Responses of Swiss forests to long- and short-term environmental changes

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Responses of Swiss Forests to Environmental Changes

Motivation

Biosphere-Atmosphere Exchange: Swiss FluxNet

- Methodology, nested approach, sites

Net CO_2 Fluxes: Long-term and Short-term Responses to the Environment

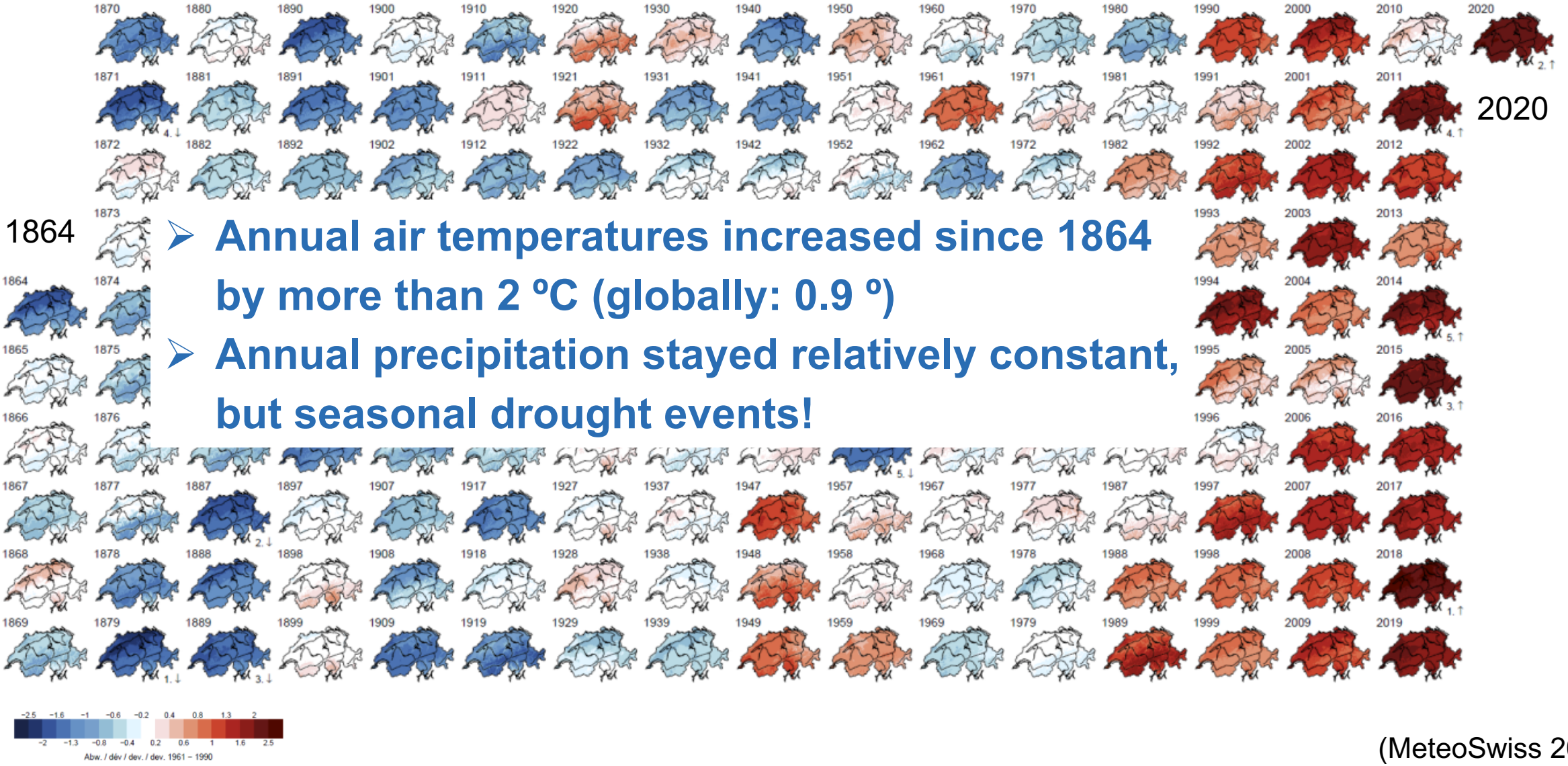
- Mixed forest, Lägeren
- Spruce forest, Davos

