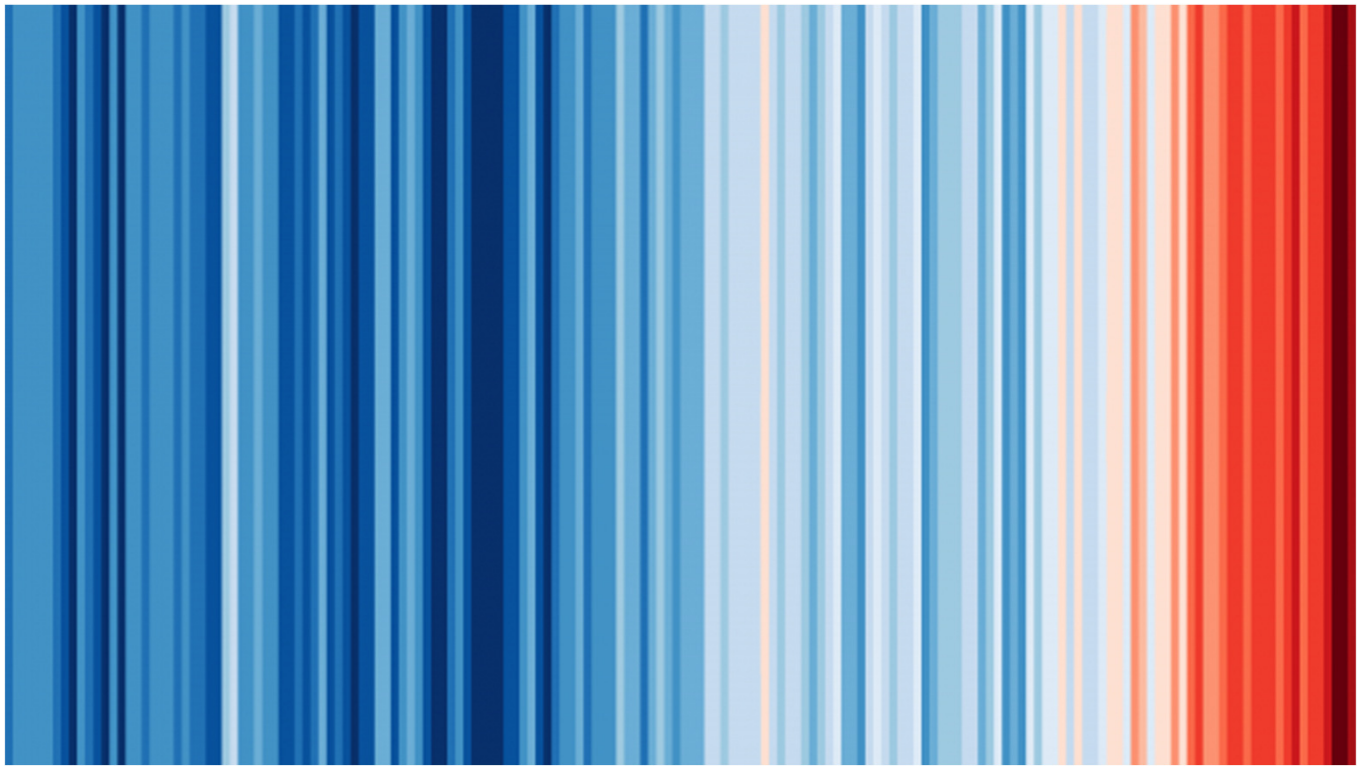
# Die Alpenflora im Klimawandel
# Stark gefährdet oder gut versichert?

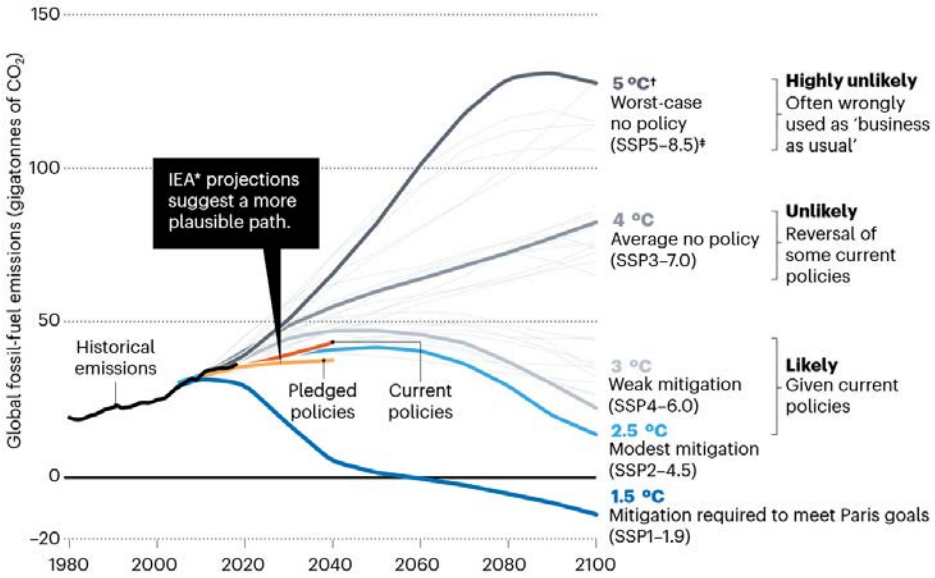
Stefan Dullinger

universität wien
Faculty of Life Sciences

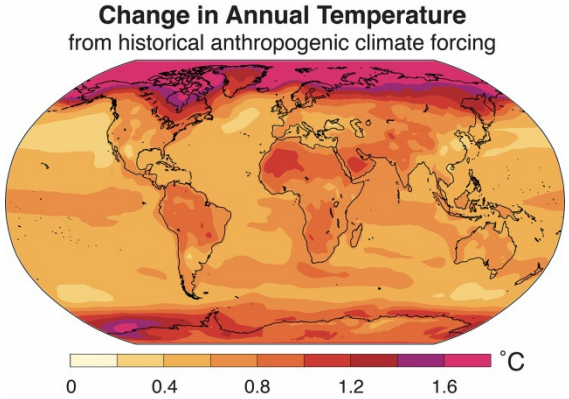
# Klimawandel

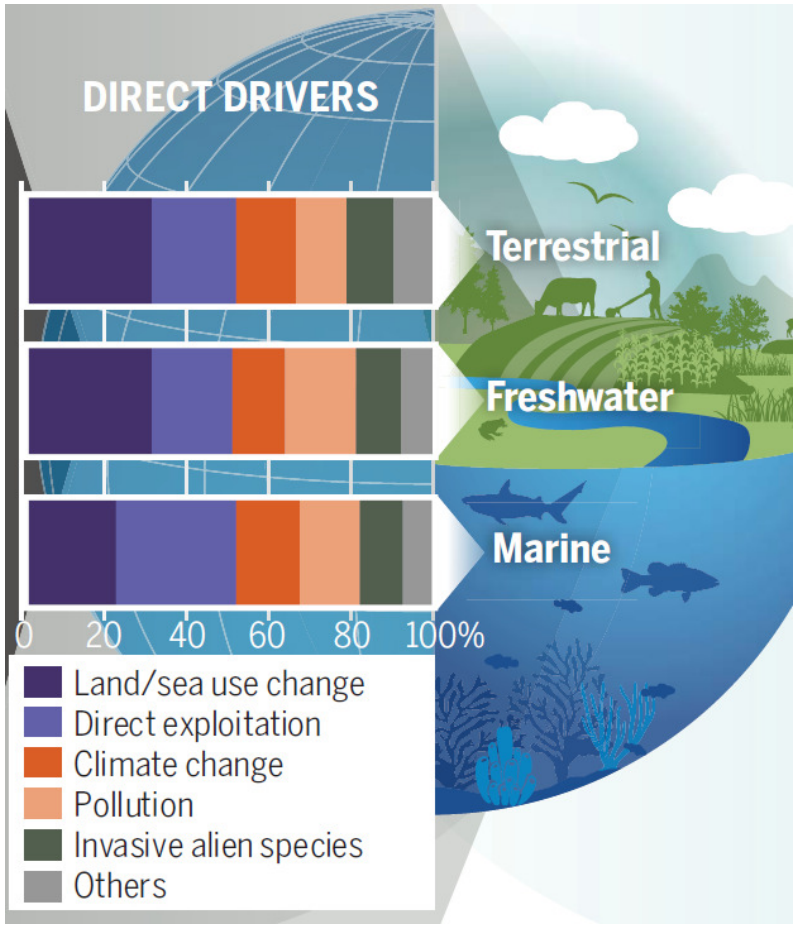


Quelle: Hawkins/ClimateLabBook

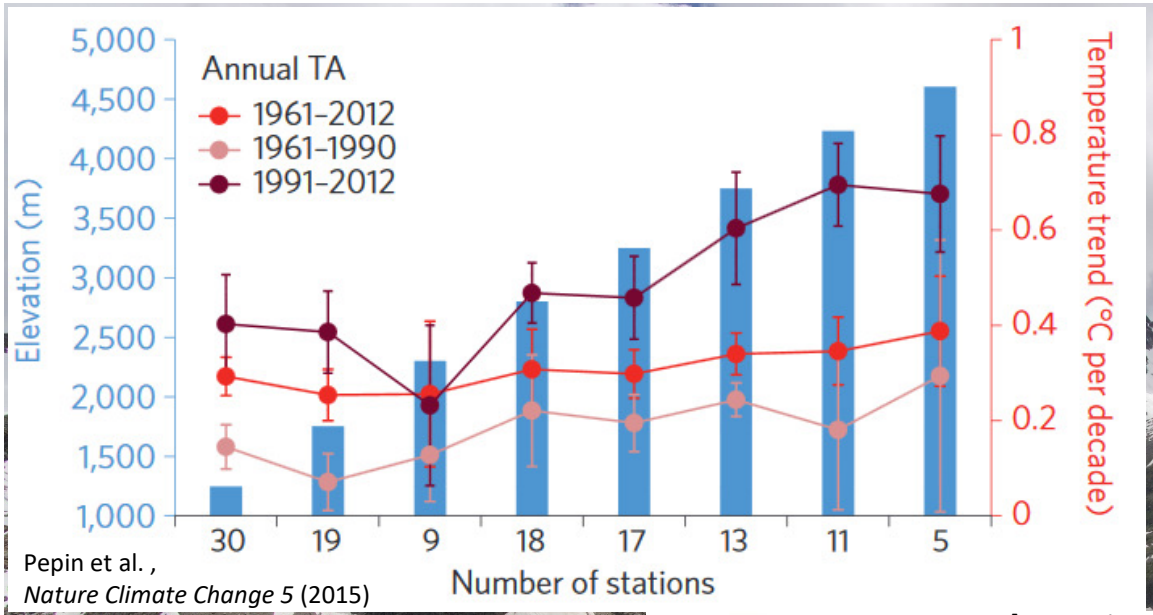



Hausfather & Peters, Nature (2020)



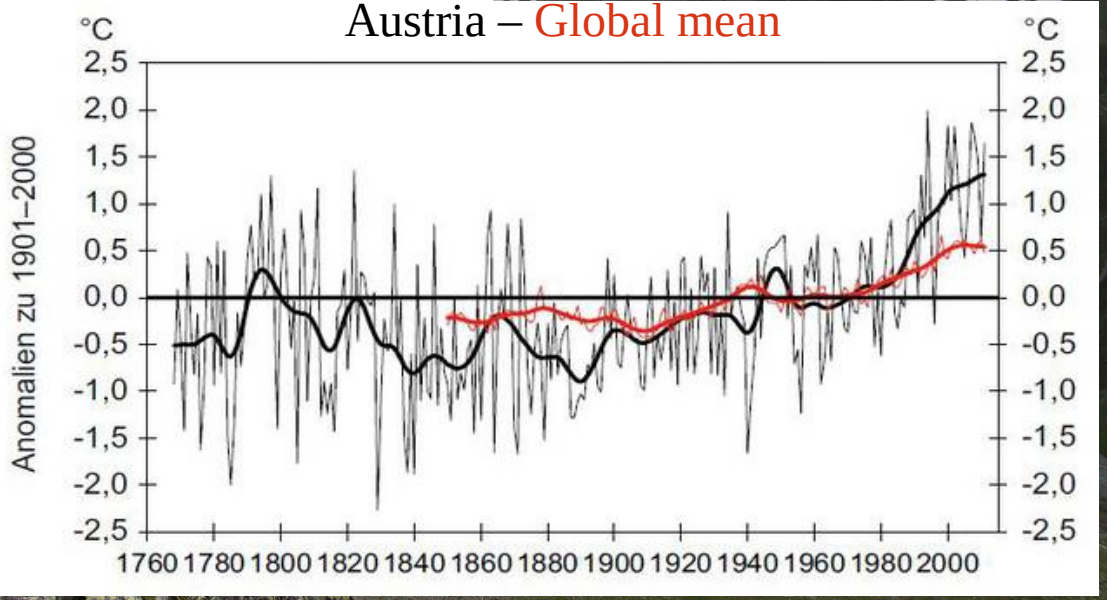

Diaz et al., Science (2019)



