Measurements and Modelling of Carbon Dioxide and Methane in Switzerland: The CarboCount-CH Project

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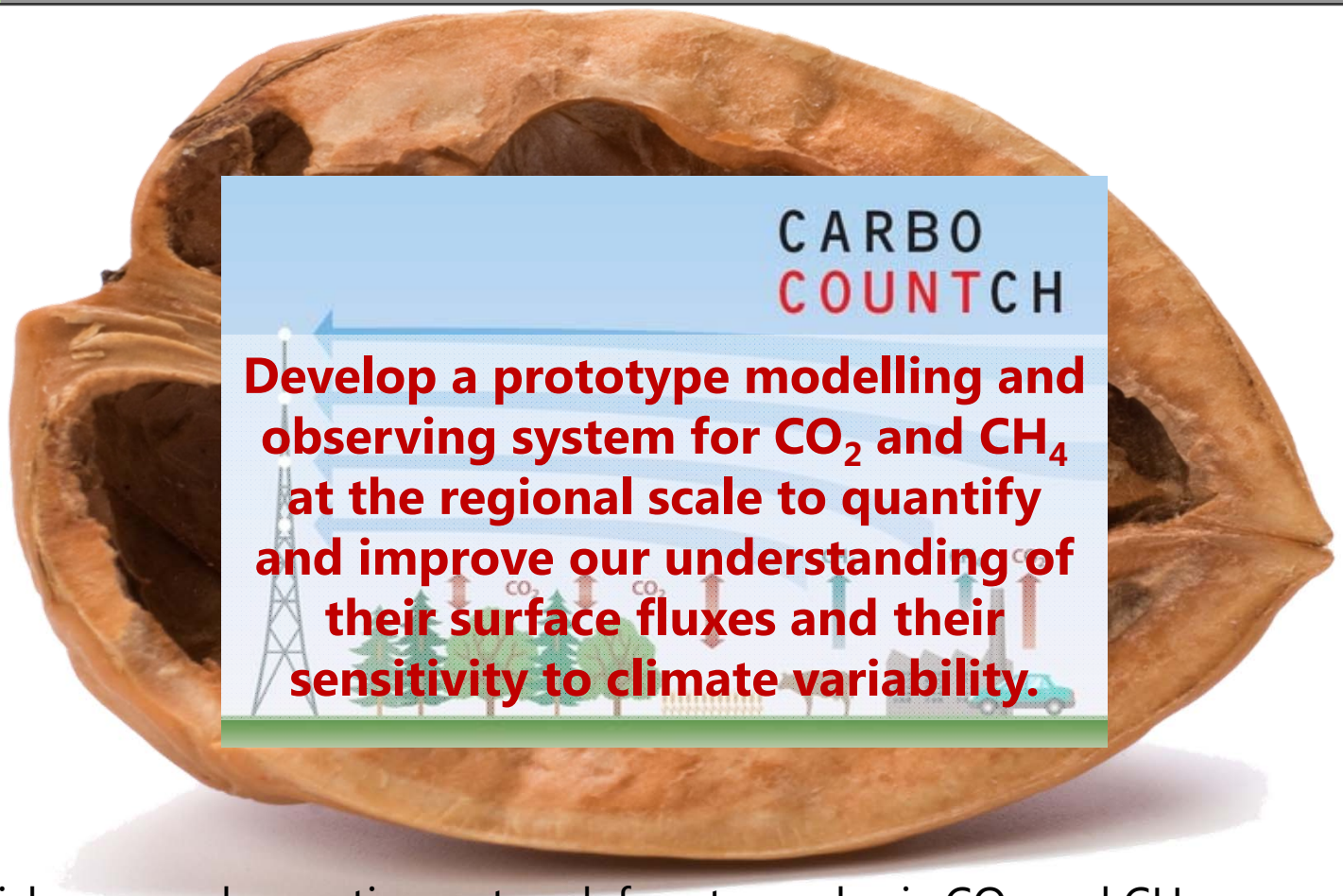
CarboCount-CH in a Nutshell



- Establish a new observation network for atmospheric CO_2 and CH_4 concentrations with four new sites in Switzerland, operated for >2 years
- Develop a comprehensive regional scale transport and inverse modeling system (resolution < 10 km)
- Develop and improve bottom-up flux inventories

CarboCount-CH Observational Network

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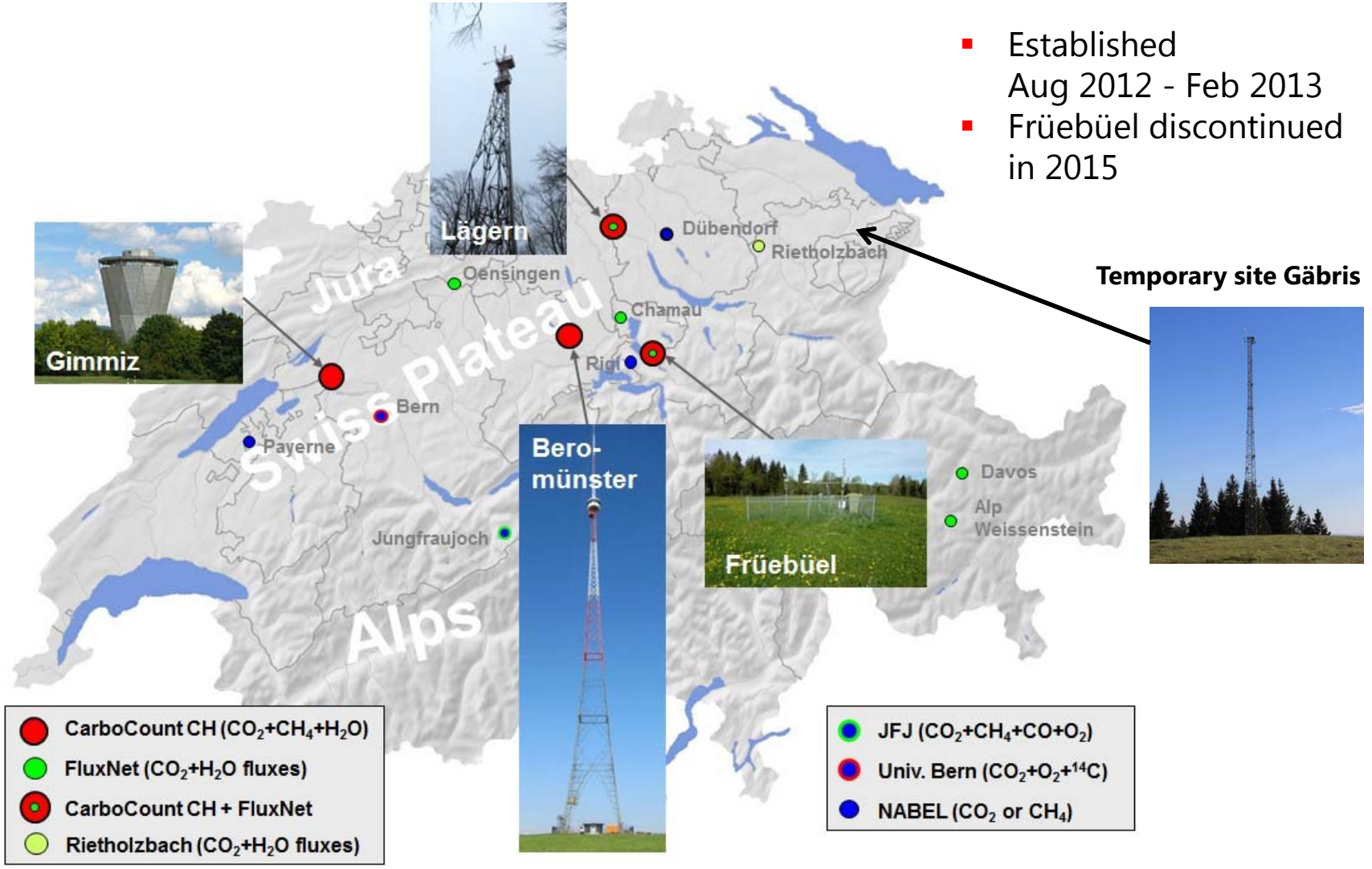
- Established
  Aug 2012 - Feb 2013
- Früebüel discontinued
  in 2015



