Three decades of global trends in microwave backscatter correlates with urban building volume and city-level GDP

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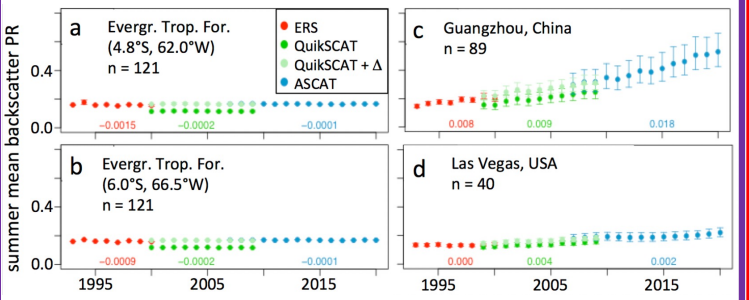
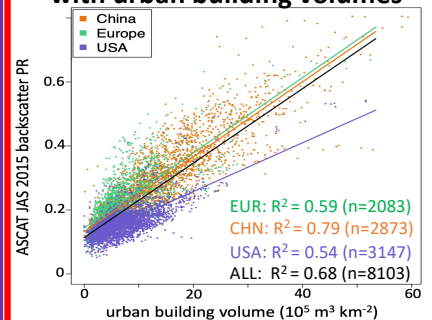
ABSTRACT: Most mapped urban information is essentially two-dimensional, and there is a gap in knowledge about global patterns and changes of urban built-up heights/volumes and development intensity. We use a recently constructed global urban microwave backscatter dataset[1] for 1993-2020 to explore this third dimension of urban growth across 470 large cities (pop. > 1M). Urban backscatter correlates with an independent estimate of building volume across 8000+ urban grid cells (0.05° lat/lon) in large cities in China, Europe, and USA. Regional rates of urban backscatter increase 1993-2020 vary substantially, with the highest increases in the 2010s across Asia. Microwave backscatter is strongly correlated with city-scale Gross Domestic Product across most regions, with weaker correlations in Africa and India.

(1) 1993-2020 backscatter PR is stable over tropical forests, but increases over cities (two examples)



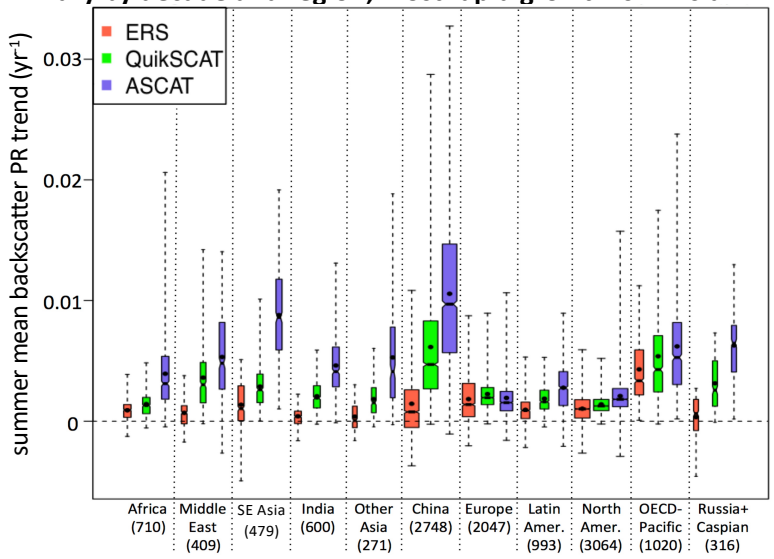
*Summer backscatter PR (=10^[σ^0/10]) time series for (**a**,**b**) evergreen tropical forest plots (mean ± sd over 0.55°x0.55° region, ~3000 km²), and, as urban examples, (**c**) Guangzhou, China (mean ± sd over 86 urban 0.05° grid cells) and (**d**) Las Vegas, USA (mean ± sd over 40 urban 0.05° grid cells). Linear trends in PR (yr⁻¹) listed for each sensor. QuikSCAT +Δ (lighter green) equals QuikSCAT PR + mean of differences in overlapping years between QuikSCAT and ERS (1999-2000) and QuikSCAT and ASCAT (2007-09).*

