Urban Green House Gas emissions monitoring in Davos, Switzerland

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Facts about the World Economic Forum and Davos

World Economic Forum Annual meeting in Davos:

- Over 2,600 participants
- Even more security forces
- Traffic: helicopters, cars

Davos, Switzerland:

- Population: 12,000 permanent residents
- Area: 300km^2 with 6km^2 urban
- Topography: Steep valley, 3km wide, 1km elevation difference

Carbon budget of Davos: 2005 inventory

- Total direct emissions: 85 ktC/year

- Main contributors:

Heating (fossil fuels): 75% of total emissions

Traffic: 17% of total emissions

Machines, Waste, ...: about 8%

- Emissions per capita: 8 tC/ year/ person (25% above national average)

From Walz et al., 2008, in Energy Policy

Demonstration experiment: Emission nowcasting

- Instrumentation:

Two 4 species CRDS analyzers from Picarro (CO_2/CH_4/CO/H_2O)

One flux analyzer (stability conditions)

One Lidar (Aerosols) from SigmaSpace

- Modeling tools:

Real-time data assimilation system (WRF-FDDA) at 1.3km resolution

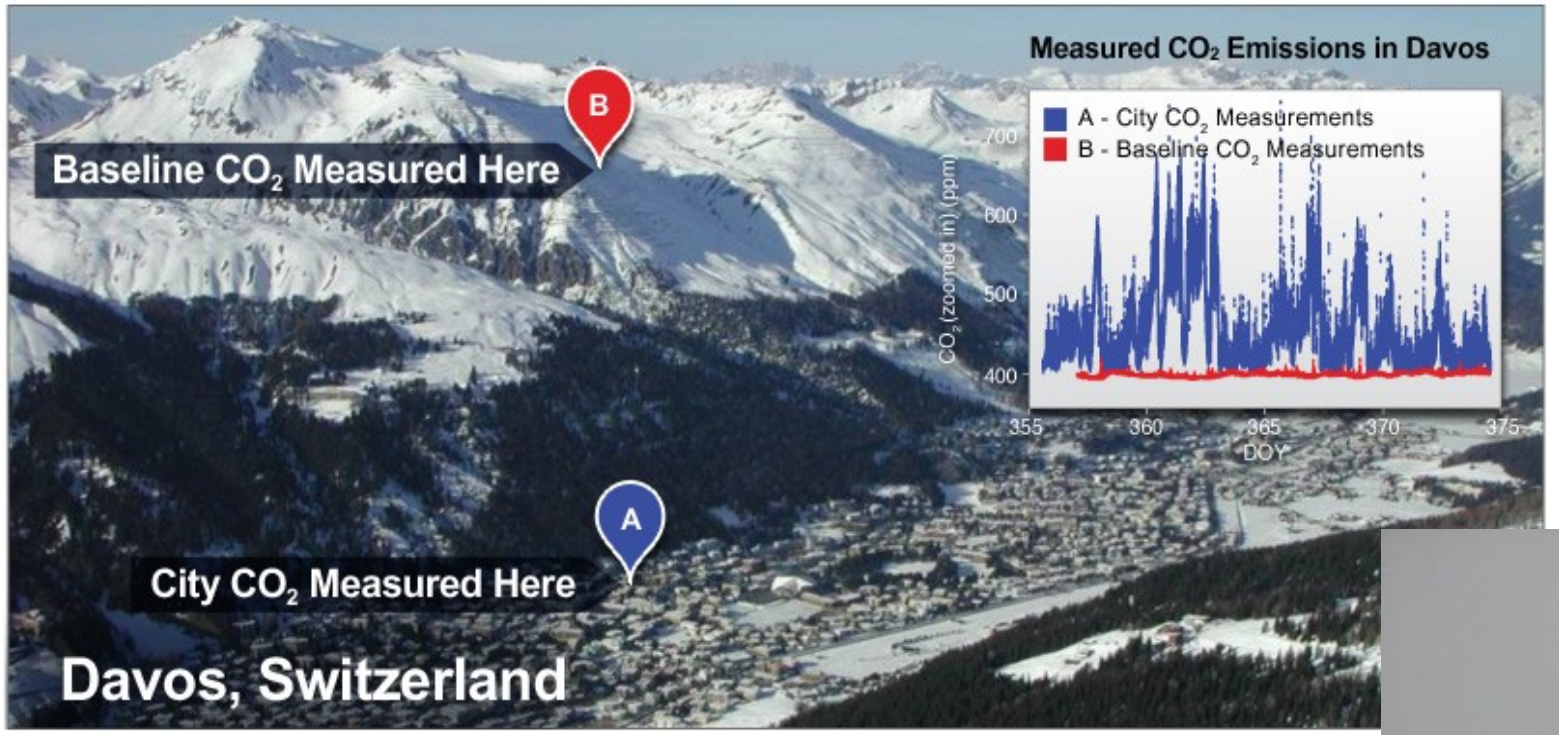
Emission map based on Walz et al. (2008) mapped on urban cover

