A multidisciplinar framework for biodiversity prediction in the Atlantic Rainforest hotspot

AF BIOTA

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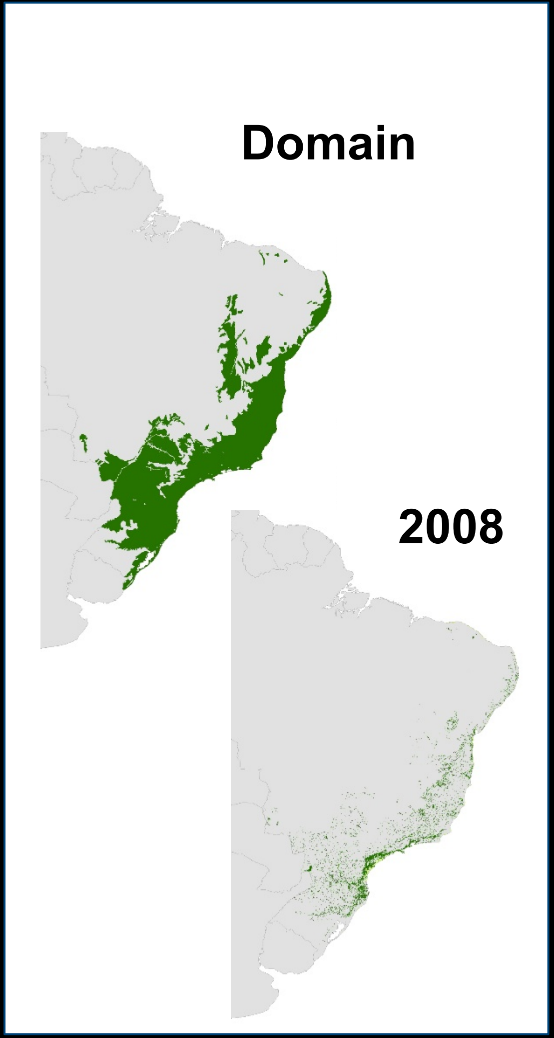
Our DoB project implements an integrative framework to improve biodiversity prediction in the Atlantic Forest hotspot



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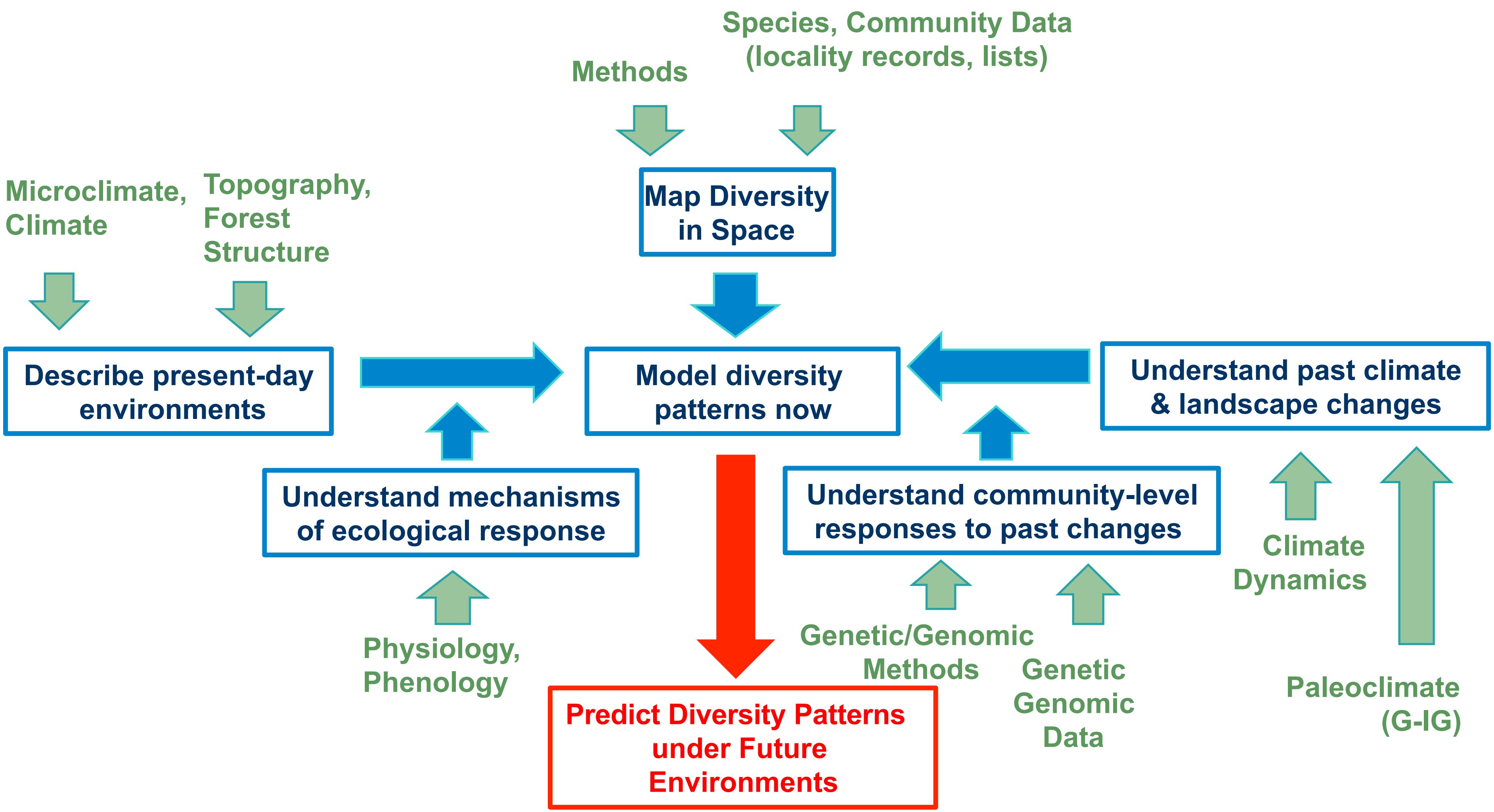
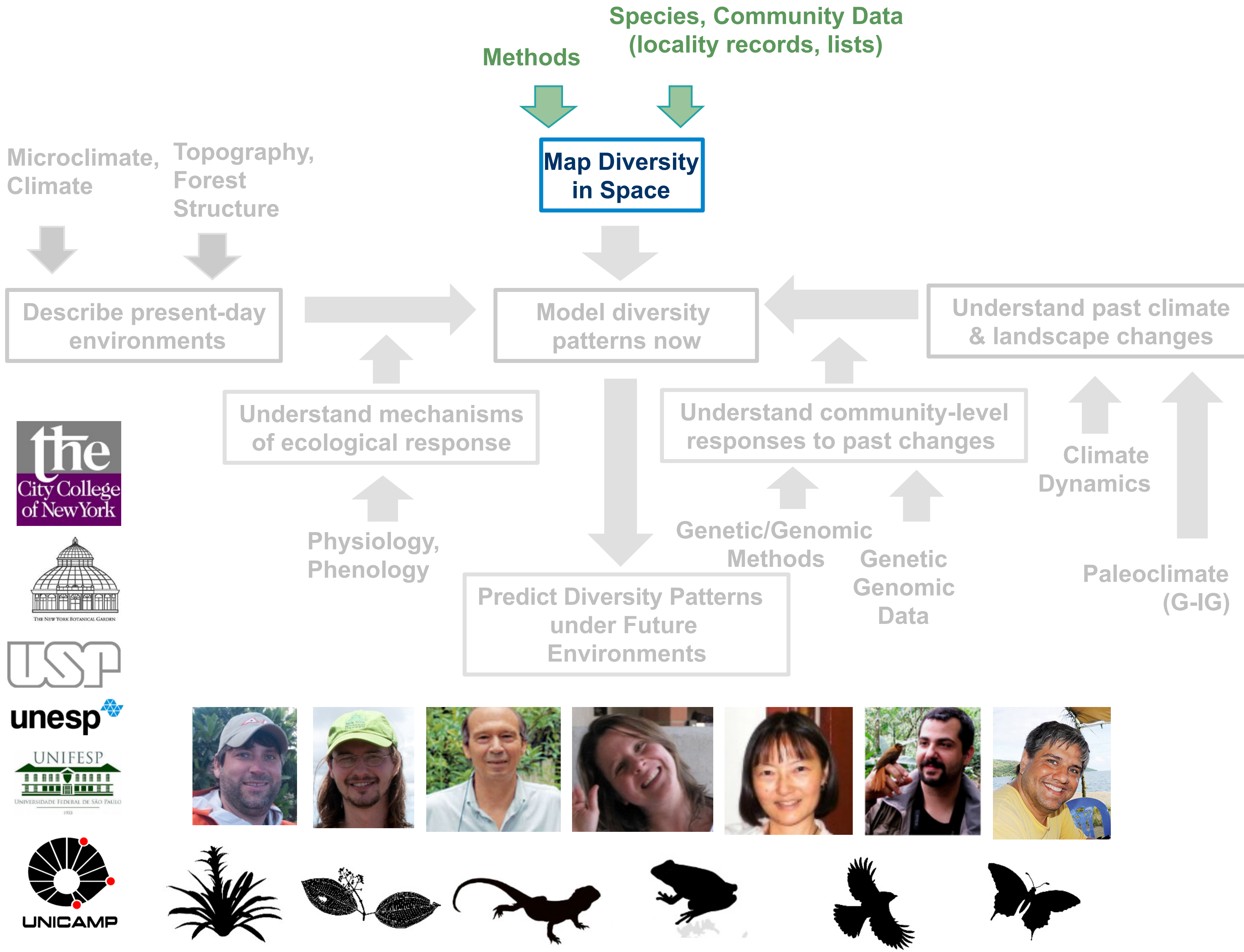
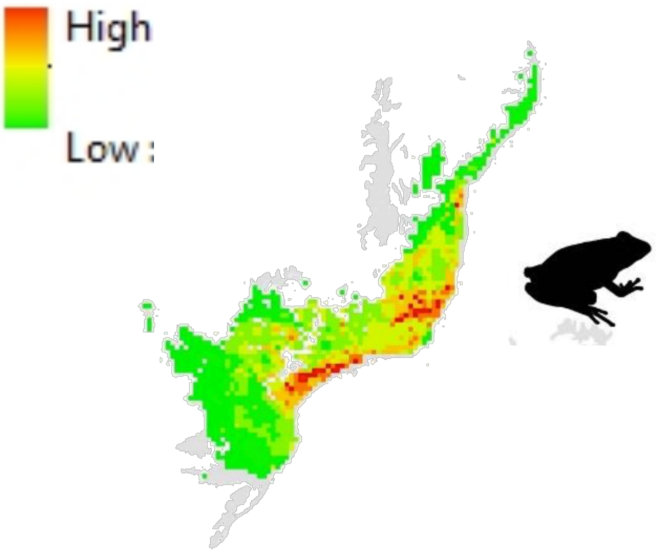


