Research and Innovation: Meeting Expectations of Society

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Grassland Sciences

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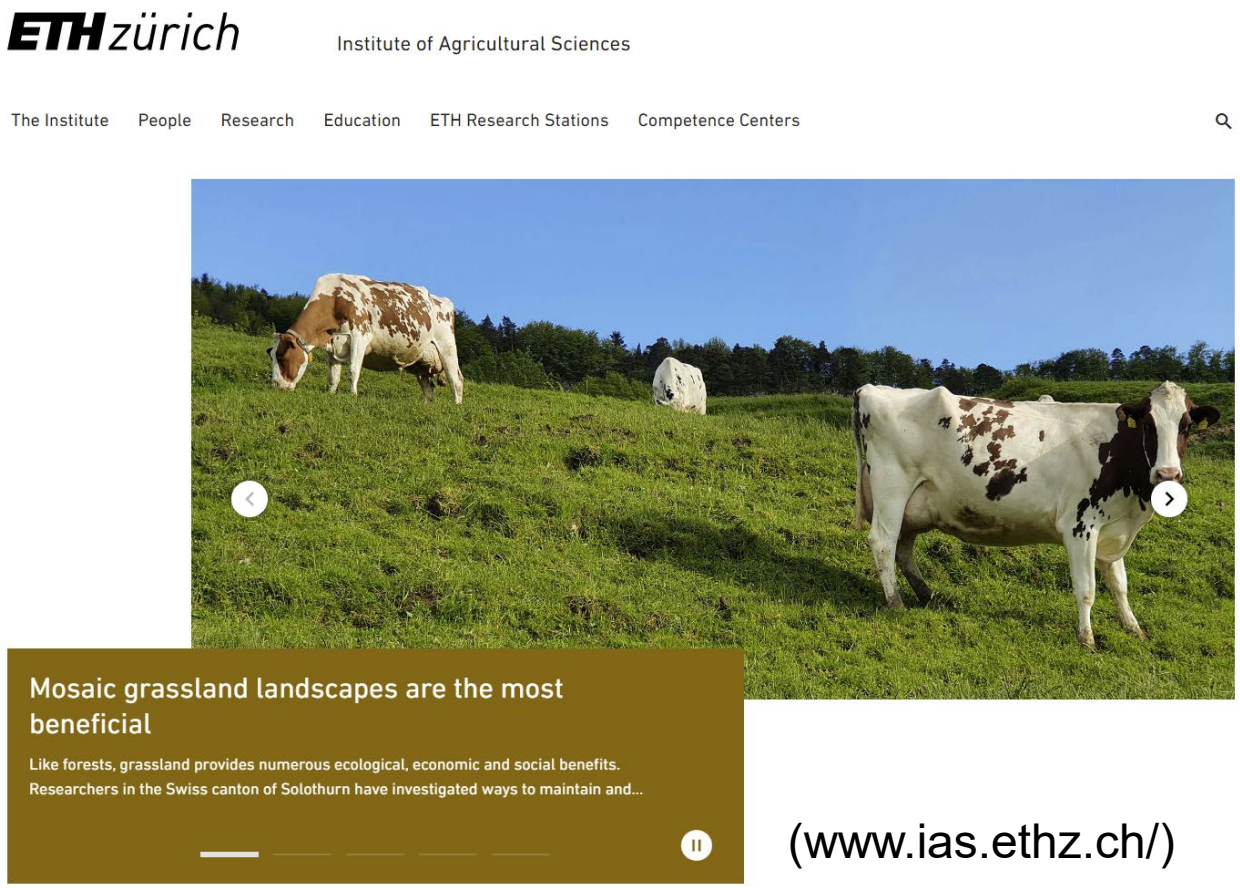
ETH Zurich: Institute of Agricultural Sciences (IAS)

ETH Zurich Rankings

ETHZ: best continental university in Europe (QS). Since 1871, the only research university in CH with Agricultural Sciences.

Agricultural and Forest Sciences: rank 3–7 in Europe, rank 6–12 globally (QS; 2021–2024)



(www.ias.ethz.ch/)

Homepage › Research

Research

Prof. Nina Buchmann, Grassland Sciences
Prof. Consuelo De Moraes, Biocommunication & Entomology
Prof. Emmanuel Frossard, Plant Nutrition
Ass.-Prof. Johanna Jacobi, Agroecolocial Transitions
Ass.-Prof. Stefano Mintchev, Environmental Robotics
Ass.-Prof. Mutian Niu, Animal Nutrition
Ass.-Prof. Hubert Pausch, Animal Genomics
Prof. Johan Six, Sustainable Agroecosystems
Prof. Bruno Studer, Molecular Plant Breeding
Prof. Susanne E. Ulbrich, Animal Physiology
Prof. Achim Walter, Crop Science

➢ Eleven professorships

Challenges for Agriculture in Switzerland and beyond

- **Growing world population, smaller areas**
  → Increased and efficient production systems
- **Natural resources, land degradation**
  → Circular, sustainable production
- **Climate change**
  → Adapted and resilient production systems
- **Loss of biodiversity**
  → Maintainance of suitable varieties and increased agrodiversity; mixtures, intercropping, agroforestry
- **Changed diets, consumer behaviour**
  → Adapted offers

→ Systems thinking !

