Grasslands & Climate Change Mitigation

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Grasslands & Climate Change Mitigation

Motivation
- Permanent grasslands and ecosystem services for climate mitigation

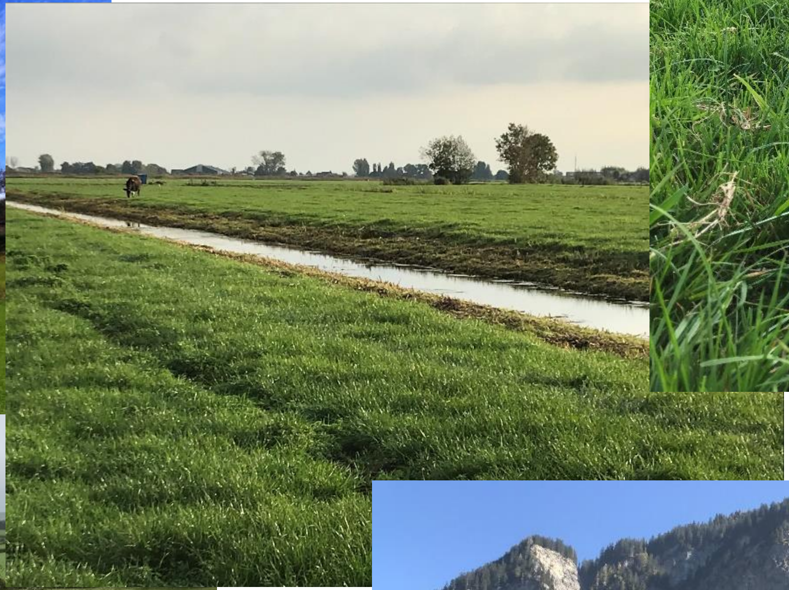
Climate Regulation
- Net grassland CO_2 fluxes and resilience to extreme droughts
- Long-term carbon sequestration

Driver of Climate Change
- Impact of restoration

Option for Climate Mitigation
- N_2O mitigation experiment

Lessons Learned

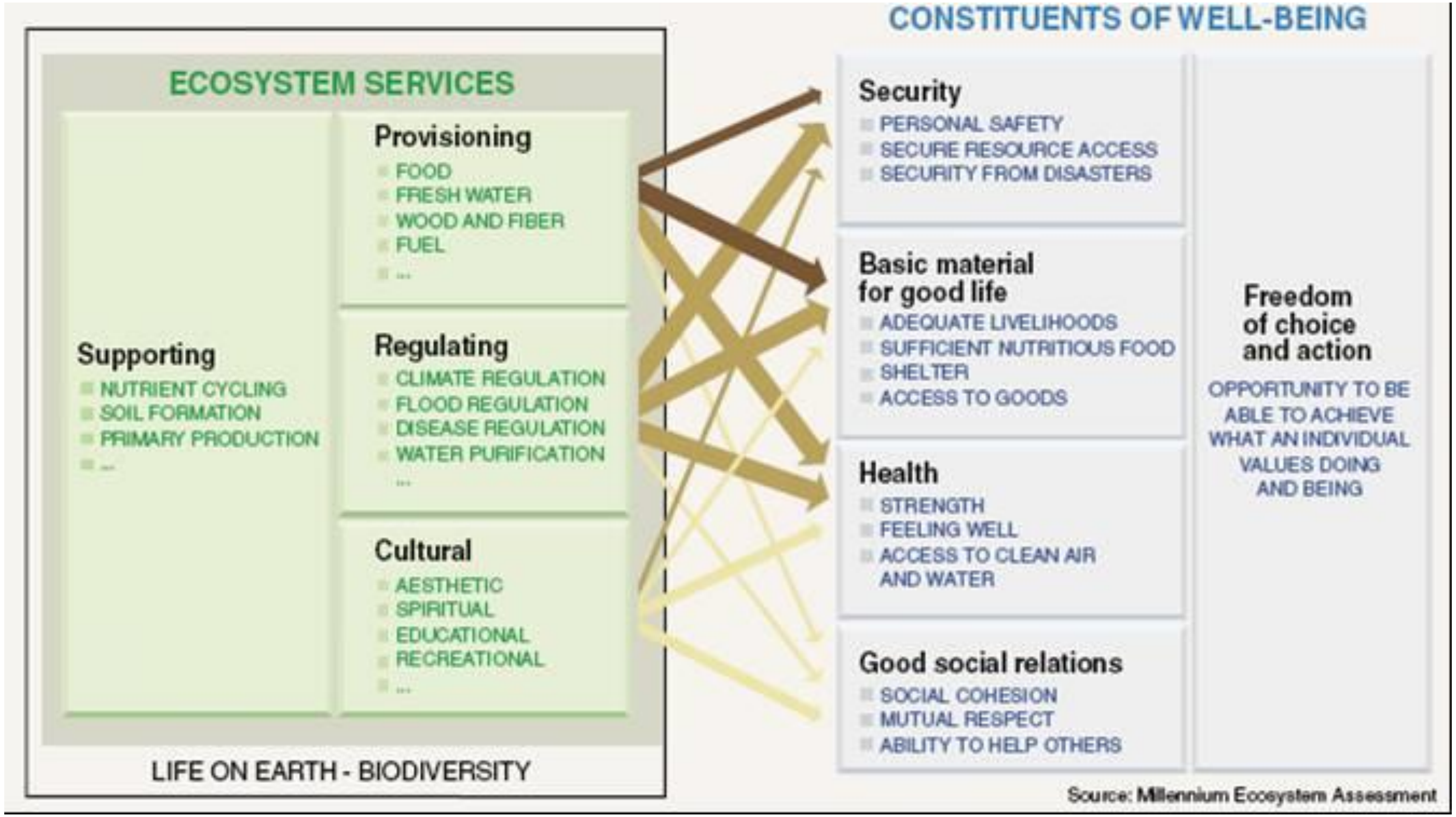
Permanent Grassland (PG)



