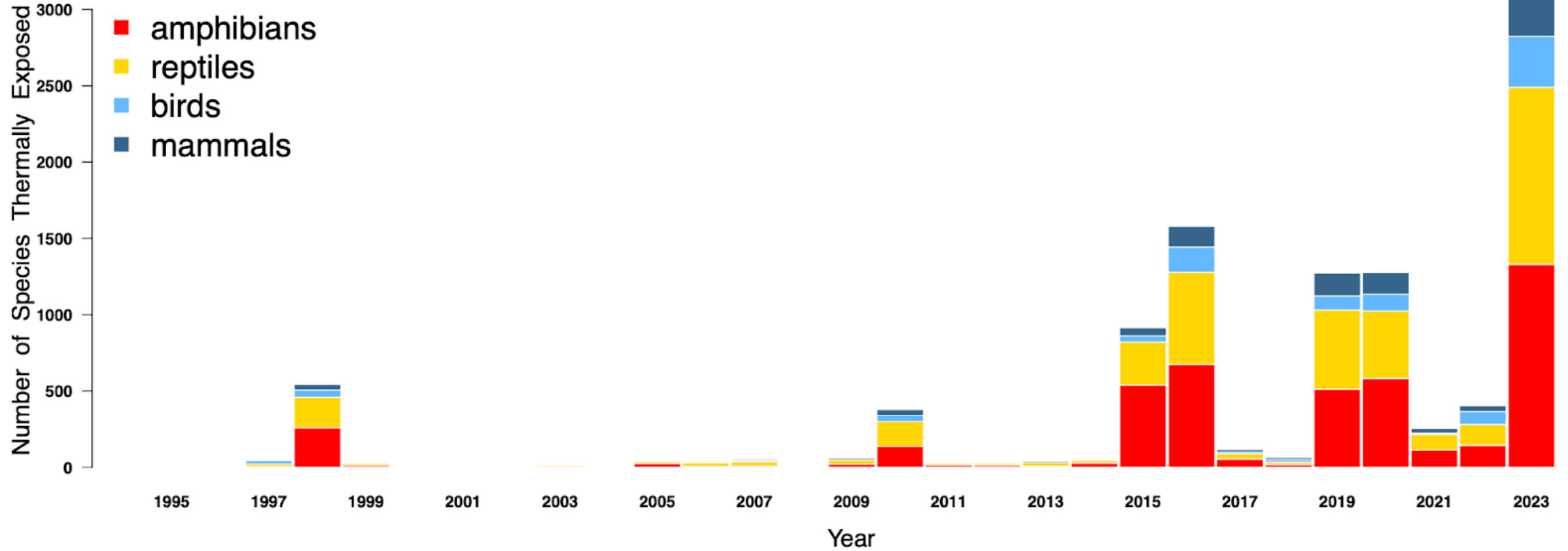
Thymios
Nikolopoulos
Diogo Araujo

Pep Serra-Diaz



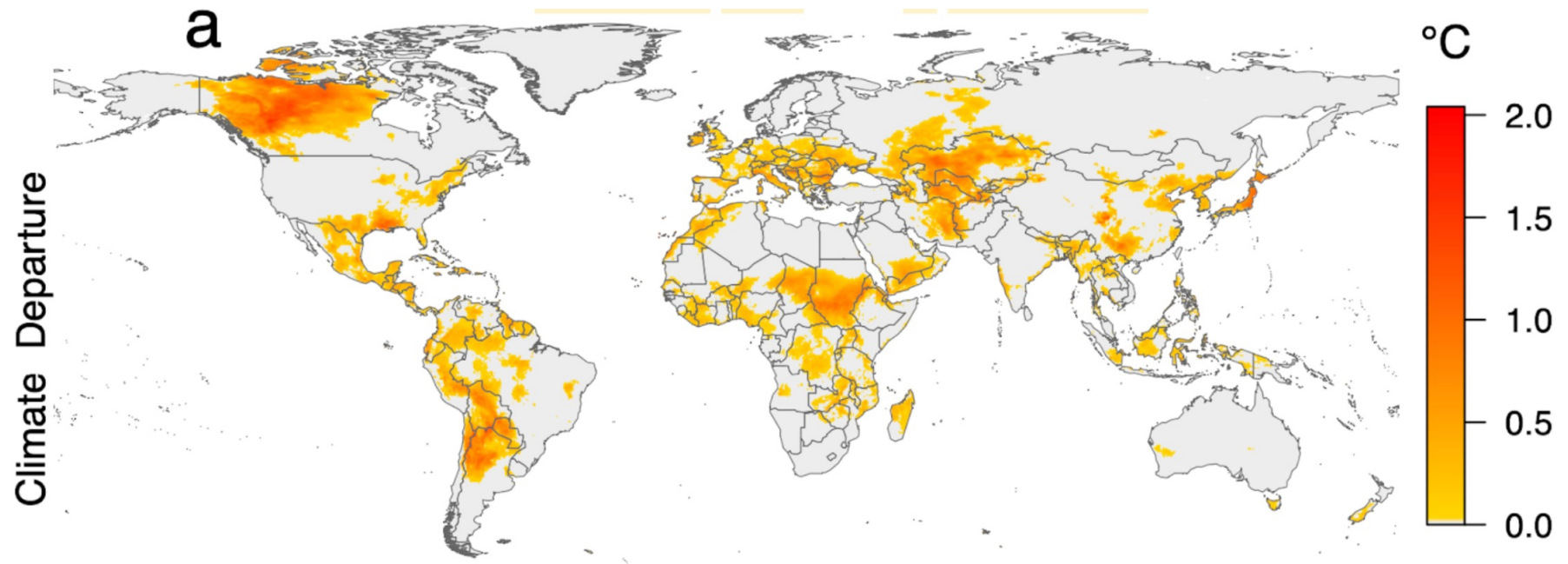
Lauren Andrews
NASA GMAO S2S

Results: 2023 Exposure



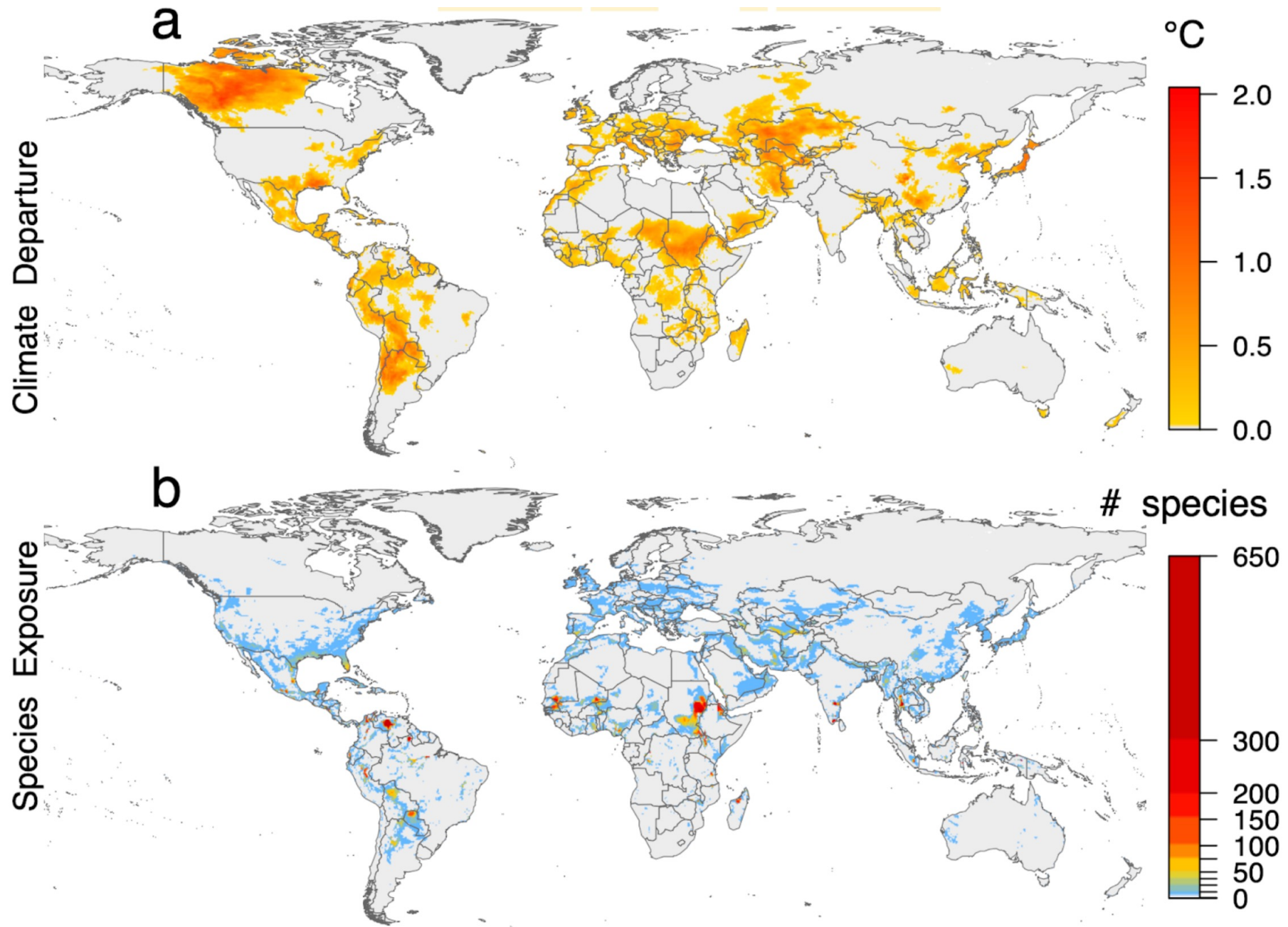
Merow et al, hopefully very soon

Results:
2023
Exposure



Merow et al, hopefully very soon

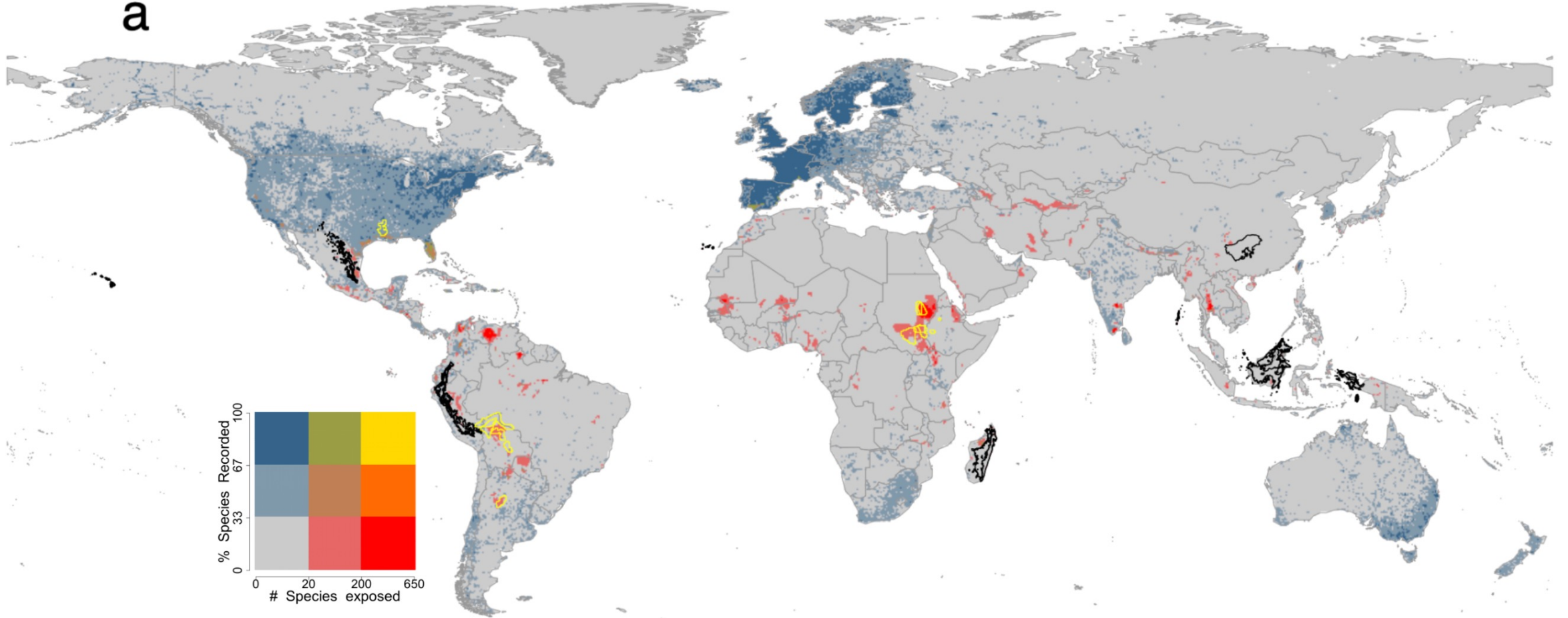
Results: 2023 Exposure



