The Eighth International Conference on Bioenvironment, Biodiversity and Renewable Energies – BIONATURE 2017

Open Interview

Interviewer: Petre Dini, IARIA

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Pasadena, California, USA

24 May 2017

Global Urbanization and Impacts on the Bio-environments

Results and findings from the NASA Interdisciplinary Research in Earth Science (IDS)
Authors and Contributors from IDS Science Team

https://urban.jpl.nasa.gov/

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California Institute of Technology

Lamont-Doherty Earth Observatory of Columbia University

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LMU|LA
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Interdisciplinary Science Team

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Objective Addressed with a New Paradigm

- **Objectives:** Detect and quantify the rural-urban transformation, and investigate its cause and impacts on the environment, agriculture, multi hazards (e.g., flood, drought, cyclone/supercyclone), demographic/population dynamics, human health (e.g., vector-borne diseases, malaria, zika), and socio-economic vulnerability in a changing climate across the world.
- **A new paradigm:** Rural-urban transformation over the landscape will be quantitatively evaluated as a time-space continuum, extensively in space (global) and in time (decadal), rather than a disparate array of individual bounded cities in separated areas and in a discontinuous collection of points in time.

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Q1. What are the approaches for monitoring global urbanization?

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Global Urban Monitoring

- **High-resolution optical imagery:** **WorldView 1, 2, 3. Sub-meter resolution, very small coverage. Collected at different and separated points in time, commercial, costly.**
- **Multi-spectral imagery:** **Landsat series, Sentinel-2 MSI, 10s-meter resolution, free an accessible data. Collected at different and separated points in time, obscured by cloud cover and darkness.**
- **Satellite Synthetic Aperture Radars (SAR):** **NASA SRTM (2000), TanDEM-X, Sentinel-1A and 1B SAR, 10s-meter resolution, some data are free and accessible.**

ALL ARE FOR 2D LATERAL OBSERVATIONS

Dense Sampling Method

Patent US8401793, US20100280756, WO2010127140A3

Enable global urban observations without gaps in times/space, 1-km grid, 2000-2009

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

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

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

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

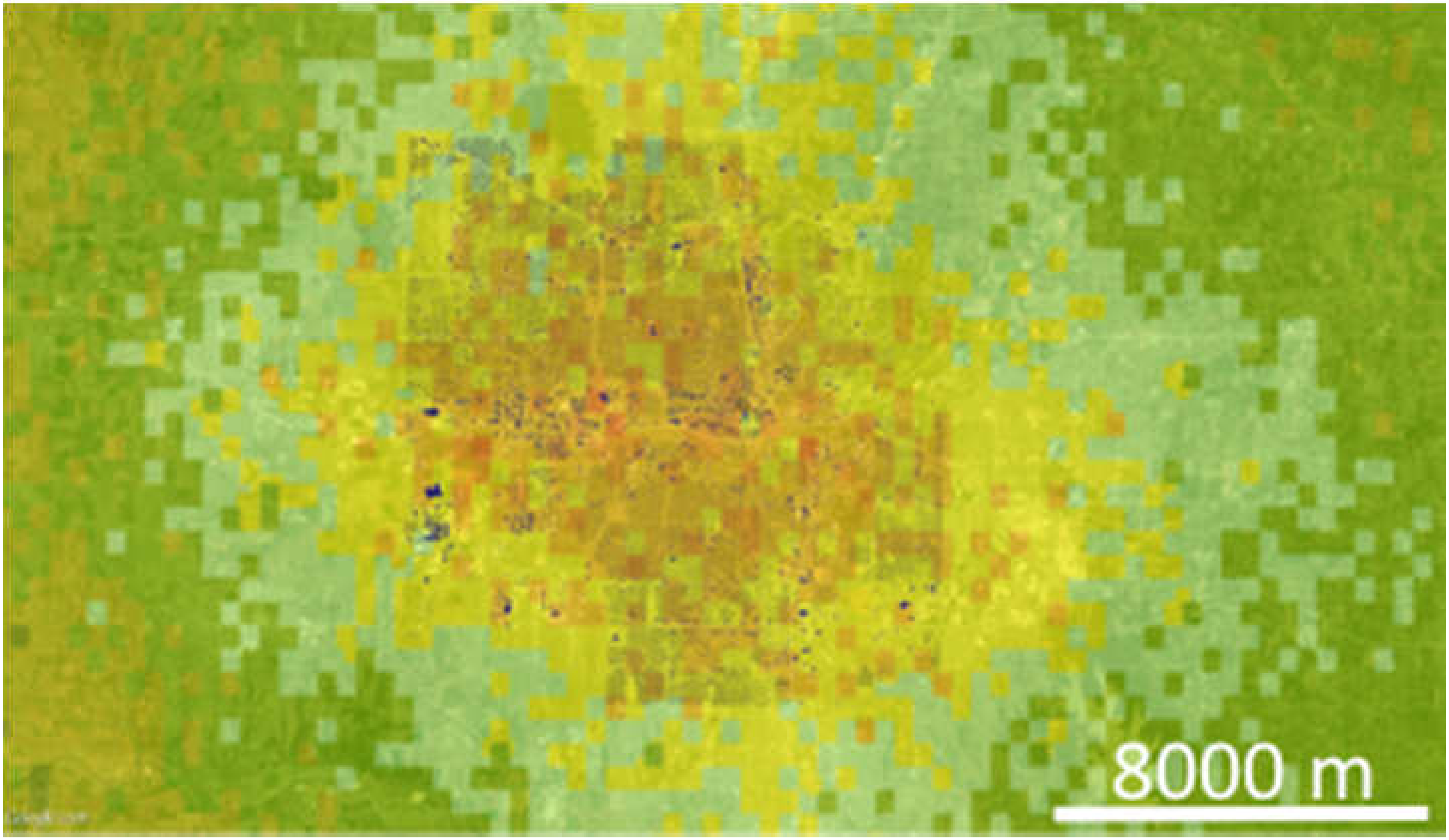
Dynamic Atlas of Global Continuum of LCLUC

