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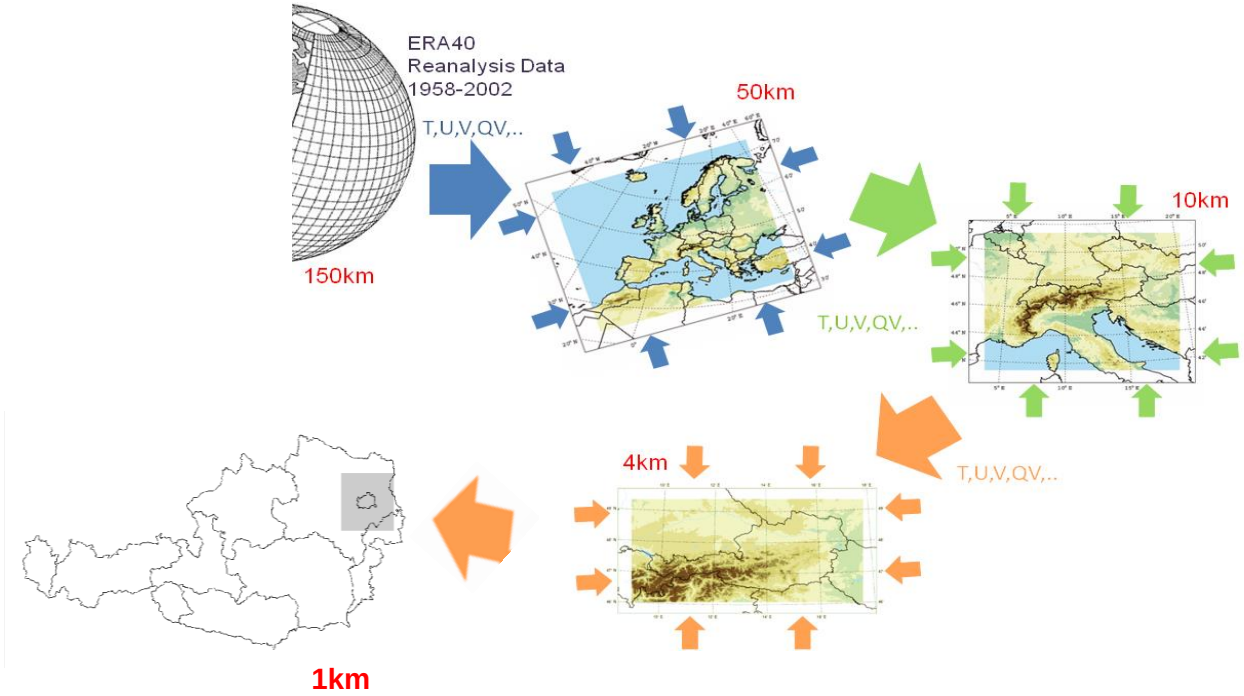
High Resolution Urban Climate Modelling

