

Faster, taller, more – patterns and drivers of change in arctic and alpine plant communities

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sUMMITDiv consortium

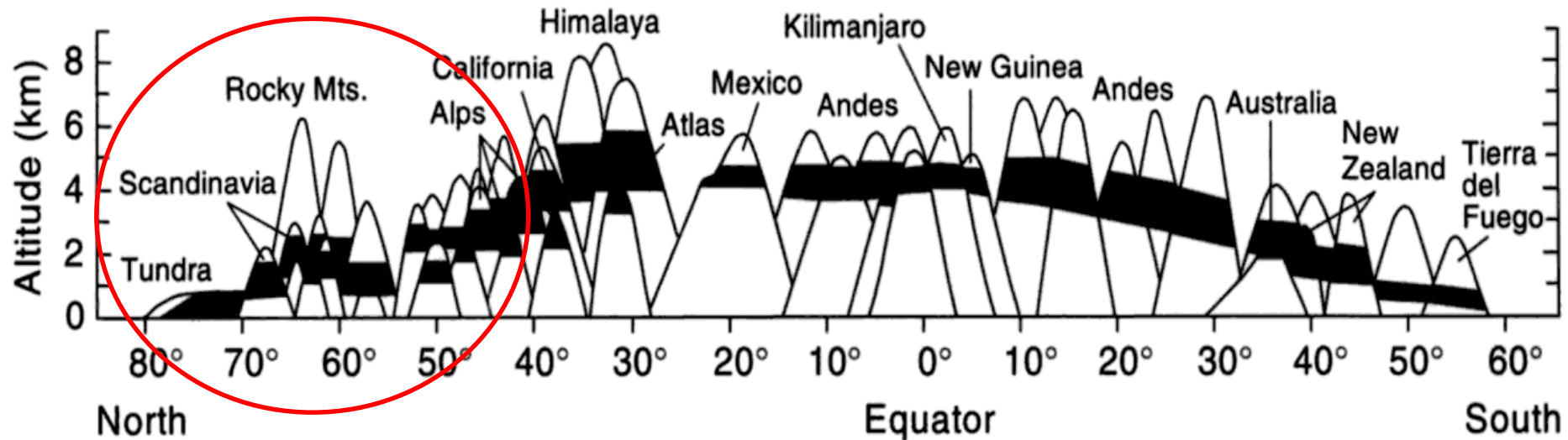


WSL Institute for Snow and Avalanche Research SLF, Davos



Linaria alpina, Piz Forun 2984 m (S. Burg)

Cold ecosystems – Arctic to alpine is a continuum



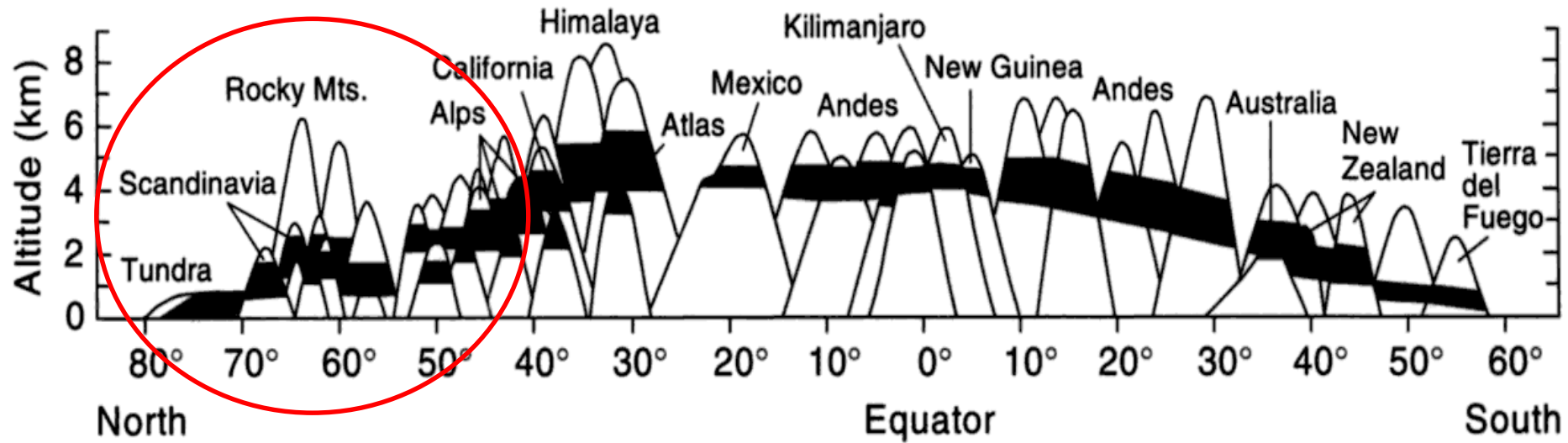
(from Körner 2003)



