СОФИЙСКИ УНИВЕРСИТЕТ

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BPU 10

SENSITIVITY OF WRF MODEL RESULTS TO TOPOGRAPHY AND LAND COVER: STUDY FOR THE SOFIA REGION

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Sofia, Bulgaria

29 August 2018

Weather numerical modelling for Sofia city - specifics

It is an urban area:

- buildings usually constructed with high heat capacity materials
- infrastructure - streets and pavements are not storing moisture
- tall buildings with high surface roughness length modifying wind profile and etc.

It is also surrounded by mountains:

- modification of local circulation
- modification of meso- and micro-scale by synoptic processes

As a result - different:

- temperatures (also different temperature range)
- moisture content
- heat fluxes
- wind circulation and etc

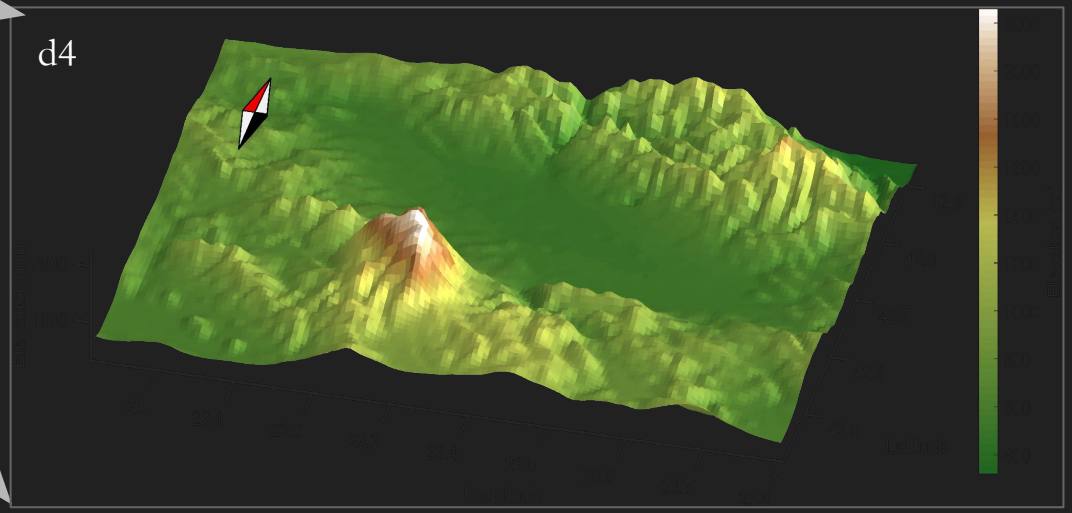
In order to represent the urban environment in complex terrain:

- better topography=orography
- better land use and its thermophysical quantities

Model and domains for the numerical experiment

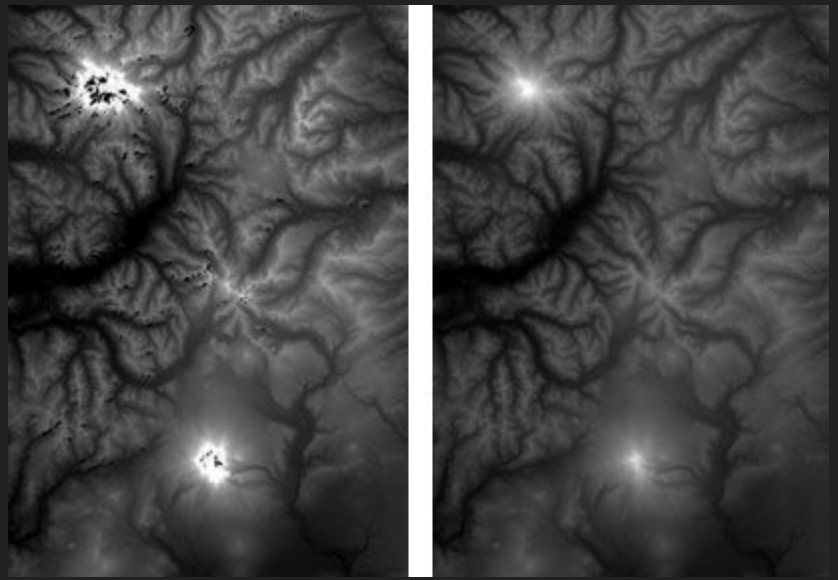
Configuration:

- Lambert projection (23.4°E, 42.68°N)
- 4 nested domains with grid sizes of 32, 8, 2 and 0.5 km
- Resolution of the inner domain: 157x129x51
- (BEST RESULTS) High terrain resolution 1 arcsec: https://lta.cr.usgs.gov/SRTM1Arc
- (BEST RESULTS) High land-use resolution 3 arcsec: Corine adopted to USGS classes: http://land.copernicus.eu/pan-european/corine-land-cover/clc-2012
- Input data: NCEP Final Analysis 0.25 deg: http://rda.ucar.edu/datasets/ds083.2;



