Interconnection of the Urban Heat Island with the spatial and temporal micrometeorological variability in Rome

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THE URBAN HEAT ISLAND ESTIMATE – SCIENTIFIC BACKGROUND

THE URBAN HEAT ISLAND (UHI) IN BIG CITIES INFLUENCES HEALTH AND LIFE CONDITION OF POPULATION

UHI IS ALSO A CRITICAL FACTOR FOR AIR QUALITY AND ENERGY CONSUMPTION MANAGEMENT

UHI IS STRONGLY RELATED TO THE RAPIDLY GROWING URBAN POPULATION AND GREATLY DEPENDS ON SITE CHARACTERISTICS

A FEW STUDIES FOR ROME

WHERE

THE FREQUENCY OF EXTREME HEAT WAVES IS INCREASED THEN REINFORCING THE UHI

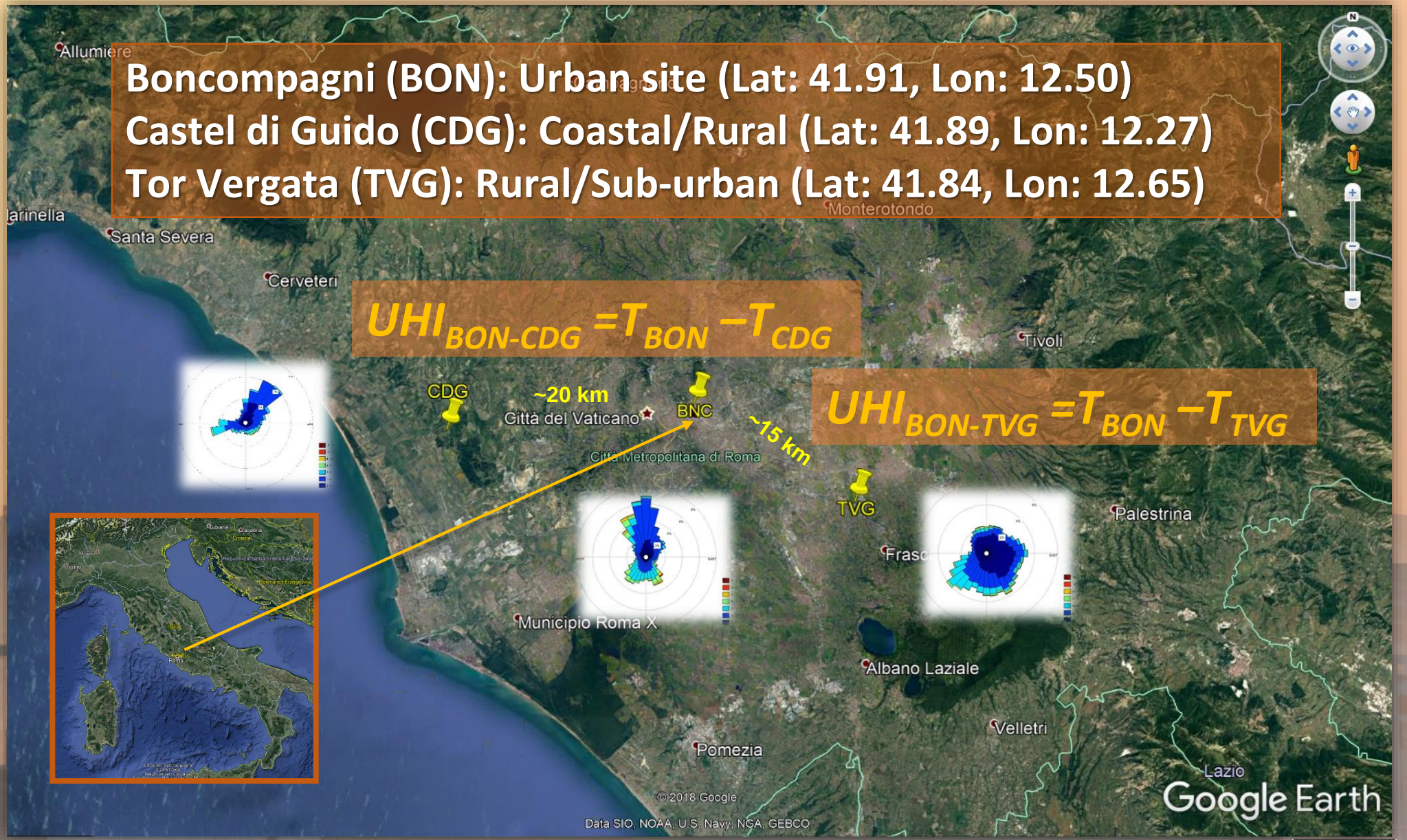
THE URBAN HEAT ISLAND ESTIMATE – SCIENTIFIC BACKGROUND

NUMERICAL MODELS ARE USED TO INVESTIGATE THE SPATIAL-TEMPORAL BEHAVIOR OF THE UHI

BUT

TO PROPERLY PARAMETRIZE THE URBAN EFFECTS, SURFACE PROPERTIES (ALBEDO, EMISSIVITY, ROUGHNESS, ETC.) ARE NEEDED.

