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MODELLING THE IMPACT OF VANISH GREEN AREAS ON LOCAL METEOROLOGICAL CONDITIONS IN SOFIA, BULGARIA

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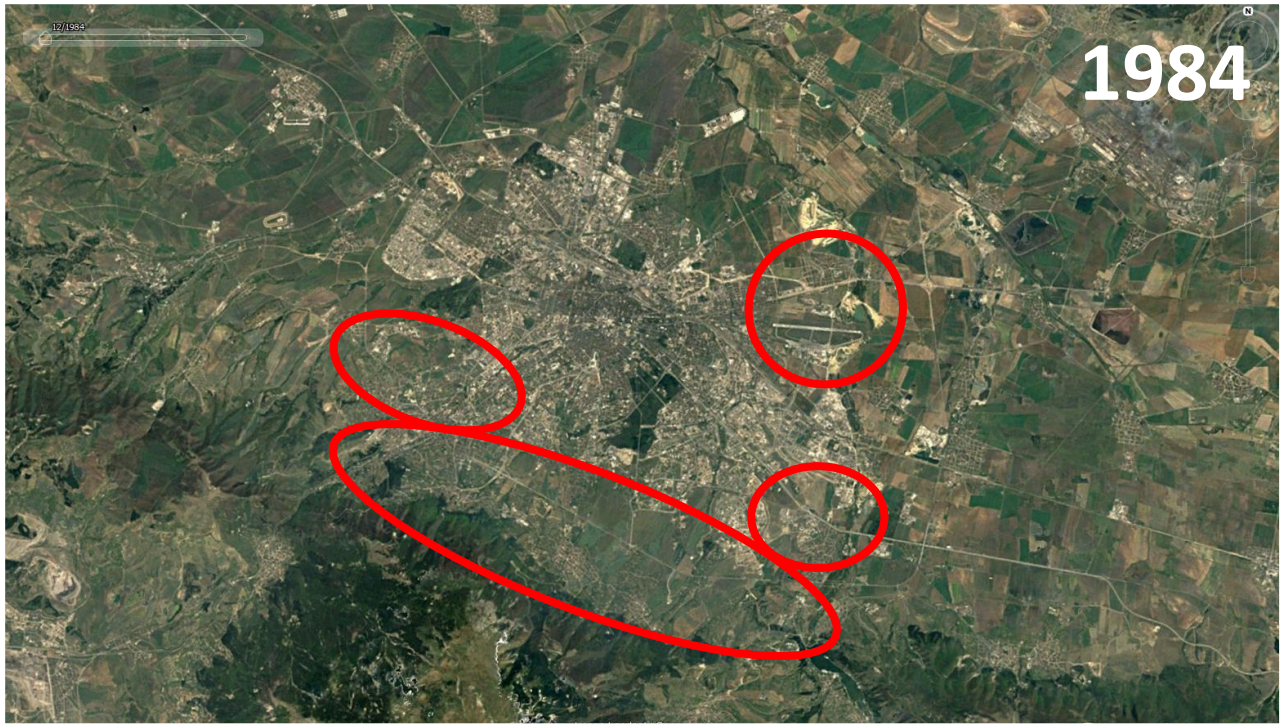
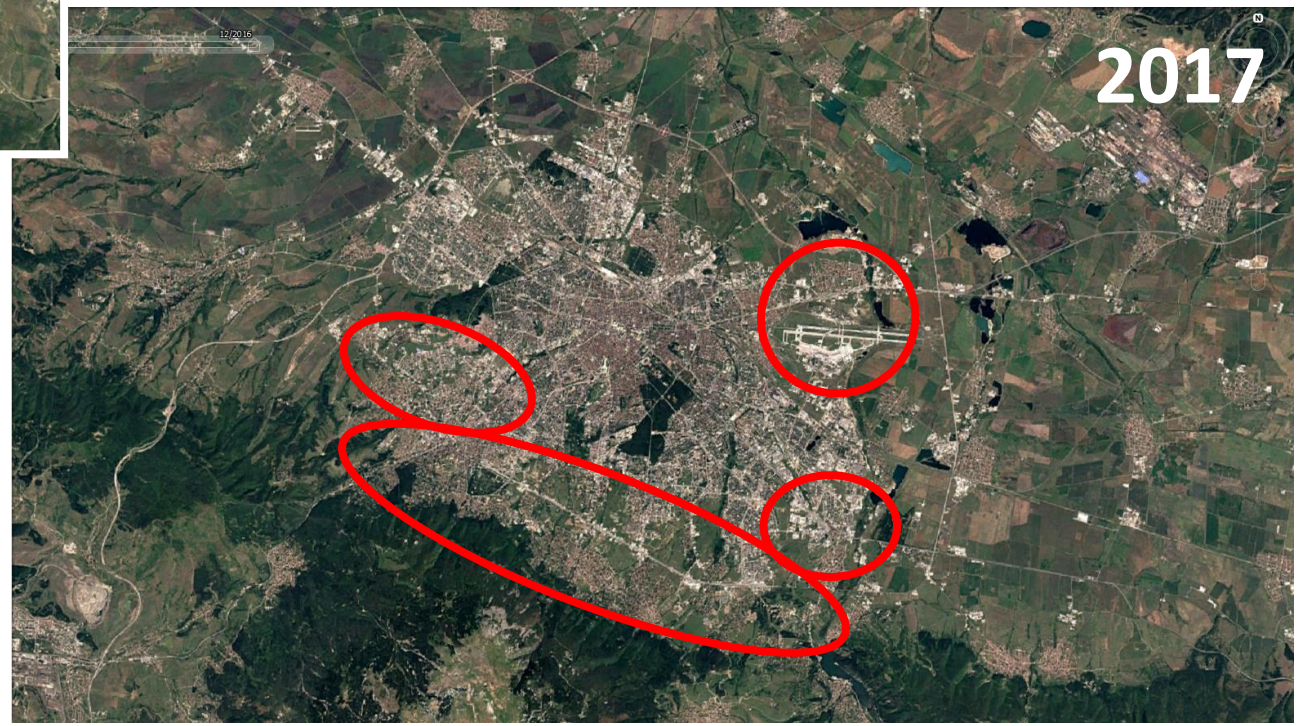
International Conference on Natural Science and Environment (ICNSE)
7th - 8th November, 2018, Tokyo, Japan



