Out of the Indian Ocean blue: Réunion, a discreet analog to Hawaii's Big Island ?

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Island Biology 2014

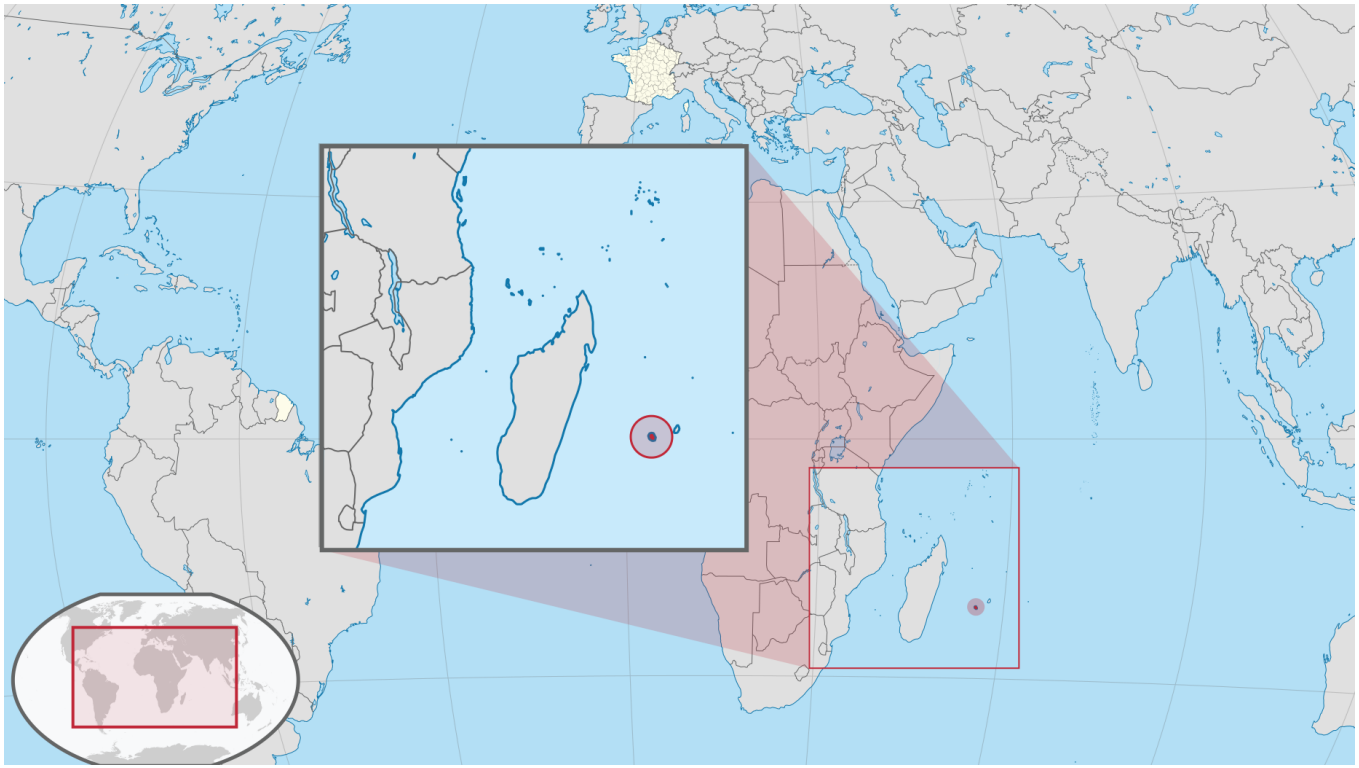
Objective

Present the main geological, ecological and biogeographical features of Réunion island, in comparison with Hawaï's Big Island

Outline

A young and remote volcanic island

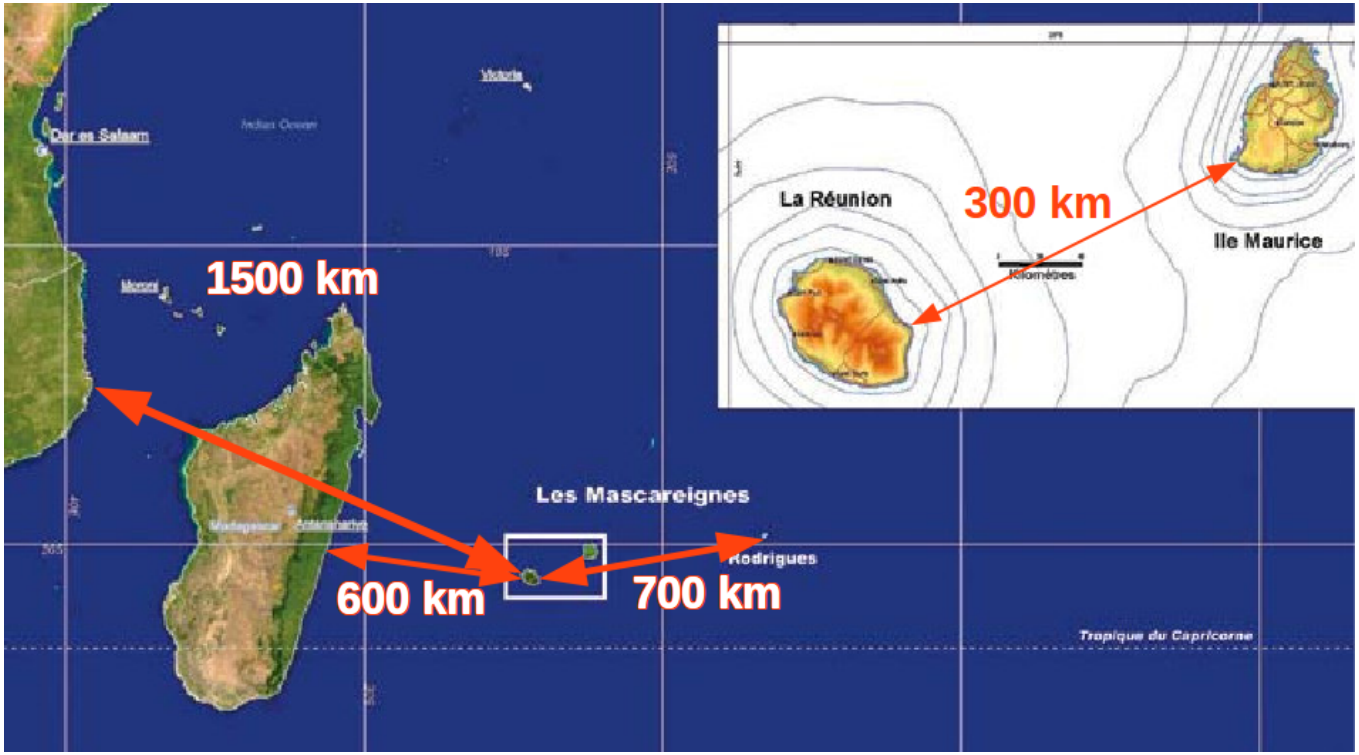
Where ?



Location of Réunion island in Indian Ocean

A young and remote volcanic island

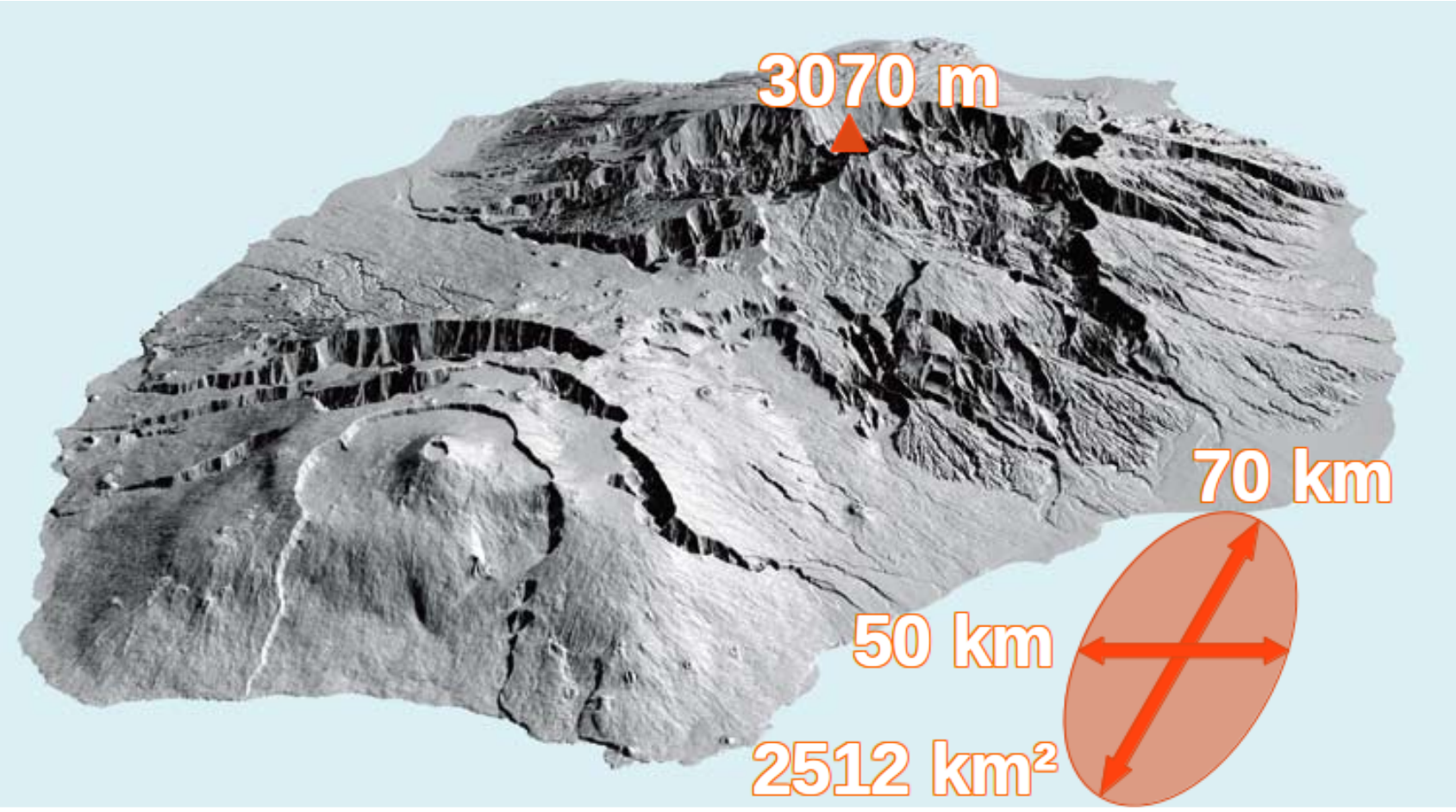
Distances ?



Distance from Réunion island to other land masses

A young and remote volcanic island

Distances ?



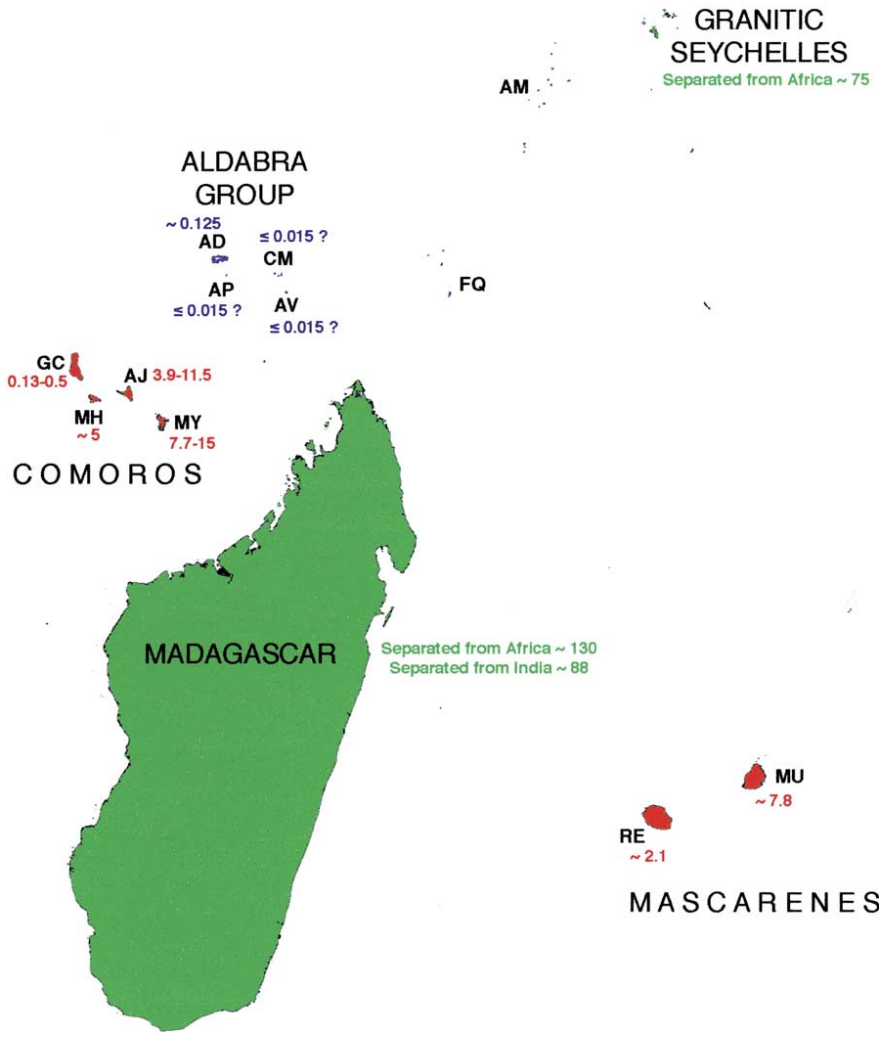
Dimensions of Réunion island

A young and remote volcanic island

How old ?