Johann Züger

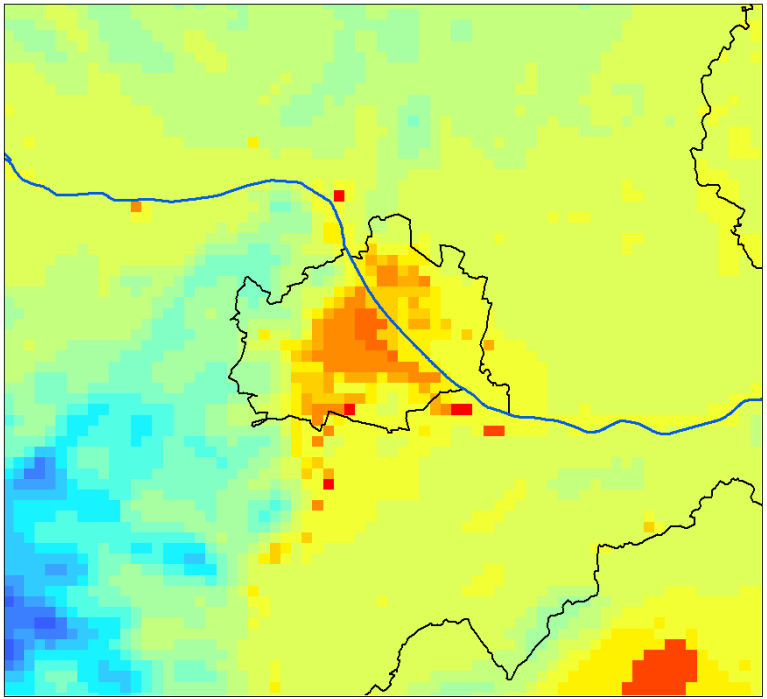
CLM Assembly 2019

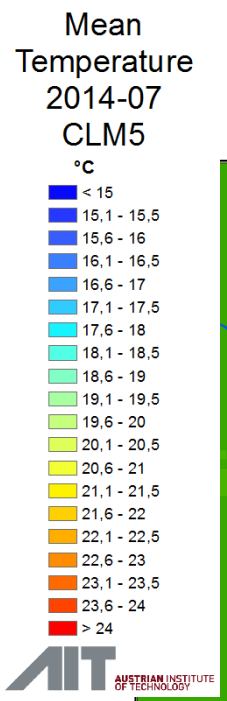
Paestum, September 16th – 20th, 2019

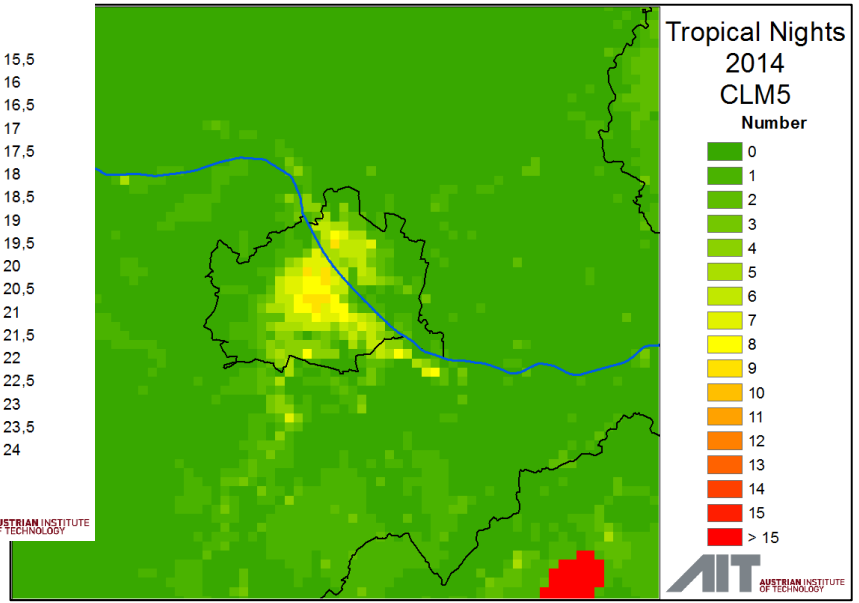
DYNAMIC DOWNSCALING



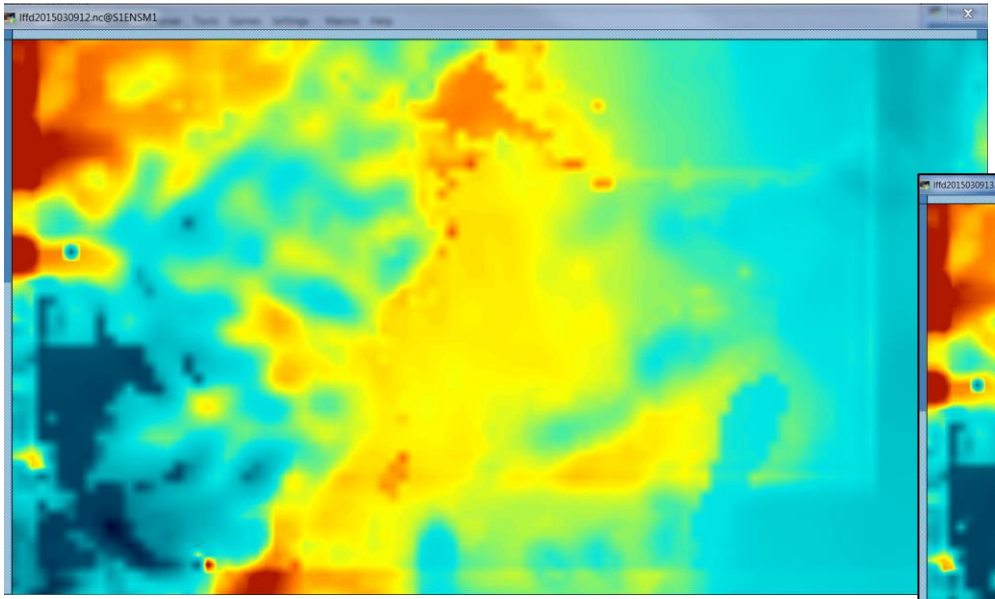
CLM-V5.0_URB_2.3





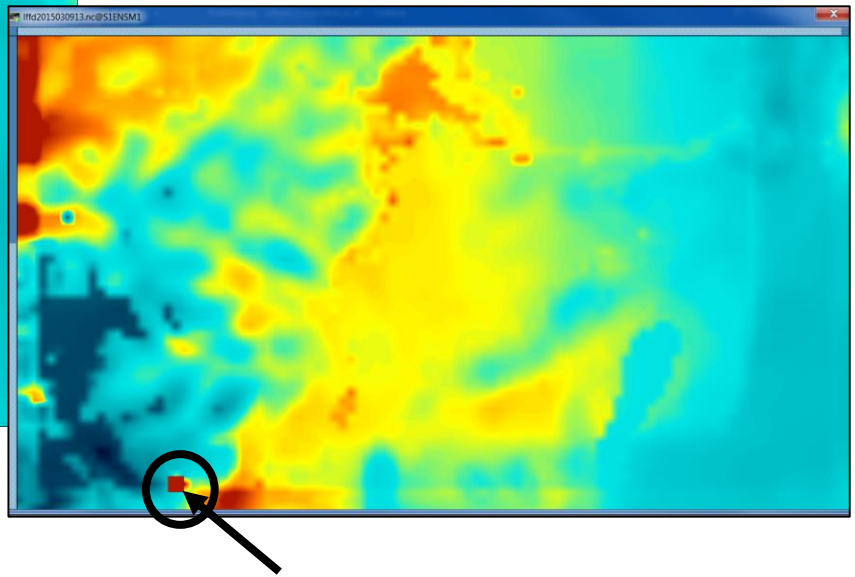


CLM-V5.0_URB_2.3

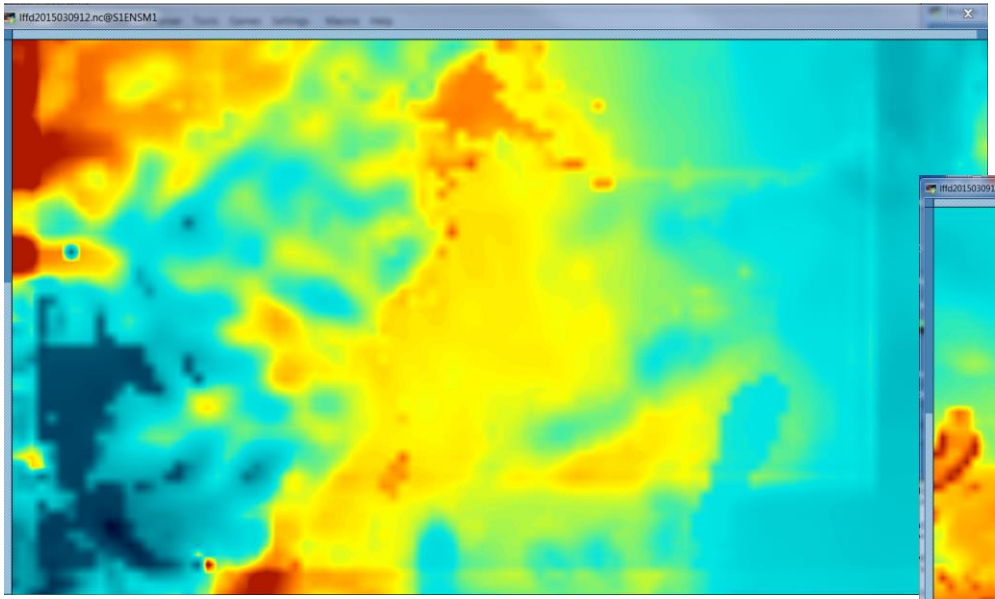


2m temperature 2015-03-09, 12:00

2m temperature 2015-03-09, 13:00

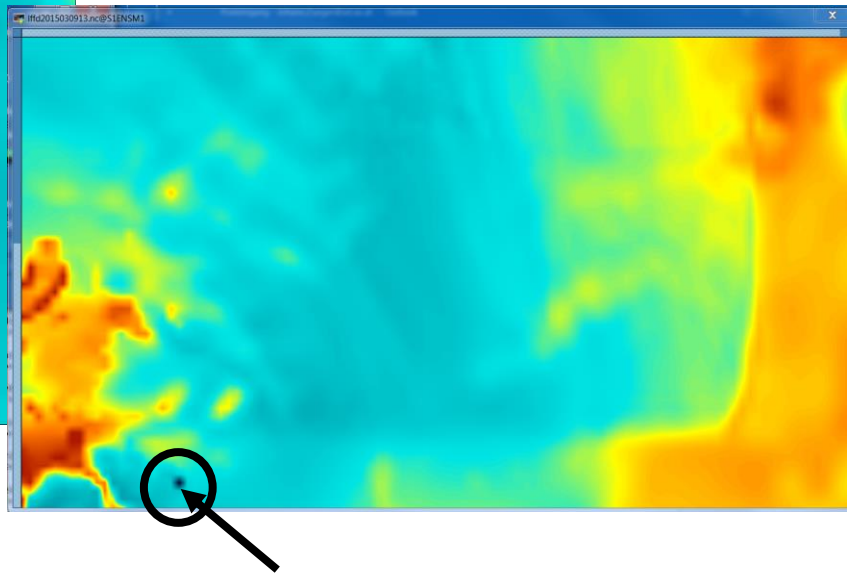


CLM-V5.0_URB_2.3



2m temperature 2015-03-09, 12:00

2m RELHUM 2015-03-09, 13:00

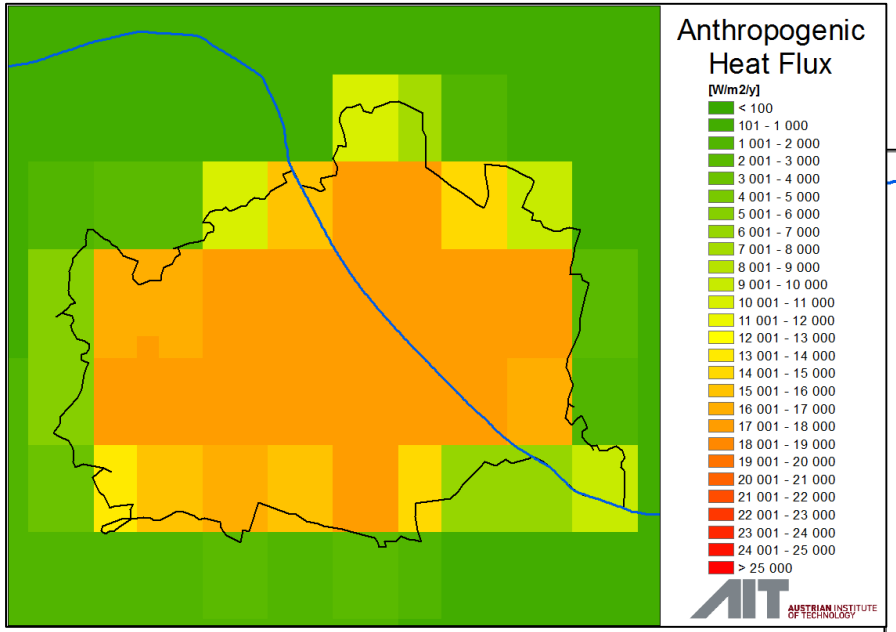


URBAN CLIMATE MODELLING

Components used for the base run:

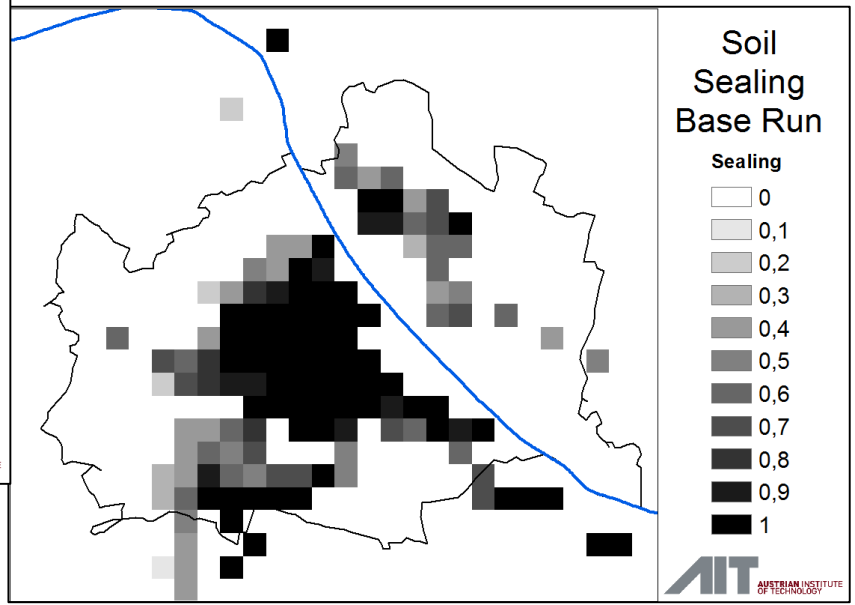
- Regional Climate Model Cosmo-CLM 4.8_19 with Urban Extension
- ERA40 und ERAInterim data from ECMWF
- Data from the Global Circulation Model HadCM3 for the SRES-scenario A1B
- Results from former project reclip:century
- High resolution sealing layer from EEA (http://www.eea.europa.eu/data-and-maps/data/eea-fast-track-service-precursor-on-land-monitoring-degree-of-soil-sealing-100m).
- Anthropogenic heat flux (http://www.cgd.ucar.edu/tss/ahf/).
- 100x100 grid points with 1 km horizontal resolution around Vienna
- Data of 12 measurement stations in and around Vienna

URBAN EXTENSIONS (BASE RUN)

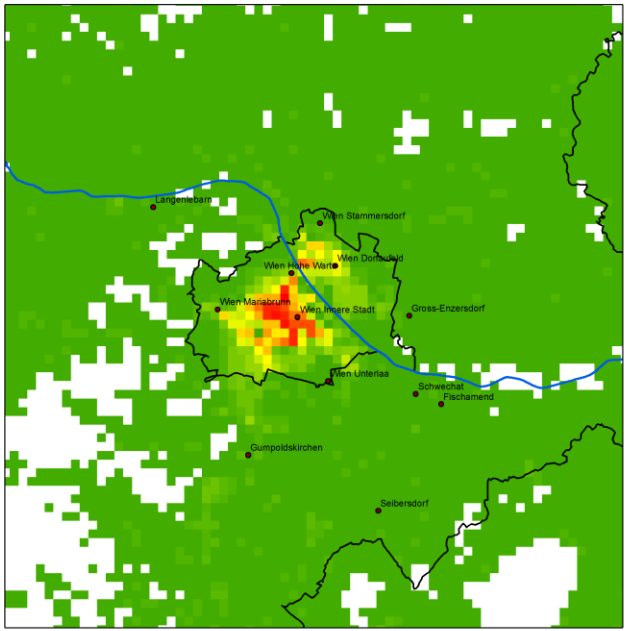


original resolution : 2.5´x 2.5´

original resolution: 100m x 100m



URBAN EXTENSIONS (BASE RUN)



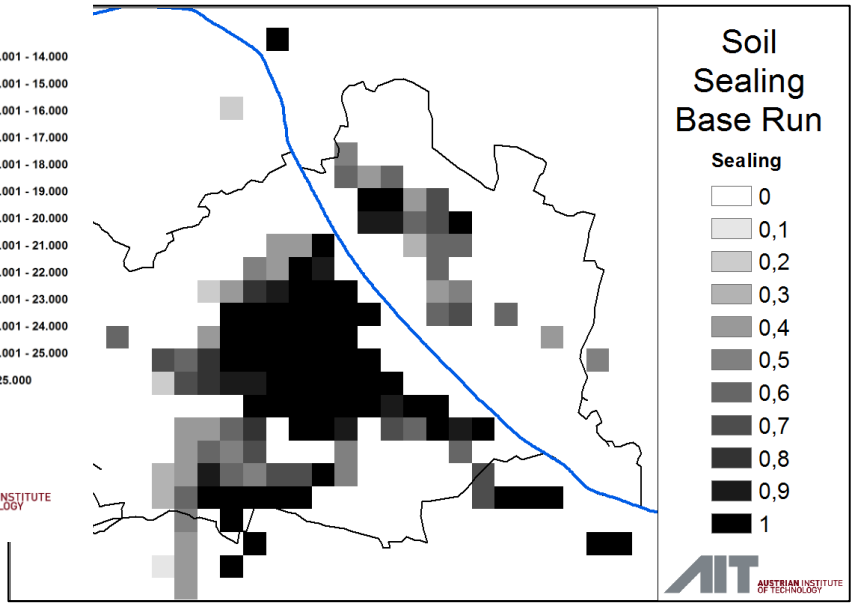
Anthropogenic Heat Emissions Yearly Sum 2013

[W/m2]

< 100	13.001 - 14.000
101 - 1.000	14.001 - 15.000
1.001 - 2.000	15.001 - 16.000
2.001 - 3.000	16.001 - 17.000
3.001 - 4.000	17.001 - 18.000
4.001 - 5.000	18.001 - 19.000
5.001 - 6.000	19.001 - 20.000
6.001 - 7.000	20.001 - 21.000
7.001 - 8.000	21.001 - 22.000
8.001 - 9.000	22.001 - 23.000
9.001 - 10.000	23.001 - 24.000
10.001 - 11.000	24.001 - 25.000
11.001 - 12.000	> 25.000
12.001 - 13.000	