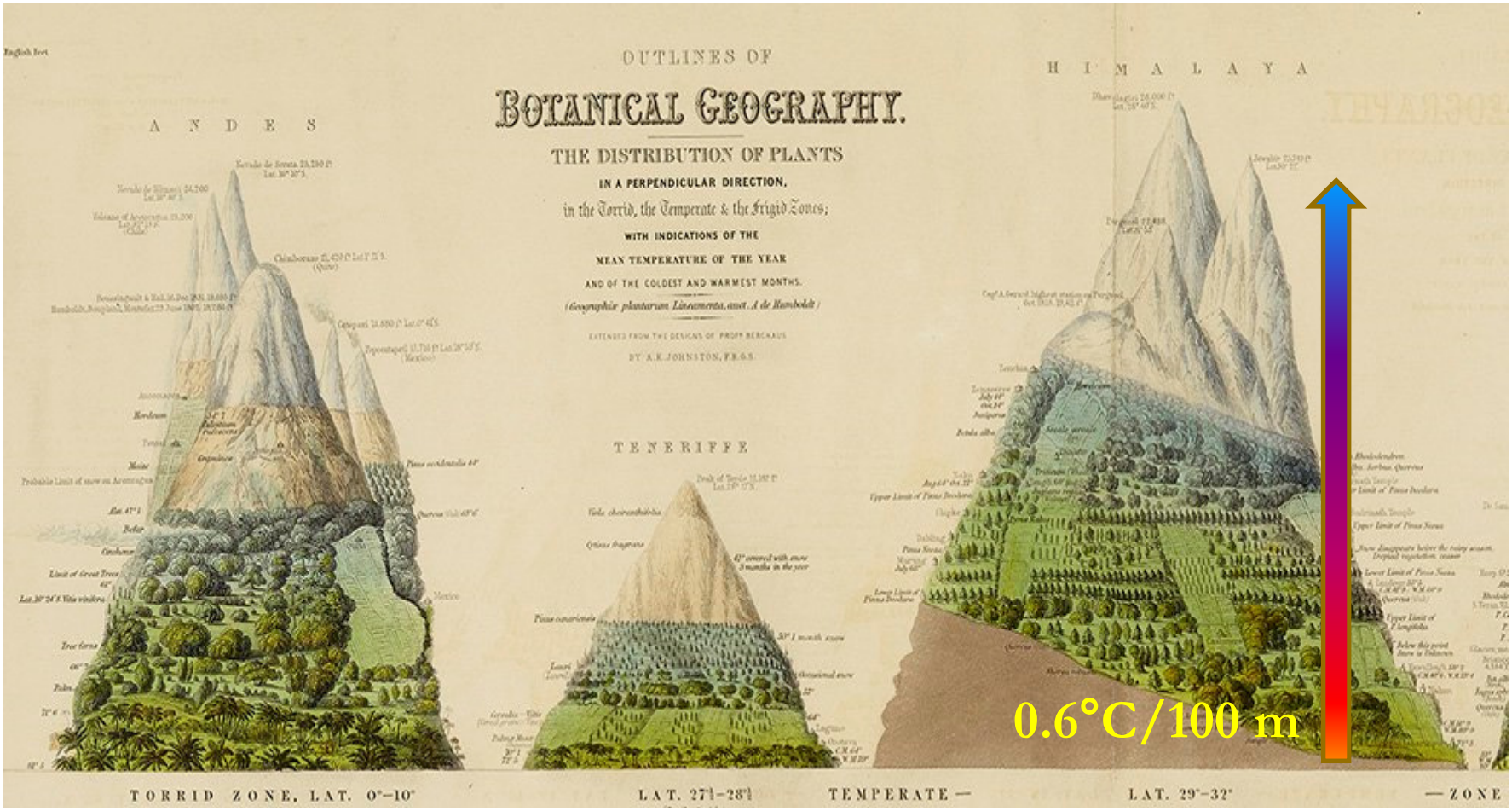

Pepin et al. ,
*Nature Climate Change 5* (2015)

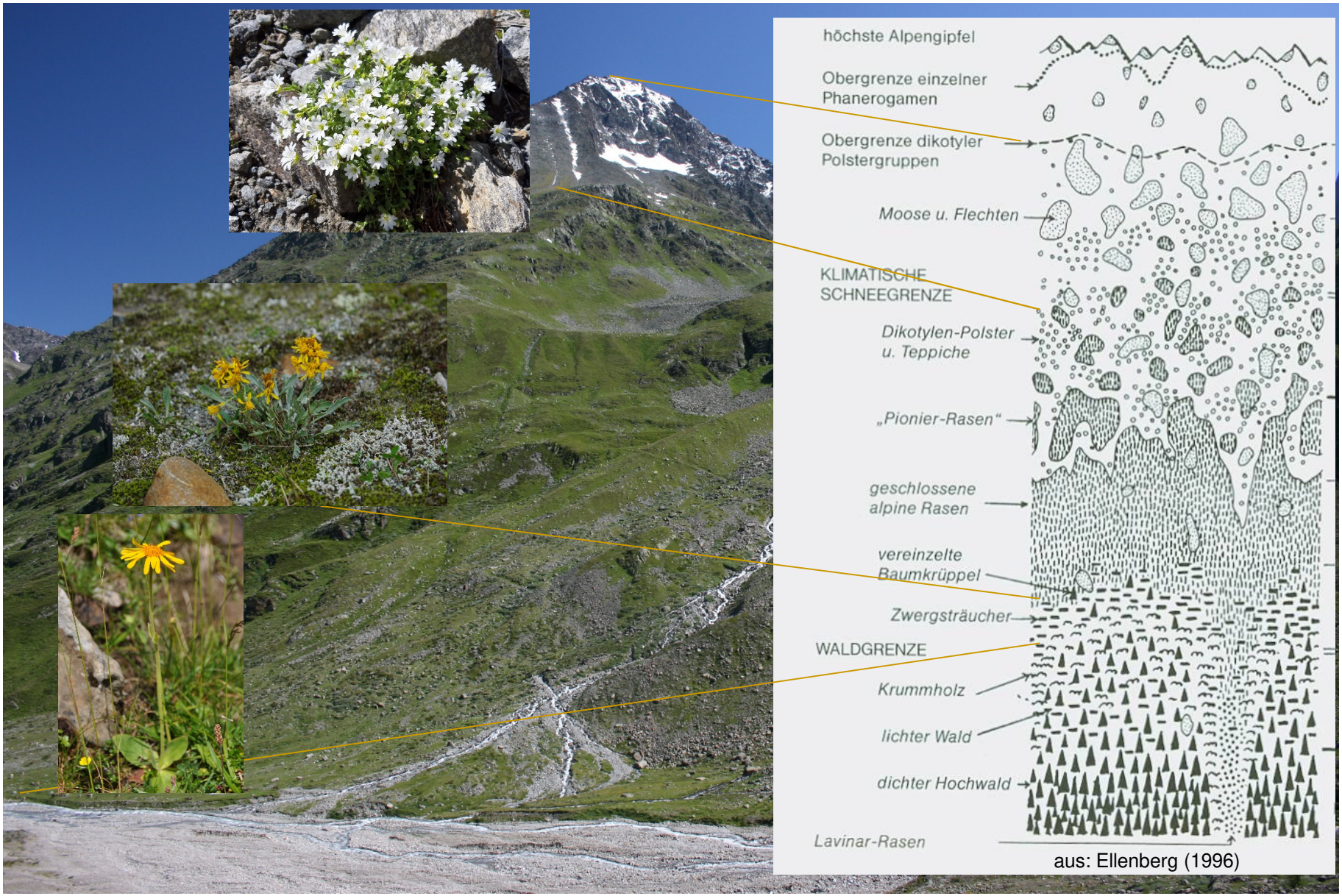
Foto: Kryštof Chytrý

## Austria – Global mean




http://www.zamg.ac.at/histalp

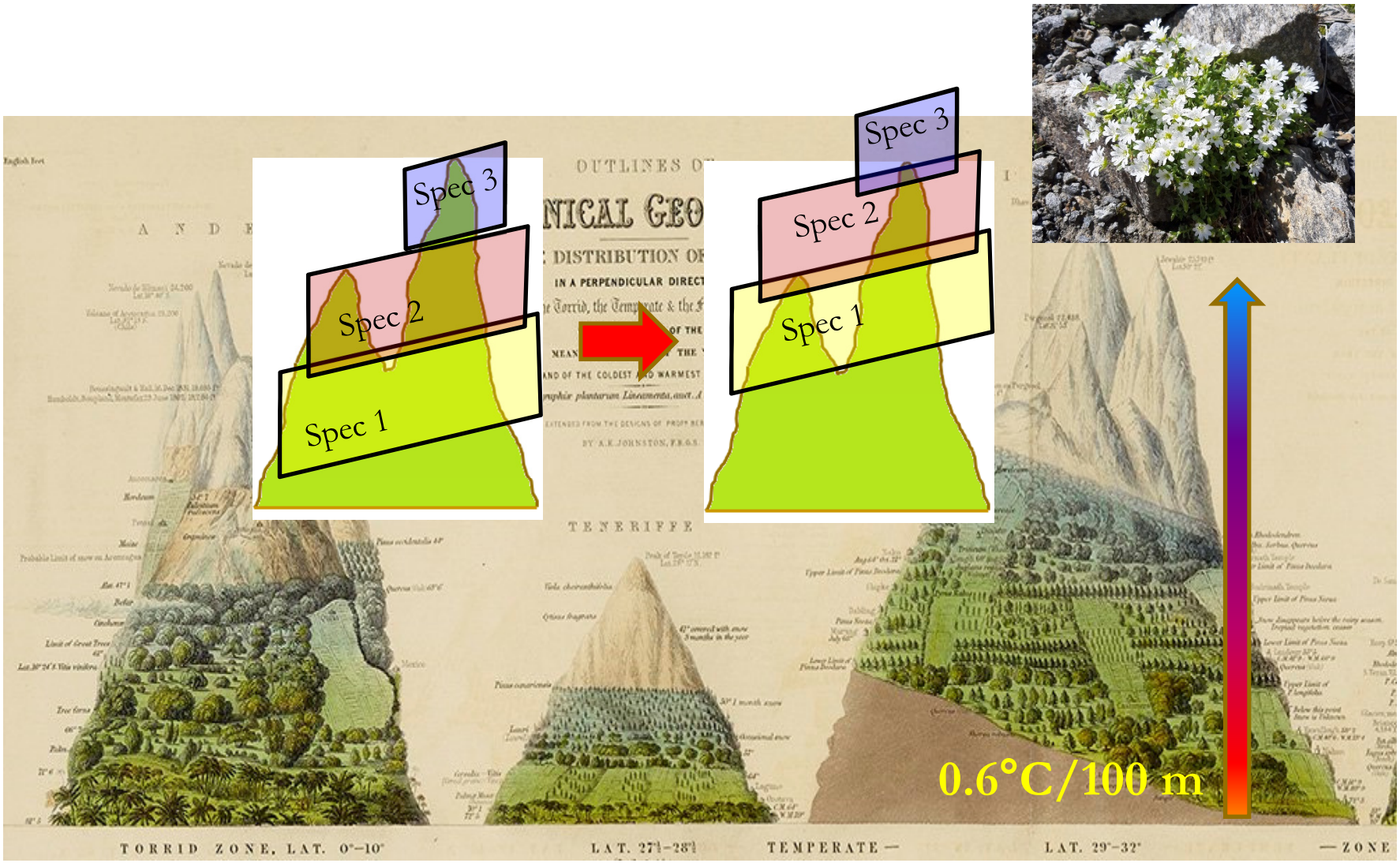

OUTLINES OF
BOTANICAL GEOGRAPHY.
THE DISTRIBUTION OF PLANTS
IN A PERPENDICULAR DIRECTION,
in the Torrid, the Temperate & the Frigid Zones;
WITH INDICATIONS OF THE
MEAN TEMPERATURE OF THE YEAR
AND OF THE COLDEST AND WARMEST MONTHS.
(Geographiæ plantarum Lineamenta, auct. A de Humboldt)
ANDES
TENERIFFE
HIMALAYA
0.6°C/100 m
TORRID ZONE, LAT. 0°–10°
LAT. 27½–28½
TEMPERATE —
LAT. 29°–32°
— ZONE



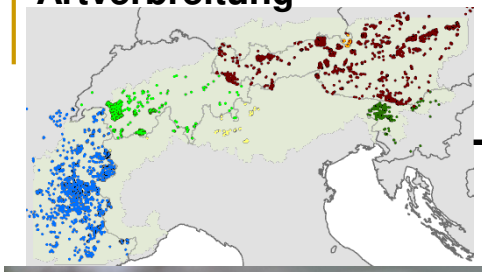

Stefan Dullinger

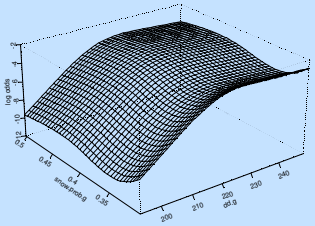
Foto-Credits:
Schrankogel: Harald Pauli
*Cerastium uniflorum* und *Senecio carniolicus*: Norbert Helm

universität wien
Faculty of Life Sciences


Spec 3
Spec 2
Spec 1
Spec 3
Spec 2
Spec 1
0.6°C/100 m
TORRID ZONE, LAT. 0°–10°
LAT. 27½–28½
TEMPERATE —
LAT. 29°–32°
— ZONE

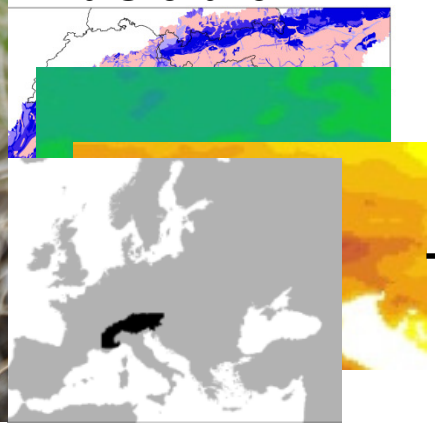
**Artverbreitung**



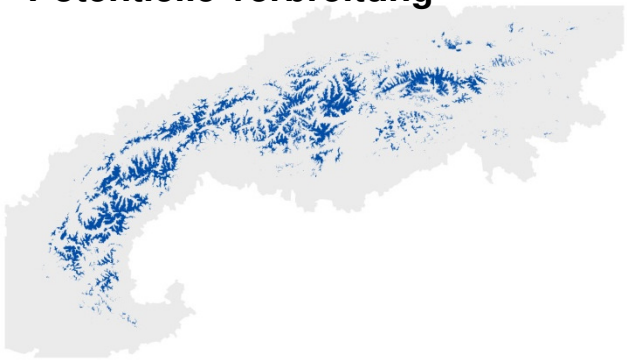


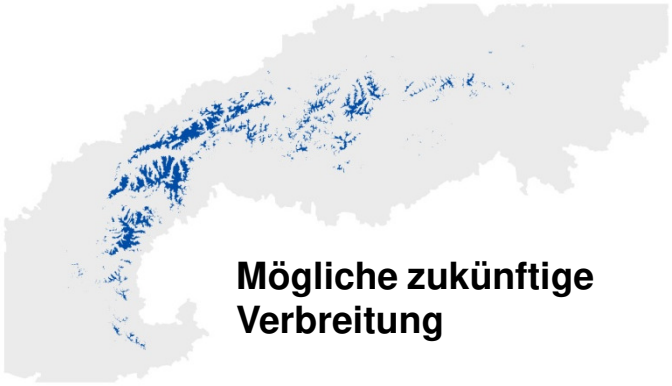
P(Art kommt vor) = f(X)

