# Urban Canyons Framework

## Spatio-temporal aspects of wind speed conditions inside the city

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## Introduction

Dynamics of cities are constantly changing. Thus, how natural phenomena interact with their organic configuration matters. Buildings are silently modified, demolished or created (Fig.1). Every change indirectly implies new issues (*i.e.*, as how high-rise buildings may affect the wind speed at the street level) or opportunities (*i.e.* how the increase in air pressure at building facades qualifies energy exploration with wind turbines). There is a need for a better process of active exploration, equipped to provide an efficient mechanism able to not only recognize these opportunities but also leverage enough knowledge to avoid repeating faulty urban planning. In this work, we aim to help the planning of **cities of the future**, by presenting a data-driven approach that generates and interacts with large spatio-temporal data produced by multiple experiment ensembles.

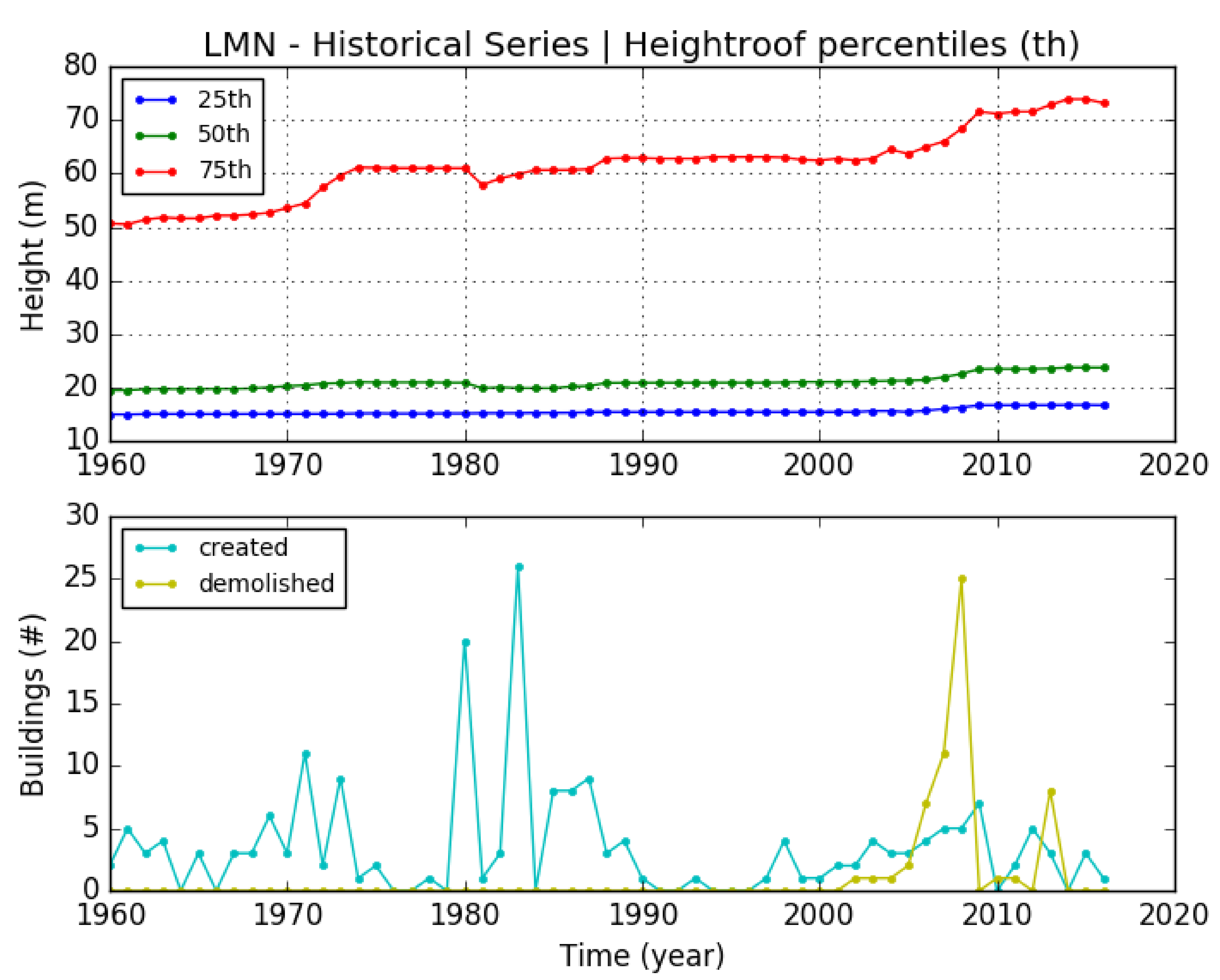


Figure 1: *How fast is the city changing? This chart shows how small buildings opened space to taller ones.*