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original resolution: 100m x 100m



MODEL RUN WITH HISTORICAL DATA (1960-2015)

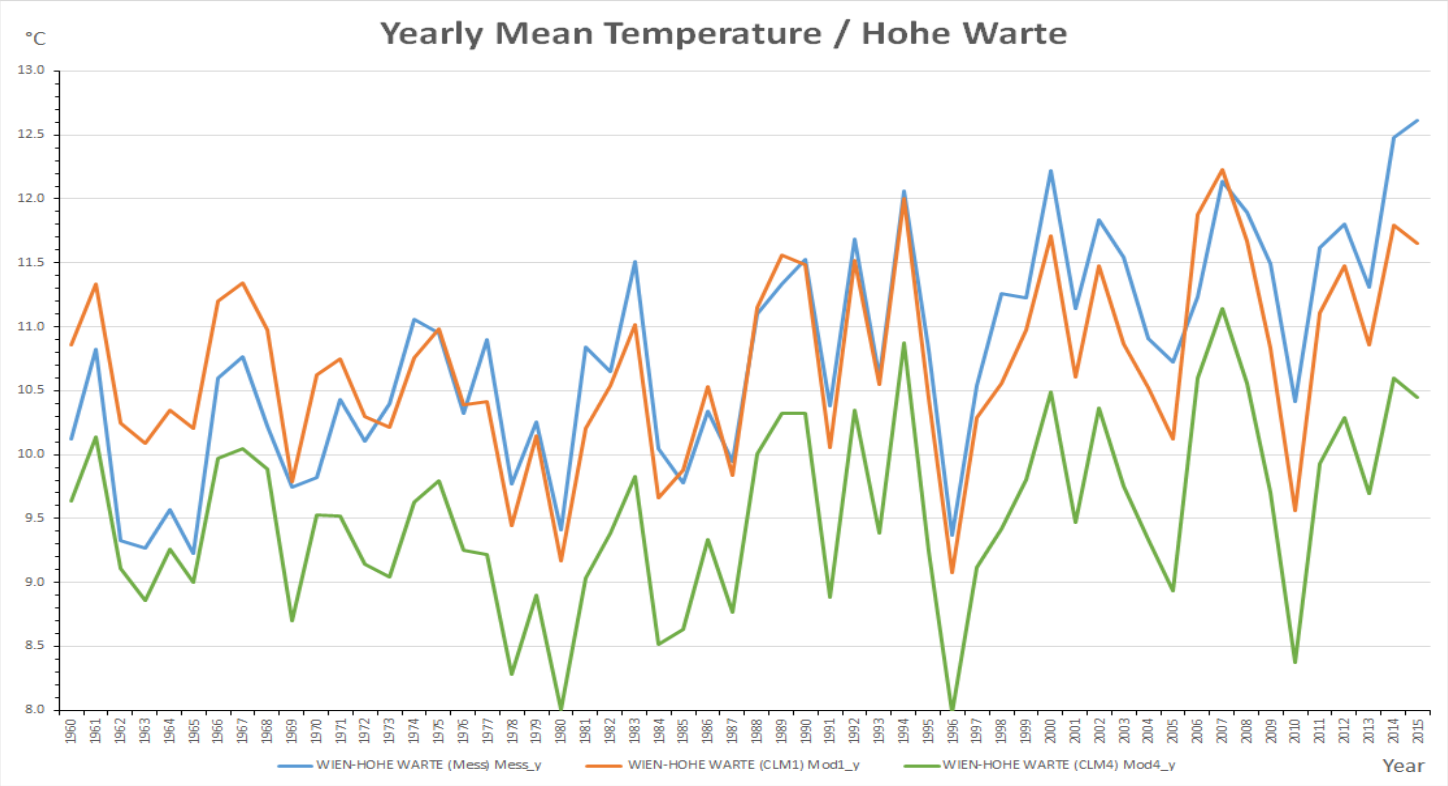
Temperature

ANALYZED PARAMETER

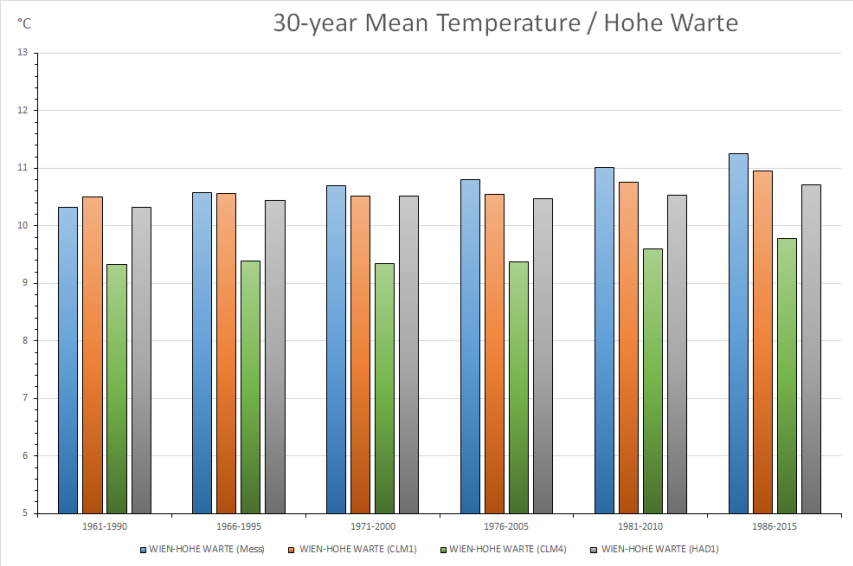
Temperature

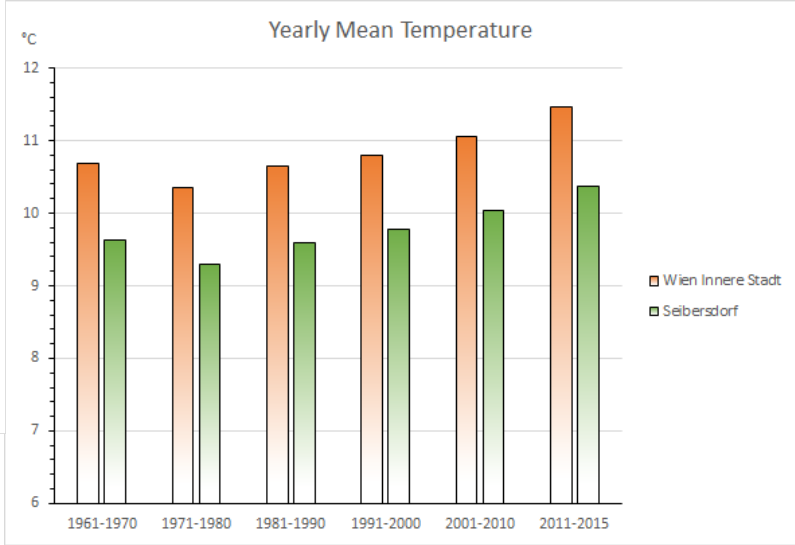
- Hourly, daily, monthly, seasonally and yearly values
- Daily means, minima and maxima
- Ice days (T_{max} < 0° C)
- Frost days (T_{min} < 0° C)
- Summer days (T_{max} > 25° C)
- Heat days (T_{max} > 30° C)
- Extremely hot days (T_{max} > 35° C)
- Heat waves (number, duration, sum of days)
- Tropical nights (T_{min} > 20° C)
- Exceedances of thresholds
- HUMIDEX (index derived from temperature and humidity)

