Satellite Remote Sensing of NO_2 as an Indicator of Aerosol Pollution: Opportunities from GEMS (and GOCI) Observations

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Inspiring Minds

with contributions from

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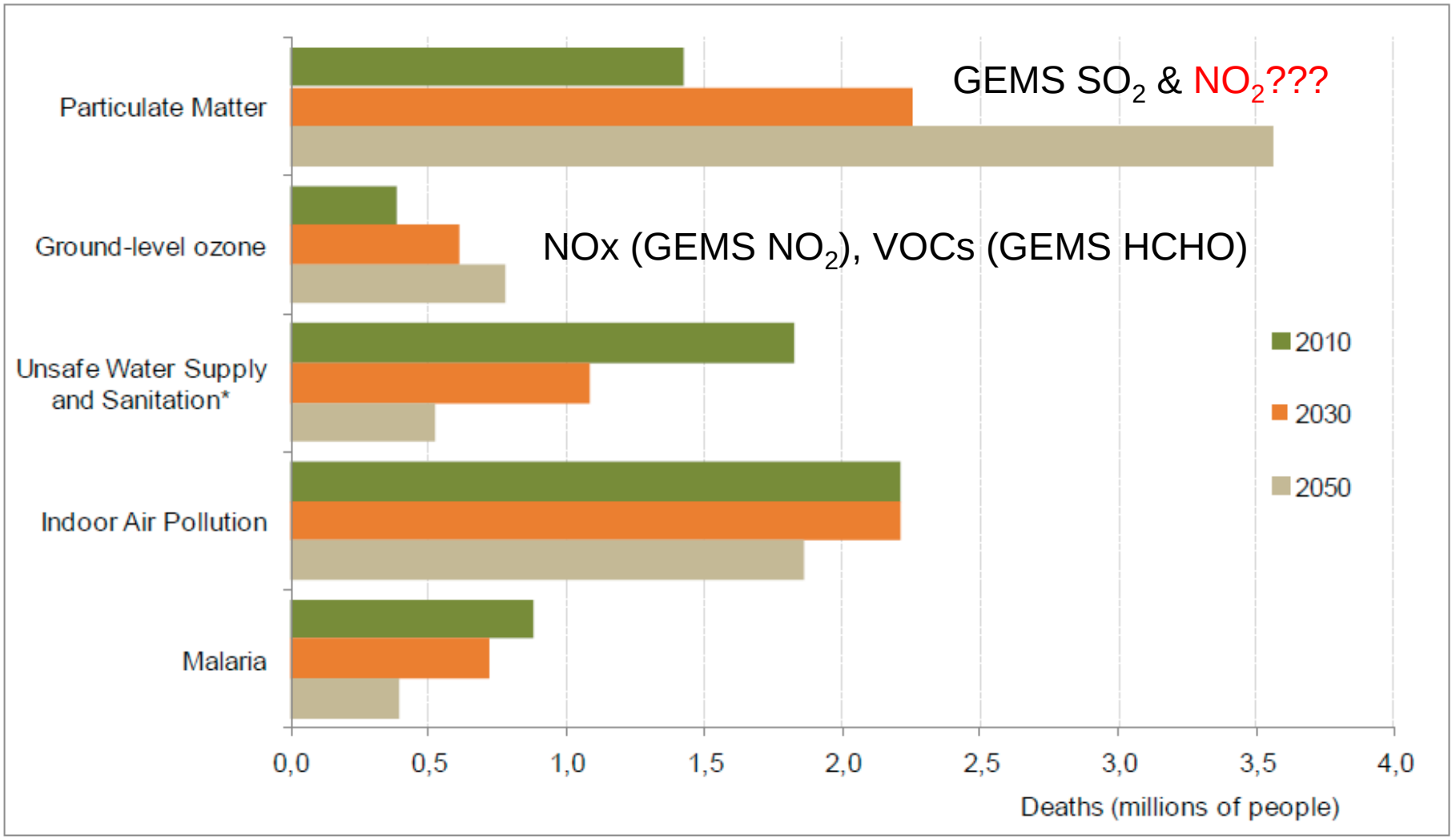
Lok Lamsal (Dalhousie → NASA)

3rd GEMS Workshop
Seoul, Korea

9 Oct 2012

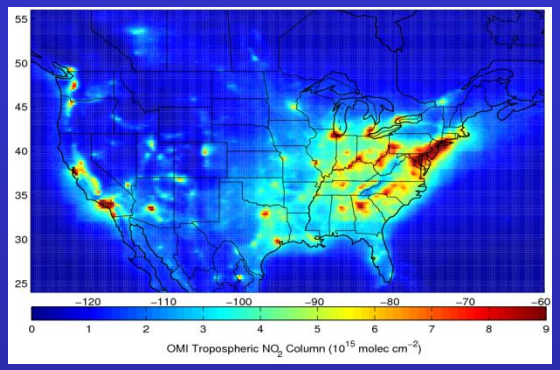
Outdoor Air Pollution is Projected to Become the Top Cause of Environmentally Related Deaths Worldwide: Need to Understand and Observe Particulate Matter and Sources



