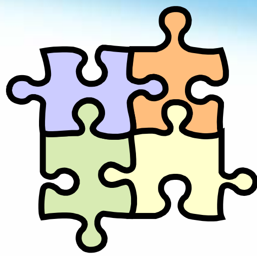
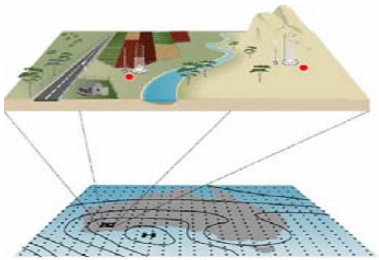
Norwegian
Meteorological Institute
met.no

An insight to the ATREUS European network

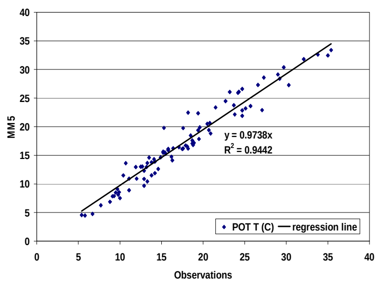
Agnès Dudek



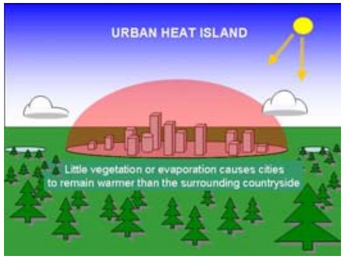
1 Description of ATREUS project



2 Downscaling procedure from mesoscale model MM5 to microscale model

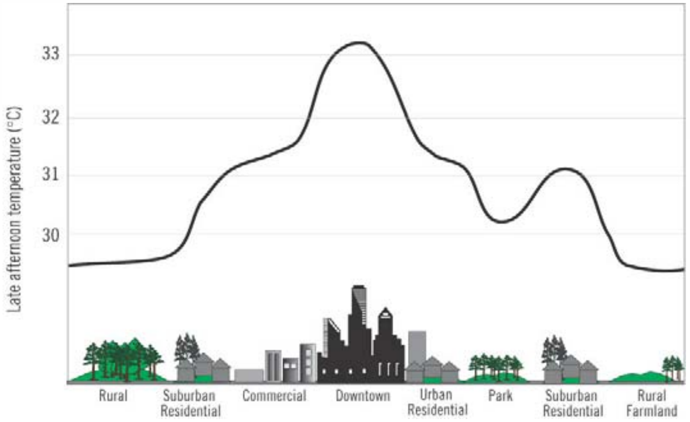


3 Evaluation of MM5 data against observational data in urban area



4 Urban heat island effect (UHI) and anthropogenic heat effect

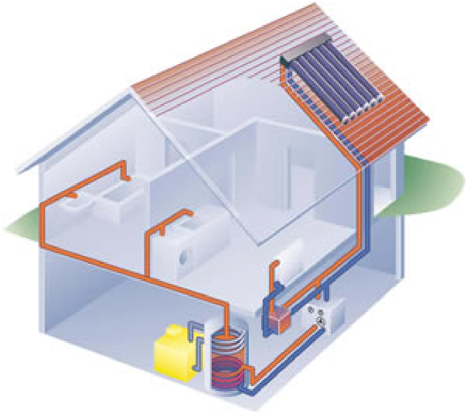
ATREUS network main objective



Convert the knowledge of urban microclimatic environment into

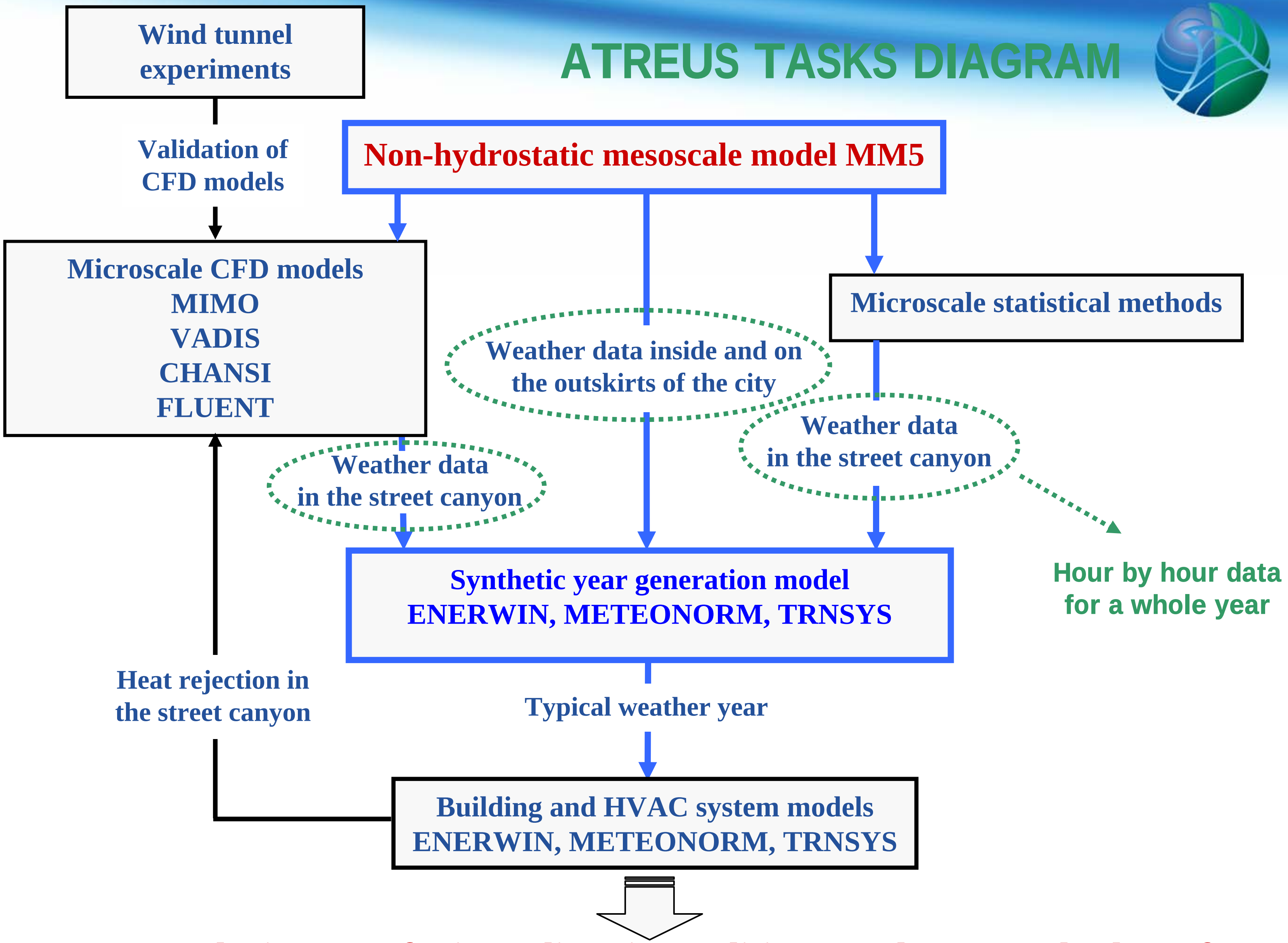
practical application for the optimization of heating and ventilations of building

+



maximizing the benefit from renewable energy sources and soft technologies

ATREUS TASKS DIAGRAM



Assess the impact of micro-climatic conditions on the energy budget of buildings and the performance of air-conditioning systems

Why? ...

There are normally no observations where we want to do energy calculations ...

IDEA Use MM5 to obtain weather info instead

Ideally → We need several years of data to produce a proper climatology ...

Not possible in this project!

Show the potential of this approach by

- → Provide MM5 data for a location inside the city
- → Provide MM5 data for a location outside the city
- → Compare the energy loads when using these two data sets

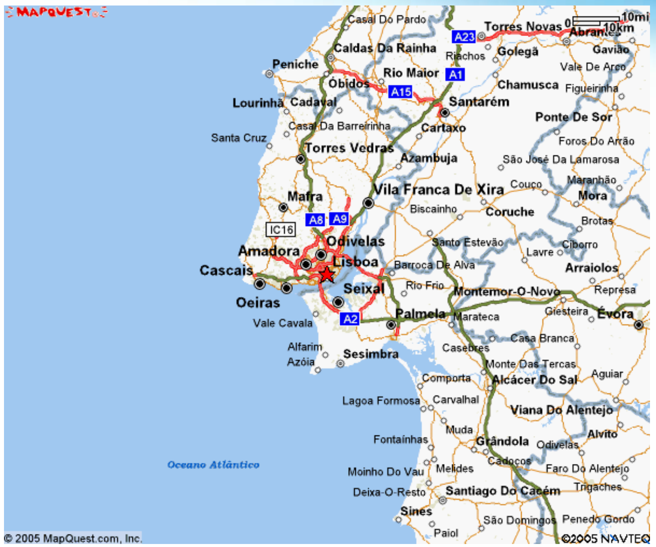
We do not have a complete climatology from MM5

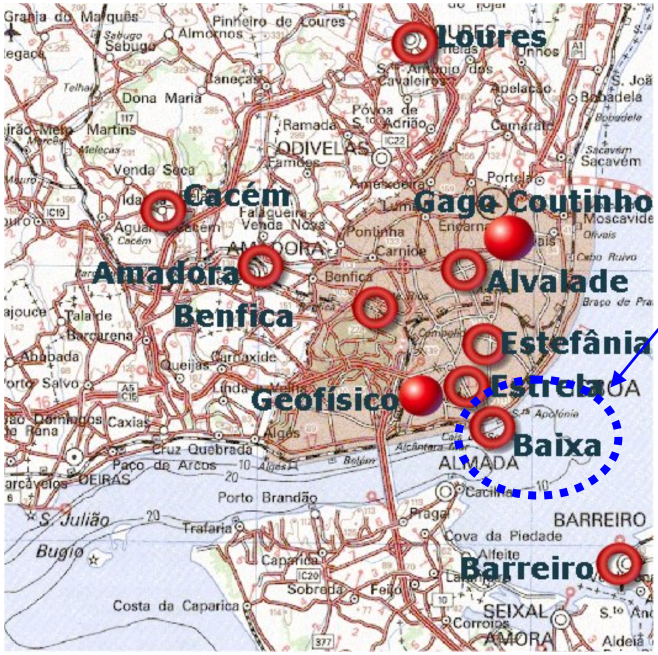
BUT We can provide a surrogate by running a limited number of days for a full year and generate a climatology from this data set.

The comparison described above will show the effect of using data for the exact location by a model as compared to a remote station.

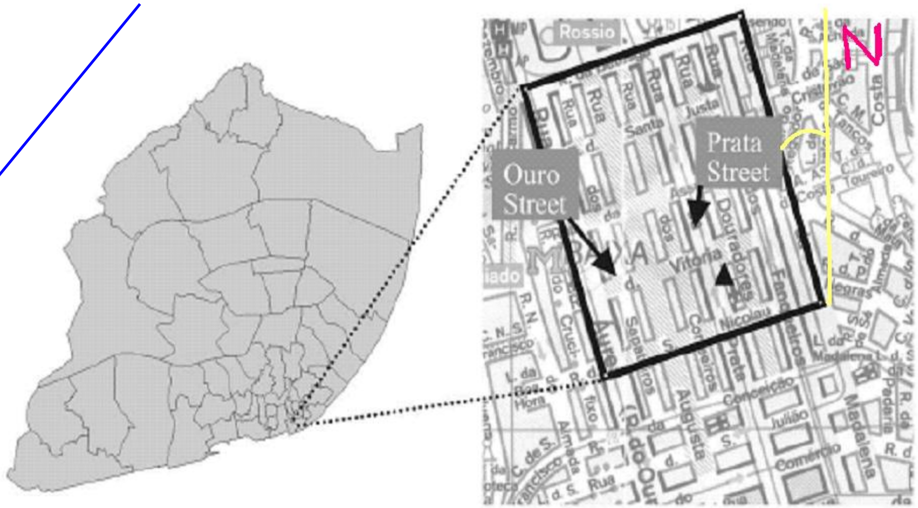
NOTE: That this simplified approach must probably will give inferior results as compared to standard method using REAL climatology, simply because of the much simplified climatology we could afford to make.

Lisbon (Portugal) as a case study

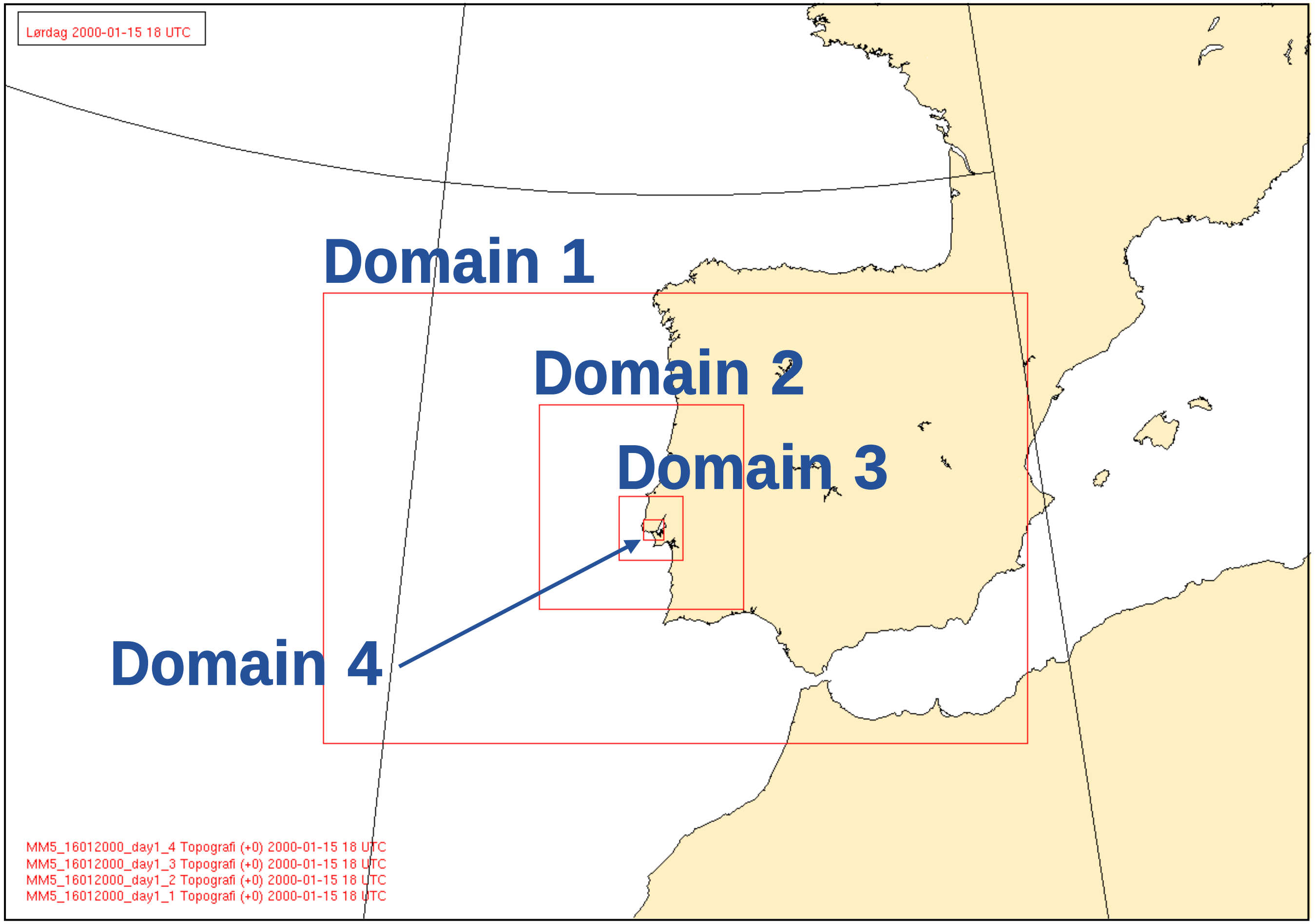




Baixa station - CFD domain



MM5 domains



ECMWF data (0.5°degrees) as boundary conditions

Selection of 12 typical days to generate a synthetic year for building simulation programs

Building simulation programs require climate information to calculate heating and cooling loads.