### References

[1] "Urban Canyons - Study Case." [Online]. Available: https://vgc.poly.edu/projects/urbancanyons/

[2] "NYC Open Data." [Online]. Available: http://www1.nyc.gov/site/planning/data-maps/open-data.page

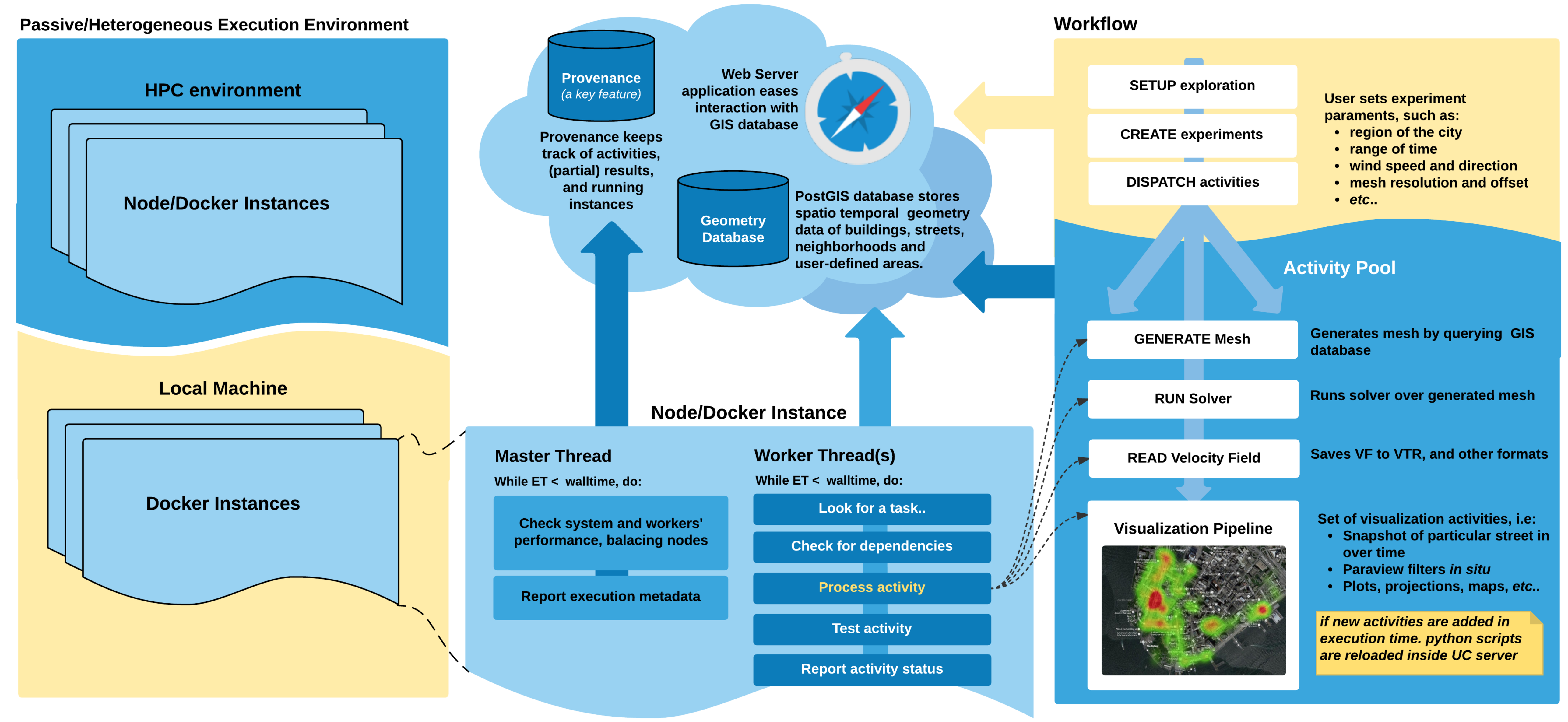


Figure 2: *Our framework integrates provenance and a geometry database providing support for a large-scale ensemble space exploration. Docker instances introduce flexibility while containerizing the worker node at general execution environments; and collecting execution's metadata. Each node acts passively, querying for the next task at provenance for consumption, and reporting the results back as tasks are finished.*