**Klima-Szenarien**



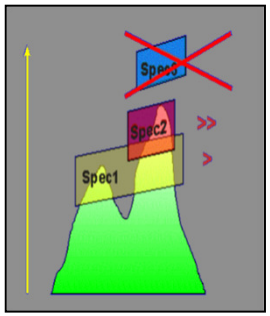
**Potentielle Verbreitung**

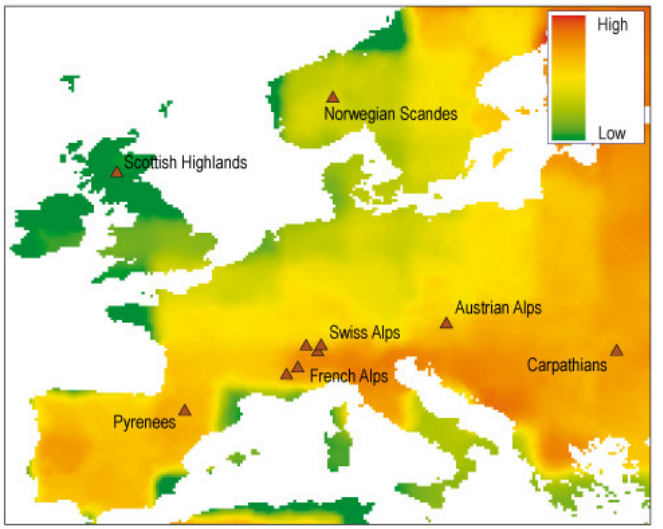


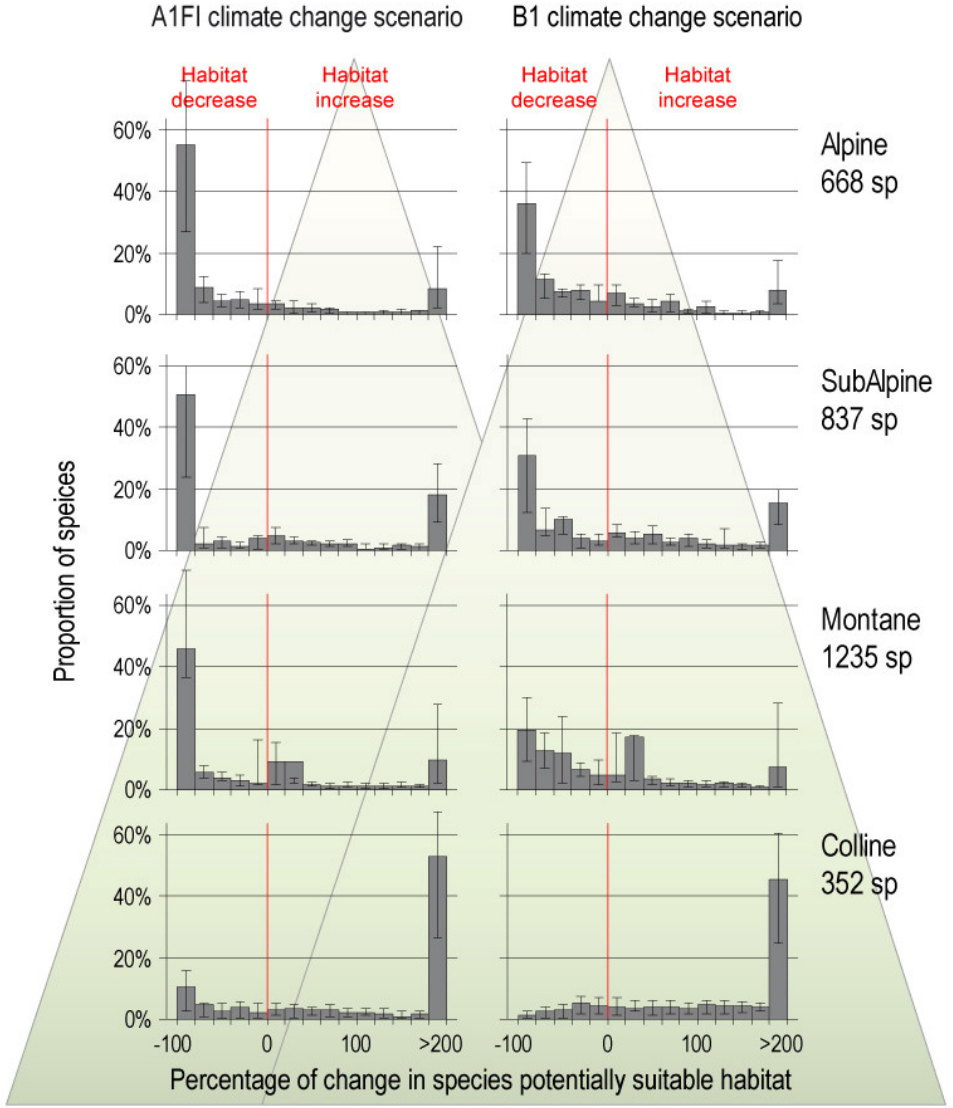


**Mögliche zukünftige Verbreitung**

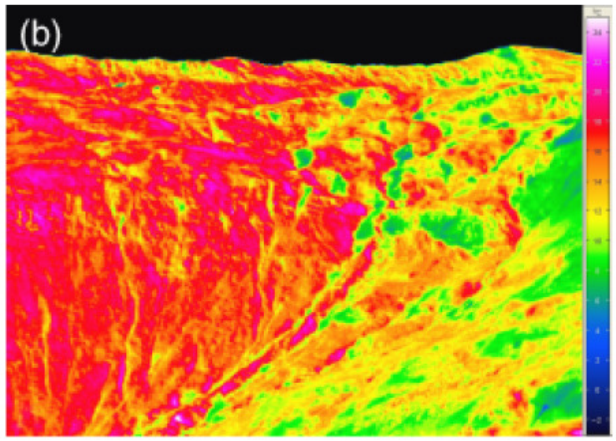
## Stark gefährdet!



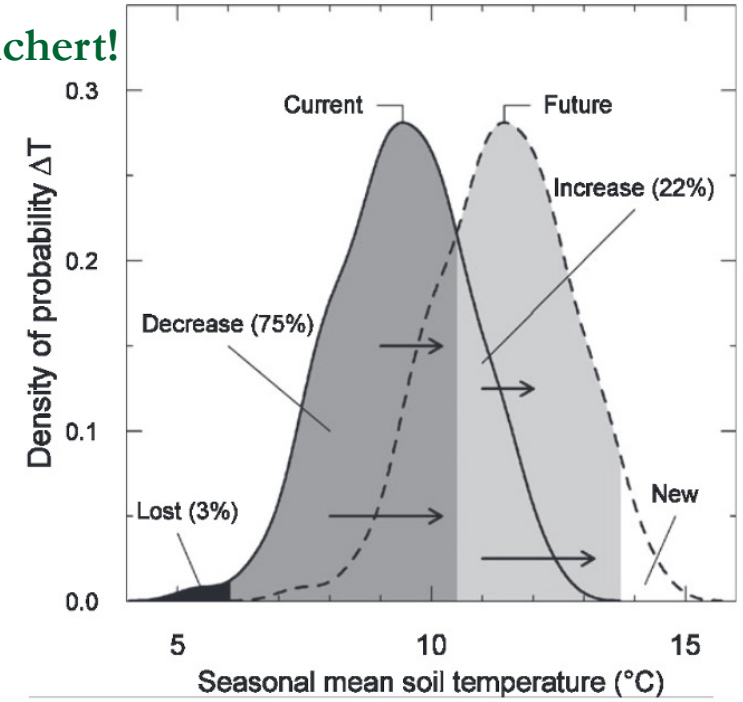




Engler et al., ***Global Change Biology*** (2011)




**Gut versichert!**

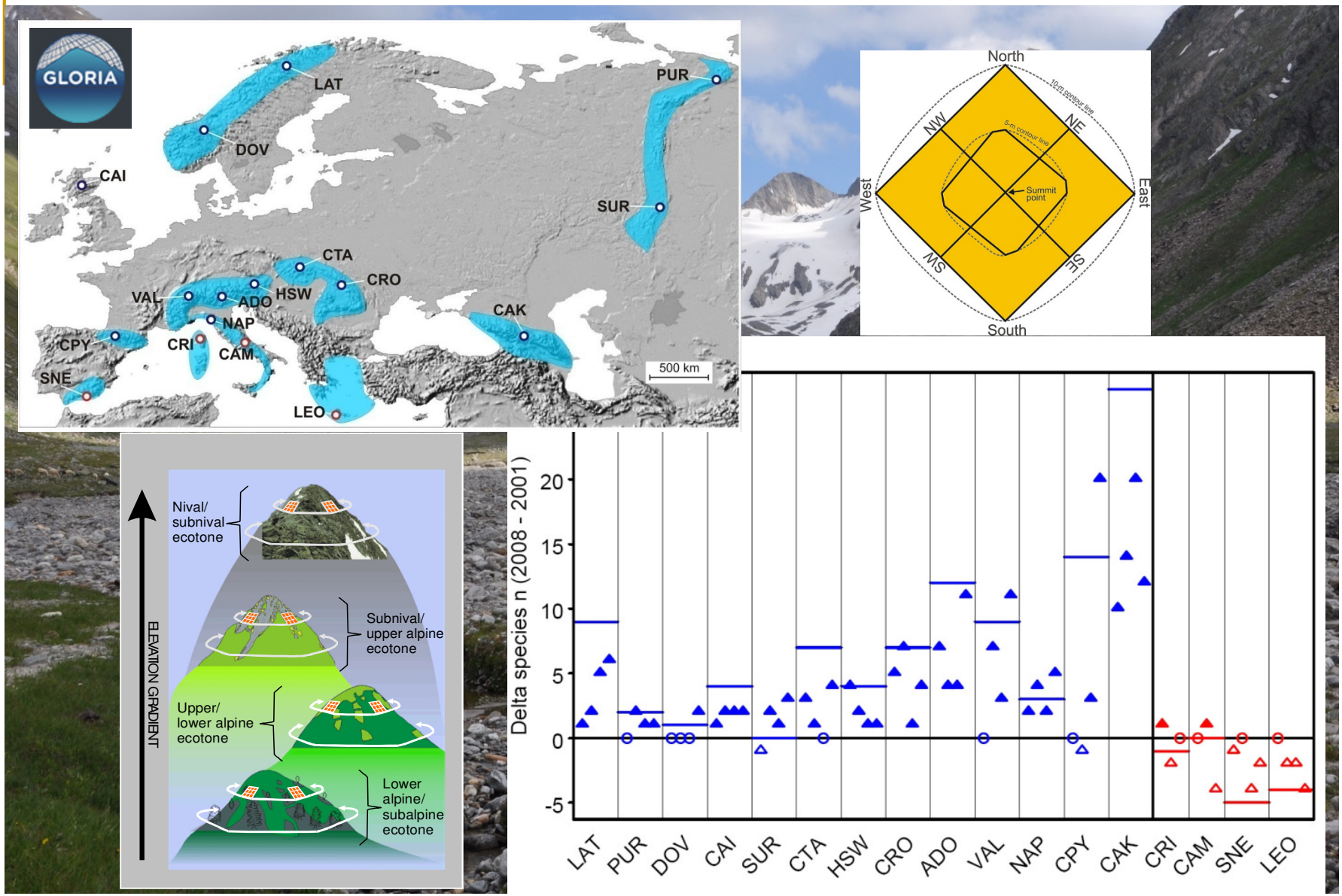



*Journal of Biogeography (J. Biogeogr.)* (2010)

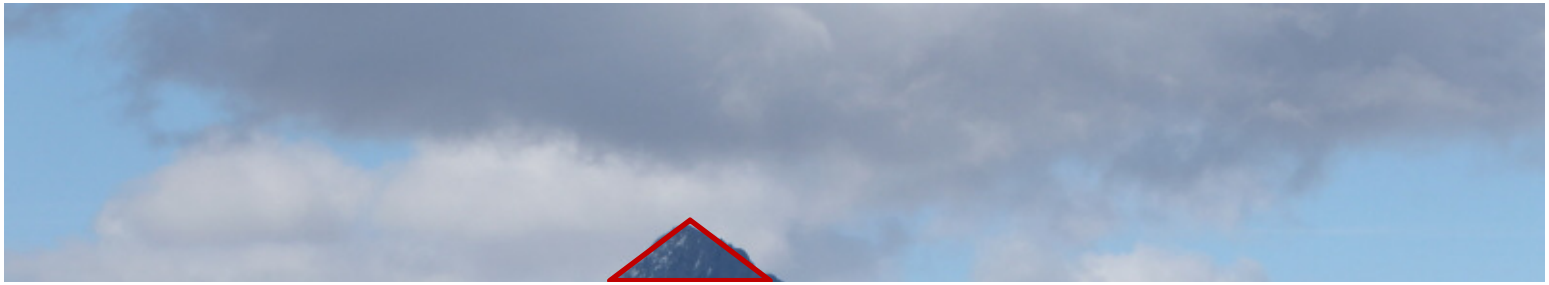
ORIGINAL ARTICLE

**Topographically controlled thermal-habitat differentiation buffers alpine plant diversity against climate warming**

Daniel Scherrer* and Christian Körner




Pauli et al., ***Science*** (2012).