Merow et al, hopefully very soon

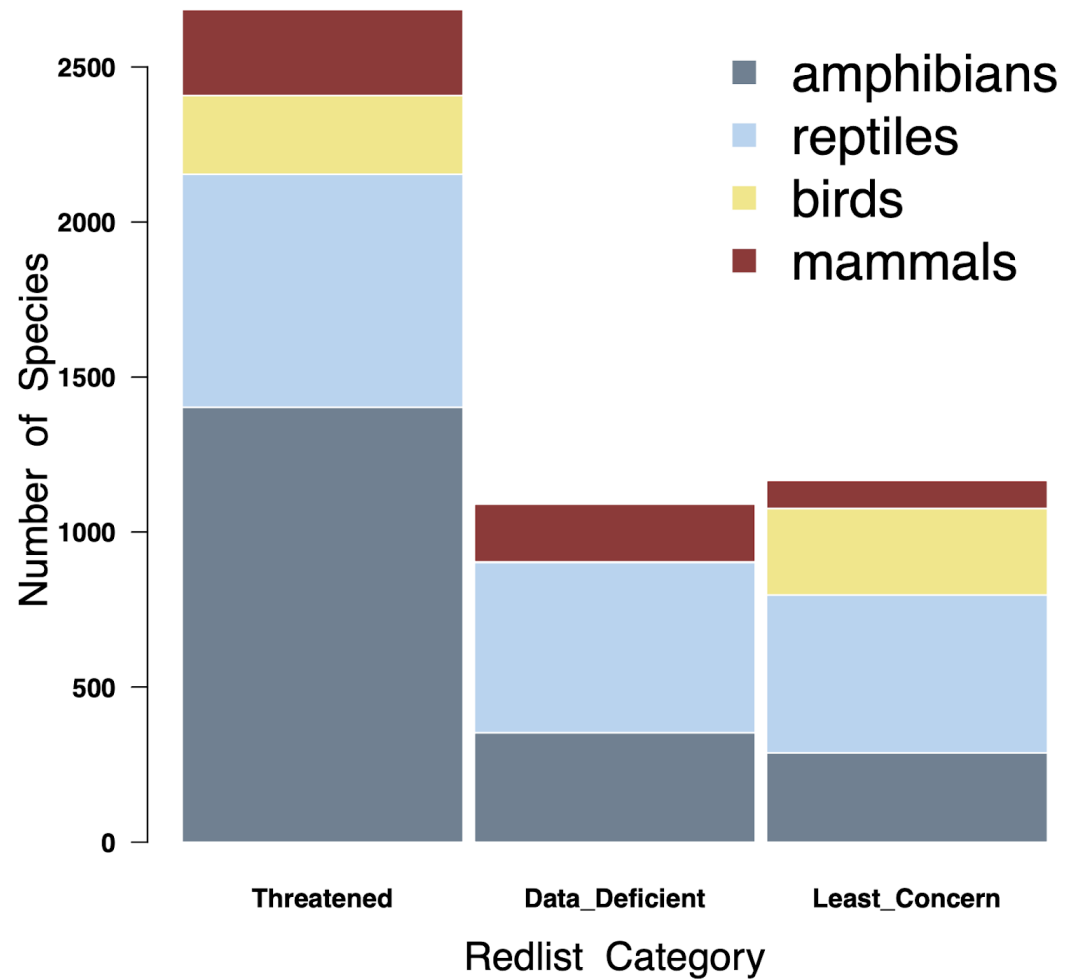
Results: 2023 Exposure x "Monitoring"

a



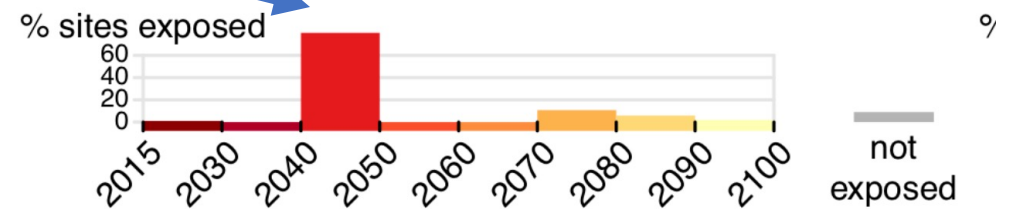
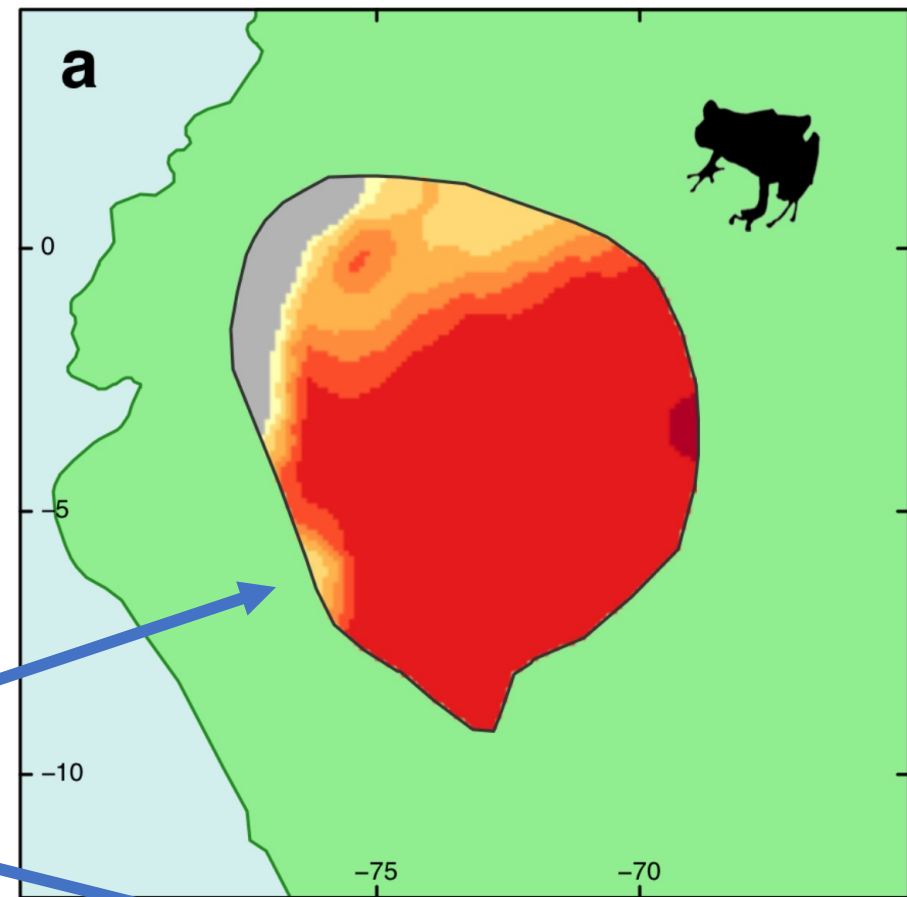
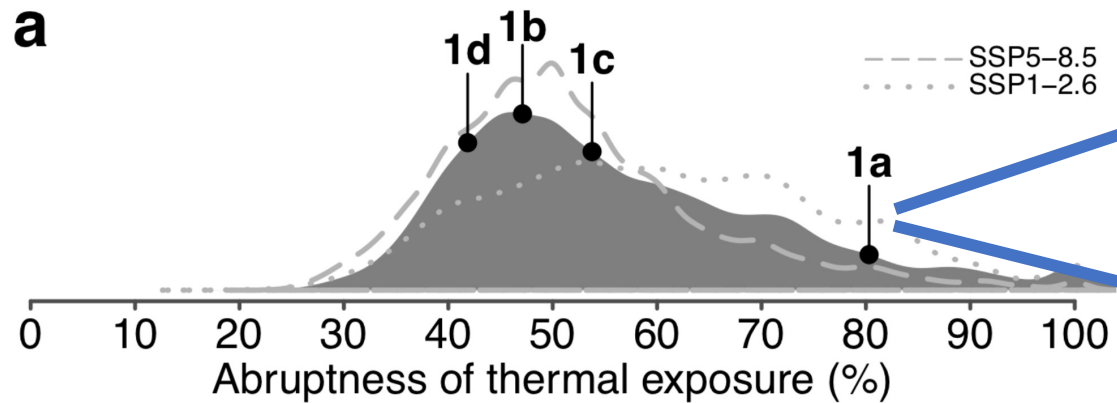
Merow et al, hopefully very soon

Results: 2023 Exposure



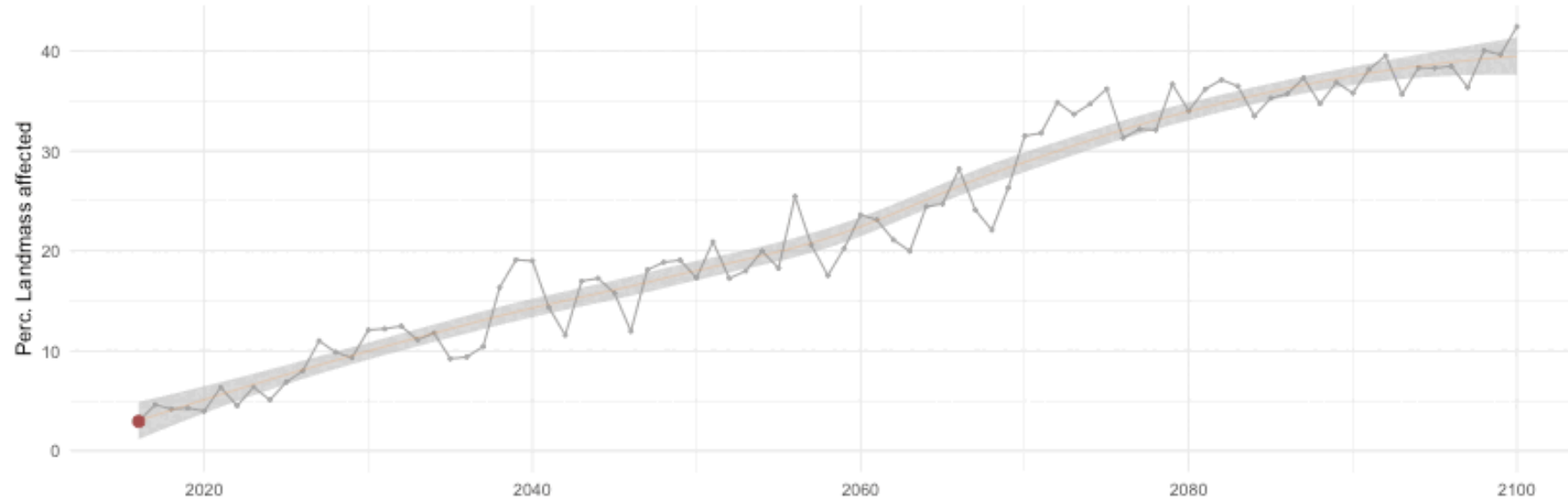
Results: Timing of exposure across species ranges