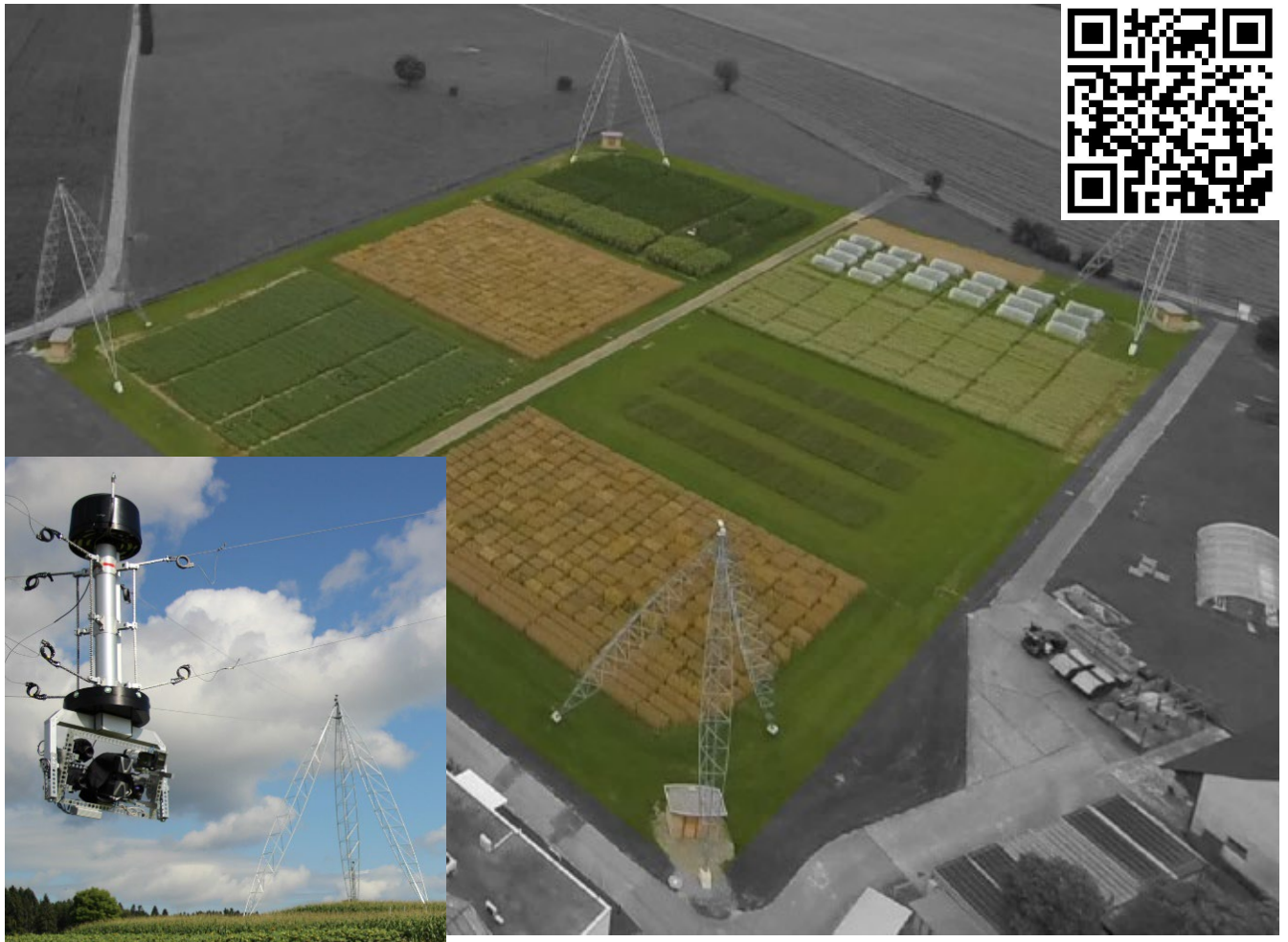
IAS

Field Phenotyping to Reduce Pesticide & Fertiliser Inputs

Septoria detection

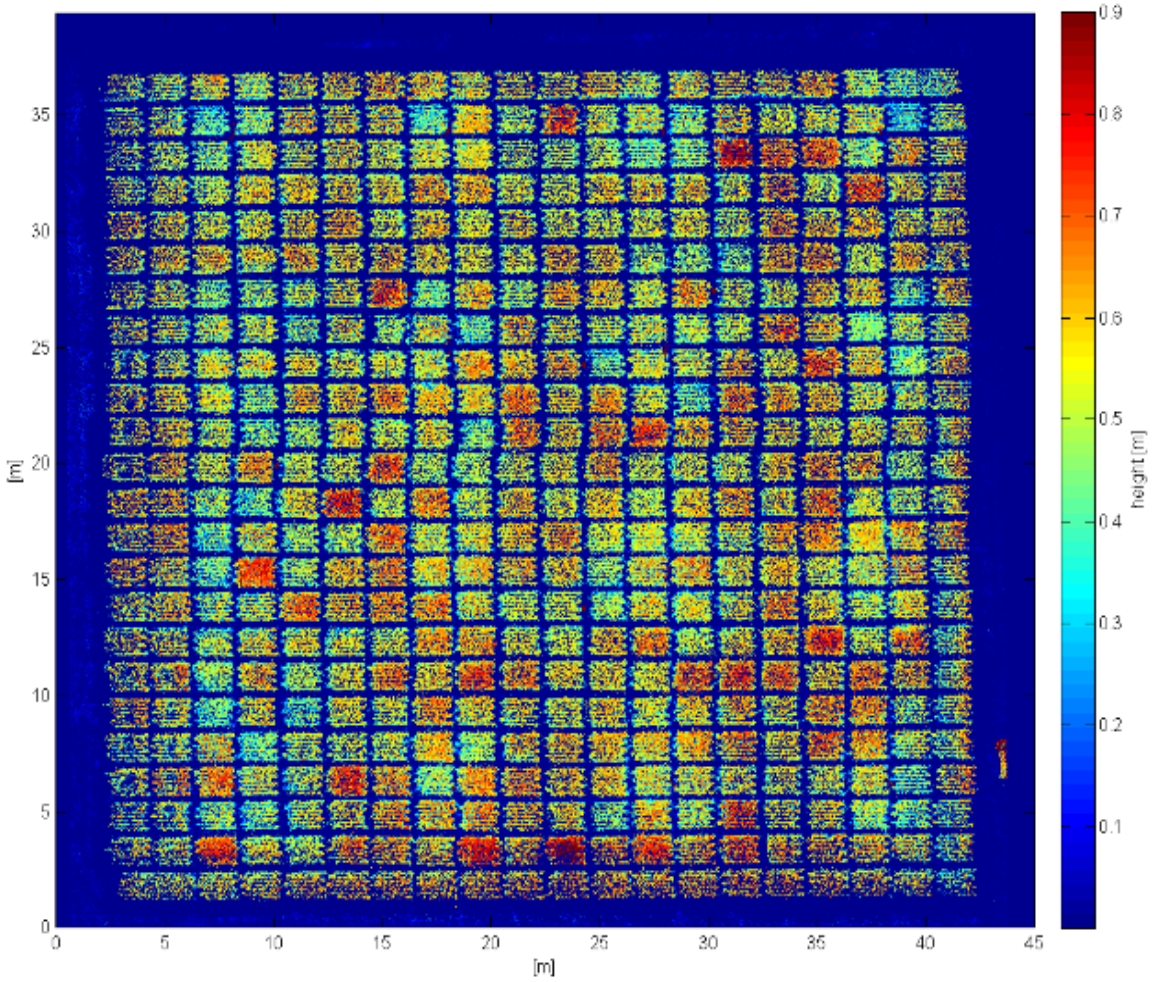
Prof. Walter

Crop Science



Field Phenotyping Platform – rope camera system with multiple sensors

Field Phenotyping to Reduce Pesticide & Fertiliser Inputs



➢ **Laser scanning produces height map of 300 wheat genotypes**

➢ **Image analysis with deep learning / AI differentiates between plants and soils**

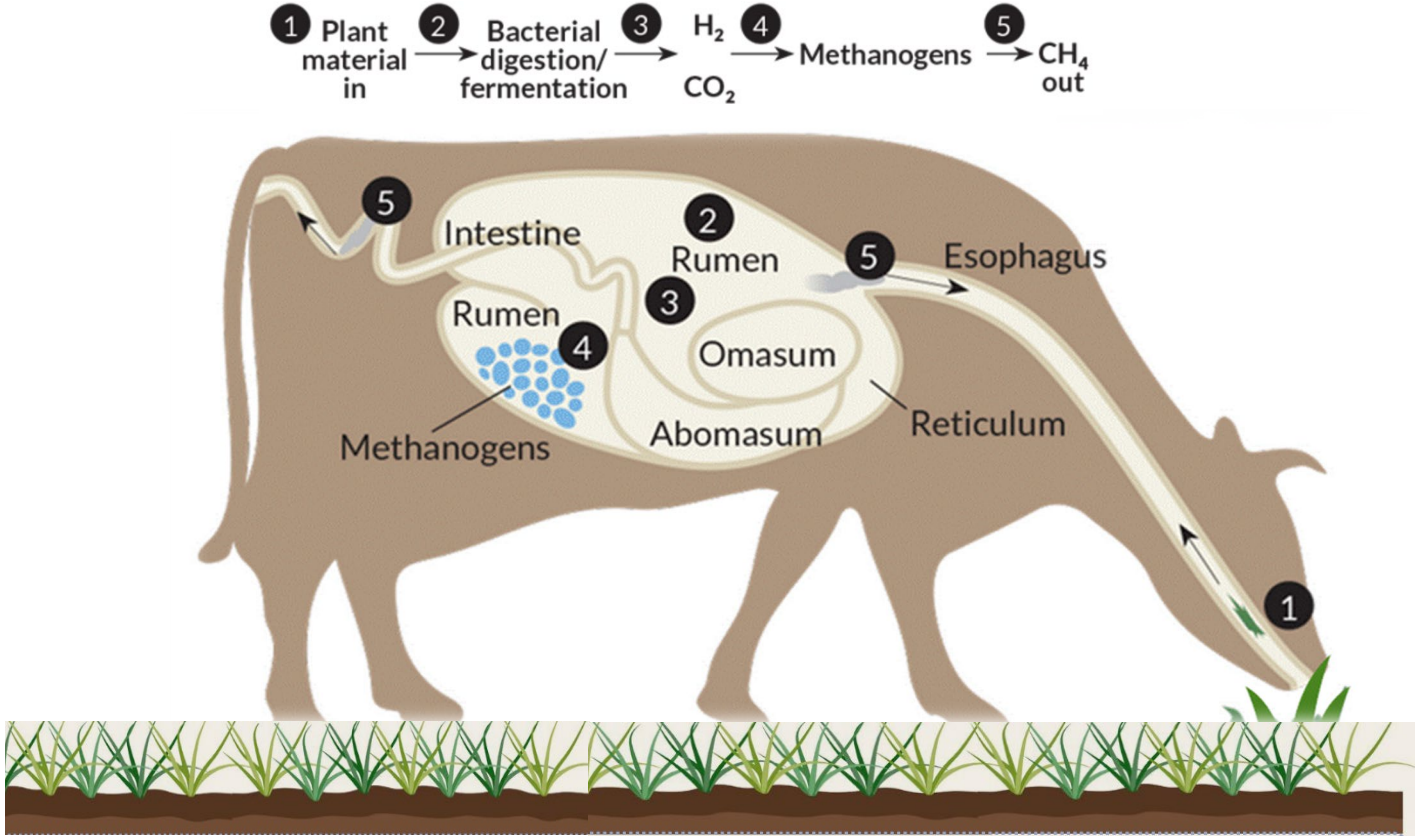
Start-up since 2023:
Laser-based weeding robot

