Observation of CO from IASI and MOPITT over megacities

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Background and motivation

Urban surface areas continue to grow and they now house more than 50% the world's population. With this, associated air quality issues are also increasing. Human activities emit vast quantities of pollutants with carbon monoxide (CO) a prime example, creating a CO "dome" over megacities.

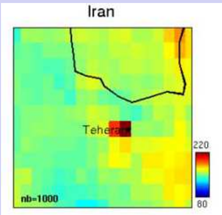
Challenge with satellite measurements

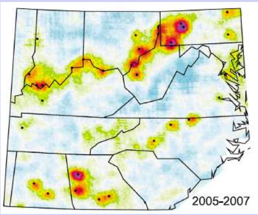
- CO = long lifetime

- Limited sensitivity in the boundary layer with nadir thermal infrared (TIR) measurements

Possible to detect CO enhancement over cities: (Clerbaux et al., 2008)

But : coarse resolution





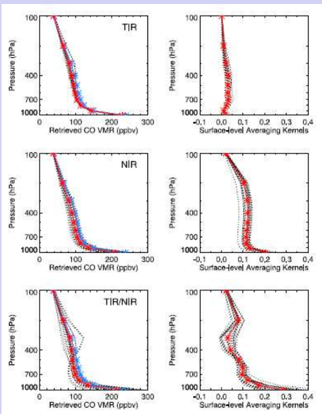
Possible to detect short-lived pollutants such as SO_2 with finer resolution (e.g. over power plants, Fioletov et al. 2011)

Data used

2 data set: IASI & MOPITT

MOPITT

(Deeter et al., 2012)



-MOPITT (Measurements of Pollution in the Troposphere) launched in 1999 on board Terra

- continuous measurements of CO since March 2000

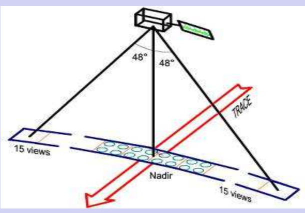
- observing simultaneously in both TIR band near 4.7 µm and near infrared (NIR) band near 2.3 µm

-new retrieval algorithm combining both channels → **better sensitivity close the surface**

Correction added:

longitude+Δlongitude (Δlongitude = 0.33 × cos (latitude))

IASI



MetOp: First European on polar orbit meteorological platform launched by Eumetsat in 2006. IASI built by CNES.

(Clerbaux et al., 2009)

-Spectral coverage = 645-2760 cm^{-1} → Medium spectral resolution

- Spectral resolution = 0.5 cm^{-1} → Medium spectral resolution

- Radiometric noise ~ <0.1-0.2 K → High radiometric performances

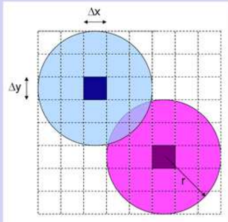
-4 pixels (12 km at nadir))

- 120 spectra along the swath (±48.3° Scan ~2400 km), each 50 km along the trace

Global coverage twice daily (morning and evening orbits) – 14 revolutions/day

Methodology: Pixel averaging technique

Δx= Δy=2 km
r=28 km



- Pixel-averaging method to better resolve features in satellite data: need to use a large amount of data

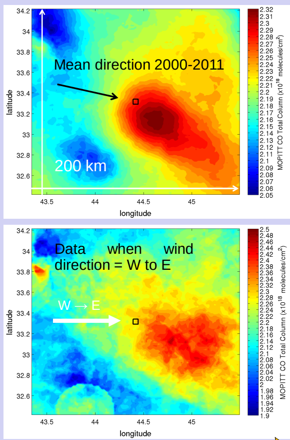
- The value assigned to a gridbox is the average of all data within radius r

- This technique oversamples the data (uses same point many times)