CH: 70% UAA

Ecosystem Services: “Multifunctionality” of PG

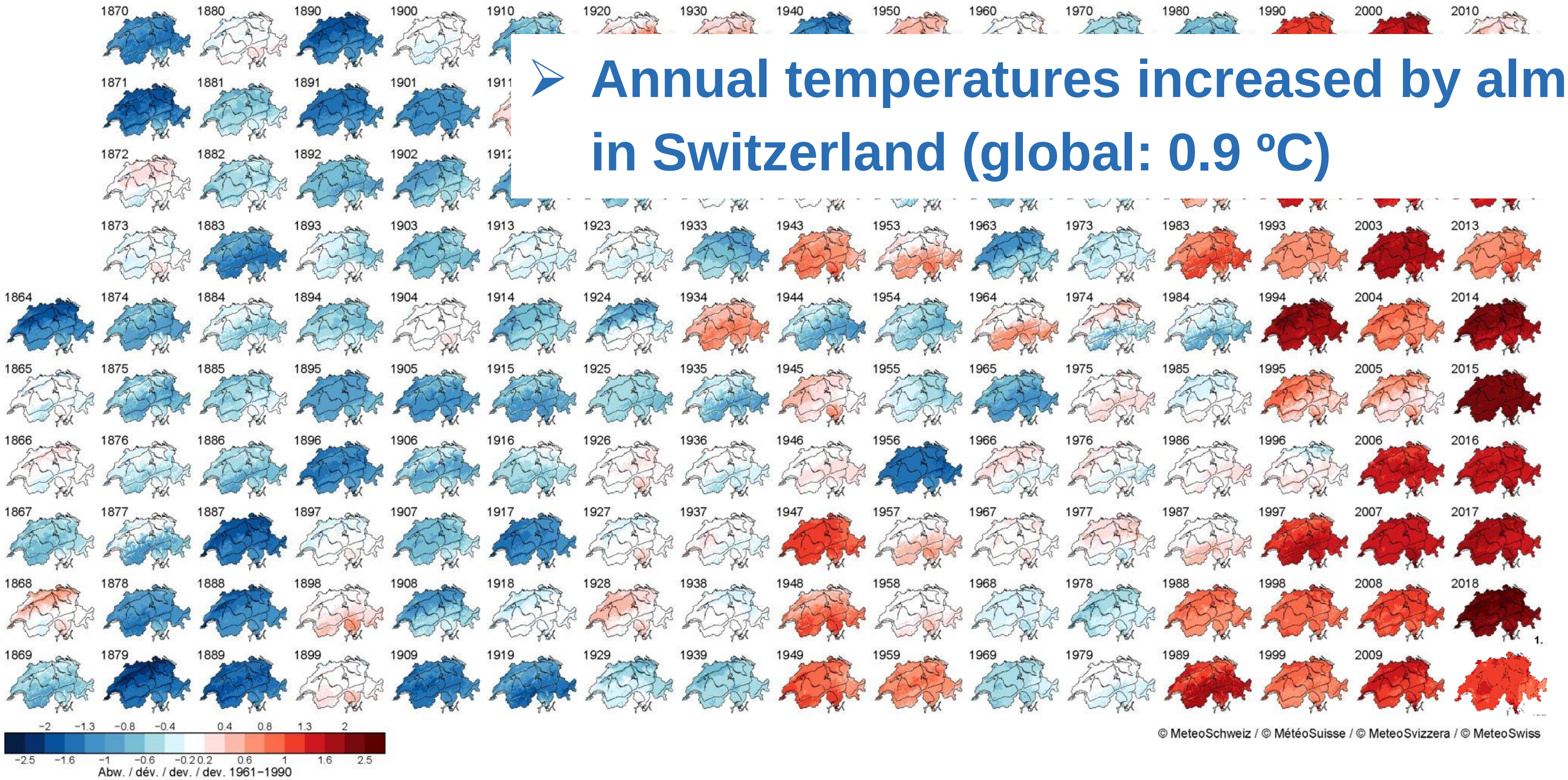





How can these services contribute to climate change mitigation?

(Millenium Ecosystem Assessment 2005)

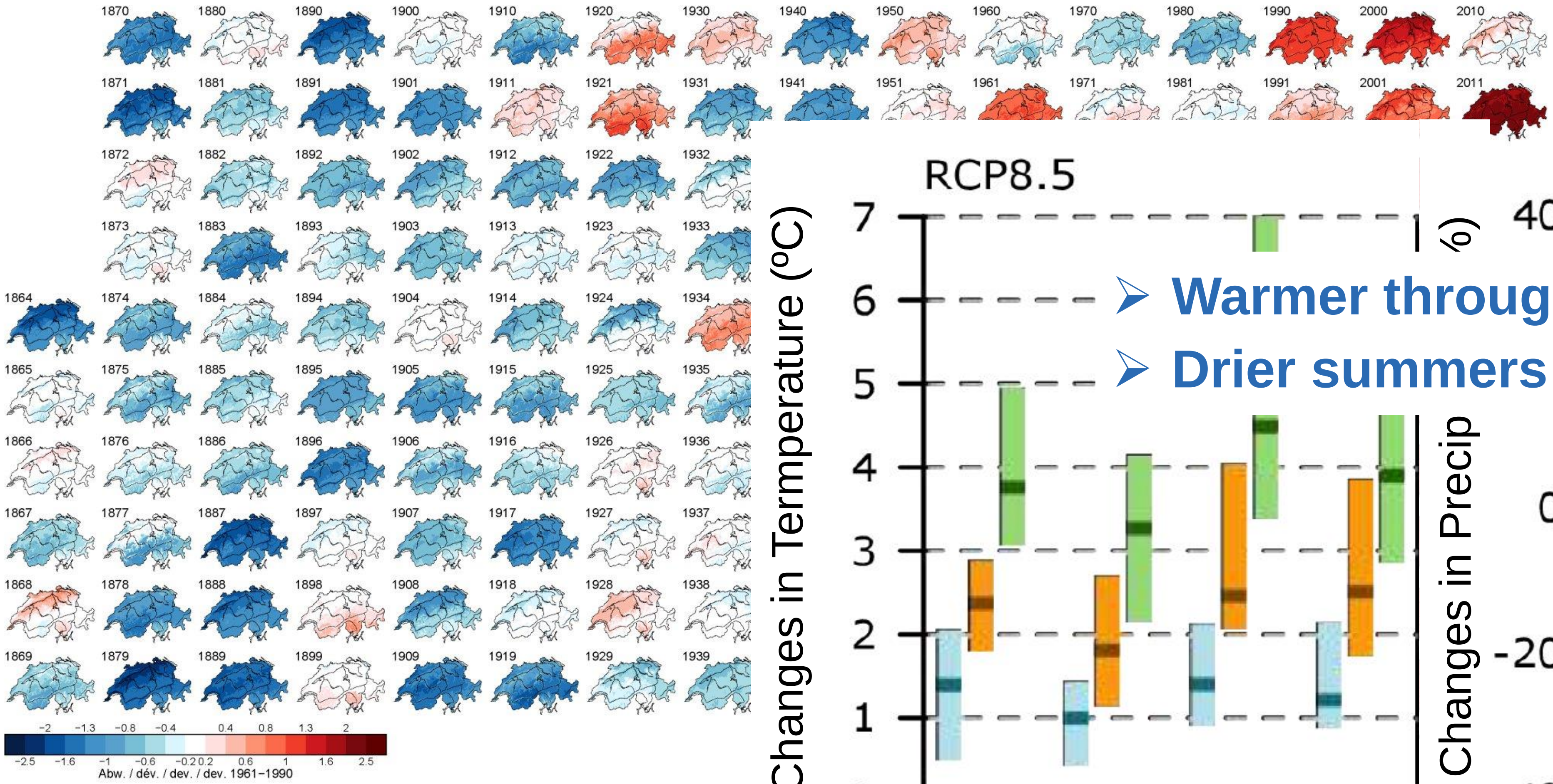
Climate Change: Challenges Now and in the Future

