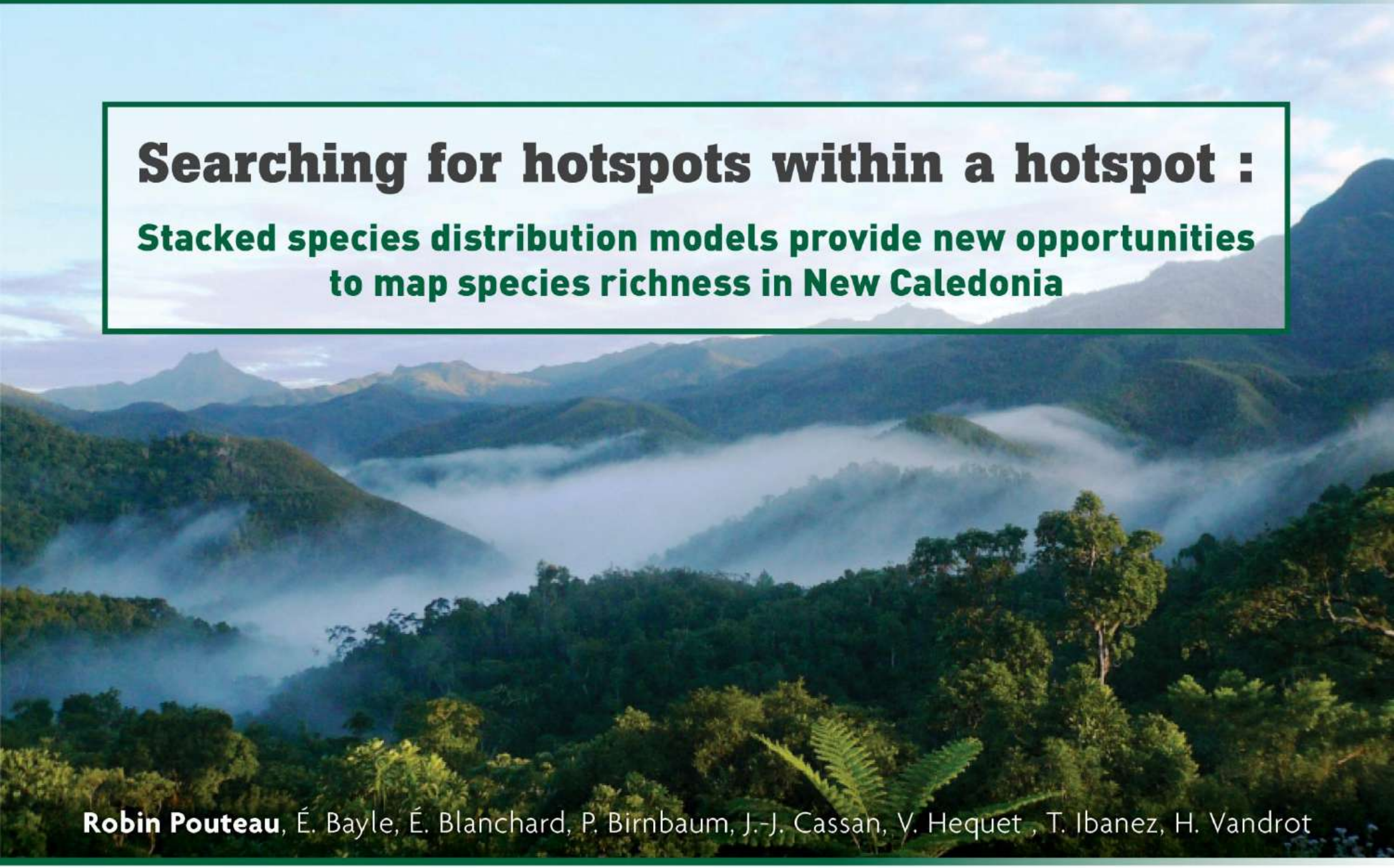


Searching for hotspots within a hotspot :

Stacked species distribution models provide new opportunities to map species richness in New Caledonia

Robin Pouteau, É. Bayle, É. Blanchard, P. Birnbaum, J.-J. Cassan, V. Hequet , T. Ibanez, H. Vandrot

ICCB ECCB 2015
MONTPELLIER (FRANCE)

IAC
Institut Agronomique
néo-Calédonien

IRD
Institut de recherche
pour le développement

cirad
LA RECHERCHE AGRONOMIQUE
POUR LE DÉVELOPPEMENT

AMAP

Introduction

THE NEED FOR FINE-SCALE BIODIVERSITY MAPS

Biodiversity hotspots for conservation priorities

Norman Myers*, Russell A. Mittermeier†, Cristina G. Mittermeier†, Gustavo A. B. da Fonseca‡ & Jennifer Kent§

Biodiversity hotspots: reservoirs of biodiversity under threat from humans

Contents lists available at ScienceDirect
Biological Conservation
journal homepage: www.elsevier.com/locate/biocon

Hotspots within hotspots: Endemic plant richness, environmental drivers, and implications for conservation

Eva M. Cañadas[a,b,*], Giuseppe Fenu[a], Julio Peñas[b], Juan Lorite[b], Efisio Mattana[a,c], Gianluigi Bacchetta[a]

Conservation of an entire biome is impossible, and strategies must focus on small areas that represent a maximum of the biome's diversity and endemism

Conservation Biology
Contributed Paper

Plant Diversity Hotspots in the Atlantic Coastal Forests of Brazil

CHARLOTTE MURRAY-SMITH,*‡ NEIL A. BRUMMITT,* ARY T. OLIVEIRA-FILHO,† STEVEN BACHMAN,* JUSTIN MOAT,* EIMEAR M. NIC LUGHADHA,* AND EVE J. LUCAS*§

Smaller local hotspots must be

Introduction

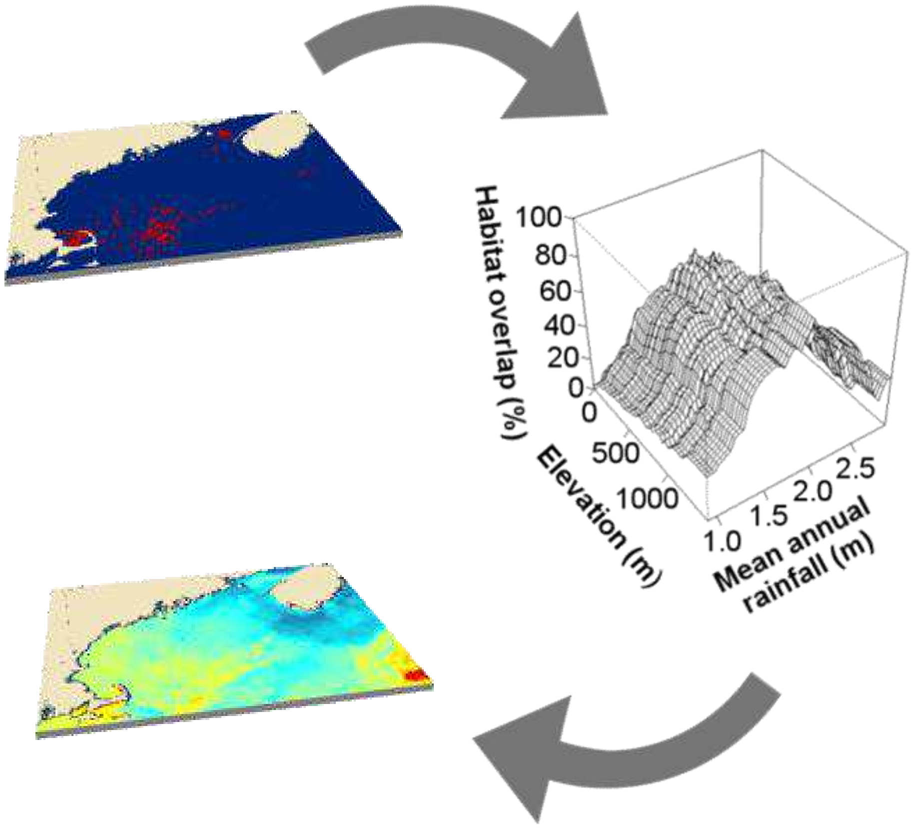
HOW TO MAP BIODIVERSITY?

