netherlands eScience center

WAGENINGEN UNIVERSITY & RESEARCH

Weather reanalysis on an urban scale using WRF

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Motivation

- Traditional weather forecasts no longer good enough
- Weather forecasts can be strongly influenced by the local environment
- General demand for high resolution forecasts and archives of (extremes in) temperature, thermal comfort, precipitation, ...

AIM: 15 year fine scale (100m) urban climatology reanalysis archive for Amsterdam

Traditional weather forecast

Motivation

DutchNews.nl

News | Features | Blogs | Jobs | Housing | Best of the Web

Home | Politics | Business | Society | Sport | Education | Health | Tech &

Heavy rain, thunderstorms lead to flooding, Schiphol airport delays

Society July 28, 2014

Very heavy showers and some thunder is set to hit much of the Netherlands on Monday, the KNMI weather bureau says.

In some south-western parts, up to four centimetres of rain may fall in some places, leading to localised flooding. Flooding has already been reported in Zeeland, Zuid-Holland and western parts of Brabant, news agency ANP says.

Het Parool

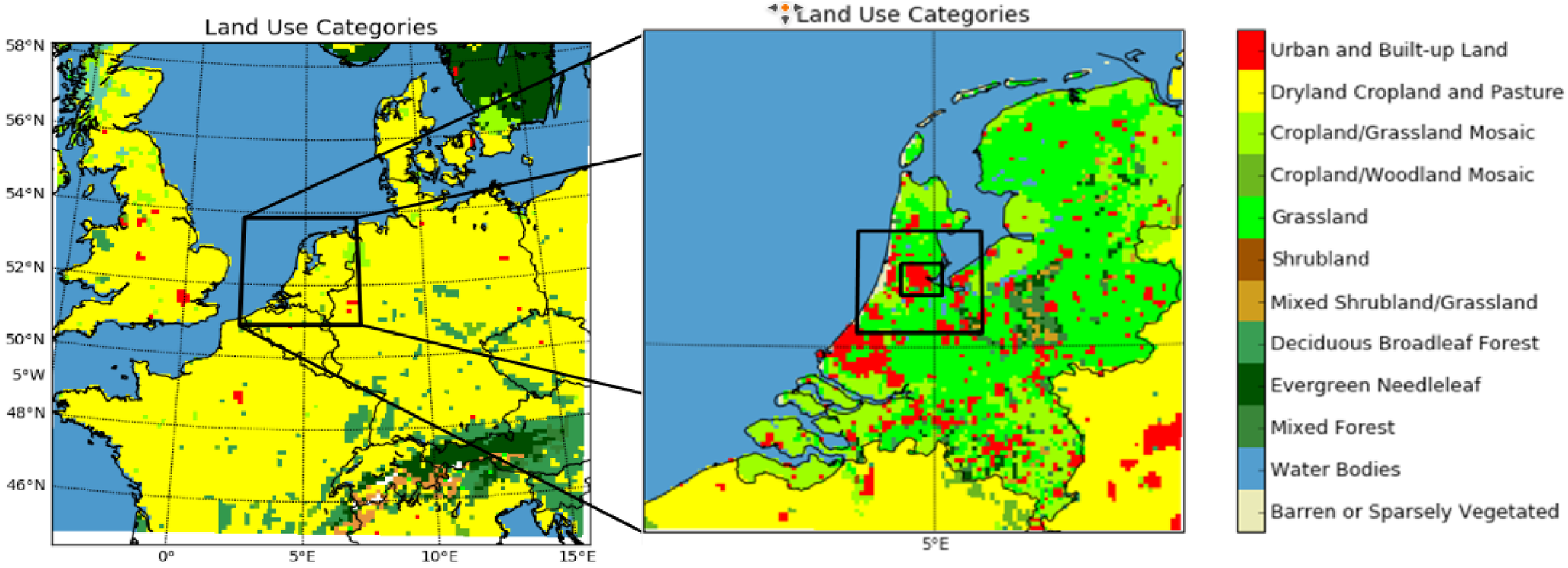
HOME AMSTERDAM STADSGIDS OPINIE

Veel wateroverlast in Amsterdam

Station Amsterdam-Zuid staat onder water © Robin Kok

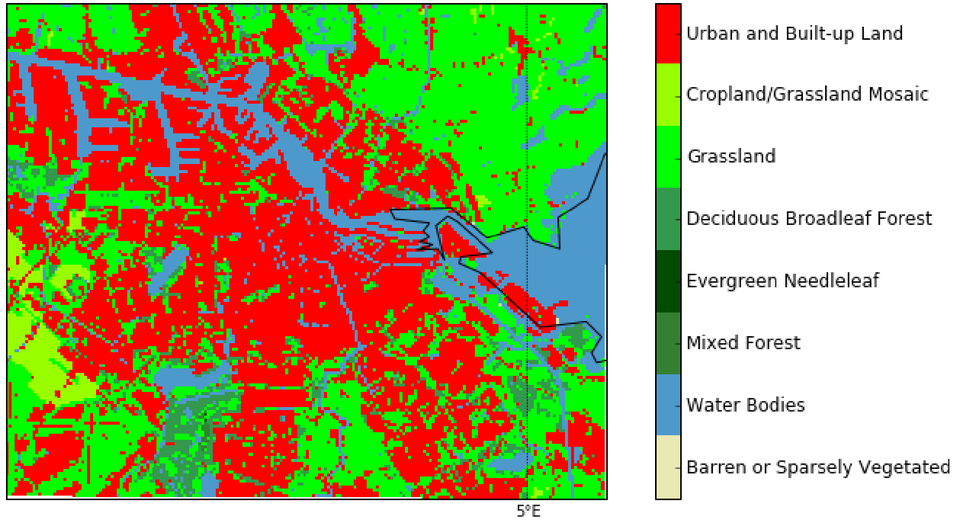
Model domains

- 4 domains with 12500, 2500, 500, 100m resolution
- ECMWF boundaries every 6 hours, 0.5x0.5deg



