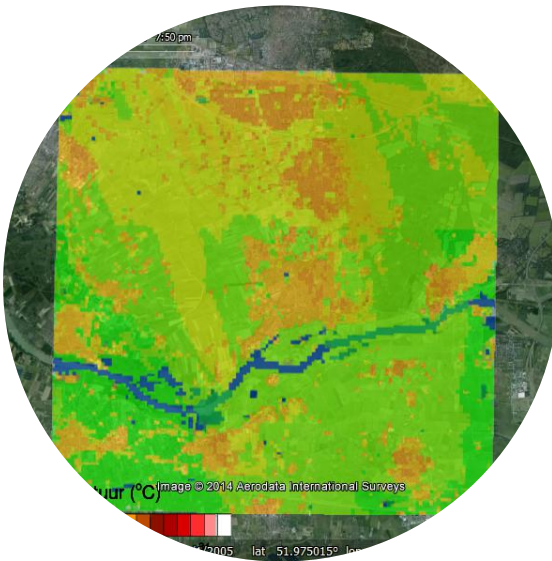


# Summer in the city: Towards high Resolution Forecasting of Urban Weather

22th July 2015, **R.J. Ronda**, J.A. Attema, G.J. Steeneveld, B.G. Heusinkveld, A.A.M. Holtslag



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# eScience project “Summer in the city”

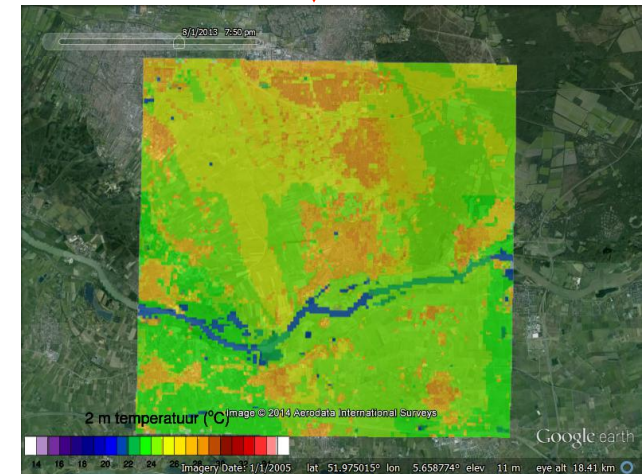
Goal:

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

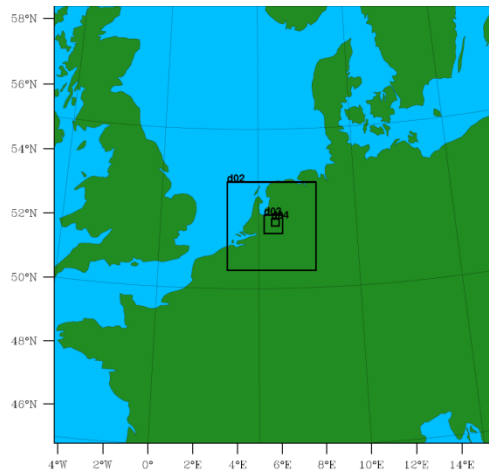
4 nested domains:

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

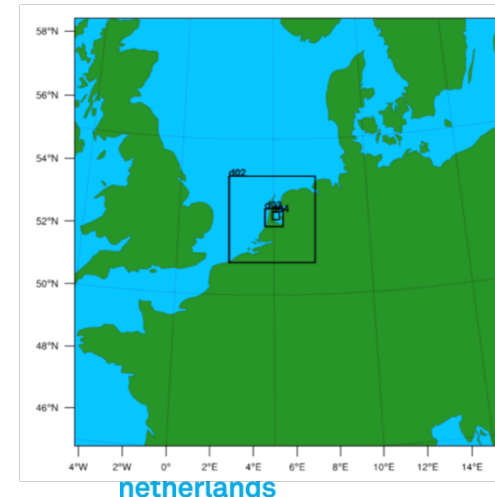
4 nested domains

domain 1: 120x120, 12.5 km res.

domain 2: 121x121, 2.5 km res.,

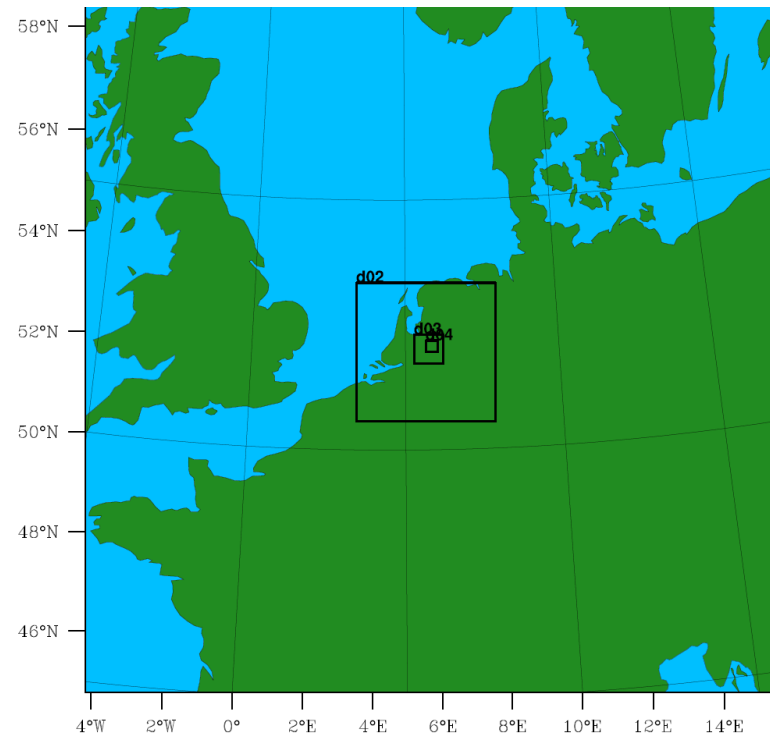
domain 3: 121x121, 0.5 km res. ,

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)



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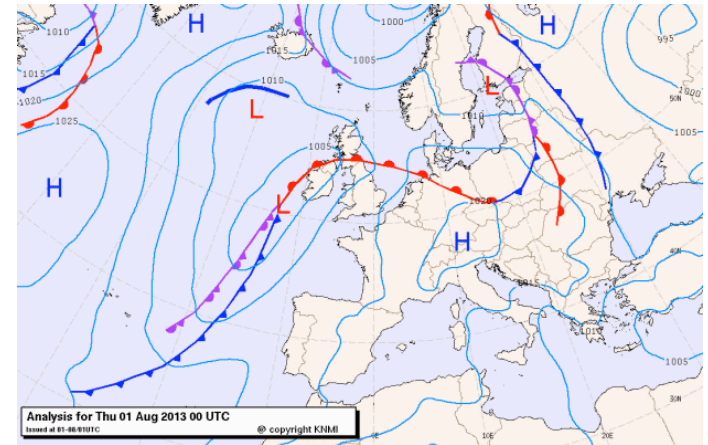


# Validation for two hindcast runs

- Wageningen

Start: 31 July 2013 0:00 UTC

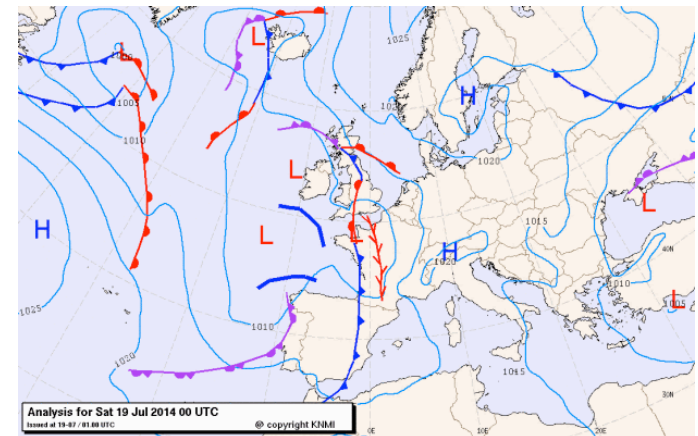
End: 2 august 2013 0:00 UTC



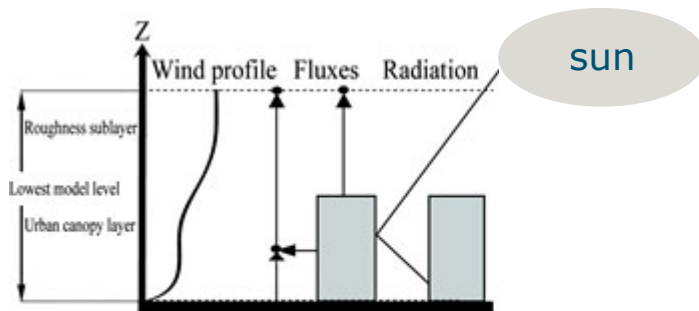
- Amsterdam

Start: 16 July 2014 0:00 UTC

End: 20 July 2014 0:00 UTC



# Surface: NOAh LSM with Single Layer Urban Canopy Model (SLUCM)



SLUCM

Infinitely long symmetric canyons with:

Thermo-physical properties (parameters):

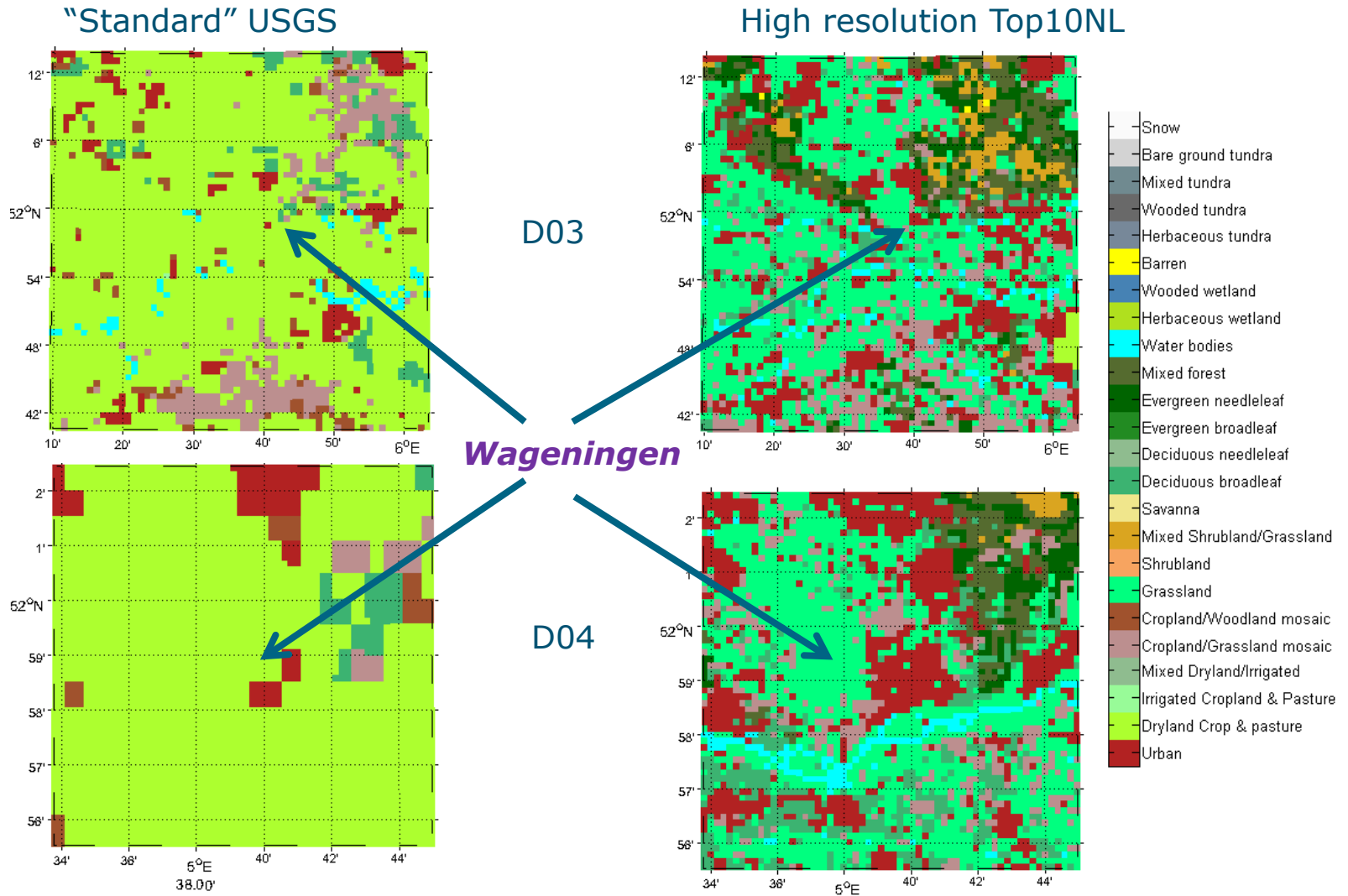
- Albedo of roofs, walls and roads,
- Heat conductivity/capacity of roofs, walls and road

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)

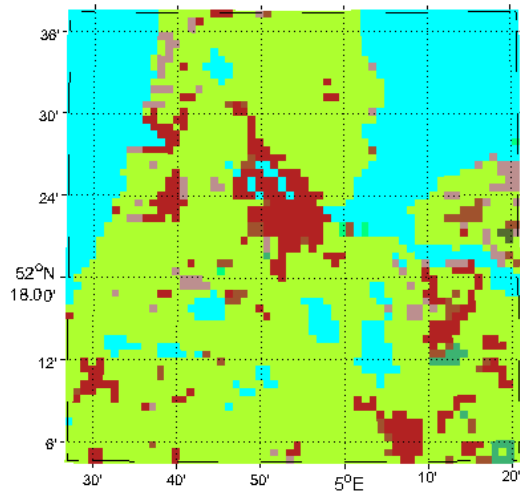
# Two LAND USE runs for Wageningen



Source: <http://www.kadaster.nl/web/artikel/productartikei/TOP10NL.htm>

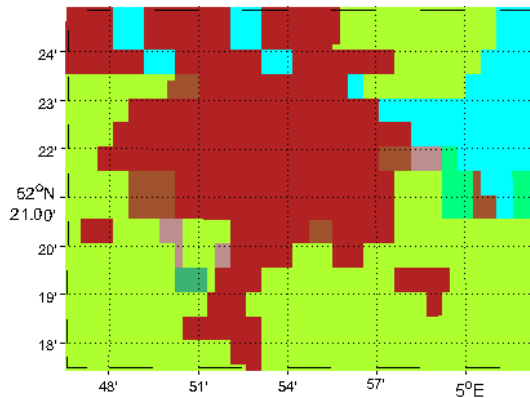
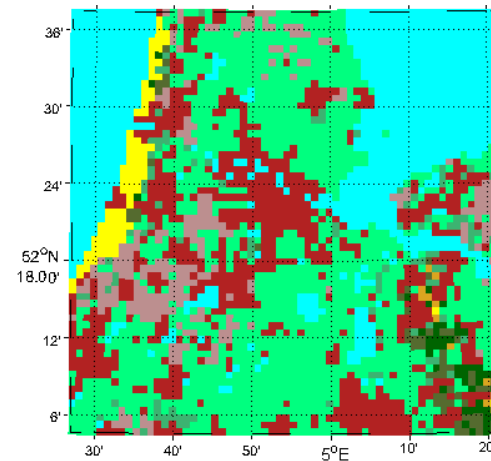
# Two LAND USE runs for Amsterdam

"Standard" USGS

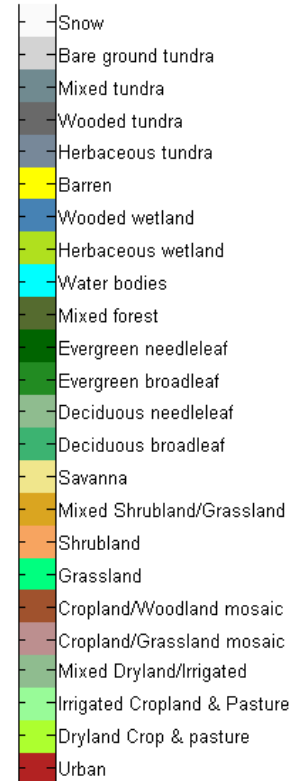
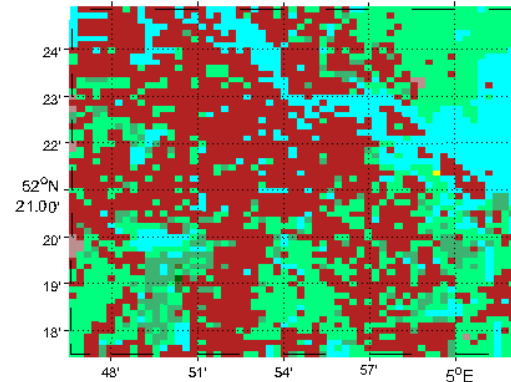