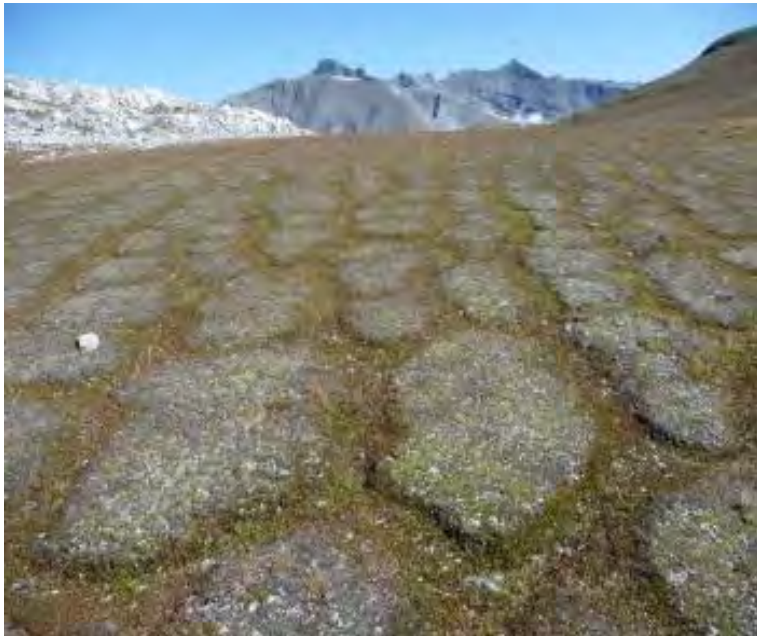
Similar environmental conditions

Similar vegetation types, genera, species, plant growth forms, functional traits, etc.

Biotic similarities



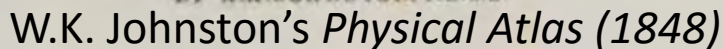
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Similar environmental conditions

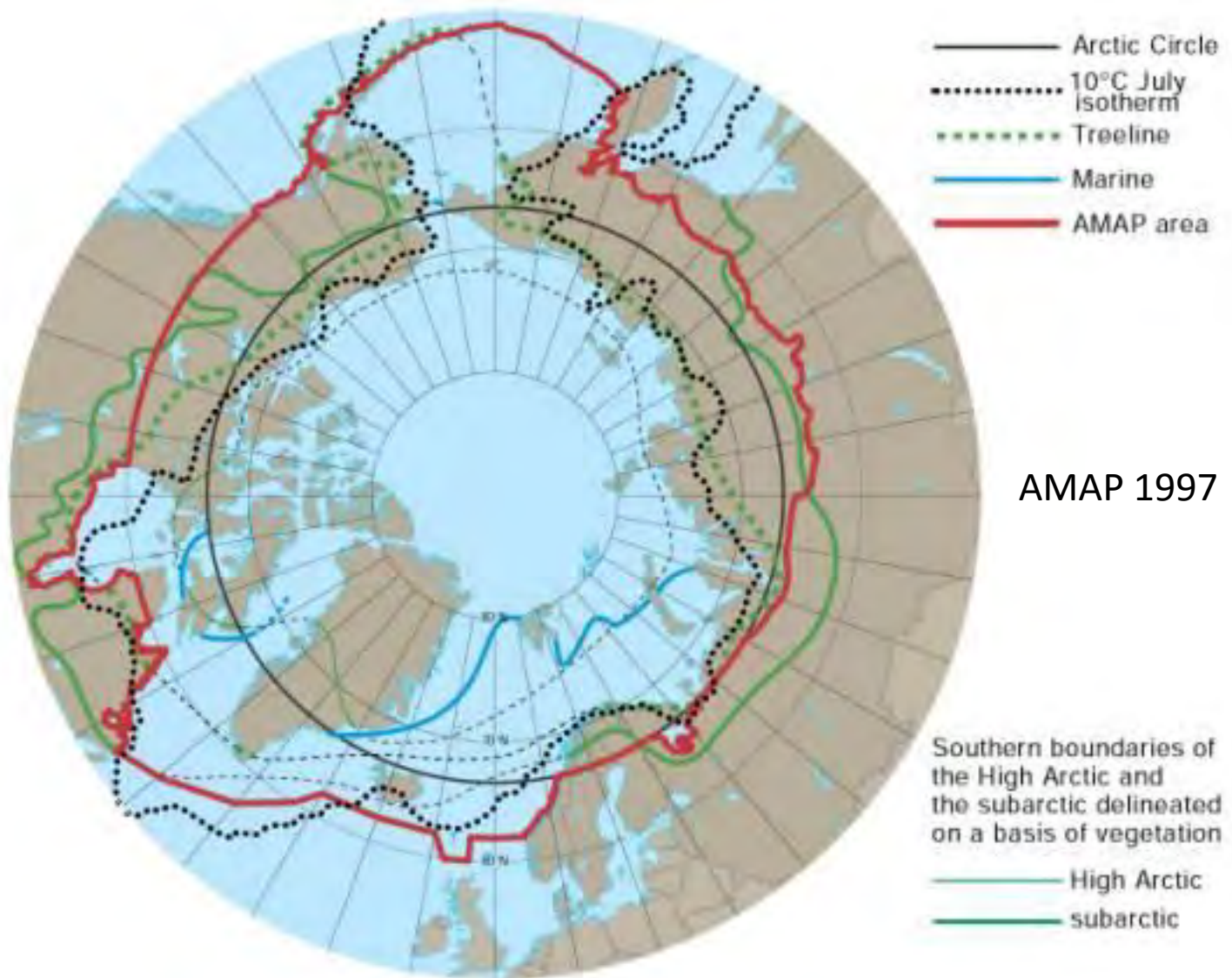
Similar vegetation types, genera, species, plant growth forms, functional traits, etc.