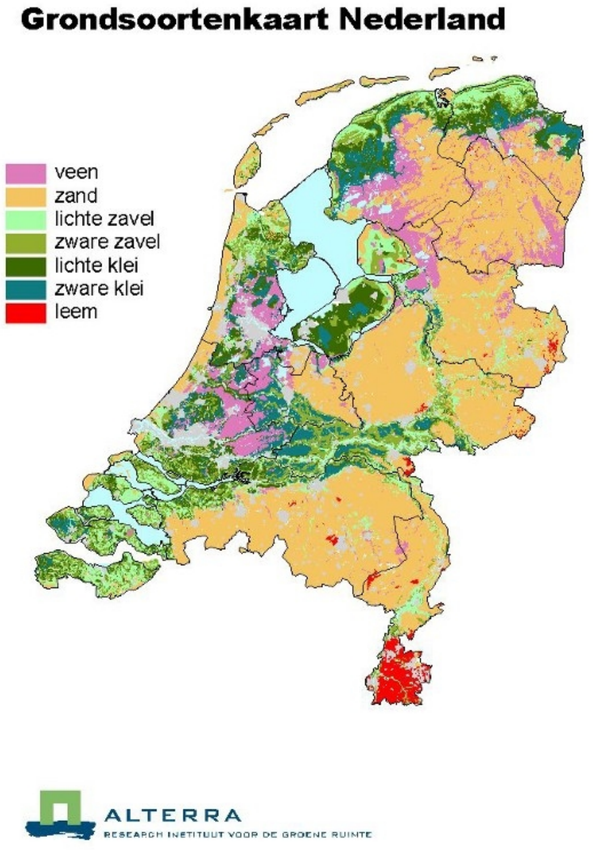
Detailed urban morphology data

Land Use Categories



Detailed elevation data (AHN2)

Detailed soil map

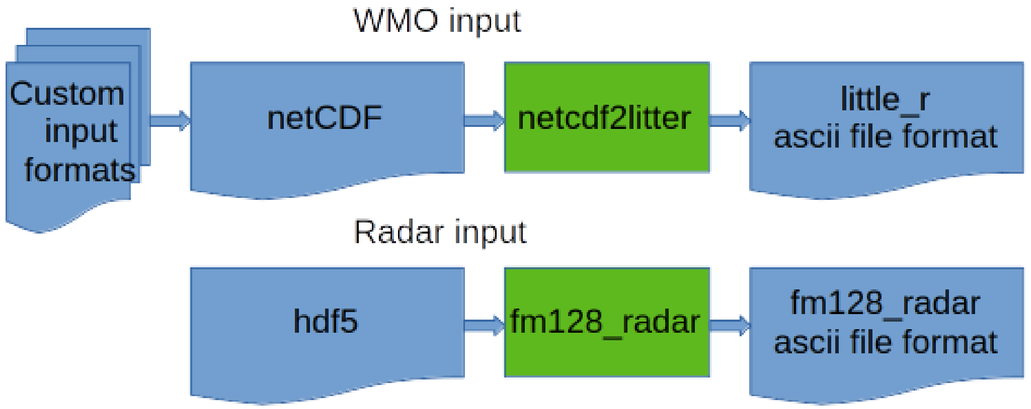


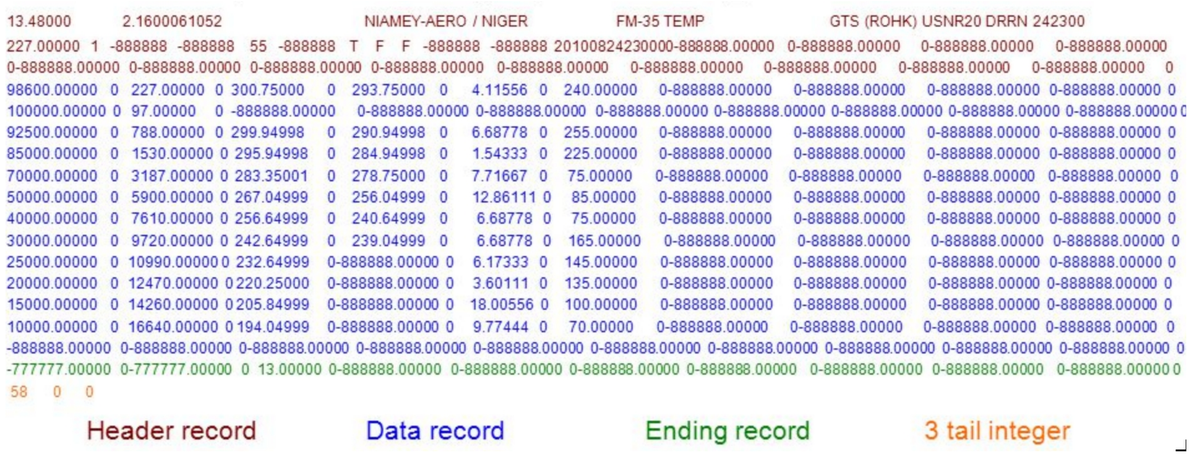
Ronda, R.J., G.J. Steeneveld, B.G. Heusinkveld, J.J. Attema, and A.A. Holtslag, 2017: doi:10.1175/BAMS-D-16-0297.1"Urban Finescale Forecasting Reveals Weather Conditions with Unprecedented Detail. Bull. Amer. Meteor. Soc., 98, 2675–2688

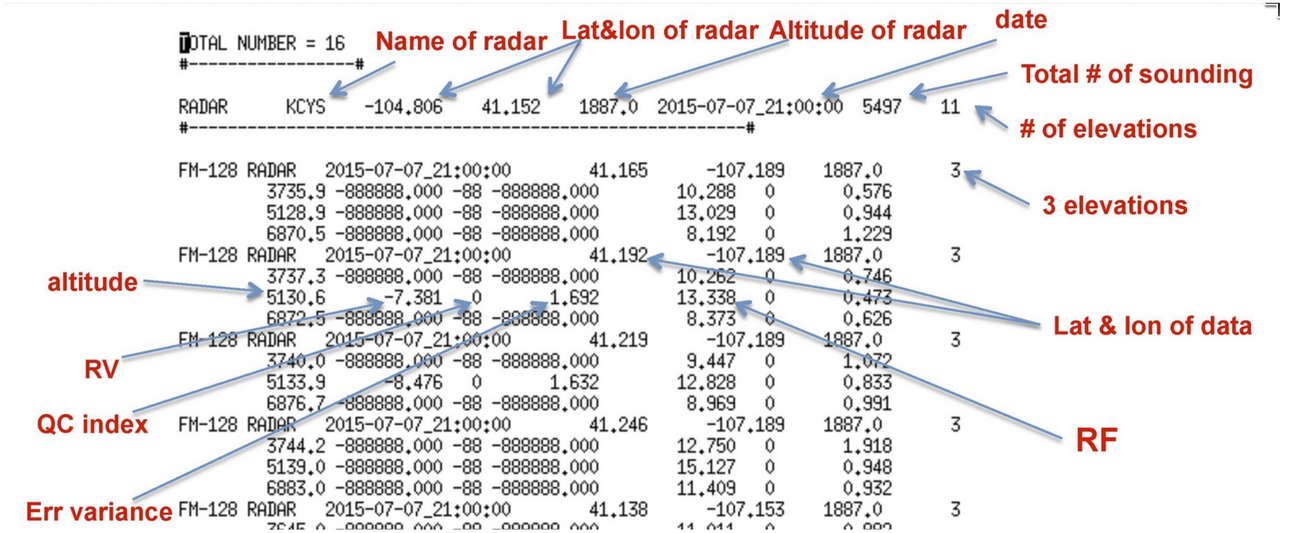
Conversion of large scale input data

- Tooling to convert upstream data format into

  WRFDA accepted data format:
  - WMO input data from KNMI, DWD and UKMO
  - Radar data from KNMI