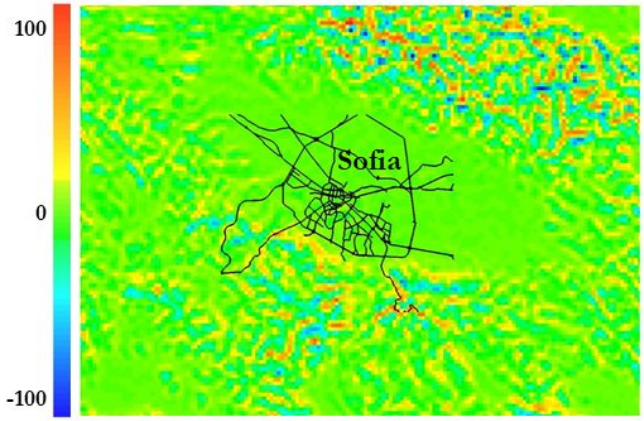
Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global (The "Topography dataset") https://lta.cr.usgs.gov/SRTM1Arc

- ***SRTM 1 Arc-Second Global*** *elevation data offer worldwide coverage of void filled data at a resolution of 1 arc-second (30 meters) and provide open distribution of this high-resolution global data set.*



These browse images of Mt. Rainier and Mt. Adams in the Cascade Mountain Range highlight the differences between SRTM (left) and SRTM Void Filled (right) data (February 11, 2000).

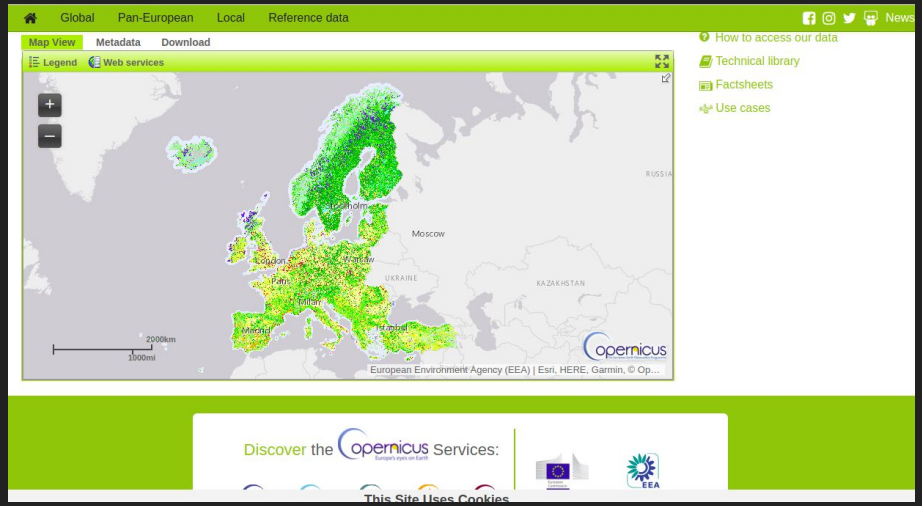
Sofia city and complex terrain: topography - different resolutions; mean sea level height for some of the meteorological stations (AFTER *geogrid.exe* preprocessing)



Observation site	Real height [m]	Topography 30s Height [m]	Topography 30s Difference [m]	Topography 1s Height [m]	Topography 1s Difference [m]
Sofia - NIMH	588	589	1	590	2
Sofia - Druzhba	548	547	-1	546	-2
Sofia - Nadezhda	534	533	-1	534	0
Sofia - Hipodruma	581	579	-2	582	1
Sofia - Pavlovo	606	612	6	607	1
Sofia - Borisova Gr.	577	572	-5	570	-7
Dragoman	716	726	10	719	3
Kopitoto	1321	1235	-86	1285	-36
Cherni Vrah	2286	2209	-77	2249	-37
Murgash	1435	1404	-31	1421	-14

The CLC2012 dataset (Corine_3s) - Copernicus, Land Monitoring Service (The "Land-use dataset")

- The CLC2012 dataset consists of 44 land categories - different from the standard USGS land-use dataset with 24 categories.
- CORINE categories - combined following the paper of Pineda et al., 2007 and adapted to the USGS categories with the same surface parameters of corresponding land category (heat capacity, moisture properties, albedo, roughness etc.).
- The downloaded data is cropped for the region of interest and remapped into 24 USGS categories.