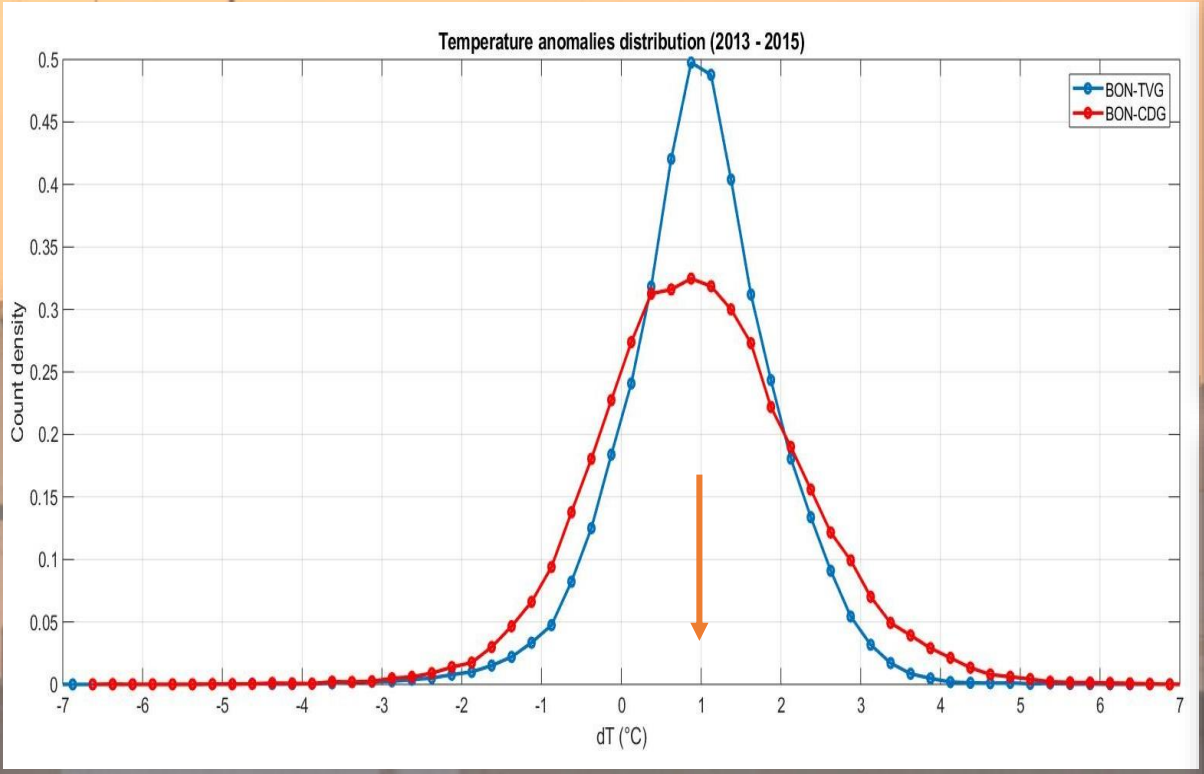
THE STUDY AREA – THE METROPOLITAN CITY OF ROME (LATIUM) - ITALY



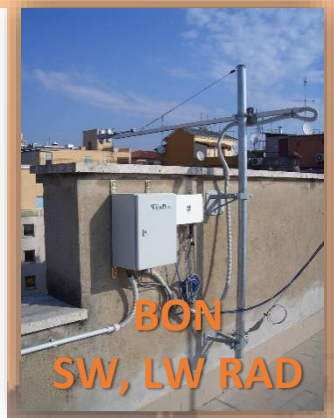
ESTIMATE OF THE UHI ($UHI=T_{urban} - T_{rural/suburban}$)
UHI DISTRIBUTION (2013-2015)

Dataset: ARPA LAZIO (Regional Agency for the Environmental Protection) Micro-meteorological Stations (2013-2015)