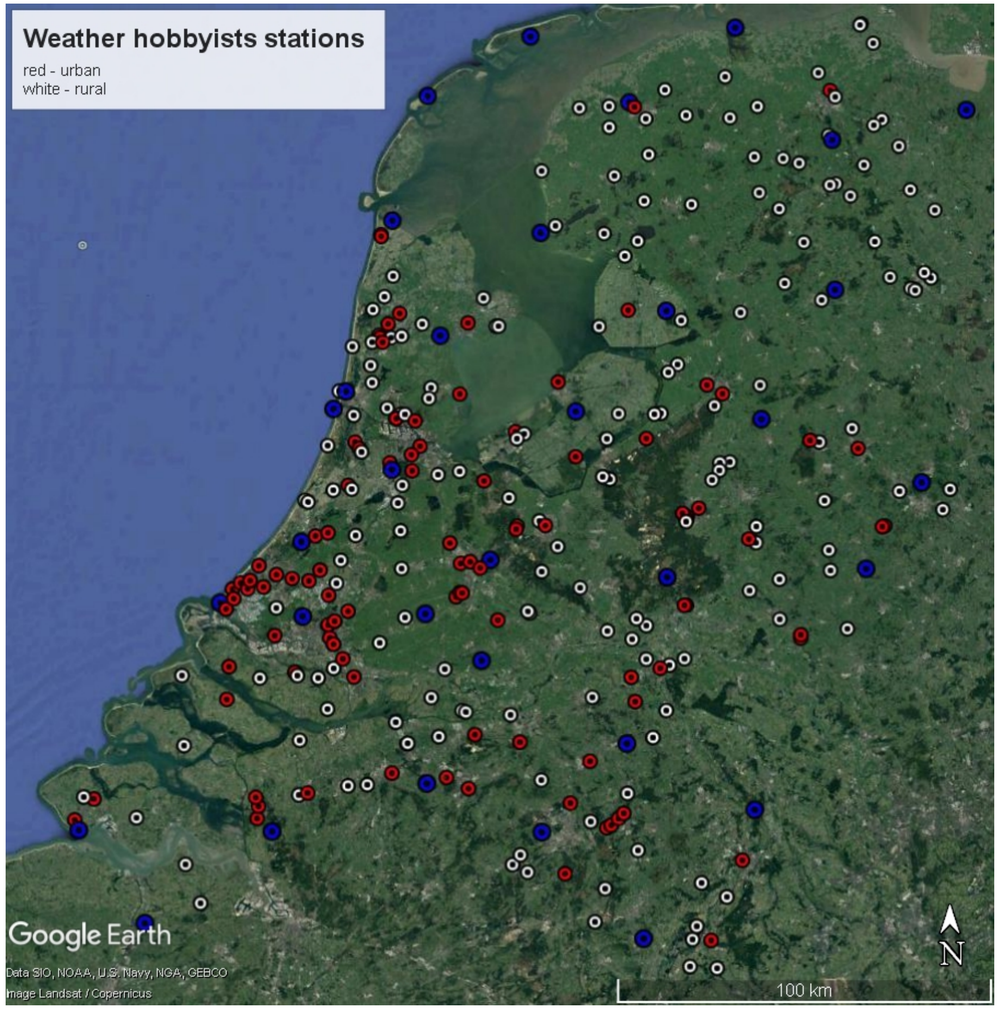




R. van Haren. (2018, September 17). fm128 radar (Version 1.2.0). doi:10.5281/zenodo.1420223

R. van Haren. (2018, June 13). netcdf2littler (Version 1.0.0). doi:10.5281/zenodo.1288465

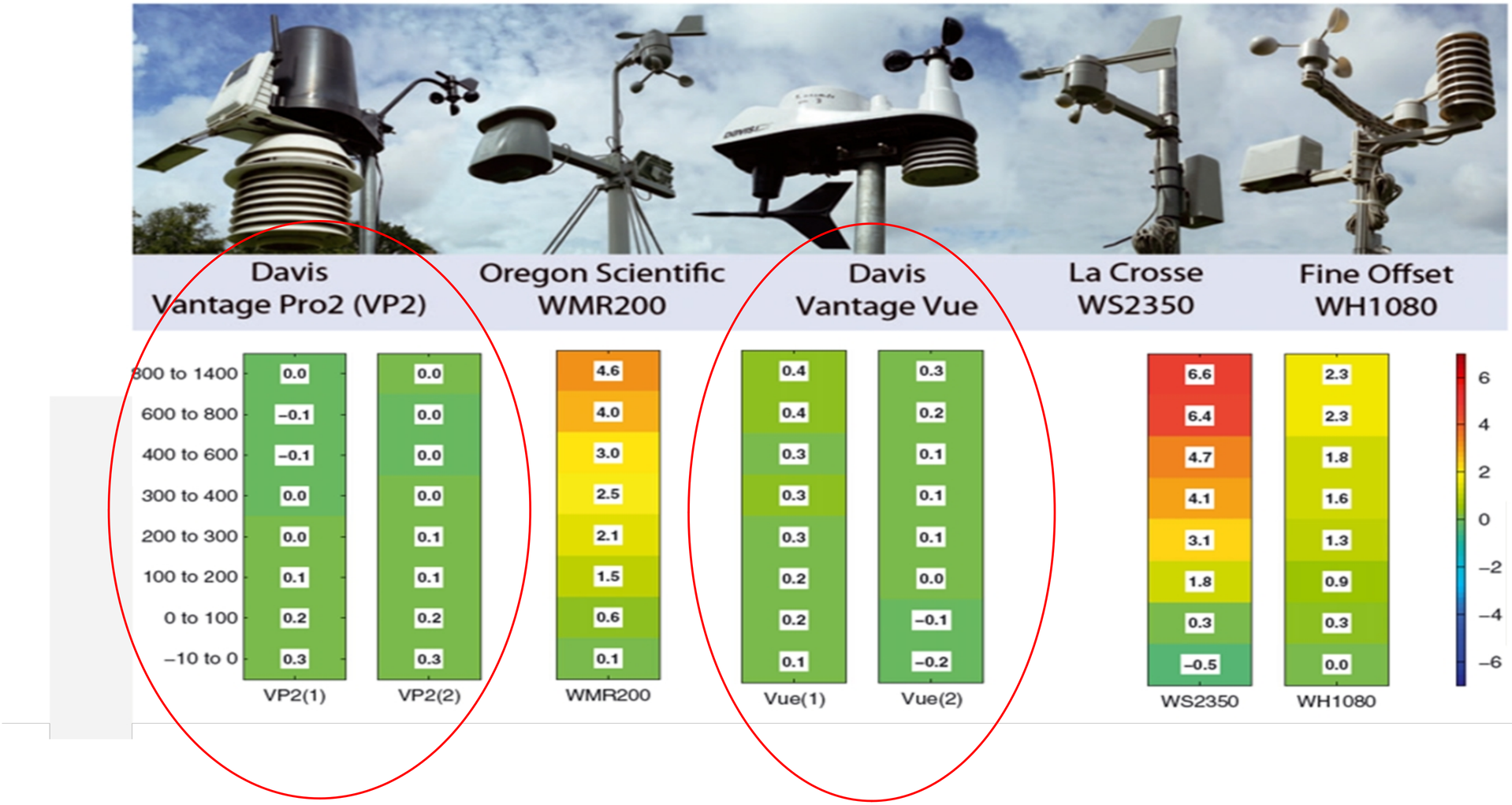
Urban weather data



About 300 stations in the Netherlands, variable quality and availability, direct transfer to Weather Underground website

Urban weather data from Weather Underground: https://www.wunderground.com/

Urban weather data



Variable quality hobby stations

Bell et al., 2005

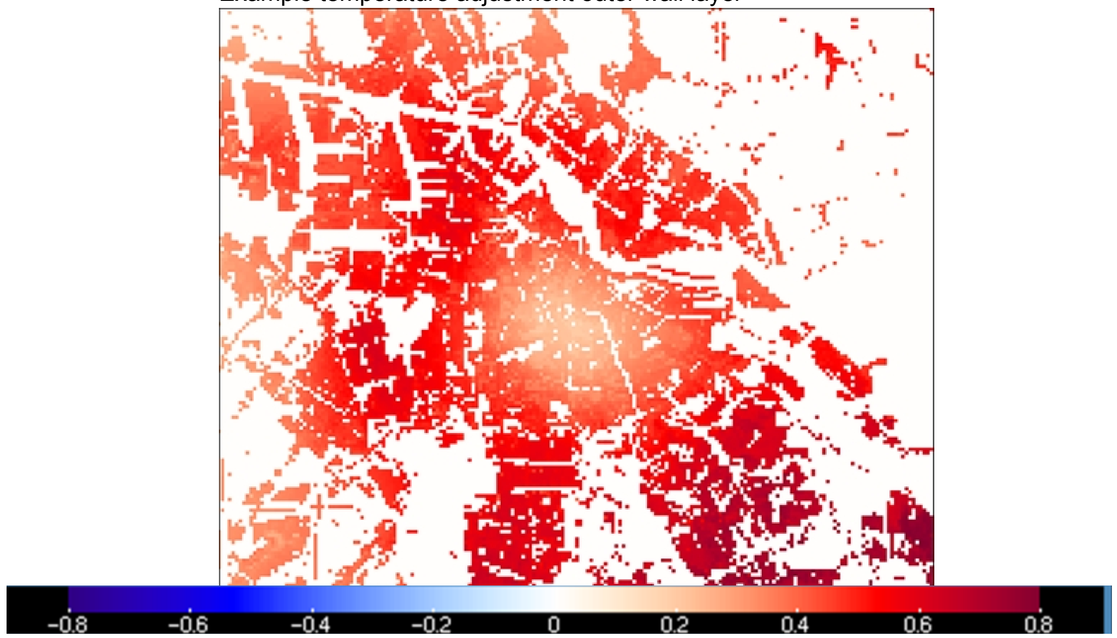
Nudging of urban fabric temperatures