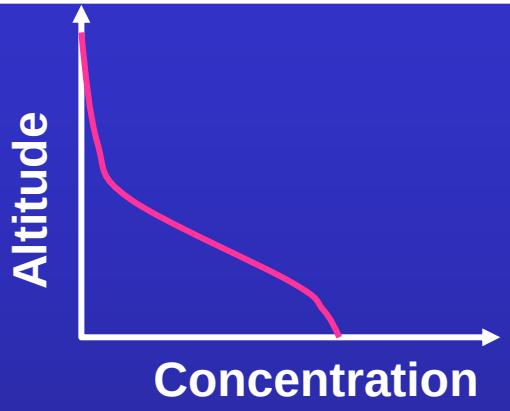
OECD, 2012

General Approach to Estimate Surface Concentration

Daily Satellite AOD and NO_2 Column



Coincident Model (GEOS-Chem) Profile



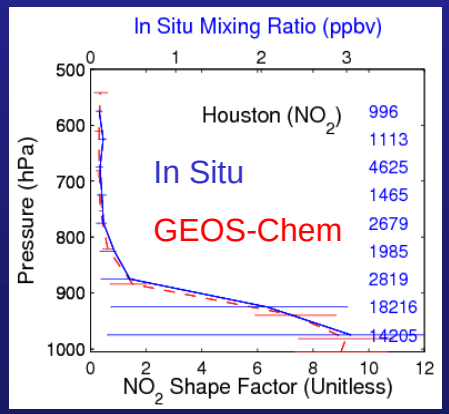
$$S_O = \Omega_O \left[\frac{S_M}{\Omega_M} \right]$$

S → Surface Concentration

Ω → Tropospheric column

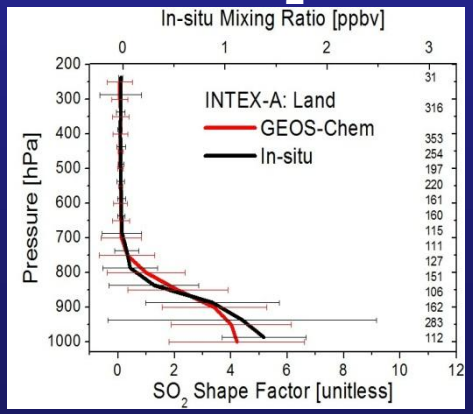
Encouraging Consistency of Simulated and Measured Profiles