Effects of Climate vs. N Deposition on WUE

- Mixed forest, Lägeren
- Spruce forest, Davos

Lessons Learned

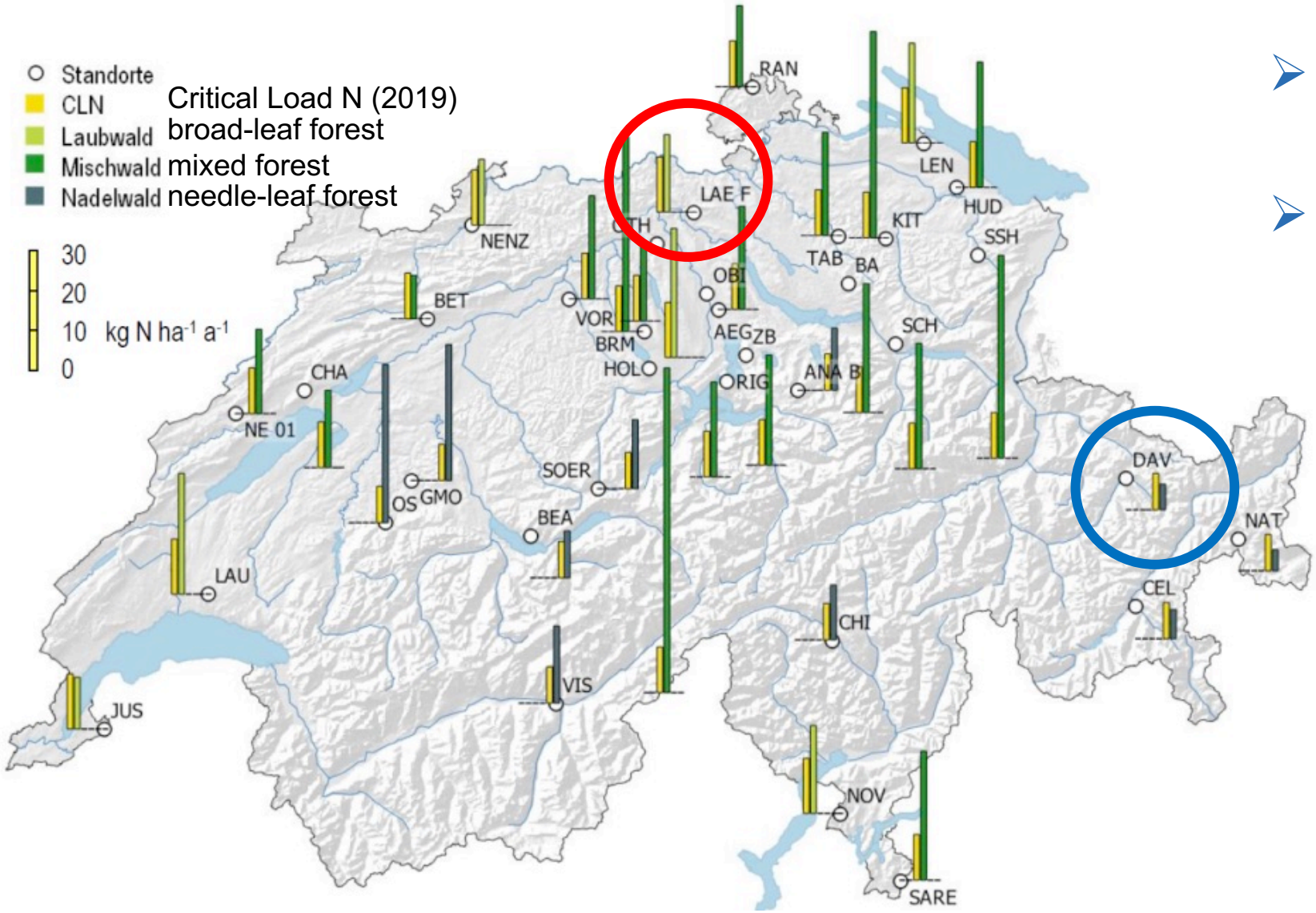
Long-term Environmental Changes: Air Temperature



- **Annual air temperatures increased since 1864 by more than 2 ºC (globally: 0.9 º)**
- **Annual precipitation stayed relatively constant, but seasonal drought events!**

(MeteoSwiss 2021)

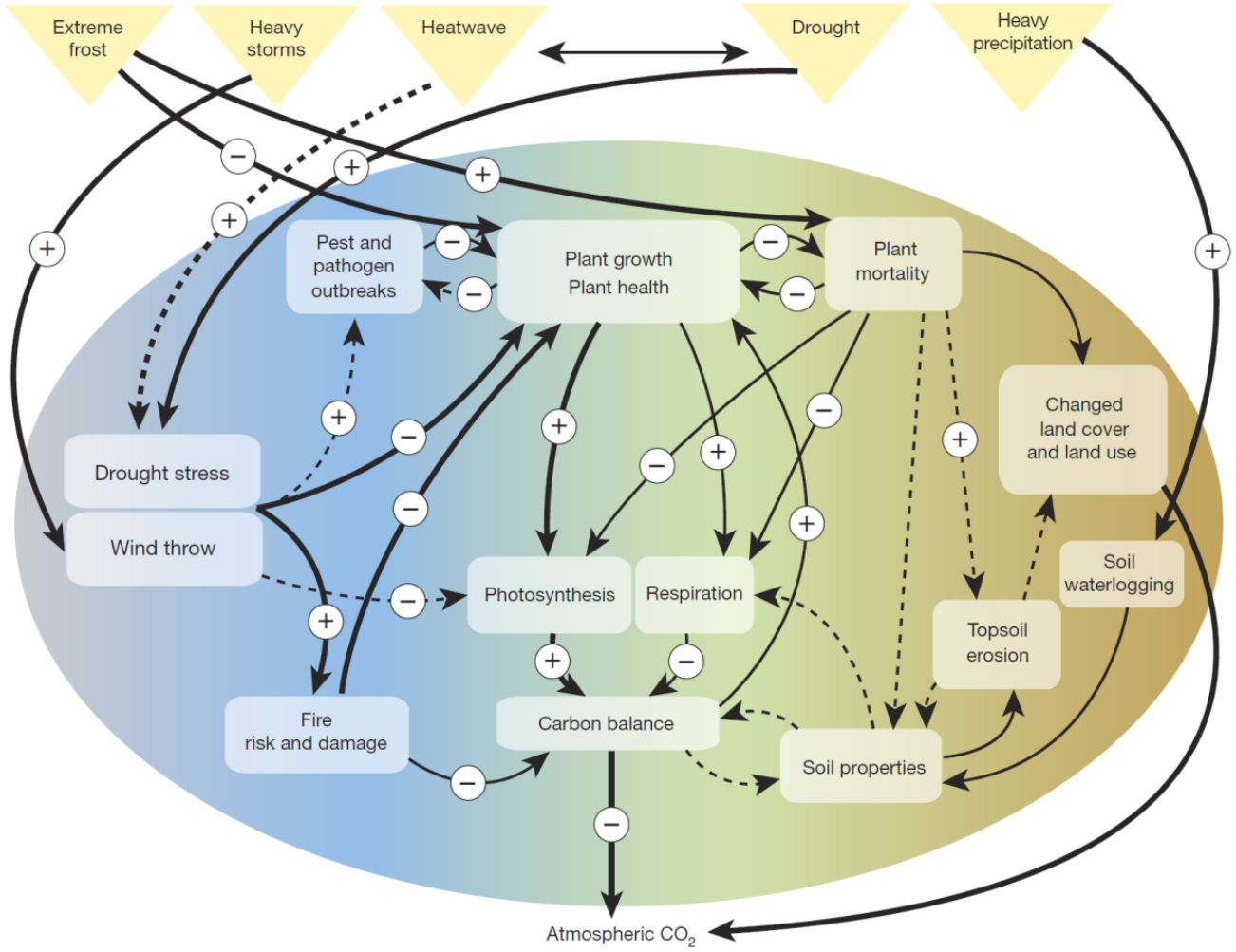
Long-Term Environmental Changes: Nitrogen Deposition