- Urban temperatures are nudged by applying corrections on urban fabric (walls and roads). Urban fabric has storage to preserve the effect of nudging between 2 cycles.
- Single urban stations are not representative for neighborhood and city scale due to local variability
- Instead we apply corrections to the temperatures of walls and roads based on downward longwave radiation and 10-m wind:

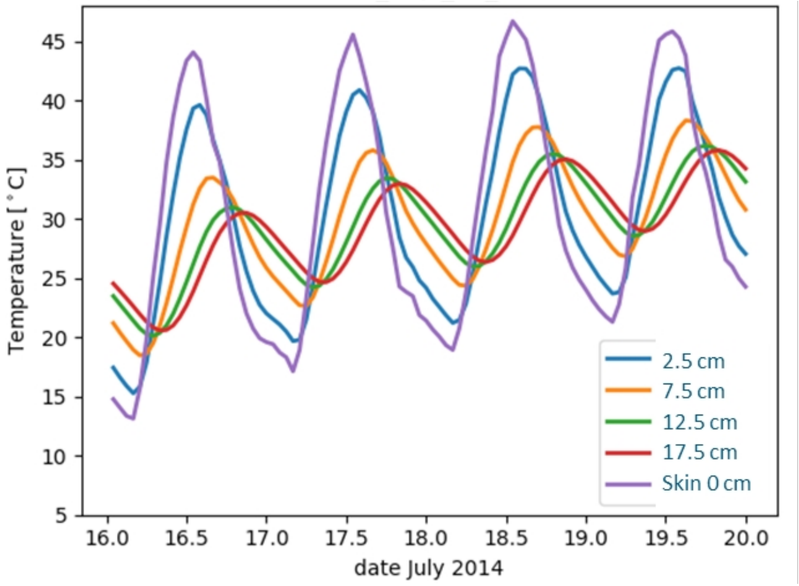
$$\Delta T = \alpha * GLW + \beta * U + \gamma$$

- Actual applied correction depends on material properties and urban morphology of the gridcell. Deeper layers have a smaller correction as it is more difficult for them to lose heat.

