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Canada

CO_2 emissions from power plants derived from the OMI NO_2 dataset

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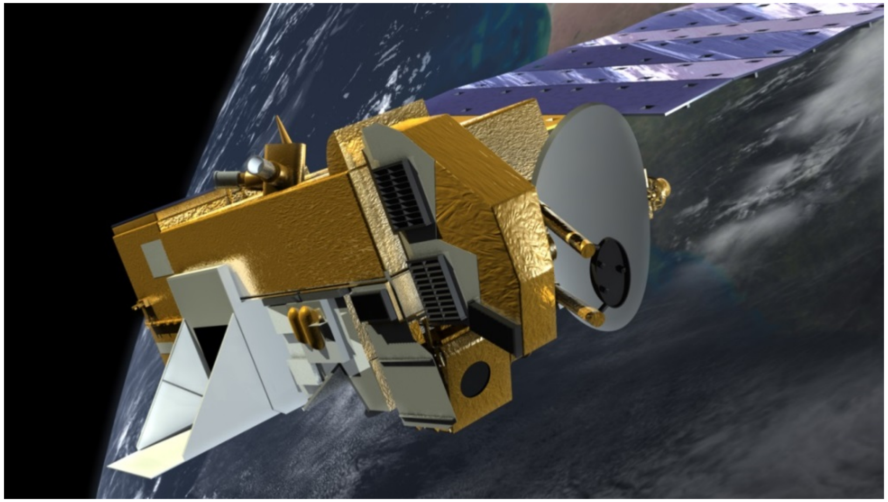
Key Points

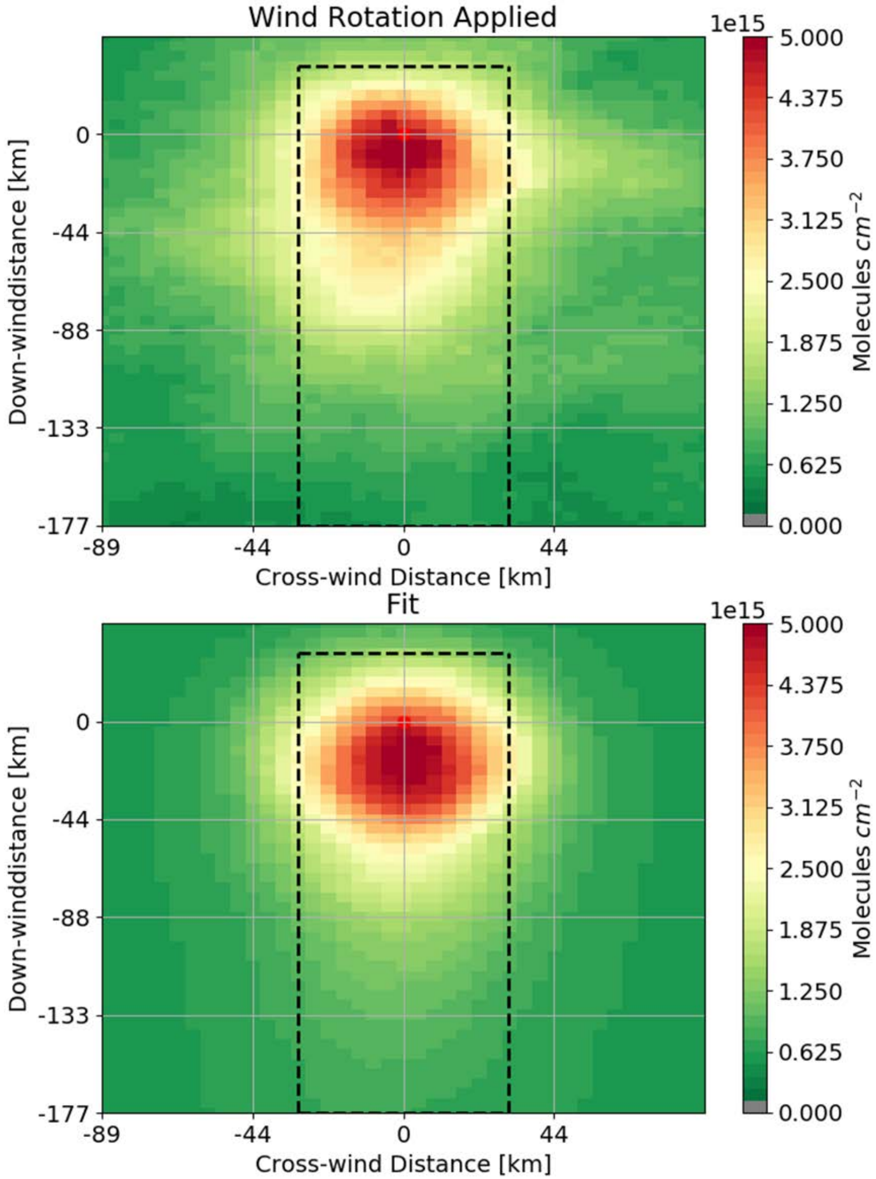
- Ozone Monitoring Instrument (OMI) annual NO_x (NO_2+NO) emissions can be estimated for individual, isolated power plants
- NO_x is a good tracer for anthropogenic CO_2 emissions
- NO_x:CO_2 ratio have been derived from the Continuous Emission Monitoring System (CEMS)
- These ratios and OMI NO_x emission estimates are used to derive CO_2 emissions from large point sources
- New approach of estimating CO_2 emissions that can help to improve emission inventories in countries where emissions have very large uncertainties