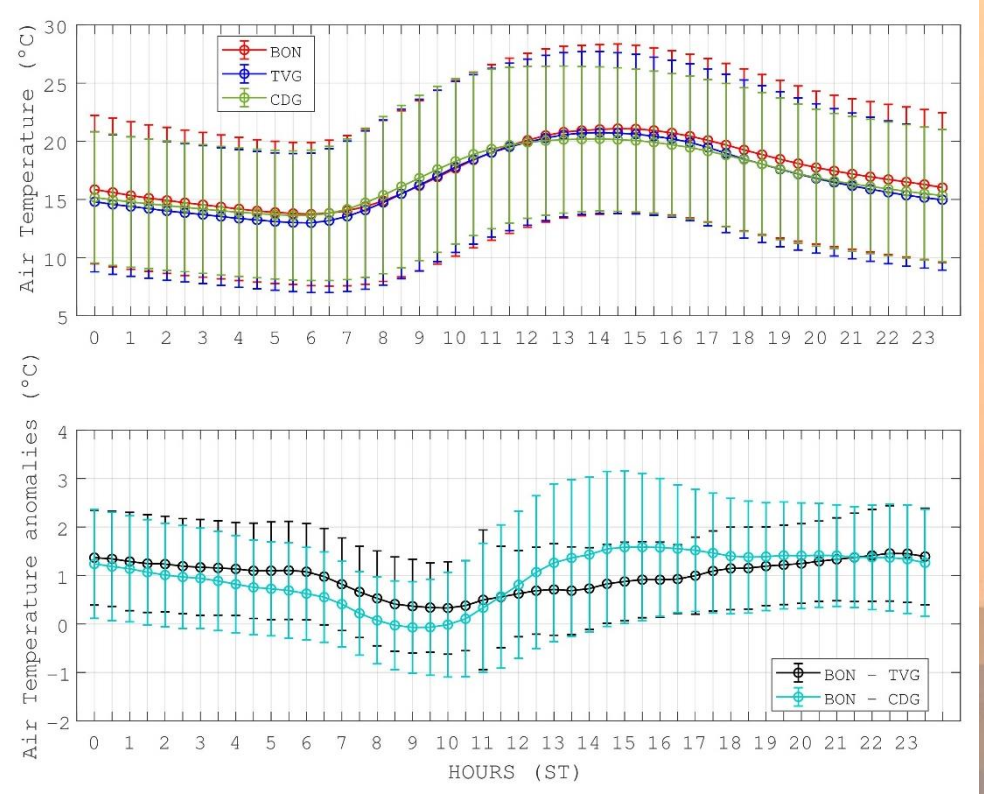
Positive UHI values occur most of the time
UHI peaks at 1 °C



Micro-meteorological Stations measure T,RH,P,WS,WD,SW and LW radiation components, H0, u*,TKE,u,v,w

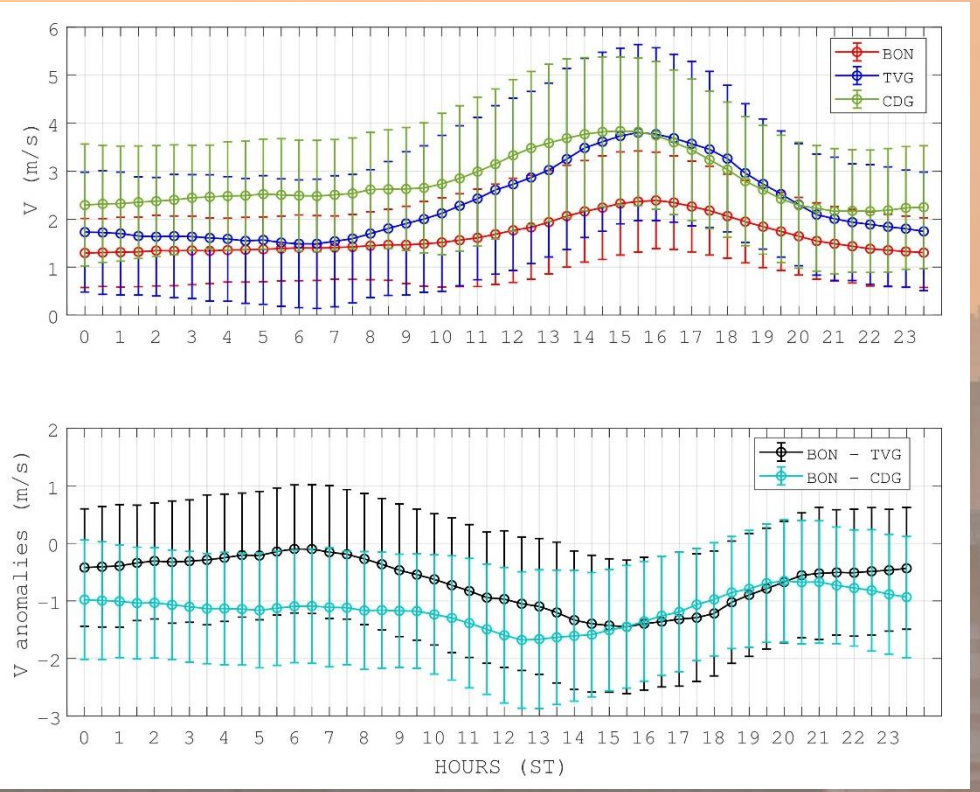


HOURLY AVERAGES OF WIND SPEED AND AIR TEMPERATURE AND THEIR ANOMALIES FOR URBAN/COASTAL AND URBAN/SUBURBAN SITES (the stdev represents the annual variability at a given hour)