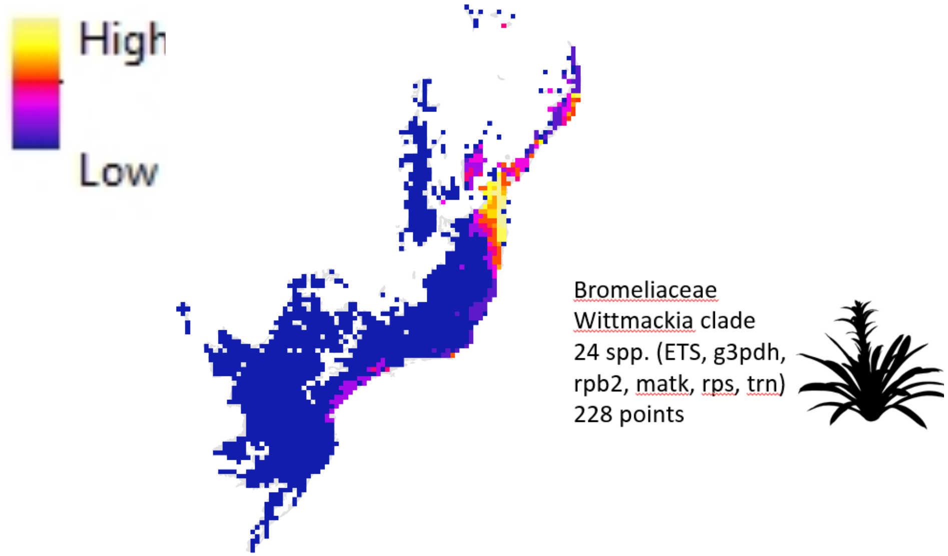

the taxonomic dimension of biodiversity
the environmental dimension
the functional dimension
the genetic dimension


Species, Community Data
(locality records, lists)
Methods
Map Diversity in Space
Microclimate, Climate
Topography, Forest Structure
Describe present-day environments
Model diversity patterns now
Understand past climate & landscape changes
Understand mechanisms of ecological response
Understand community-level responses to past changes
Climate Dynamics
Physiology, Phenology
Genetic/Genomic Methods
Genetic Genomic Data
Paleoclimate (G-IG)
Predict Diversity Patterns under Future Environments
the City College of New York
The New York Botanical Garden
USP
unesp
UNIFESP
Universidade Federal de São Paulo
UNICAMP

