Summer in the city: Towards high Resolution Forecasting of Urban Weather

22th July 2015, R.J. Ronda, J.A. Attema, G.J. Steeneveld, B.G. Heusinkveld, A.A.M. Holtslag
eScience project “Summer in the city”

Goal:
To develop a novel prototype hourly forecasting system for temperatures in urban areas on “street level”.

Typical weather forecast for “rural areas”

“Forecast” on urban street level (~100 m)
Forecast model: high-resolution WRF 3.5.1

Wageningen

4 nested domains:

- domain 1: 120x120, 12.5 km res.
- domain 2: 121x121, 2.5 km res.
- domain 3: 121x121, 0.5 km res.
- domain 4: 126x126, 100 m res.

Amsterdam

4 nested domains:

- domain 1: 120x120, 12.5 km res.
- domain 2: 121x121, 2.5 km res.
- domain 3: 121x121, 0.5 km res.
- domain 4: 176x136, 100 m
Forecast model: high-resolution WRF 3.5.1

- One-way nesting
- WSM6 microphysics
- RRTMG scheme for long and short wave radiation
- Convection: Grell-Freitas ensemble (domain 1)
- PBL: domain 1, 2 & 3: YSU
- domain 4: Smagorinsky first order closure
- Land surface: NOAh LSM
- Urban: SLUCM
- BC/IC: ECMWF operational forecast (Wageningen)

NCEP GFS (Amsterdam)
Validation for two hindcast runs

• Wageningen
  Start: 31 July 2013 0:00 UTC
  End: 2 August 2013 0:00 UTC

• Amsterdam
  Start: 16 July 2014 0:00 UTC
  End: 20 July 2014 0:00 UTC
Surface: NOAhl LSM with Single Layer Urban Canopy Model (SLUCM)

Infinitely long symmetric canyons with:

Thermo-physical properties (parameters):
• Albedo of roofs, walls and roads,
• Heat conductivity/capacity of roofs, walls and road

Geometrical properties (parameters):
• Mean Building height
• Standard deviation of building height
• Mean canyon (road) width
• Urbanized fraction

Available for Netherlands on 25 m res., discussed by J.A. Attema (GD5: 14:15-16:00 on 22th July)
Two LAND USE runs for Wageningen

“Standard” USGS

High resolution Top10NL

Source: hJp://www.kadaster.nl/web/ar5kel/productar5kel/TOP10NL.htm
Two LAND USE runs for Amsterdam

“Standard” USGS

High resolution Top10NL

Source: http://www.kadaster.nl/web/artikel/productar5kel/TOP10NL.htm
Amsterdam weather stations
(see B.G. Heusinkveld: NOMTM11 for details)

Measuring:
- Humidity
- Temperature

Rural station: Schiphol airport
Wageningen weather stations and cargo bike tracks
temperature JULY 18\textsuperscript{st} 2014, 21:00 UTC

Results: Amsterdam

Observations: interpolated station observations

WRF: Detailed land use map

WRF model is in general slightly too warm

WRF: USGS land use

WRF model is in general too warm and lacks detail
(obs-mod) temp JULY 18$^{st}$ 2014, 21:00 UTC
Results: Amsterdam

WRF: Detailed land use map
100 m resolution

WRF: USGS land use
100m resolution
Results: Amsterdam

WRF: Detailed land use map
100 m resolution

WRF: detailed land use map
500 m resolution

WRF: detailed land use map
2.5 km resolution
temperature August 1st 2013, 21:00 UTC

Results: Wageningen

Observations: bike routes and Interpolated station observations

Reasonable agreement among observations

WRF model is (slightly) too cold

WRF model is much too cold, and only shows an UHI in a few locations
When WRF is run on a coarser resolution, the UHI of Wageningen is still visible in the model, but detail is lost leading to larger discrepancies between model and observations.
temperature August 2nd 2013, 15:00 UTC
WRF on 100 m res.

Observations: bike routes and Interpolated station observations

Detailed land use map

USGS land use

Reasonable agreement among observations

WRF model is too cold and only little temperature variation is modeled

WRF model is much too cold, and only shows an UHI in a few locations
Highlights

- High resolution urban forecasts are achievable

- For the heat waves of 2013 and 2014 model results are in reasonable to good agreement with observations, especially during the evening;

- High resolution forecasting improves forecasts of temperature on forecasting on low resolution

- Effective high-resolution forecasting requires however input data such as land use map on high resolution, which are now available for the Netherlands!
Next steps

- Comparison WRF with LES: “grey zone”

Domain averaged heat flux

U-spectrum at station “Oudezijds”

EMS conference in Sofia
Thank you!

Operational forecasts now available for Amsterdam
New detailed land use map, discussed by Attema (GD5: 14:15-16:00 on 22th July)

- Land use and information on buildings is provided by KADASTER data
- Heights are taken from AHN2 (& OHN)
- Urban fraction reduced using satellite imagery for urban classified areas with green areas

Information is used to calculate parameters of the SLUCM urban module of WRF on 100 resolution
Surface: NOAh LSM with Single Layer Urban Canopy Model (SLUCM)

Infinitely long symmetric canyons with:

Thermo-physical properties (parameters):
• Albedo of roofs, walls and roads,
• Heat conductivity/capacity of roofs, walls and road

Geometrical properties (parameters):
• Mean Building height
• Standard deviation of building height
• Mean canyon (road) width
• Urbanized fraction

Available for Netherlands on 25 m res., discussed by J.A. Attema (GD5: 14:15-16:00 on 22th July)
2 m temperature: centre and rural

Results: Wageningen detailed land use

WRF on 100 m resolution gives reasonable estimates temperature at night, but slightly underestimates afternoon temperature.

WRF on 500 m resolution underestimates both nighttime and afternoon temperature.
2 m temperature: center and rural

Results: Wageningen USGS land use

Both the 100 m resolution run and the 500 m resolution run underestimate both the nighttime and daytime temperature.
Station Markt (Center) and Veenkampen (rural): WRF “canyon” temperature

WRF on 100 m resolution gives reasonable estimates temperature at night, but overestimates afternoon temperature

WRF on 500 m resolution underestimates both nighttime and afternoon temperature
Station Markt (Center) and Veenkampen (rural): extrapolated 2 m temperature

WRF on 100 m resolution gives reasonable estimates temperature at night, but slightly underestimates afternoon temperature.

WRF on 500 m resolution underestimates both nighttime and afternoon temperature.
Both the 100 m resolution run and the 500 m resolution run underestimate both the nighttime and daytime temperature.