The OMI instrument

- The Ozone Monitoring Instrument (OMI), on-board the Aura satellite, launched 2004 [Levelt et al., 2006]
- OMI is a nadir-viewing UV-visible instrument that detects scattered reflected sunlight (270-500 nm, at 0.42 nm resolution)
- Global daily coverage, ~30 km pixel size
- Measures NO_2, O_3, SO_2, and aerosols

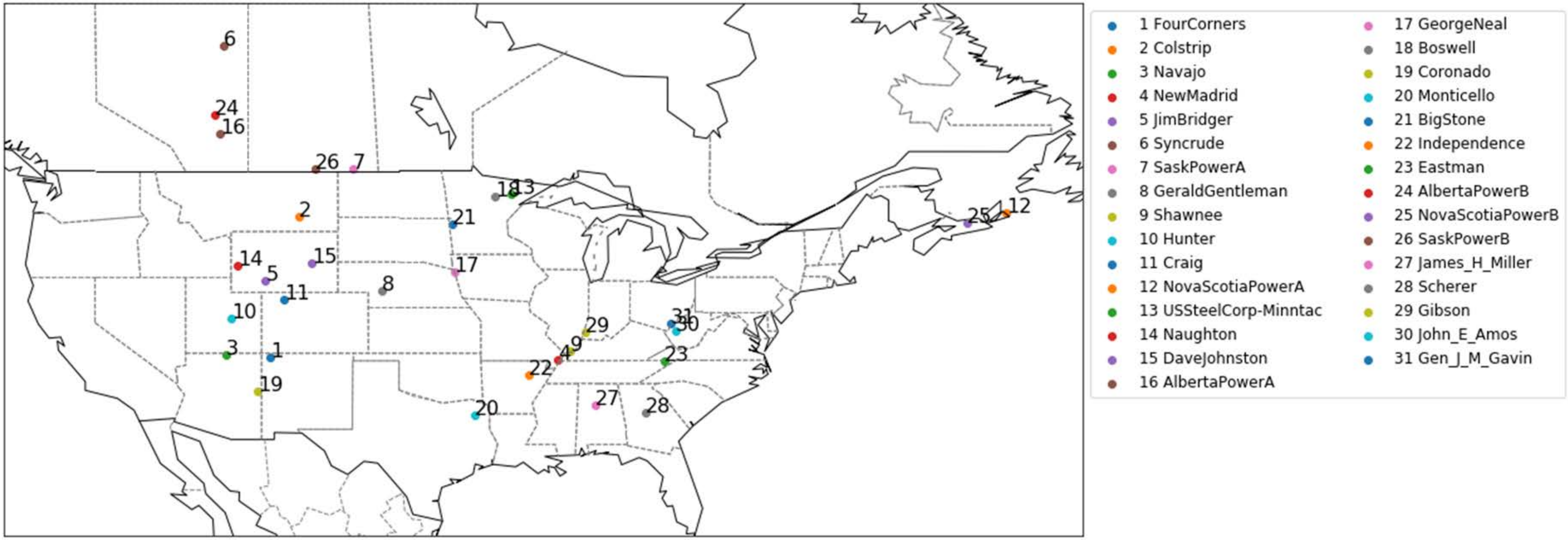


OMI NO_x emission estimates



- Tropospheric NO_2 VCD, SPv3 with air mass factor (AMF) corrections for North America [McLinden et al., 2014]
- Exponentially modified Gaussian (EMG) function to derive emissions from power plants (point source) [Fioletov et al., 2015]
- Before the fitting, a wind rotation is applied, wind speed > 0.5m/s
- Assuming lifetime 3h, plume spread σ=22km (for EMG)
- ERA-Interim wind fields merged with the OMI dataset, 900-950hPa
- April-October was used for sites located above 40°N