Ages in the Mascarenes

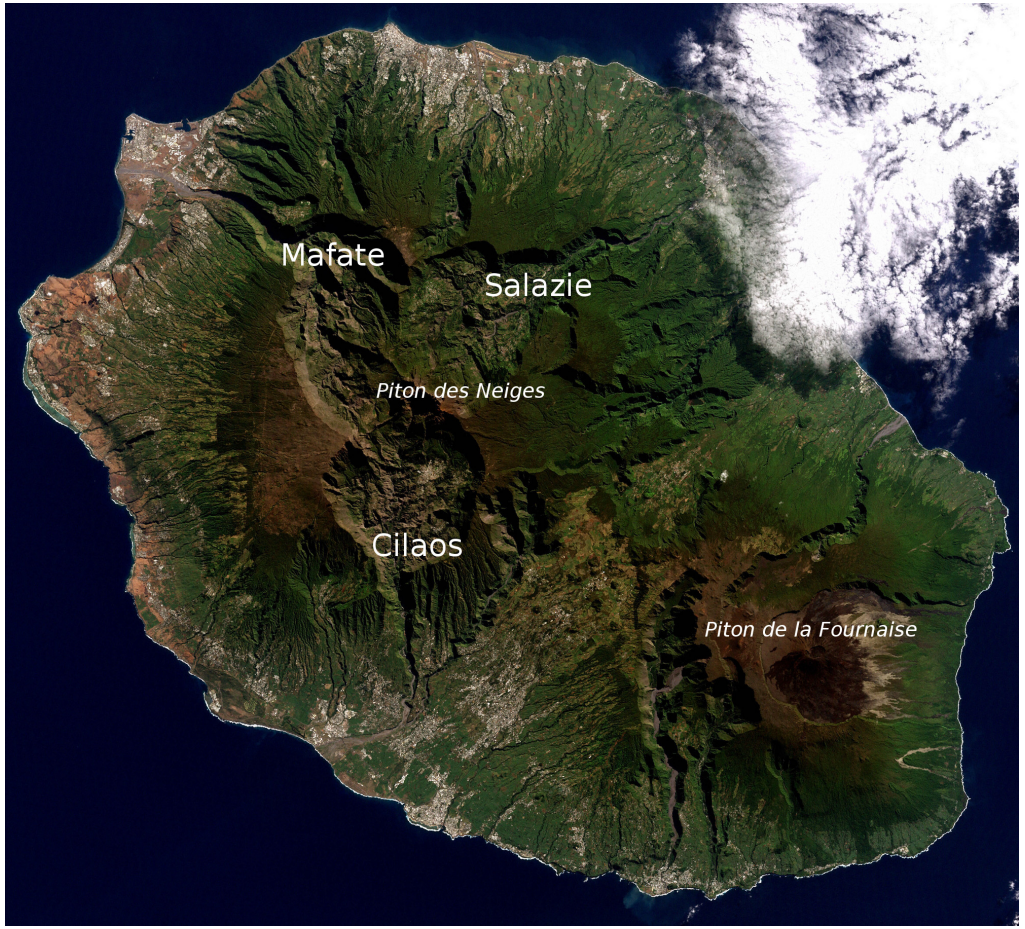
- **Réunion: 2.1 Myr**
- Mauritius: 7.5 Myr
- + Rodrigues: 11 Myr



Ages of land masses in South-Western Indian Ocean (SWIO)

