


Soils in a changing world

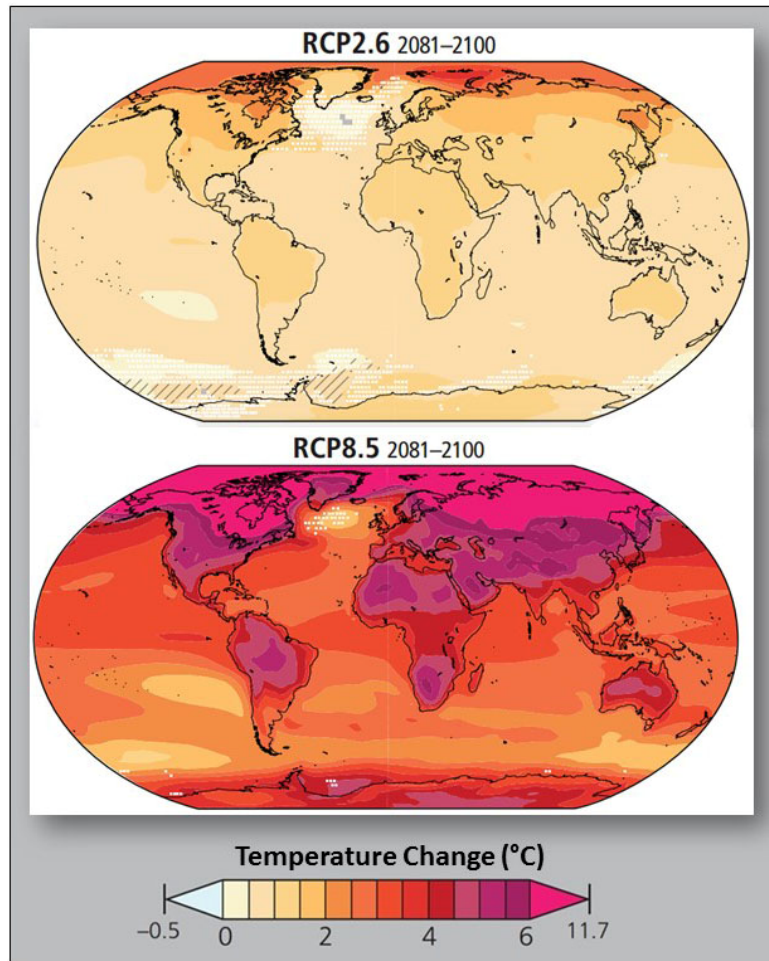
The development of new soil landscapes and their relevance for biogeochemical cycles in the 21st century and beyond.