[Oney et al., ACP, 2015]

http://www.carbocount.ch

Flagship Tall Tower Site Beromünster

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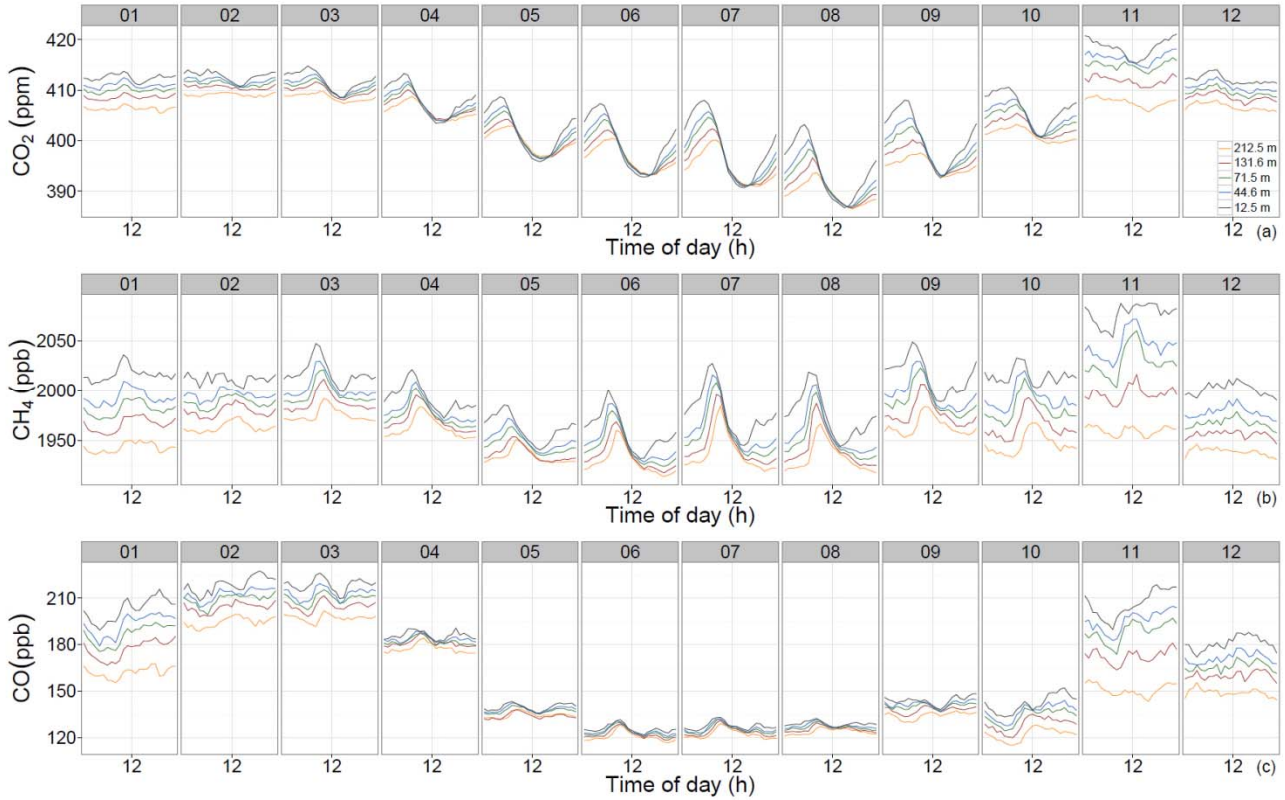
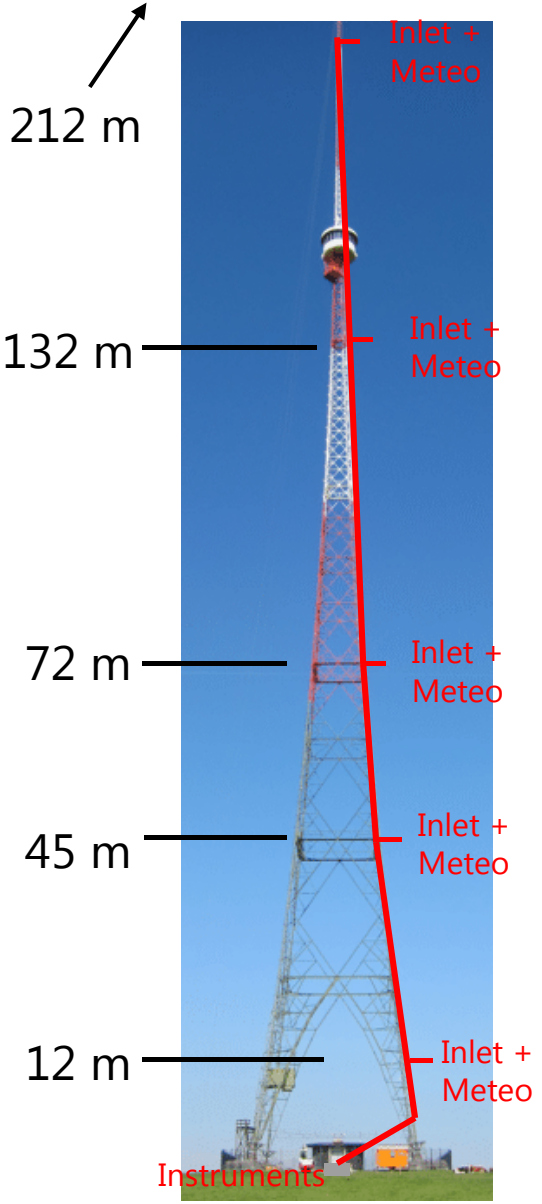
Monthly mean diurnal cycles at different sampling heights

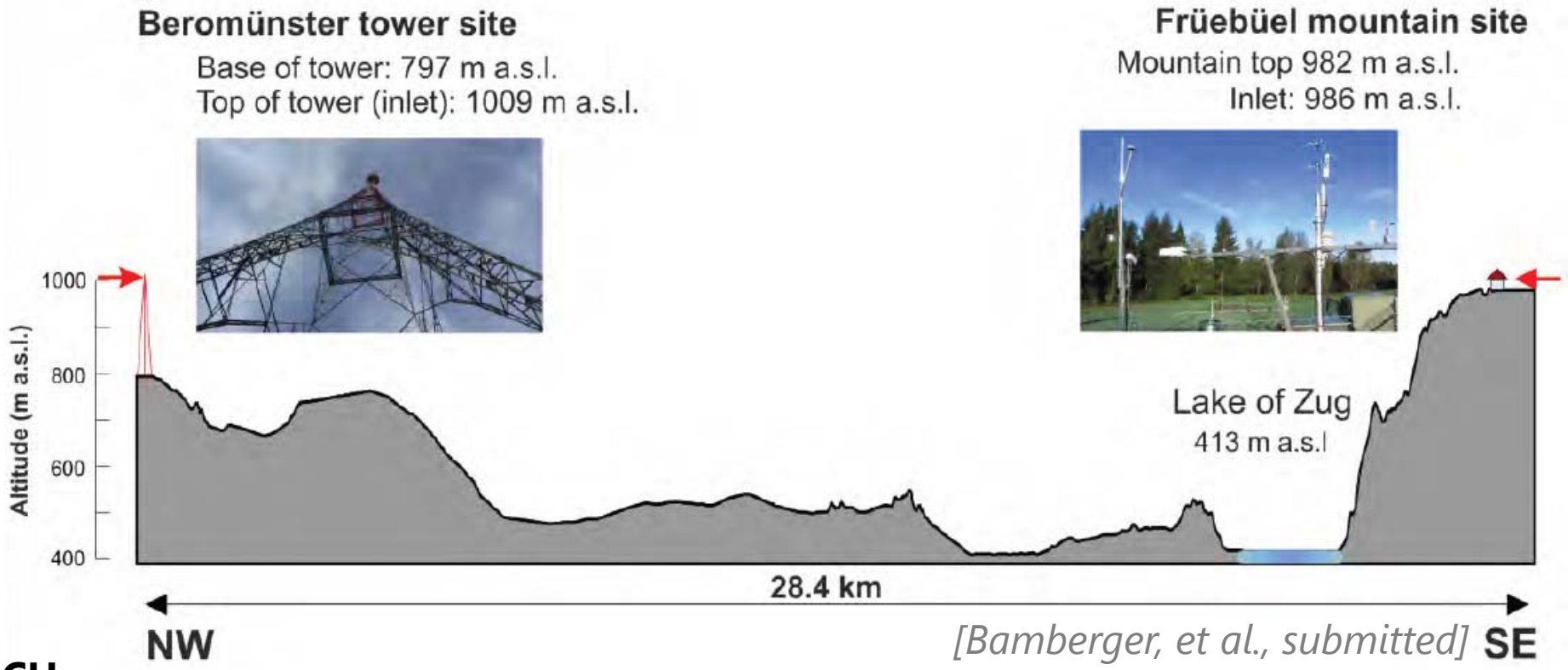




[Satar et al., BG, 2016]
[Berhanu et al., AMT, 2016]

For ^{14}C measurements, see poster 32 by Berhanu et al.

