MOMO-NBS

MOnitoring the impact of the ever-changing urban 2D/3D MOrphology on Nature-based Solutions for urban resilience to climate change

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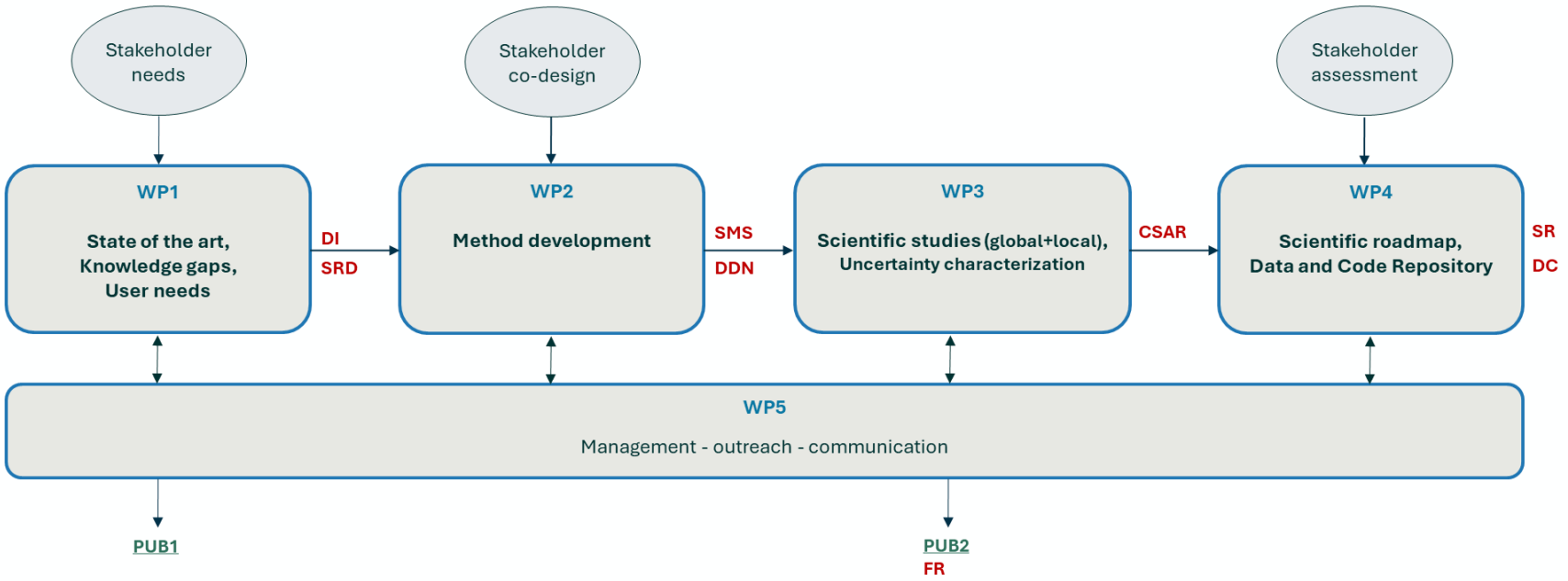
Overview

- **ITT**: CLIMATE SPACE - CLIMATE CHANGE AND CITIES ACTIVITY - EXPRO+ (ESA AO/1-12660/25/I/LR)
- **Team**: Università di Pavia, Brockmann Consult, German Aerospace Center - DLR, KTH Royal Institute of Technology
- **Motivation**:
  - Nature-based solutions (NBS) are widely recognized as effective measures to enhance urban climate resilience.
  - City-scale impacts and interactions of NBS with urban morphology remain poorly understood.
- **Objective**: Understanding the potential of ECVs for urban climate services.
  - How does climate change affect cities with different morphologies - from regional to global level?
  - To what extent can existing ECVs be used to assess the effects of NBS on urban climate at city level?
  - Can data on 3D morphology and green/grey infrastructure be linked to ECVs to support local NBS deployment?
- **Time frame**: Sep 2025 – Mar 2027
- **Connections with community and policy activities**:
  - Communities: IPCC, Local Governments for Sustainability (ICLEI), Global Covenant of Mayors for Climate & Energy, C40 Cities Climate Leadership Group, European Urban Resilience Forum, Global Urban Climate Research Network (UCCRN).
  - Policy: EU Green Deal, EU Biodiversity Strategy 2030, EU Climate Adaptation Strategy, New European Bauhaus, UN Sustainable Development Goals (SDG 11/13/15), UN-Habitat/UNDRR/UNEP/UNFCCC.