**Sebastian Doetterl, ETH Zurich
EGU 2021; April 21st 2021**

The big challenges of our time

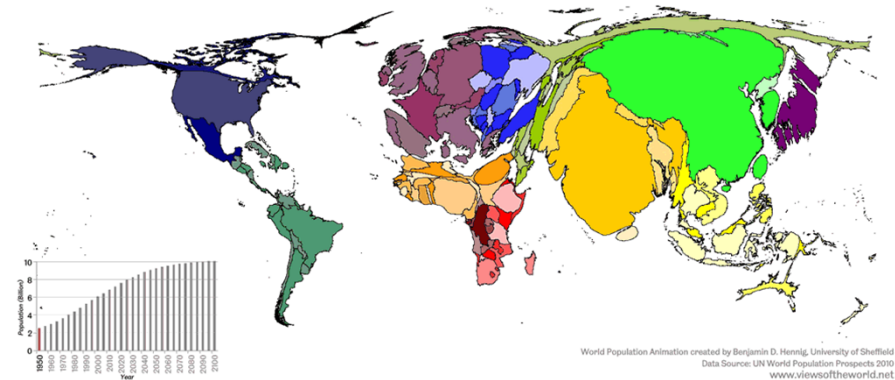
Climate



IPCC 2013

Population growth

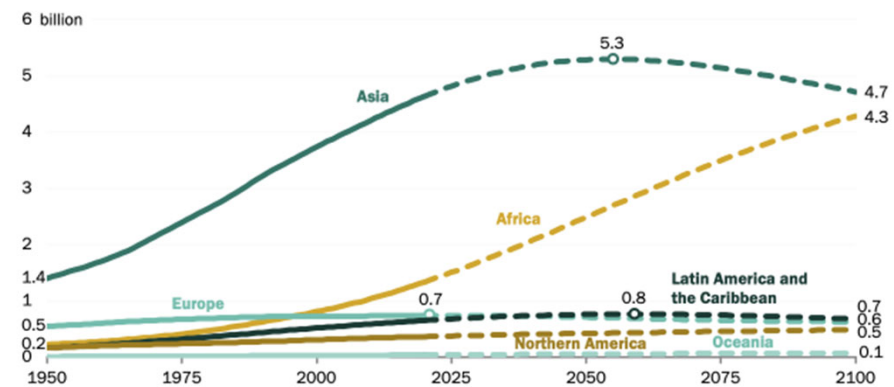
World Population 1950



Hennig 2011; UN World population prospect 2010

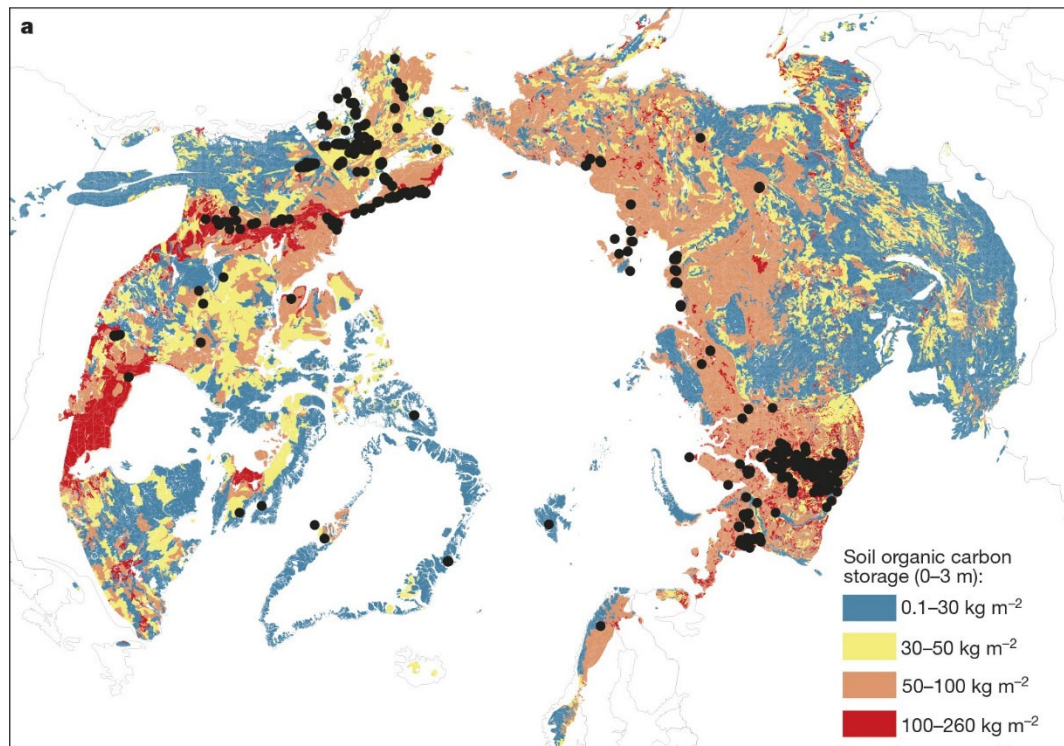
Population growth in Africa is projected to remain strong throughout this century

Population by region, in billions

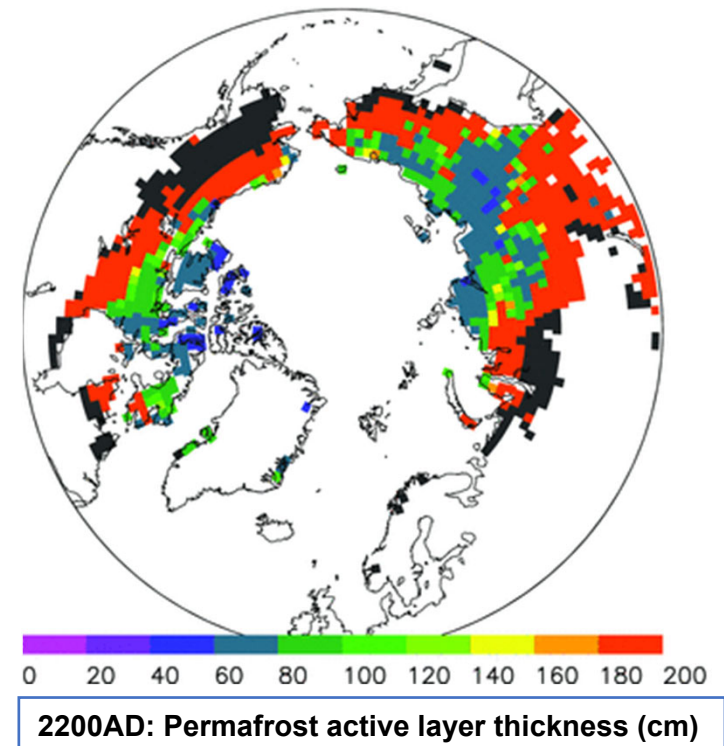


PEW Research Center 2019

The changing Arctic – Loss of permafrost (and organic matter)

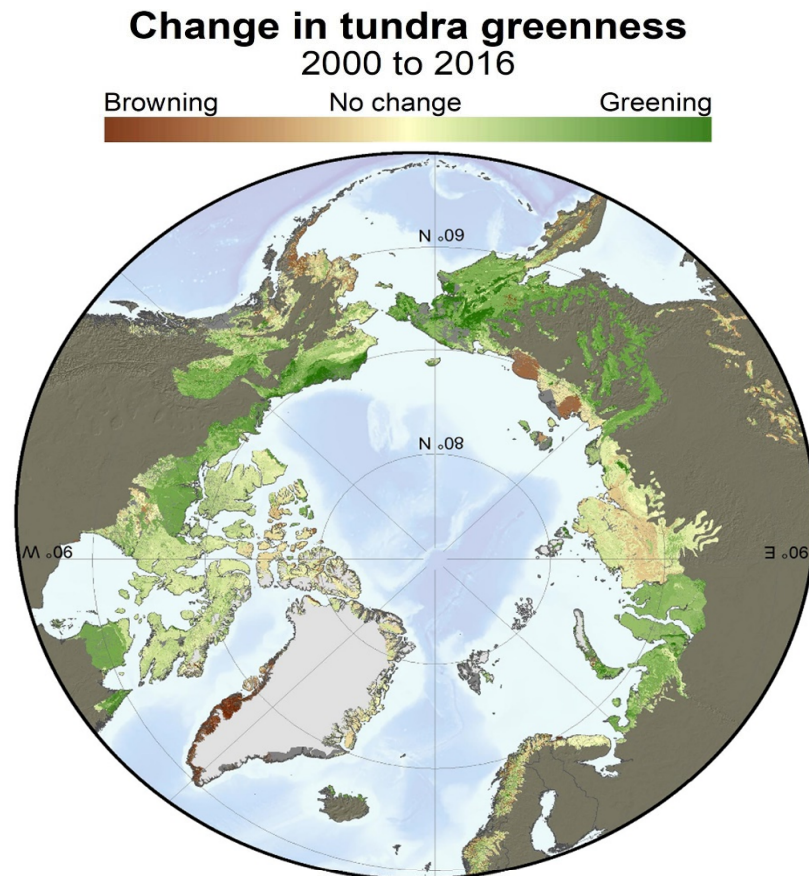


Schuur et al. 2015



Schaefer et al. 2011

The changing Arctic – Arctic greening (and gain of organic matter)