NO_2



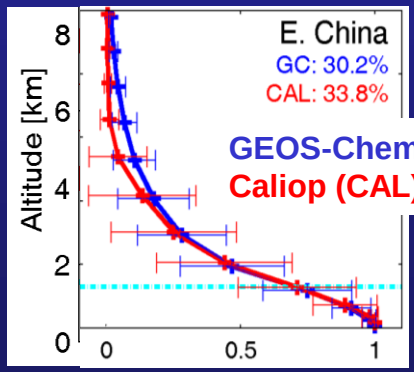
Martin et al., JGR, 2004

SO_2



Lee et al., JGR, 2009

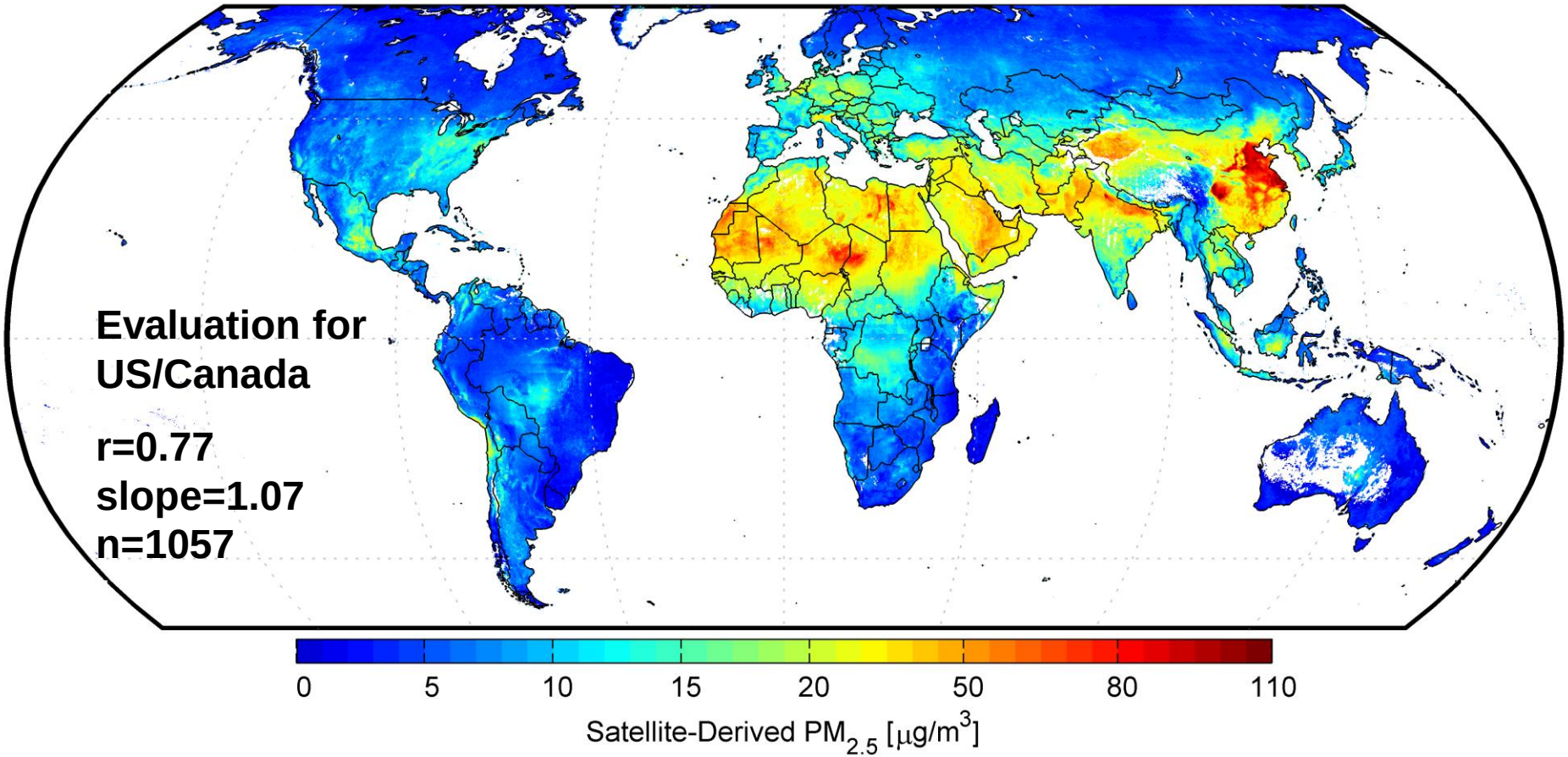
Aerosol Extinction



$$\frac{\text{Optical depth above altitude z}}{\text{Total column optical depth}}$$

van Donkelaar et al., EHP, 2010

Global Climatology (2001-2006) of $PM_{2.5}$ Derived from MODIS & MISR AOD



Evaluation with measurements outside Canada/US

	Number sites	Correlation	Slope
Including Europe	244	0.83	0.86
Excluding Europe	84	0.83	0.91

