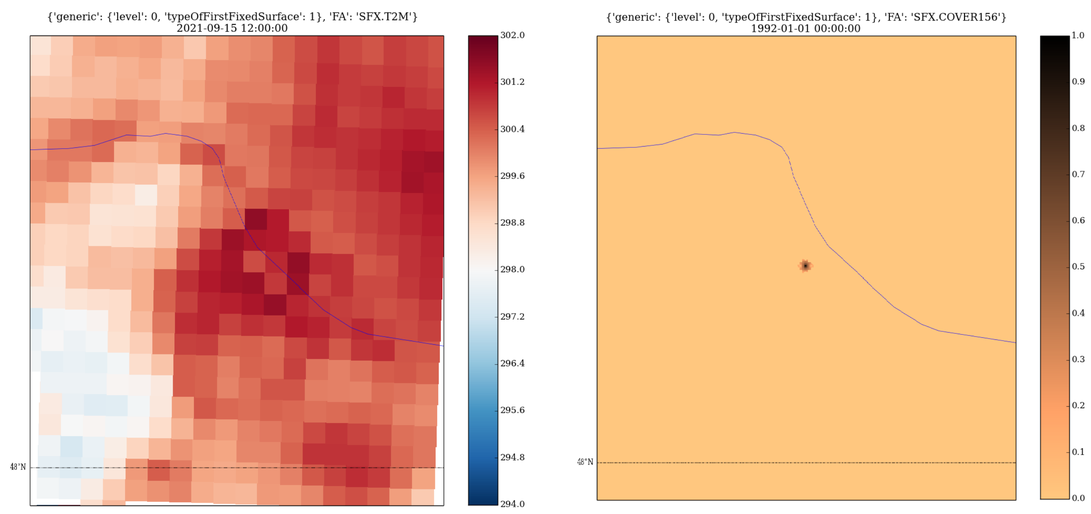
ZAMG
Zentralanstalt für Meteorologie und Geodynamik

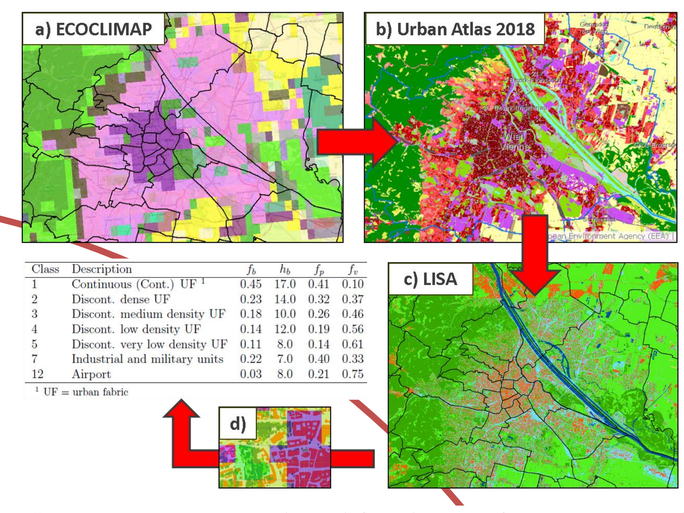
Using stand-alone SURFEX to forecast urban heat islands

Stefan Schneider and Sandro Oswald

During heat waves, the Urban Heat Island (UHI) effect increases the risk of heat-related threats for citizens. Temperature forecasts on the local scale (e.g. town districts) could be an important data source for impact-based warnings to reduce these threats.
Hence, ZAMG is testing a downscaling approach for AROME forecasts with stand-alone SURFEX to produce real-time city temperature forecasts on a 100m-scale.