Berner et al. 2020



ARTICLE

<https://doi.org/10.1038/s41467-020-18479-5>

OPEN

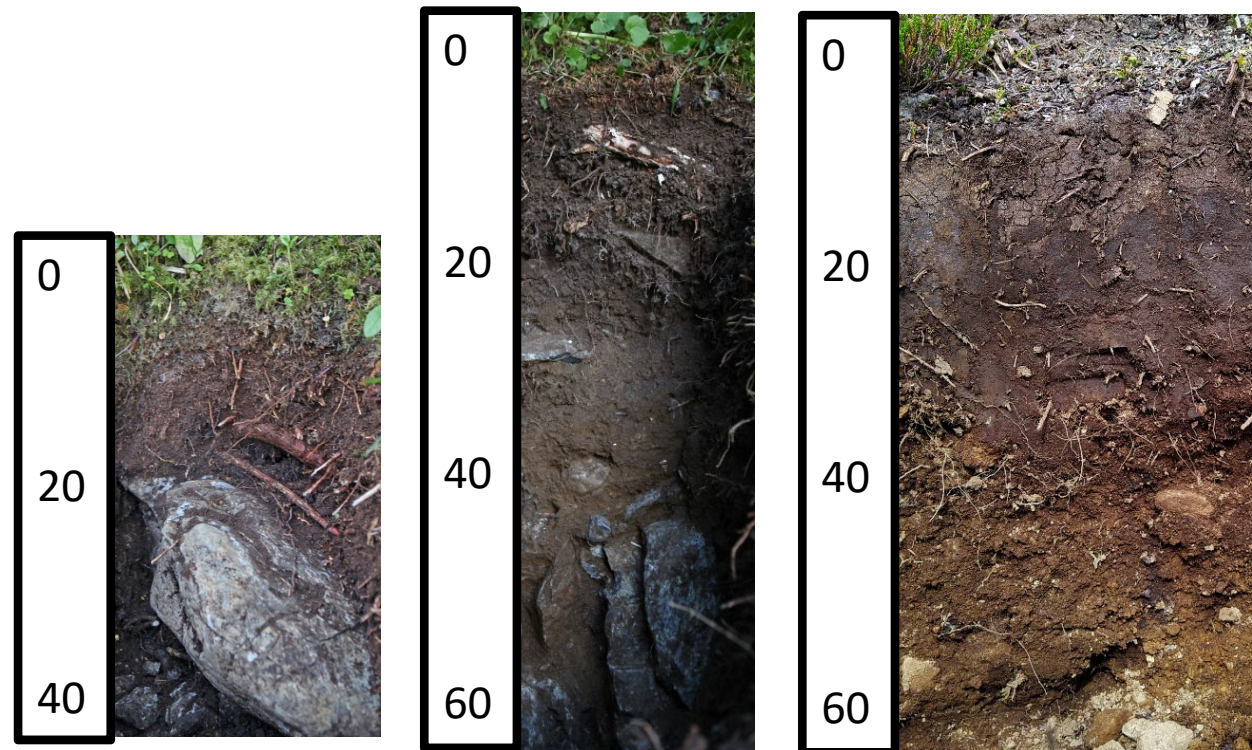
Check for updates

Summer warming explains widespread but not uniform greening in the Arctic tundra biome

Logan T. Berner^{1,✉}, Richard Massey¹, Patrick Jantz¹, Bruce C. Forbes², Marc Macias-Fauria³, Isla Myers-Smith⁴, Timo Kumpula⁵, Gilles Gauthier⁶, Laia Andreu-Hayles⁷, Benjamin V. Gaglioti⁸, Patrick Burns¹, Pentti Zetterberg⁹, Rosanne D'Arrigo⁷ & Scott J. Goetz¹

“...results support the hypothesis that summer warming stimulated plant productivity across much, but not all, of the Arctic tundra biome during recent decades.”

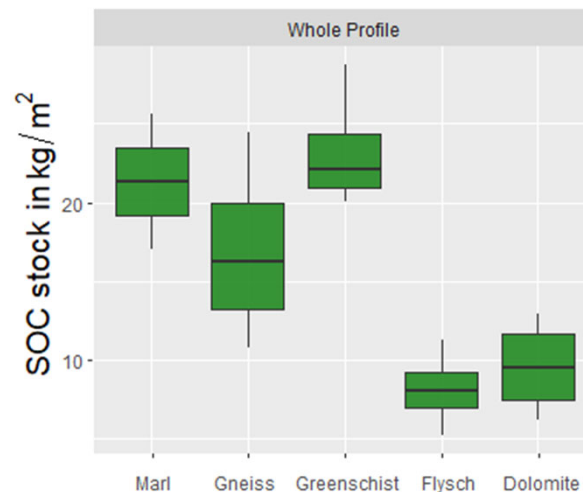
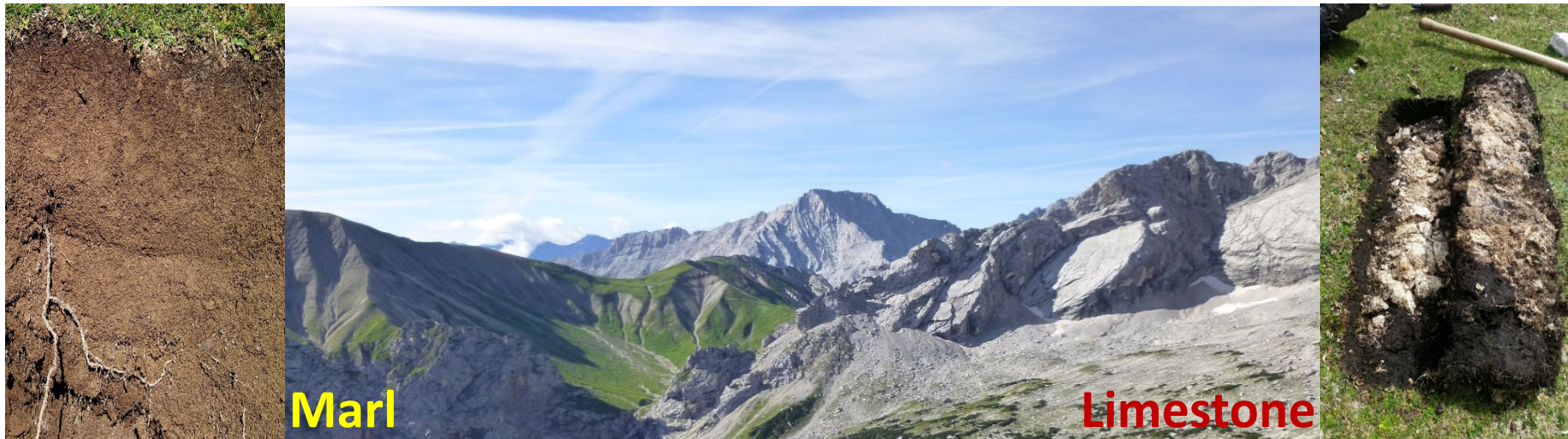
The role of soils and weathering for plant establishment in the Arctic