Hour by hour data for a whole climatological year

Data for a whole year using NWP is time consuming !

The typical days are selected using a classification weather type method

Instead, we proposed to use 12 typical days, one for each months, representative of the long term monthly average.

Day 1 : 16 Jan 2000	Day 5 : 14 May 2000	Day 9 : 26 Sep 2000
Day 2 : 23 Feb 2000	Day 6 : 16 Jun 2000	Day 10 : 24 Oct 2001
Day 3 : 6 Mars 2000	Day 7 : 9 Jul 2000	Day 11 : 14 Nov 2000
Day 4 : 18 Apr 2000	Day 8 : 7 Aug 2000	Day 12 : 21 Dec 2000

MM5 simulations

Weather generator ENERWIN METEONORM

MM5 configuration

MM5 version: MM5 3.6

Landuse classification: USGS 24 categories

PBL scheme: Gayno-Seaman scheme

Explicit moisture scheme: Simple ice (Dudhia)

Cumulus parameterization scheme: None

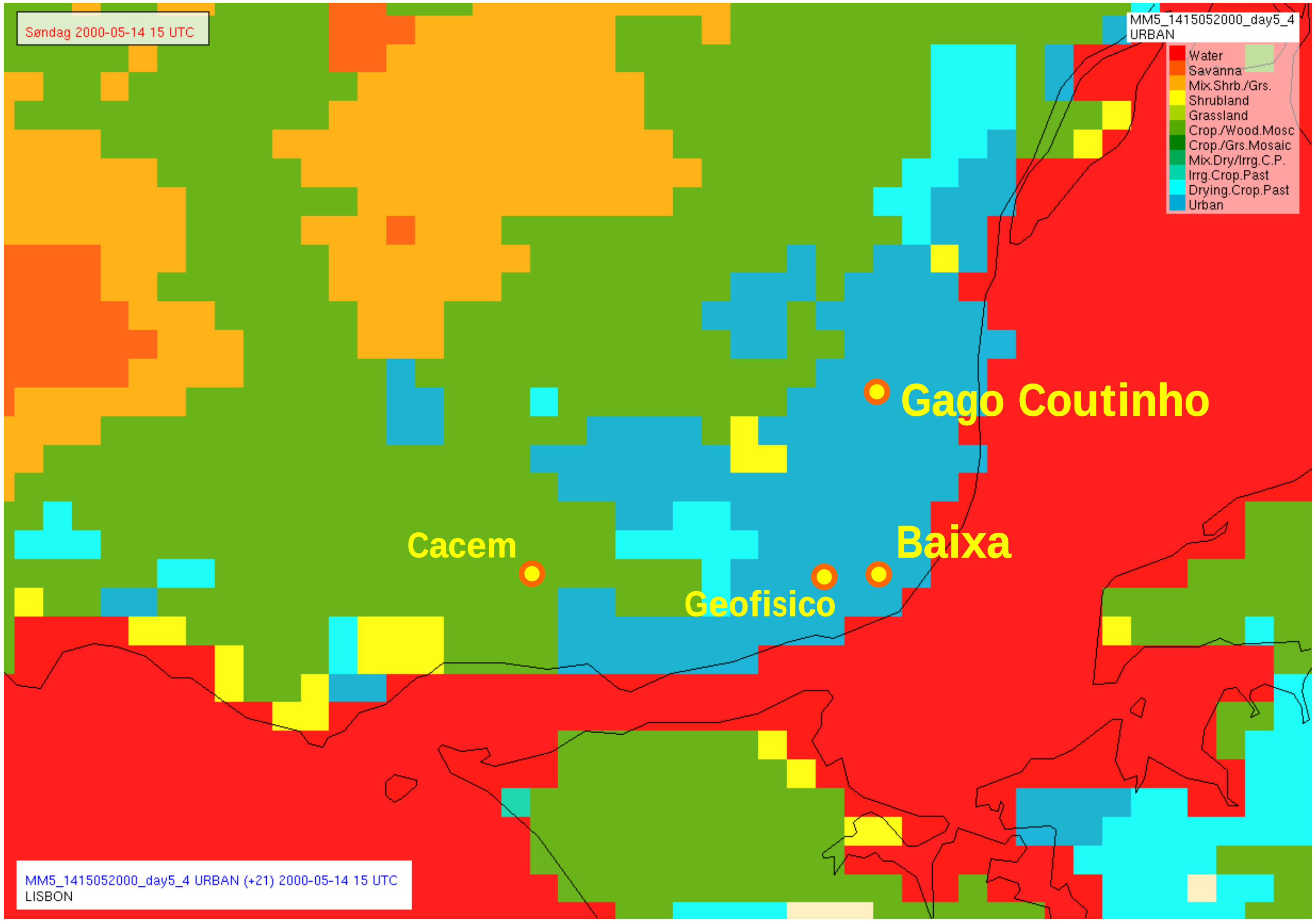
Radiation scheme: cloud-radiation (Dudhia, 1989)

Ground temperature scheme: five layer soil model

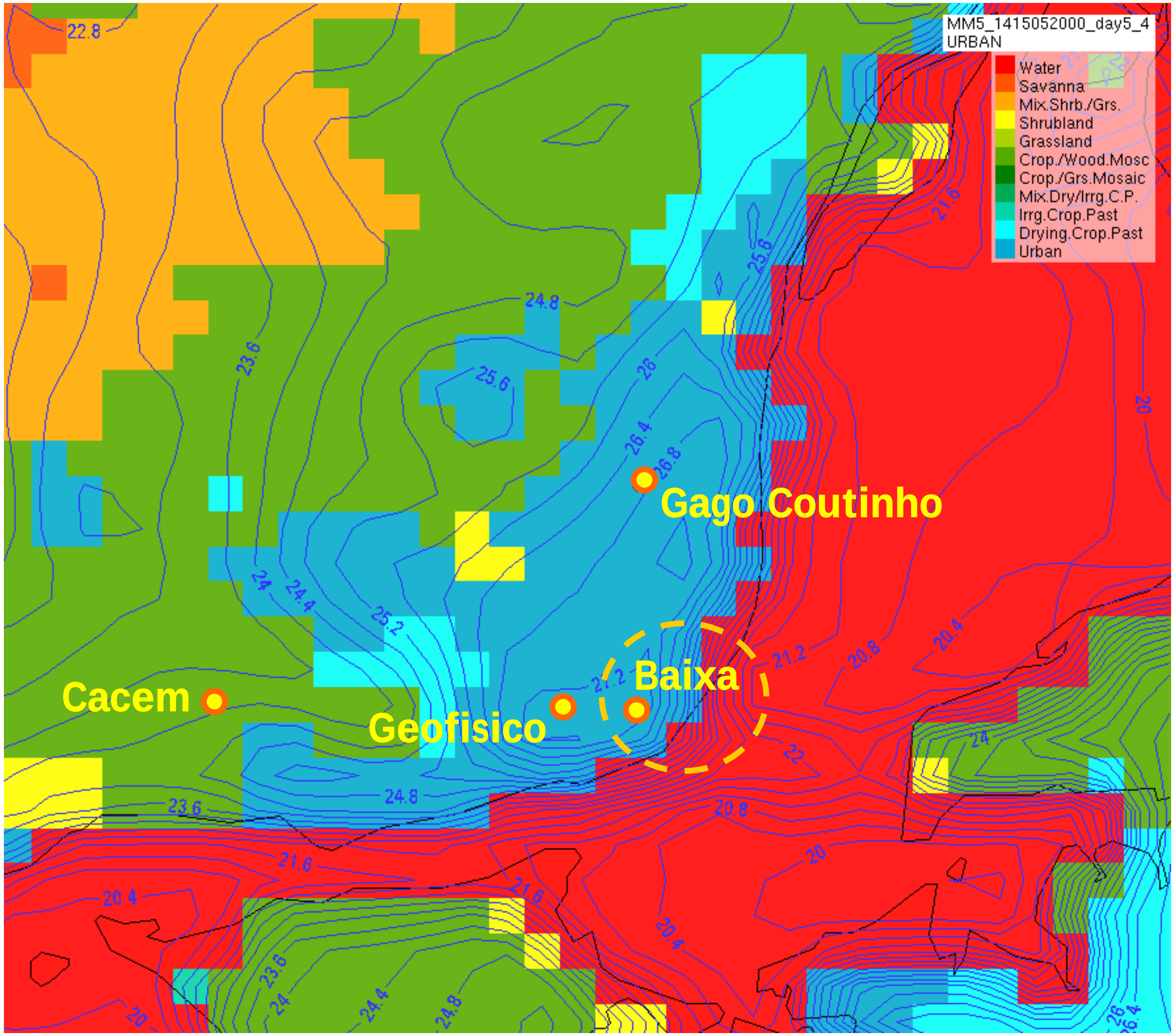
Surface roughness length: 1.0 m

Number of sigma levels: 26

MM5 simulations at 4 station locations for the 12 typical days



Day 5 140500 15:00 T2m



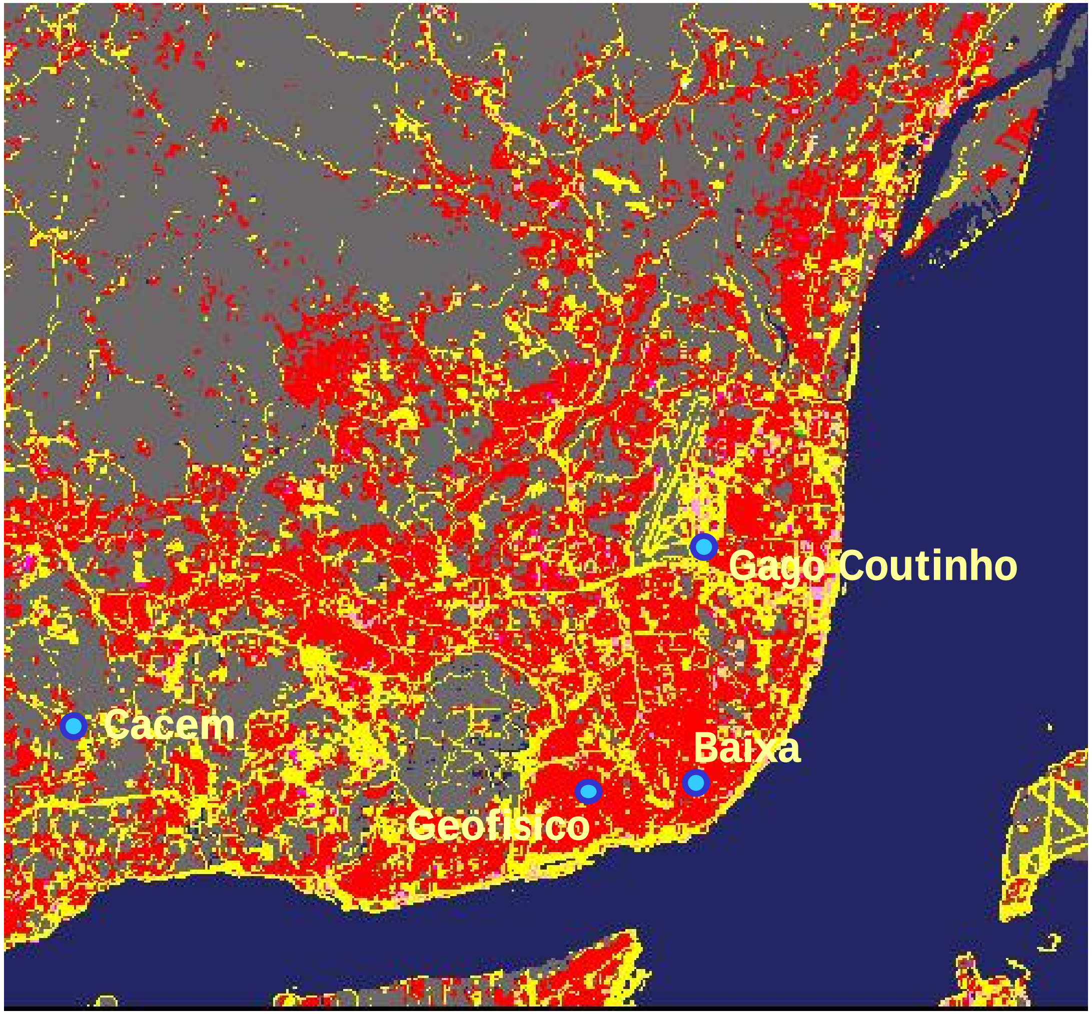
High temperature gradient at Baixa

Station coordinates not accurate

Baixa located on the land/sea boudnary

Urban heat island effect

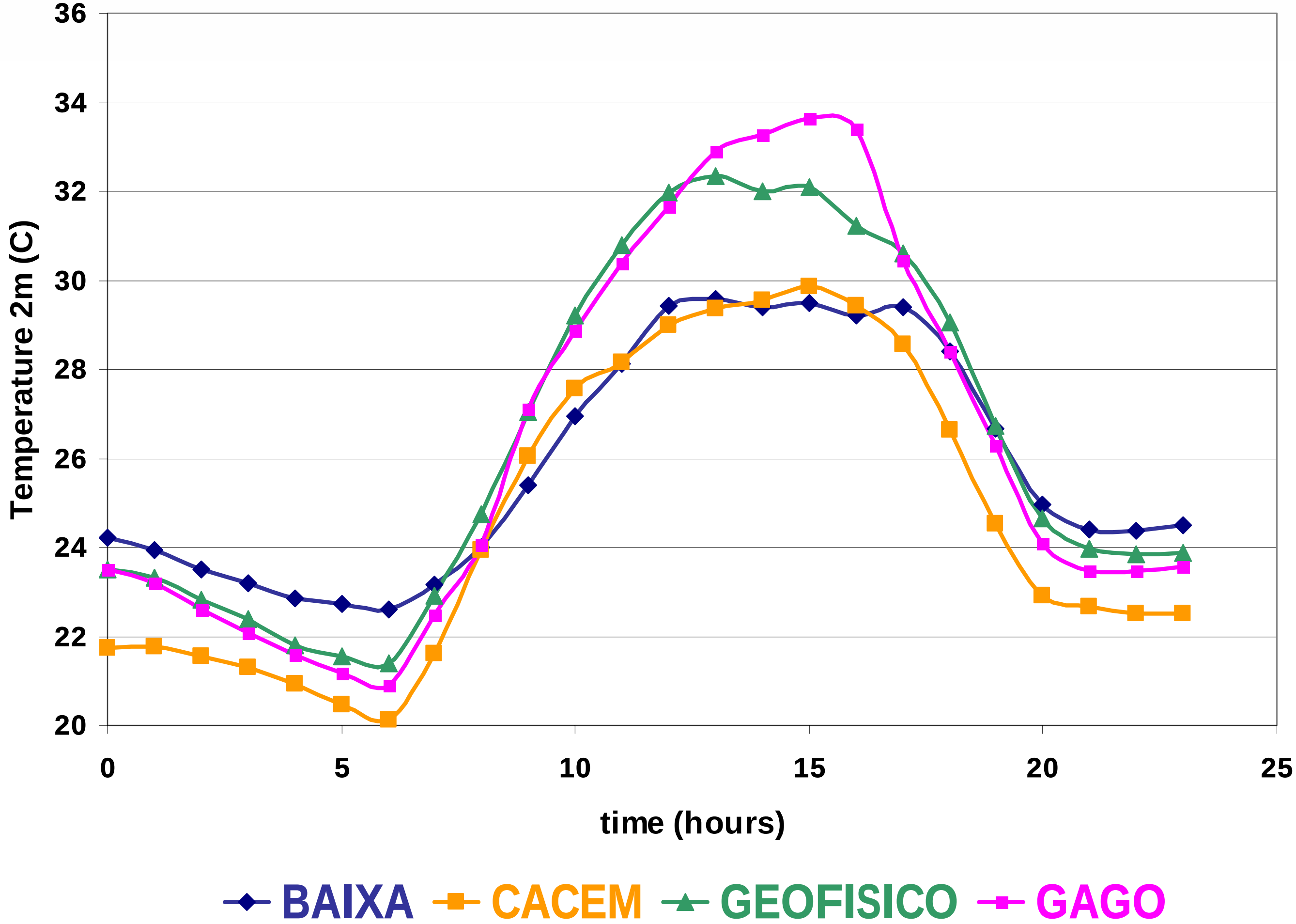
Lisbon landuse



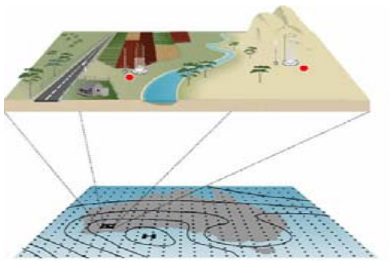
- Transport
- Residentiel area
- Others

Data from Portugal National Centre for Geographic Information (NCGI)