D03

High resolution Top10NL

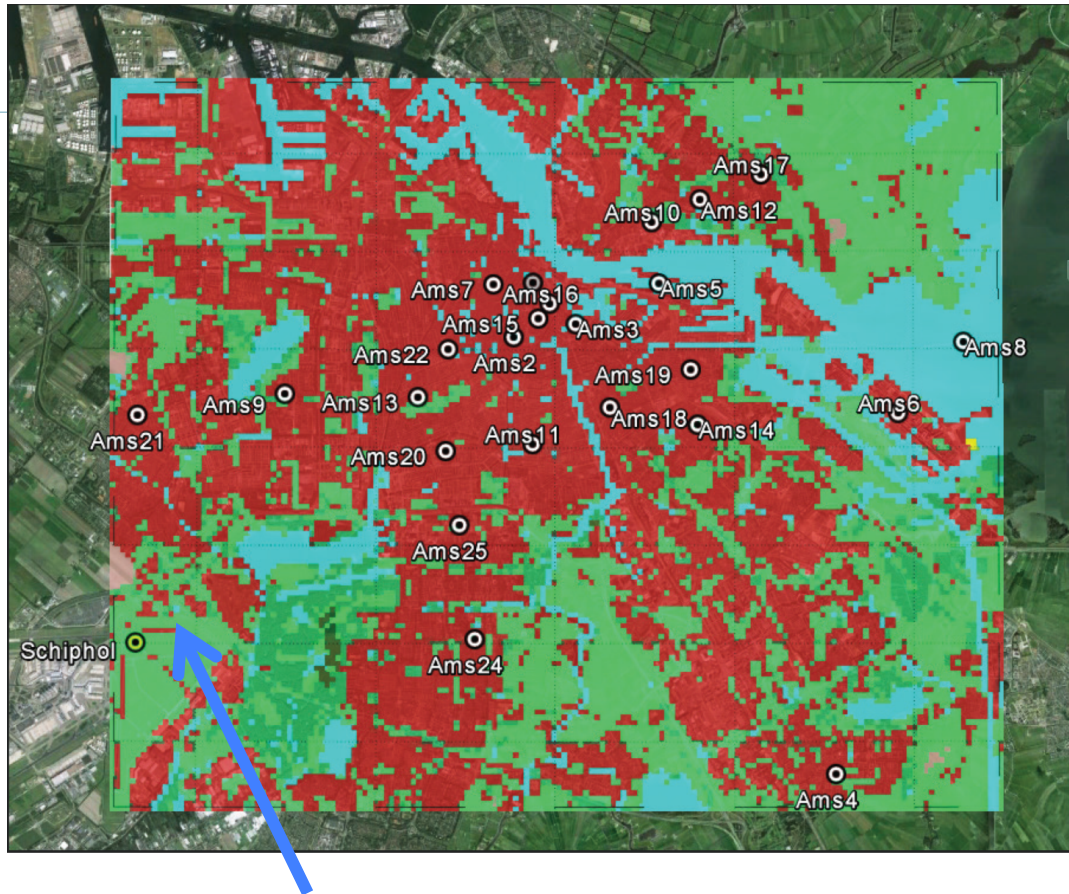


D04



Source: <http://www.kadaster.nl/web/artikel/productartike/Top10NL.htm>

# Amsterdam weather stations (see B.G. Heusinkveld: NOMTM11 for details)



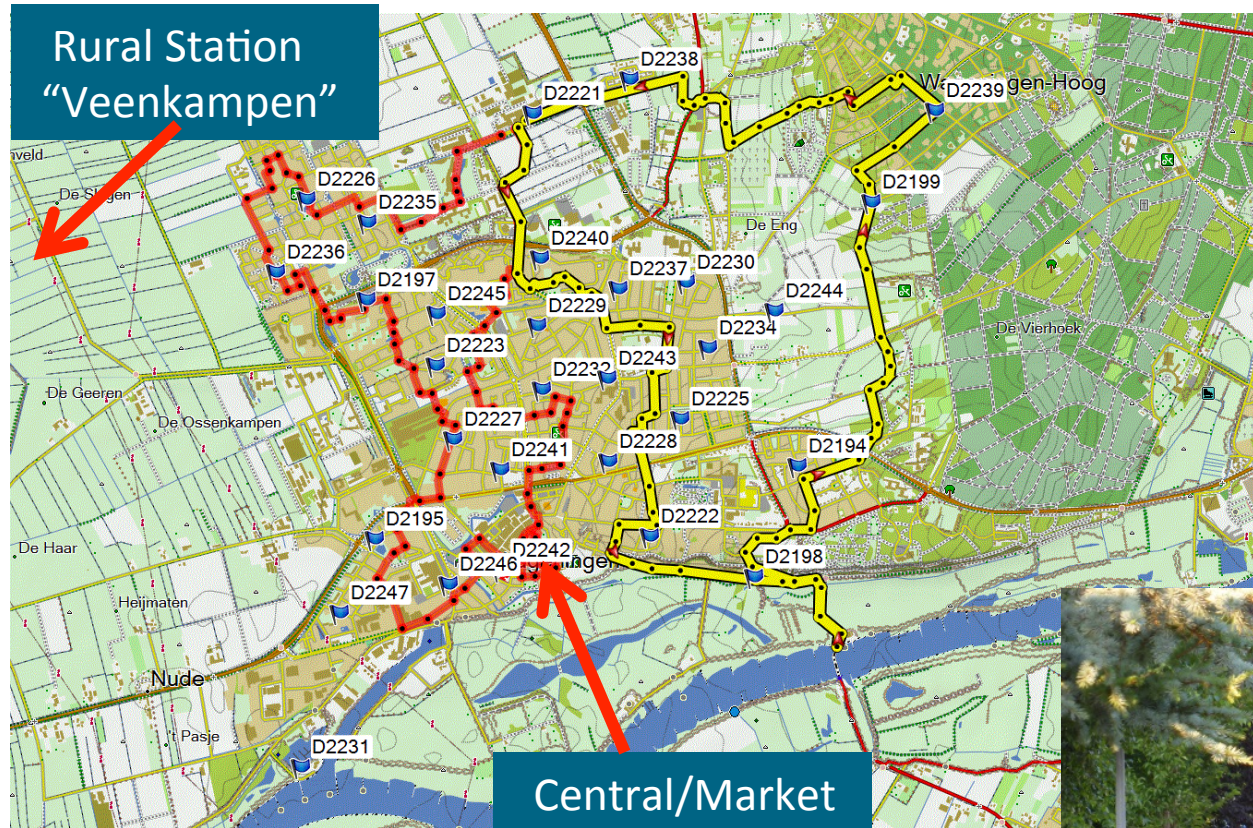
Measuring:

- Humidity
- Temperature

Rural station: Schiphol airport



# Wageningen weather stations and cargo bike tracks



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NWO



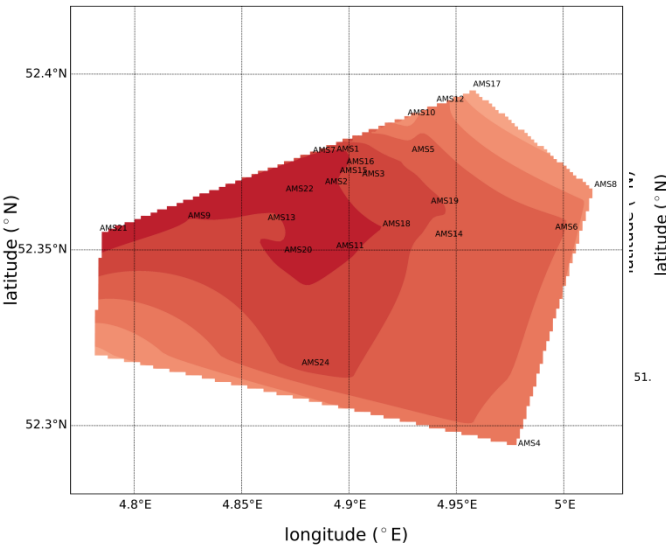
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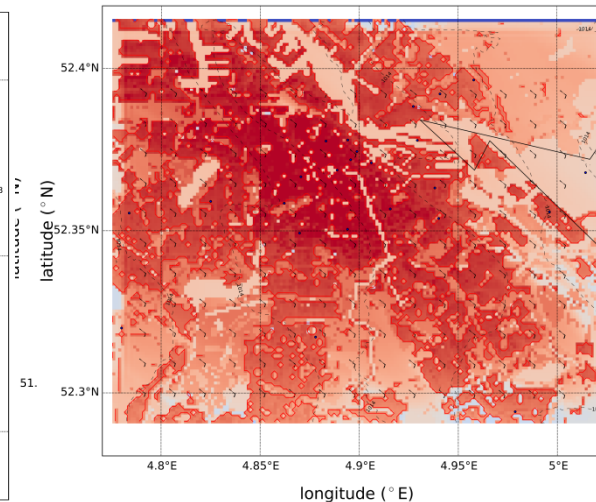
# temperature JULY 18<sup>st</sup> 2014, 21:00 UTC