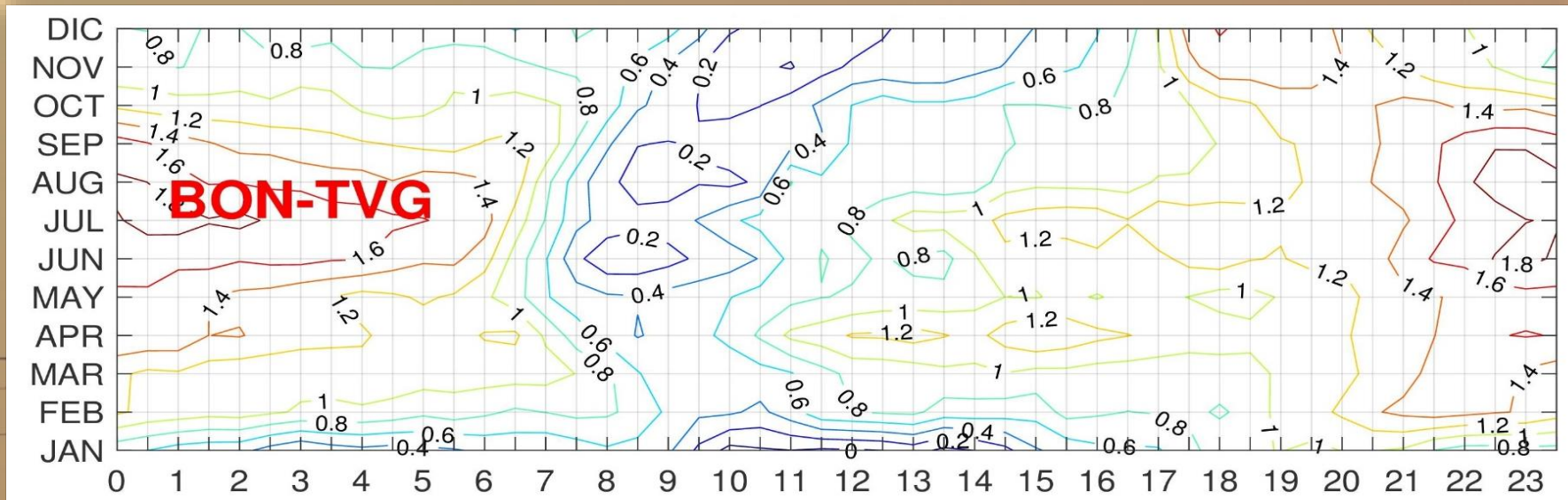


- City is always warmer then its surroundings
- The minimum is reached on average at 9:00 ST

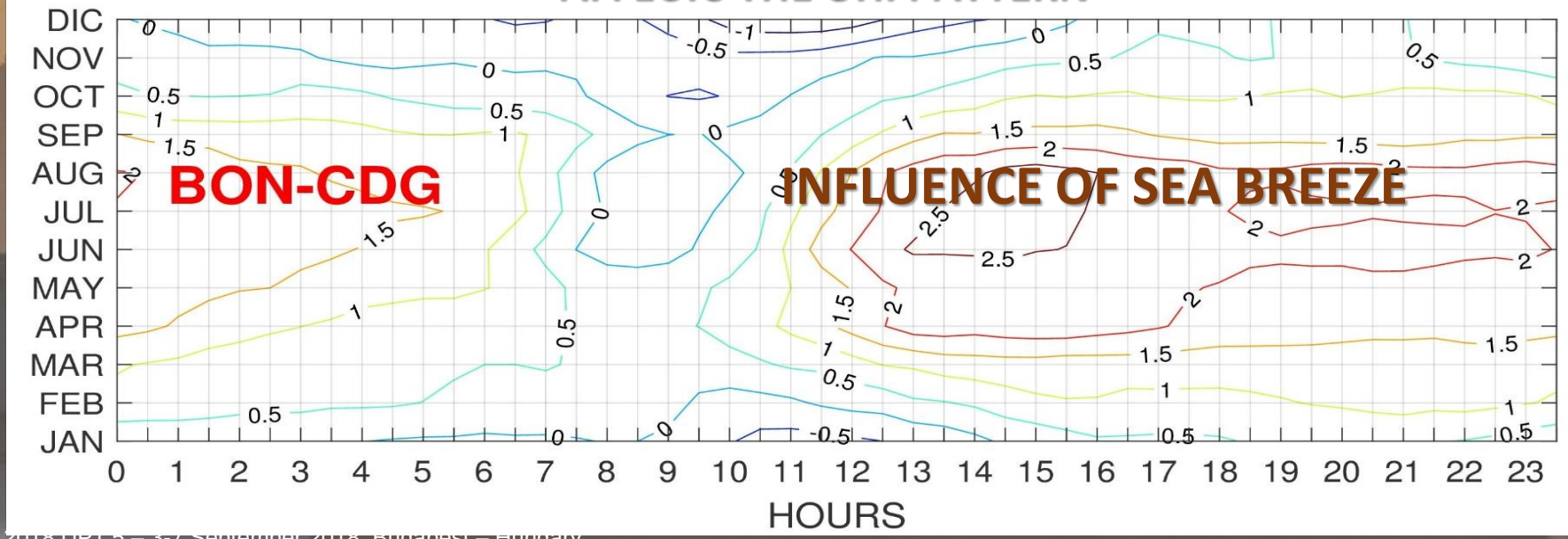
- The city always experienced lower wind speed than its surroundings (lower ventilation)
- CDG is strongly affected by the sea breeze



UHI AS FUNCTION OF MONTH AND TIME (ST)