EHP Paper of the Year

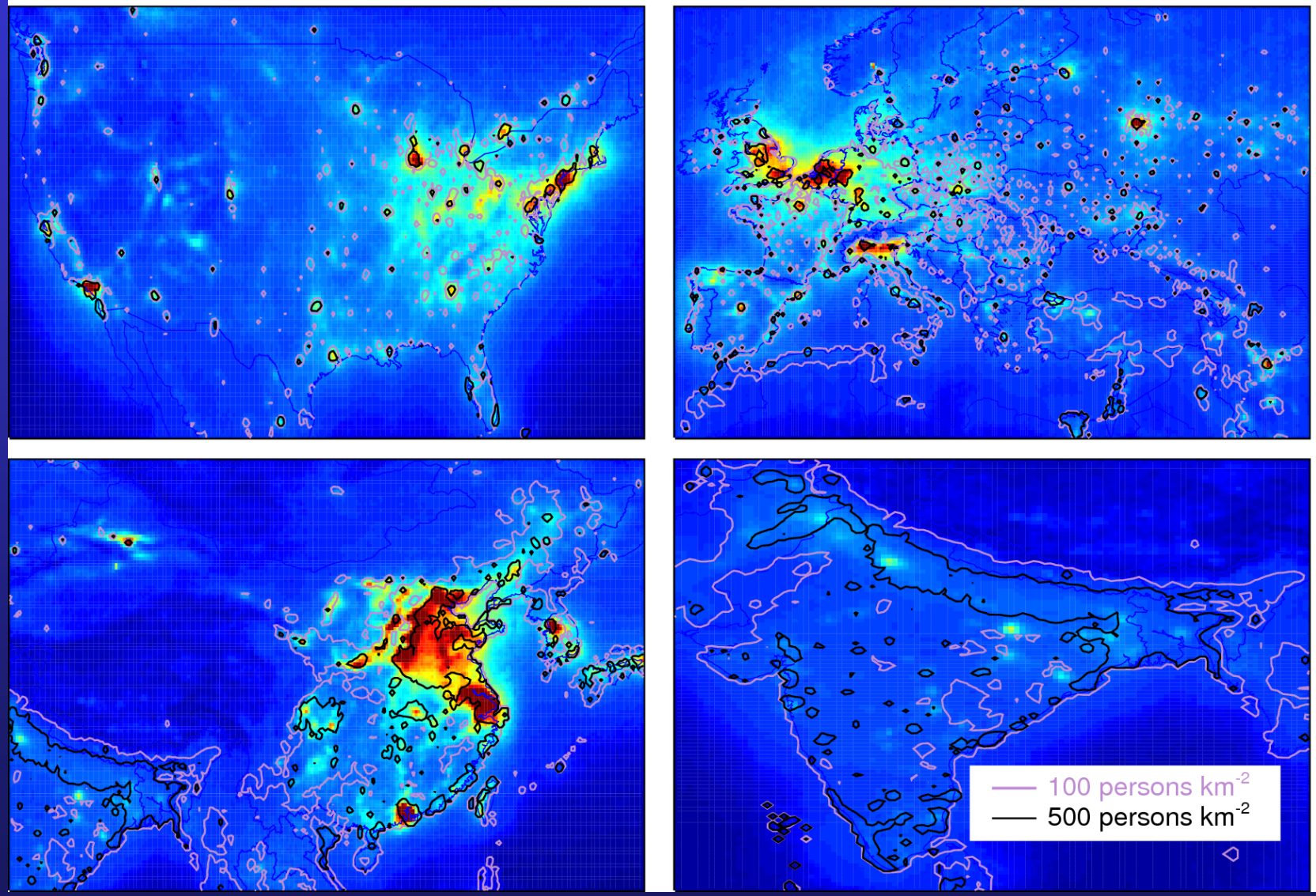
van Donkelaar et al., EHP, 2010

Multiple Pollutants Affect Air Quality

- Mortality not well explained by $PM_{2.5}$ and O_3 alone
- Mortality can be more strongly associated with NO_2 than either $PM_{2.5}$ or O_3 (e.g. Stieb et al. 2007)
- NO_2 is an indicator of exposure to combustion sources that increase airmass toxicity (Brook et al., 2007)

NO_2: Indicator of Population Exposure to Combustion Sources

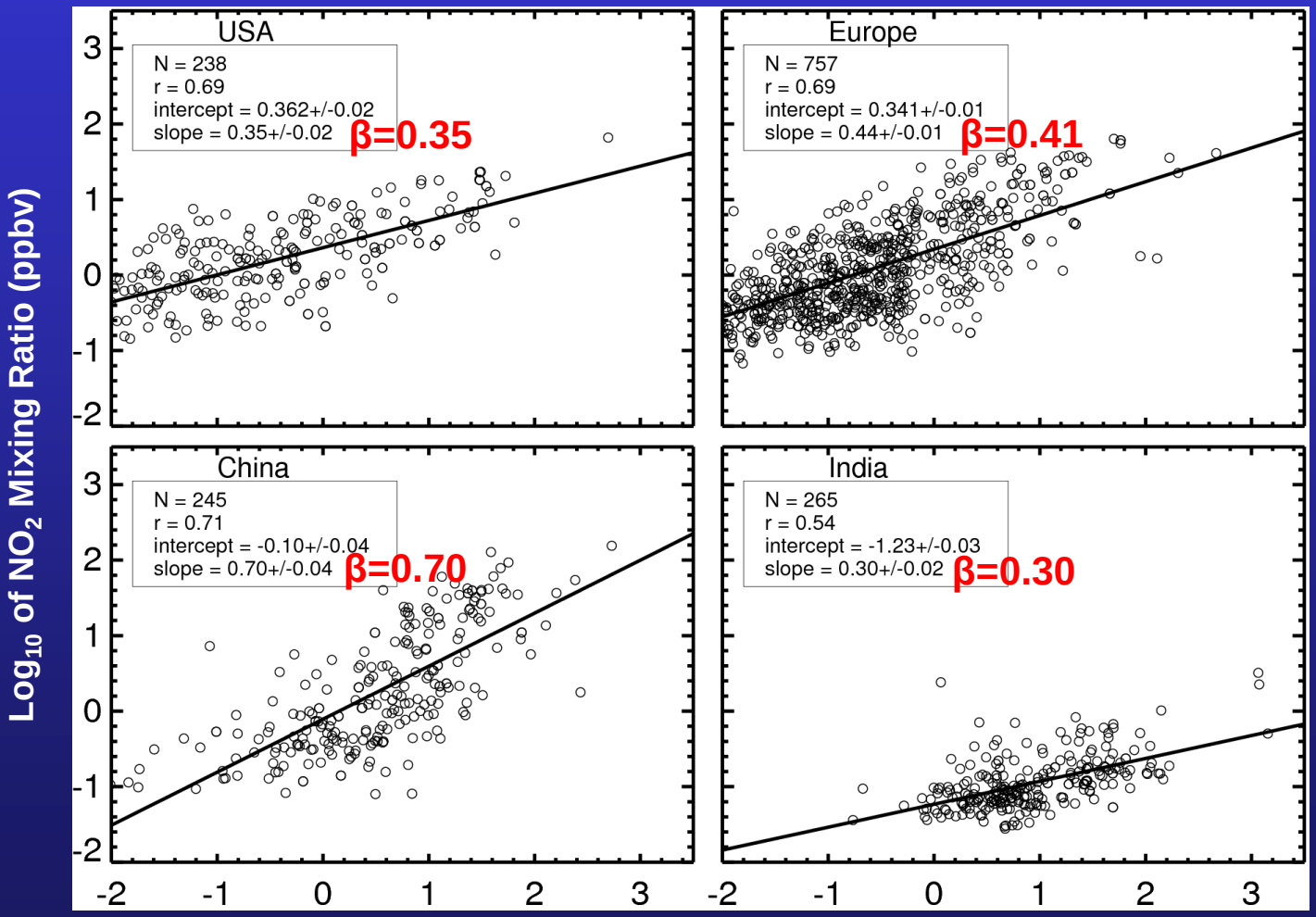
OMI-Derived NO_2



Lamsal et al., ES&T, in prep

Regional Relation of NO_2 Concentration with Urban Population ($NO_2 \sim Population^{\beta}$)