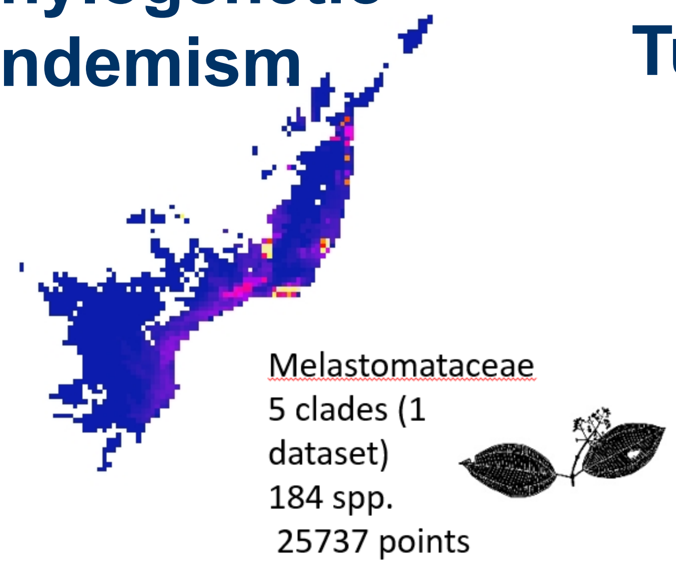
Species Richness



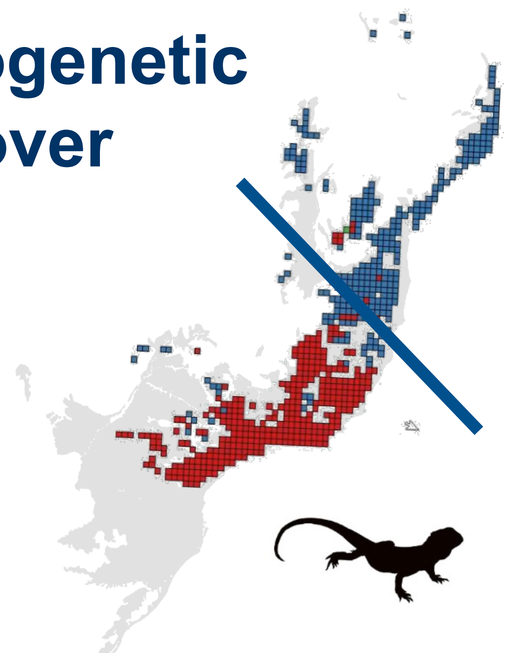
Phylogenetic Diversity



Phylogenetic Endemism

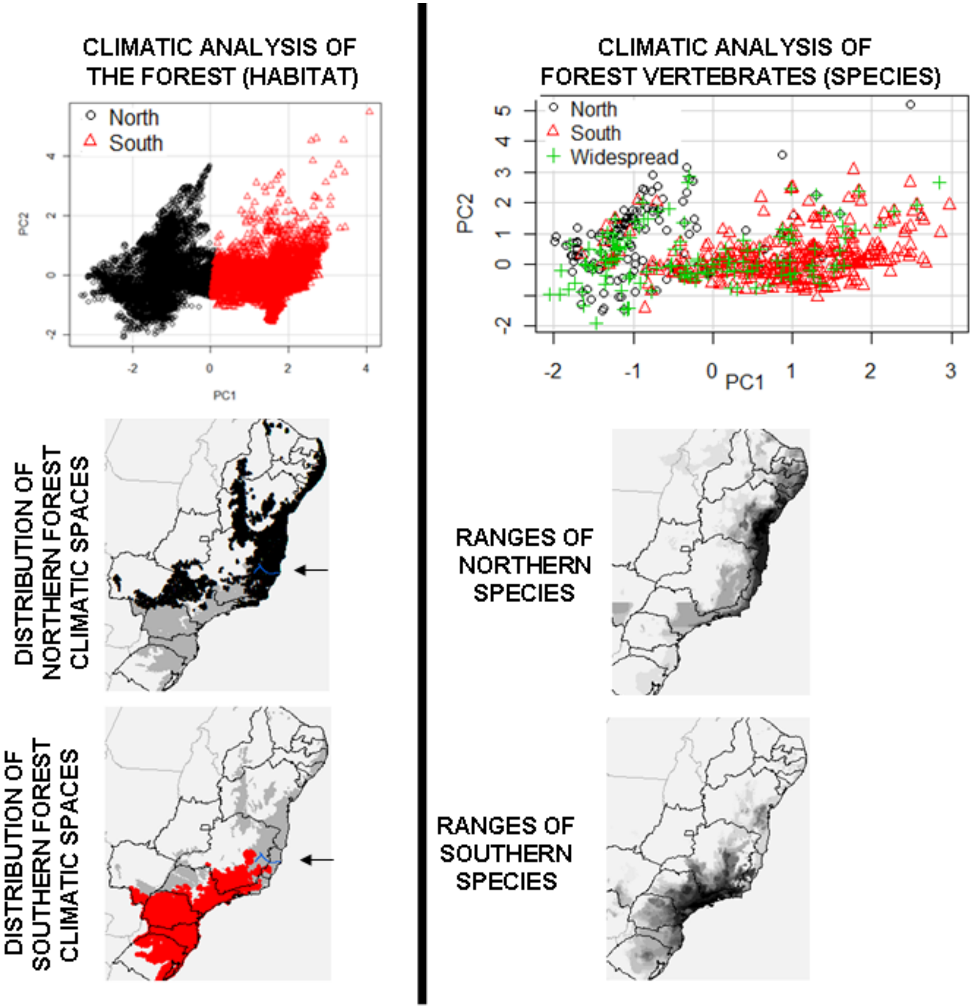


Phylogenetic Turnover



Improving characterization of present-day environments for biodiversity modeling

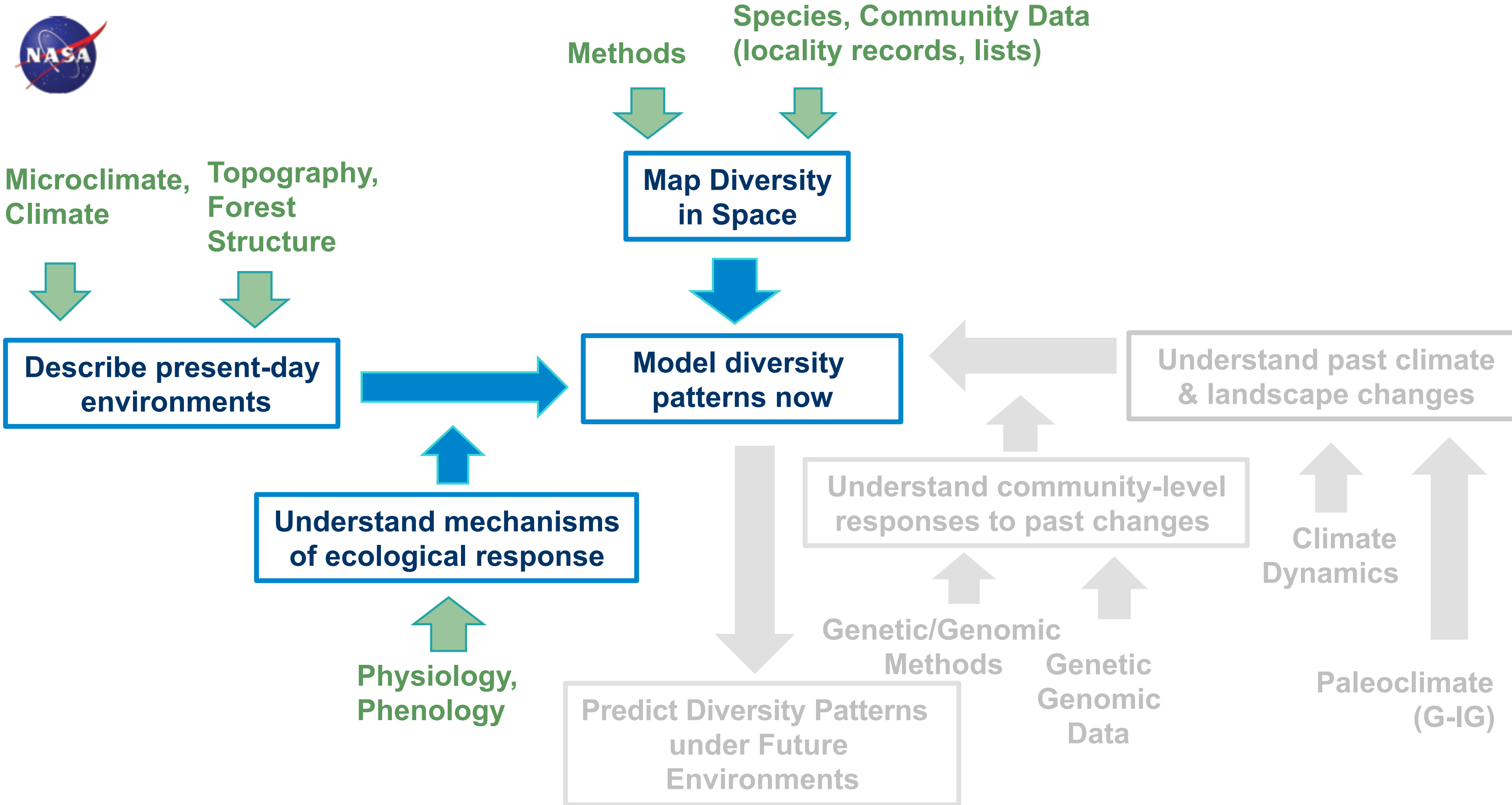
Many forests and forest communities in the AF



Left: PCA-based identification of two climatically distinct spaces within the Atlantic rainforest (top), and their respective northern (black) and southern (red) geographical ranges (bottom).

Right: PCA-based identification of species assemblages along the climatic axes of the Atlantic forest (top) depicting their northern (black), southern (red), or widespread (green) distributions.

Carnaval et al. 2014.
Proc Roy Soc.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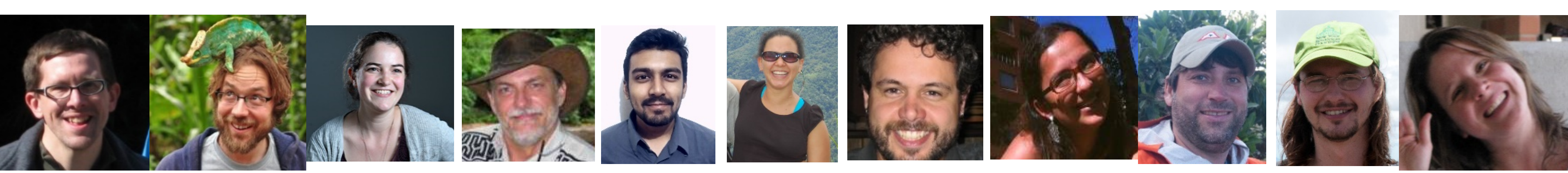


Improving characterization of present-day environments for biodiversity modeling

Methods in Ecology and Evolution

British Ecological Society

Methods in Ecology and Evolution 2014

doi: 10.1111/2041-210X.12264

Bioclimatic variables derived from remote sensing: assessment and application for species distribution modelling

Eric Waltari[1*], Ronny Schroeder[1,2], Kyle McDonald[1,3], Robert P. Anderson[1,3,4,5] and Ana Carnaval[1,3,4]

NASA products

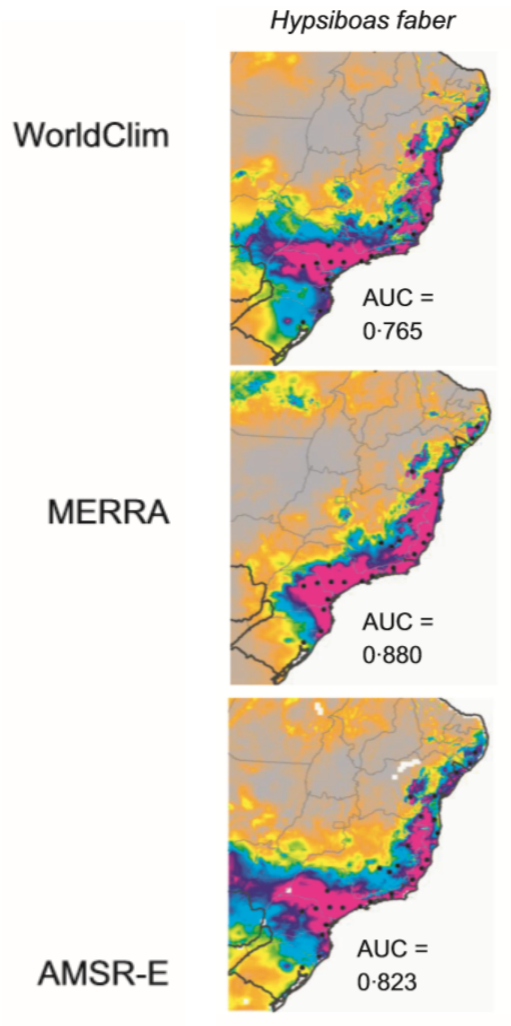
- the Modern-Era Retrospective Analysis (MERRA), which incorporates remote sensing information and a subset of the station-based data
- pure remote sensing information (Advanced Microwave Scanning Radiometer-Earth Observations, AMSR-E).