Distribution of abruptness across 30,000 species assessed by IUCN

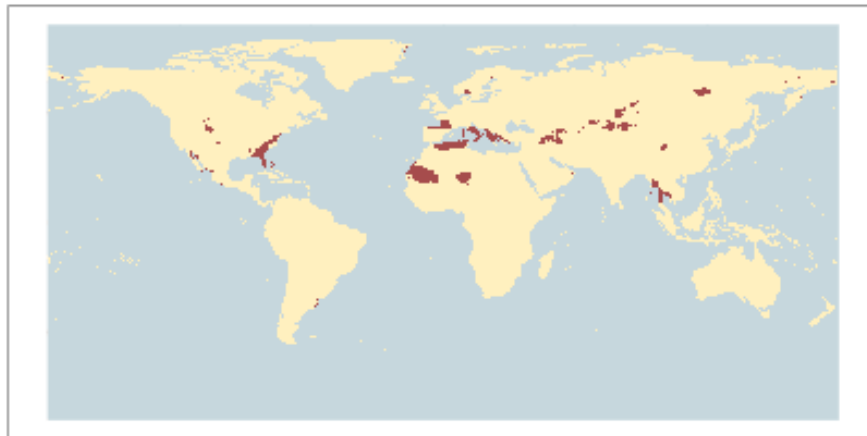


Pigot, Merow, Wilson, Trisos, NEE, 2023

Results: Plant Drought Exposure

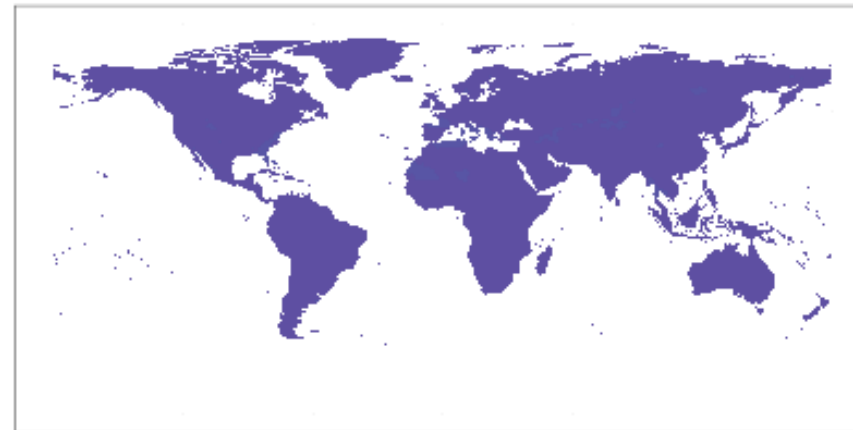


Drought severity



historical unprecedented

Cummulative departure events

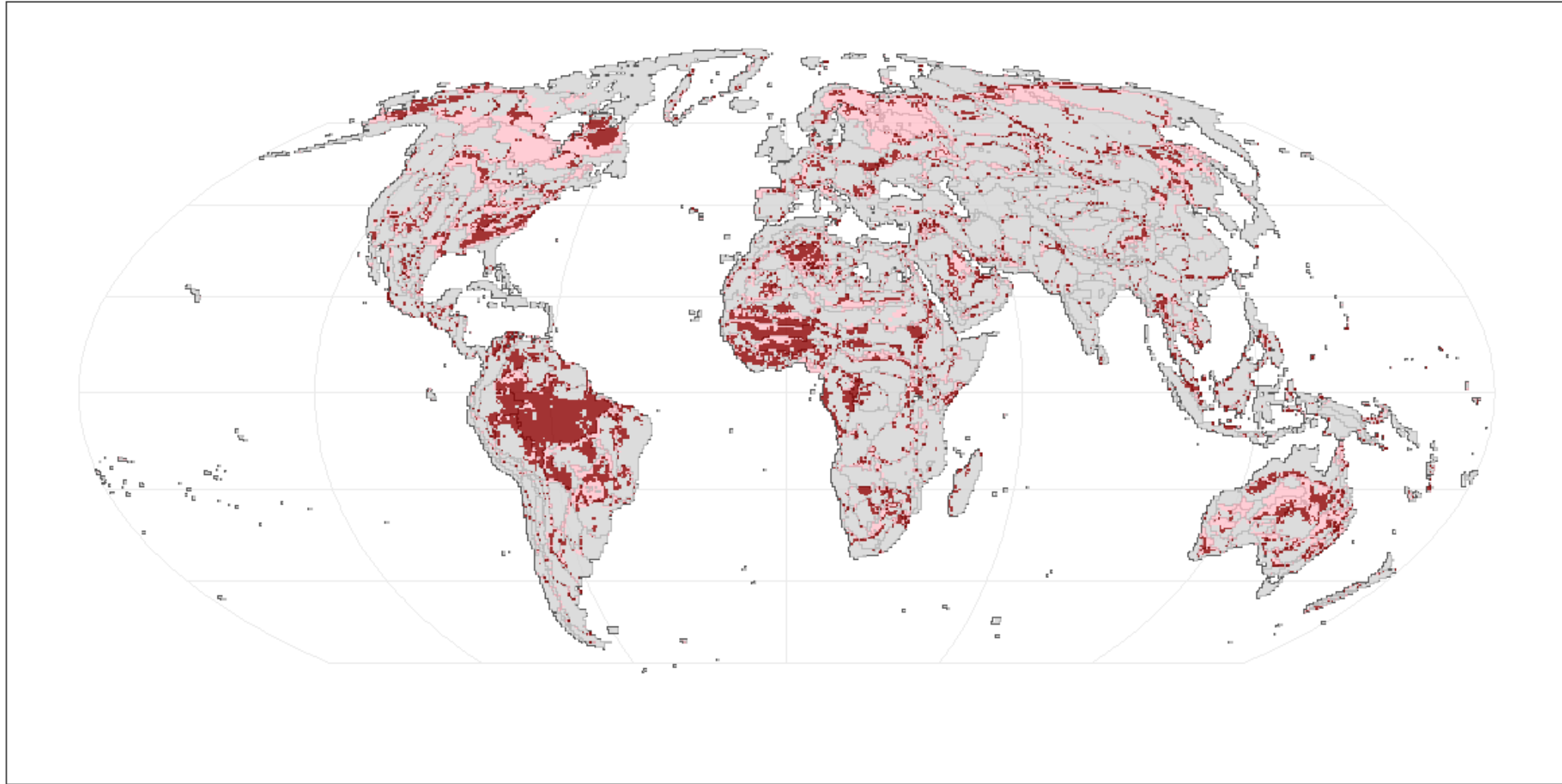
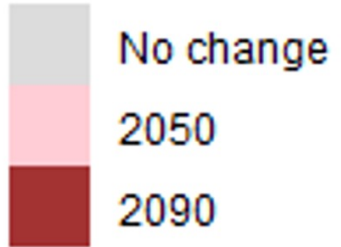


0 20 40 60 80



Results: Ecoregion shifts

Timing of
Ecoregion Shift



Brian Maitner

Results: The global plant threat assessment

Evaluating future increases to extinction risk under multiple threats



Drought



Fire



Deforestation



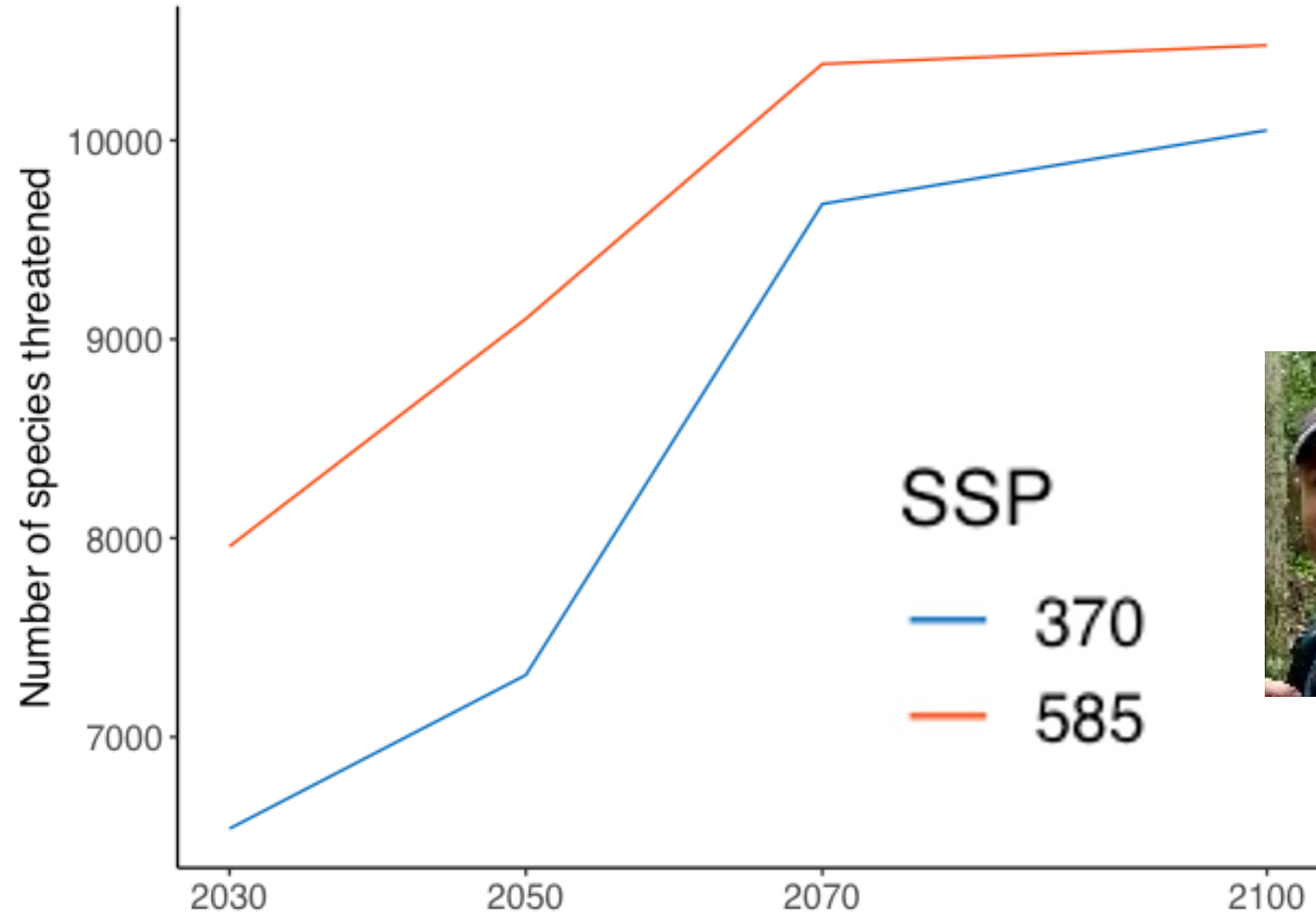
Climate change



Urban expansion



Agricultural expansion



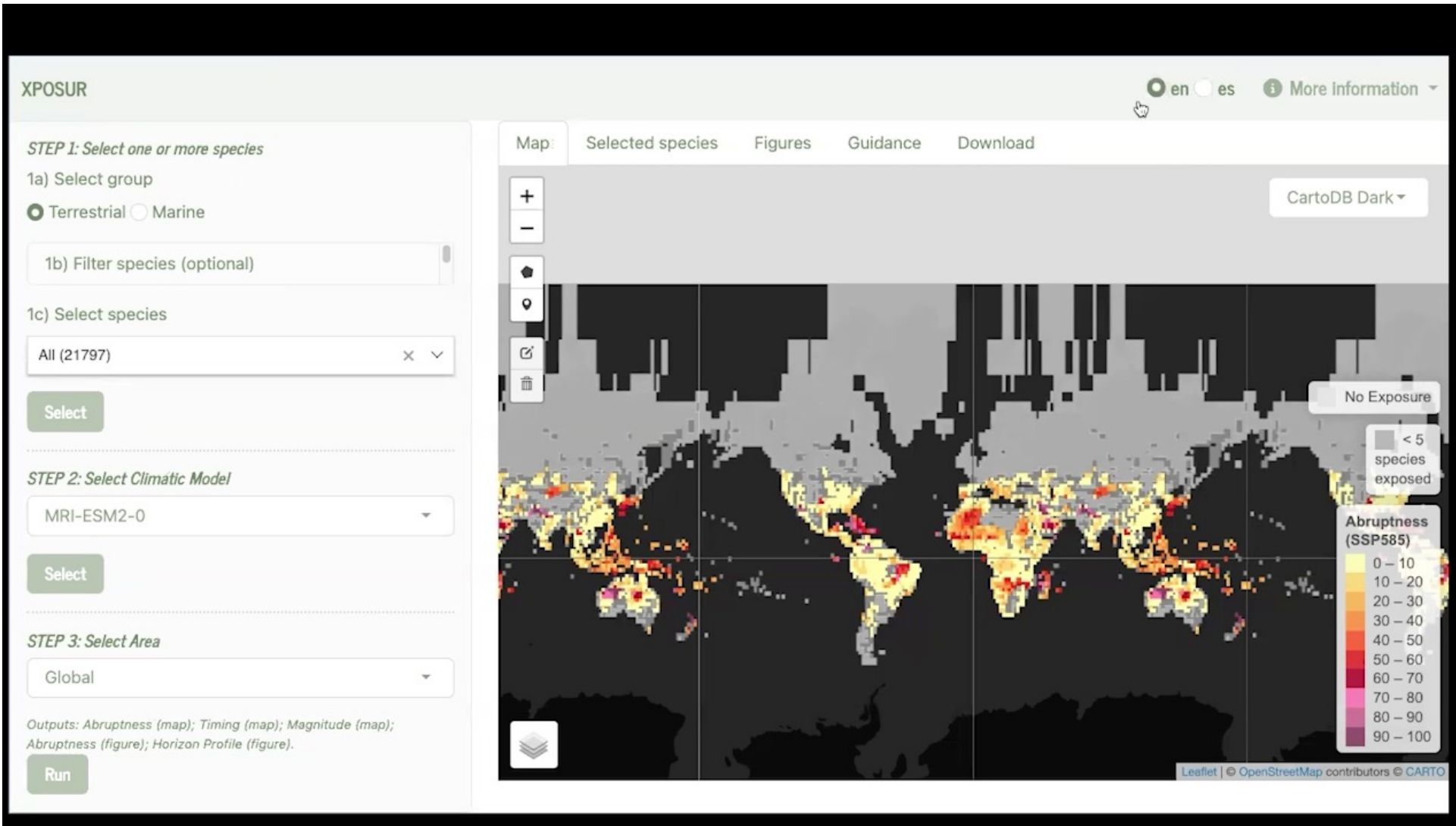
Ben
Carlson



Results: Web App Serving Data Products

R package:
fastRanger

Gonzalo
Pinilla-Buitrago



Soon: Monitoring Exposure Events

Significant Summer 2020 Biodiversity Exposure Events

GLOBAL BIODIVERSITY EXPOSURE

Summer 2020 temperatures were 1.5 C above average and 1,234 species were exposed to temperatures outside their known tolerance

(hypothetical example!)

CONTIGUOUS UNITED STATES

A weather front exposed 52 bird and 12 mammal species exposed to extreme temperatures. This is the most species exposed in the US since since 1970.

GREENLAND

High sea surface temperatures resulted in 12 marine mammal species exposed.

EUROPE

52 species exposed to temperatures exposed to extreme temperatures

ASIA

85 species exposed to dry conditions sea surface temperatures resulted in 12 marine mammal species exposed.