Gago Coutinho / Baixa / Cacem / Geofisico T2m

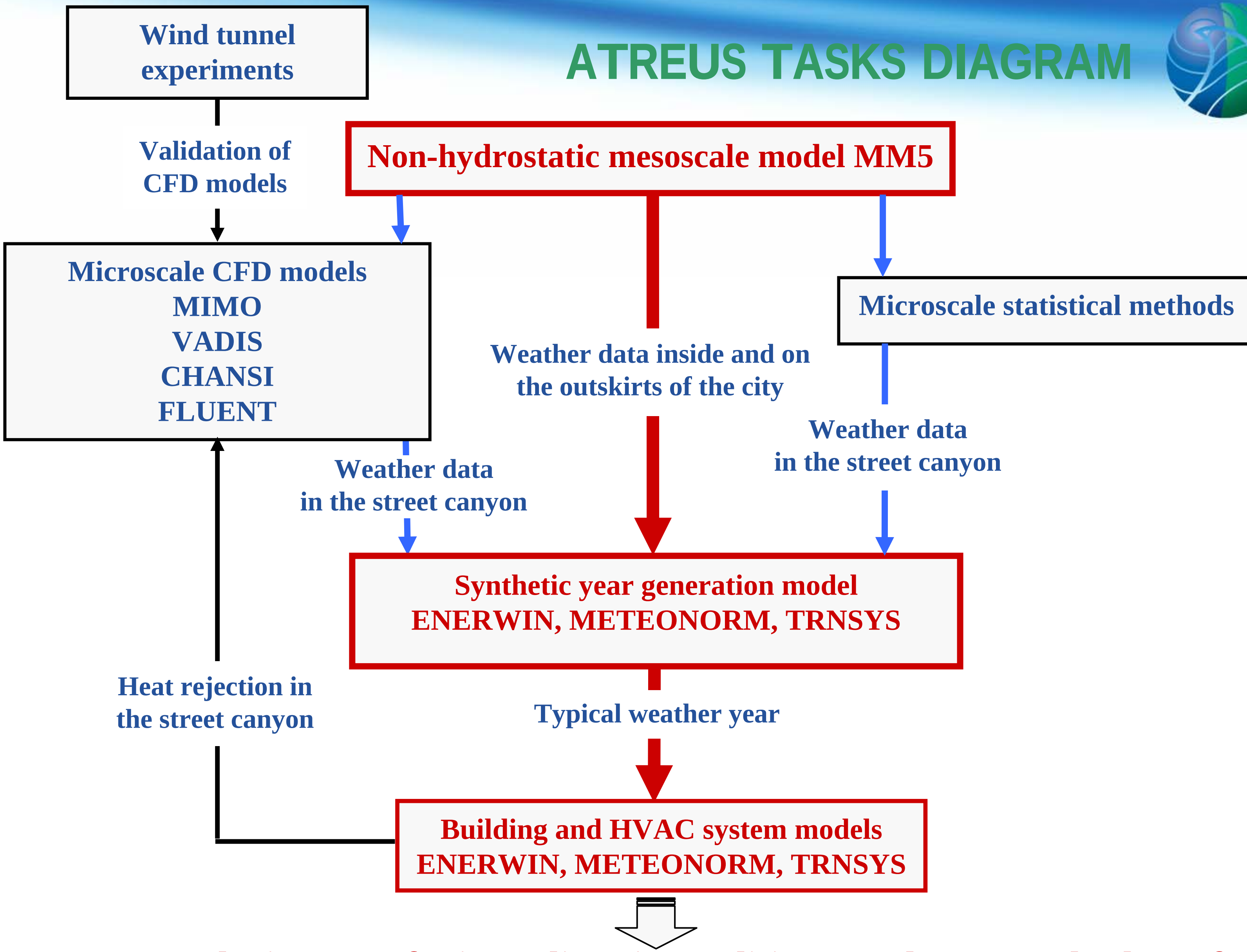


2



Downscaling procedure

ATREUS TASKS DIAGRAM



Assess the impact of micro-climatic conditions on the energy budget of buildings and the performance of air-conditioning systems

Downscaling procedure
MM5 → building simulation

Time series
12 typical days

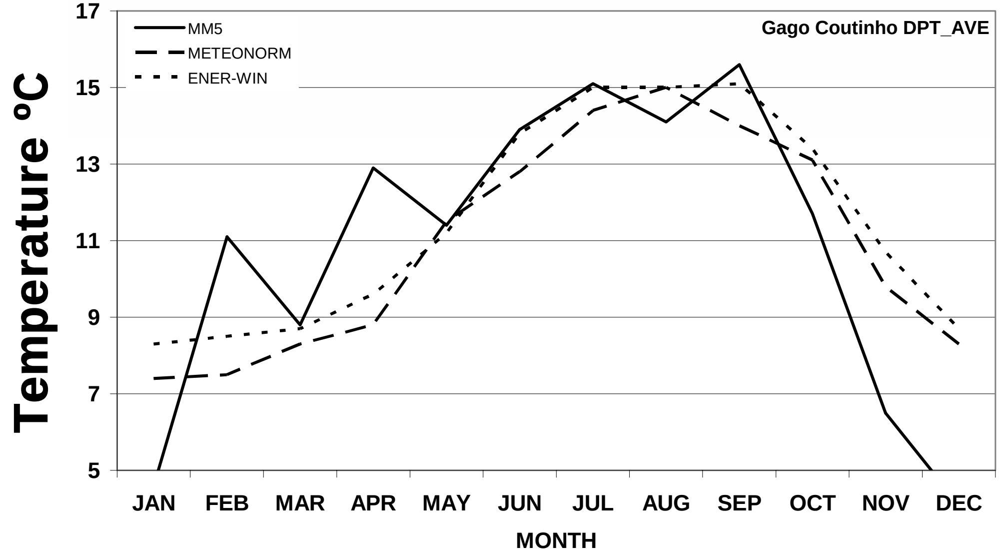
- temperature at 2 meters
- relative humidity
- wind speed at 10 meters
- global horizontal solar radiation

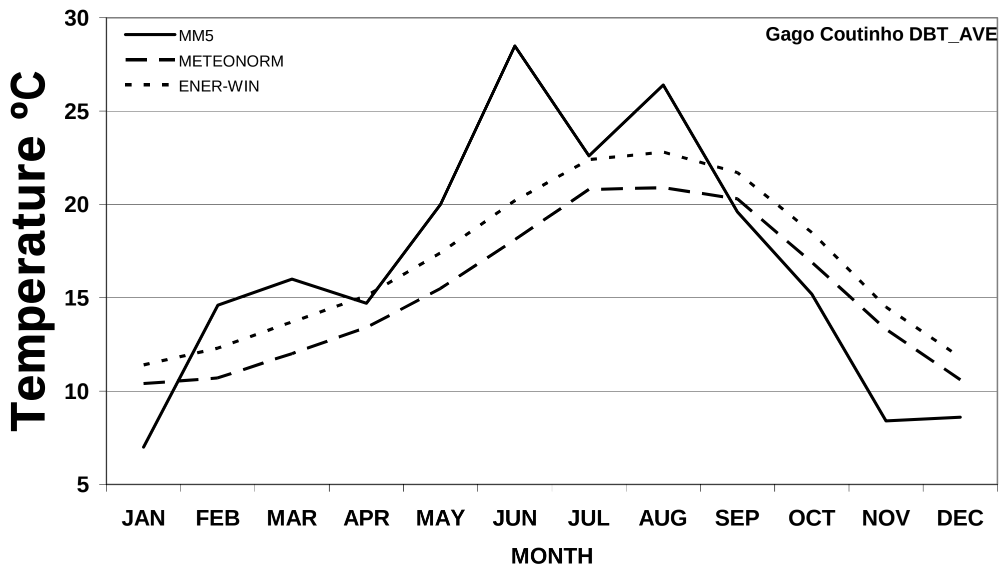
Time series are used in weather generators to produce a synthetic year

Synthetic year is used as input in building simulation programs

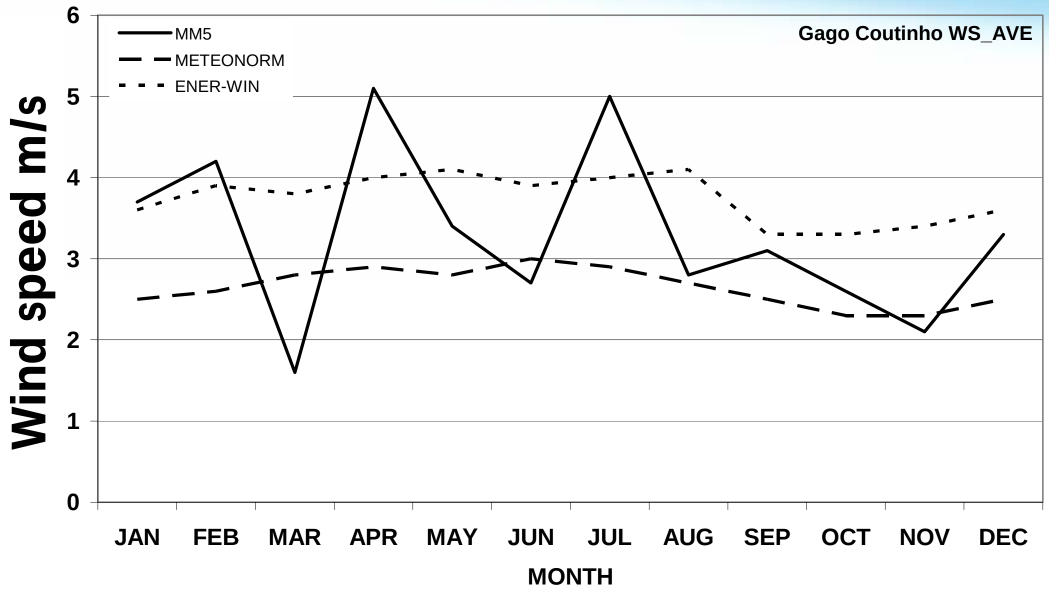
MM5/12 days vs Climatology data from weather generator

Dew point temperature average (DPT_AVE)





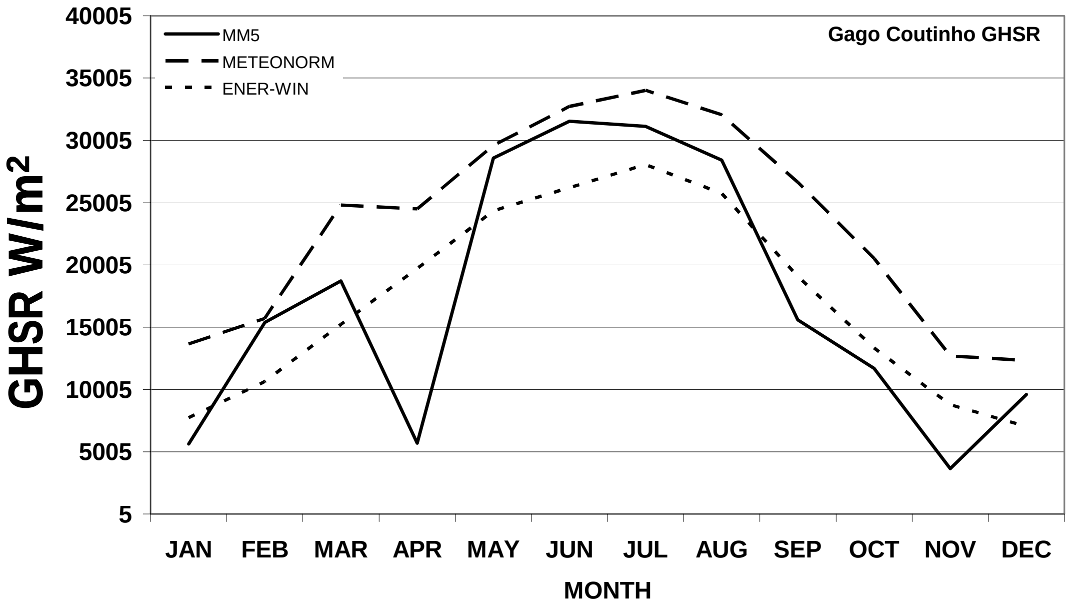
Dew bulb temperature average (DBT_AVE)



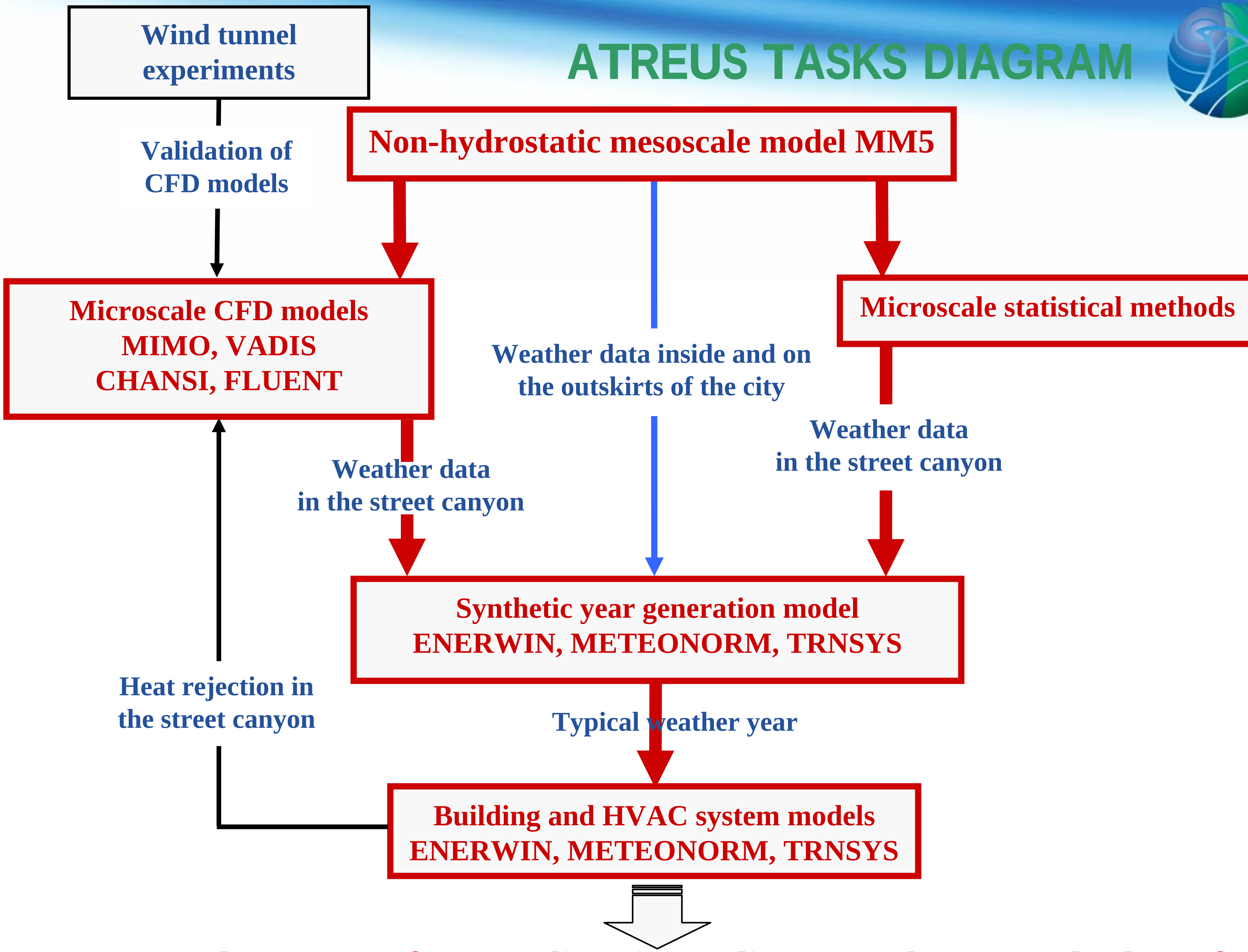
Wind speed average (WS_AVE)