CATERRA

Dietary Strategies for Climate-Smart Livestock Farming

Agriculture in CH: 14.1% of greenhouse gas (GHG) emissions

CH_4 from ruminants: 61% of GHG emissions from Swiss agriculture (globally: 11% and 45%)



Head chamber

Prof. Niu

Animal Nutrition

Dietary Strategies for Climate-Smart Livestock Farming

Developing dietary strategies to mitigate CH_4 emissions

ANIMAL & FEED MANAGEMENT

- Feed processing
- Genetic selection
- Improving animal health
- Improving pasture management
- Increasing feeding level
- Increasing forage quality
- Optimizing temperature
- TMR feeding

DIET FORMULATION

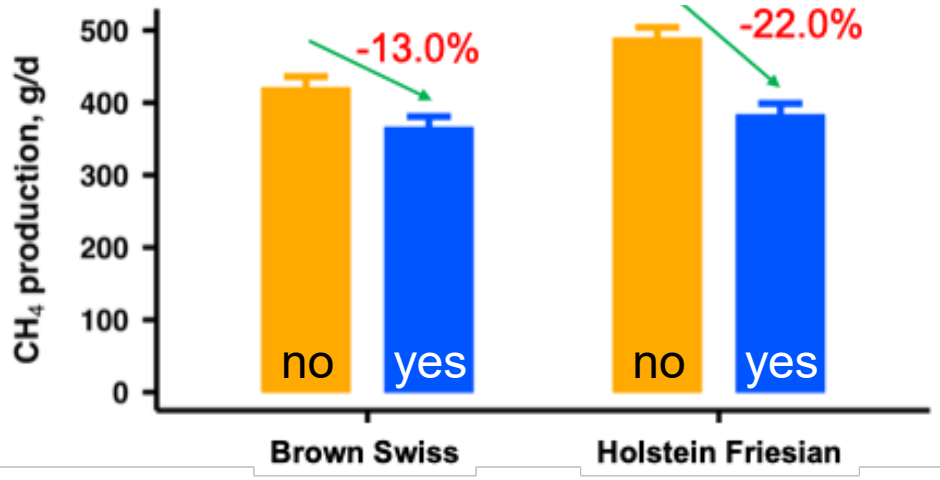
- By-products
- Decreasing forage-to-concentrate ratios
- Minerals and salts
- Oils and fats
- Oilseeds
- Increasing protein
- Tanniferous forages
- Urea

RUMEN MANIPULATION

- Additives
- Defaunation
- Electron sinks

Additive (3-NOP): reduced emissions

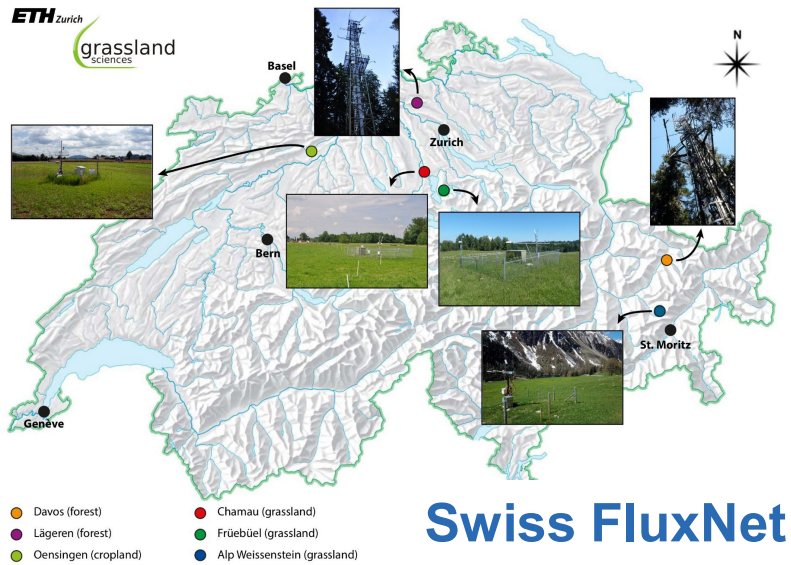
Breed: differences among breeds



- **Breed-dependent CH_4 mitigation efficacy for a commercially available CH_4 inhibitor**
- **Decisive for policy-makers and farmers**

(Arndt 2022; Islam et al. 2024)