## Results: Amsterdam

Observations: interpolated station observations

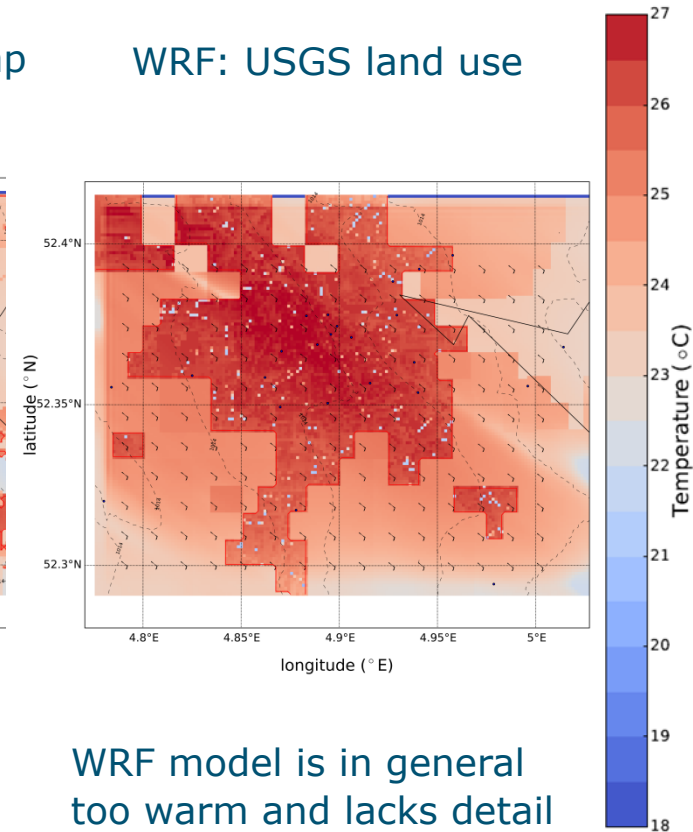


WRF: Detailed land use map



WRF model is in general slightly too warm

WRF: USGS land use

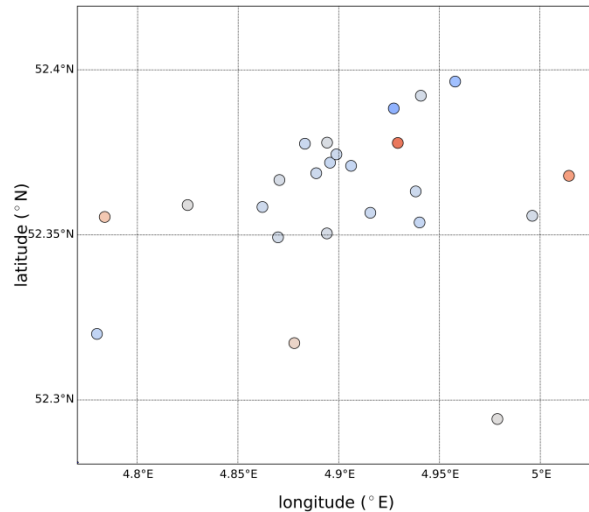


WRF model is in general too warm and lacks detail

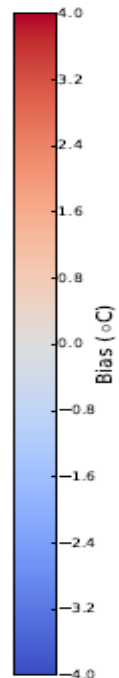
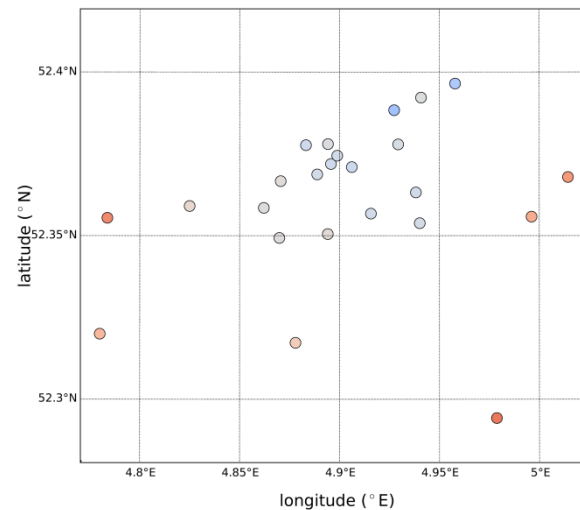
# (obs-mod) temp JULY 18<sup>st</sup> 2014, 21:00 UTC

## Results: Amsterdam

WRF: Detailed land use map  
100 m resolution



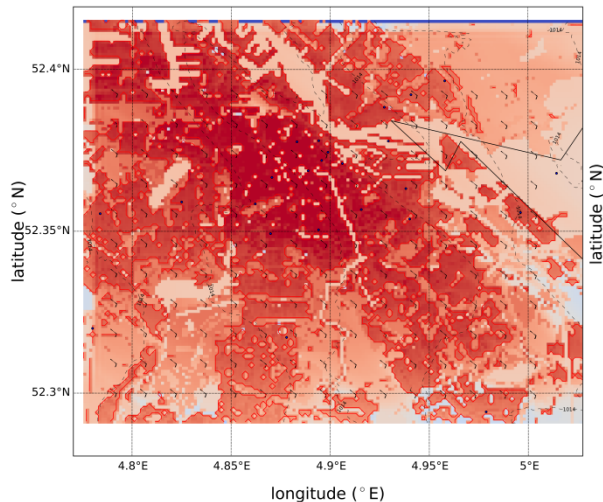
WRF: USGS land use  
100m resolution



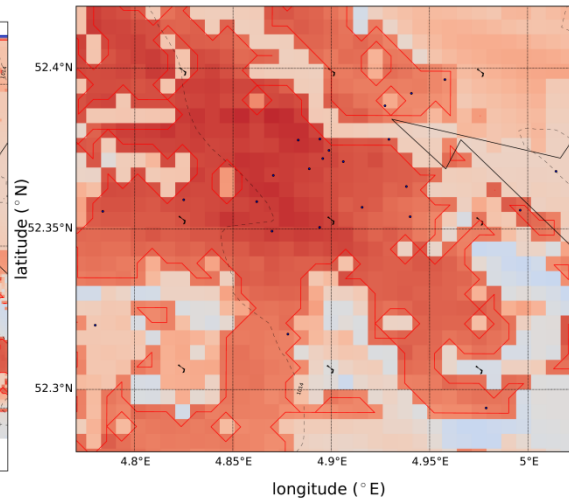
# temperature JULY 18<sup>st</sup> 2014, 21:00 UTC

## Results: Amsterdam

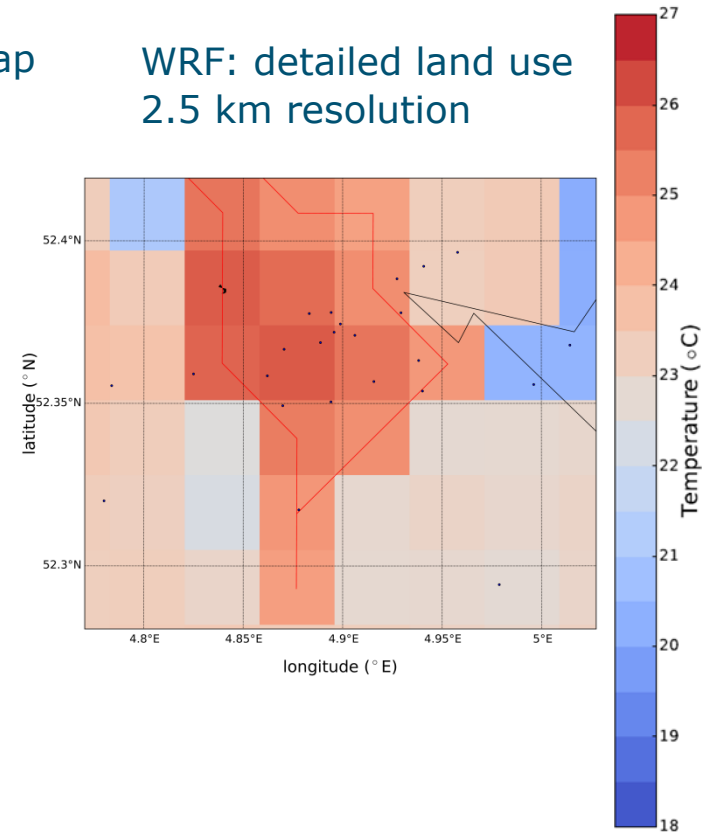
WRF: Detailed land use map  
100 m resolution



WRF: detailed land use map  
500 m resolution



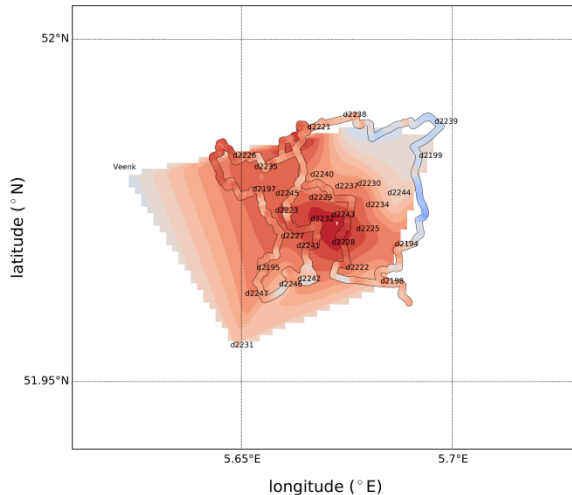
WRF: detailed land use  
2.5 km resolution