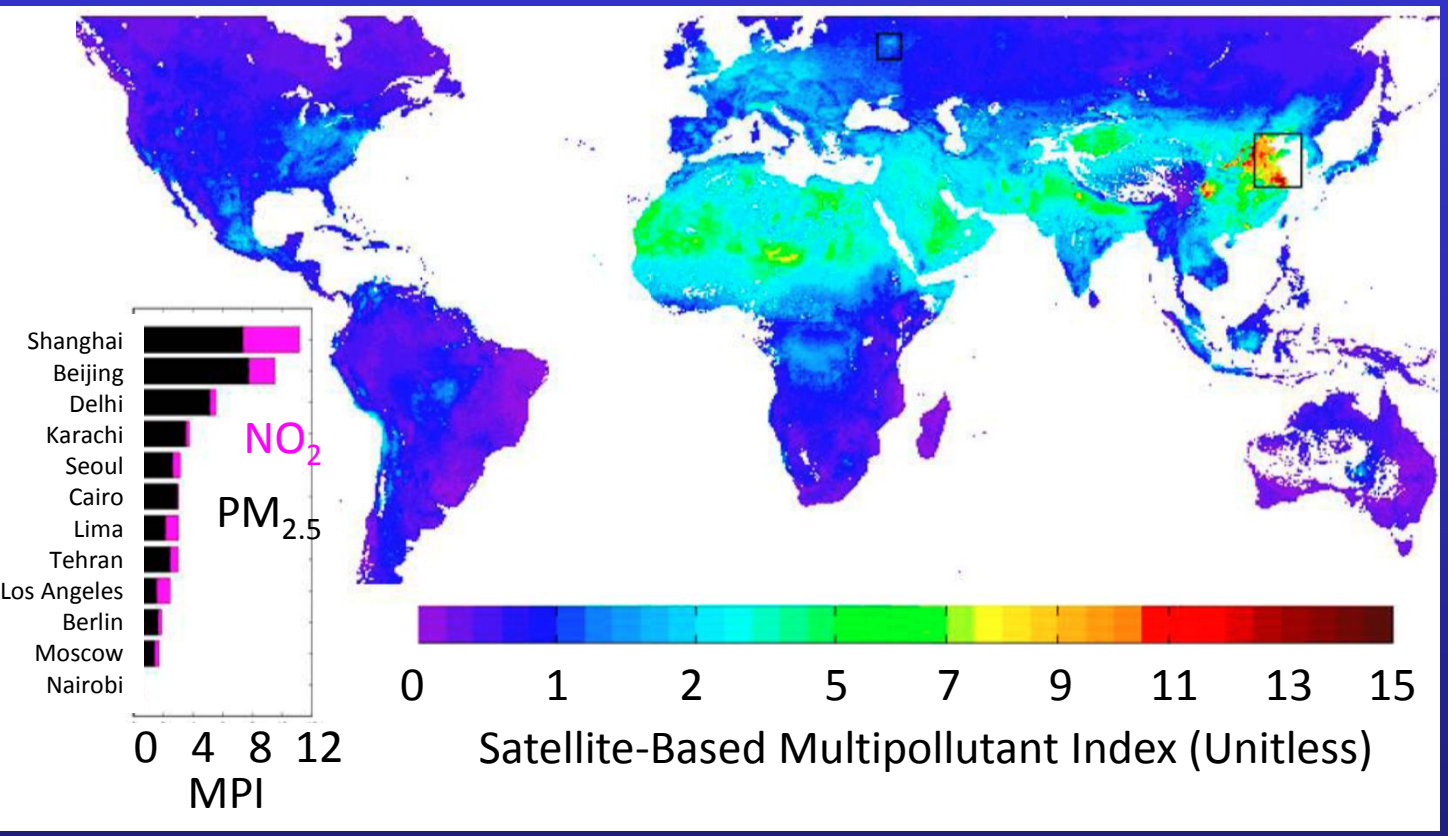
Increasing Population Density Increases Pollution Levels Despite Decreases in Per Capita Local Emissions