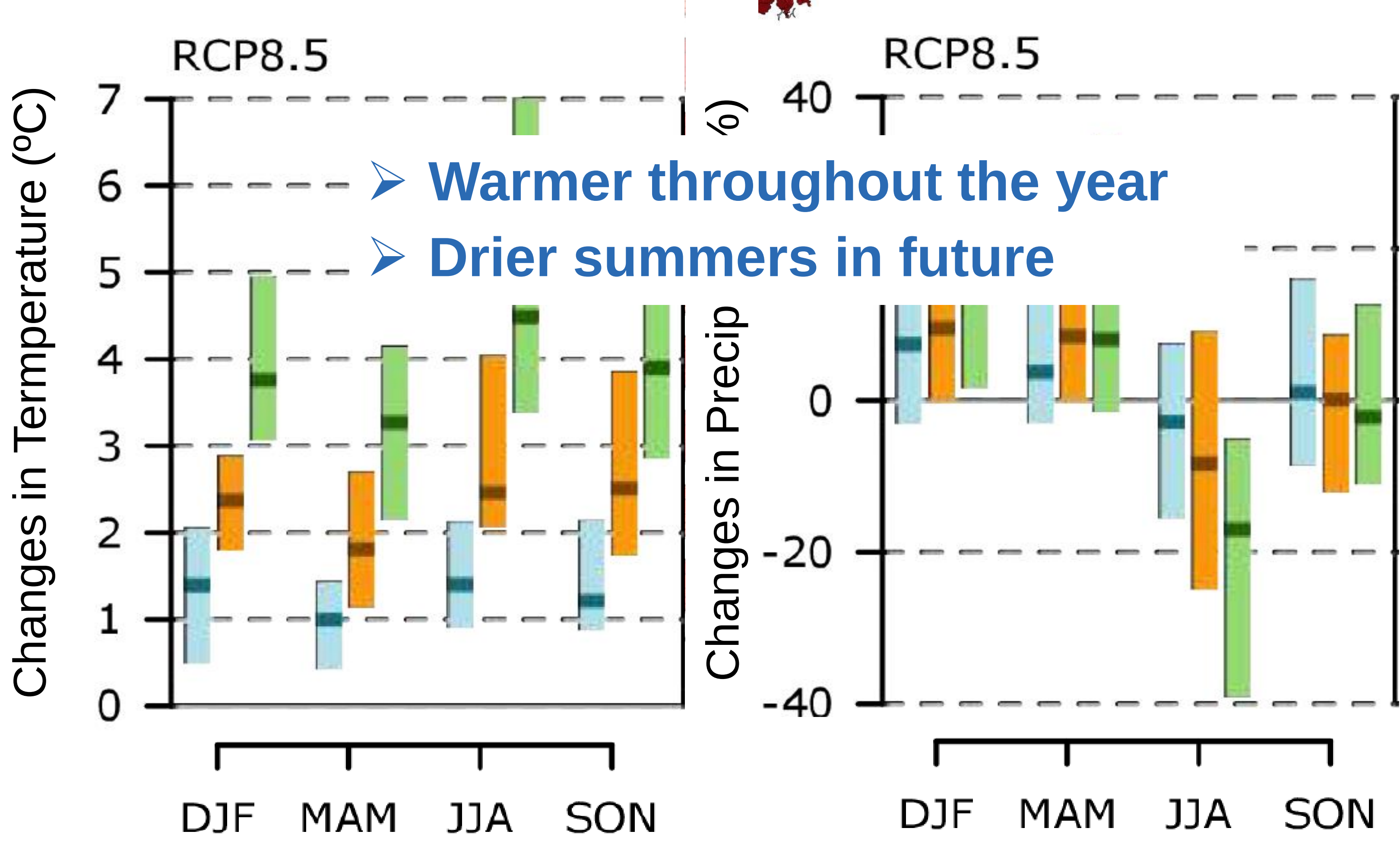


- **Annual temperatures increased by almost 2 ºC since 1864 in Switzerland (global: 0.9 ºC)**

(MeteoSwiss 2019; CH2018)

Climate Change: Challenges Now and in the Future



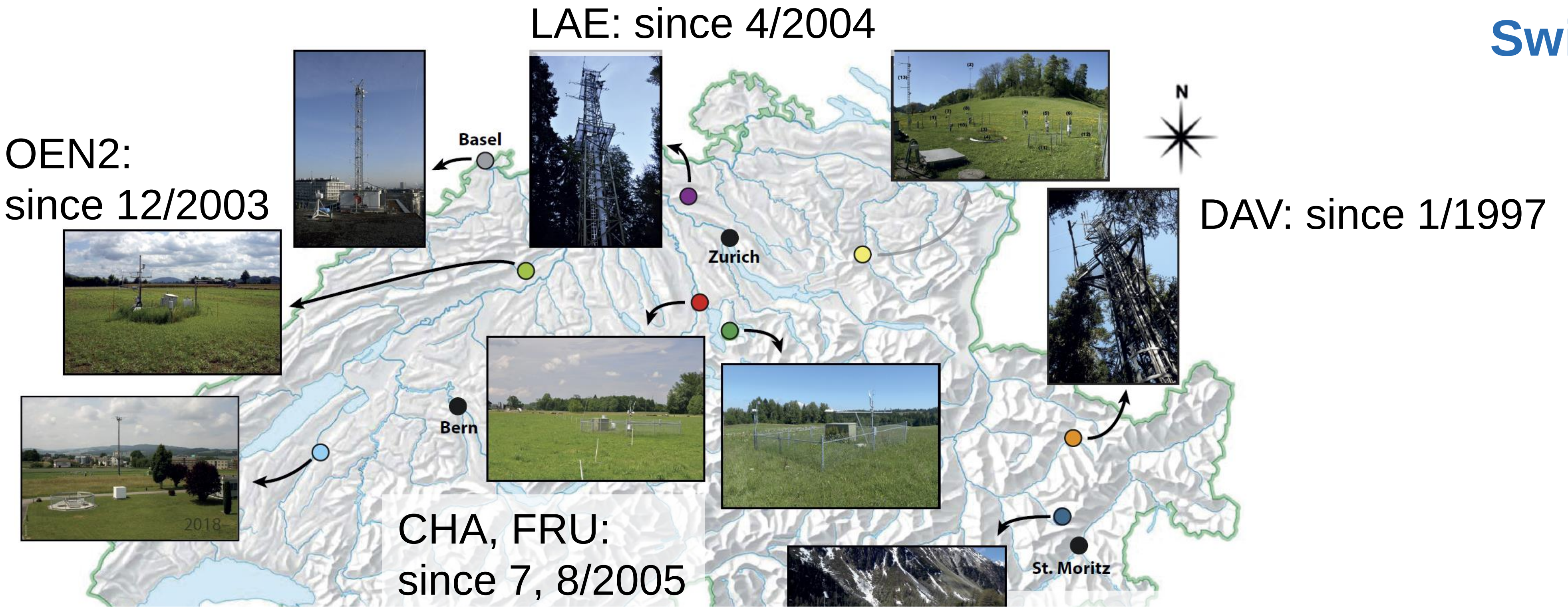


- ➢ **Warmer throughout the year**
- ➢ **Drier summers in future**

(MeteoSwiss 2019; CH2018)