- **Macroecological mode**

  Himalayas
  Bhattarai & Vetaas (2003)

  Mesoamerica
  Sanchez-Gonzalez & Lopez-Mat

  New Zealand
  Tomasetto *et al.* (2013)

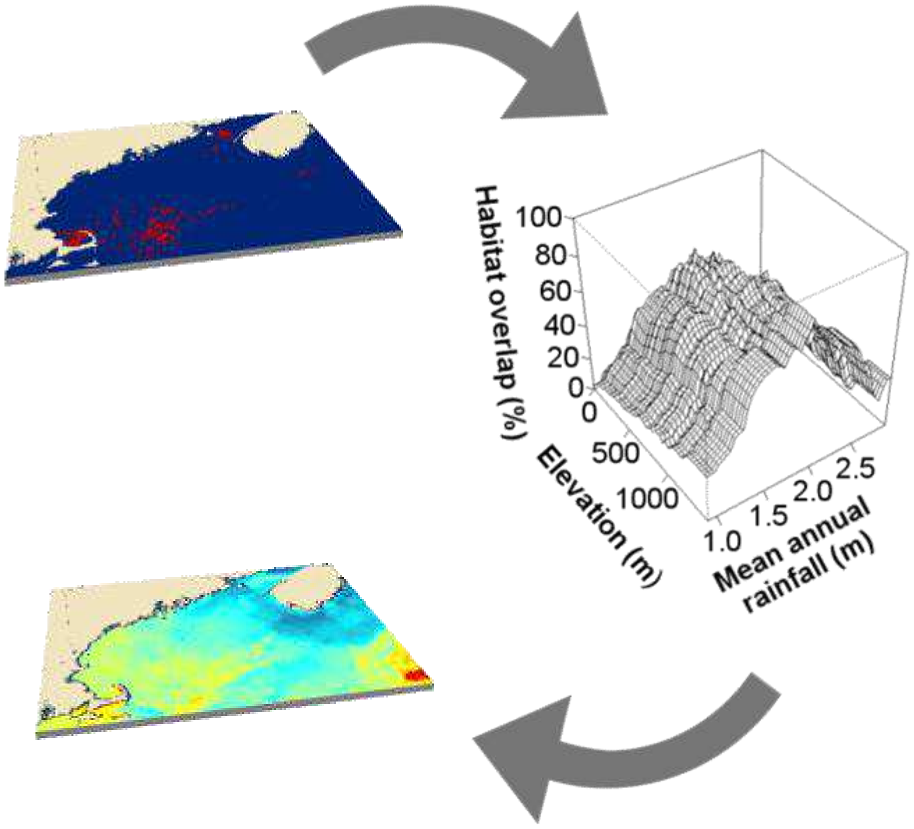


Introduction

HOW TO MAP BIODIVERSITY?

- **Macroecological mode**

→ Time- and cost-demar



Introduction

HOW TO MAP BIODIVERSITY?

- **Macroecological models?**

→ Time- and cost-demanding

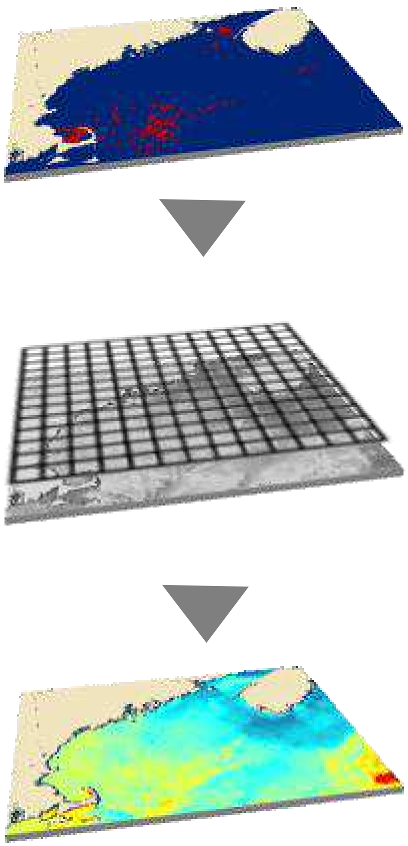
- **Point-to-grid maps?**

Guinean Forests of West Africa
Droissart *et al*. (2006)

New Caledonia
Wulff *et al*. (2012)

Indo-Burma
Tovaranonte *et al*. (2014)

Mediterranean Basin
Cañadas *et al*. (2014)



Introduction

HOW TO MAP BIODIVERSITY?

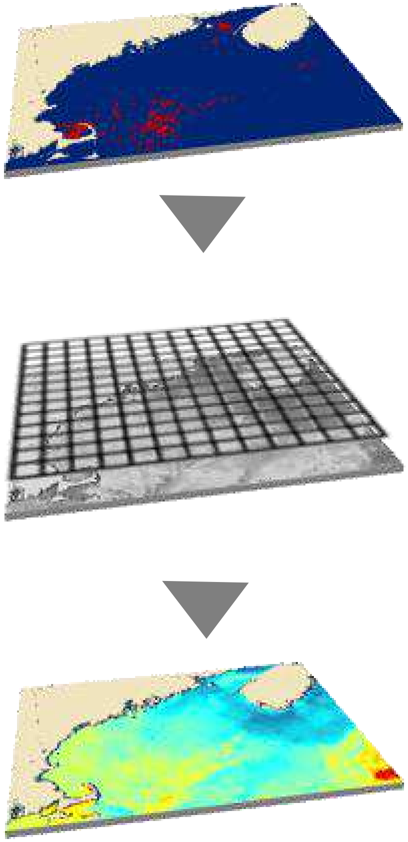
- **Macroecological models?**

→ Time- and cost-demanding

- **Point-to-grid maps?**

→ Not accurate at fine scale

Graham & Hijmans (2006)



Introduction

HOW TO MAP BIODIVERSITY?

- **Macroecological models?**

→ Time- and cost-demanding

- **Point-to-grid maps?**

→ Not accurate at fine scale

Graham & Hijmans (2006)

- **Stacked species distribution models?**

Sundaland **(Raes *et al*. 2009)**

Atlantic Forest **(Murray-Smith *et al*. 2009)**

Tumbes-Choco-Magdalena **(Mateo *et al*. 2013)**

Introduction

HOW TO MAP BIODIVERSITY?