HAWAII

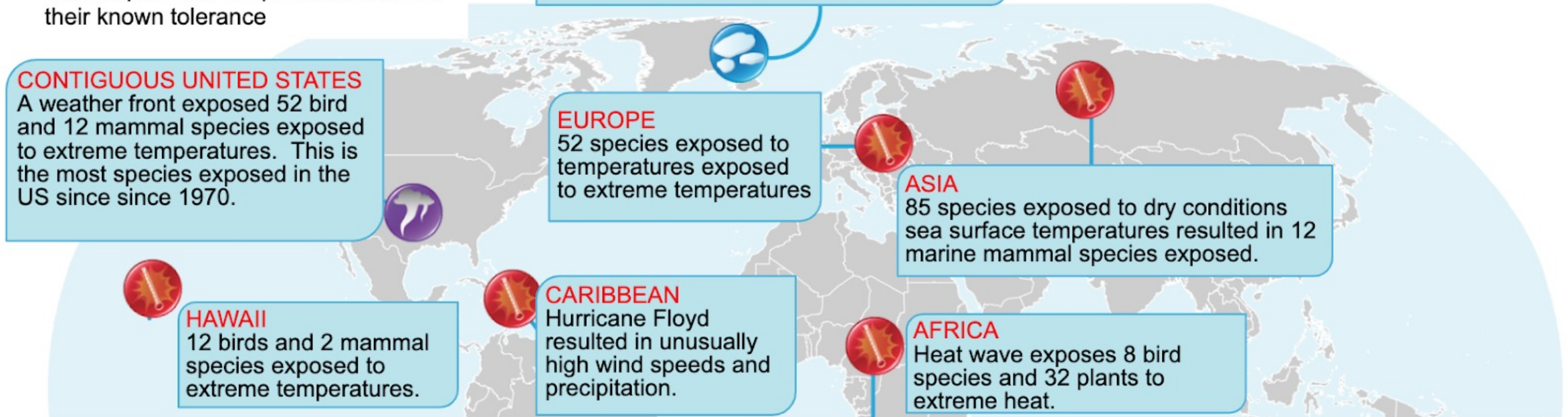
12 birds and 2 mammal species exposed to extreme temperatures.

CARIBBEAN

Hurricane Floyd resulted in unusually high wind speeds and precipitation.

AFRICA

Heat wave exposes 8 bird species and 32 plants to extreme heat.



Thanks!

Pep Serra-Diaz

Gonzalo Pinilla-Buitrago

Ben Carlson

Brian Maitner

Mark Urban

Brian Enquist

Brad Boyle

Xiao Feng

Patrick Roerdantz

The BIEN Working Group

Manos Anagnostou

Thymios Niklolooulos

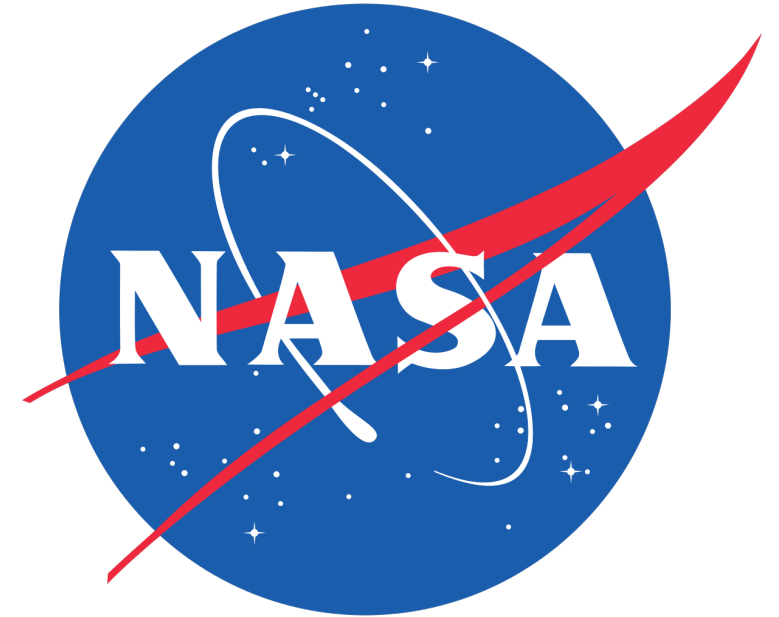
Diogo Araujo

Adam Wilson

Chris Trisos

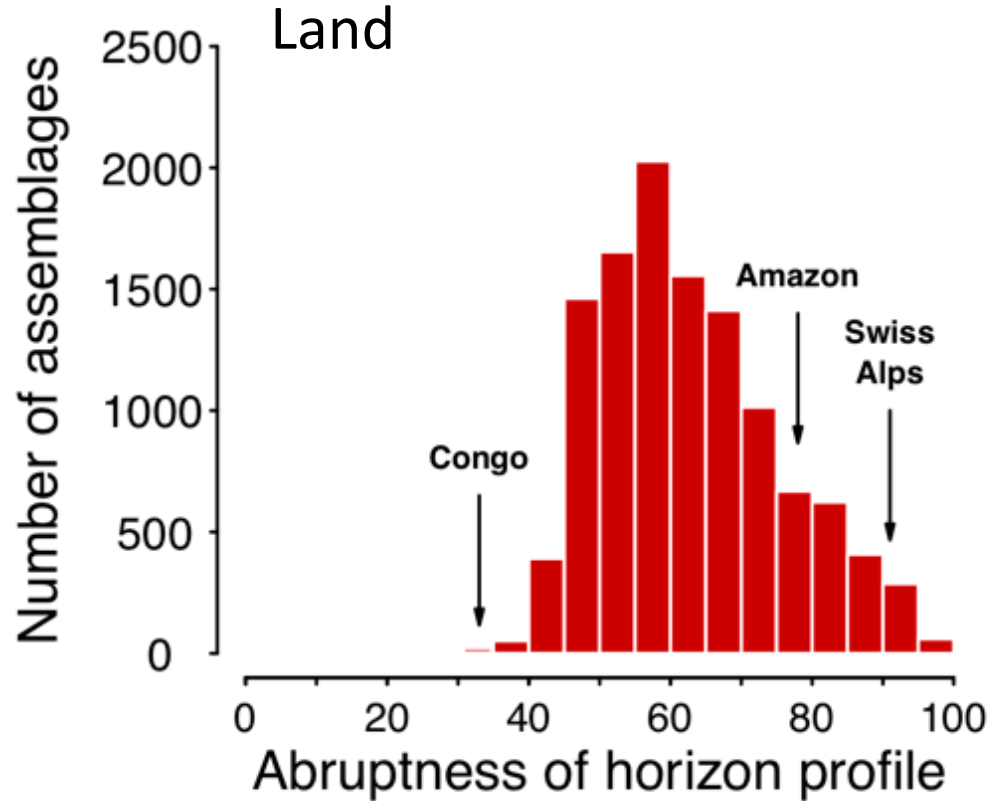
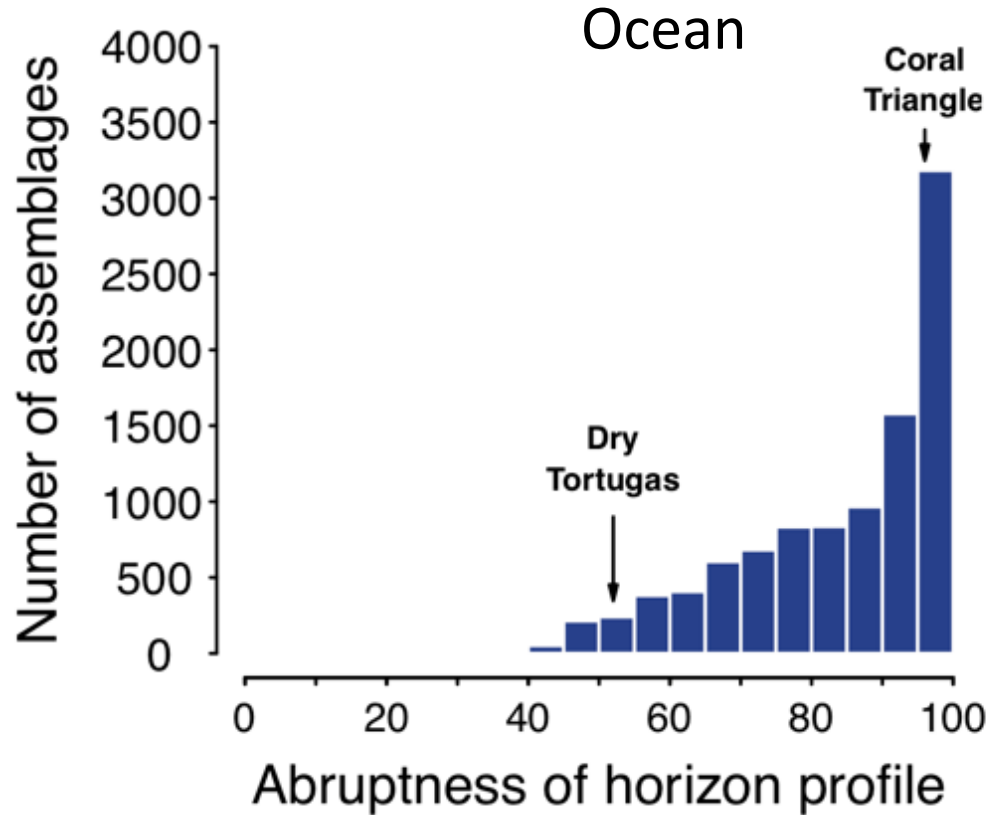
Alex Pigot

Questions?



BONUS SLIDES

Background: Abruptness is the rule!