Tall Tower vs. Mountain Top



[Bamberger, et al., submitted]

CH_4

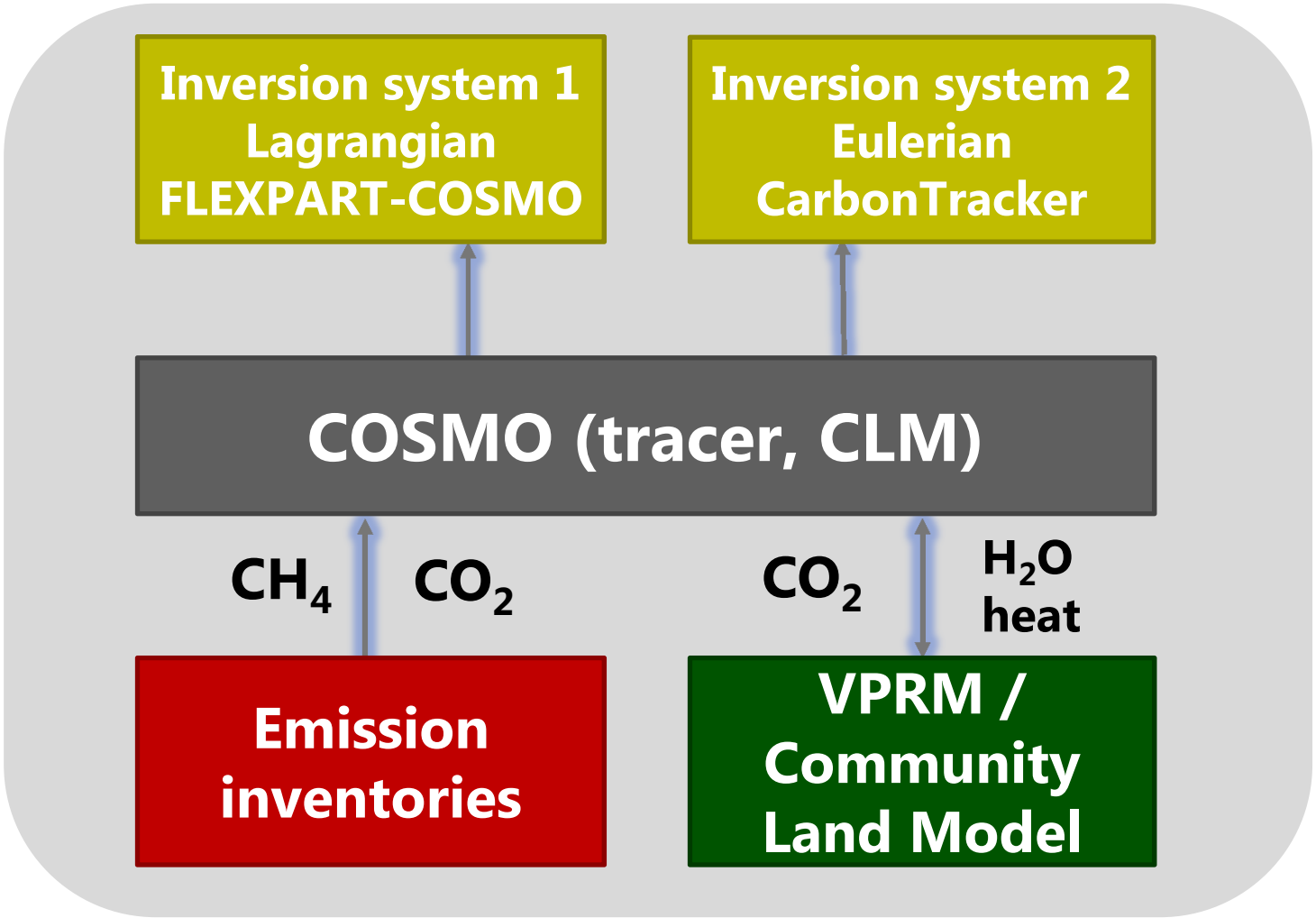
- With data filtering good agreement can be achieved between sites
- Some local influence under specific conditions remains

CO_2

- Good agreement only during winter

In absence of local sources, a mountain top station may provide GHG observations with similar spatial representativeness to those measured at a tall tower station