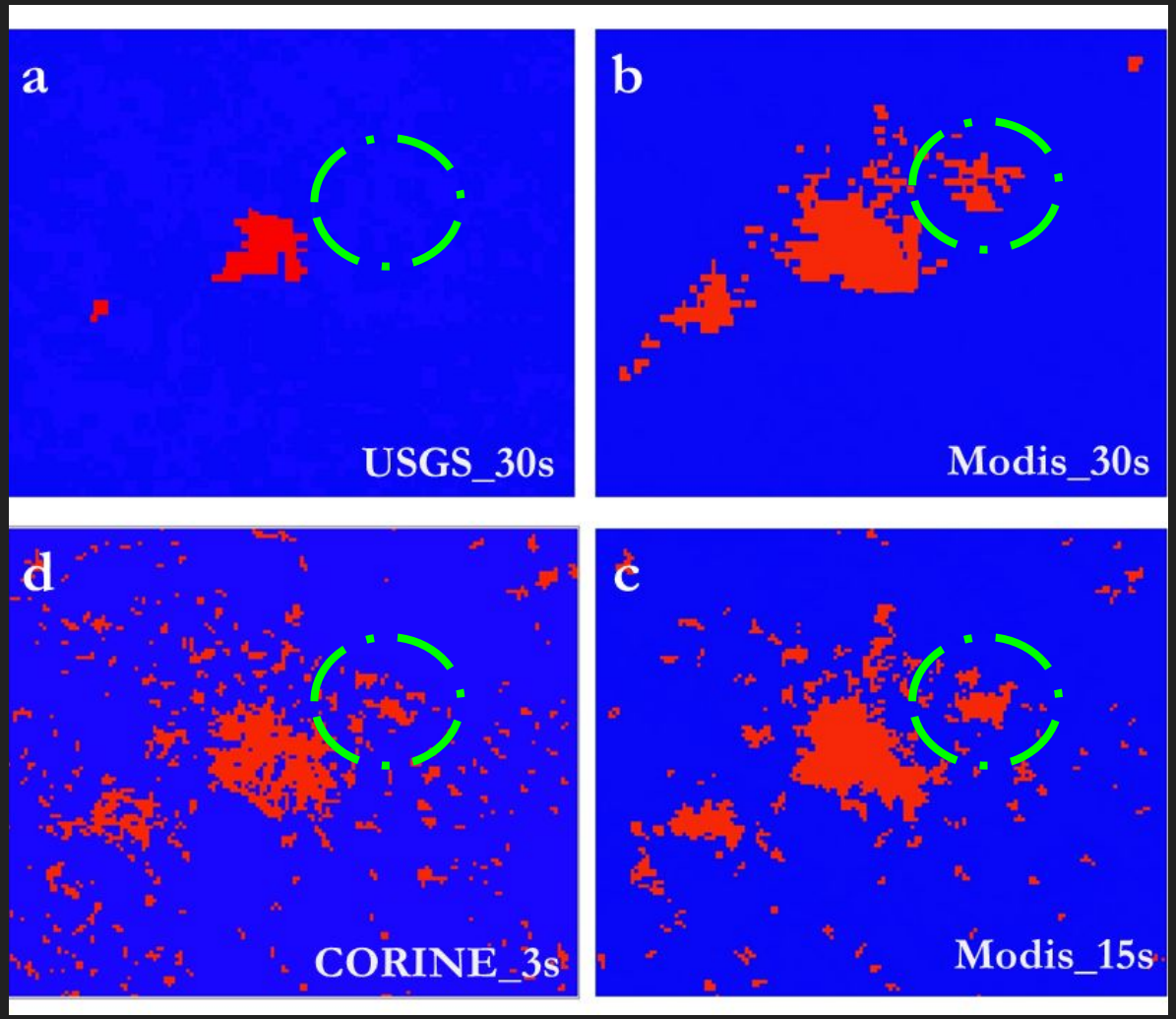


Urban area in different datasets (AFTER *geogrid.exe* **preprocessing):**

USGS_30s (a)
Modis_30s (b)
Modis_15s (c)
CORINE_3s (d), adapted to USGS categories