Power plants in North America

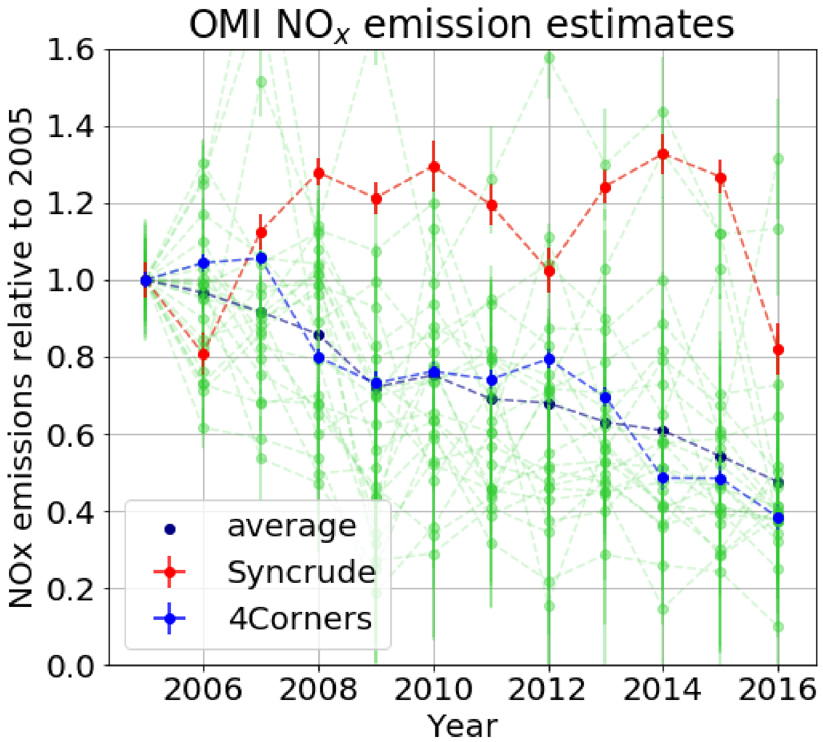


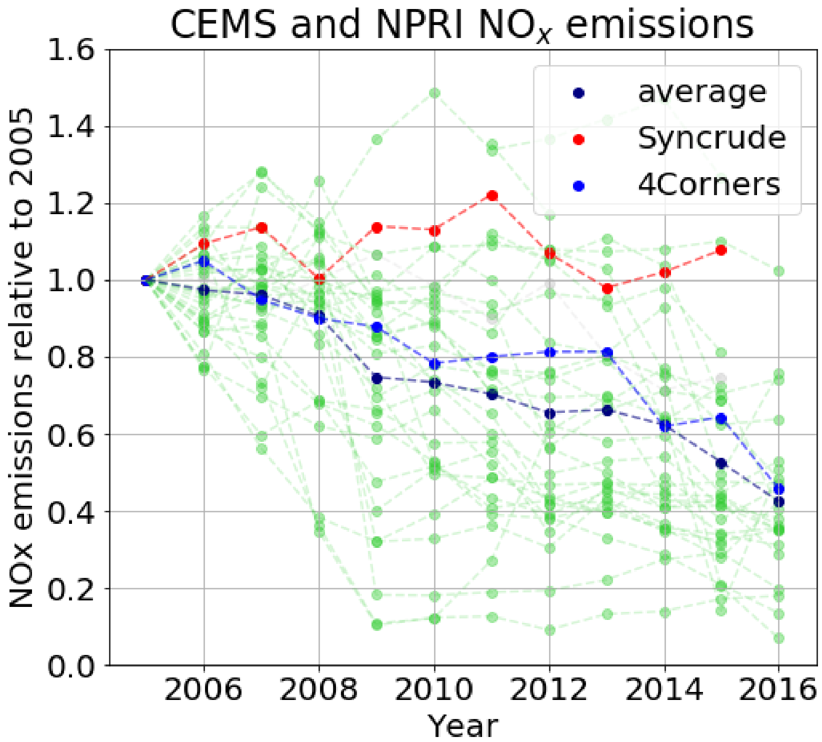
Isolated, large- to mid-size (coal-fired) power plants