Global horizontal solar radiation (GHRS)

Importance of accurately select 12 typical days to generate a synthetic year



ATREUS TASKS DIAGRAM



Assess the impact of micro-climatic conditions on the energy budget of buildings and the performance of air-conditioning systems

Downscaling procedure MM5 ➡ microscale models

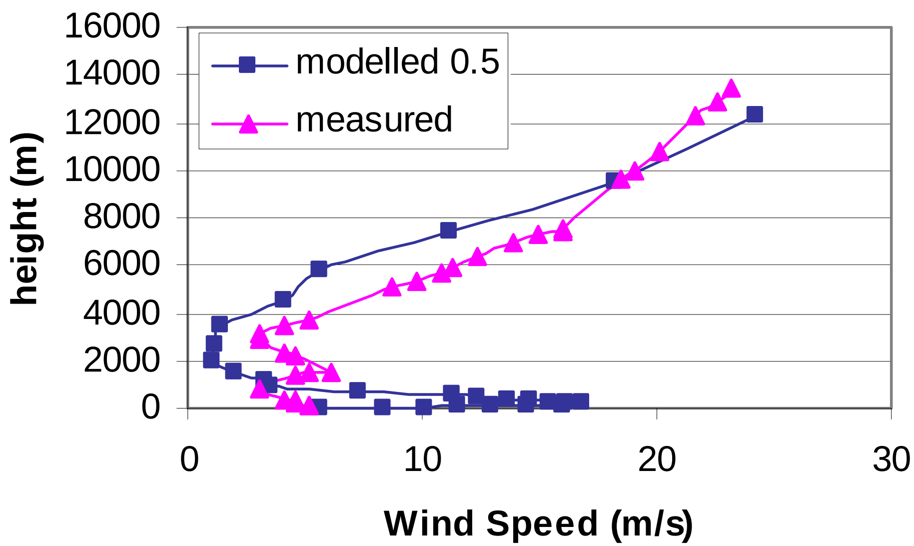
Vertical profiles
2m temperature
Relative humidity
Wind speed and direction
Turbulent kinetic energy

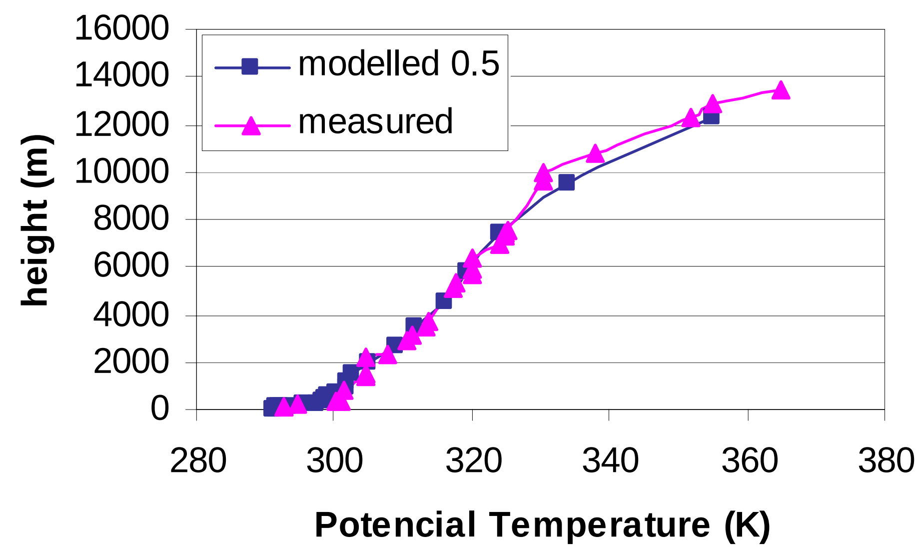
Time series
Short wave radiation
Long wave radiation
Surface sensible heat flux
Surface latent heat

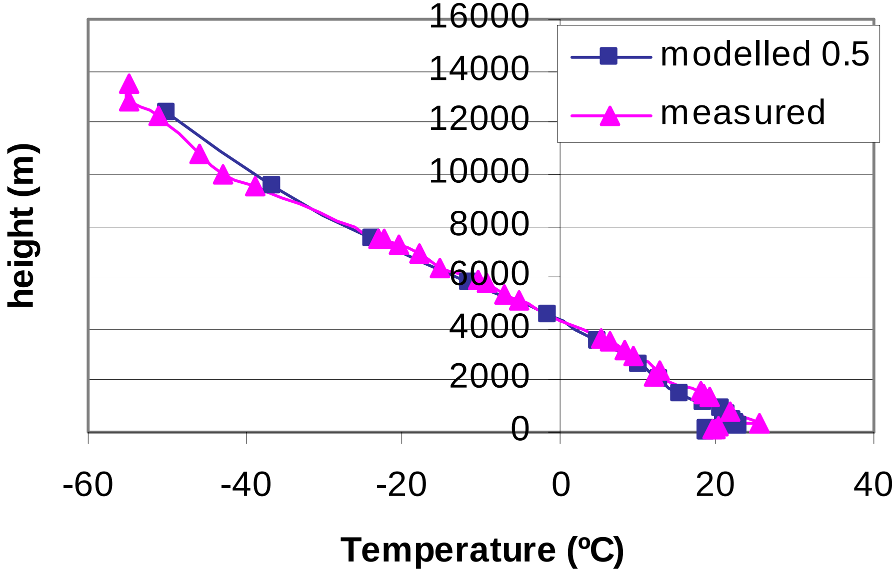
Vertical profiles are used as boundary conditions in microscale models

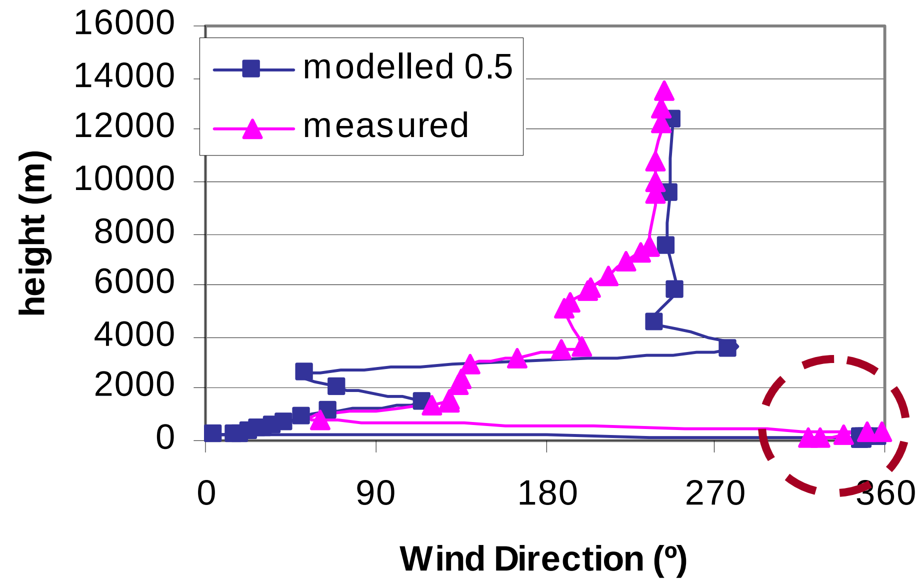
Microscale models generates vertical profiles in the street canyons