Flimserstein, Swiss Alps, Foto: C. Rixen



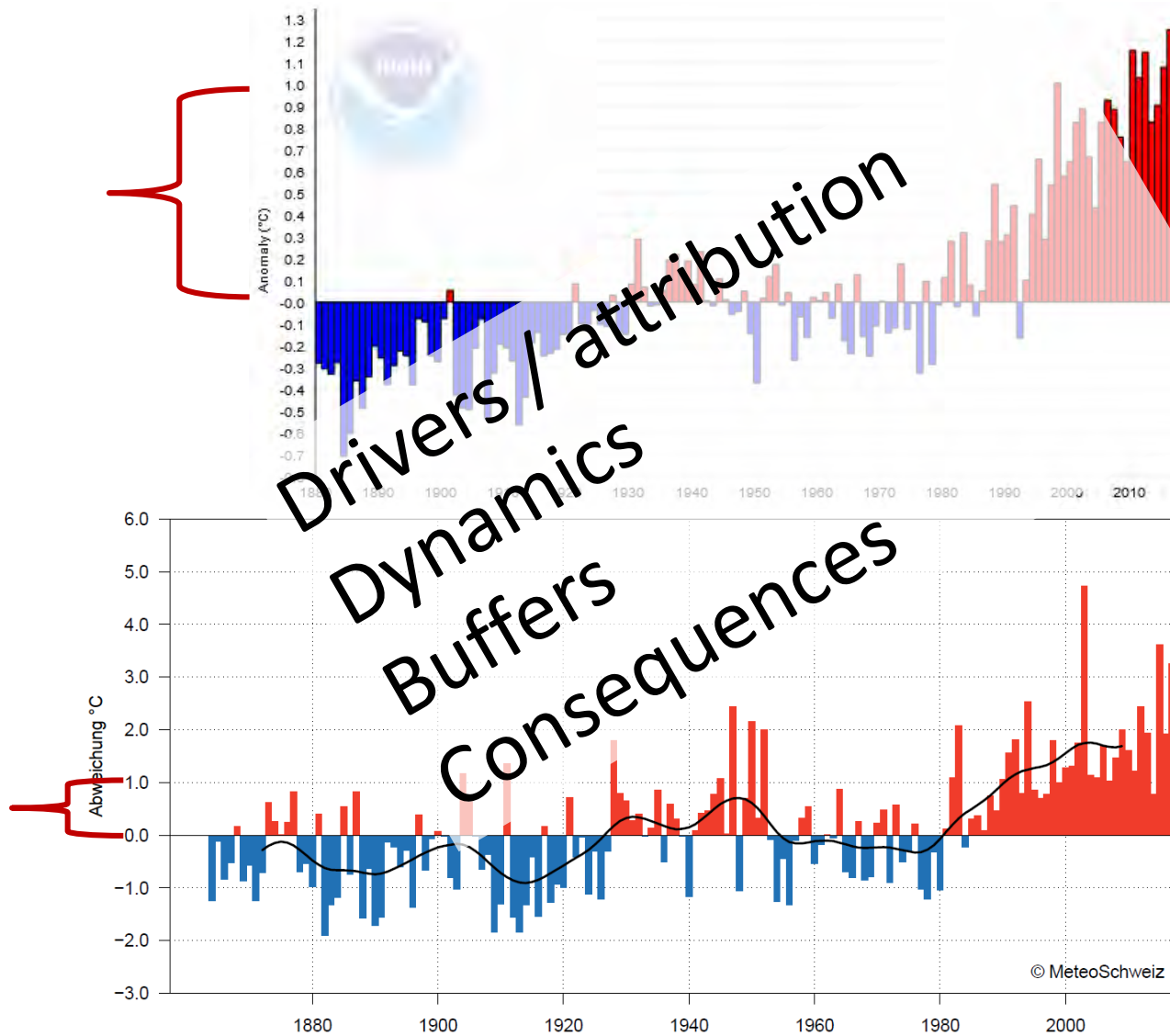


«Alpine» and «nival» belts defined by position of treeline and closed vegetation, respectively, which correlate well with growing season temperatures



Similarly, «Arctic» often defined by 10°C July isotherm or by position of treeline

Warming = change?