# temperature August 1<sup>st</sup> 2013, 21:00 UTC

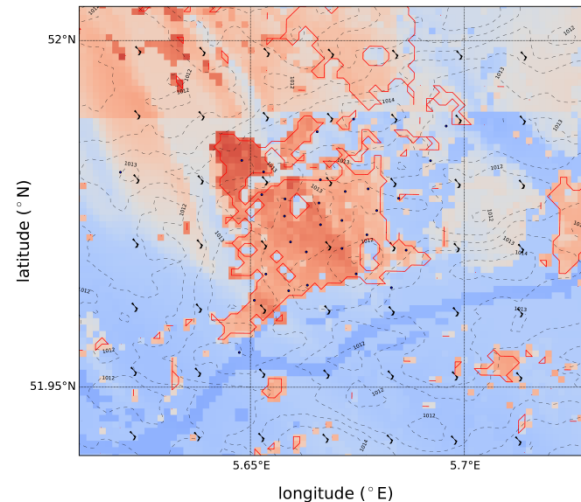
## Results: Wageningen

Observations : bike routes and Interpolatated station observations



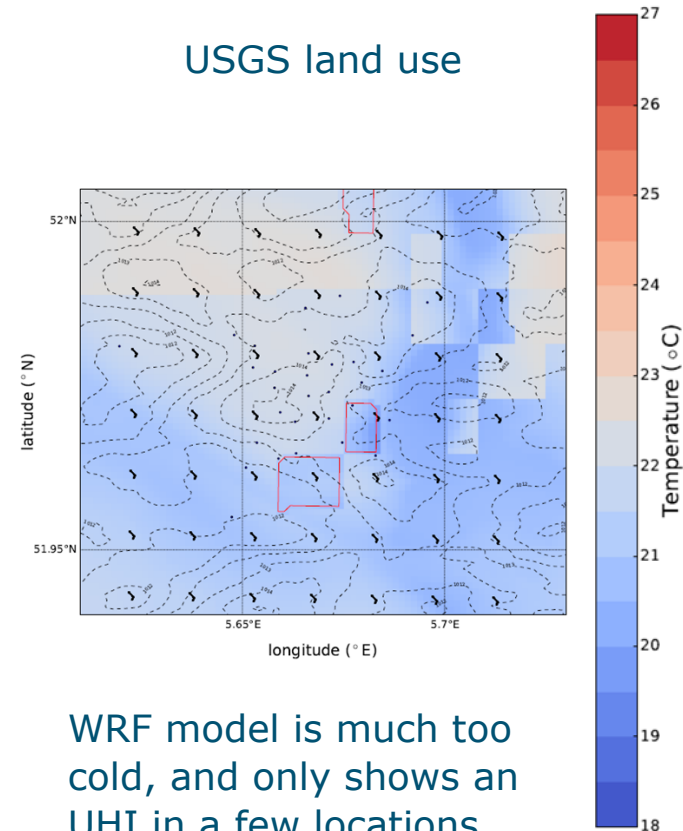
Reasonable agreement among observations

Detailed land use map



WRF model is (slightly) too cold

USGS land use



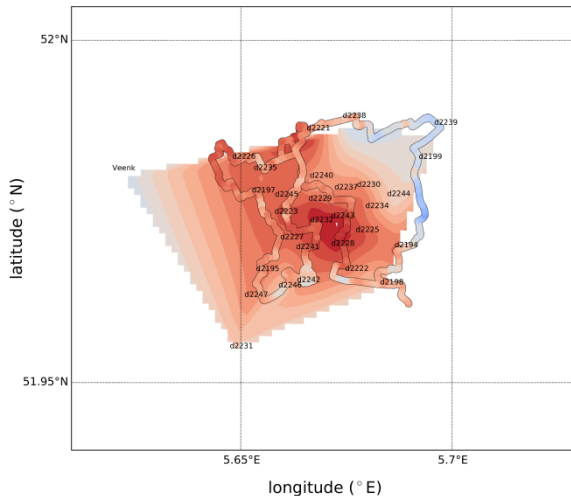
WRF model is much too cold, and only shows an UHI in a few locations



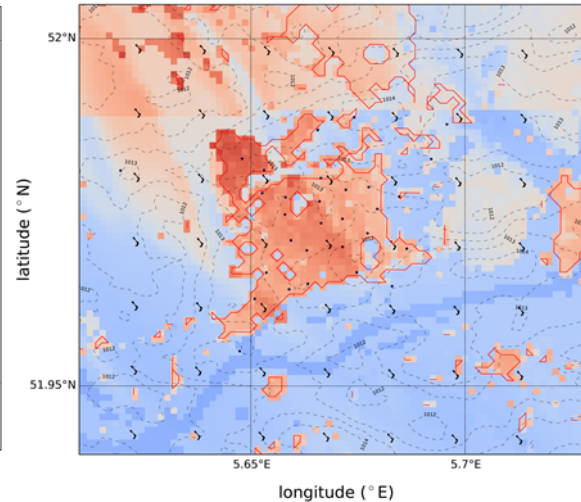
# temperature August 1<sup>st</sup> 2013, 21:00 UTC

## Wageningen: detailed land use

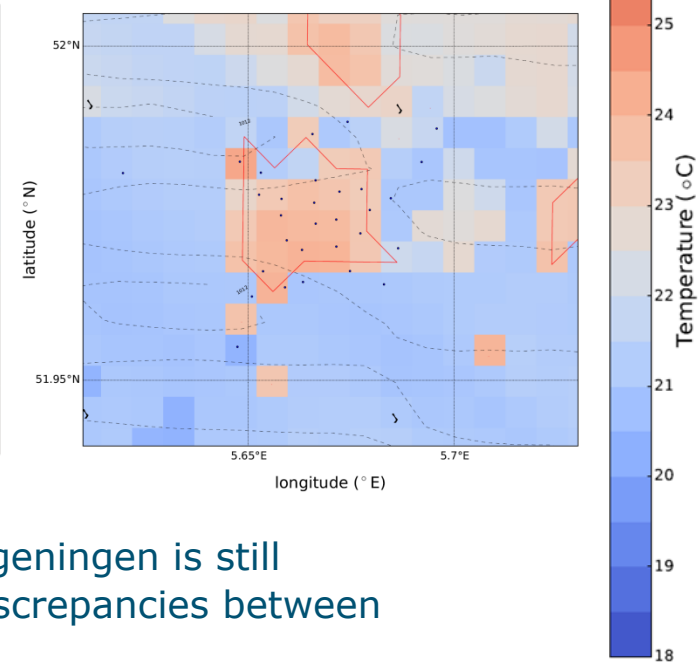
Observations : bike routes and interpolated station observations



WRF detailed land use on 100 m resolution



WRF detailed land use on 500 m resolution

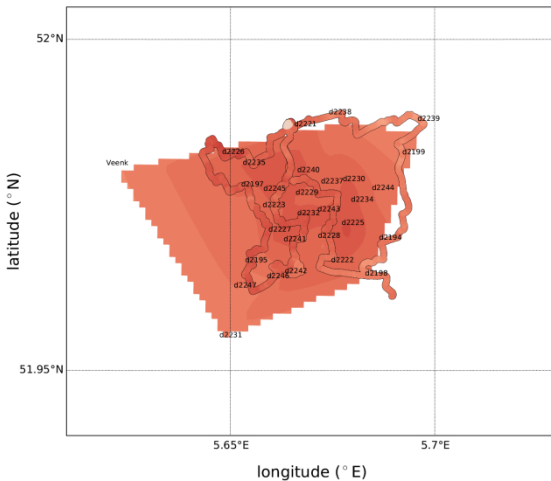


When WRF is run on a coarser resolution, the UHI of Wageningen is still visible in the model, but detail is lost leading to larger discrepancies between model and observations

# temperature August 2<sup>st</sup> 2013, 15:00 UTC

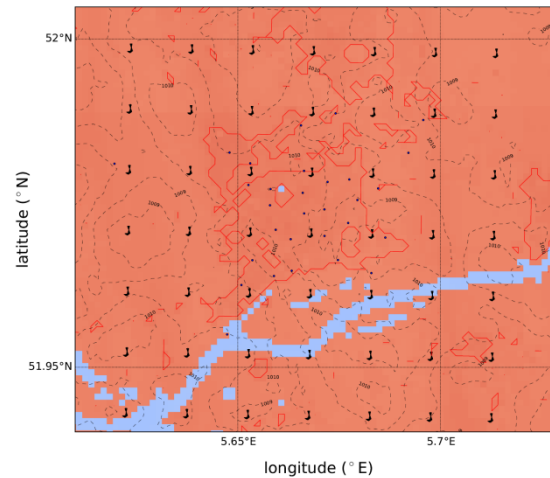
## WRF on 100 m res.