Impact of boundary layer wind on CO distribution

Baghdad (2000-2011) - MOPITT

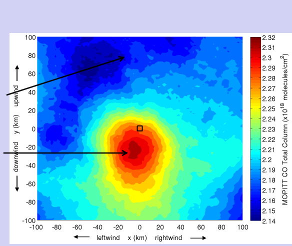
ECMWF wind data: 700-1000 hPa averaged



New distribution: result

background

emission



Megacity	Diff MOPITT tot col 2000-2003 (10^{17} molecules/ cm^2)	Diff MOPITT tot col 2004-2008 (10^{17} molecules/ cm^2)	RD (%)	RD MACcity (%)	RD EDGAR v4.2 (%)
Moscow	2.8 ± 0.03	2.3 ± 0.06	-18.5 ± 3.7	-10.7	-12.9 ± 44.6
Paris	1.3 ± 0.05	1.0 ± 0.03	-22.2 ± 6.9	-34.9	-54.4 ± 36.6
Mexico	7.0 ± 0.09	4.2 ± 0.06	-39.9 ± 2.6	+12.1	-12.7 ± 42.2
Tehran	4.4 ± 0.02	2.5 ± 0.06	-42.9 ± 2.8	+6.0	+4.6 ± 72.2
Baghdad	2.2 ± 0.01	1.2 ± 0.03	-46.5 ± 2.9	+3.5	+11.7 ± 42.5
Los Angeles	6.1 ± 0.11	4.9 ± 0.07	-19.6 ± 3.4	-39.5	-32.6 ± 31.1
Sao Paulo	1.5 ± 0.04	1.1 ± 0.03	-26.9 ± 5.4	+7.8	-0.1 ± 33.1
Delhi	0.9 ± 0.02	1.1 ± 0.04	+22.4 ± 5.8	+2.7	-1.8 ± 64.1

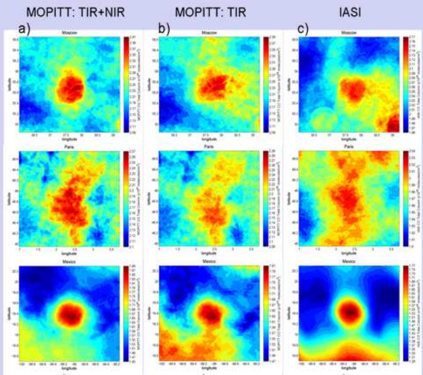
Results

Total column, daytime data
Jan 2008 - Dec 2011

Moscow

Paris

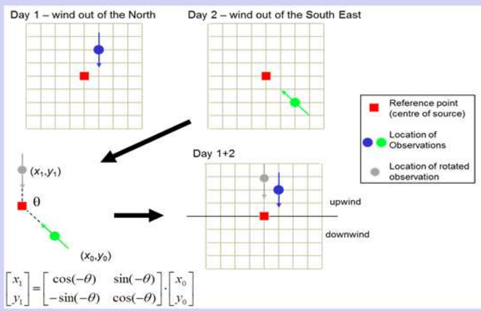
Mexico



New distribution: technique

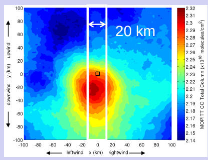
Rotate location of observation about reference point so that its wind vector is co-aligned with that of other observation

This preserves the relative upwind-downwind location



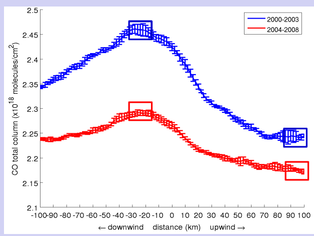
$$\begin{bmatrix} x_1 \\ y_1 \end{bmatrix} = \begin{bmatrix} \cos(-\theta) & \sin(-\theta) \\ -\sin(-\theta) & \cos(-\theta) \end{bmatrix} \cdot \begin{bmatrix} x_0 \\ y_0 \end{bmatrix}$$

Proxy of emission



Diff downwind-upwind MOPITT tot col 2000-2003 = mean 5 max – mean 5 min

Diff downwind-upwind MOPITT tot col 2004-2008 = mean 5 max – mean 5 min



RD = (Diff 2004-2008 – Diff 2000-2003) / Diff 2000-2003

Conclusions

- First attempt to use remote sensing measurements to determine CO relative changes over megacities

- New distribution performed

- Over most of selected sites, a clear reduction of CO emission is observed between both periods: 2000-2003 and 2004-2008

- Mexico and LA most polluted cities

- Larger reduction over Baghdad and Tehran

- Increase of CO over Delhi

References

Clerbaux, C., et al. (2008), Carbon monoxide pollution from cities and urban areas observed by the Terra/MOPITT mission, Geophys. Res. Lett., 35, L03817, doi:10.1029/2007GL032300. Clerbaux, C., et al. (2009), Monitoring of atmospheric composition using the thermal infrared IASI/MetOp sounder, Atmos. Chem. Phys., 9, 6041-6054, doi:10.5194/acp-9-6041-2009. Deeter, M. N., et al. (2012), Evaluation of MOPITT retrievals of lower-tropospheric carbon monoxide over the United States, J. Geophys. Res., 117, D13306, doi:10.1029/2012JD017553. Fioletov, V. E., et al. (2011), Estimation of SO_2 emissions using OMI retrievals, Geophys. Res. Lett., 38, L21811, doi:10.1029/2011GL049402.

Acknowledgements

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