Coarse spatial resolution (MERRA 55 x 75 km. AMSR-E 25 km), high temporal frequency of data collection (near-daily at low latitudes).

Improving characterization of present-day environments for use in correlative modeling

- Species Distribution Models derived from <u>MERRA-derived layers performed better</u> than models built with WorldClim data.

- Models constructed with <u>AMSR-E-based layers had similar performance</u> to models built with WorldClim.

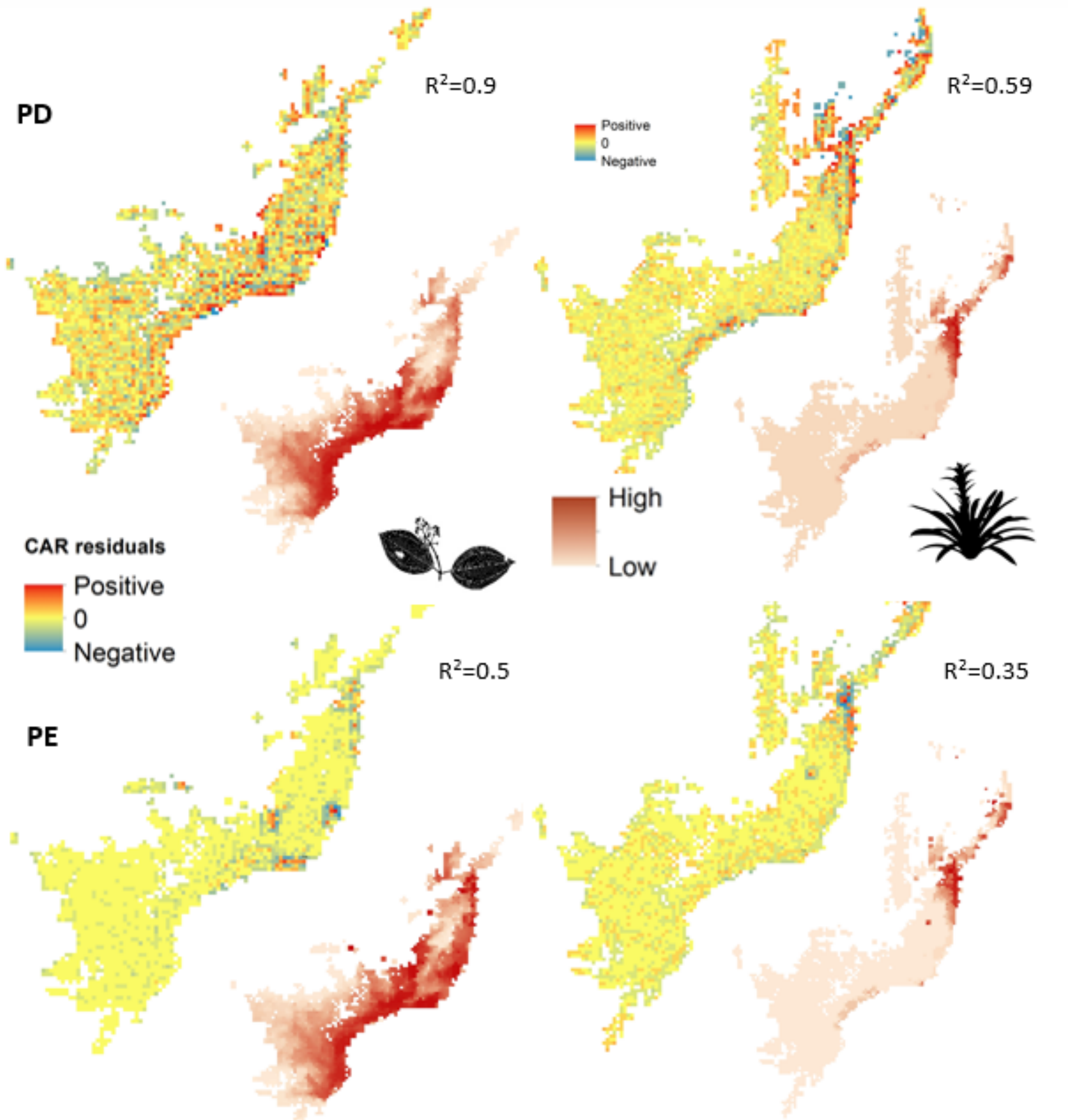


Improving characterization of present-day environments for biodiversity modeling

Conditional autoregressive (CAR) model analysis: using bioclimatic variables (from WorldClim vs. MODIS/ CHIRPS*) as predictors of PD and PE.

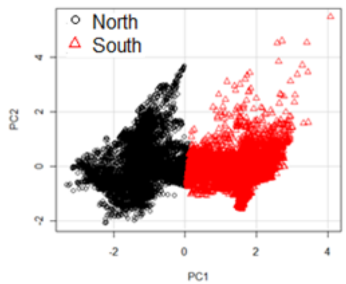
Response variable	**AIC** **(CAR with MODIS/CHIRPS vs. CAR with Worldclim)**
Bromeliads PD	61.79
Bromeliads PE	**-42.52**
Melastomataceae PD	**-103.75**
Melastomataceae PE	**-39.88**

*Deblawe et al. 2016. Glob Change Biol

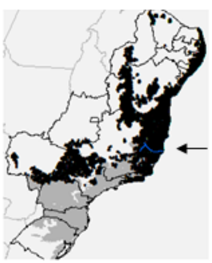


We are studying the physiological limits of AF species to understand the MECHANISMS that underscore the distribution of diversity

CLIMATIC ANALYSIS OF THE FOREST (HABITAT)

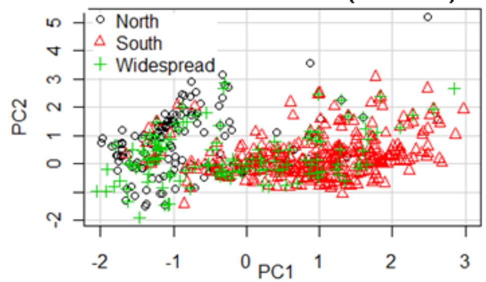


DISTRIBUTION OF NORTHERN FOREST CLIMATIC SPACES

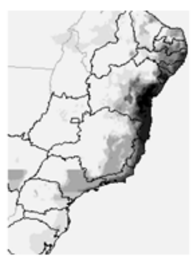


DISTRIBUTION OF SOUTHERN FOREST CLIMATIC SPACES

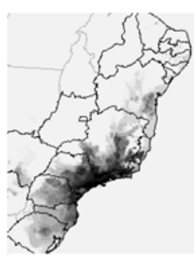
CLIMATIC ANALYSIS OF FOREST VERTEBRATES (SPECIES)