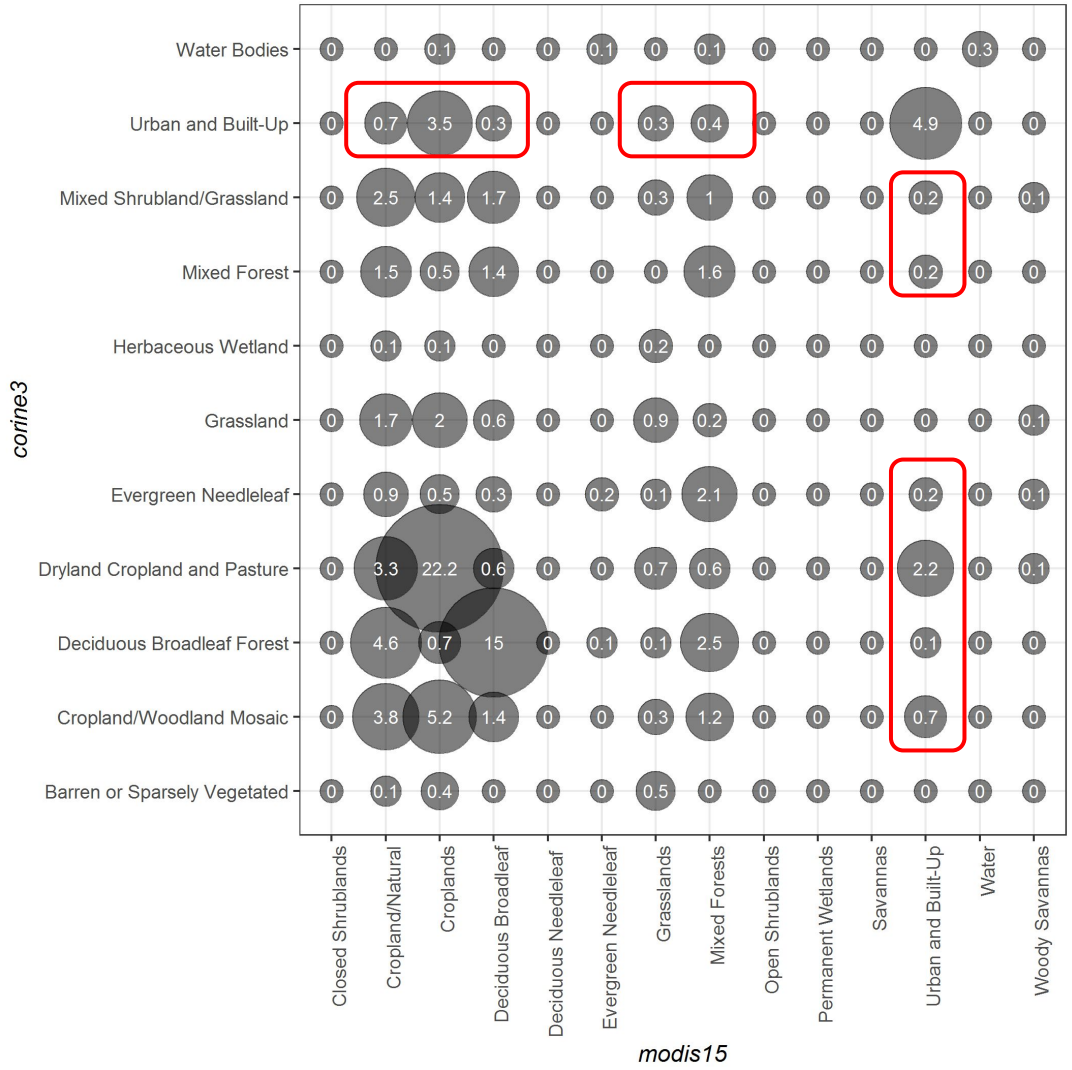
- ➔ USGS_30s - 1992-1993
- ➔ Modis_30s/15s - 2001
- ➔ CORINE_3s - 2010

In the circle ⇒ "Kremikovci" was one of the largest metalworking facilities in Bulgaria - till early 2000's

