Understanding and Quantifying CO₂ and CH₄ Greenhouse Gas Fluxes on the Regional Scale: The Project CarboCount CH

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CarboCount CH

Goals

- Improved understanding of CO₂ fluxes in Europe and their sensitivity to climate variations
- Develop prototype of a modeling and observation system of CO₂ and CH₄ fluxes in Switzerland

Approach

- Simulations of biosphere-atmosphere exchange of CO₂ in Europe over past 33 years (1979-2012)
- Setup of CarboCount-CH GHG observation network in CH
- Estimation of CO₂ and CH₄ fluxes in CH through combination of top-down & bottom-up methods:
  - Top-down: Two independent inversion systems
  - Bottom up 1: Hi-res inventories of CO₂ und CH₄ emissions
  - Bottom up 2: Biogeochemistry model to simulate exchange of CO₂ between biosphere and atmosphere
Measurement network

- **4 new sites** for CO₂, CH₄ and CO dry VMR
- regular \(^{14}\text{C}\) samples at Beromünster
- 3 NABEL sites with CO and CO₂ + 2 sites with CO and CH₄
- 4 FLUXNET sites
- Central calibration lab at Empa (GAW World Calibration Center)
Tall tower site Beromünster

building hosting instruments

valve switch box

CarboCount
- Project goals
- Network
- Model system
- input data

First results
- FLEXPART simulations

Conclusions
**Model System**

- **Inversion system 1**
  - Lagrangian
  - FLEXPART

- **Inversion system 2**
  - Eulerian
  - CarbonTracker

- **footprints**

- **CO₂ VMR**

- **COSMO + ..**

- **CH₄**

- **CO₂**

- **Community Land Model**

- **Emission inventories**

- **CO₂**

- **H₂O heat**

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**Conclusions**
Coupled system COSMO-CLM$^2$

COSMO mesoscale NWP model
- model of a consortium of weather services in Europe (Germany, Switzerland, Italy, Poland, Greece, Rumania, Russia)
- COSMO-CLM: Climate version of COSMO


Community Land Model CLM 4.0

Lawrence et al. (2011)
Two inversion systems

Goal:
- Inverse estimation of CO₂ and CH₄ fluxes from observations
- Optimal integration of measurements, model, and a priori knowledge

Lagrangian
- FLEXPART-COSMO
- 4 day backward simulations
- nested simulations at 2 km and 7 km resolution
- footprints (residence time maps) provide source sensitivities
- Bayesian inversion or Kalman filter
  Brunner et al. (2012)

Eulerian
- COSMO-CLM² + tracers
- O(100) ensemble simulations, varying CO₂ fluxes from PFT
- nested simulations
- source sensitivities approx.
  with Ensemble Kalman Filter
- CarbonTracker inversion
  Peters et al. (2007)
Collection of high-resolution input data

**Community Land Model 4.0**
- 1 hydrology parameter
- 4 land cover parameters
- 4 soil parameters
- 7 vegetation parameters

**Emission Inventories**
- Switzerland
  - CarboCount CO₂, 500 m x 500 m
  - MAIOLICA CH₄, 500 m x 500 m
- Europe
  - EDGAR v4.2: CO₂, CH₄, 0.1°x0.1°

**Evergreen Needleleaf Boreal Forest**

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<th>NCAR 0.05°</th>
<th>CarboCount 0.01°</th>
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**MAIOLICA CH₄ inventory**
First results – Simulations for Beromünster

FLEXPART-COSMO simulations for CO$_2$, CO and CH$_4$

Footprints

Emissions

= concentration time series
First results – Simulations for Beromünster

Beromünster Measurement Site: emissions contributions
Release height: 212 m, Measurement height 212 m

- Modeled CO2
- Measured CO2

CO2

CH4

CO

Conclusions

- FLEXPART simulations

CarboCount

- Project goals
- Network
- Model system
- Input data
First results – CO and CO₂ at Beromünster

Beromünster Tower: 2012-11-23 to 2013-04-11

- FLEXPART simulations

Conclusions
Outlook and conclusions

Next steps:
- further processing of measurement data
- integrate new input data sets into CLM4.0
- complete setup of COSMO-CLM$^2$ and perform 30-yr simulations of CO$_2$ fluxes over Europe
- Setup CarbonTracker inversion system and test with idealized tracers
- Setup and test FLEXPART-based inversion system

Conclusions:
- Goal of CarboCount CH is to quantify CO$_2$ and CH$_4$ fluxes at regional scale and to understand feedbacks with climate
- Measurement network complete
- Model system still under construction
- First results for Beromünster (and Lägern) demonstrate high quality of transport simulations based on COSMO meteorology