Motivation

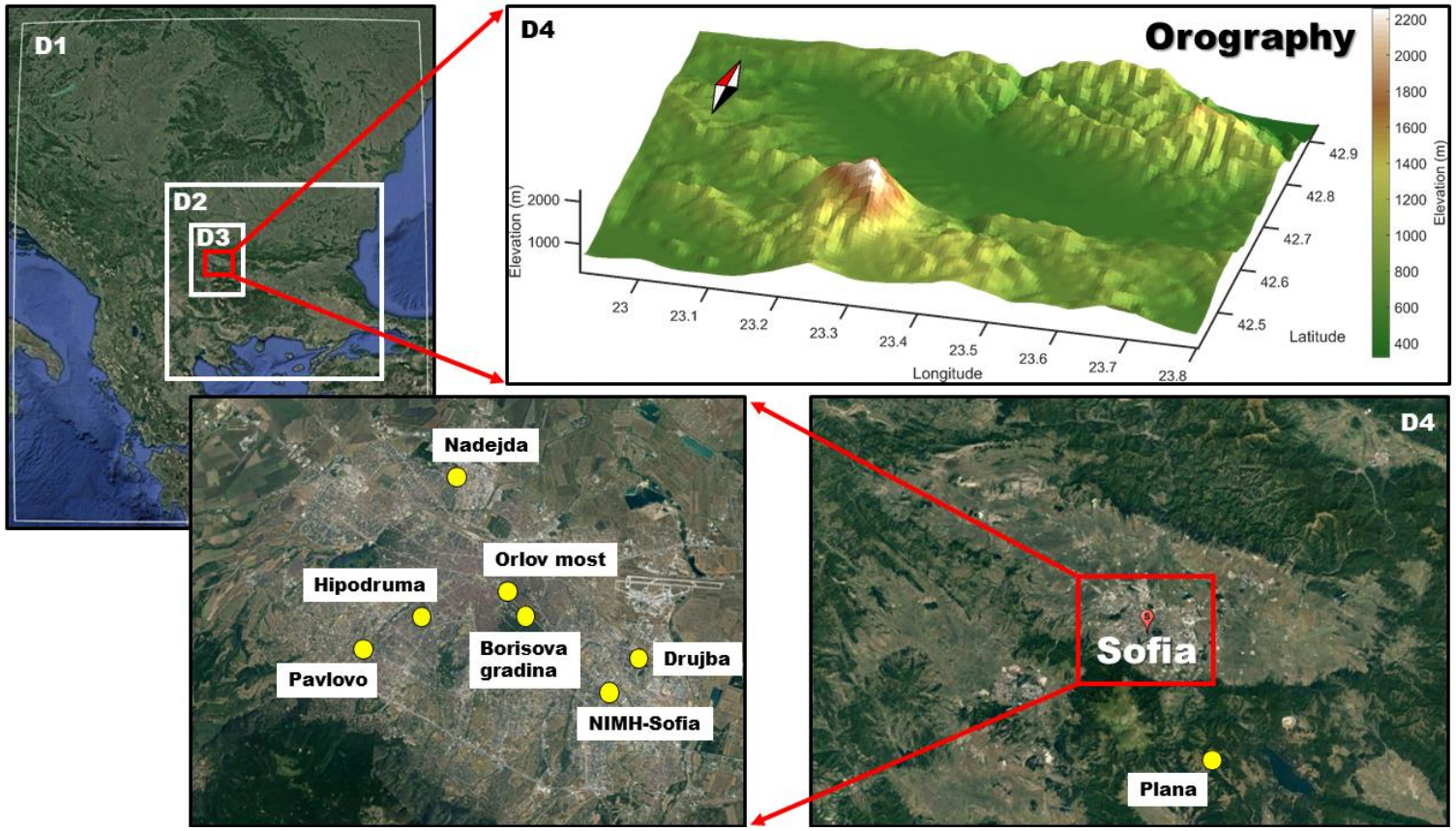
Bulgarian population living in the urban areas has increased approximately 2.7 times, from 27.6% in 1950, up to 74% in 2015; a quarter live in Sofia city at present.



