Global Atmosphere Watch
QA/SAC Switzerland

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Federal Office of Meteorology and Climatology MeteoSwiss

EMPA
Materials Science & Technology

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Empa, Air Pollution/Environmental Technology,
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Outline

- Motivation, Challenge & Approach
- Model description
- Model validation
- Case study
- Conclusions

Motivation, Challenge & Approach

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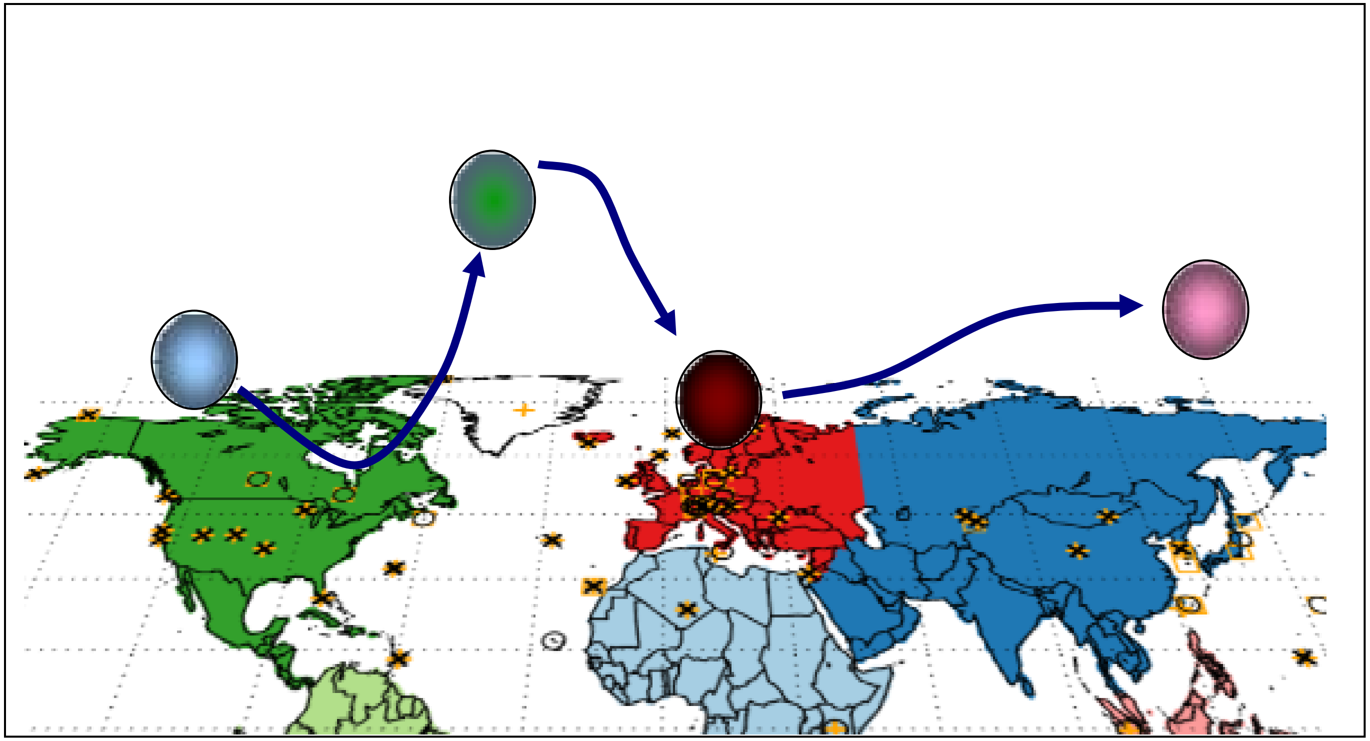
- "Detection of long-term man-made trends in the concentration of greenhouse gases and aerosols related to climate change above natural variability and the corollary impacts of climate change on atmospheric composition."
  [GAW Strategic Plan 2008-2015]

- Trends masked by inter-annual variability
  - Understanding of inter-annual variability will help to obtain more robust and earlier trend estimates from observations

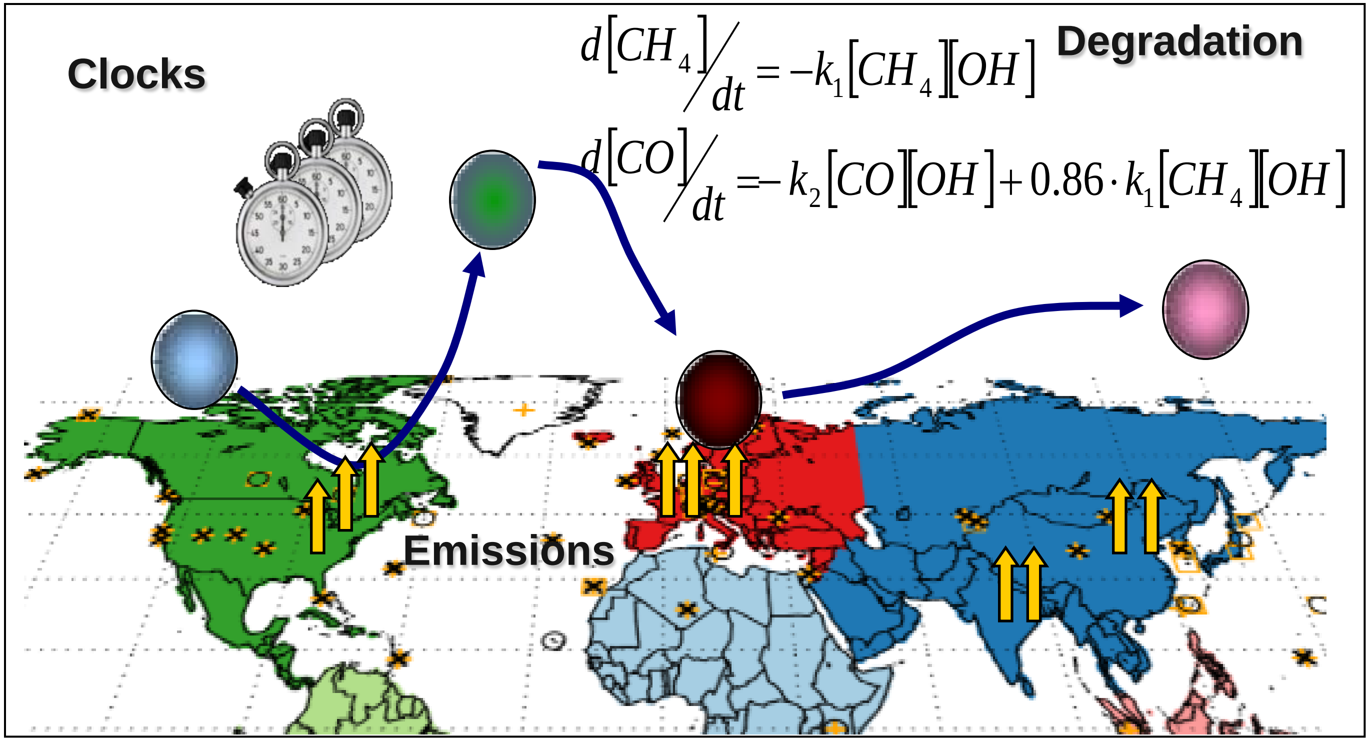
- Lagrangian transport model with limited chemistry
  - Focus on CO and CH_4
    - Largely controlling oxidizing capacity of the troposphere
    - About 1/3 of atmospheric CO produced from CH_4 oxidation
  - Why Lagrangian?
    - transport times, age spectra
    - no numerical diffusion
    - computationally cheap

Lagrangian Model Approach: Basics



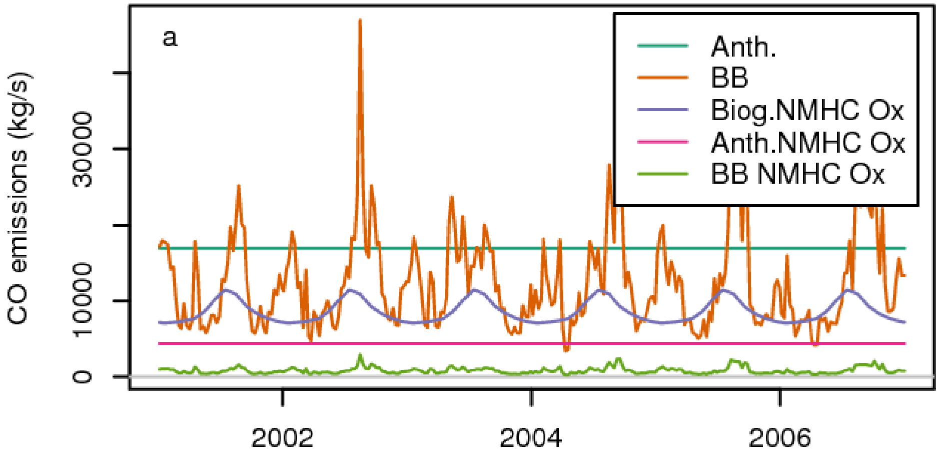
- Based on FLEXPART V8.1 (Stohl, 2005, ACP)
- Global domain filled with 3 mio particles,
  carrying 7 CO, 7 CH_4 species, 1 inert air mass tracer
- Driven by 1° x 1° ECMWF analysis
- Initialised by NOAA MBL obs.; 3 year spin-up

Lagrangian Model Approach: Specifics



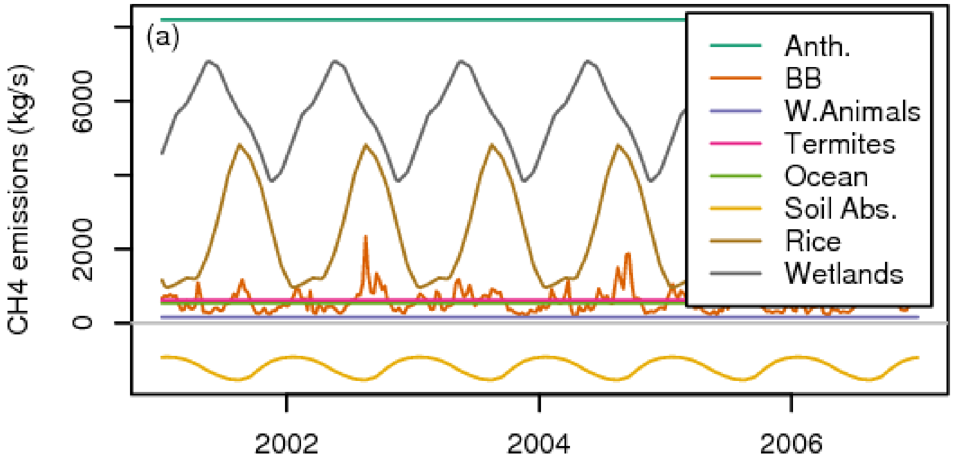
- Emission *uptake* by particles in ABL (7 source regions)
- Clocks, counting the time since a particle left the ABL of a source region (lower limit of pollutant age)
- CO and CH_4 degradation by OH (HTAP climatology for 2001)
- Inter-particle mixing for particles in the same ABL box

Gridded emission: 1° x 1°; distributed over atmospheric boundary layer
No trend, only variability in biomass burning



Anthropogenic: EDGAR 3.2, const.
Ox. Anth. NMVOC: EDGAR 3.2, const
Ox. Bio. NMVOC: EDGAR 3.2, monthly

Biomass burning: GFED 2.1, 8-daily
Ox. Biomass burning NMVOC: GFED 2.1



Anthropogenic: EDGAR 3.2, const.
Wild animals: (Houweling et al. 1999), const.
Termites: (Sanderson et al. 1996), const.
Ocean: (Houweling et al. 1999), const.
Rice: (Matthews et al. 1991), monthly
Wetlands: (Bergamaschi et al. 2007), monthly
Soil abs.: (Ridgewell et al. 1999) monthly

Biomass burning: GFED 2.1, 8-daily

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Model Validation

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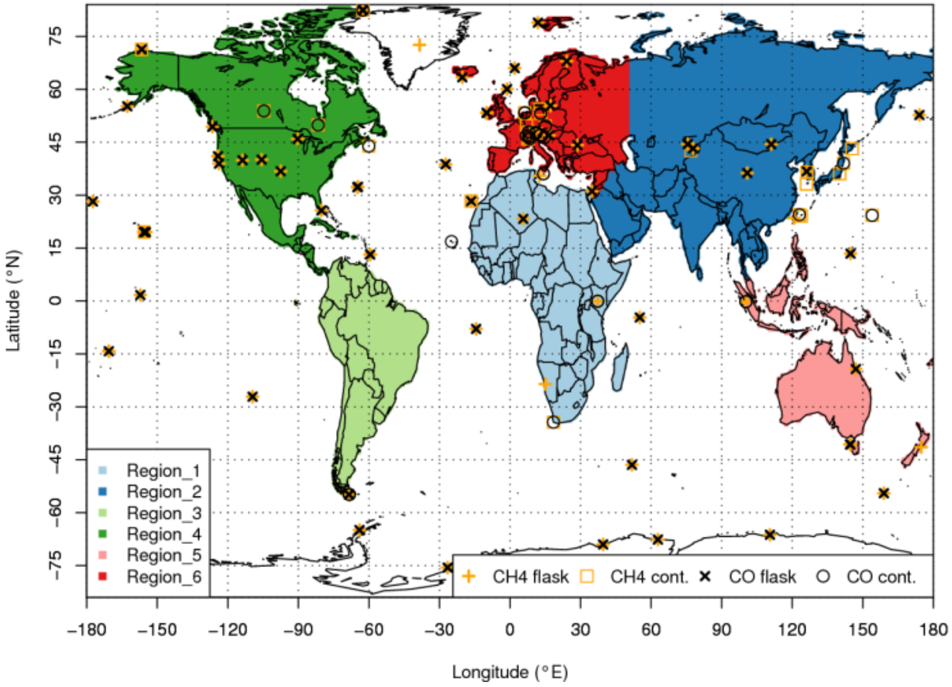
- For which temporal resolution is particle statistics sufficient?
  - Original aim: monthly aggregates
  - Analysed: daily aggregates at receptor sites

