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Inventories, Monitoring and Mitigation
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Effects of Three-Dimensional (3D) Urbanization Patterns and Topography on Air Pollution Processes in Asia

Son V. Nghiem[1] et al next page

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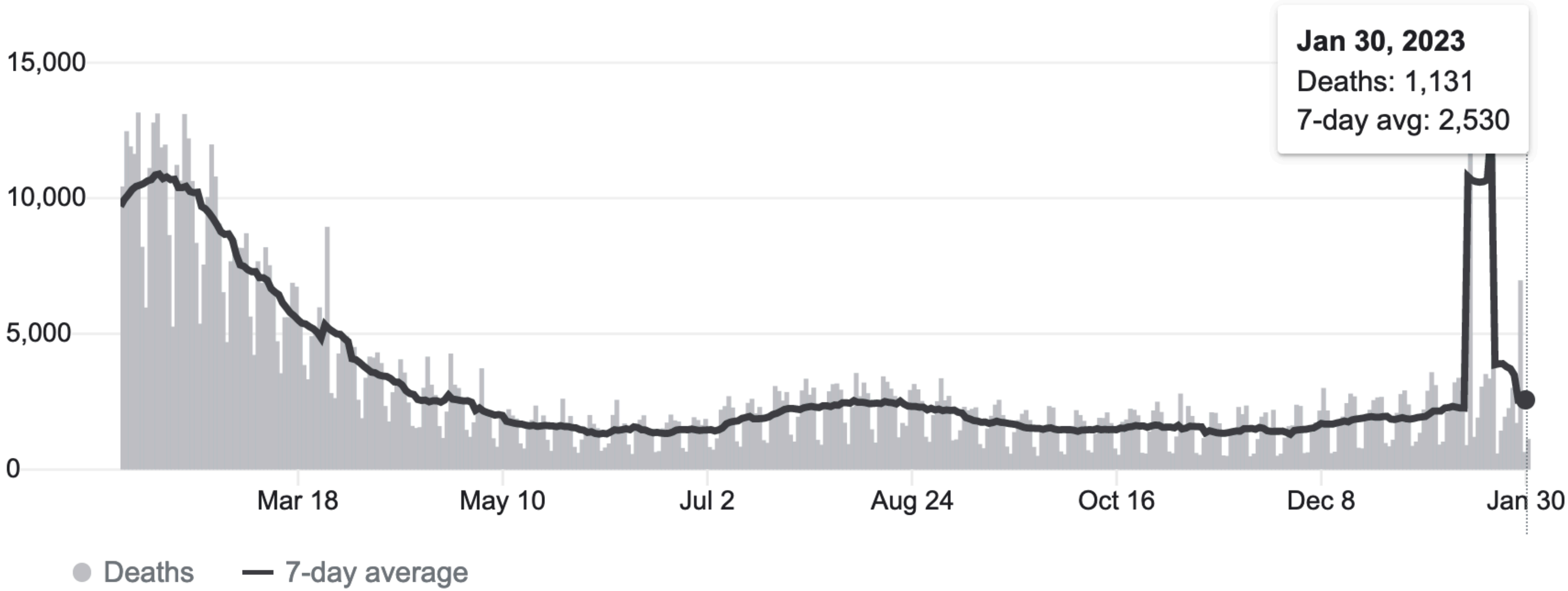
Air Pollution Problems

COMPARE TO WORLD COVID PANDEMIC



Reporting data is subject to change and might not reflect all new cases · About this data

All-time cases & deaths

Total cases

670M

World COVID Death Toll

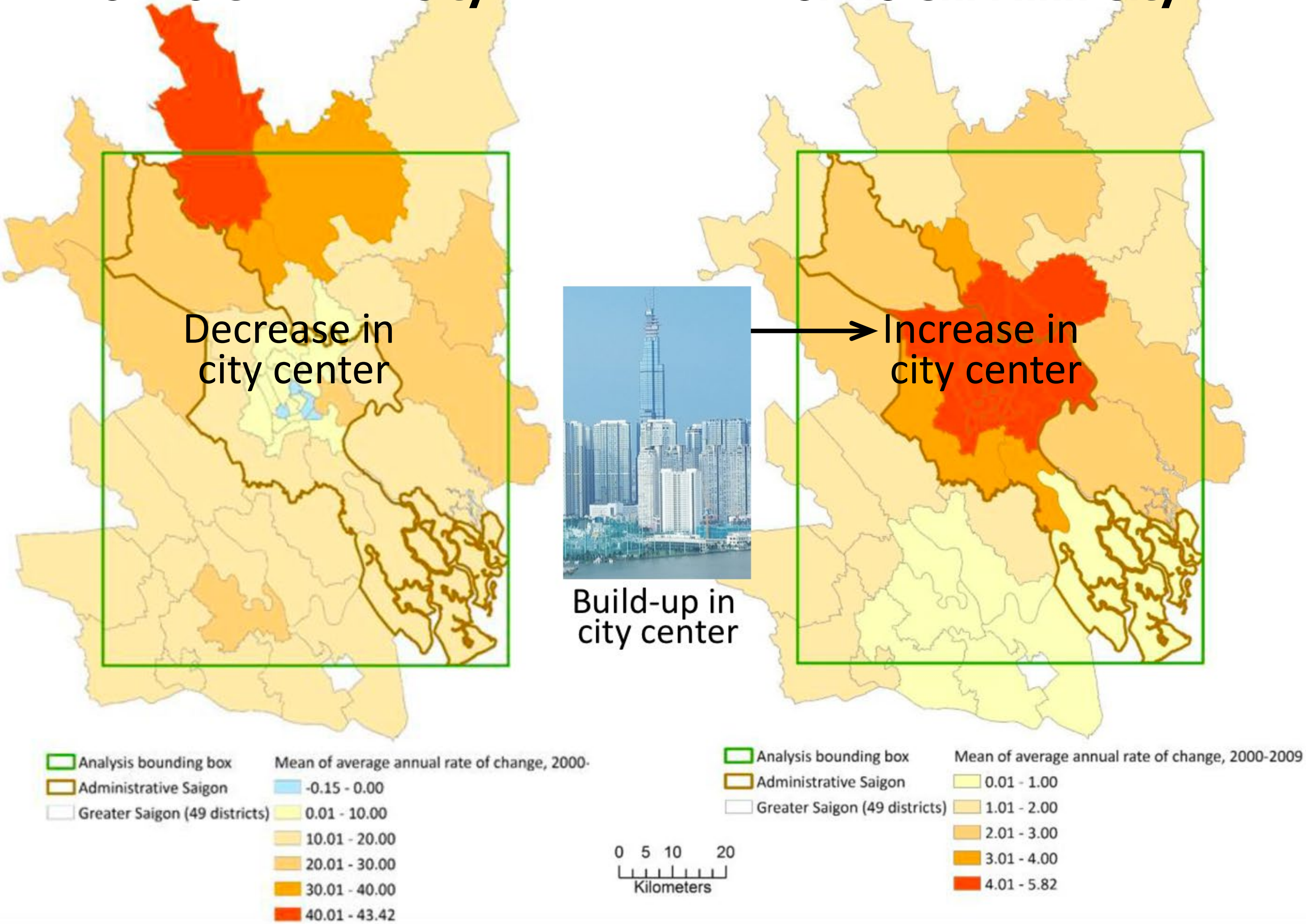
Total deaths

6.83M < 7M/y by air pollution

Urbanization in 2D versus 3D

GHSL 2D rate of change misrepresents urbanization of Ho Chi Minh City

DSM 3D rate of change captures urbanization of Ho Chi Minh City



D. L Balk, S. V. Nghiem, B. Jones, Z. Liu, and G. Dunn, https://doi.org/10.1016/j.landurbplan.2018.07.009, 2019

Dense Sampling Method (DSM)

Patent US8401793, US20100280756, WO2010127140A3

Enable global observations without gaps in time and space with QuikSCAT radar, 1-km grid, 2000-2009

$$\overline{\sigma}_0 = \frac{1}{N}\sum_{i=1}^{N}\overline{\sigma}_0(\phi_i, t_i) = \frac{1}{N\Gamma_A}\sum_{i=1}^{N}\iint_A dx\,dy\,G(\phi_i, x, y)\,\sigma_0(\phi_i, t_i, x, y)$$

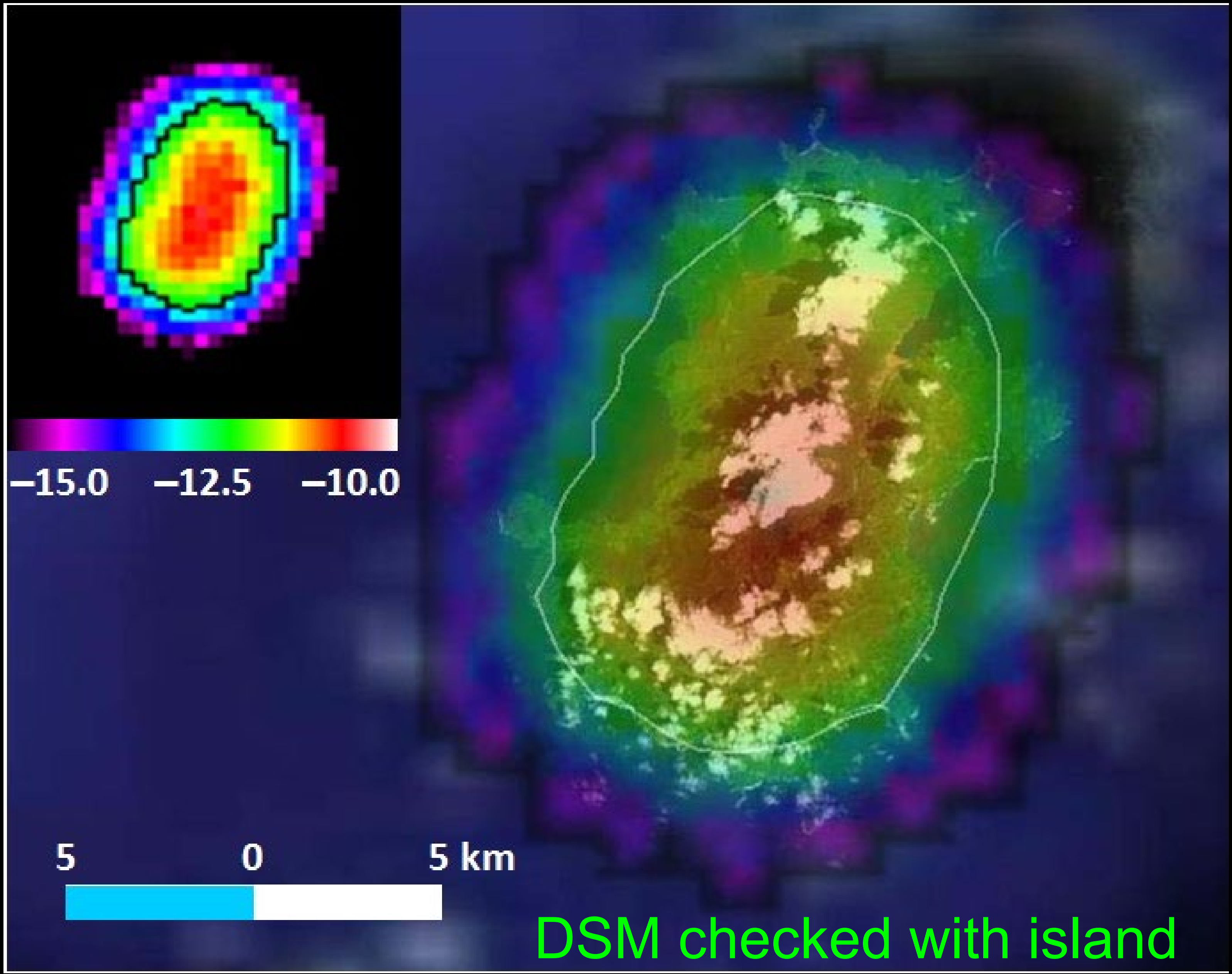
$$\sigma_0(\phi_i, t_i, x, y) = \overline{\sigma}_0(x, y) + \varepsilon(\phi_i, t_i, x, y)$$

$$\overline{\sigma}_{0M} = \frac{1}{\Gamma_A}\iint_A dx\,dy\left[\sum_{i=1}^{N}\frac{G(\phi_i, x, y)}{N}\right]\overline{\sigma}_0(x, y)$$

$$\mathcal{R} = \frac{1}{\Gamma_A}\iint_A dx\,dy\sum_{i=1}^{N}\left[\frac{G(\phi_i, x, y)}{N}\varepsilon(\phi_i, t_i, x, y)\right]$$

Dynamic Atlas of Global Continuum for 4D Urban
Observations: 3D (volume = lateral x vertical) + 1D in time

Verification - Príncipe Island



Verification - Nukunonu Atoll in the South Pacific

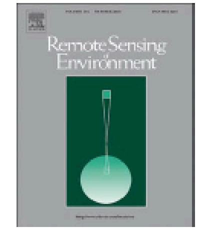
DSM checked with atoll

Validation of DSM 2D Urban Extent

Contents lists available at ScienceDirect

Remote Sensing of Environment

journal homepage: www.elsevier.com/locate/rse



Expansion of major urban areas in the US Great Plains from 2000 to 2009 using satellite scatterometer data

