Webinar : Future weather data and heatwaves | 31 May 2022

Motivation & determination of world-wide future weather data and heatwaves

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On behalf of:

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Future weather data and heatwaves: structure of the presentation

- **Purpose** of the future Weather datatsets generated for the Annex 80
- **Methodology**: selected cities, data source, validation
- **Results**
  - Expected changes in "*Typical Metheorological Years*"
  - Future *heatwaves* (Anaïs Machard – following presentation)

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Future weather data and heatwaves: motivation

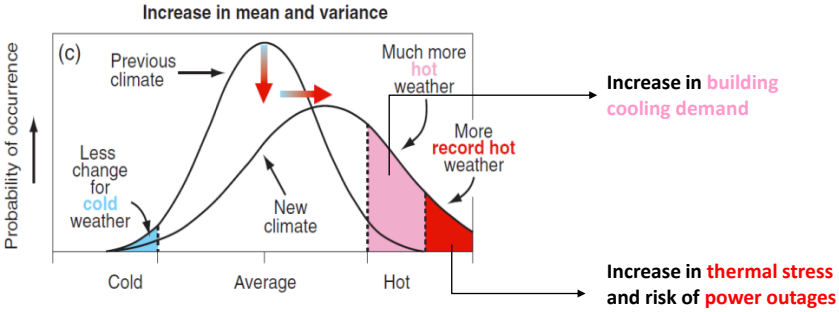
*The world is facing a rapid **increase of air conditioning** of buildings. This is driven by multiple factors, such as **urban growth and climate change.***

It is the motivation** of the Annex 80 **to develop, assess and communicate solutions of resilient cooling and overheating protection** (…) to withstand, and also prevent, **thermal stress** and **building cooling demand increase** due **to higher ambient temperatures** and increased frequency and severity of **heat wave events.

The **WEATHER DATA TASK FORCE** of the **IEA EBC Annex80** was created to agree on a common and scientifically robust methodology to **produce sets of weather data** of **characteristics climate zones worldwide.**

The **purpose** of the data is to carry out **building performance simulations** to **assess thermal stress** and **building cooling demand** in **present and future periods**

Future weather data and heatwaves: what kind of future weather data?



Source: (IPCC). Climate Change 2001: The scientific basis. Contribution of Working Group I

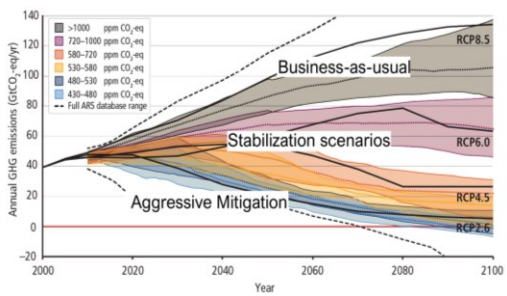
Two kinds of weather files are needed :

1) **Typical Meteorological Years**
2) **Weather files including heatwaves**

For **present** and **future** periods
For **representative climate zones**

Future weather data and heatwaves: climate projections and emission scenarios

- The analysis of future climate is based on **projections of climate models**
- Assumptions for climate models are the **green house gas concentration** scenarios developed by the **Intergovernmental Panel for Climate Change's (IPCC)** assessment reports (AR)
- 5th AR, released four Representative Concentration Pathways (RCPs) in 2014, which are identified by their associated warming effect (radiative forcing) in the year 2100 .



Selected RCP:

RCP8.5: Assumes a '*business-as-usual*' approach (worse case scenario)

Selected periods

- Historical **2010s**: (2001-2020)
- Future med-term **2050s**: (2041-2060)
- Future long term **2090s**: (2081-2100)

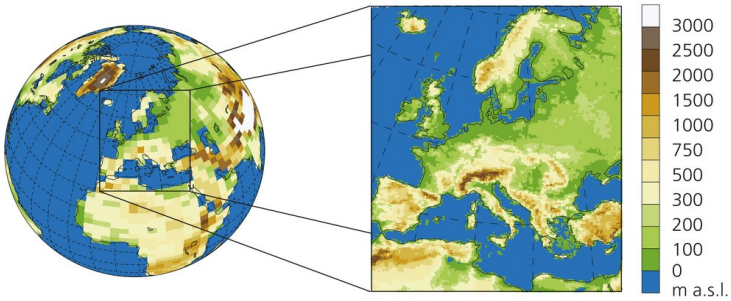
! **20-years** : minimum recommended length of time for climate change impact assessment studies.