Challenges:

- **environmental degradation;**
- **human health risks associated with heat, noise, pollution;**
- **crowd and human comfort.**

Method of research and case study

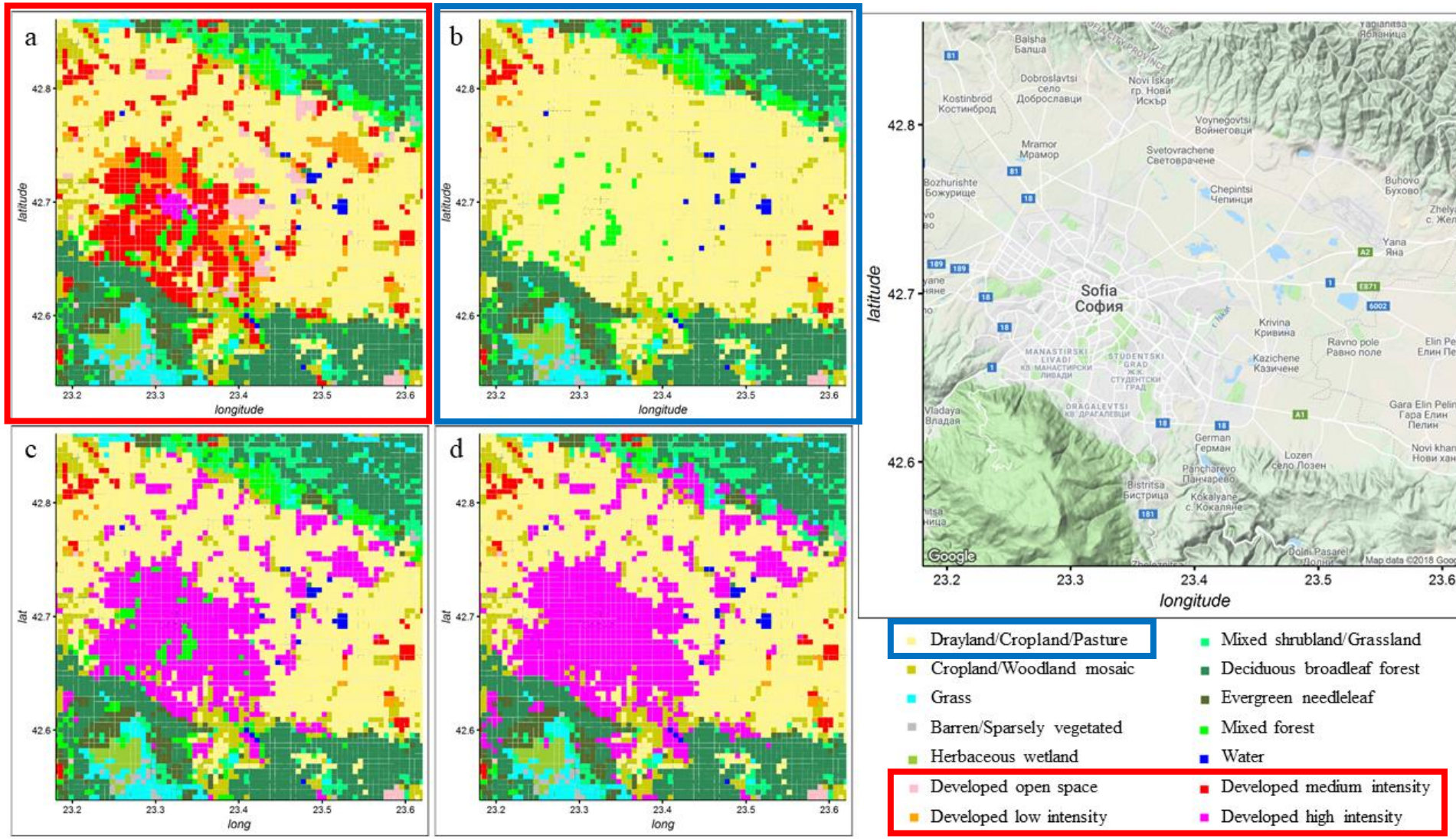


ARW-WRF v.3.8.1 MODEL CONFIGURATION

- Lambert projection (23.4°E, 42.68ºN)
- 4 nested domains with grid sizes of 32, 8, 2 and 0.5 kms
- Resolution of the inner domain: 157x129x100
- High terrain resolution 1 arcsec, https://lta.cr.usgs.gov/SRTM1Arc
- 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/

Study case - 11 days (25 August – 4 September, 2016) with anticyclonic fair weather, dry (low humidity less than 50 % relative humidity, averaged for the all stations in Sofia) and quiescent (wind speed < 5 m/s at 850-hPa) conditions.

Numerical experiments with land-use



a) base urban

b) non-urban

c) urban-high-intensity

d) urban-no-parks

Model validation

Statistical measures for temperature and mixing ratio (all stations located in Sofia)