Example temperature adjustment outer wall layer

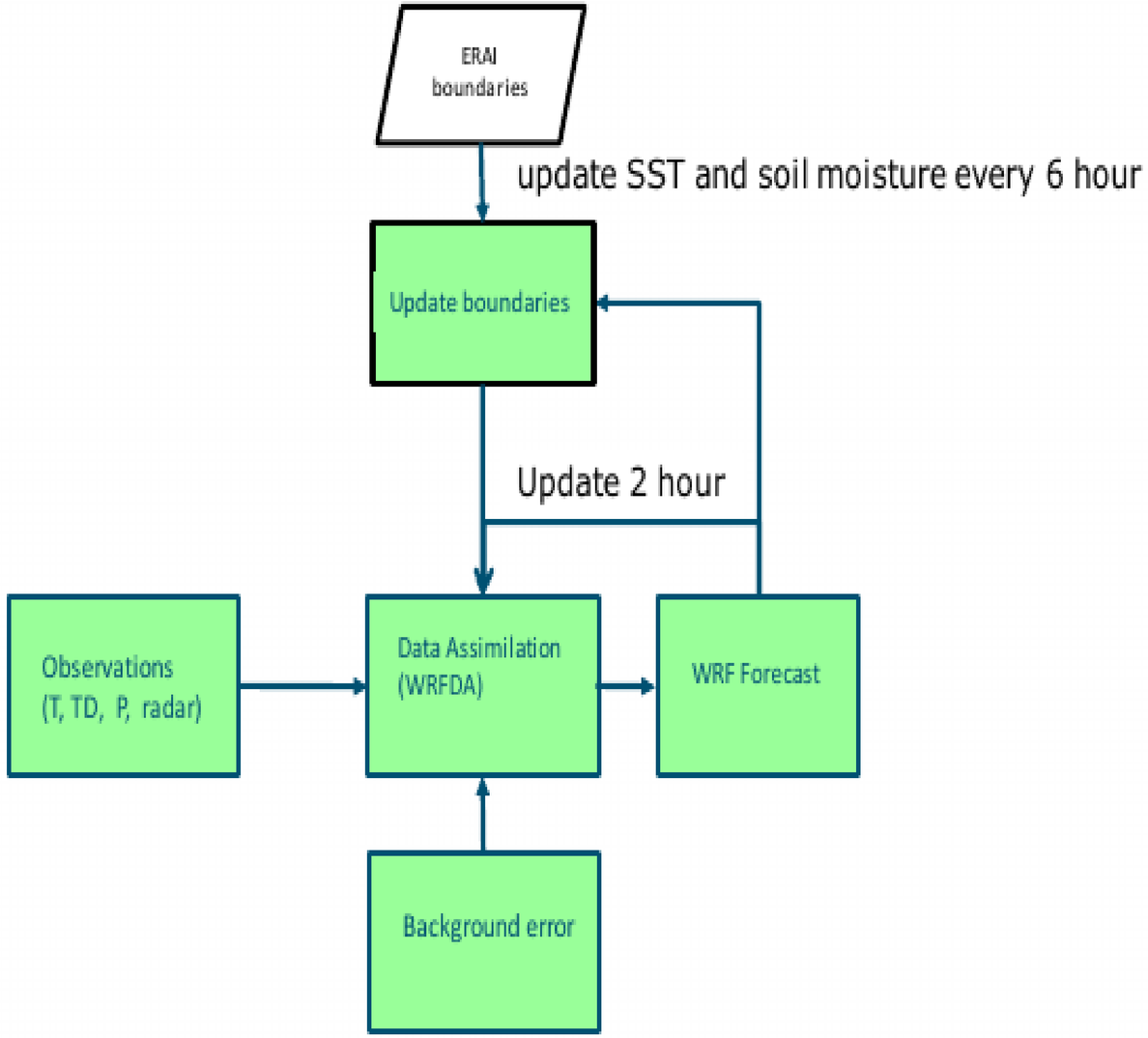


Temperature amplitude wall layers



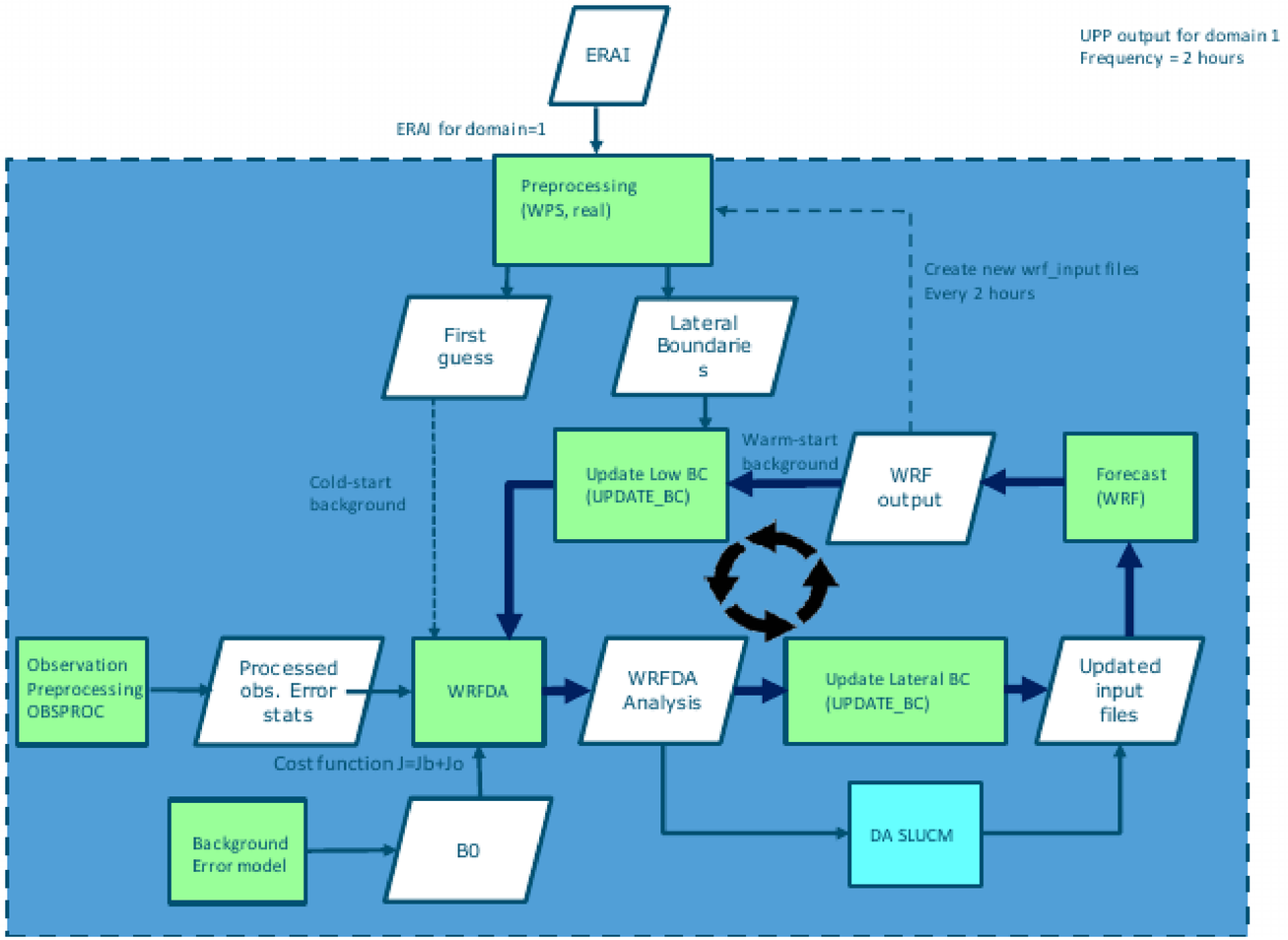
Data assimilation and nudging

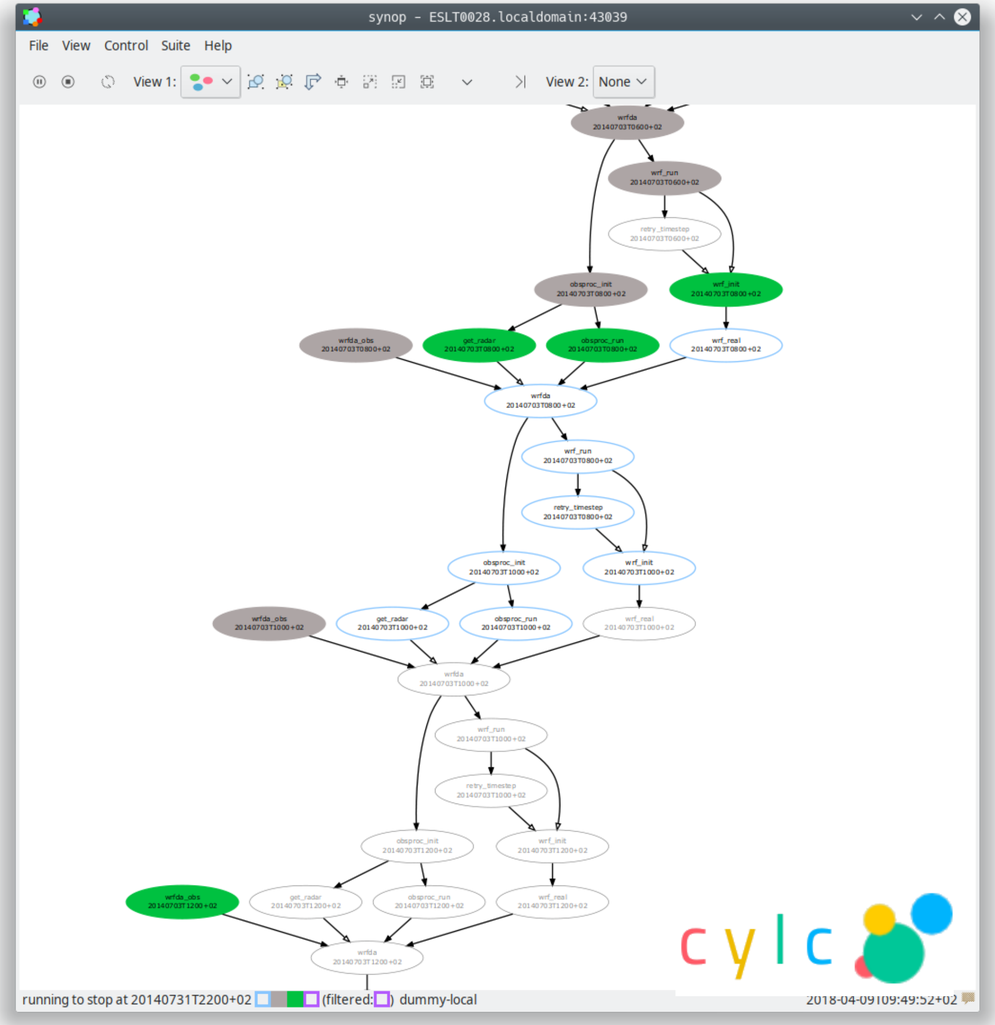
- Data assimilation (3DVAR) for WMO and radar data
- For assimilation of radar data, volumetric radar reflectivity and radial wind velocity is used. Clutter removal from reflectivity and interpolated to domain grid.