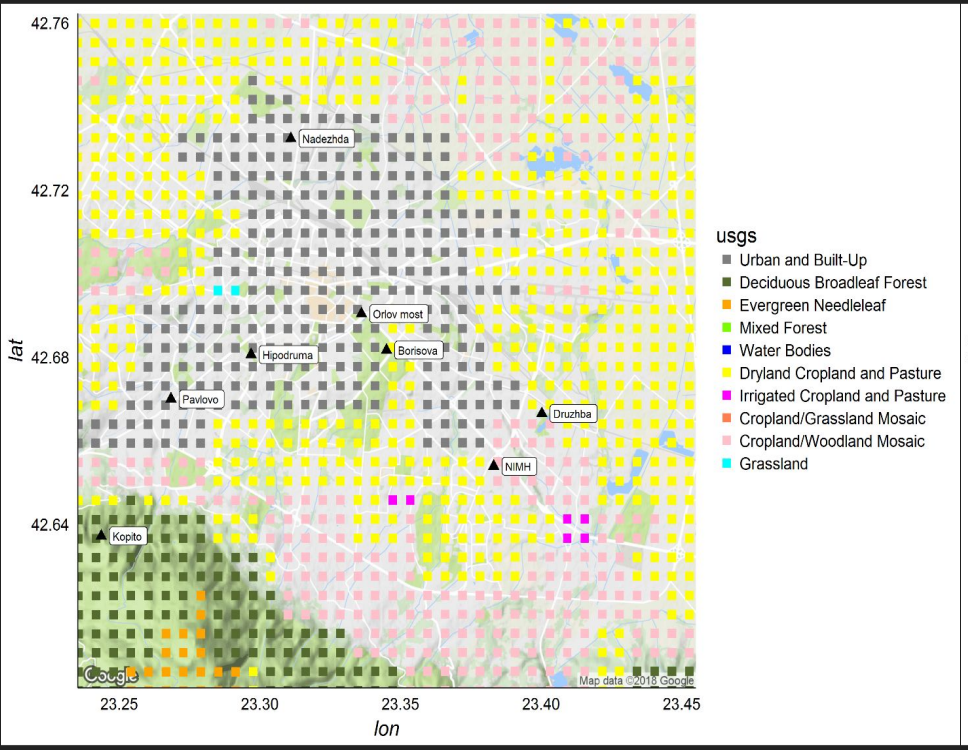


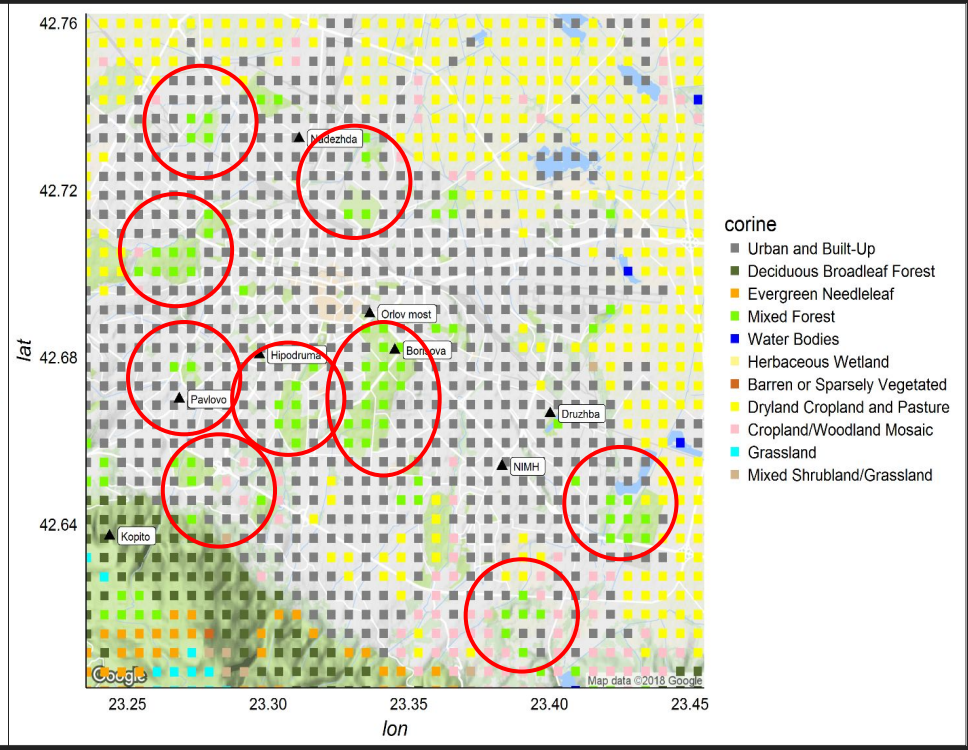
Correspondence between different land-use categories in CORINE_3s and Modis_15s (AFTER *geogrid.exe* preprocessing) (*Only for the d4 domain!*)

Corine_3s		Modis_15s
"Dryland cropland and Pasture"	⇔	"Cropland/Natural"
"Cropland/ Woodland Mosaic"	⇔	"Croplands"
"Mixed Shrubland/ Grassland"	⇔	"Grassland" , "Closed Shrublands"

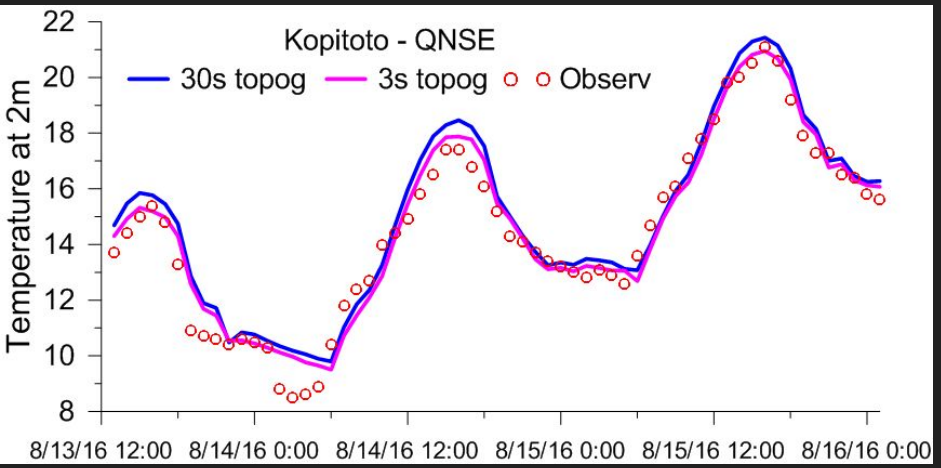


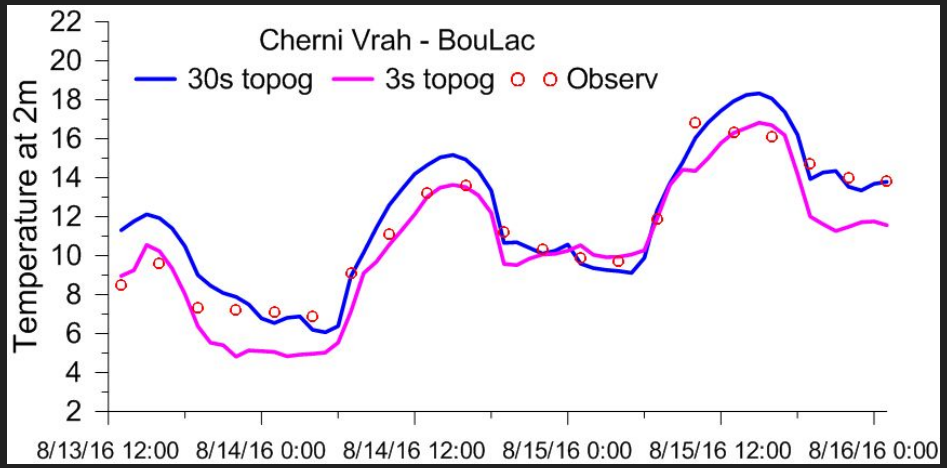
Comparison of different land categories mapped using USGS_30s and adapted CORINE_3s high resolution land-use data (AFTER *geogrid.exe* preprocessing)