Skeleton of Approach

- Data-driven research to quantify impact and optimize effectiveness of nature-based solutions at city level.
  - Global scale: Linking 3D Urban Structure and Essential Climate Variables
    Study based on based on several hundred globally distributed cities, investigating the correlation between 3D morphologic city design and key climate-/environment-/health-related properties.
  - Local scale: Monitoring the effects of Nature-based Solutions at City Scale
    Study about NBS monitoring at intra-city scale by combining ECVs with more spatially and temporally detailed 2D/3D/4D morphological information extracted from EO and other data sources.



National stakeholders
Istituto Superiore per la Protezione e la Ricerca Ambientale (ISPRA), IT
Umweltbundesamt (UBA), DE
Swedish Meteorological and Hydrological Institute (SMHI), SE

Local stakeholders
City of Milan, Italy
City of Hamburg, Germany
City of Stockholm, Sweden
City of Beijing, China

PUB1	Submitted review manuscript (D1.1)
SRD	Science Requirements Document (D1.2)
DI	Dataset inventory document (D1.3)
SMS	Scientific Methodology Strategy (D2.1)
DDN	Tailored Data Delivery Note (D2.2)
CSAR	Core Scientific Activities Progress Report (D3.1)
PUB2	Submitted review manuscript (D3.2)
FR	Final scientific report (D3.3)
SR	Scientific Roadmap (D4.1)
DC	Data/Code output (D4.2)

Use of ECVs

- Urban density
  - Land surface temperature, greenhouse gases, aerosol, surface radiation budget, air temperature, humidity.
- Building height
  - Land surface temperature, wind speed & direction, air temperature, humidity.
- Materials
  - Land surface temperature, albedo, surface radiation budget, air temperature, humidity.
- Street canyon
  - Wind speed & direction, greenhouse gases, surface radiation budget, boundary layer height.
- Morphology of territory
  - Precipitation.

Key design principle:

- **Open** + **long-term** + **scalable** datasets
- Suitable for **global + local analysis**
- Responds to **stakeholder needs**:
  - NBS performance review
  - Lack of consistent city-scale data

Together they capture:

- **Drivers** (radiation, morphology)
- **Processes** (energy balance, ventilation, hydrology)
- **Impacts** (UHI, air quality, flood risk, etc.)

Use of ECVs

Strengths

- **System approach**: atmosphere + surface + vegetation.
- **Long-term consistency**: climate-scale analysis (≥30 yrs).
- **Scalable:** global → city comparison.

Weaknesses

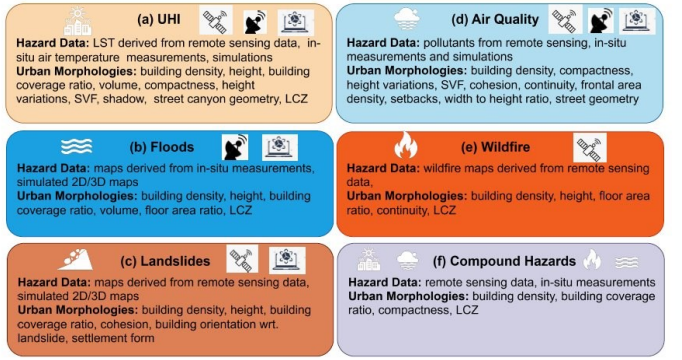
- **Mismatch**: Surface temperature vs air temperature.
- **Spatial resolution**: Often non suitable for city-level and intra-urban analyses.
- **Temporal resolution**: Inconsistencies.

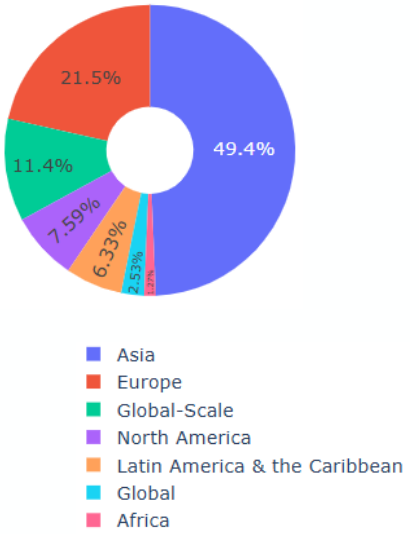
Potential for improvement:

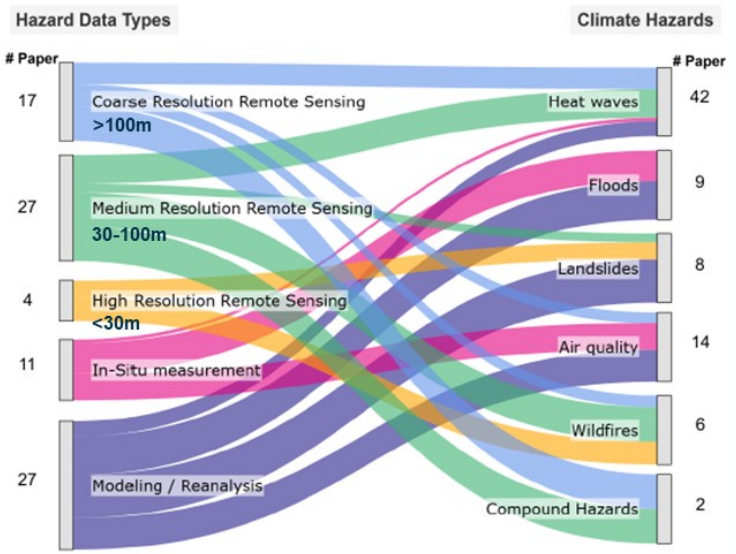
- Harmonized **high-resolution** ECVs (LST, ET, LAI) => urban scale.
- **Event-oriented products** (e.g., urban energy balance components, ET-based cooling maps, etc.).

Results and Relevance to CCI community

- **Urban morphology strongly influences local climate and hazards**
  - Compact, mid-rise, high impervious fraction and low-vegetation forms intensify UHI.
  - Dense, low height variability, enclosed canyons trap pollutants and reduce ventilation.
  - Impervious, dense, and poorly connected layouts amplify flood risk.
  - Slope-modifying, heavily, dense development increases landslide susceptibility.
  - Sparse, fuel-connected expansion at the Wildlife-Urban Interface raises wildfire exposure.
- **Imbalanced evidence base**
  - ~52% heat-focused.
  - ~50% Asia/China focused.
  - Underrepresented: Global South + informal settlements.
- **Constrains**
  - Low resolution of 3D Data for neighborhood-scale analysis
  - Temporal Data Limitations for monitoring
  - Limited multi-hazard integration (compound hazards)
  - Limitations of surface-based temperature metrics







**Publication: *Yadav, R., Nascetti, A., Esch, T., Gamba, P., Yifang B.(2026): Climate Hazards and Urban Morphology: A Systematic Global Review of Data, Methods and Impacts. Submitted to Nature Climate Change.*