CarboCount-CH Modelling System

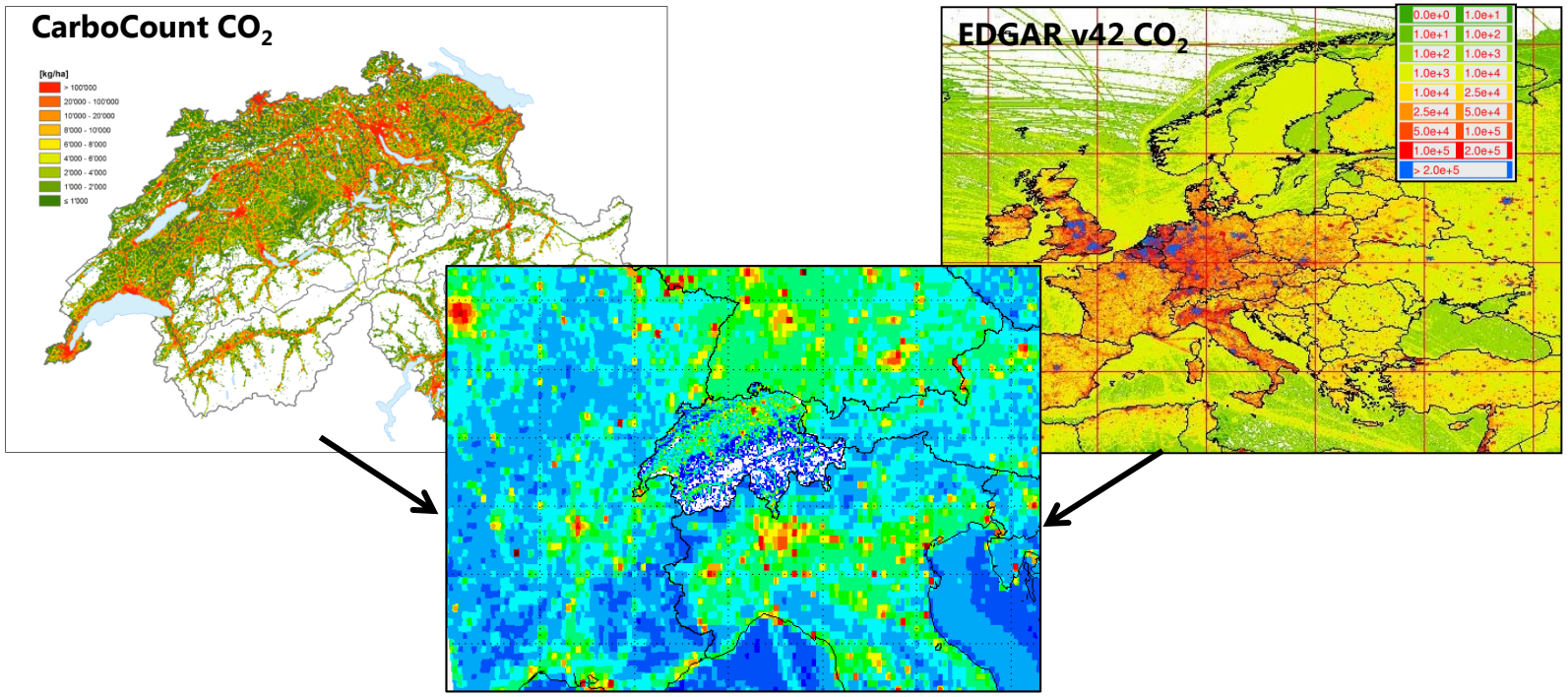


Anthropogenic Emission Inventories

Switzerland
- CarboCount CO_2
- MAIOLICA CH_4
- 500 m x 500 m

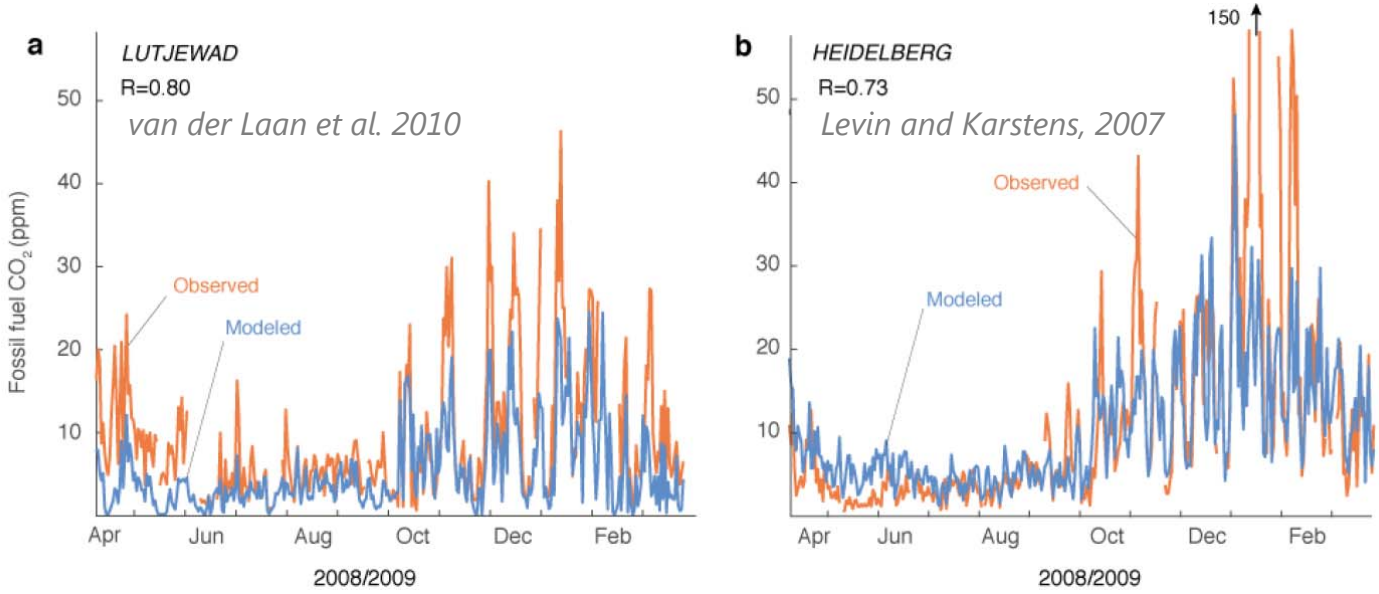
Europe
- EDGAR v4.2: CO_2, CH_4
- TNO/MACC: CO_2, CH_4
- Approx. 10 km x 10 km

- Time profiles (daily, weekly, seasonal, trend)
- Projection onto (COSMO) model grid
- Merging of inventories



Evaluation COSMO CO_2 Simulations

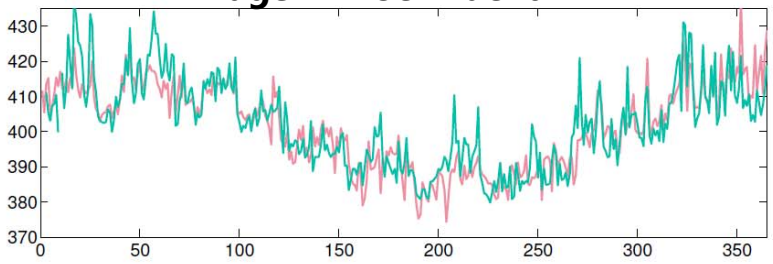
Comparison with fossil fuel CO_2 from measured $^{14}CO_2$ and CO in 2008/2009



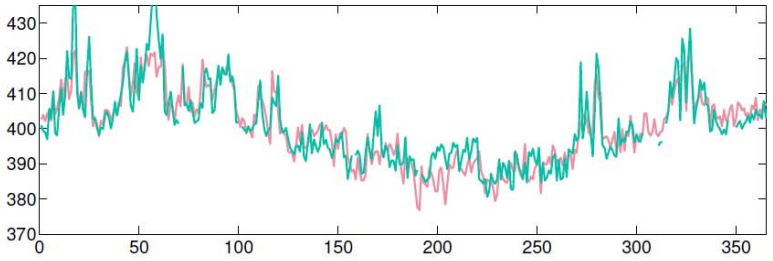
Daily mean

Comparison with total CO_2 at two sites in Switzerland in 2013 (12-15 UTC)

Lägern-Hochwacht



Beromünster



[Liu et al., in prep.]

Contributions to COSMO Simulated CO_2 Concentrations

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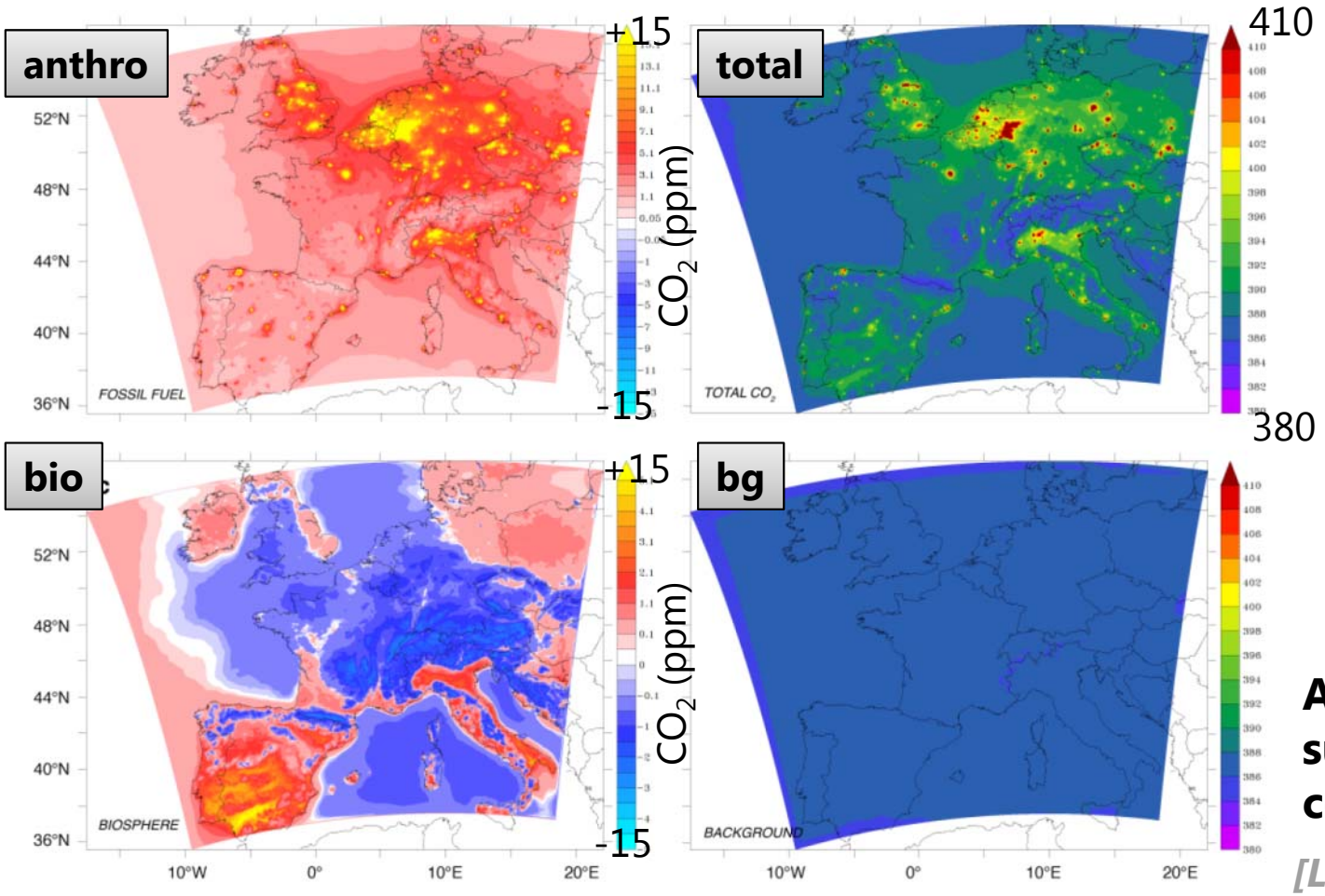
- 5 different anthropogenic sources, 10 individual countries/country groups
- photosynthesis & respiration separately