Example of comparison of 2m temperature (in ºC) calculated with rough (30s) and high (1s) resolution topography against observations for two selected sites and PBL schemes



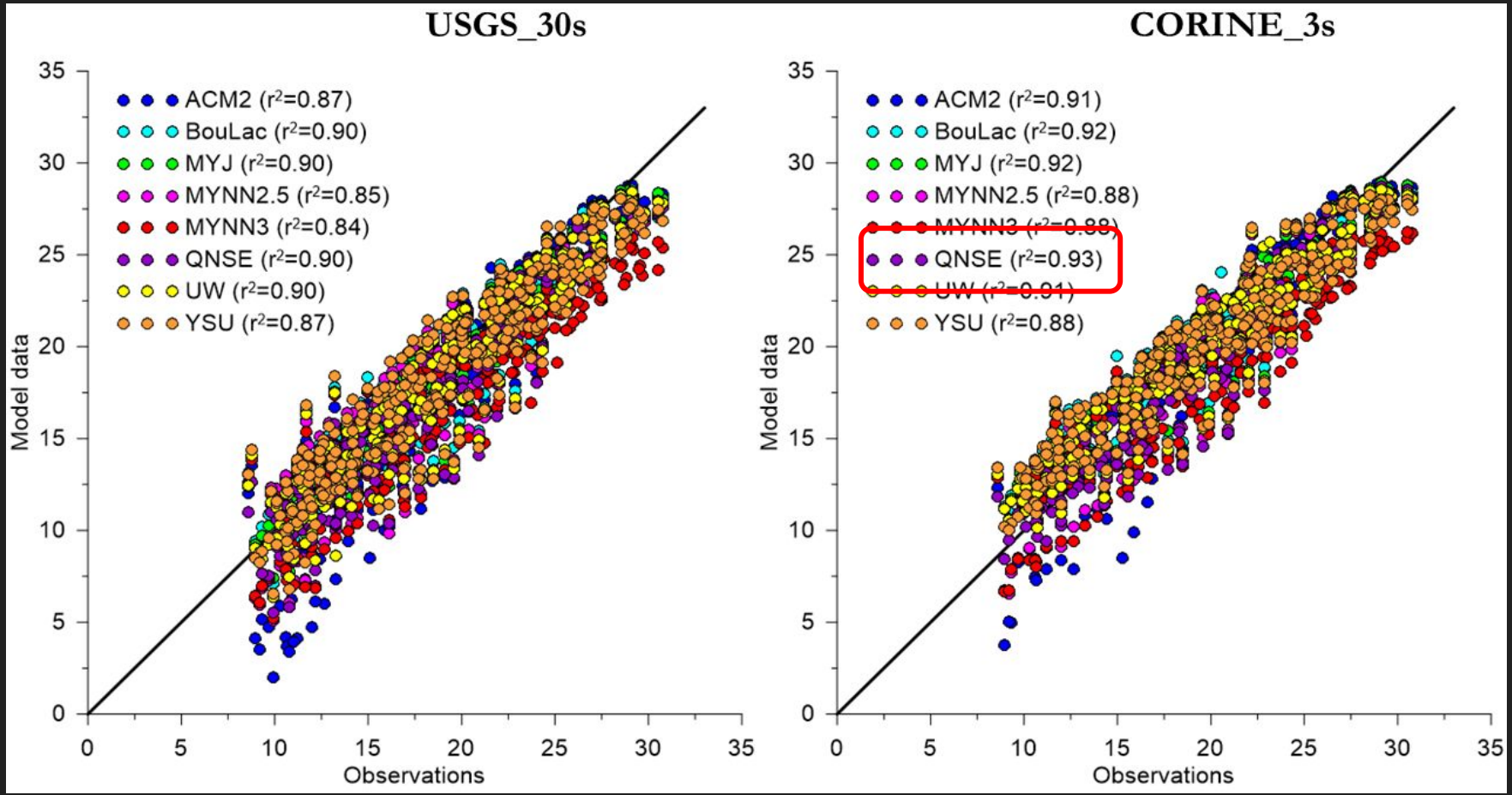


PBL scheme	Topography 30s		Topography 3s	
	Mean bias	Mean error	Mean bias	Mean Error
ACM2	0.8	1.36	0.44	1.19
BouLac	1.06	1.24	0.66	1.04
MYJ	1.04	1.24	0.65	1.01
MYNN2.5	0.57	1.32	0.21	1.16
MYNN3	-0.15	1.18	-0.5	1.32
QNSE	0.86	1.15	-0.5	0.94
UW	0.89	1.12	0.52	0.95
YSU	0.67	1.16	0.34	1.11