	TEMPERATURE		MIXING RATIO	
	Observations	Modelling	Observations	Modelling
Mean	23.9	23.2	7.1	6.8
St. Dev.	5.6	5.3	1.0	1.2
MB		-0.7		-0.3
MAE		1.4		1.0
RMSE		1.6		1.2
IA		0.98		0.71
r		0.98		0.64

Indexes of agreement

$$IA = 1 - \frac{\sum_{i=1}^{N}(P_i - O_i)^2}{\sum_{i=1}^{N}\left(\left|P_i - \bar{O}\right| + \left|O_i - \bar{O}\right|\right)^2}$$

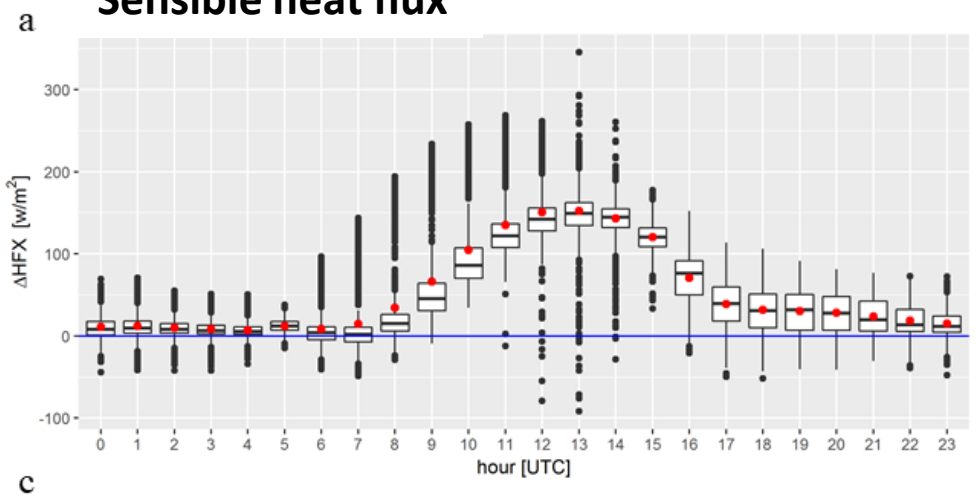
(source: C. J. Willmott, "On the validation of models", Phys Geogr, vol. 2, pp. 184–194, 1981)

MODEL PARAMETRIZATION

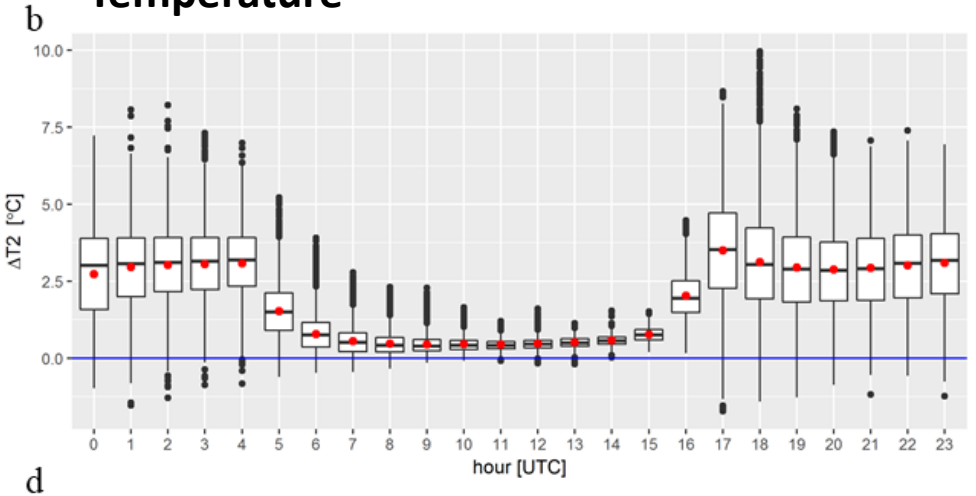
- Longwave Radiation: Rapid Radiative Transfer Model (RRTM) (Mlawer et al., 1997)
- Shortwave Radiation: Dudhia (Dudhia, 1989)
- PBL: Yonsei University scheme YSU (Hong et al., 2006)
- Micro Physics: Lin et al. (Lin et al., 1983)
- Noah land surface model (F. Chen, and J. Dudhia, 2001)
- Grell-Freitas (GF) cumulus scheme - only for the coarse simulation with 32 and 8 km grids (G. A. Grell, and S. R. Freitas, 2014).