- Nudging of urban fabric temperatures using data from weather hobbyists.



Heistermann, M & Pfaff, Th & Jacobi, Stephan. (2012). wradlib - An Open Source Library for Weather Radar Data Processing

Integration with workflow engine





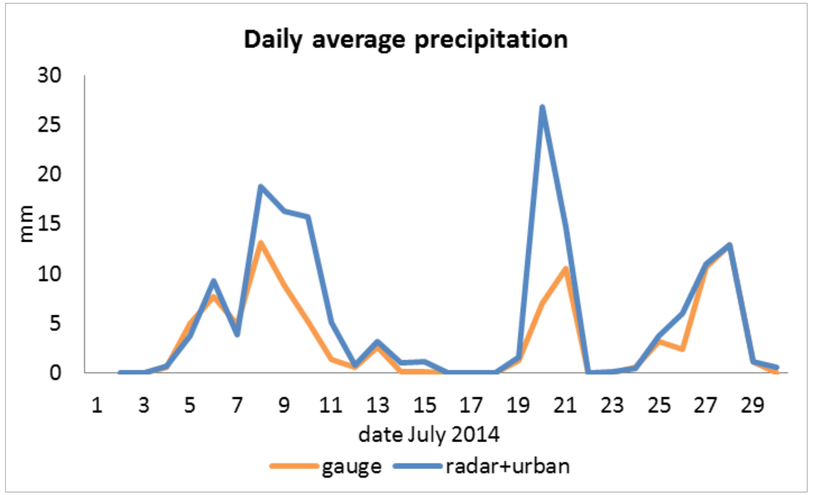
R. van Haren. (2018, September 18). WRFpy (Version 0.2.1). doi:10.5281/zenodo.1420918

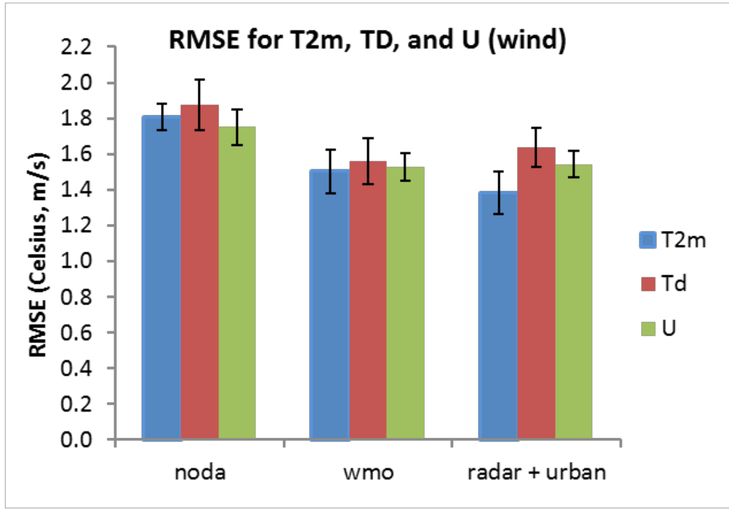
H.J. Oliver et al., (2018, May 22). CYLC (Version 7.7.0). doi: 10.5281/zenodo.1251084