STRONGER ANOMALIES IN THE NIGHTTIME AND IN SUMMER SEA BREEZE AFFECTS THE UHI PATTERN

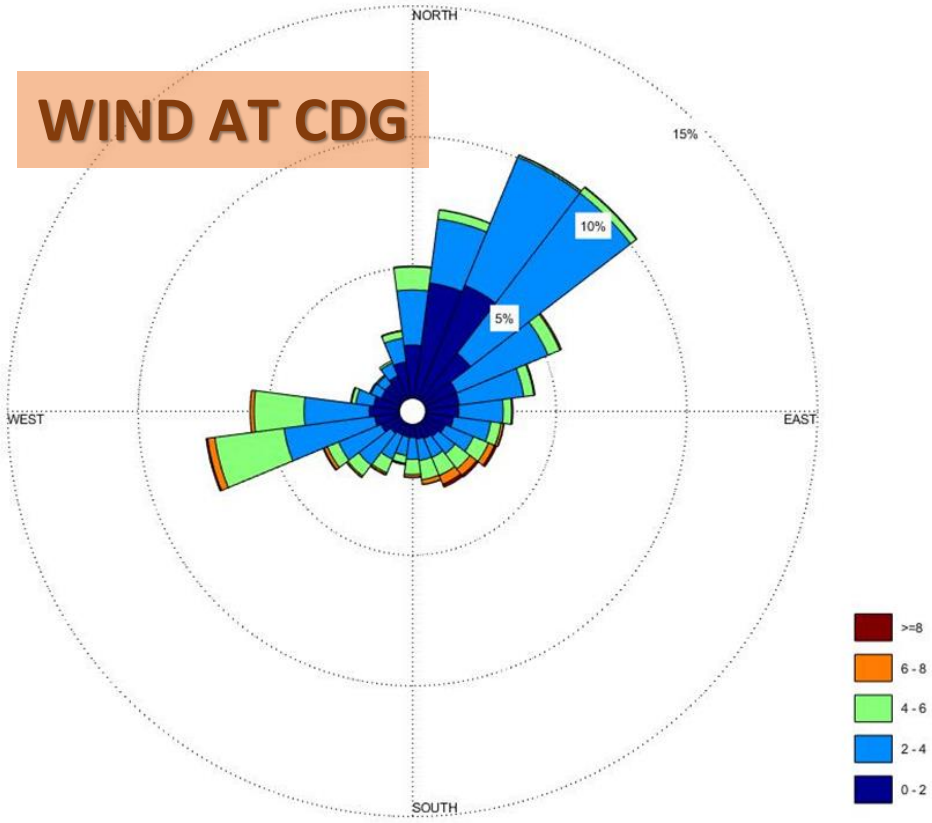


INFLUENCE OF SEA-BREEZE ON UHI

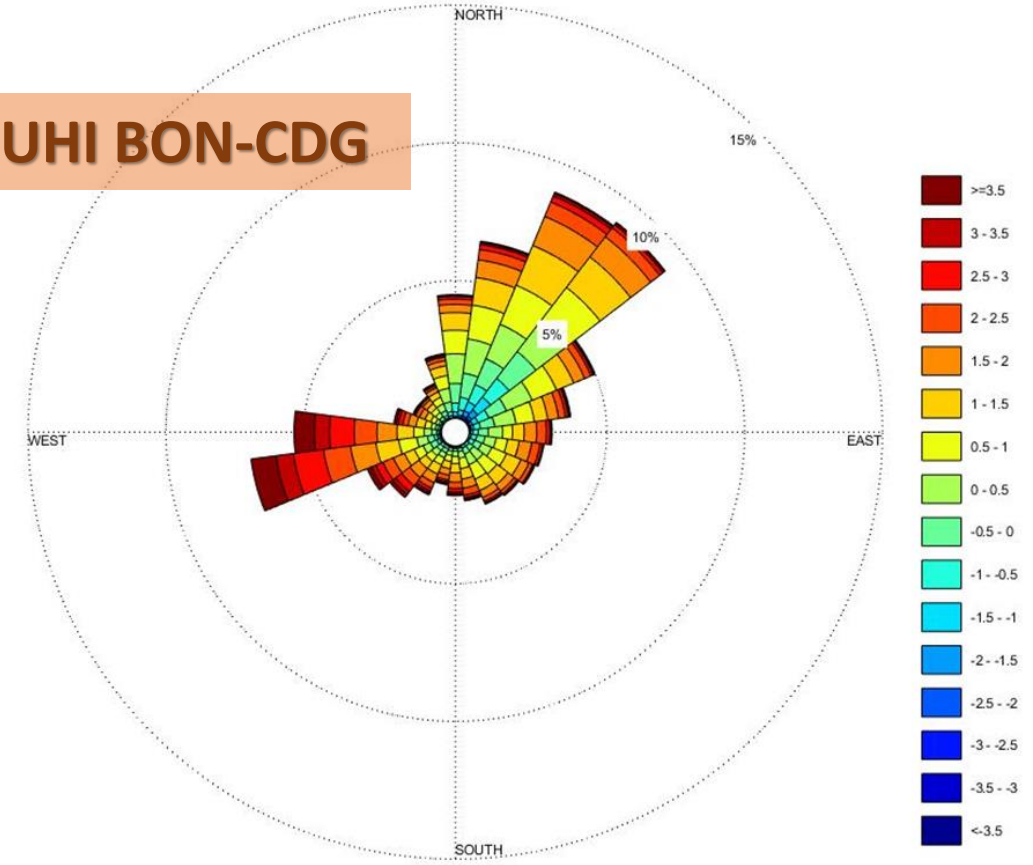
INCREASING WIND SPEEDS ARE RESPONSIBLE FOR STRONGER TEMPERATURE ANOMALIES BETWEEN URBAN AND COASTAL SITES