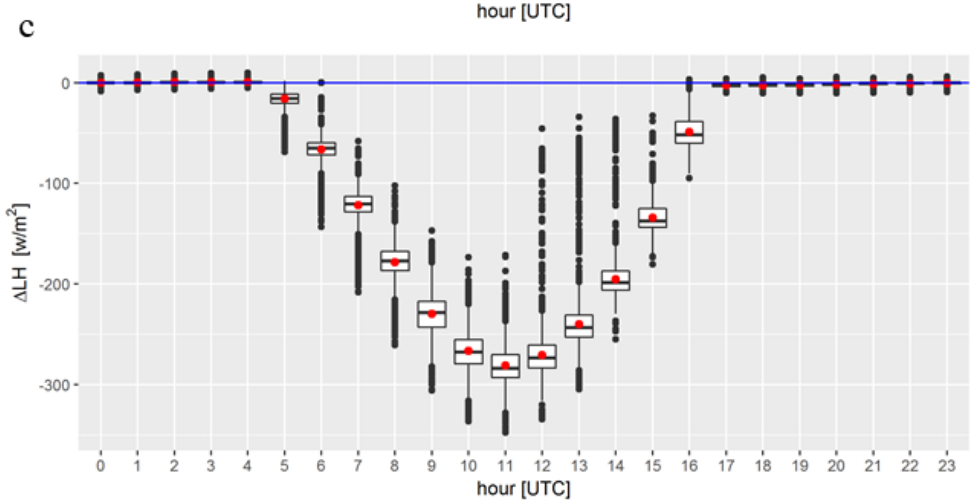
Box plots - base urban minus non-urban scenarios