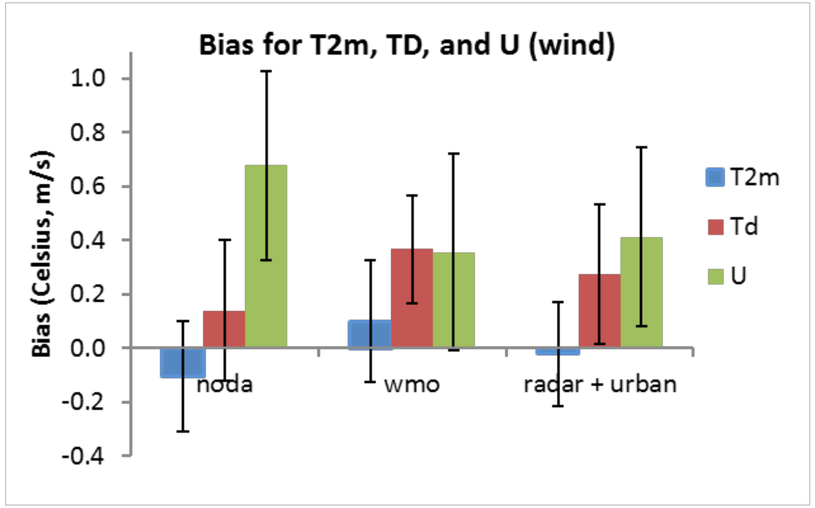
General results

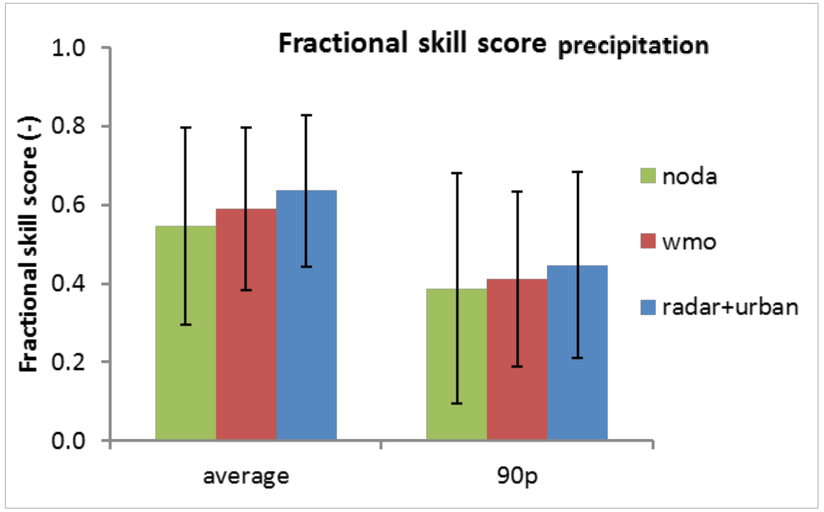
- **Verification on subset of WMO stations**

  1 and 2 hours after data assimilation







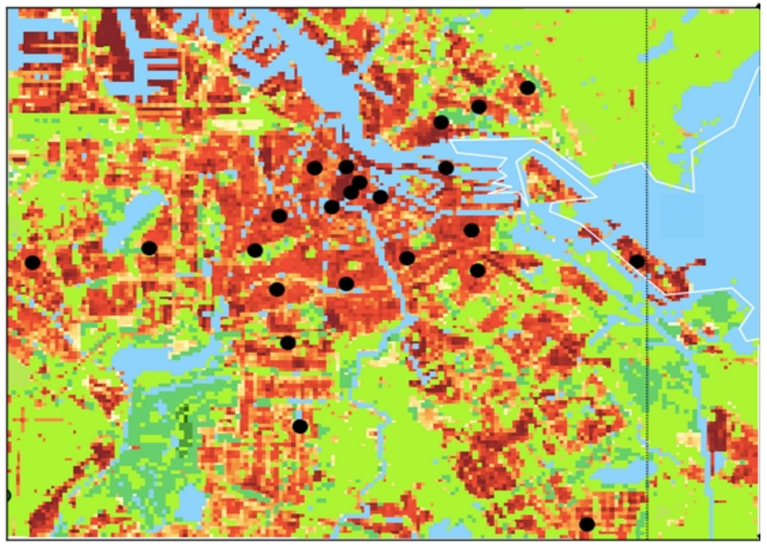


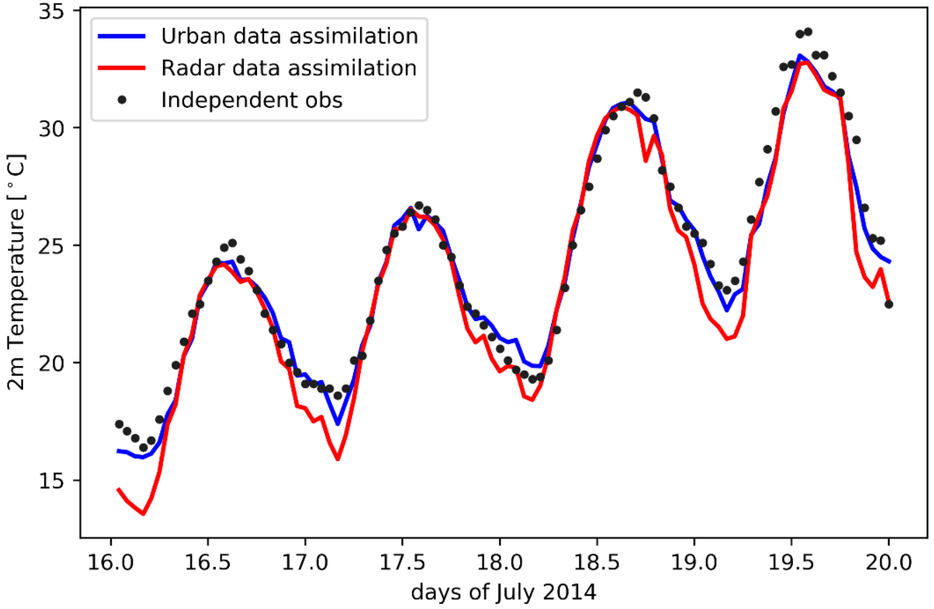
Urban results – comparison with independent urban stations