DSM: All Mega Cities Worldwide

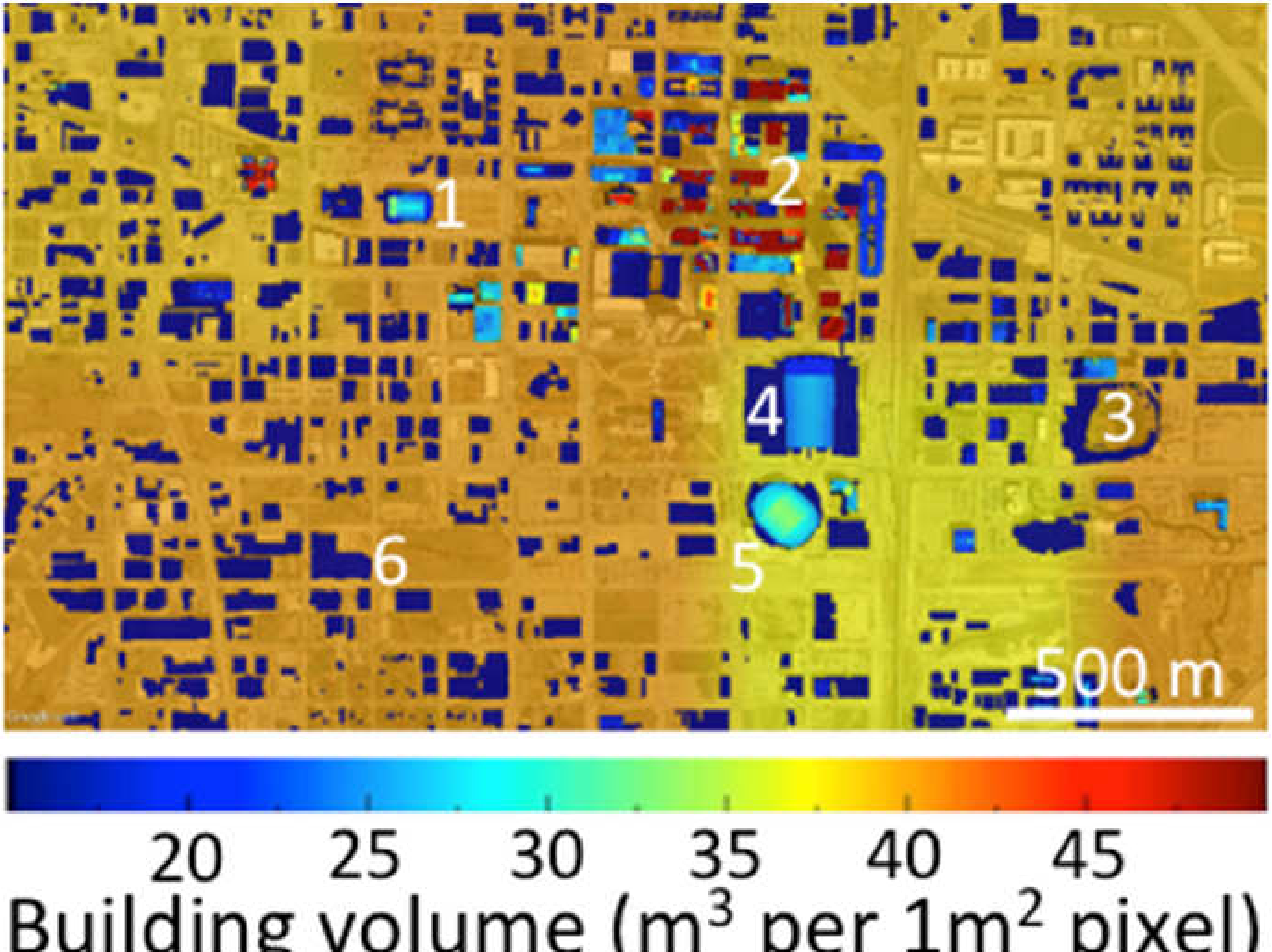
Rank	Megacity	Country	Continent	Population	DSM Latitude (°)		DSM Longitude (°)	
1	Tokyo	Japan	Asia	34,800,000	33.8	37.9	137.5	142.3
2	Guangzhou	China	Asia	31,700,000	21.0	25.0	111.2	115.5
3	Shanghai	China	Asia	28,900,000	30.4	31.9	120.4	122.6
4	Jakarta	Indonesia	Asia	26,400,000	-6.8	-5.6	106.1	107.5
5	Seoul	South Korea	Asia	25,800,000	37.0	38.0	126.3	127.8
6	Delhi	India	Asia	24,000,000	28.2	29.1	76.6	77.7
7	Mexico City	Mexico	North America	23,800,000	18.4	20.5	-99.9	-98.1
8	Karachi	Pakistan	Asia	22,700,000	24.4	25.2	66.5	67.6
9	Manila	Philippines	Asia	22,200,000	14.0	15.2	120.6	121.5
10	New York City	United States	North America	21,600,000	39.9	41.5	-76.1	-71.6
11	São Paulo	Brazil	South America	21,500,000	-24.2	-22.9	-47.6	-45.5
12	Mumbai	India	Asia	21,400,000	18.5	19.7	72.6	73.4
13	Beijing	China	Asia	19,300,000	39.2	40.7	115.5	117.3
14	Los Angeles	United States	North America	17,200,000	32.8	34.9	-120.0	-116.2
15	Osaka	Japan	Asia	16,800,000	33.8	35.4	134.2	136.4
16	Moscow	Russia	Europe	16,500,000	55.3	56.2	36.9	38.4
17	Dhaka	Bangladesh	Asia	16,300,000	23.4	24.1	90.1	90.7
18	Cairo	Egypt	Africa	16,100,000	29.7	30.4	30.8	31.7
19	Kolkata	India	Asia	16,000,000	21.9	23.3	87.7	88.8
20	London	United Kingdom	Europe	15,500,000	51.0	52.0	-1.1	1.0
21	Buenos Aires	Argentina	South America	14,500,000	-35.4	-33.9	-59.5	-57.2
21	Bangkok	Thailand	Asia	14,500,000	13.0	14.8	99.7	101.3
23	Istanbul	Turkey	Europe/Asia	13,800,000	40.4	41.6	27.9	30.2
24	Lagos	Nigeria	Africa	13,200,000	6.0	7.3	2.7	4.2
25	Tehran	Iran	Asia	13,200,000	35.3	36.1	50.8	51.9
26	Rio de Janeiro	Brazil	South America	12,900,000	-23.4	-22.3	-44.2	-42.4
27	Shenzhen	China	Asia	11,700,000	21.5	24.0	112.4	115.0
28	Paris	France	Europe	10,700,000	48.5	49.2	1.7	2.9
29	Tianjin	China	Asia	10,600,000	38.6	39.6	116.6	118.0