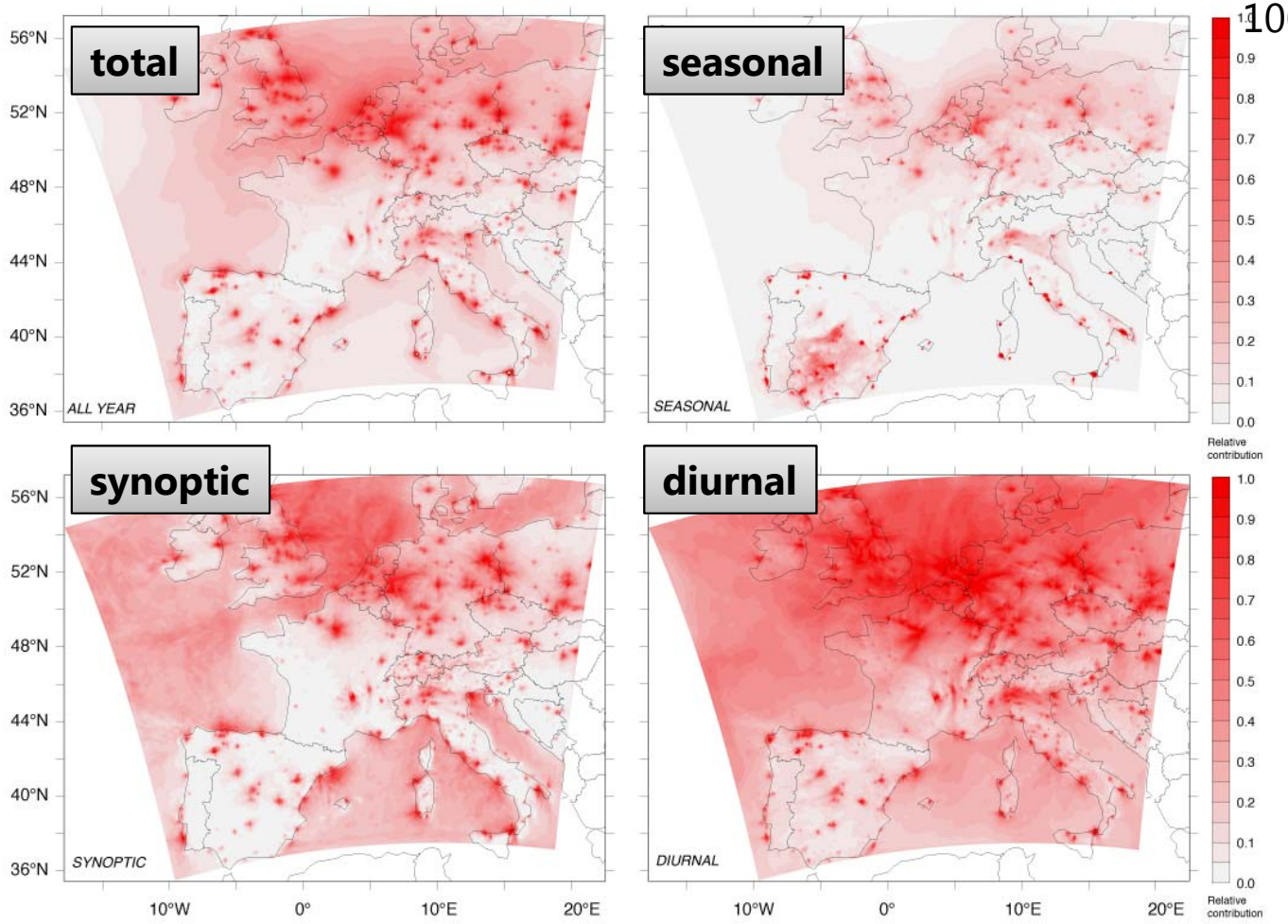


Annual mean surface concentrations

[Liu et al., in prep.]

Contributions to COSMO Simulated CO_2 Variability

- Variability split into different time scales



Relative contribution of anthropogenic tracer to simulated variability

[Liu et al., in prep.]

COSMO-CLM coupled to Community Land Model

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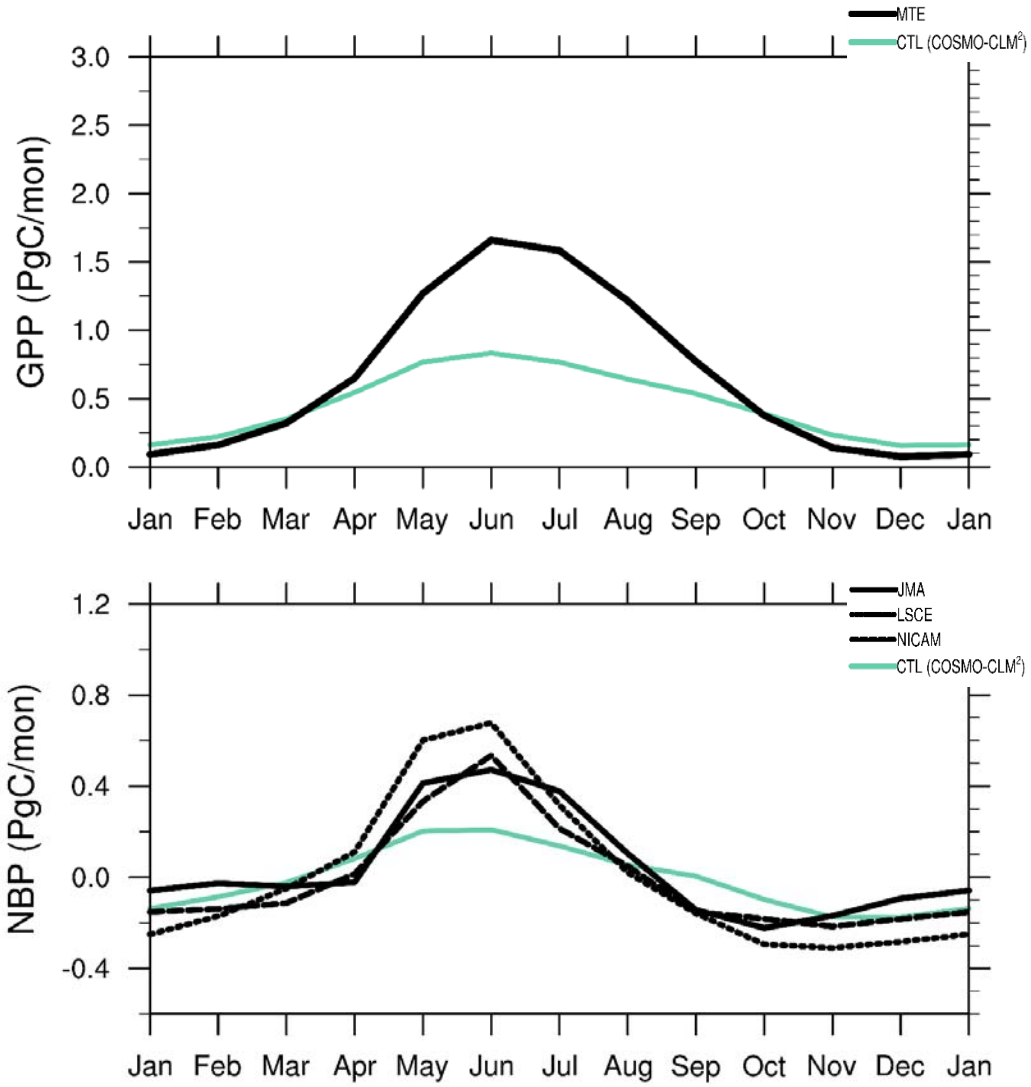
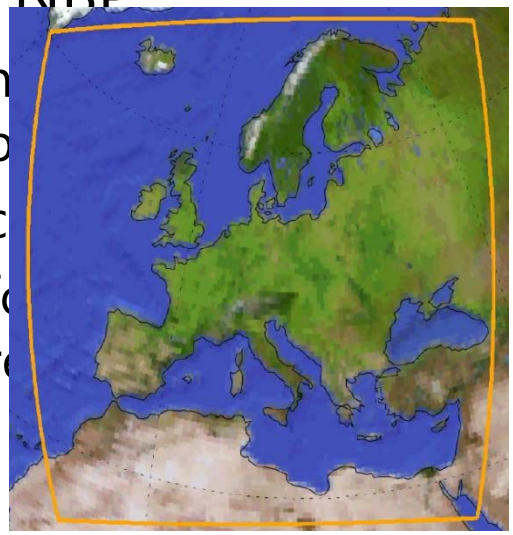
Seasonal variation of GPP and NBP 1989-2005