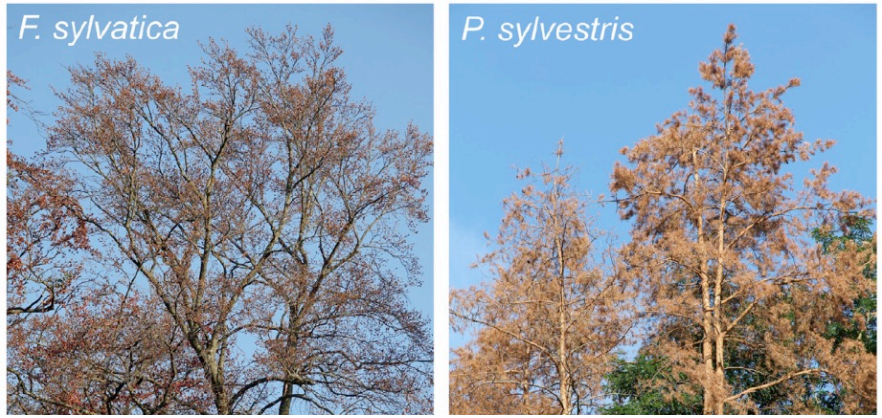
- **Annual N deposition often > CLN**
- **Total N deposition relatively stable over the last 20 yrs**

(FOEN 2021)

Short-Term Environmental Changes: Drought



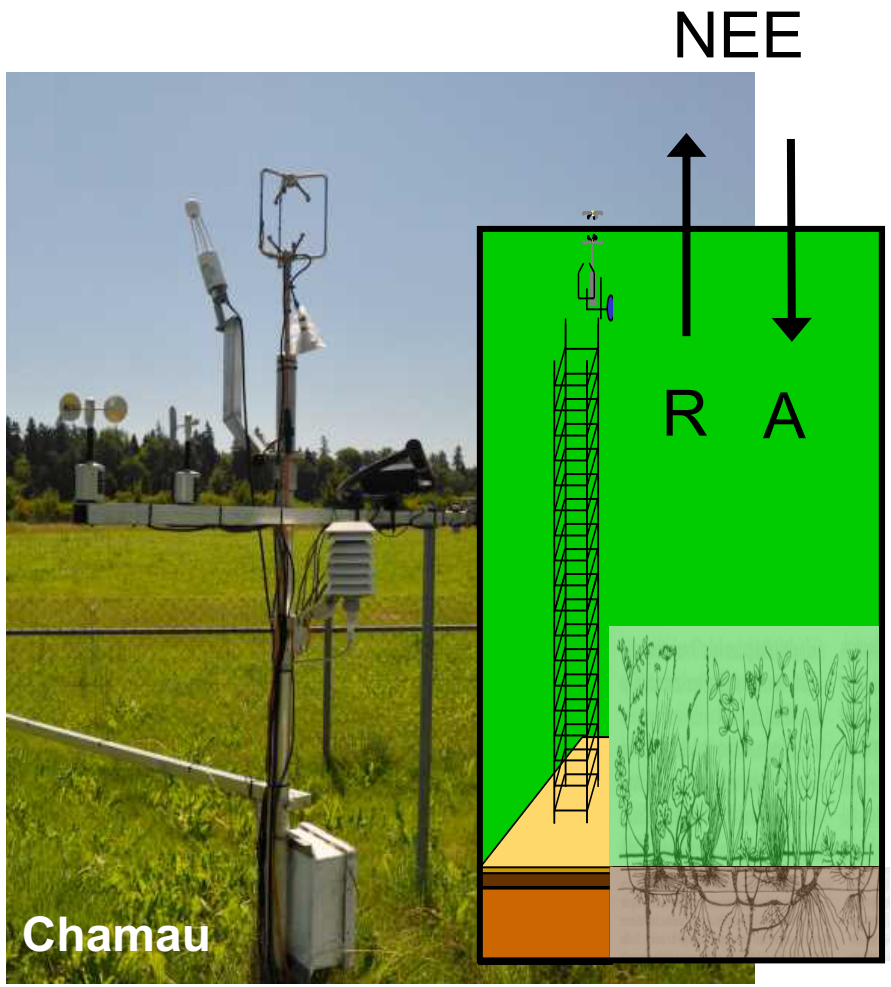
(Reichstein et al. 2013; Schuldt et al. 2020)



- **More frequent in the future**
- **Effects via soil & atmosphere**

Biosphere-Atmosphere Trace Gas Exchange

Core measurements: **eddy-covariance technique** for CO_2, but also for other gases (H_2O vapor, CH_4, N_2O)



F_c = Net ecosystem exchange NEE

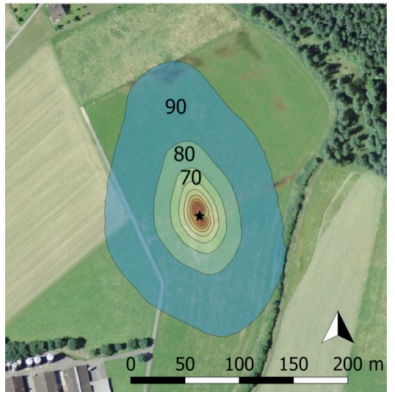
R = Respiration

A = Assimilation

- C sink: Assimilation >> Respiration
- C source: Respiration >> Assimilation

- Continuous measurements (20 Hz, 24 h/day, 7 days/week, 365 days/year, multiple years to decades)
- Spatial integration

(swisstopo; modell Kljun et al. 2015)