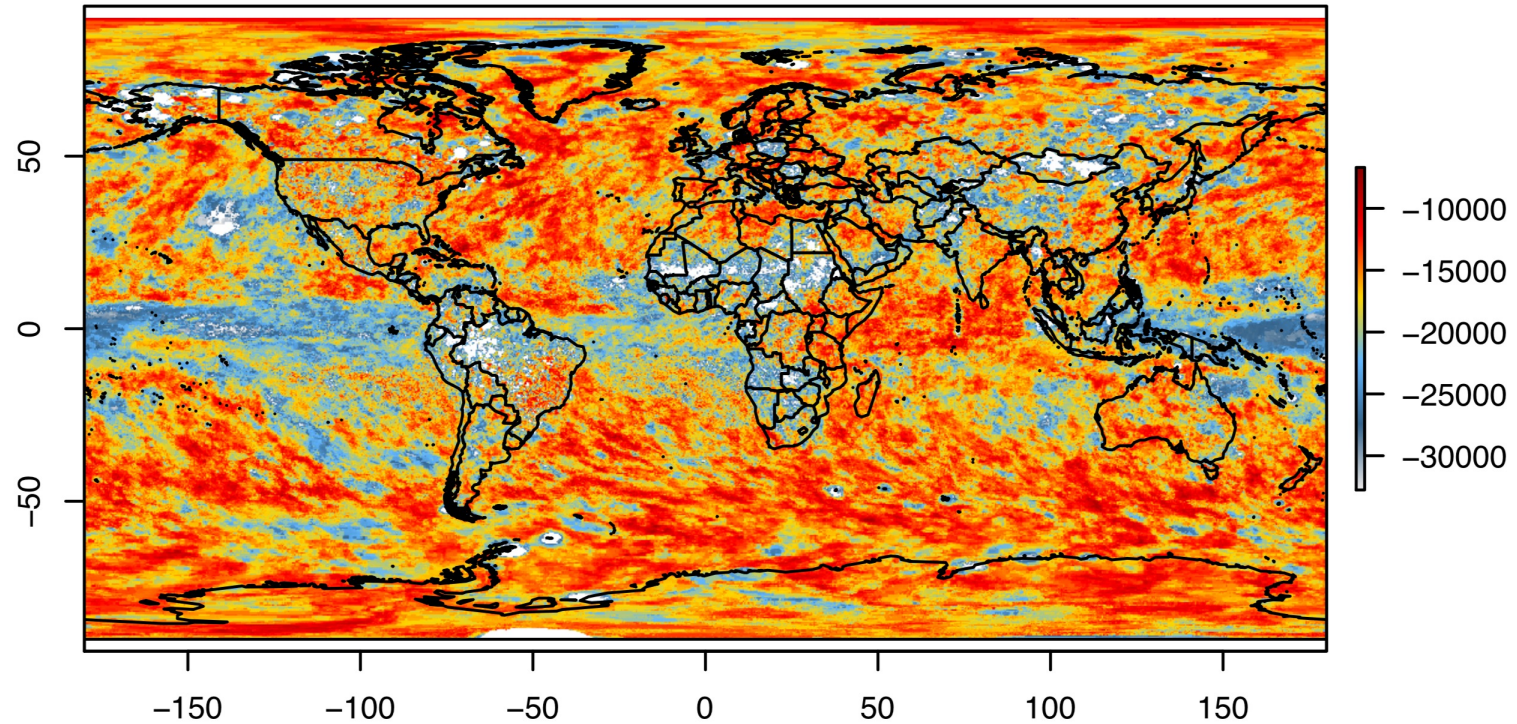
Trisos, Merow and Pigot, *Nature*, 2020

New Environmental Layers

Global drought intensity, frequency, duration and severity

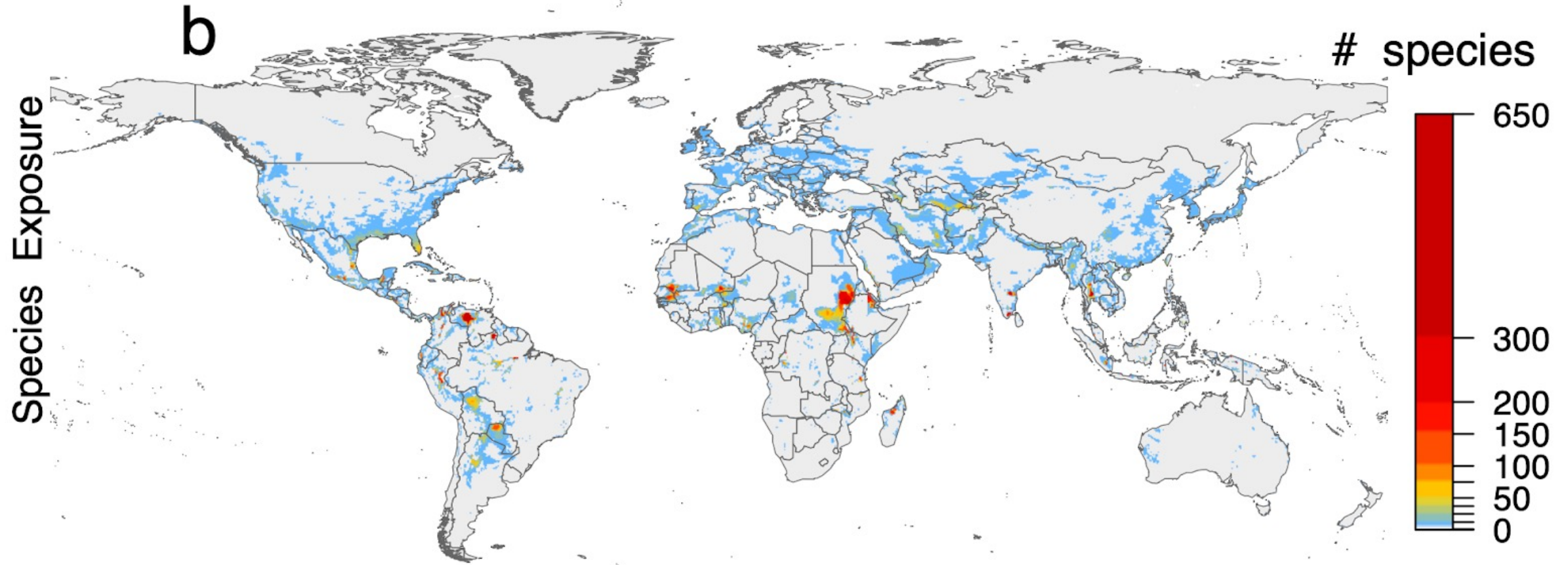
(NASA NEXGDDP CMIP6)

Average 12 Month Severity 1979-2016



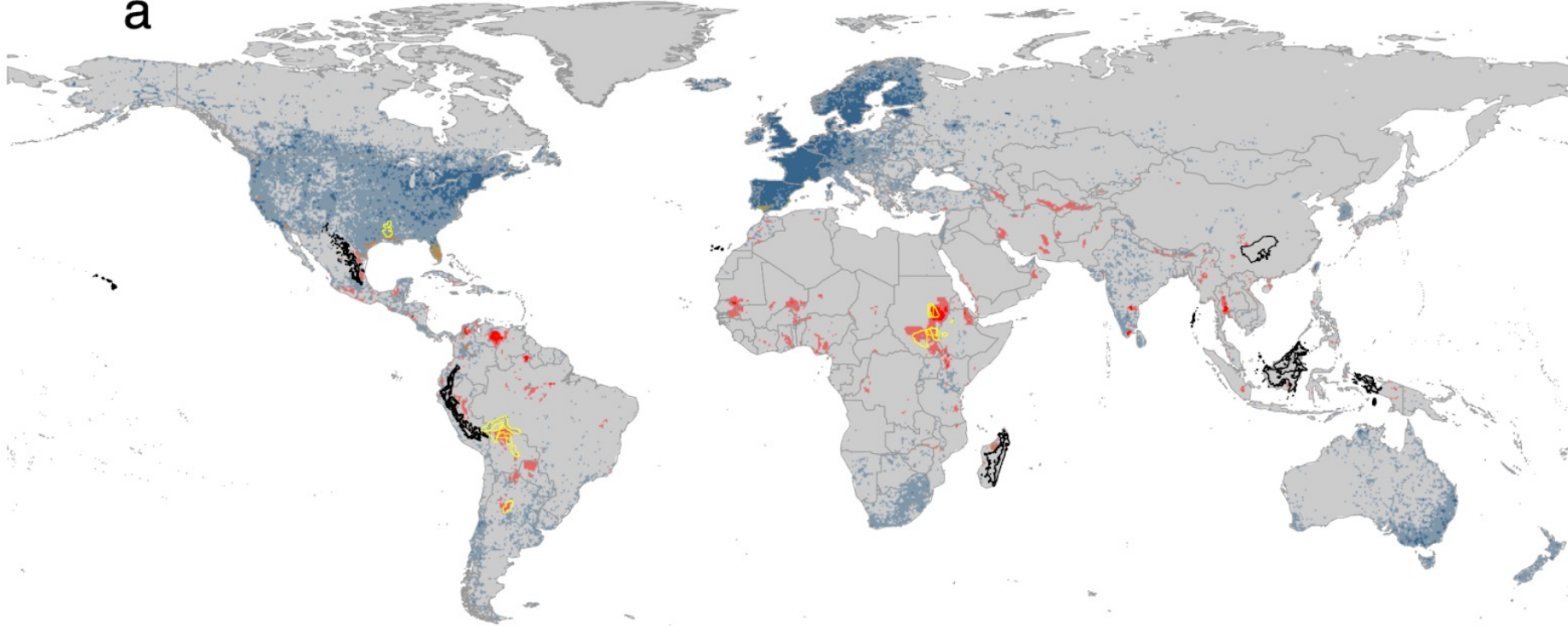
Nikolopoulos, Araujo, and Merow, *In Prep*

Results: 2023 Exposure

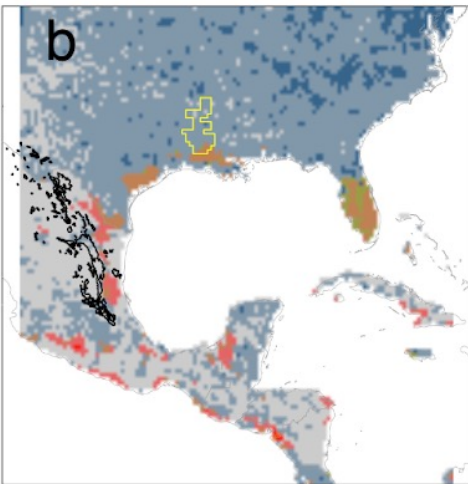


Results: 2023 Exposure

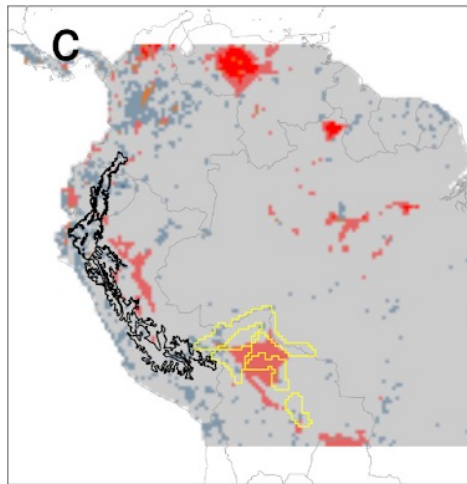
a



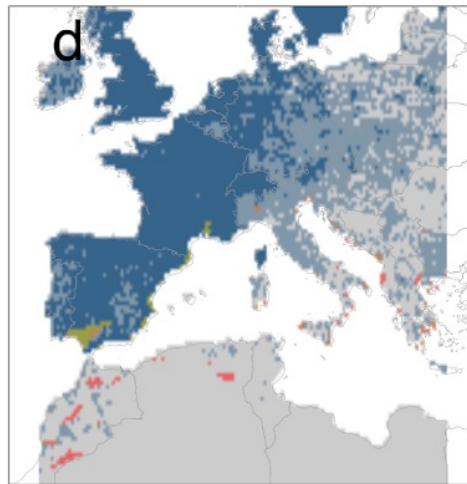
b



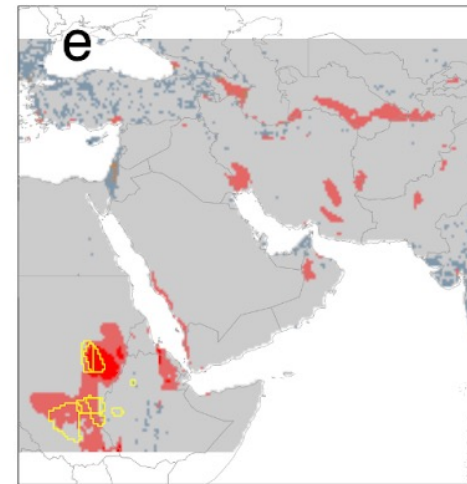
c



d

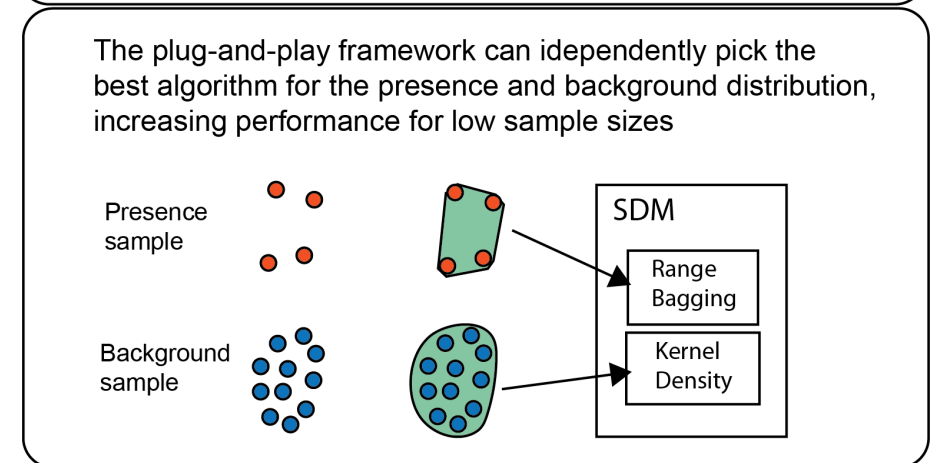
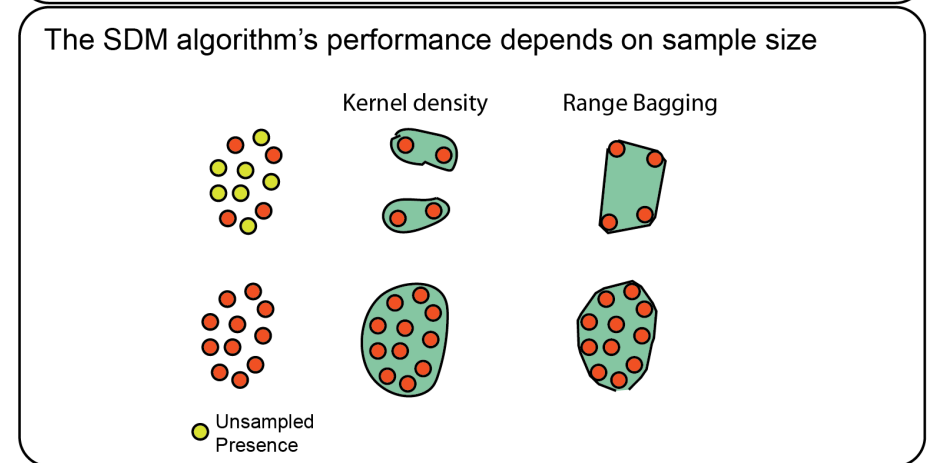
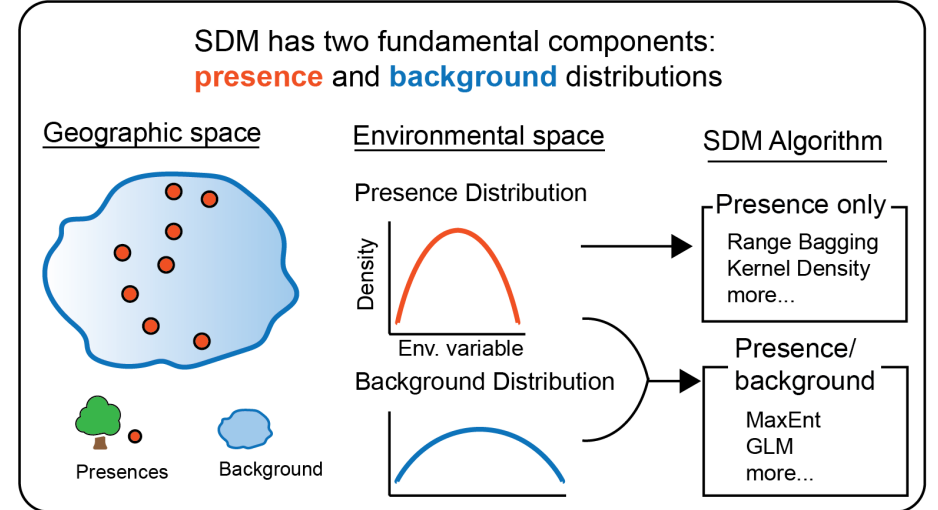


e



Results: New Modeling Algorithms

Brian Maitner(s)