NO_x emissions from the NO_2 measurements we assume:
NO_2:NO_x=0.7 (GEM-MACH)

NO_x emissions from NA power plants

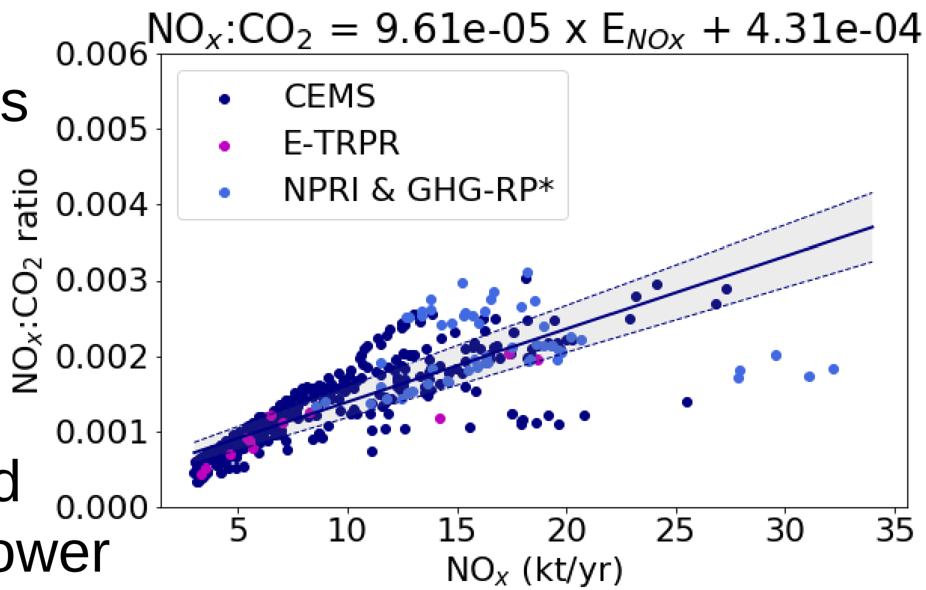
- NO_x emissions are decreasing across North America (US+CA)
- On average by 50% between 2005 and 2016
- Good agreement between the trends from OMI estimates and CEMS
- Individual NO_x emissions estimated with the OMI NO_2 dataset correlate well with the CEMS dataset (s=0.78 and R=0.84)


OMI NO_x emission estimates


CEMS and NPRI NO_x emissions

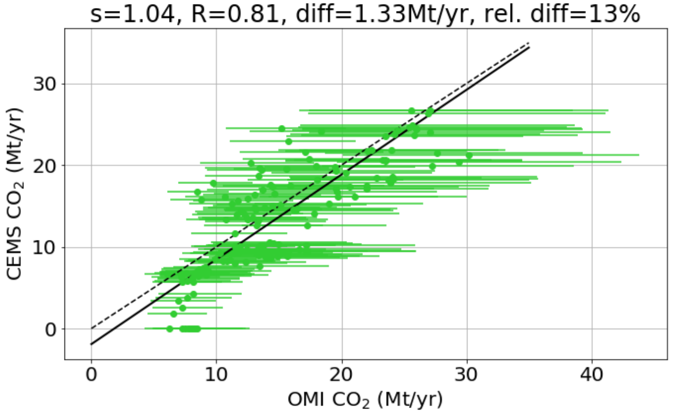
NO_x:CO_2 ratios

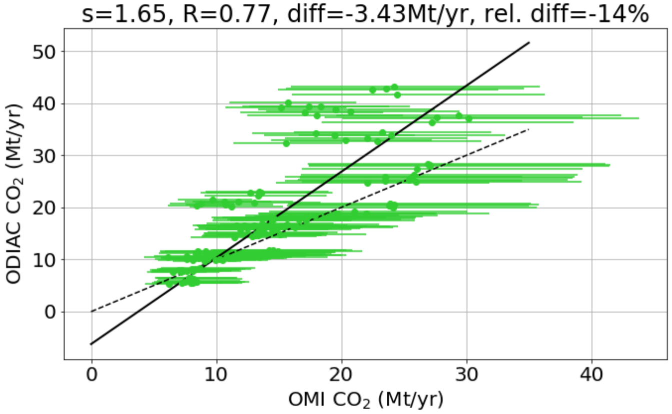
- CEMS data, emissions by stack, 2004-2016
- For large/mid-size power plants (>5 MW-h) with NO_x controls
- Increasing NO_x:CO_2 ratio for increasing NO_x emissions
- Also shown: the Canadian (NPRI/GHG-RP, light blue) and European (E-TRPR, purple) power plant emissions, the ratio also seems to be valid for those
- For facilities without NO_x controls, we found a ratio of approximately: NOx:CO2~$(2.38 \pm 0.94) \times 10^{-3}$