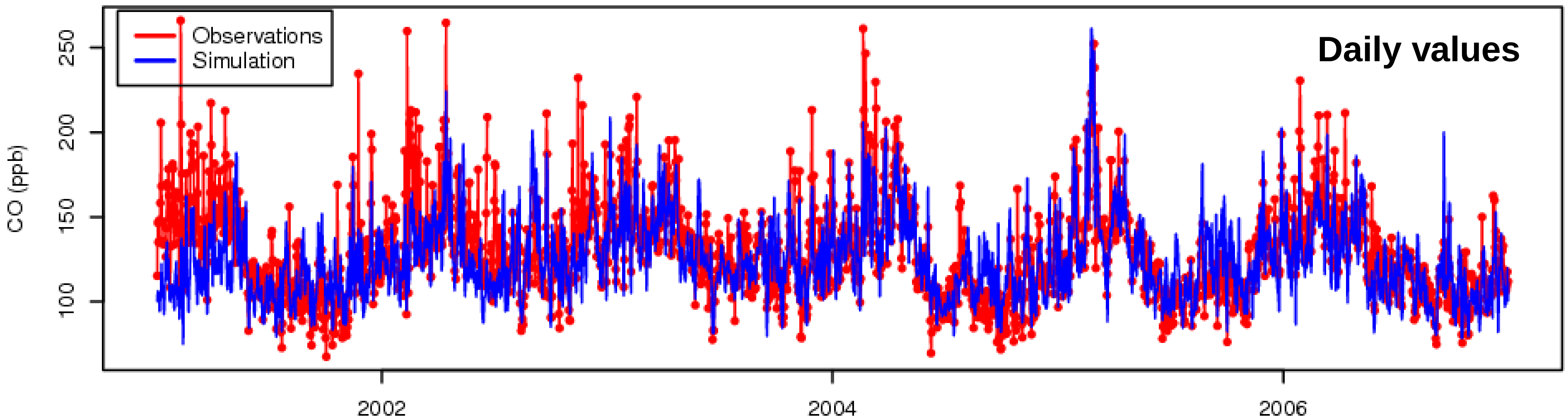
- Ground based observations: GAW WDCGG

- Period: 2001-2006

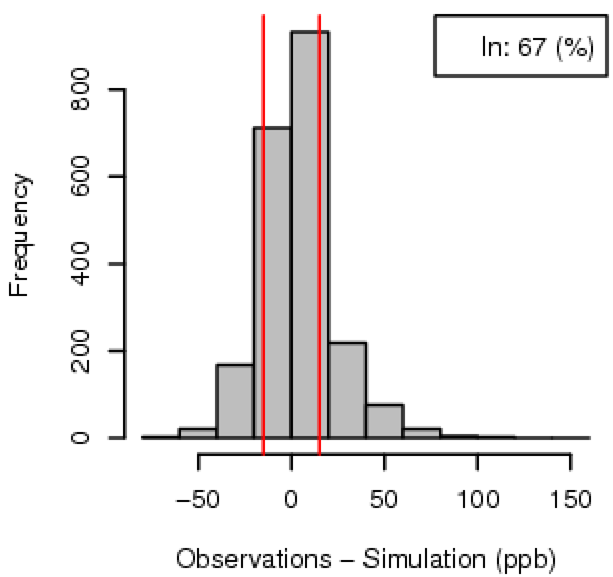
- Compared time-series
  - CO
    - # Flask: 56
    - # Cont.: 15
  - CH4
    - # Flask: 56
    - # Cont.: 19

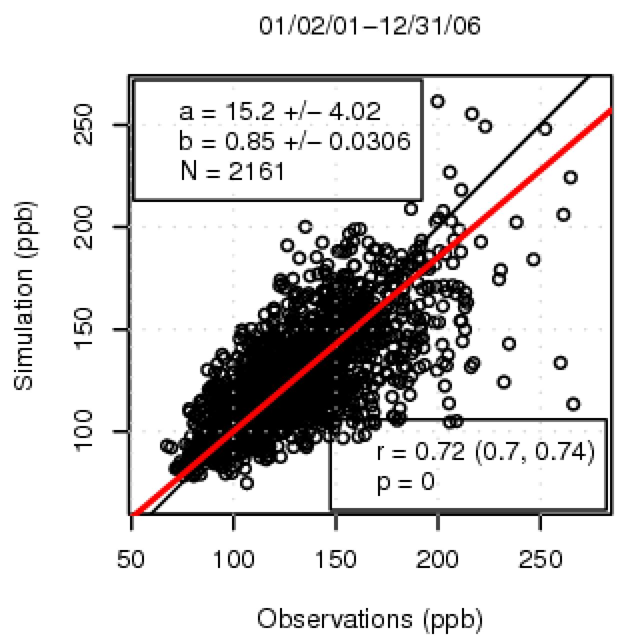


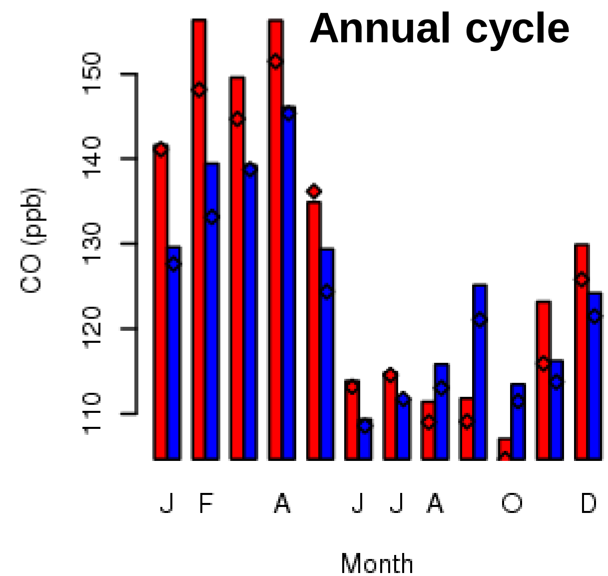
Model Validation
CO (Jungfraujoch, CH)



PDF of obs - sim

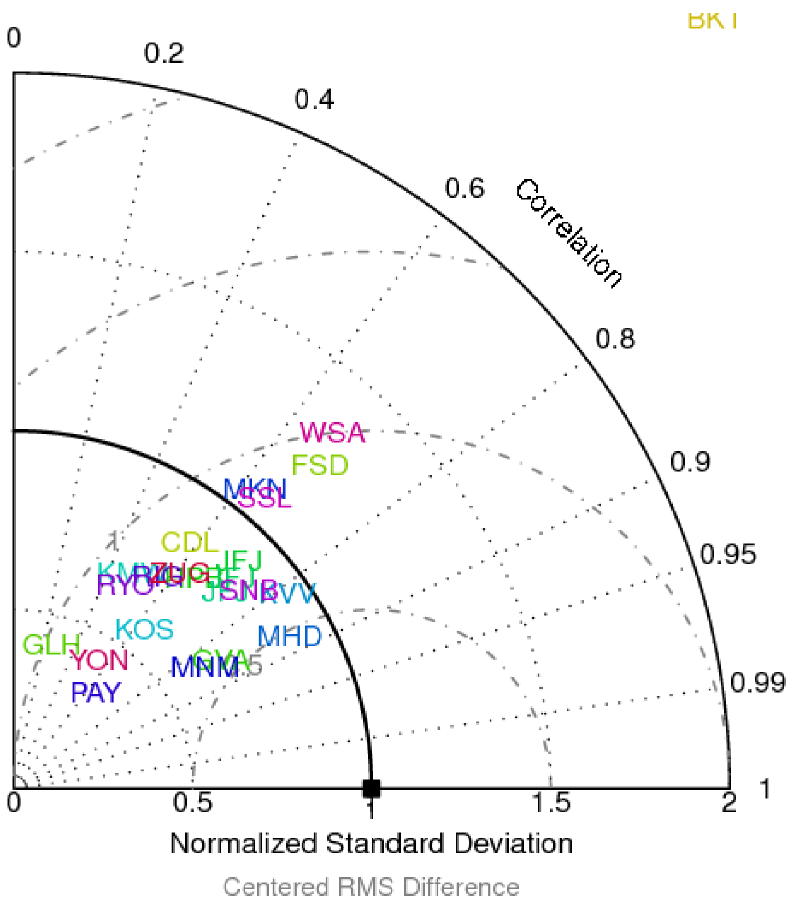






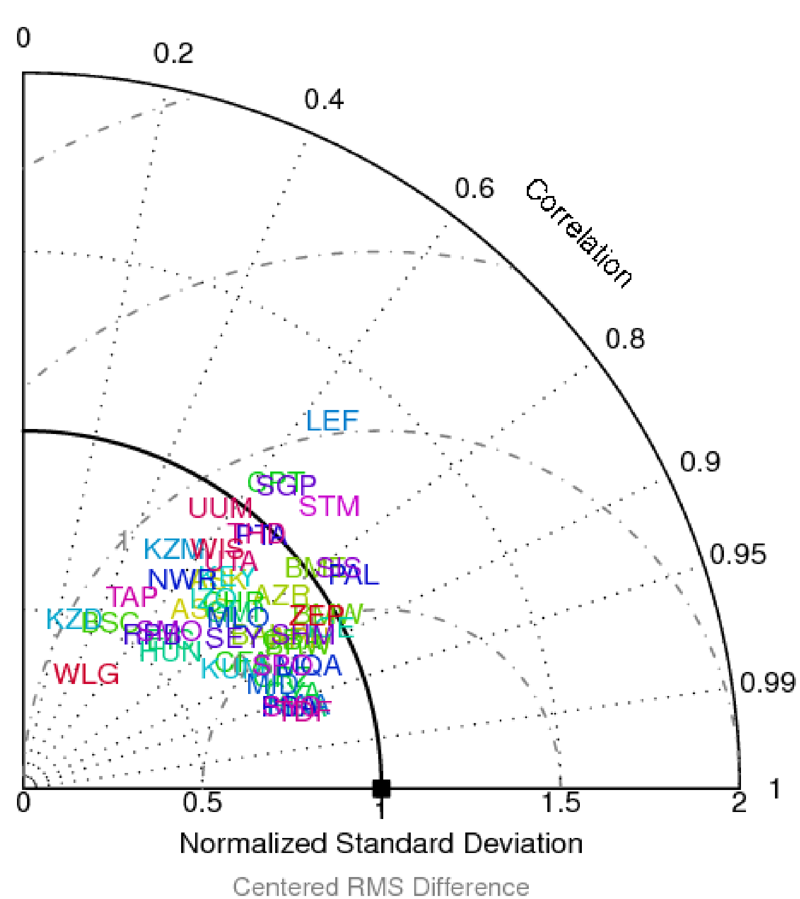
Taylor Diagrams: CO

Continuous



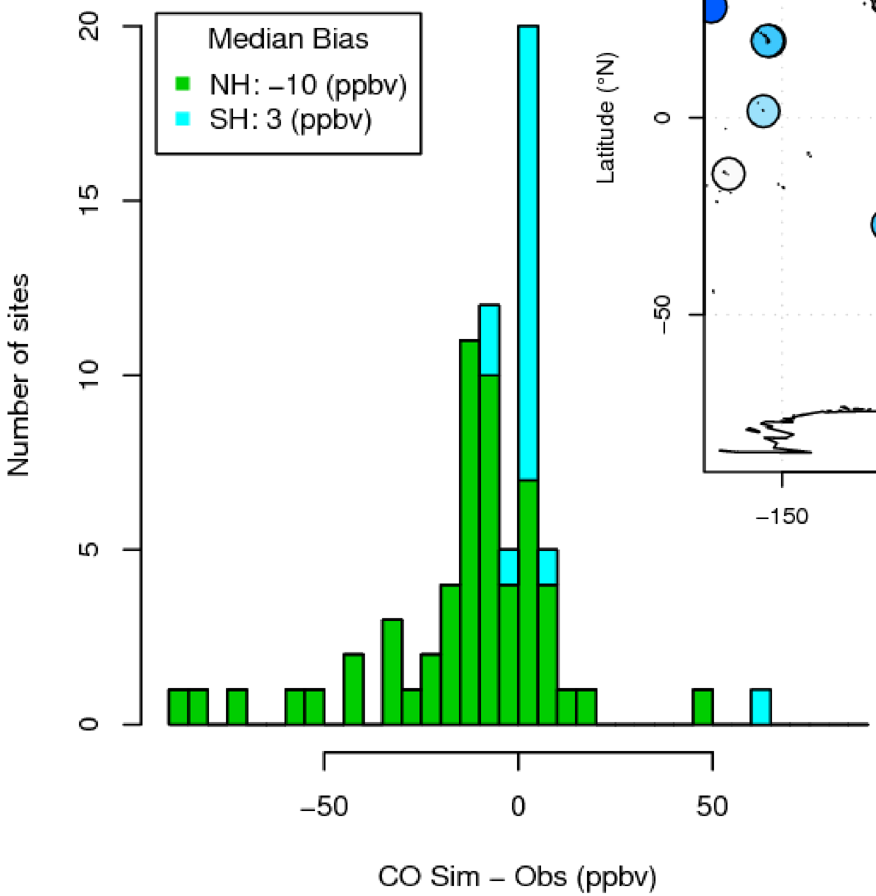
R: 0.6 – 0.9
Underestimation of variability