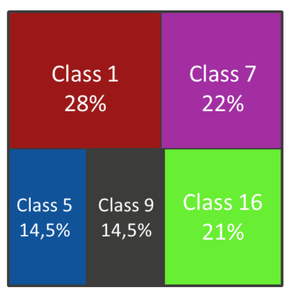
This is the operational AROME (CY43) T2M forecast (2021091500+12). Although TEB is activated, the UHI is not well pronounced, which is mainly due to the coarse model grid (2.5km) and the global ECOCLIMAP land cover data (see here COVER 156 [roads and railways] as example) .



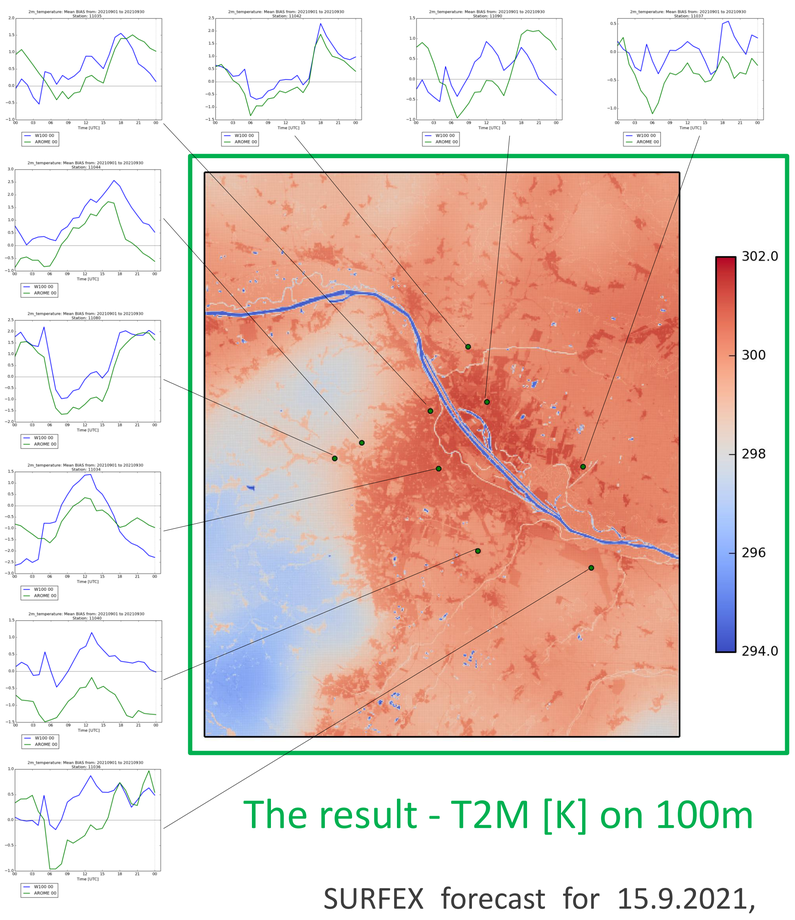
Class	Description	f_b	h_b	f_p	f_v
1	Continuous (Cont.) UF [1]	0.45	17.0	0.41	0.10
2	Discont. dense UF	0.23	14.0	0.32	0.37
3	Discont. medium density UF	0.18	10.0	0.26	0.46
4	Discont. low density UF	0.14	12.0	0.19	0.56
5	Discont. very low density UF	0.11	8.0	0.14	0.61
7	Industrial and military units	0.22	7.0	0.40	0.33
12	Airport	0.03	8.0	0.21	0.75

[1] UF = urban fabric

Each SURFEX 100m grid cell gets a weighting scheme of each Urban Atlas class (b).