SOIL DEVELOPMENT

- + Thicker soils, more rooting zone
- + Nutrient release and retention
- + Water and nutrient retention
- + More soil organic matter
- + Darker, warmer soils

Soil development and its role for BGCs in other regions affected by Global Warming - Alpine greening



Moser et al., in prep

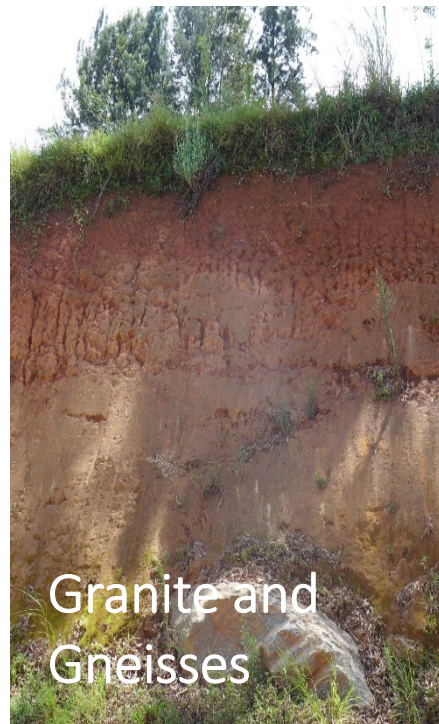
Variability in soil development across the globe

- What soils look like and how they work is a function of their genesis and their current usage
- Depending on soil type external forcing and disturbance will have different consequences

Geochemistry: Mafic



Felsic



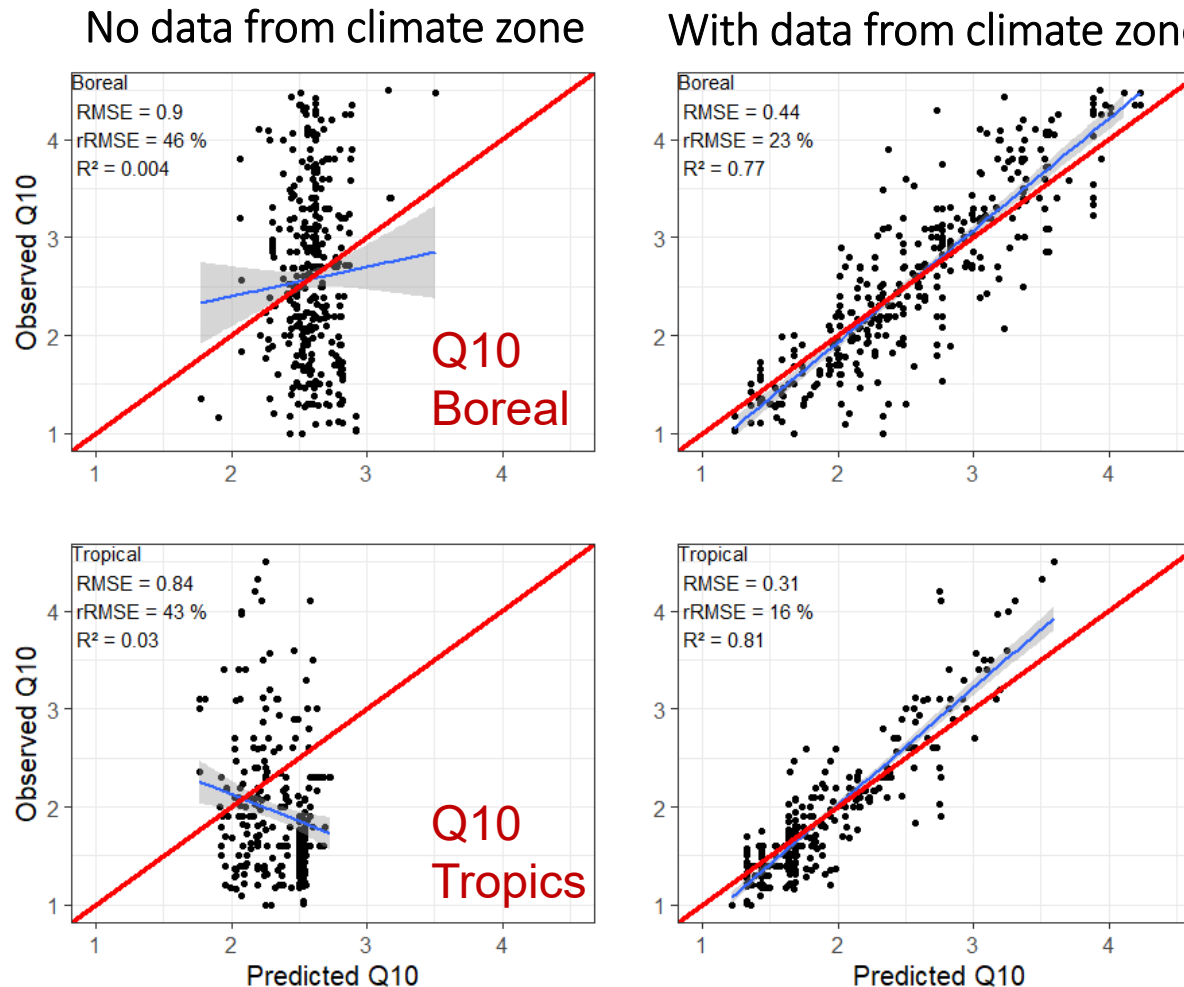
Mixed (sediments)