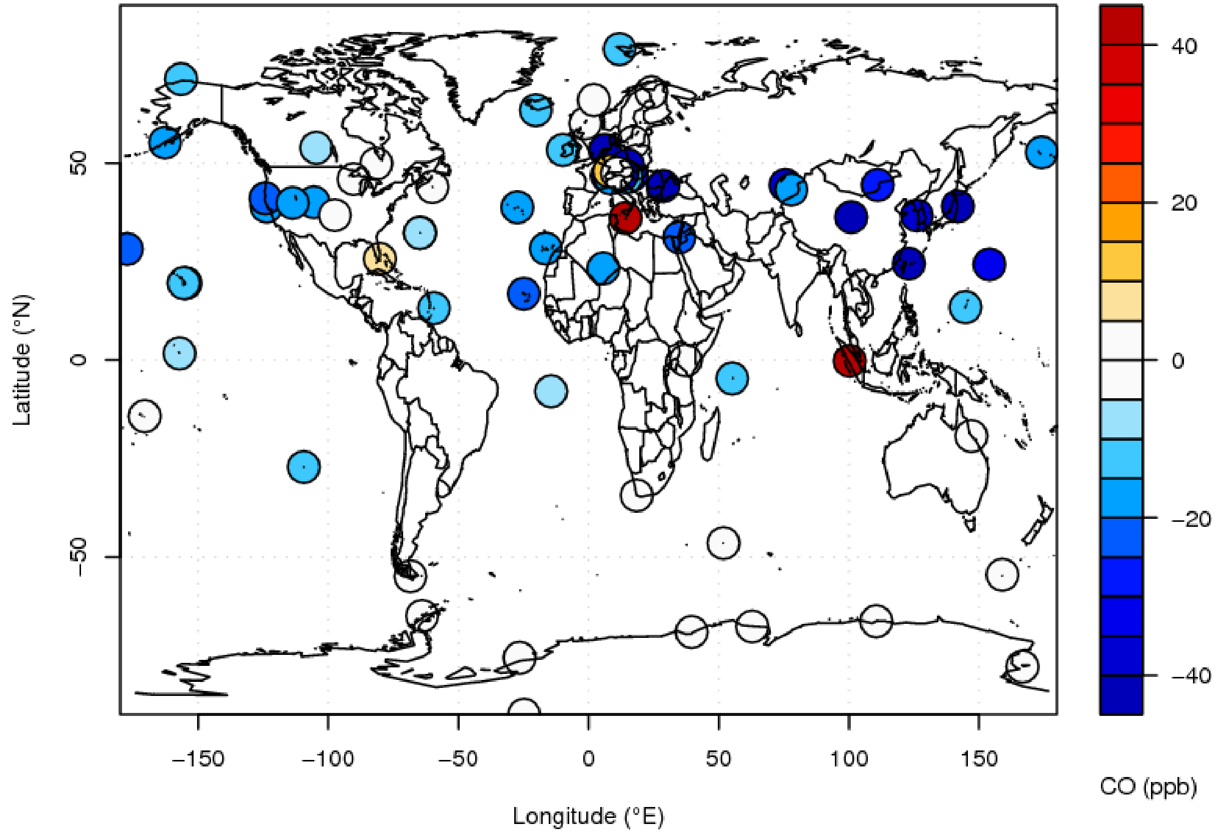
Flask



R: 0.6 – 0.95
Underestimation of variability

CO Bias





Negative bias in Northern hemisphere
More pronounced close to emissions

>> Emissions missing?!

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Model Validation
CH_4 (Jungfraujoch, CH)

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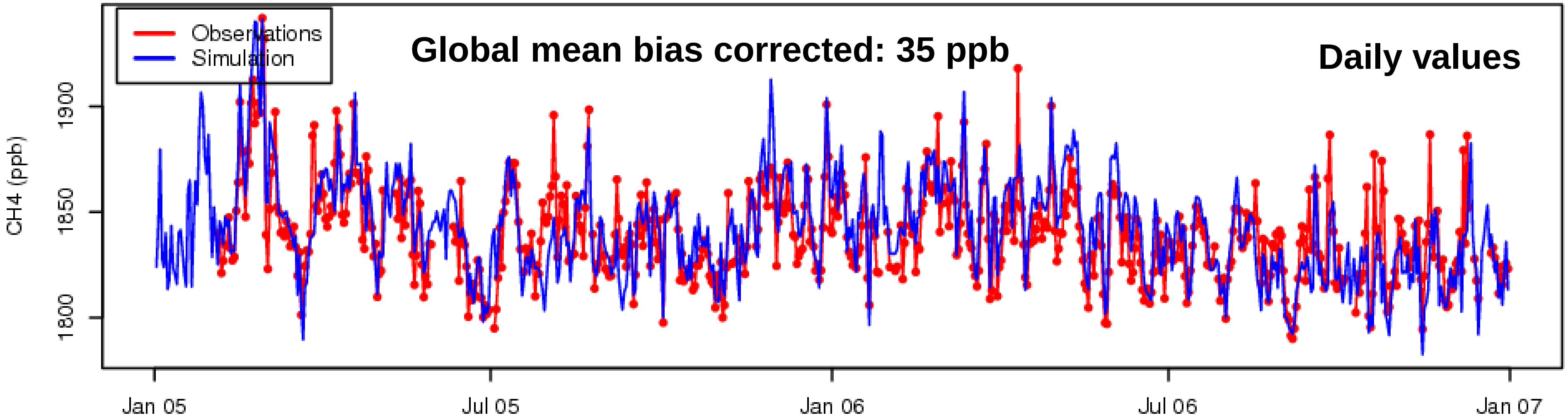
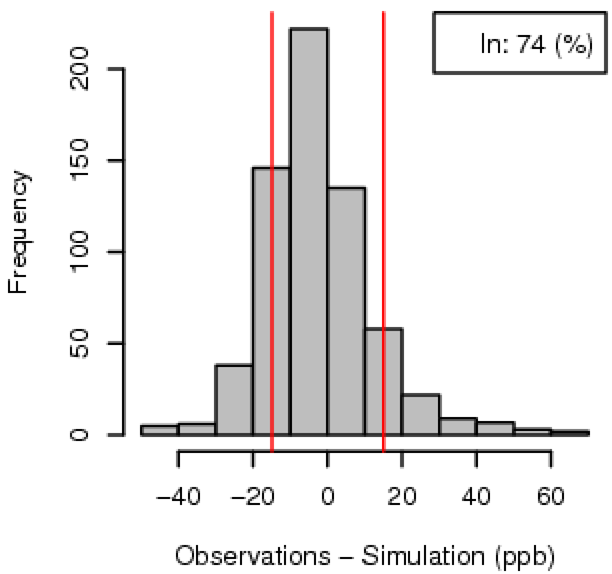
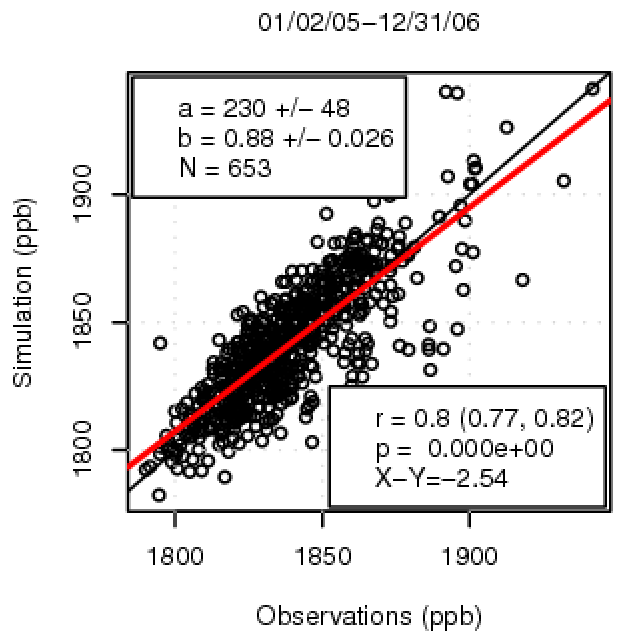
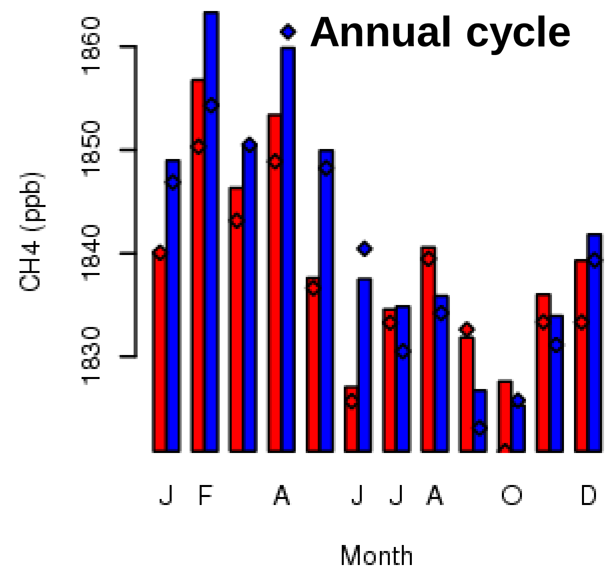


PDF of obs - sim







Taylor plots: Daily CH_4

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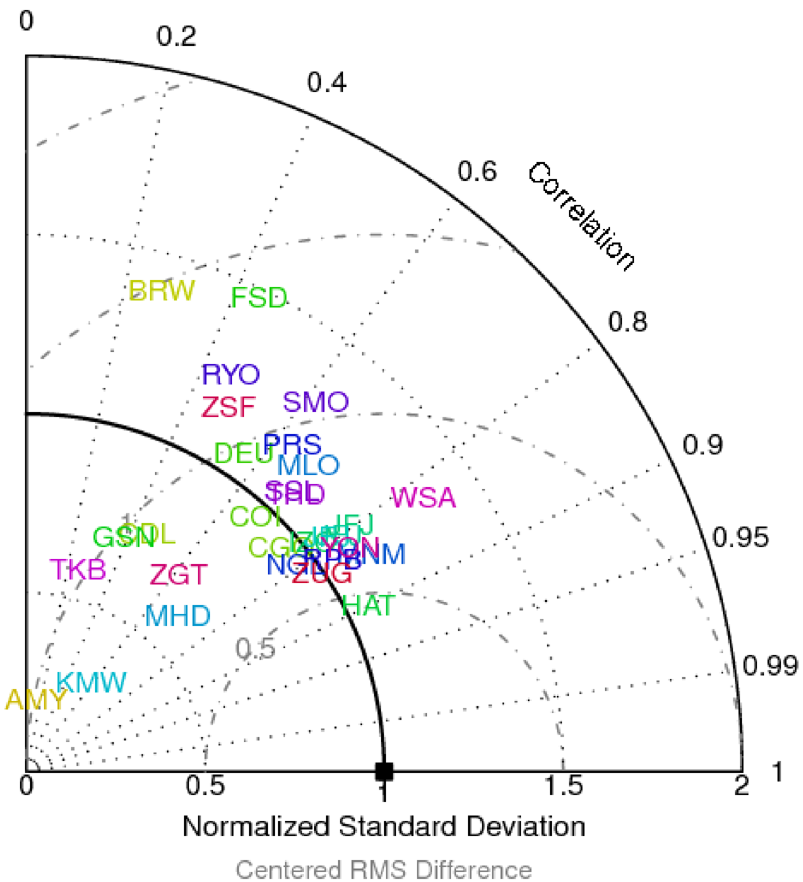
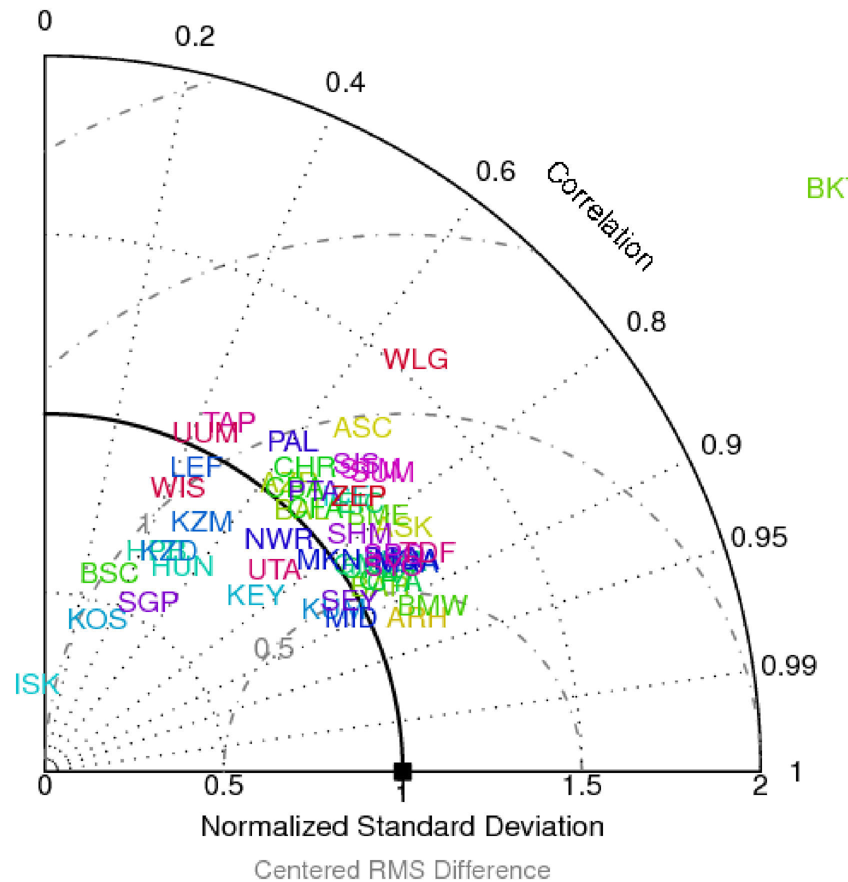
Continuous



