site analysis

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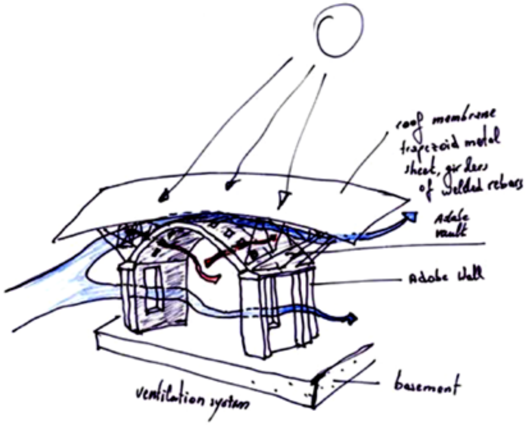
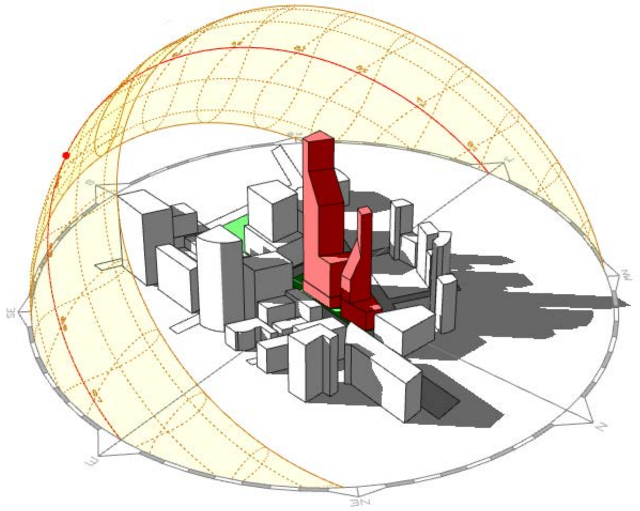
passive design process

- **Context (social & economic)**
- **Site & microclimate assessment**
- Define strategic options (environmental design)
- Test the strategies (using analytic tools)
- Refine & develop design in detail
- Post-occupancy evaluation of performance (POE)