Future weather data and heatwaves: what methodology?

Need downscaling:
To obtain higher resolution data

Statistical downscaling (Morphing Method) → using Future mean value (GCMs) to modify observed weather data

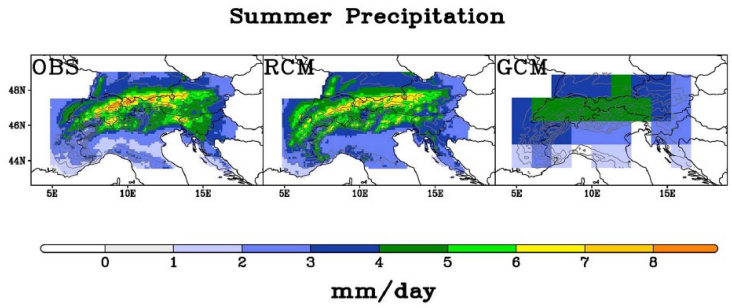
Dynamical downscaling → Using **RCM**s models forced by boundary conditions from a GCM model



General Circulation Models - GCM
Spatial resolution:150–600 km

Regional Climate Models - RCM
Spatial resolution: down to 2.5 km

Future weather data and heatwaves: advantages of dynamical downscaling using RCMs



Source: Giorgi, F. Thirty Years of Regional Climate Modeling: Where Are We and Where Are We Going next? J. Geophys. Res. Atmos. **2019**, 124, 5696–5723.

RCMs allow representation of extreme events such as **heatwaves**, which is not possible with other weather generators based on statistical downscaling (i.e. METENORM).

Future weather data and heatwaves: CORDEX datasets

CORDEX: COrdinated **R**egional **D**ownscaling **EX**periment
Project sponsored by World Climate Research Program (WCRP) to provide **regional-scale** climate projections for **impact assessment** and **adaptation studies**

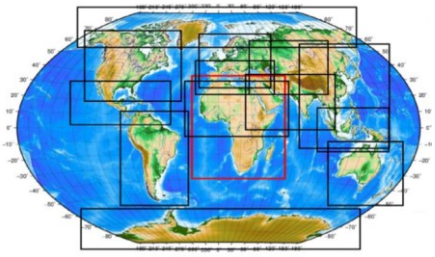
Several climate models and socio-economic projections worldwide, within the IPCC AR5 timeline

Specifications of the CORDEX data used:

GCM-RCM models: *MPI-ESM-LR/REMO*
Model combination that is closer to the median temperature of all climate models projections.

Data resolution:
- Minimum 3h temporal frequency
- Minimum 25 km spatial resolution

Variables:
- Dry-bulb air Temp
- Relative humidity
- Global horizontal irradiation
- Wind Speed
- Atmospheric pressure



Future weather data and heatwaves: bias-correction of RCM data

Goal : to reduce long term bias associated with climate model data

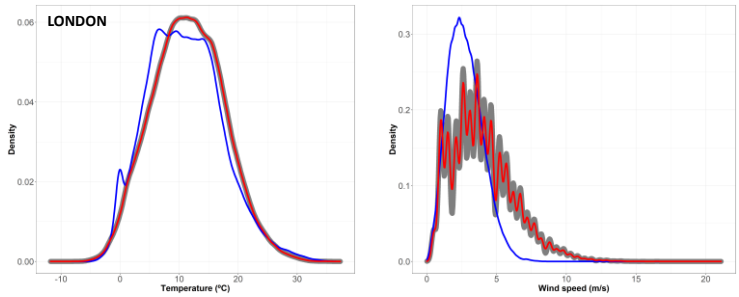
Hourly **historical observations**
(20-years ideally, 5 years minimum)

Hourly **CORDEX climate data**
(same period for which observations are available)