TEMPERATURE MEAN VALUES

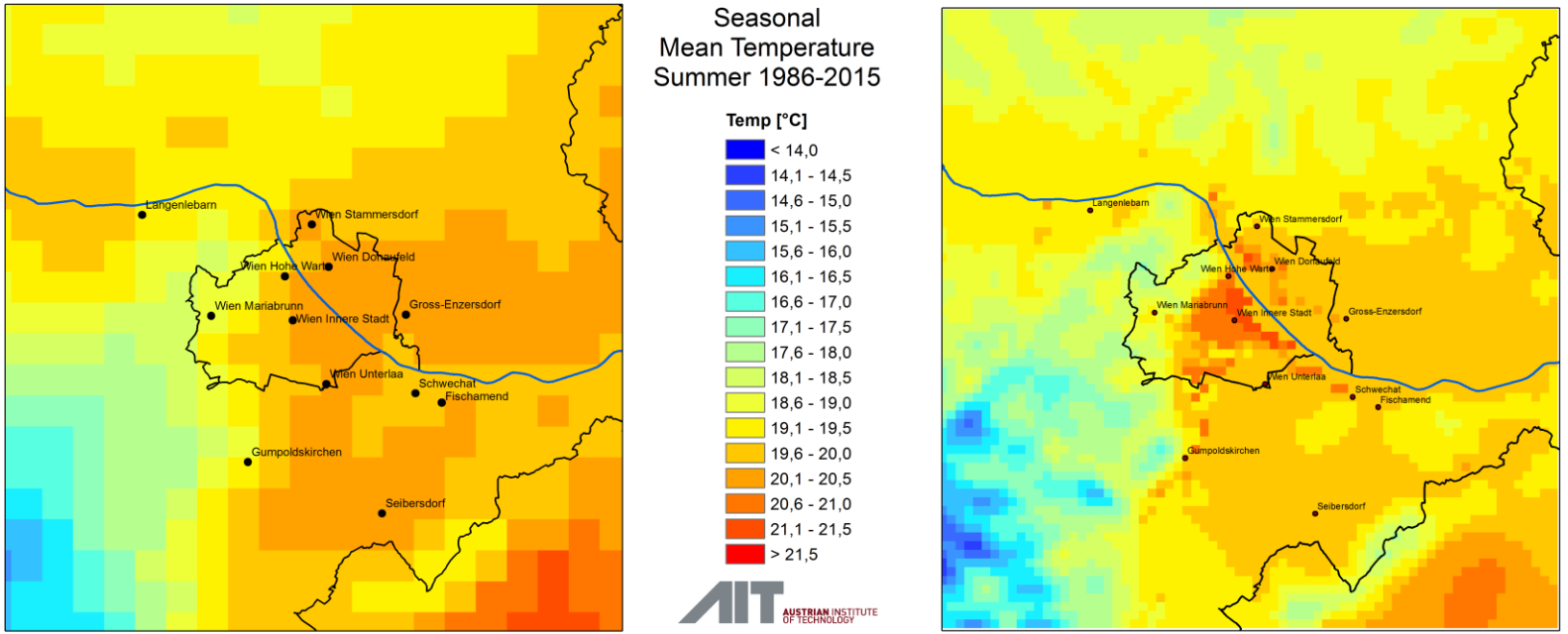


TEMPERATURE CLIMATIC MEANS / URBAN HEAT ISLAND

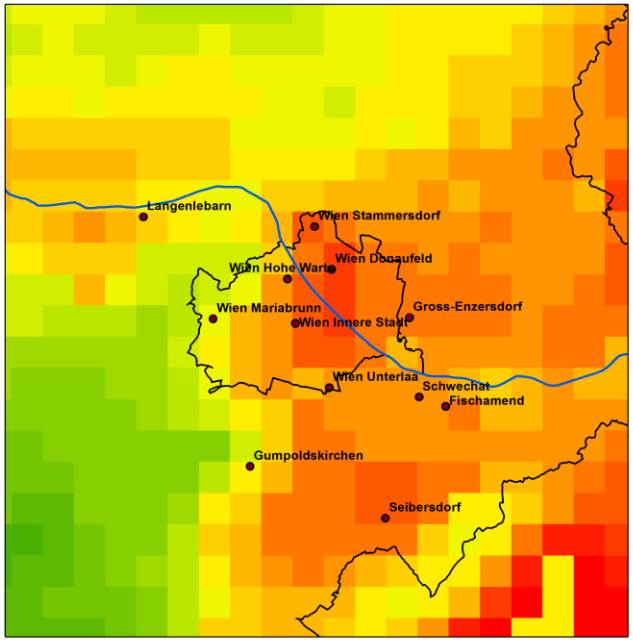




TEMPERATURE SEASONAL MEAN VALUES - SUMMER



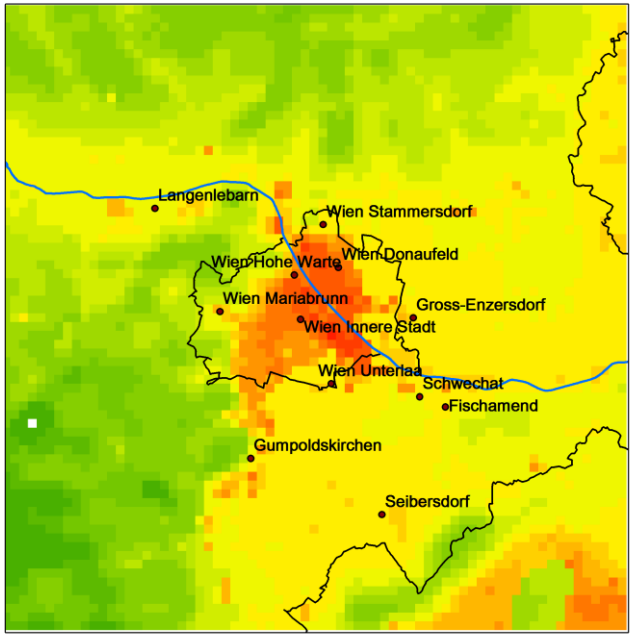
HEAT WAVES



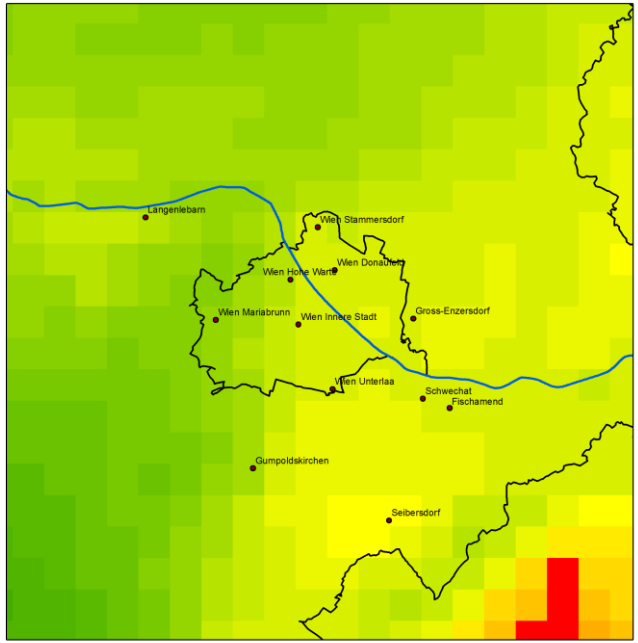
Number of Days during Heat Waves Mean 1986-2015

[days]

- 0
- 0,1 - 0,5
- 0,6 - 1,0
- 1,1 - 1,5
- 1,6 - 2,0
- 2,1 - 2,5
- 2,6 - 3,0
- 3,1 - 3,5
- 3,6 - 4,0
- 4,1 - 4,5
- 4,6 - 5,0
- 5,1 - 5,5
- 5,6 - 6,0
- 6,1 - 6,5
- 6,6 - 7,0
- 7,1 - 7,5
- 7,6 - 8,0
- > 8,0



TROPICAL NIGHTS

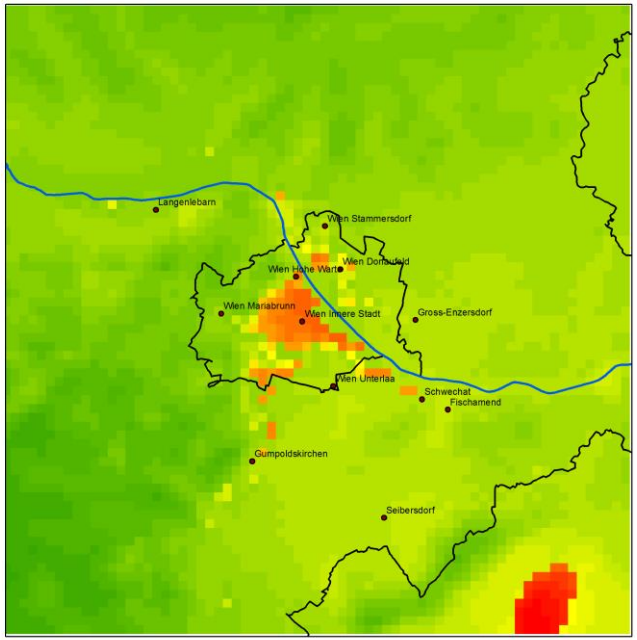


Tropical Nights
(Tmin > 20° C)
Mean 1986-2015

[nights]

0	14
1	15
2	16
3	17
4	18
5	19
6	20
7	21
8	22
9	23
10	24
11	25
12	> 25
13	

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MODEL RUN WITH HISTORICAL DATA (1960-2015)

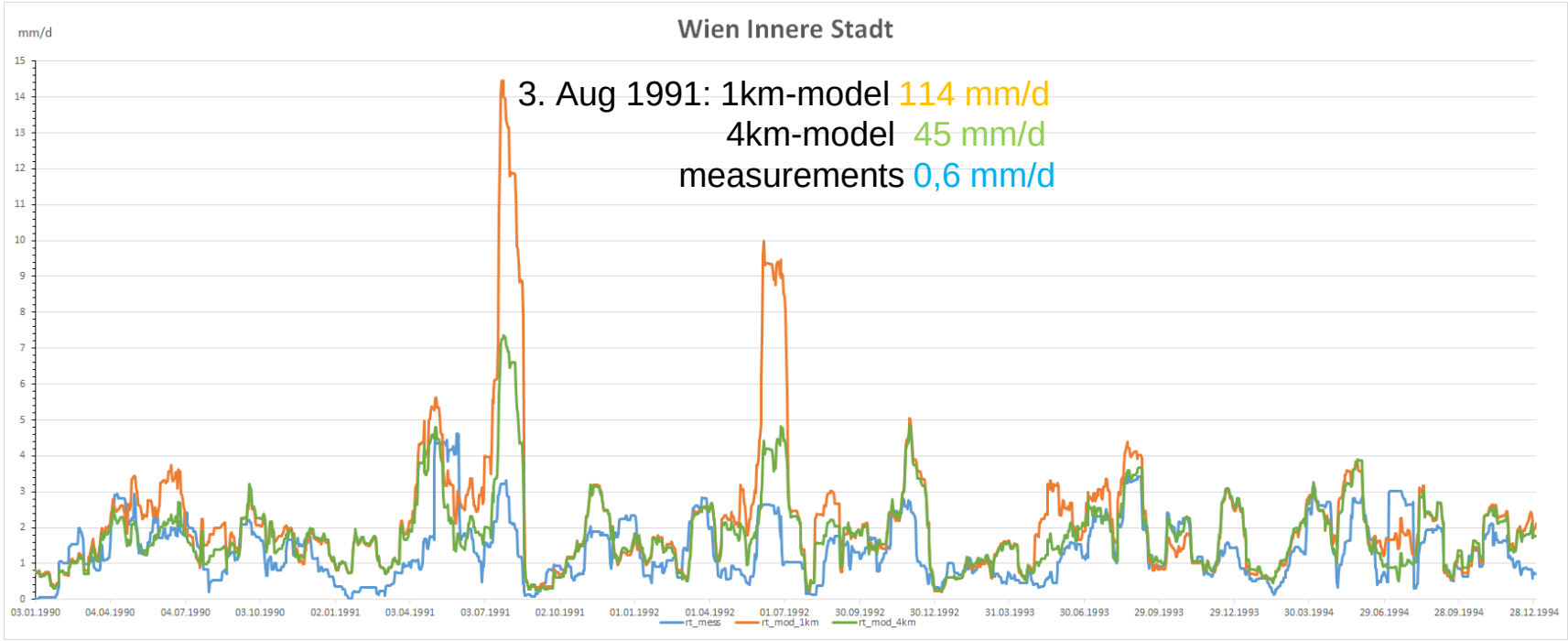
Precipitation

ANALYZED PARAMETER

Precipitation

- Hourly, daily, monthly, seasonally and yearly values
- Snow
- Rainfall
- Heavy precipitation (> 20 mm/d)
- Exceedance of threshold for heavy precipitation
- Surface runoff
- Total runoff

PRECIPITATION – DAILY SUMS

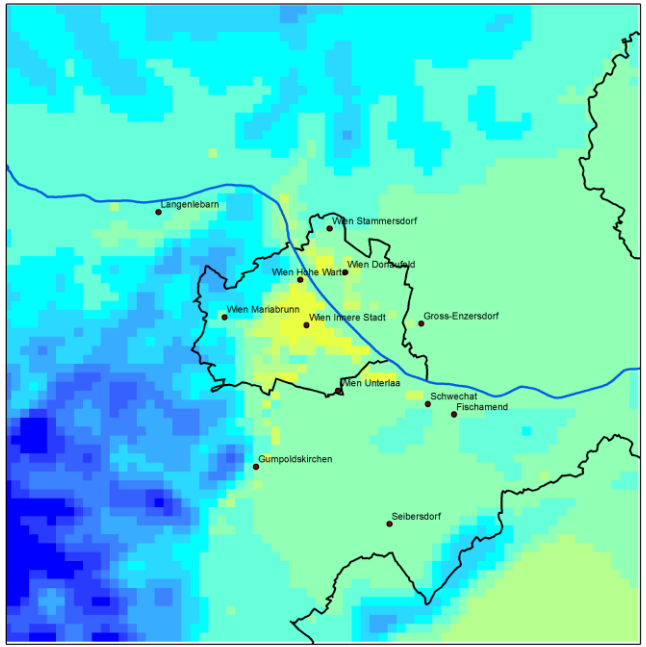


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TOMORROW TODAY

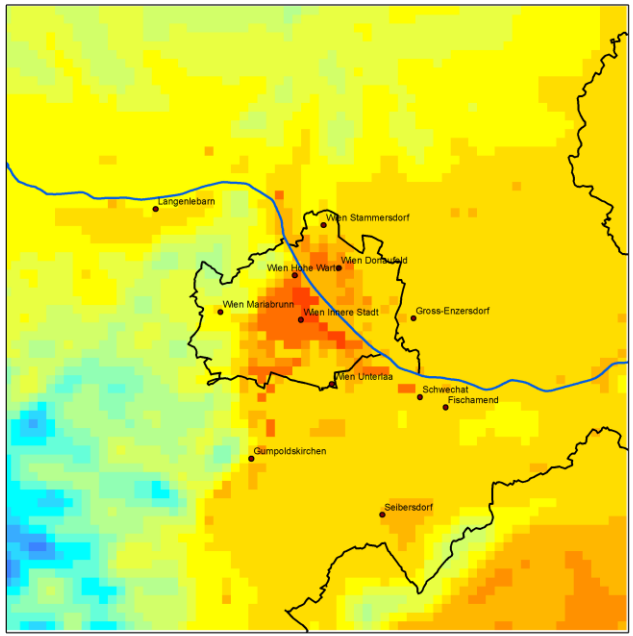
MODEL RUN WITH SCENARIO DATA (1960-2100)