Observations : bike  
routes and  
Interpolatated station  
observations



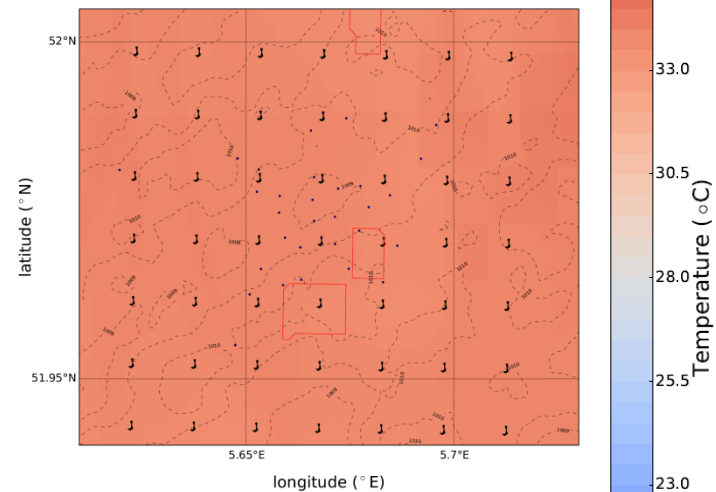
Reasonable agreement  
among observations

Detailed land use map



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

USGS land use



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

# Highlights

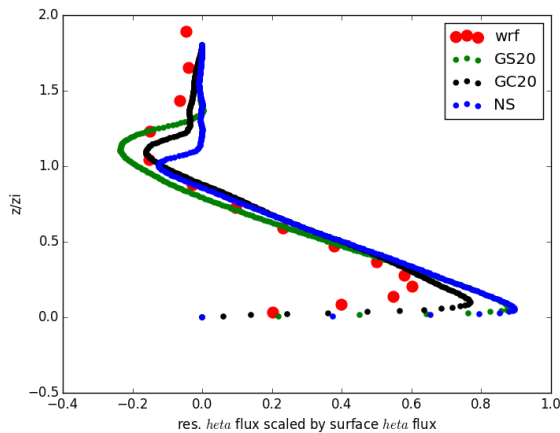
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- High resolution urban forecasts are achievable
- For the heat waves of 2013 and 2014 model results are in reasonable to good agreement with observations, especially during the evening;
- High resolution forecasting improves forecasts of temperature 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!.

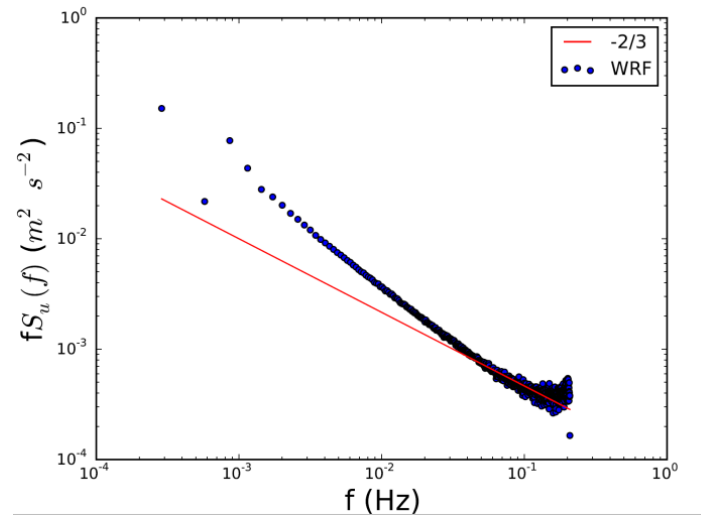
# Next steps

## ■ Comparison WRF with LES: “grey zone”

Domain averaged heat flux



U-spectrum at station “Oudezijds”



EMS conference in Sofia



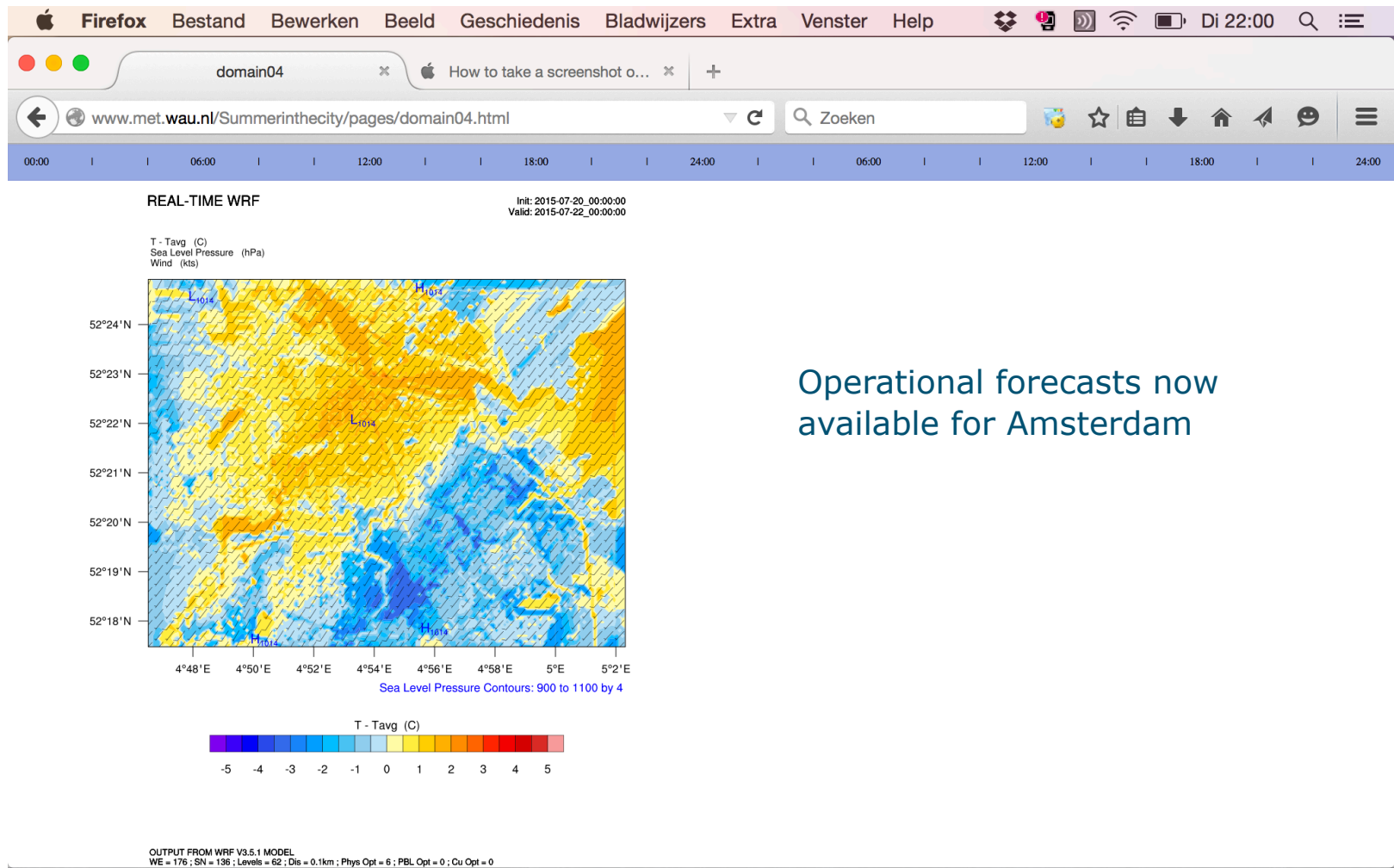
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# Thank you!