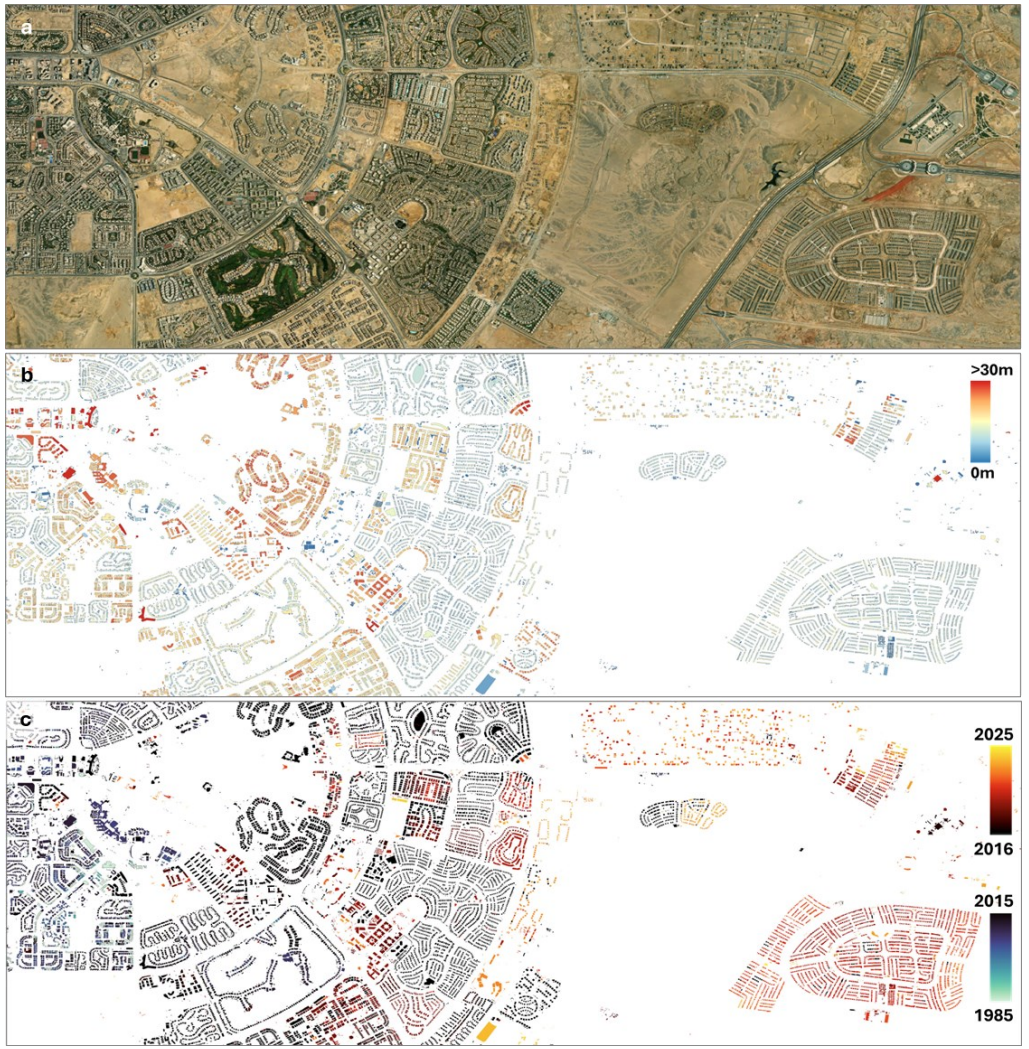
Results and Relevance to CCI community

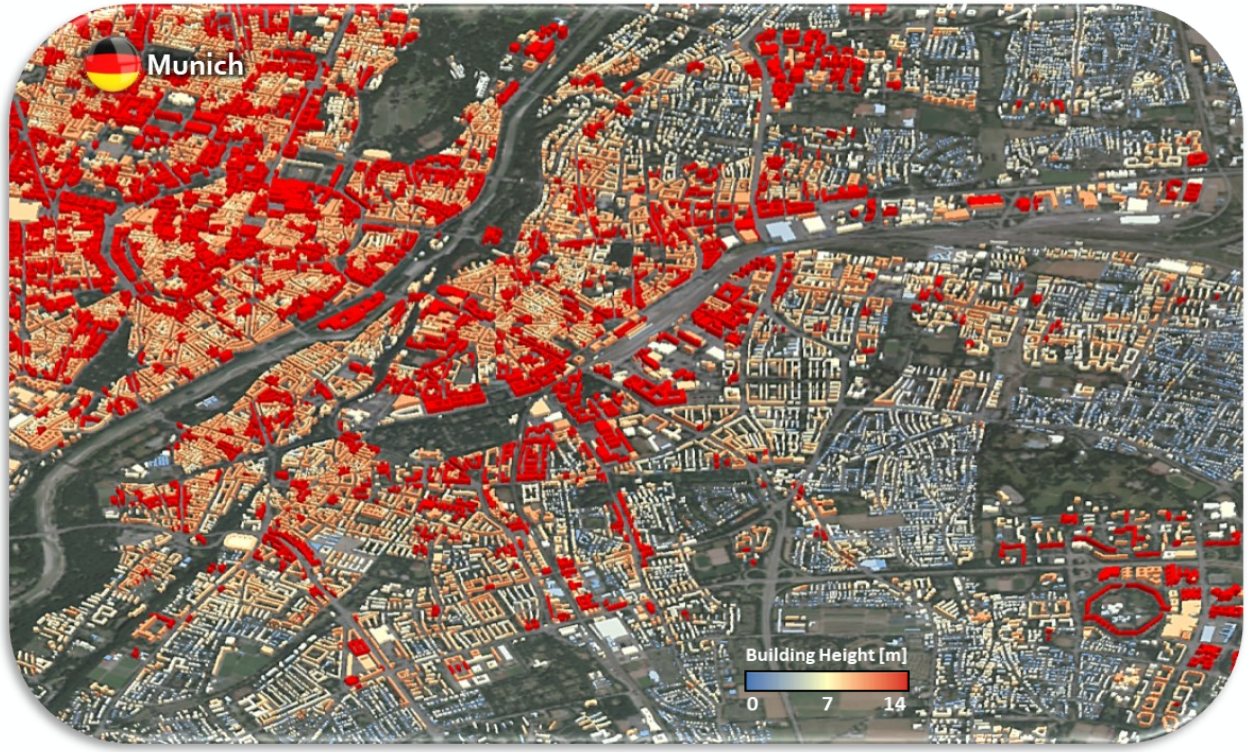
- **Novel data**: Urban imperviousness/greenness