Baixa Day 7 090700 00h

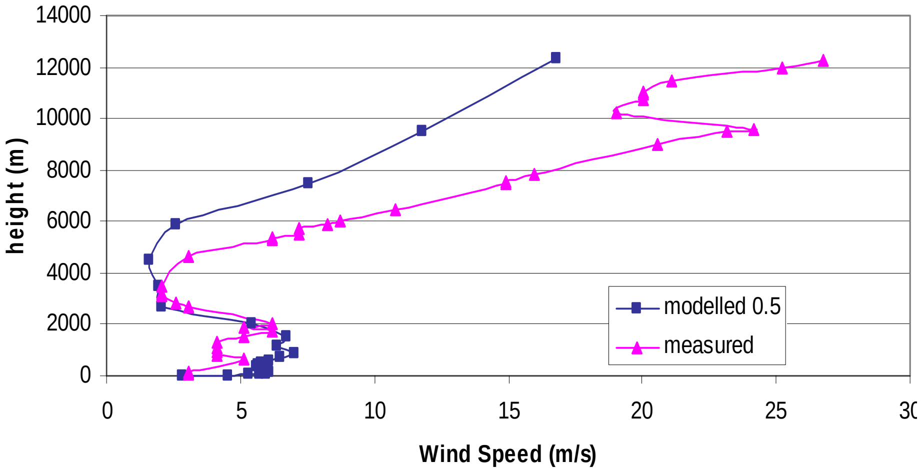


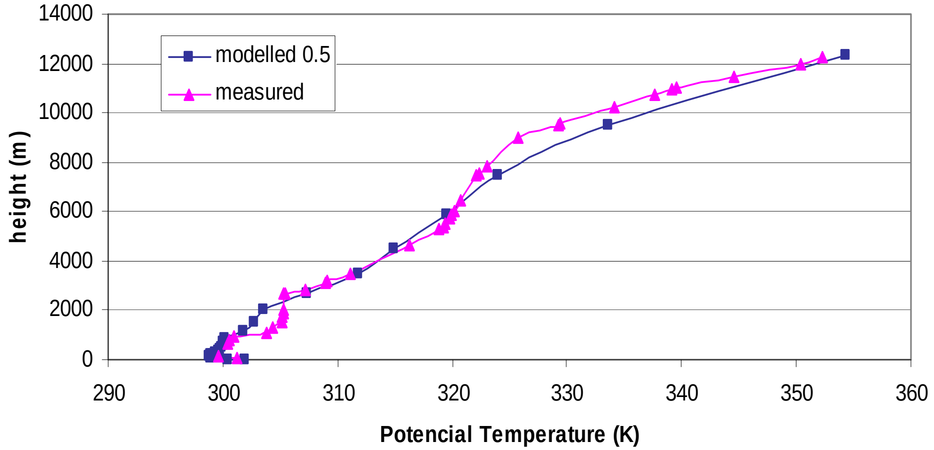


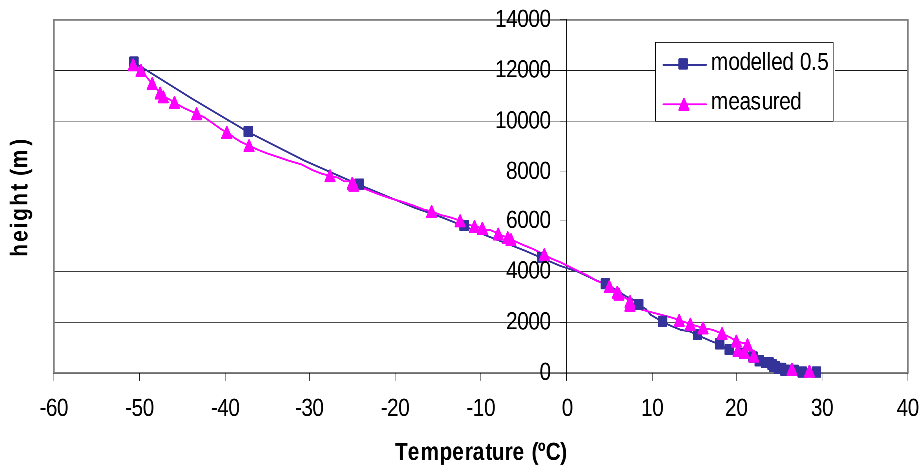


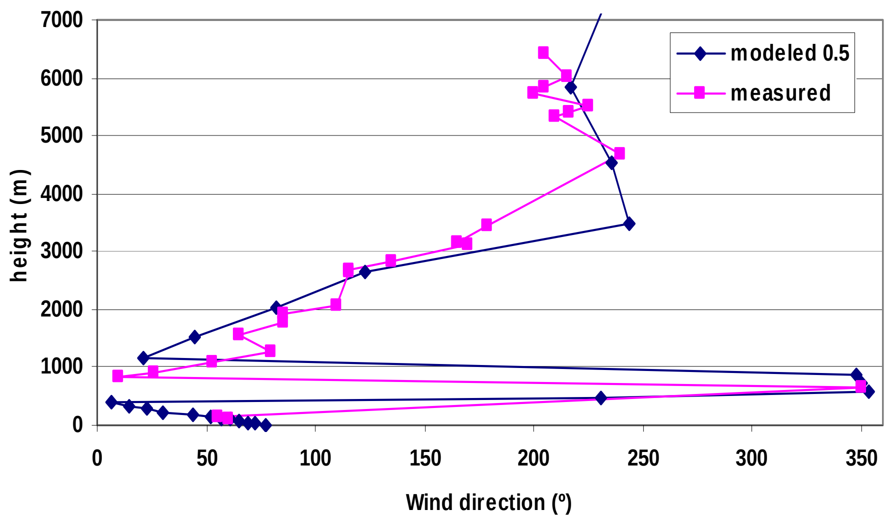


Baixa Day 7 090700 12h

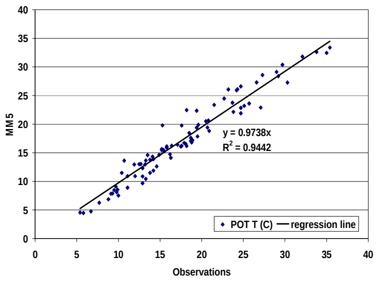






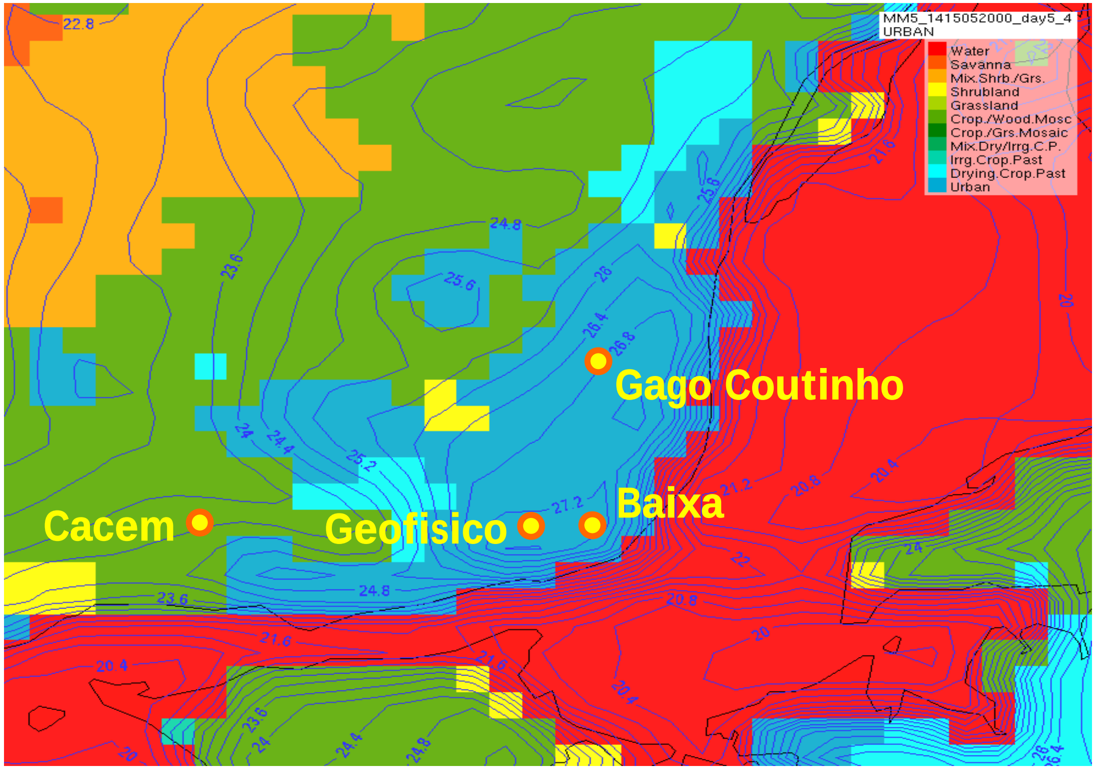


3

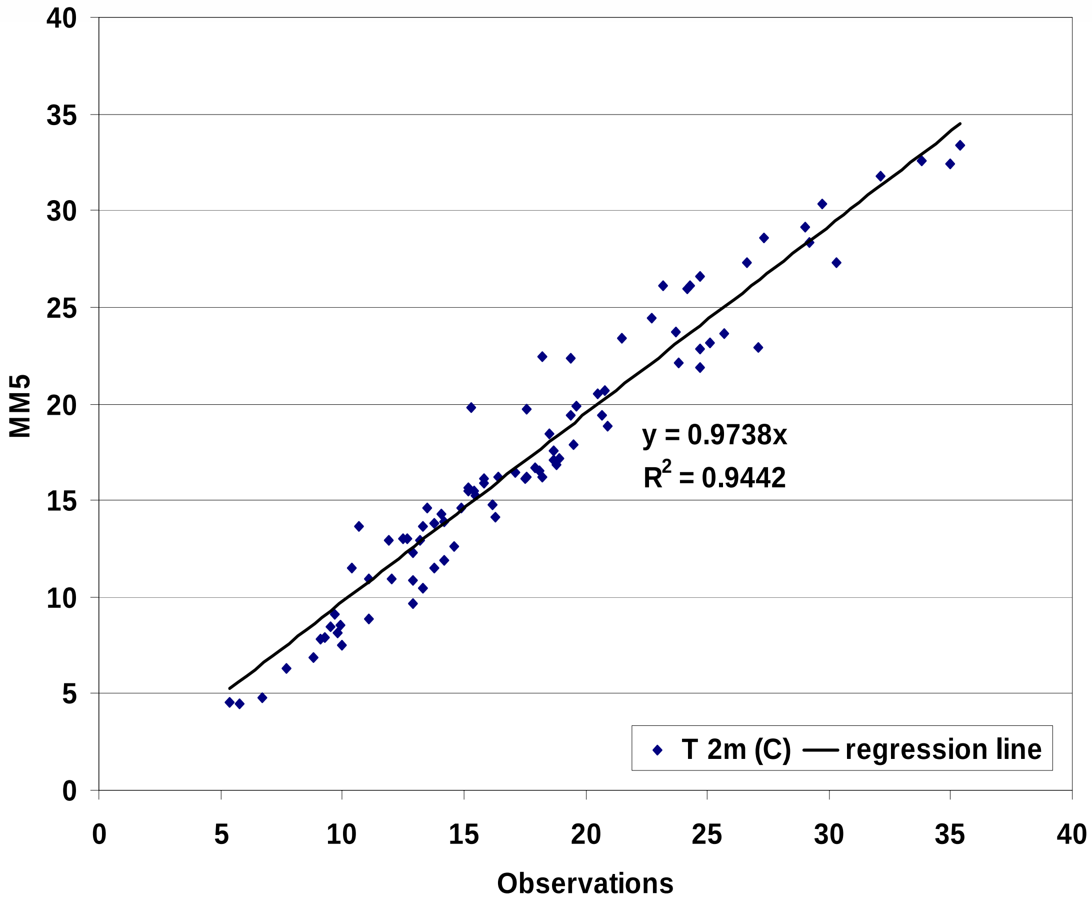


Evaluation of MM5 data against observational data in urban area

Gago Coutinho station in Lisbon urban area



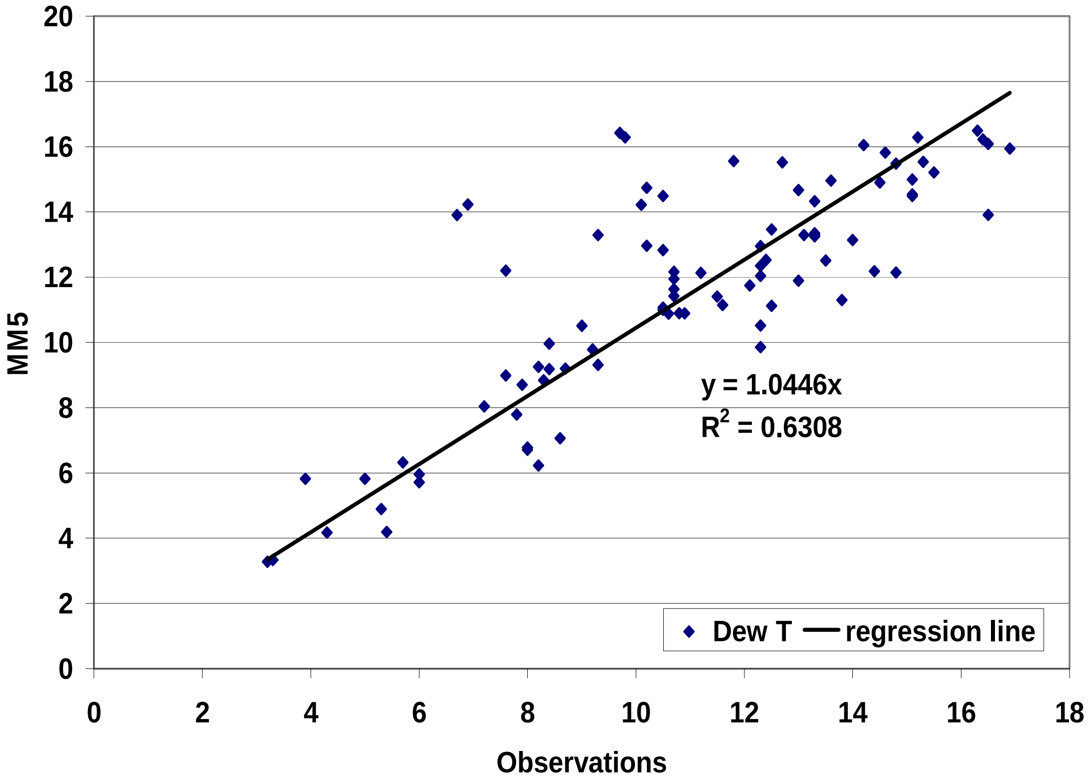
Temperature at 2m (°C)



bias of -0.75

standard deviation 1.67°C

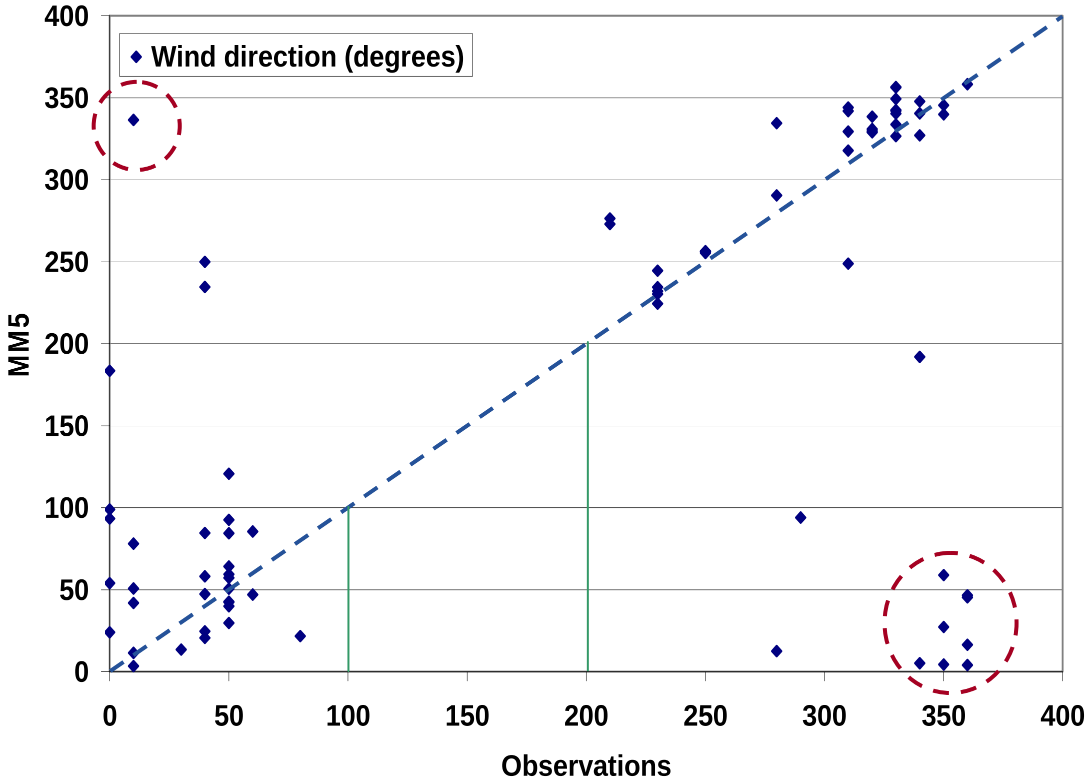
Dew temperature (°C)



bias of 0.25 °C

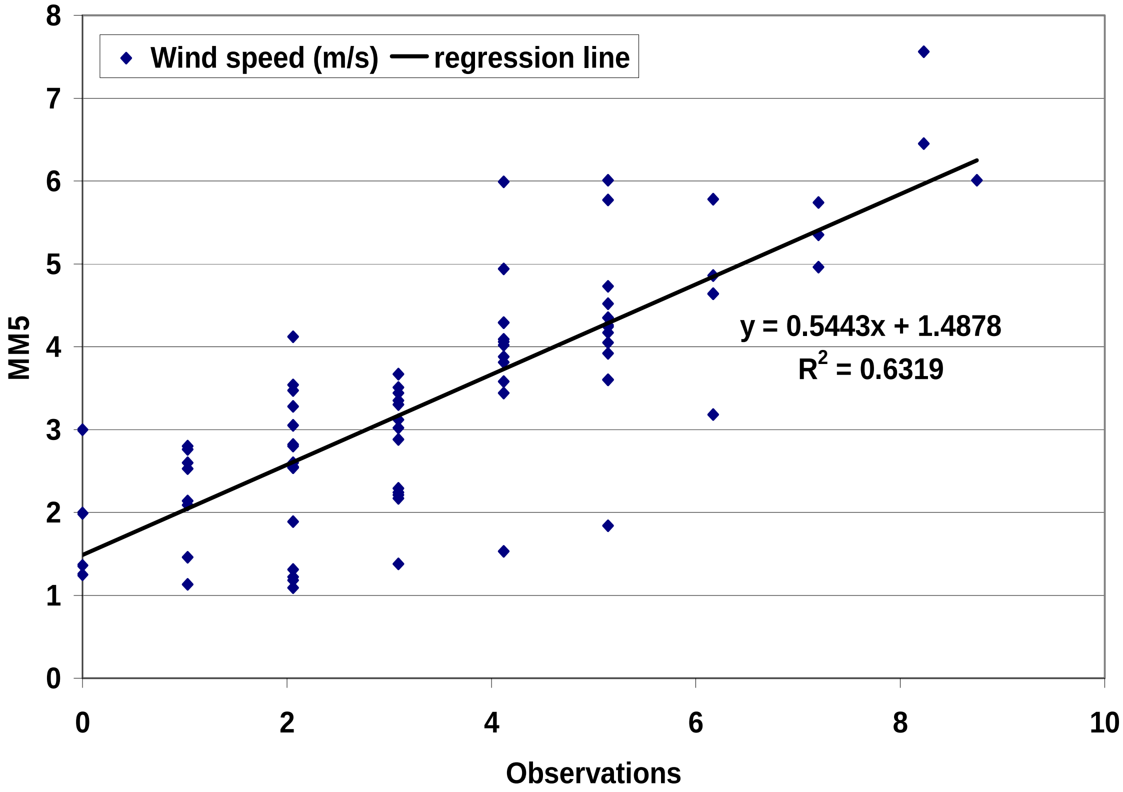
standard deviation 2.10°C

Wind direction (degrees)



bias of 7.27 °

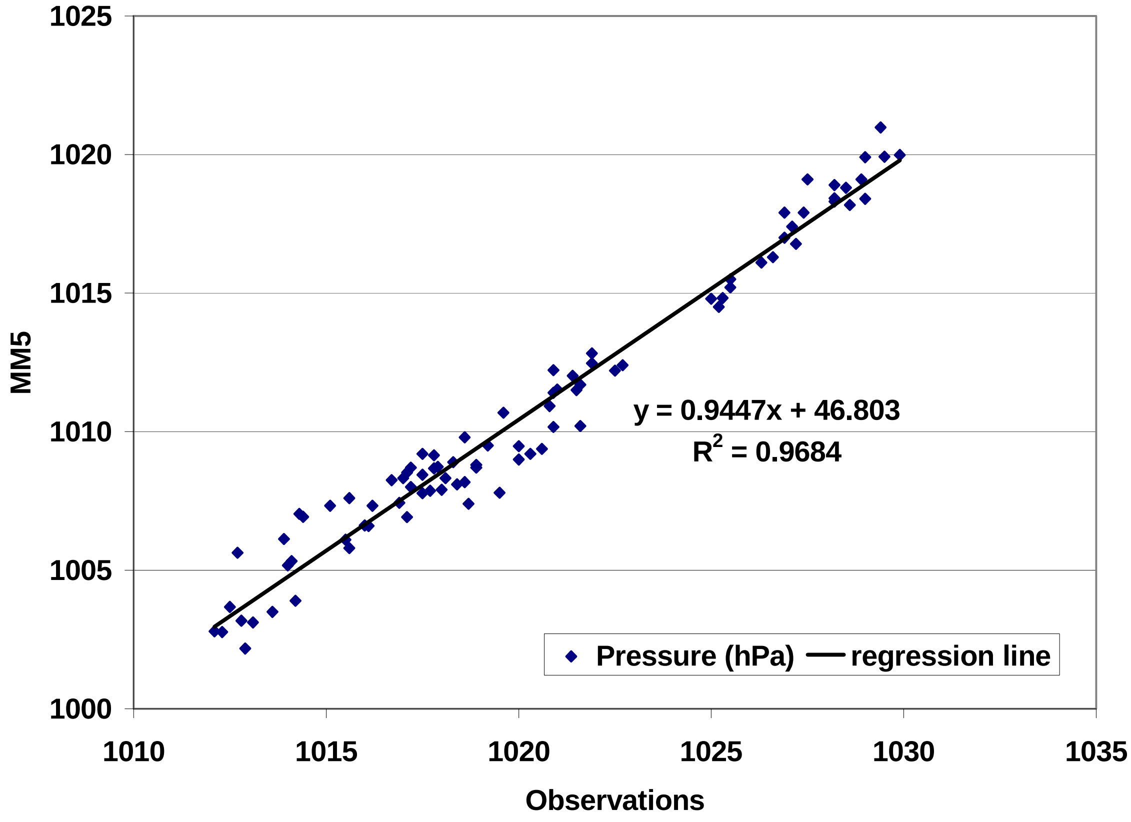
Wind speed (m s^{-1})