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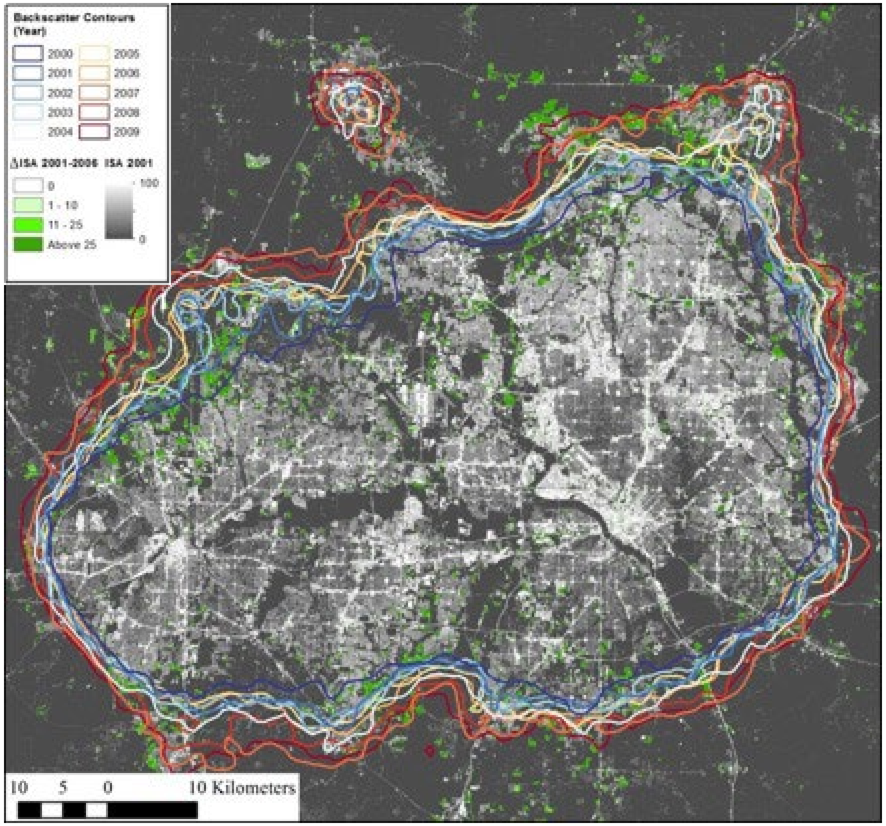
ARTICLE INFO

Keywords:
Urbanization
QuikSCAT
Dense Sampling Method
Impervious surface
LandScan

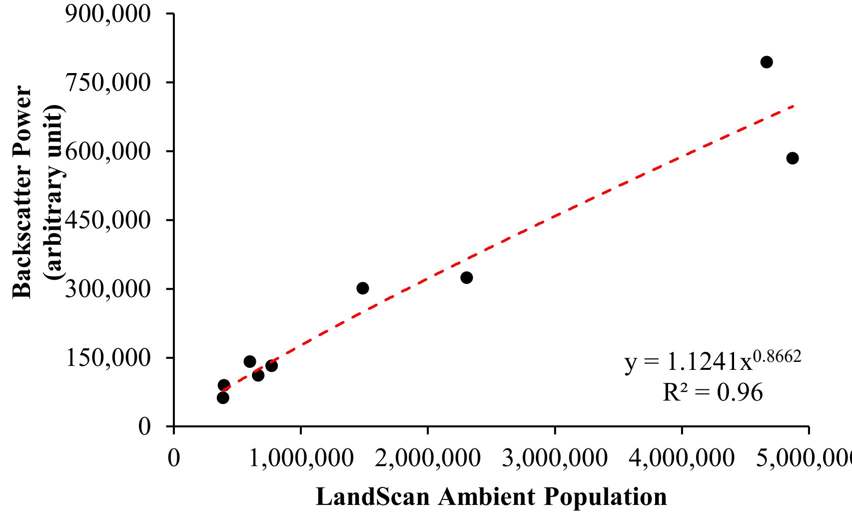
ABSTRACT

A consistent dataset delineating and characterizing changes in urban environments will be valuable for socio-economic and environmental research and for sustainable urban development. Remotely sensed data have been long used to map urban extent and infrastructure at various spatial and spectral resolutions. Although many datasets and approaches have been tried, there is not yet a universal way to map urban extents across the world. Here we combined a microwave scatterometer (QuikSCAT) dataset at ~1 km posting with percent impervious surface area (%ISA) data from the National Land Cover Dataset (NLCD) that was generated from Landsat data, and ambient population data from the LandScan product to characterize and quantify growth in nine major urban areas in the US Great Plains from 2000 to 2009. Nonparametric Mann-Kendall trend tests on backscatter time series from urban areas show significant expanding trends in eight of nine urban areas with *p*-values ranging 0.032 to 0.001. The sole exception is Houston, which has a substantial non-urban backscatter at the northeastern edge of the urban core. Strong power law scaling relationships between ambient population and either urban area or backscatter power (r^2 of 0.96 in either model) with sub-linear exponents (β of 0.911 and 0.866, respectively) indicate urban areas become more compact with more vertical built-up structure than lateral expansion to accommodate the increased population. Increases in backscatter and %ISA datasets between 2001 and 2006 show agreement in both magnitude and direction for all urban areas except Minneapolis-St. Paul (MSP), likely due to the presence of many lakes and ponds throughout the MSP metropolitan area. We conclude discussing complexities in the backscatter data caused by large metal structures and rainfall.

Validation of DSM 2D Urban Extent



Dallas-Ft.Worth: DSM Backscatter contours (2000-2009) and %ISA from Landsat (2001 and 2006)



Dallas-Ft.Worth: DSM Backscatter vs LandScan Ambient Population

DSM Correlation with Impervious Surface Area

Urban Area	r^2	cor	rho	tau
Dallas-Ft. Worth	0.70**	0.84**	0.52	0.43
Houston	0.83**	0.91*	0.90**	0.79**
Kansas City	0.87***	0.94***	0.98***	0.93***
Oklahoma City	0.87***	0.93***	0.88**	0.71*
Omaha	0.68*	0.82*	0.88**	0.71*
Wichita	0.79**	0.89**	0.76*	0.57
Des Moines	0.88***	0.94***	0.95**	0.86**

*, **, and *** for p-values less than 0.05, 0.01, and 0.001

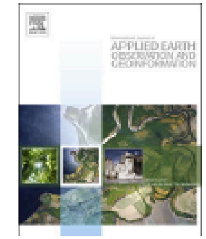
Nguyen, Nghiem, and Henebry, RSE, 204, 524-533, 2018

Validation of DSM 3D Buildings Volume

Contents lists available at ScienceDirect

Int J Appl Earth Obs Geoinformation

journal homepage: www.elsevier.com/locate/jag



Satellite scatterometer estimation of urban built-up volume: Validation with airborne lidar data

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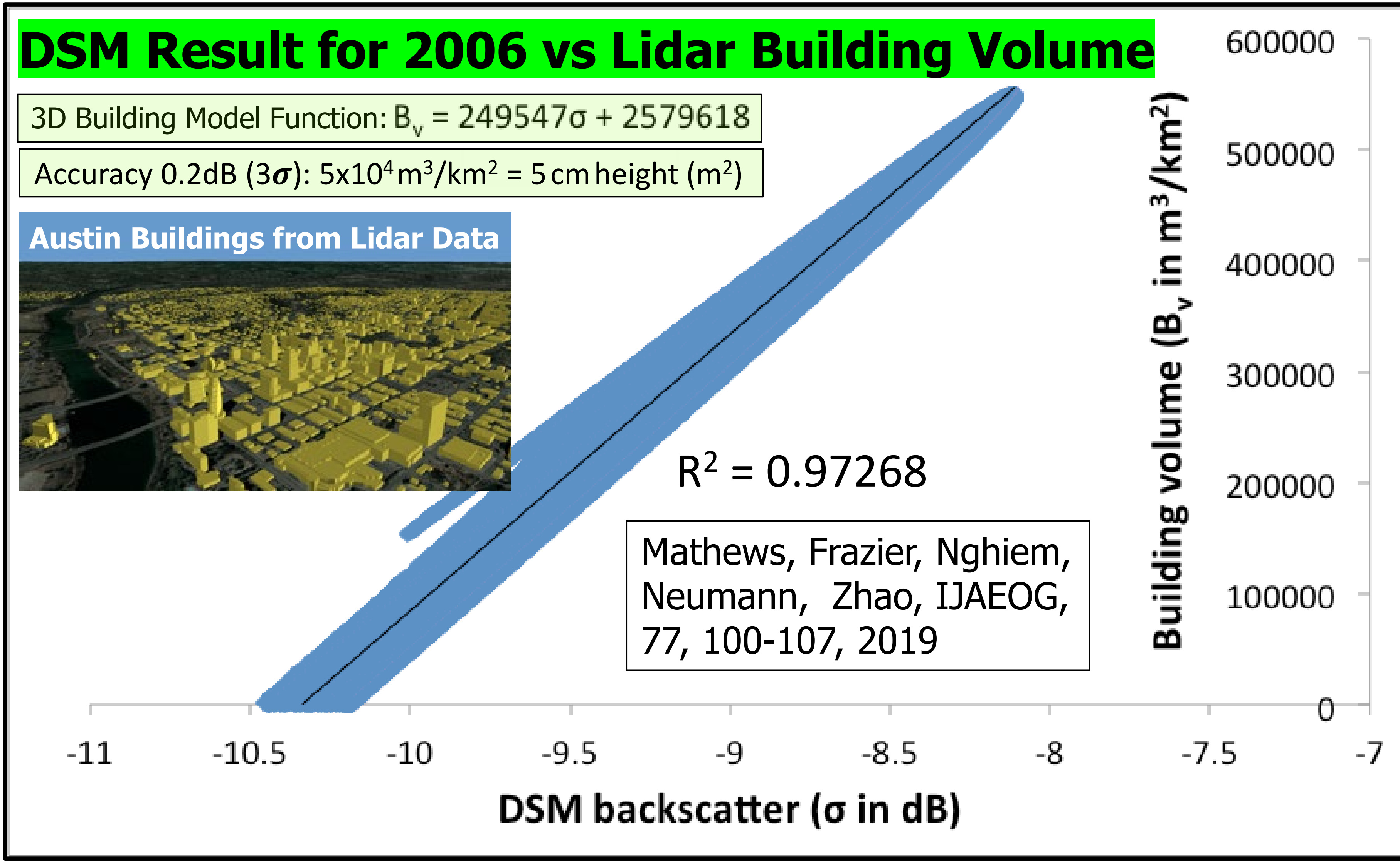
ARTICLE INFO

Keywords:
Radar
Dense sampling method
Lidar
Built-up volume
Land use
Land cover

ABSTRACT

Accurately mapping urban infrastructure and extent is a high priority for resource management and service allocation as well as for addressing environmental, socioeconomic, and geopolitical concerns. Most available data products only document surficial (two-dimensional) land use and land cover (LULC), yet a substantial component of urban growth occurs in the vertical dimension. Light detection and ranging (lidar) data offer the potential for monitoring three-dimensional (3D) change, but the extreme lack of systematic lidar coverage worldwide inflicts considerable gaps in both spatial and temporal coverage. Satellite scatterometer (radar) data may serve as an alternative data source for characterizing urban growth and development in both the horizontal and vertical directions. The accuracy of these radar-based datasets for estimating building volumes remains to be validated quantitatively. For nine U.S. cities, we test whether scatterometer data can be used to estimate 3D urban built-up volume. We found strong, linear correlations between the lidar-derived and radar-derived building volume estimates for all cities with r^2 values as high as 0.98 when using spatial trend analysis. Given the high expense that limits lidar data acquisition to small areas at sporadic points in time, satellite scatterometer data provide a breakthrough method for monitoring both vertical growth and horizontal expansion of cities across the world with a continuous decadal time scale.

Validation of DSM 3D Buildings Volume



DSM Result for 2000-2009: Austin B_v grew by 9.3%/decade

Validation of DSM 3D Buildings Volume

Validation with seven metropolitan areas distributed across the continental United States: Large differences among cities, located across a variety of ecoregions and environmental conditions.

EXCELLENT VALIDATION FOR 7 CITIES IN 6 STATES and DC

City	Lidar Year	Lidar Area	Pop. (2010)	r^2	r	ρ	τ
Atlanta, GA	2003	79 km^2	420,003	0.76	0.86	0.90	0.73
Austin, TX	2006	390 km^2	720,390	0.97	0.99	0.99	0.91
Buffalo, NY	2004	342 km^2	261,310	0.69	0.83	0.86	0.67
Detroit, MI	2004	347 km^2	713,777	0.81	0.90	0.93	0.78
San Antonio, TX	2003	640 km^2	1,327,407	0.97	0.98	0.97	0.87
Tulsa, OK	2008	1,329 km^2	391,906	0.84	0.92	0.93	0.77
Washington, DC	2008	8,297 km^2	601,723	0.98	0.99	0.98	0.91

r^2: coefficient of determination in linear model; r: Pearson correlation coefficient; ρ: Spearman rank correlation coefficient; τ: Kendall rank correlation coefficient. All correlations significant with p-values < 0.01.