- Inversion system

Linear interpolation based on direct modeling

- Daily emission updates and 3D model results posted every morning

Instrumentation: GHG sites



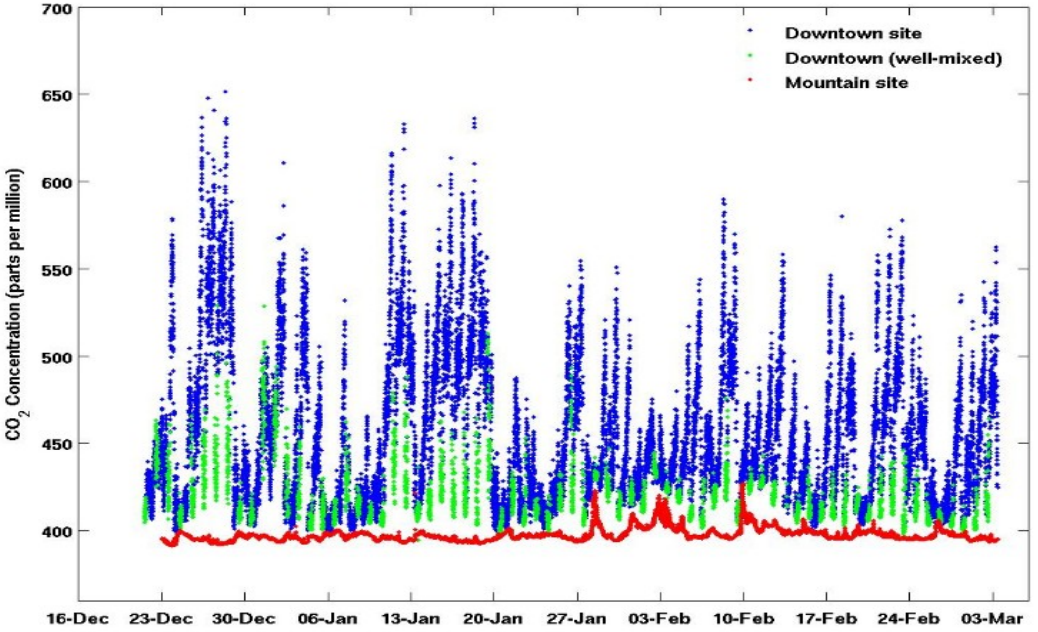
- Concept

Two sites (downtown and background) to measure the city plume
Use of site-to-site differences

Valley circulation in wintertime: emissions trapped in shallow layer
No valley breeze and reduced vertical mixing

Limitations: stable conditions challenging for models
Footprint of the downtown site

Instrumentation: GHG sites



- CO_2 atmospheric mixing ratios

Strong diurnal cycle despite reduced vertical Mixing (up to 650ppm at night)

Constant background (no major sources in the surrounding areas)

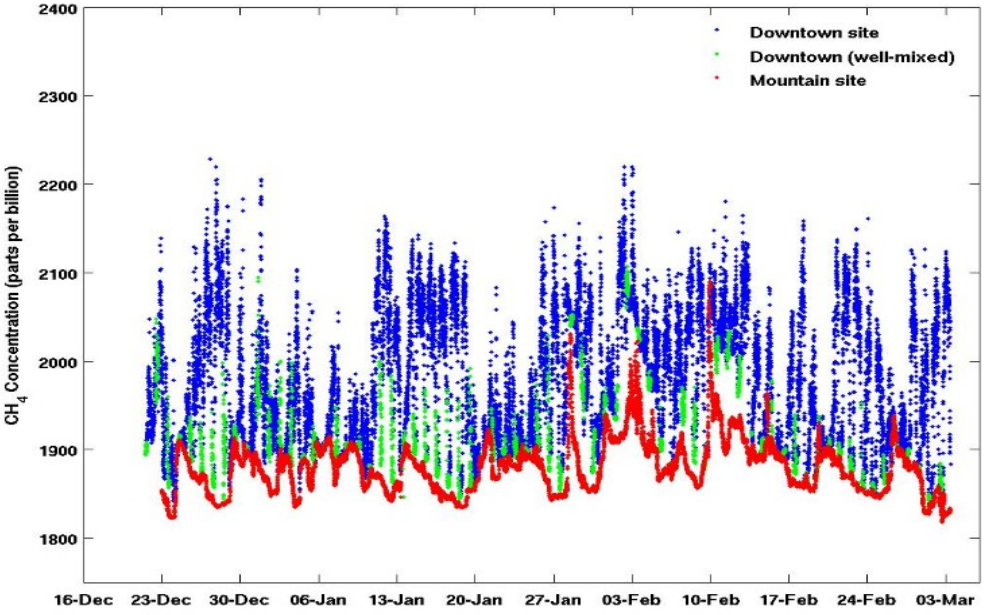
Site-to-site difference: not correlated with temperature or the WEF meeting