3D Oklahoma City in 2006

Building volume overlaid on DSM radar signature



Building volume from Oklahoma State University in collaboration with JPL under a NASA EPSCoR project



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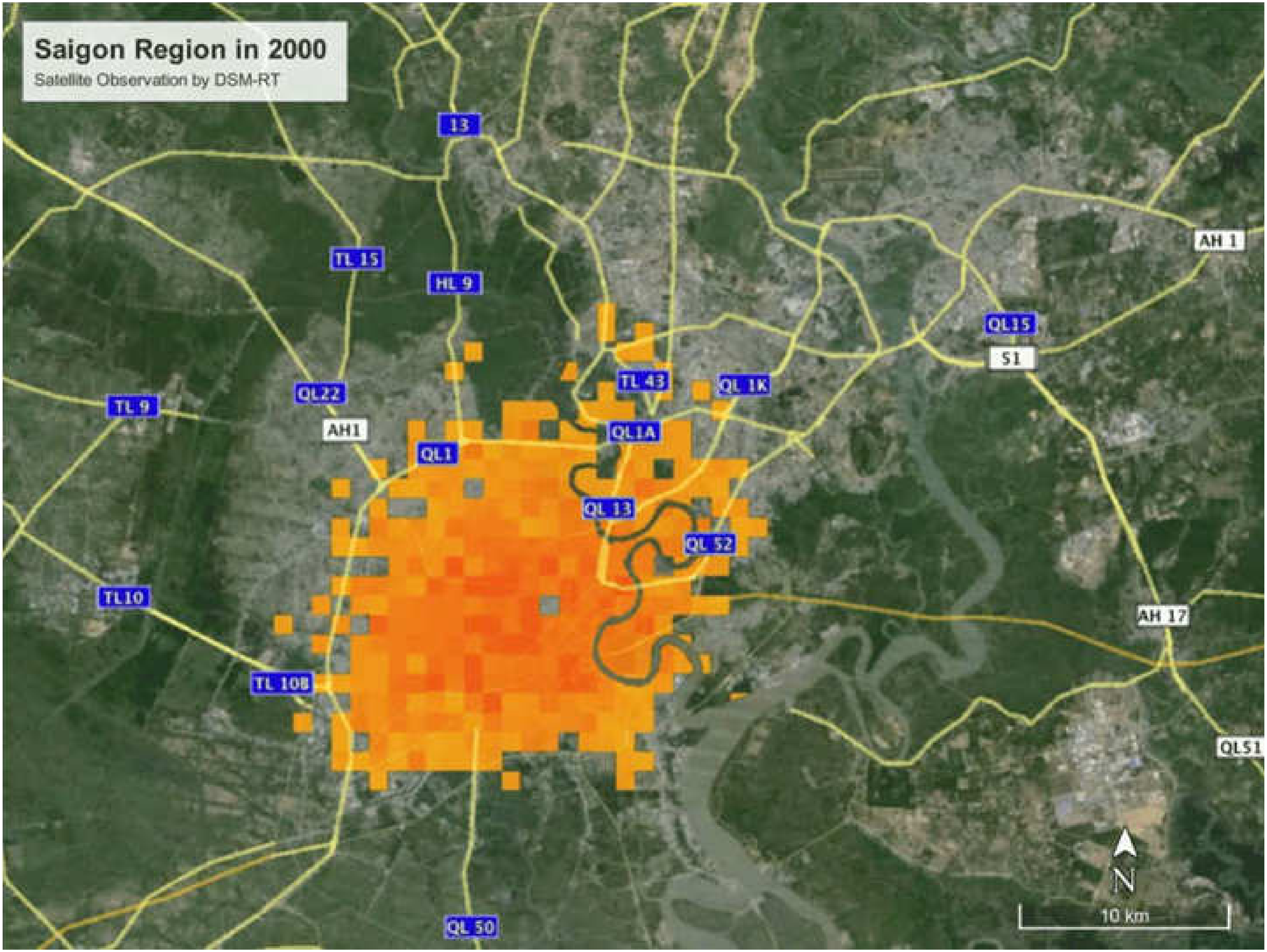
Saigon Region in 2000
Satellite Observation by DSM-RT
13
TL 15
HL 9
QL22
TL 9
AH1
QL1
TL 43
QL 1K
QL1A
QL 13
QL 52
TL10
TL 108
QL 50
AH 1
QL15
51
AH 17
QL51
N
10 km

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Q2. Can current methods deal with urban modeling complexity?

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Modeling – GATOR-GCMOM
from global circulation to urban scale

Model by Jacobson: http://web.stanford.edu/group/efmh/jacobson/GATOR/

Gas, Aerosol, Transport, Radiation, General Circulation, Mesoscale, and Ocean Model .

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.

Modeling – GATOR-GCMOM
from global circulation to urban scale

Model by Jacobson: http://web.stanford.edu/group/efmh/jacobson/GATOR/

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.

Modeling – GATOR-GCMOM
from global circulation to urban scale

Model by Jacobson: http://web.stanford.edu/group/efmh/jacobson/GATOR/

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.