Urbanization and Air Pollution in Beijing

Transformative Urban Changes of Beijing in the Decade of the 2000s

remote sensing

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4 Department of Geography, Université de Namur, rue de Bruxelles 61, B-5000 Namur, Belgium; catherine.linard@unamur.be
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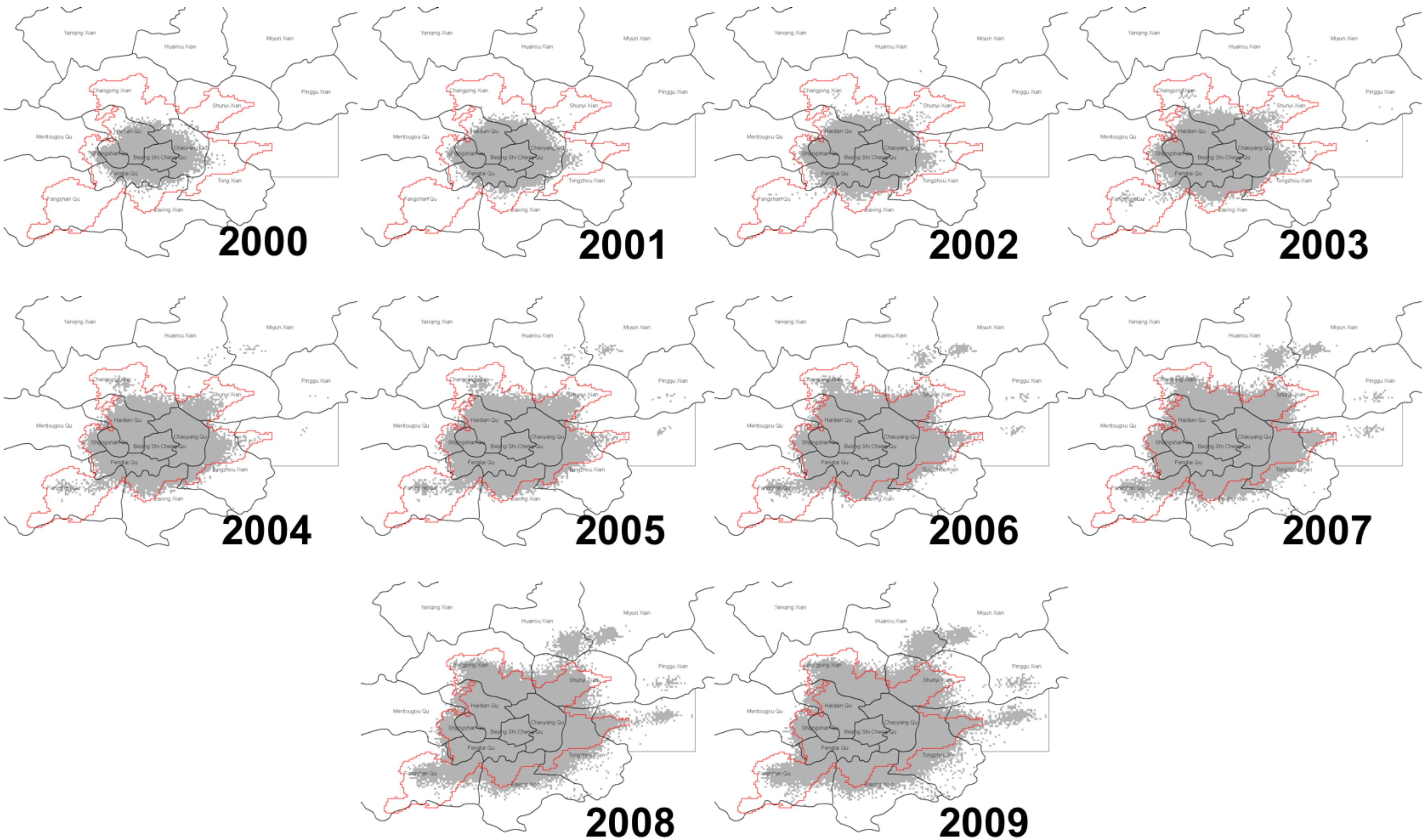
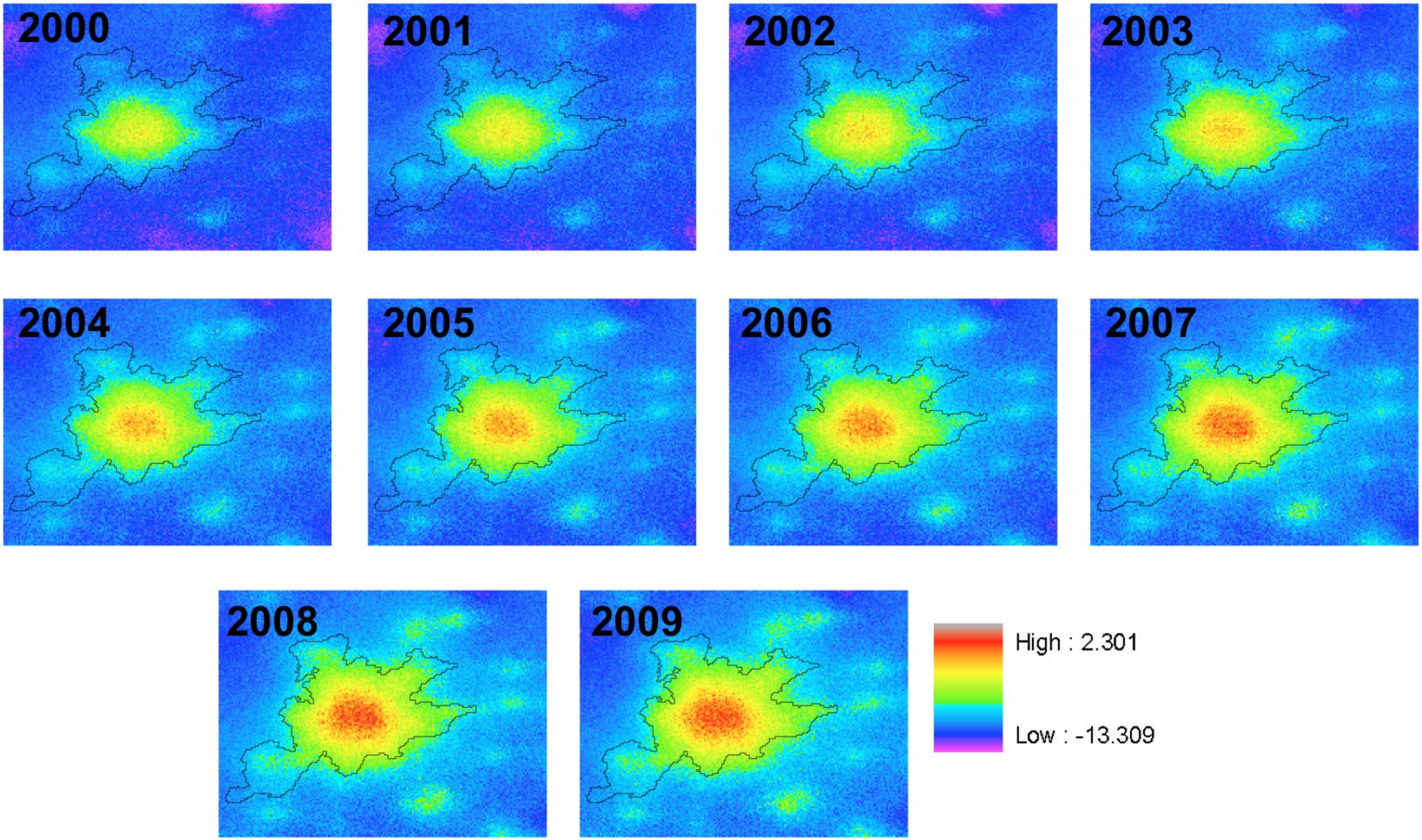
check for updates

Abstract: The rapid economic growth, the exodus from rural to urban areas, and the associated extreme urban development that occurred in China in the decade of the 2000s have severely impacted the environment in Beijing, its vicinity, and beyond. This article presents an innovative approach for assessing mega-urban changes and their impact on the environment based on the use of decadal QuikSCAT (QSCAT) satellite data, acquired globally by the SeaWinds scatterometer over that period. The Dense Sampling Method (DSM) is applied to QSCAT data to obtain reliable annual infrastructure-based urban observations at a posting of ~1 km. The DSM-QSCAT data,