R: 0.4 – 0.9

Flask



R: 0.6 – 0.9

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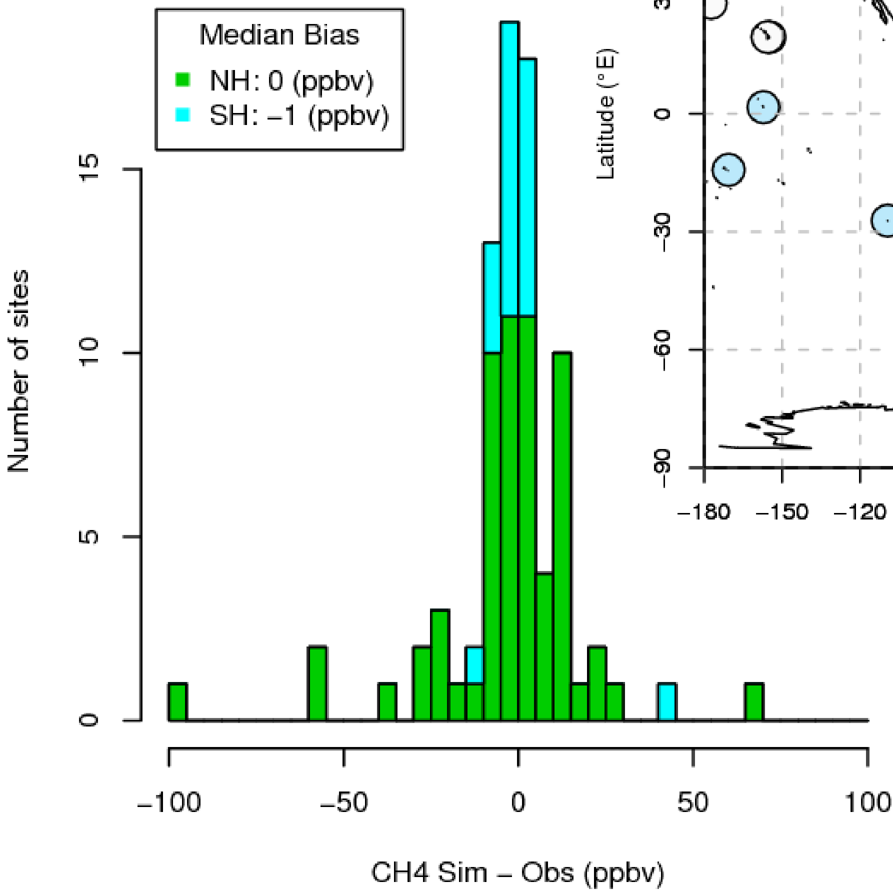
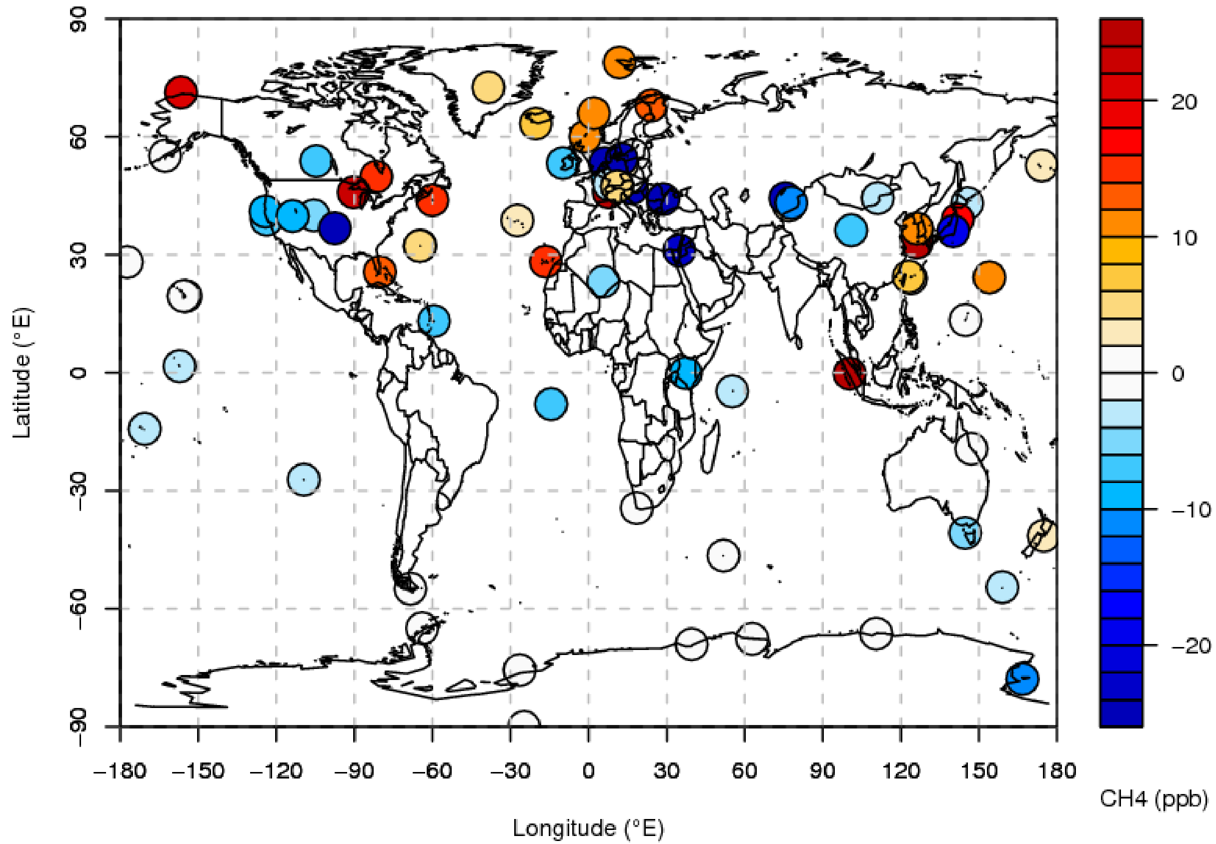
Model Validation
CH_4 Bias





No median bias after global correction
Strong variability of bias in NH

>> over-estimating emissions in NH?!

CO Anomaly, Mace Head (IR)

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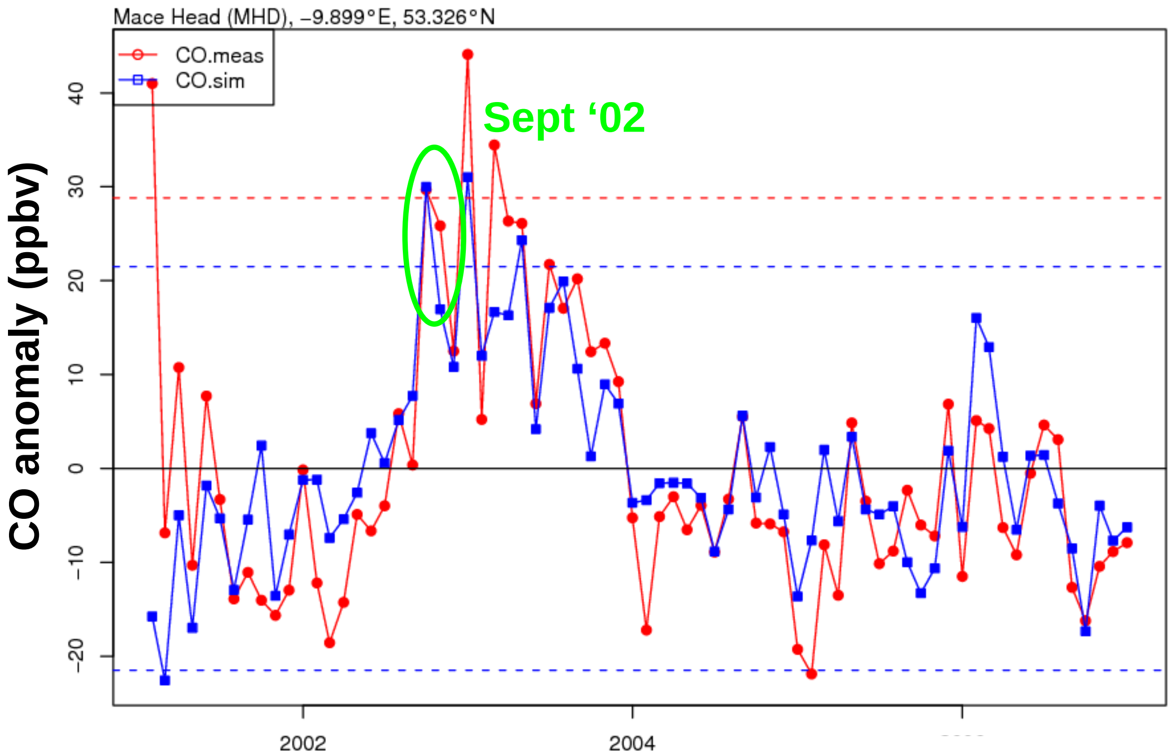
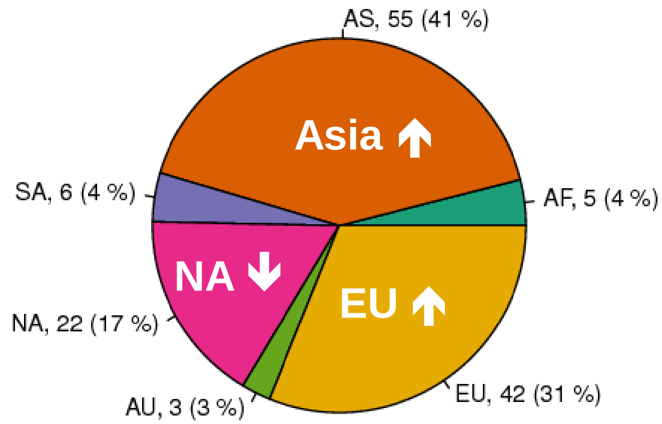
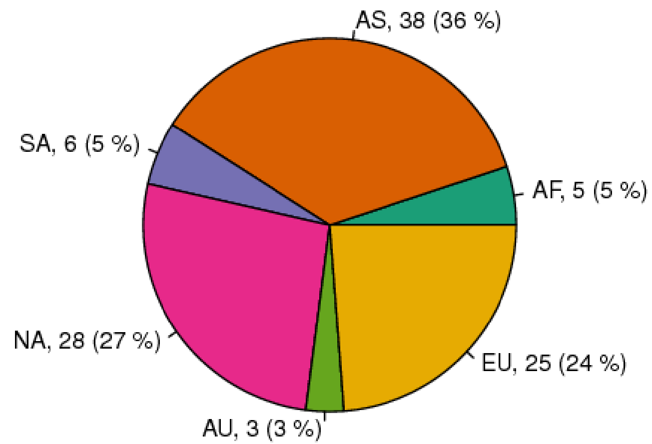




September 2002



Average September

CO Anomaly, Mace Head (IR)

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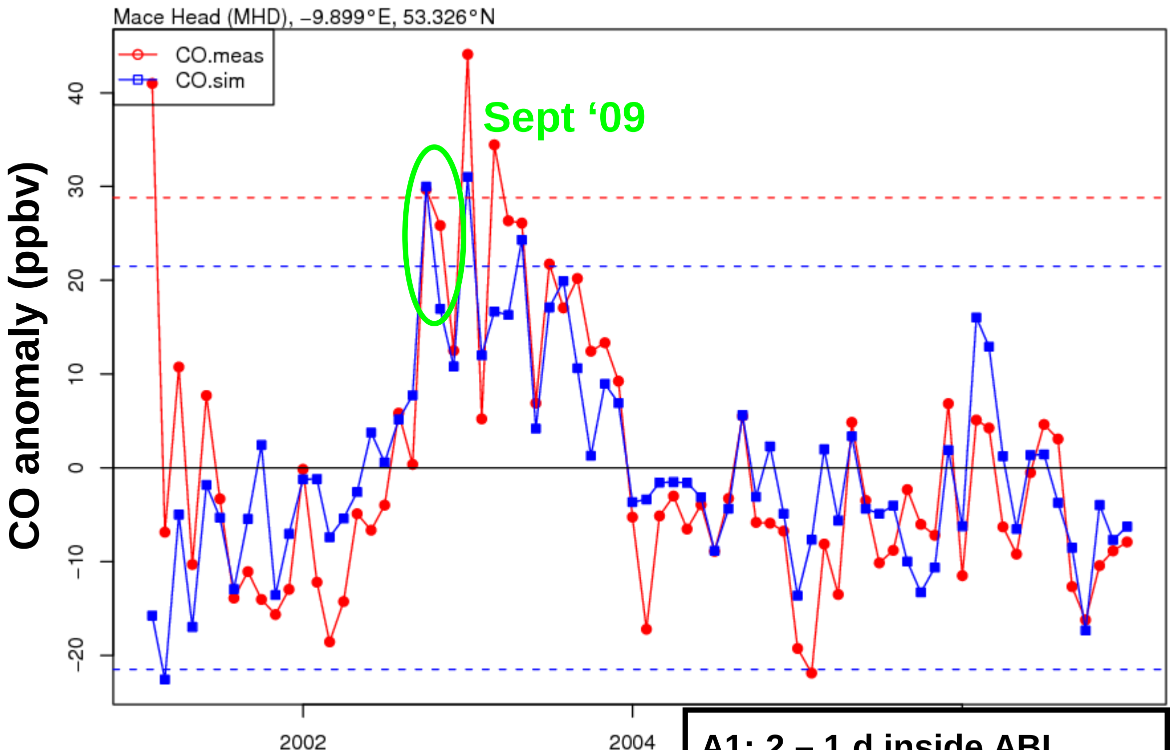
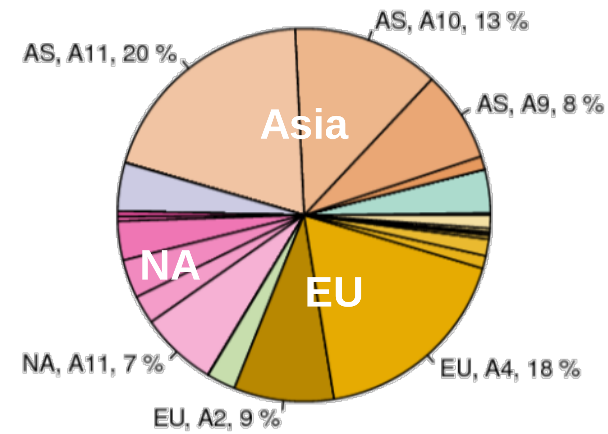
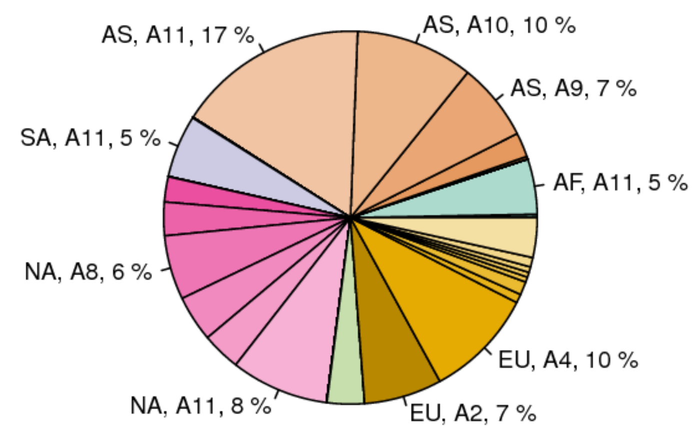


A1: 2 – 1 d inside ABL
A2: 1 – 0 d inside ABL
A4: 0 – 1 d outside ABL
A5: 1 – 2 d outside ABL
A6: 2 – 4 d outside ABL
A7: 4 – 7 d outside ABL
A8: 7 – 15 d outside ABL
A9: 15 – 30 d outside ABL
A10: 30 – 60 d outside ABL
A11: >60 d outside ABL