GHG Flux Measurements for Climate-Smart Agriculture



Swiss FluxNet

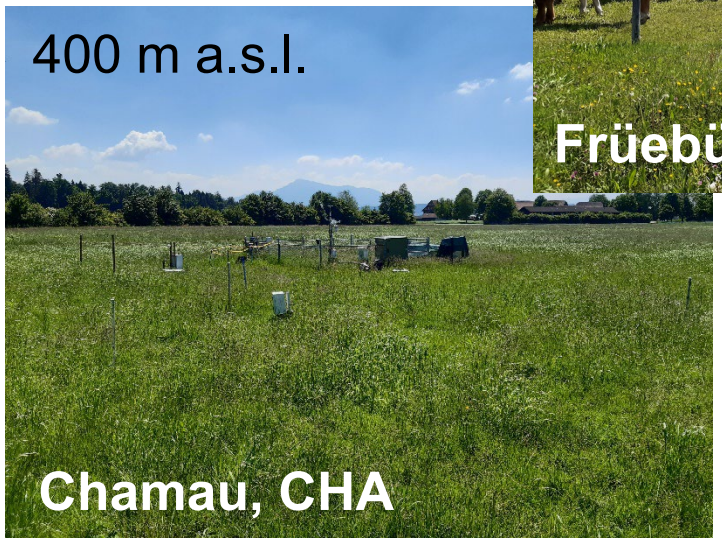
Swiss FluxNet

Eddy-covariance technique

- Continuous at 20 Hz, for decades
- Spatial integration

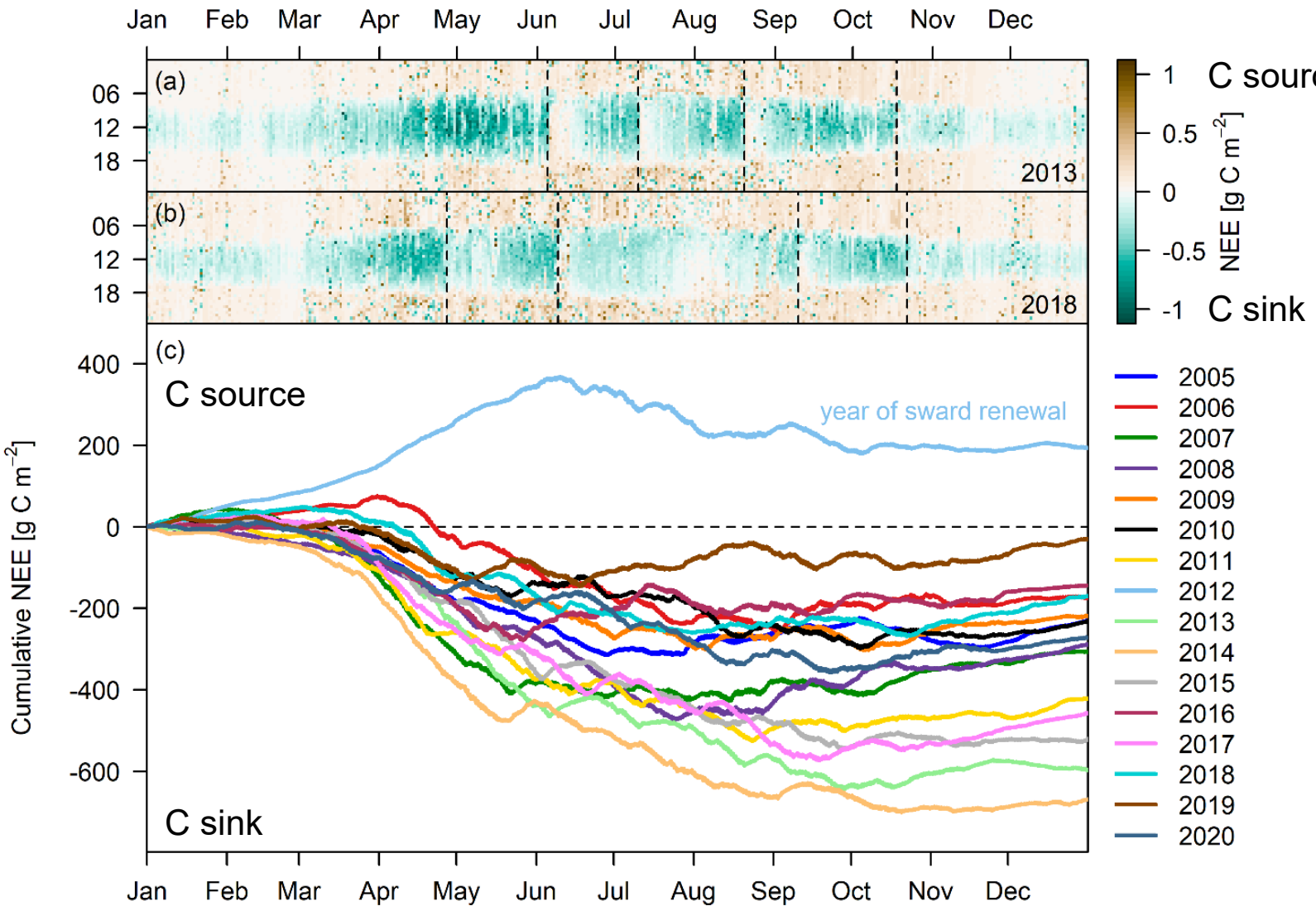
2000 m a.s.l.

1000 m a.s.l.



High Time-Resolution CO_2 Measurements

Chamau



- **Highly dynamic net ecosystem CO_2 fluxes (NEE) depend on management & environment**
- **Permanent Grassland = CO_2 sink**

➢ **Network provides long-term insights into ecosystem responses, allows management recommendations:**

➢ **Avoid destructive sward renewal**

(Feigenwinter et al. 2023)

Carbon Budgets of Cropland → C Source

Oensingen

Bare soil

slurry

C Budget = NEE + C exports + C imports

manure

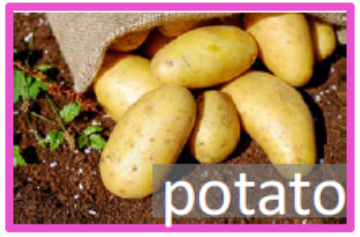
C source

C sink

C Budget (g m^{-2})

1500
1000
500
0
−500

2004
2006
2008
2010
2012
2014
2016



(Emmel et al. 2018)

Carbon Budgets of Cropland → C Source

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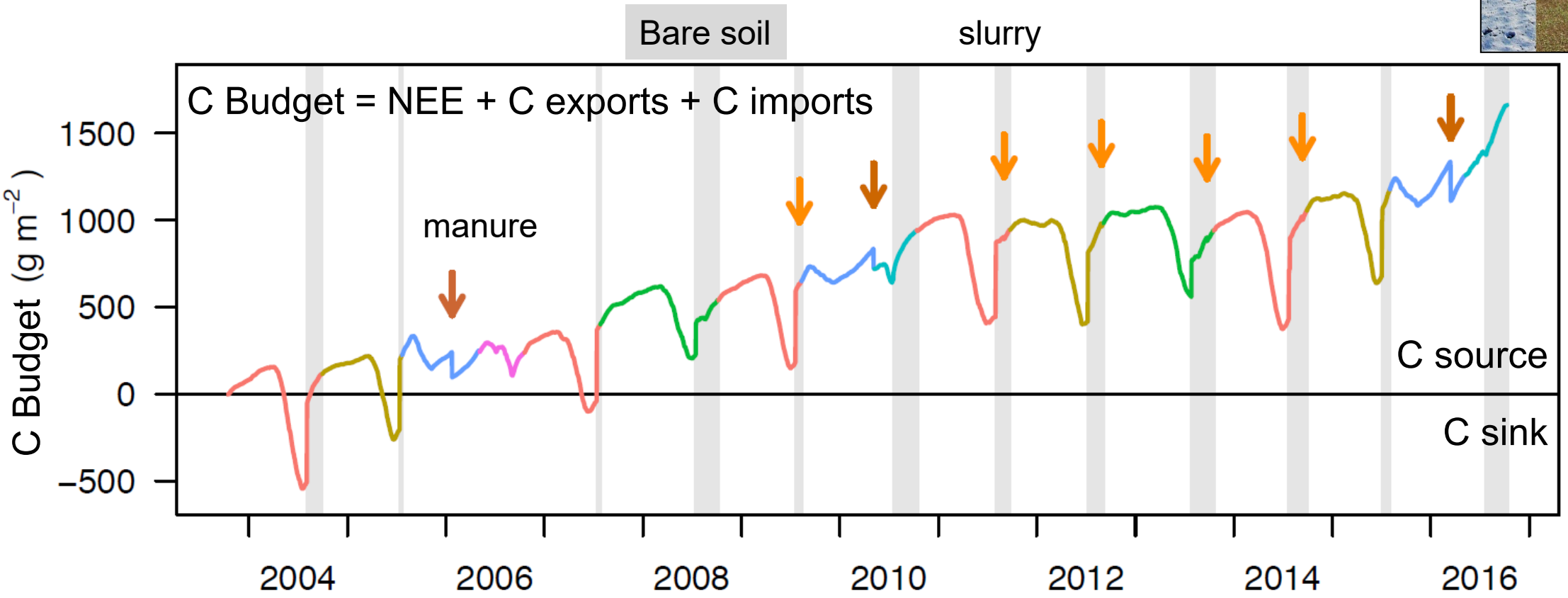
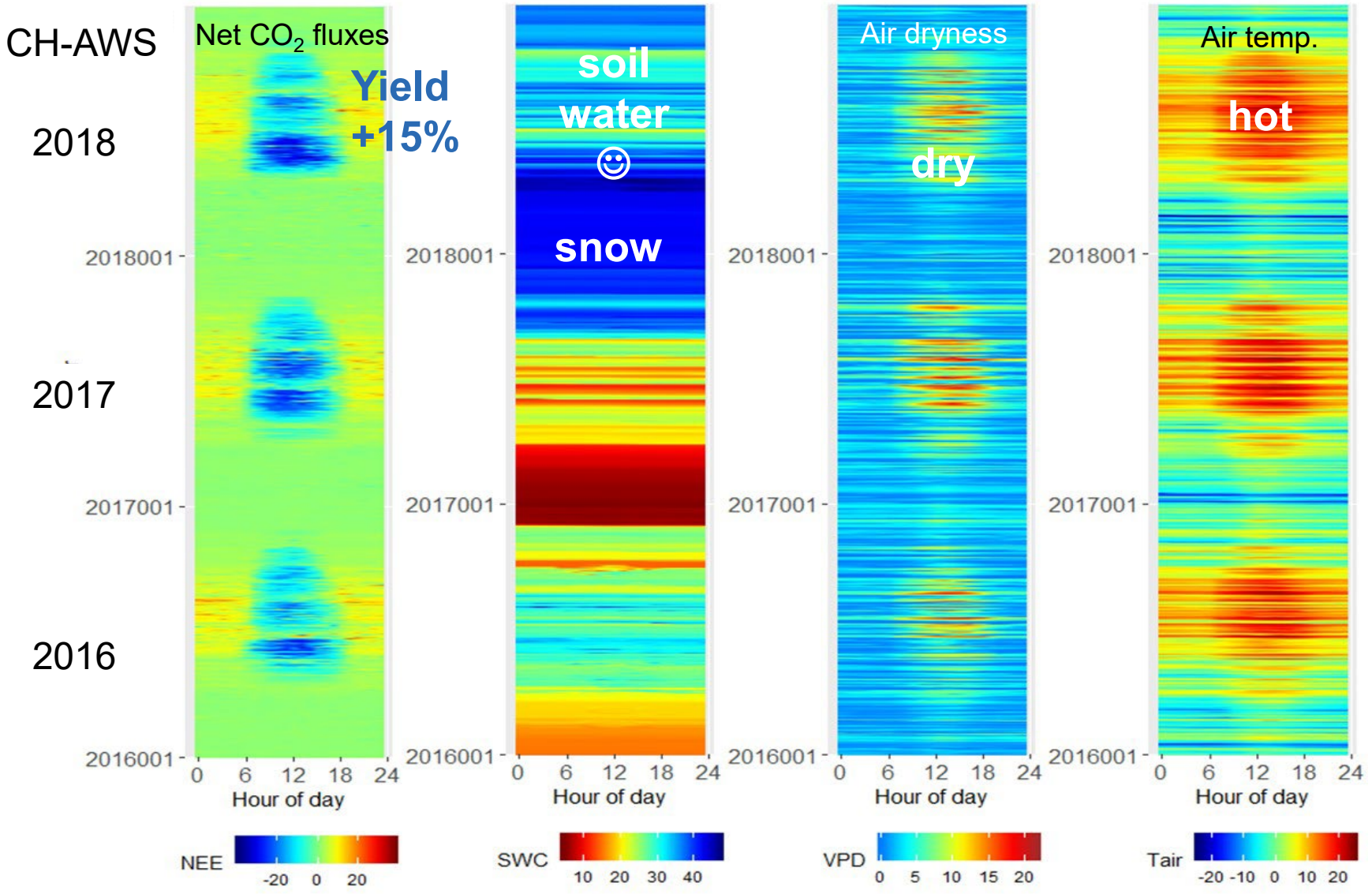