bias of -0.1 m s^{-1}

standard deviation 1.24 m s-1

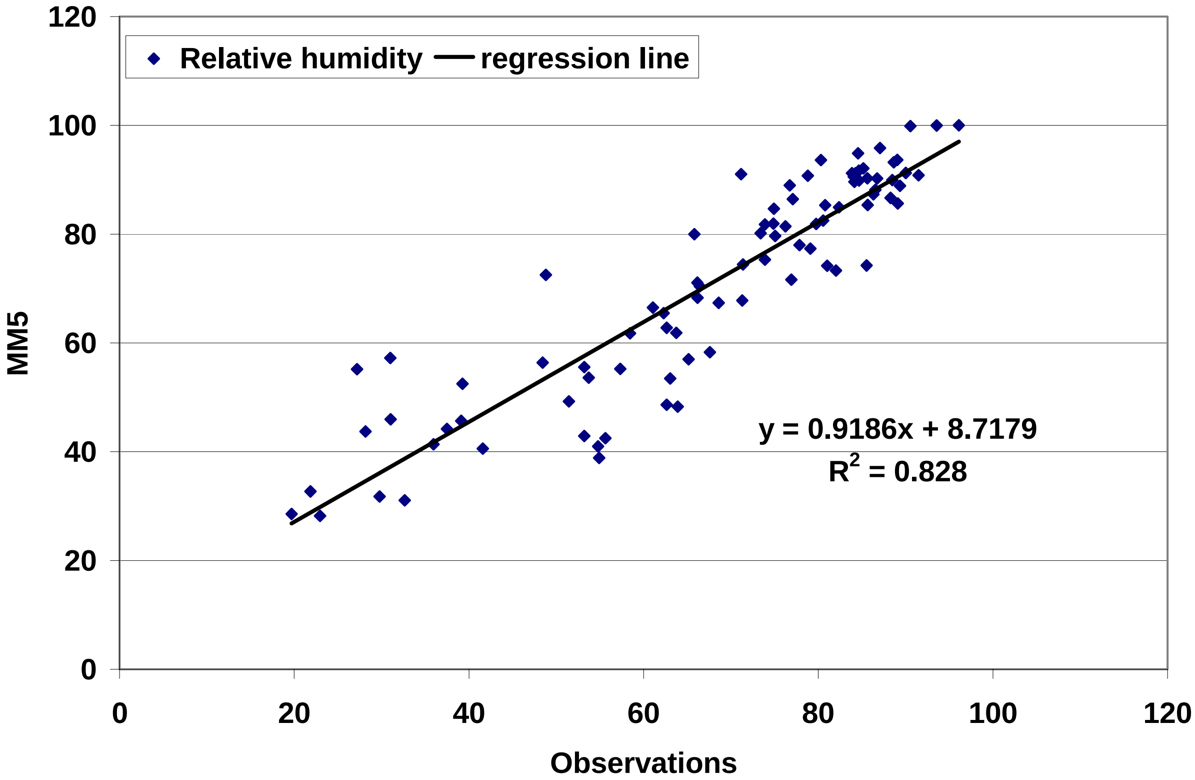
Surface Pressure (hPa)



bias of -0.97 hPa

standard deviation 0.94 hPa

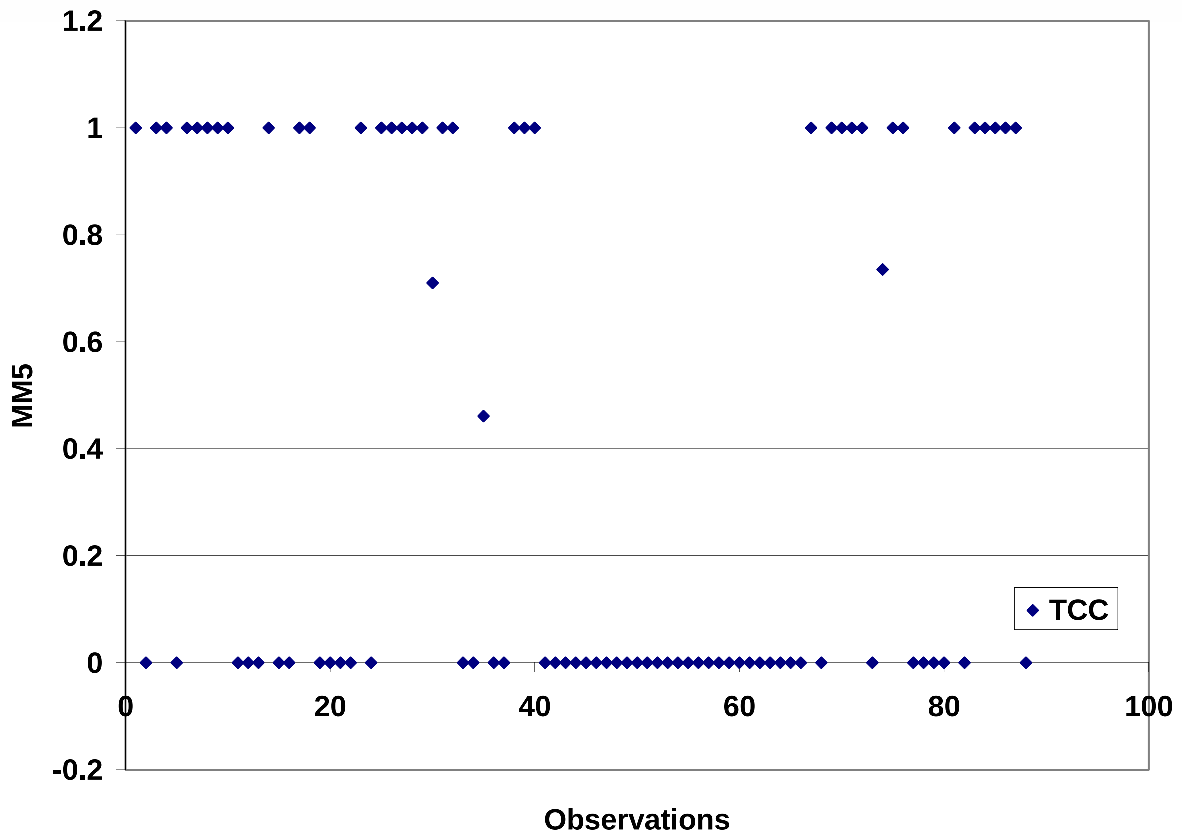
Relative humidity



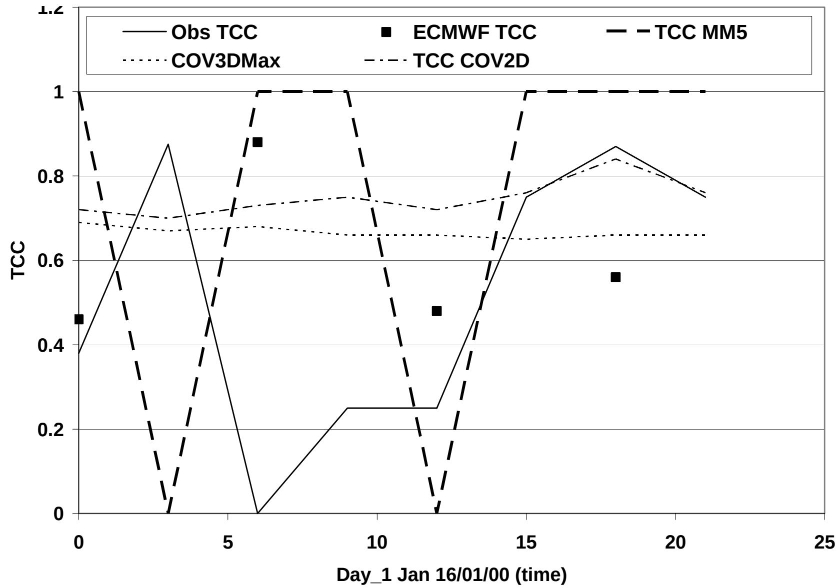
bias of 3.69 hPa

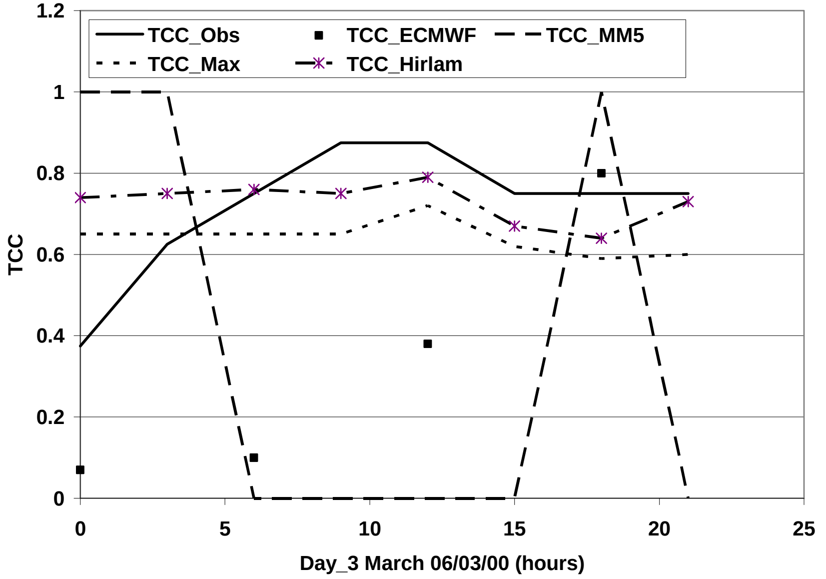
standard deviation 8.53 hPa

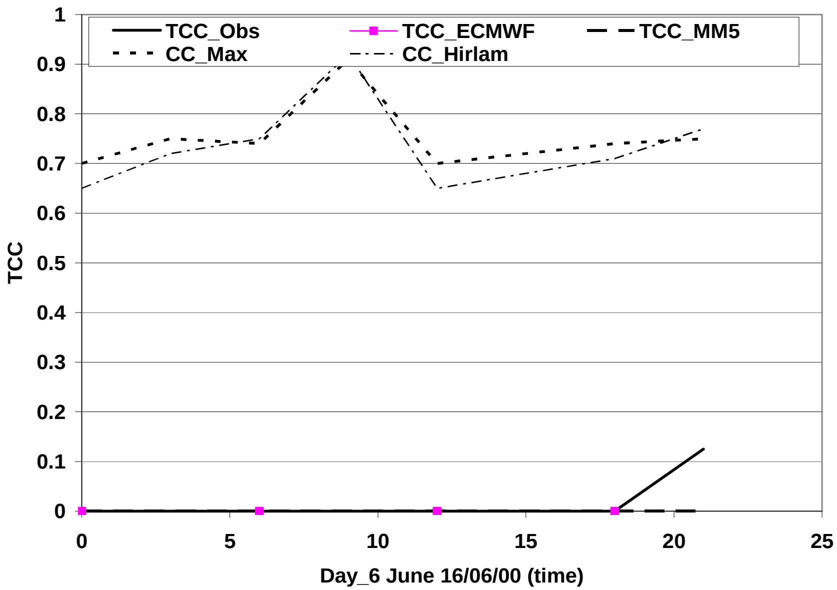
Total cloud cover (from 0 to 1)

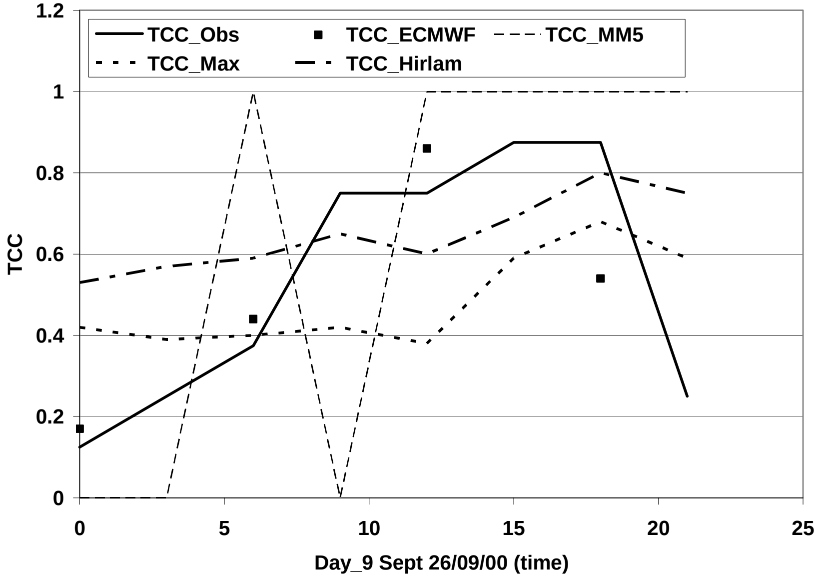


Compare MM5 TCC against ECMWF observation TCC_Max TCC_Hirlam (random overlap)

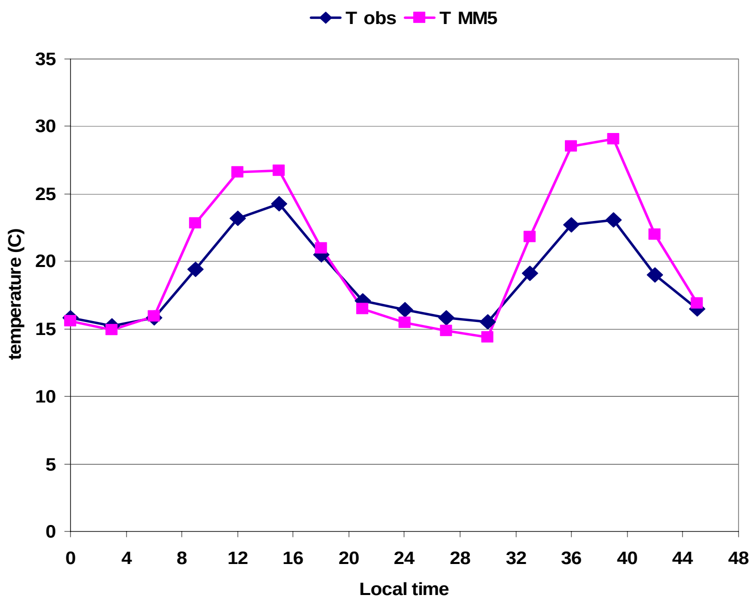








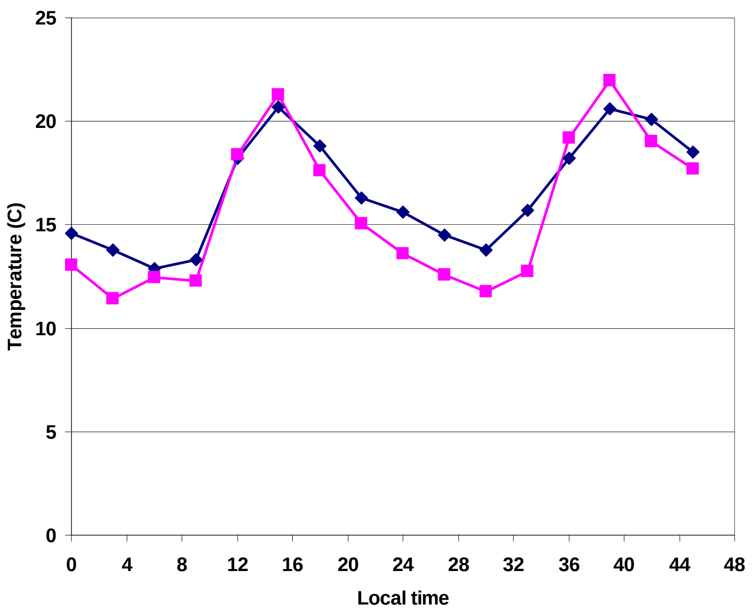
Gago Coutinho Station



Summer simulations Day 5

MM5 overestimate daytime T

Noctural cooling rate comparable to observations



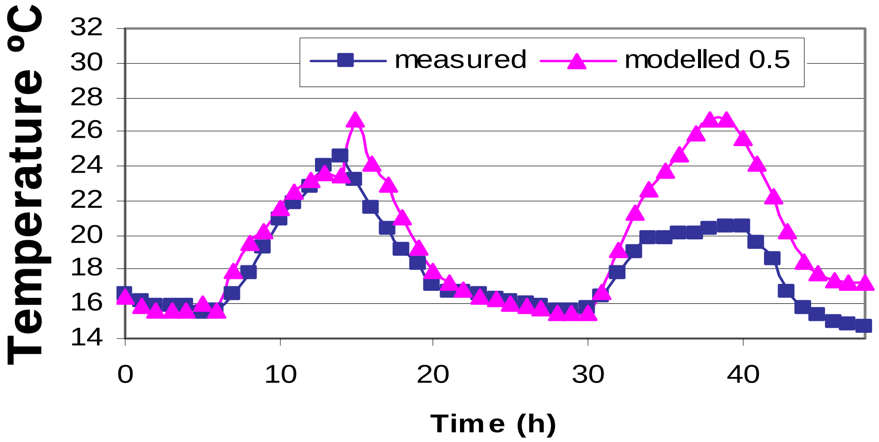
Winter simulations Day 10

Modeled T underestimate noctural T

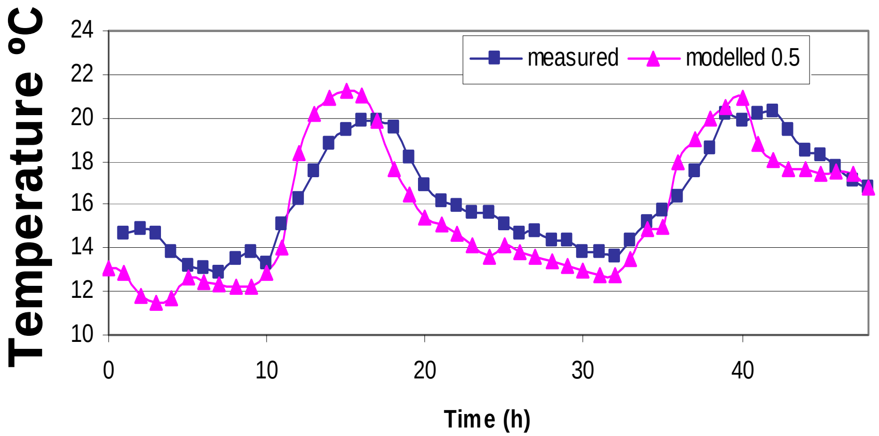
More cooling at night than is actually occurring in the urban area