Climate Change Signals for Temperature

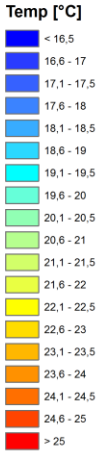
CLIMATE CHANGE SIGNAL – SEASONAL TEMPERATURE



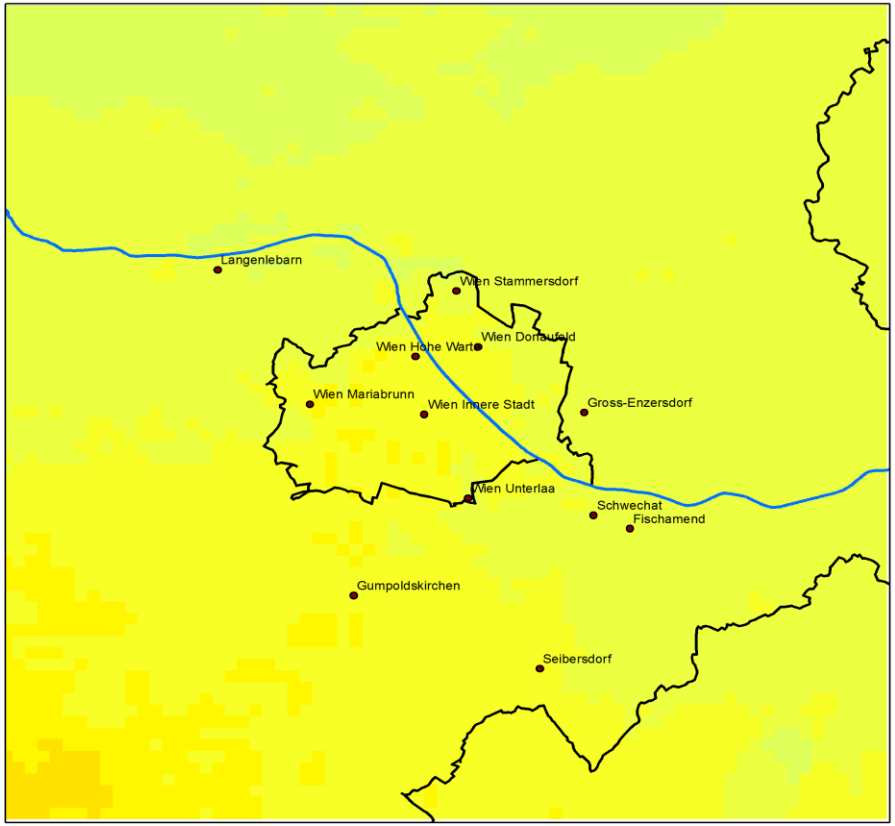
Seasonal
Mean Temperature
Summer 1971-2000



Seasonal
Mean Temperature
Summer 2041-2070



CLIMATE CHANGE SIGNAL – SEASONAL TEMPERATURE

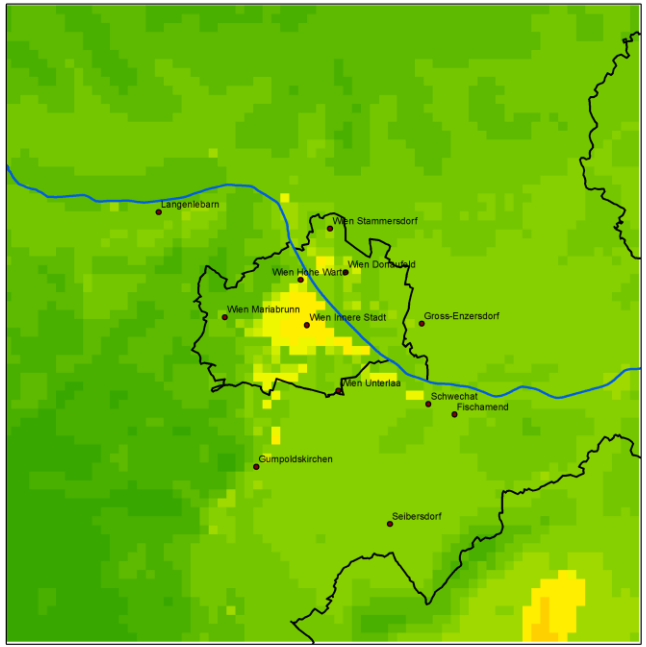


Change Seasonal Mean Temperature Summer 2041-2070

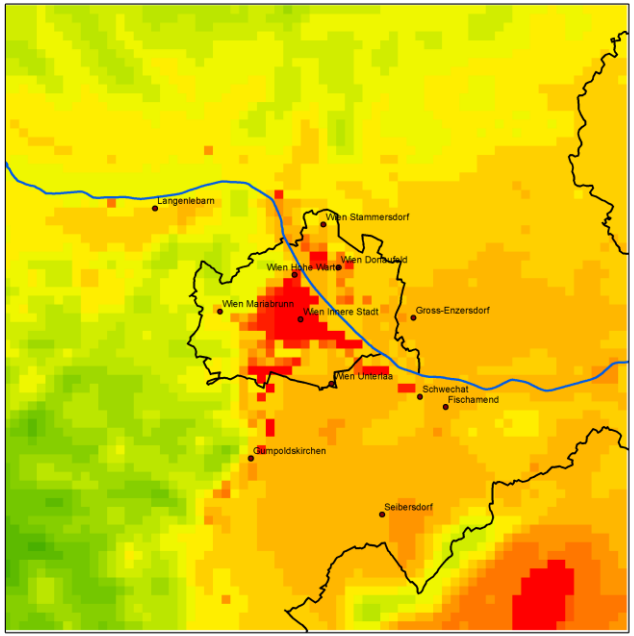
Change [°C]

< 0,8	2,4
0,9	2,5
1	2,6
1,1	2,7
1,2	2,8
1,3	2,9
1,4	3
1,5	3,1
1,6	3,2
1,7	3,3
1,8	3,4
1,9	3,5
2	3,6
2,1	3,7
2,2	3,8
2,3	> 3,8

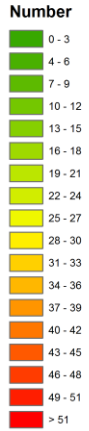
CLIMATE CHANGE SIGNAL – TROPICAL NIGHTS



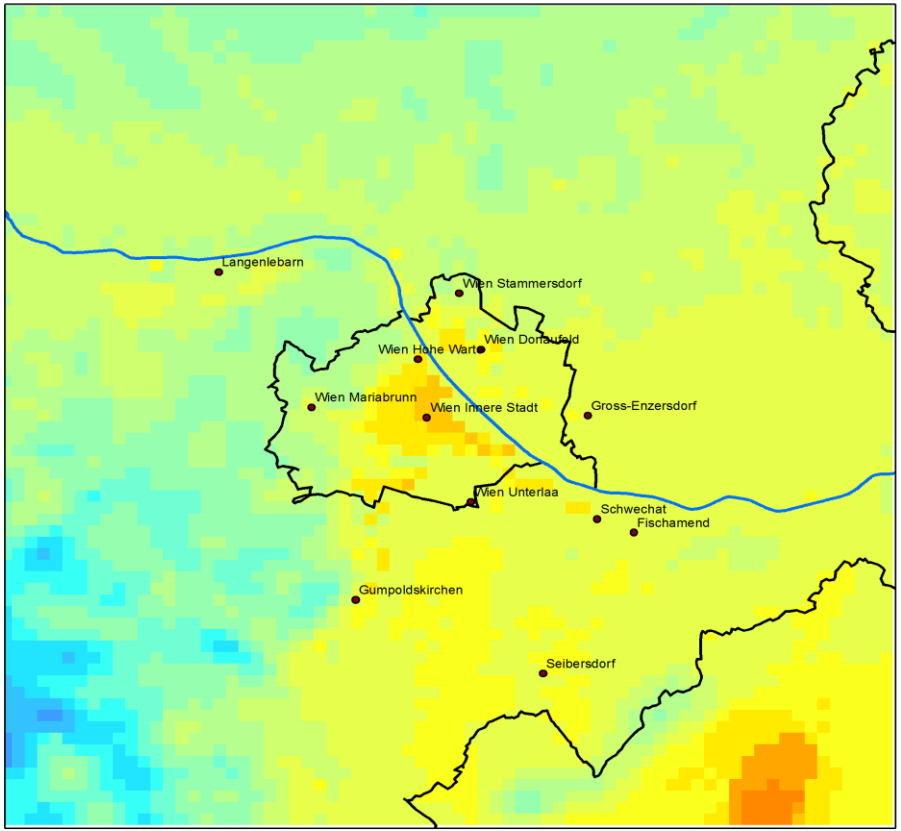
Tropical Nights
(Tmin > 20° C)
Mean 1971-2000