Swiss FluxNet = Six Active Flux Sites

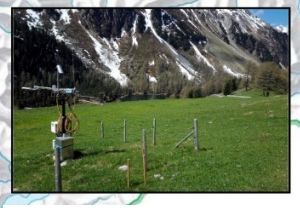
ETH Zurich grassland sciences

LAE: since 4/2004

OEN2: since 12/2003

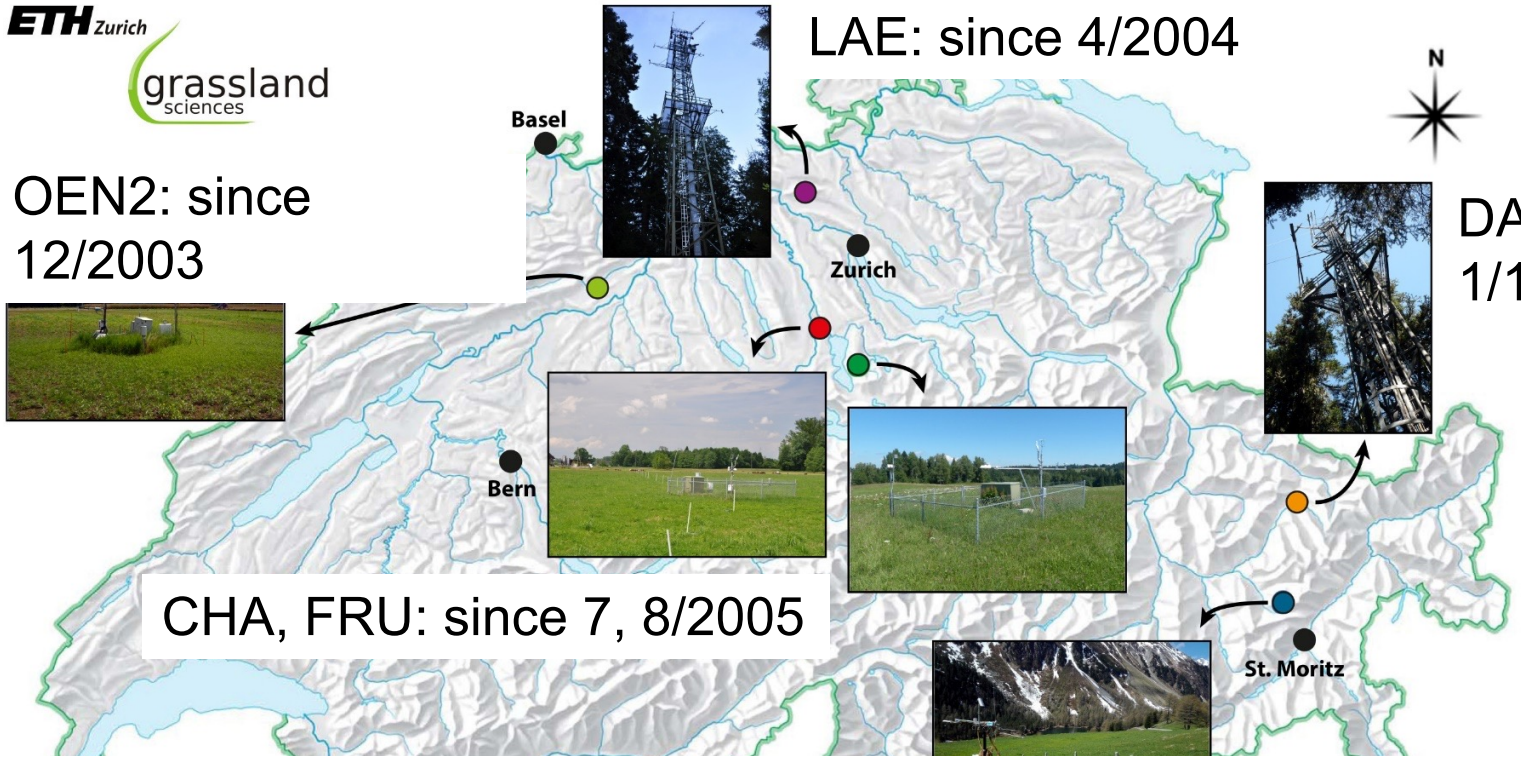
DAV: since 1/1997

CHA, FRU: since 7, 8/2005



AWS: in summers (since 2006),
since Nov. 2014 year-round

Swiss FluxNet = Six Active Flux Sites



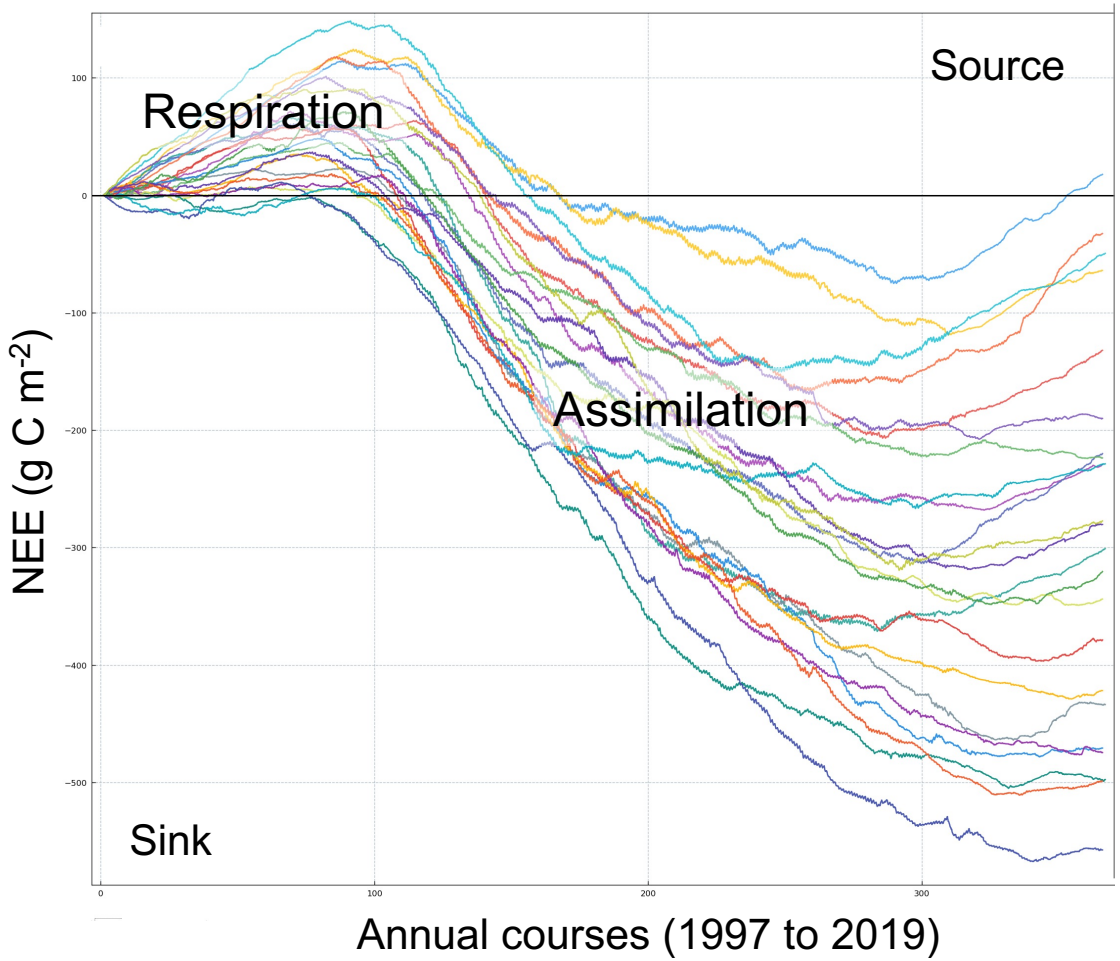
Continuous CO_2, H_2O vapor fluxes, meteo available (… plus much more …)