- CH_4 atmospheric mixing ratios

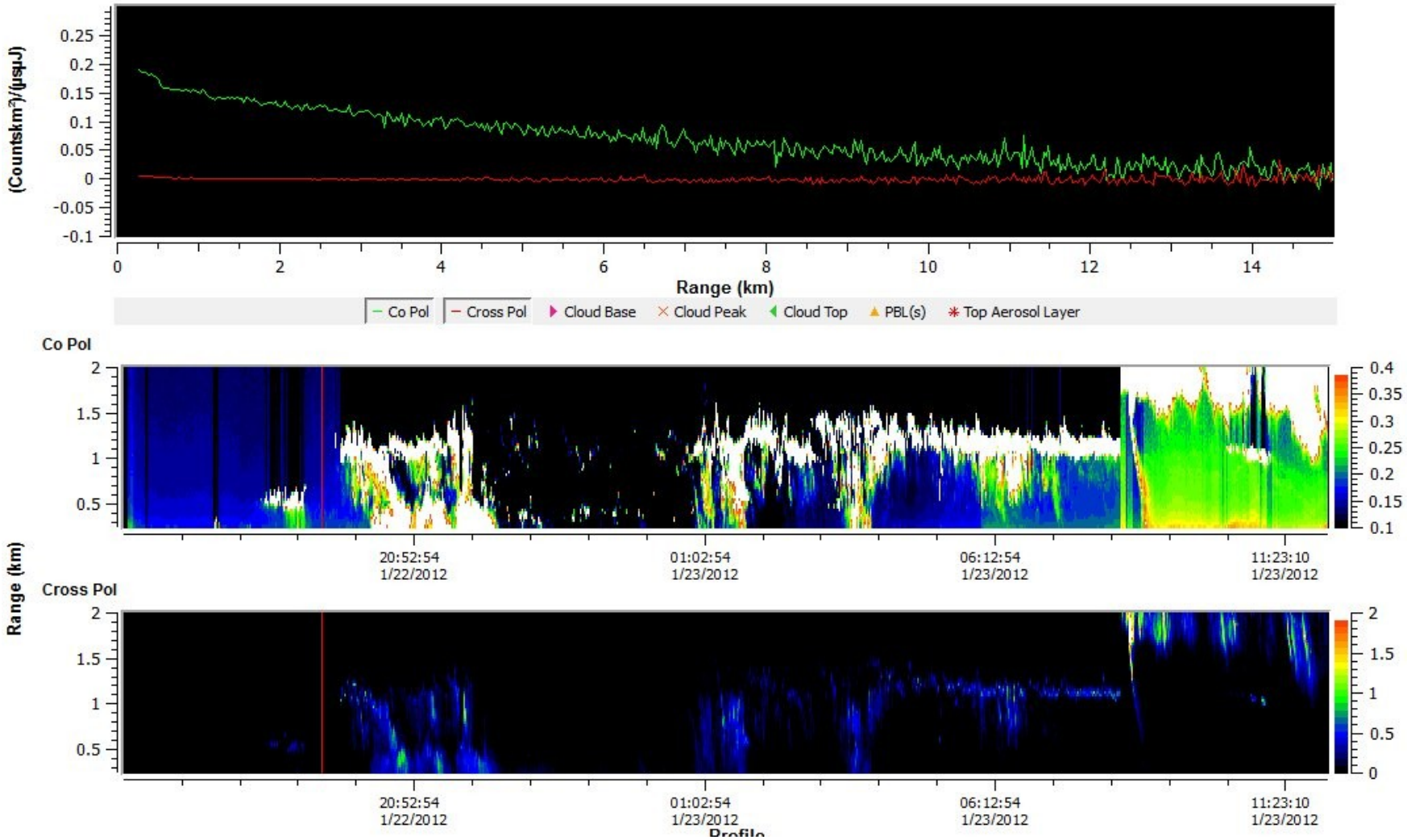
Strong diurnal cycle despite reduced vertical Mixing (up to 2200ppb at night)

Variable background (sources in the surrounding areas): farming?