A young and remote volcanic island

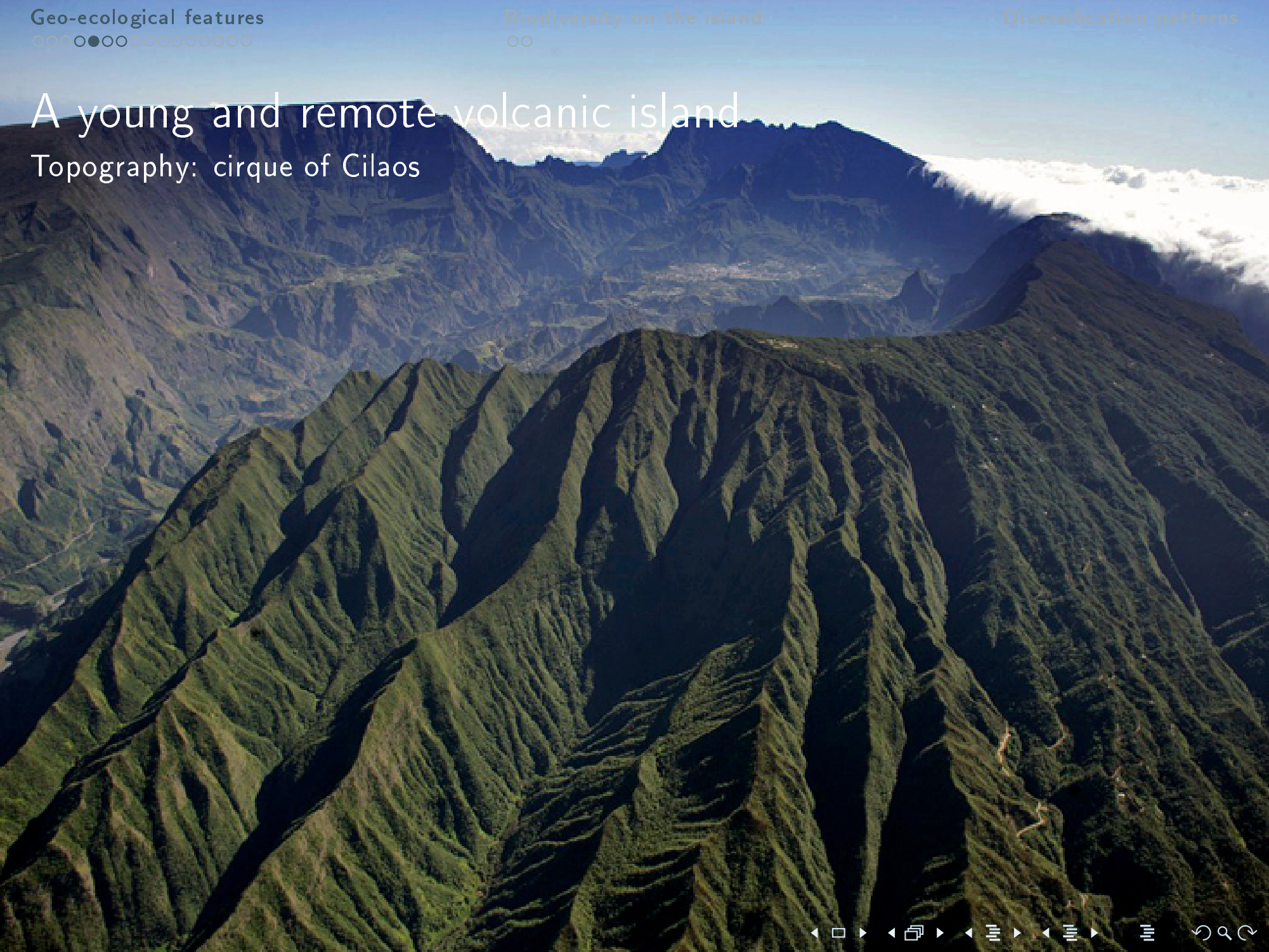
Topography : peaks, cliffs and cirques



Satellite view showing the three major cirques: Cilaos, Mafate, Salazie

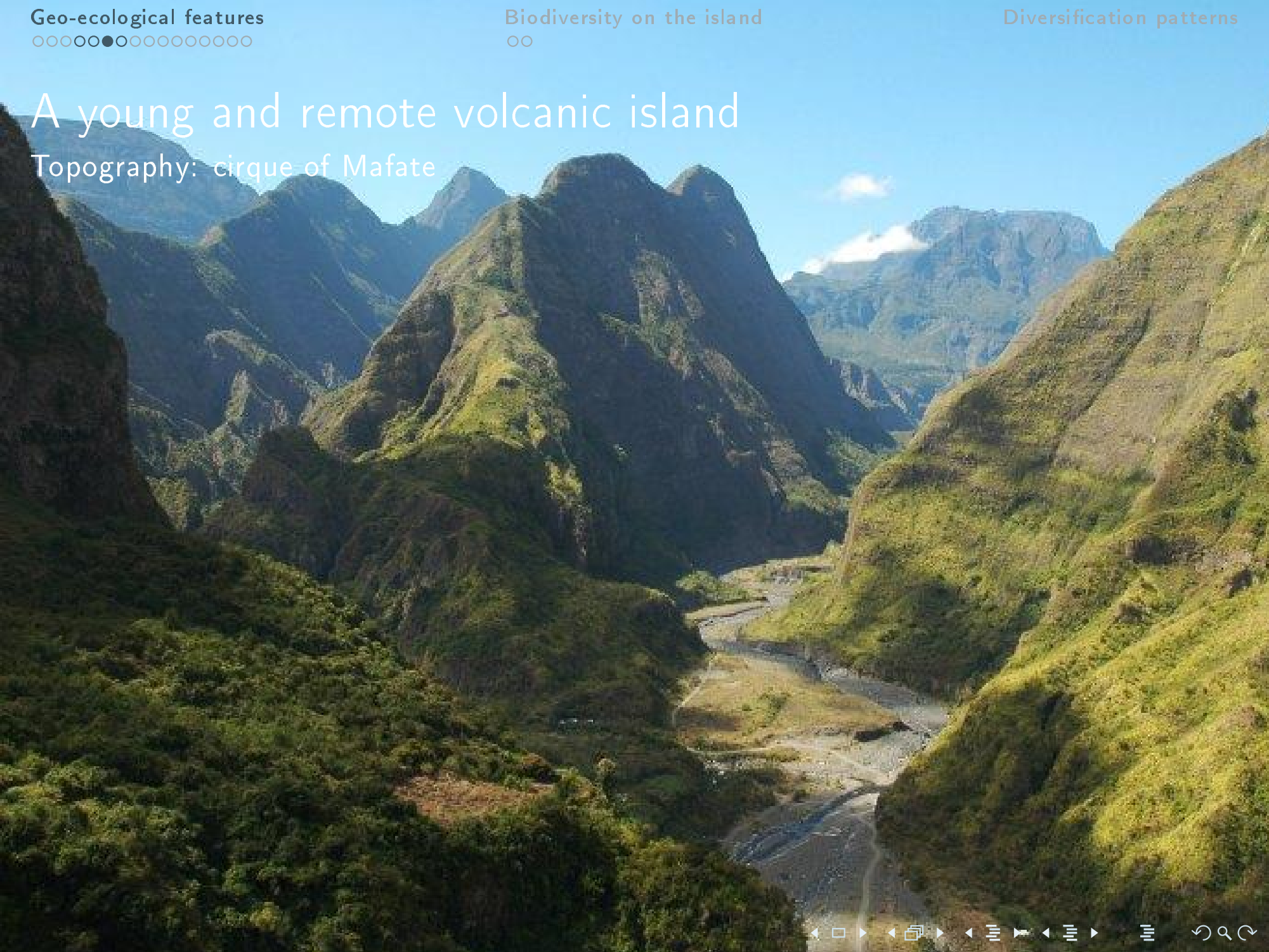
A young and remote volcanic island

Topography: cirque of Cilaos



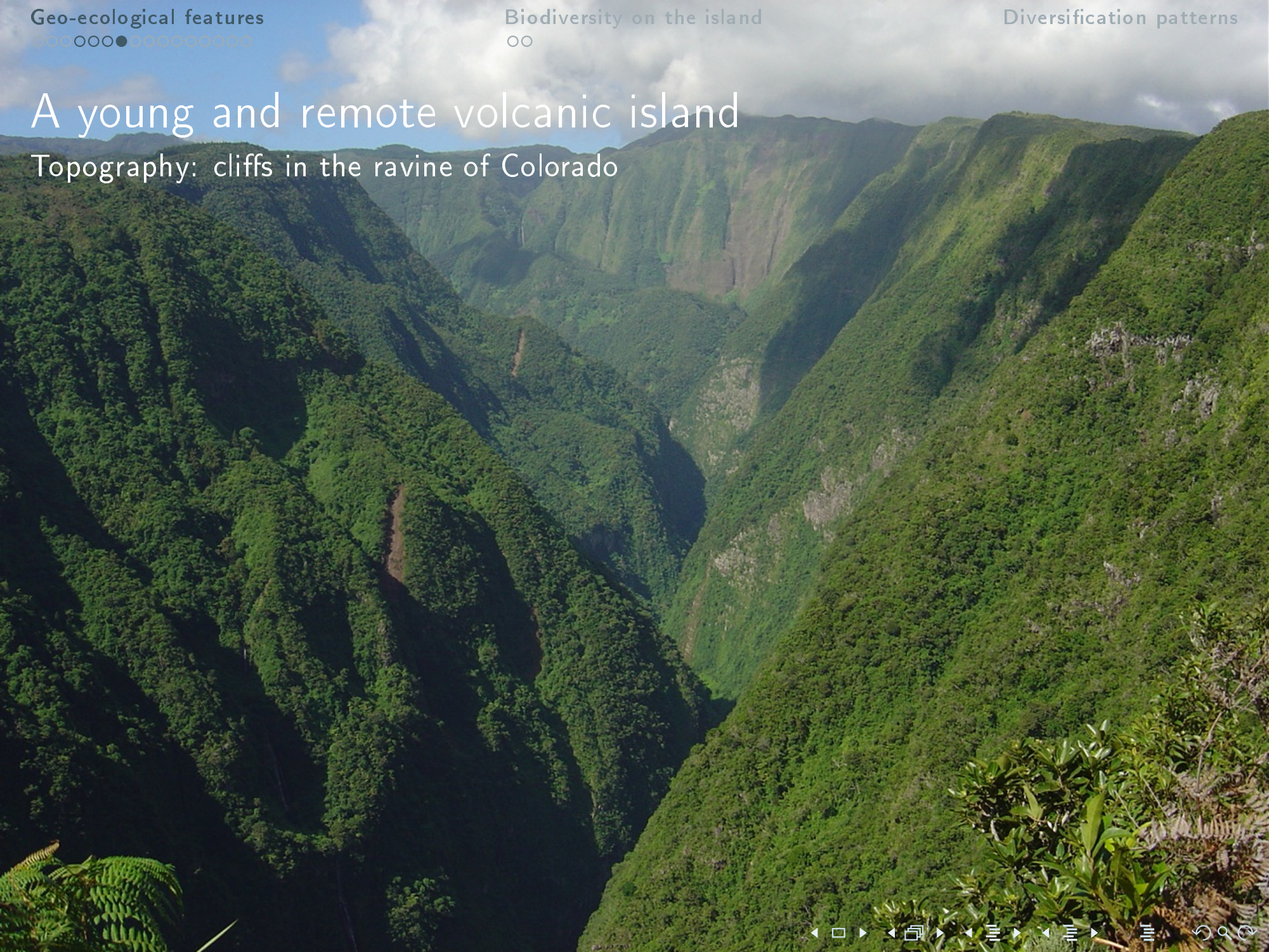
A young and remote volcanic island

Topography: cirque of Mafate



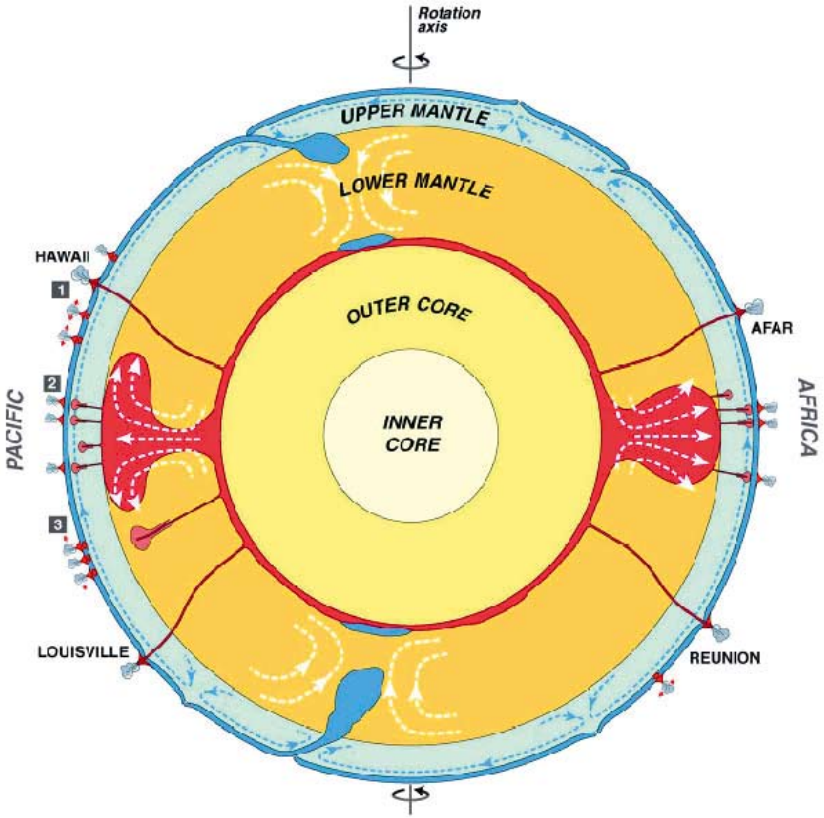
A young and remote volcanic island

Topography: cliffs in the ravine of Colorado

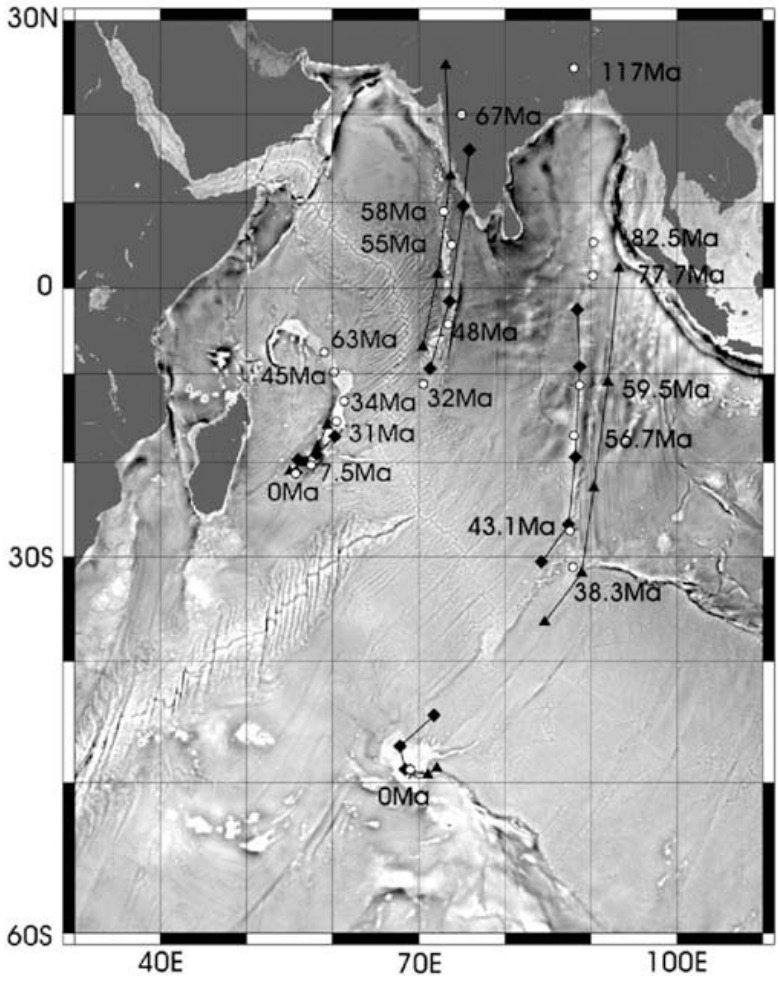


A young and remote volcanic island

Origin



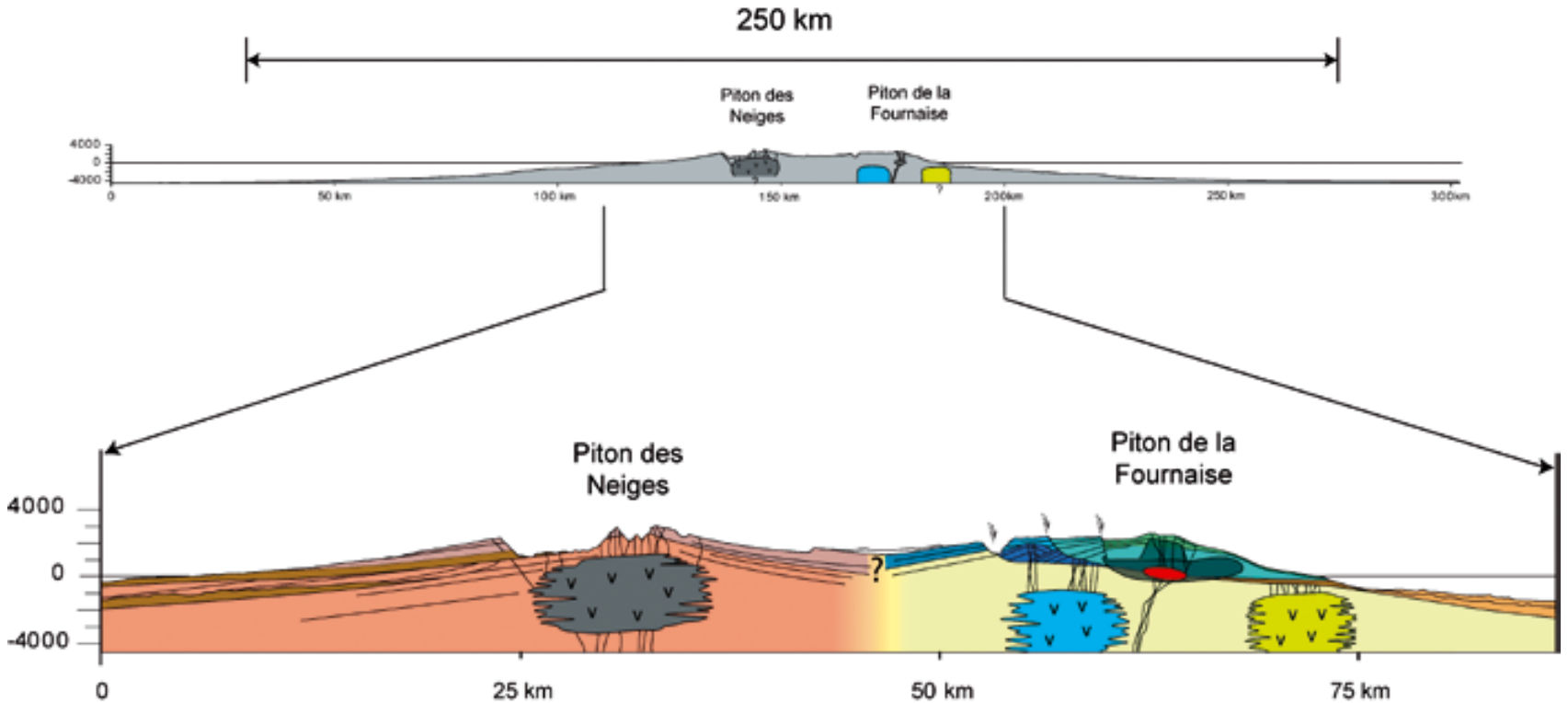
Réunion and Hawaï: from a similar type of geological hot-spot



Volcanism ages in SWIO

A young and remote volcanic island

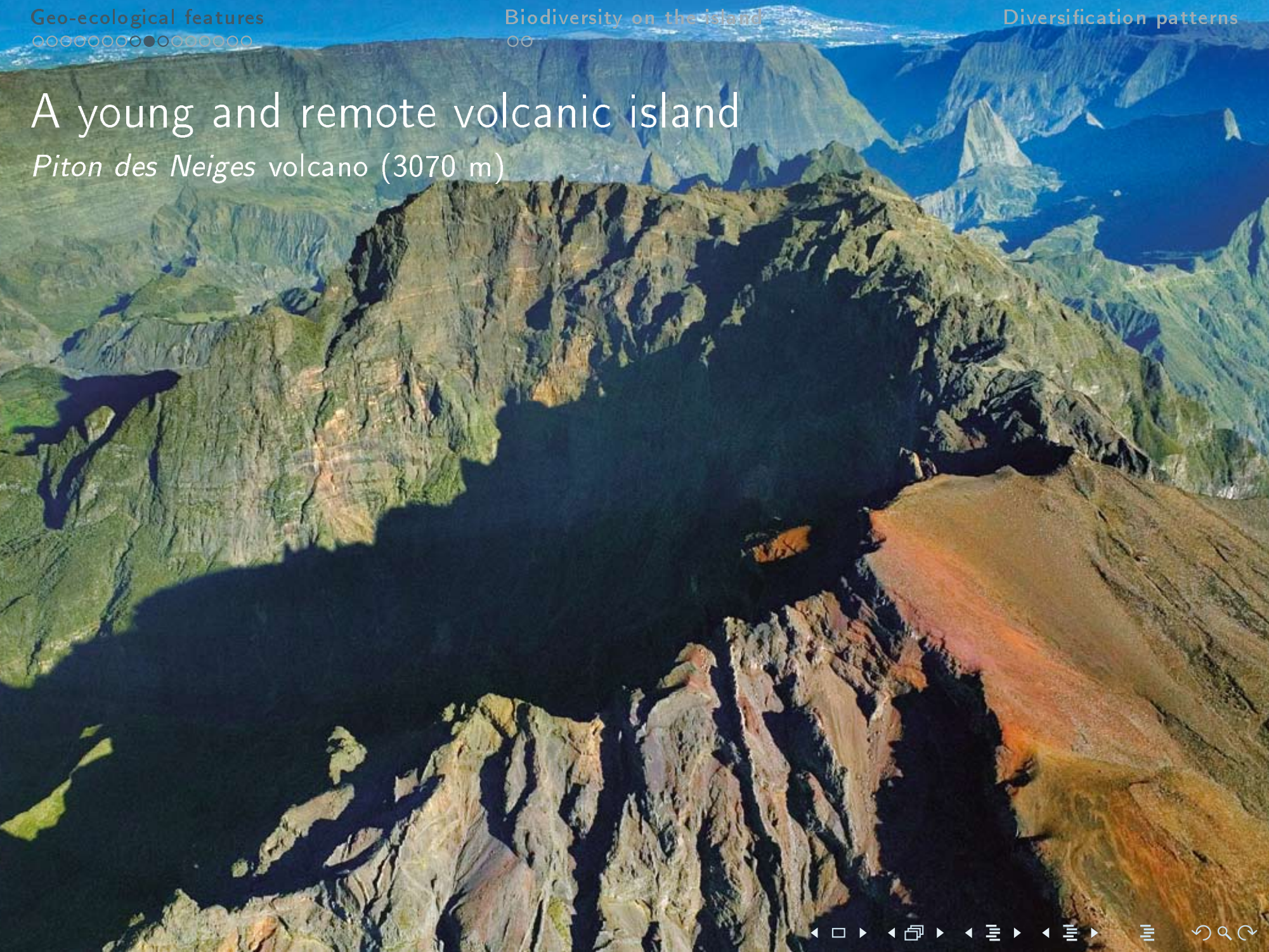
Origin



Two volcanos: Piton des Neiges *(North, inactive)* *and* Piton de la Fournaise *(South, active)*