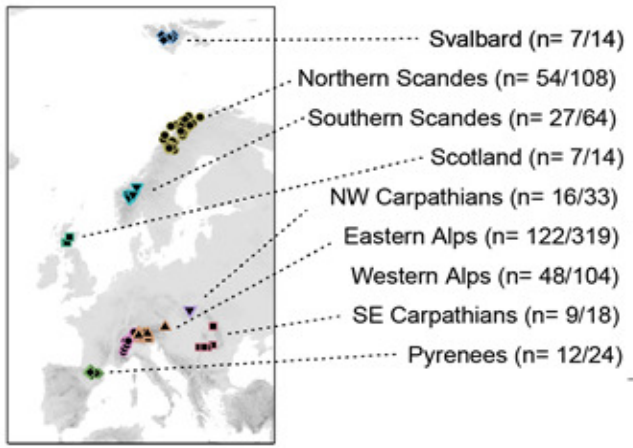


Above: Bogumil Pawlowski (1898-1971)
Left: Pawlowski`s herbarium

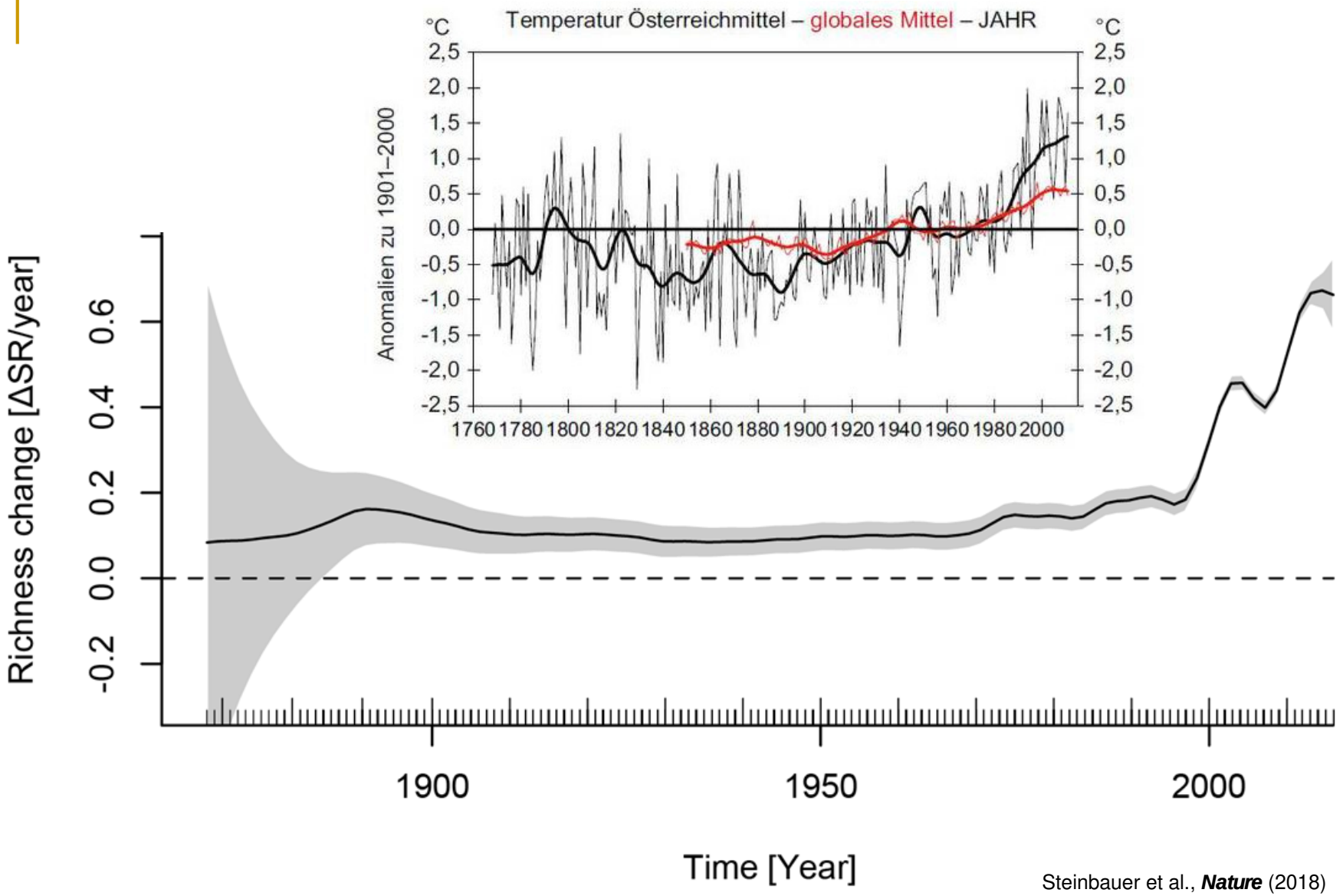
Josias Braun-Blanquet (1884-1980)

Botanists expedition (Pawlowski)

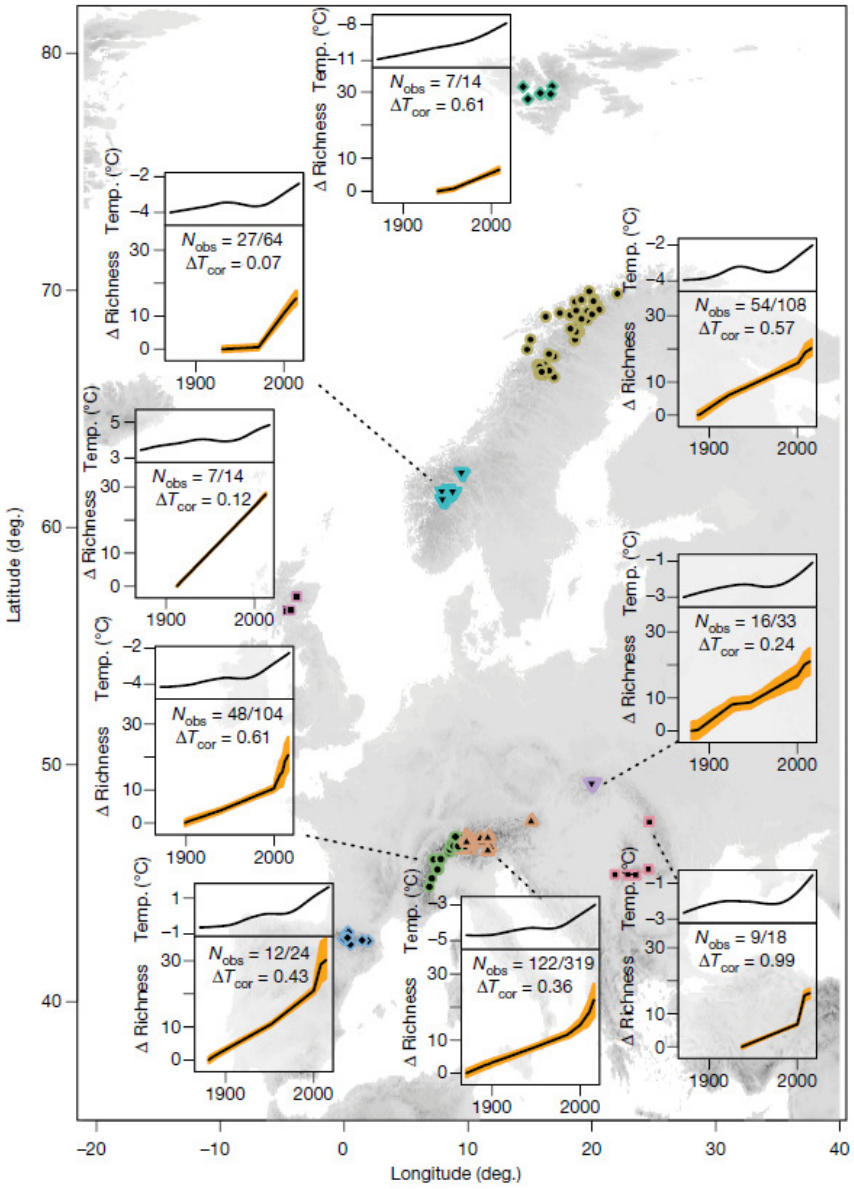
Eduard Rübel (1867-1960)

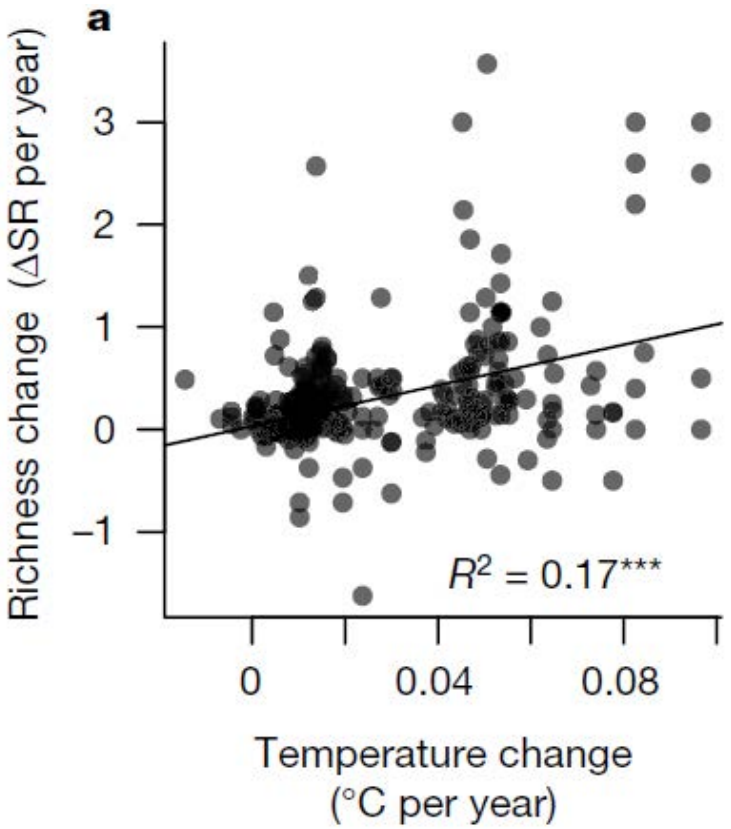



Steinbauer et al., ***Nature*** (2018)