N hemisphere land
JJA mean temps

N Switzerland >1000m
JJA mean temps



European summit flora network

Vegetation re-surveys on the same summits as historical predecessors

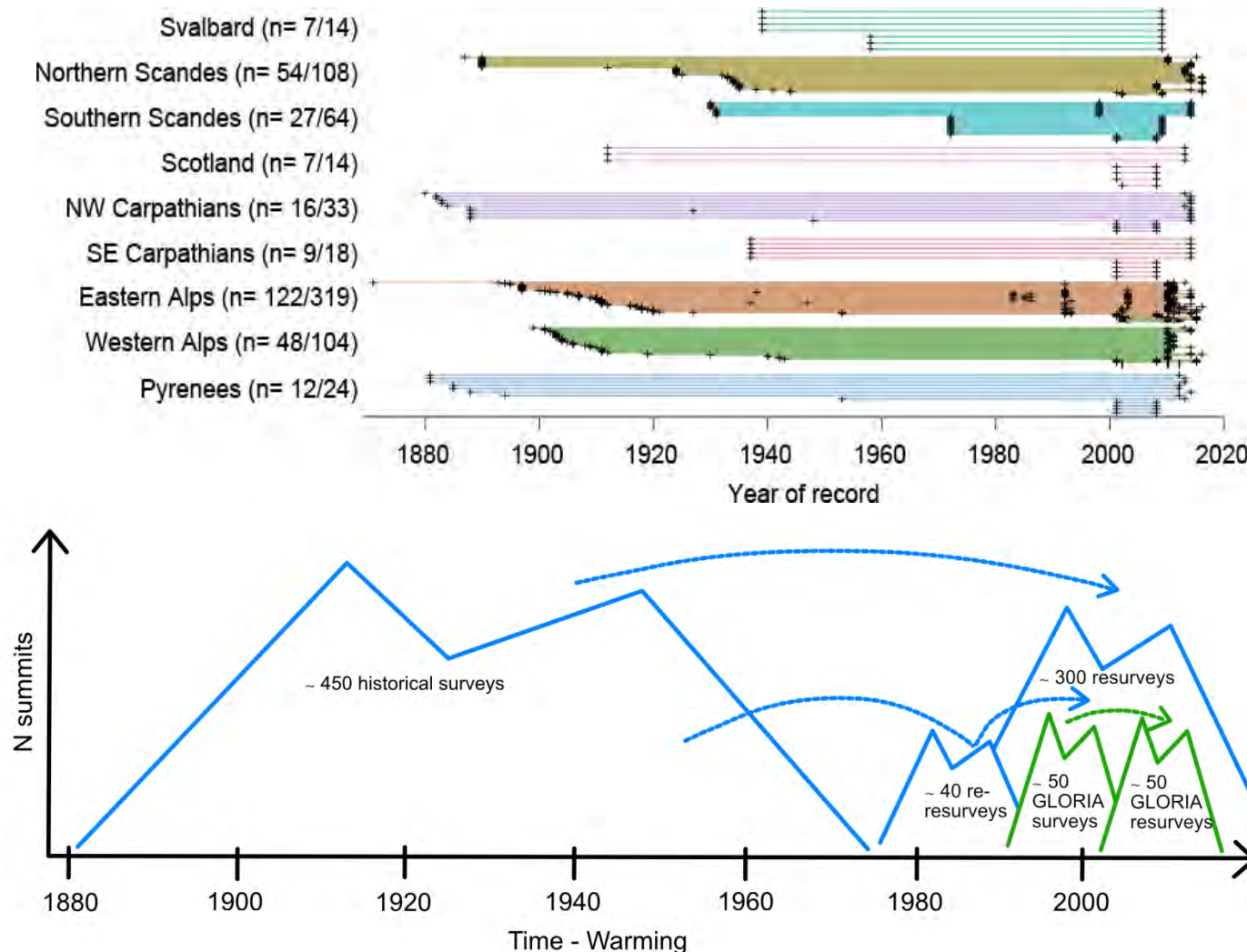
2009: weekend activity of 3 people in CH, masters thesis in Scandinavia