Anthropogenic heat impact on noctural profiles

Baixa Station

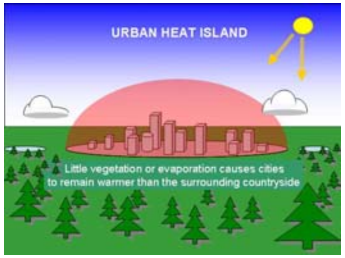


Summer simulations Day 5

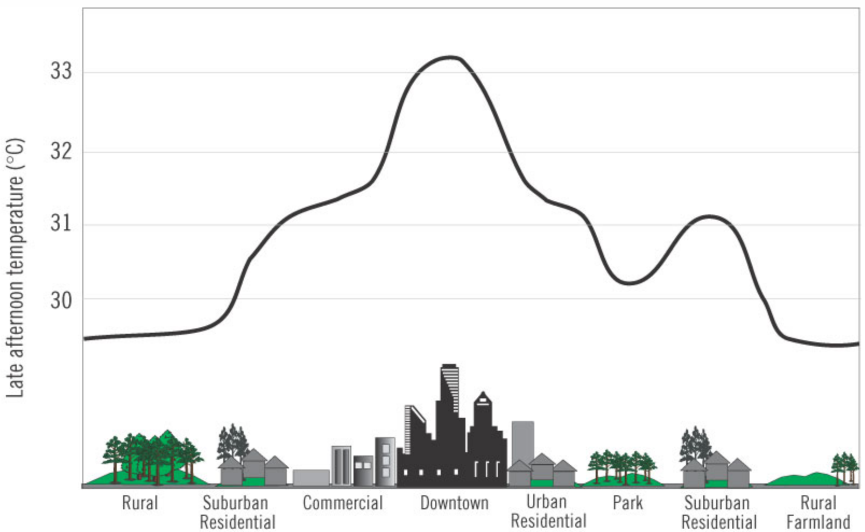


Winter simulations Day 10

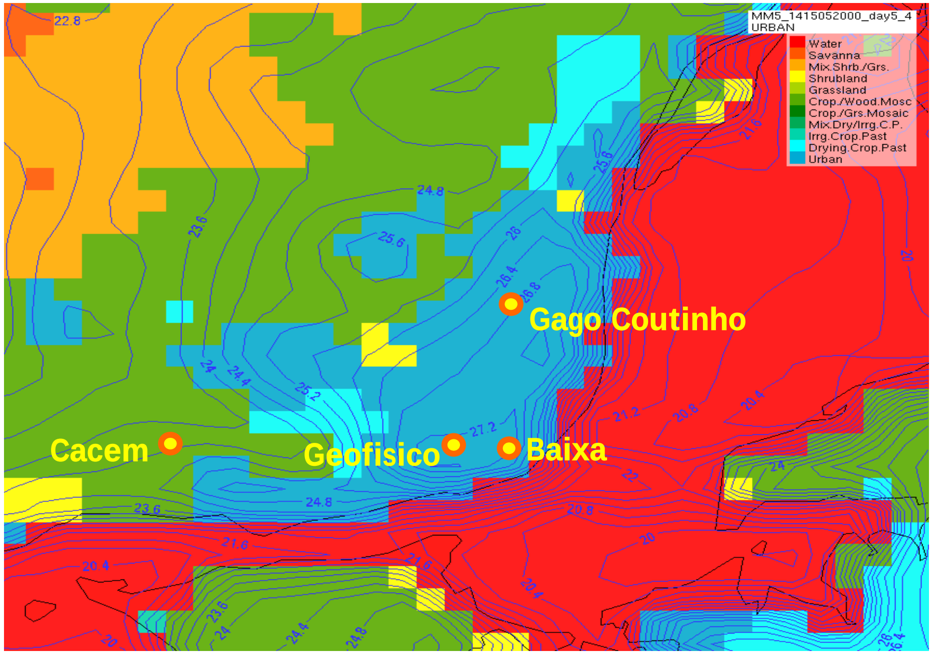
4



Urban heat island effect (UHI) and anthropogenic heat effect

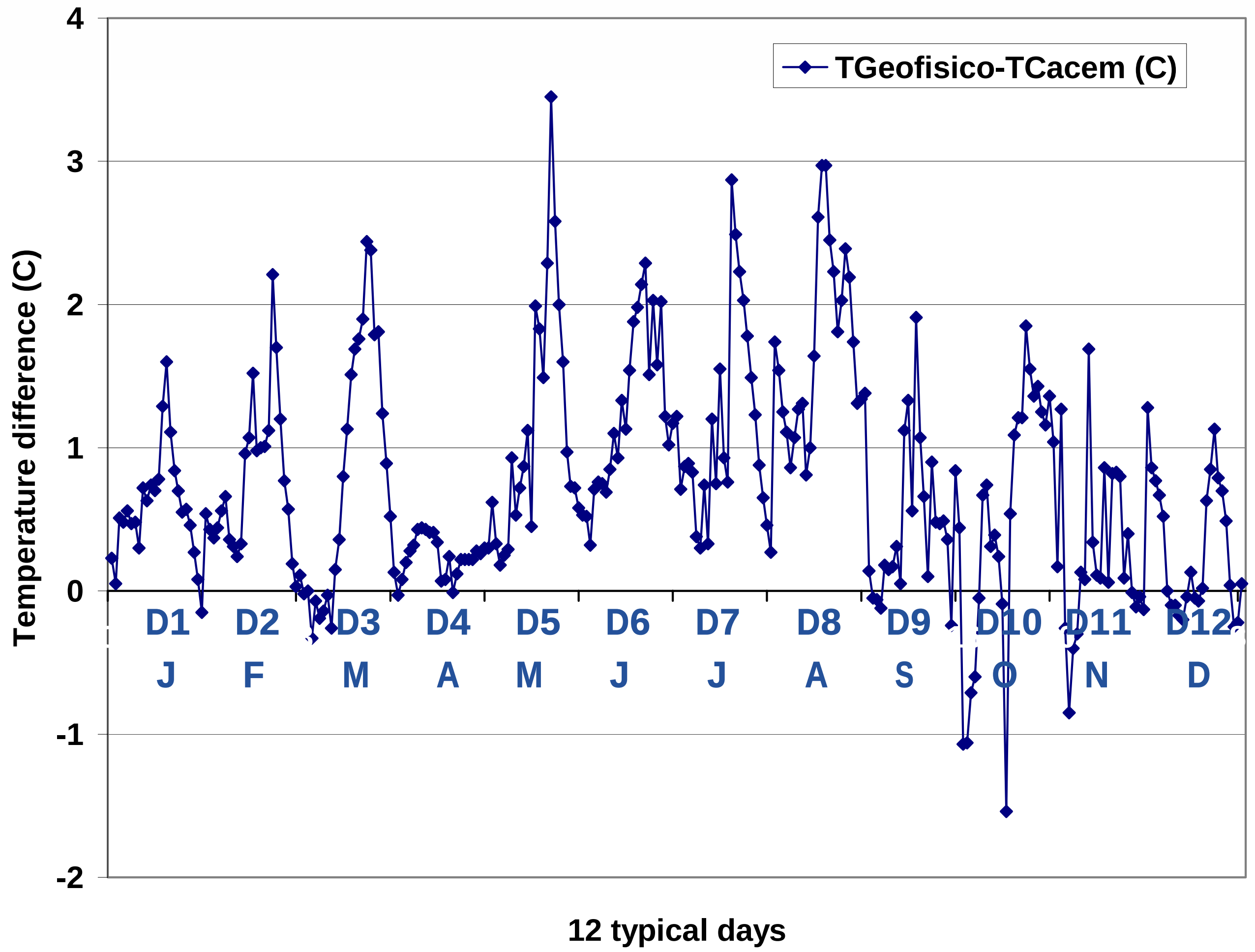


URBAN HEAT ISLAND EFFECT

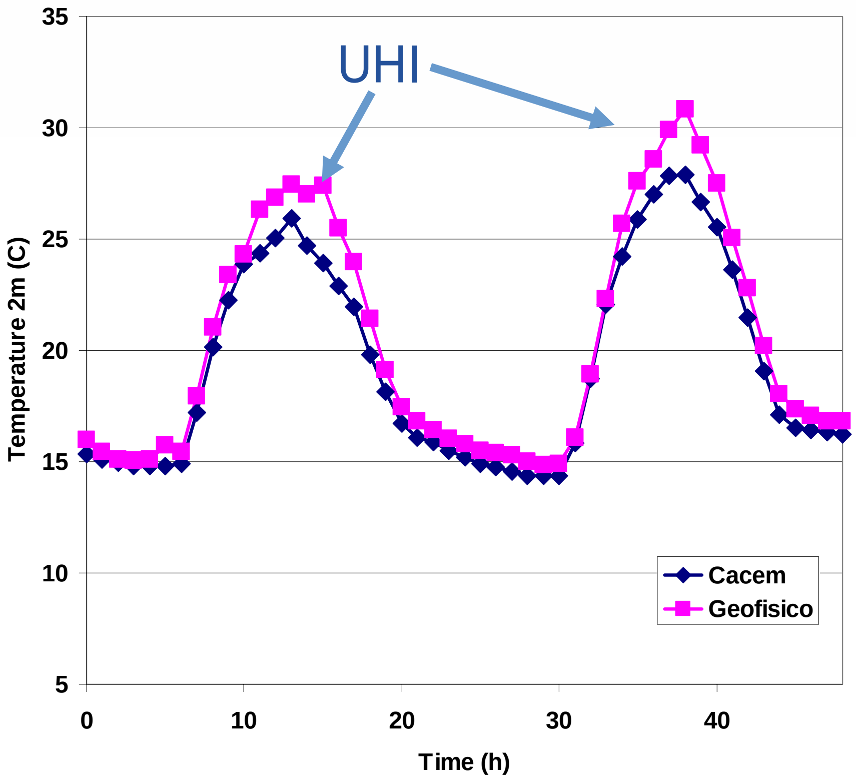


- **Landuse**
- **Anthropogenic heat**

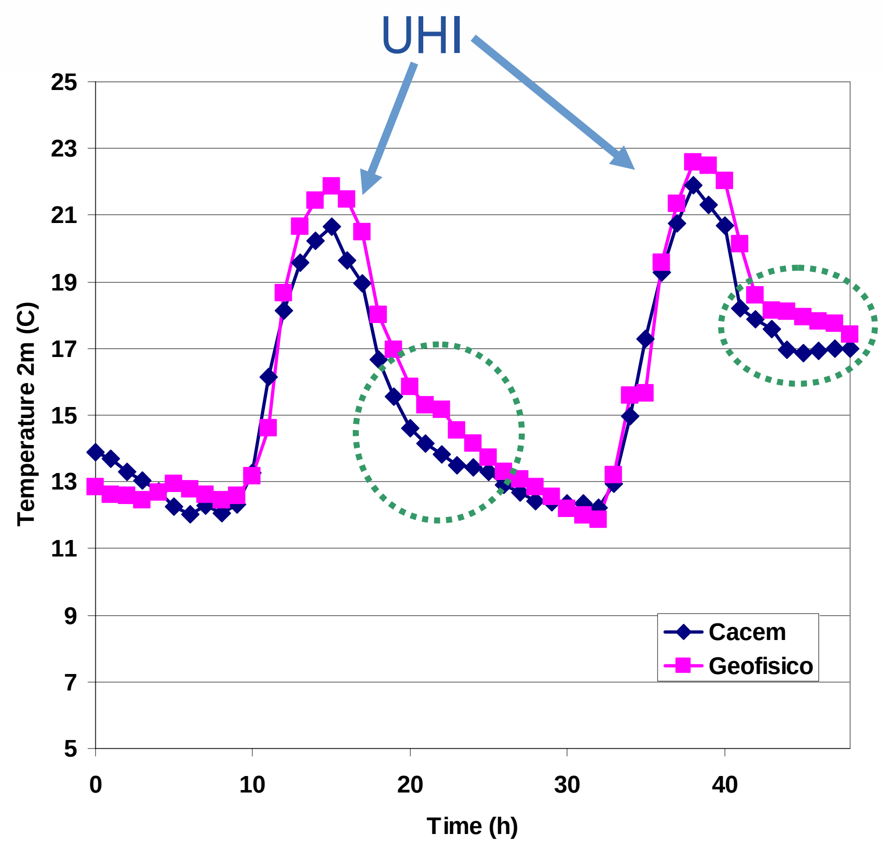
Bias between ouskirt and city center stations Geofisico vs Cacem T2m