- **Macroecological models?**

→ Time- and cost-demanding

- **Point-to-grid maps?**

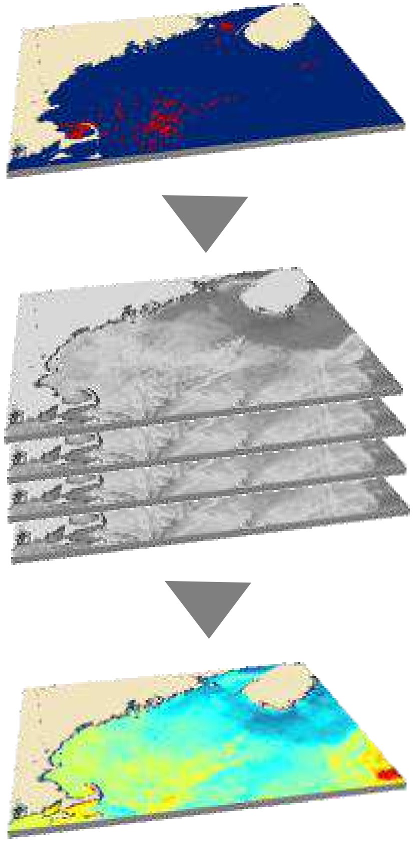
→ Not accurate at fine scale

Graham & Hijmans (2006)

- **Stacked species distribution models?**

→ Time- and cost-effective

→ Accurate at fine scale



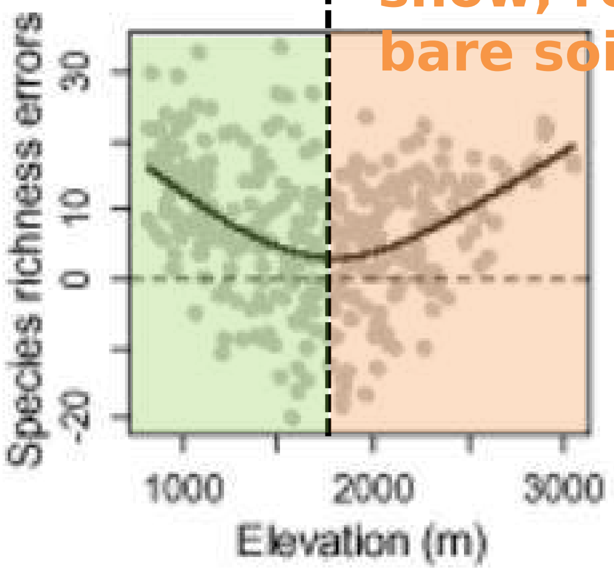
Introduction

S-SDM ACCURACY ASSESSMENT

3 studies have used comprehensive plot inventories to assess S-SDMs **Guisan *et al*. (1999); Dubuis *et al*. (2012); Pottier *et al*. (2013)**

Increasing environmental filtering

Unpredictable extrem environments: snow, rocky and bare soil?



Introduction

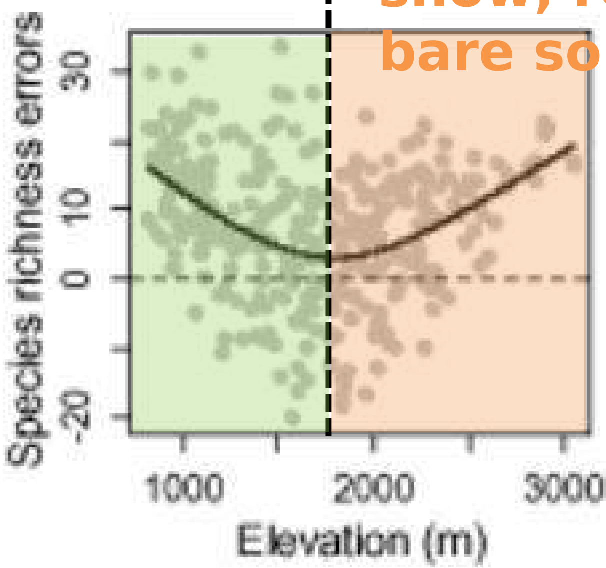
S-SDM ACCURACY ASSESSMENT

3 studies have used comprehensive plot inventories to assess S-SDMs **Guisan *et al*. (1999); Dubuis *et al*. (2012); Pottier *et al*. (2013)**

Increasing environmental filtering

Unpredictable extrem environments: snow, rocky and bare soil?

We need a study in a non-glacial and fully vegetated area such as in the

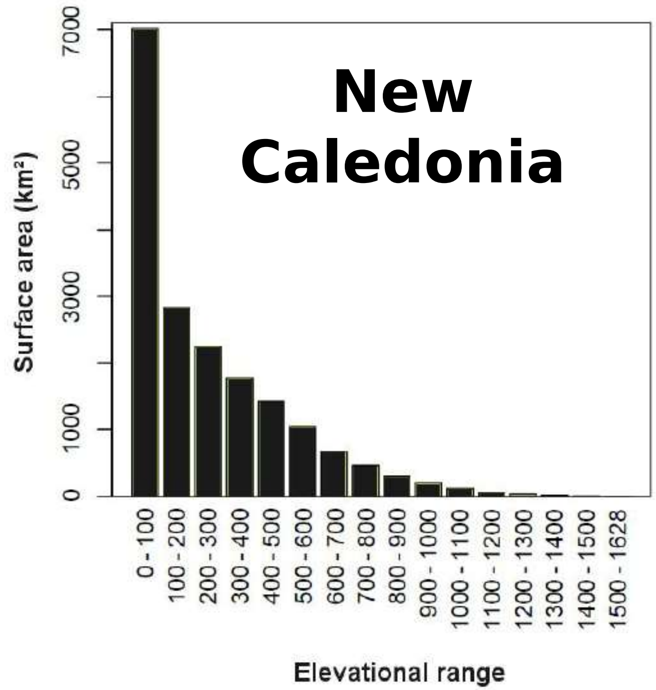


Alpine grassland and tundra

Tropical montane cloud forest

Introduction

THE INDIRECT AREA EFFECT ON S-SDM ACCURACY



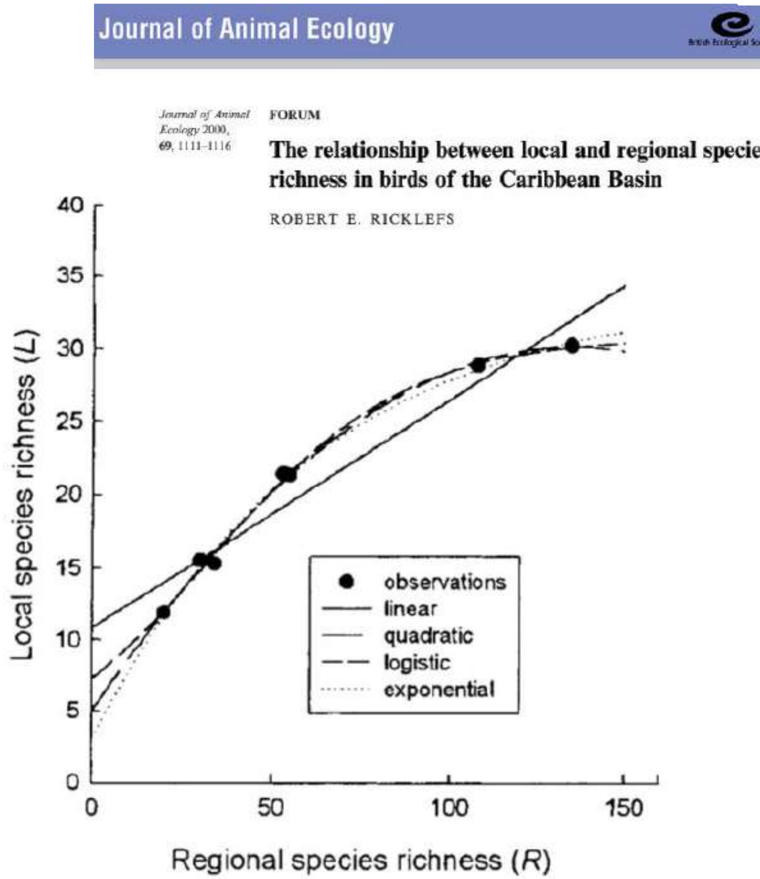
$S = c\,A^z$ Arrhenius (1921)