(Doetterl et al., 2020)

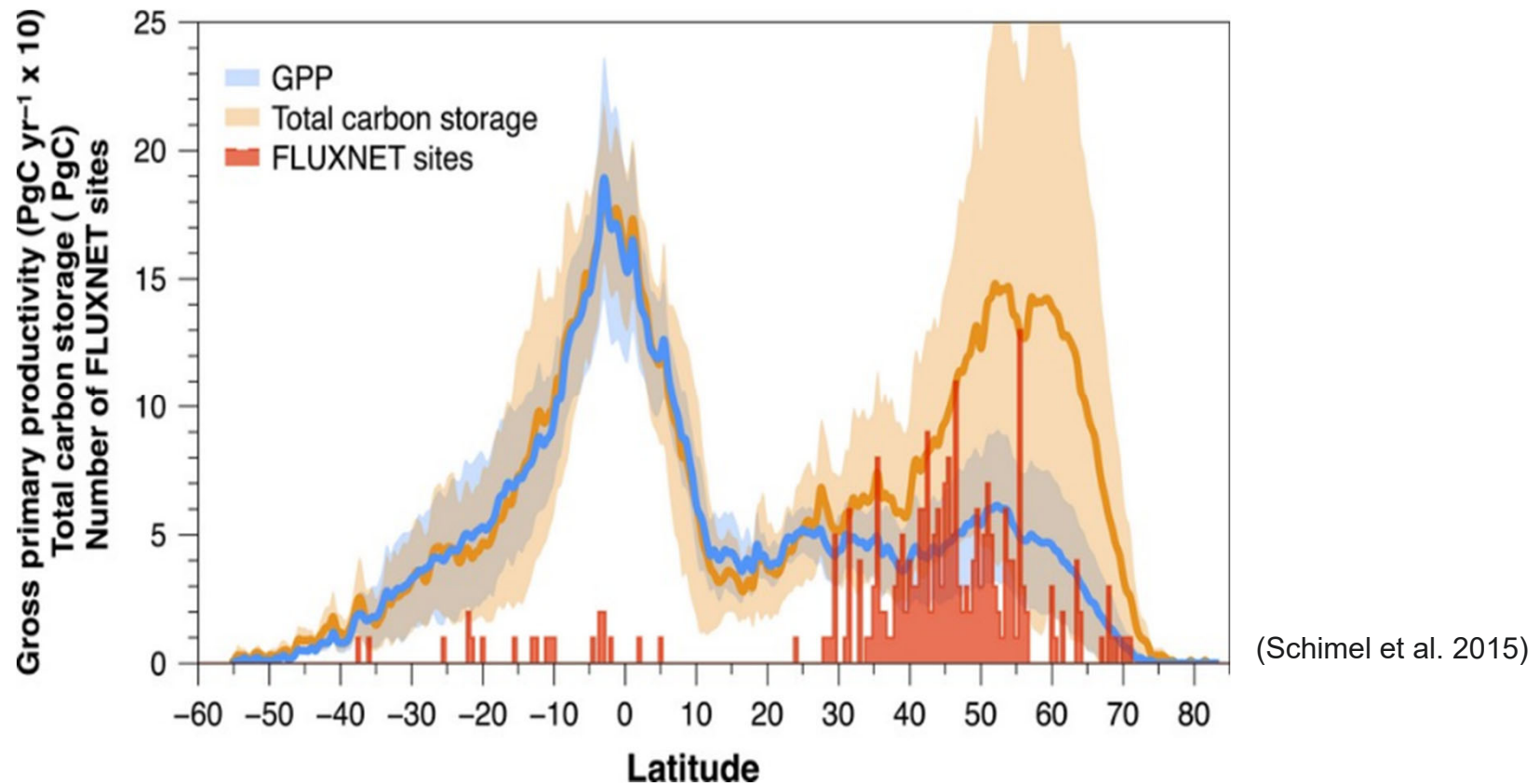
Train models here and apply them globally?

Predicting temperature sensitivity of soil C (Q_{10}) using machine learning



Based on Haaf et al NCC (accepted)

How good a job is carbon research doing to fill these gaps?