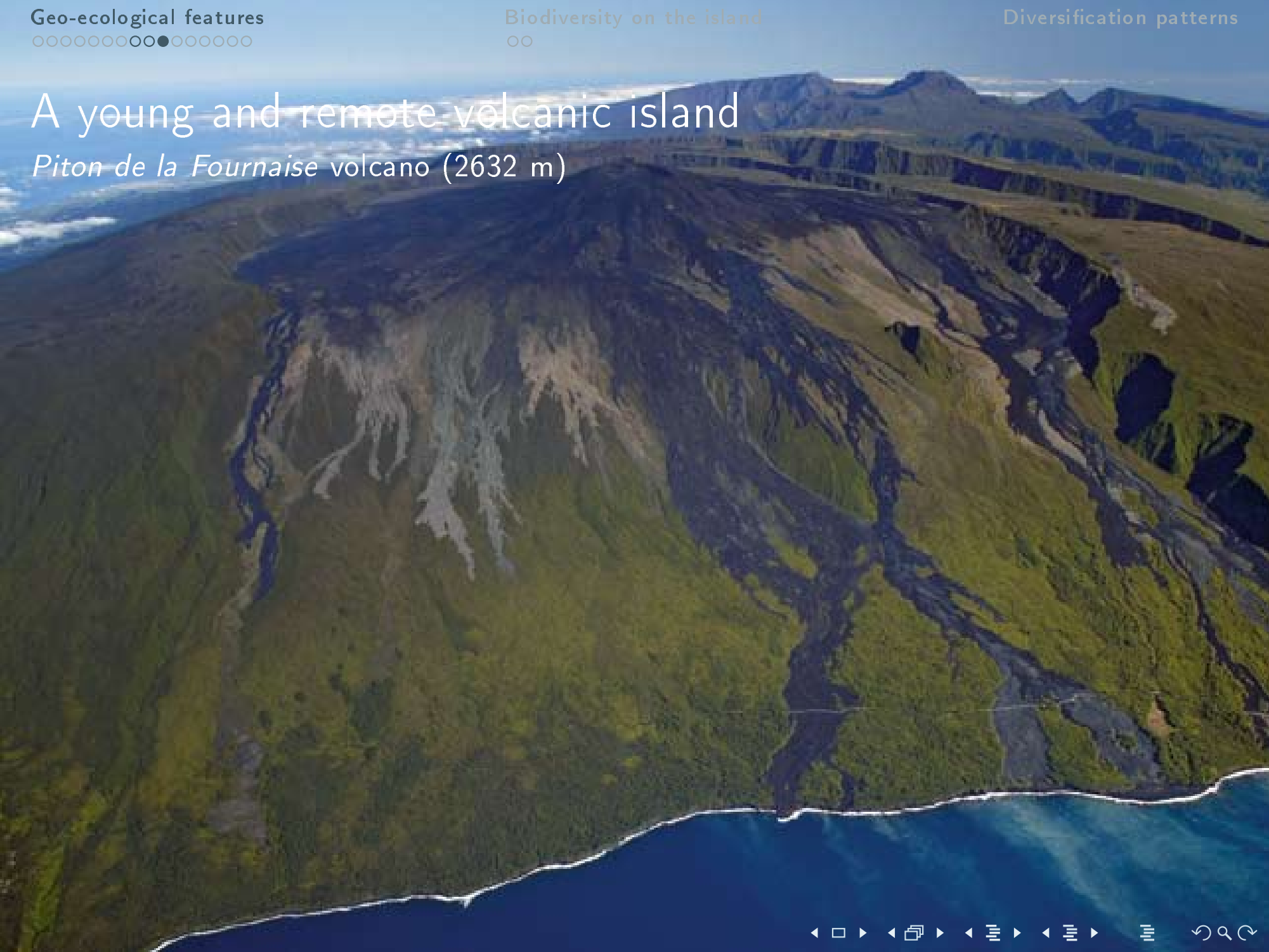
A young and remote volcanic island

Piton des Neiges volcano (3070 m)



A young and remote volcanic island

Piton de la Fournaise volcano (2632 m)



A young and remote volcanic island

Eruptions: reaching the sea (2007)

A young and remote volcanic island

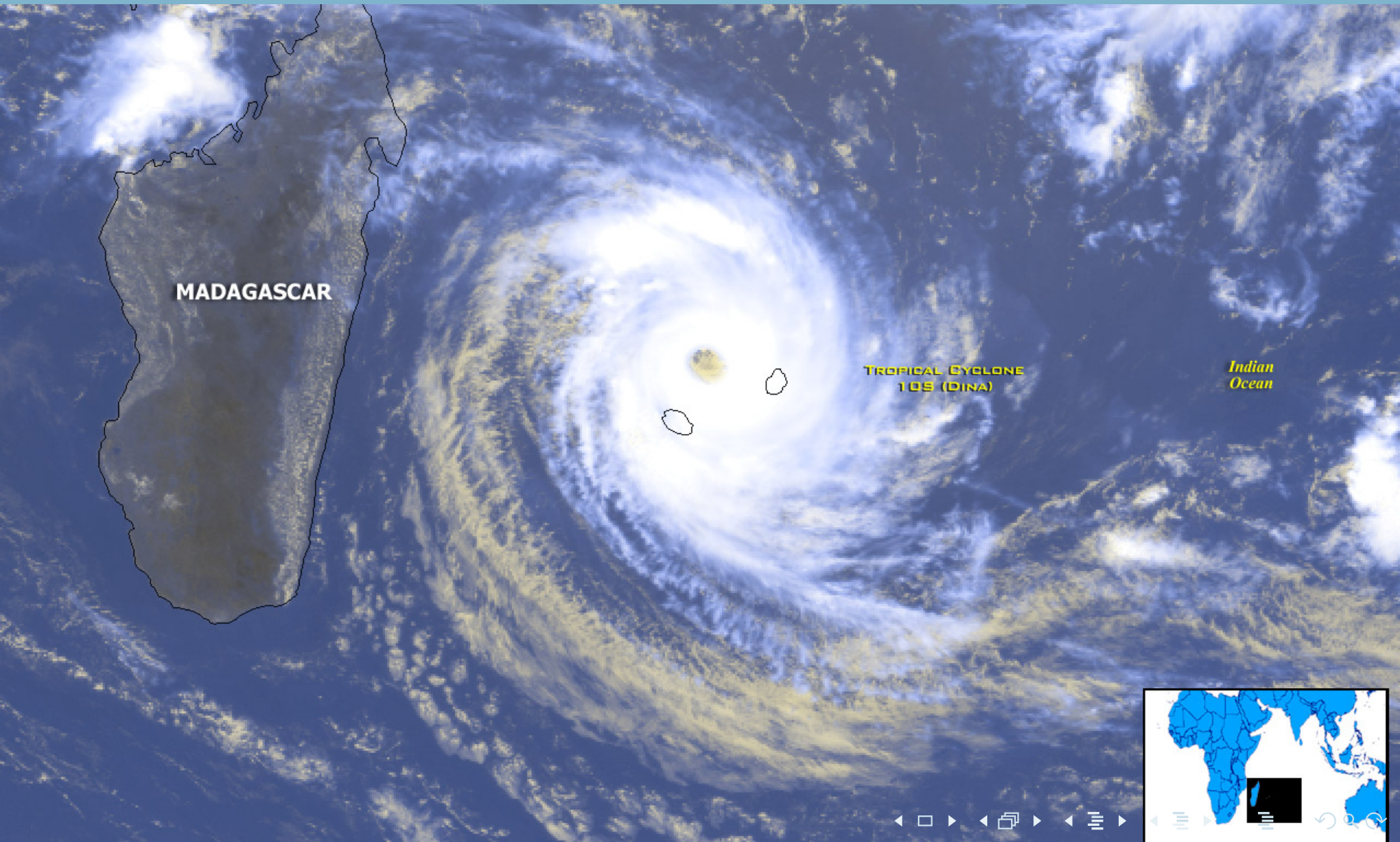
Eruptions : the latest (21/06/2014)

Tropical Cyclone 10S (Dina) was located over the Indian Ocean near 19.5S 56.8E at 06:00 UTC. Dina has been moving westward at 18 knots with maximum sustained winds estimated at 120 knots, gusts to 145 knots.

CREDIT: NOAA

Nigh disturbance

Hurricanes



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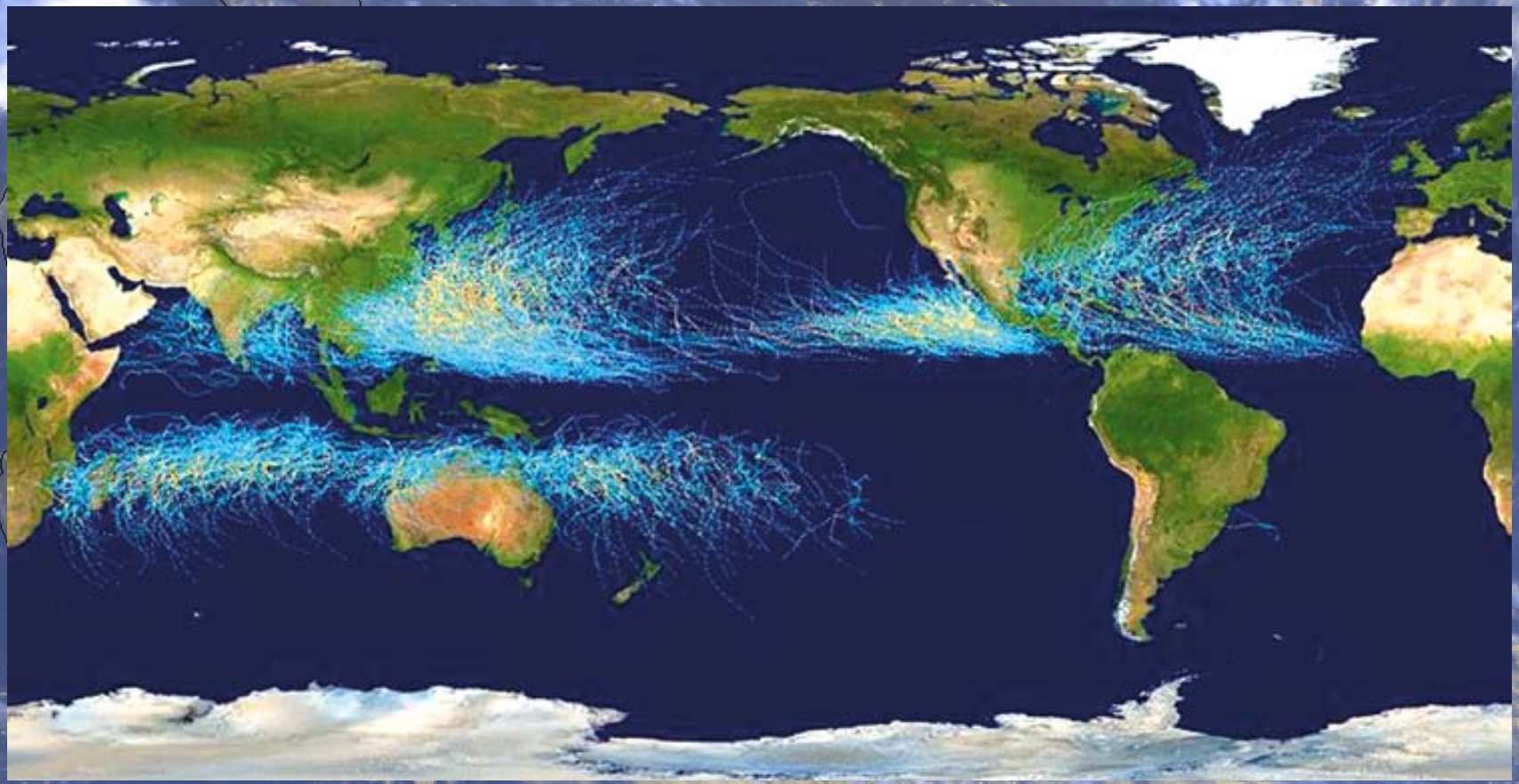
Nigh disturbance