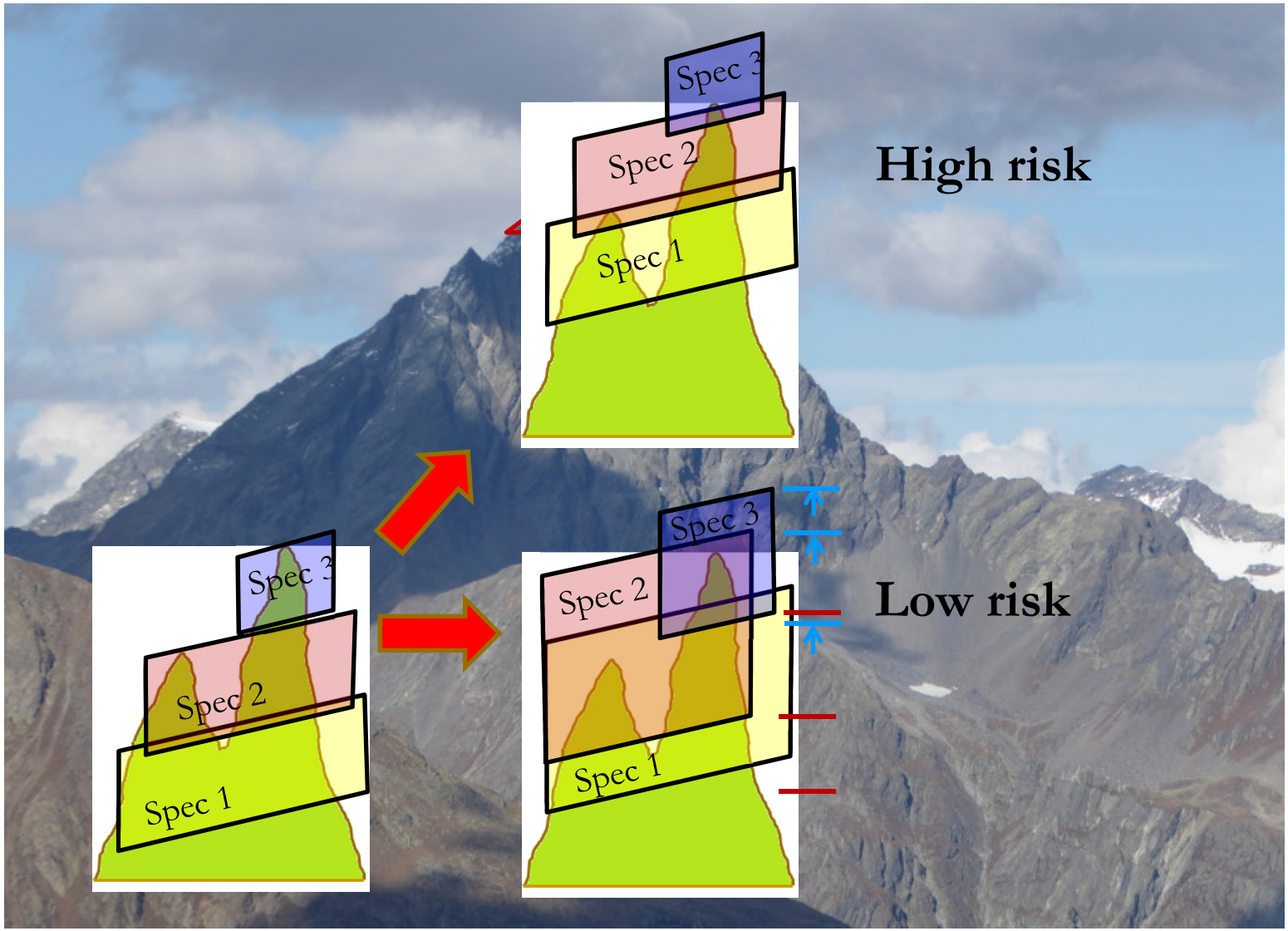


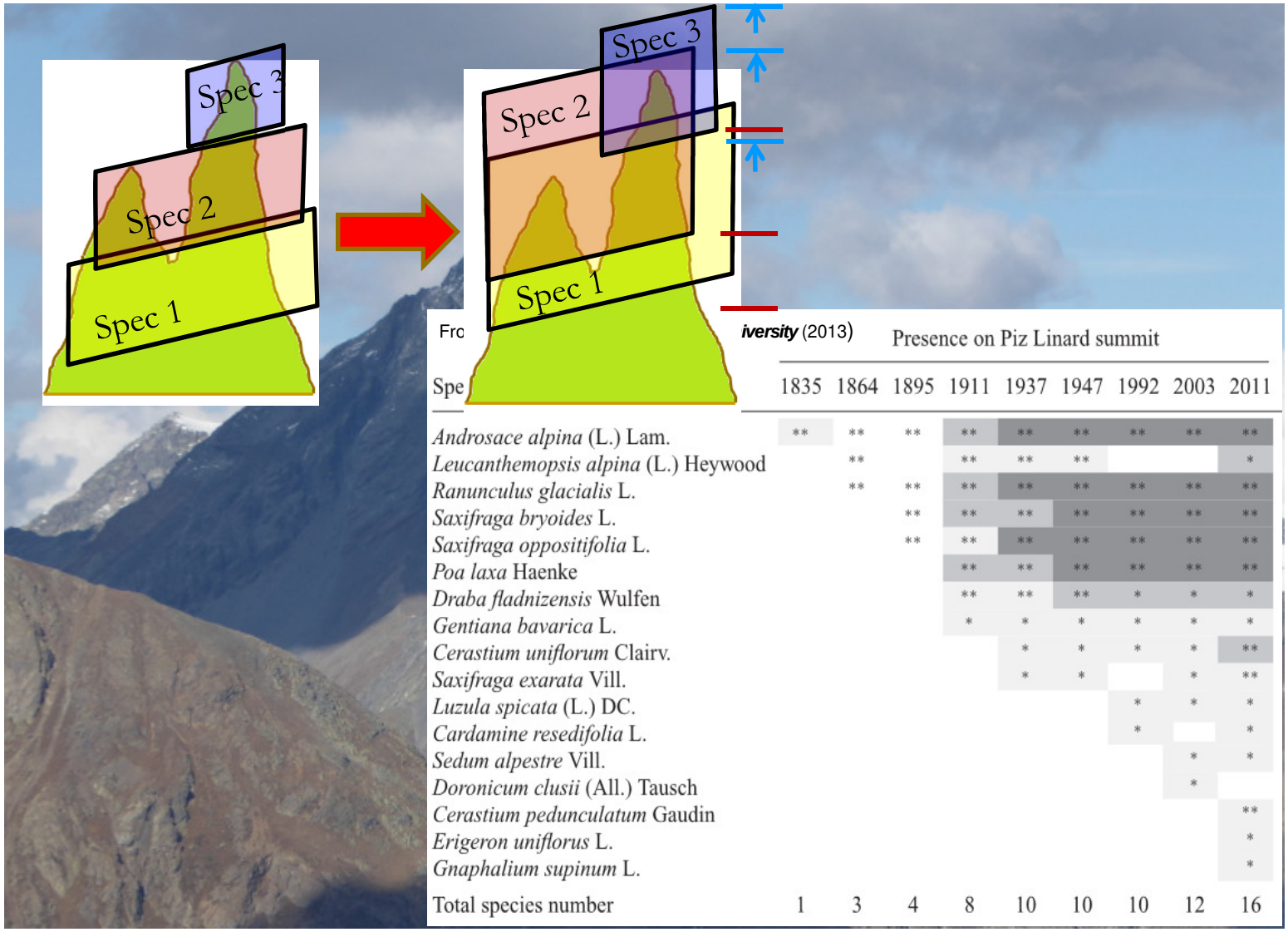

Steinbauer et al., ***Nature*** (2018)




Steinbauer et al., ***Nature*** (2018)


Spec 3
Spec 2
Spec 1
High risk
Spec 3
Spec 2
Spec 1
Spec 3
Spec 2
Spec 1
Low risk




Fro ***iversity*** (2013)

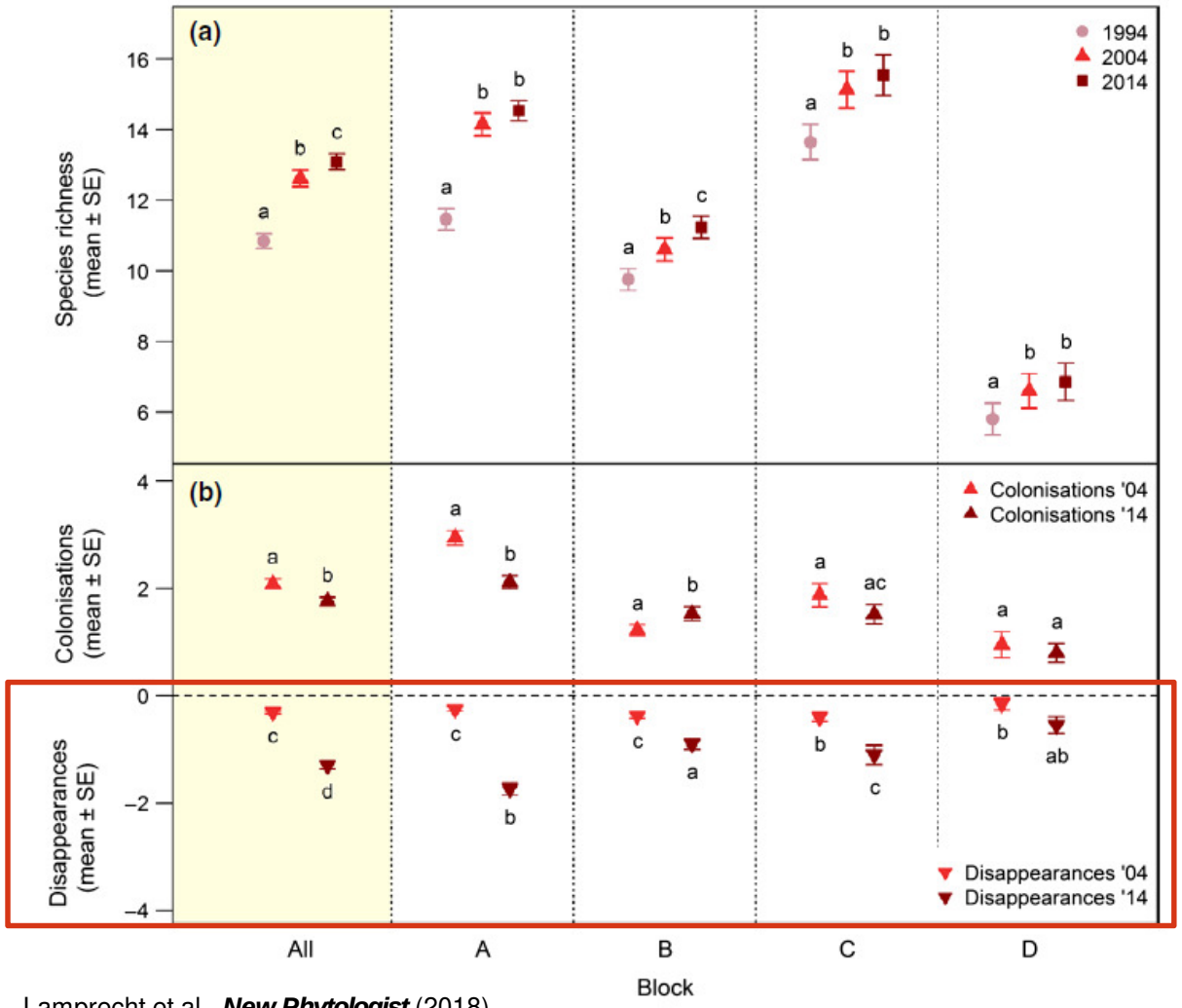
| Spe | Presence on Piz Linard summit | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 1835 | 1864 | 1895 | 1911 | 1937 | 1947 | 1992 | 2003 | 2011 |
| *Androsace alpina* (L.) Lam. | ** | ** | ** | ** | ** | ** | ** | ** | ** |
| *Leucanthemopsis alpina* (L.) Heywood | | ** | | ** | ** | ** | | | * |
| *Ranunculus glacialis* L. | | ** | ** | ** | ** | ** | ** | ** | ** |
| *Saxifraga bryoides* L. | | | ** | ** | ** | ** | ** | ** | ** |
| *Saxifraga oppositifolia* L. | | | ** | ** | ** | ** | ** | ** | ** |
| *Poa laxa* Haenke | | | | ** | ** | ** | ** | ** | ** |
| *Draba fladnizensis* Wulfen | | | | ** | ** | ** | * | * | * |
| *Gentiana bavarica* L. | | | | * | * | * | * | * | * |
| *Cerastium uniflorum* Clairv. | | | | | * | * | * | * | ** |
| *Saxifraga exarata* Vill. | | | | | * | * | | * | ** |
| *Luzula spicata* (L.) DC. | | | | | | | * | * | * |
| *Cardamine resedifolia* L. | | | | | | | * | | * |
| *Sedum alpestre* Vill. | | | | | | | | * | * |
| *Doronicum clusii* (All.) Tausch | | | | | | | | * | |
| *Cerastium pedunculatum* Gaudin | | | | | | | | | ** |
| *Erigeron uniflorus* L. | | | | | | | | | * |
| *Gnaphalium supinum* L. | | | | | | | | | * |
| Total species number | 1 | 3 | 4 | 8 | 10 | 10 | 10 | 12 | 16 |

Stefan Dullinger

Foto-Credits:
Sampling: Harald Pauli

universität wien
Faculty of Life Sciences

**1641** Kolonisierungs- und **388** Extinktionsereignisse zwischen 1994 und 2014




Lamprecht et al., ***New Phytologist*** (2018)

**ABER:**
Extinktionsereignisse werden häufiger

Besonders in den tiefstgelegenen Flächen → Zurückweichen der unteren Verbreitungsgrenzen?

*Androsace alpina*:
59 Extinktionen

*Poa laxa*:
40 Extinktionen

*Cerastium uniflorum*: 37 Extinktionen

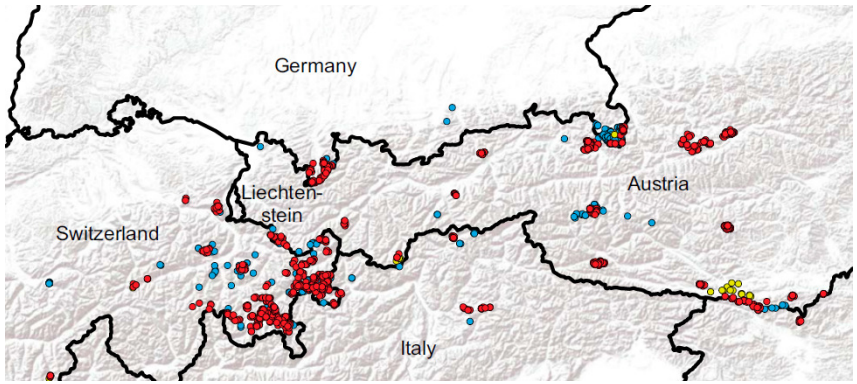
*Ranunculus glacialis*: 43 Extinktionen

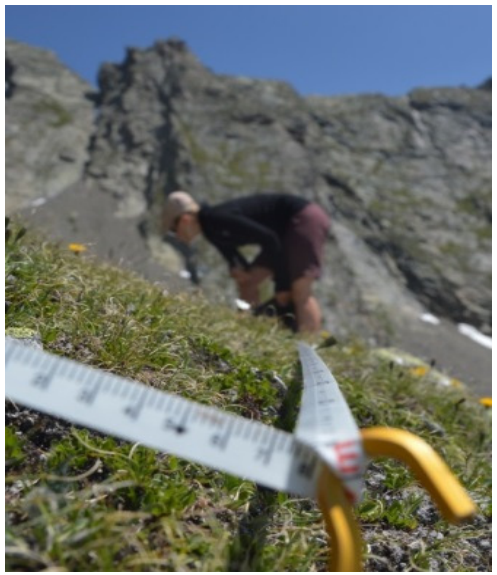
Stefan Dullinger

Foto-Credits:
*Poa*, *Cerastium* und *Ranunculus*: Norbert Helm

universität wien
Faculty of Life Sciences

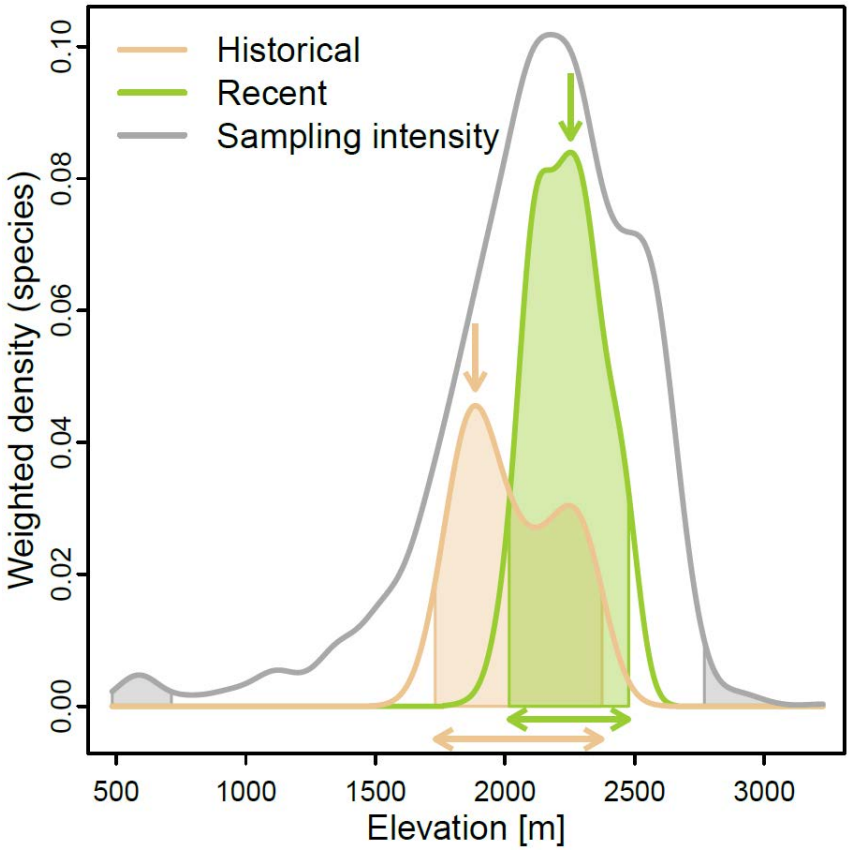
Resurvey mit Fokus auf Gesamtverbreitung: **Ober- und Untergrenze: 300 – 3000 m.ü.M.**