Bias-correction methods:
1) Solar Irradiation:
Quantile delta mapping (QDM
(Cannon et al., 2015)

2) Rest of climate variables:
Multivariate Bias Correction (MBC)
(Cannon, 2018)

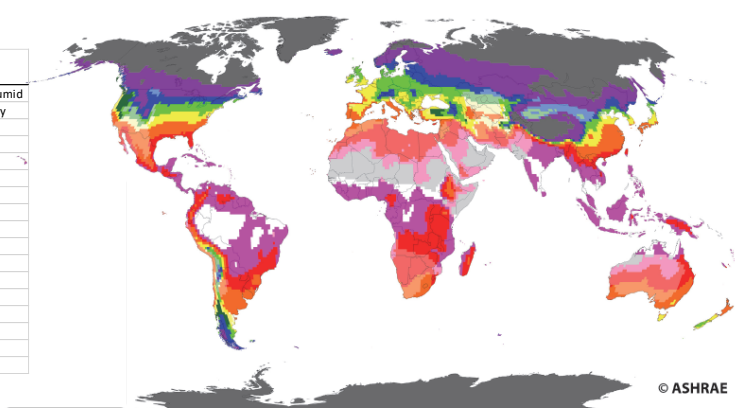
RCM
Observations
Bias-corrected RCM



Future weather data and heatwaves: Selecting representative cities

Criteria:
1. At least **one city for climate zones** considering the ASHRAE classification

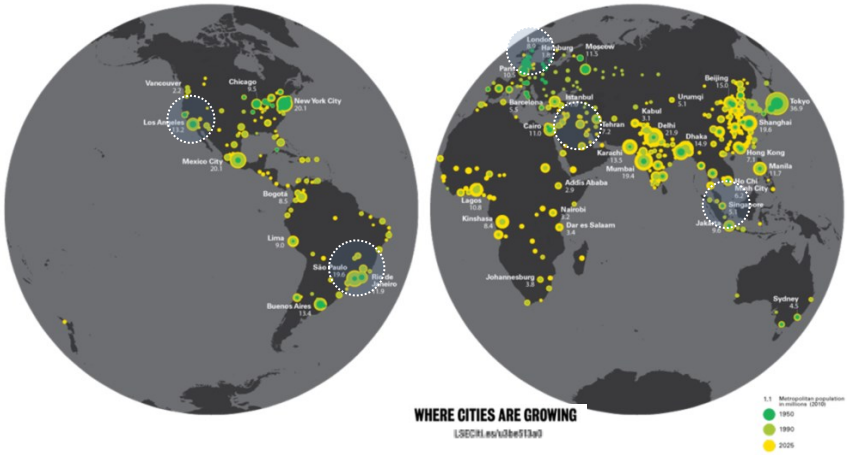
CZ	Description
0A	Extremely Hot Humid
0B	Extremely Hot Dry
1A	Very Hot Humid
1B	Very Hot Dry
2A	Hot Humid
2B	Hot Dry
3A	Warm Humid
3B	Warm Dry
3C	Warm Marine
4A	Mixed Humid
4B	Mixed Dry
4C	Mixed Marine
5A	Cold Humid
5B	Cold Dry
5C	Cool Marine
6A	Cold Humid
6B	Cold Dry



Future weather data and heatwaves: Selecting representative cities

Criteria:

1. At least **one city for climate zones** considering the ASHRAE classification
2. Cities with high **population and growth**