September 2002



Average September

Monthly CO Anomaly: 2002-07

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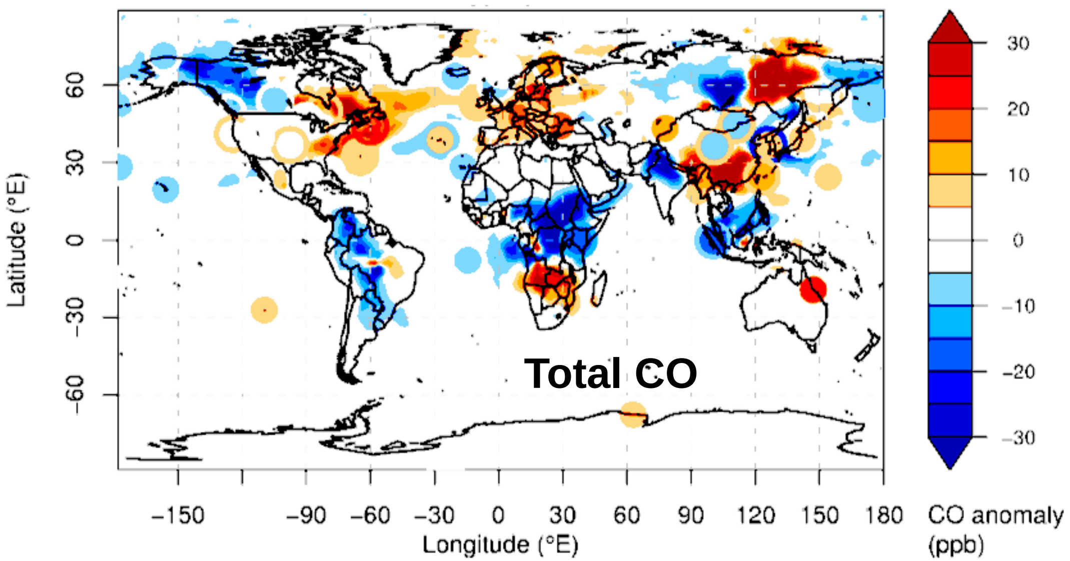
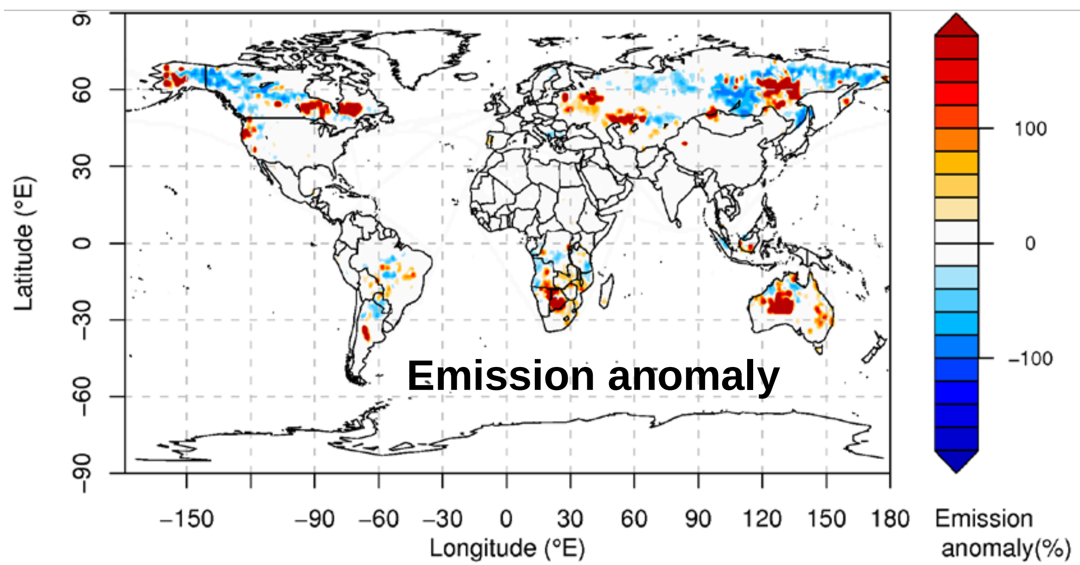
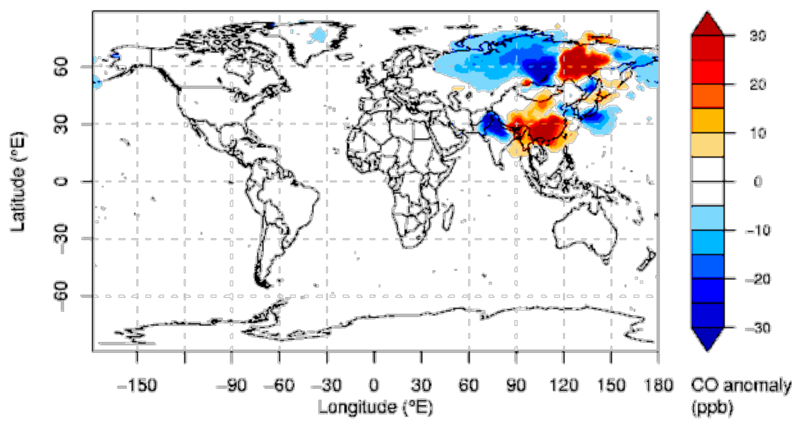


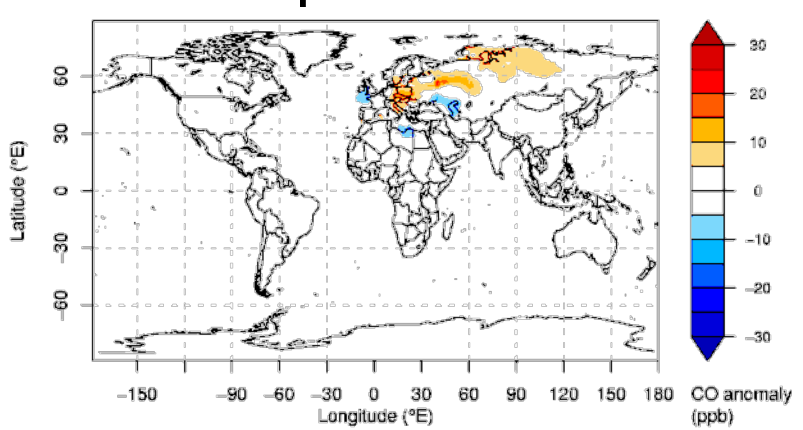


Anomaly by source

Asian CO



European CO



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Monthly CO Anomaly: 2002-08

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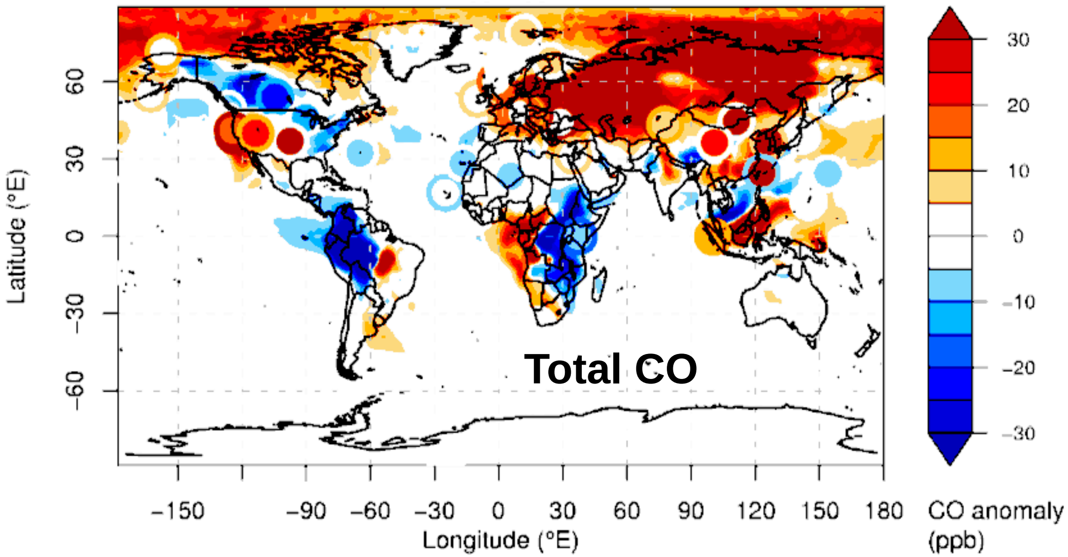
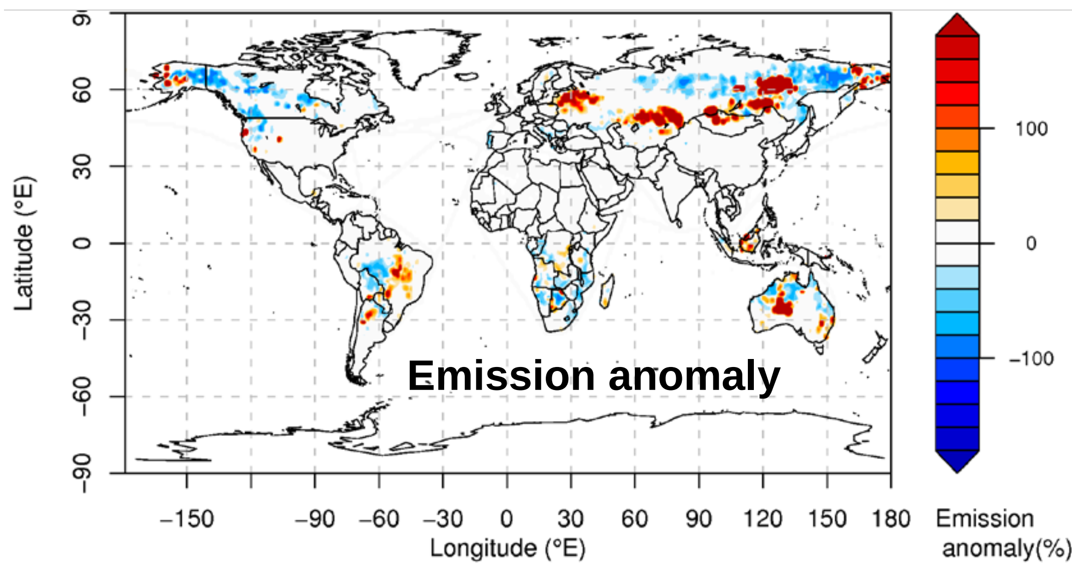
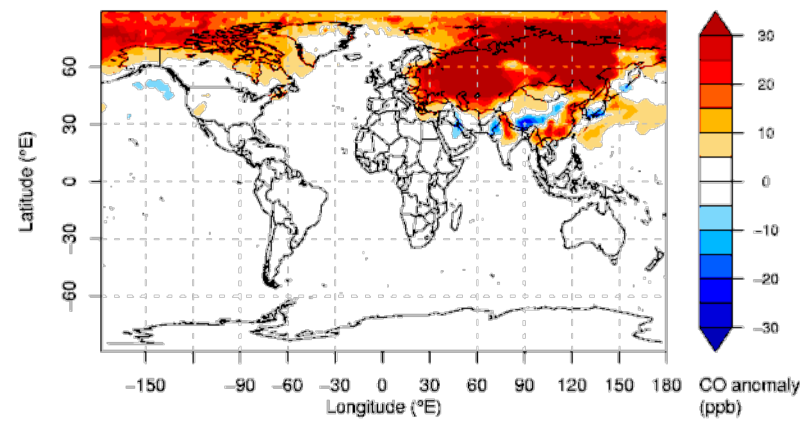