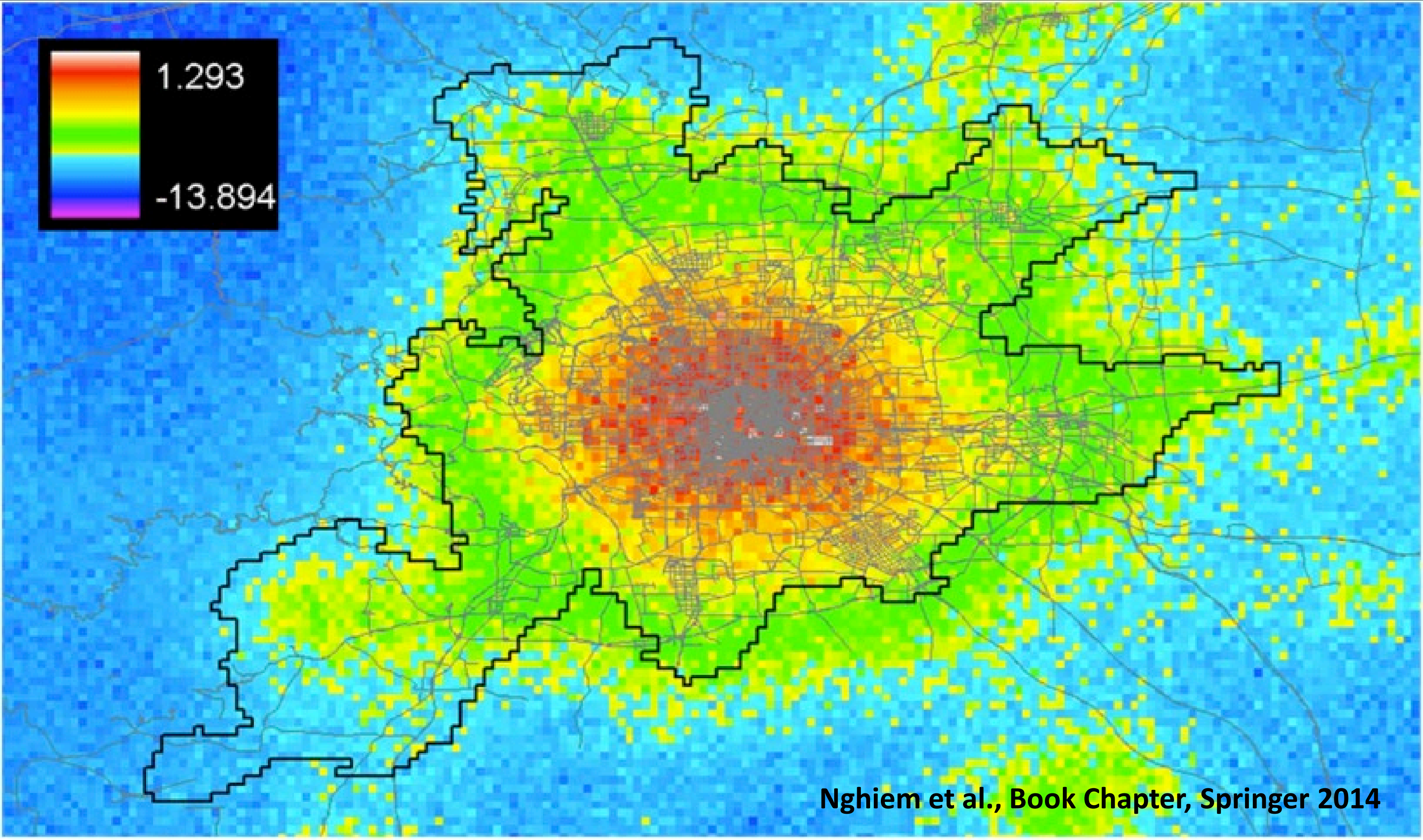
Beijing Urban Extent from DSM



Beijing Building Volume Pattern

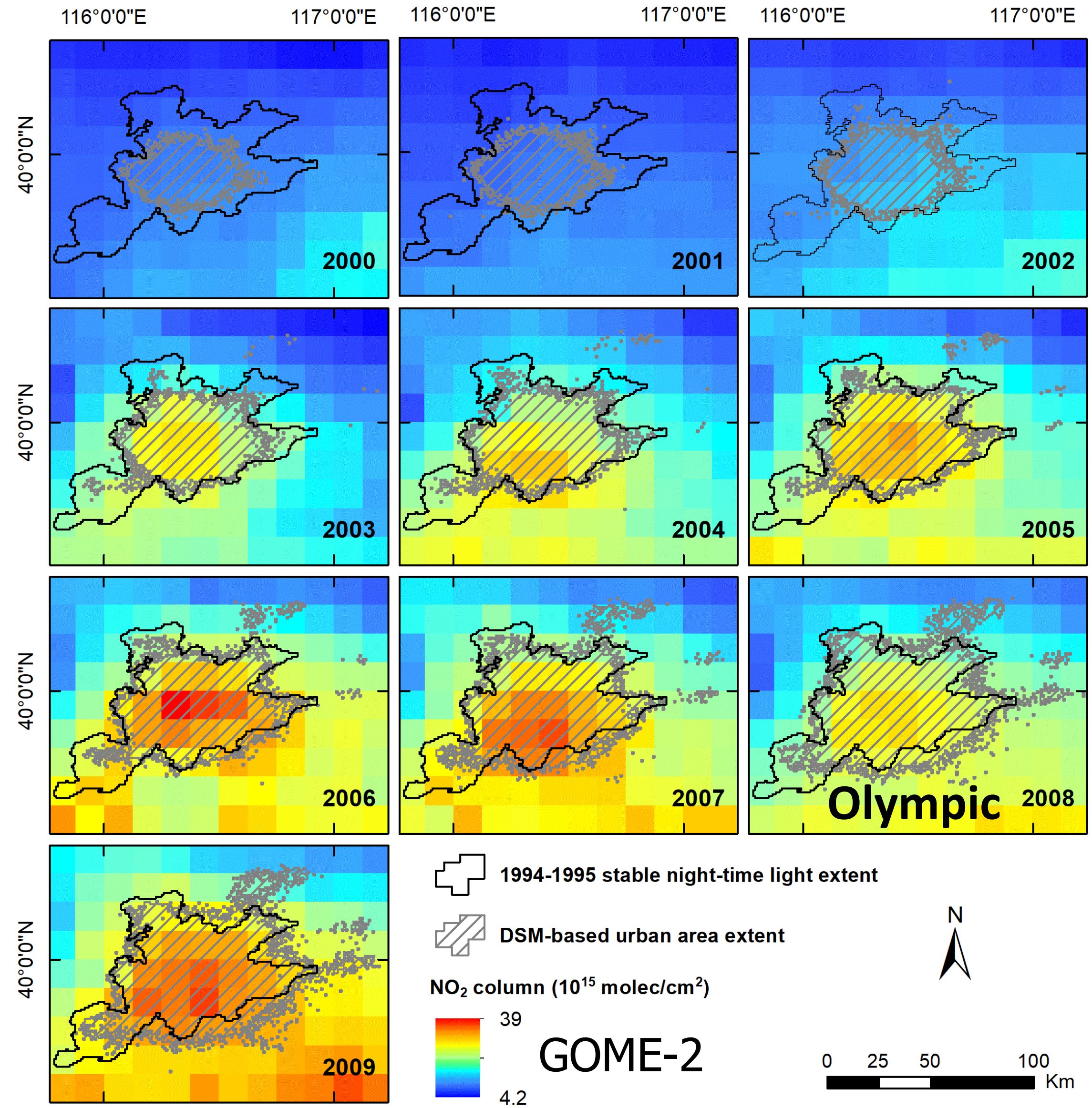


Infrastructure – Road Network



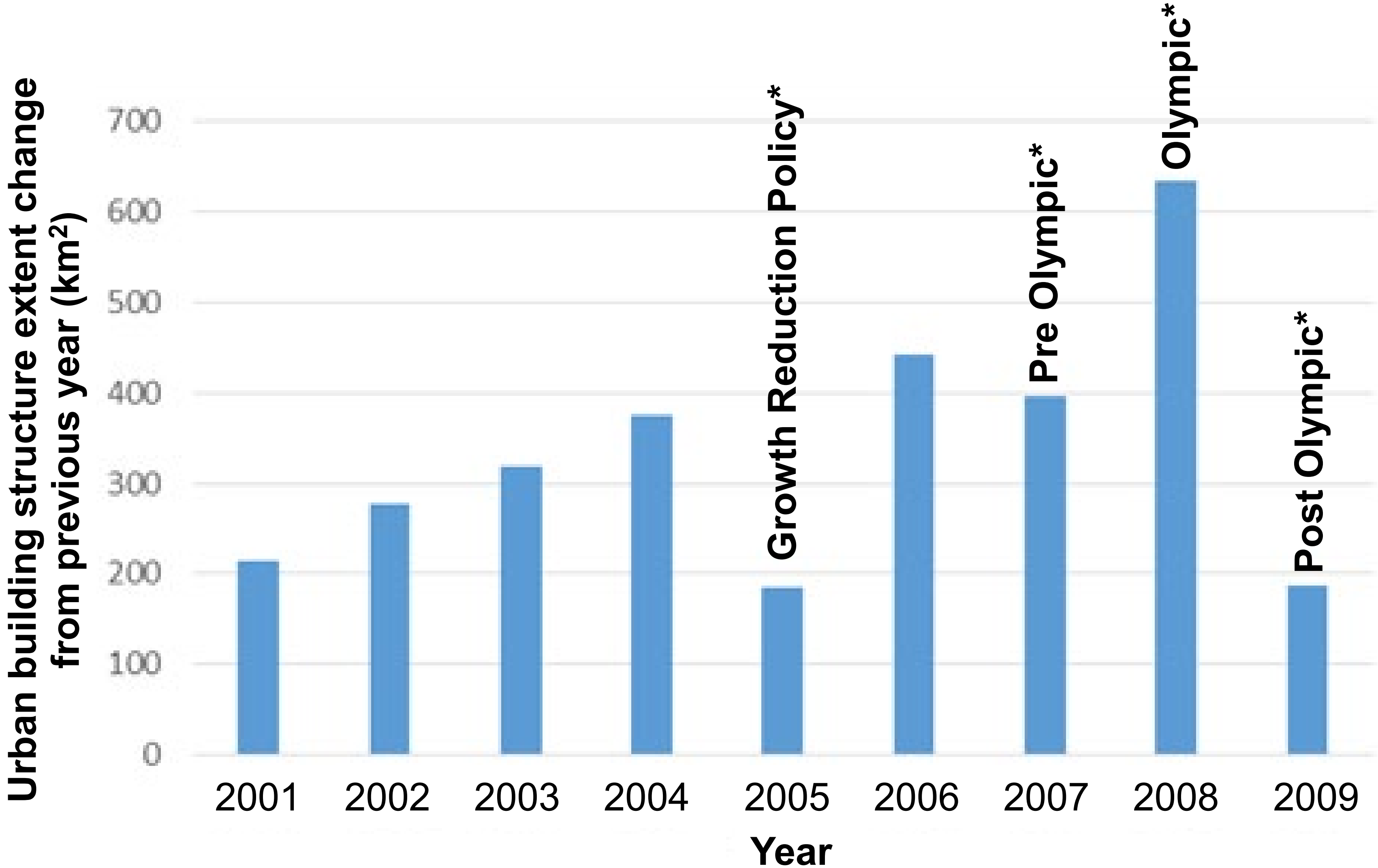
Beijing DSM with road network (grey) and Night-Light urban extent (black).

Beijing Urban Change and NO_2



Sorichetta, Nghiem, Masetti, Linard, and Richter, Transformative Changes of Beijing in the Decade of the 2000s, 2020.

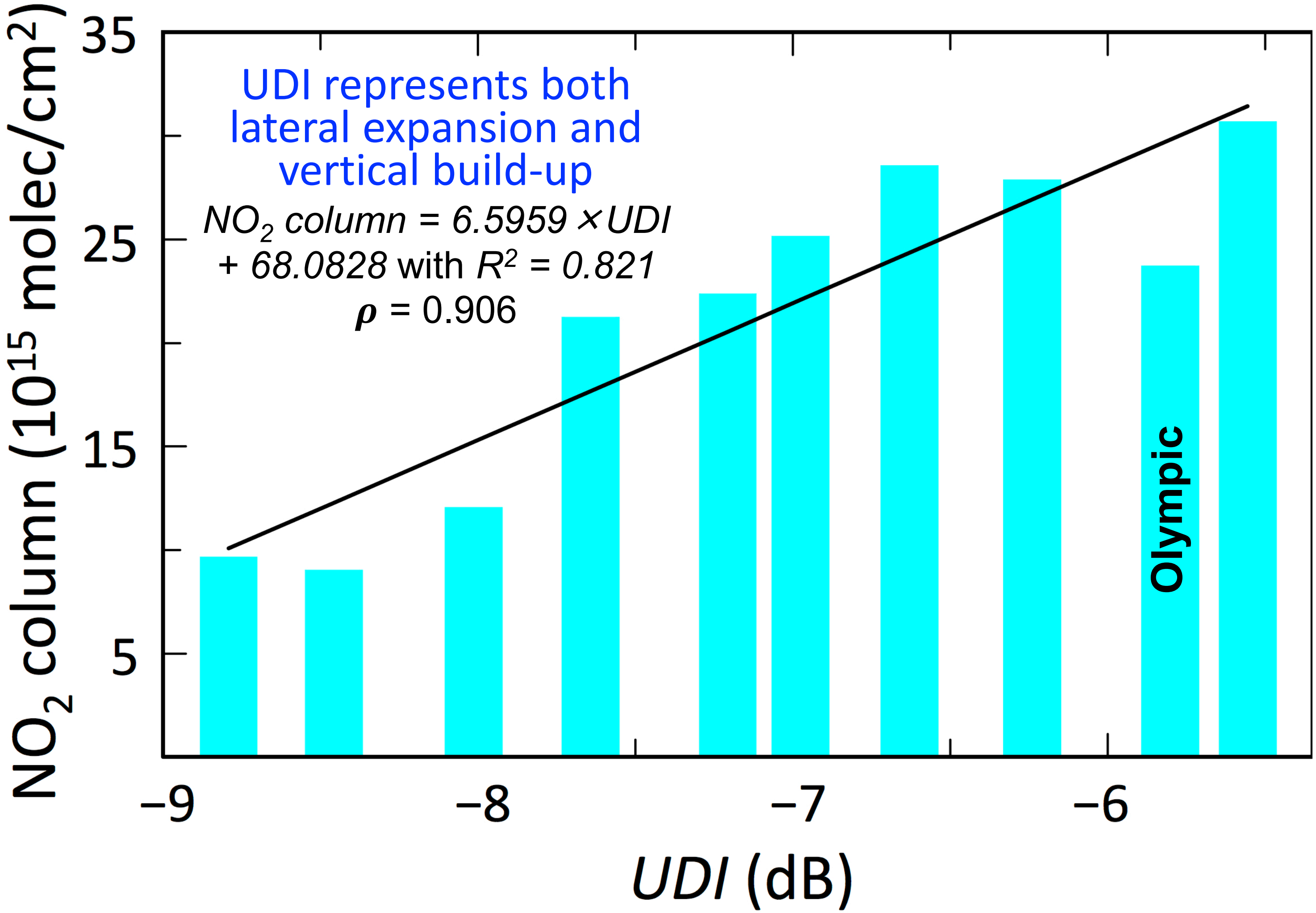
Annual Growth of the Beijing Building Structure Extent in the Decade of the 2000s



* Broudehoux, A.M., 2007. Spectacular Beijing: The Conspicuous Construction of an Olympic Metropolis, *J. Urban Affairs*, 29(4), 383-399.

Sorichetta A., Nghiem S.V., Masetti M., Richter A., Linard C., Gaughan A.E., Stevens F.R., and Tatem A.J, 2014

Beijing Urban Development Index (UDI) vs NO_2



Sorichetta, Nghiem, and Masetti, Transformative Changes of Beijing in the Decade of the 2000s, 2020.

3D Urban Building Volume from DSM

New Advances for Urban-Climate Nested Physical Model to Assess Air Pollution

Decadal DSM 3D urban building volume data products were successfully used as input to the urban-climate-nested Gas-Aerosol-Transport-Radiation-General-Circulation-Mesoscale-and-Ocean Model (GATOR-GCMOM, developed by Jacobson et al.) to physically examine and quantitatively assess air pollution due to urbanization.

3D Modeling – GATOR-GCMOM from global circulation to urban scale

- **GATOR-GCMOM is used to simulate the global, regional, and urban climate and air pollution health impacts resulting from urbanization.** The goal is to investigate effects on climate and air quality of annual changes in the extent of urbanization over regions of mega urbanization in Asia and to compare with other regions in the 2000s.

- This model nests climate, meteorological, gas, aerosol, and radiative parameters simultaneously from the global through urban scale. simulates meteorology and its feedback among gases, aerosol particles, cloud hydrometeor particles, surfaces, and radiation. Gas processes include emissions, photochemistry, gas-to-particle conversion, gas-to-hydrometeor conversion and exchange, gas-ocean exchange, advection, convection, molecular diffusion, turbulent diffusion, and dry deposition.

- At the land surface, each subgrid soil class is divided into vegetated and bare soil. Snow can accumulate on both soil and vegetation. For bare and vegetated soil, the surface energy balance equation accounts for latent heat, sensible heat, solar, thermal-IR, and energy fluxes.

- Oceans are represented in 3-D for some calculations and 2-D for others. A 2-D time-dependent mixed-layer ocean dynamics model driven by surface wind stress is used to solve for mixed-layer velocities, heights, and horizontal energy transport in each cell. The scheme conserves potential enstrophy, vorticity, energy, and mass and predicts gyres and major currents. Air ocean exchange, vertical diffusion, 3-D ocean equilibrium chemistry and pH are solved among the Na-Cl-Mg-Ca-K-H-O-Li-Sr-C-S-N-Br-F-B-Si-P system.

3D GATOR GCMOM – Beijing

AGU PUBLICATIONS

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE
10.1002/2014JD023008

Ring of impact from the mega-urbanization of Beijing between 2000 and 2009

Mark Z. Jacobson[1], Son V. Nghiem[2], Alessandro Sorichetta[3,4], and Natasha Whitney[1]

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Key Points:
- Beijing's urban extent, in terms of physical infrastructure change, quadrupled between 2000 and 2009
- Beijing's expansion created a ring of impact in the new portion of the city
- Urbanization slowed winds and increased pollution vertical dilution, temperature, and ozone

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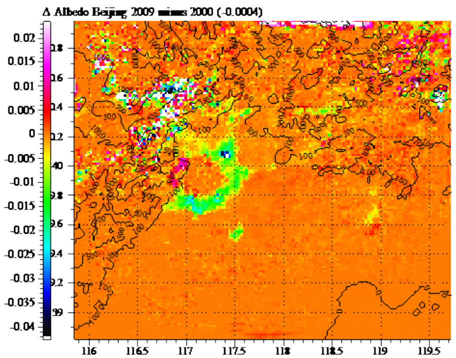
Citation:
Jacobson, M. Z., S. V. Nghiem, A. Sorichetta, and N. Whitney (2015), Ring of impact from the mega-urbanization of Beijing between 2000 and 2009, *J. Geophys. Res. Atmos.*, *120*, 5740–5756, doi:10.1002/2014JD023008.