2018: Network of > 50 researchers in 11 countries

> 300 summits in 9 European mountain ranges

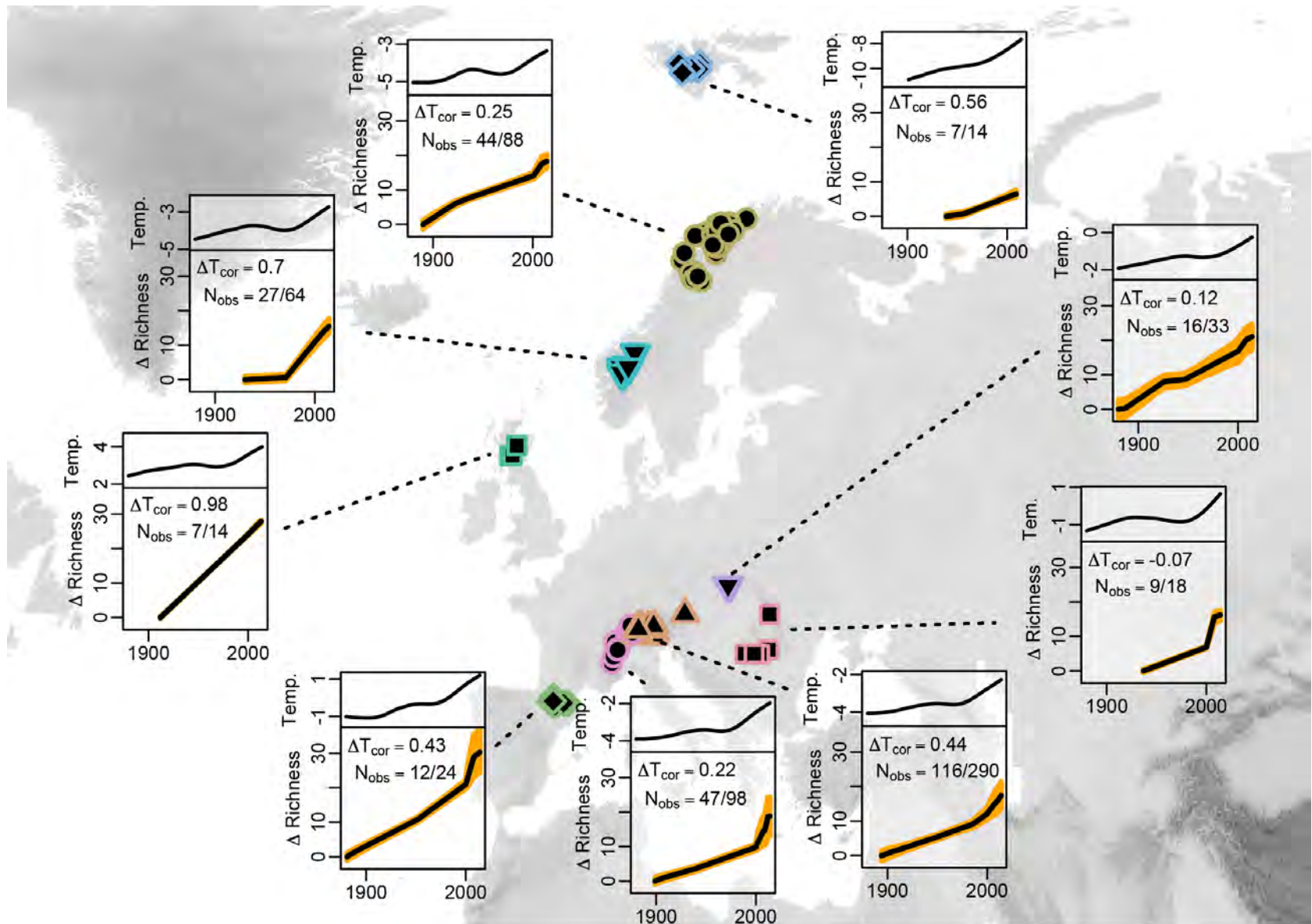


Summit flora re-surveys in Europe

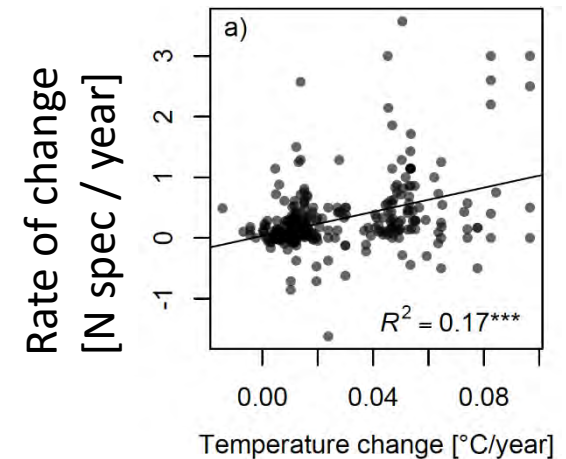
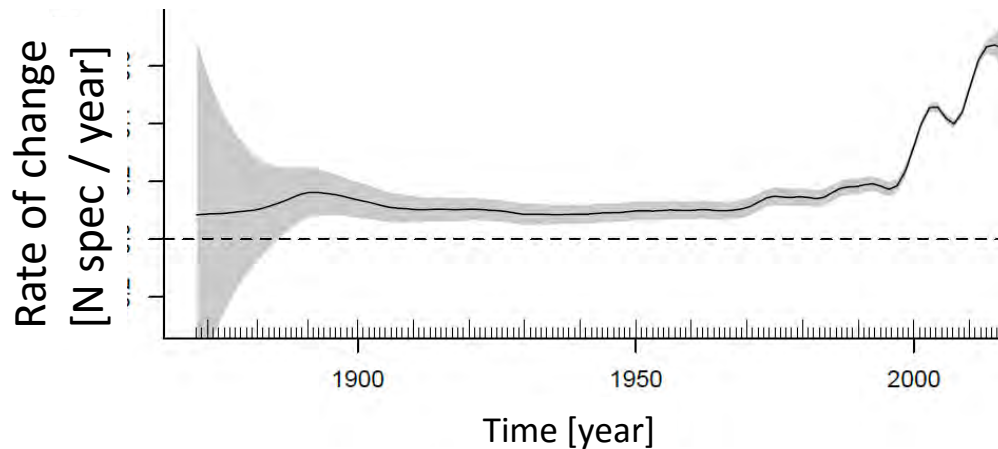


698 relevés on 302 summits over 145 years in 9 mountain ranges

Plant species richness



Accelerated increase in richness correlates with accelerated warming

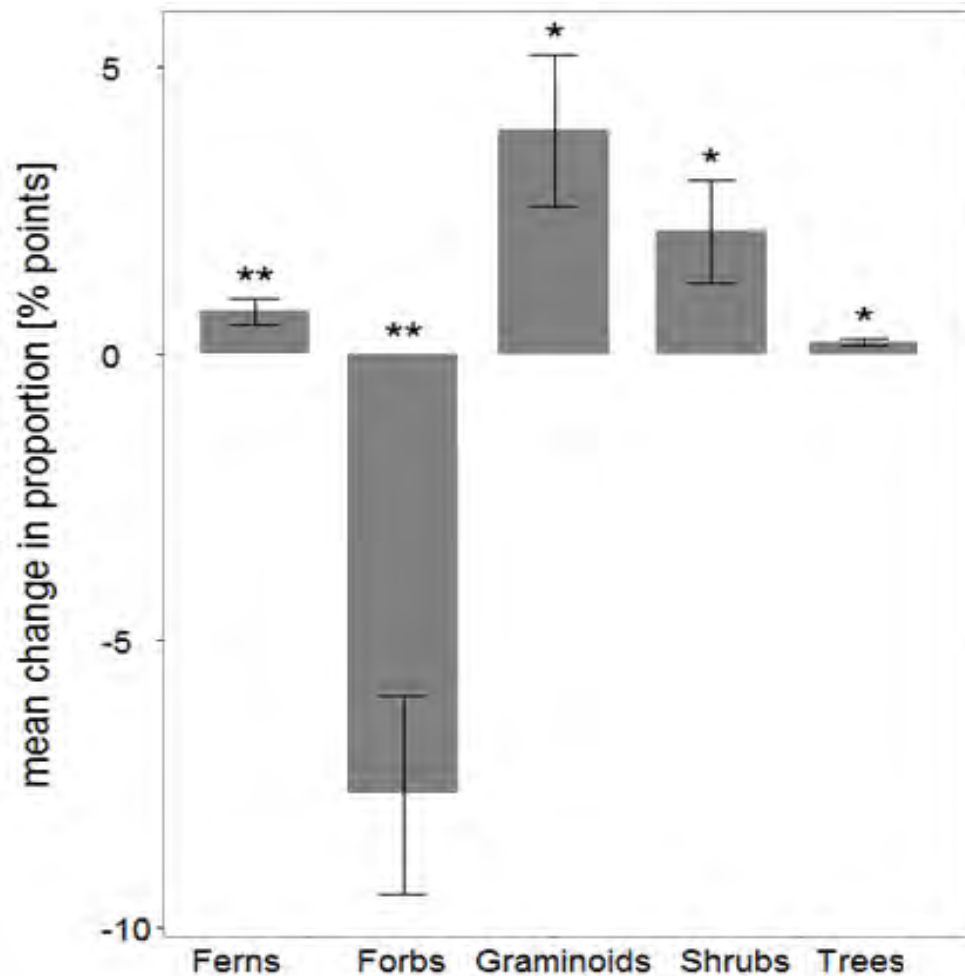


Illegal immigrants?