Sensible heat flux

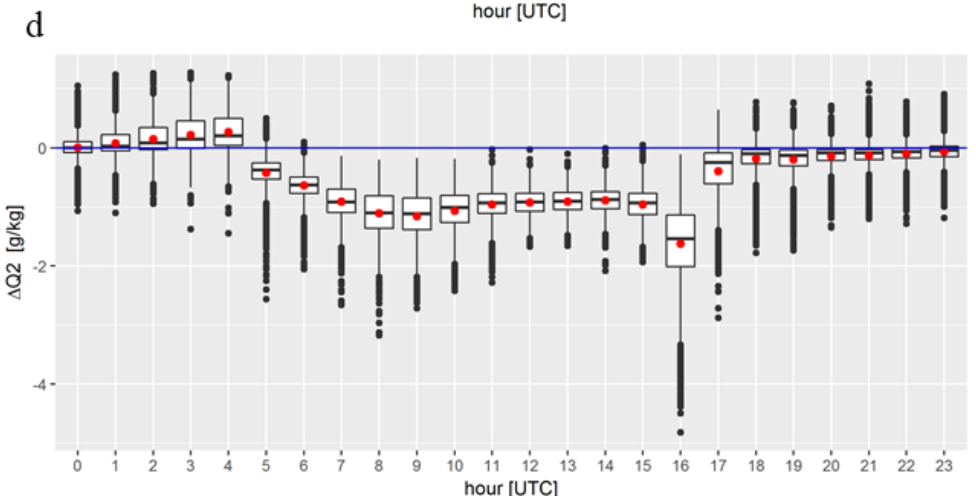


Temperature





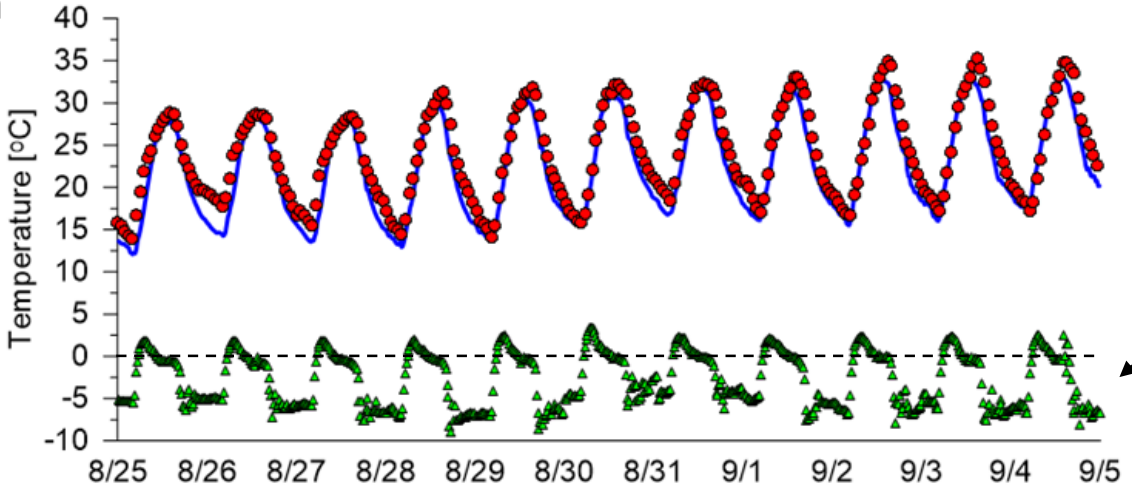
Latent heat flux



Water vapor mixing ratio

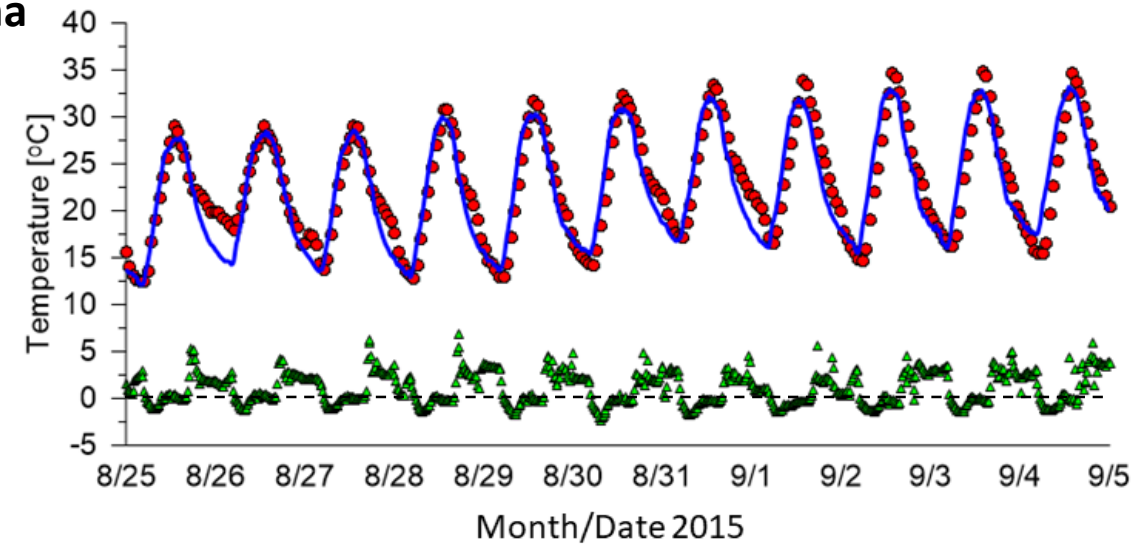
The effect of denser build-up and urban landscape extension