- **Cover crops & organic fertilizer reduce C losses**
- **Over 13 years, C source of about 1.3 t C per ha & yr, validated with soil C stocks**

➢ **Options to reduce C loss from temperate croplands are limited**

(Emmel et al. 2018)

Sometimes, there are winners: Alpine Grassland



Alp Weissenstein

(Gharun et al. 2020)

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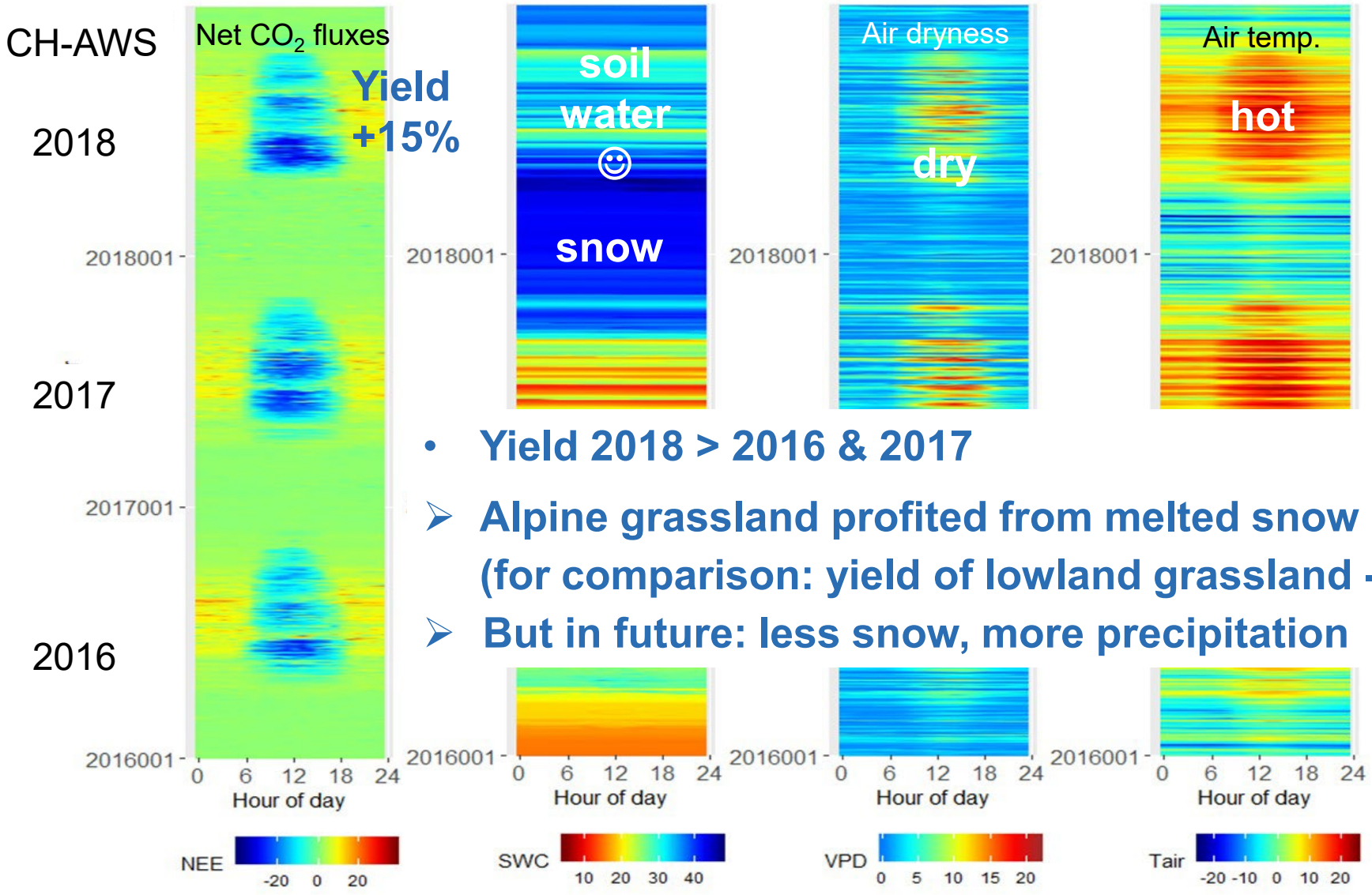