Against illegal
immigrants



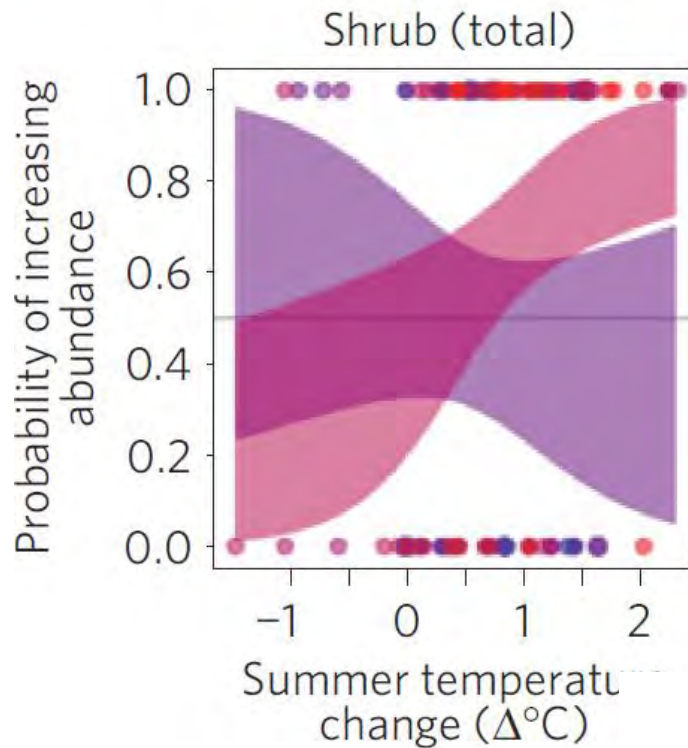
Shrubi- and grassification on summits



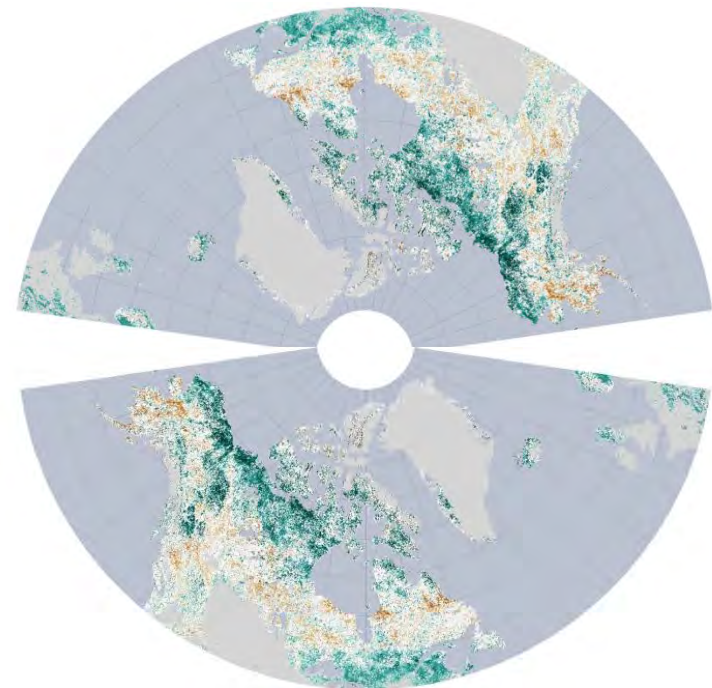
ITEX \leftrightarrow Summits



Arctic shrubs and biomass increasing -> Arctic greening



Elmendorf et al (2012) NCC



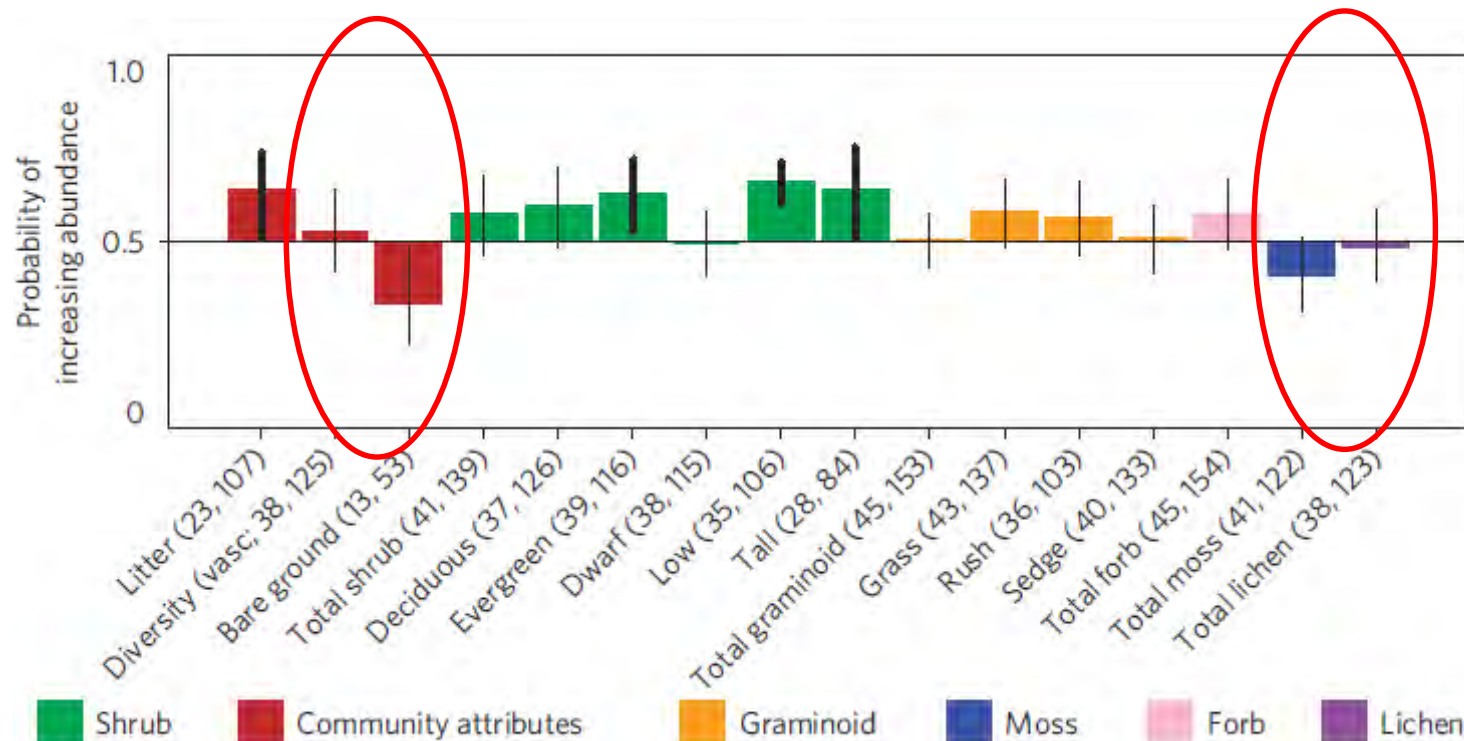
Vegetation Index Trend (percent per decade)

-7.5 -5 -2.5 0 2.5 5 7.5

NASA (2016)

Mostly in the low Arctic

Denser, taller vascular plant cover