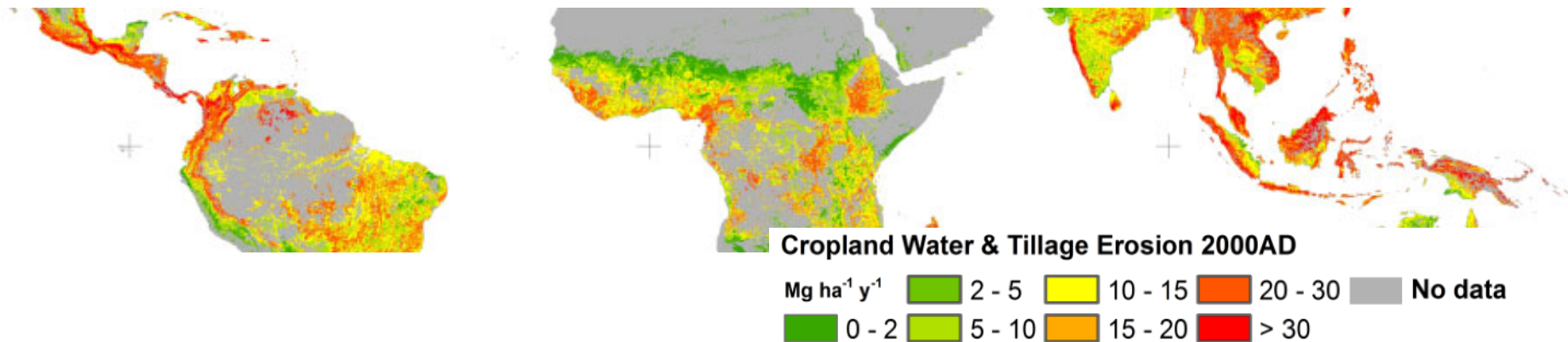


(Schimel et al. 2015)

The two 'poles' – tropical and arctic/boreal – of the terrestrial carbon cycle as displayed.

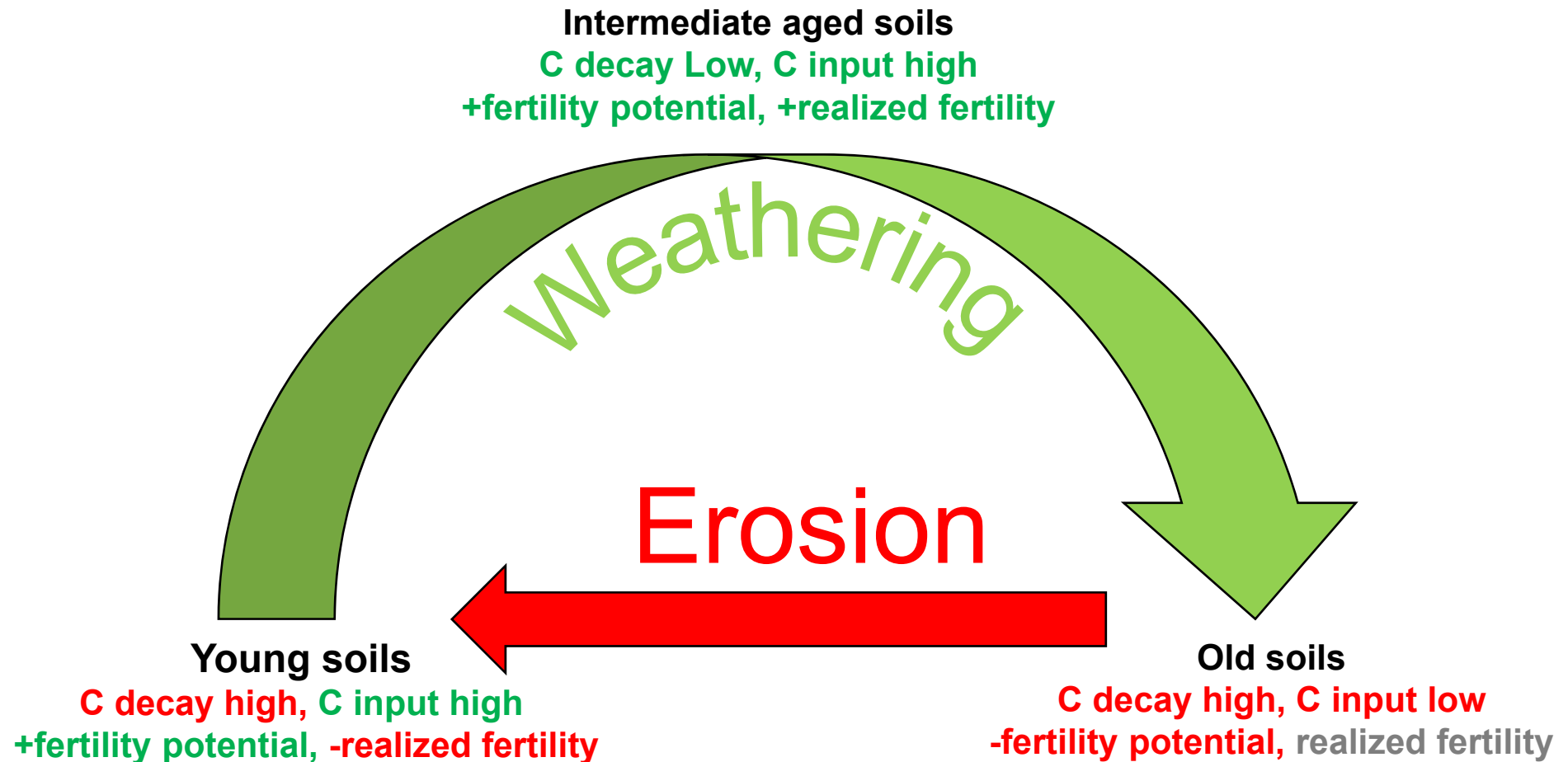
Consequences of tropical land use change

- **Human activity moves directly and indirectly 10 times more soil than all other natural causes combined globally**
- Tropical agricultural land (20% of total agricultural land) is responsible for 50% of total agricultural erosion annually!