Site-to-site difference: farming activity in Davos



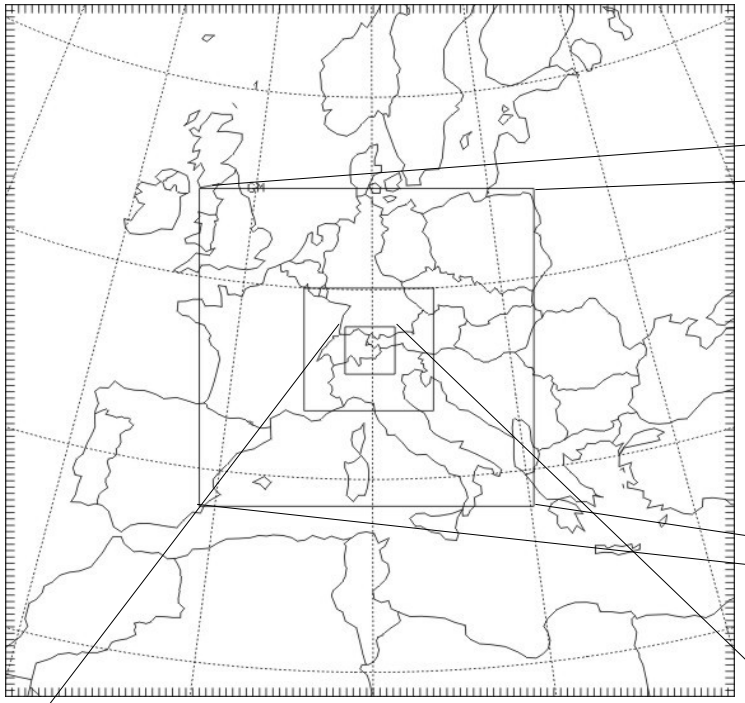
Instrumentation: Lidar

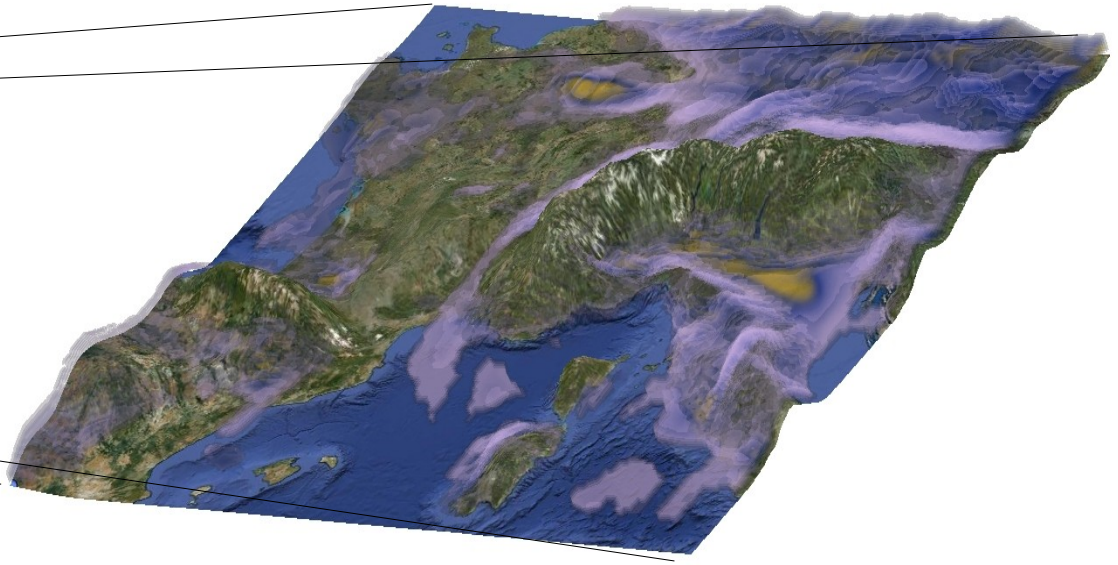


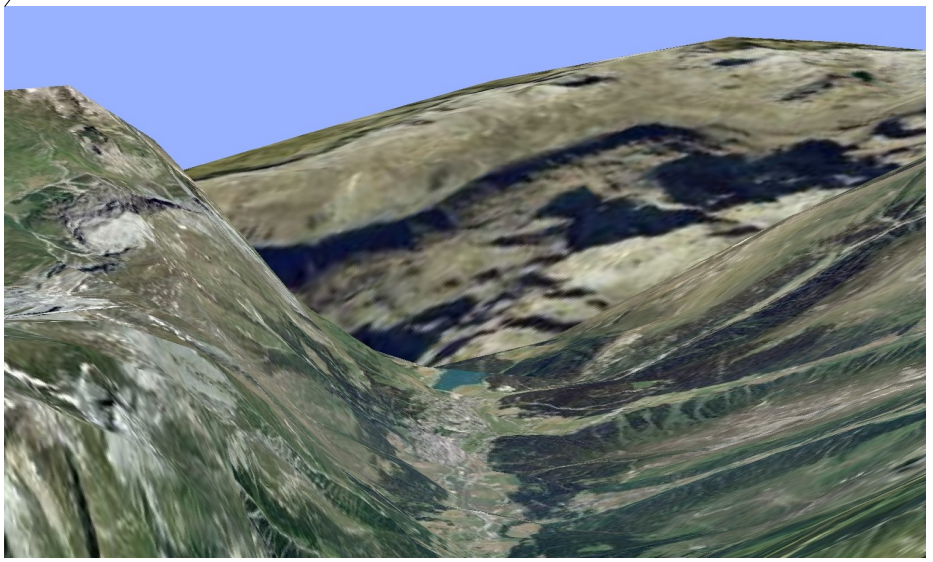
- PBL depth evaluation in “unstable” conditions (limited in stable conditions)

- Two PBL schemes used over 2 weeks: Quasi-Normal Scale Elimination (for stable conditions)
MYJ scheme

Modeling tools







WRF-FDDA modeling system

- 4 grids: 36km/12km/4km/1.33km

- run twice a day (12 hour intervals)

- nudged to WMO database

- Using FFDAS emissions for Europe and interpolated inventory for Davos (based on Walz et al., 2008)