Observational Approach to Measure the «Breathing of the Biosphere»

Swiss FluxNet



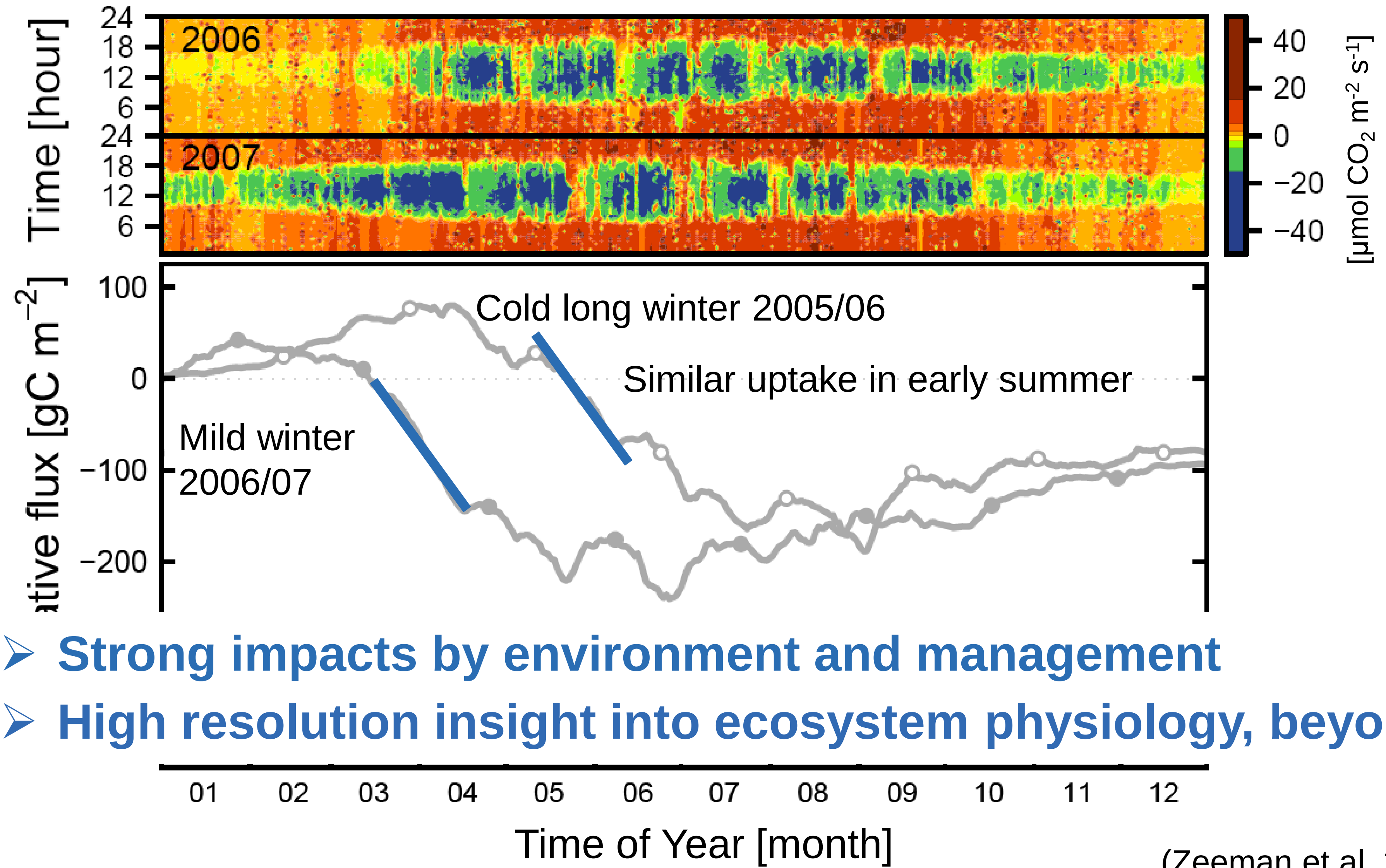
Continuous CO_2, H_2O vapor fluxes, meteo available (… plus much more …)

- ➢ **Response to environmental change and management**
- ➢ **Use as a research platform (isotopes, phenology, remote sensing…)**

Long-term data sets (> 99 site-years)

- ➢ **Response to slow changes, e.g., climate change; provision of climate regulation**

Grassland CO_2 Fluxes = function of (Environment, Management)