Modeling – GATOR-GCMOM
from global circulation to urban scale

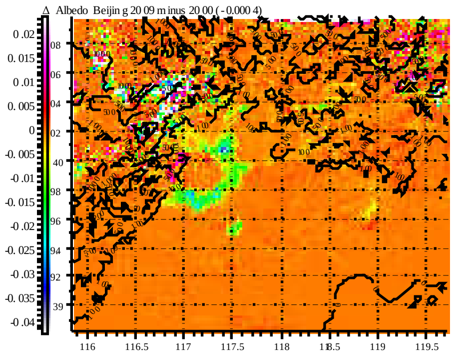
Model by Jacobson: http://web.stanford.edu/group/efmh/jacobson/GATOR/

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.

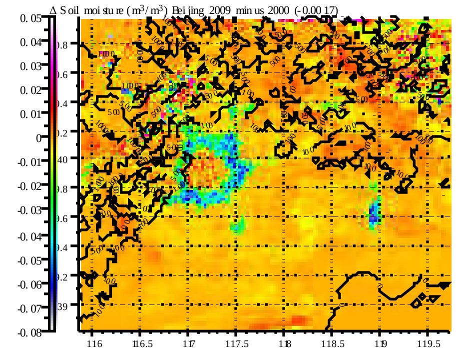
Modeling – GATOR-GCMOM

Mega urbanization impacts in 2000s

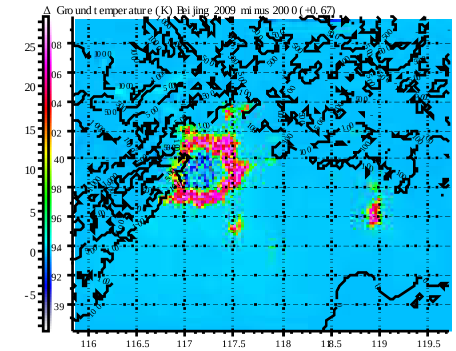
Quantifying changes in 2000-2009



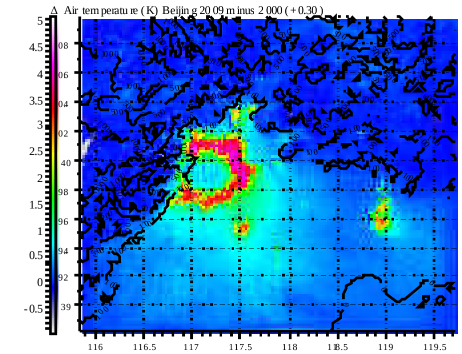
Albedo Change



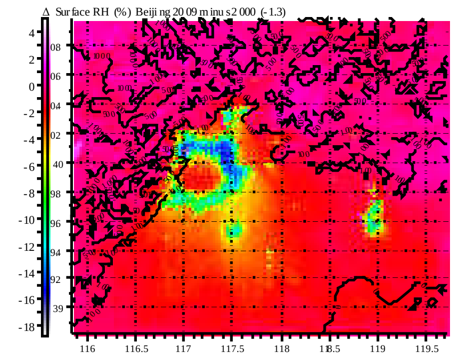
Soil Moisture Change



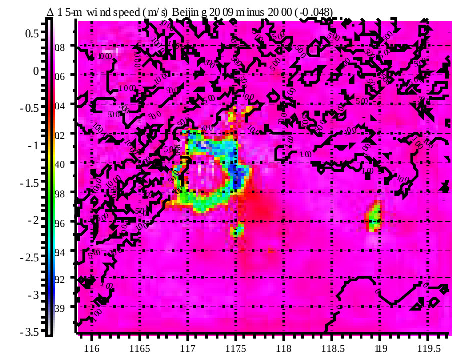
Ground Temperature



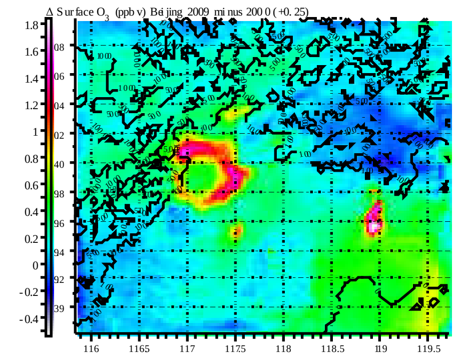
Surface Air Temperature



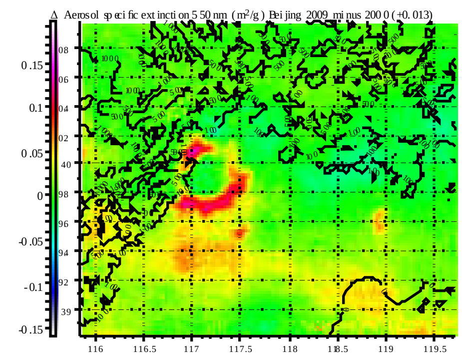
Surface Rel. Humidity



15-m Wind Speed



Surface Ozone



Aerosol Spc. Extinction

Jacobson, Nghiem, Sorichetta, and Whitney, JGR, 2015

Model – GATOR-GCMOM
Mega urbanization impacts in 2000s

"Ring Around the Beijing"

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

Jacobson, Nghiem, Sorichetta, and Whitney, JGR, 2015

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Q3. What are the main challenges in environmental sensing?