The global plant threat assessment

Variable importance

Drought threat



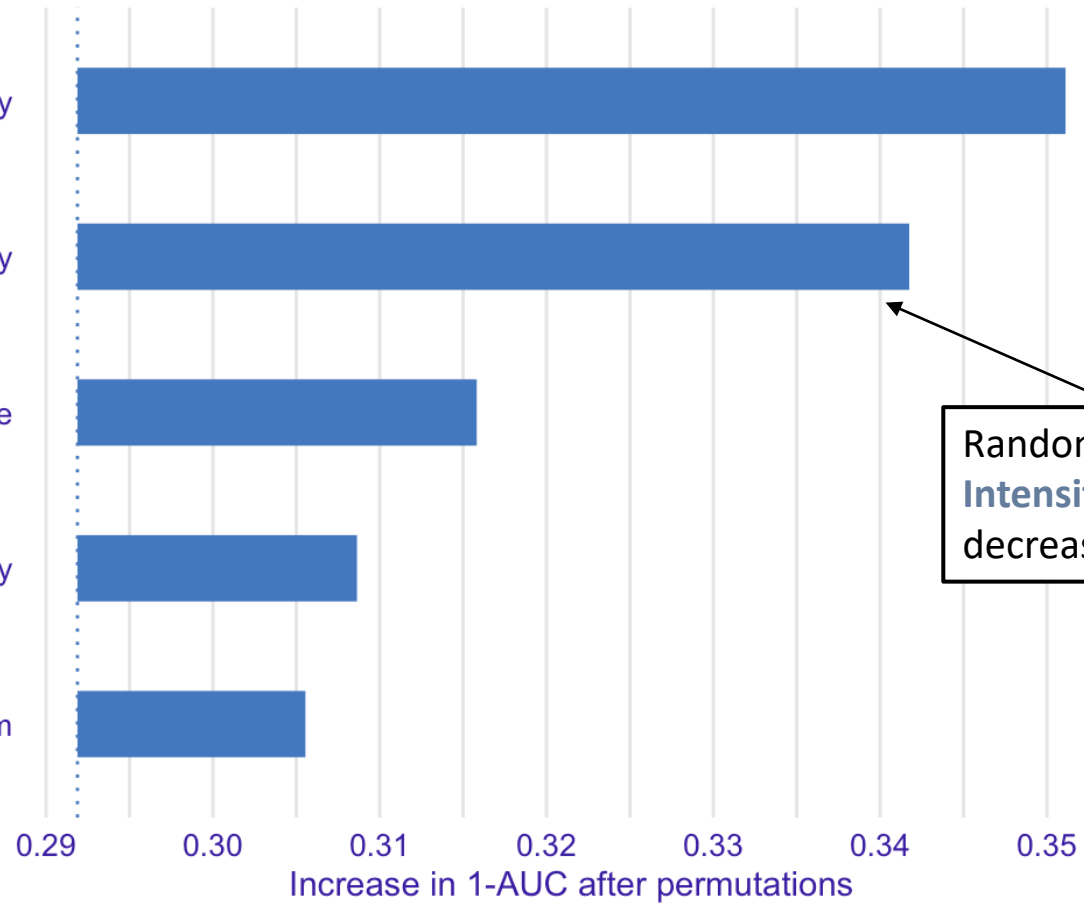
Drought exposure max intensity

Drought exposure rate

Drought exposure mean intensity

Family

Lifeform



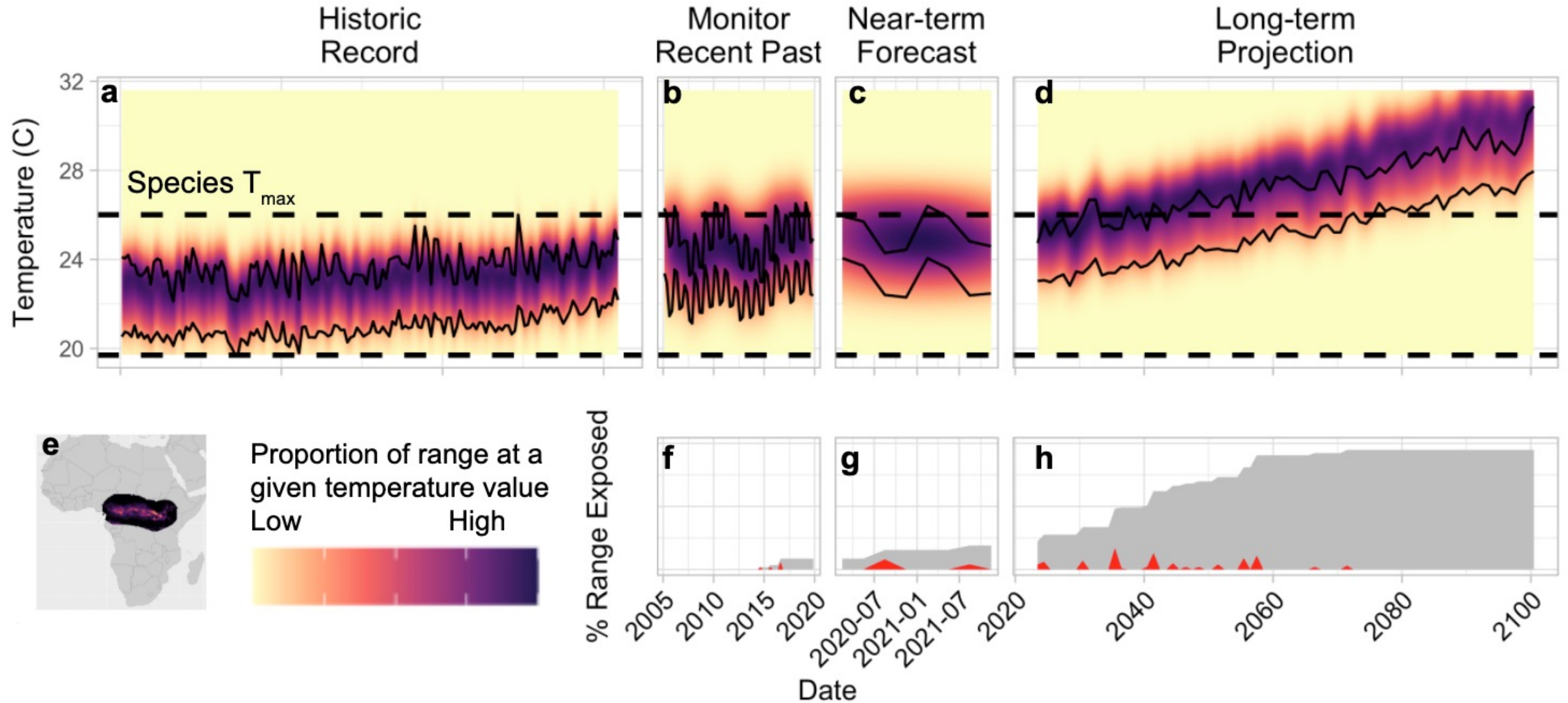
Randomizing **Drought Max Intensity** caused AUC to decrease by 0.34

Goal: Include other threats to understand relative importance to extinction risk

Ben Carlson

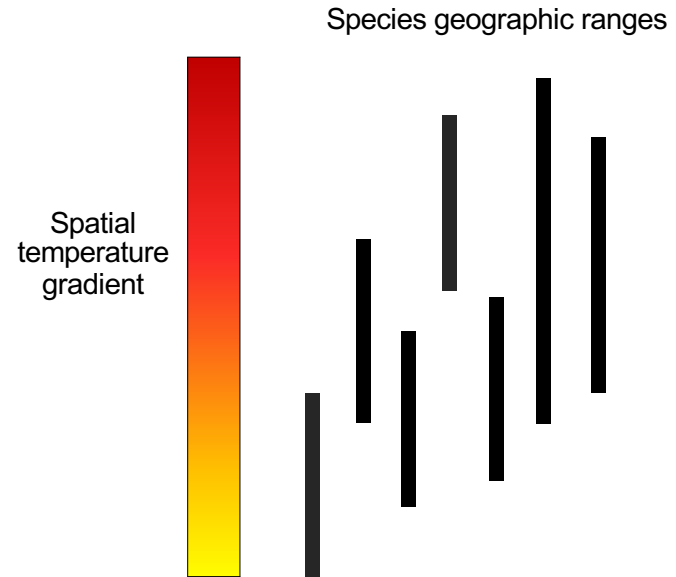


Exposure of locations across species' ranges



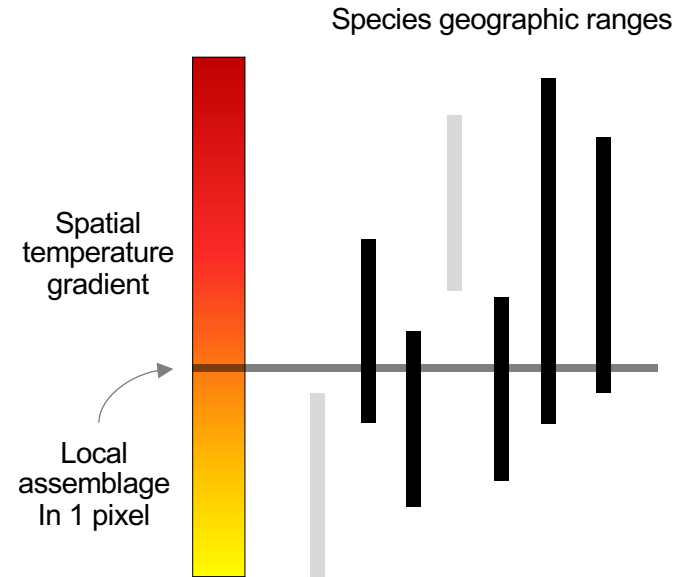
Assessing species' exposure to novel climate

The climate horizon profile



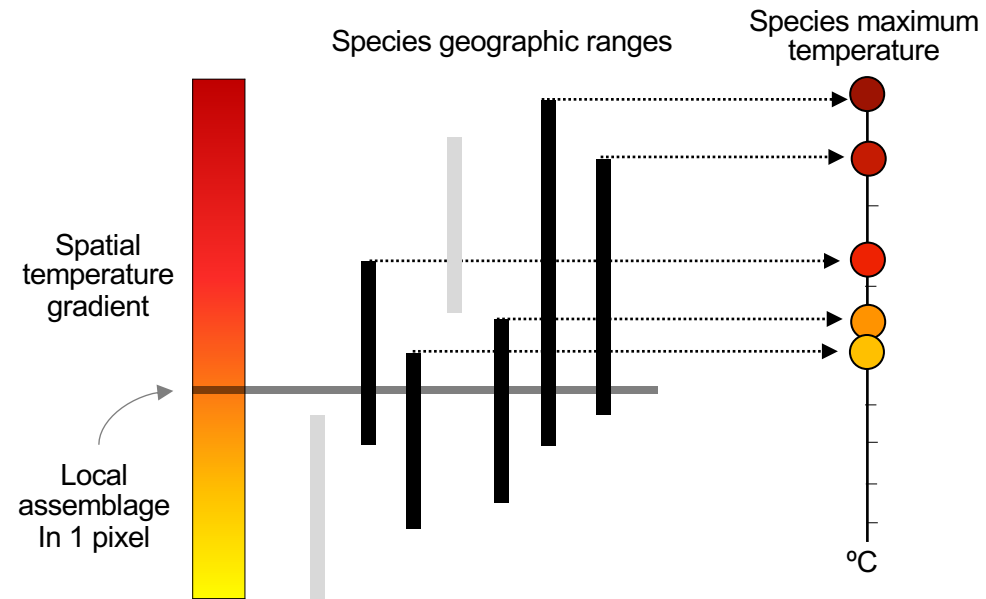
Assessing species' exposure to novel climate