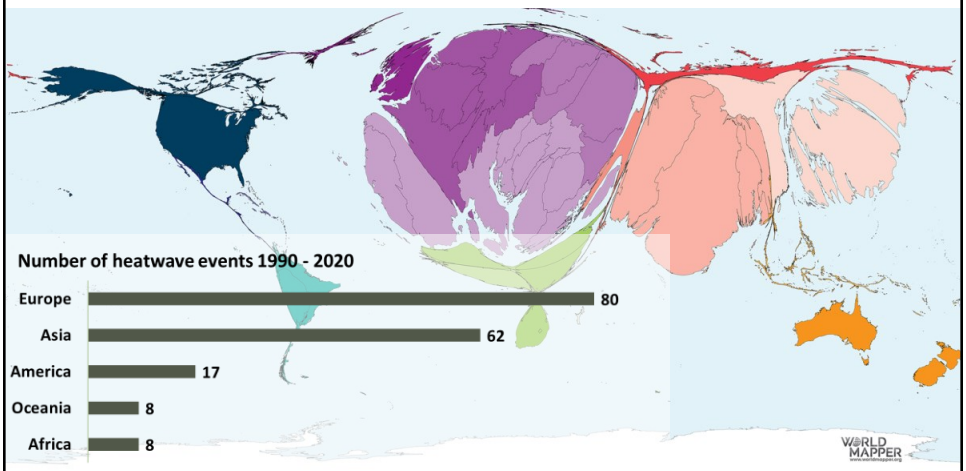


Source: Urban Age project, LSE Cities (2013)

Future weather data and heatwaves: Selecting representative cities

Criteria:

1. At least **one city for climate zones** considering the ASHRAE classification
2. Cities with high **population and growth**
3. Cities in **different continents**



Source: Source: EM-Dat International disaster database, Centre for Research on the Epidemiology of Disasters (CRED), https://www.emdat.be/

Future weather data and heatwaves: Selected cities

CLIMATE ZONE	City	Population 2022	Change % (since 2021)	Country	Continent
0A	Singapore	6,039,577	0.80%	Singapore	Asia
0B	Abu Dhabi	1,539,830	1.86%	UAE	Asia
1A	Guayaquil	3,092,355	1.62%	Ecuador	South America
2A	Sao Paulo	22,429,800	0.86%	Brazil	South America
3A	Buenos Aires	15,369,919	0.74%	Argentina	South America
3A	Rome	4297877	0.46%	Italy	Europe
3B	Los Angeles	3,985,516	0.05%	California	North America
4A	Brussels	2,109,631	0.67%	Belgium	Europe
4A	Gent	n/a	n/a	Belgium	Europe
4A	London	9,540,576	1.22%	UK	Europe
4C	Vancouver	2,631,690	0.97%	Canada	North America
5A	Toronto	6,312,974	0.93%	Canada	North America
5A	Copenhagen	1,370,131	0.85%	Denmark	Europe
5A	Vienna	1.960.023	0.78%	Austria	Europe
6A	Montreal	4,276,526	0.68%	Canada	North America
6A	Stockholm	1,679,050	1.36%	Sweden	Europe

Future weather data and heatwaves: Summary of methods and outputs

RCM projections (CORDEX) + Bias-adjustment (Using Observations)

Hourly bias-adjusted datasets of:

- Dry-bulb air Temp
- Relative humidity
- Global horizontal irradiation
- Wind Speed
- Atmospheric pressure

For 20-years periods:

- Historical: (2001-2020)
- Future medium term (2041-2060)
- Future long term (2081-2100)

Statistical analysis of the 20-years periods

OUTPUT 1:

Typical Meteorological Years (TMYs)

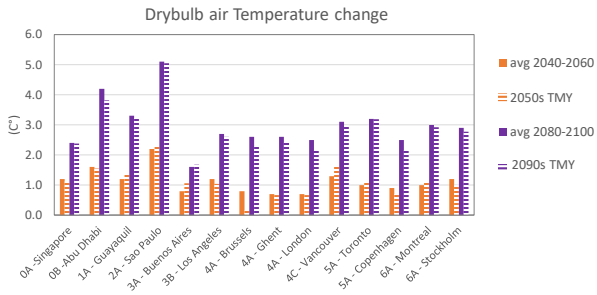
Method: EN ISO 15927-4:2005 standard
TMYs are constructed from the 12 most representative months ("Best months") from the multi-year period.