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

Long-term data sets (> 105 site-years)

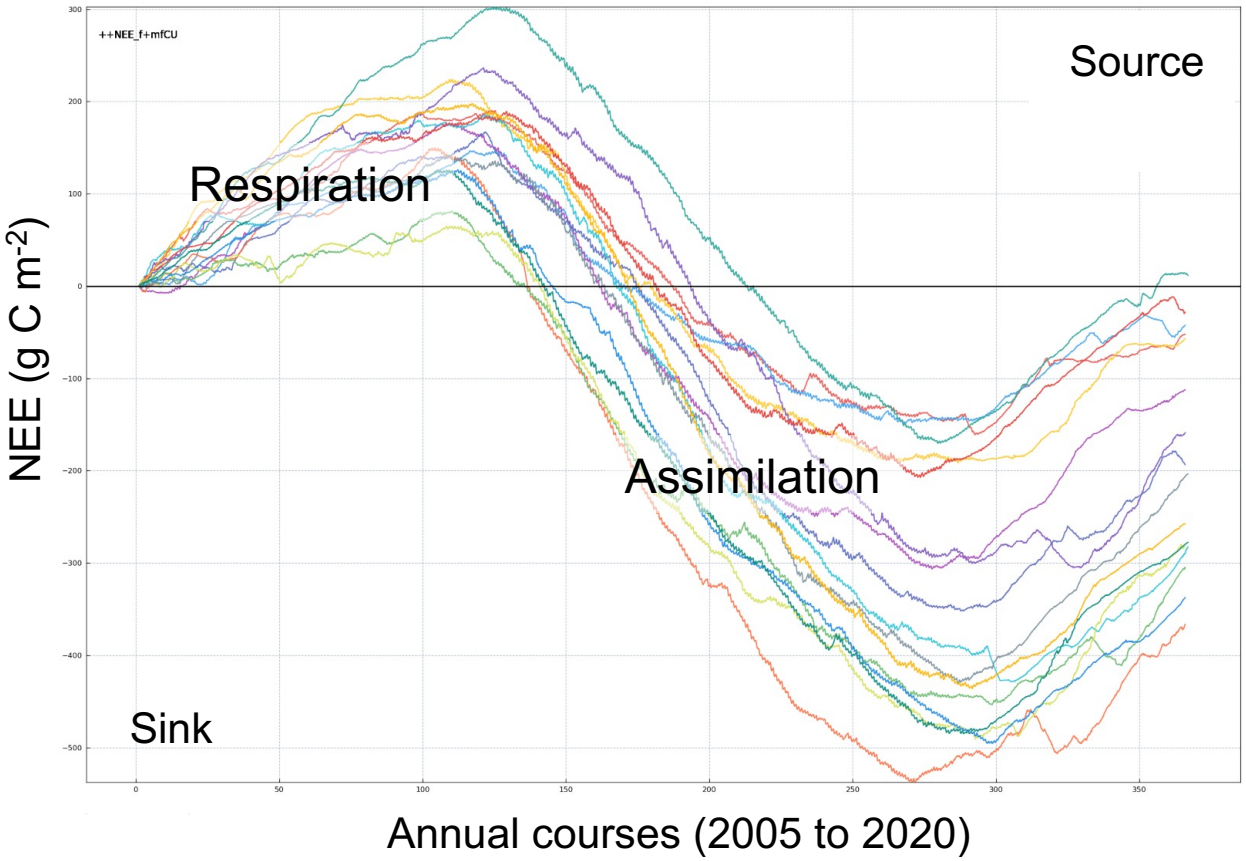
- **Response to slow changes, e.g., climate change**