Operational forecasts now  
available for Amsterdam



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# New detailed land use map, discussed by Attema (GD5: 14:15-16:00 on 22th July)

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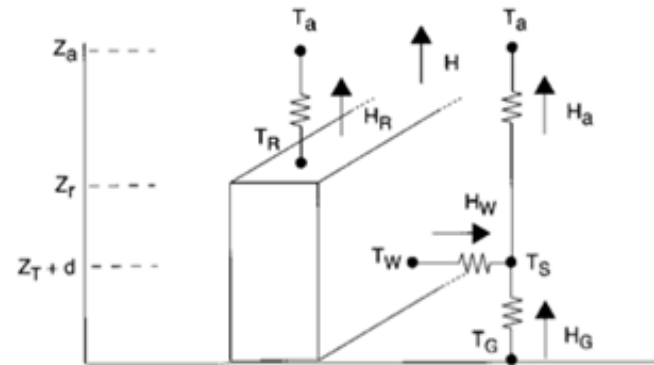
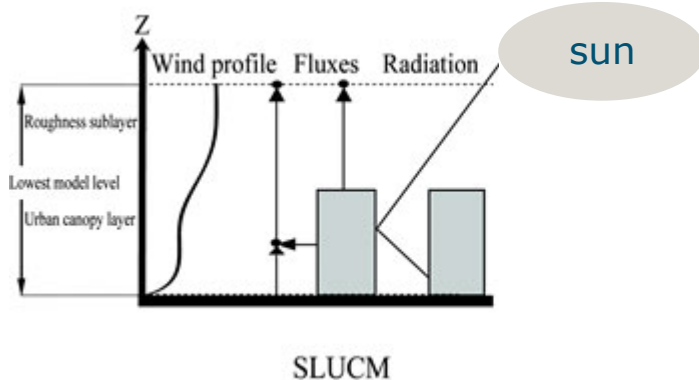
- Land use and information on buildings is provided by KADASTER data
- Heights are taken from AHN2 (& OHN)
- Urban fraction reduced using satellite imagery for urban classified areas with green areas



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

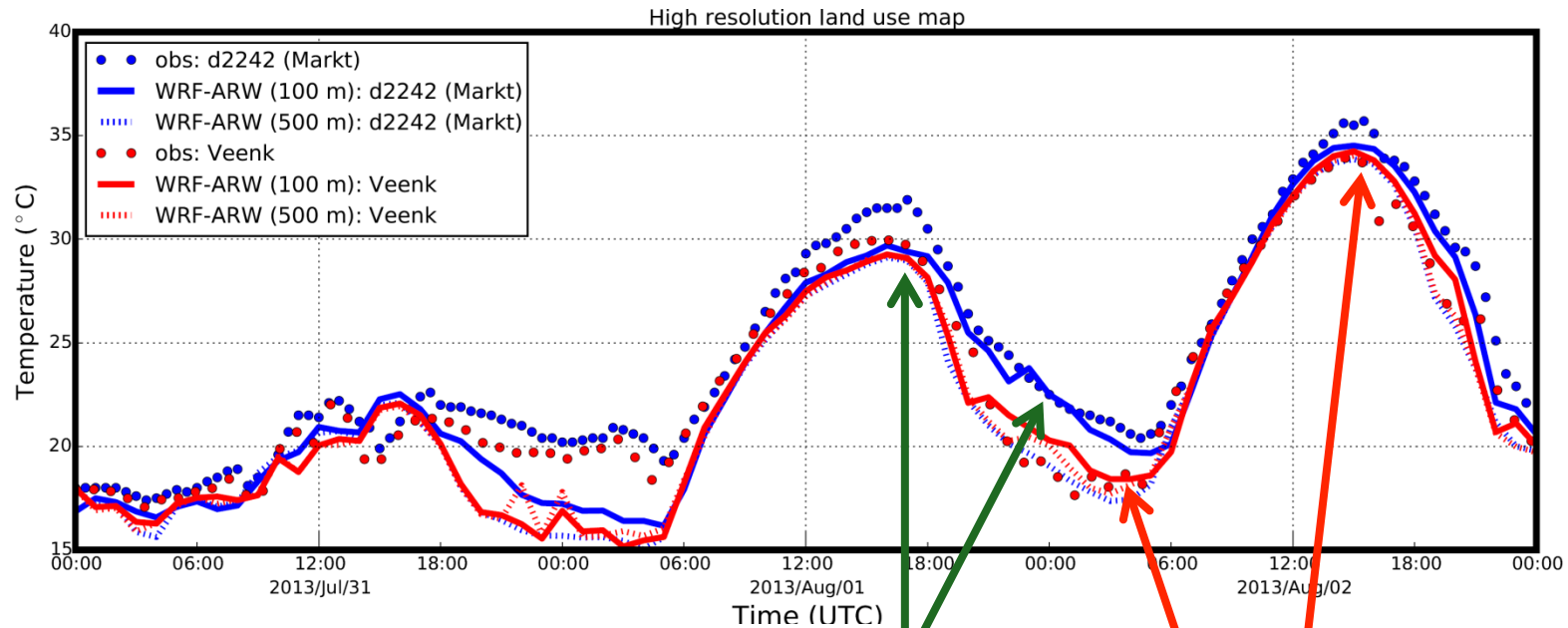
Geometrical properties (parameters):

- 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

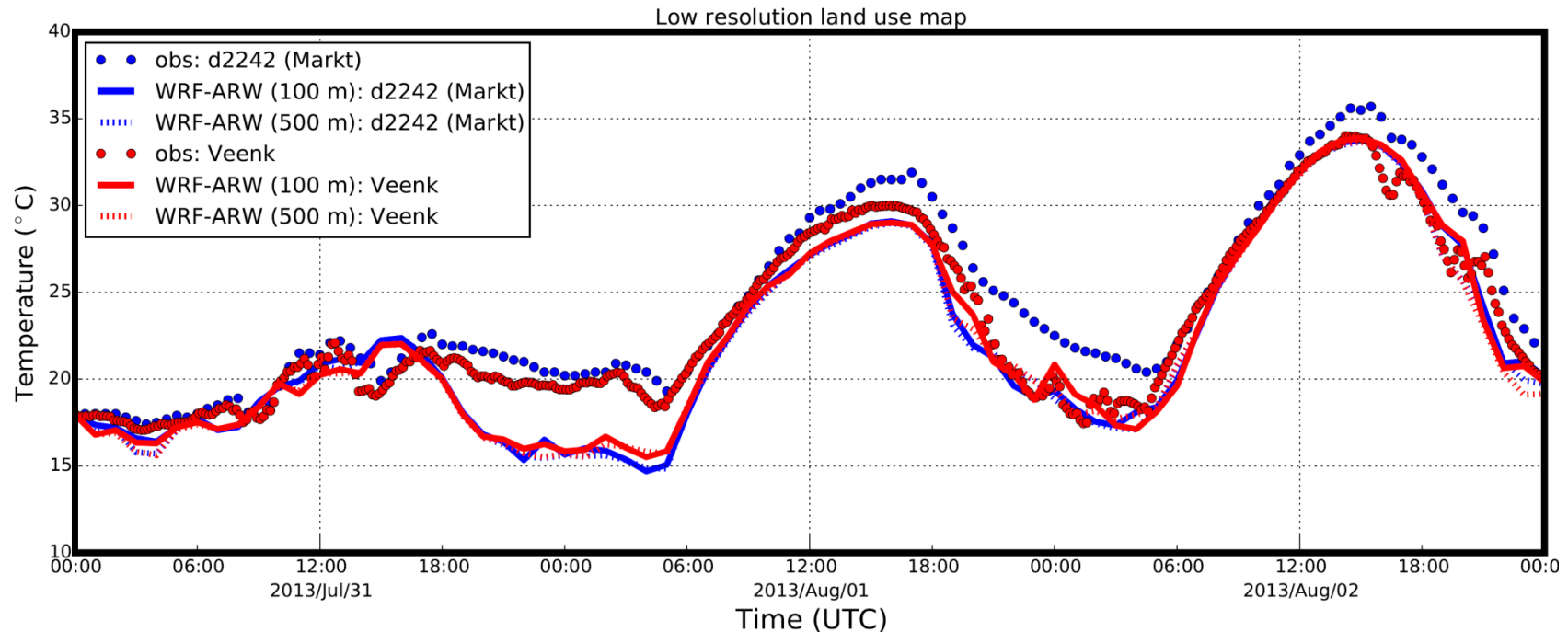


WRF on 100 m resolution gives reasonable estimates temperature at night, but slightly underestimates afternoon temperature