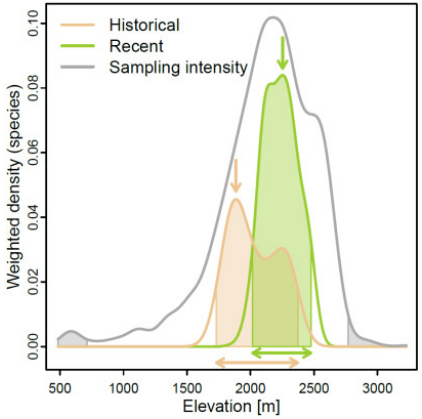
1500 wiederholte Vegetationsaufnahmen

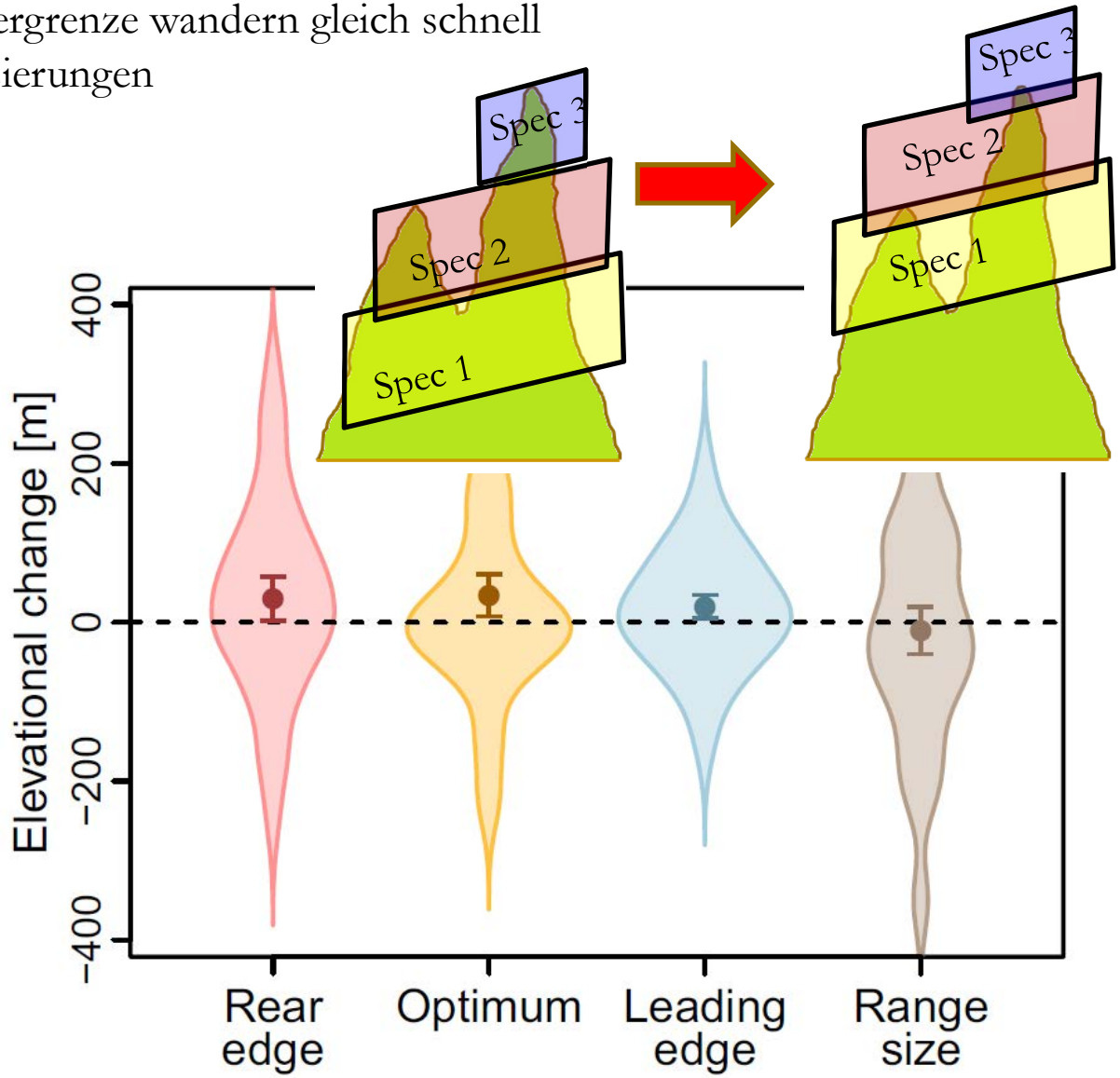
Historisch – vor 1970
Rezent – 2013/14




Rumpf et al., ***PNAS*** 2018

**183 Arten**: Ober- und Untergrenze wandern gleich schnell
→ Extinktionen ~ Kolonisierungen

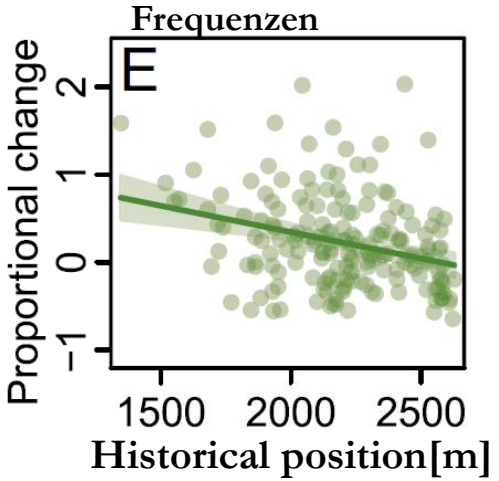


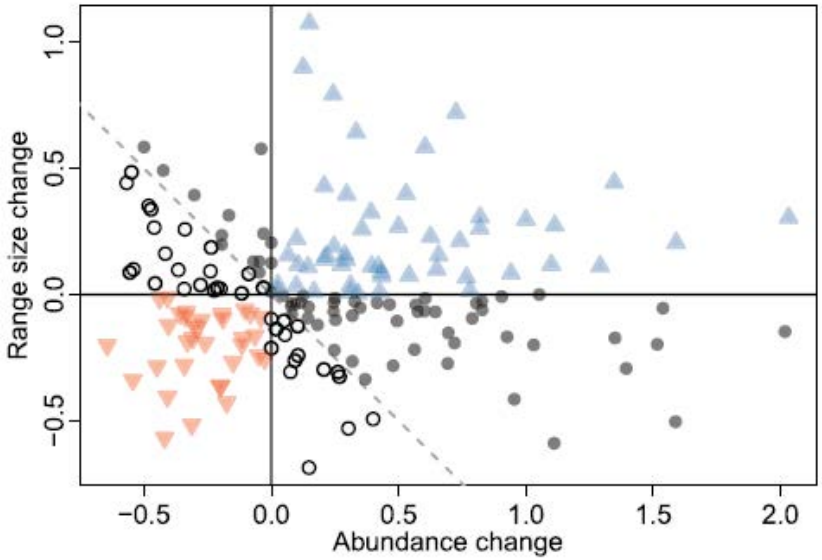



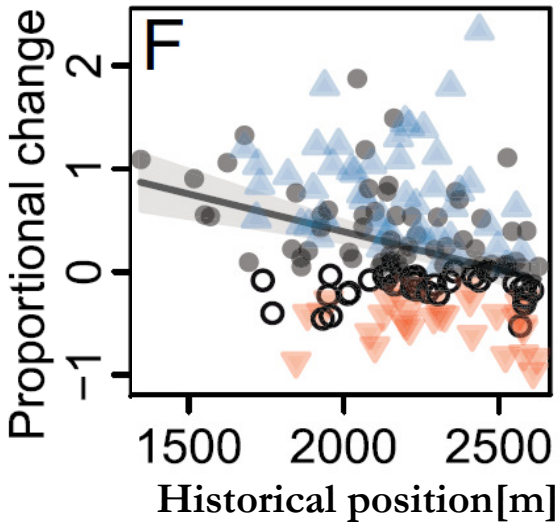



Rumpf et al., ***PNAS*** (2018)

Je höher der Verbreitungschwerpunkt, desto größer die Wahrscheinlichkeit von **Abundanzrückgang** und **Verengung der Höhenverbreitung**



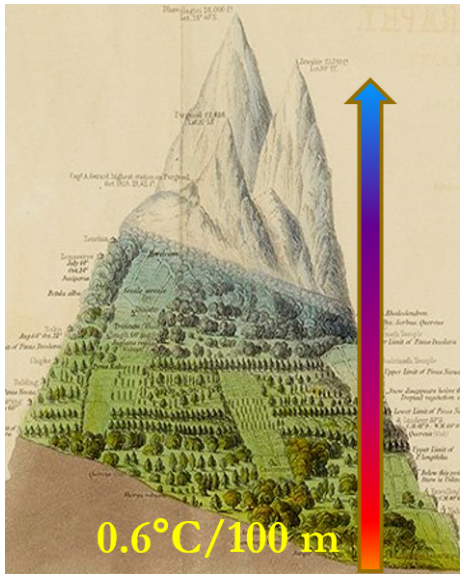

Rumpf et al., ***PNAS*** (2018)

# Zwischenbilanz

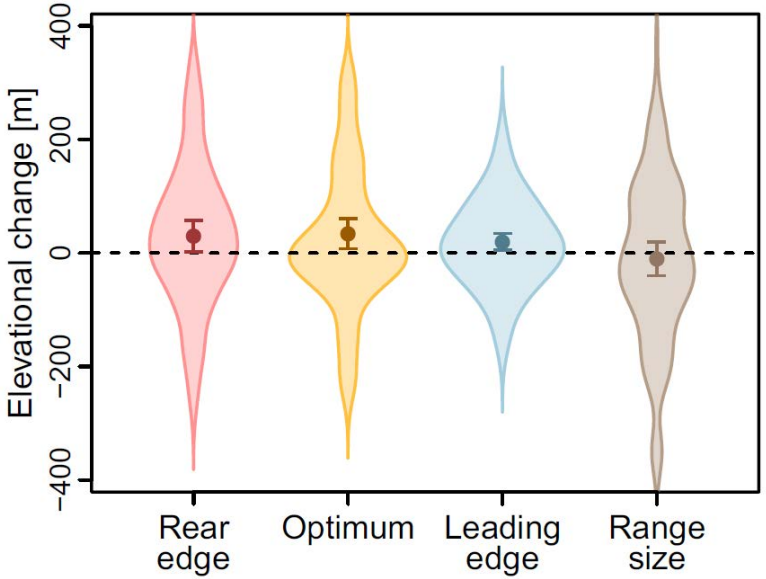
**Es passiert was:** Kolonisierungen und Extinktionen, gerichtet = nach oben → Klimawandeleffekt