Mapping of imperviousness/greenness [10m] within the built-up area based on analysis of multi-seasonal Sentinel-2 imagery

Results and Relevance to CCI community

- **Novel data**: Global LoD1 building model

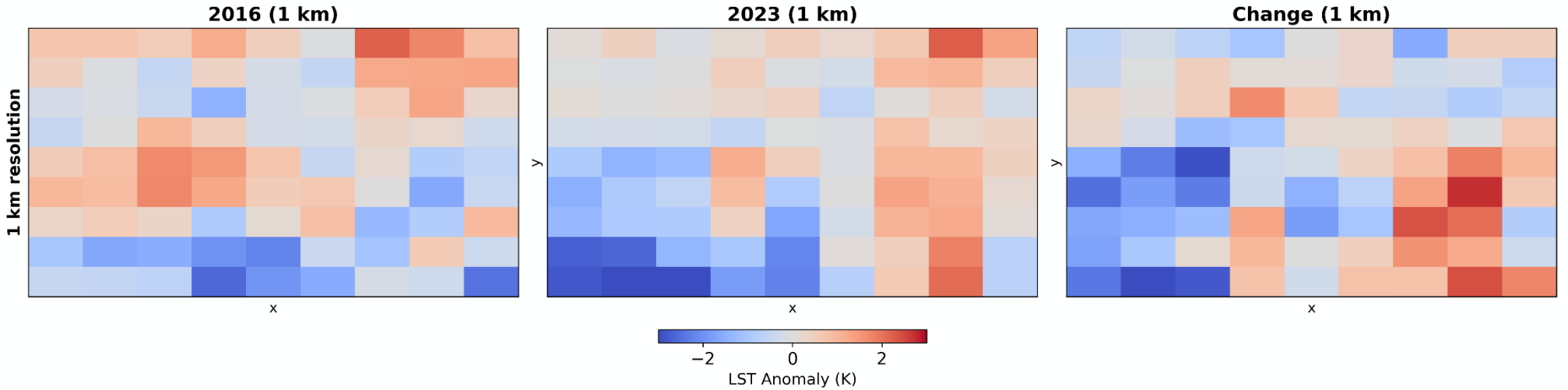




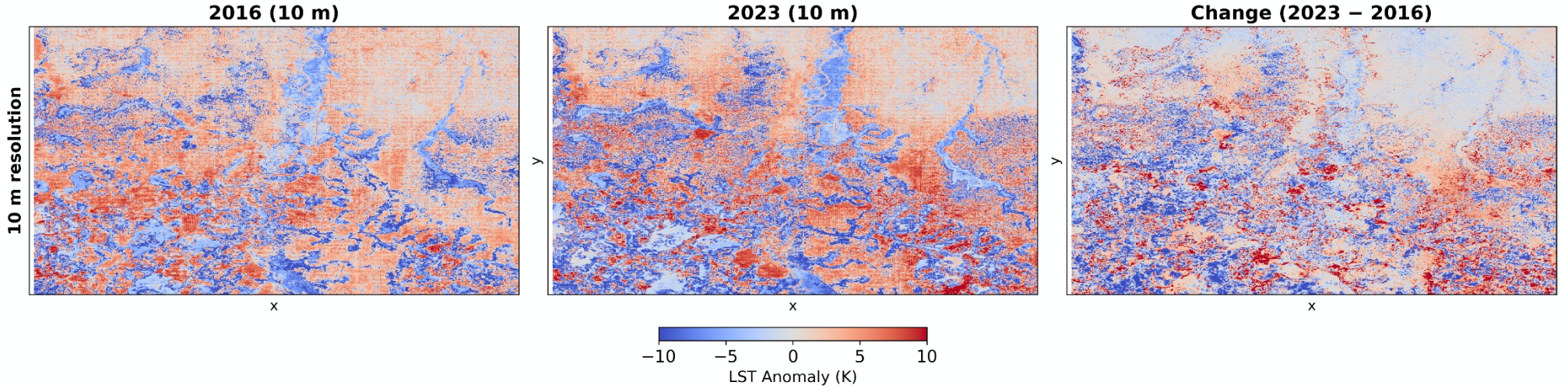
World Settlement Footprint 4D (WSF®4D) dataset characterizing the 3D morphology and temporal evolution of the building stock