Long-term Net CO_2 Fluxes: Davos



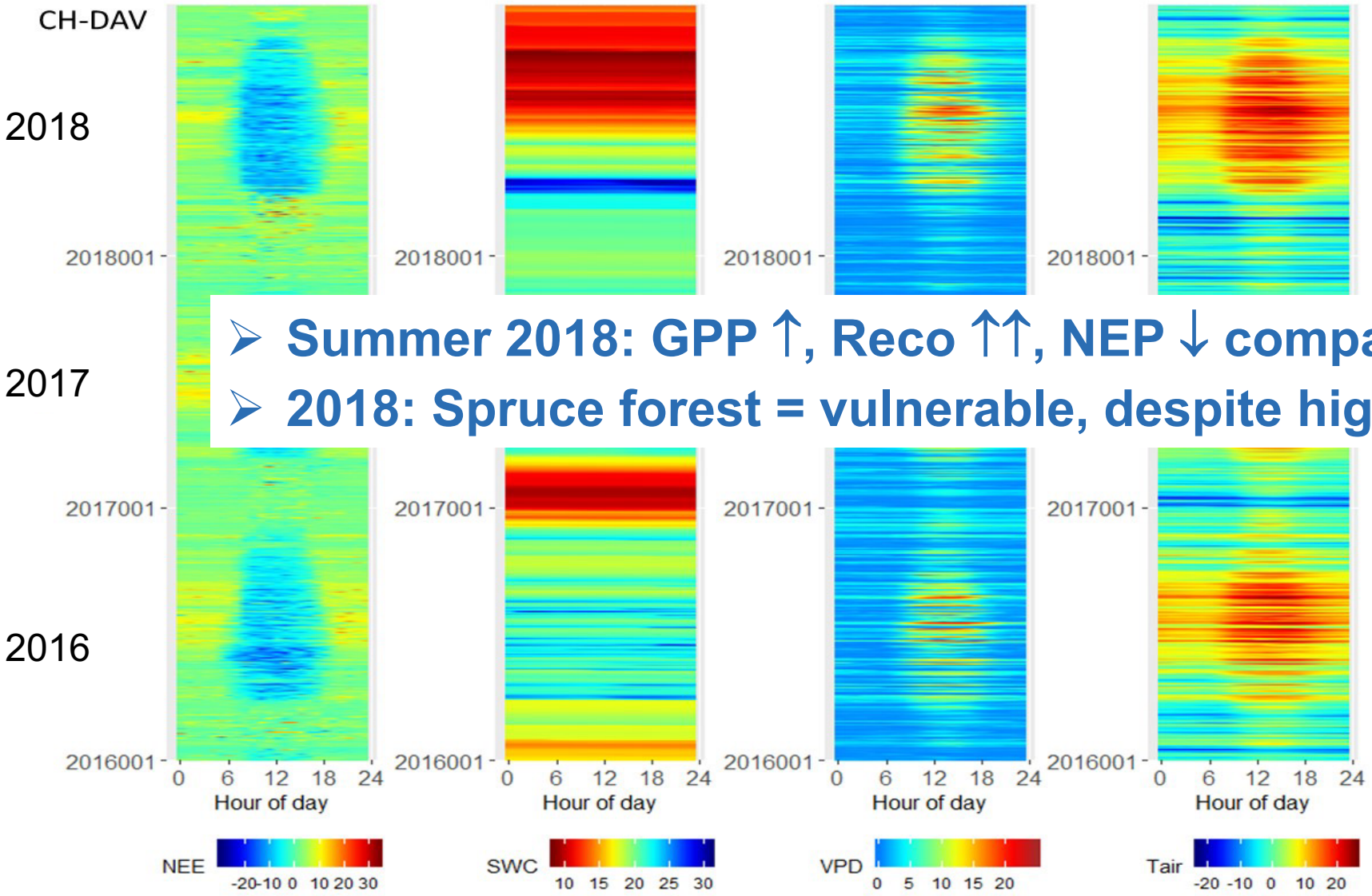
- **Typically a C sink**
- **Early start of C sink activity: April (even at 1639 m asl)**
- **Spring most important, also seen in tree rings**

Long-term Net CO_2 Fluxes: Lägeren



- **Typically a C sink**
- **C sink activity starts in May, role of understory vegetation**
- **Largest uptake in summer, strong impact of phenology**

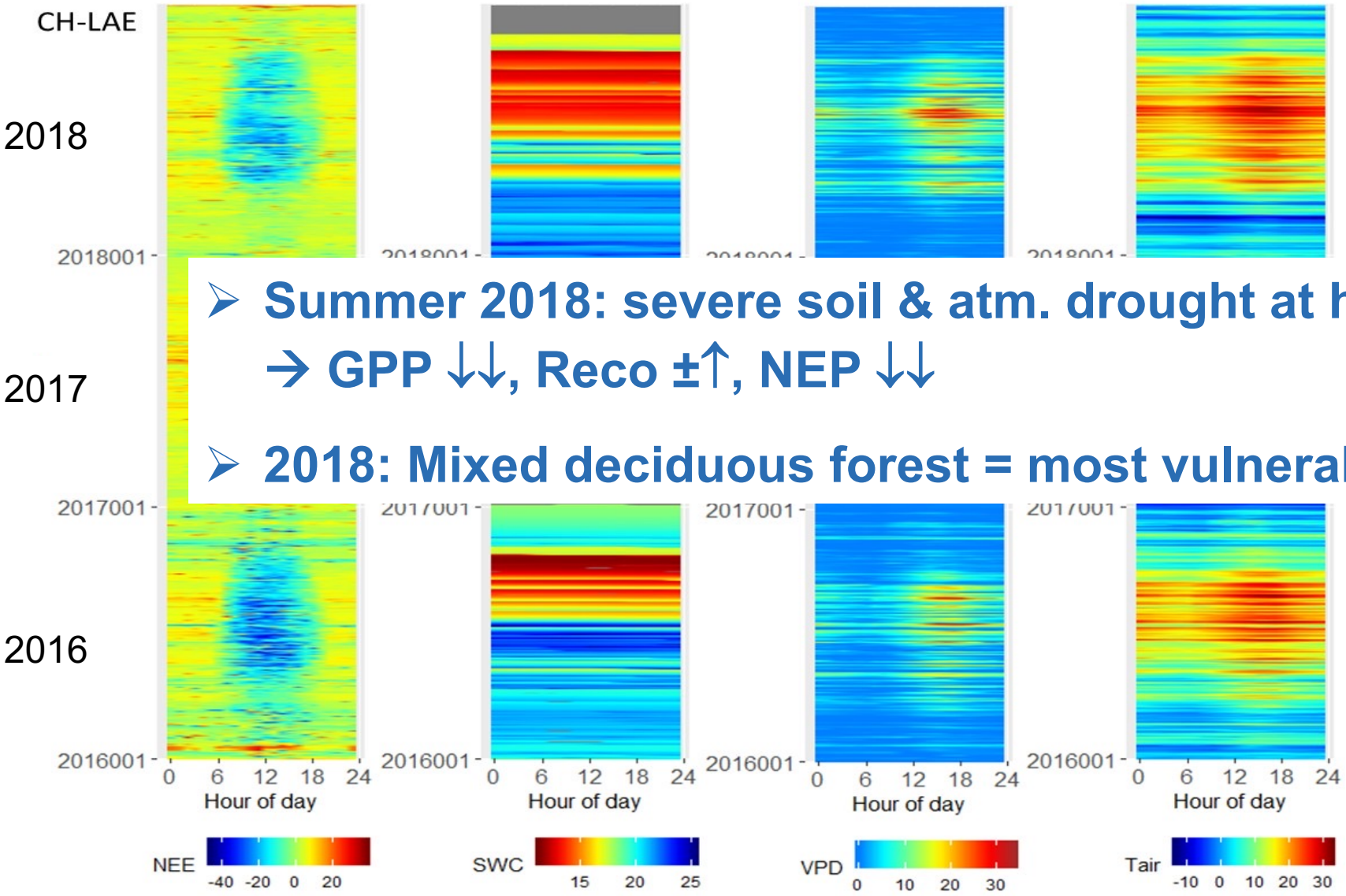
Short-term Response to Extreme Summer: Davos