Received 22 DEC 2014
Accepted 19 MAY 2015

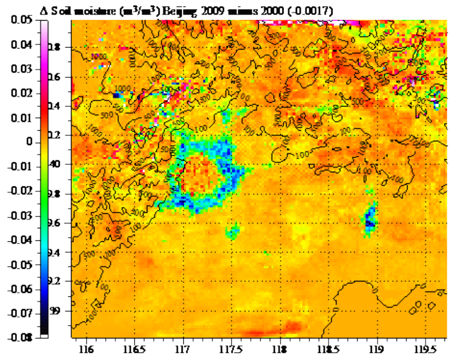
Abstract The transient climate, soil, and air quality impacts of the rapid urbanization of Beijing between 2000 and 2009 are investigated with three-dimensional computer model simulations. The simulations integrate a new satellite data set for urban extent and a geolocated crowd-sourced data set for road surface area and consider differences only in urban land cover and its physical properties. The simulations account for changes in meteorologically driven natural emissions but do not include changes in anthropogenic emissions resulting from urbanization and road network variations. The astounding urbanization, which quadrupled Beijing urban extent between 2000 and 2009 in terms of physical infrastructure change, created a *ring of impact* that decreased surface albedo, increased ground and near-surface air temperatures, increased vertical turbulent kinetic energy, and decreased the near-surface relative humidity and wind speed. The meteorological changes alone decreased near-surface particulate matter, nitrogen oxides (NO_x), and many other chemicals due to vertical dilution but increased near-surface ozone due to the higher temperature and lower NO. Vertical dilution and wind stagnation increased elevated pollution layers and column aerosol extinction. In sum, the ring of impact around Beijing may have increased urban heating, dried soil, mixed pollutants vertically, aggravated air stagnation, and increased near-surface oxidant pollution even before accounting for changes in anthropogenic emissions.

3D GATOR GCMOM – Beijing

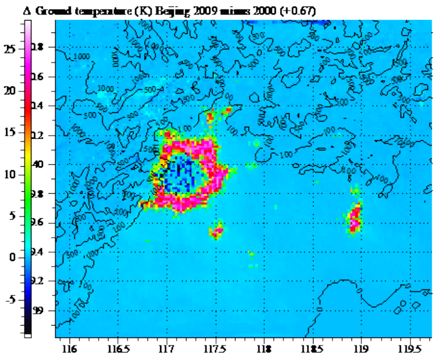
Quantifying changes in 2000-2009



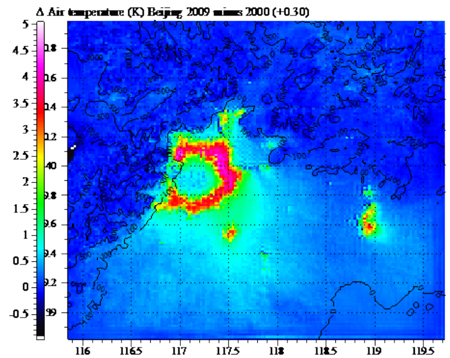
Albedo Change



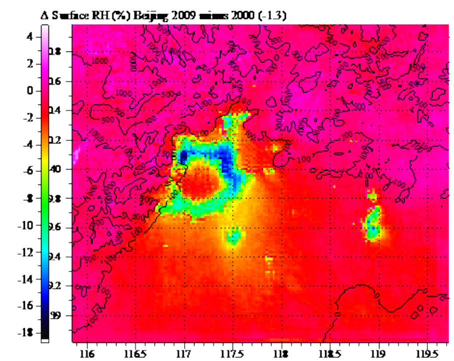
Soil Moisture Change



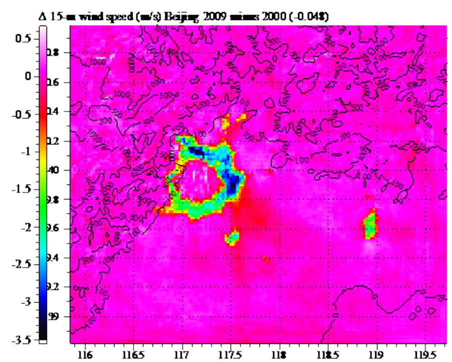
Ground Temperature



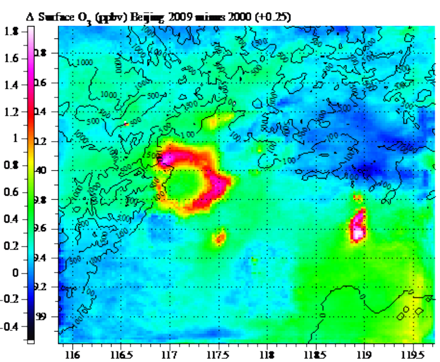
Surface Air Temperature



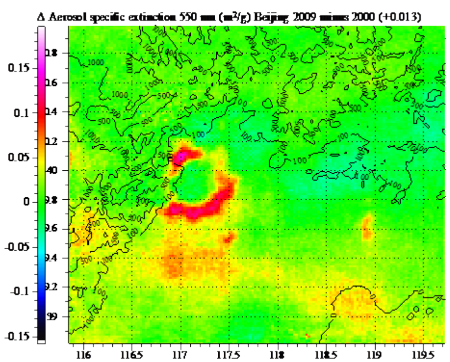
Surface Rel. Humidity



15-m Wind Speed



Surface Ozone



Aerosol Spc. Extinction

3D GATOR GCMOM – Beijing

"Ring Around the Beijing"

- Increasing urban heat
- Drier soil condition
- More air stagnation
- Worse smog condition
- More ozone pollution
- More pollutant mixing upward

AGU100 ADVANCING EARTH AND SPACE SCIENCE

JGR

Journal of Geophysical Research: Atmospheres

RESEARCH ARTICLE
10.1029/2018JD029310

Short-Term Impacts of the Megaurbanizations of New Delhi and Los Angeles Between 2000 and 2009

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Key Points:
- A new method of quantifying urban extent from satellite data is derived
- New Delhi and Los Angeles urban extents increased ~80% and ~22.5% from 2000 to 2009
- Such changes alone had substantial modeled impacts on short-term weather and pollution

Supporting Information:
- Supporting Information S1

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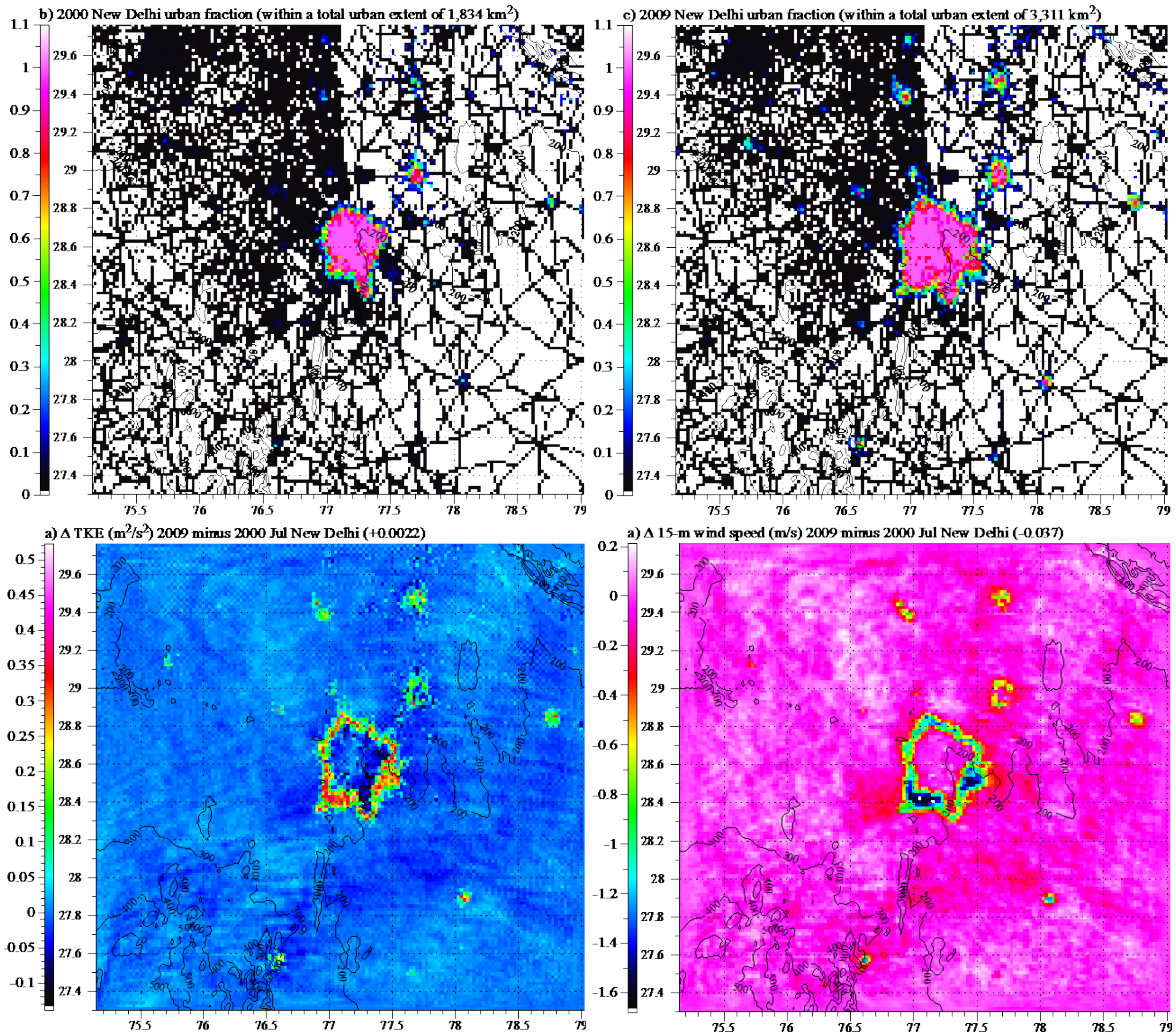
Citation:
Jacobson, M. Z., Nghiem, S. V., & Sorichetta, A. (2019). Short-term impacts of the megaurbanizations of New Delhi and Los Angeles between 2000 and 2009. *Journal of Geophysical Research: Atmospheres*, *124*, 35–56. https://doi.org/10.1029/2018JD029310

Abstract Urban areas are expanding worldwide due to increasing population, standard of living, and migration from rural areas. This study uses satellite and road data to quantify the urbanization of two megacities, New Delhi and Los Angeles, between 2000 and 2009. It then estimates, with a three-dimensional nested global-through-urban climate, weather, and air pollution model, Gas, Aerosol, Transport, Radiation, General Circulation, Mesoscale, and Ocean Model, the short-term atmospheric impacts of such urbanization alone. The simulations account for changes in meteorologically driven natural emissions, but not anthropogenic emissions, between 2000 and 2009. New Delhi's urban extent, defined based on the physical existence of its built structures and the transitional gradient from buildings to rural areas rather than on abrupt administrative borders, increased by ~80% and Los Angeles's by ~22.5% between 2000 and 2009. New Delhi experienced a larger increase in its urban extent relative to its population during this period than did Los Angeles. In both megacities, urbanization increased surface roughness, increasing shearing stress and vertical turbulent kinetic energy, decreasing near-surface and boundary layer wind speed, contributing to higher column pollution levels. Urbanization may also have increased downward solar plus thermal infrared radiation fluxes to the ground and consequently upward latent and sensible heat fluxes from the ground to the air, increasing near-surface air temperatures. As such, urbanization alone may have had notable impacts on both meteorology and air quality.

3D GATOR GCMOM – New Delhi



Using DSM for 4D observations of New Delhi in 2000-2009

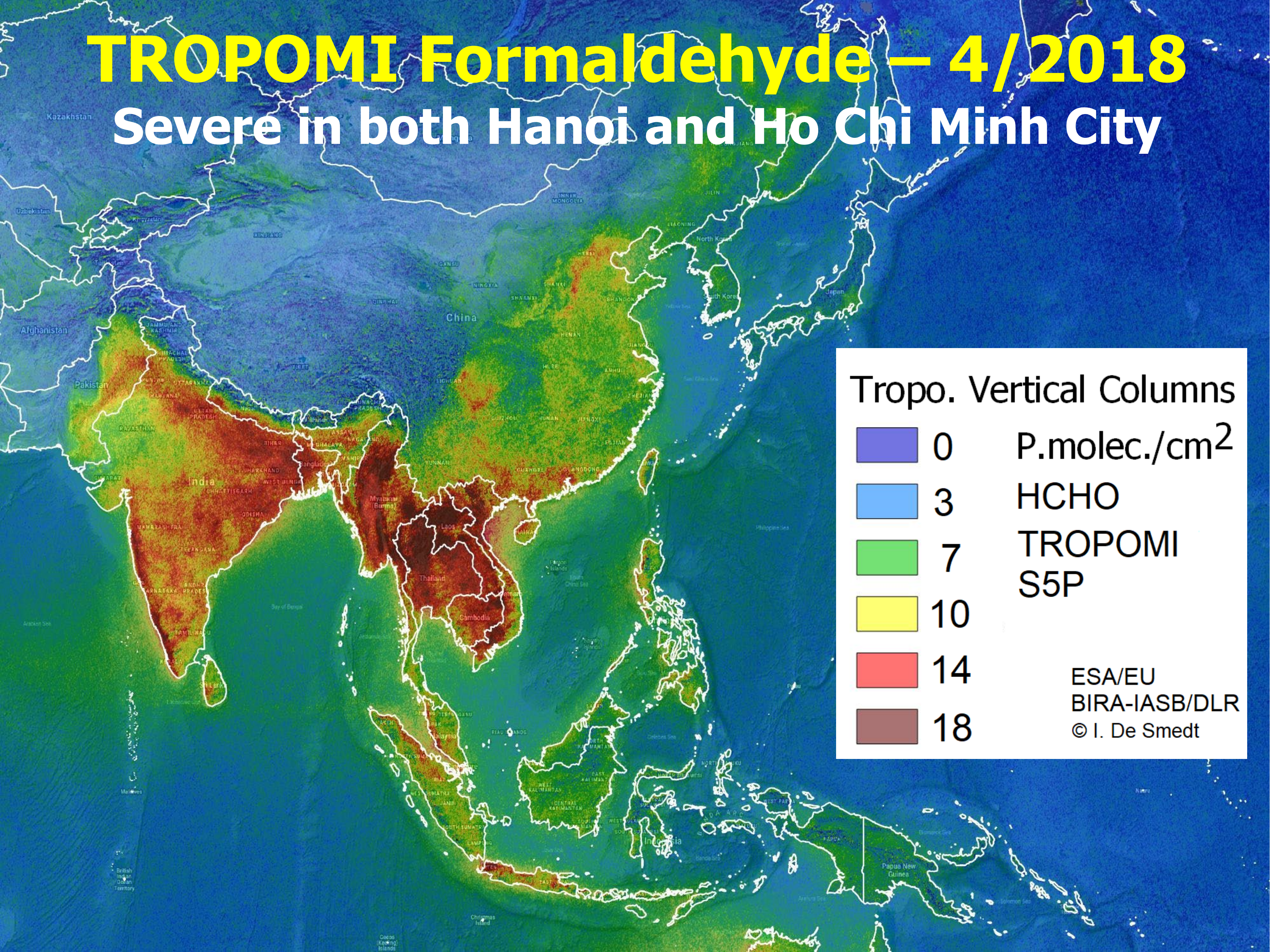
Air pollution over New Delhi outskirt – Credit R. Schmidt

GATOR-GCMOM (Gas, Aerosol, Transport, Radiation, General Circulation, Mesoscale, and Ocean Model) results for New Delhi, using DSM urban change input, showed “ring effects” with high turbulent kinetic energy and low wind: More mixing and stagnant air, more severe air pollution.