Tropical Nights
(Tmin > 20° C)
Mean 2041-2070



CLIMATE CHANGE SIGNAL – TROPICAL NIGHTS

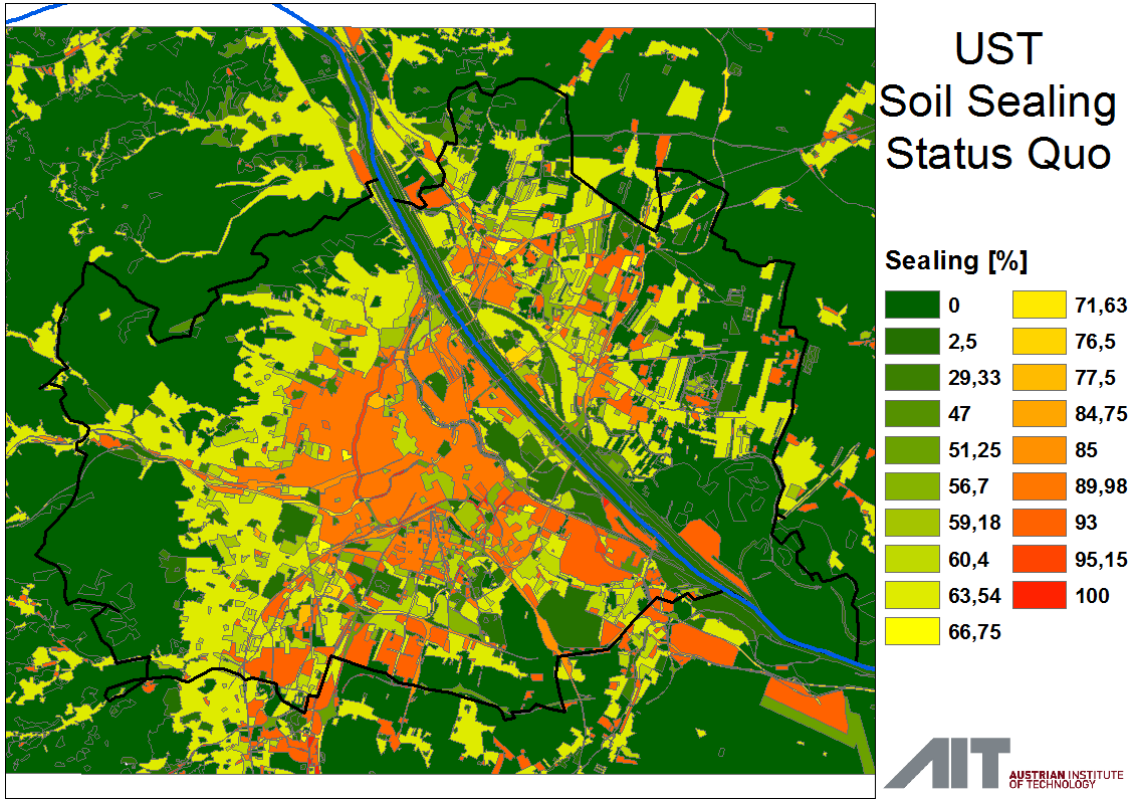


Change Number of Yearly Tropical Nights 2041-2070

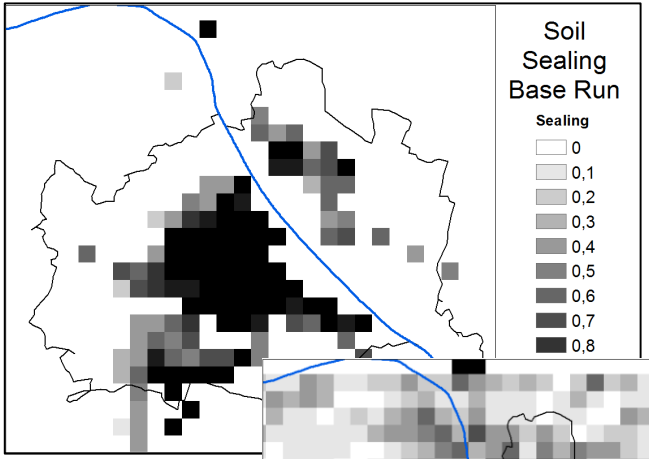
Change [nights]

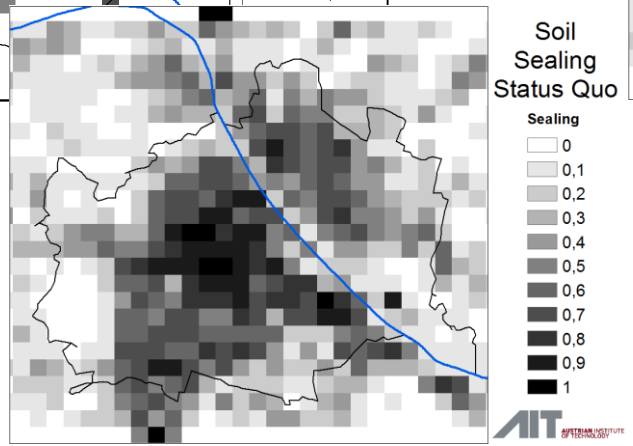
- < -2
- -1 - 0
- 1 - 2
- 3 - 4
- 5 - 6
- 7 - 8
- 9 - 10
- 11 - 12
- 13 - 14
- 15 - 16
- 17 - 18
- 19 - 20
- 21 - 22
- 23 - 24
- 25 - 26
- 27 - 28
- 29 - 30
- 31 - 32
- 33 - 34
- 35 - 36
- > 36

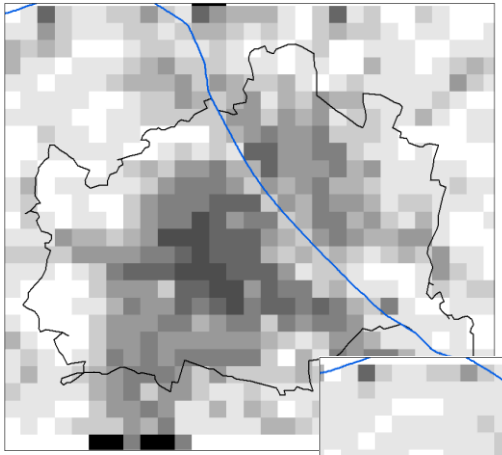
URBAN STANDARD TOPOLOGY

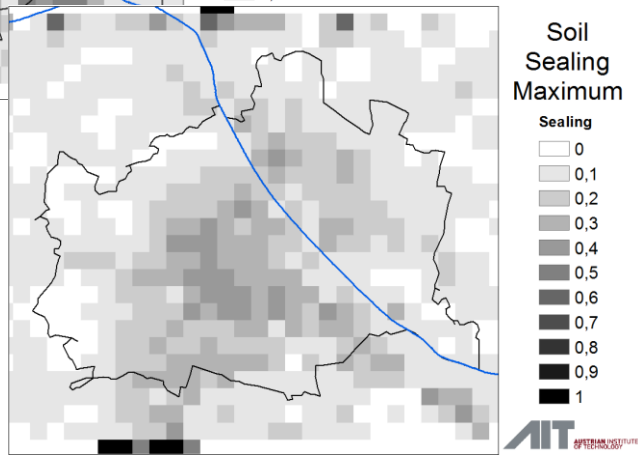


URBAN STANDARD TOPOLOGY – SEALING

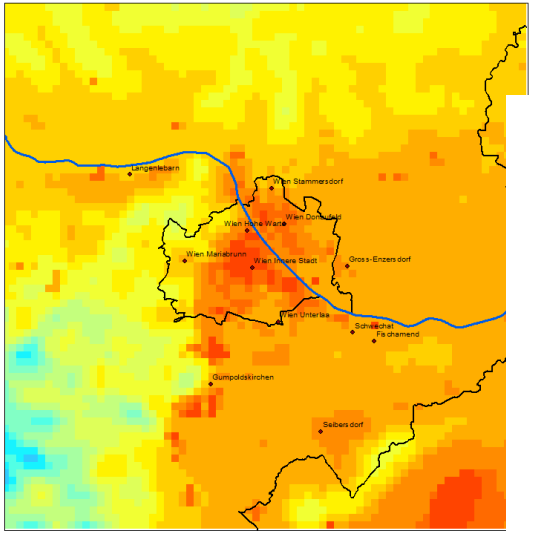




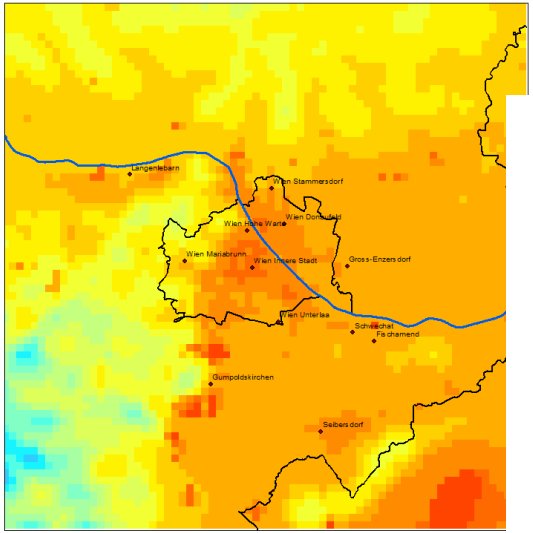




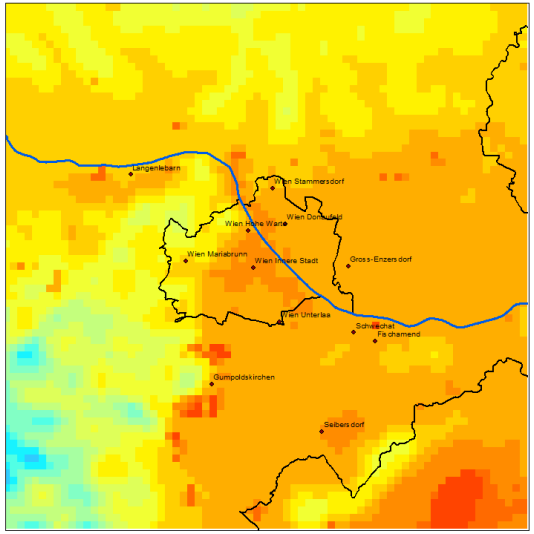
ADAPTATION STRATEGIES



Seasonal Mean
Temperature
Summer 2003
UST Status Quo



Seasonal Mean
Temperature
Summer 2003
UST Moderate

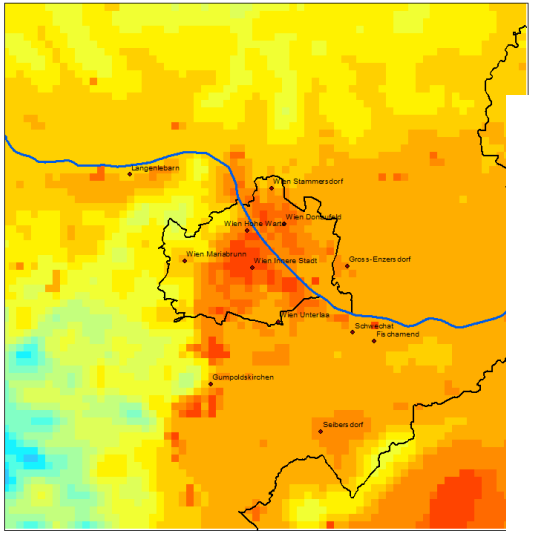


Seasonal Mean
Temperature
Summer 2003
UST Maximum

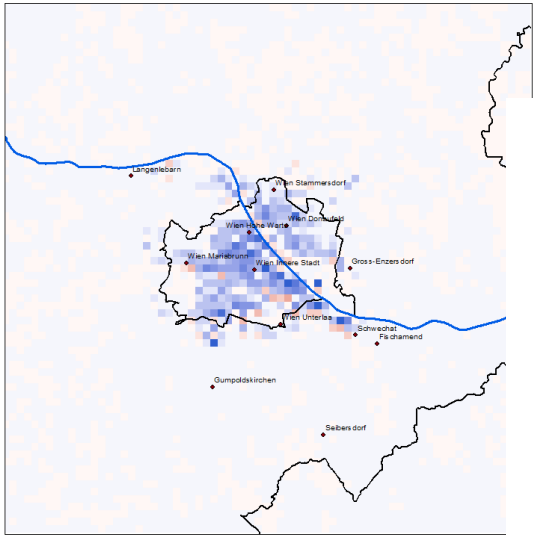
Temp [°C]

< 14	18,6 - 19,0
14,1 - 14,5	19,1 - 19,5
14,6 - 15,0	19,6 - 20,0
15,1 - 15,5	20,1 - 20,5
15,6 - 16,0	20,6 - 21,0
16,1 - 16,5	21,1 - 21,5
16,6 - 17,0	21,6 - 22,0
17,1 - 17,5	22,1 - 22,5
17,6 - 18,0	22,6 - 23,0
18,1 - 18,5	> 23