Bad news for mosses & lichens (...and reindeer)



Bad news for small alpine plants

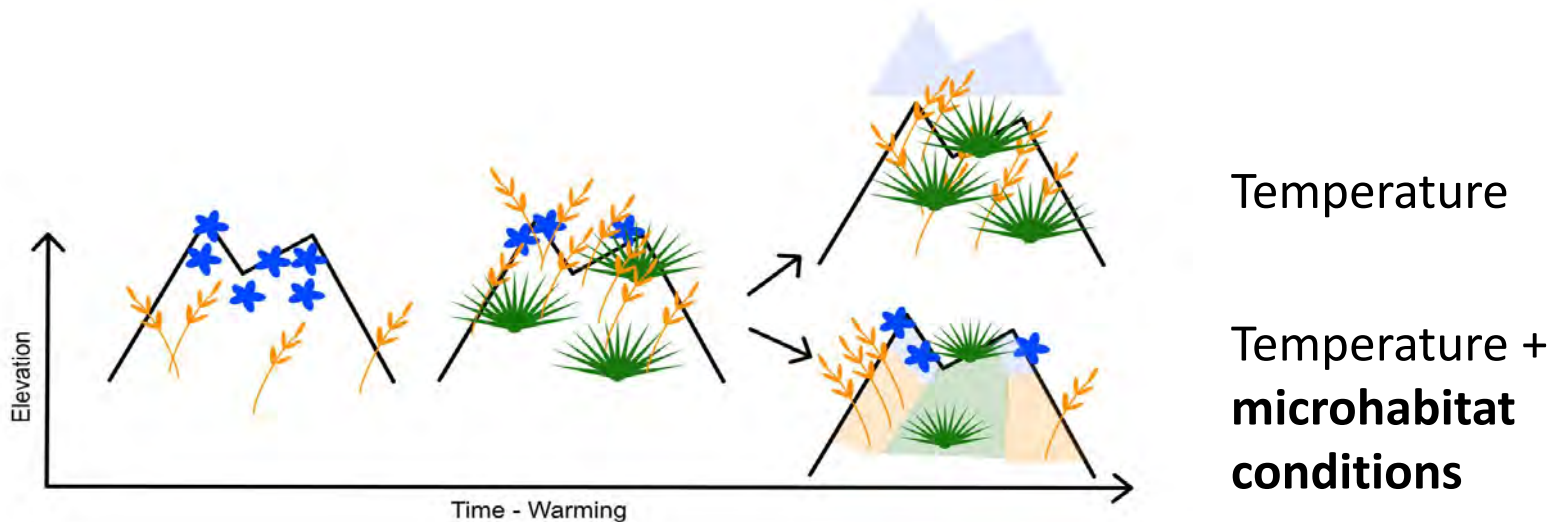


Androsace alpina (S. Burg)

Alpine and Arctic vegetation change with warming

| | Summits | ITEX |
|---------------------|---------|------|
| Species richness | ↗ | → |
| Shrubs/trees | ↗ | ↗ |
| Graminoids | ↗ | → ↗ |
| Ferns | ↗ | ? |
| Forbs | ↘ | → ↗ |
| Vegetation height | ↗ | ↗ |
| Bare ground | (↘) | ↘ |
| Warm-loving species | ↗ | ↗ |