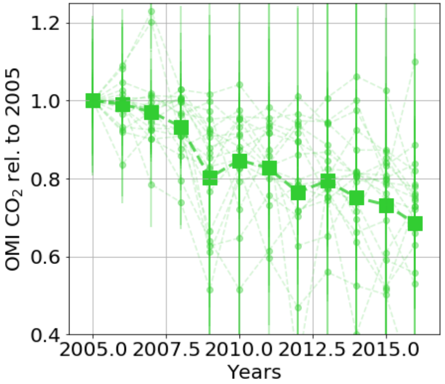


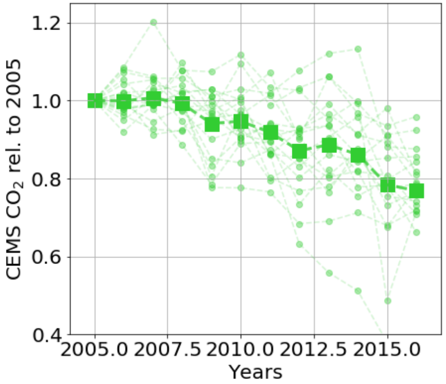
CO_2 emissions from US power plants

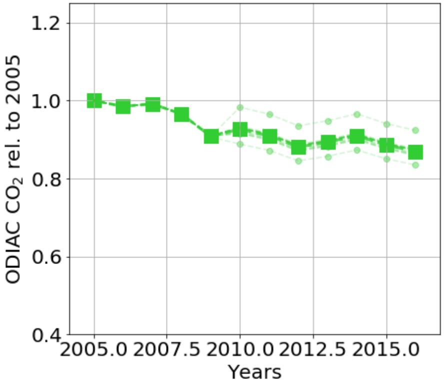
"OMI CO_2":
From annual OMI NO_x emission estimate and the linear NO_x:CO_2 ratio (per stack) → total emissions are divided by the number of emitting stacks of the facility to obtain NO_x:CO_2 ratio