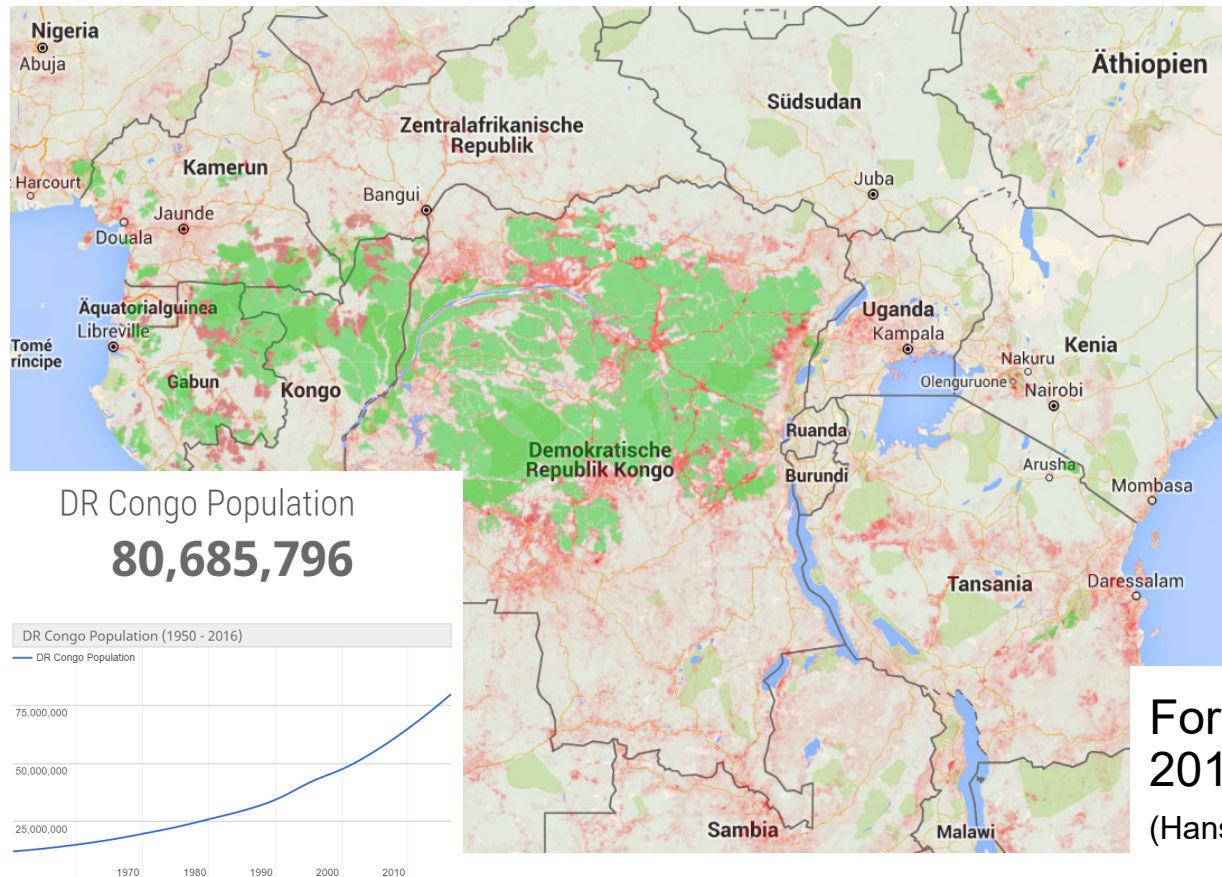


Doetterl et al., ESPL, 2012

Weathering, erosion and nutrient cycles



Tropical Land Use Change in Africa



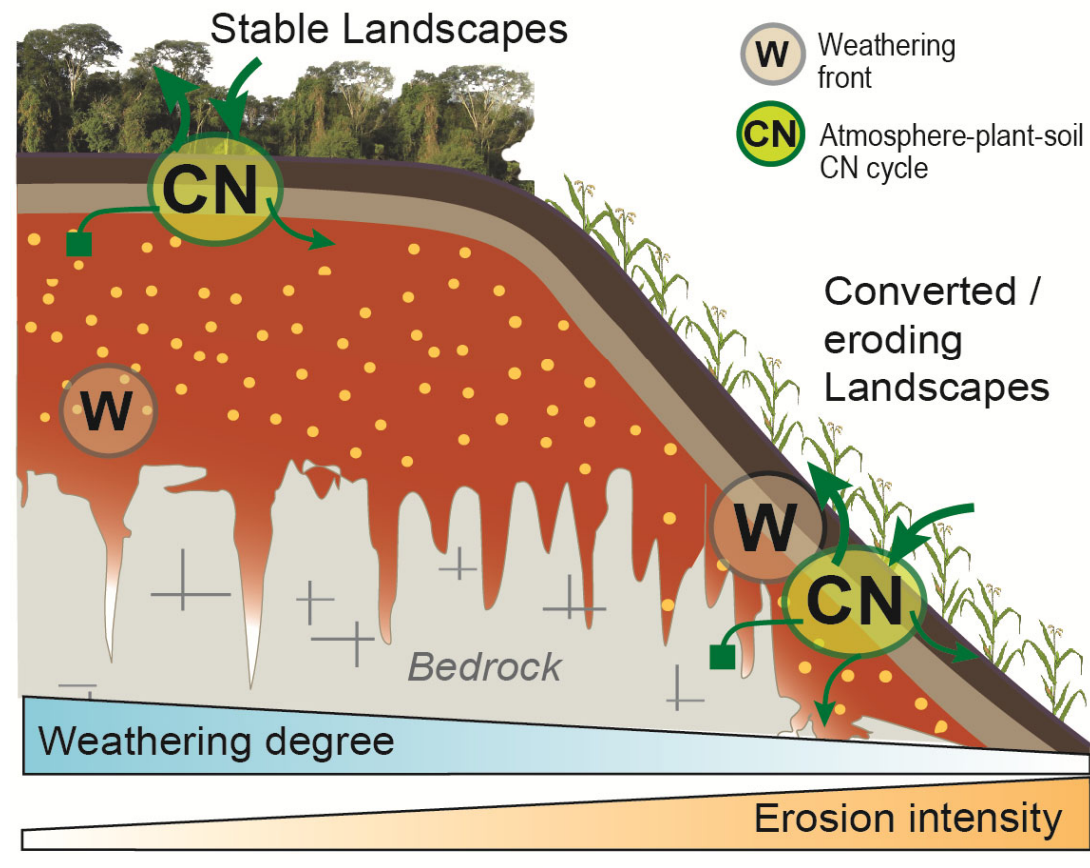
Forrest cover losses (2000 - 2014) – LANDSAT based
(Hansen et al. 2013)