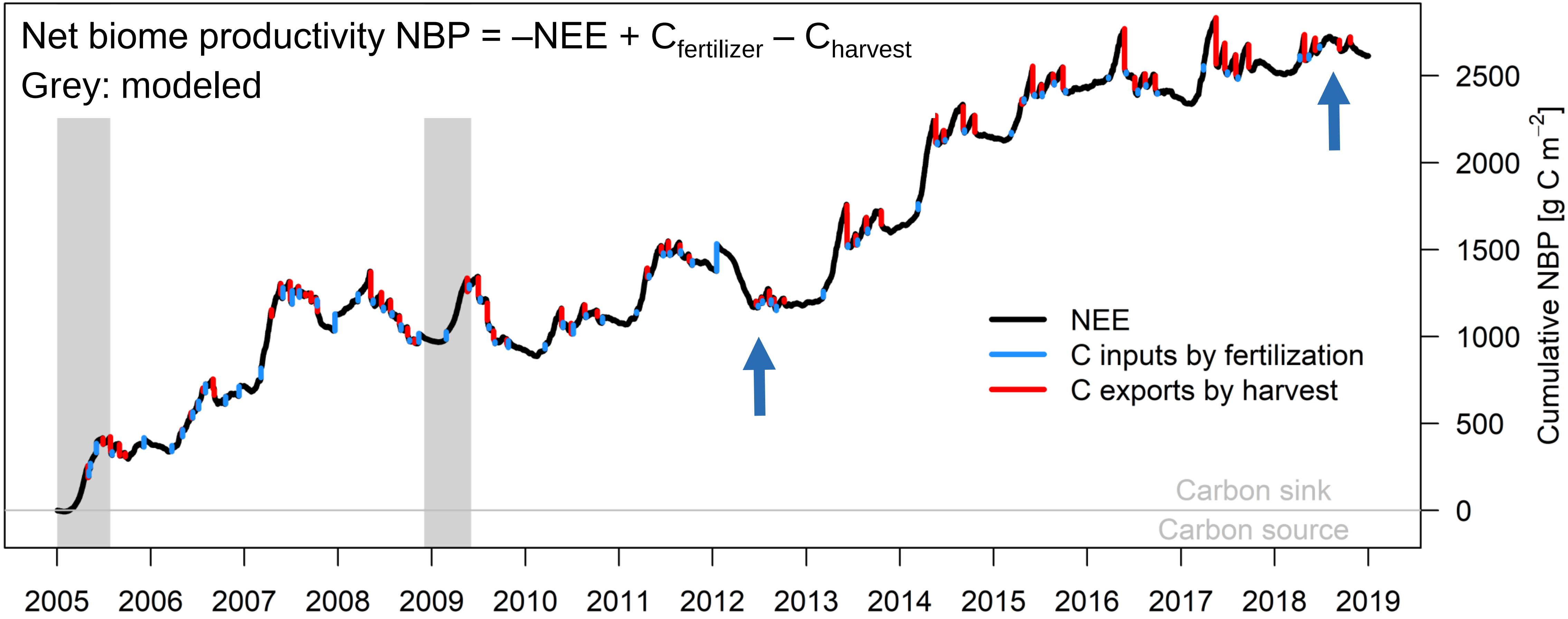


- **Strong impacts by environment and management**
- **High resolution insight into ecosystem physiology, beyond carbon budgets**

(Zeeman et al. 2010, AFM; Buchmann et al. 2019)

Long-term Carbon (C) Sequestration (NBP)

Chamau, 400 m

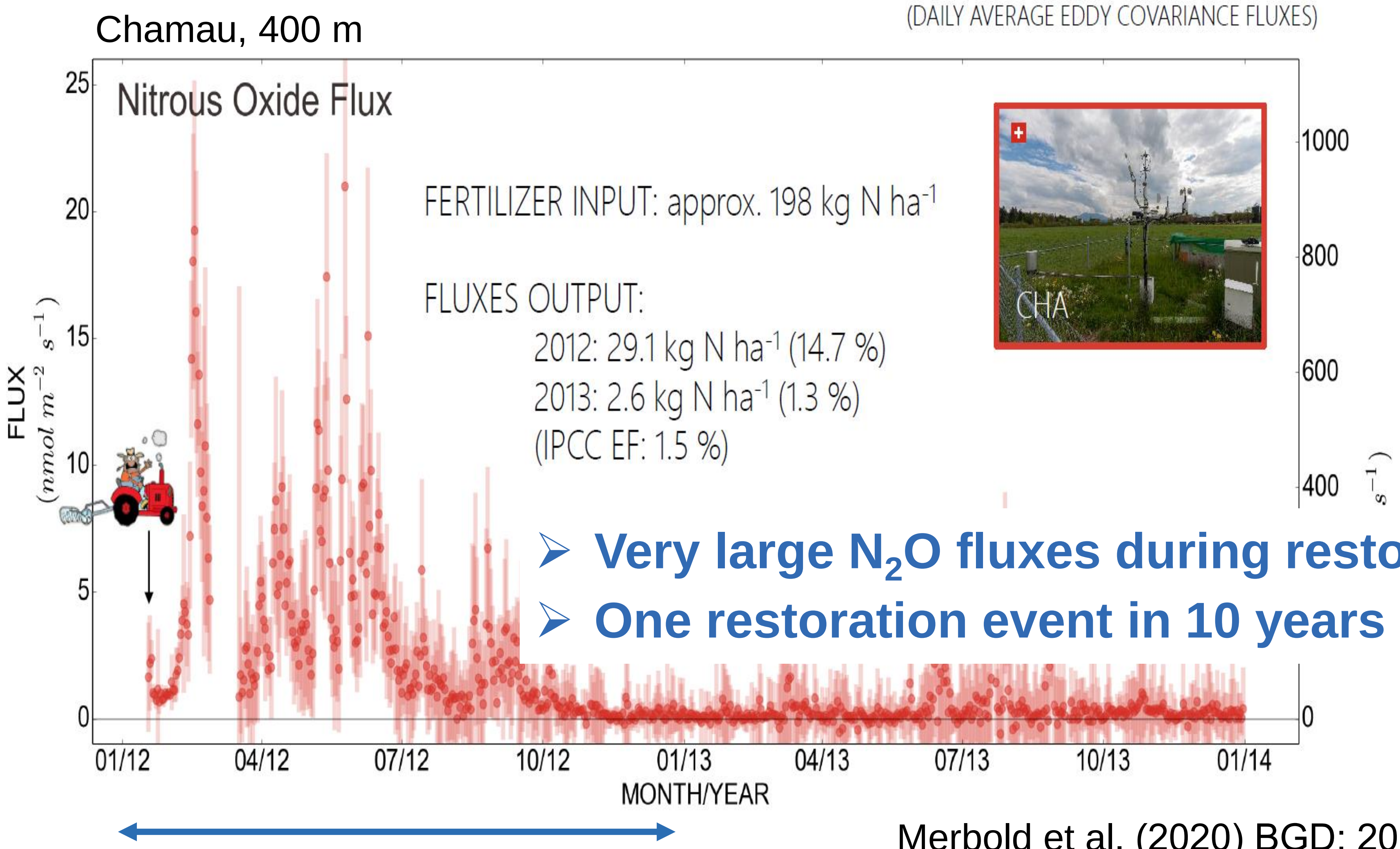


- **Over 14 years: small annual C sinks**
- **Sink = f (Environment, Management)**

(Feigenwinter et al. 2019)