s=1.04, R=0.81, diff=1.33Mt/yr, rel. diff=13%


s=1.65, R=0.77, diff=-3.43Mt/yr, rel. diff=-14%



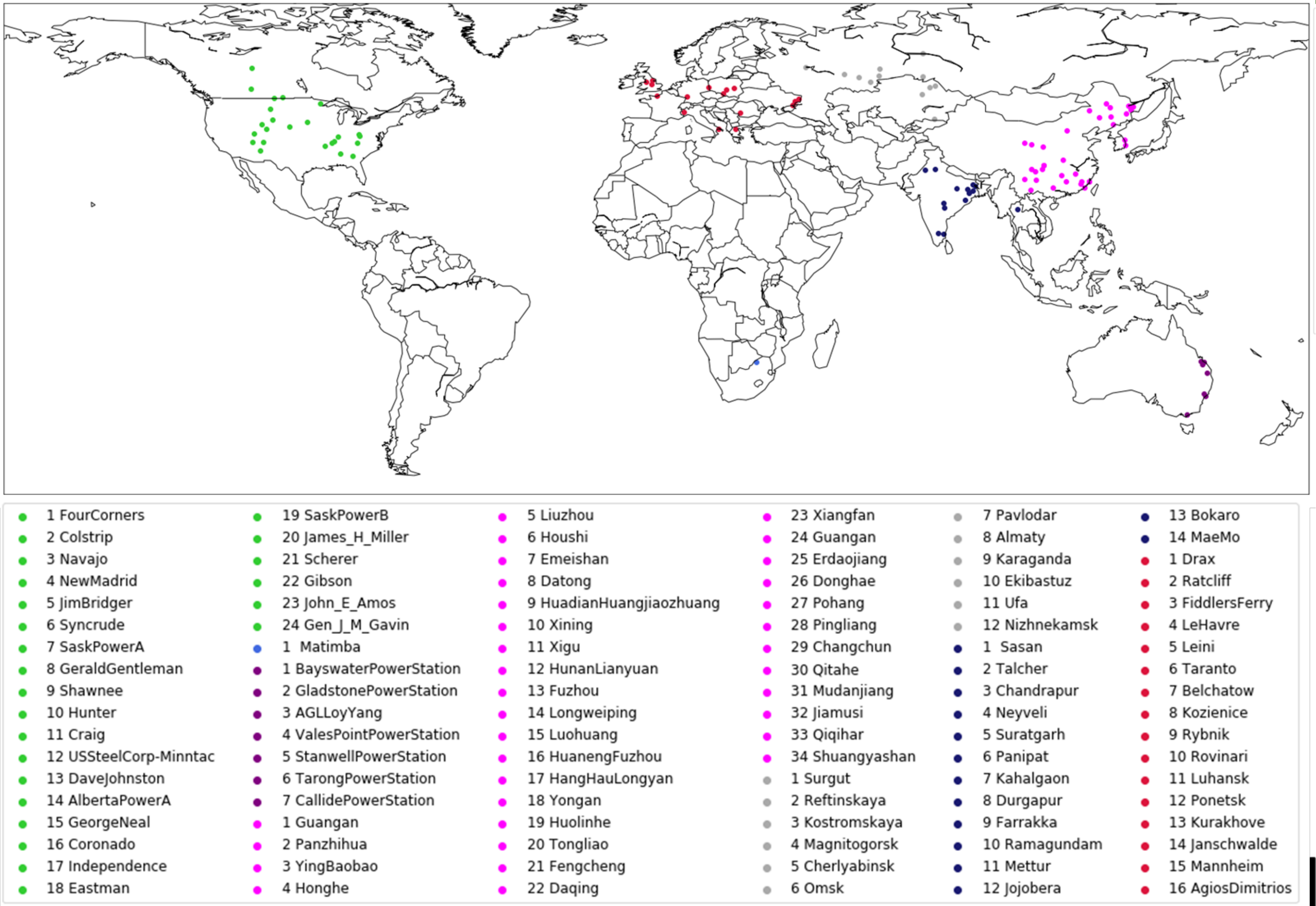




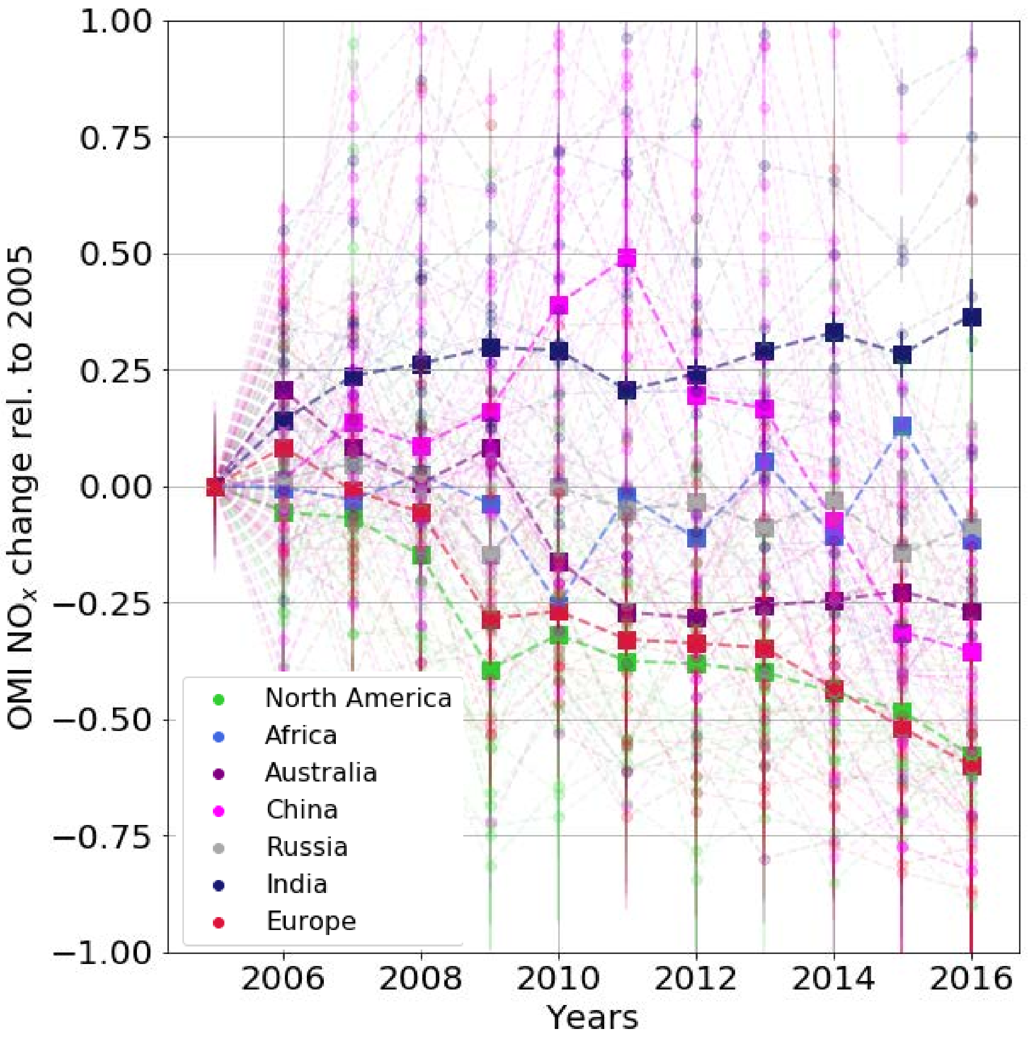
CO_2 emissions in 2016 relative to 2005:

- OMI: ~30%
- CEMS: ~23%
- ODIAC: ~13%

NOx emissions around the world

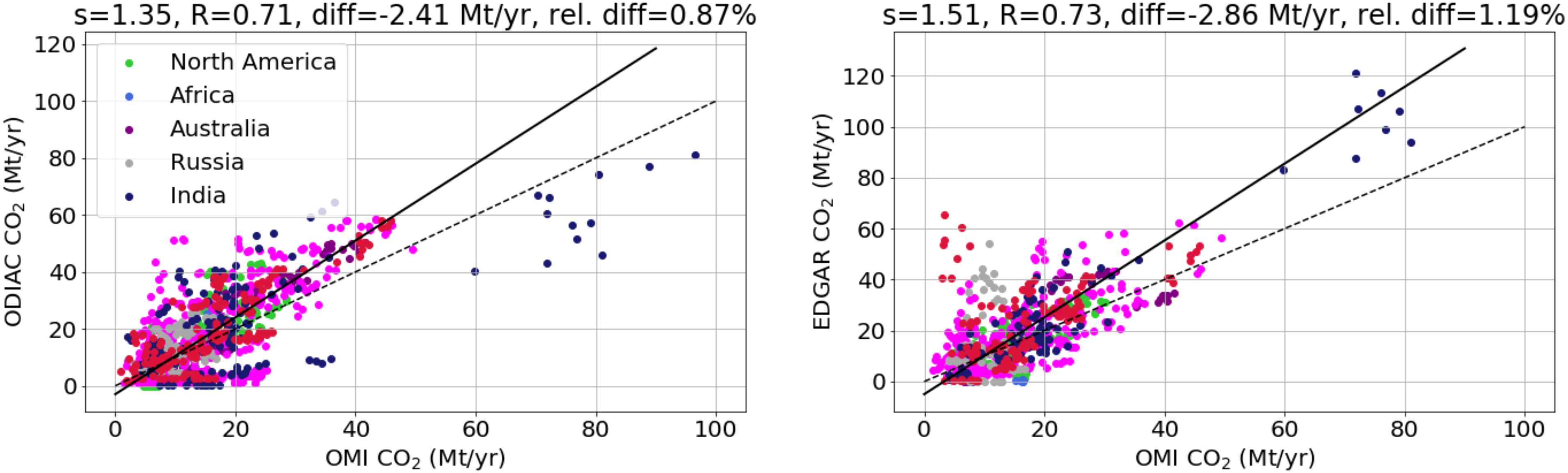


NOx emissions around the world



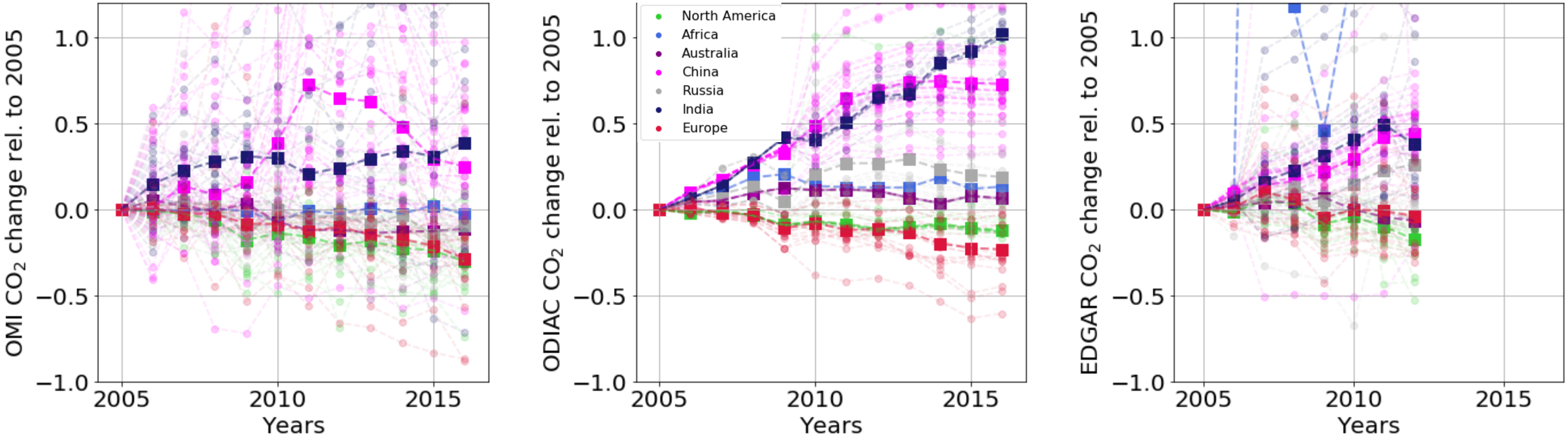
- Reduction of NO_x emissions by over 50% for the power plants in North America (US+CA) and Europe, and a reduction in Australia by around 25%
- Reduction of NO_x emissions for the power plants in China since 2011
- Increasing NO_x emissions for the power plants in India (~40%)
- Nearly constant emissions for Russia and South Africa

CO_2 emissions around the world



- Overall good agreement between the “OMI CO_2” emissions and the ODIAC and EDGAR v4.2.3 CO_2 inventories
- Some missing sources (possibly due to wrong coordinates in the ODIAC inventory in China and India)
- EDGAR CO_2 for Matimba (South Africa) are underestimated

CO_2 emissions around the world



- Reduction in North America and Europe by ~25% since 2005
- According to OMI estimates reduction for of CO_2 for power plants in China after 2011, not seen in ODIAC
- Increasing trend in India (different rate for OMI and ODIAC)
- Note, only for the power plants shown on slide 9, this is not a national average

Comparison with OCO-2 estimates

plant	year	NO_x:CO_2	OMI CO_2 (kt/d)	ODIAC CO_2 (kt/d)	OCO-2 overpass	OCO-2 CO_2 (kt/d)
Gavin +Kyger	2015	$1.28\text{x}10^{-3}$	56	104	2015/07/30	49±10
Matimba	2014	$1.86\text{x}10^{-3}$	44	71	2014/11/07	33±3
Matimba	2016	$1.85\text{x}10^{-3}$	44	68	2016/10/11	34±10

- OCO-2 CO_2 emission estimates from Nassar et al., 2017, GRL
- OCO-2 emission estimates are based on one overpass at a specific time and date
- OMI are estimated from all measurements from the specified year (or April-October for Gavin/Kyger power plants)
- Nevertheless, the emission estimates between OCO-2 and OMI agree reasonably well

Conclusions

- NO_x emission can be estimated from OMI measurements for large- to mid-size power plants and refineries, with uncertainties around 30%
- NO_x:CO_2 emission ratios in good agreement with previous studies [Berezin et al., 2013; Reuter et al., 2014, Tong et al., 2018]
- CO_2 emission can be estimated from the OMI NO_x emission estimates and the NO_x:CO_2 emission ratio (from CEMS), uncertainties are around 35-45%
- Can be applied outside North America, however, there are larger uncertainties for China and India

Implications for future research

- This method can help to improve current emission inventories by identifying missing sources
- It help improve emission inventories in countries where emissions have large uncertainties
- It can be used when CO_2 measurements are not available
- NO_x emissions from cities can be estimated from the OMI dataset [Beirle et al., 2011] and can help estimate CO_2 emissions from cities
- It can be applied to new satellite instruments such as TROPOMI that has a smaller pixel size that can make it possible to estimate monthly, weekly emissions or even for single overpasses.