Druzhba



Replacement of urban low to high intensity

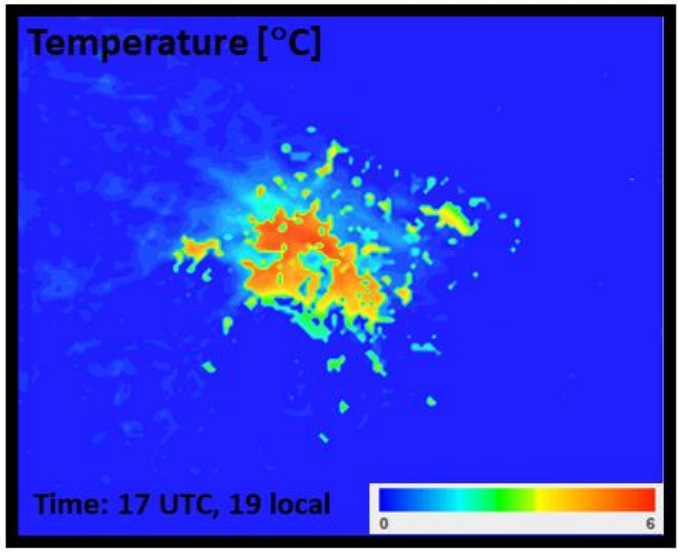
Borisova Gradina

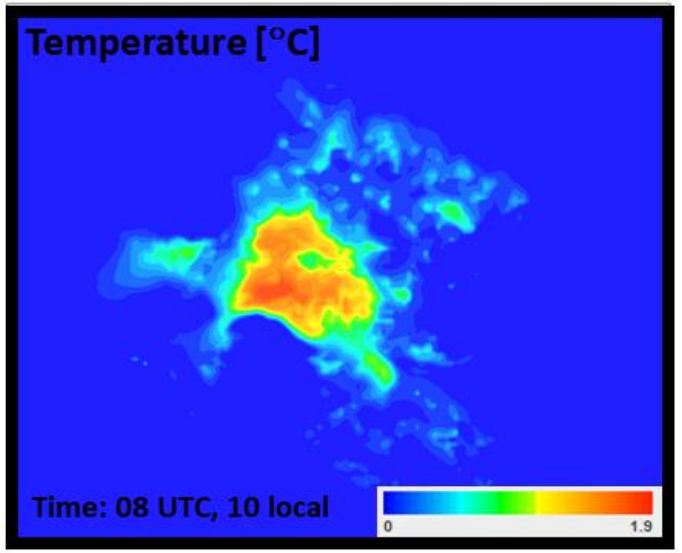


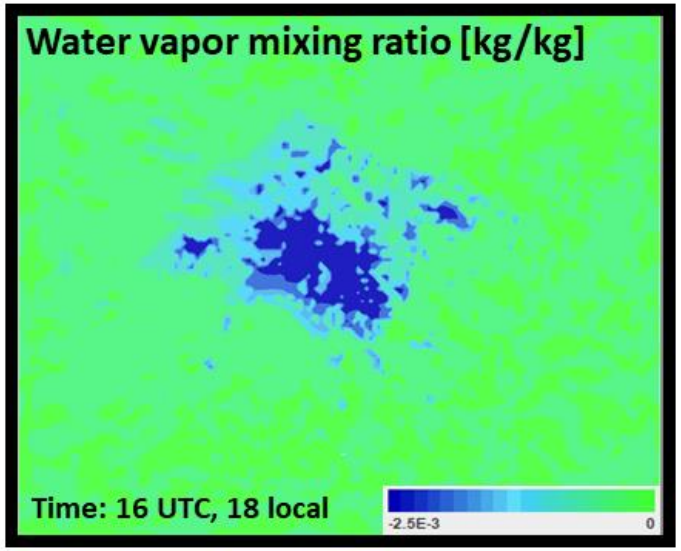
Expansion of the urban landscape over the parks and green areas

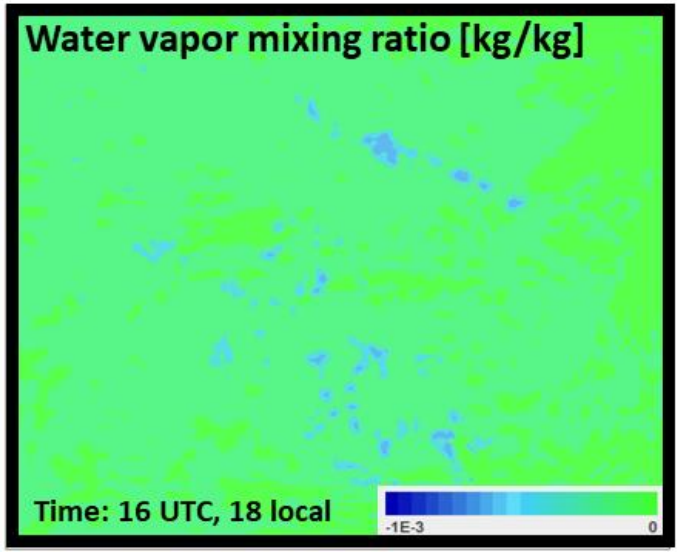
Spatial distribution of difference in average fields