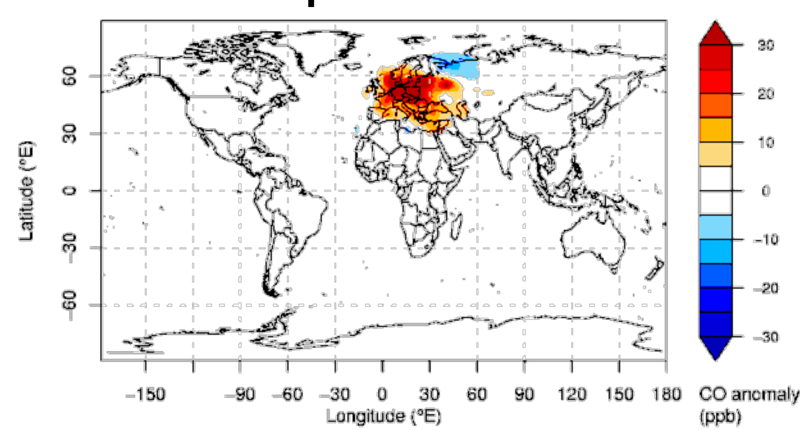


Anomaly by source

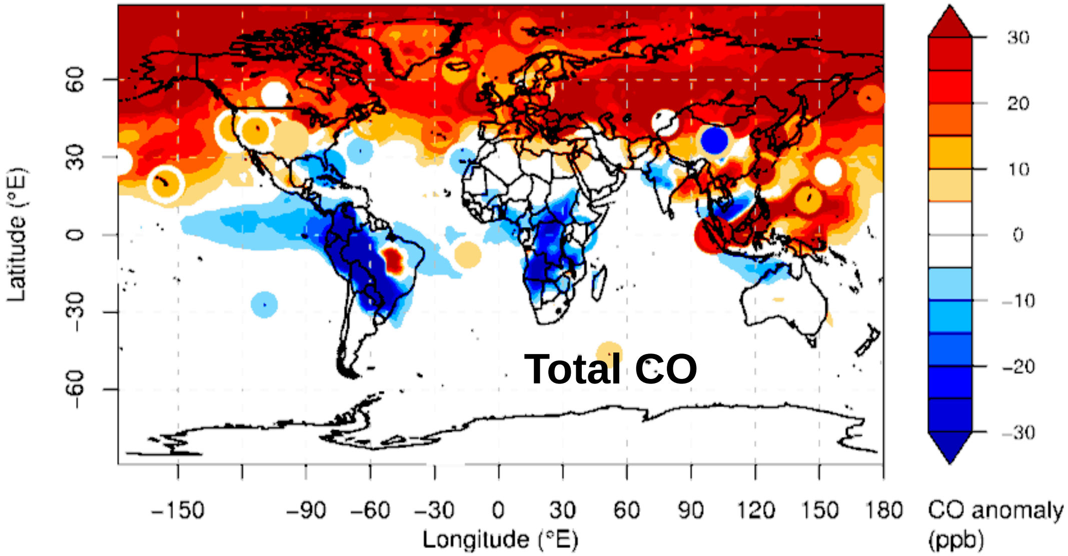
Asian CO

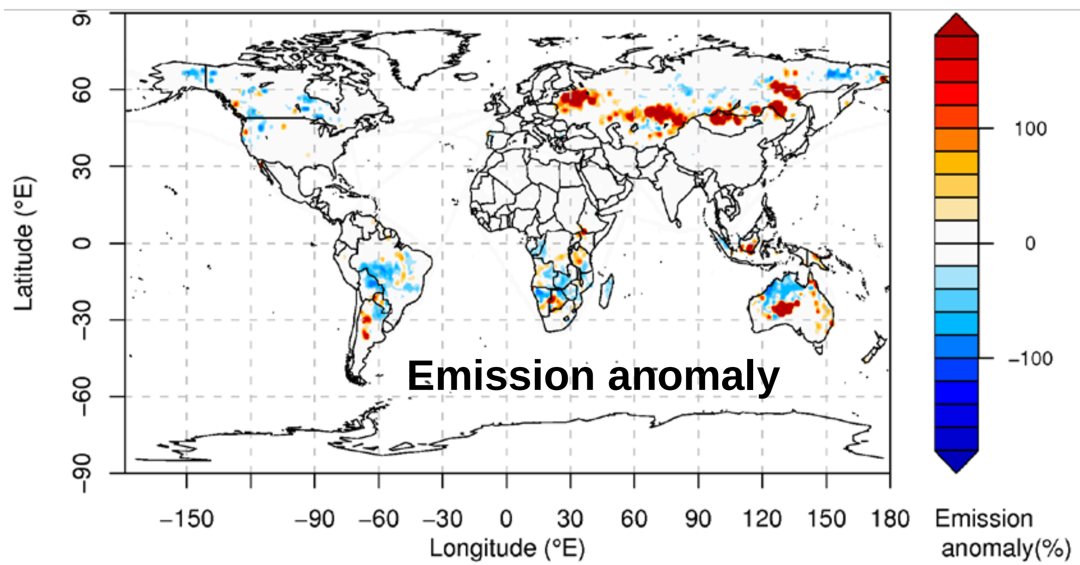


European CO



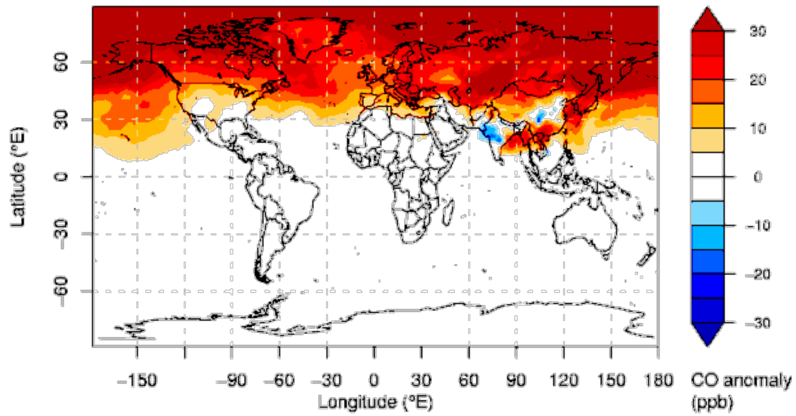
Monthly CO Anomaly: 2002-09



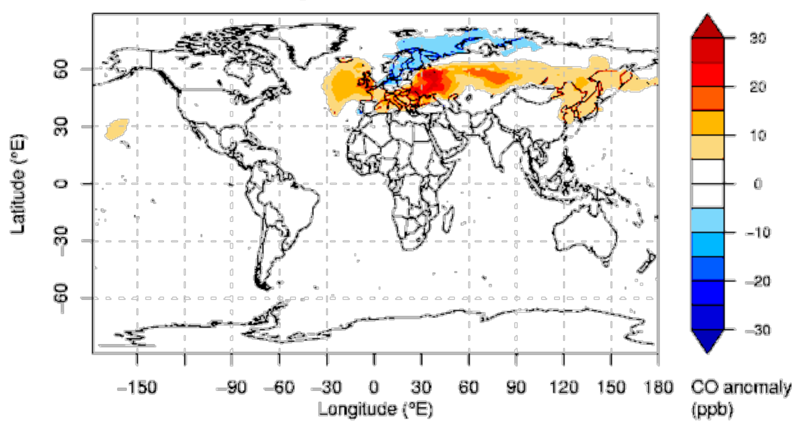


Anomaly by source

Asian CO



European CO



Monthly CO Anomaly: 2002-10

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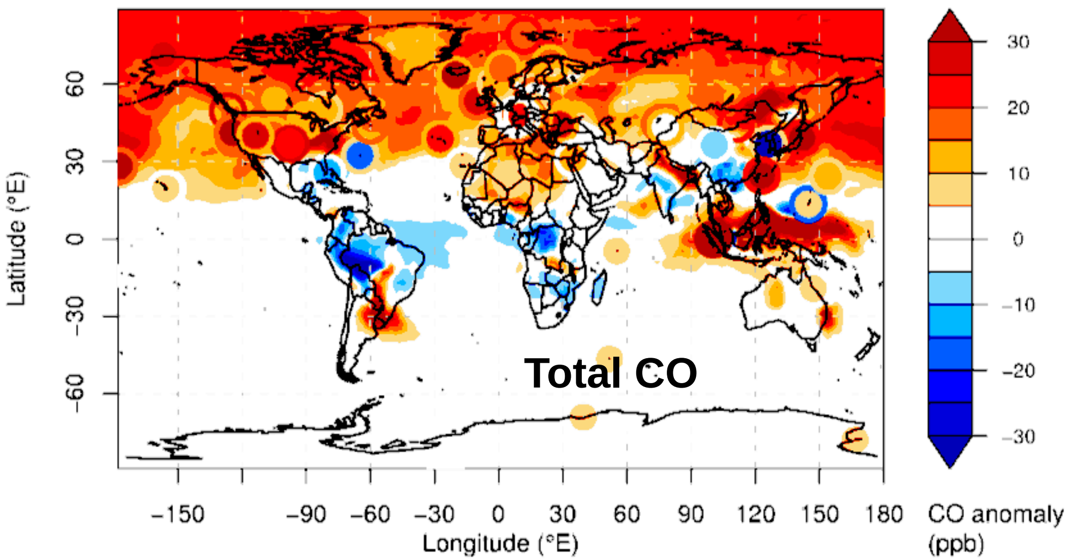
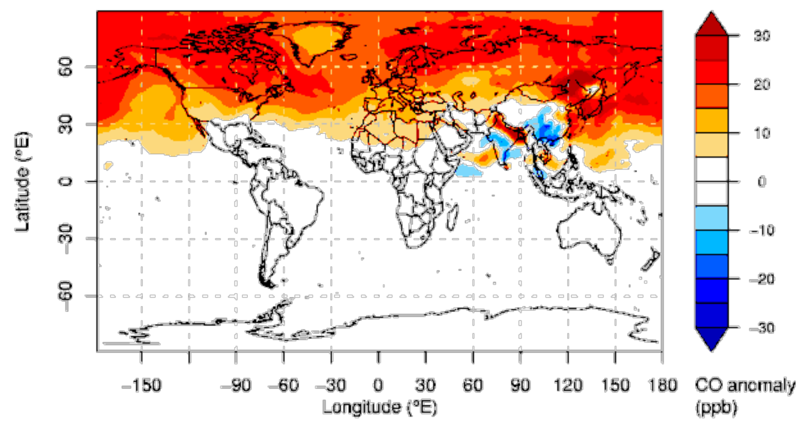
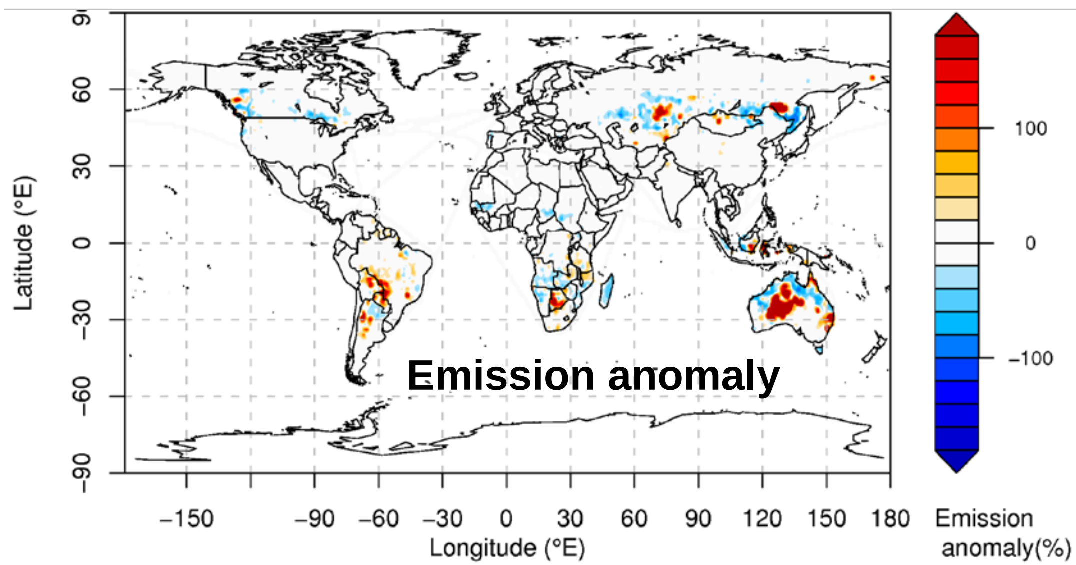


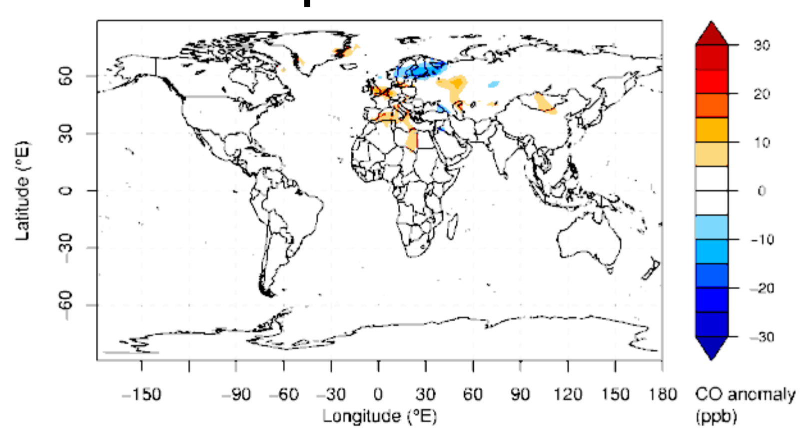
Anomaly by source

Asian CO





European CO



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Monthly CO Anomaly: 2002-11

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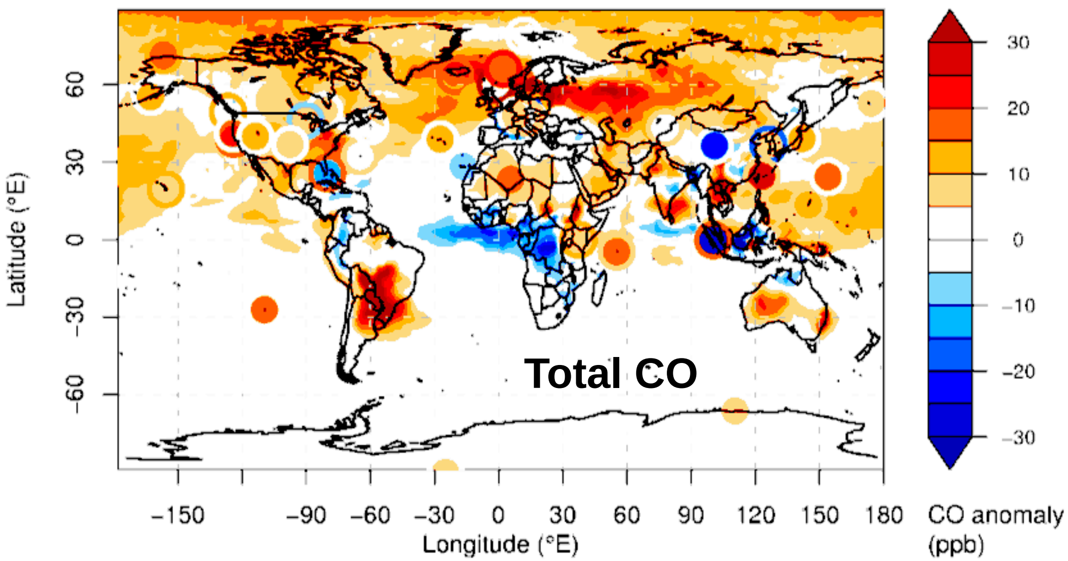
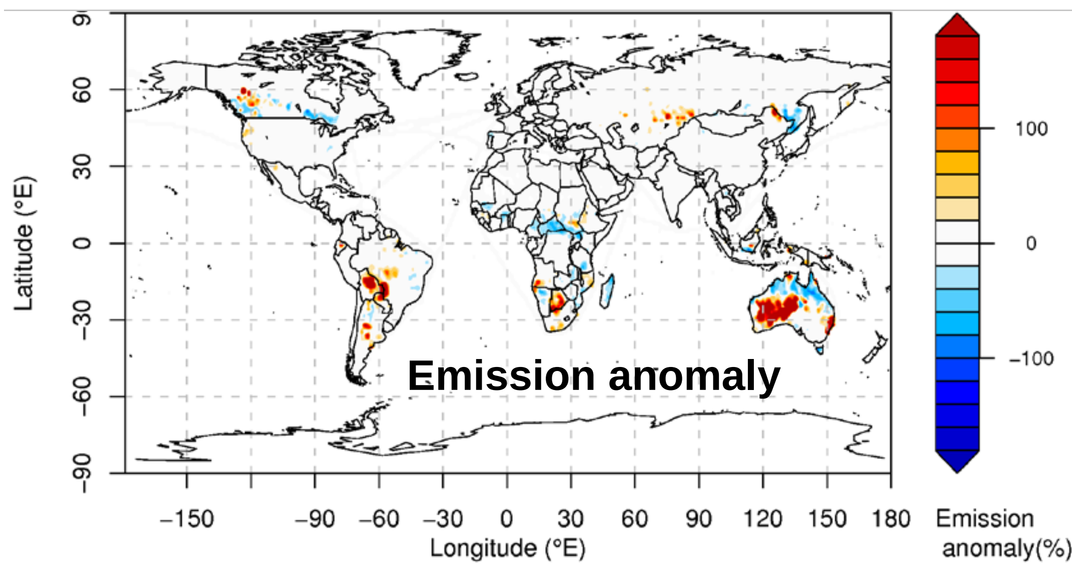
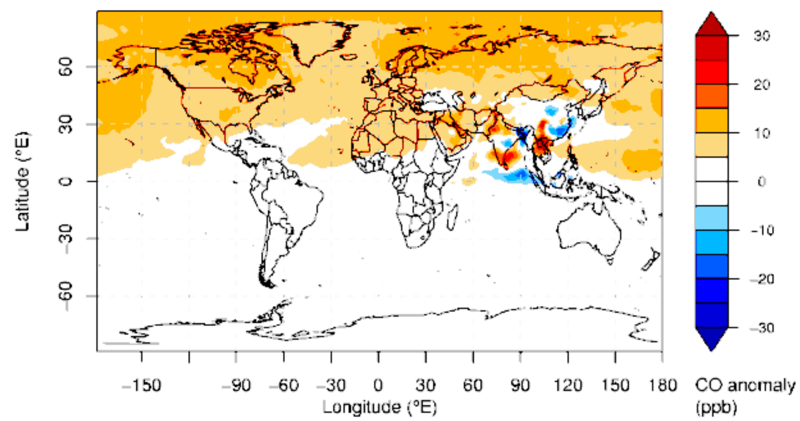