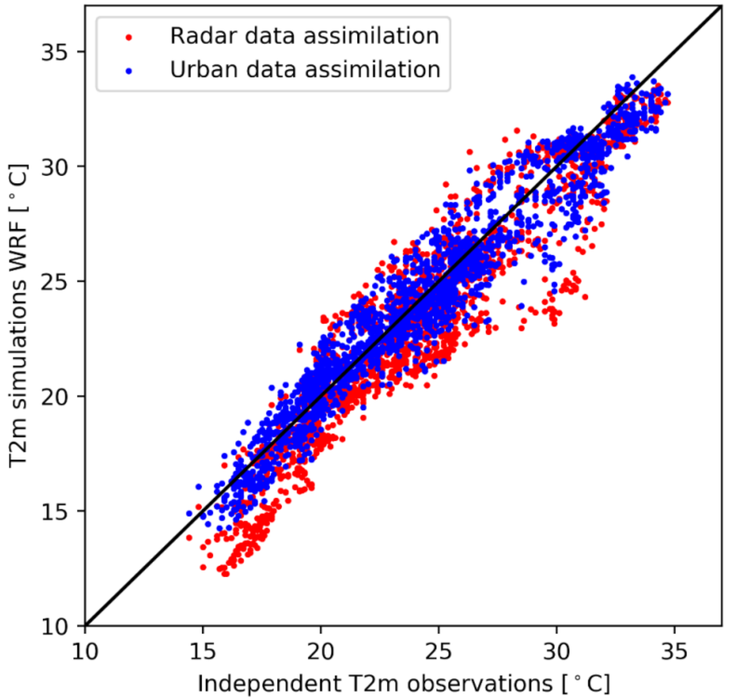
- **WMO + radar:**
  - RMSE = 1.84 ºC
  - Bias = -0.84 ºC

- **WMO + radar + urban:**
  - RMSE = 1.25 ºC
  - Bias = -0.18 ºC

Location independent stations



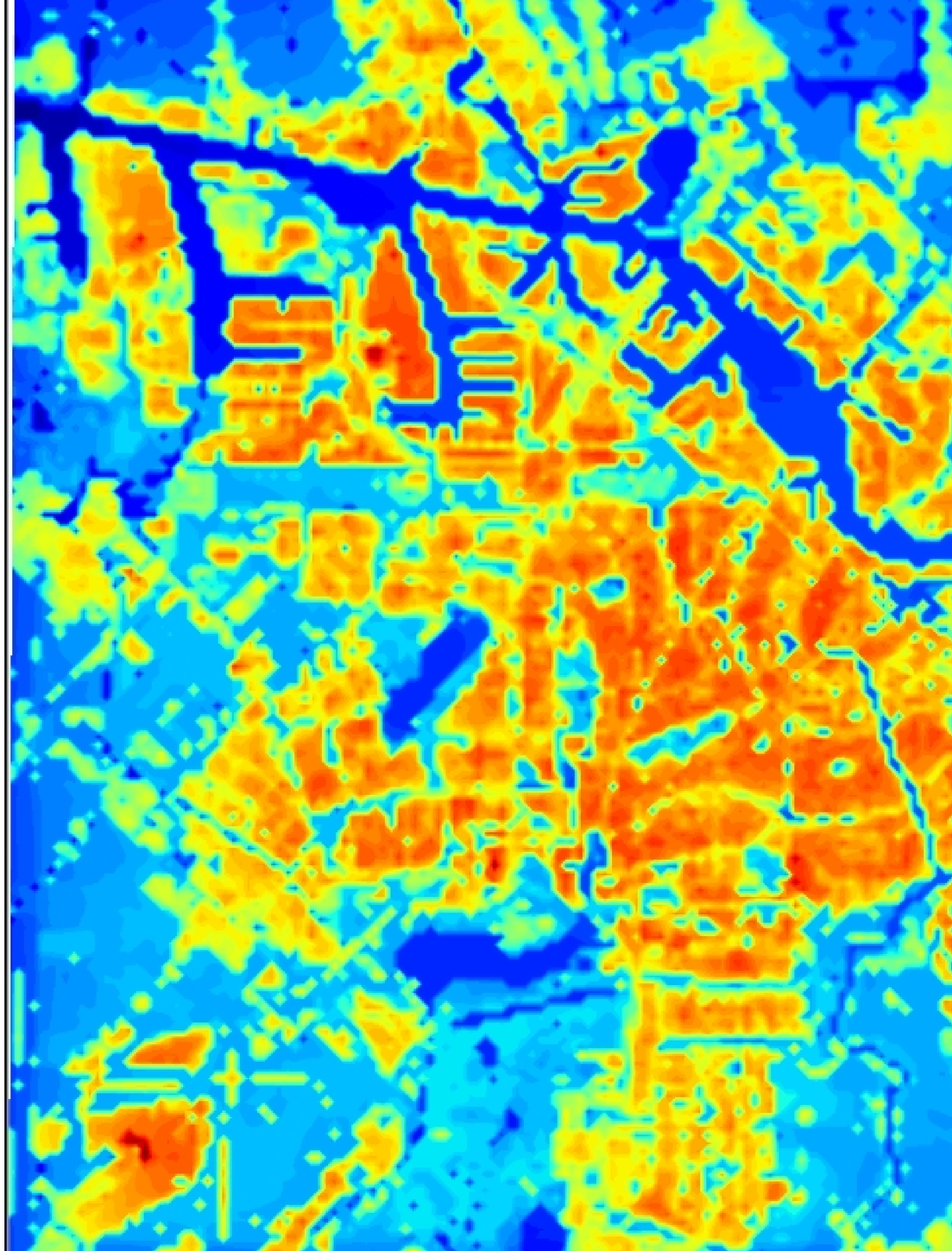




Results

Tooling around WRF ecosystem to facilitate setting-up and running (long) WRF simulations with (optional) data assimilation

- Novel approach to nudge modeled urban canyon temperatures with quality controlled urban weather observations
- WMO data assimilation improves forecasts substantially in various meteorological metrics
- Radar data assimilation is challenging, slightly/moderately better in prediction location of precipitation
- Nudging urban fabric temperatures with citizen weather data reduces the cold biases present in WRF



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Thank you!

Project github: https://github.com/era-urban
Presentation: doi://10.5281/zenodo.1475377
Conference proceeding: doi://10.1109/eScience.2018.00049