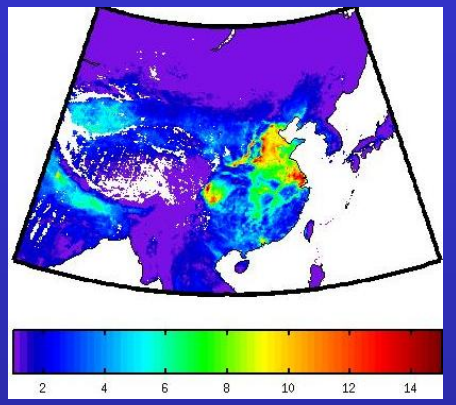


Similar slopes for NO_x emissions vs population

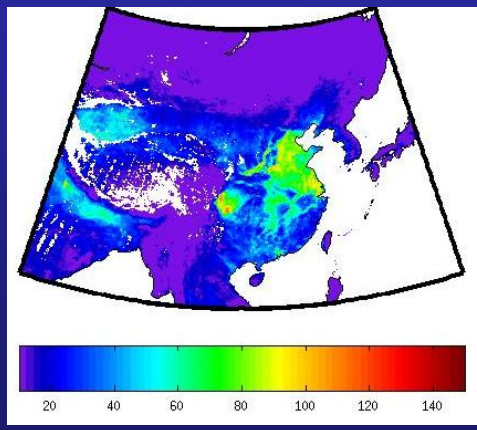
Lamsal et al., ES&T, in prep

A Satellite-Based Multipollutant Index from $PM_{2.5}$ & NO_2





MPI (unitless)



$PM_{2.5}$ (ug/m^3)

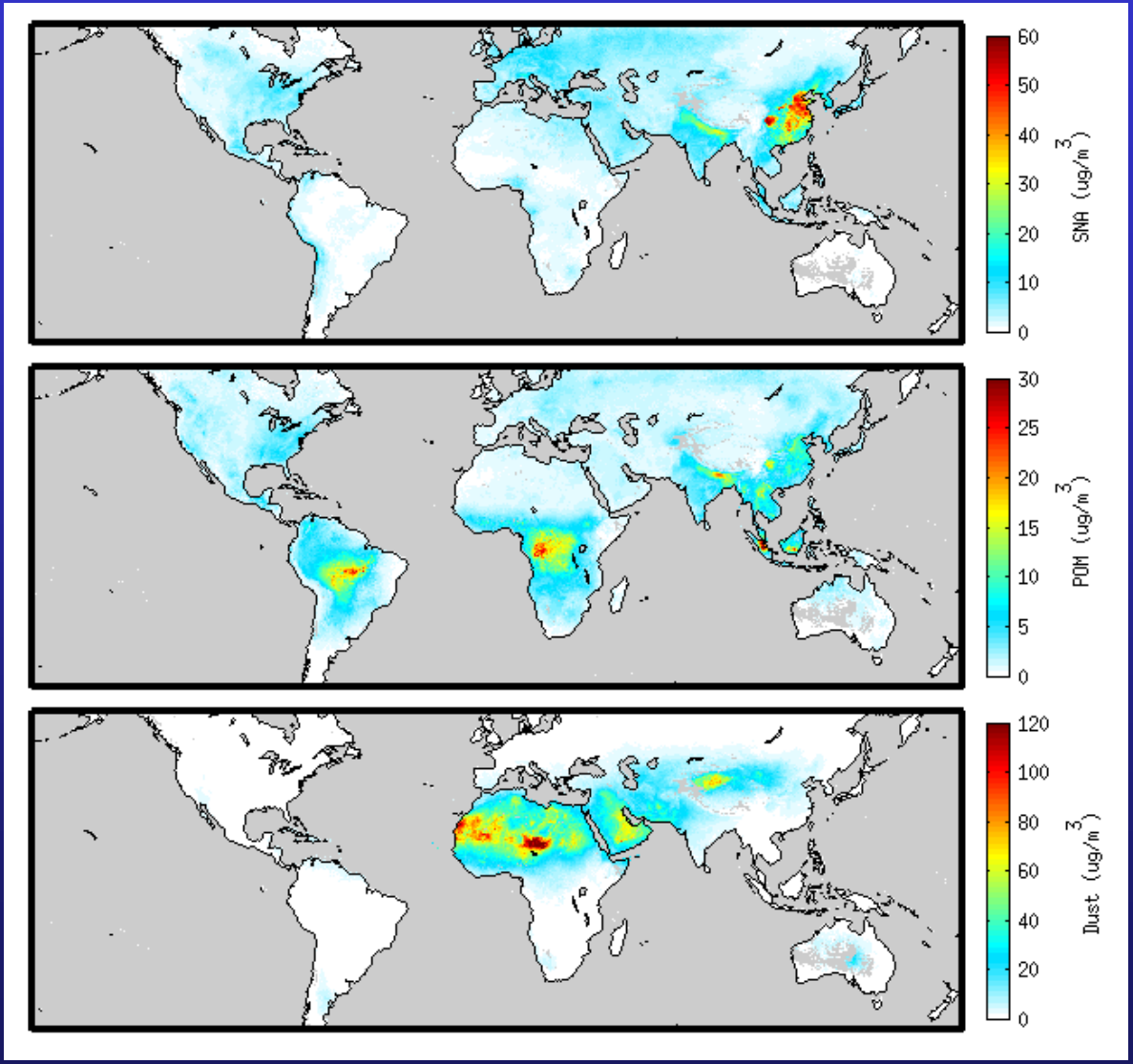
Multipollutant Index

$$MPI = \frac{PM_{2.5}}{AQG_{PM2.5}}\left[1 + \frac{NO_2}{AQG_{NO2}}\right]$$

AQG = WHO Air Quality Guideline

Cooper et al., ES&T, 2012

Satellite-Model Estimate of Aerosol Composition Indicates Sulfate-Nitrate-Ammonium Aerosol Dominates Global Health Burden