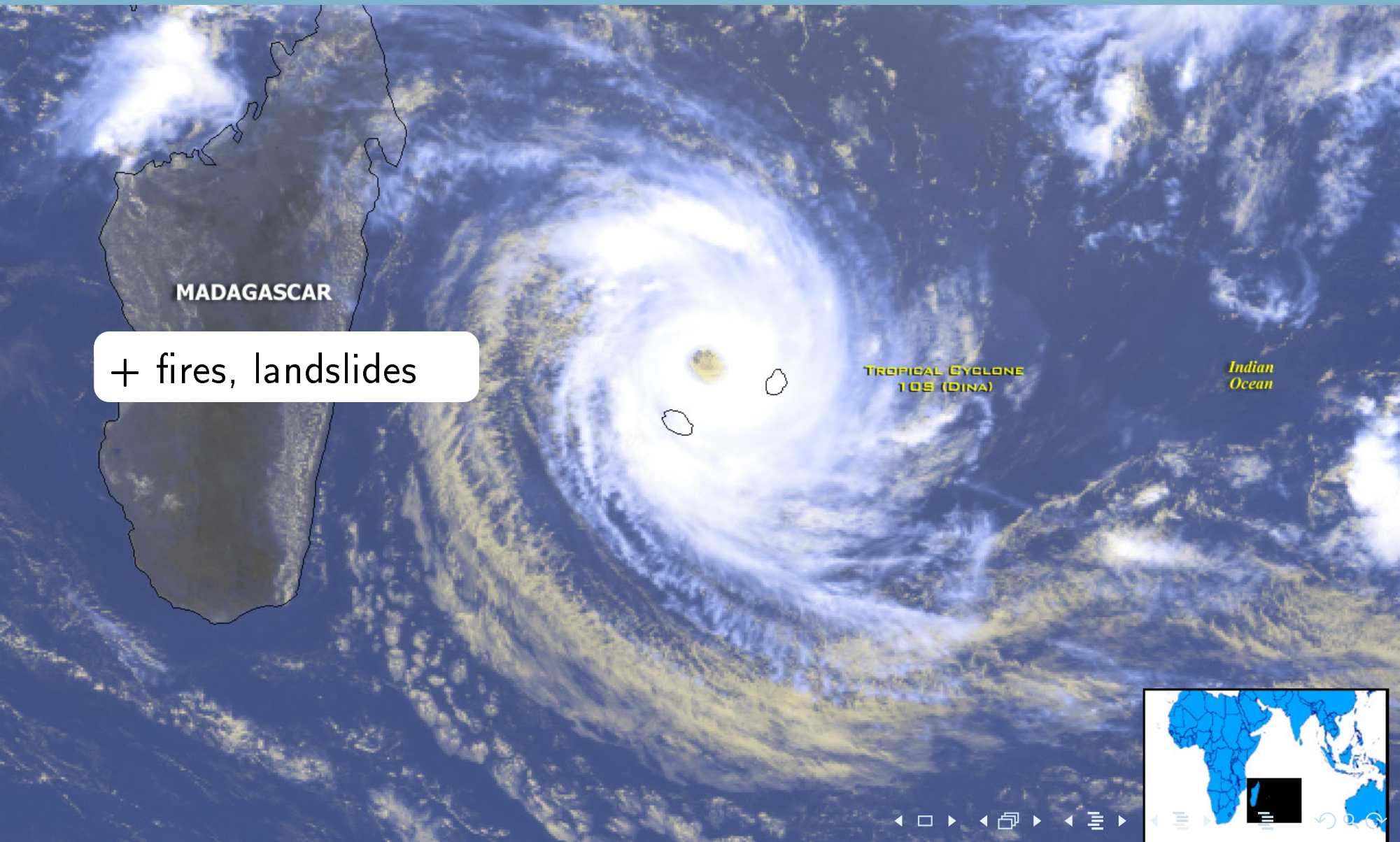
Hurricanes



Hurricanes trajectories

Nigh disturbance

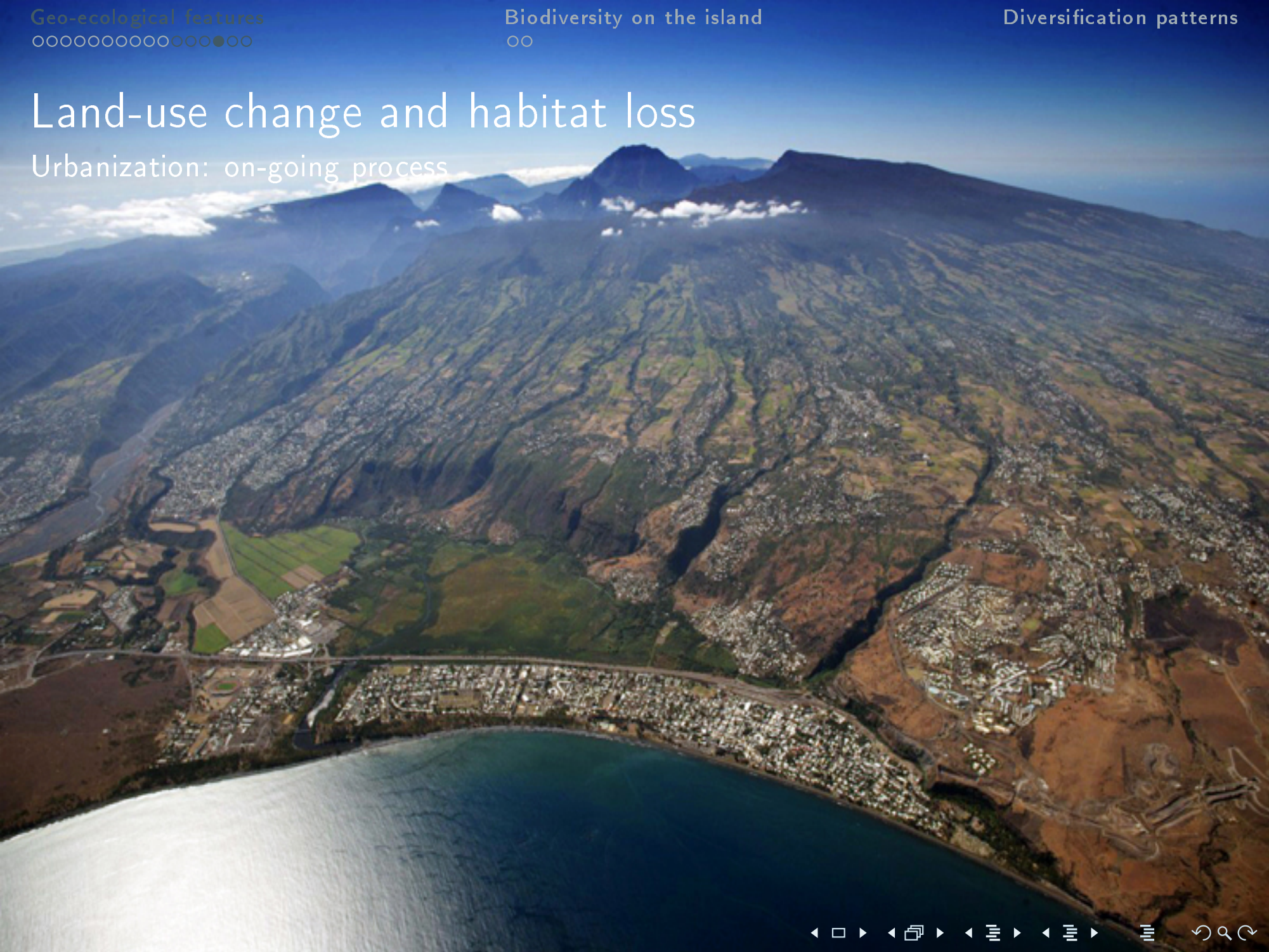
Hurricanes



+ fires, landslides

Land-use change and habitat loss

Urbanization: on-going process

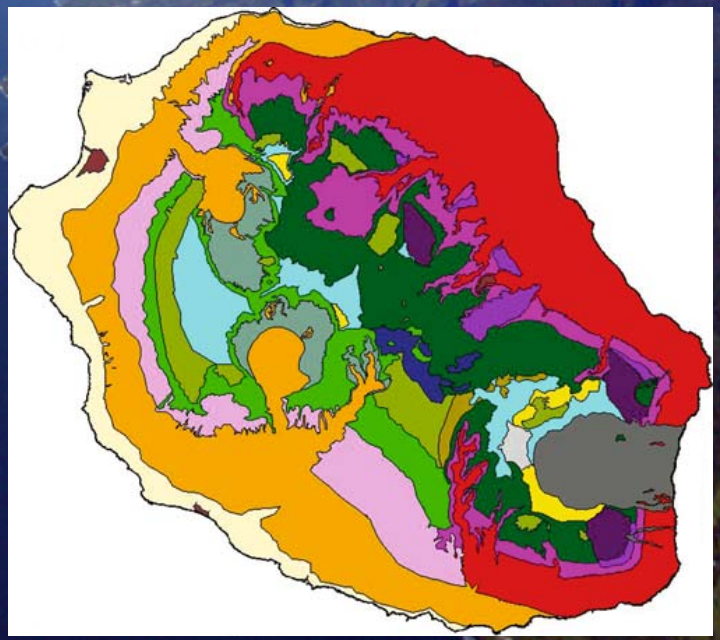


Land-use change and habitat loss

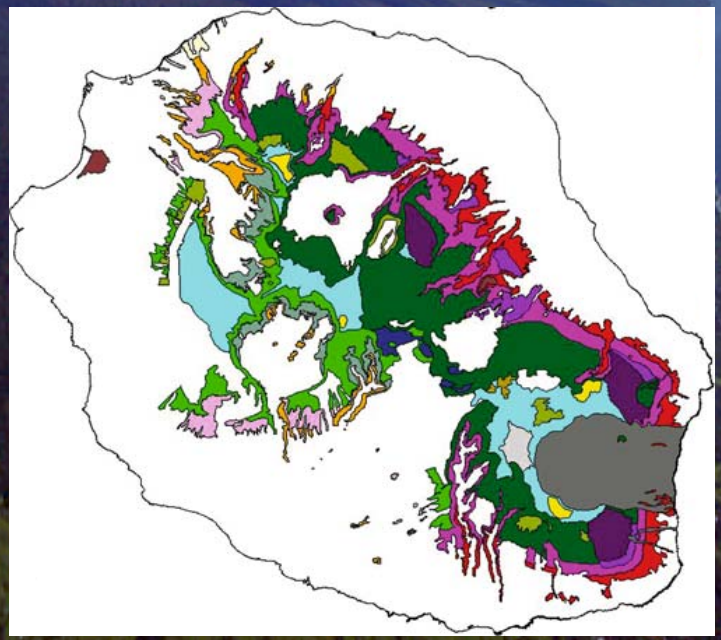
Fragmentation

Land-use change and habitat loss

Fragmentation



Original extent of ecosystems



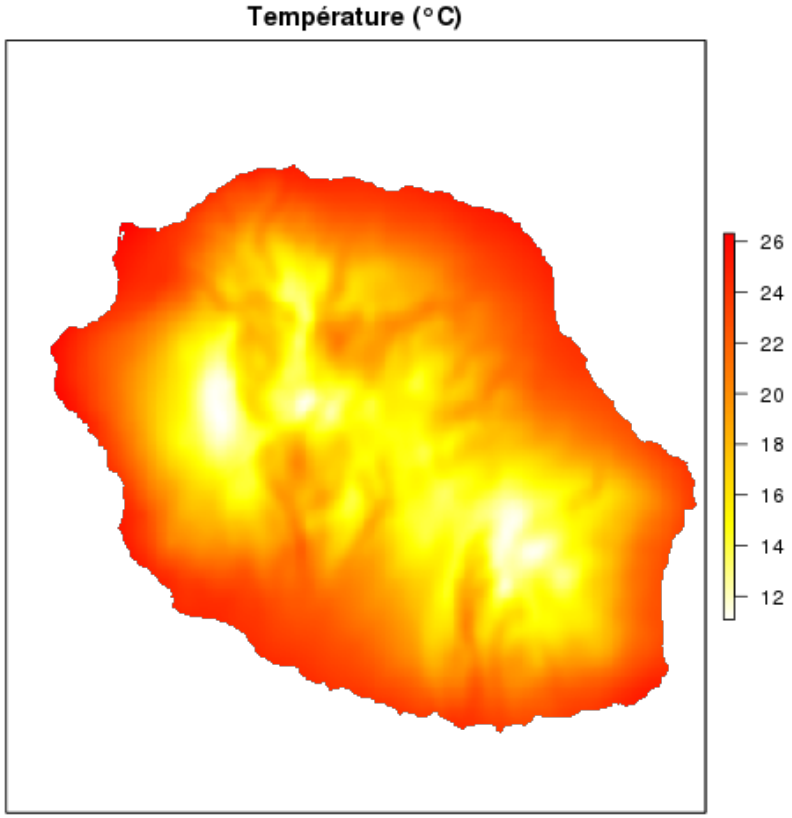
Current extent of ecosystems

- About 30% of natural habitats remain

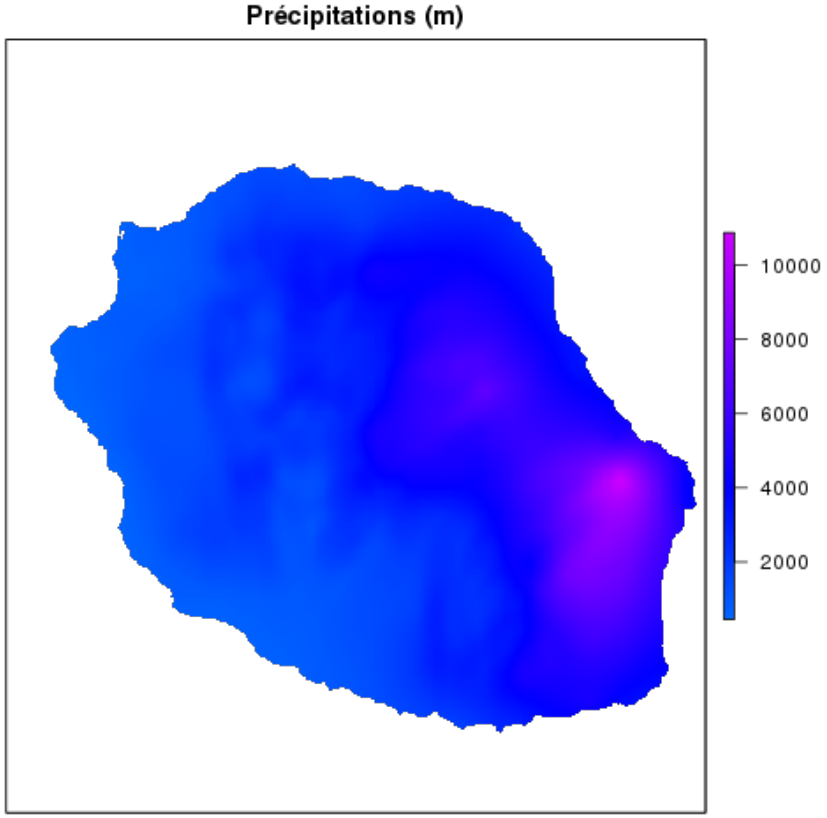
A young and remote volcanic island

Climate: typical insular patterns

- Wide ecological gradients
- Eastern trade-winds

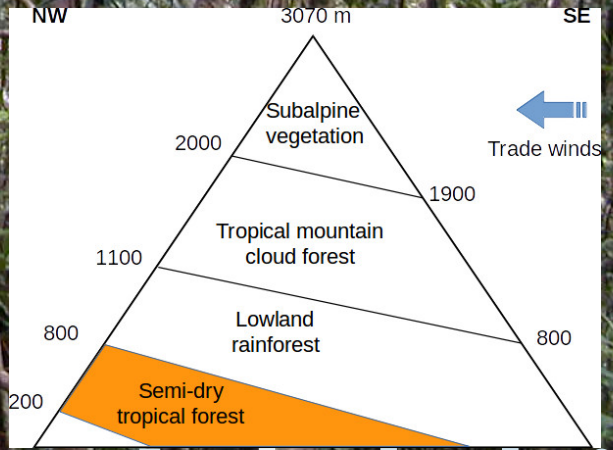


- Windward (E)/leeward (W)
- Rainy / dry seasons



Ecosystem diversity

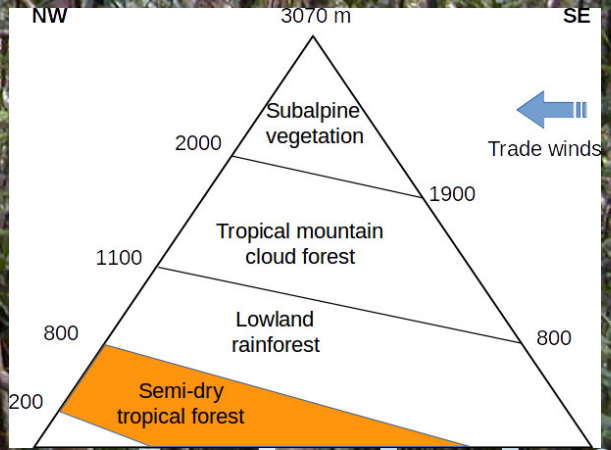
Tropical semi-dry forests



Ecosystem diversity

Tropical semi-dry forests

- 1% remaining
- Highly threatened
- Numerous protected species



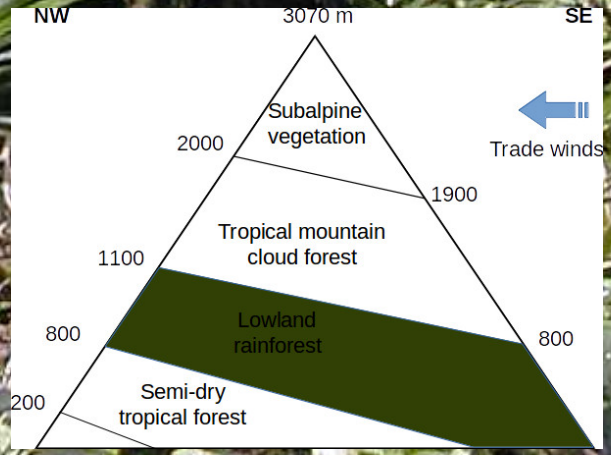
Ecosystem diversity

Tropical rainforests

Ecosystem diversity

Tropical rainforests

- Last remnants of the Mascarenes
- ≈40 spp./ha
- High density: > 1000 trees/ha (>8 cm dbh)



Ecosystem diversity

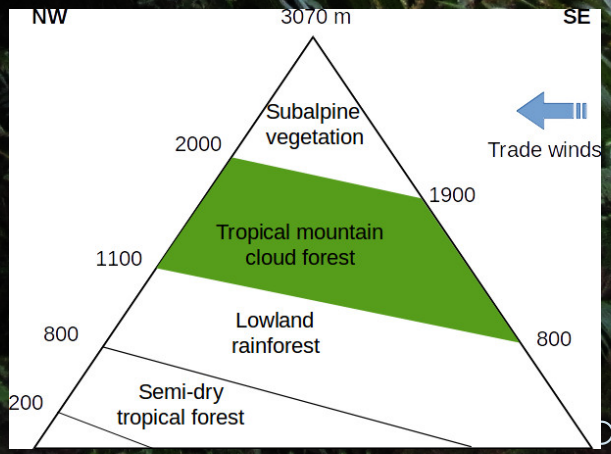
Tropical montane forests

Ecosystem diversity

Tropical montane forests

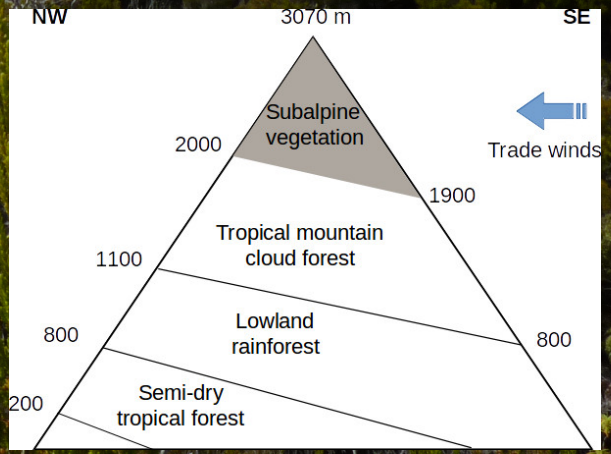
Locally abundant tree-fern species

- High conservation stake
- Highest diversity in Bryophytes/Pteridophytes
- Numerous epiphytic species



Ecosystem diversity