Results and Relevance to CCI community

- **Novel data**: XGboost Upscaling of ECV



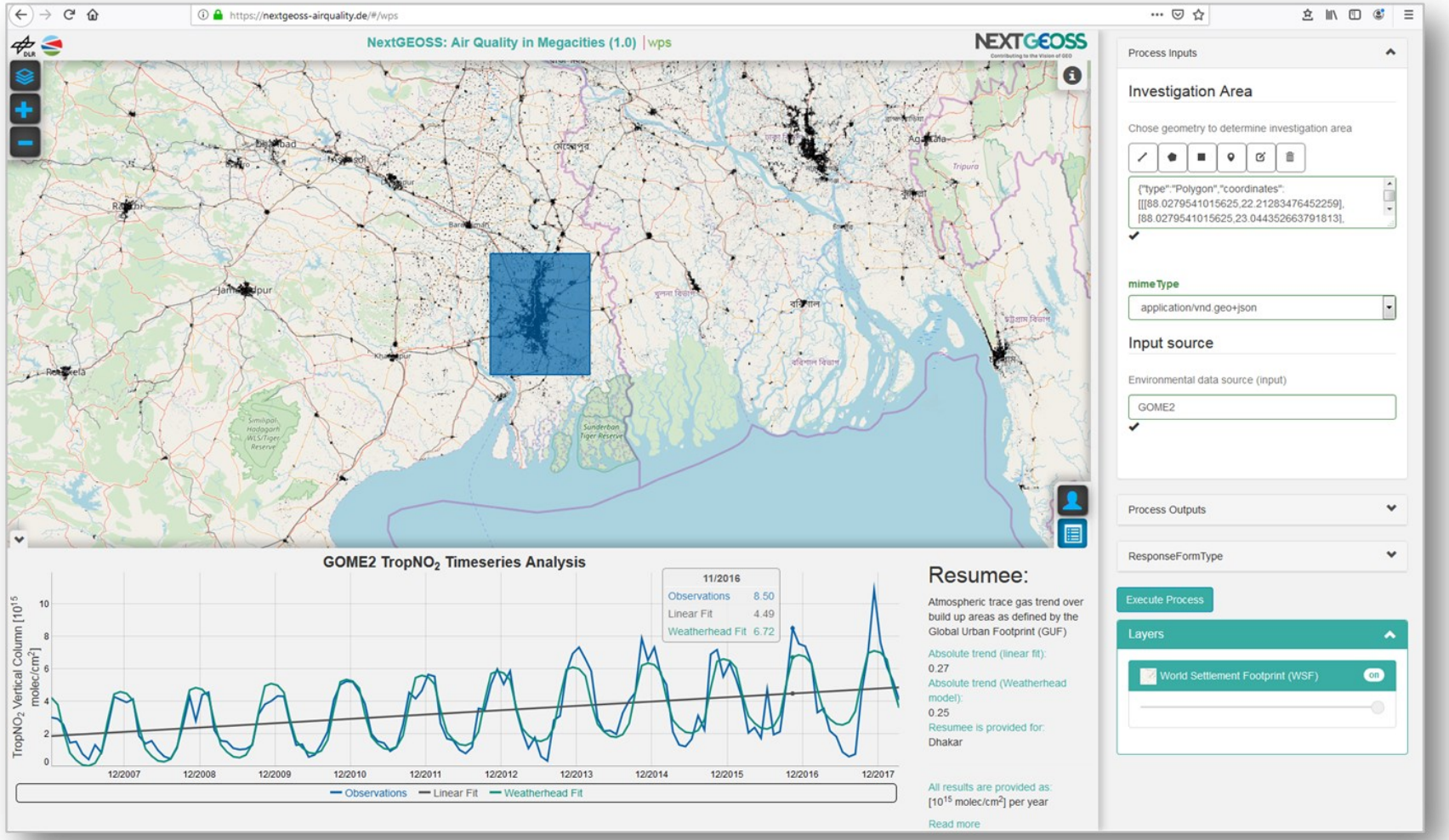
Original LST data



Boosted LST data

Results and Relevance to CCI community

- **Outlook:** Trend analyses based on combined assessment of ECV and urban morphology data



Interactive visualization of temporal evolution of $TropNo_2$ concentration over the built-up area based on user defined areas of interest