Alp Weissenstein

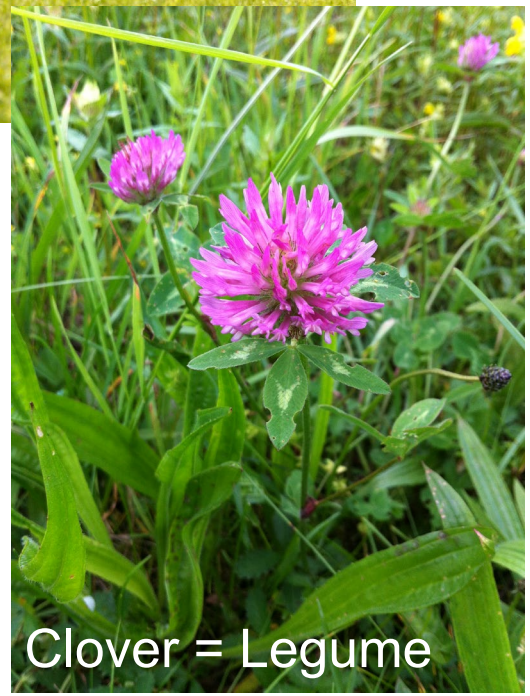
- **Yield 2018 > 2016 & 2017**
  - ➢ **Alpine grassland profited from melted snow pack (for comparison: yield of lowland grassland -25%).**
  - ➢ **But in future: less snow, more precipitation**

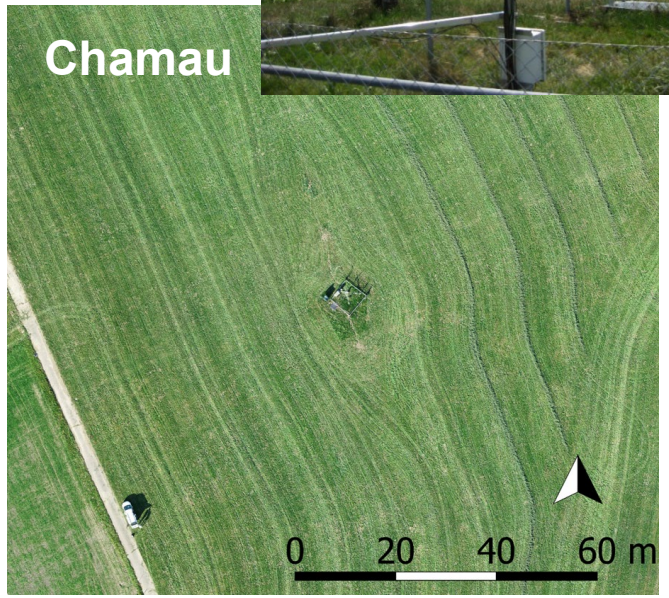
(Gharun et al. 2020)

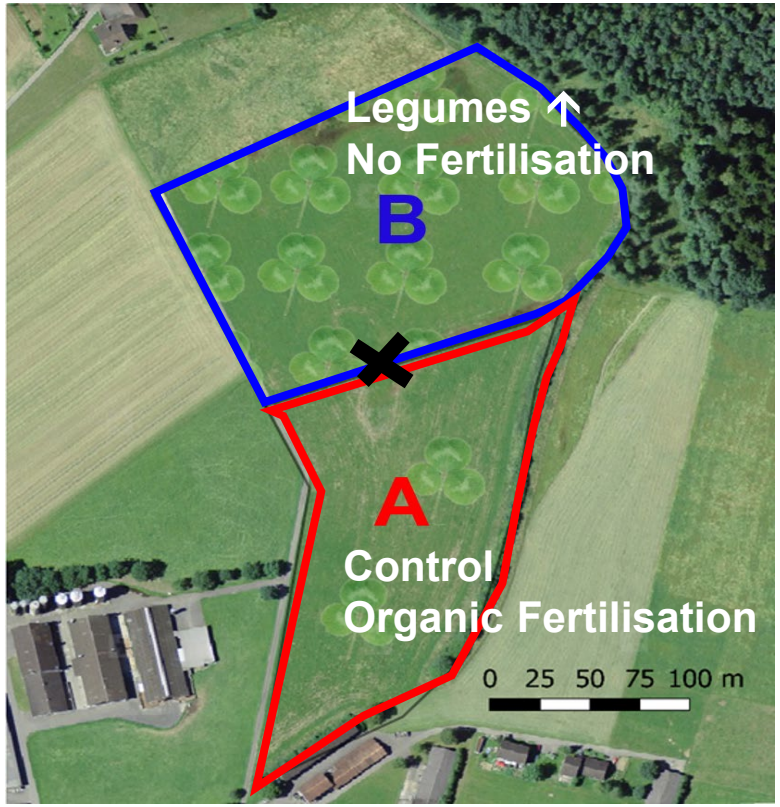
Grassland Management: Lessons from Biodiversity Research

Replace organic fertilisation by increased legume fraction?

$N_2O \downarrow$?