Formaldehyde in the Troposphere over Asia

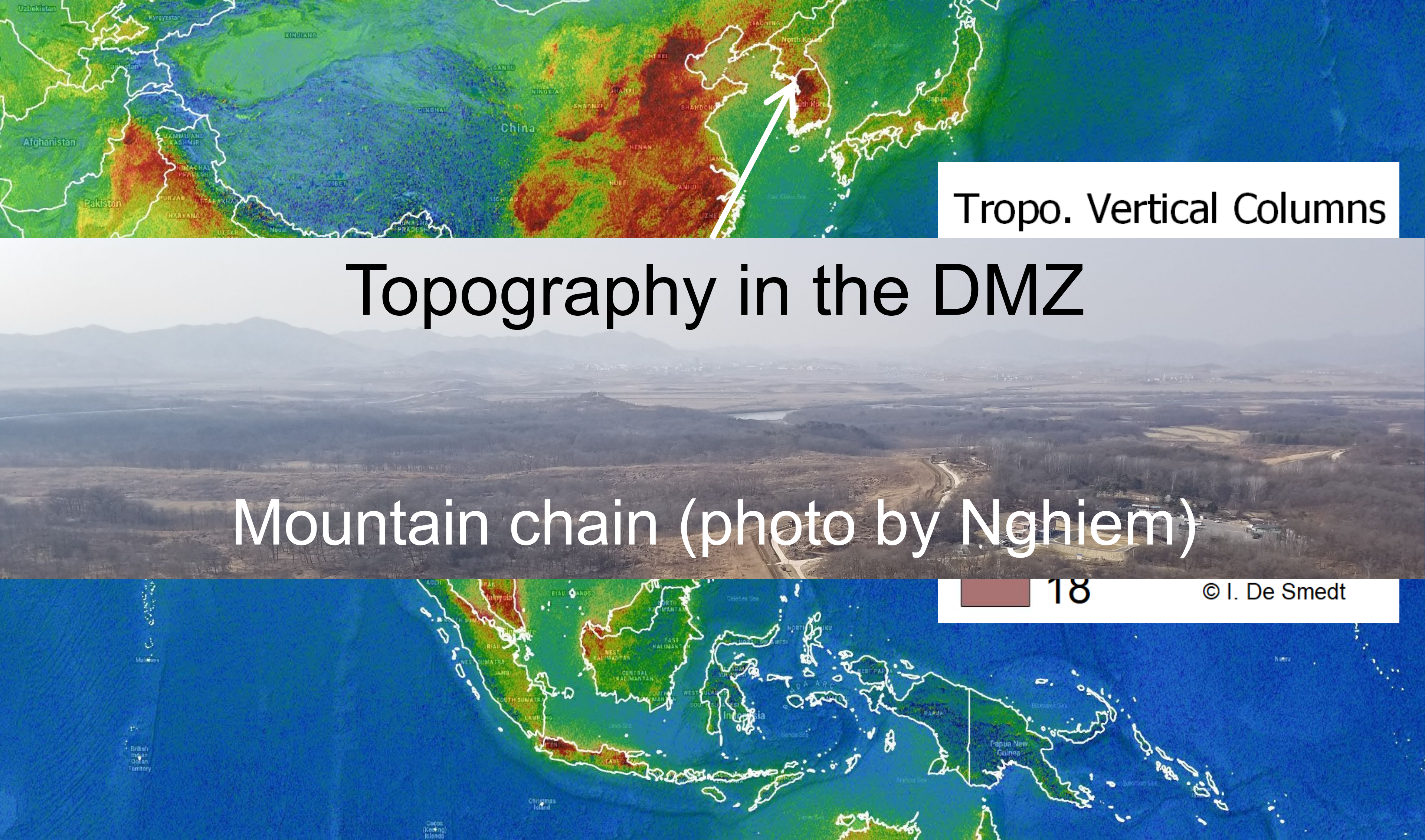
Formaldehyde (HCHO) is a gas pollutant and it can cause cancer.

It is a precursor of Hydoxymethane Sulfonate (HMS) giving mass to particulate matters (PM)


TROPOMI Formaldehyde – 4/2018
Severe in both Hanoi and Ho Chi Minh City
Tropo. Vertical Columns
0
3
7
10
14
18
P.molec./cm2
HCHO
TROPOMI
S5P
ESA/EU
BIRA-IASB/DLR
© I. De Smedt
China
India
Thailand
Cambodia
Afghanistan
Pakistan
Kazakhstan

TROPOMI Formaldehyde – 8/2018

Persist in Hanoi, clear-up in Ho Chi Minh City
Worsen in China and South Korea



Formaldehyde Sources

Geophysical Research Letters

Free Access

Biomass burning as a source of formaldehyde, acetaldehyde, methanol, acetone, acetonitrile, and hydrogen cyanide

Rupert Holzinger, Carsten Warneke, Armin Hansel, Alfons Jordan, Werner Lindinger, Dieter H. Scharffe, Gunnar Schade, Paul J. Crutzen

First published: 15 April 1999 | https://doi.org/10.1029/1999GL900156 | Citations: 278

Full-text

PDF TOOLS SHA

Abstract

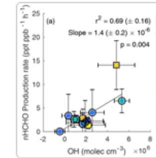
Using a novel experimental technique, based on proton transfer reaction mass spectrometry, from measurements of emissions from laboratory scale biomass burning experiments, we have estimated the source strengths of several potential HO_x producin

Atmos. Chem. Phys., 21, 18319–18331, 2021
https://doi.org/10.5194/acp-21-18319-2021

Article | Assets | Peer review | Metrics | Related articles

Research article 17 Dec 2021

Formaldehyde evolution in US wildfire plumes during the Fire Influence on Regional to Global Environments and Air Quality experiment (FIREX-AQ)



Jin Liao[1,2], Glenn M. Wolfe[1], Reem A. Hannun[1,3], Jason M. St. Clair[1,3], Thomas F. Hanisco[1], Jessica B. Gilman[4], Aaron Lamplugh[4,5], Vanessa Selimovic[6], Glenn S. Diskin[7], John B. Nowak[7], Hannah S. Halliday[8], Joshua P. DiGangi[7], Samuel R. Hall[9], Kirk Ullmann[9], Christopher D. Holmes[10], Charles H. Fite[10], Anxhelo Agastra[10], Thomas B. Ryerson[4,a], Jeff Peischl[4,5], Ilann Bourgeois[4,5], Carsten Warneke[4], Matthew M. Coggon[4,5], Georgios I. Gkatzelis[4,5,b], Kanako Sekimoto[11], Alan Fried[12], Dirk Richter[12], Petter Weibring[12], Eric C. Apel[9], Rebecca S. Hornbrook[9], Steven S. Brown[4], Caroline C. Womack[4,5], Michael A. Robinson[4,5], Rebecca A. Washenfelder[4], Patrick R. Veres[4], and J. Andrew Neuman[4,5]

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[6]Department of Chemistry, University of Montana, Missoula, MT, USA
[7]NASA Langley Research Center, Hampton, VA, USA
[8]Environmental Protection Agency, Durham, NC, USA

energies MDPI

Article

Real-Time Measurements of Formaldehyde Emissions from Modern Vehicles

Ricardo Suarez-Bertoa [1,*], Tommaso Selleri [1,2], Roberto Gioria [1], Anastasios D. Melas [1], Christian Ferrarese [1], Jacopo Franzetti [1], Bertold Arlit [3], Naoki Nagura [4], Takaaki Hanada [4] and Barouch Giechaskiel [1]

1 European Commission, Joint Research Centre (JRC), 21027 Ispra, Italy
2 European Environmental Agency (EEA), 1050 Copenhagen, Denmark
3 AVL Emission Test Systems GmbH, 76571 Gaggenau, Germany
4 HORIBA Ltd., Shiga 520-0102, Japan
* Correspondence: ricardo.suarez-bertoa@ec.europa.eu

Abstract: Formaldehyde (HCHO), a carcinogenic carbonyl compound and precursor of tropospheric ozone, can be found in vehicle exhaust. Even though the continuous monitoring of HCHO has been recommended, the real-world emissions from the road transport sector are not commonly available. The main reason for this knowledge gap has been the difficulty to measure HCHO in real-time and during real-world testing. This, for instance, increases the uncertainty of the O_3 simulated by air quality models. The present study investigates real-time HCHO measurements comparing three Fourier Transform InfraRed spectrometers (FTIRs) and one Quantum Cascade Laser InfraRed spectrometer (QCL-IR) directly sampling from the exhaust of one gasoline passenger car, one Diesel commercial vehicle and one Diesel heavy-duty vehicle, all meeting recent European

Formaldehyde in the Indoor Environment

Tunga Salthammer*†, Sibel Mentese‡, and Rainer Marutzky†

View Author Information

Cite this: *Chem. Rev.* 2010, 110, 4, 2536–2572
Publication Date: January 12, 2010
https://doi.org/10.1021/cr800399g

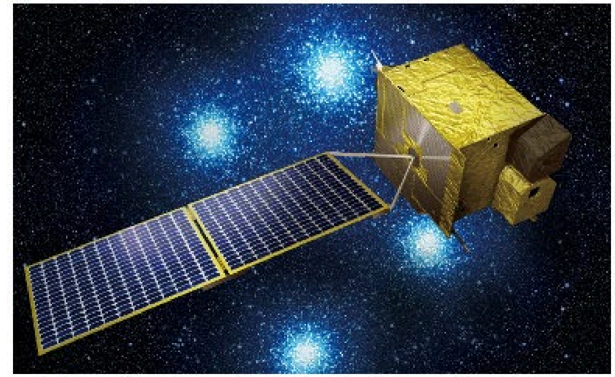
SUBJECTS: Aldehydes, Atmospheric chemistry, Computer simulations, Ma