POLAR DISTRIBUTION (15°SECTORS)

WIND AT CDG



UHI BON-CDG



INFLUENCE OF RADIATIVE AND MICRO-METEOROLOGICAL PARAMETERS ON UHI AT ROME

WE BELIEVE ON THE NEED TO GIVE A BETTER REPRESENTATION OF THE URBAN PBL SCHEMES IN MODELS TO REPRESENT THE COMPLEX URBAN PROCESSES; THAT IS WHY WE ESTIMATE RELEVANT PARAMETERS FROM MICRO-METEOTOROLOGICAL STATIONS OVER THE METROPOLITAN AREA OF ROME

AMONG OTHERS:

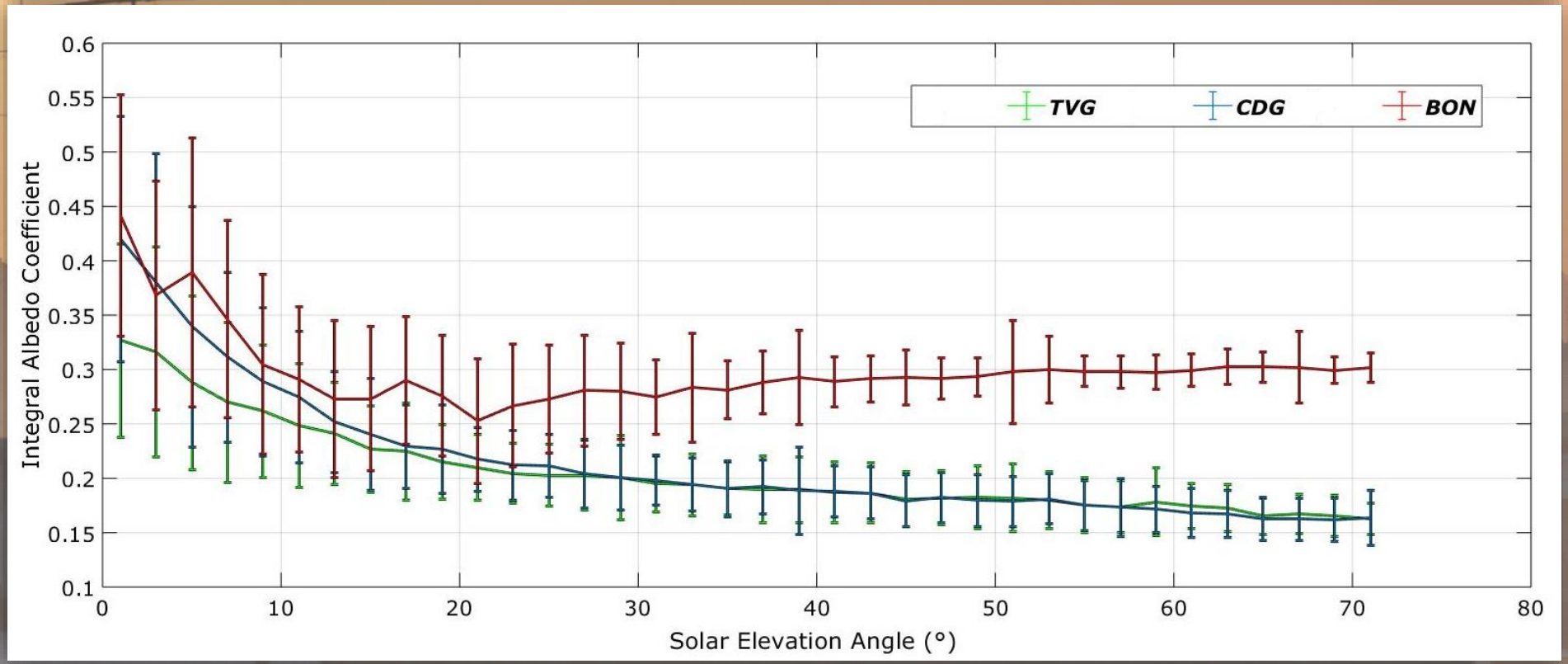
1. **ALBEDO**
2. **ROUGHNESS LENGTH AND ZERO DISPLACEMENT HEIGHT**
3. **DRAG COEFFICIENT**

ALBEDO AS FUNCTION OF THE SOLAR ELEVATION ANGLE ψ

A_0 IS THE COEFFICIENT CORRESPONDING TO THE SOLAR ZENITH POSITION

Sites	A_0
Boncompagni (BON) - URBAN	0.3016
Tor Vergata (TVG) – SUBURBAN/RURAL	0.1673
Castel di Guido (CDG) – COASTAL/RURAL	0.1640