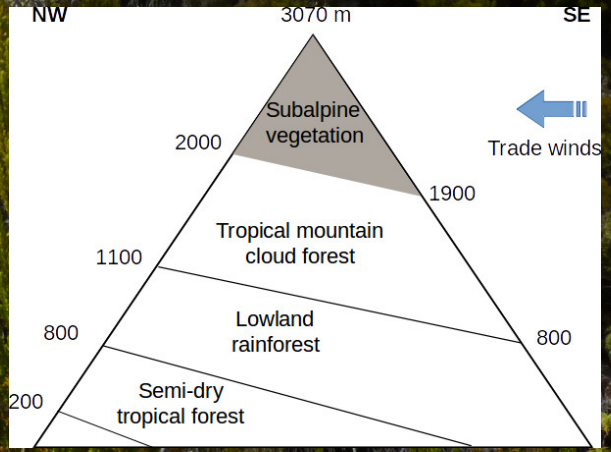
Subalpine shrublands



Ecosystem diversity

Subalpine shrublands

- *Erica ssp.*
- *Hypericum lanceolatum*



Ecosystem diversity

Acacia heterophylla and *Sophora denudata* forests

Ecosystem diversity

Acacia heterophylla and *Sophora denudata* forests

- *Acacia heterophylla*, one of many heterophyllous species
- Endemic daughter species of *Acacia koa*

New Phytologist Research

Relatedness defies biogeography: the tale of two island endemics (*Acacia heterophylla* and *A. koa*)

Johannes J. Le Roux[1], Dominique Strasberg[2], Mathieu Rouget[3], Clifford W. Morden[4], Megan Koordom[1] and David M. Richardson[1]

[1]Department of Botany & Zoology, Centre for Invasion Biology, Stellenbosch University, Matieland 7602, South Africa; [2]UMR PVBMT, Peuplements Végétaux et Bioagresseurs en Milieu Tropical, Université de La Réunion, 15 avenue René Cassin, CS 93002, 97 744 Saint-Denis Messag. Cedex 9, France; [3]Centre for Invasion Biology, Land Use Planning and Management, School of Agricultural, Earth and Environmental Sciences, University of KwaZulu-Natal, Pietermaritzburg 3209, South Africa; [4]Department of Botany, University of Hawai'i, 3190 Maile Way, Honolulu, HI 96822, USA

Fig. 1 *Acacia koa* from the Hawaiian Islands (a, b) and *A. heterophylla* from Réunion Island (c, d), showing the strong morphological similarities between these two island endemics. Photographs courtesy of Johannes Le Roux.

Ecosystem diversity

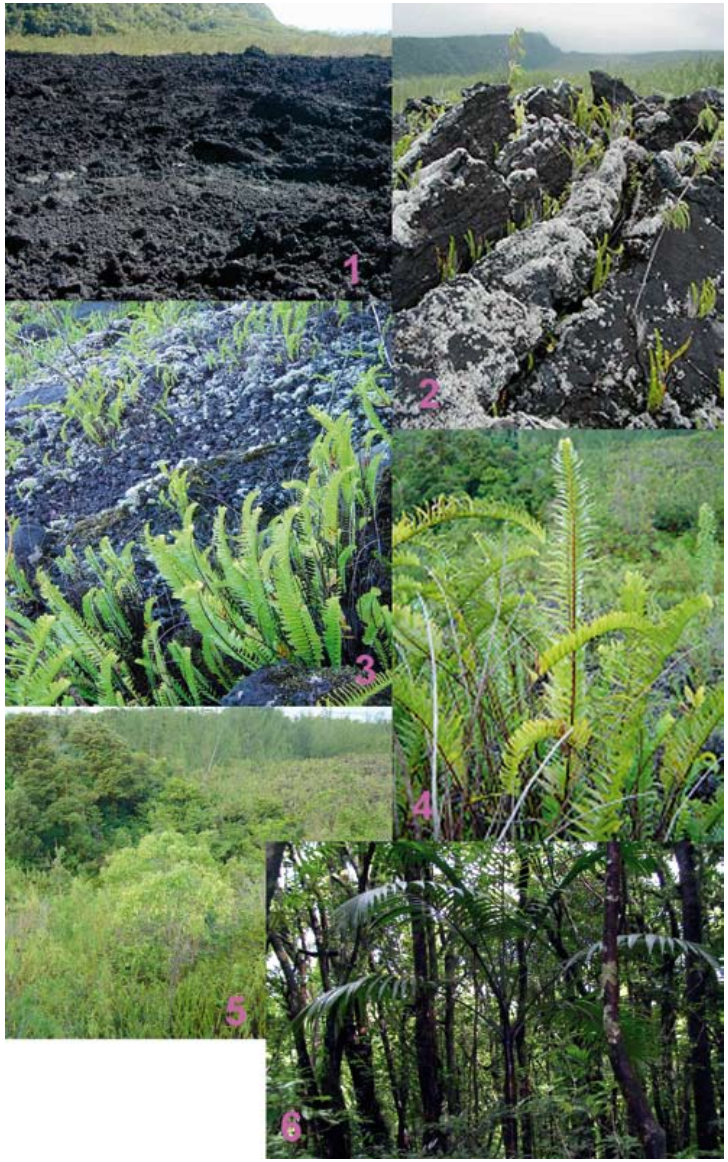
Acacia heterophylla and *Sophora denudata* forests