1 Introduction

ARTICLE SECTIONS Jump To

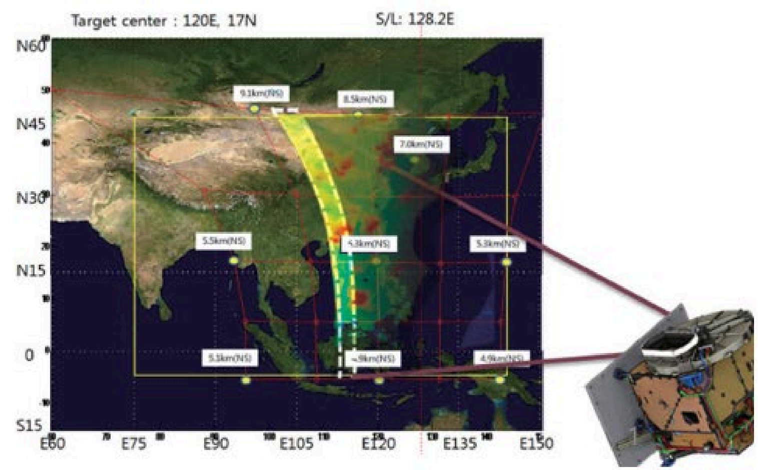
GEMS

Geostationary Environment Monitoring Spectrometer



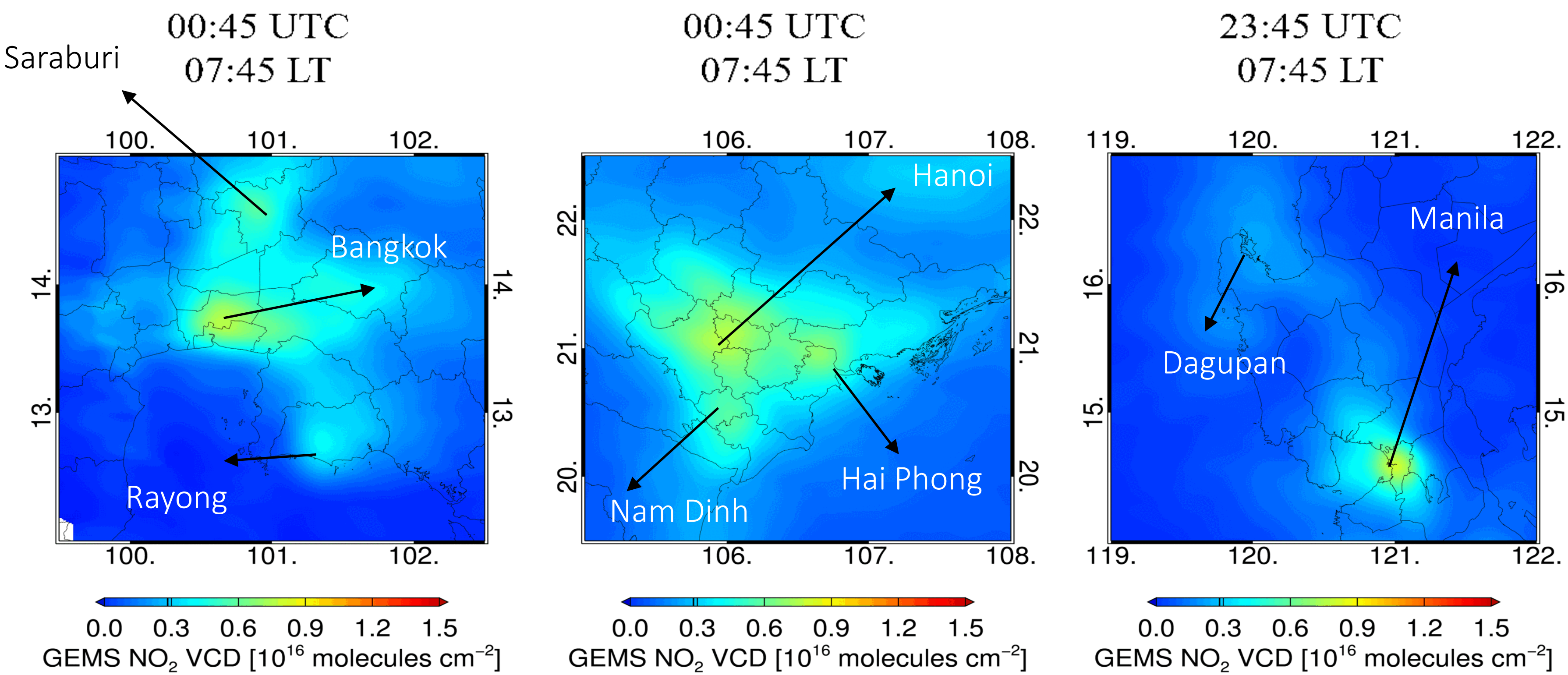
- On board GEO-KOMPSAT2B
- World first UV-Vis hyperspectral sensor in space

Wavelength range	300-500nm
FWHM	0.6nm
Time resol.	hourly
Spatial resol.	3.5km x 8km (Seoul)
FOR	5,000km x 5,000km (5°S - 45°N, 75°E - 145°E/**East Asia**)
Major products	SO_2, NO_2, O_3, HCHO, AOD



Hanlim Lee, 2023

GEMS Total NO_2 VCD



Park J.S. and Lee H., under review, Nature Geoscience

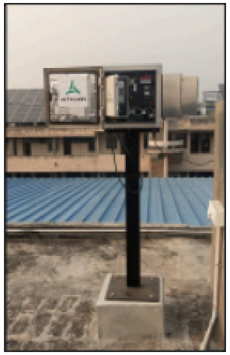
In-Situ Ambient Particulate Matter Monitoring for the MAIA Mission

JPL deployed PM monitors in selected MAIA target areas around the world to augment existing monitoring networks.

				
	SS5-$PM_{2.5}$ filter-based sampler	**Aerosol Mass and Optical Depth (AMOD)**	**microAeth MA350 aethalometer**	**PA-II-SD**
Vendor	AirPhoton (SPARTAN network)	Colorado State University	AethLabs	PurpleAir
Pollutants	$PM_{2.5}$ speciation	$PM_{2.5}$ speciation	Black carbon	Total $PM_{2.5}$
MAIA Target Areas (x Qty)	CHN-Beijing (x1) ETH-AddisAbaba (x1) IND-Delhi (x1) ISR-TelAviv (x2) TWN-Taipei (x2) USA-Los Angeles (x1) ZAF-Johannesburg (x2)	CHN-Beijing (x1) ETH-AddisAbaba (x2) IND-Delhi (x3) TWN-Taipei (x2) USA-Atlanta (x1) USA-Los Angeles (x1) ZAF-Johannesburg (x1)	CHN-Beijing (x1) ETH-AddisAbaba (x2) IND-Delhi (x1) USA-Los Angeles (x1)	ETH-AddisAbaba (x10)

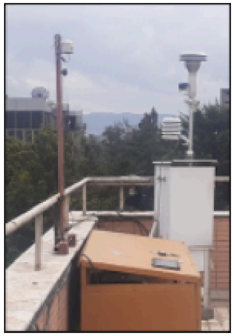
AMODs in Tainan, Taiwan
Cheng Kung University

MA350 in New Delhi, India
IIT Delhi



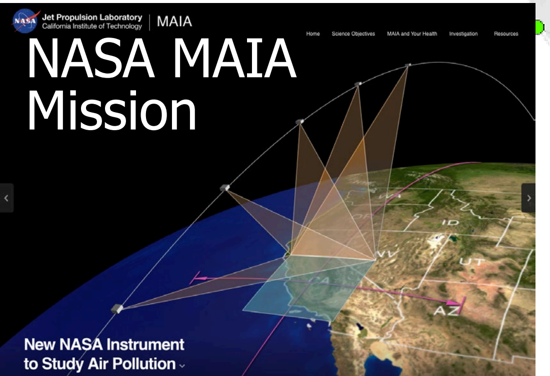
AirPhoton Sampler in Haifa, Israel
Technion Israel Institute of Technology

PurpleAir in Addis Ababa Ethiopia
Black Lion Hospital



Example photos of the MAIA monitoring sites around the world

Study areas include Hanoi



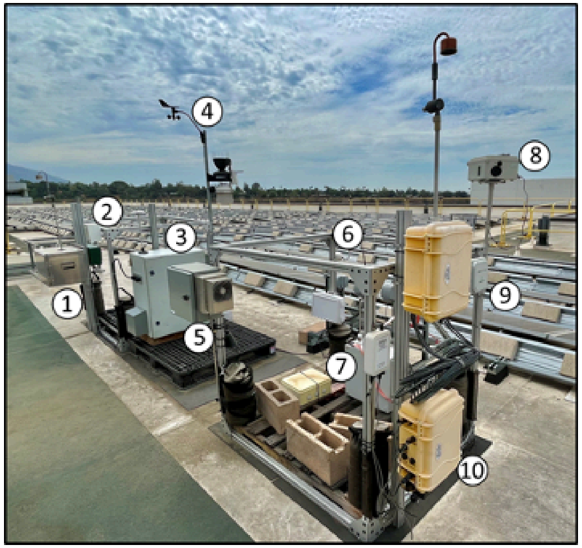
https://maia.jpl.nasa.gov/ **Multi-Angle Imager for Aerosols (MAIA)**
Satellite mission to study human health and improve lives

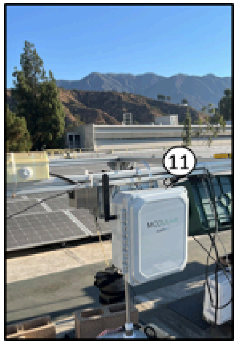
In-Situ Ambient Air Monitoring at the Jet Propulsion Laboratory

- Monitors the physical and chemical properties of a wide range of air pollutants.
- Supports the MAIA flight mission and several in-house projects at JPL.

	Instrument	Measured Parameter(s)	Measurement Type	Measurement Interval	Data Latency	Measurement Start Date
①	Airphoton Nephelometer MPP100	Multi-Angle, Multi-wavelength Polarized Aerosol Scattering	Continuous	2 minutes	Real-time	Jun 2022
②	Aeroqual AQY	NO2, O3, PM2.5	Continuous	1 hour	Real-time	Nov 2022
③	Aerosol Dynamics Scanning Electrical Mobility Spectrometer (SEMS)	Ultrafine Particle Number Size Distribution (8 - 420 nm)	Continuous	1 minute	Real-time	Aug 2022
④	Davis Vantage Pro2 Weather Station	T, RH, WS/WD, Dew Point, Barometric Pressure, etc.	Continuous	15 minutes	Real-time	March 2021
⑤	AethLabs microAeth MA350	Multi-wavelength Particle Absorption	Continuous	1 minute	Real-time	March 2021
⑥	PurpleAir PA-II	PM1, PM2.5, PM10 Mass	Continuous	2 minutes	Real-time	Nov 2020
⑦	GRIMM EDM 164	Size-resolved PM Mass and Number (0.25 - 32 µm)	Continuous	15 minutes	Real-time	Nov 2020
⑧	Colorado State University Aerosol Mass and Optical Depth (AMOD)	PM2.5, Aerosol Optical Depth	Continuous	2 minutes	Real-time	Nov 2021
		PM2.5 Chemical Components (e.g., Sulfate, Nitrate, Elemental Carbon, Organic Carbon, Metals, etc.)	24-hr Integrated	Every 3rd Day	3-6 Months	
⑨	QuantAQ Modulair-PM	Size-resolved PM Mass and Number (0.35 - 40 µm)	Continuous	1 minute	Real-time	Mar 2022
⑩	AirPhoton SS5 (as part of SPARTAN network)	PM2.5 Chemical Components (e.g., Sulfate, Nitrate, Elemental Carbon, Organic Carbon, Metals, etc.)	24-hr Integrated	Every 3rd Day	3-6 Months	Nov 2021
⑪	QuantAQ Modulair	Size-resolved PM Mass and Number (0.35 - 40 µm), CO, NO, NO2, O3, CO2	Continuous	1 minute	Real-time	Sep 2022
⑫	CIMEL Sun Sky Lunar Multispectral Photometer (as part of AERONET network)	Aerosol Optical Depth, Volume Size Distribution, Complex Refractive Index, Shape Factor, Water Vapor Content	Continuous	2 minutes	Real-time	Oct 2022
*	2B Technologies NOx Monitor	NO, NO2, NOx	Continuous	5 minutes	Real-time	Nov 2021
*	Serinus 51 SO2 Monitor	SO2	Continuous	5 minute	Real-time	Nov 2021