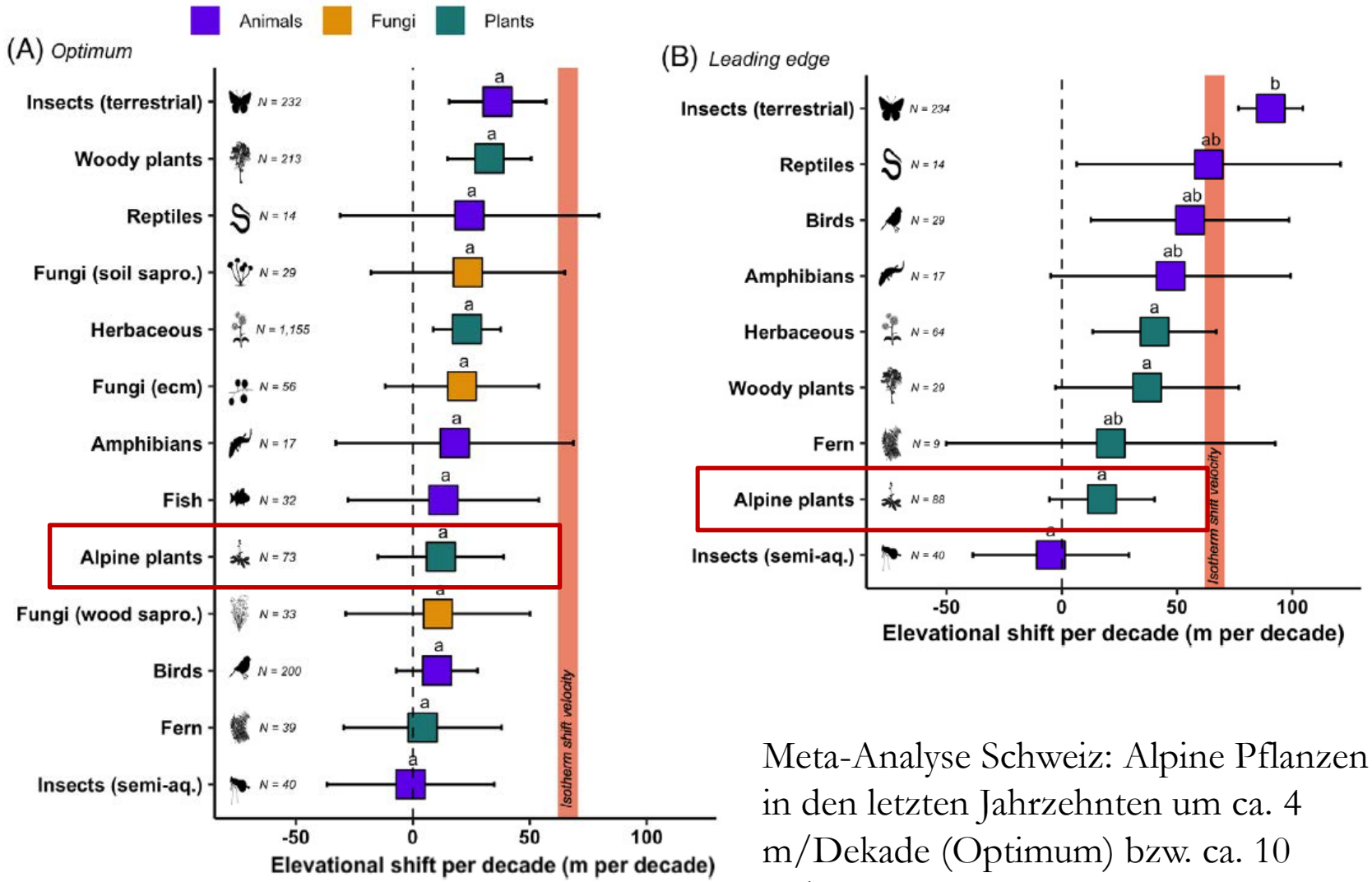
**Gipfel**: viele Kolonisierungen, wenig Extinktion: Expansion.
**Gesamte Höhenverbreitung**: Kolonosierungen an der Obergrenze, Extinktionen an der Untergrenze: Parallelverschiebung

**Erwartet: 1,5/0,6 = 2,5*100 ~ 250 m**




**Beobachtet: ~ 30 m**



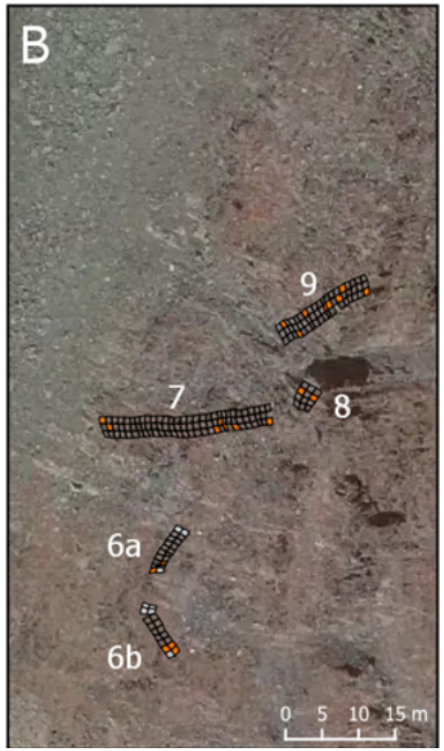


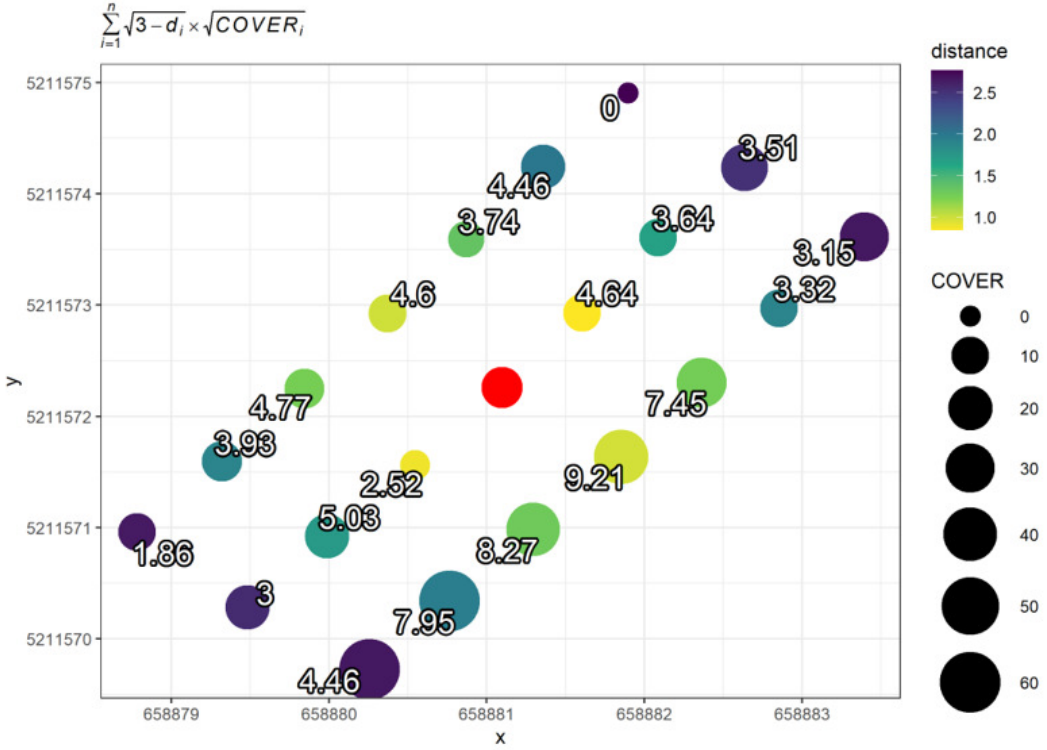

Vitasse et al., ***Biological Reviews*** (2021)

Meta-Analyse Schweiz: Alpine Pflanzen sind in den letzten Jahrzehnten um ca. 4 m/Dekade (Optimum) bzw. ca. 10 m/Dekade (Obergrenze) gewandert

Ist die Wahrscheinlichkeit einer Kolonisierung *innerhalb von 20 Jahren* (1994 – 2014) mit
- Habitat-Eignung der 1 m²-Fläche
- **Diasporendruck** (Abundanz in **r = 3 m** im Jahr 1994)
- Dichte der Vegetationsdecke

korreliert?



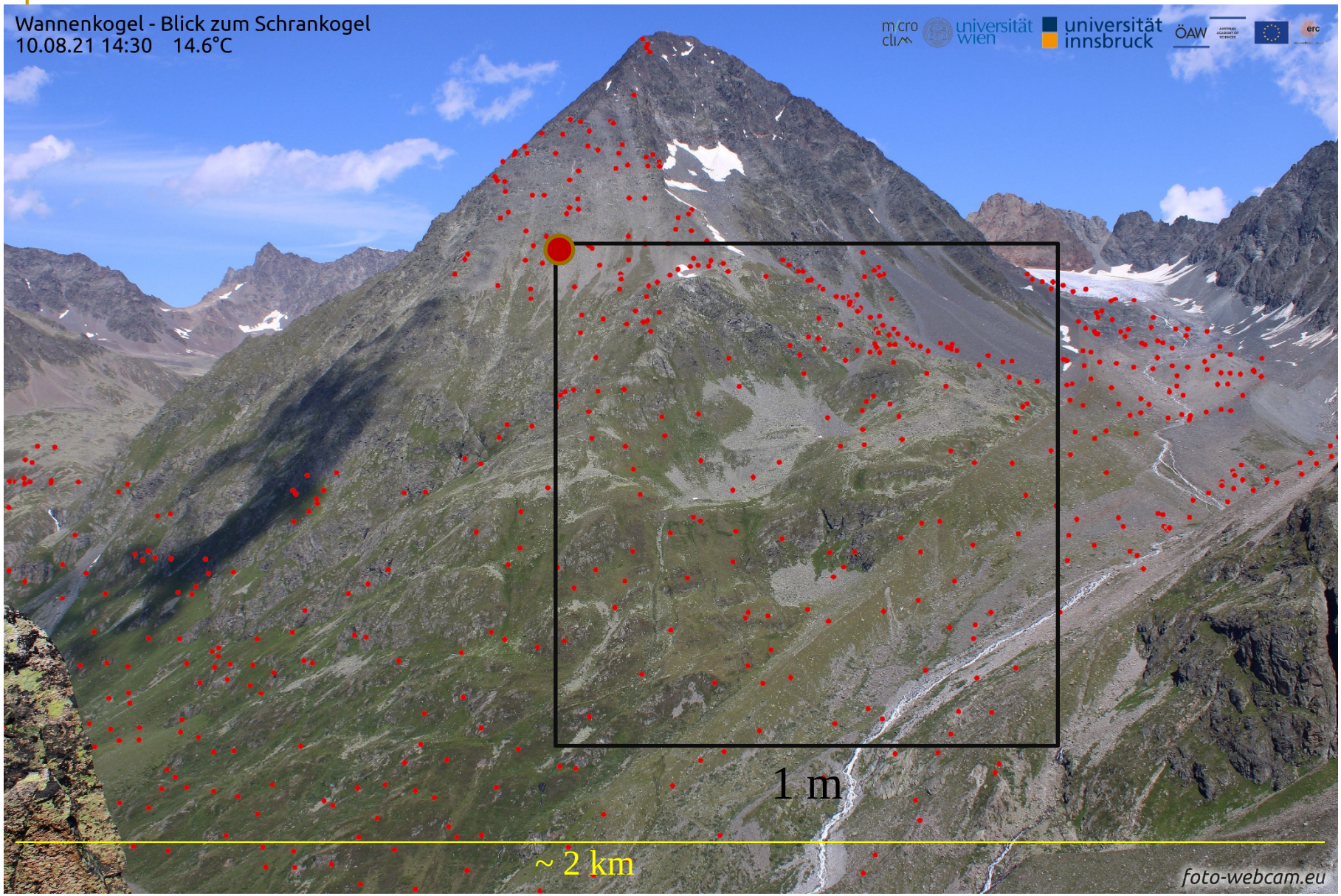
Ausbreitungsfähigkeit vieler Arten ist sehr beschränkt

Helm et al., ***in prep.***

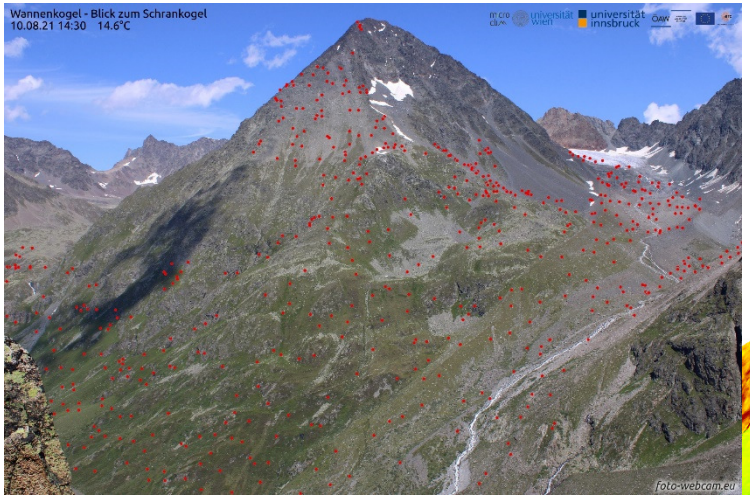
Stefan Dullinger

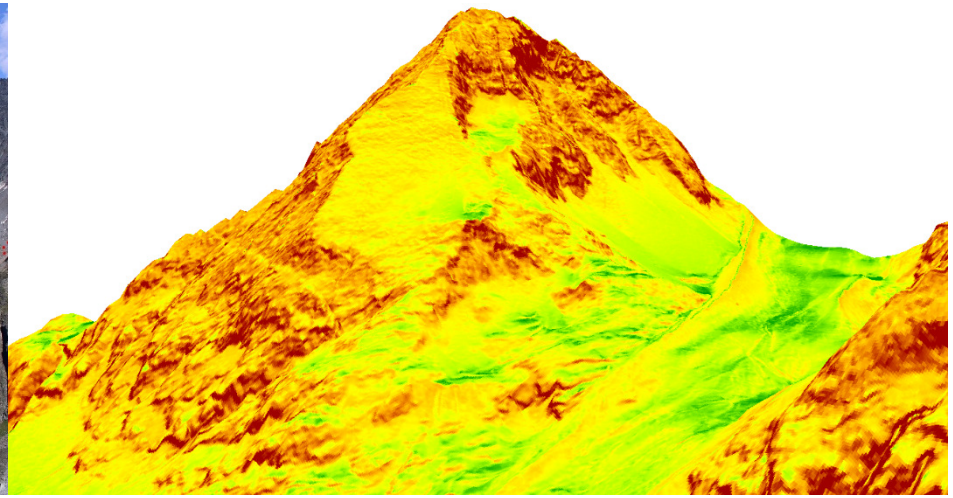
Foto-Credits:
*Gnaphalium supinum*: Oliver Tackenberg
*Helictochloa versicolor*: Flora de Aragon