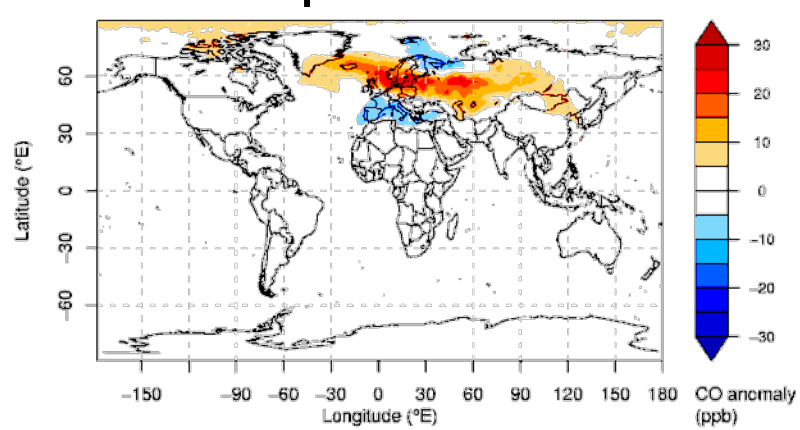


Anomaly by source

Asian CO



European CO



Monthly CO Anomaly: 2002-12

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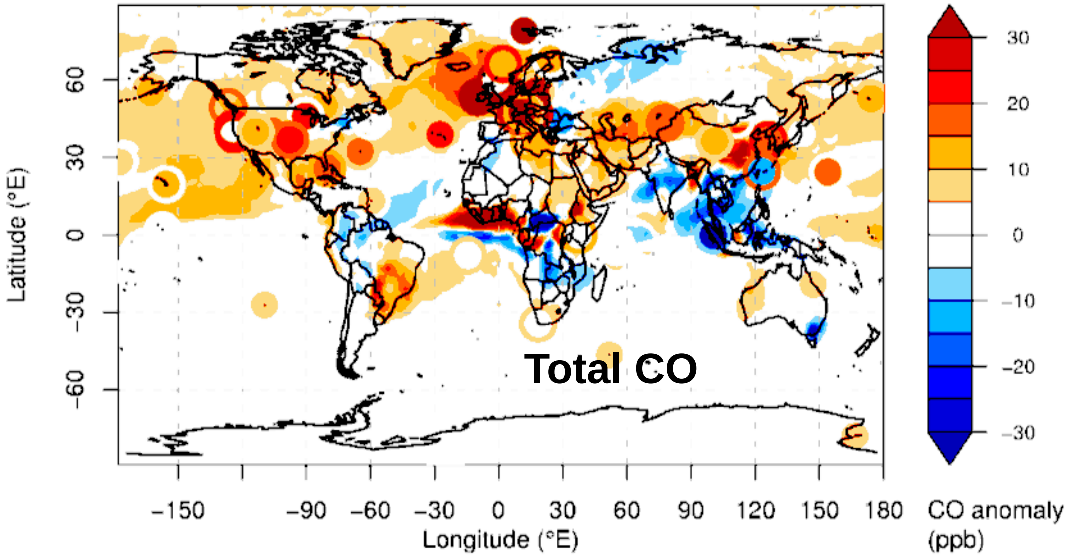
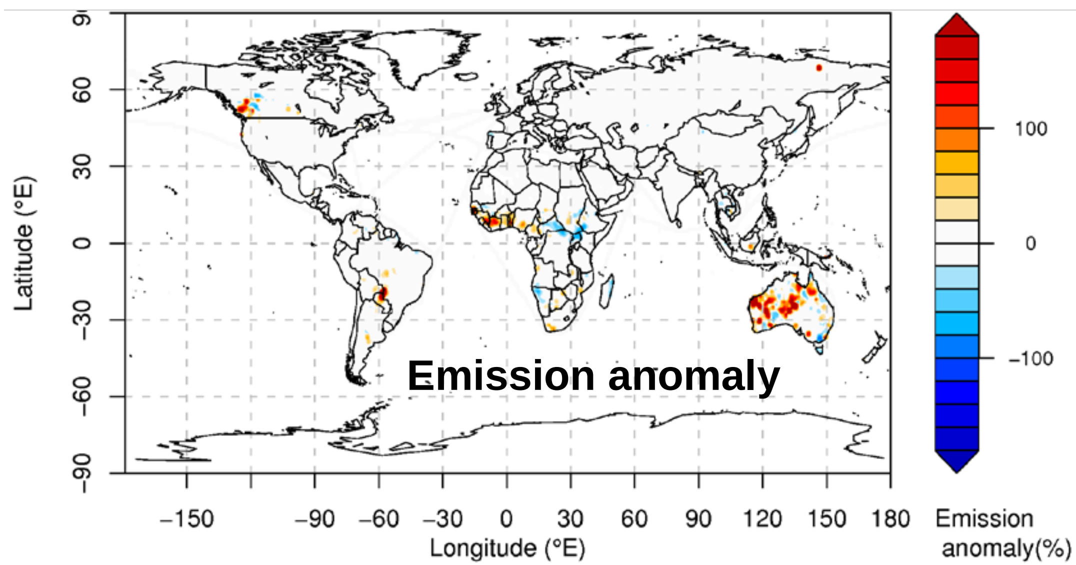
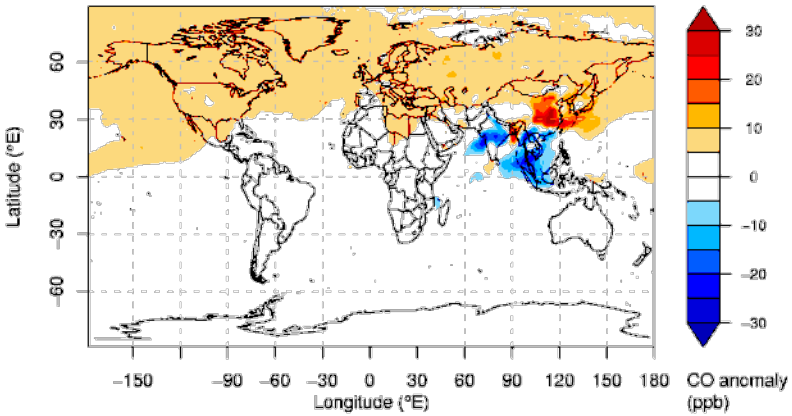


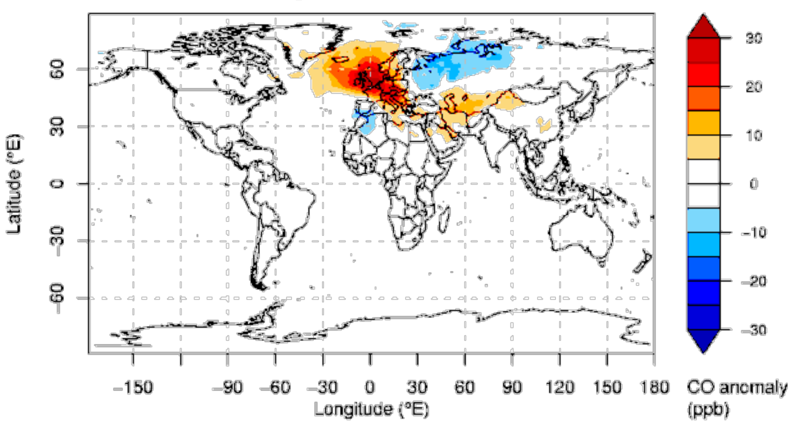


Anomaly by source

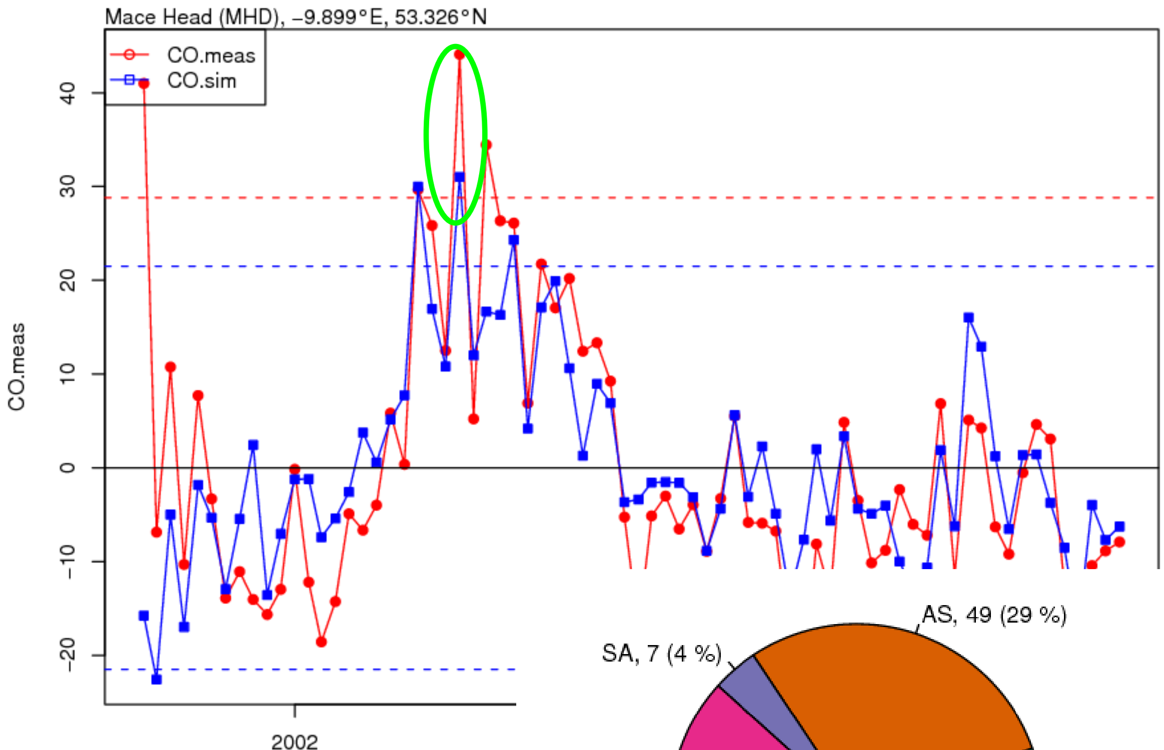
Asian CO

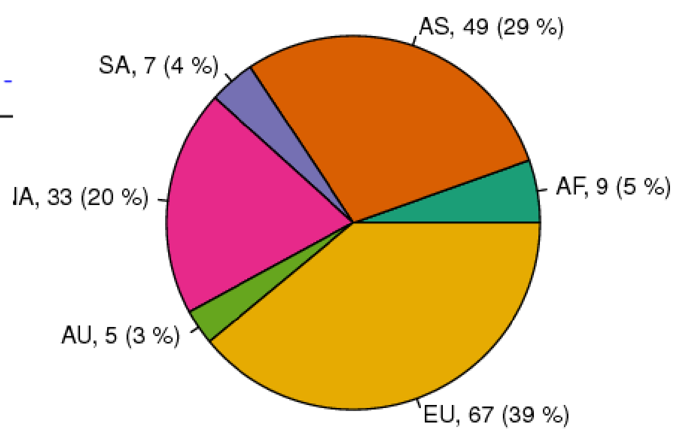


European CO

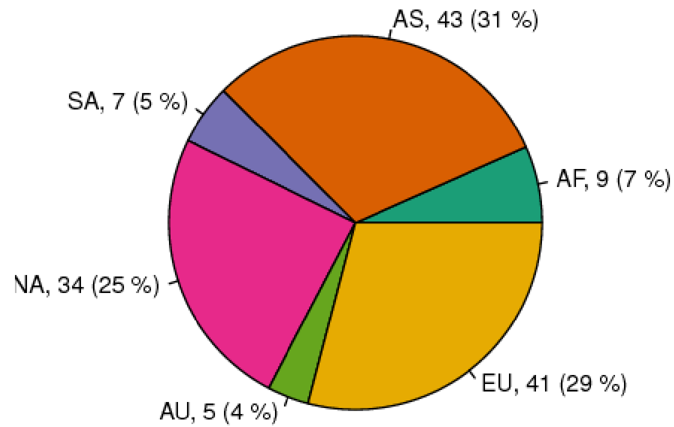


CO Anomaly, Mace Head (IR)