Base urban case - Non-urban case









Urban-no-parks – Base urban case

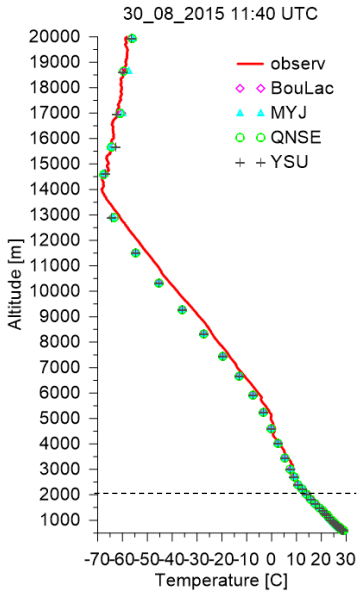
Conclusions

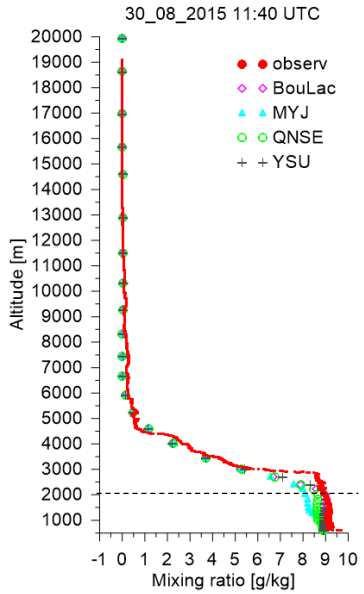
- Urban environmental challenges need to be solved promptly and in parallel with the cities development to ensure a sustainable future and healthy and happy population.
- An integral approach that considers both the environment problems related to human activity, and the health and comfort of the city inhabitants, is the only way to avoid costly and harmful mistakes due to wrong assumptions and lack of proper expansion planning.
- The numerical modelling techniques deal with the challenges of future city development scenarios. These are extremely powerful tools that deliver critical data to the city planners, authorities and decision makers.

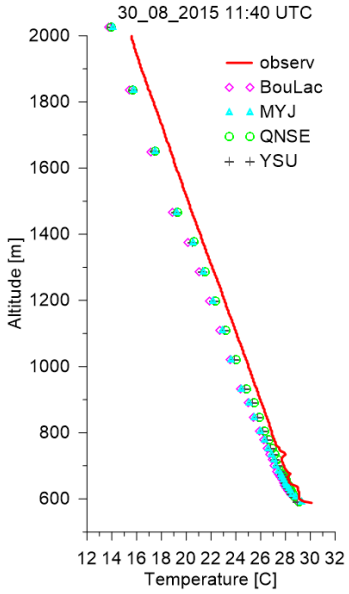
ACKNOWLEDGMENTS

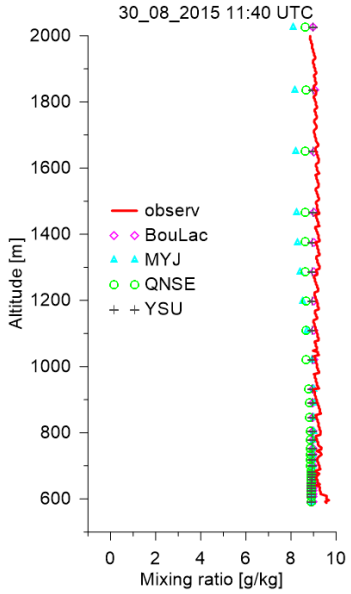
This research was funded by NSF Research Grant № DN04/7. The computer support was provided by the Nestum HPC cluster at Sofia Tech Park (http://nestum.phys.uni-sofia.bg/).

Model validation

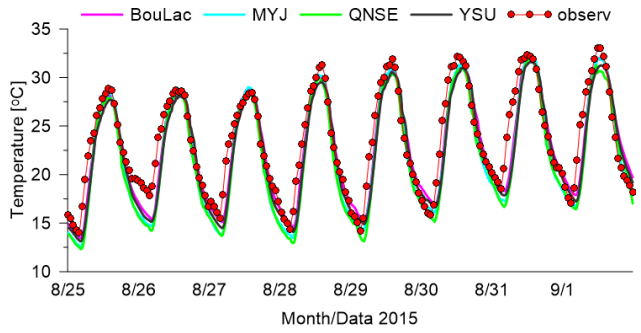


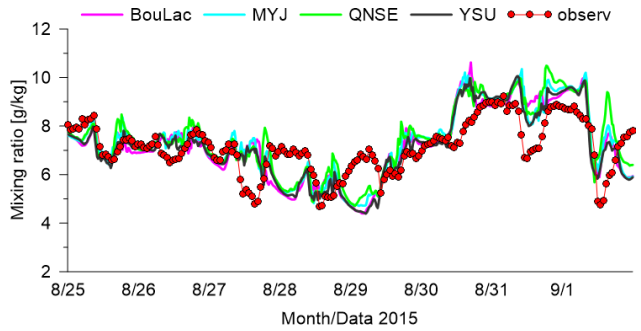






Druzhba





PBL: Yonsei University scheme YSU (Hong et al., 2006)
Mellor–Yamada–Janjic scheme MYJ (Janjic, 1990)
Bougeault and Lacarrere scheme BouLac (Bougeault&Lacarrere, 1989)
Quasi-Normal Scale Elimination scheme, QNSE (Sukoriansky et al., 2005)