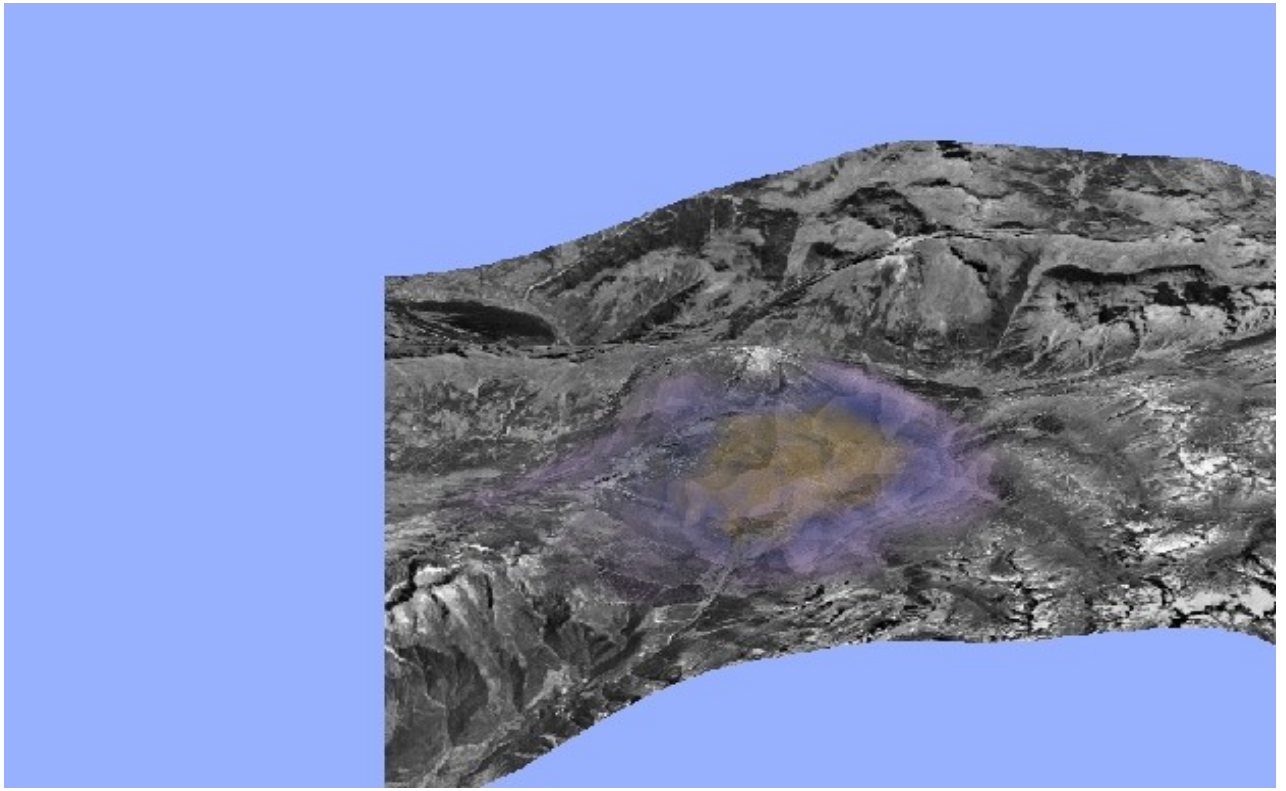
Modeling tools

WRF-FDDA modeling system

- Daily update of model-data residuals to estimate the emissions

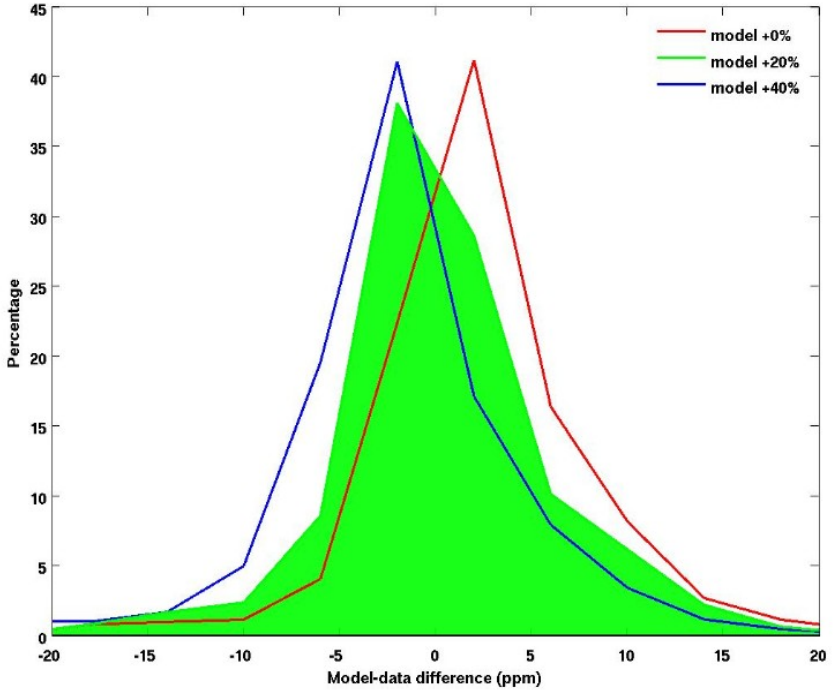
- 24-hour simulations (each 12 hours) in historical mode

- Daily 3D plume videos for visualization of the valley circulation and the CO2 plume