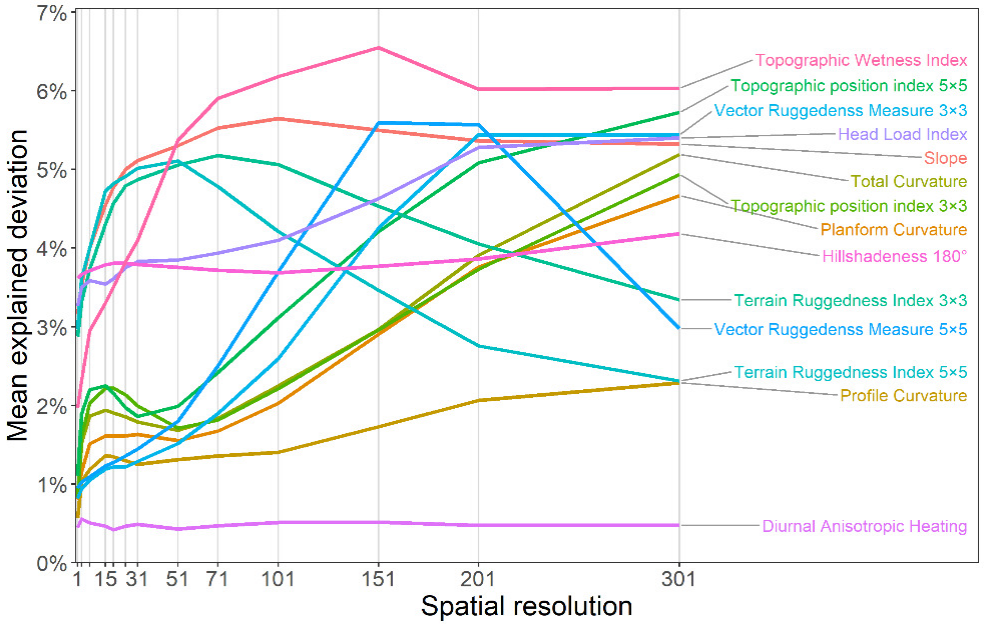
universität wien
Faculty of Life Sciences




Stefan Dullinger



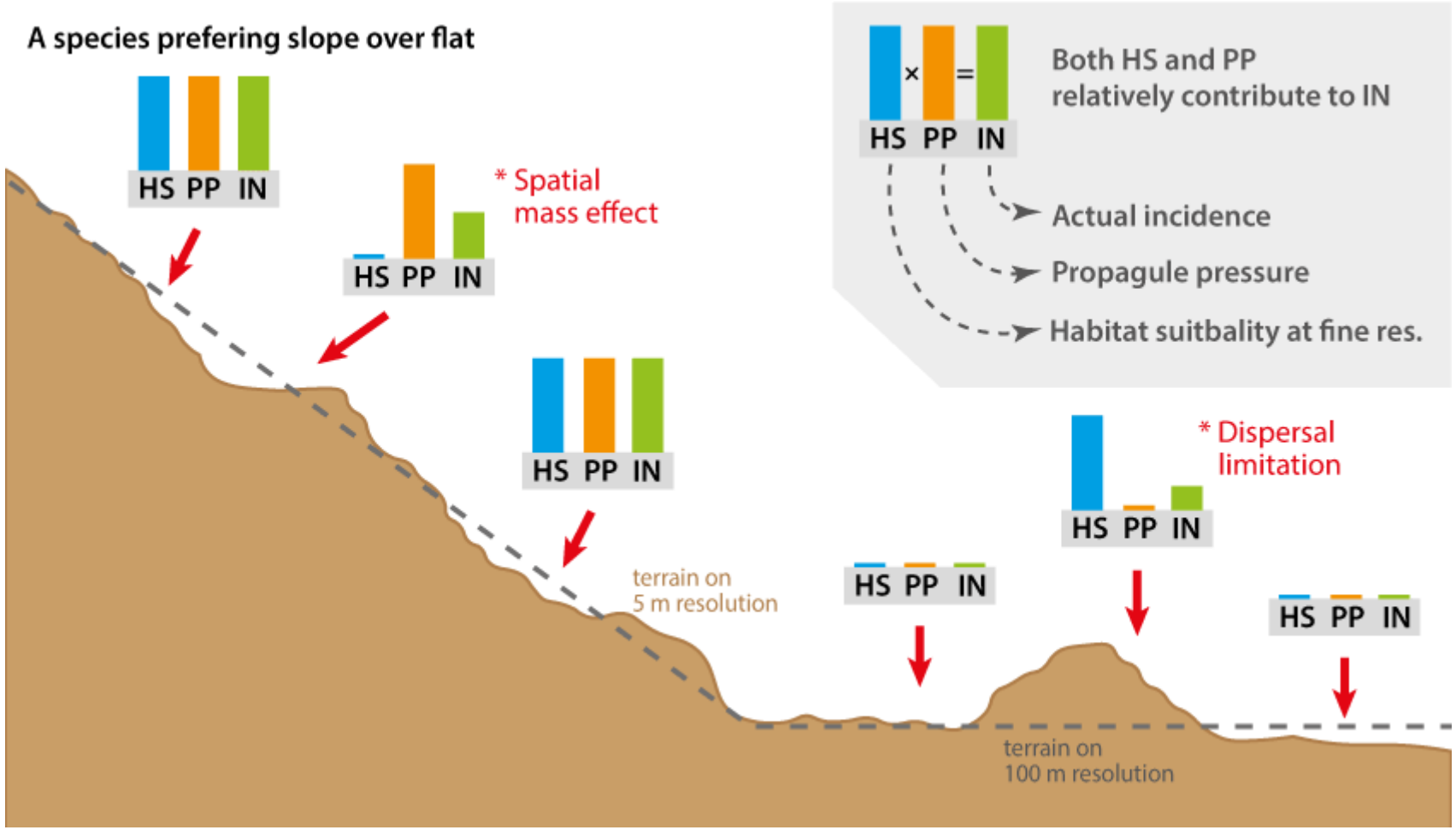






Chytrý et al., ***in review***

Mean deviation explained by elevation: 17.02%

Beschränkte Ausbreitungsfähigkeit beeinflusst, ob Arten Kleinstandorte besetzen (können) oder nicht




Chytrý et al., ***in review***



erc European Research Council
universität wien
Faculty of Life Sciences

# Stark gefährdet oder gut versichert?

Die Verbreitungsmuster der alpinen Pflanzen ändern sich, viele Arten wandern nach oben.

Dem Vordringen nach oben steht ein etwa gleich schneller Rückzug an den unteren Verbreitungsgrenzen gegenüber.

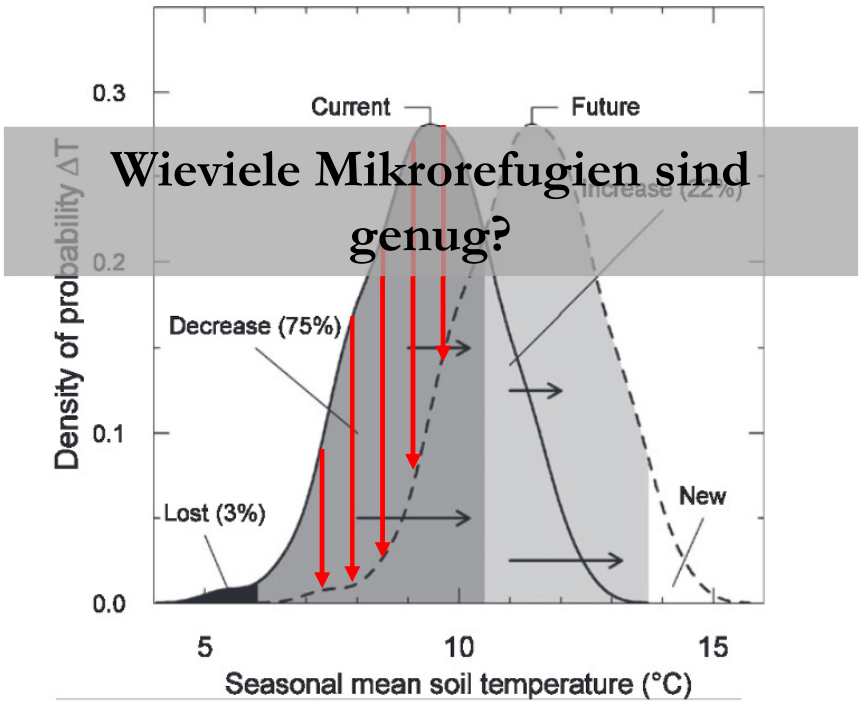
Insgesamt wandern die Arten im Vergleich zur Geschwindigkeit des Klimawandels langsam, vielleicht zu langsam.

# Stark gefährdet oder gut versichert?

Starke mikroklimatische Variabilität könnte Überlebensnischen in tieferen Lagen bieten.

ABER: Geringe Mobilität der Arten
→ Erreichbarkeit kleiner und isolierter Refugien?
→ Individuen und Genaustausch zwischen ihnen?

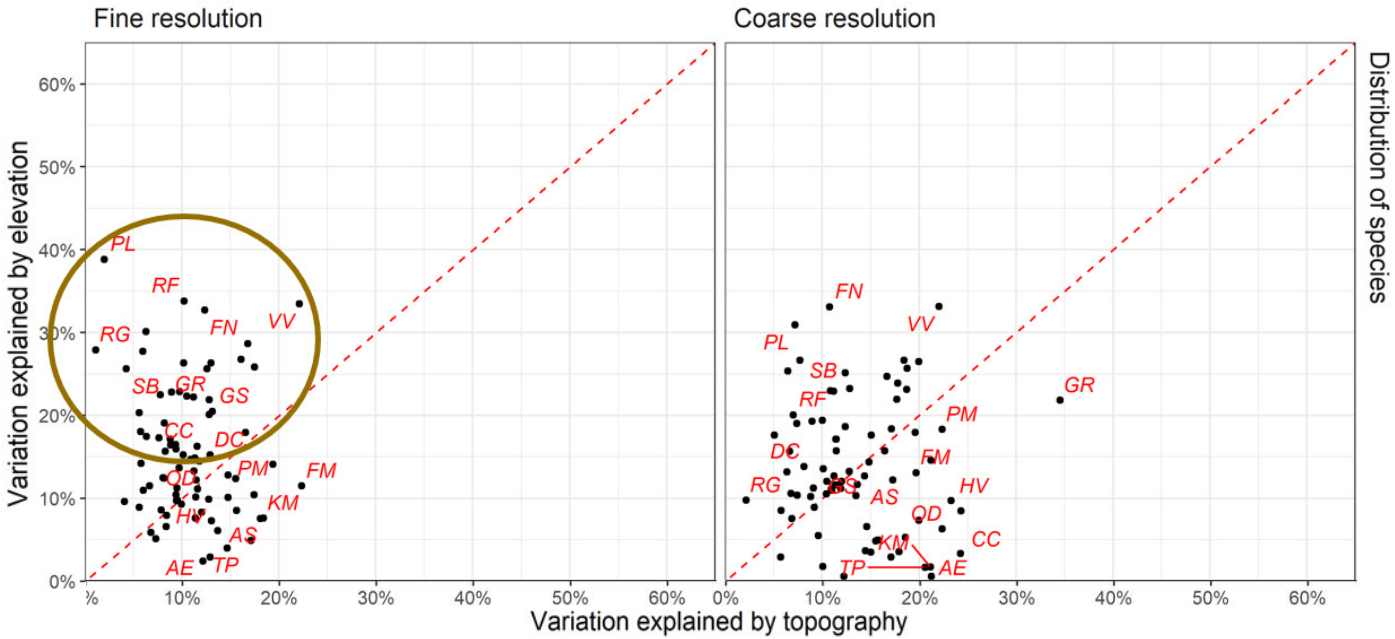
Effizienz von mikroklimatischer Refugien möglicherweise beschränkt, insbesondere, wenn sie klein und isoliert sind.



# Stark gefährdet oder gut versichert?

Regionale und artspezifische Unterschiede werden eine Rolle spielen
z.B.

- in der Ausbreitungsfähigkeit
- in der Fähigkeit geeignete Kleinstandorte im Relief effizient zu nutzen



Der Klimawandel stellt ein erhebliches Risiko für die Flora oberhalb der Waldgenze dar, insbesondere für die oberalpinen und subnivalen Arten

Das Mikroklima bietet potentiell Refugien, aber nicht alle Arten werden in der Lage sein, diese Refugien effizient zu nutzen

Es wird dauern, bis die Risken sich realisieren, aber langfristig wird die Anzahl alpiner und nivaler Arten auf unseren Bergen abnehmen

Alle diese Prognosen berücksichtigen das Höherwandern des Bergwaldes und die damit verbundene Verkleinerung der waldfreien Areale nicht!

# Danke!

Kryštof Chytrý, Andreas Gattringer, Karl Hülber, Dietmar Moser, Norbert Helm, Harald Pauli, Sabine Rumpf, Manuel Steinbauer, Johannes Wessely, Sonja Wipf & many others

# References

Hausfather, Z. & Peters, G.P (2020): Emissions – the ‚business-as-usual' story is misleading. Nature 577: 618-620.
Diaz, S. et al. (2019): Pervasive human-driven decline of life on Earth points to the need of transformative change. Science 366: eaax3100
Pepin et al. (2015): Elevation-dependent warming in mountain regions of the world. Nature Climate Change 5: 424-430.
Ellenberg (1986): Vegetation Mitteleuropas mit den Alpen. Eugen Ulmer Verlag.
Engler et al. (2011): 21st century climate change threatens mountain flora unequally across Europe. Global Change Biology 17: 2330-2341.
Scherrer & Körner (2011): Topographically controlled thermal-habitat differentiation buffers alpine plant diversity against climate warming. Journal of Biogeography 38: 406-416.
Pauli et al. (2012): Recent plant diversity changes on Europe's mountain summits. Science 336: 353-355.
Lamprecht et al. (2018): Climate change leads to accelerated transformation of high-elevation vegetation in the central Alps. New Phytologist 220: 447-459.
Rumpf et al. (2018): Climate-driven range dynamics of mountain plants decrease with elevation. Proceedings of the National Academy of Sciences of the U.S.A. 115: 1848-1853.
Wipf et al. (2013): The oldest monitoring sites of the Alps revisited: accelerated increase in plant species richness on Piz Linard summit since 1835. Plant Ecology and Diversity 6: 447-455.
Steinbauer et al. (2018): Climate warming accelerates the increase in plant species richness on European mountain summits. Nature 556: 231-234.
Vitasse et al. (2021): Phenological and elevational shifts of plants, animals and fungi uner climate change in the European Alps. Biological Reviews 96: 1816-1835.