Impact of Restoration on Grassland N_2O Fluxes

Chamau, 400 m



Restoration: ploughing, harrowing, resowing and fertilisation

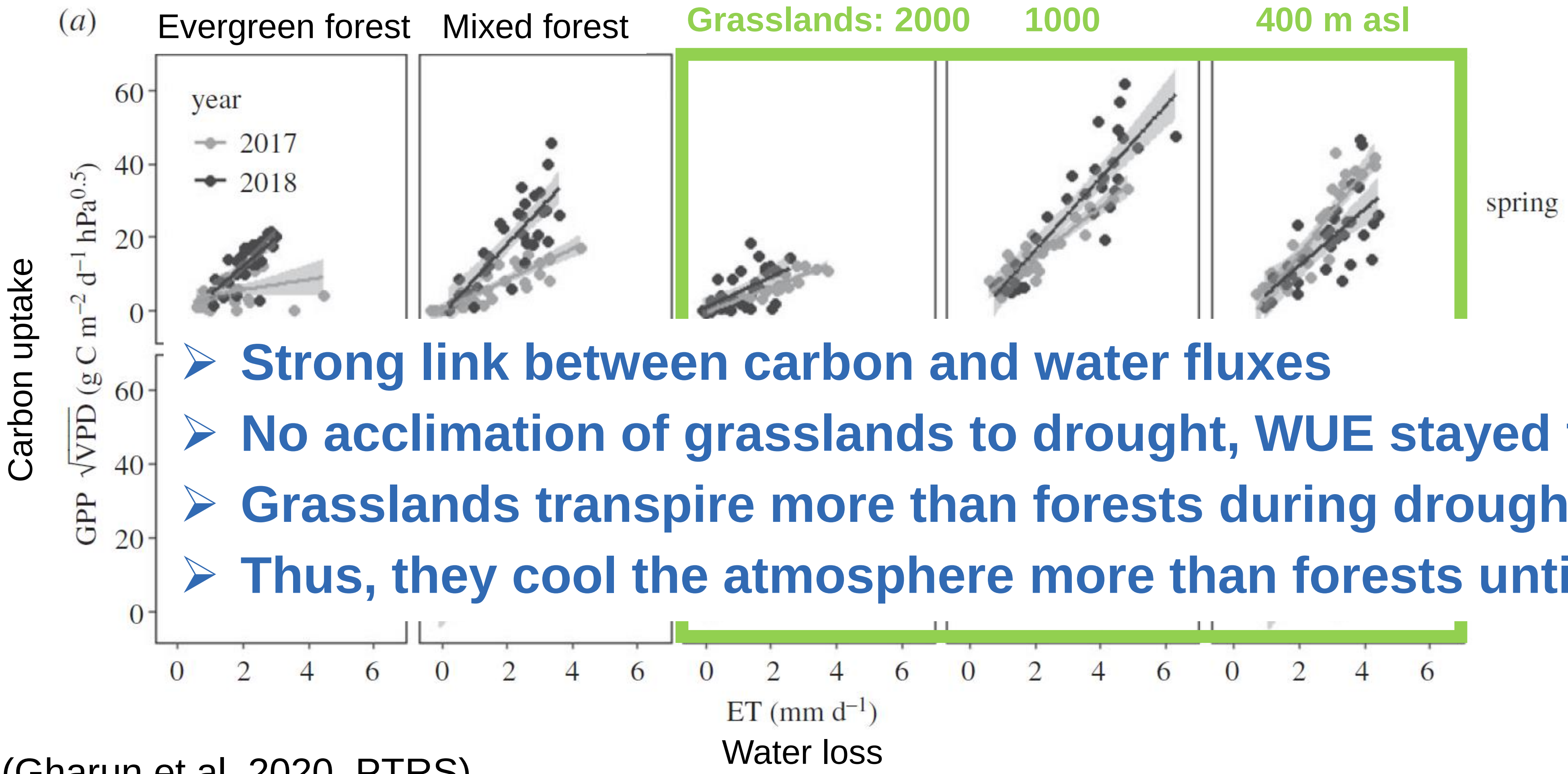
- **Very large N_2O fluxes during restoration year**
- **One restoration event in 10 years sets off a 5-yr C sink**

Merbold et al. (2014) GCB

Merbold et al. (2020) BGD: 2010–2015

Resilience to Extreme Droughts

Summer drought 2018: annual precip -30% (CHA), -27% (FRU), +3% (AWS)



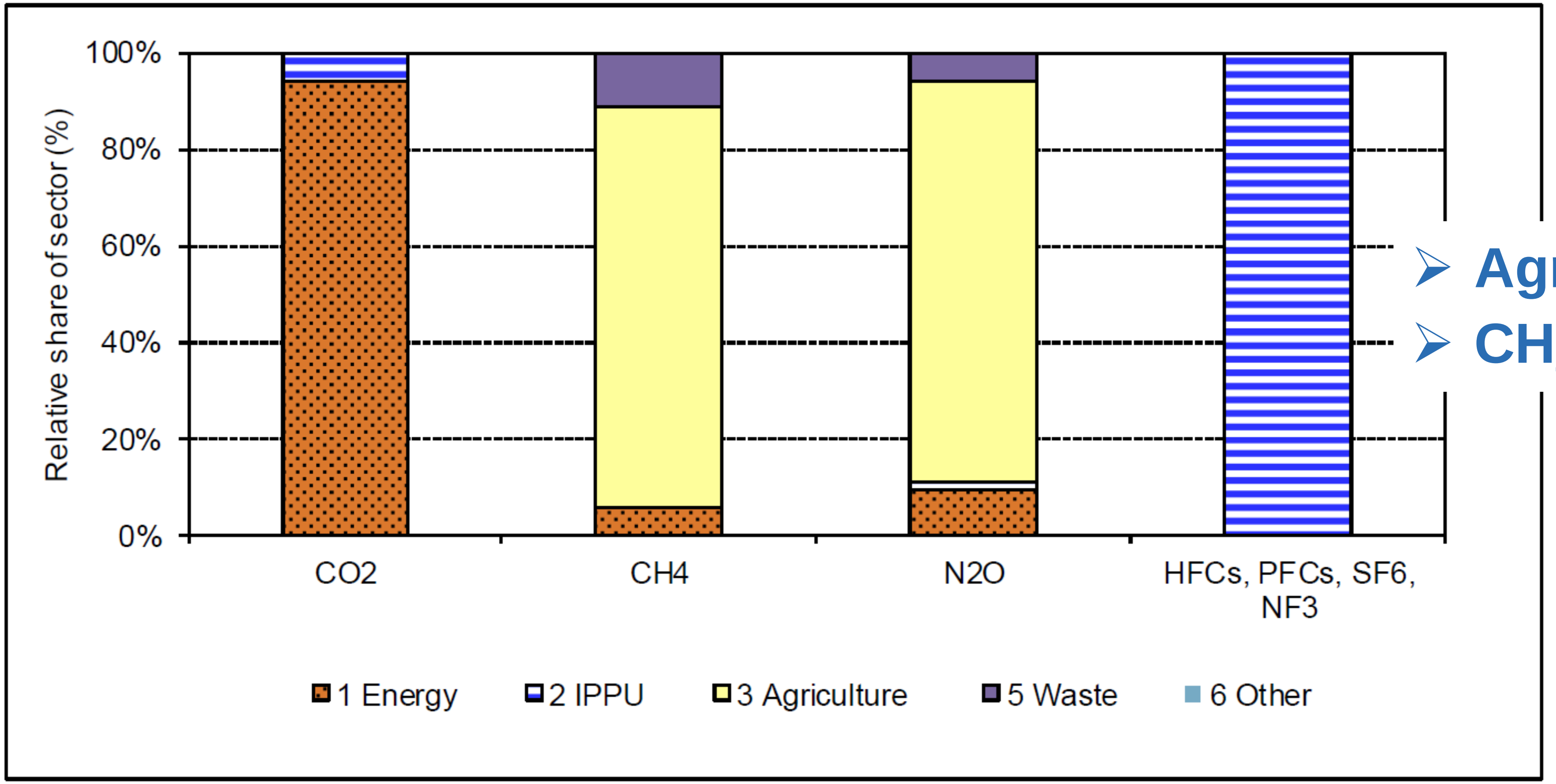
Slope = $\frac{\text{carbon uptake}}{\text{water loss}}$