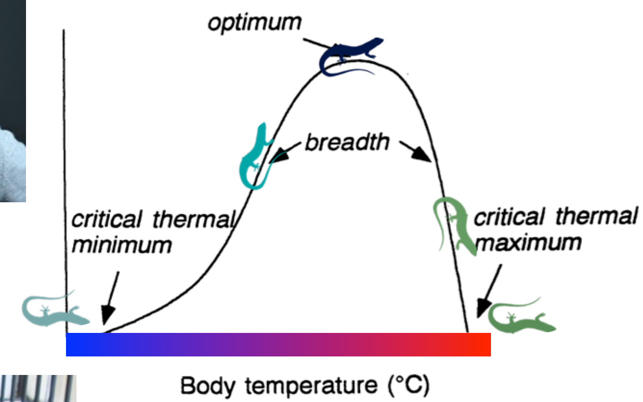


RANGES OF NORTHERN SPECIES



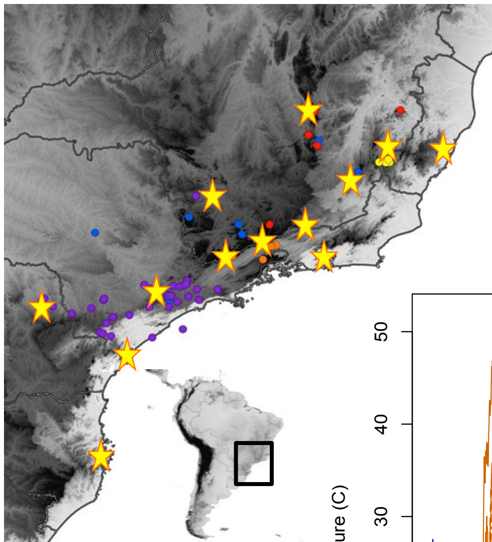
RANGES OF SOUTHERN SPECIES

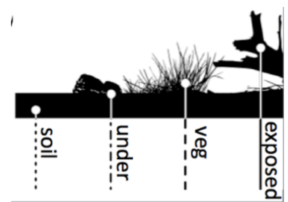


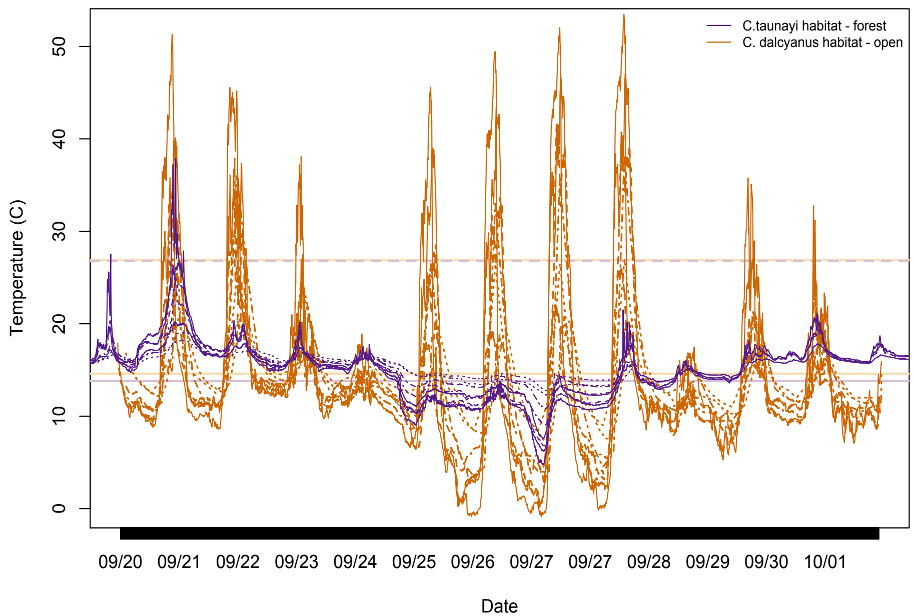


Improving characterization of present-day environments for biodiversity modeling

Characterizing microclimates with hygrobuttons







Precise measurements, limited coverage

Improving characterization of present-day environments for biodiversity modeling

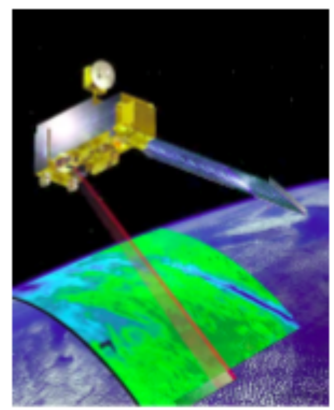
Ibutton day
& ibutton night
(8-day and monthly)

Why ibutton?

Represents environment at the scale of the organisms

MODIS day
& MODIS night
(8-day and monthly)

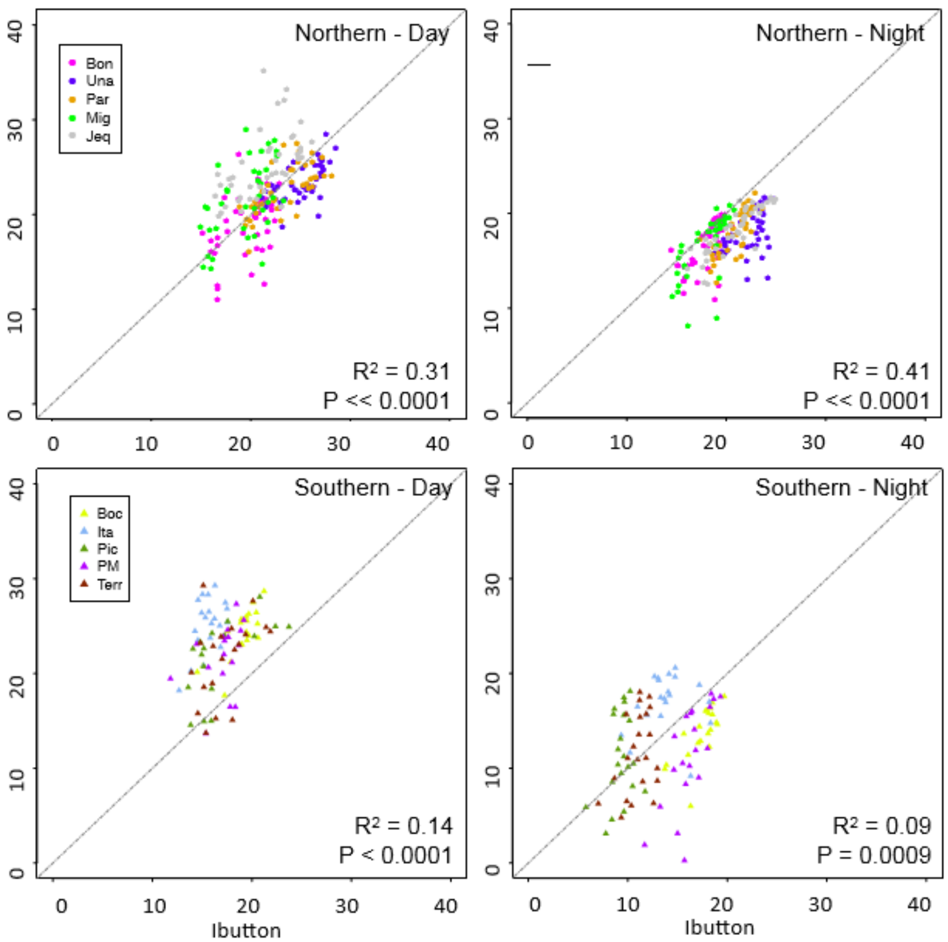
Why remote sensing and MODIS?

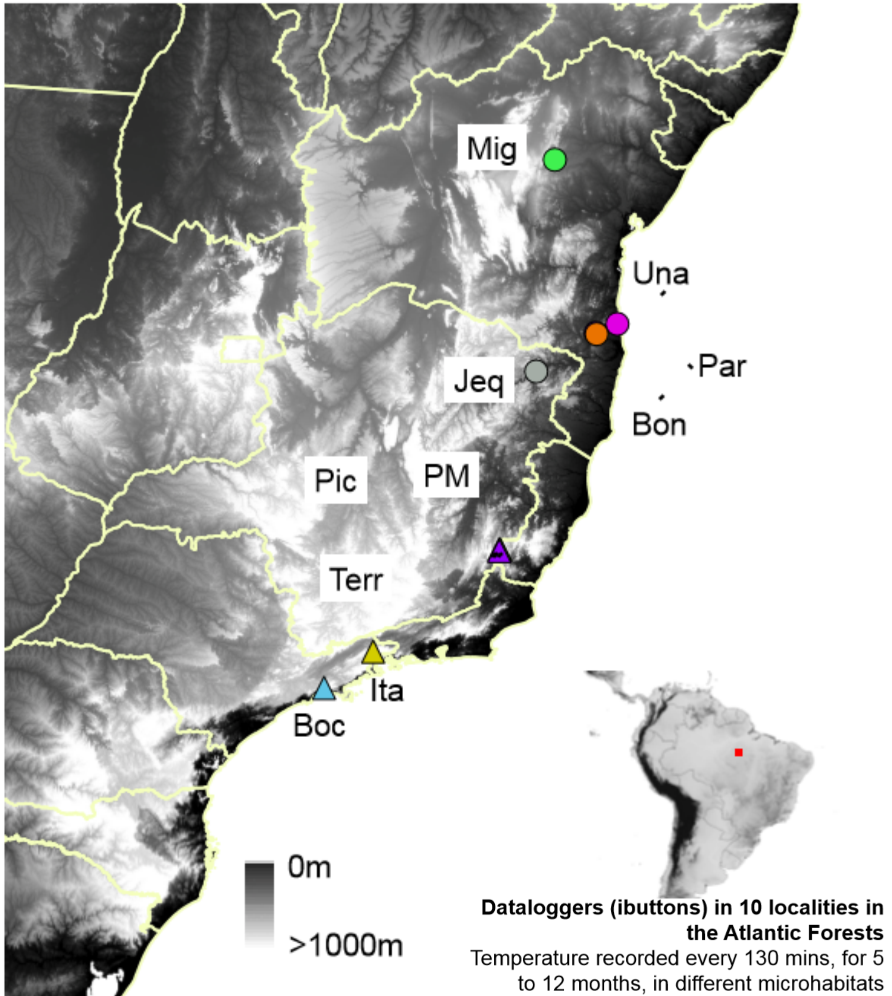


Broad and even coverage with high spatial resolution

Microclimate (ibutton) vs. MODIS (8-day comparison)