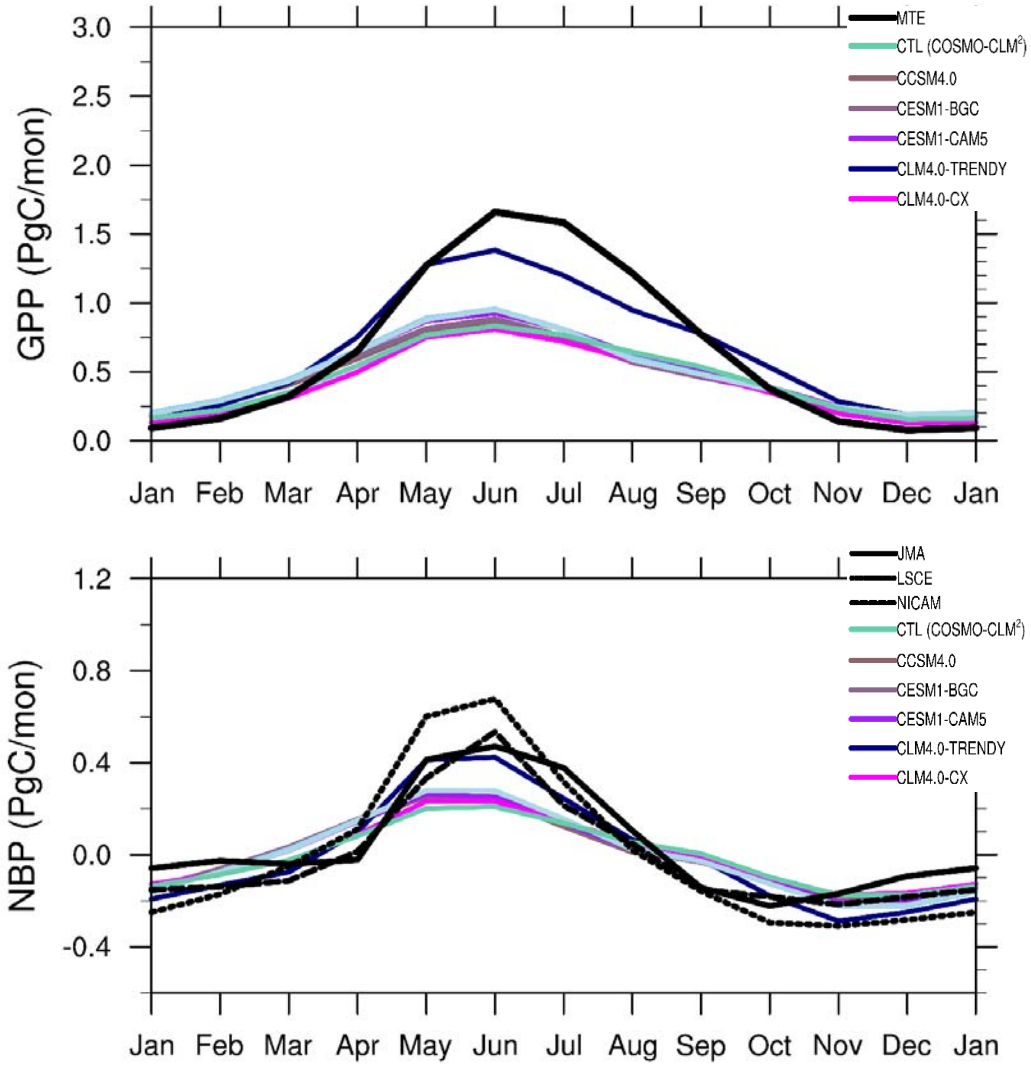
- COSMO-CLM²-C/N
  - CORDEX EU domain
  - 0.44° x 0.44°
  - Active C/N module
- Reasons for the low GPP and NBP
  - n… plant p…
  - c…
  - f… r…



[Mystakidis et al., in prep.]

COSMO coupled to Community Land Model

Seasonal variation of GPP and NBP 1989-2005

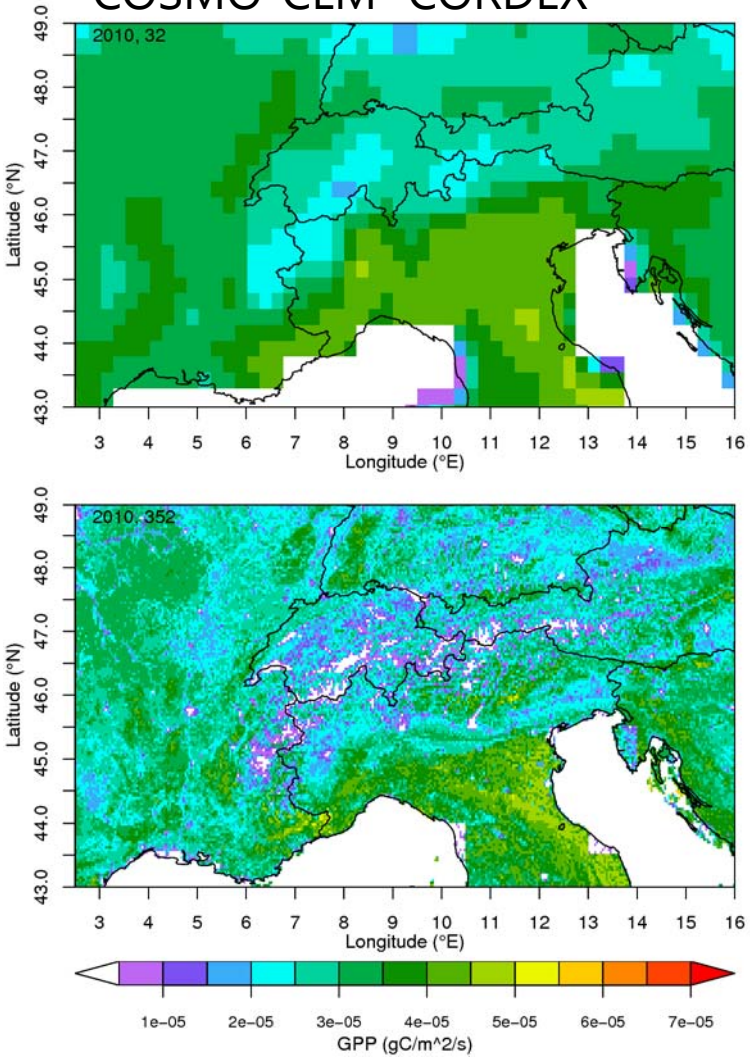


- Reasons for the low GPP and NBP
  - nitrogen limitation on plant productivity
  - cropland fertilization
  - forest regrowth and recovery
- Coupling to COSMO does not introduce additional biases in the seasonal variation of GPP and NBP

[Mystakidis et al., in prep.]