Sophora denudata

Remnants of Sophora denudata forests

Ecosystem diversity

Azonal communities: ecological succession on lava flows



1. Cooling recent lava flow
2. Colonization by *Stereocaulon vulcani* + first mosses
3. First ferns: *Nephrolepis abrupta*, *Blechnum ssp.*, *Dicranopteris linearis*
   Vascular plants: *Machaerina iridifolia*, *Scaevola sp.*, *Agarista salicifolia*
4. Herbs and shrubs: *Stoebe passerinoïdes*, *Senecio ambavilla*
   Trees: *Antirrhea borbonica*, *Aphloïa theiformis*, *Nuxia verticillata*, *Sideroxylon borbonicum*
5. Shade-tolerant woody species: *Gaertnera vaginata*, *Pittosporum senecia*, *Labourdonnaisia callophylloïdes*, *Mimusops maxima*
   Tree-ferns: *Cyathea borbonica*
6. Mature forest

Ecosystem diversity

Azonal communities: ecological succession on lava flows

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Ecosystem diversity

Azonal communities: ecological succession on lava flows

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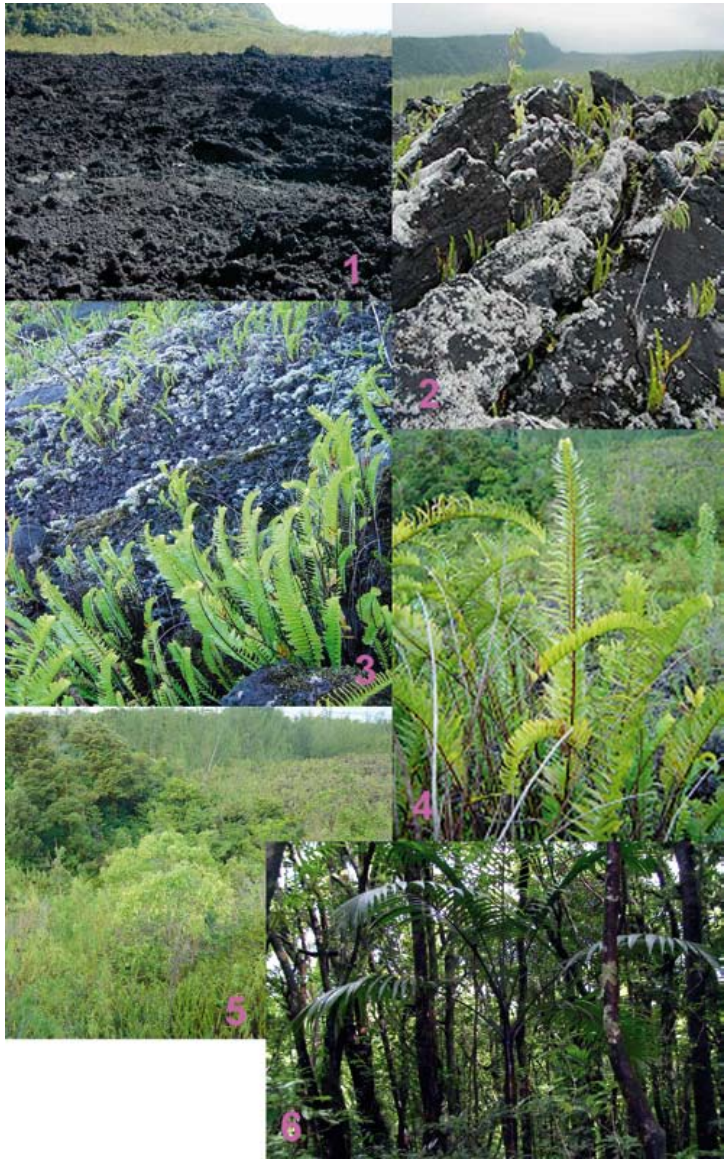
Agarista salicifolia (Ericaceae): long-lived pioneer tree on laval flows, wind-dispersed

Functional equivalent of *Metrosideros polymorpha*, but co-dominant

Ecosystem diversity

Azonal communities: ecological succession on lava flows



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6. Mature forest

Ecosystem diversity

Azonal communities: ecological succession on lava flows

A kipuka on the 1986-lava flow (2005)

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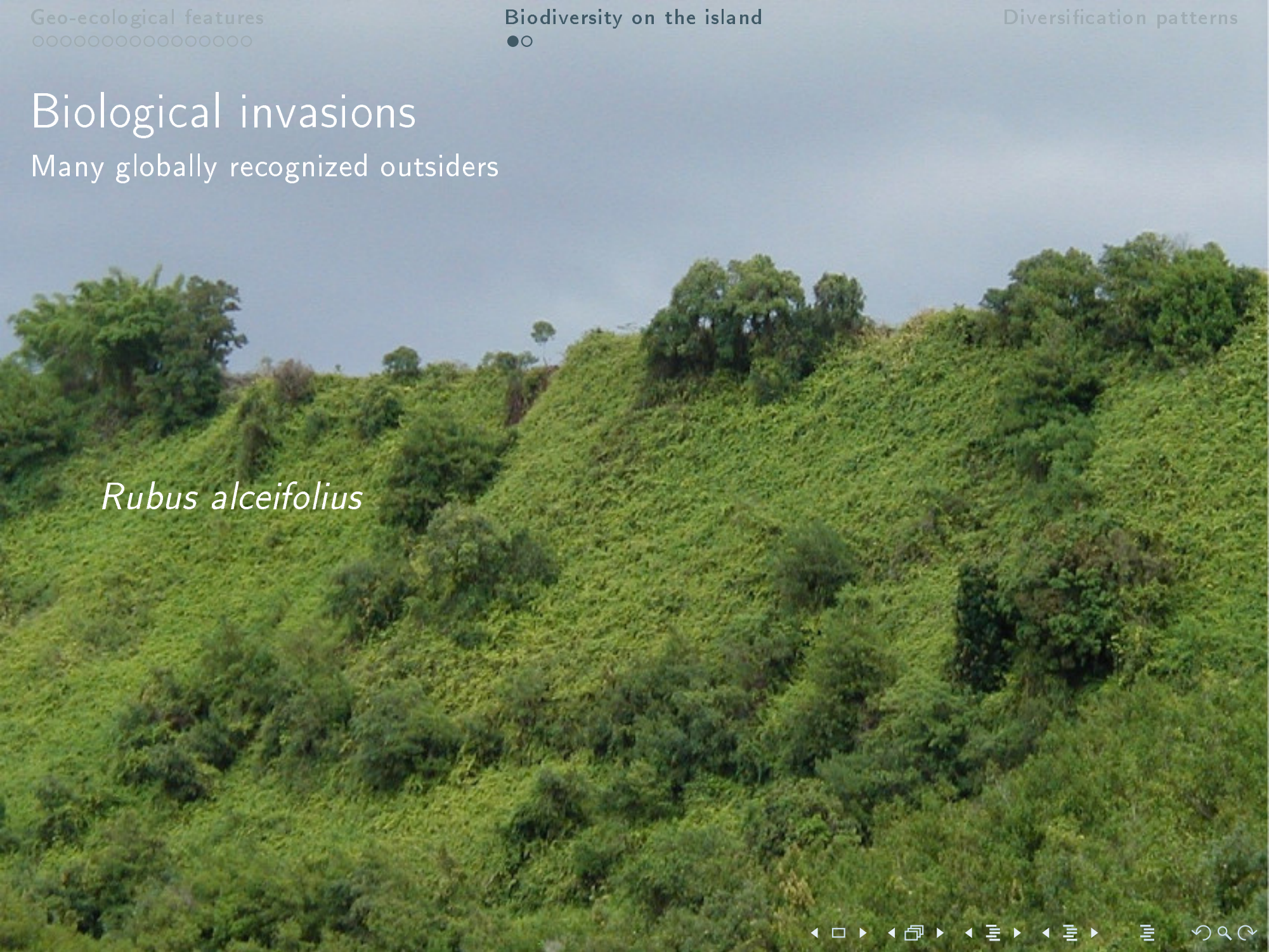
Biological invasions

Many globally recognized outsiders

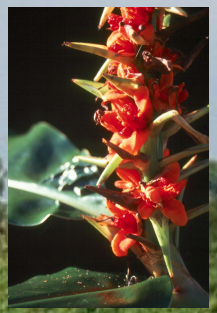


Biological invasions

Many globally recognized outsiders

Syzygium jambos

Psidium cattleianum



Hedychium gardnerianum

Clidemia hirta

Fushia exonensis

Furcraea foetida

Leucaena leucocephala

Lantana camara

Acacia mearnsii

\+ *Ageratina riparia*, *Boehmeria penduliflora*, *Casuarina equisetifolia*, *Schinus terebenthifolius*. . .

Réunion: in one the 34 global biodiversity hotspots

Madagascar and the South-Western Indian Ocean (SWIO) islands

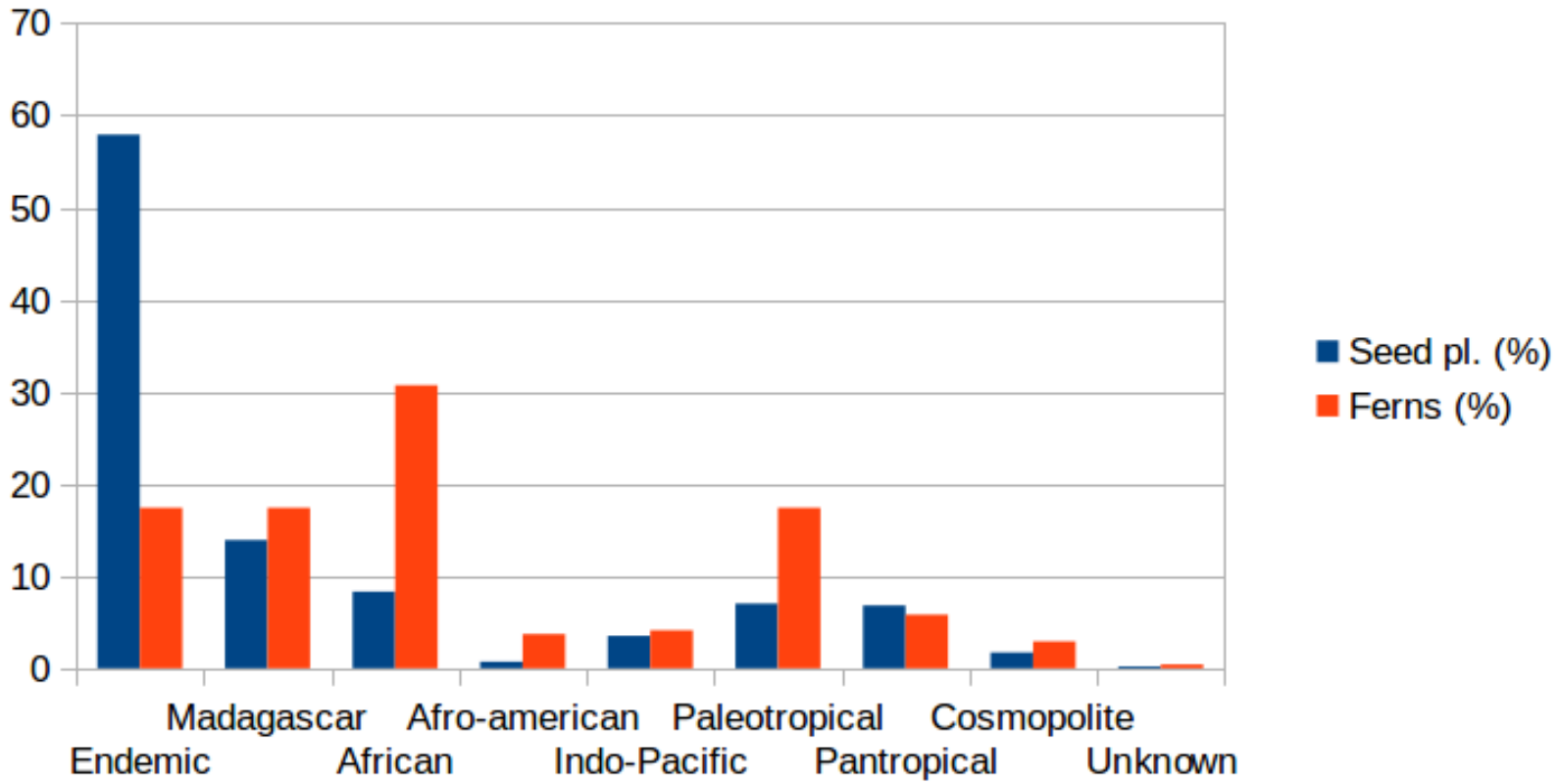
- 57.6% regional endemism in vascular plants

Species diversity and (local) endemism in major plant groups

Taxa	Species	Species/genus	Endemics	Endemism (%)
Spermatophytes	599	1.95	219	36.6
Pteridophytes	241	2.74	17	7.1
Bryophytes	754	2.95	86	11.4
Total	1594	2.45	322	20.2

A unique flora I

African and Asian flavours



Origin of vascular plant species in Réunion island

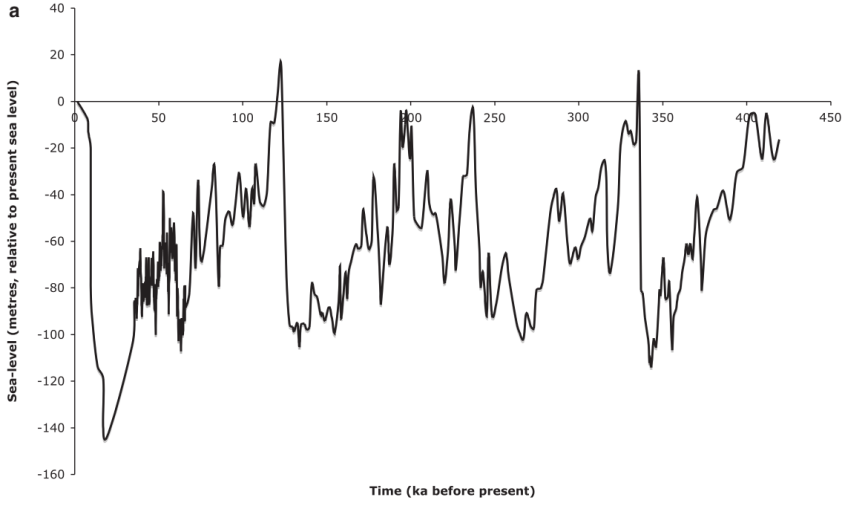
Lineages origin and diversification

Role of stepping-stone islands?