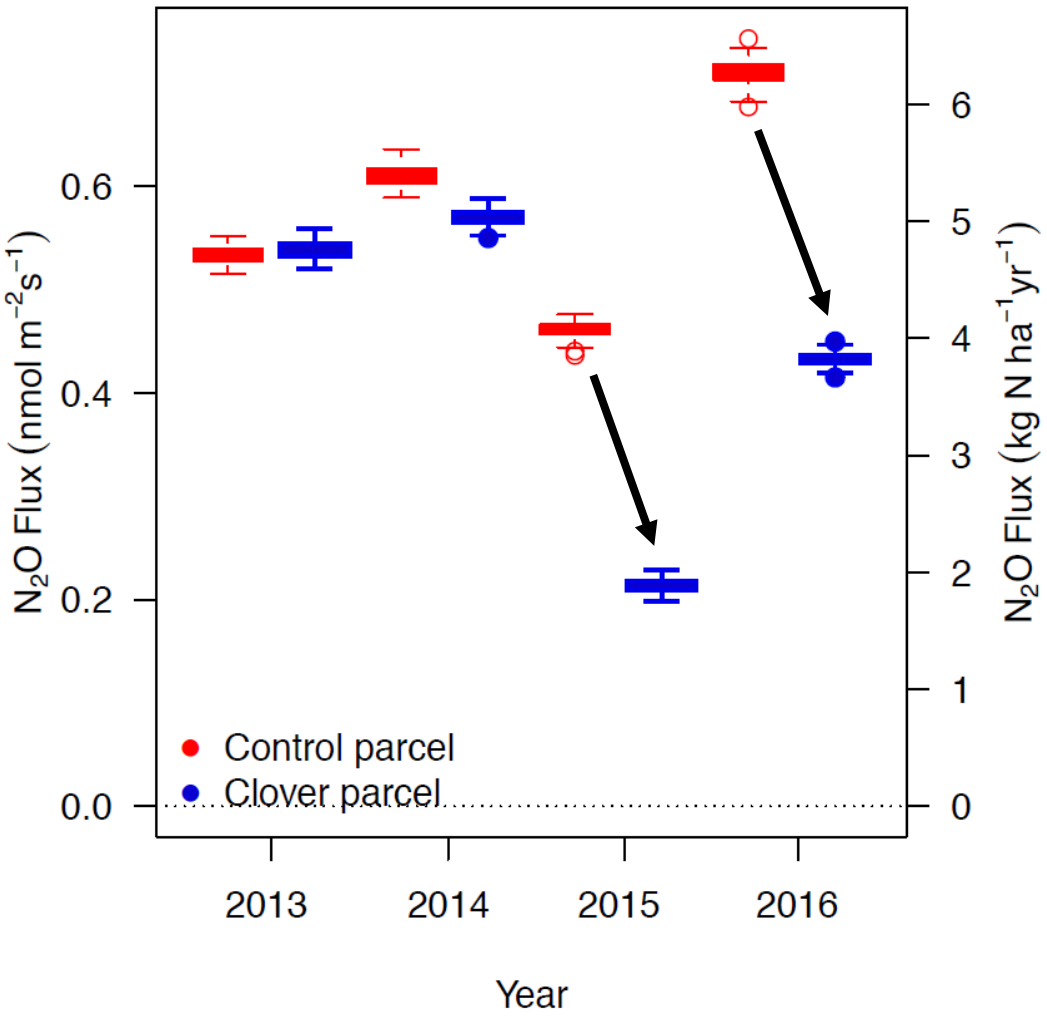






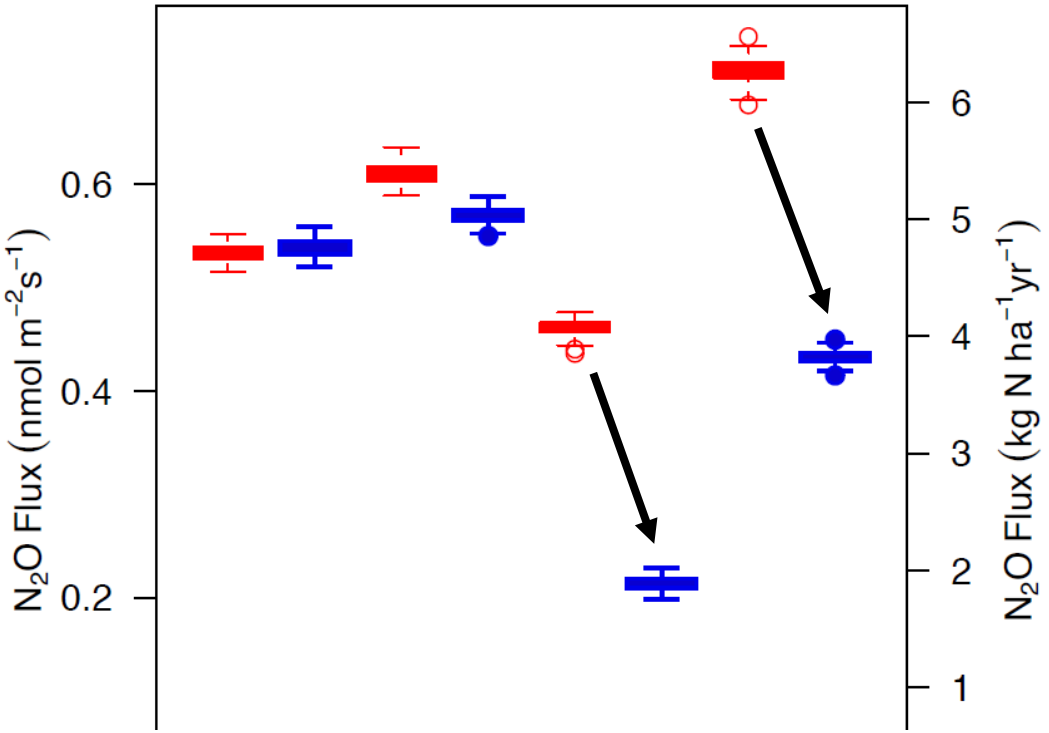
(Fuchs et al. 2018)

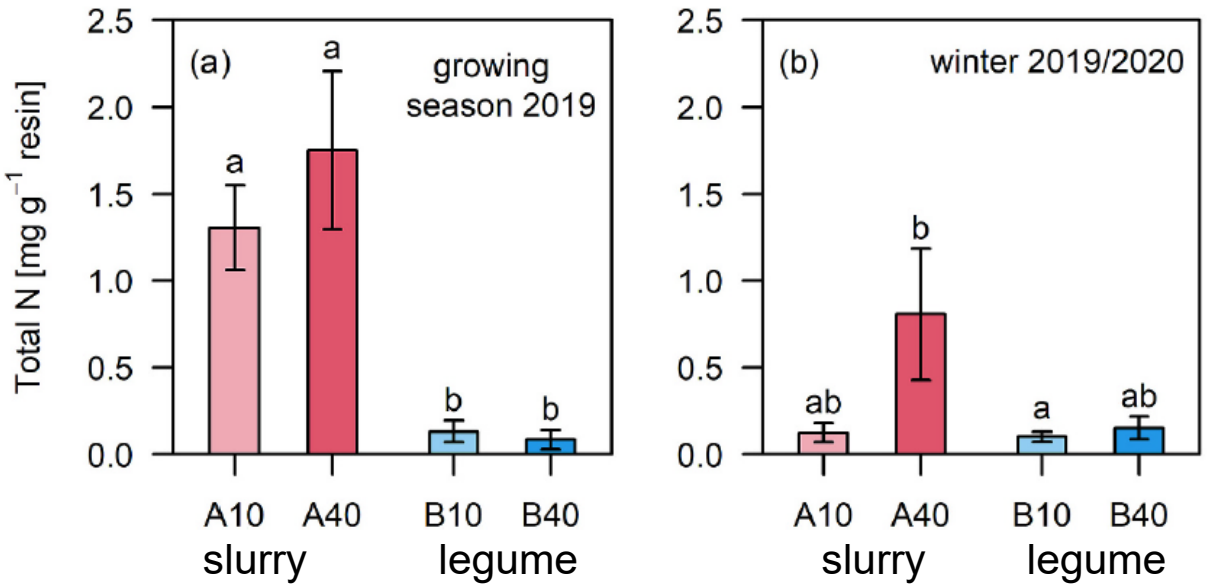
↑ in Legumes → N_2O Losses ↓



(Fuchs et al. 2018; Feigenwinter et al. 2023a,b)

↑ in Legumes → N_2O Losses ↓ and NO_3^- Leaching ↓





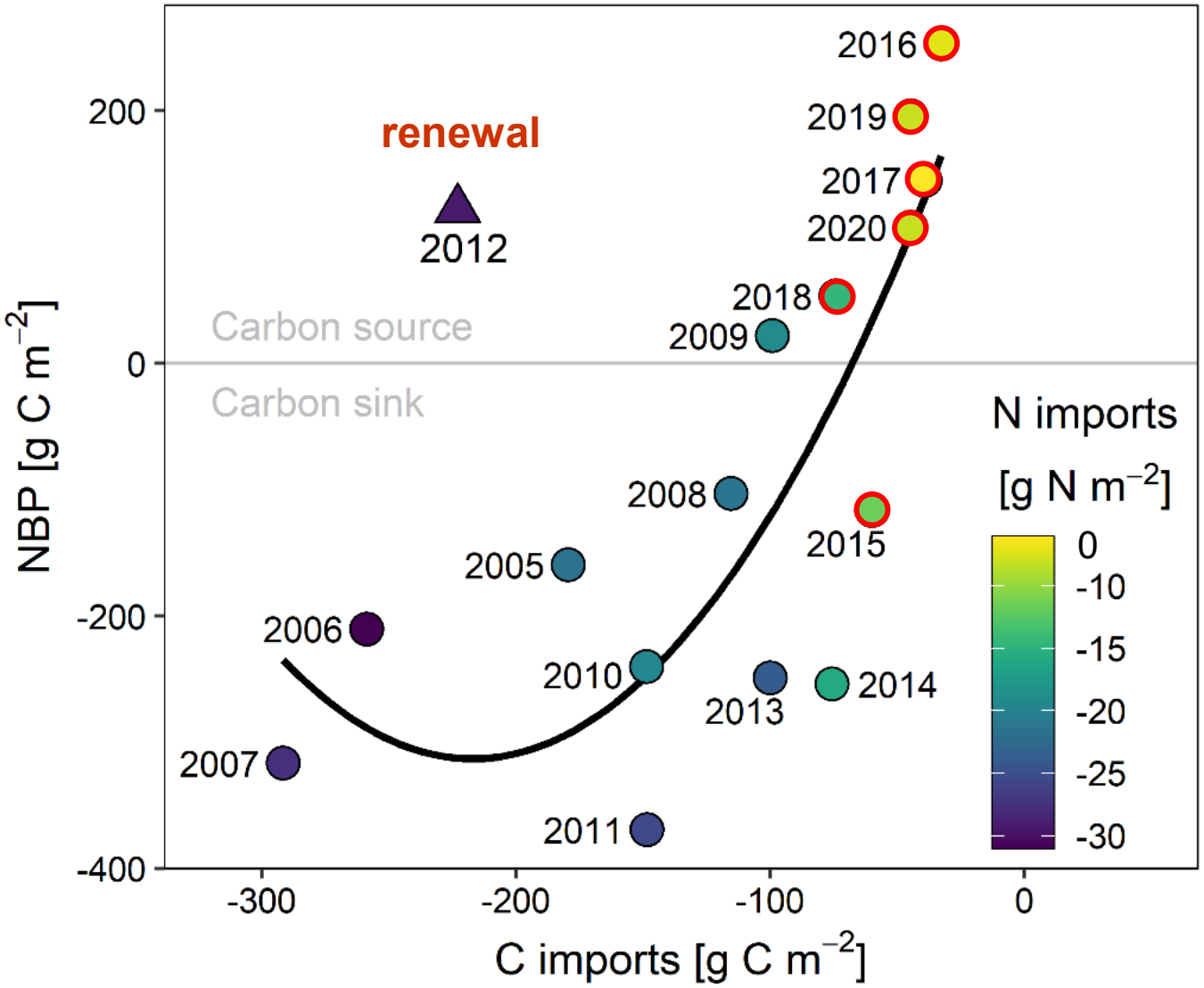
Higher fraction of legumes in sward:

- **30 to 53% lower N_2O emissions (during 6 yrs)**
- **10% lower yields, but higher quality**
- **supporting biodiversity**

- **NO_3^- leaching reduced compared to organic fertilisation with slurry**

(Fuchs et al. 2018; Feigenwinter et al. 2023a,b)

Only Positive Effects? No!



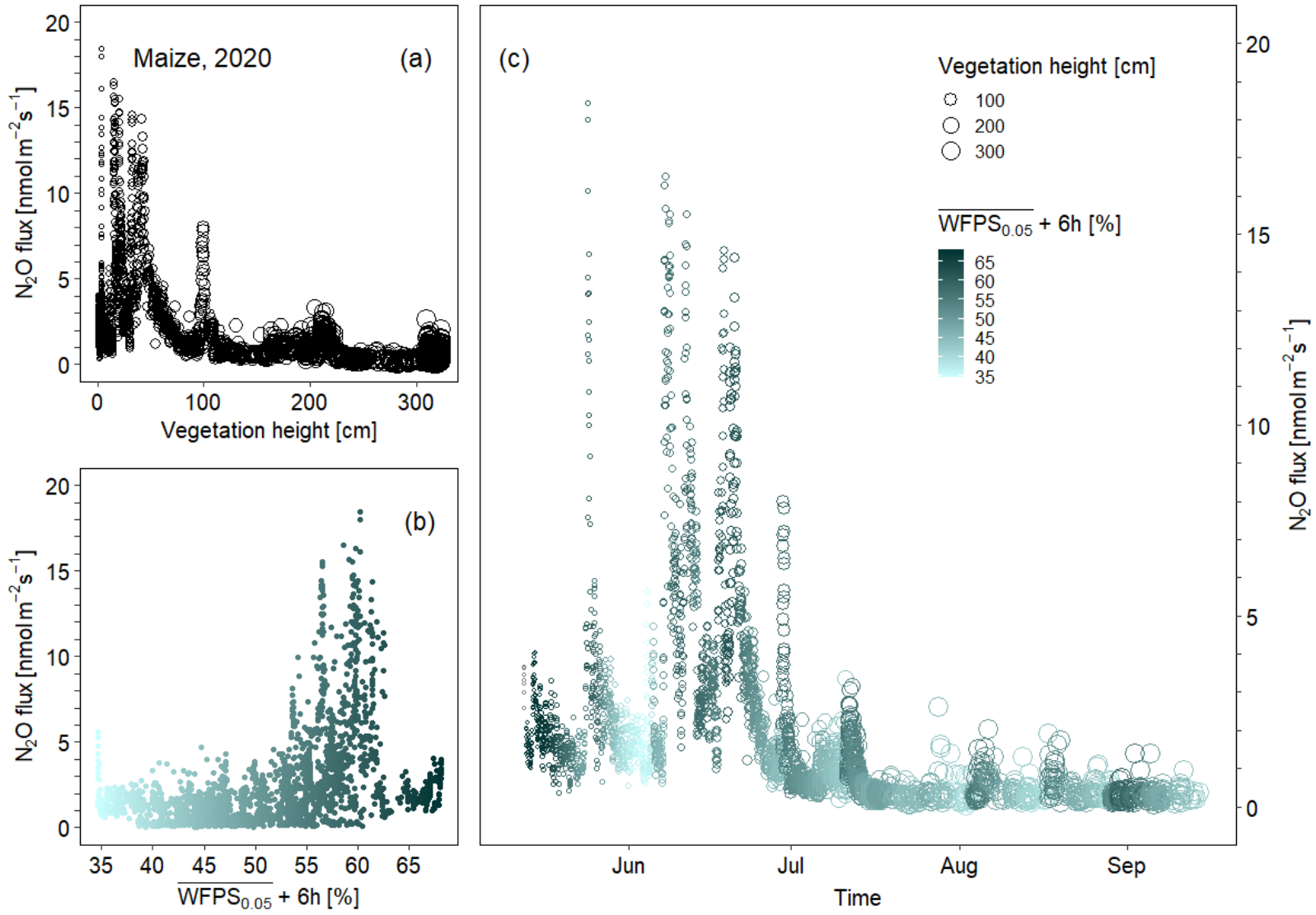
- Years with higher legume fraction and no organic fertilisation

- **Without adequate organic imports as slurry, i.e., C and N, grassland becomes a C source**

➢ **Trade-offs for climate-smart agriculture, still to be solved (e.g., biological nitrification inhibitors)**

(Feigenwinter et al. 2023)

Further (Ignored) Drivers of N_2O fluxes: Competition



- N_2O fluxes very dynamic
- N_2O loss 4.8 kg N_2O-N ha^{-1}
- Emission factor (EF) 4.4%

➢ EF much higher than IPCC Tier 1 (1.5%)

- Competition for N between plant roots and microbes, independent of soil moisture
- Small plants → microbes win
- Tall plants → plants win

➢ Growth-adapted fertilisation for climate-smart agriculture

Meeting Expectations of Society: Yes!

Field Phenotyping to Reduce Pesticide and Fertiliser Inputs

- Using high-resolution, high throughput image analyses and artificial intelligence to quantify growth at cm scale or identify color shades of leaves → important for breeding and precision farming

Climate-Smart Agriculture to Reduce Anthropogenic Climate Change

- Feeding additives in climate-smart livestock farming to reduce CH_4 emissions of ruminants → relevant for climate change mitigation and food security
- Cover crops, crop rotations, avoidance of bare soil and of sward renewals to prevent large CO_2 and N_2O emissions → key management practices of regenerative farming
- Organic fertilisation to maintain soil C sinks and closed nutrient cycles → beneficial for integrated production
- Plant-adapted N fertilisation to avoid N_2O emissions when plants were small/absent → key to precision farming
- Less organic fertilisation by substitution with legumes to reduce N_2O fluxes and NO_3^- leaching …

Agrobiodiversity to Enhance Ecosystem Services

- … and enhance agrodiversity at field scale → simple practice to reduce negative environmental impacts
- Diverse landscapes across elevations to maintain productivity and ecosystem services despite climate extremes

Stakeholder Dialogue to Share Knowledge

- Measurement networks to collect high quality data → essential for evidence-based decision-making of politicians, farmers and society
- Successful start-ups and industry collaborations to implement scientific innovation into practice → knowledge transfer

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Science can provide solutions.
Further examples:
Thanks for listening!

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