December 2002



Average December

Transport Event: Zugspitze

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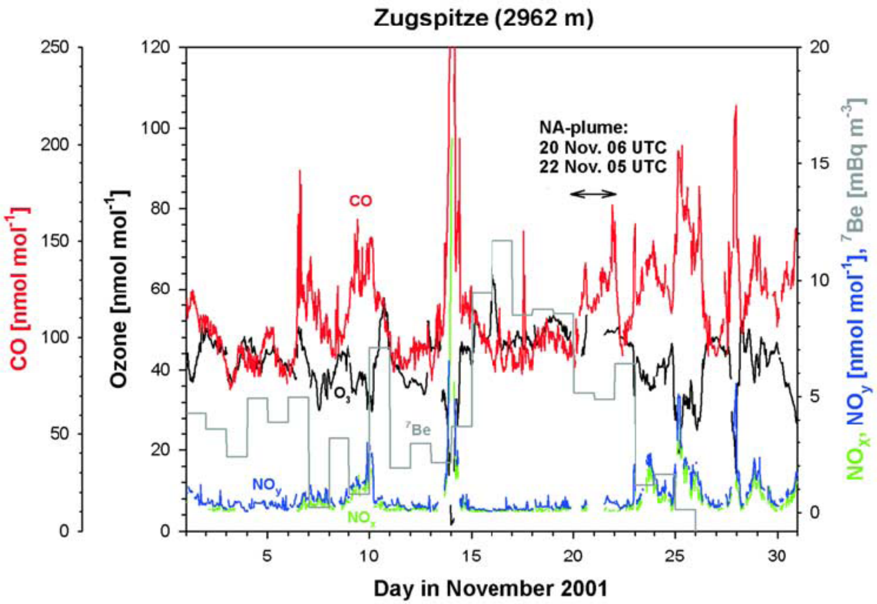
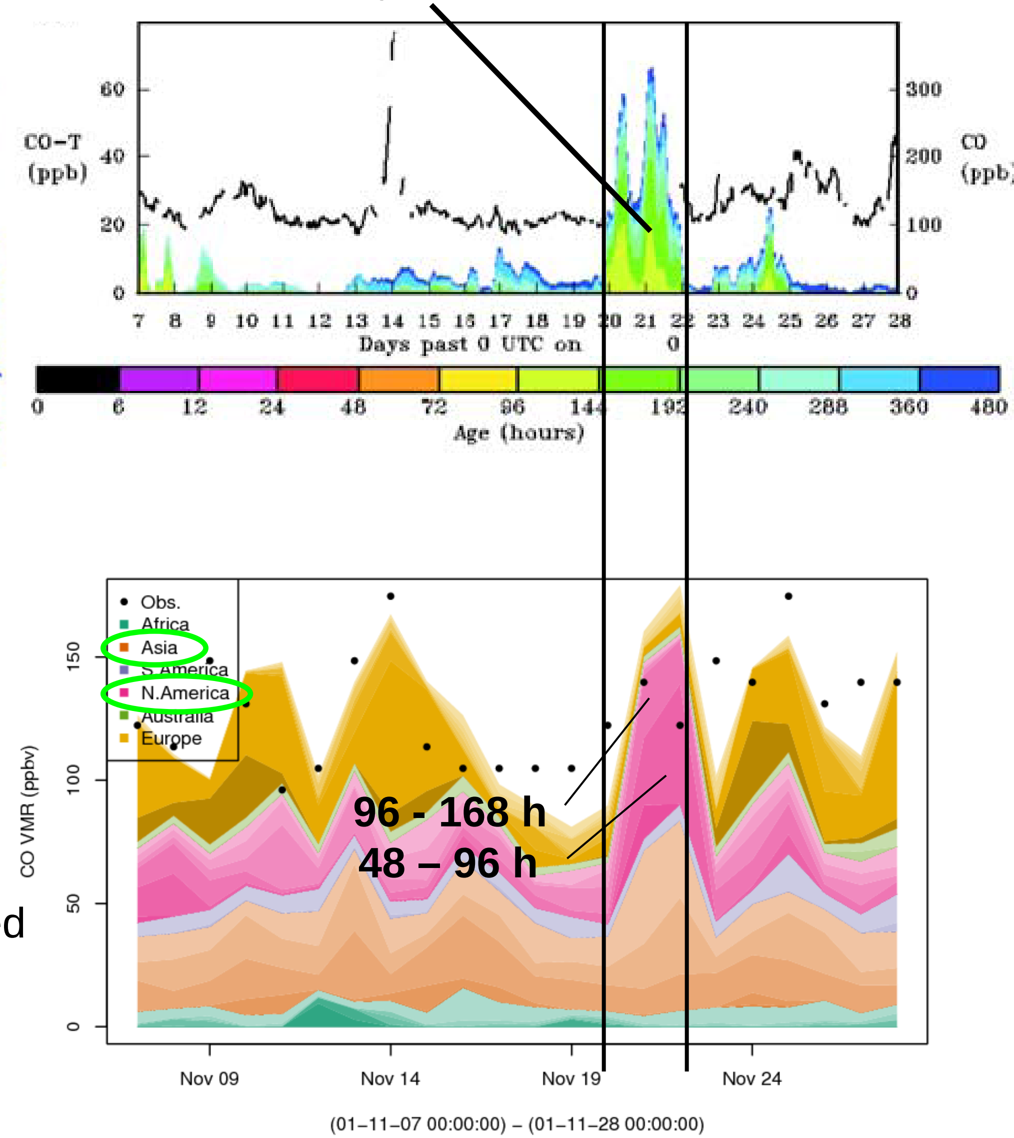


Attributed only to North American CO



- CONTRACE field experiment
- Pollution lifted by WCB over US east cost
- Transport for about 7 days in free troposphere towards Europe
- Influence on CO and O_3 in Alps documented

(Huntrieser, et al., 2005, JGR)

Transport Event: ZUG & JFJ

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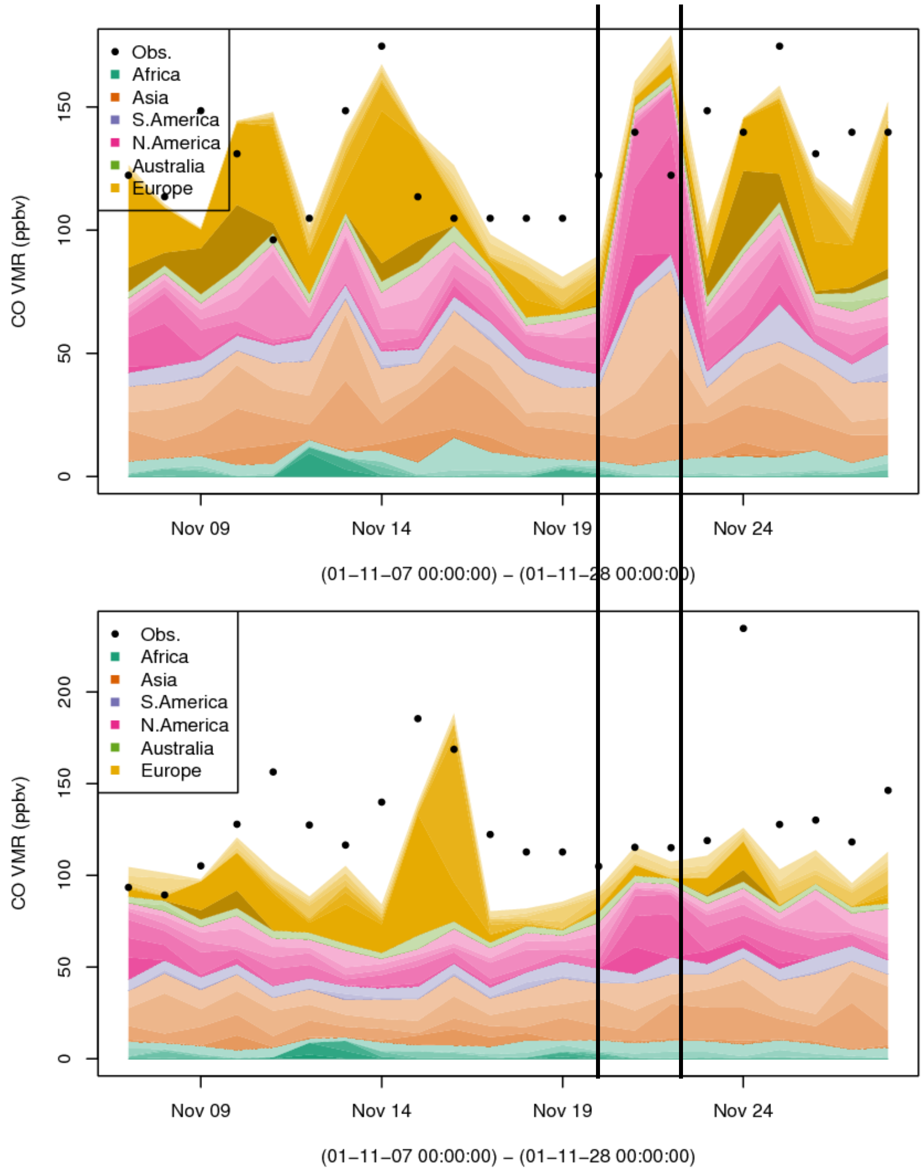
Zugspitze

Jungfraujoch



Horizontal distance ca. 250 km

>> fine-scale features of plume are preserved

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Summary & Conclusions

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- Global domain filling Lagrangian approach for simulation of CO, CH_4
- Very satisfactory results for simulated **daily** CO and CH_4 wrt surface observations
  - Negative CO bias (missing emissions?)
  - Positive CH_4 bias and trend (overestimated emissions?)
- Inter-annual variability well simulated
  - Allows interpretation of variability in terms of emission vs. transport anomalies
- Inter-continental transport events traceable

Simulated monthly mean surface concentrations

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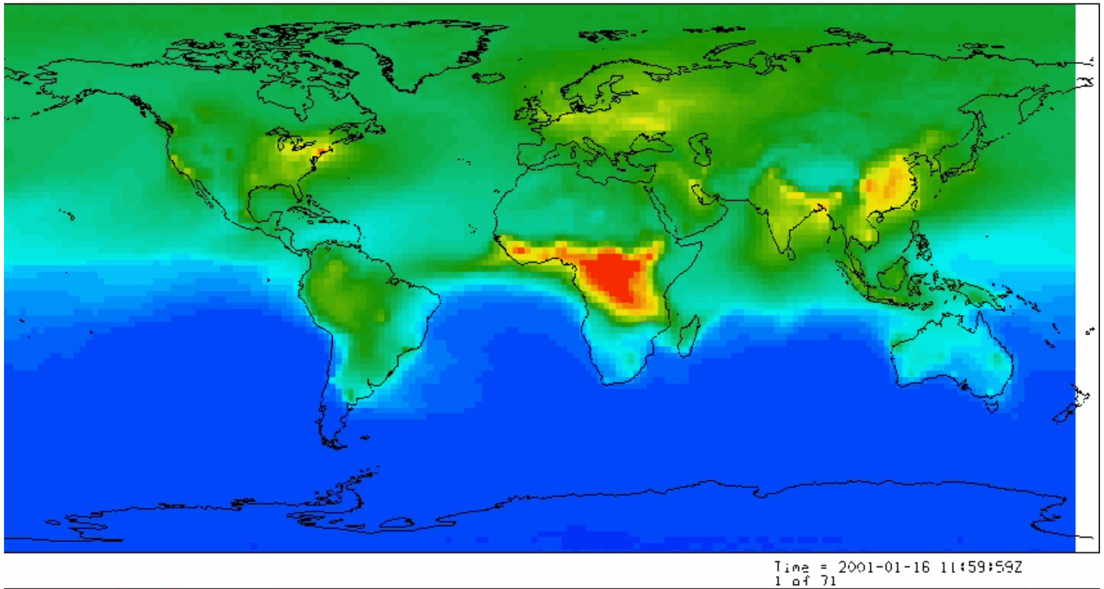
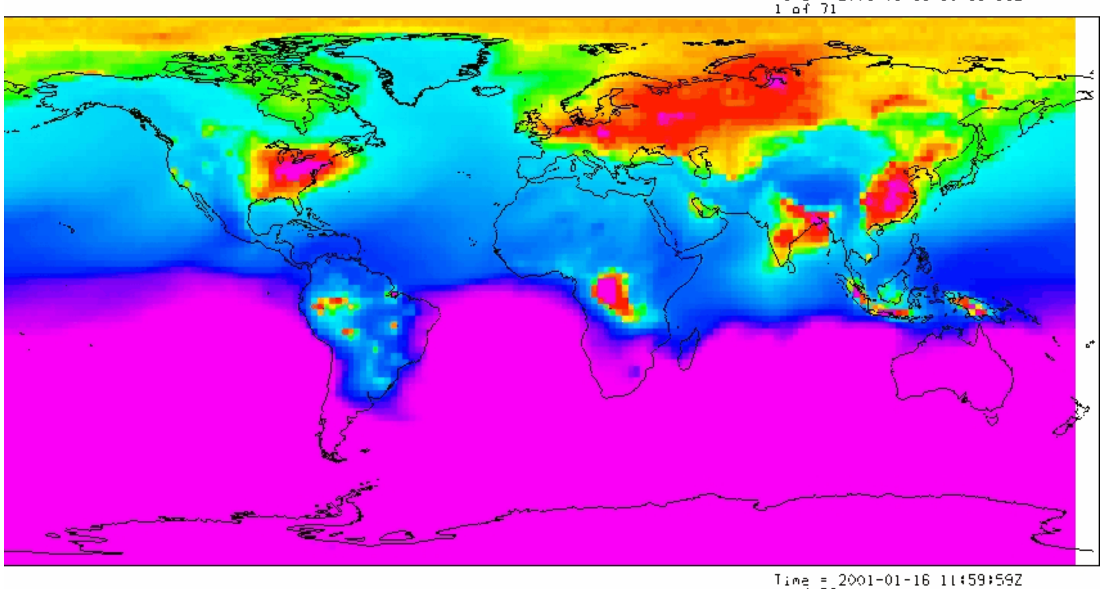
CO



2001
thru
2006

CH_4



Acknowledment:
Funding from MeteoSwiss

Thank you for your attention!

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