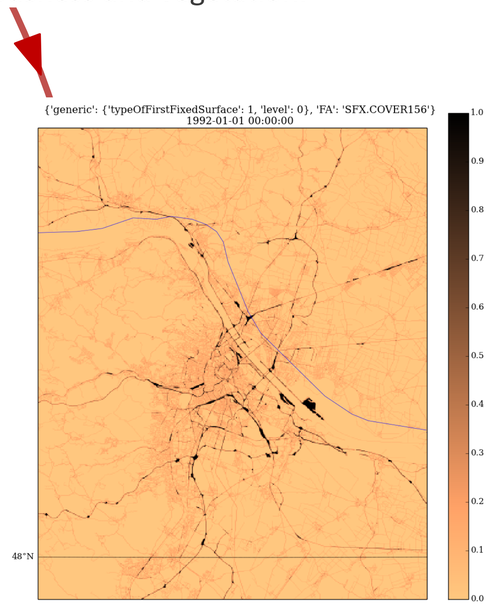
So we prepare updated land use classes using the Urban Atlas (UA) 2018 instead of ECOCLIMAP. After the weighting scheme, UA classes are resampled also to a 100m grid (majority). The high resolution land cover layer LISA (1m) is used to calculate the properties of each UA class resulting in average fractions of buildings, imperviousness and vegetation.



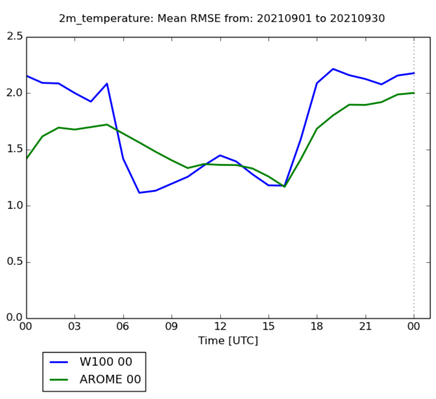
The result - T2M [K] on 100m

SURFEX forecast for 15.9.2021, 00UTC+12h on the 100m grid. Stations which are used for comparison are displayed as green dots. Looking at the Bias (model minus obs.; averaged for 30 forecasts in 2021/09) for the driving AROME 2.5km (green) and SURFEX 100m (blue) shows significant differences in the diurnal cycle for all 9 stations with a clear tendency of the downscaled forecast to be warmer.

This is the resulting improved COVER 156 on the 100m grid.
The modified PGD file is used to create an initial soil file (PREP.fa) once.
SURFEX is computed as soon as the operational AROME 001 is finished and the forcing files are created.



The forecast range is currently +24 hours and the soil file is cycle (=the +24 hour forecast is used as initial soil file for the next run). Output is stored in netCDF.



A first validation (averaged RMSE for 9 stations and 30 forecasts in September 2021) shows no clear improvement for the downscaled (blue) vs. reference (green) forecast. The larger RMSE at the initial state (00UTC) indicates that a data assimilation on the 100m grid might be beneficial.

SURFEX v8.1 configuration	
Domain size	565x469
Soil scheme	DIF, 14 layers
NPATCH	1
LCANOPY_ISBA	T
LCANOPY_TEB	T
Snow scheme	ES (3-L), 6 layers
Forcing height	30m

Conclusions and outlook

The approach to add more realistic spatial pattern to the AROME 2m air temperature forecasts for cities by SURFEX downscaling and high-resolution land cover data is working.
Like in many other NWP applications, the increase of the spatial resolution does not automatically lead to a better forecast performance.

Therefore, further tests are planned for a better understanding of the involved processes (e.g. impact of the forcing height and the Canopy scheme) and a better model tuning.
As further surface properties such as the albedo, building heights and vegetation properties (e.g. NDVI and LAI) are important for an accurate simulation, Landsat pictures and national building polygons will be used together with machine learning methods (e.g. Random Forest regression) to improve the overall properties for each Urban Atlas class.
Surface data assimilation with some kind of Kalman Filter in the SODA framework should be tested.
Finally, a roll out for other major cities in Austria (Linz, Innsbruck, Klagenfurt) will be initialized to monitor air temperature and to test an improved extreme weather warning system.

contact: Stefan Schneider, Department for Remote Sensing, stefan.schneider@zamg.ac.at, Tel. 0043 1 360 26 / 2329, www.zamg.ac.at
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