Domain of simulation and CO2 plume dynamics over 12 hours

Inversion technique: direct interpolation



- Adjoint-free inversion

Model-data mismatch from WRF-FDDA

First guess from the projected inventory

Linearity of the source-receptor function

Emissions trapped in the valley

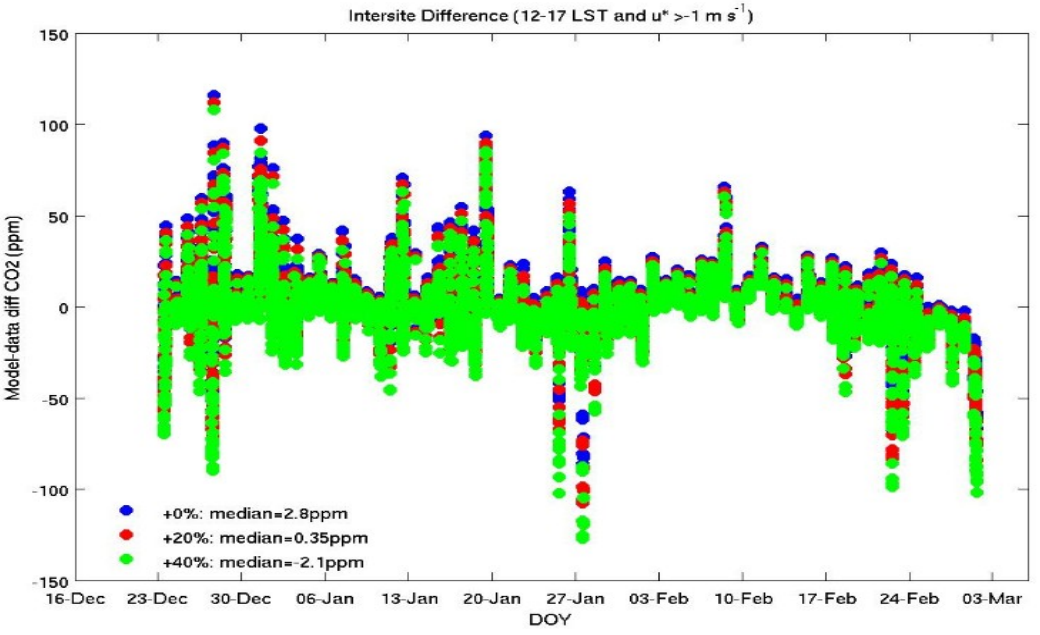
=> direct interpolation of the source term

- CO2 residuals: daily estimates

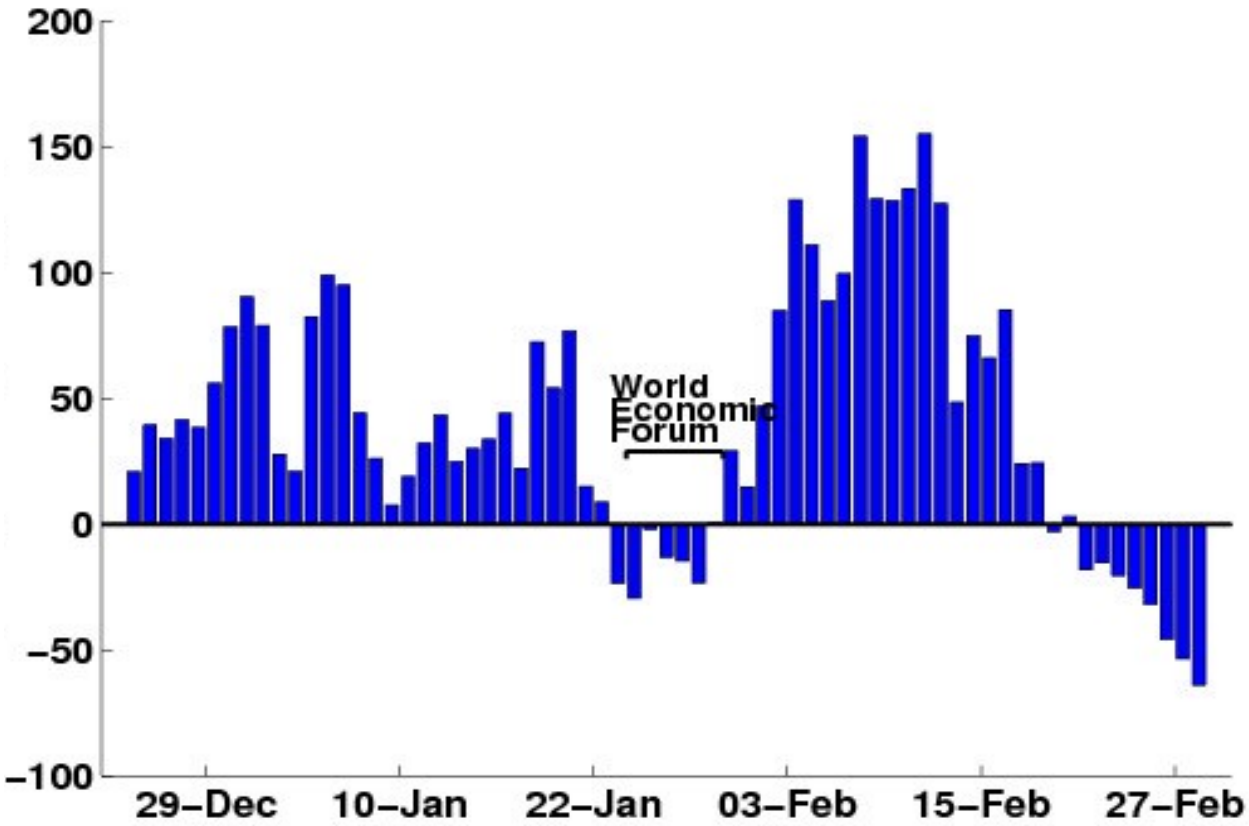
Use site-to-site differences: no boundary conditions