- Timing of divergences between local taxa and sisters Asian species

  Plants, reptiles, insect, birds, fish,...

- Reduction in dispersal distances with lower sea-level



Reconstruction of past sea-level

WILEY-BLACKWELL

Cladistics

Cladistics 26 (2010) 526–538

10.1111/j.1096-0031.2009.00300.x

Why does the biota of the Madagascar region have such a strong Asiatic flavour?

Ben H. Warren[a,*], Dominique Strasberg[b], J. Henrich Bruggemann[b], Robert P. Prys-Jones[c] and Christophe Thébaud[d]

[a]UMR PVBMT, Université de La Réunion—CIRAD, 7 Chemin de l'IRAT, Ligne Paradis, 97410 Saint Pierre, Réunion, France; [b]UMR PVBMT and Laboratoire ECOMAR, Faculté des Sciences et Technologies, Université de La Réunion, 15 Avenue René Cassin BP 7151, 97715 Saint-Denis Cedex 9, Réunion, France; [c]Bird Group, Department of Zoology, The Natural History Museum, Akeman Street, Tring, Herts HP23 6AP, UK; [d]Laboratoire Evolution et Diversité Biologique, UMR CNRS 5174, Université Paul Sabatier, 118 Route de Narbonne, 31062 Toulouse Cedex 4, France

Geography of SWIO region with sea-level -135 m relative to current situation

Lineage origin and diversification I

An example in Asteraceae: *Psiadia* genus

- Rich endemic genus of Madagascar and Mascarenes
- Two colonizations events from Africa/Madagascar:
  - 1 from old to younger islands: Rodr. ↷ Maur. ↷ Réunion
  - 1 to Reunion
- \+ intra-island speciation

OPEN ACCESS Freely available online PLOS ONE

In and out of Madagascar: Dispersal to Peripheral Islands, Insular Speciation and Diversification of Indian Ocean Daisy Trees (*Psiadia*, Asteraceae)

Joeri S. Strijk[1,2*], Richard D. Noyes[3], Dominique Strasberg[4], Corinne Cruaud[5], Frédéric Gavory[5], Mark W. Chase[6], Richard J. Abbott[7], Christophe Thébaud[2]

1 Key Laboratory of Tropical Forest Ecology, Xishuangbanna Tropical Botanical Garden, Chinese Academy of Sciences, Menglun, Mengla, Yunnan, People's Republic of China, **2** Laboratoire Evolution et Diversité Biologique, UMR CNRS 5174 – Université Paul Sabatier – ENFA, Toulouse, France, **3** Department of Biology, University of Central Arkansas, Conway, Arkansas, United States of America, **4** Université de la Réunion, UMR PVBMT, Faculté des Sciences et Technologies, Saint-Denis, La Réunion, France, **5** CEA, Institut de Génomique, Genoscope, Centre National de Séquençage, Evry, France, **6** Jodrell Laboratory, Royal Botanic Gardens, Kew, Richmond, Surrey, United Kingdom, **7** Mitchell Building, School of Biology, University of St. Andrews, St. Andrews, Fife, United Kingdom

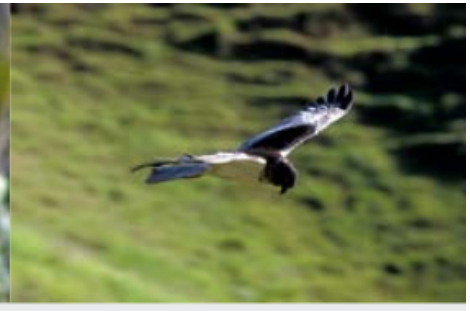
Diversity of Psiadia species and habitats on Réunion island

Example of on-going radiation in fauna

Bird diversity

Oiseau blanc (Zosterops borbonicus borbonicus)

Oiseau vert (Zosterops olivaceus)

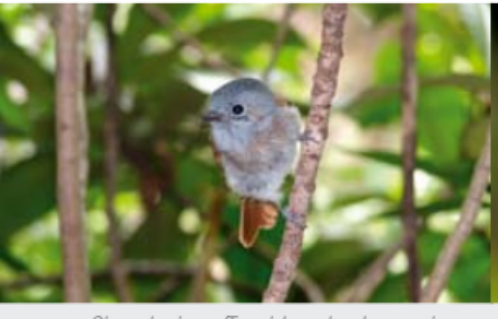


Papangue (Circus maillardi)

Tuit-Tuit (Coracina newtoni)

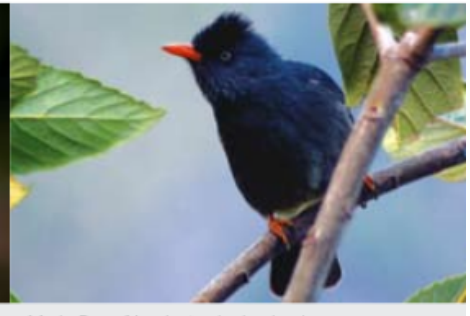
Pétrel de Barau (Pterodroma baraui)

Puffin de Baillon (Puffinus therminieri bailloni)



Oiseau la vierge (Terpsiphone bourbonnensis bourbonnensis)

Tec-tec (Saxicola tectes)

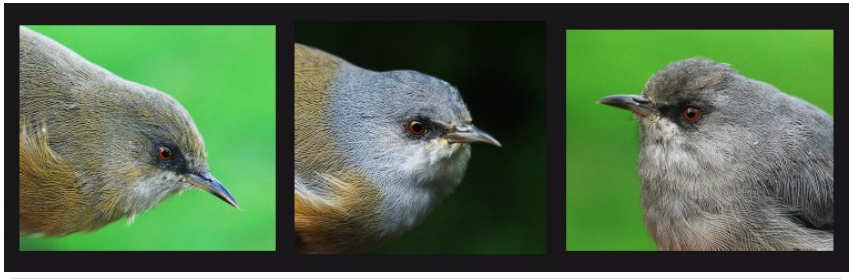


Merle Pays (Hypsipetes barbonicus)

- 19 native species
- 9 endemics + 2 sub-sp.
- 22 extinctions in 300 yrs
- 20 introductions (*Pycnonotus jocosus*, *Acridotheres tristis*,...)

Intra-island diversification

Landscape-structured populations in *Zosterops borboniucs*



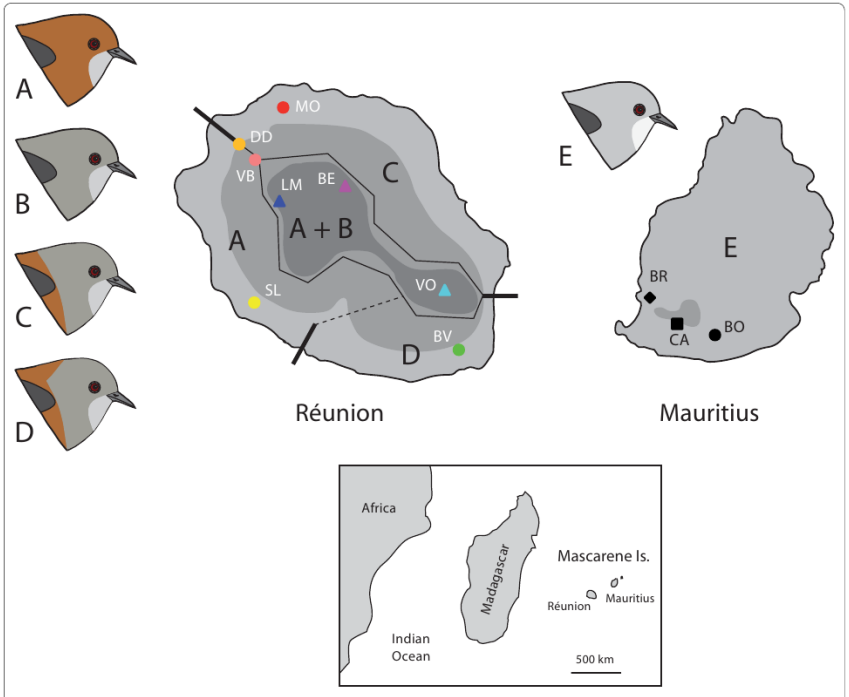
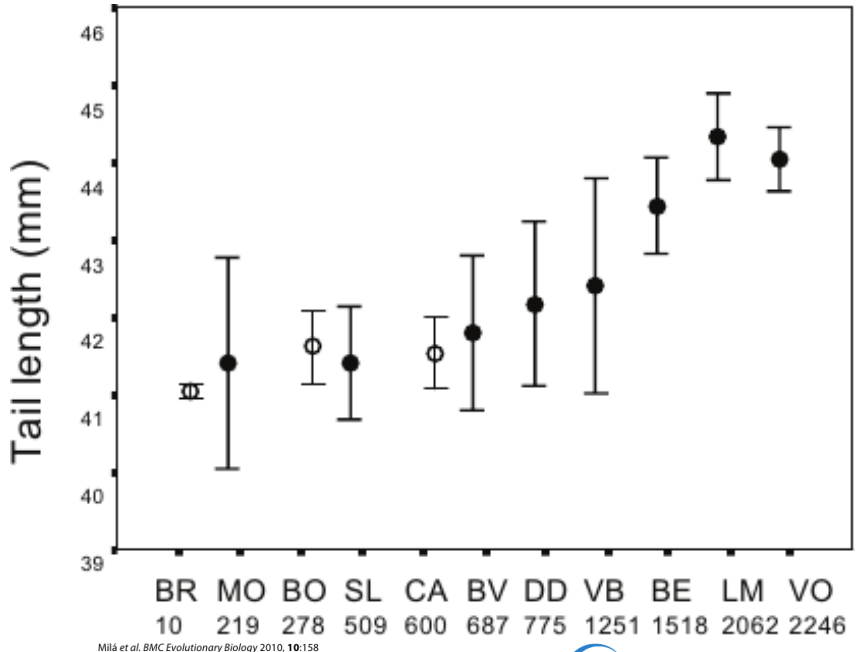


Figure 1 Sampling localities and geographic distribution of *Z. borbonicus* plumage morphs in Réunion and Mauritius, the two largest Mascarene Islands. Light, medium and dark grey layers on maps correspond to elevations 0-600 m, 600-1000 m, and 1000-3000 m, respectively. Thick lines correspond to sharp contact zones between morphs with narrow hybrid zones at rivers or lava flows. Thin black lines represent approximate boundaries between morphs away from contact zones (where considerable intergradation occurs). Dashed line indicates inferred boundary in unsurveyed area. Plumage morphs are coded as follows: A = brown, B = grey, C = grey-headed brown, D = grey-headed brown nape, E = Mauritius grey.



Milá *et al. BMC Evolutionary Biology* 2010, **10**:158
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BMC Evolutionary Biology

RESEARCH ARTICLE Open Access

The geographic scale of diversification on islands: genetic and morphological divergence at a very small spatial scale in the Mascarene grey white-eye (Aves: *Zosterops borbonicus*)

Borja Milá*[1], Ben H Warren[2], Philipp Heeb[3] and Christophe Thébaud[3]

Conclusions: Réunion island

Unique features

- Complex landscape heterogeneity, cirques
- Highly structured biodiversity at various levels
- High endemism

(Un-)expected patterns

- Continent/island model with Africa/Madagascar
- But multiple sources
- Significant Asian contribution despite distance

Many similarities with Hawaï's Big Island

- Geo-ecological features
- Remote continental colonizers
- Convergence in ecological strategies

Thank you for your attention