SO_4^{2-}

NO_3^-

NH_4^+

Organic Matter

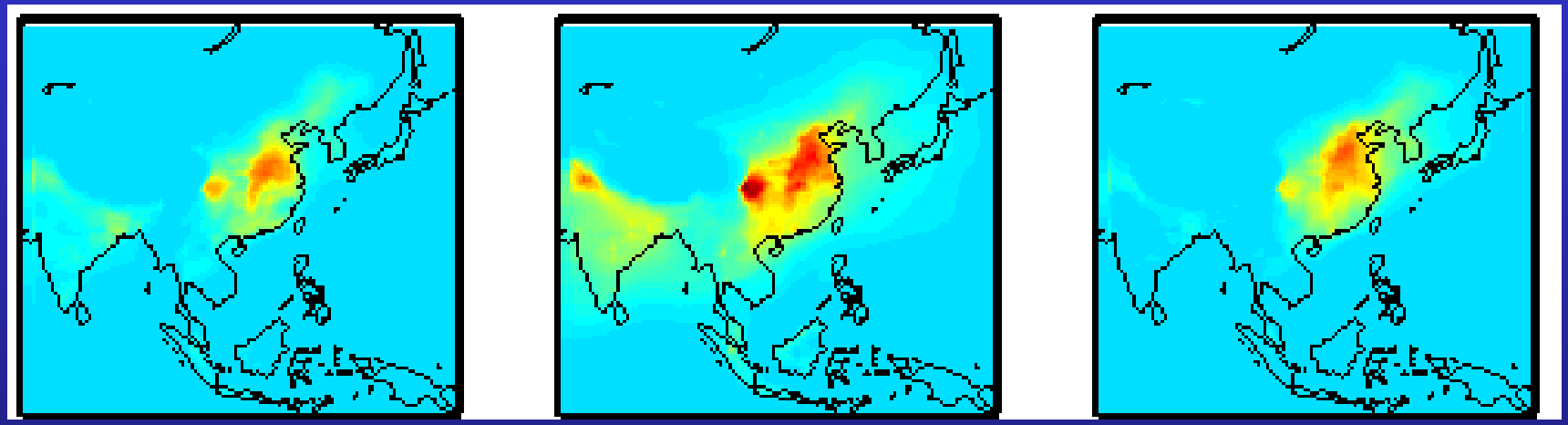
Mineral Dust

Philip et al., EHP, in prep.

$PM_{2.5}$ Nearly as Sensitive to NO_x as to SO_2 and NH_3

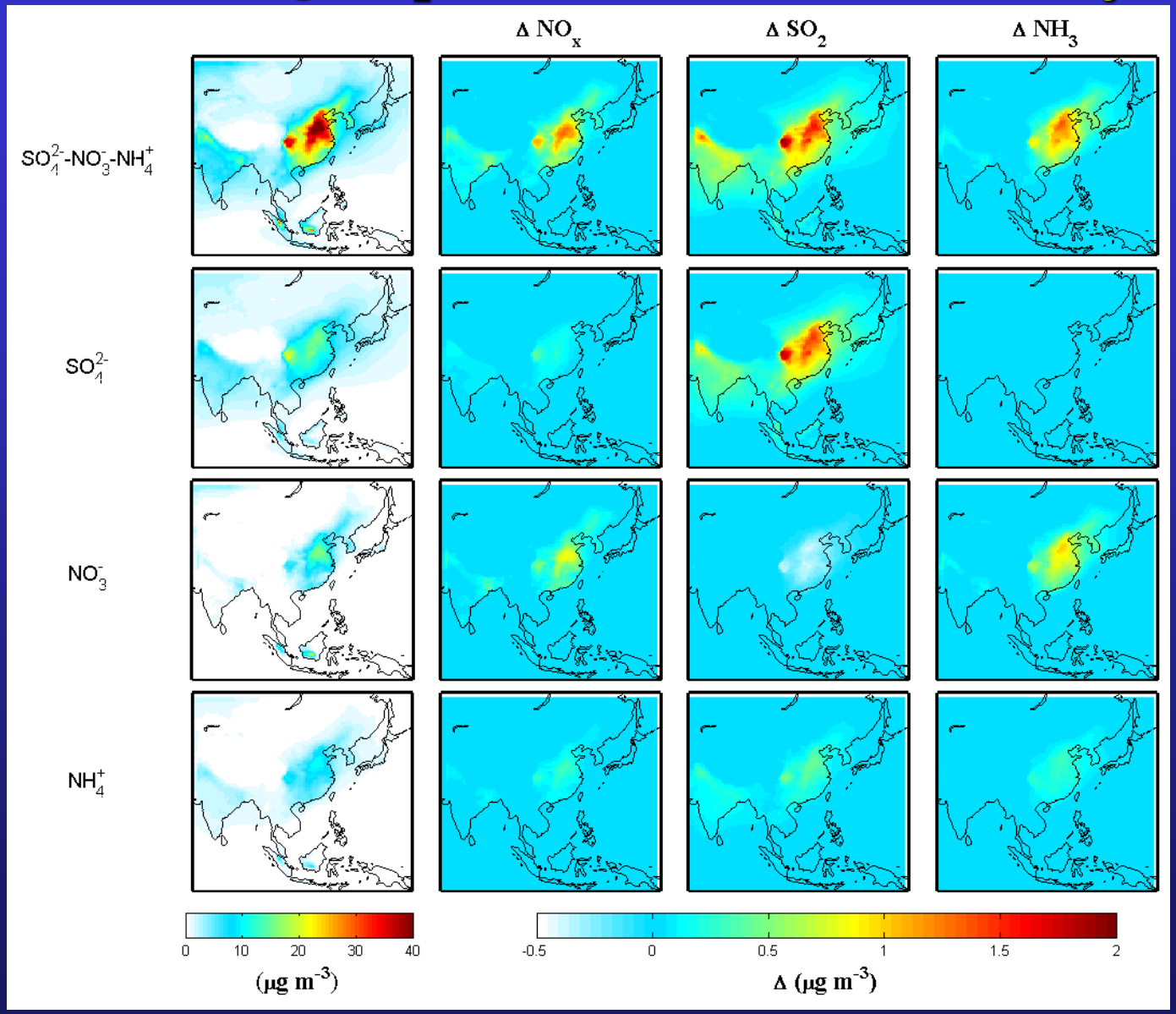
GEOS-Chem Calculation of Annual $PM_{2.5}$ Response to 10% Change in Emissions