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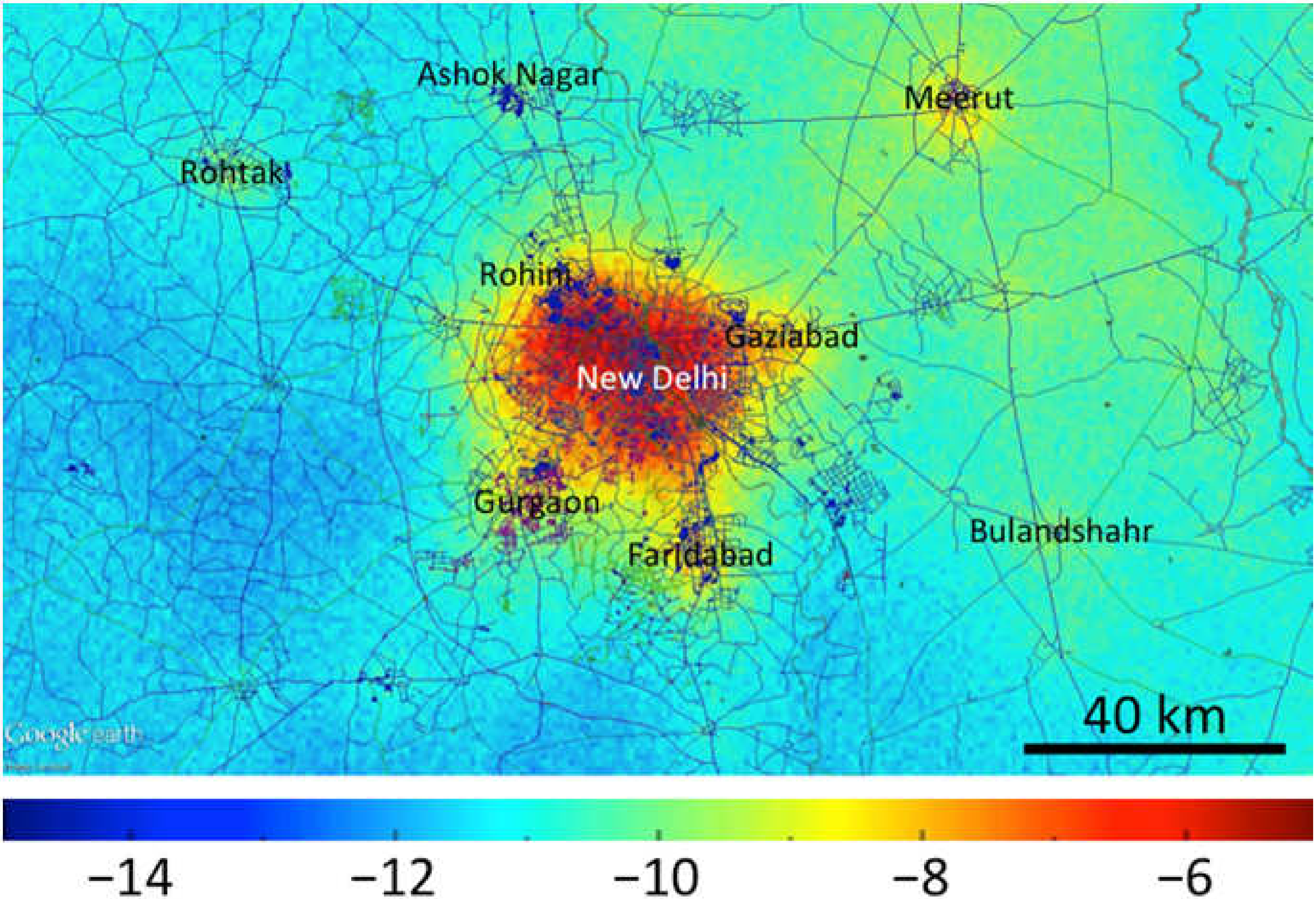
Main Challenges in Environmental sensing

- Surface monitoring networks: Temperature, pressure, rain, snow, soil moisture, stream flow, chemical and bio contaminants, etc. Cross-calibration, bias, data quality, consistency, continuity, coverage, etc.
- Satellite monitoring systems: Multiple types remote sensing instrument, array of environmental parameters over land, ocean, air and subsurface. Cross-calibration, bias, data quality, consistency, continuity, coverage, etc.
- Connection between natural/environmental and human/socioeconomic dimensions: Interdisciplinary science and applications. Need right kinds of parameters and right data.

Rate of Change of Urban Vertical Built-Up in WUI in the Decade of the 2000s (in % per decade)

14 cities and JPL from Ventura to Mentone, CA

DSM Y-Intercept Continuum with OSM Road Network and SRTM Water Bodies



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Q4: Where bio-environment monitoring mostly needed / feasible?

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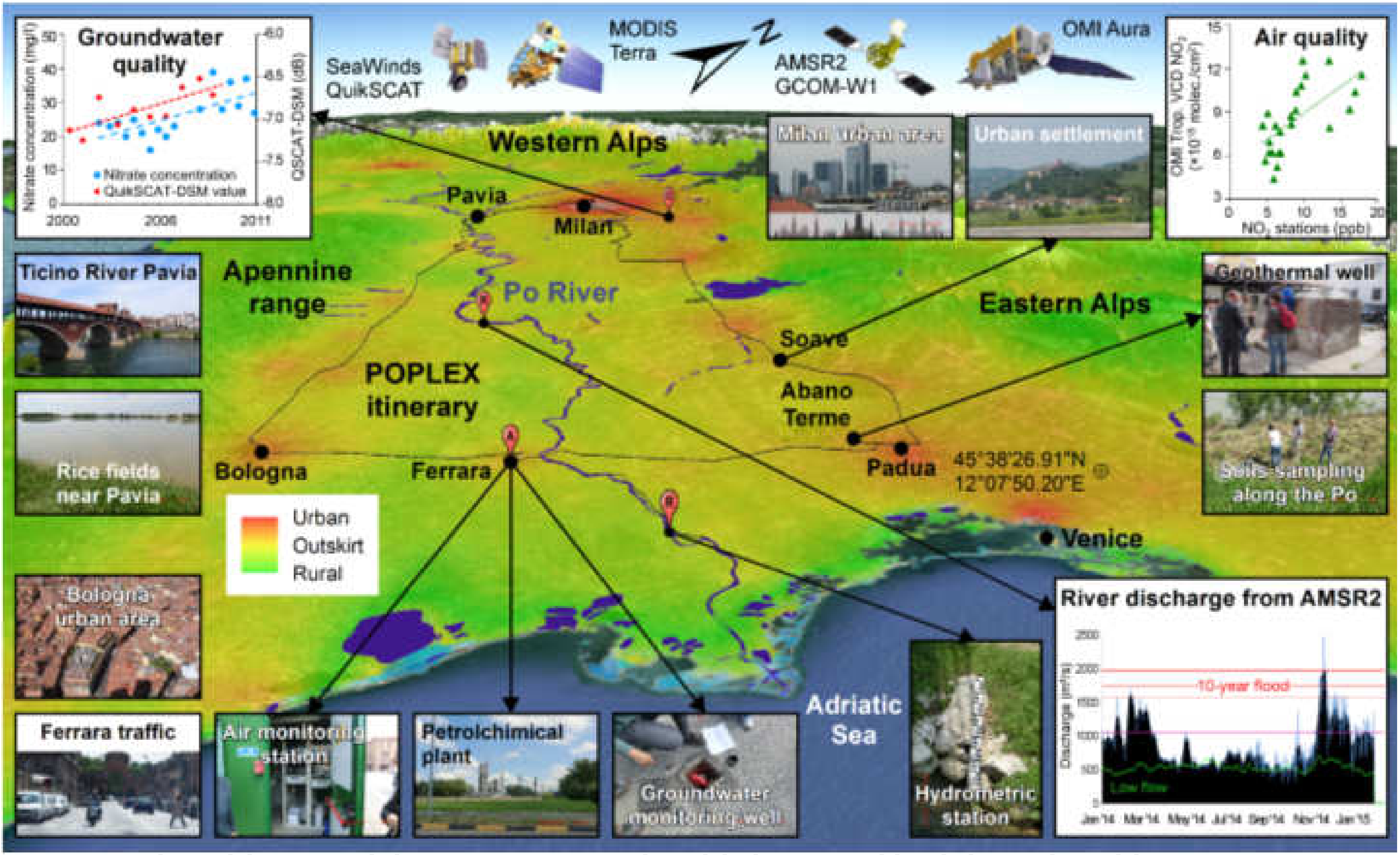
Where Monitoring mostly needed and feasible