The climate horizon profile



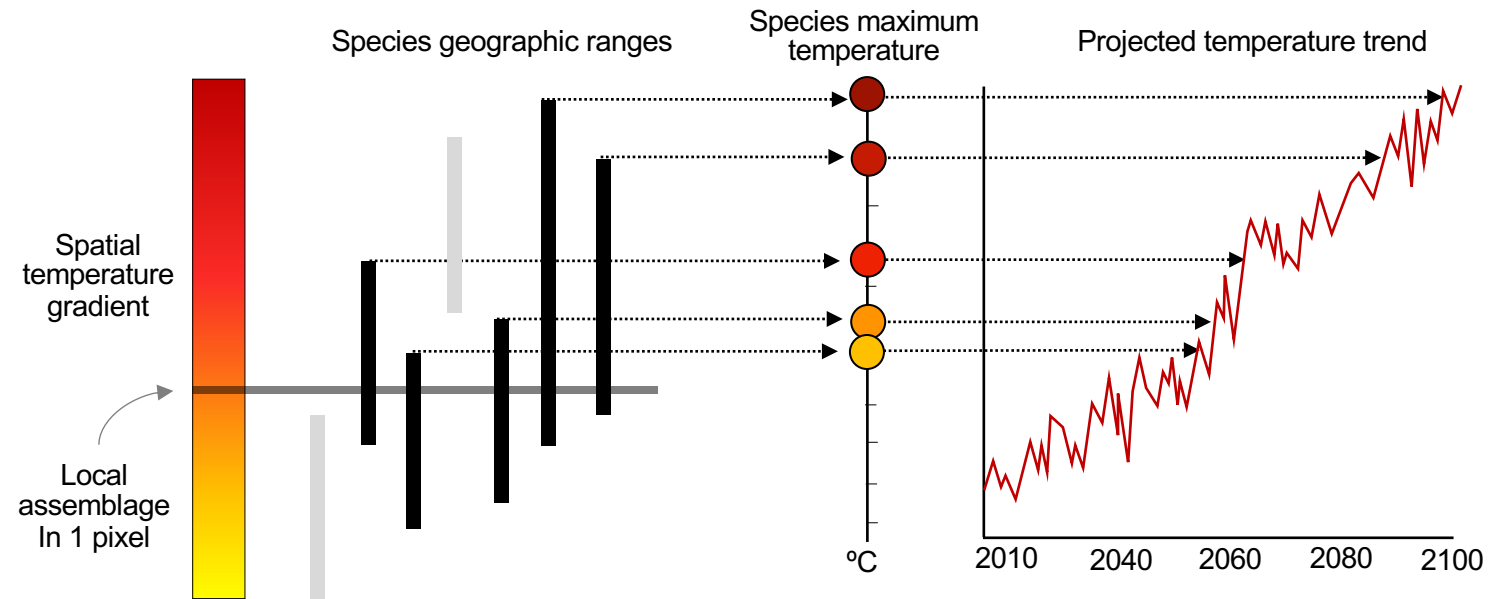
Assessing species' exposure to novel climate

The climate horizon profile



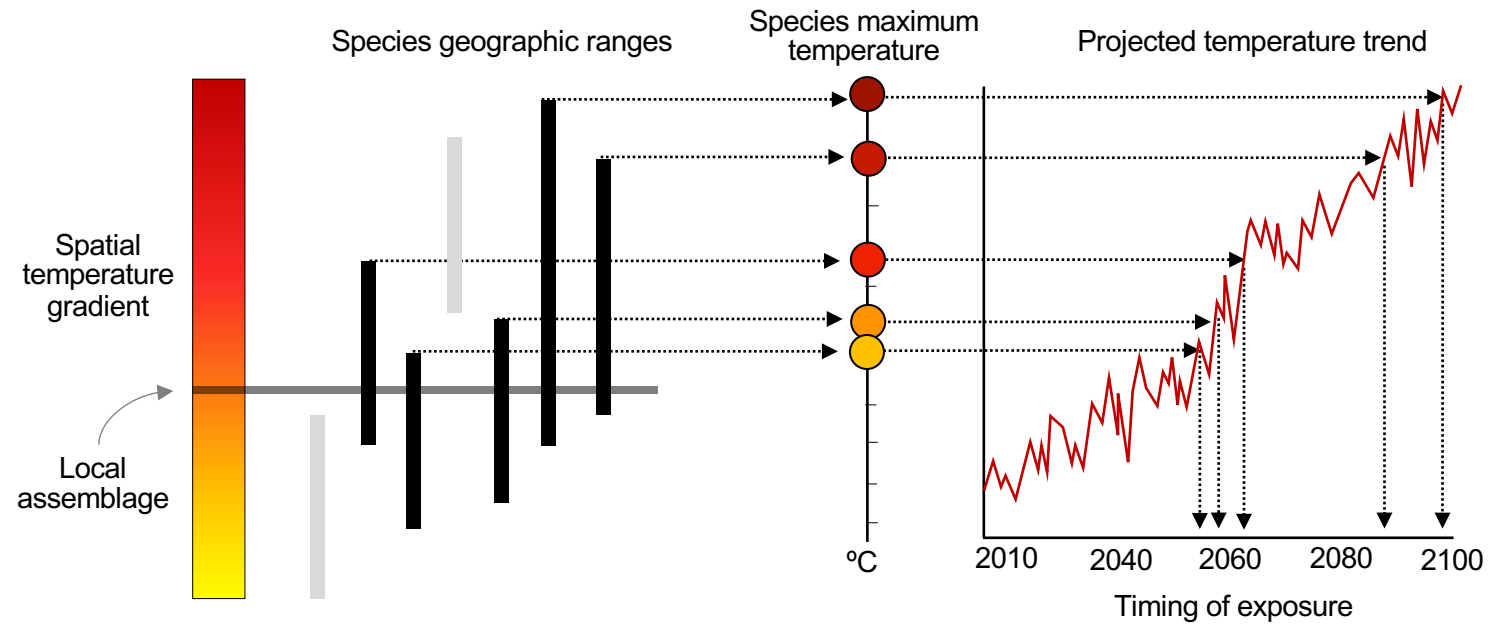
Assessing species' exposure to novel climate

The climate horizon profile



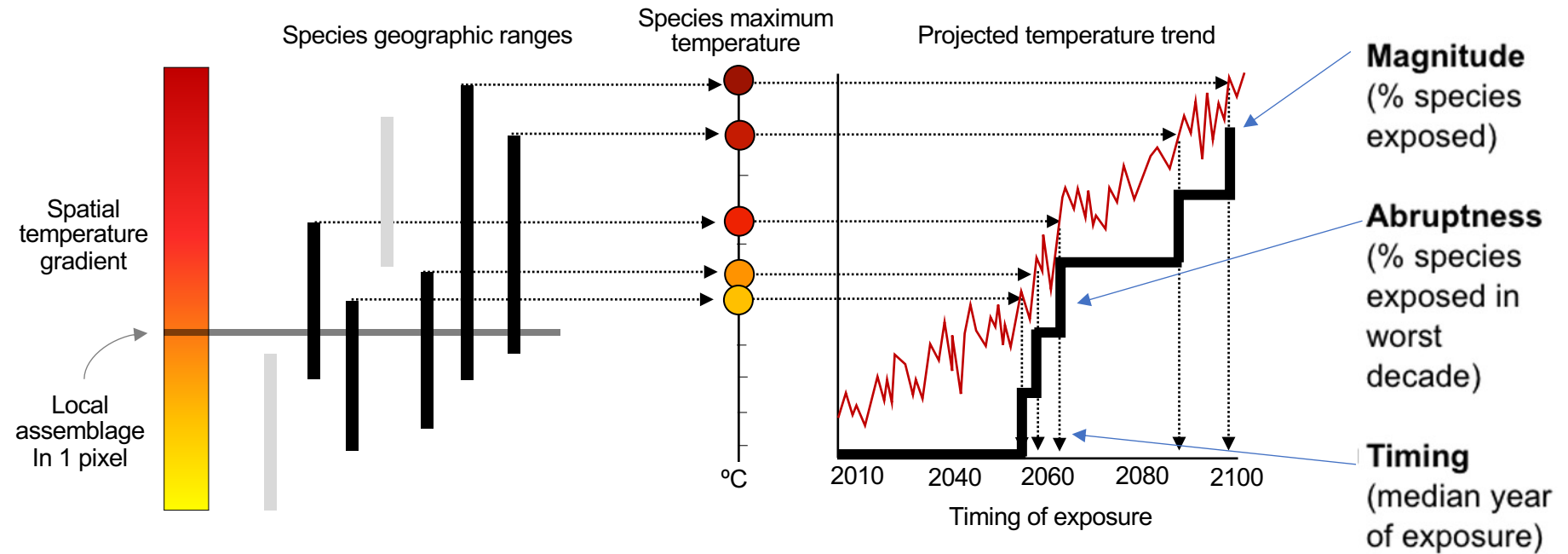
Assessing species' exposure to novel climate