Filtering based on wind variance (eddy-flux Site): threshold on u*

=> daily corrections of prior fluxes



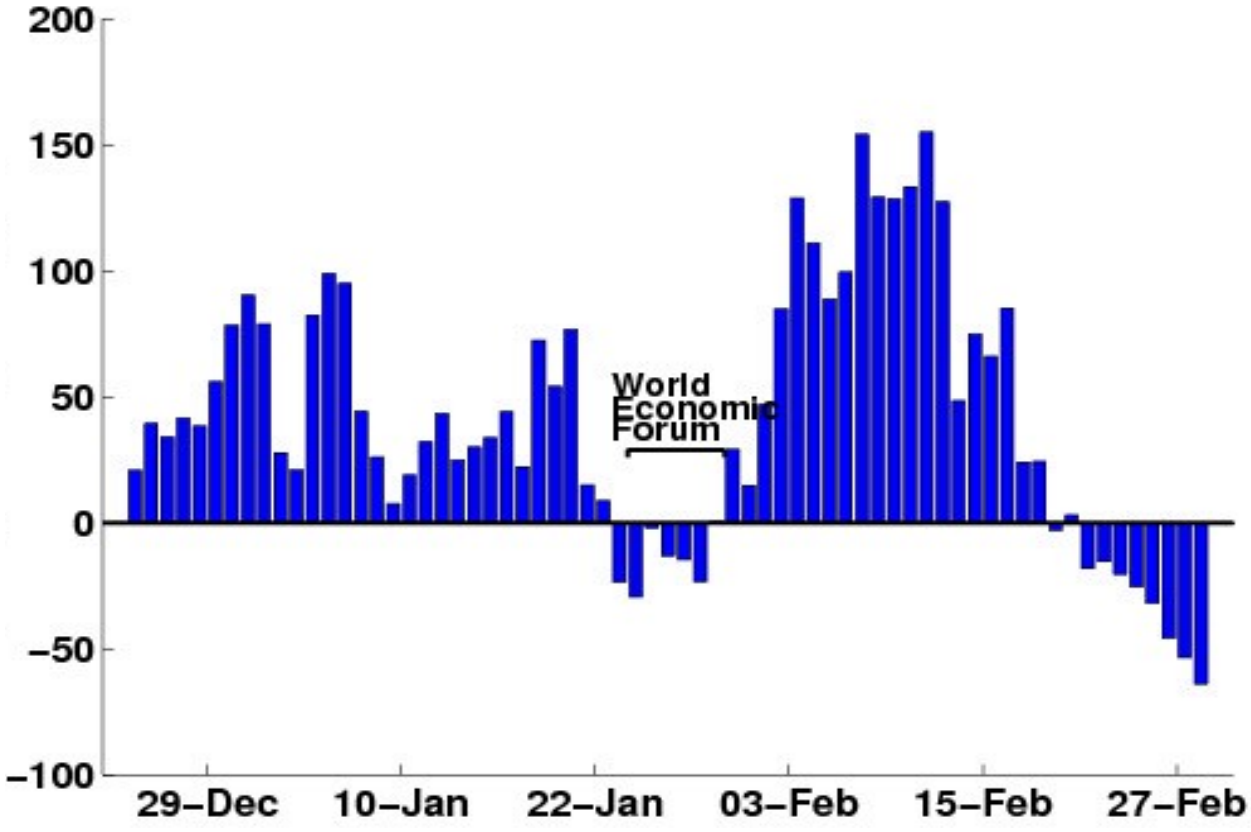
Inverse fluxes: results (no filtering)