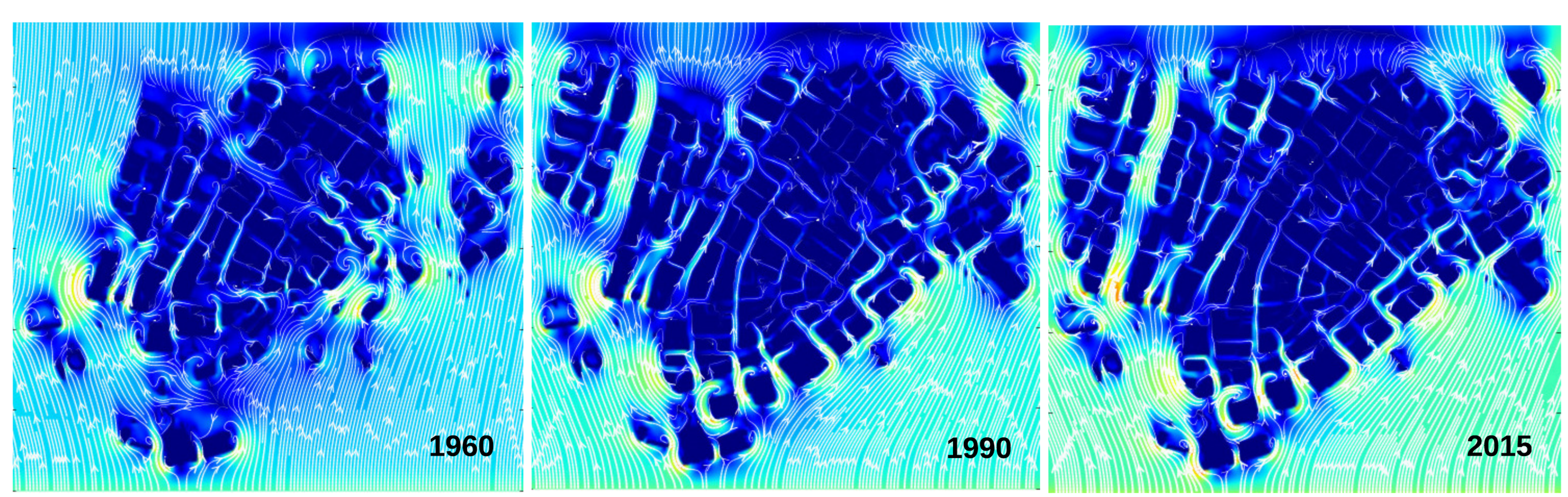


Figure 3: *Manhattanization. Velocity (mag.) at street level as the city drastically changes since 1960. Three simulations of different snapshots of the city reveal canyons formations inside the city as new buildings arise.*

## Study Case

- **Lower Manhattan**
  - **17 years** (1999-2016)
  - **7** wind directions (from south)
  - **3** mesh resolutions (2/5/9 m)
  - **6** reference speeds (2-12 m/s)
  - **2268** ensembles
- **9073** unique tasks were dispatched
  - **154** unique jobs at a cluster and local machine
  - **756** different worker instances
- ≊ **4TB** of CFD results in disk, NOT staged out
- Relevant data is captured and exported back to provenance

## Conclusion

Exploration of spatio-temporal aspects of natural phenomena at scale can also be achieved in urban space. This work makes use of provenance to keep track of and orchestrate the execution of exploratory wind analysis. Moreover, a scientific workflow approach takes over debugging by taking advantage from "knowing" what is behind workflow tasks and data-flow. Due this alliance, we improve our experiment management and data uniformity at scale, easing the retrieval of partial/final results in a distributed system. When data of interest is achieved, it is streamlined (bypassing costly I/O) into a visualization pipeline. Finally, the outcome of this work can be studied and correlated from multiple points of view, *i.e.* pedestrian comfort level, urban ventilation, or mobility, or energy generation.

Figure 4: *Heatmap of significantly increased wind velocity at pedestrian level from 1999 to 2016 at Lower Manhattan.*