***S*: # species; *c*: # species per square unit; *A*: regional area; *z*: constant**

The conical shape of mountains decreases the regional species richness

Introduction

THE INDIRECT AREA EFFECT ON S-SDM ACCURACY



The regional species richness is correlated to the local species richness

Introduction

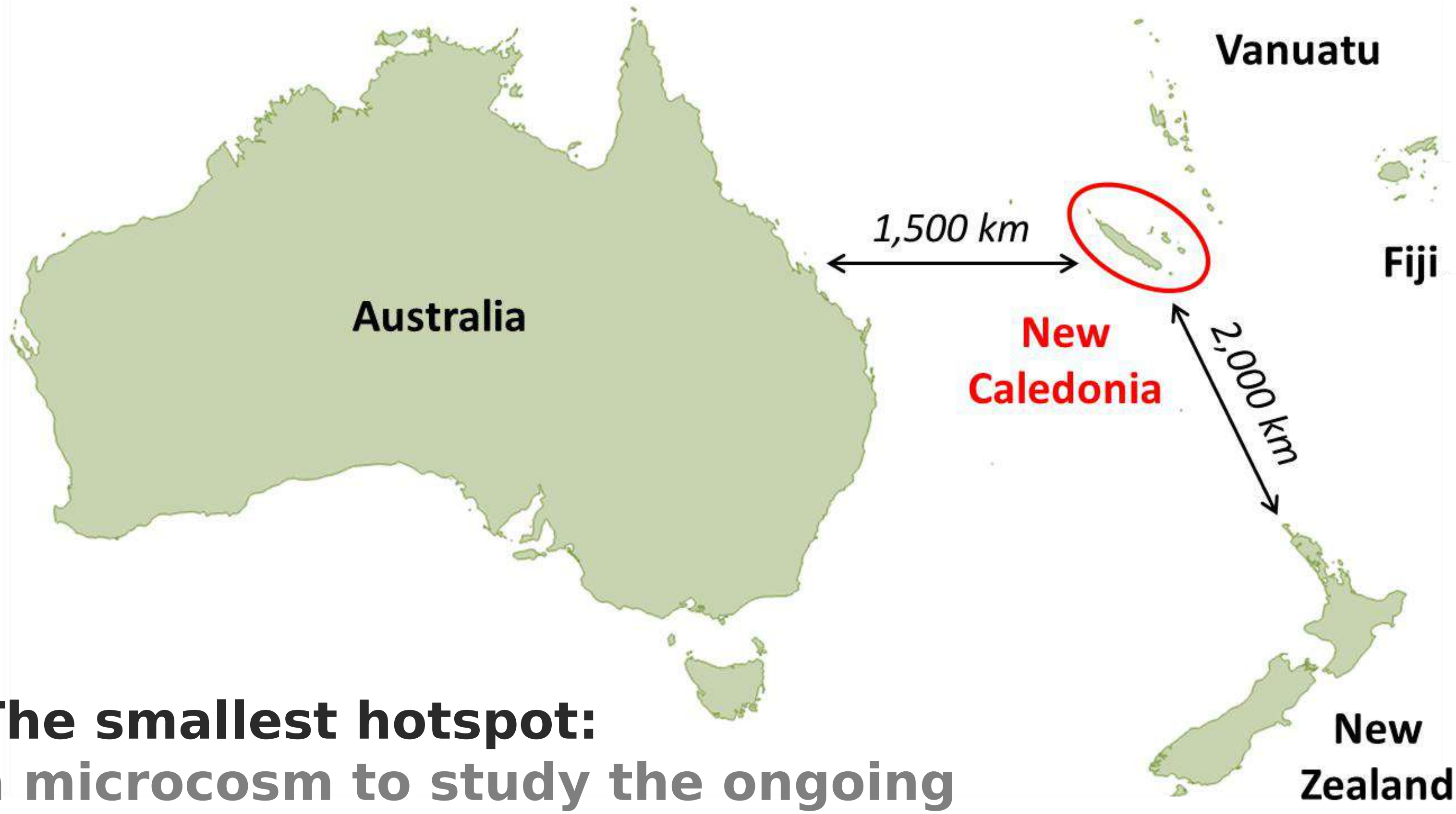
AIM

- **Are S-SDMs able to map local species richness in a biodiversity hotspot?**
- **How does S-SDM accuracy vary along an environmental gradient in tropical mountains?**
- **And why?**

1) **Increasingly unpredictible environment?**
2) **Indirect area effect?**

Materials and methods

NEW CALEDONIA



- **The smallest hotspot:**
  a microcosm to study the ongoing biodiversity crisis
- **Megadiverse:**
  > 3300 vascular plant species, 75% of endemism

Materials and methods

NEW CALEDONIA

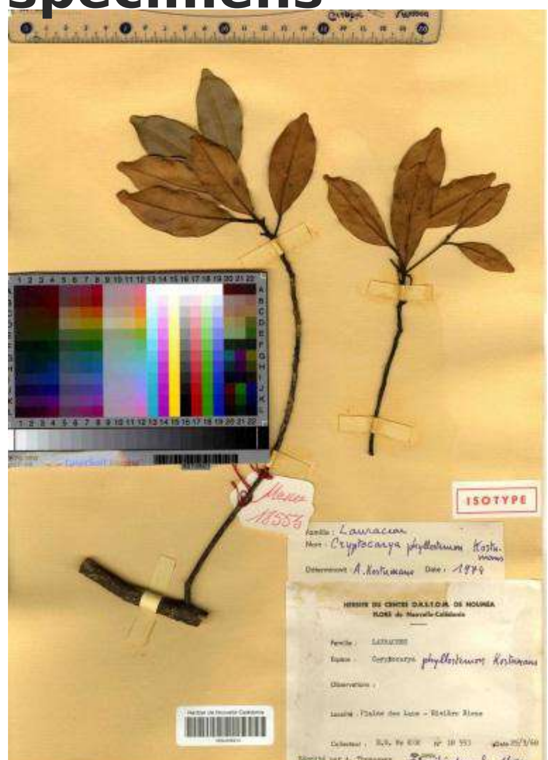
Materials and methods

SPECIES, OCCURRENCE AND BIODIVERSITY DATA

562 tree, tree fern and palm species

At least one individual with a DBH > 10 cm within the NC-PIPPN plot

>10,000 herbarium specimens

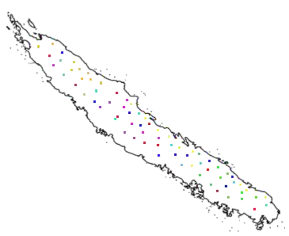


11 independent 1 ha evaluation plots

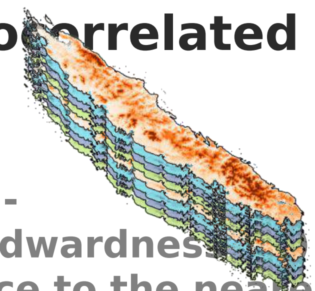
Materials and methods

S-SDM IMPLEMENTATION

562 tree species
>10,000 presences



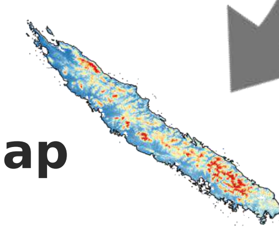
Eight 100 m-resolution non-autocorrelated environmental variables:



- **6 non-categorical**
  Elevation (m) - Slope steepness (°) -
  Potential insolation (kWh.m^{-2}) - Windwardness -
  Topographic wetness index - Distance to the nearest road (km)
- **2 categorical**
  Substrate types - Phytogeographical sectors

562 individual MAXENT models } **562 habitat suitability maps** } **Map summing i.e. no threshold**
(Calabrese *et al.* 2014)

Species richness map



11 independent evaluation plots

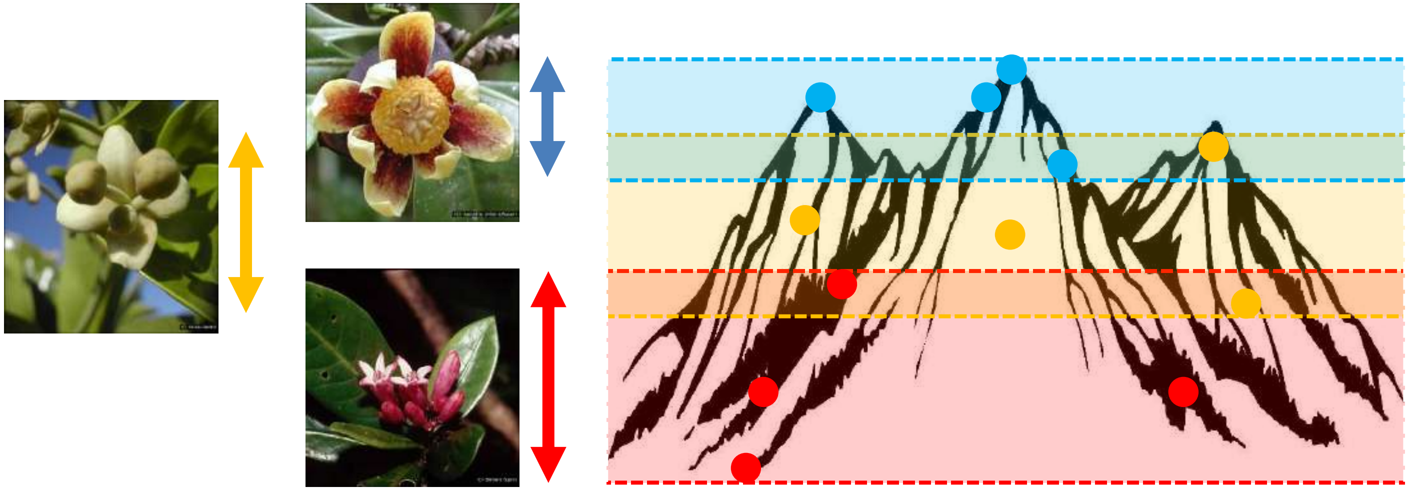
S-SDM accuracy assessment

Materials and methods

ACCOUNTING FOR THE INDIRECT AREA EFFECT

- **Elevation ranges determined by using the minimum and maximum elevations where a species occurs**

Wang *et al.* (2007); McCain & Grytnes (2010); Tang *et al.* (2014)



Materials and methods

ACCOUNTING FOR THE INDIRECT AREA EFFECT

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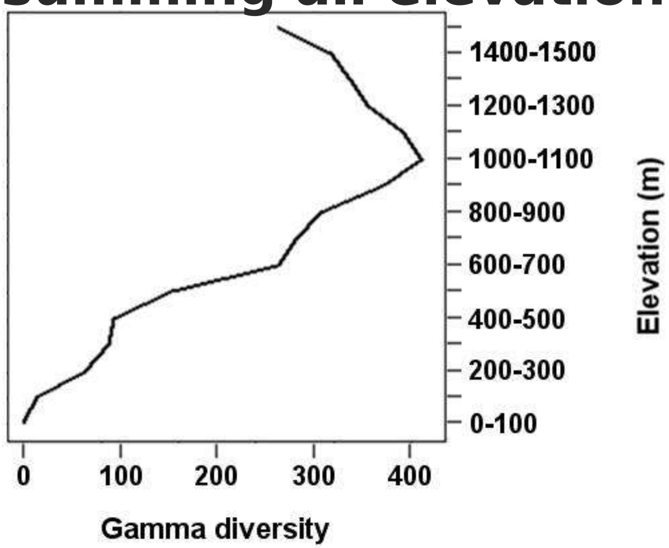
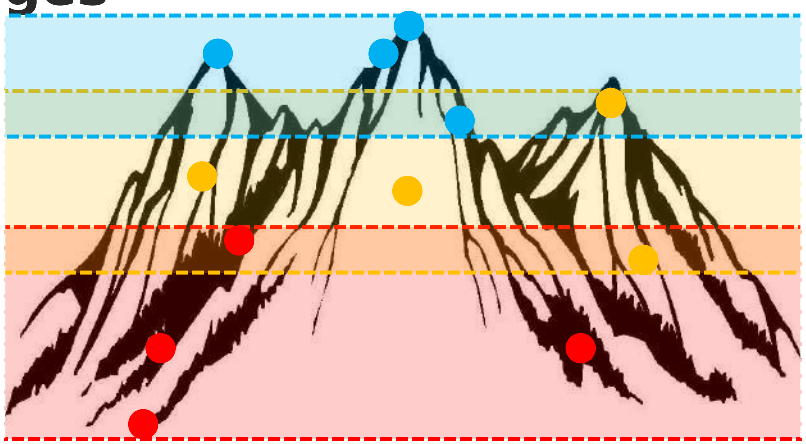
Wang *et al.* (2007); McCain & Grytnes (2010); Tang *et al.* (2014)