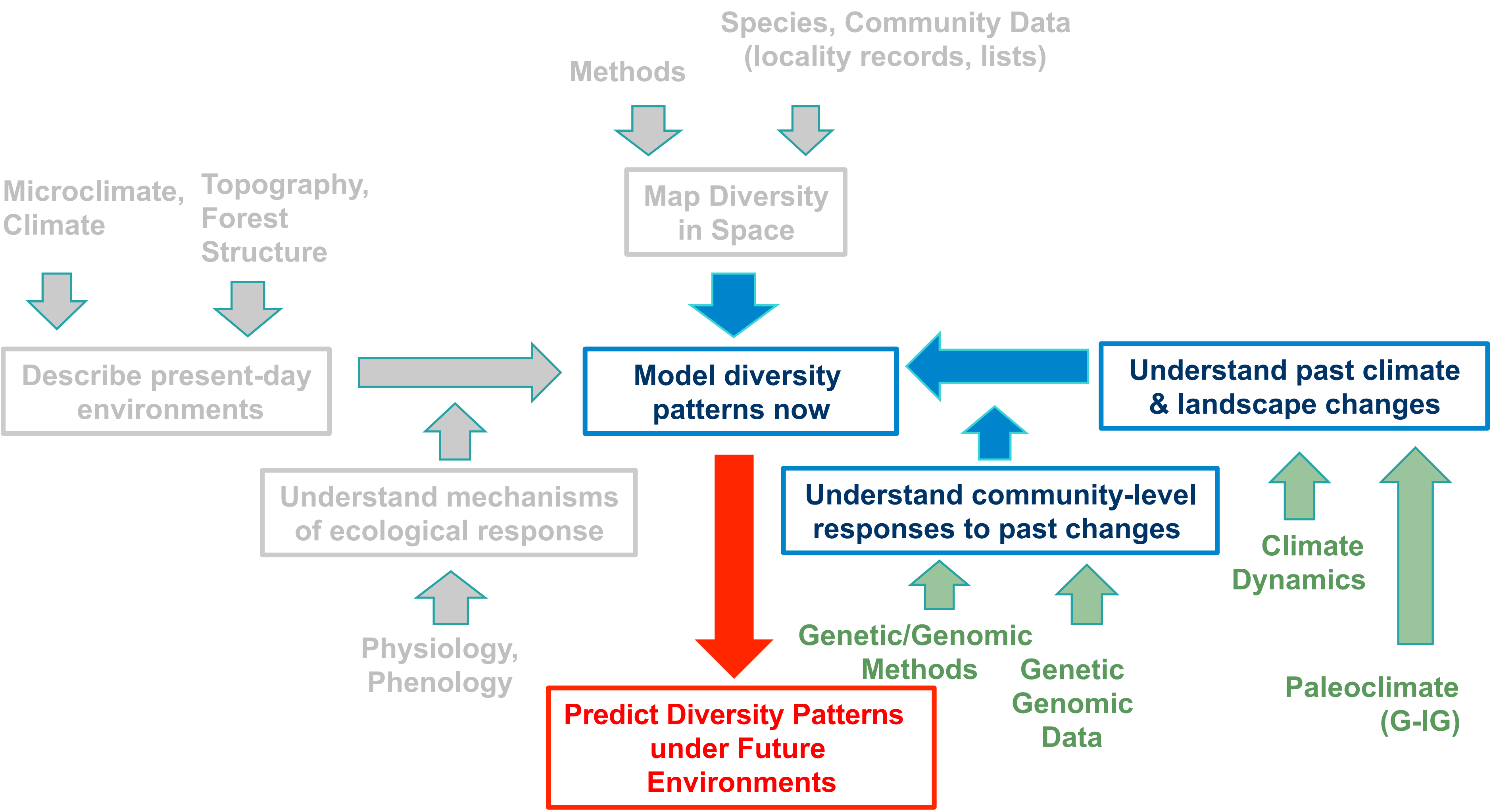
Stronger correlations in North (effect of S topography)
MODIS: higher diurnal temperatures, lower nocturnal temperatures (buffering effect of vegetation)
MODIS 8-day composite seem to perform reasonably well in cloud-covered areas





Dataloggers (ibuttons) in 10 localities in the Atlantic Forests
Temperature recorded every 130 mins, for 5 to 12 months, in different microhabitats

Our DoB project implements an integrative framework to improve biodiversity prediction in the Atlantic Forest hotspot

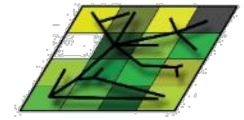


A framework with two phases

- Phase 1: Learning from the past

Use empirical genetic data and SDMs under paleoclimate to estimate demographic parameters

Current



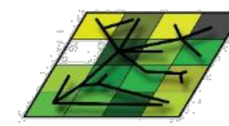
120,000 **60,000** **21,000**

YEARS BEFORE PRESENT

- Phase 2: Using inferred parameters to infer plausible distribution of diversity in the future

Estimate genetic composition of landscape: Past to Present and Future

2080

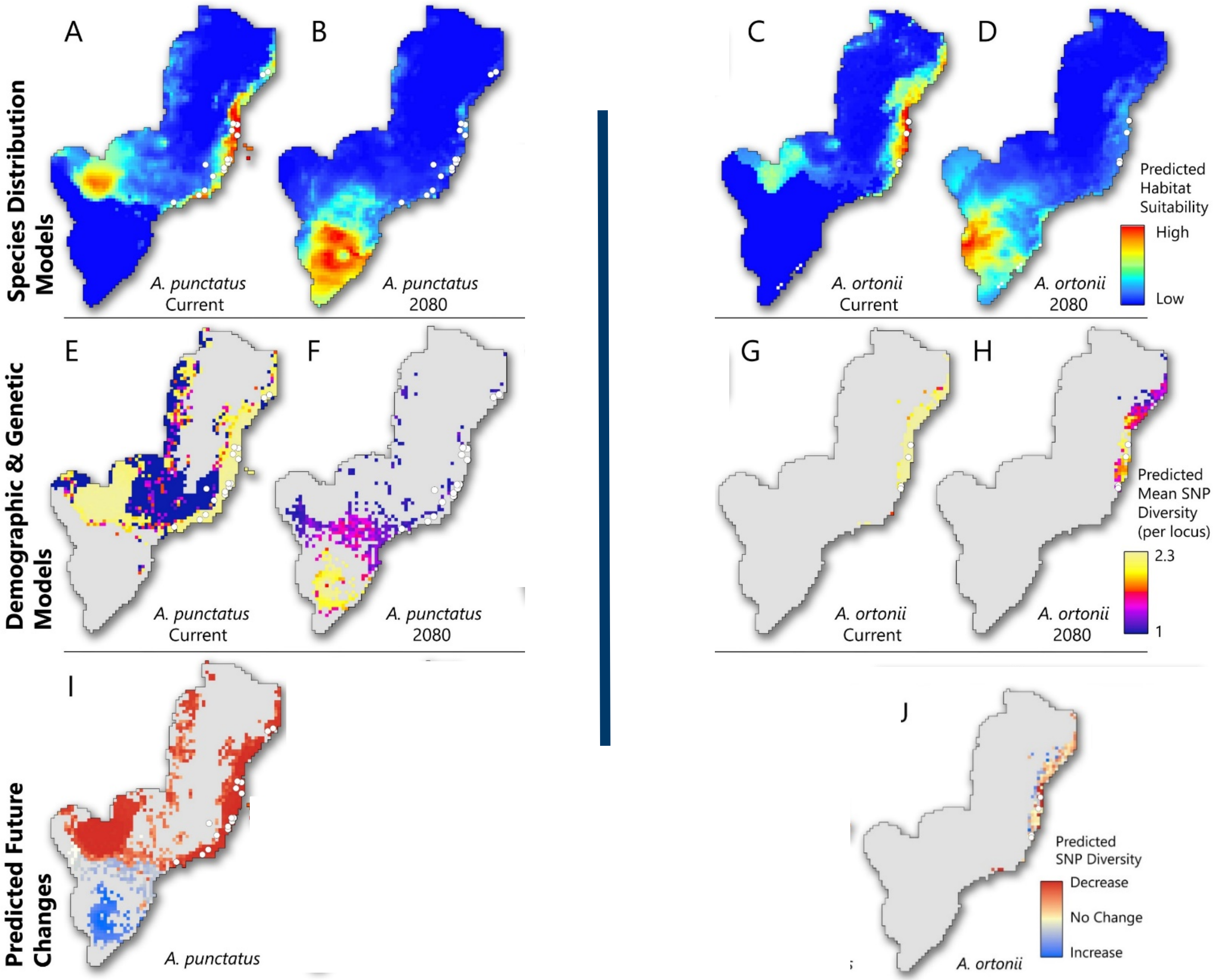


120,000 **60,000** **21,000** **Current**

Spatially explicit genetic effects of climate change

Brown et al. 2016. Am. J. Botany,
Prates et al. accepted, PNAS

Plausible scenarios of the spatial distribution of genetic diversity of two anole species differ extensively