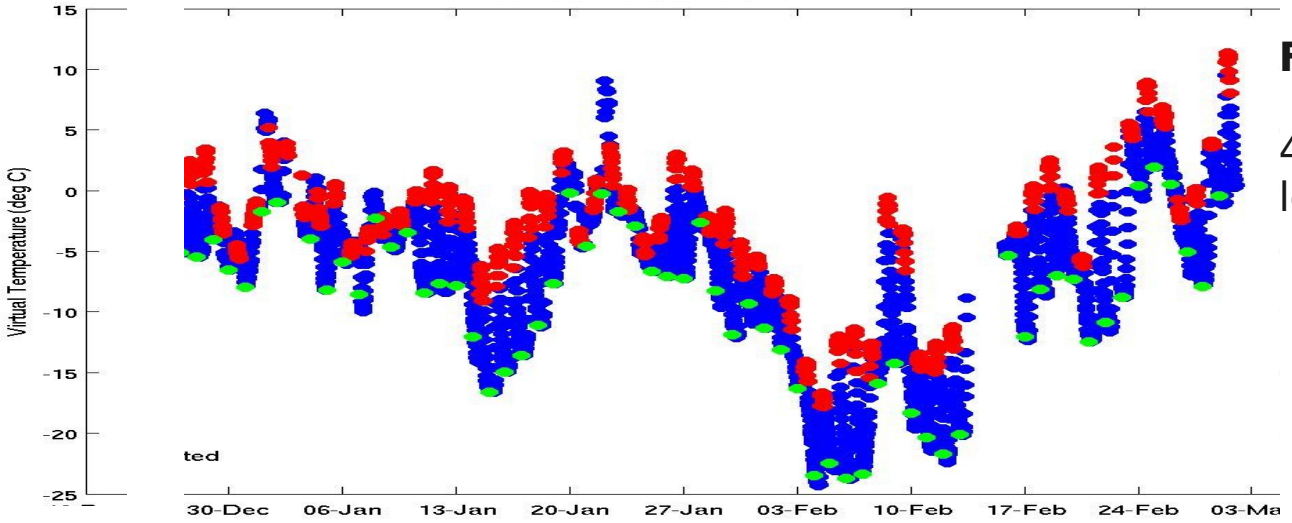


CO2 emissions in % between December 27th 2011 and March 1st

The baseline corresponds to the direct emissions from (Walz et al., 2008)

Inverse fluxes: results (no filtering)





Correlation between CO_2 emissions and temperature (DD or min)

Inversion: **0.57**

Consistent with Walz et al., 2008

Prior to WEF:

35% *above* inventory

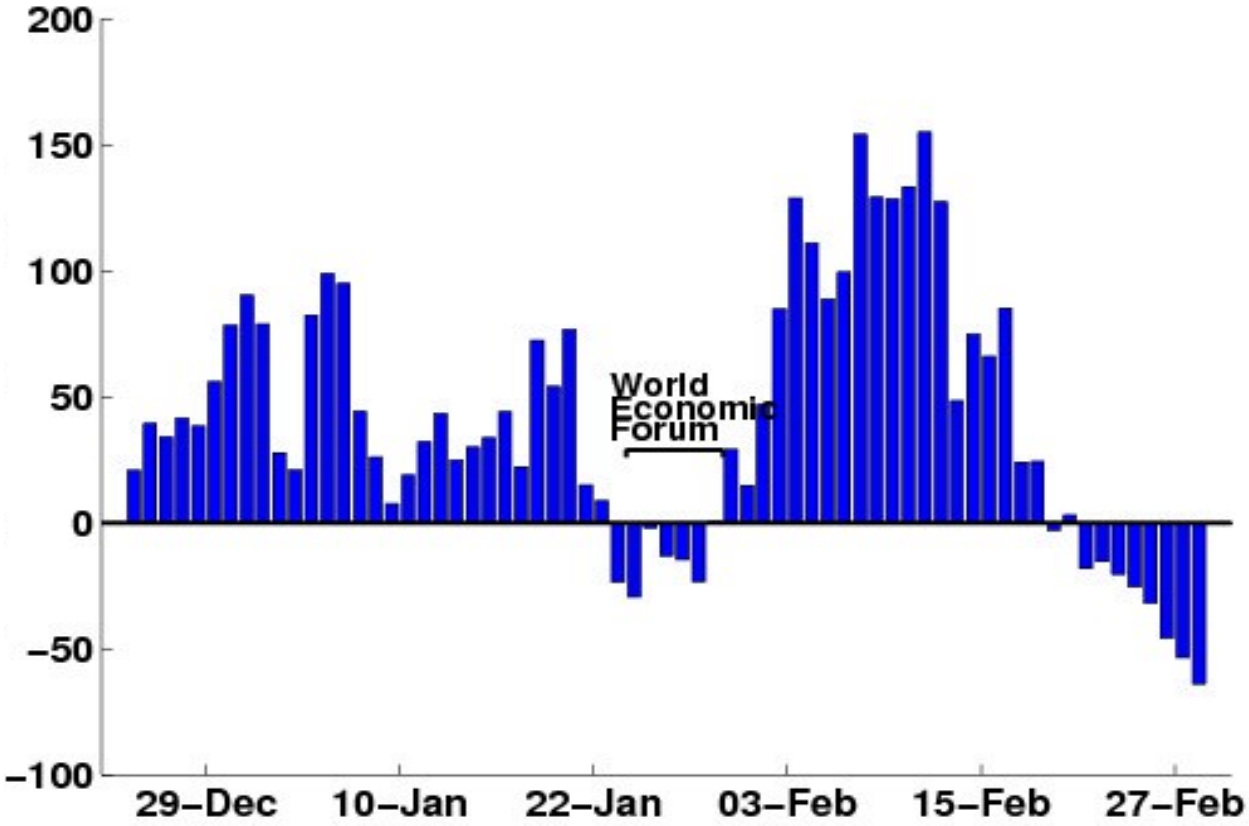
During WEF:

dropped by 40% *below* pre-WEF levels.

Following WEF:

40% *above* pre-WEF
levels (during an extremely cold period)

Decrease during the WEF: Signal or artifact?



Decrease during the WEF :

Least intuitive response to an increase of 25% of population (using helicopters and limousines)

No temperature change compared to January

Potential causes:

Site location or small tower footprint due to low vertical mixing

Transport model error: why during the WEF?

Conclusions

- First real-time monitoring system for urban emissions

- Promising tool applied to the least model-friendly region on Earth

- ... in winter

- Consistent temperature dependence with PBL depth evaluation ongoing

- Discussions with local scientists (SLF) to maintain GHG measurement sites