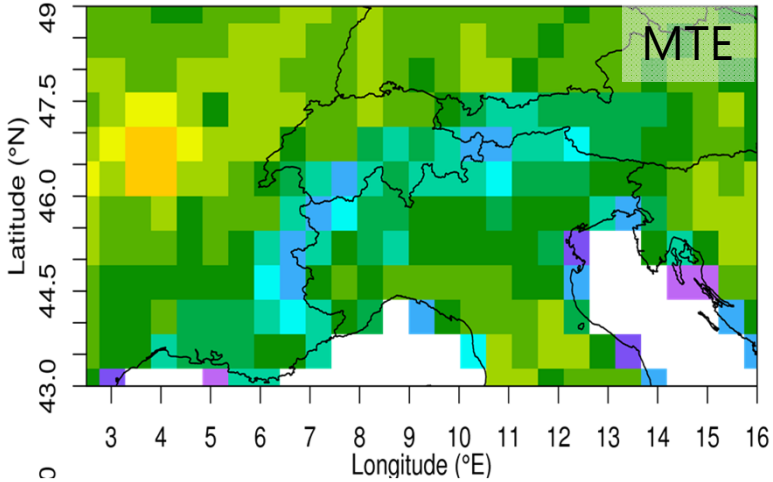
CLM Simulations with Newly Developed High-resolution Land Data

COSMO-CLM^2 CORDEX

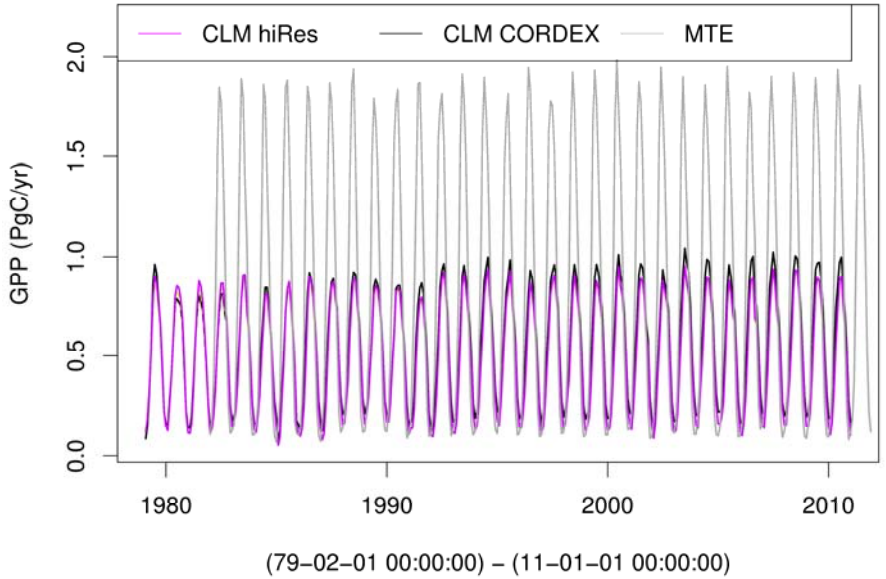


GPP 2010 mean

CLM-CH (0.04°)

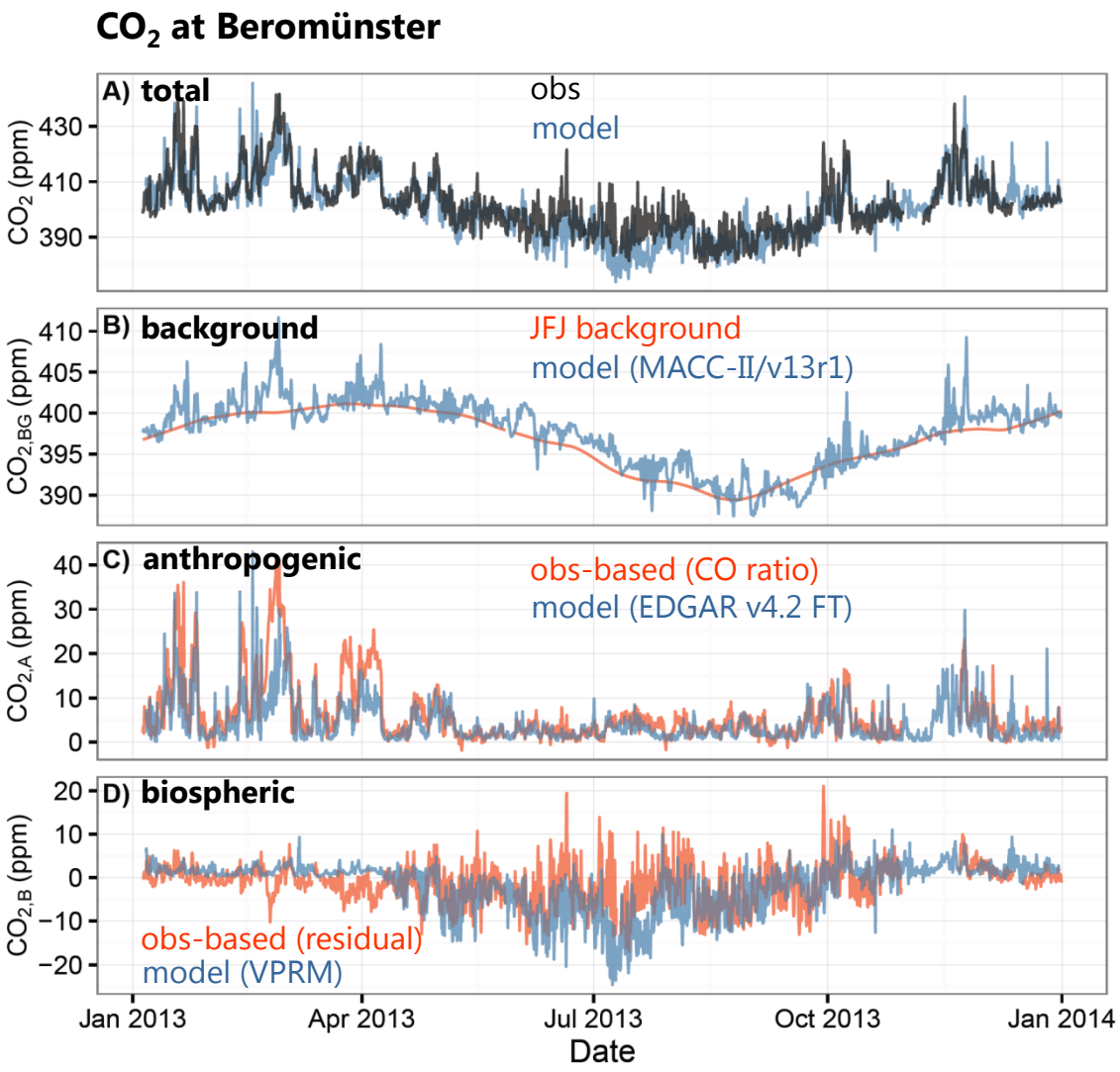


Alpine domain total



FLEXPART-COSMO CO_2 Simulations

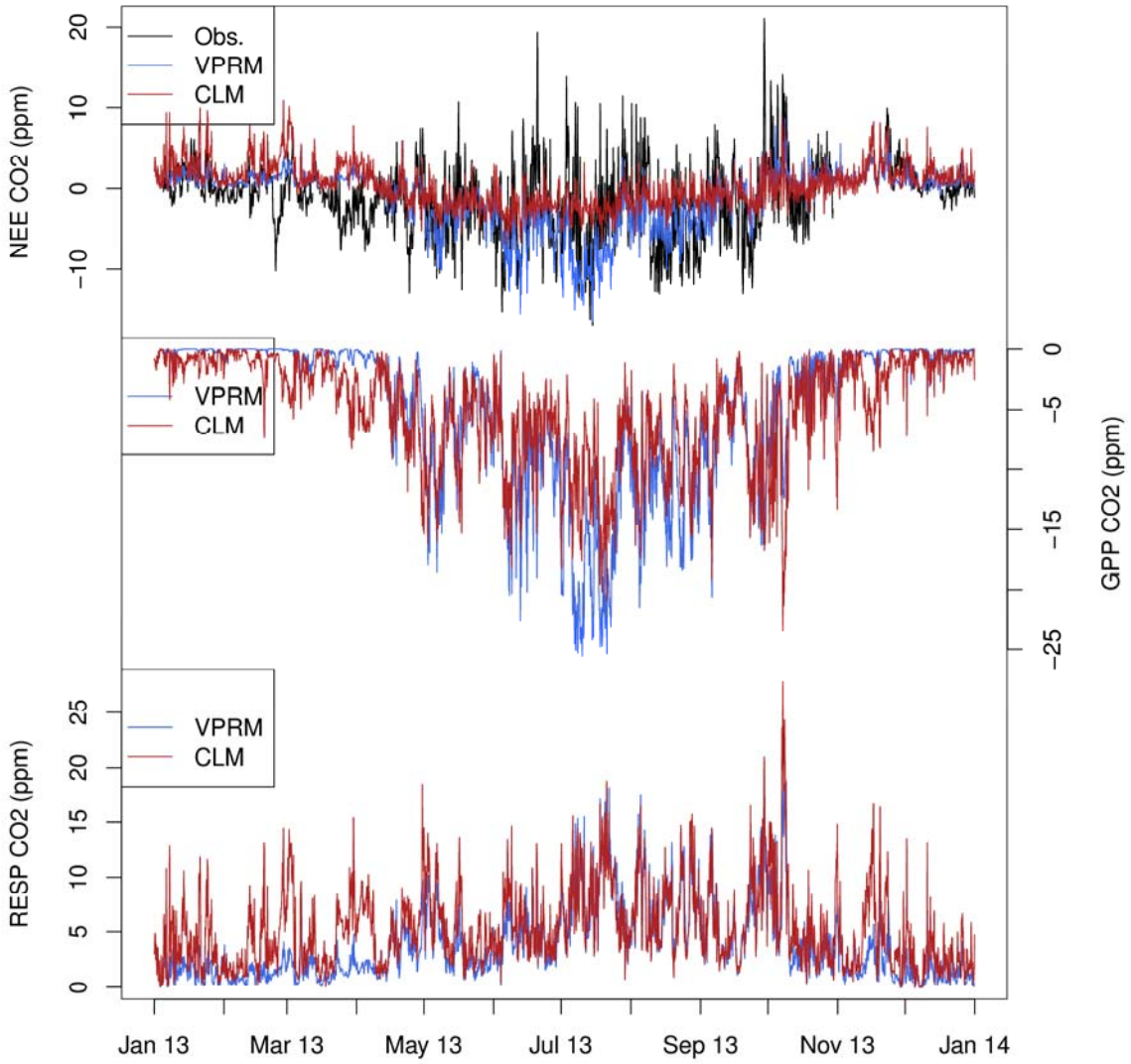
Directly modelled vs. observation-based estimates of fossil fuel and biospheric CO_2