Aims for years 3+

- Continue to explore MODIS, AMSR-E, improve environmental characterization

- Develop models to describe microclimatic conditions, link with physiological data
- Link predictions of changes in diversity with near-real time monitoring of the forest

New Bioclims - MERRA

- Used time-averaged hourly MERRA single-level temperature at 2 m above the displacement height.
- Created monthly maximum and minimum temperatures, which we converted to four bioclimatic temperature fields matching those available through WorldClim.
- Reanalysis of temperature provided at the native spatial resolution of MERRA. Using ancillary information on elevation and geopotential height from the Global Land One-km Base Elevation Project (GLOBE) and MERRA, the native resolution temperature fields from MERRA were downscaled to match the 1km spatial resolution of GLOBE using cubic convolution interpolation
- Used MERRA data from its inception in 1979 to 2000 to focus on the overlap with the existing WorldClim data set, which employed weather station data primarily from 1960 to 2000.

New Bioclims – AMSR-E

- Near-daily temperature minima and maxima obtained by inversion of a simplified semi-physical radiometric model that uses morning and evening brightness temperature observations. The temperature dataset provides global temperature retrievals over land for snow and ice-free non-frozen conditions for periods of no precipitation.
- Descending (morning) and ascending (evening) orbital nodes from AMSR-E's temperature retrieval provide respective minima and maxima for temperature at approximately 2 m height (Jones et al. 2010).
- We used the temperature observation from the morning and evening satellite overpasses, converted these temperatures to average monthly values, and then derived the four bioclimatic temperature fields.
- The grid resolution of the AMSR-E temperature fields is approximately 25 km; we downscaled the fields to 1 Km using cubic convolution interpolation. Downscaling followed that of the MERRA data set, except that the geopotential height was replaced by the 25-km EASE grid GLOBE DEM.
- Data generated from the 2003–2010 AMSR-E observation period.

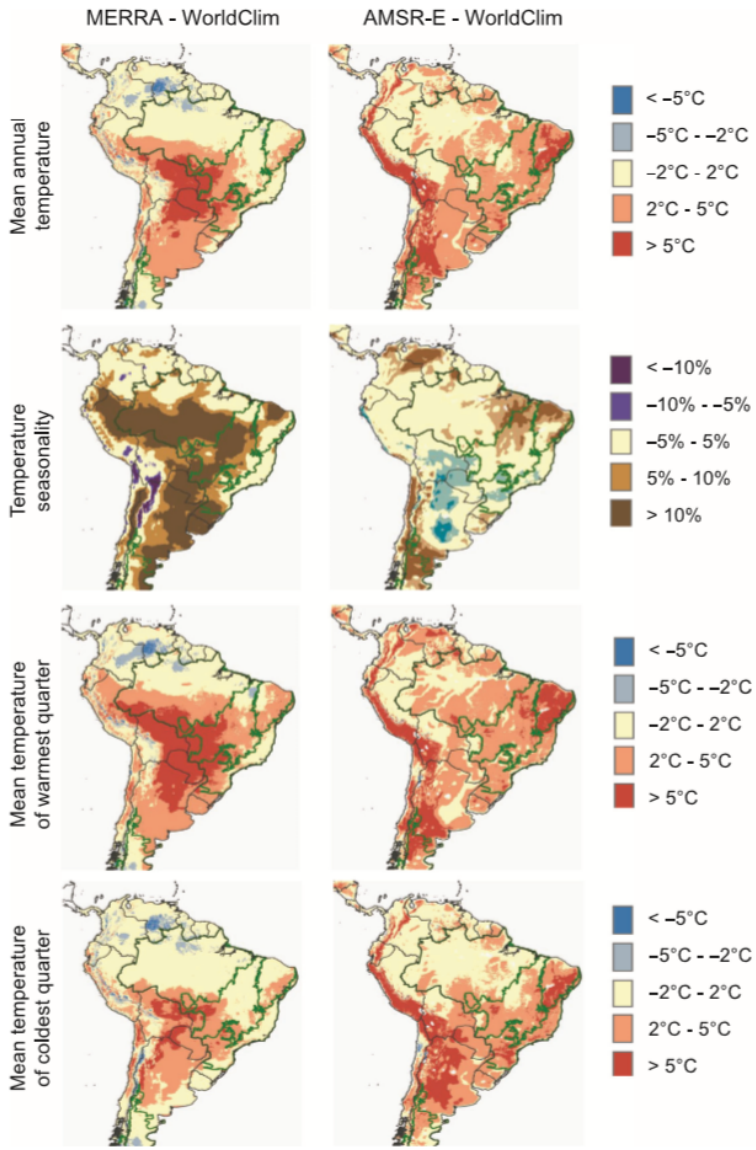


Fig. 3. Differences across values of bioclimatic variables for temperature estimated from MERRA and AMSR-E data sets relative to WorldClim values. Left: difference between MERRA-derived and WorldClim values; right: difference between AMSR-E-derived and WorldClim values. Four bioclimatic variables are illustrated: Bioclim 1 (mean annual temperature), Bioclim 4 (temperature seasonality), Bioclim 10 (mean temperature of warmest quarter) and Bioclim 11 (mean temperature of coldest quarter; Hijmans *et al.* 2005). Values for Bioclim 1, 10 and 11 are given in degrees Celsius, whereas Bioclim 4 values are percentages.