- ➢ **Strong link between carbon and water fluxes**
- ➢ **No acclimation of grasslands to drought, WUE stayed the same**
- ➢ **Grasslands transpire more than forests during drought**
- ➢ **Thus, they cool the atmosphere more than forests until they dry out**

(Gharun et al. 2020, PTRS)

Drivers of Climate Change: Greenhouse Gas Emissions

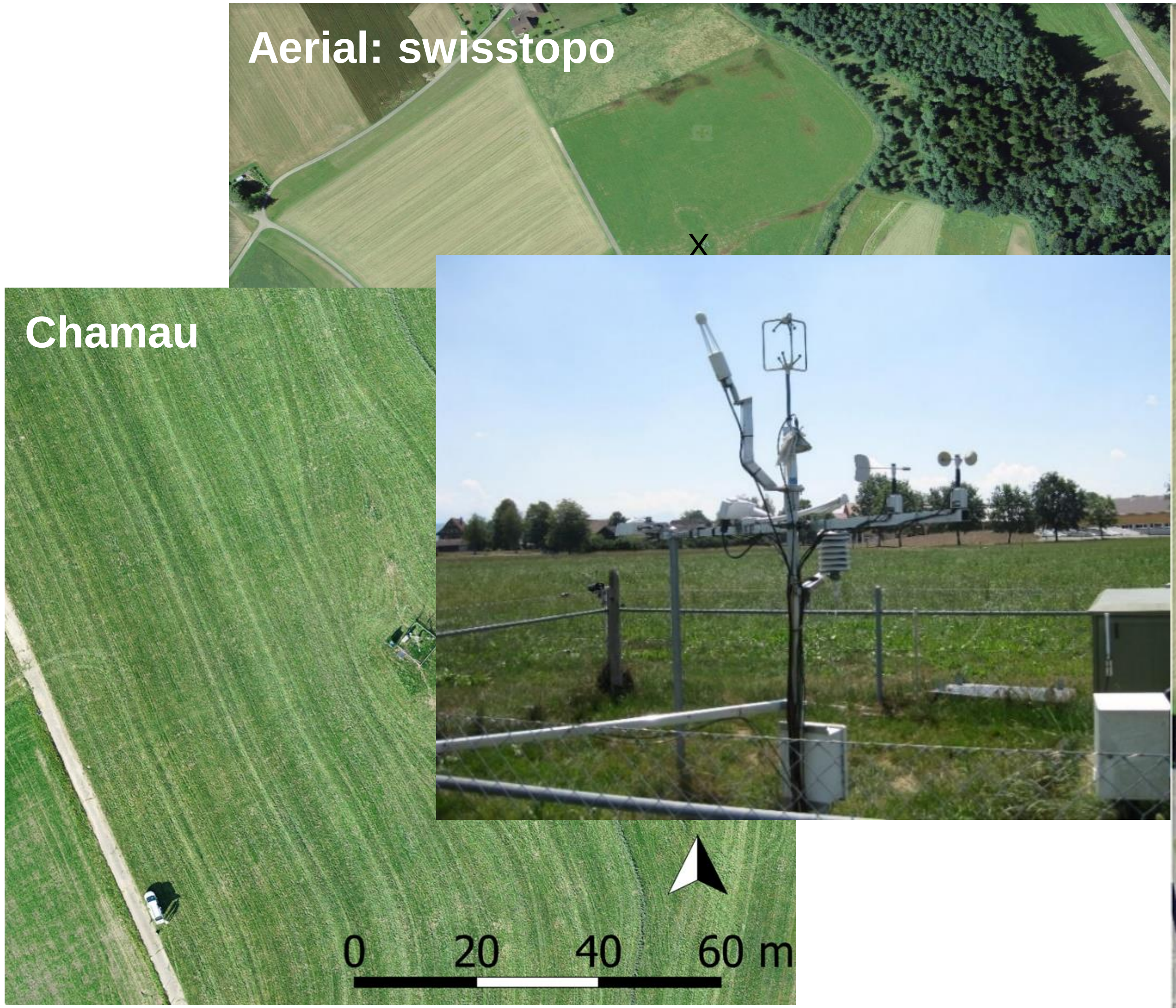
Greenhouse gas emissions in Switzerland (2017)