- Tropical Africa is changing at an unprecedented speed and scale
- Research in tropical Africa is scarce
- Transfer of findings from S-America or S-Asia is limited

On- and offsite effects of erosion

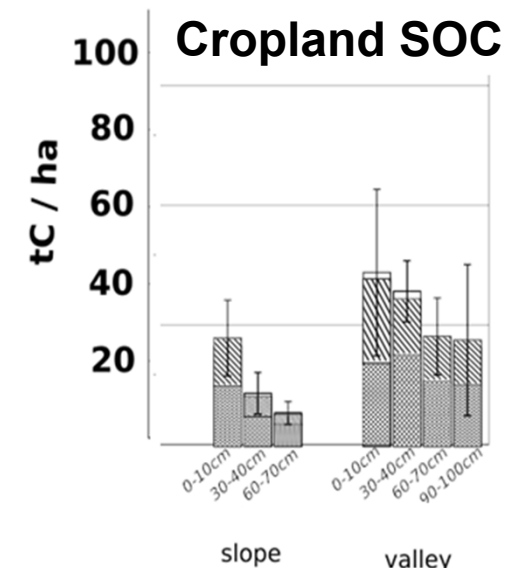
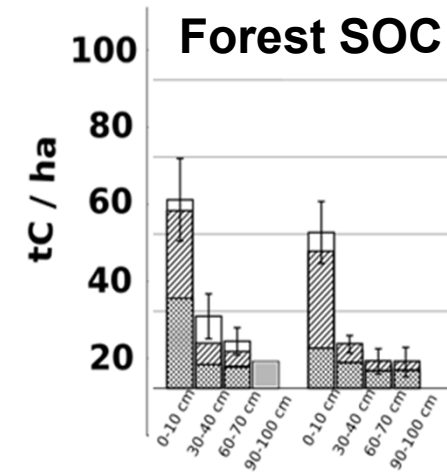
B. Human impact on weathering

B.1 Direct: Land conversion + Erosion



Doetterl et al. 2018, NGeo

On- and offsite effects of erosion



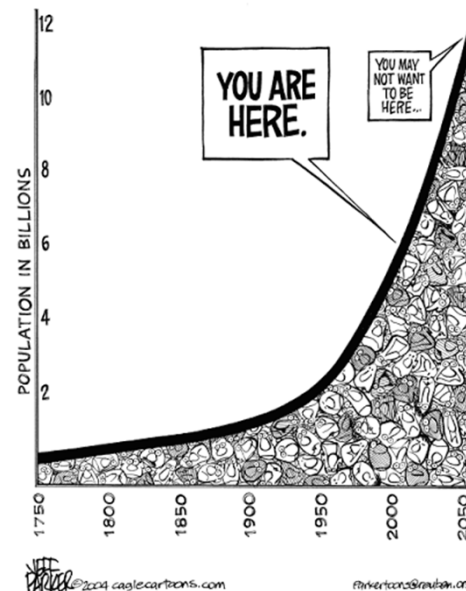
Doetterl et al. 2021, ESSD

Feed people AND keep climate stable:
An unsolvable conflict? No, but we need to act now, invest
and use soils smart.



Only 60 Years of Farming Left If Soil Degradation Continues?!

“Generating three centimeters of top soil takes 1 000 years, and if current rates of degradation continue all of the world's top soil could be gone within 60 years, a senior UN official said (Reuters 05/12/2014).”



Congo Biogeochemistry Observatory



<https://www.congo-biogeochem.com>

<https://www.soilres.ethz.ch>

Congo Biogeochemistry Observatory

Partners



Catholic University of Bukavu, DRC



Mountains of the Moon University, Uganda



Institute of National Research in Exact and Natural Science



Trans-African Hydro-Meteorological Observatory



International Institute of Tropical Agriculture



University of Lubumbashi, DRC



Max Planck Institute for Biogeochemistry, Jena



University of Natural Resources and Life Sciences, Vienna



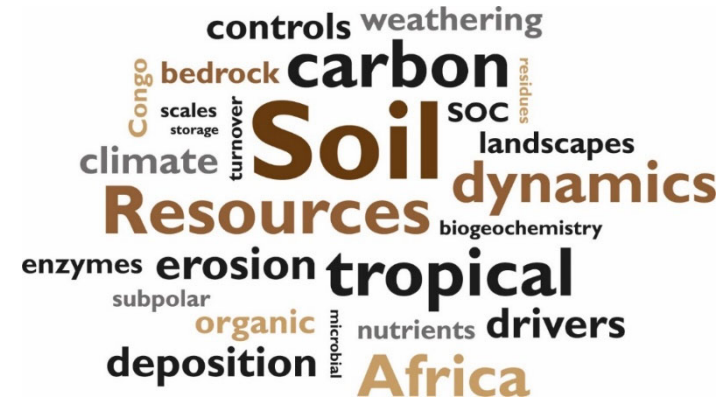
LABORATOIRE DES SCIENCES DU CLIMAT
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Thank you for your attention!

Check us out at:

<https://soilres.ethz.ch/>

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Congo Biogeochemistry
Observatory