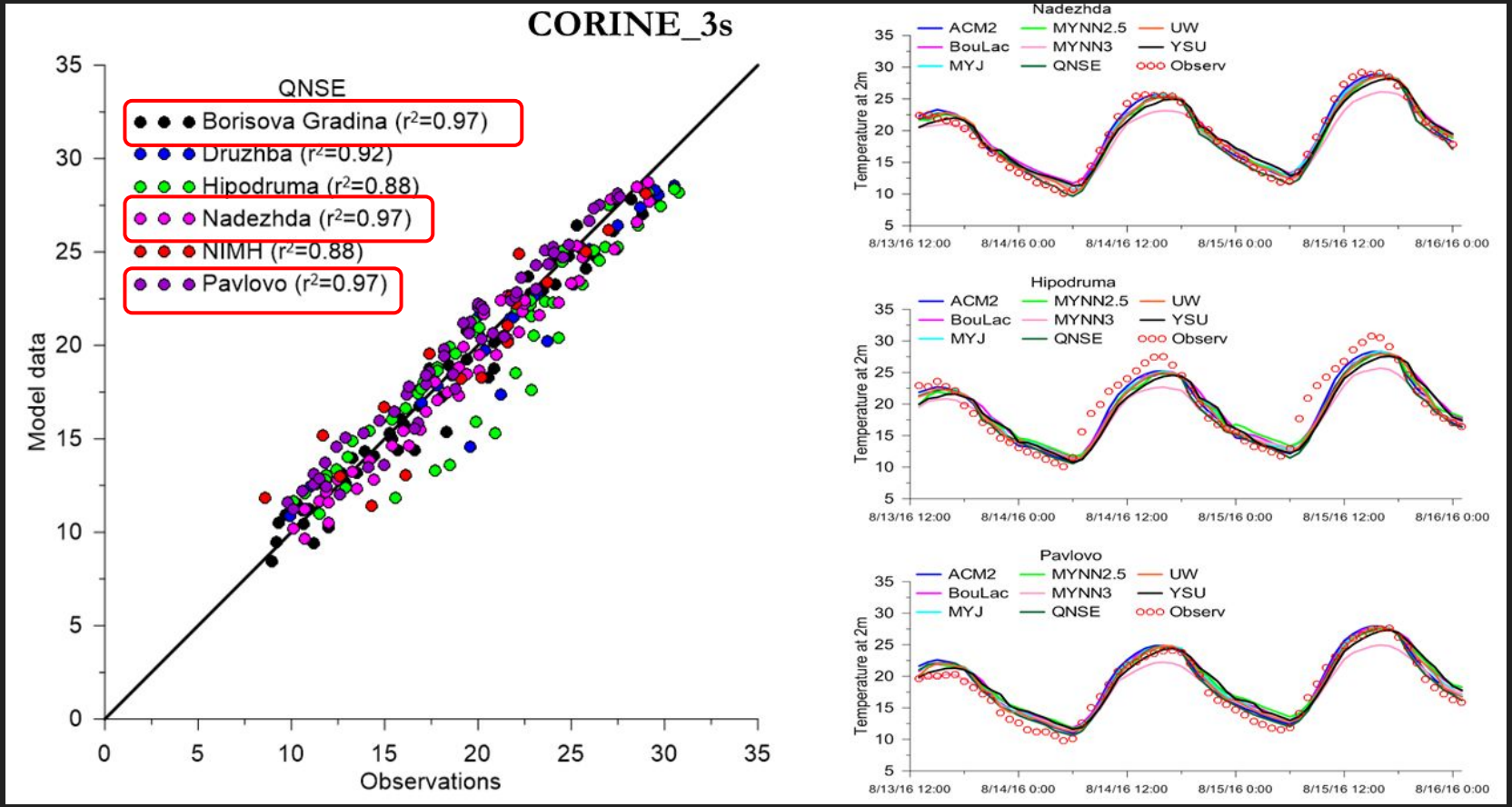
Period of the numerical experiment:

- 3 days (13-16 August, 2016) with a 12 hour spin-up
- anti-cyclonic synoptic setting
- dry and calm weather (wind speed below 5 m/s at 850 hPa)