* *Installed at a nearby building*





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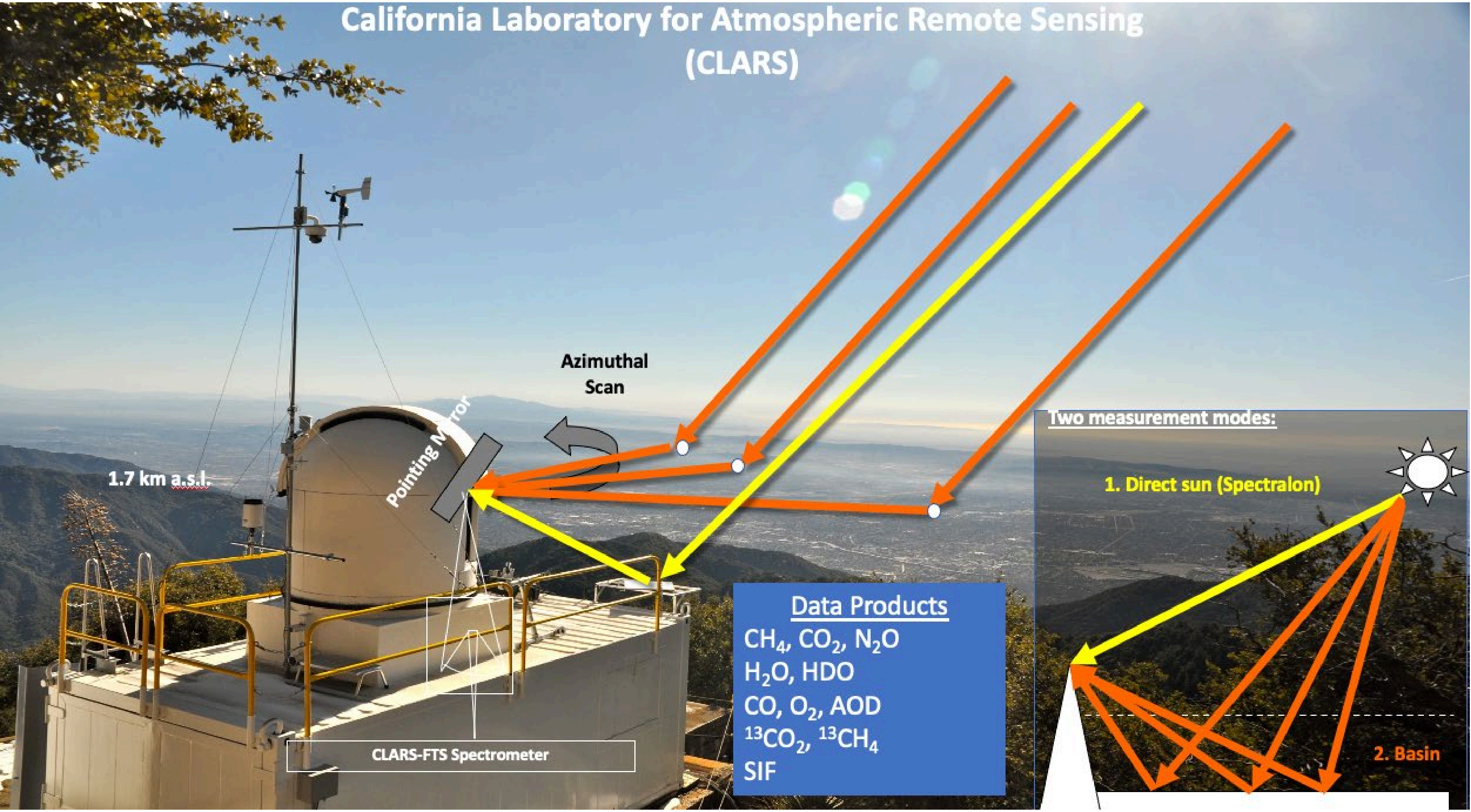
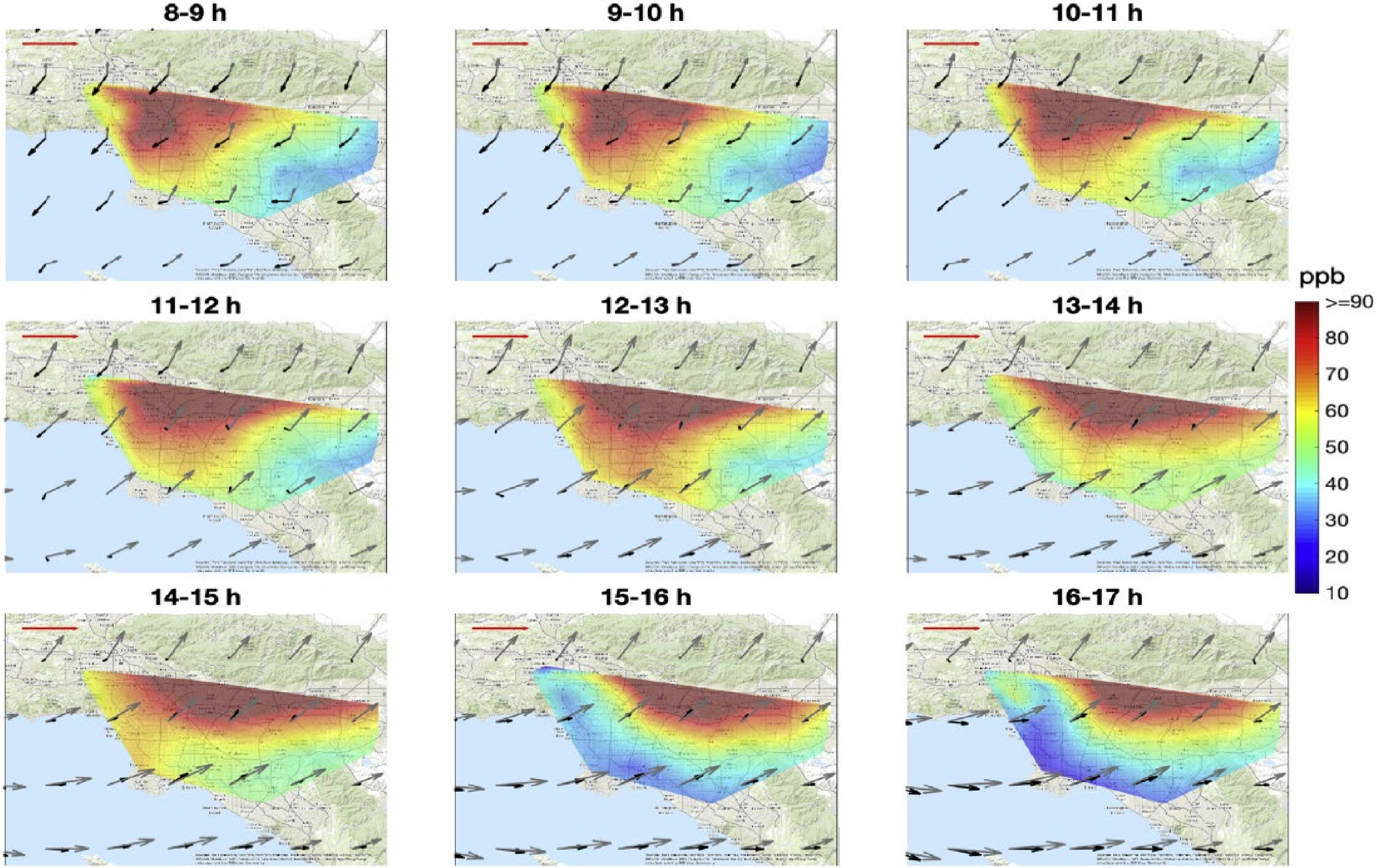
Sina Hasheminassab
sina.hasheminassab@jpl.nasa.gov

In-Situ Air Monitoring by JPL from Mountain Top over LA Basin



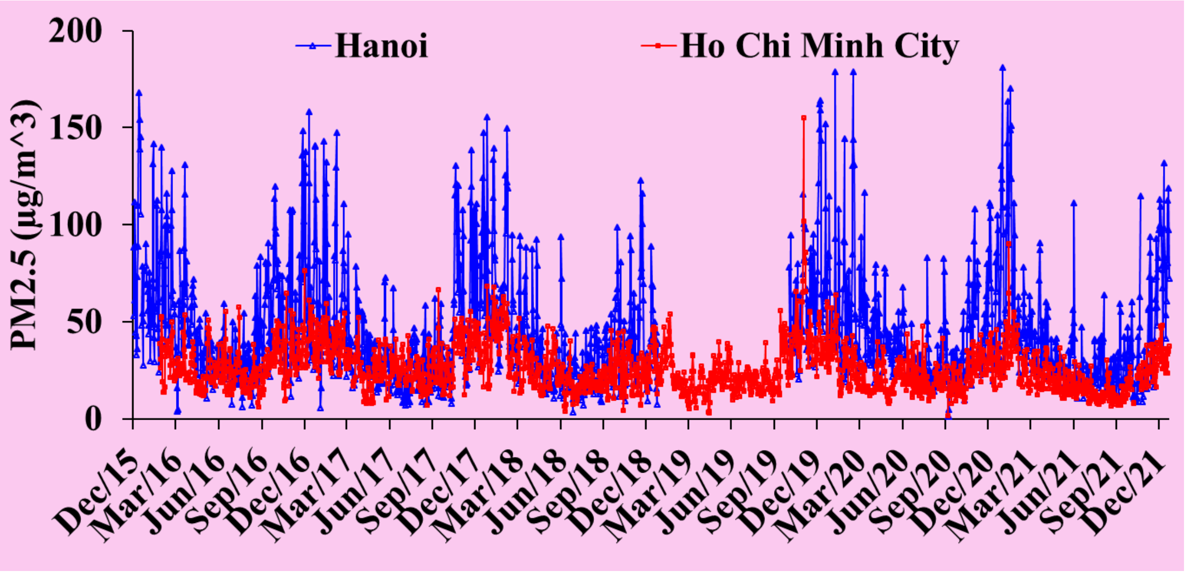
Stan Sander, JPL, 2023

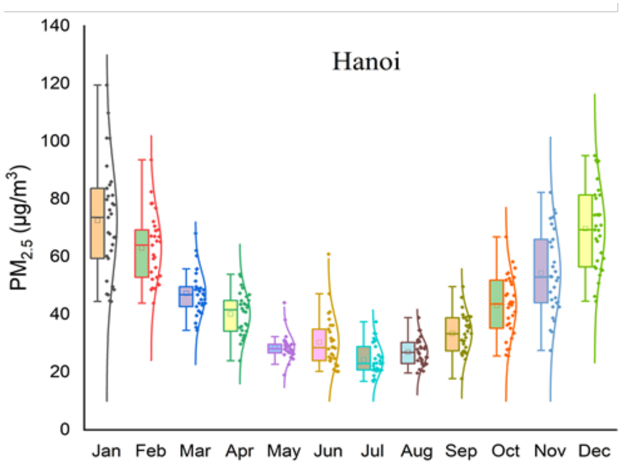
Hourly Maps of Carbon Monoxide by JPL in the Los Angeles Basin

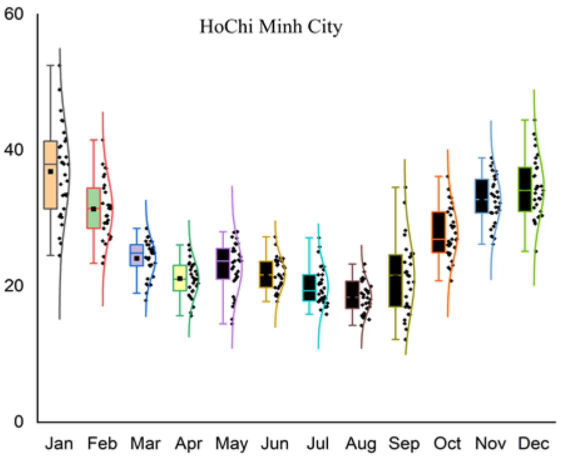


Zeng, et al., with Stan Sander, *Remote Sens. Envir.*, doi:10.1016/j.rse.2020.112000, 2020

In-Situ Measurements of PM2.5 in Hanoi and Ho Chi Minh City (Data from US Embassy)





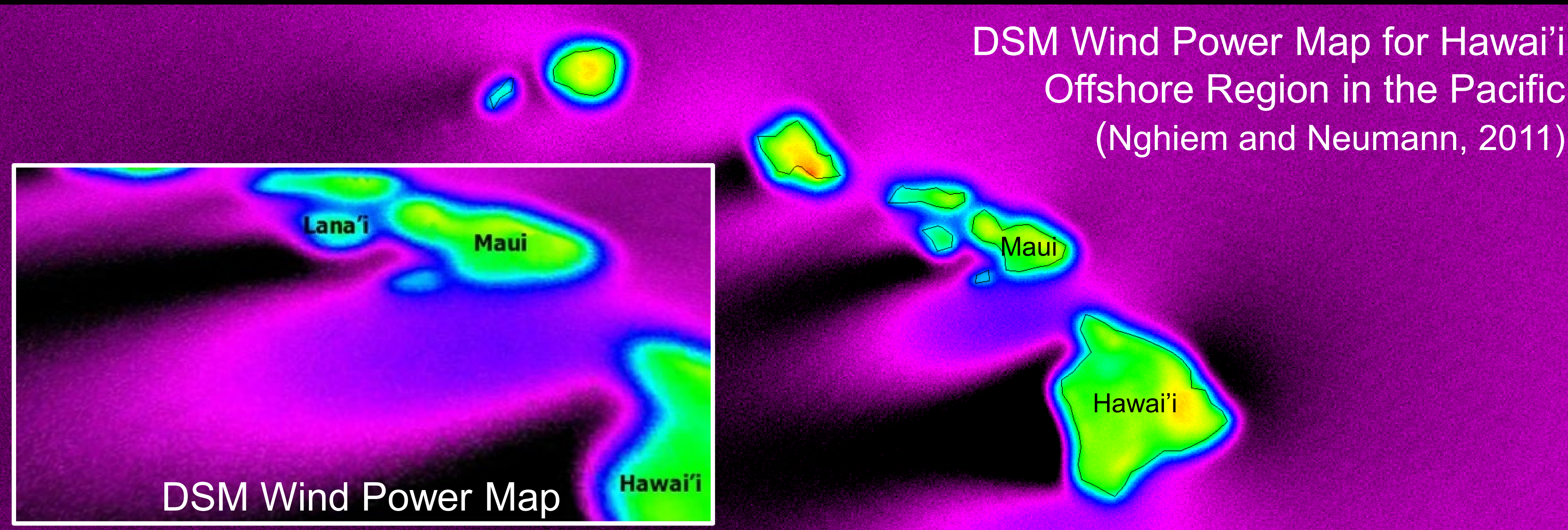


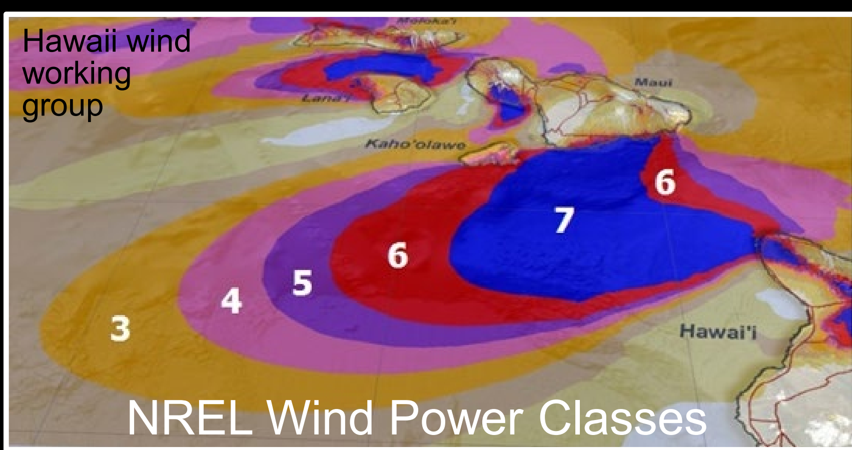
PM2.5 at the US Embassy in Hanoi, and US Consulate in Ho Chi Minh City.

Tran, Chauhan, and Singh, IGARSS, 2022

Air Pollution Solutions

Renewable Energy: Off-Shore Wind Powers





Bạc Liêu Offshore Wind (the first and largest in Vietnam)	
Phase	Annual power production
1	>20 million kWh
2	130 million kWh
3	373 million kWh
June 2013 to March 2020: 1 billion kWh	

https://vi.wikipedia.org/wiki/Nh%C3%A0_m%C3%A1y_%C4%91i%E1%BB%87n_gi%C3%B3_B%E1%BA%A1c_Li%C3%AAu

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National Aeronautics and
Space Administration

Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California

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