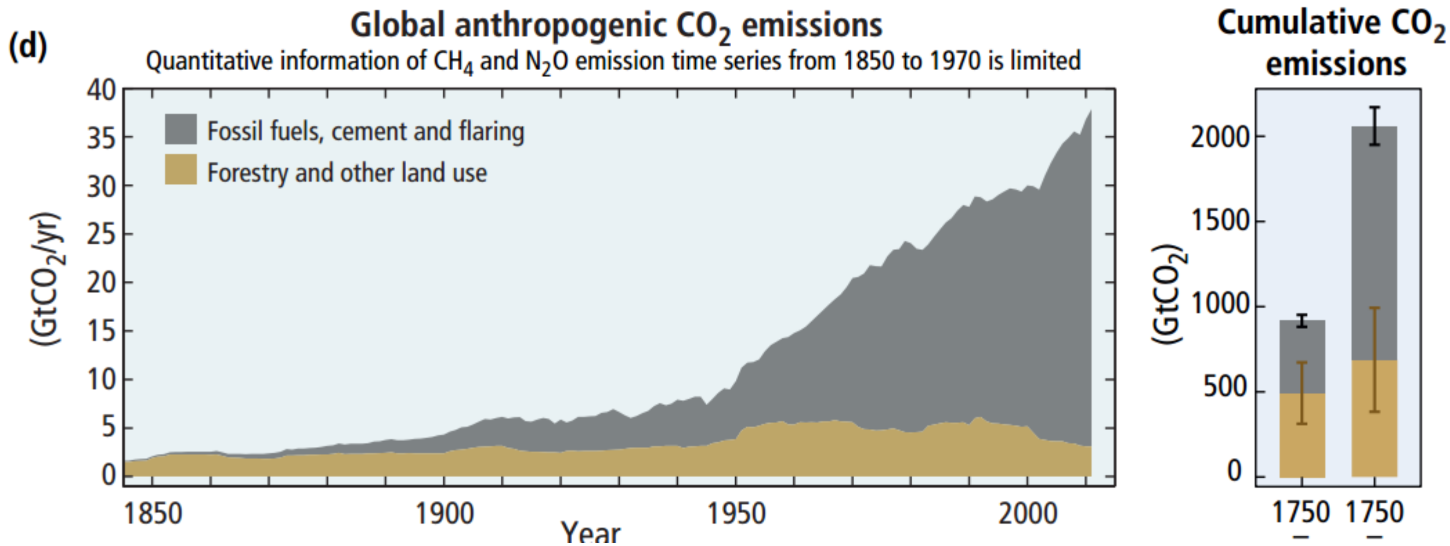


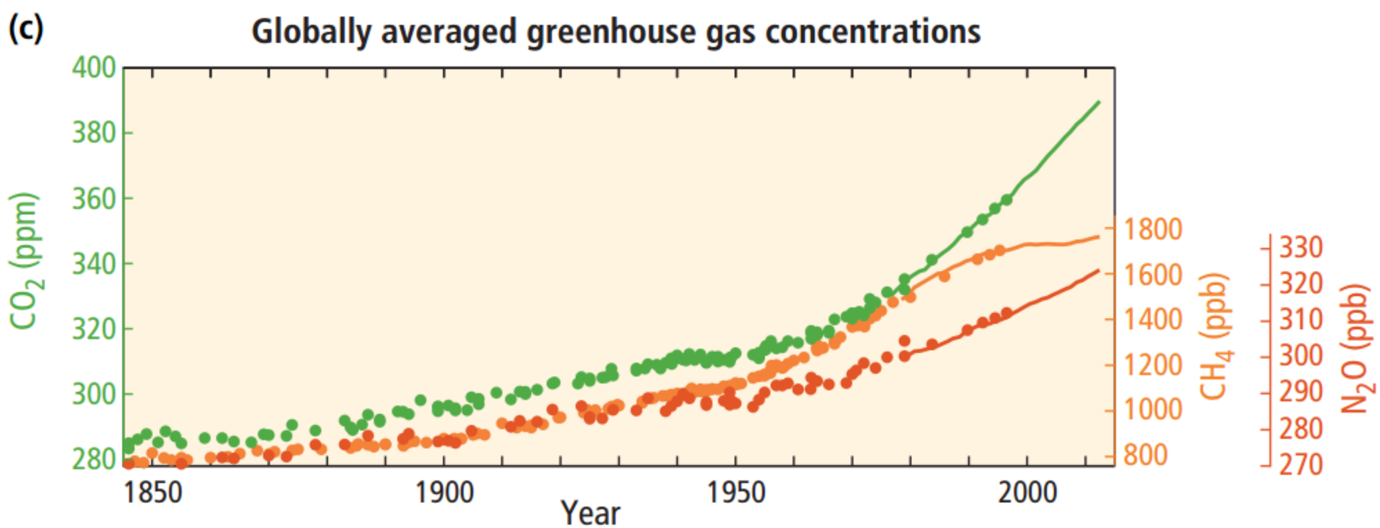


greenhouse effect

Photograph by Martin Meissner

greenhouse effect





IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

Science & Environment

CO2 levels mark 'new era' in the world's changing climate

By Matt McGrath
Environment correspondent

24 October 2016 | Science & Environment

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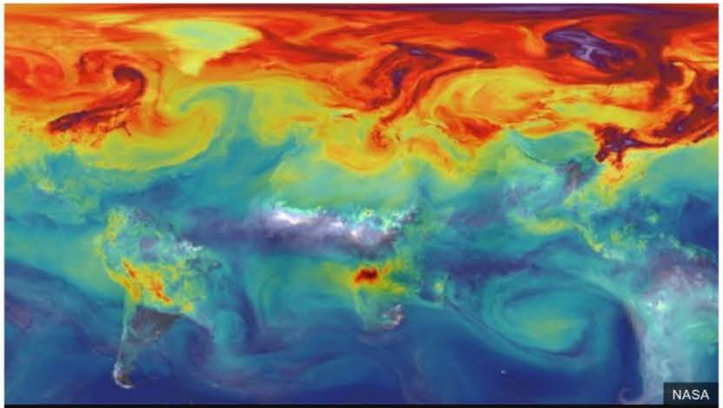

A depiction of the global sources of CO2 which are dominated by the US, China and Europe

Levels of CO2 in the atmosphere have surged past an important threshold and may not dip below it for "many generations".