- **Species richness estimated by summing all elevation ranges**

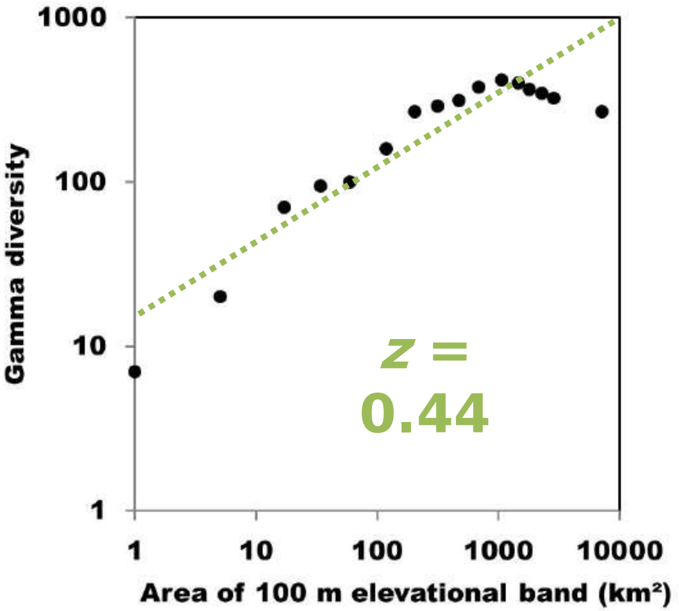




Materials and methods

ACCOUNTING FOR THE INDIRECT AREA EFFECT

- **Elevation ranges determined by using the minimum and maximum elevations where a species occurs** Wang *et al.* (2007); McCain & Grytnes (2010); Tang *et al.* (2014)
- **Species richness estimated by summing all elevation ranges**
- ***z* parameter determined as the slope of the species-area curve on a log-log scale** (McCain 2007)



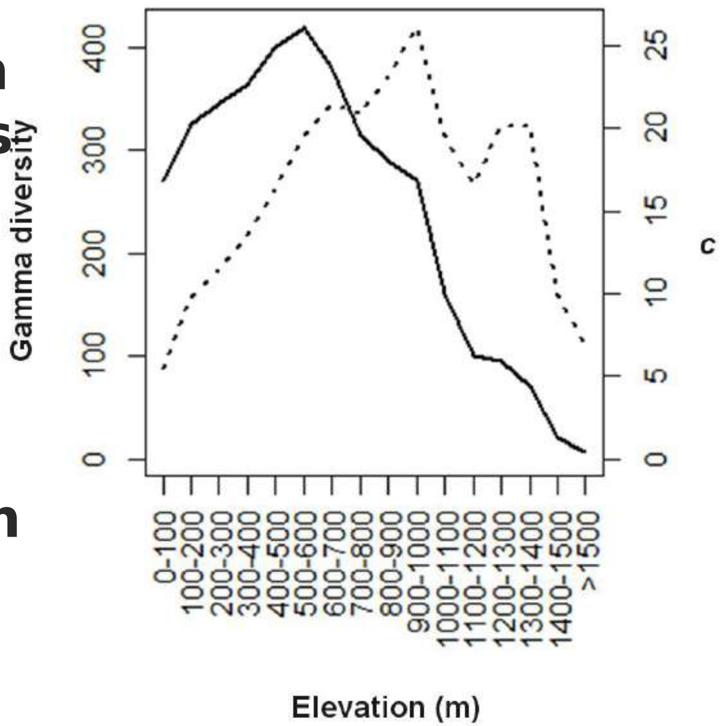
$S = c\,A^{z}$ Arrhenius (1921)

S : # species; *c* : # species per square unit; *A* : regional area; *z* : constant

Materials and methods

ACCOUNTING FOR THE INDIRECT AREA EFFECT

- **Elevation ranges determined by using the minimum and maximum elevations where a species occurs**
  Wang *et al.* (2007); McCain & Grytnes (2010); Tang *et al.* (2014)
- **Species richness estimated by summing all elevation ranges**
- ***z* parameter determined as the slope of the species-area curve on a log-log scale (McCain 2007)**
- **The area-dependent species richness *S* determined by multiplying S-SDM estimates by A^z**