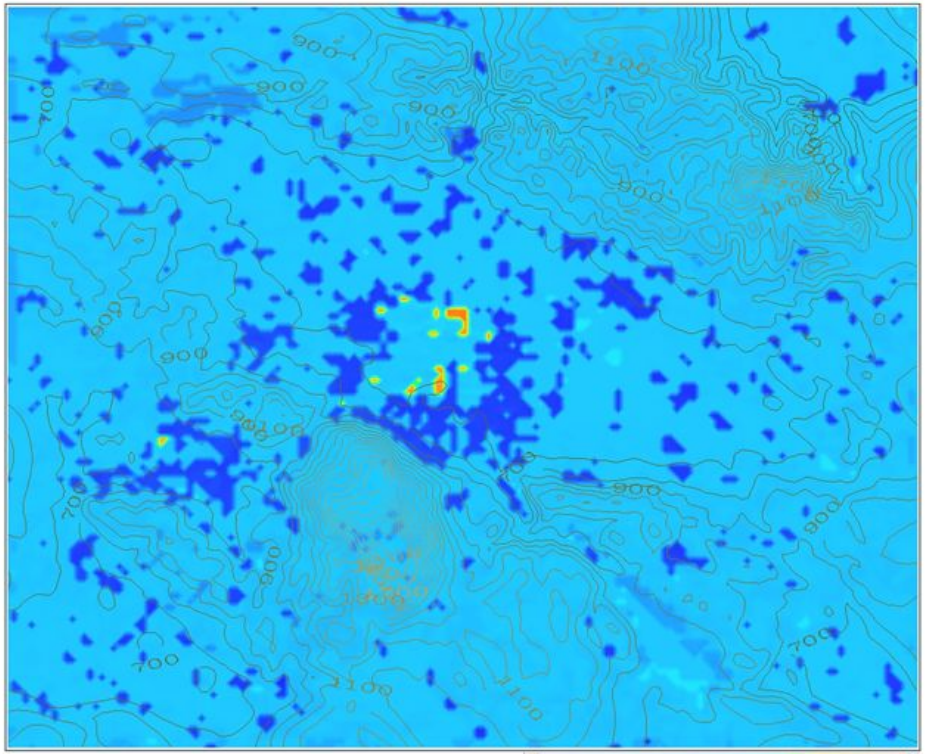
WRF evaluation for eight PBL schemes using USGS and adapted CORINE datasets



Evaluation of different observational sites for modelling results using adapted CORINE land-use and comparison of temperature at 2m for all PBL schemes at selected sites



Difference (CORINE-USGS) between *ground heat fluxes* calculated using different land-use datasets; model data with MYJ PBL scheme are shown at 09:00 and 20:00UTC on 14 August 2016



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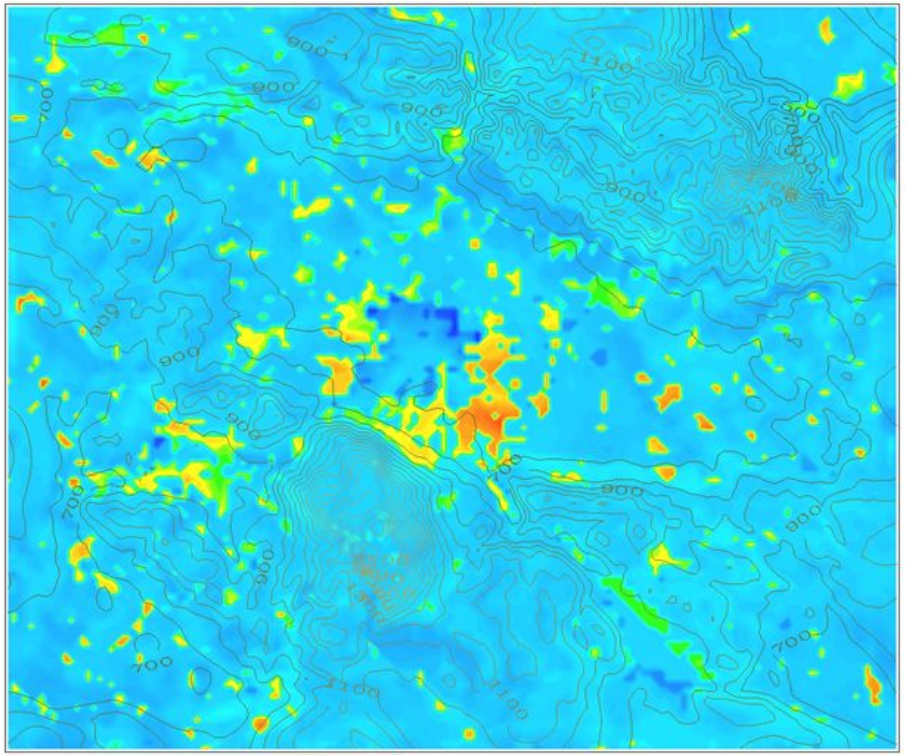

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Results & Conclusions

- Two new datasets have been implemented and adapted in WRF model
  - SRTM 1-arc-second topography
  - CORINE Land Cover 2012 with 3-arc-second resolution
- Better representation of topography and land cover resulted in improvements in temperatures at 2 meters and heat fluxes
- An increase in peaks height indicates reduction in calculated temperature
- Improvement in model results produced by all different PBL parametrizations
  - WRF underestimates the maximum (day) temperature at two sites Hipodruma and Druzhba
  - overestimates the minimum (night) temperature at NIMH site
  - shift in calculated minimum temperature is found for all sites except Borisova Gradina
- A positive difference in ground heat flux (CORINE–USGS) appears in areas corresponding to park regions in Sofia city from the adapted CORINE categories
- All added “Urban and Build-Up” areas with high resolution data lead to negative difference in ground heat flux during the first hours after the sunrise and positive in the evening

Acknowledgements:

This research is developed within the scope of the project DN4/7 (Study of the PBL structure and dynamics over complex terrain and urban area), funded by Research Fund at the Bulgarian Ministry of Education and Science.

Thank you for your attention!