WRF on 500 m resolution underestimates both nighttime and afternoon temperature

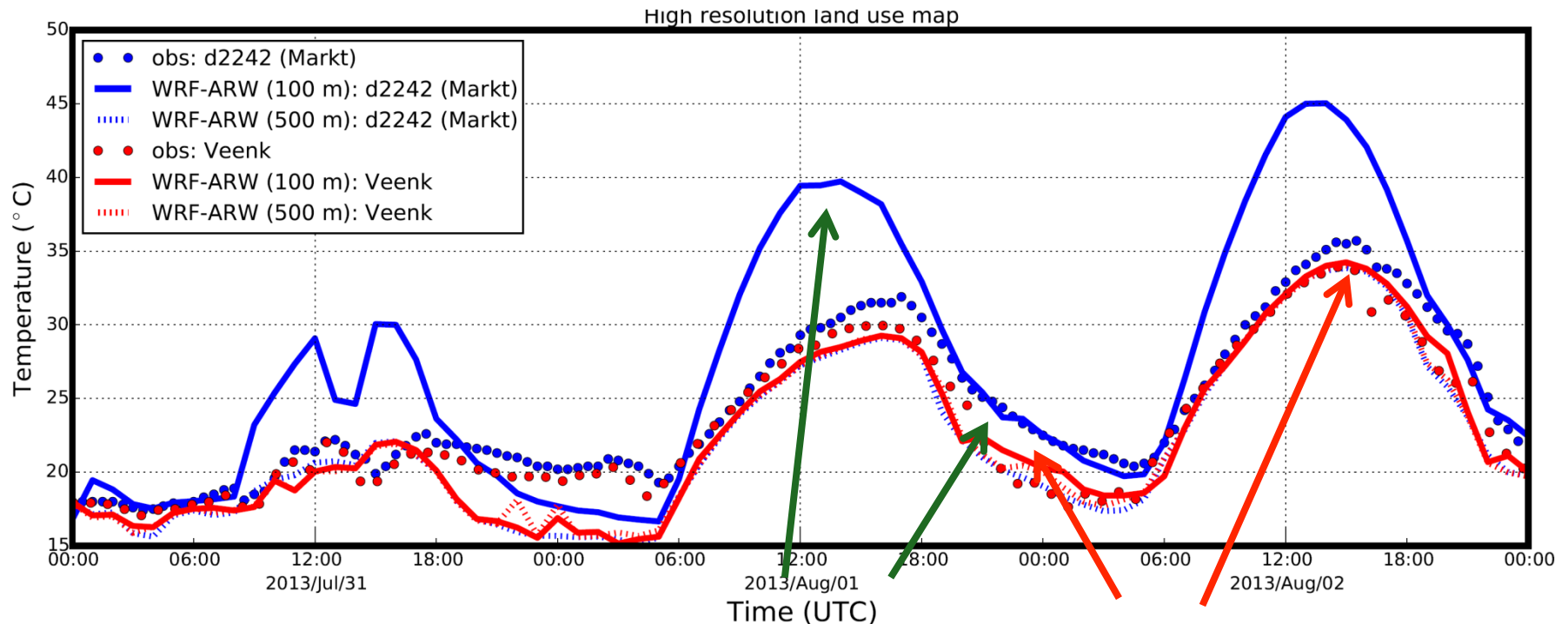
# 2 m temperature: center and rural

## 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



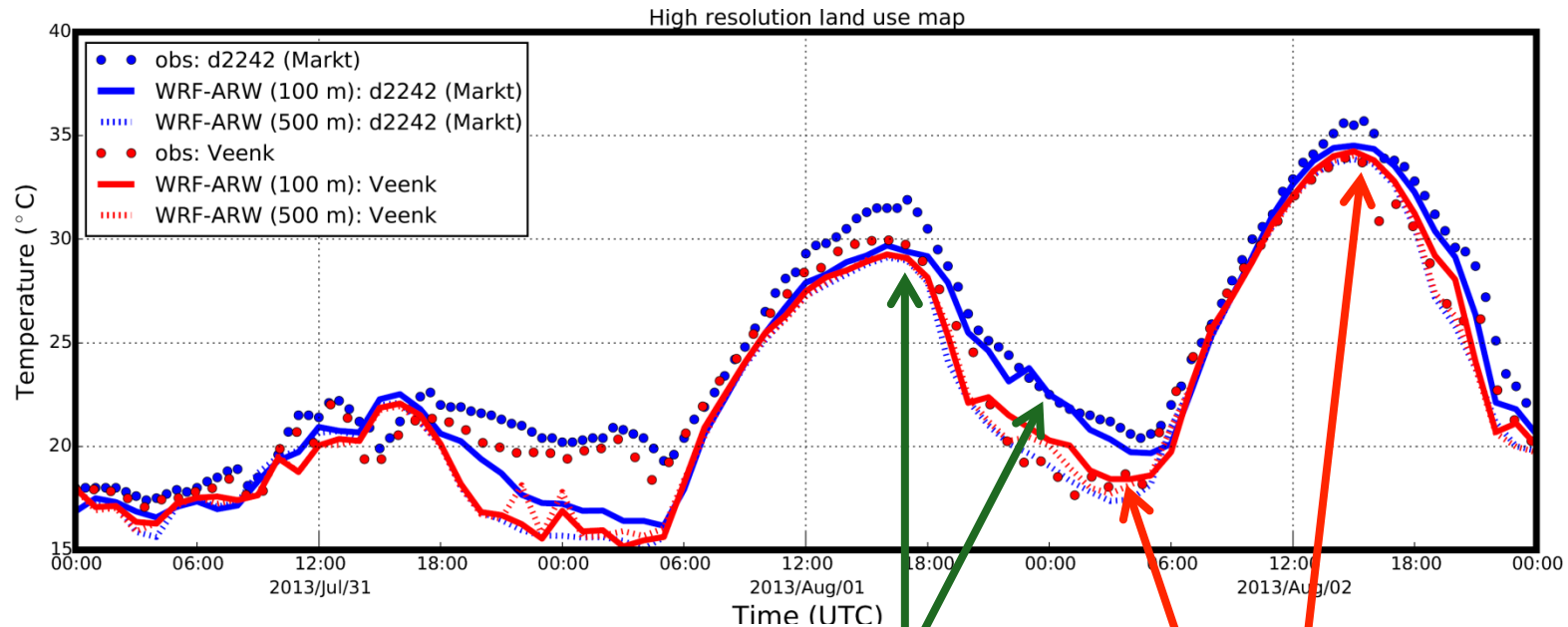
WRF on 100 m resolution gives reasonable estimates temperature at night, but overestimates afternoon temperature

WRF on 500 m resolution underestimates both nighttime and afternoon temperature





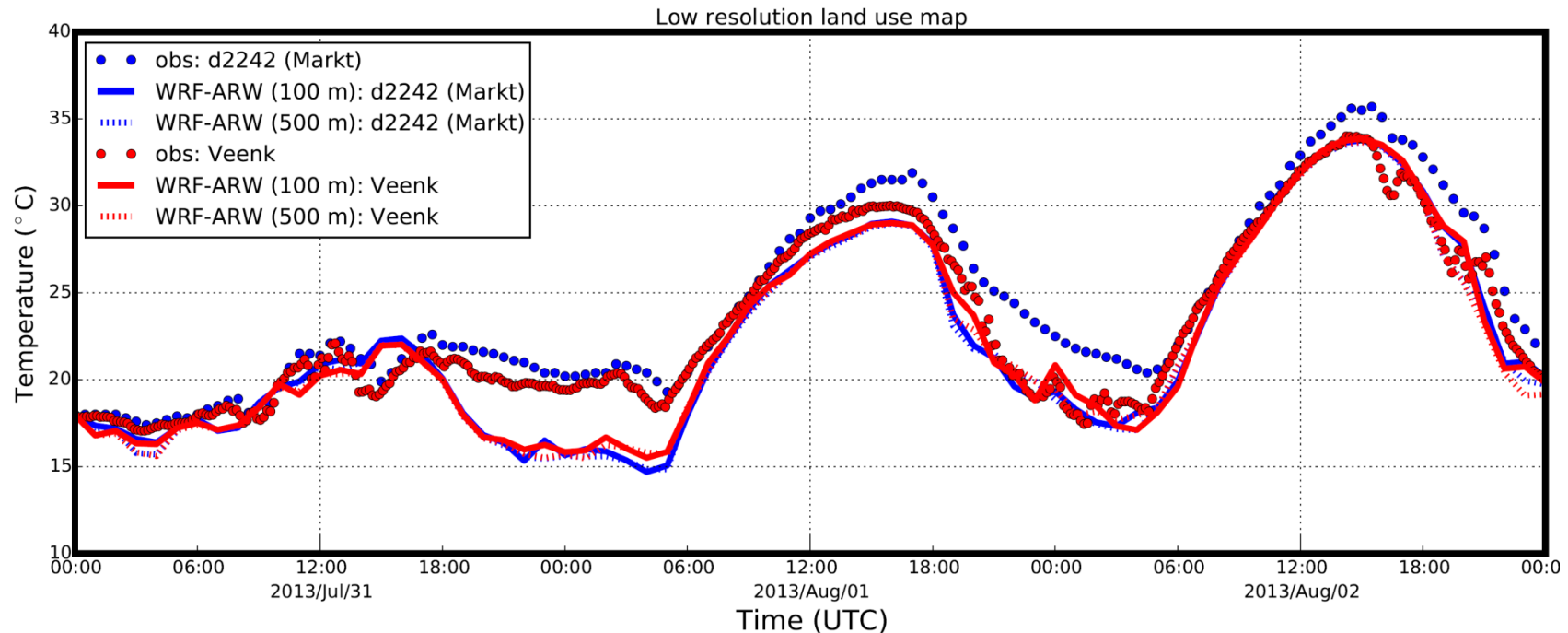
# Station Markt (Center) and Veenkampen (rural): extrapolated 2 m temperature



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

# Station Markt (Center) and Veenkampen (rural): standard USGS land use map



Both the 100 m resolution run and the 500 m resolution run underestimate both the nighttime and daytime temperature