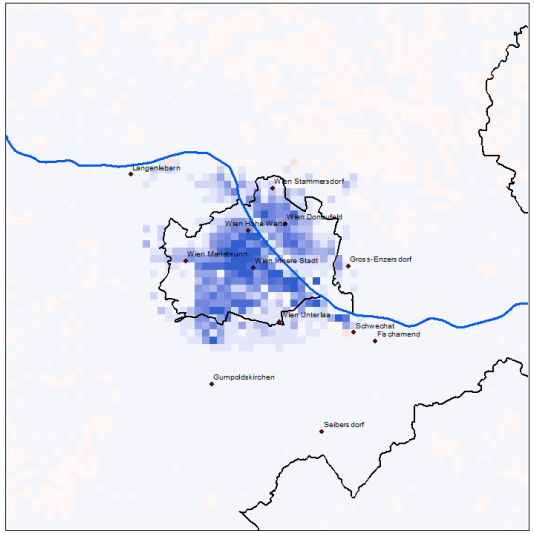
ADAPTATION STRATEGIES



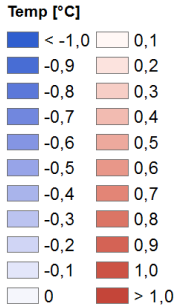
Seasonal Mean
Temperature
Summer 2003
UST Status Quo



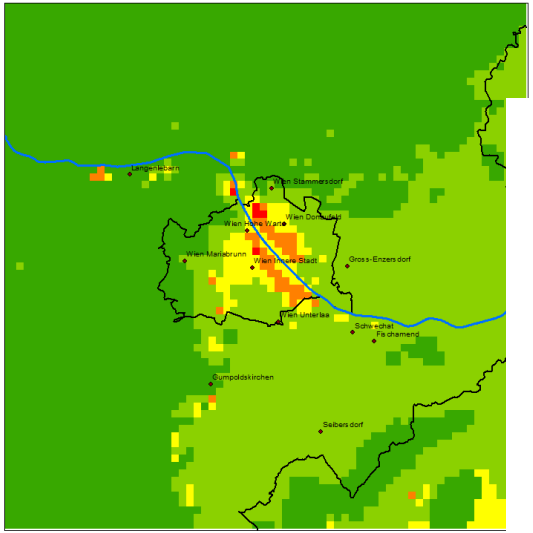
Seasonally Mean
Temperature Difference
UST Mod - STQ
Summer 2003



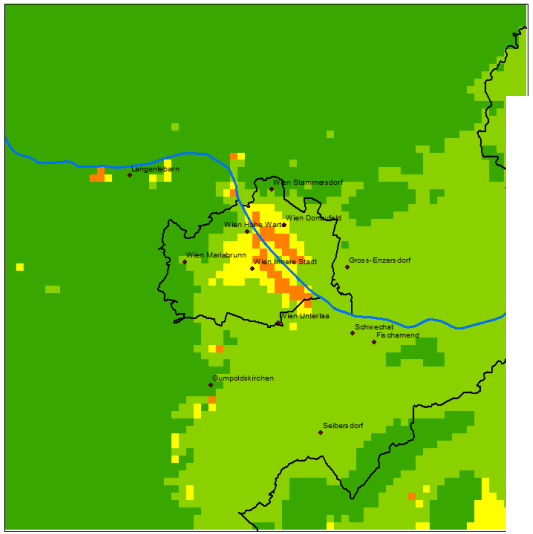
Seasonally Mean
Temperature Difference
UST Max - STQ
Summer 2003



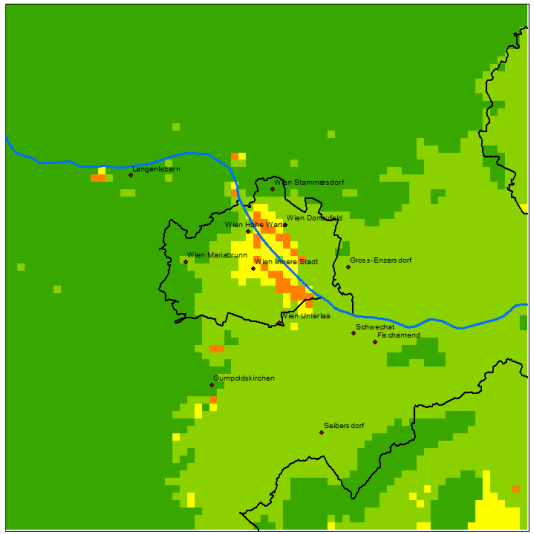
ADAPTATION STRATEGIES



Number of Days during Heat Waves UST Status Quo 2003



Number of Days during Heat Waves UST Moderate 2003

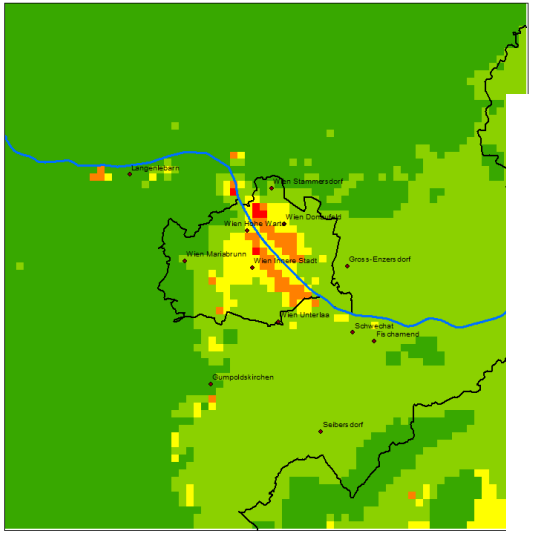


Number of Days during Heat Waves UST Maximum 2003

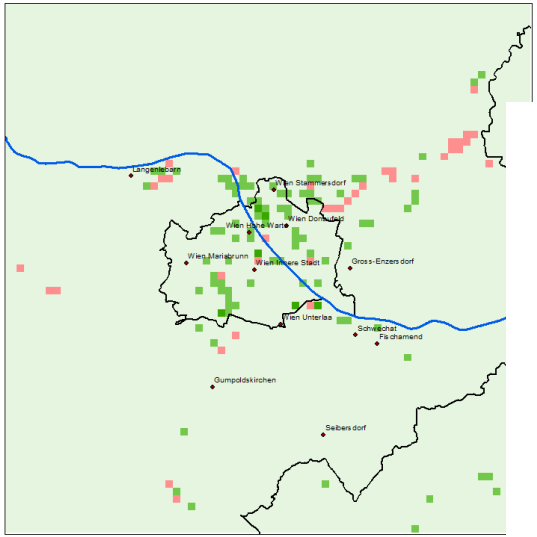
days

- 0
- 1
- 2
- 3
- 4
- 5
- 6
- 7
- 8
- 9
- 10
- 11
- > 11

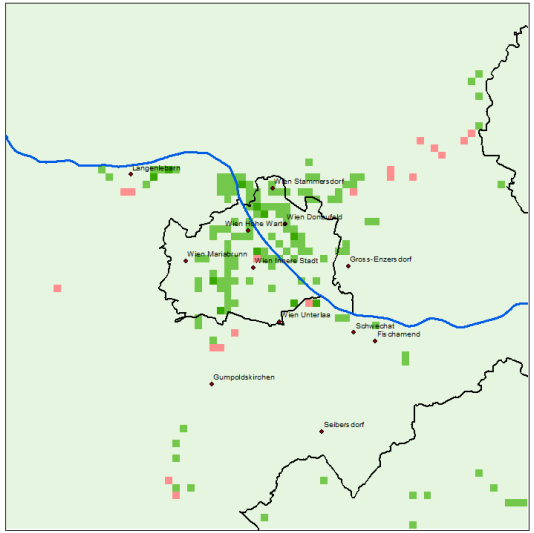
ADAPTATION STRATEGIES



Number of Days during Heat Waves UST Status Quo 2003



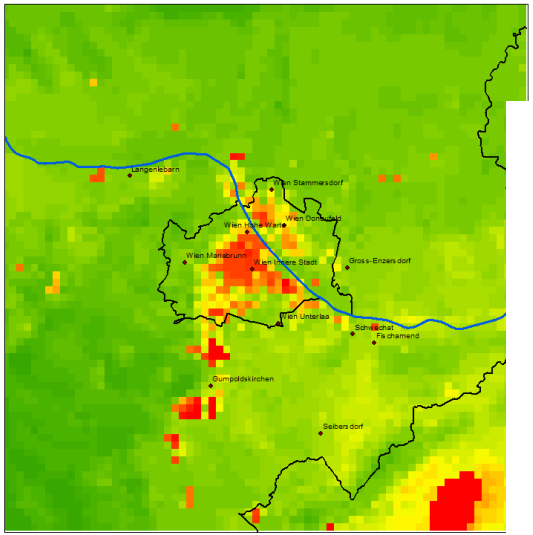
Difference Number of Heat Wave Days UST Mod - STQ 2003



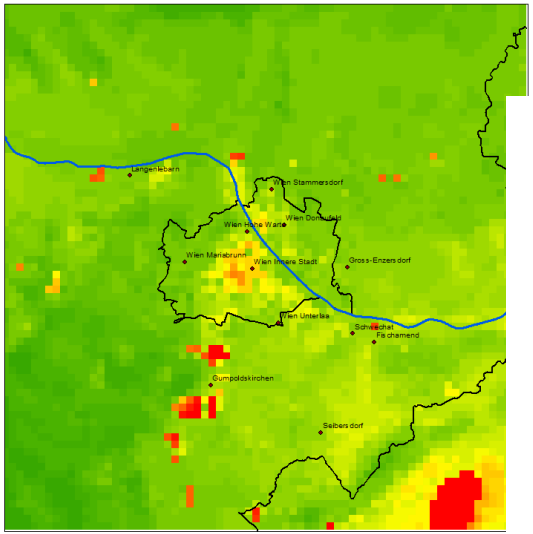
Difference Number of Heat Wave Days UST Max - STQ 2003