- **No one size fits all:** Characteristics, patterns, causes/effects, and changes of bio-environments are complex. Inadequate monitoring in times/places and generalization may be misleading and resulting in ineffective and costly policies/measures.
- **To determine how and where to monitor: Need to understand and quantify the key controlling bio-geophysical processes in time and space.** Lacking science understanding and missing pathways impacting bioenvironments.
- **Feasibility:** At right location/time to monitor bio-environments, cost effective and innovative methods are needed for it to be feasible.

PO PLain EXperiment (POPLEX) Field Campaign, 2014 & 2015

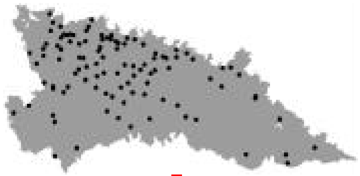


Masetti, Nghiem, Sorichetta, Stevennazi, Fabbri, Pola, Filippini, Brakenridge, Eos, 2015

Lombardy, Italy: Groundwater Vulnerability Assessment in the Shallow Aquifer

Training points

Urban area



Rural area

Natural predictors
(not time-dependent)

- ✓ Groundwater depth
- ✓ Groundwater velocity
- ✓ Hydraulic conductivity of the vadose zone
- ✓ Soil protective capacity

Anthropogenic predictors
(time dependent)

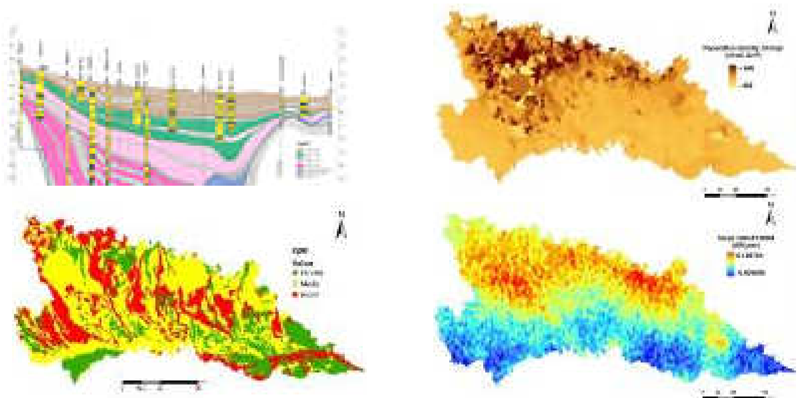
- ✓ Population density change

or

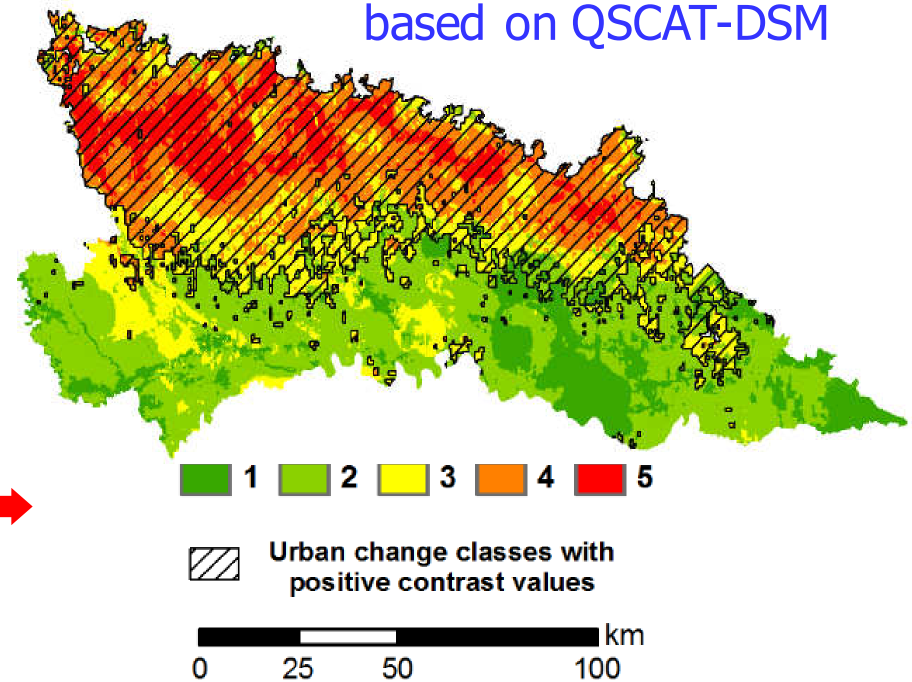
- ✓ Land cover change (QSCAT-DSM slope)

