Weather reanalysis on an urban scale using WRF

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***Abstract*—In this study, we improve the Weather Research and Forecasting mesoscale model (WRF) performance by incorporating observations of a variety of sources using data assimilation and nudging techniques on a resolution up to 100 meter for urban areas. Our final goal is to create a 15 year climatological urban re-analysis data archive of (hydro)meteorological variables for Amsterdam which is named ERA-urban. This will enable us to trace trends in thermal comfort and extreme precipitation.**

***Index Terms*—climate, reanalysis, urban, data assimilation, workflow**

I. Introduction

Ongoing world-wide climate change and urbanization illustrate the need to understand urban hydrometeorology and its implications for human thermal comfort and water management. Climate models can assist to understand these issues, as they progress increasingly towards finer scales. With high model resolutions (grid spacing of 100m), effective representation of cities becomes crucial. The complex structures of cities, configuration of buildings, streets and scattered vegetation, require a different modelling approach than the homogeneous rural surroundings. The current urban canopy-layer schemes account for these city specific characteristics, but differ substantially amongst each other due to uncertainty in land use parameters and incomplete physical understanding. Therefore, the hindcasting of the urban environment needs improvement [1].

II. Data & methods

A. Data assimilation & nudging

The Weather Research and Forecasting mesoscale model (WRF) performance is improved by incorporating observations of a variety of sources using data assimilation (WRF-3DVAR) and nudging techniques on a resolution up to 100 meter. Data assimilation aims to accurately describe the most probable atmospheric state by steering the model fields in the direction of the observations. Data sources include World Meteorological Organization (WMO) synoptic weather observations [8]–[10], volume radar data [8] and urban weather observations recorded by hobby meteorologists [6].

1) Synoptic weather & radar observations: Data assimilation of synoptic weather and radar observations is performed using WRFDA, the data assimilation toolkit included in the WRF ecosystem. WRFDA accepts only non-standard ascii-based input data, different for both synoptic weather and radar observations. As an intermediate step between the online data repositories and the ascii-based file format, synoptic weather observations are converted to the netCDF file format. Using [4] the netCDF files are converted to the by WRFDA accepted file format. Similarly, [5] is used to write the radar data to the accepted format.

2) Nudging of the urban fabric temperatures: Specific to urban boundary layers, a novel approach [7] has been developed to nudge modelled urban canyon temperatures with quality controlled urban weather observations [6]. It is crucial to adjust the urban fabric, as the accompanied heat storage enables the adjustment of urban temperatures over time. The road and wall layers of the urban canopy are adjusted depending on the bulk heat transfer coefficient and urban geometry. In addition, the anthropogenic heat release within the single-layer urban canopy model (SLUCM) of WRF is improved by incorporating this flux predominantly into the canyon instead of the first model layer above the canyon.

B. Workflow & integration

For integration of the different tools and handling the data flow between them, a python package [7] has been developed within this project. It provides an easy way to set up, run, and monitor (long) WRF simulations. Integration with a workflow engine [2] takes care of monitoring and orchestration of tasks.

III. Results

Tooling has been developed around the WRF ecosystem to facilitate setting-up and running (long) WRF simulations with (optionally) data assimilation. In addition a novel approach has been developed to nudge modelled urban canyon temperatures with quality controlled urban weather observations.

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