Microhabitat preference as buffer



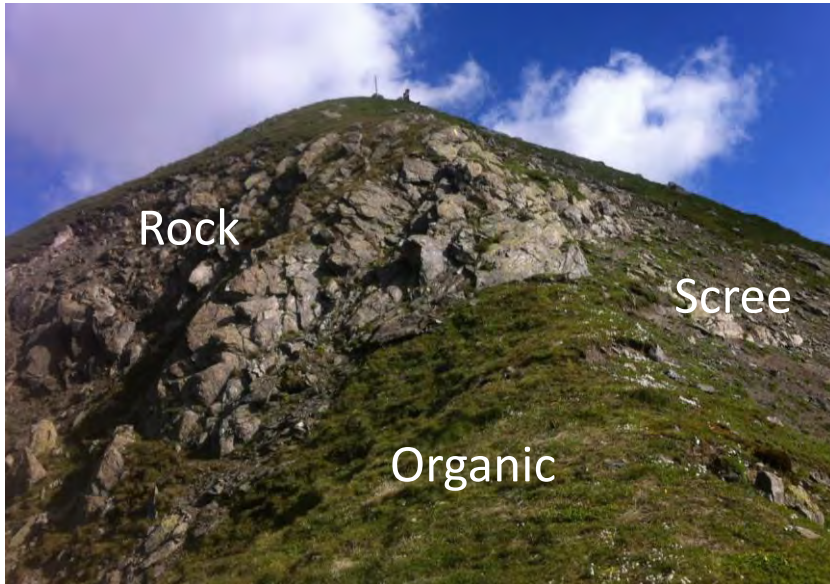
Consequences of species migrating upwards with warming

- Increasing species richness on summits
- Lowland plants -> competition for high-altitude specialists
- High microhabitat variability as a buffer against local extinctions

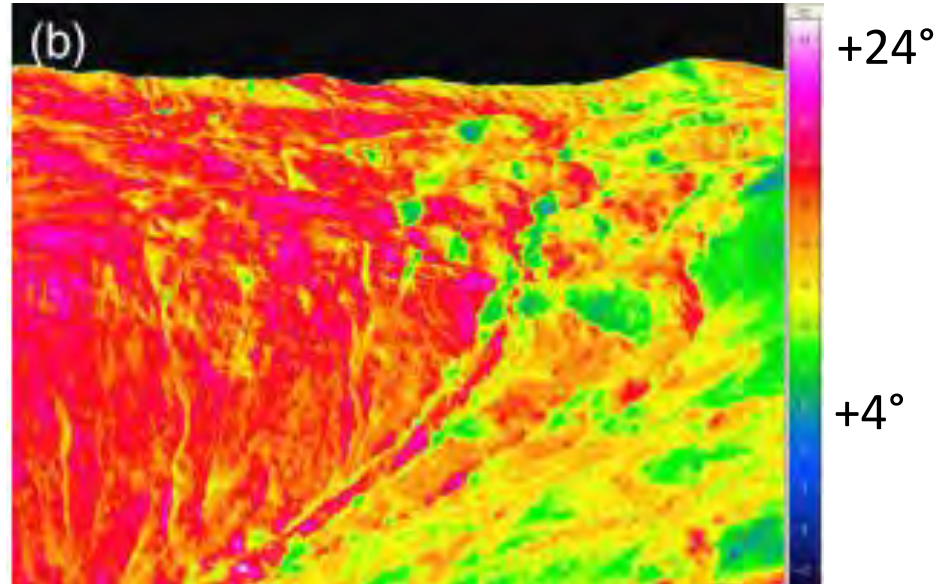
Microhabitat diversity on summits

Alpine ecosystems have high variability in:

Substrates



Temperatures



Scherrer & Körner 2010, GCB





Piz Linard, 3410 m; Foto H. Rhyner

Important differences



| | Alpine | Arctic |
|---------------------|---------------|--------------|
| Heterogeneity | <i>Higher</i> | <i>Lower</i> |
| Biodiversity | <i>Higher</i> | <i>Lower</i> |
| Fragmentation | <i>High</i> | <i>Low</i> |
| Migration distances | <i>Short</i> | <i>Long</i> |
| Seed sources | <i>Close</i> | <i>Far</i> |
| Gene flow | <i>Fast</i> | <i>Slow</i> |

Summary

- Alpine and Arctic ecosystems are very sensitive to warming temperatures
- Upon warming, tall and competitive species are winning, small species are losing
- Environmental heterogeneity, fragmentation and rapid geneflow potentially buffer plant species composition in the alpine
- Large distances potentially buffer communities in the Arctic



Saype – A story of the future (Rocher de Naye 2017)

Co-Authors



Accelerated increase in plant species richness on mountain summits is linked to warming.

Steinbauer MJ, Grytnes J-A, Jurasinski G, Kulonen A, Lenoir J, Pauli H, **Rixen** C, Winkler M, Bardy-Durchhalter M, Barni E, **Bjorkman** AD, Breiner FT, Burg S, Czortek P, Dawes MA, Delimat A, Dullinger S, Erschbamer B, Felde VA, Fernández-Arberas O, Fossheim KF, Gómez-García D, Georges D, Grindrud ET, Haider S, Haugum SV, Henriksen H, Herreros MJ, Jaroszewicz B, **Jaroszynska** F, Kanka R, Kapfer J, **Klanderud** K, Kühn I, Lamprecht A, Matteodo M, Morra di Cella U, Normand S, Odland A, **Olsen** SL, Palacio S, Petey M, Piscová V, Sedlakova B, Steinbauer K, Stöckli V, Svenning J-C, Teppa G, Theurillat J-P, Vittoz P, Woodin SJ, Zimmermann NE, **Wipf** S.

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