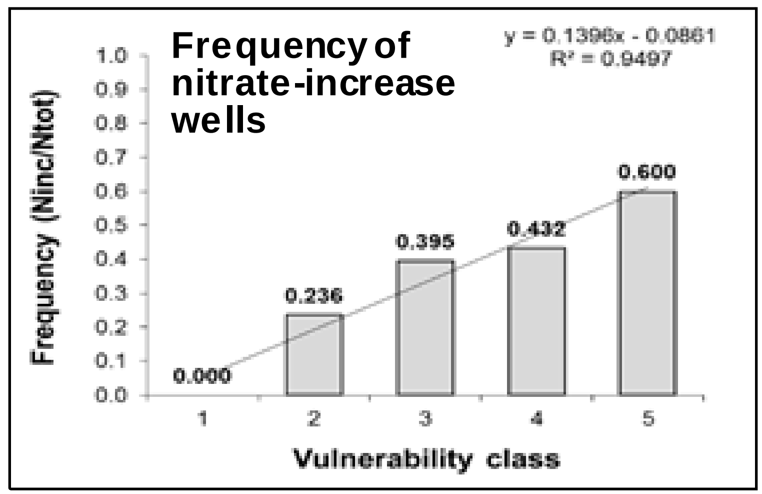
or

- ✓ Urban change (DUSAF data set)



Groundwater vulnerability maps
based on QSCAT-DSM





Stevennazi, Masetti, Nghiem, Sorichetta, HJ, 2015

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Q5: Can long-term projection be made to safeguarding bio-environments?