Cacem/Geofisico stations



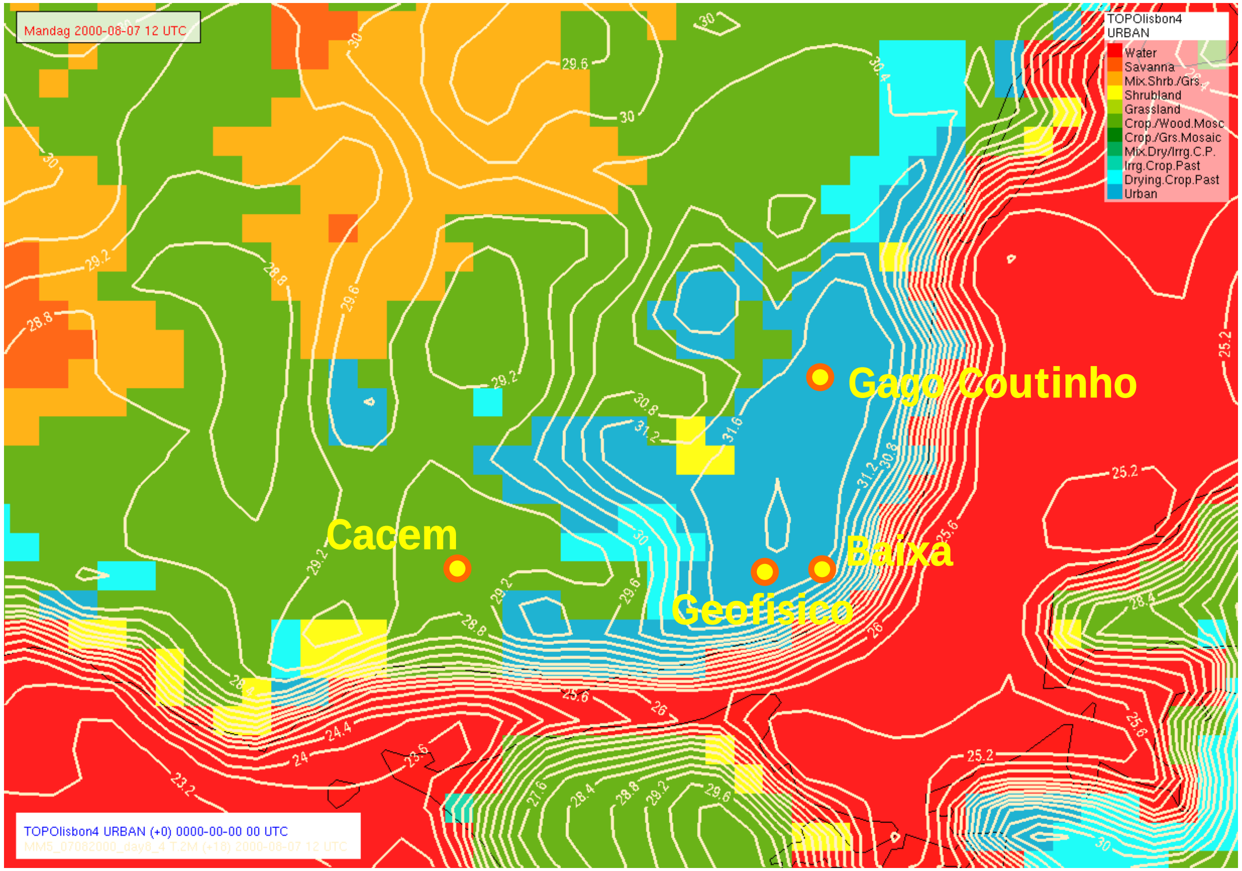
Summer simulations Day 5



Winter simulations Day 10

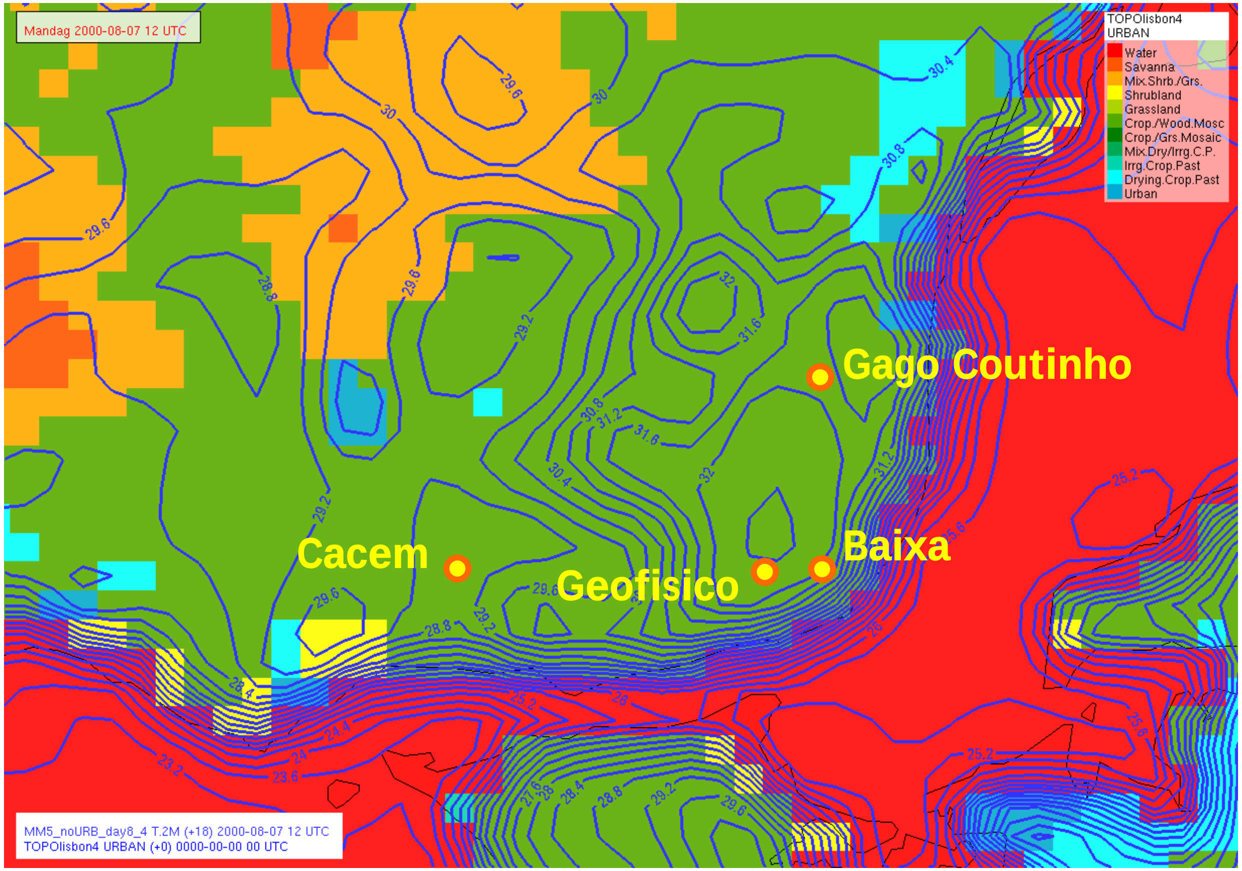
What happens when we remove MM5 urban area?

Day 8 August 2000 12h



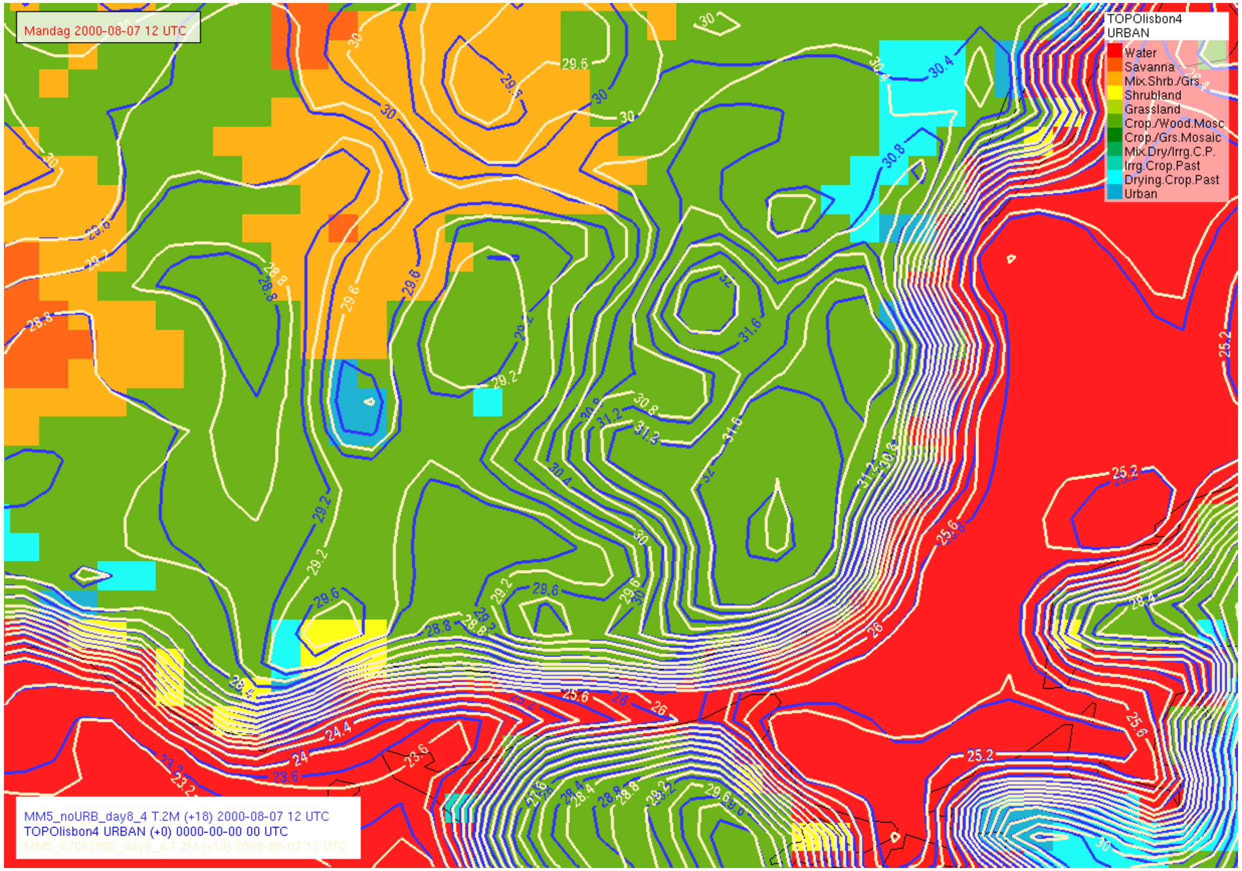
... without MM5 urban area

Day 8 August 2000 12h

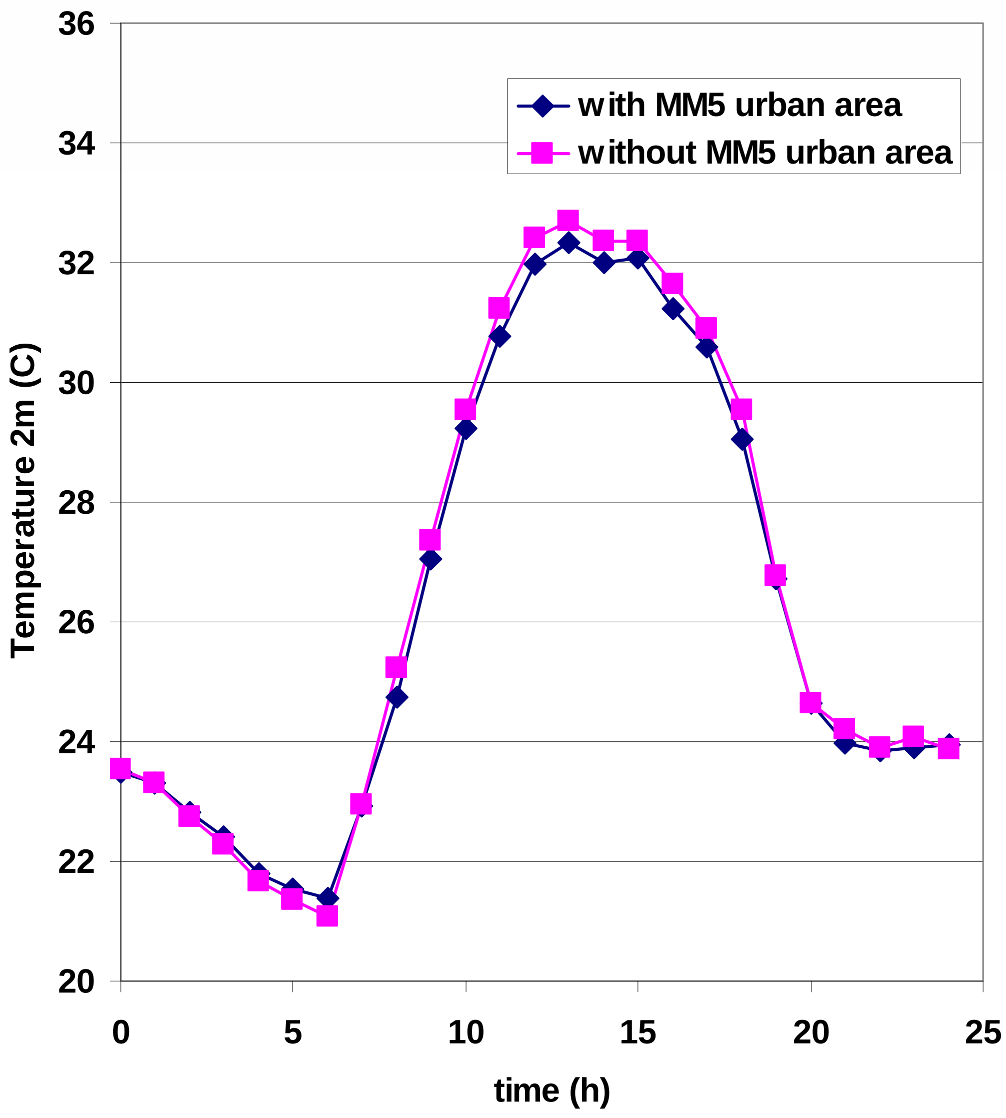


Compare with and without MM5 urban area

Day 8 August 2000 12h



Geofisico station



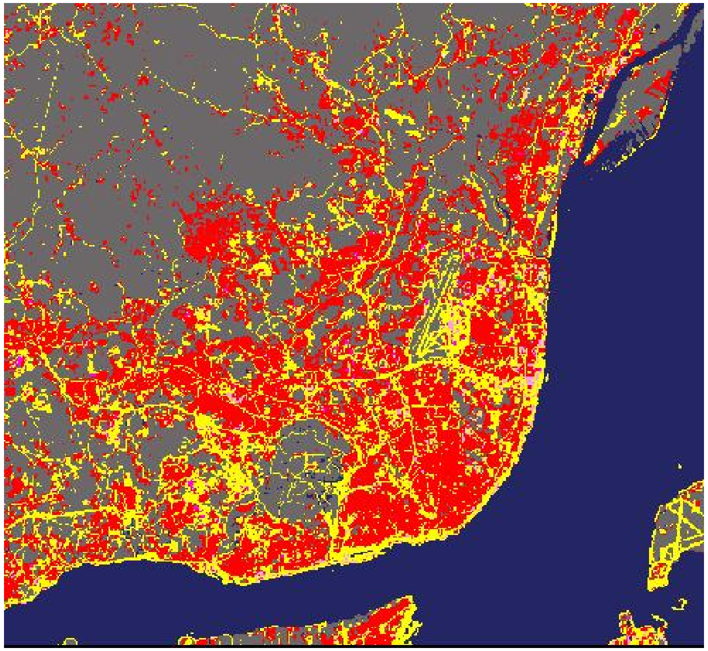
DAY 8

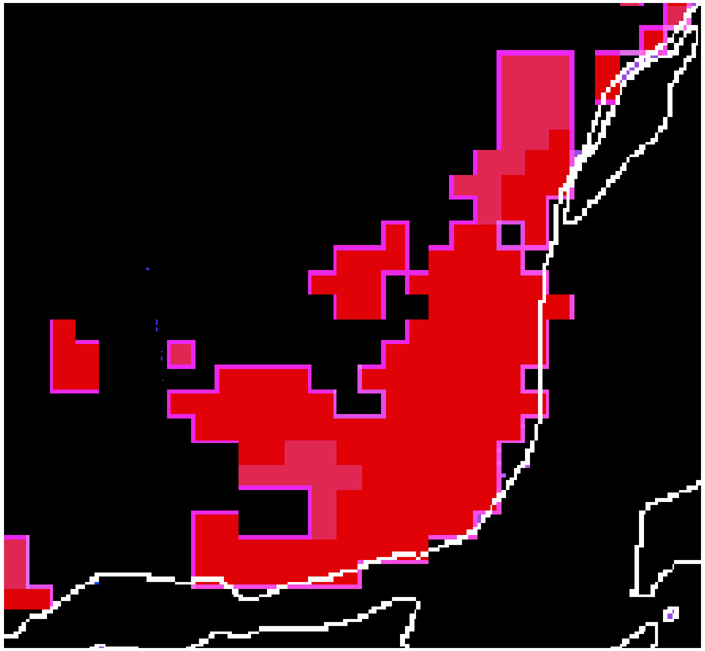
MM5 Time series

Lisbon urban area: NCGI vs MM5

Data from Portugal National Centre for Geographic Information (NCGI)

MM5 urban category from USGS 24-category





Transport

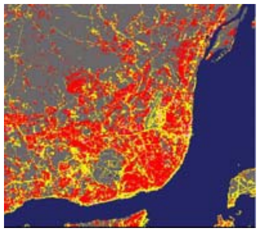
Residentiel area

Others

Urban area

Others

Multi-urban classification approach



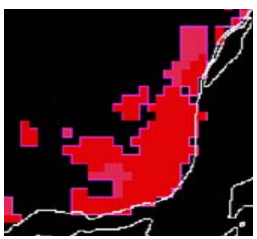
Local institutions or satellite data

Real urban mask

Roughness length

Physical parameters

Albedo, Emissivity, Thermal inertia and moisture availability derivable from thermal AVHRR channels



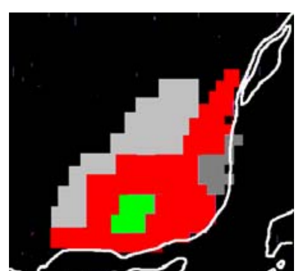
MM5 - New urban area

Modify terrain file to implement updated Lisbon urban area

MM5 - Implement new urban categories

Modification of existing USGS 24 category and implementation of multi-urban classification in landuse category

Use literature to define multi-urban categories



MM5 + Multi urban classification

FUTURE WORK

Implement anthropogenic heating effect in MM5

Improve urban classification using satellite data