(2) 2015 backscatter correlates with urban building volumes



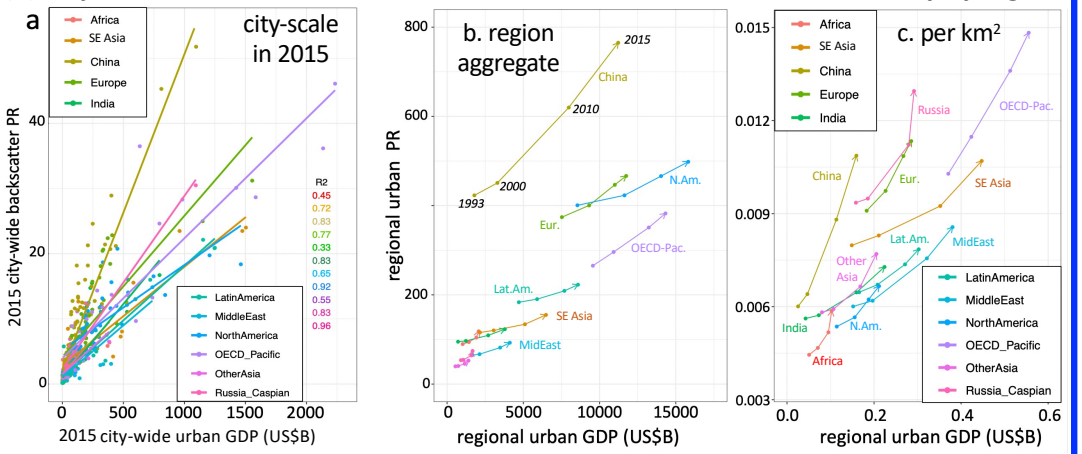
Mean summer 2015 ASCAT backscatter power return (PR) vs. building volume for urban grid cells (0.05° lat/lon) in 209 large cities in China, Europe, and the USA (building volume data from Li et al., (2020). Regional linear fits are shown as colored lines, linear fit for all data as a black line.

(3) Linear trends in grid-cell-scale summer mean backscatter PR vary by decade and region; most rapid growth is in Asia



Ranges of linear trends in summer mean backscatter PR by sensor/era for 1993-2000 (ERS; red), 1999-2009 (QuikSCAT, green), and 2010-2020 (ASCAT, blue) for urban grid cells (0.05° lat/lon, n = 12,657) in 470 major cities (pop. >1M) in eleven regions. Boxes: 25th to 75th percentile range in linear trends; dashed lines: full range; black points: mean; notches: median; notch widths: median confidence interval; box widths: proportional to square root of number of urban grid cells, listed below region names.

(4) City-scale summer mean backscatter PR correlates with GDP; trends vary by region



*(**a**) City-scale total urban mean summer ASCAT backscatter (PR) vs. total GDP (US$B PPP) for 469 large cities (population > 1M) in 11 regions in 2015. Linear fit lines shown for each region, with correlation (R^2) listed. Gridded GDP data from Kummu et al. (2018; doi.org/10.1038/sdata.2018.4). (**b-c**) Regional aggregate of major city urban backscatter PR vs. GDP (US$B PPP) shown as (**b**) totals and (**c**) per km² of urban land. Each line connects the regional points representing aggregate values for urban grid cells in all large cities for 1993, 2000, 2010, and 2015, with arrowheads at 2015.*

[1] ***Backscatter data***: Frolking S, Milliman T, Mahtta R, Paget AC, Long DG, Seto KC. 2022. Global monthly and seasonal urban and land backscatter time series (1993-2020), v1. Palisades, NY: NASA Socioeconomic Data and Applications Center (SEDAC). DOI: https://doi.org/10.7927/gr2e-dh86.
Backscatter Data Descriptor: Frolking S, T Milliman, R Mahtta, A Paget, DG Long, KC Seto. 2022. A global urban microwave backscatter time series data set for 1993-2020 using ERS, QuikSCAT, and ASCAT data. *Scientific Data*. DOI: 10.1038/s41597-022-01193-w.

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