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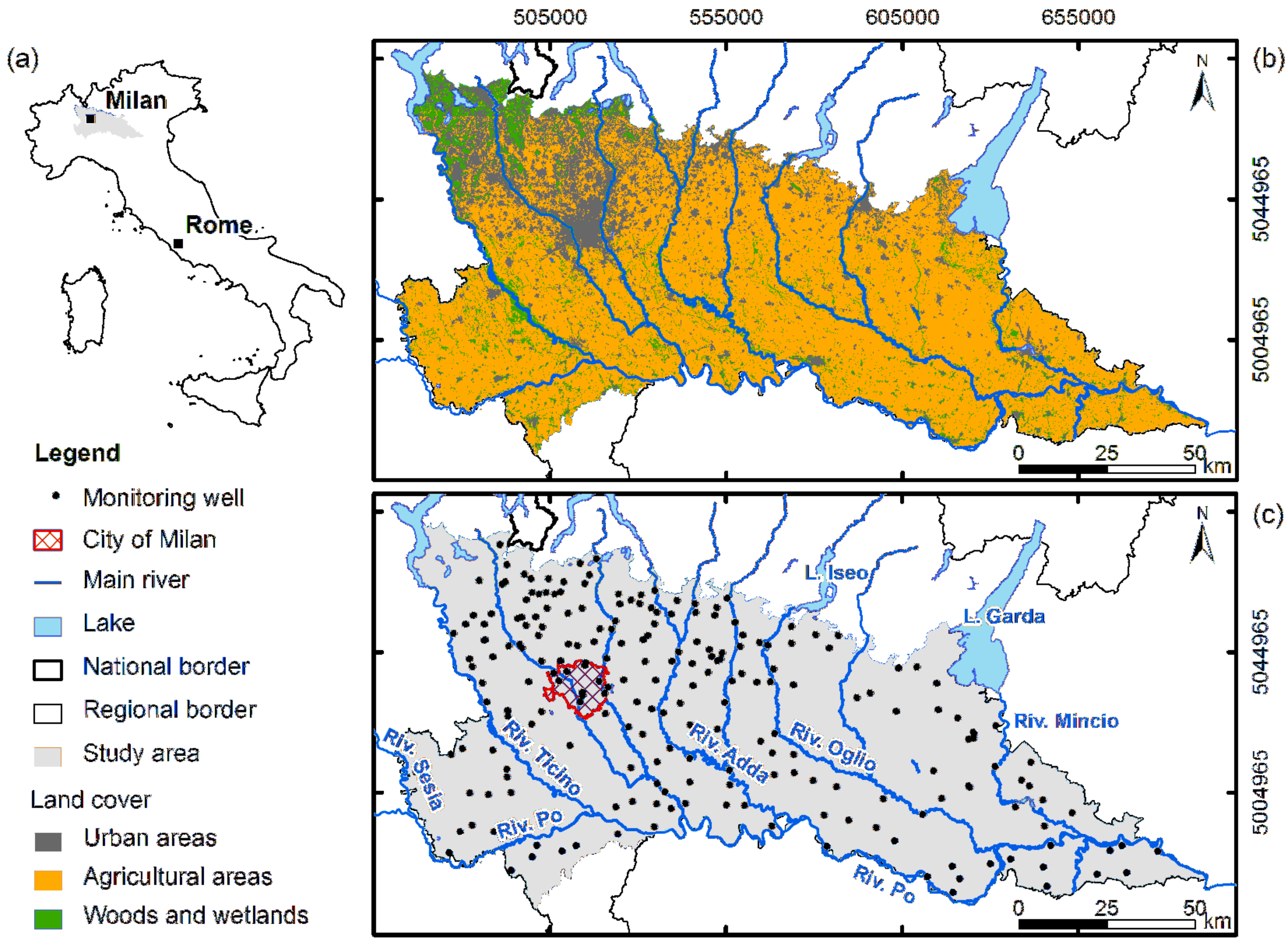
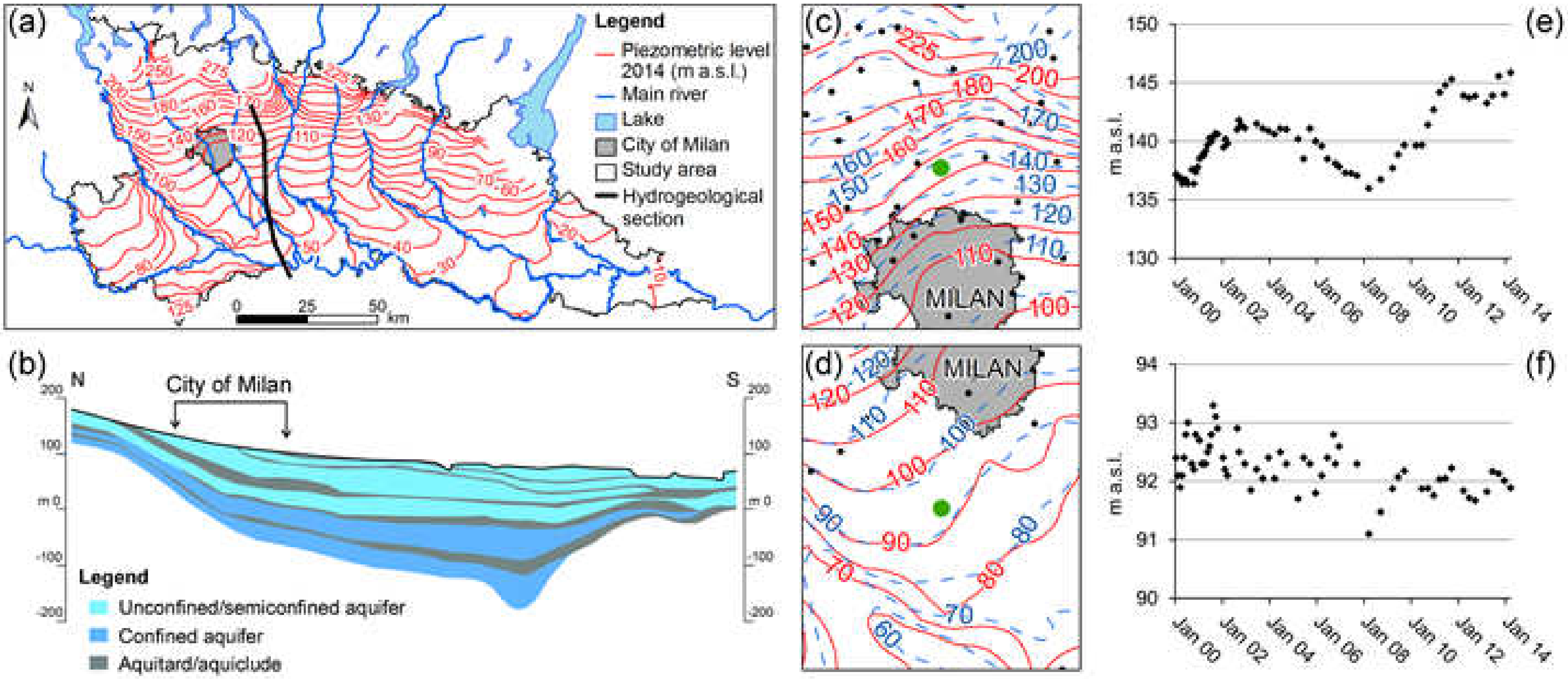
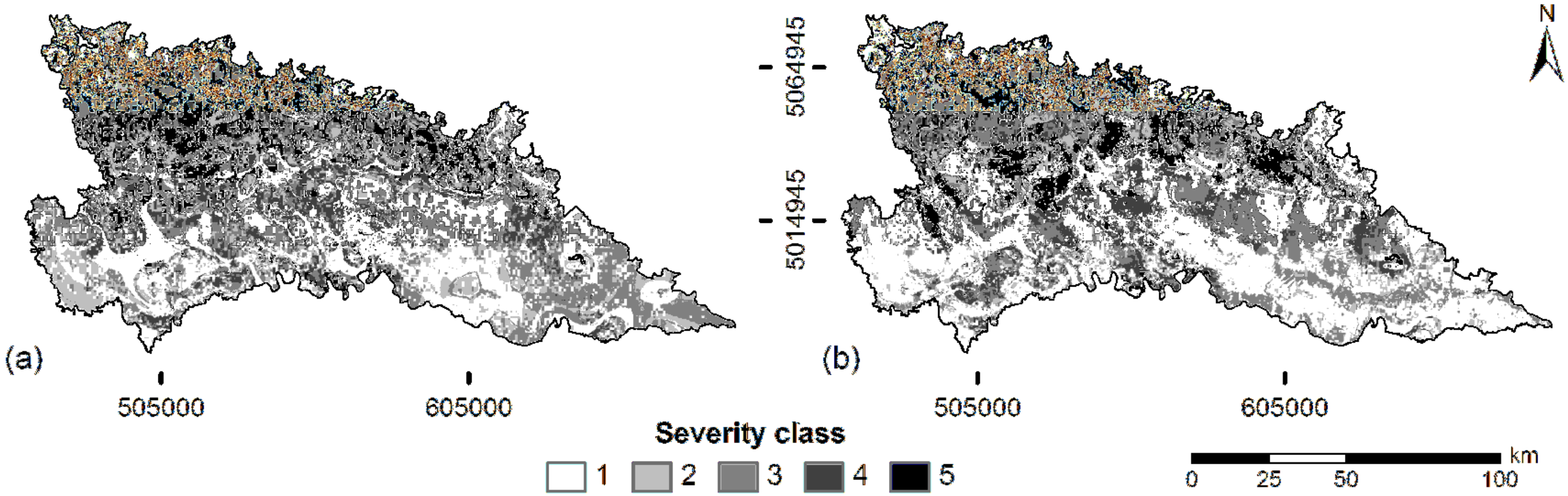
Study Domain – Po Plain in Italy



Hydrogeological Conditions



Year 2020 - Projection of Groundwater Contamination Severity in Two Scenarios



Scenario 1: Rate of rural and urban change estimated from DSM data, assuming no change in water depth.

Scenario 2: Rate of rural and urban change estimated from DSM data, using rate of water depth change estimated from station data.

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Q6: Challenges of multi-model approaches and model-observation integrations?

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Multi-model approaches and model-observation integrations

- **Consistency and conflicts in model approaches: May cause opposing/contrasting results and thus large uncertainties. An imperfect way out is multi-model ensembles.**
- **Model-observation integrations: Different definitions, time/space scales and coverage, natural-human coupled systems, inter-disciplinary complexities.**
- **OTHERS ???**

Contact

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