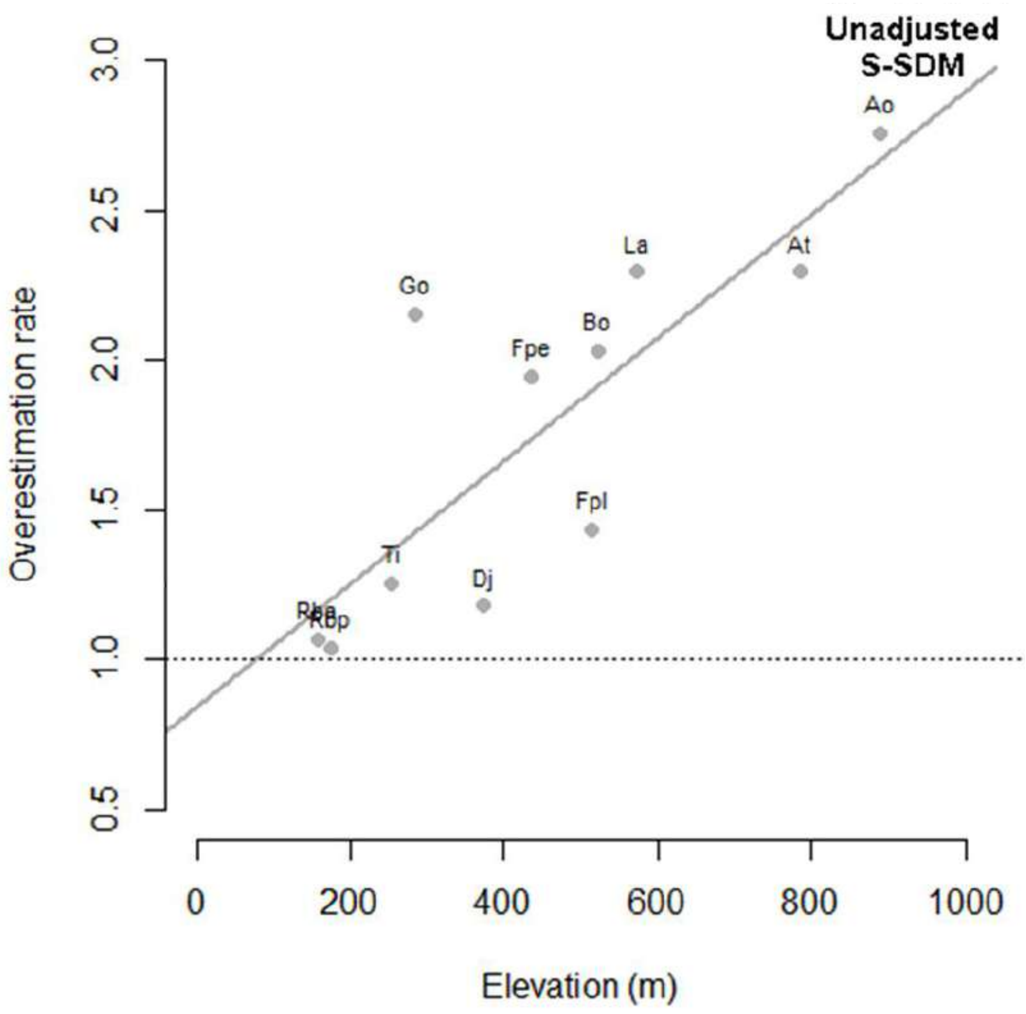


$S = c\,A^z$ **Arrhenius (1921)**

***S*: # species; *c*: # species per square unit; *A*: regional area; *z*: constant**

Results and discussion

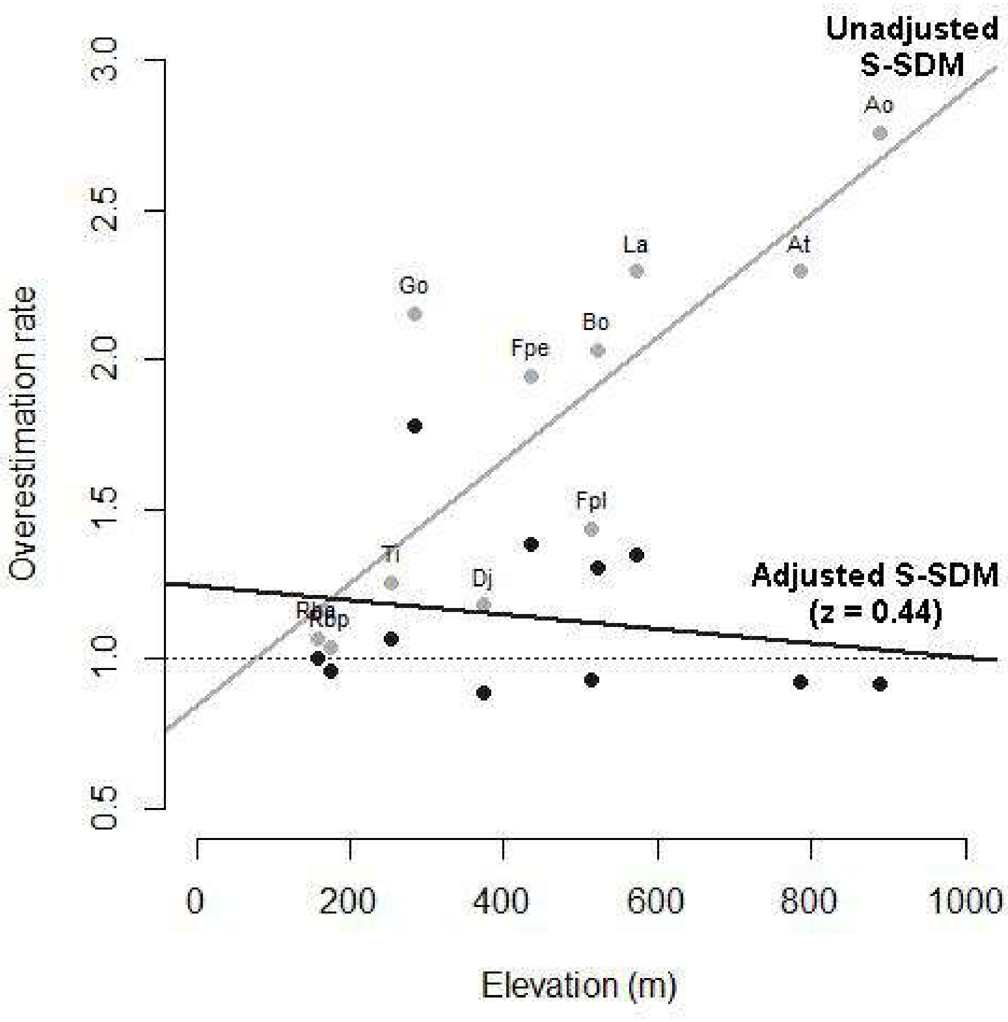
S-SDM ACCURACY DECREASES WITH ELEVATION



- **No correlation between S-SDM overestimation and variables other than elevation** **($r^2 < 0.15$)**
- **Significant correlation between S-SDM overestimation and elevation** **($r^2 = 0.71$*)**

Results and discussion

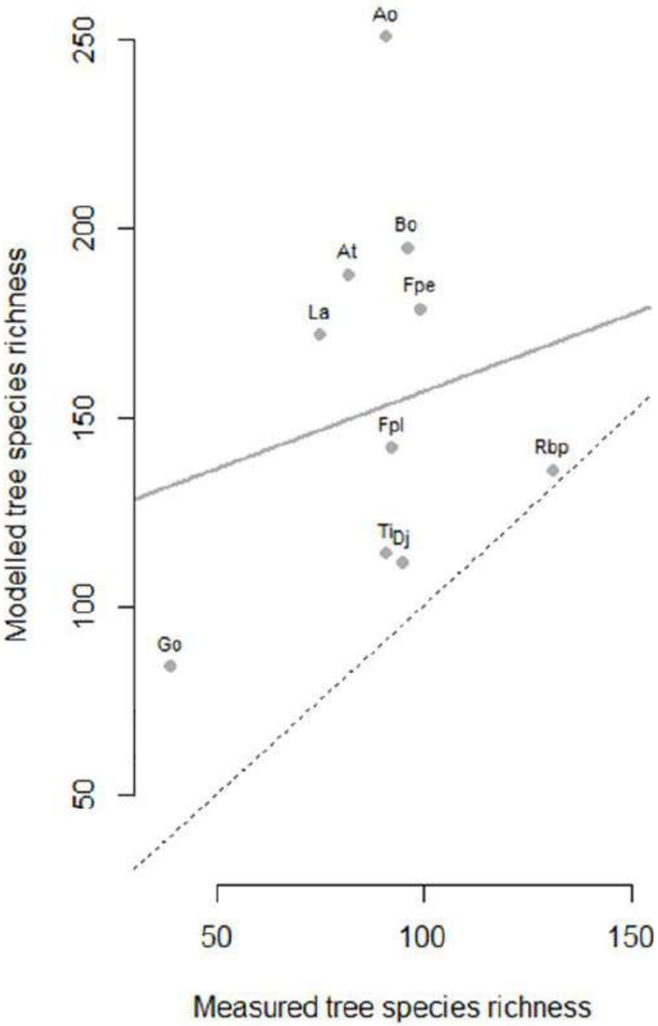
S-SDM ACCURACY DECREASES WITH ELEVATION



- **No correlation between S-SDM overestimation and variables other than elevation** **($r^2 < 0.15$)**
- **Significant correlation between S-SDM overestimation and elevation** **($r^2 = 0.71$*)**
- **Accounting for the indirect area effect allows de-correlating overestimation**