- **Summer 2018: GPP ↑, Reco ↑↑, NEP ↓ compared to 2016 & 2017**
- **2018: Spruce forest = vulnerable, despite high elevation**

(Gharun et al. 2020, PTRS)

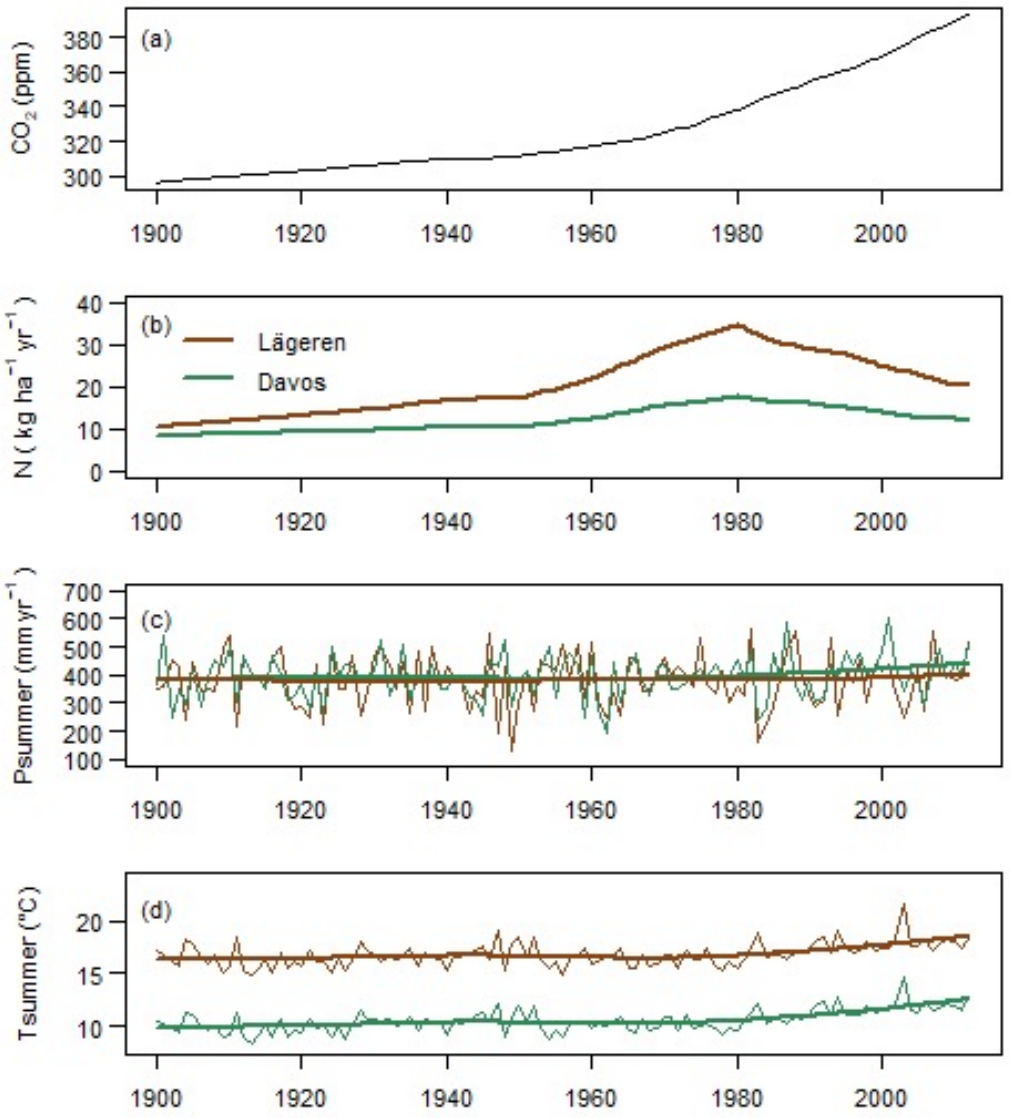
Short-term Response to Extreme Summer: Lägeren



- **Summer 2018: severe soil & atm. drought at high air temps**
  → GPP ↓↓, Reco ±↑, NEP ↓↓
- **2018: Mixed deciduous forest = most vulnerable**

(Gharun et al. 2020, PTRS)