- Simulated total CO_2 generally agrees well with observations
- JFJ BG smoother than simulated BG from global assimilation system
- Mostly good agreement btw. CO-based and modelled anthrop. CO_2, except for pollution episodes in spring
- VPRM CO_2 in summer much lower than obs-based residual biospheric CO_2

[Oney et al., submitted]

FLEXPART Simulated Biospheric CO_2 @ Beromünster

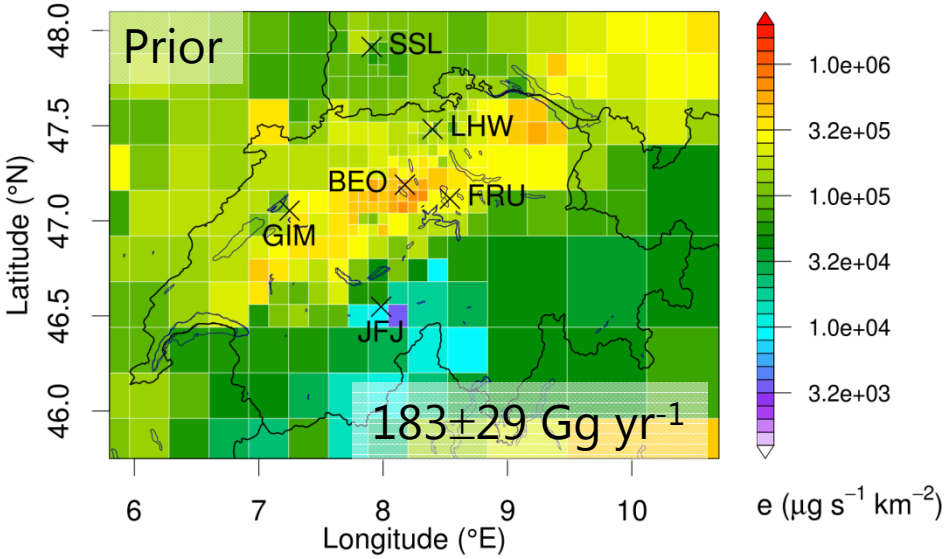


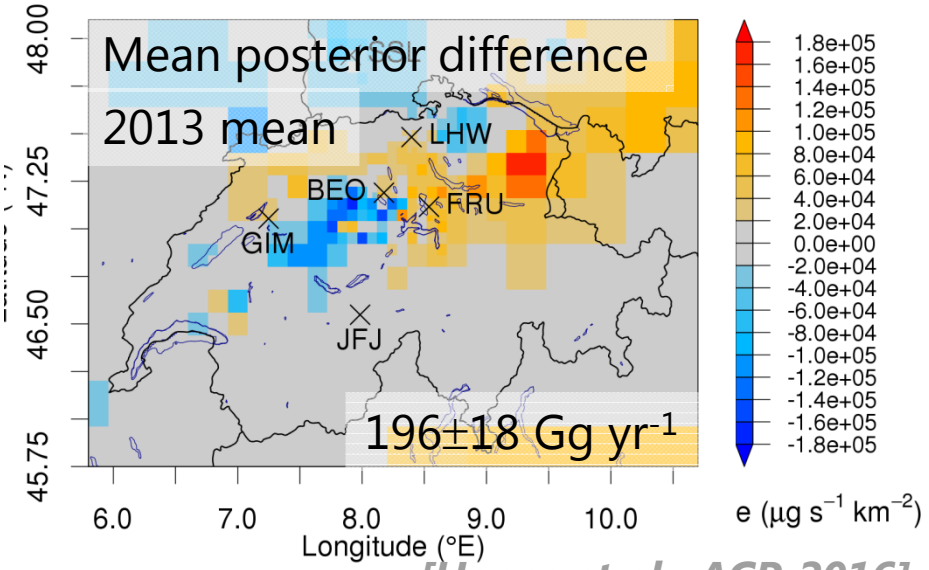
Observation based
FLEXPART-VPRM **UPDATED!**
FLEXPART-CLM

R:	0.54	0.48	
Bias:	0.02	1.6	ppm

Biospheric CO_2 at Beromünster, 212 m
3-hourly resolution
Mole fraction **NOT** flux!

Country Scale Inversion of CH_4 Emissions



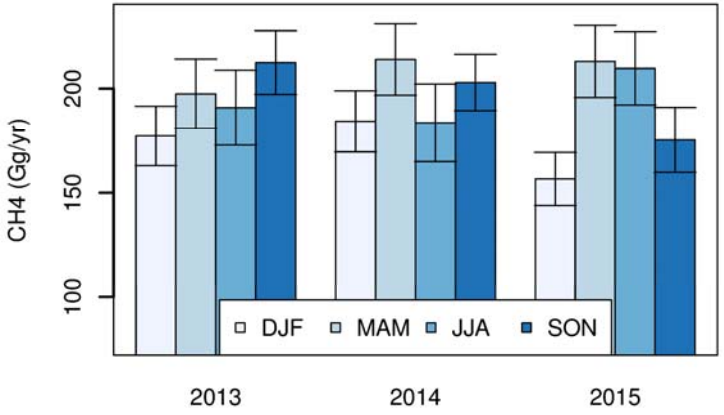


[Henne et al., ACP, 2016]

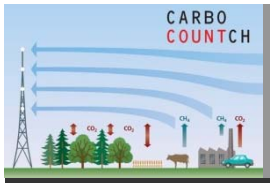
- 30 sensitivity inversions
- Good agreement with bottom-up inventory
- No significant contribution from urban centres
- Decrease in agricultural areas on Swiss Plateau
- Undetermined increase in Appenzell area
- Seasonal minimum in winter

Updates

- Findings robust for 2013 – 2015
- Strong sensitivity to baseline levels (observation based vs. TM5)



See poster 33 by Henne et al.



Summary

Empa
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- Established a dense observation network in Switzerland in 2013 (ongoing at 3/4 CarboCount-CH sites)
- Tall tower site Beromünster to be integrated into national air quality network and extended by N_2O, isotopes, halocarbons
- High-resolution modelling system developed around the COSMO NWP, FLEXPART-COSMO and CLM4.0 land surface model
- First inverse modelling results for CO_2 suggest comparable biospheric sink as in VPRM-based prior, but seasonal shift towards spring
- CLM model results highlight the importance of correctly treating nitrogen limitations when applied to croplands
- CH_4 inverse modelling results corroborate national GHG inventory, but indicate additional unknown source in Eastern Switzerland and show sensitivity to applied baseline

Acknowledgements

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SCHWEIZERISCHER NATIONALFONDS ZUR FÖRDERUNG DER WISSENSCHAFTLICHEN FORSCHUNG

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Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra

Bundesamt für Umwelt BAFU