Results and discussion

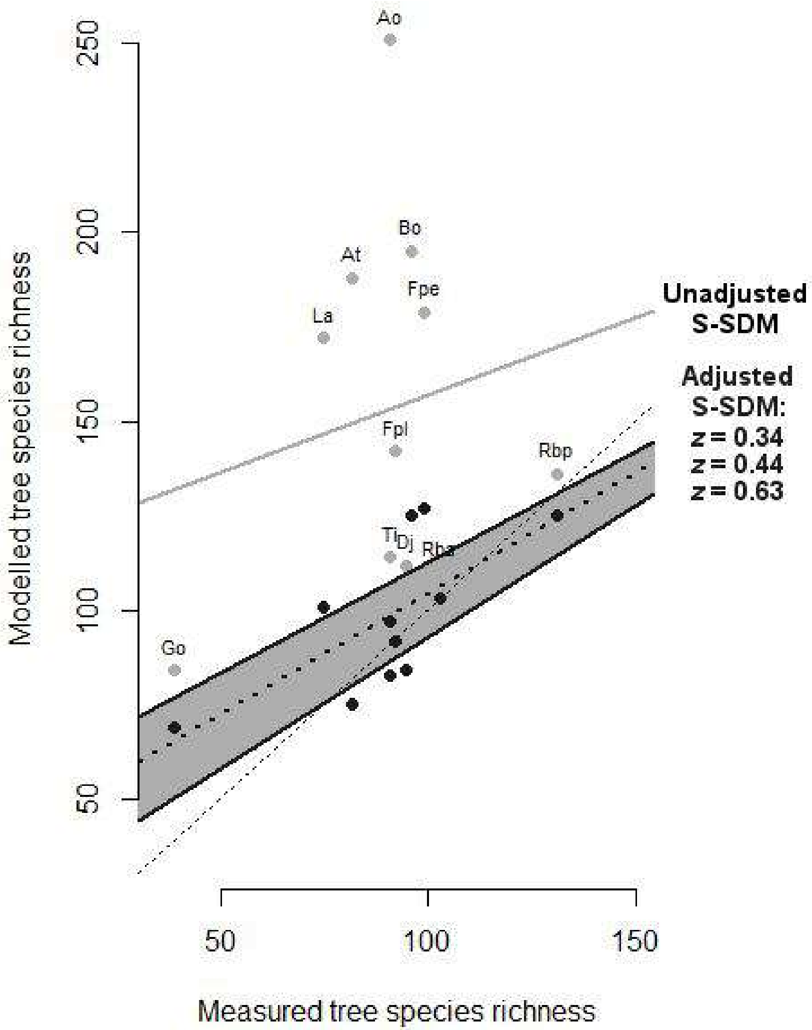
S-SDMs ARE ABLE TO MAP ALPHA DIVERSITY



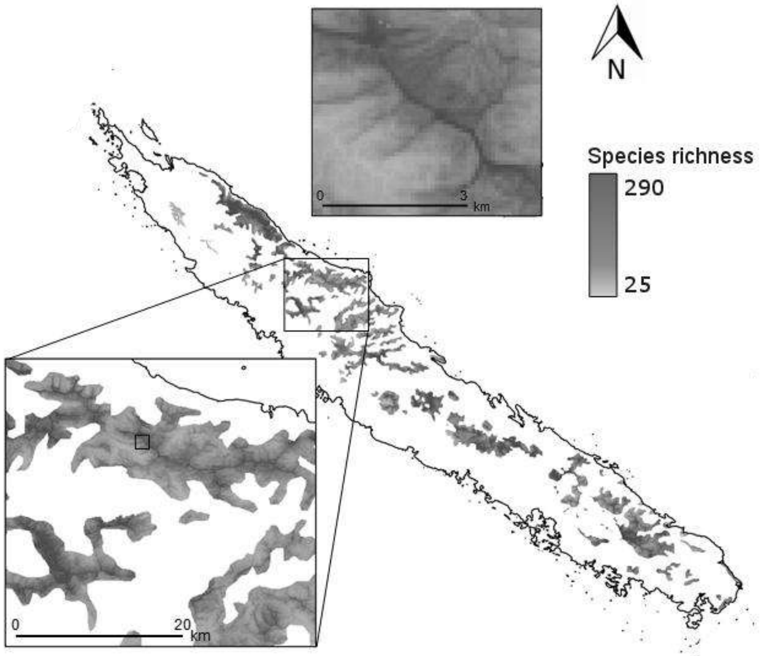
- **No correlation between unadjusted S-SDM estimates and empirical species richness** (**$r^2 = 0.03$**)

Results and discussion

S-SDMs ARE ABLE TO MAP ALPHA DIVERSITY



- No correlation between unadjusted S-SDM estimates and empirical species richness ($r^2 = 0.03$)
- **Significant correlation**



Results and discussion

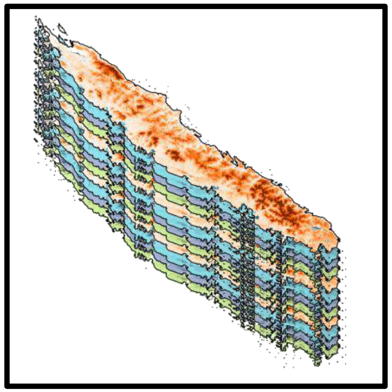
OTHER CAUSES THAT MIGHT INFLUENCE S-SDM ACCURACY

- **Difference between relative suitability and true occupancy probability that only presence-absence SDMs are able to provide (Guillera-Arroita *et al*. 2014)**
- **Micro-topography neglected by our 100 m-resolution GIS variables**
- **The variety of forest dynamic stages observed in evaluation plots**
- **Dispersal limitation and narrow-range endemism that can induce commission errors**
- **Species that are present in independent inventories but with a DBH < 10 cm**

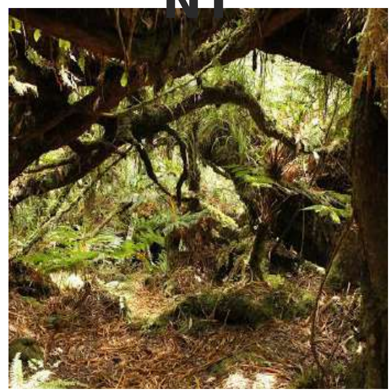
Conclusion

TAKE HOME MESSAGE

S-SDM

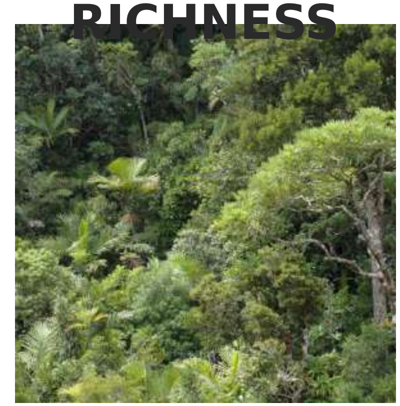


ABIOTIC ENVIRONMENT



Spatial bias

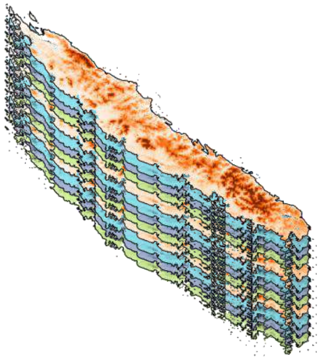
LOCAL SPECIES RICHNESS



Conclusion

TAKE HOME MESSAGE

S-SDM

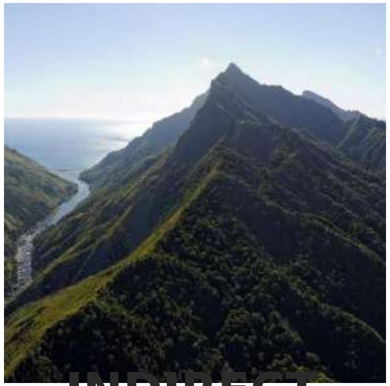


$$S = C A^{z}$$

Arrhenius (1921)

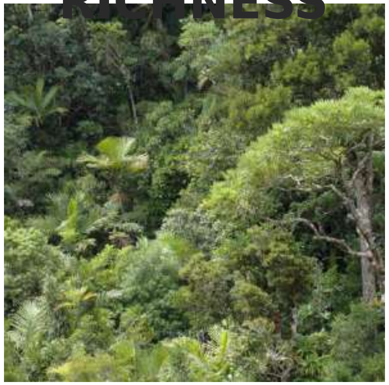
AREA ADJUSTMENT METHOD

ABIOTIC ENVIRONMENT



INDIRECT AREA EFFECT

LOCAL SPECIES RICHNESS



Oleti – Merci – Thank you for your attention

robin.pouteau@ird.fr

Pouteau, R. *et al*. Ability of a stacked species distribution model to map species richness in a biodiversity hotspot decreases with elevation: the need to account for the indirect area effect. Diversity and Distributions. Accepted with modifications.