THE AVERAGED INTEGRAL ALBEDO COEFFICIENT FOR THE SUBURBAN/RURAL SITE EXHIBIT THE SAME BEHAVIOR (AS FUNCTION OF ψ AND AS ABSOLUTE VALUES) WHILE FOR *BON*, THE URBAN SITE, VALUES ARE CONSISTENTLY HIGHER (ASSOCIATED TO A HIGHER REFLECTIVITY OF THE SURFACES) BUT LESS DEPENDENT FROM THE ELEVATION ANGLE



ROUGHNESS LENGTH AND ZERO DISPLACEMENT HEIGHT

Sector	d mean (m)	d median (m)	z_0 mean (m)	z_0 median (m)
N	14,265	14,954	1,901	1,931
N-E	16,397	17,593	1,631	1,654
E	12,021	11,675	1,924	1,969
S-E	11,992	12,38	1,04	1,005
S	17,766	19,149	1,348	1,373
S-W	16,089	17,144	1,377	1,348
W	13,904	14,674	1,263	1,255
N-W	12,852	13,646	1,458	1,365

Zero-plane displacement height and roughness length for BON

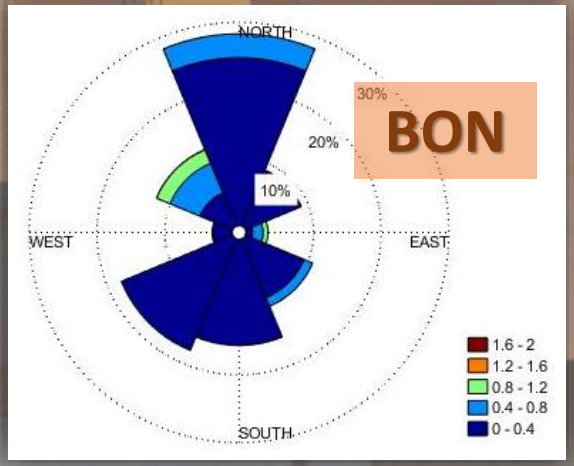
Roughness length (m) for TVG

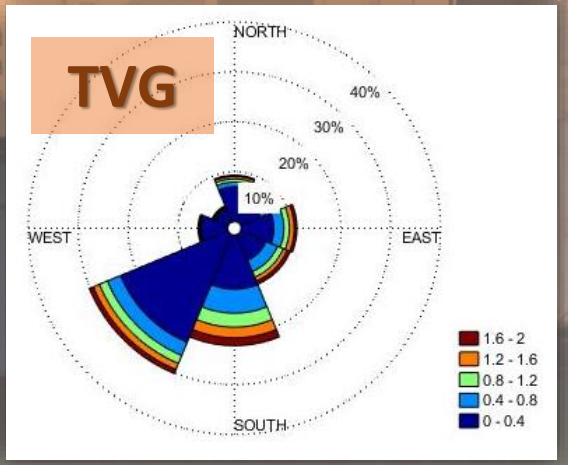
Sector	Mean z0	25° Percentile	50° Percentile	75° Percentile	Number of data
N	0,175	0,047	0,085	0,173	2597
N-E	0,199	0,046	0,097	0,206	2397
E	0,236	0,074	0,155	0,267	3004
S-E	0,324	0,095	0,219	0,421	2660
S	0,512	0,347	0,476	0,625	5305
S-W	0,189	0,069	0,13	0,233	6856
W	0,175	0,031	0,063	0,145	2373
N-W	0,274	0,059	0,126	0,332	1670

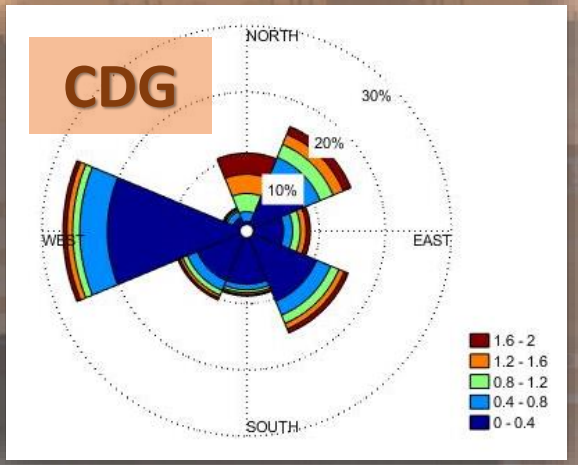
Roughness length (m) for CDG

Sector	Mean z0	25° Percentile	50° Percentile	75° Percentile	Number of data
N	1,299	0,998	1,362	1,673	3835
N-E	0,492	0,091	0,269	0,754	9624
E	0,155	0,048	0,096	0,18	4010
S-E	0,182	0,087	0,137	0,212	3546
S	0,212	0,102	0,16	0,241	2583
S-W	0,383	0,197	0,331	0,496	3751
W	0,427	0,252	0,363	0,54	7221
N-W	0,626	0,294	0,555	0,87	1408