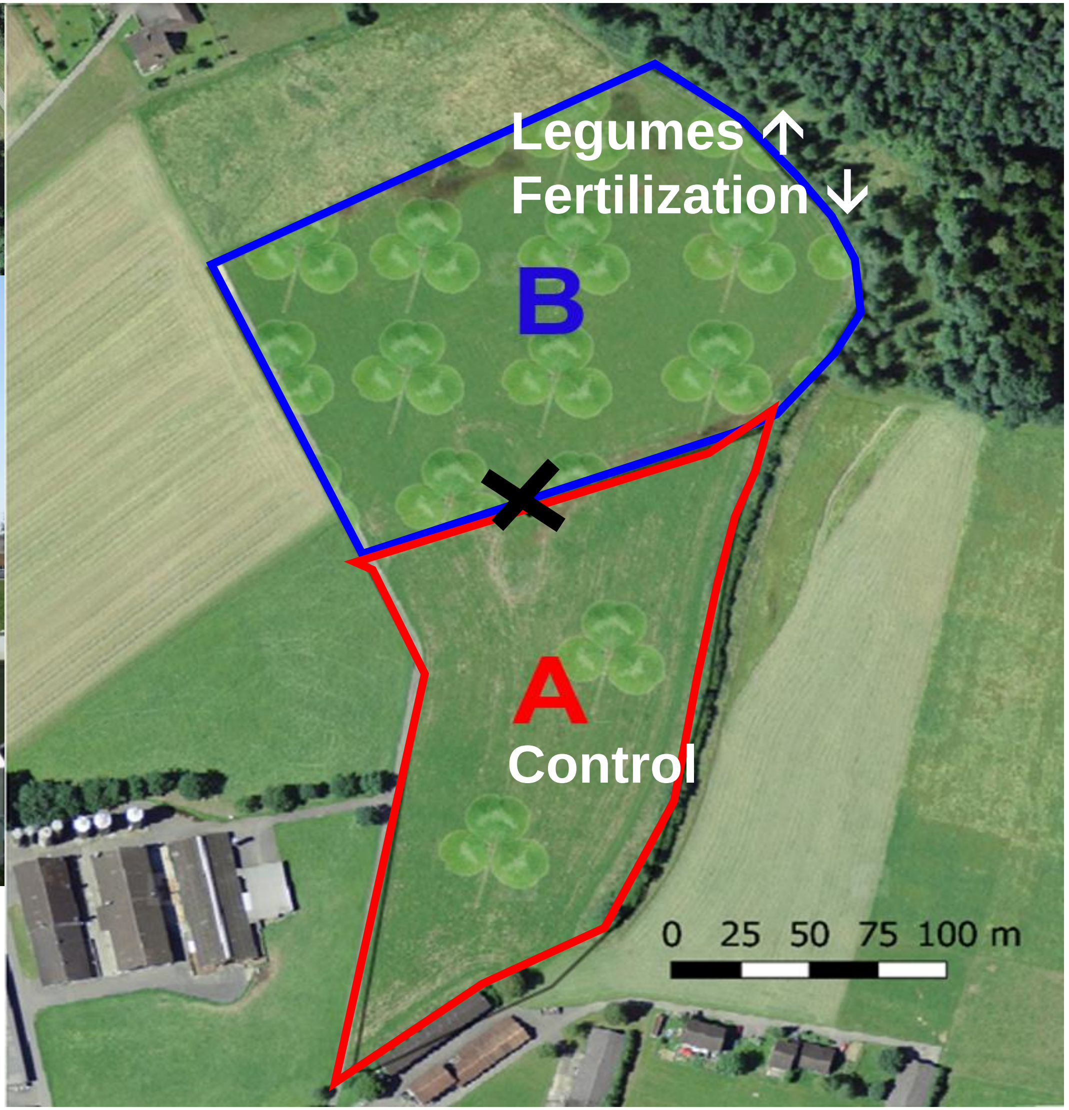


- **Agriculture: 12.9%**
- **CH_4, N_2O,** CO_2

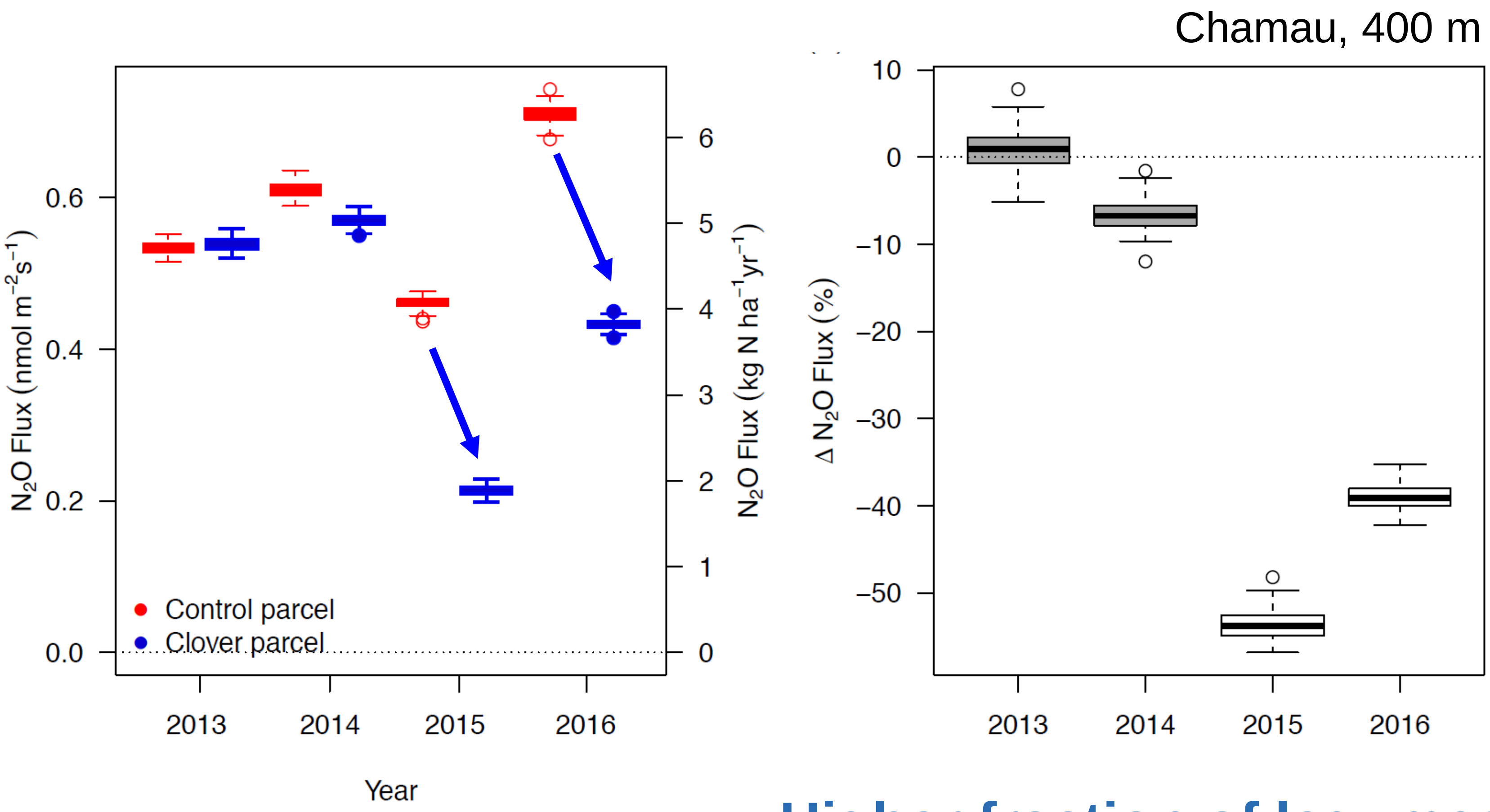
(FOEN 2019)

Can legume fractions substitute N fertilization & reduce N_2O emissions?





N_2O Mitigation Experiment



Higher fraction of legumes in sward:

- **40-50 % lower N_2O emissions**
- **10 % lower yields, but higher forage quality**

(Fuchs et al. 2018, BG)

Grasslands and Climate Change Mitigation

Thank You !

Ecosystem Services of Permanent Grasslands

- Permanent grasslands provide multiple services, incl. climate regulation.
- High-resolution flux measurements are key to collect data on „Breathing of Biosphere“.

Climate Regulation of Permanent Grasslands

- Management and environment affect ecosystem greenhouse gas exchange.
- Permanent grassland soils are small annual C sinks.
- Restoration events can offset long-term soil carbon sinks.

Resilience to Drought Extremes and Option for Climate Mitigation

- Resilience of grassland productivity is high.
- Strong link between carbon and water fluxes at ecosystem level.
- Grasslands cool the atmosphere longer than forests during a drought.
- Mixtures with legumes can strongly reduce N_2O emissions w/out trade-offs for yield or quality.