The 400 parts per million benchmark was **broken globally for the first time in recorded history in 2015**.

But according to the **World Meteorological Organisation** (WMO), 2016 will likely be the first full year to exceed the mark.

The high levels can be partly attributed to a strong El Niño event.

Gas spike

While human emissions of CO2 remained fairly static between 2014 and 2015, the onset of a strong El Niño weather phenomenon caused **a spike in levels of the gas** in the atmosphere.

That's because the drought conditions in tropical regions produced by El Niño meant that vegetation was less able to absorb CO2. There were also extra emissions from fires, sparked by the drier conditions.

In its annual Greenhouse Gas Bulletin, the World Meteorological Organisation says

Top Stories

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A Democrat says the FBI chief may have broken the law by revealing a probe into emails possibly linked to Hillary Clinton.
1 hour ago

£10bn NHS figure is 'false', MPs say
1 hour ago

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5 minutes ago

Features

Station Road
The place that young people want to leave

The Unswayables
Who exactly are Trump's loyal army?

Stolen childhoods
Is a child bride really married every seven seconds?

Climate change: Data shows 2016 likely to be warmest year yet

By Matt McGrath
Environment correspondent

18 January 2017 | Science & Environment | Share

GETTY IMAGES

Record warm temperatures were seen all over the world in 2016, including the Arctic

Temperature data for 2016 shows it is likely to have edged ahead of 2015 as the world's warmest year.

Data from Nasa and the UK Met Office shows temperatures were about 0.07 degrees Celsius above the 2015 mark.

Although the Met Office increase was within the margin of error, Nasa says that 2016 was the third year in a row to break the record.

The El Niño weather phenomenon played a role, say scientists, but the main factor was human emissions of CO_2.

The latest conclusions won't come as a much of a shock to observers, as the likely outcome was **trailed heavily towards the end of last year**.

Animation: Climate change explained in six graphics

What is climate change?

So warm was the early part of 2016 - influenced by a powerful El Niño - that some leading climate scientists were predicting **as early as May that a new record was probable**.

Carbon Dioxide

LATEST MEASUREMENT: September 2016

404.42 ppm

DOWNLOAD DATA

Carbon dioxide (CO_2) is an important heat-trapping (greenhouse) gas, which is released through human activities such as deforestation and burning fossil fuels, as well as natural processes such as respiration and volcanic eruptions. The first chart shows atmospheric CO_2 levels in recent years, with average seasonal cycle removed. The second chart shows CO_2 levels during the last three glacial cycles, as reconstructed from ice cores.

The time series below shows global distribution and variation of the concentration of mid-tropospheric carbon dioxide in parts per million (ppm). The overall color of the map shifts toward the red with advancing time due to the annual increase of CO_2.

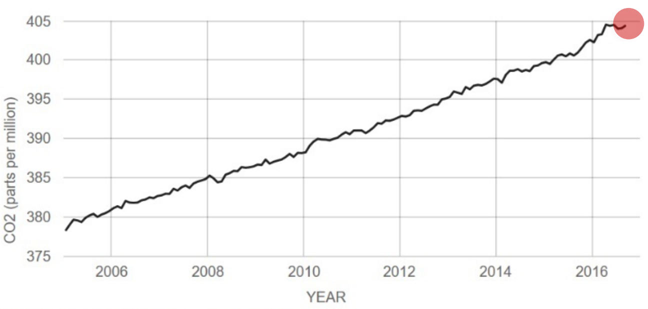
Missions that observe CO_2

Atmospheric Infrared Sounder (AIRS)