POLAR DISTRIBUTION OF ROUGHNESS (45°SECTORS)





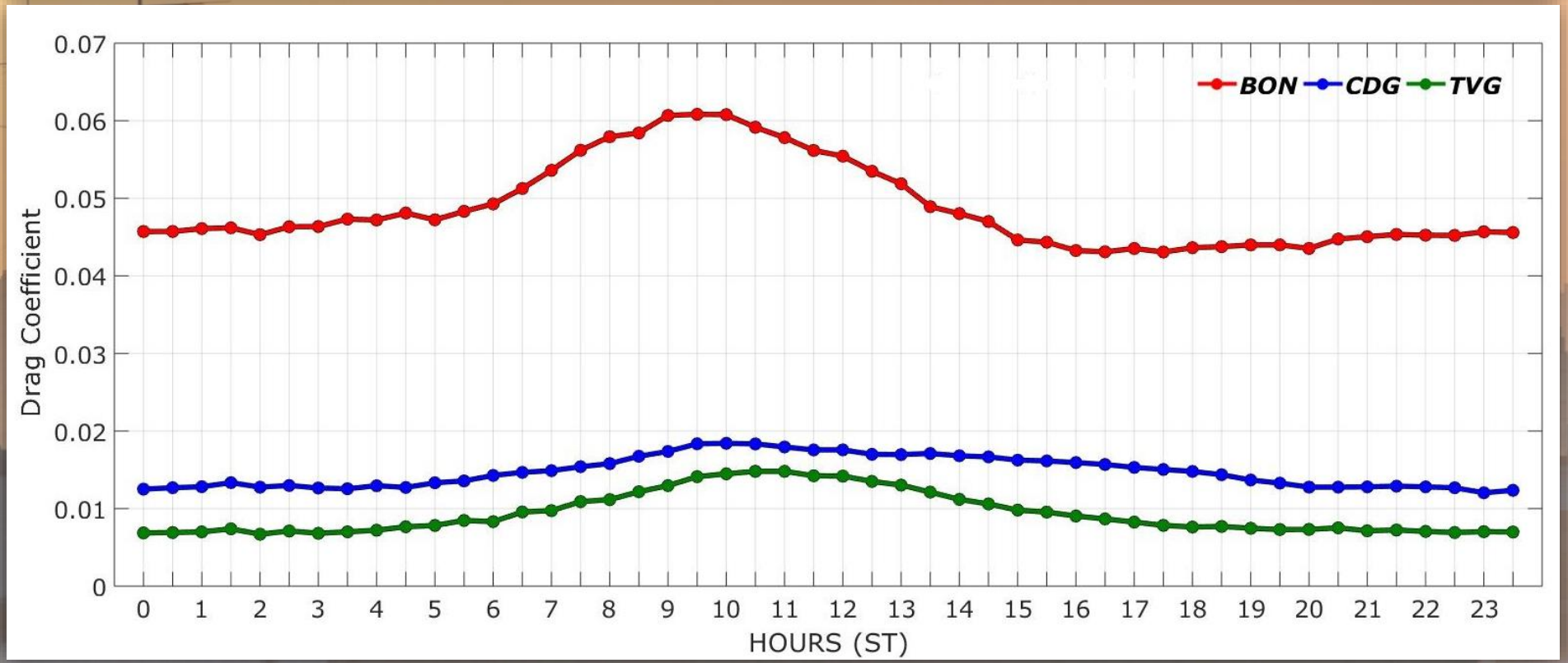


DRAG COEFFICIENET

$u_*^2 = C_D * M_{10}^2$ C_D THE DRAG COEFFICIENT AND M_{10} THE WIND SPEED AT 10 m

FOR FLUIDS THE FLOW TURBULENT STRESS IS PROPORTIONAL TO WIND SPEED SQUARED.
STRESS IS GREATER OVER ROUGHER SURFACE

THE DRAG COEFFICIENT RANGES FROM $2*10^{-3}$ OVER SMOOTH SURFACE TO $2*10^{-2}$ OVER ROUGH TO FORESTED SURFACE;
***CDG* AND *TVG* HAVE VALUES CORRESPONDING TO A ROUGH SURFACE BUT,**
***BON* C_D IS THREE TIMES LARGER!**



REMARKS AND FUTURE WORK

A FEW WORKS ARE DEDICATED TO THE UHI CHARACTERIZATION IN ROME USING A COMPREHENSIVE APPROACH WHICH INCLUDED MEASUREMENTS, MODELS AND SATELLITE DATA.

A COMPLETE DESCRIPTION OF THE UHI IS NEEDED AND MICROMETEOROLOGICAL MEASUREMENTS WILL ADD VALUES THROUGH THE ESTIMATION OF SEVERAL CRUCIAL PARAMETERS IN PBL SCHEMES OVER URBAN AREAS

LIFE CLIMATE CHANGE ADAPTATION PROJECT

ASTI

Implementation of a forecAsting System for urban heaT Island effect for the development of urban adaptation strategies. 09/2018 – 09/2021