Exploring new ways to improve characterization of present-day environments

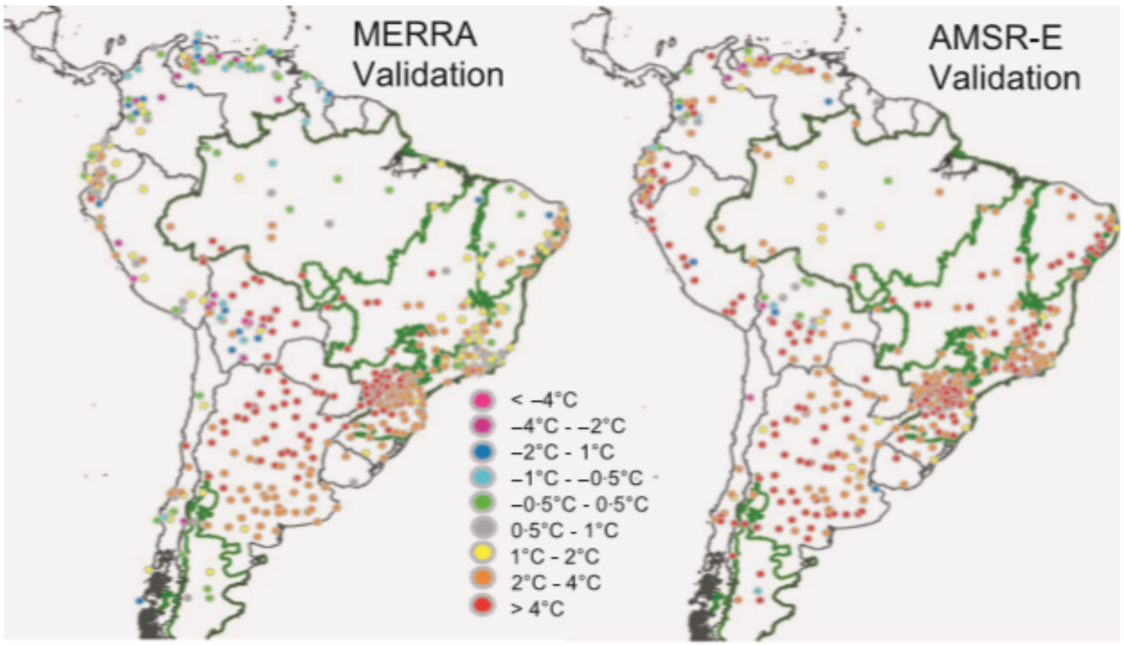


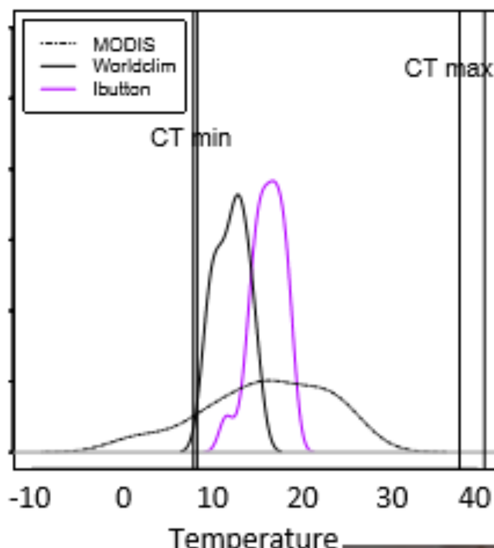
Fig. 2. Ground-validation of MERRA and AMSR-E data relative to mean ground temperatures recorded at 1006 weather stations (years 1950–2000) by the Global Historical Climatology Network and the World Meteorological Organization. Each dot represents a weather station; colours in a) and b) depict the net difference between respective MERRA and AMSR-E estimated temperatures and recorded ground temperature and those in c) indicate the difference in mean temperature recorded at surface weather stations between the more heavily sampled 1950–2000 period and the 2003–2008 period. Green boundaries outline the South American regions examined in the study.

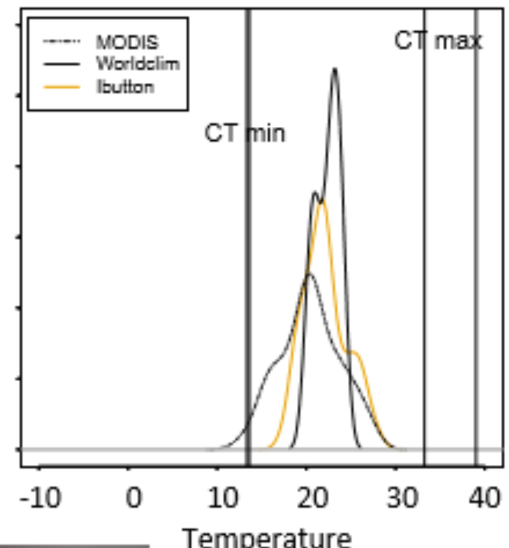
Surface temperature estimates showed warm temperature biases relative to in situ data fields; reliability of these datasets varied in space.

Waltari et al. 2014.
Methods in Ecol. & Evol.

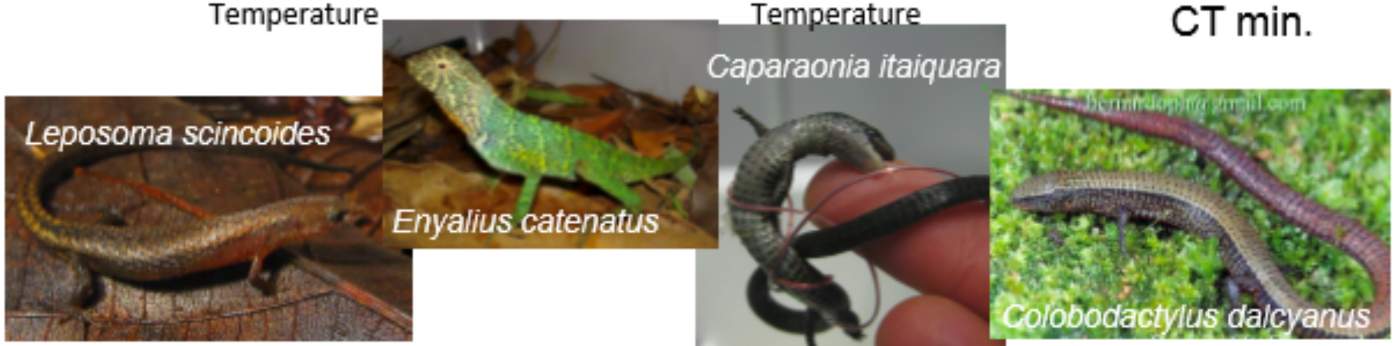
Validating environmental temperatures with thermal physiology

MODIS LSTs fall outside CT's more often than Worldclim and ibutton temperatures, especially in the topographically complex southern AF.

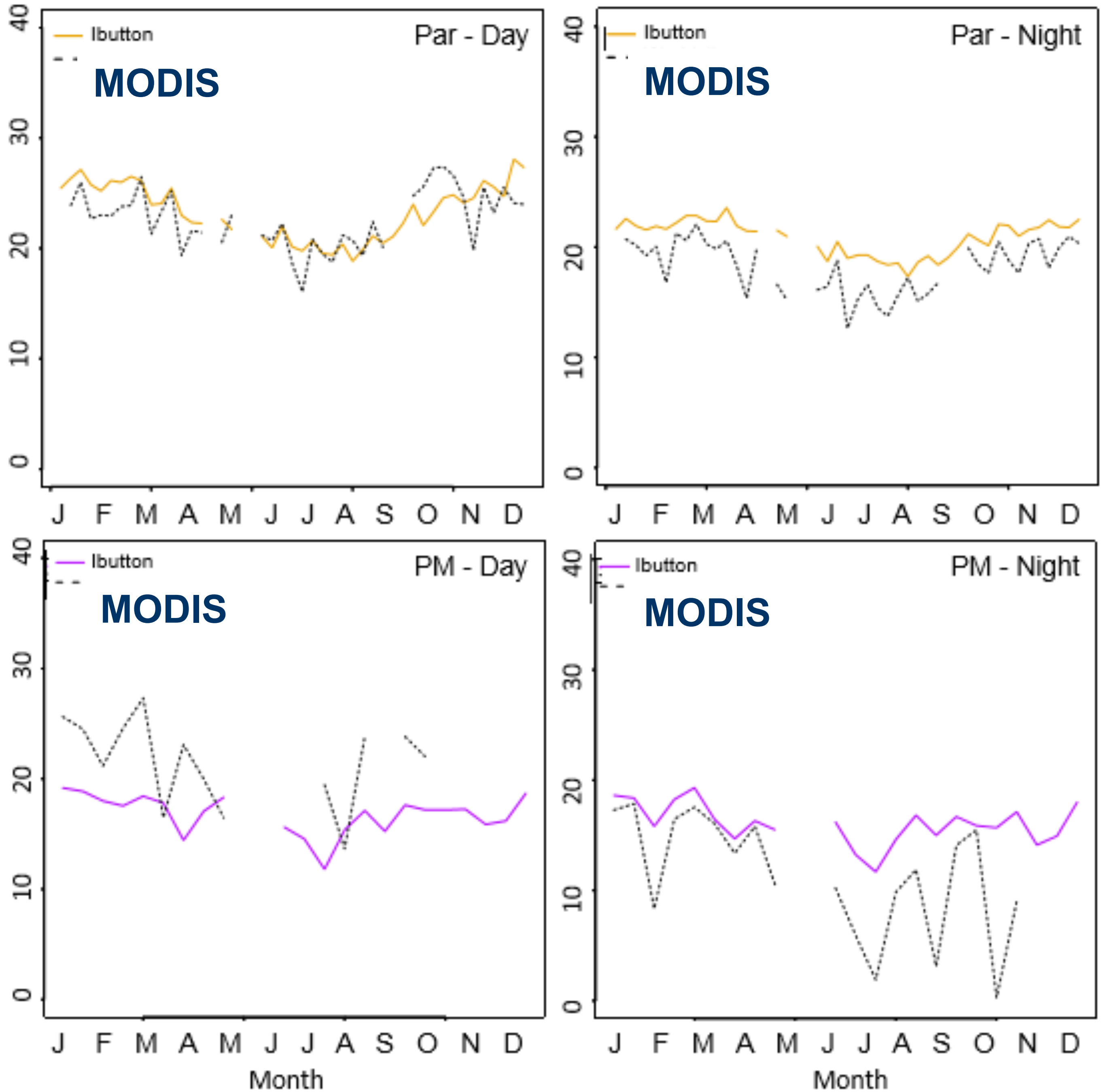




Critical temperatures (CT min and CT max) represent tolerance limits, with CT max potentially being a harder boundary than CT min.



CT min and max were estimated experimentally in 5 species of lizards, by heating up or cooling down lizards until they lose coordination.


Ibutton
MODIS
Par - Day
Par - Night
PM - Day
PM - Night
0
10
20
30
40
J F M A M J J A S O N D
Month