ΔNO_x Emissions **ΔSO_2 Emissions** **ΔNH_3 Emissions**



Kharol et al., GRL, in prep

Increasing NO_x Emissions Increases NO_3^-, NH_4^+, and SO_4^{2-}
Increasing SO_2 Emissions Decreases NO_3^-



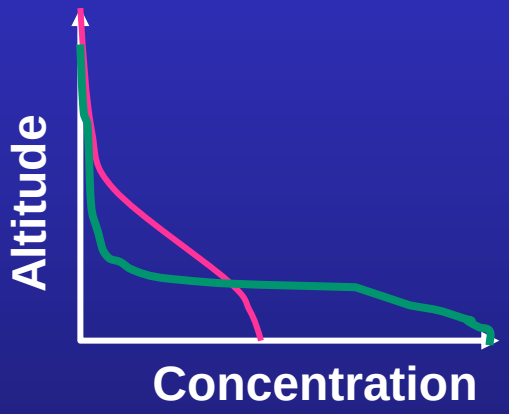
Kharol et al., GRL, in prep

Challenges in Development of AMF Calculation for GEMS

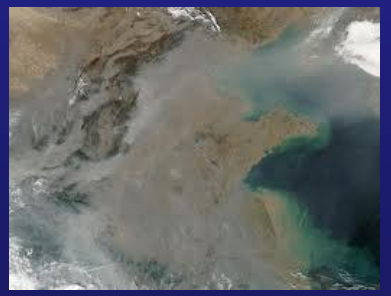
Largest Source of Uncertainty in LEO Trace Gas Retrievals

- Representing diurnal variation in surface reflectance during the period before measured from GEMS (use GOCI?)

- Diurnal variation in trace gas profile (changes rapidly in morning)



- Accounting for aerosols (still unresolved for LEO). Existing cloud products partially account for aerosol



SPARTAN: An Emerging Global Network to Evaluate and Improve Satellite-Based Estimates of $PM_{2.5}$

Measures $PM_{2.5}$ Mass & Composition at AERONET sites

Opportunity to Coordinate with GEMS Validation?

$PM_{2.5}$ Sampling Station from Vanderlei Martins (UMBC)

AOD from CIMEL Sunphotometer (AERONET)

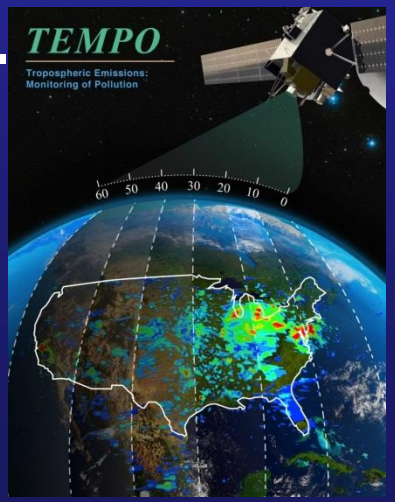
Contribute to Global Constellation by Linking GEMS with Other Geostationary Missions Through PCW/PHEOS Observing All Three Regions over 30N-60N

PCW / PHEOS

PHEOS PI: Jack McConnell

North America

e.g.



Europe
(e.g. Sentinel-4)

Asia (e.g. GEMS)

GEMS NO_2 Observations Will Be a Key Indicator of Aerosol Pollution

NO_2 Indicator of Combustion Sources

Sulfate-Nitrate-Ammonium Aerosol Sensitive to NO_x Emissions

Challenges

- Intercalibration of geostationary instruments & retrievals
- Slant to Column (i.e. diurnal components of AMF)

Acknowledgements:

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