The climate horizon profile



Assessing species' exposure to novel climate

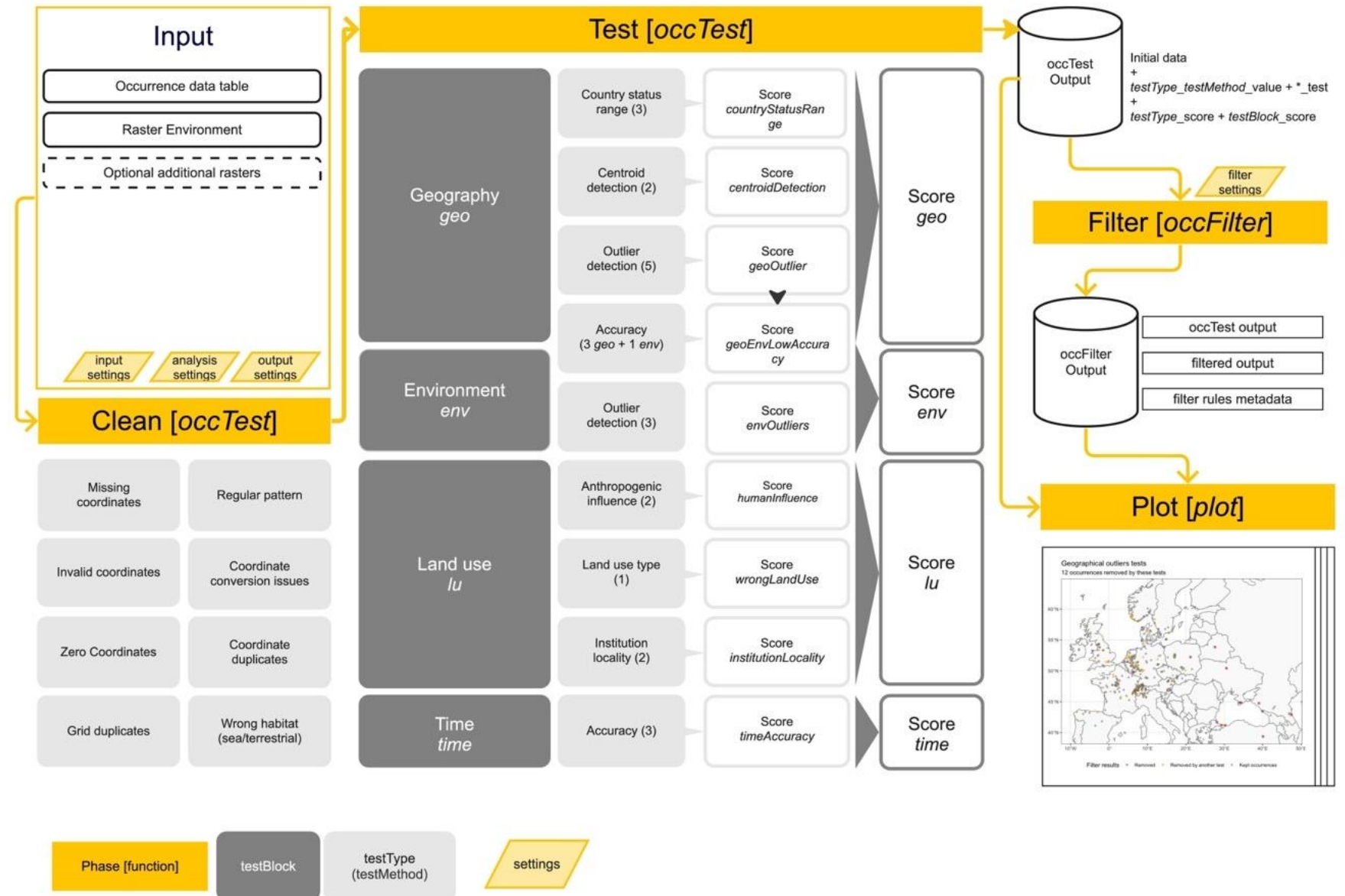
The climate horizon profile



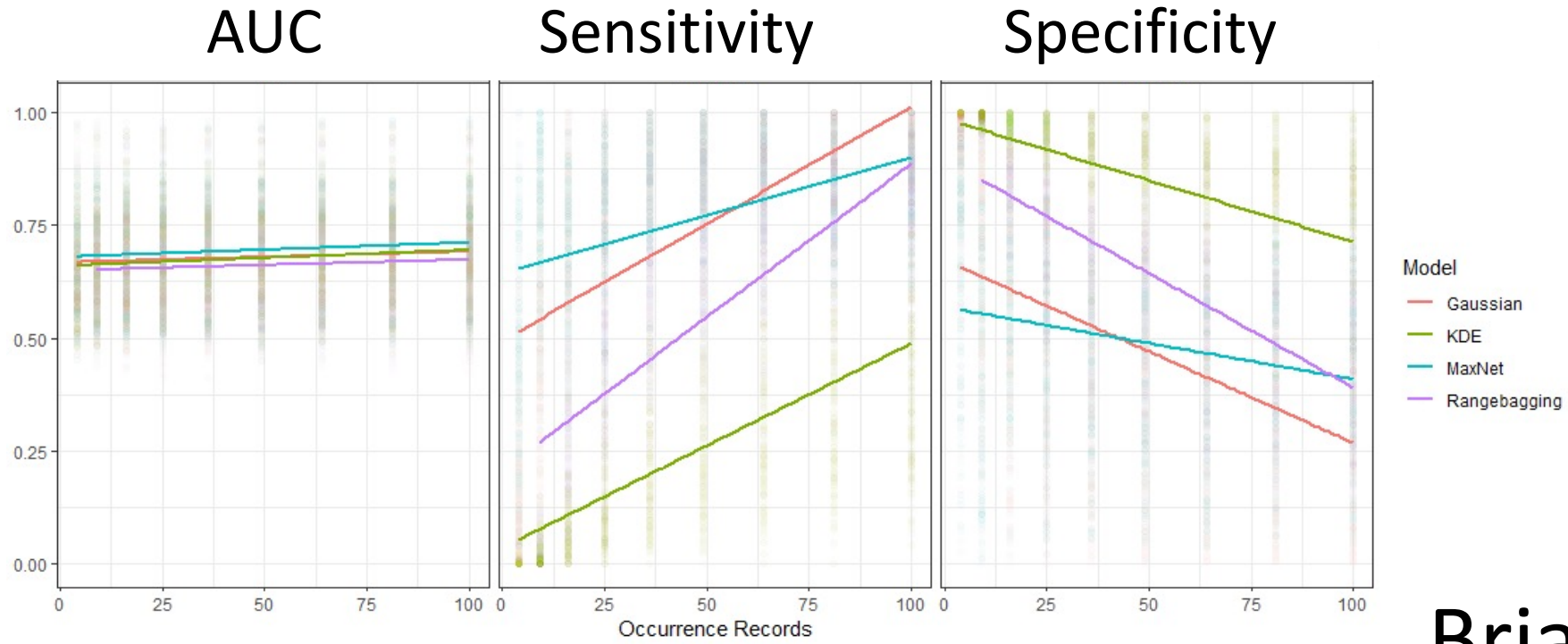
Results: Data Cleaning

R package:
occTest

Pep Serra-Diaz



Results: New Modeling Algorithms



R package: pbSDM

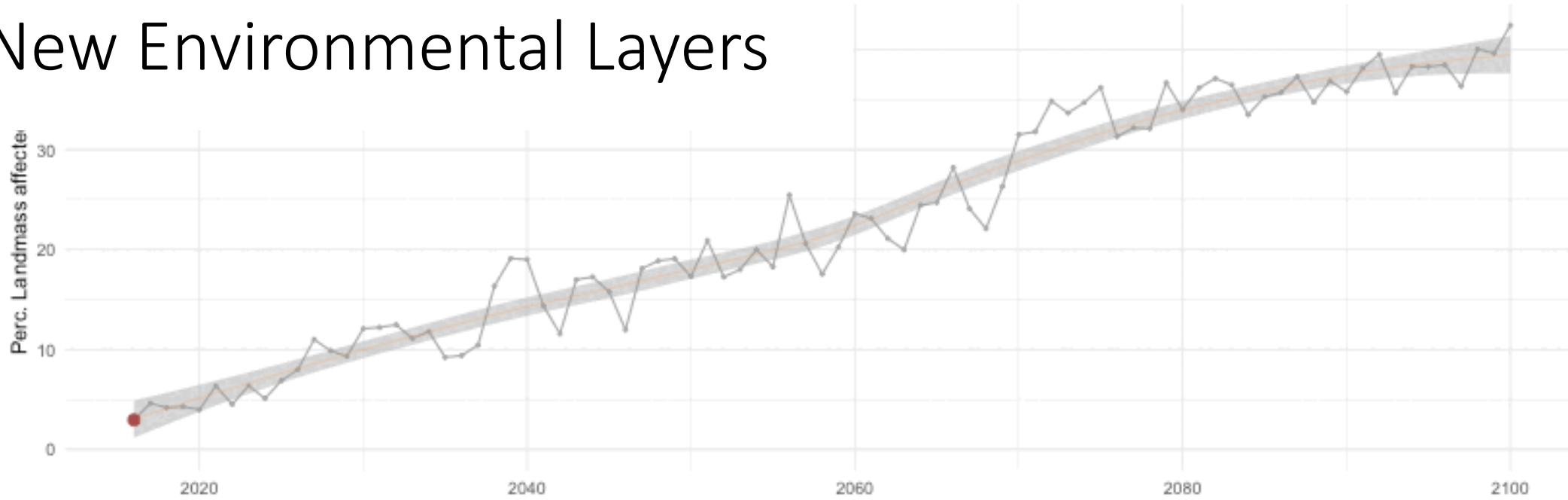
Brian Maitner(s)

Important for **capturing uncertainty** with small sample sizes, **i.e. most species**



Results: New Environmental Layers

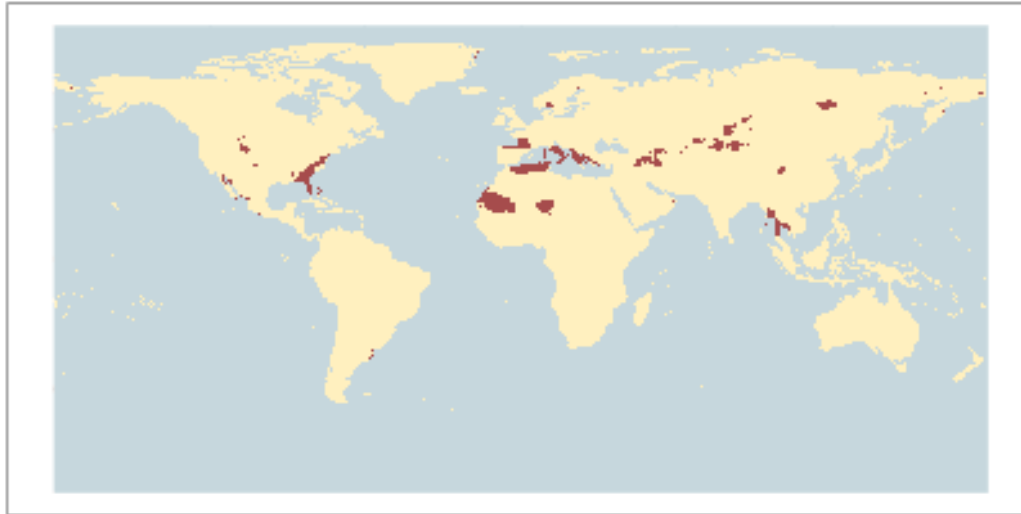
E.g.,
12 month
drought
Severity



Pep Serra-Diaz

Thymios
Nikolopoulos
Diogo Araujo

Drought severity



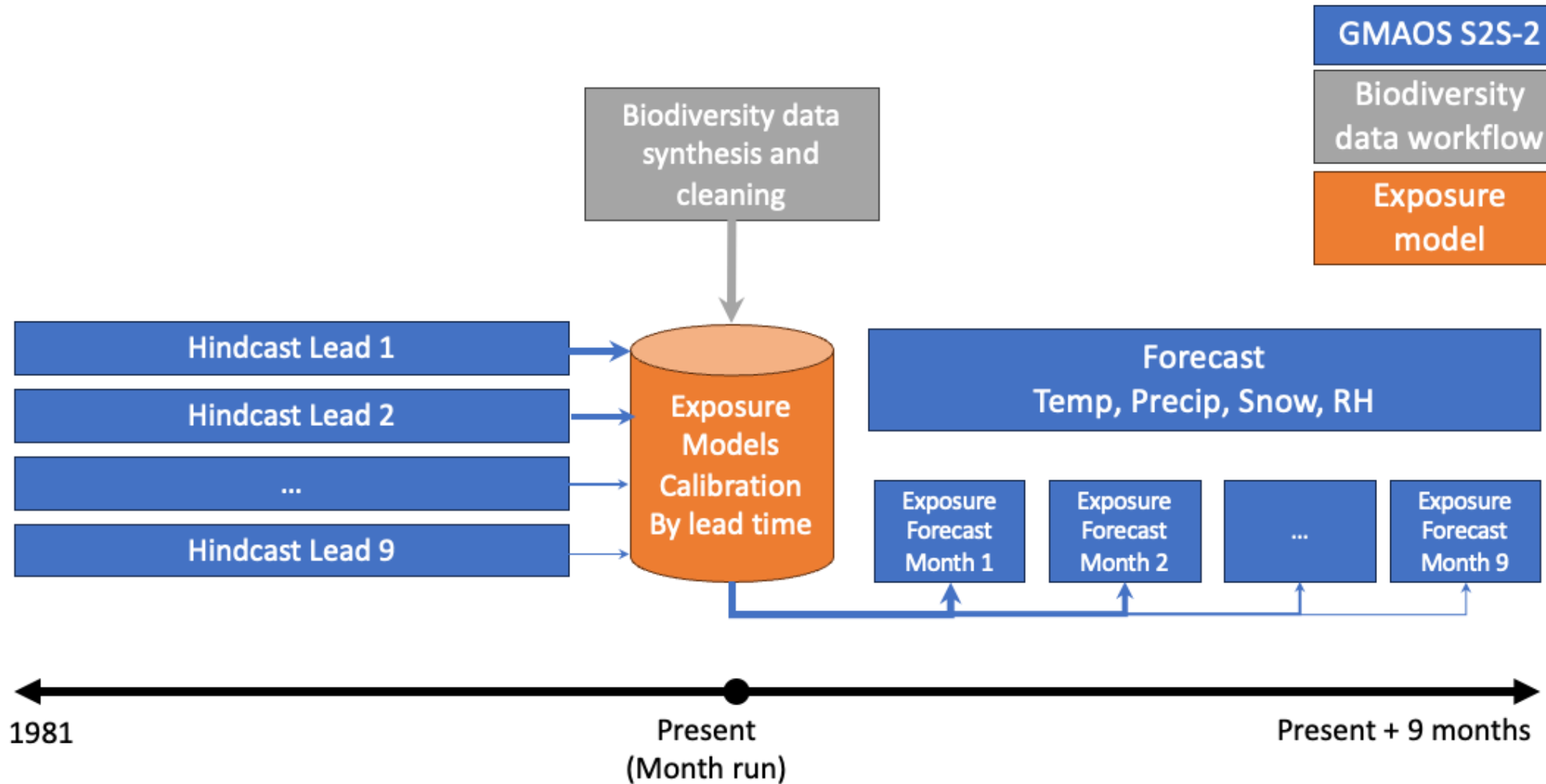
historical unprecedented

Cummulative departure events



0 20 40 60 80

Results: S2S forecasts



GMAOS S2S-2
Biodiversity data workflow
Exposure model



Pep Serra-Diaz

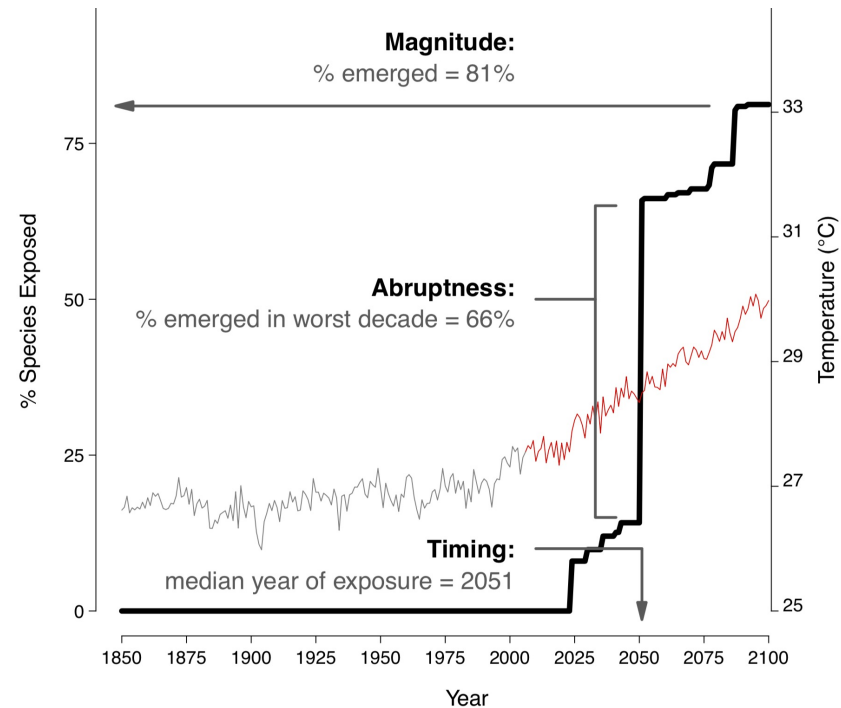
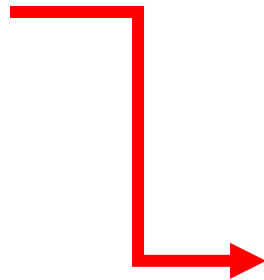


Lauren Andrews

Global Modeling and Assimilation Office
Subseasonal to Seasonal group

Results: Customizable Data Products

- R package: fastRanger
- **Custom Biodiversity summary statistics in a few seconds**
 - And clade, region, etc in 1-3s



Gonzalo
Pinilla-Buitrago



A world map with a heatmap overlay. The colors range from light pink to dark red, indicating different levels of biodiversity or monitoring intensity across the globe. The text is overlaid on the map.

A global monitoring network for all biodiversity at the species level

Inputs:

1. species occurrence data
2. weather/climate data
3. tunable algorithms

Outputs:

4. timing
5. and severity of exposure to extreme events
6. accessible, customizable, useful