OUTPUT 2:

Weather files including heatwaves (HWs)

Method: Ouzeau et al., 2016
Based on relative temperature thresholds to detect heatwaves

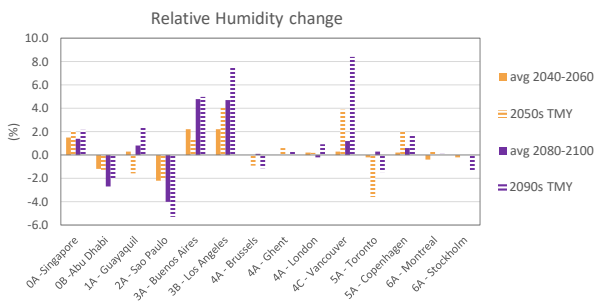
Future weather data : Projected changes in climate variables



TMYs well represent the 20-year period trend.

The **air temperature is consistently higher in the future for all the cities**.

Higher increase in the long term that in the mid-term TMY

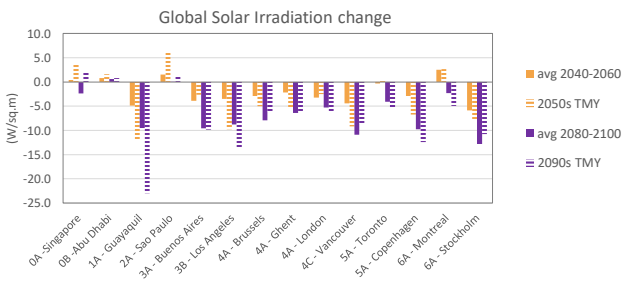


High variability in the sign of **future changes in relative humidity**.

Increasing RH:
Singapore (CZ: Extremely Hot Humid)
Guayaquil (CZ: Very Hot Humid)
Buenos Aires (CZ: Warm Humid)
Los Angeles (CZ: Warm Dry)
Vancouver (CZ: Mixed Marine).

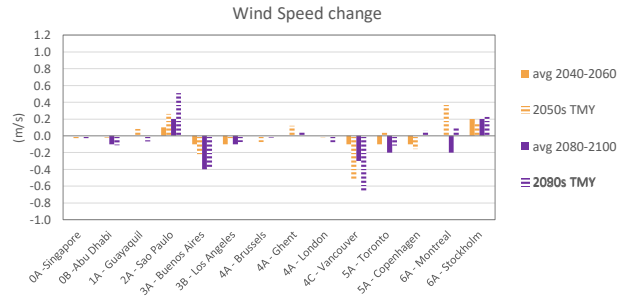
Decreasing RH:
Sao Paulo (CZ: Hot Humid)
Abu Dhabi (CZ: Extremely Hot Dry)

Future weather data : Projected changes in climate variables



Global solar radiation is **reduced in the future TMYs of the majority of the cities**.
This is in agreement with the 20-years projections.

Same results found in other studies. It can be explained by increasing aerosol concentrations and increasing cloudiness



The **changes in wind speed are minimal** for most of the cities.

The 2090s-TMY of Vancouver (CZ: Mixed Marine) has the largest decreases in mean wind speeds of 0.7 m/s.

Future weather data : References and data availablity

The outcomes of this work will be made soon available through a **data paper** (in progress).

The following datasets will be **available for download from the IEA EBC Annex80 webpage**:

- 20-years hourly datatsets
- TMYs in EPW format
- Weather files including heat waves in EPW format

For each city and time period analaysed

Weather Data Task force : Institutions contributing to the data generation

Politecnico di Torino, Italy
La Rochelle Université & CSTB, France
Brunel University London, United Kingdom
Concordia University, Canada
Natural Research Council of Canada
Fraunhofer Institute for Building Physics IBP, Germany
Lawrence Berkeley National Laboratory, California
CIMEC/ CONICET, Argentina
Federal University of Santa Catarina, Brasil
Institute of Building Research & Innovation, Austria
Belgian Building Research Institute (BBRI), Belgium
University of Liege, Belgium
KU Leuven, Belgium
Aalborg University, Denmark
University of Gävle, Sweden
ENEA, Italy

Future weather data : References

REFERENCES:

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European Committee for Standardization, EN ISO 15927: Hygrothermal Performance of Buildings – Calculation and Presentation of Climatic Data – Part 4: Hourly Data for Assessing the Annual Energy Use for Heating and Cooling. Brussels: European Committee for Standardization (2005).

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Thank you!

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