Compound Effects: Climate & N Deposition



↑↑

↑↓

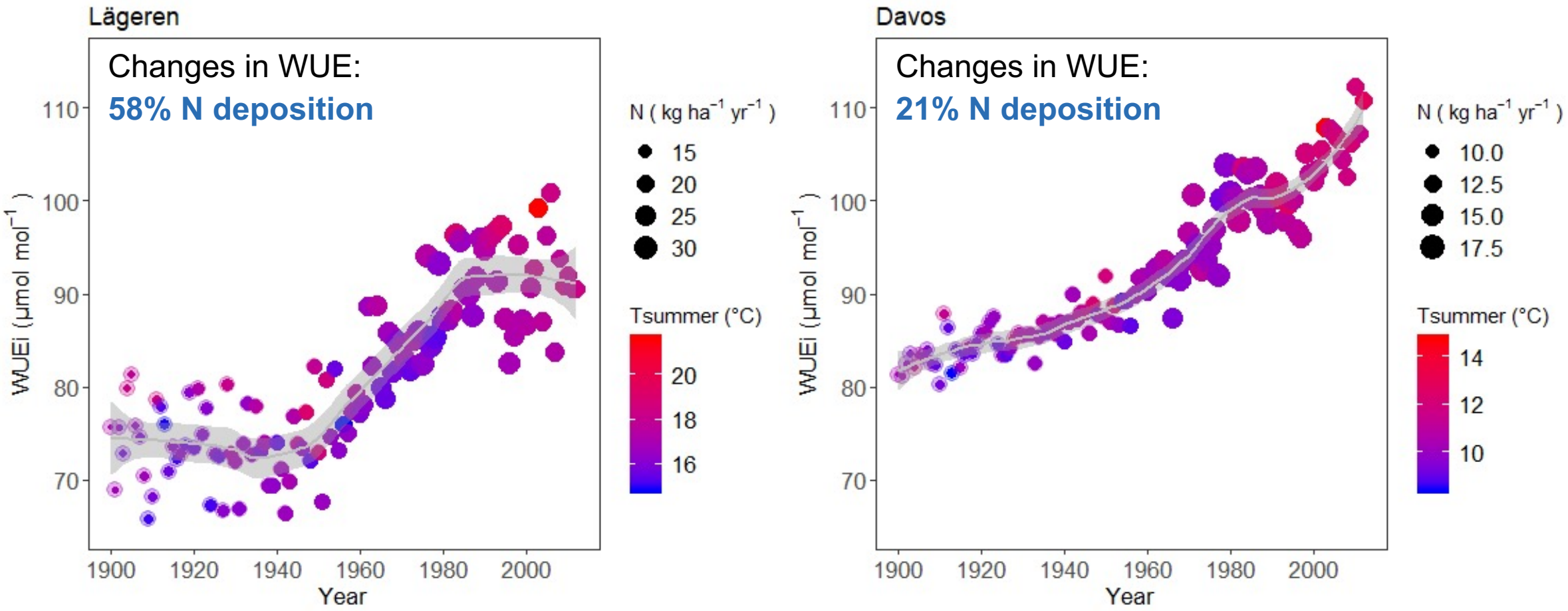
±

↑↑

- Many environmental factors changed simultaneously in past 112 years
- Effects on WUE?
  - CO_2 ↑, N ↑, Tair ↑ → WUE ↑
- Disentangle climate from N deposition?

(Gharun et al., subm.)

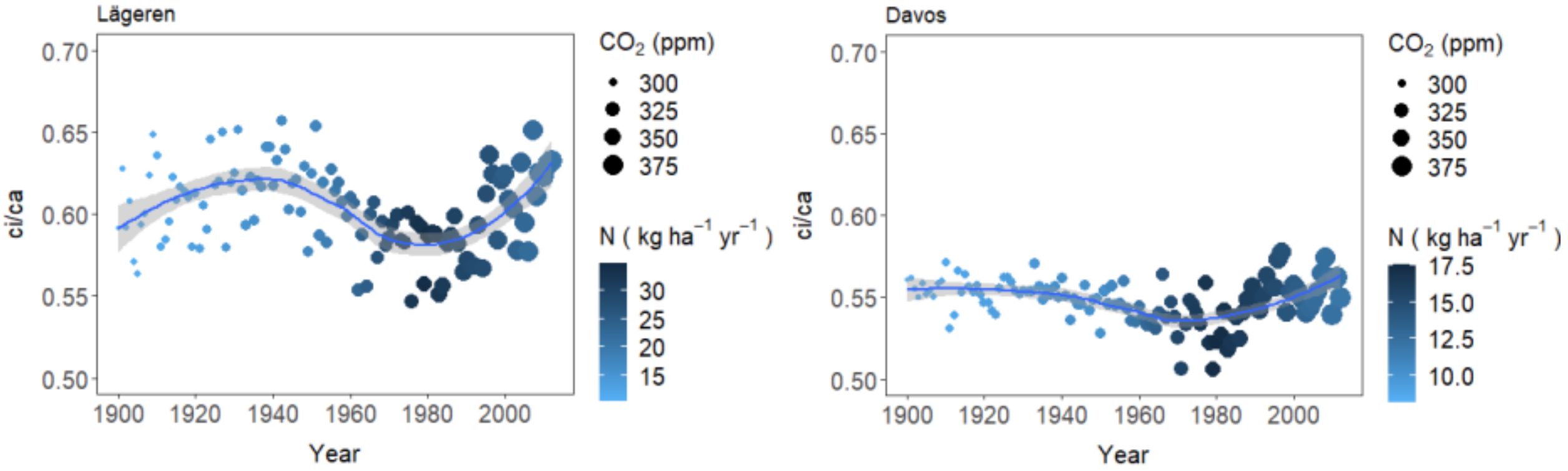
WUE = f (Climate & N Deposition)



- **WUE ↑↑, particularly after 1950**
- **Driven by N deposition, CO_2, summer precip. & temperature (88%, 61%)**

(Gharun et al., subm.)

Ci/Ca = f (CO_2 & N Deposition)



- **Ci/Ca ↓, N deposition ↑, particularly 1950 to 1980 (max. N dep.): via PS**
- **Ci/Ca ↑, with CO_2 ↑ and N dep. ↓, particularly after 1980: typically unaccounted …**

(Gharun et al., subm.)

Responses of Swiss Forests to Environmental Changes

Biosphere-Atmosphere Exchange: Swiss FluxNet

- Network with long-term measurements pay out over time.

Net CO_2 Fluxes: Long-term and Short-term Responses to the Environment

- Large inter-annual variations; both forests C sinks so far.
- Mixed forest on Swiss plateau (lowland) highly vulnerable to low SWC and high VPD.
- C budget of evergreen forest driven by ecosystem respiration.

Effects of Climate vs. N Deposition on WUE

- Strong N deposition effects on WUE.
- If neglected, WUE reconstruction solely based on climate might be biased.

Thanks for watching!