Days
< -5
-4
-3
-2
-1
0
1
2
3
4
5
> 5

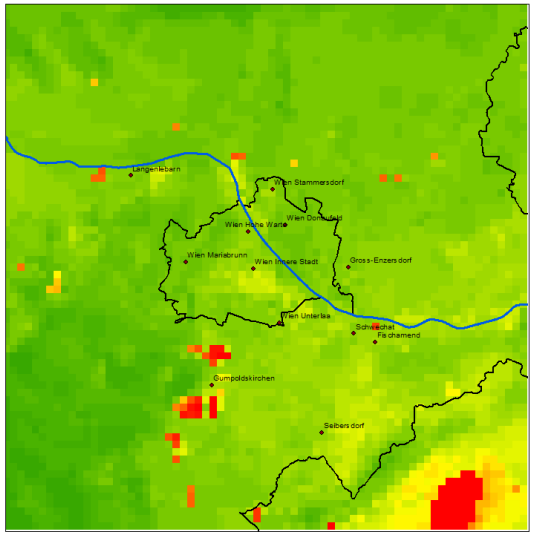
ADAPTATION STRATEGIES



Tropical Nights
(Tmin > 20° C)
UST Status Quo
2003



Tropical Nights
(Tmin > 20° C)
UST Moderate
2003

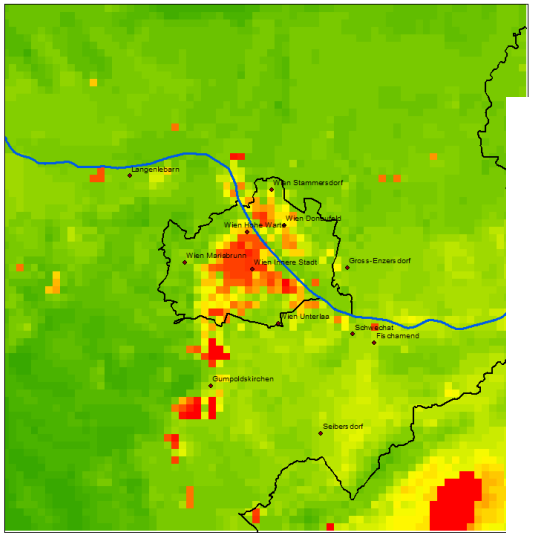


Tropical Nights
(Tmin > 20° C)
UST Maximum
2003

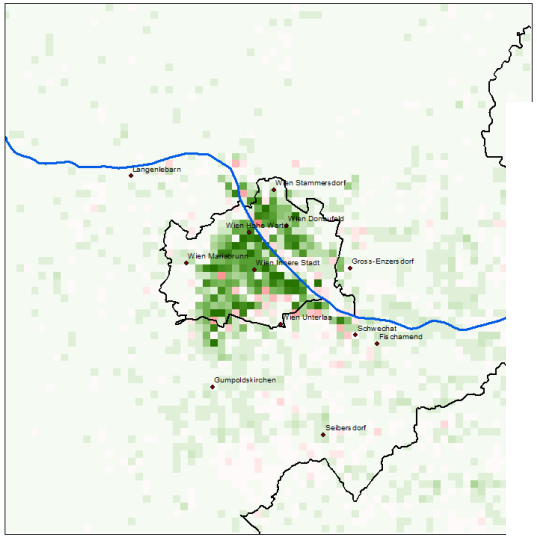
Number

0	11	22
1	12	23
2	13	24
3	14	25
4	15	26
5	16	27
6	17	28
7	18	29
8	19	30
9	20	> 30
10	21	

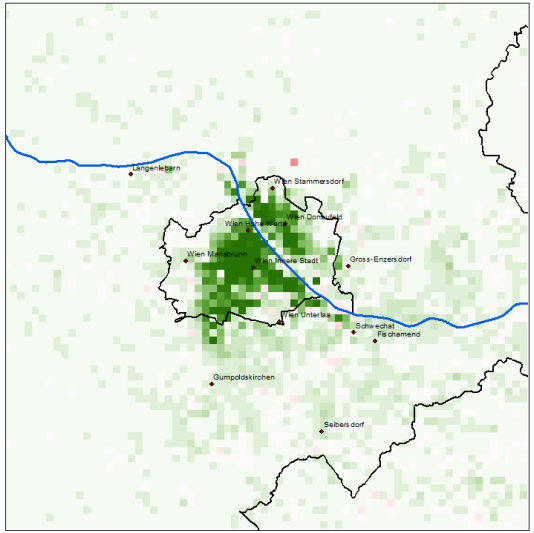
ADAPTATION STRATEGIES



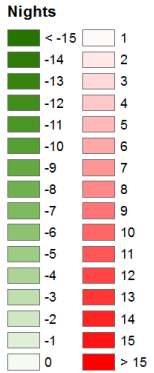
Tropical Nights
(Tmin > 20° C)
UST Status Quo
2003



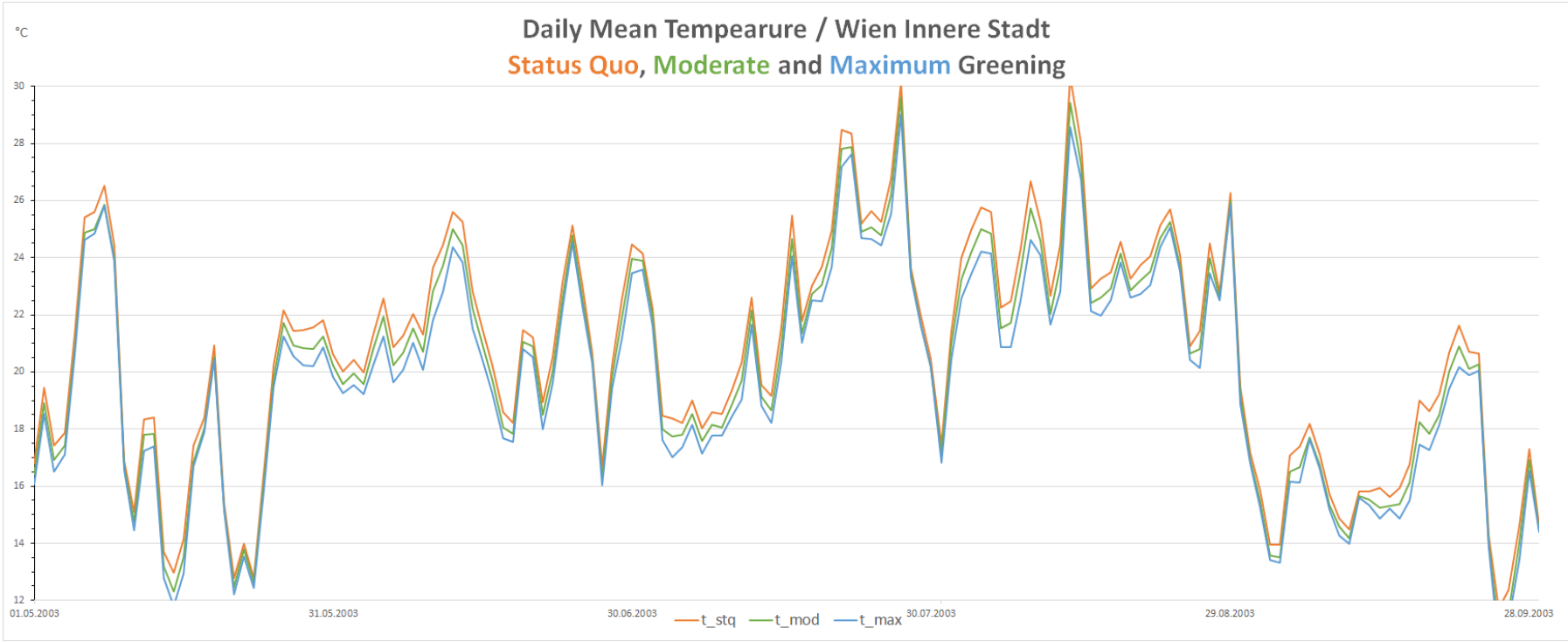
Difference Number of
Tropical Nights
UST Mod - STQ
2003



Difference Number of
Tropical Nights
UST Max - STQ
2003

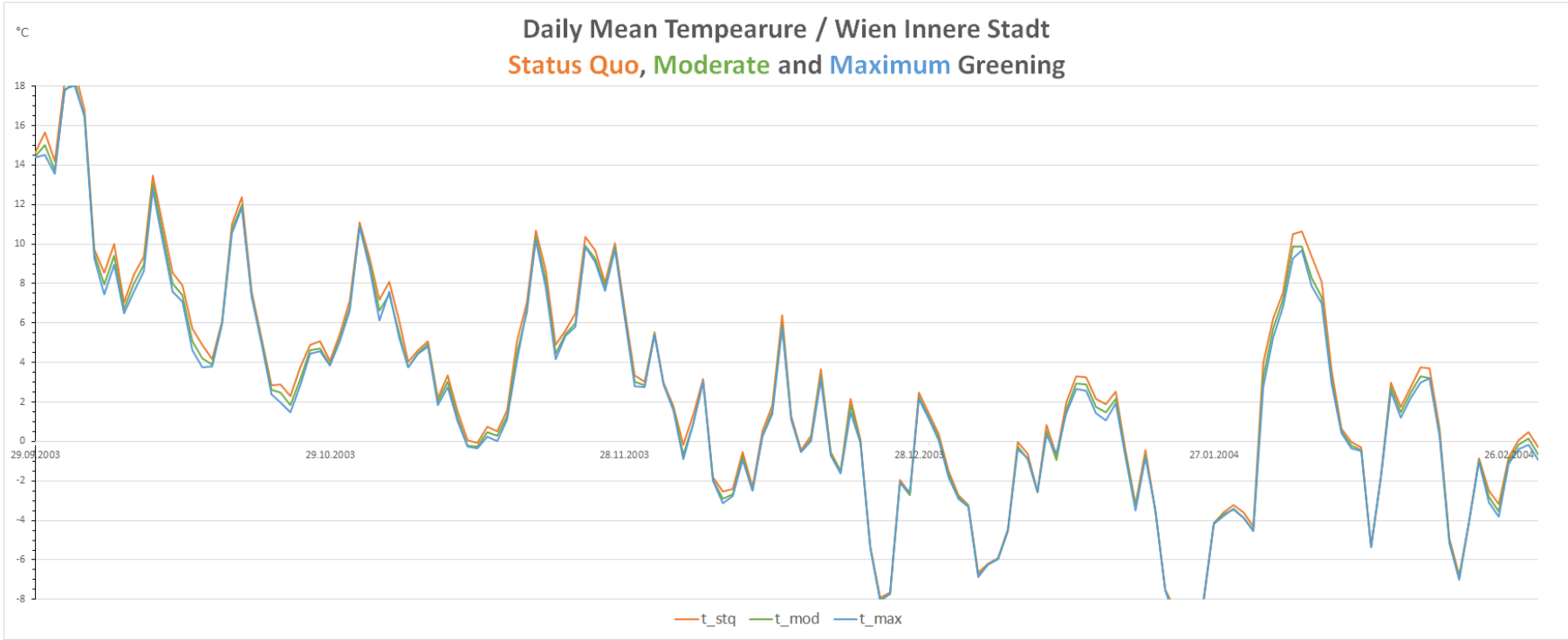


ADAPTATION STRATEGIES



Summer

ADAPTATION STRATEGIES



Winter

CONCLUSIONS

- Cosmo CLM with TERRA-URB can very accurate reproduce the urban heat island effect
- Introduction of high resolution local data enhances posibilities
- Greening scenarios show significant reduction of temperatures in summer
- This is especially visible during night time
- Winter temperatures are not effected
- Precipitation is clearly overestimated, even more for convection permitting simulations
- During summer time unrealistic high precipitation events are produced

OUTLOOK

- Detection and extraction of interesting episodes or years and detection of hotspots
- Introduction of additional local high resolution input data
- Scenario runs with modified input data
- Further increase of resolution (numeric stability, computing time?)
- Interfaces to micro climatic models
- Derive recommendations for city planners
- Additional cities (Linz already in progress)

AUSTRIAN INSTITUTE OF TECHNOLOGY
TOMORROW TODAY

THANK YOU!

johann.zueger@ait.ac.at