Orbiting Carbon Observatory (OCO-2)

DIRECT MEASUREMENTS: 2005-PRESENT

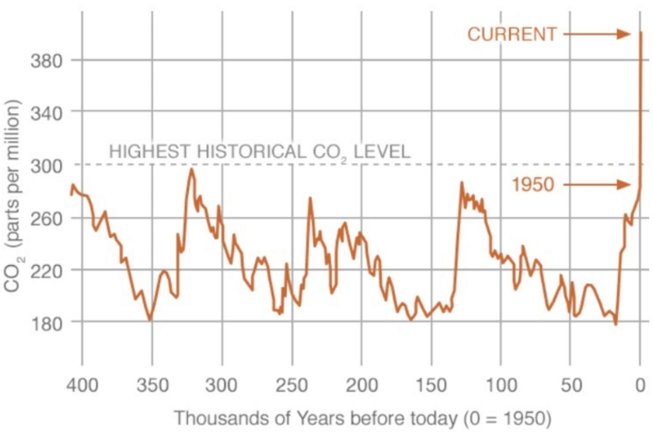
Data source: Monthly measurements (average seasonal cycle removed). Credit: NOAA



Get Data: FTP | **Snapshot:** PNG

PROXY (INDIRECT) MEASUREMENTS

Data source: Reconstruction from ice cores.
Credit: NOAA



Global Temperature

LATEST ANNUAL AVERAGE: 2015

0.87 °C

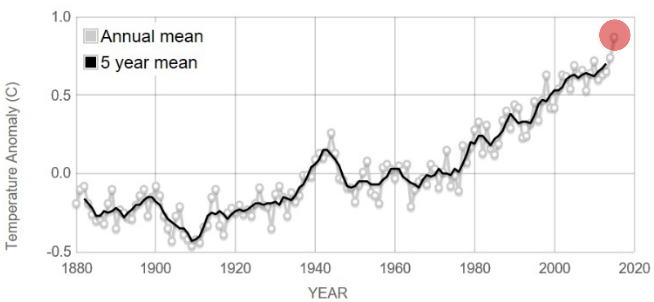
DOWNLOAD DATA

This graph illustrates the change in global surface temperature relative to 1951-1980 average temperatures. The 10 warmest years in the 134-year record all have occurred since 2000, with the exception of 1998. The year 2015 ranks as the warmest on record. (Source: NASA/GISS). This research is broadly consistent with similar constructions prepared by the Climatic Research Unit and the National Oceanic and Atmospheric Administration.

The time series below shows the five-year average variation of global surface temperatures from 1884 to 2015. Dark blue indicates areas cooler than average. Dark red indicates areas warmer than average.

GLOBAL LAND-OCEAN TEMPERATURE INDEX

Data source: NASA's Goddard Institute for Space Studies (GISS).
Credit: NASA/GISS

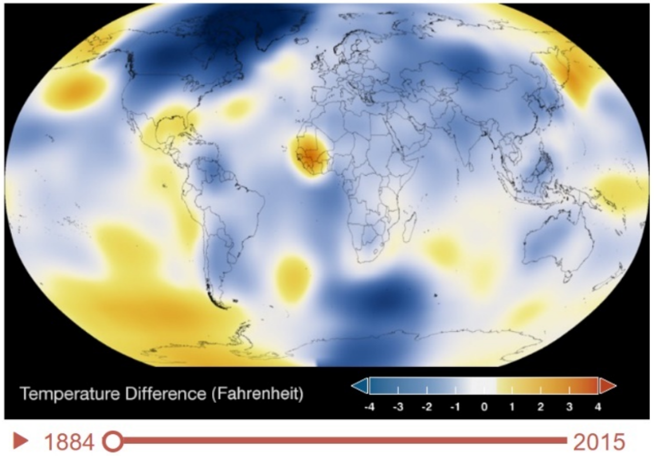


Get Data: HTTP | **Snapshot:** PNG

TIME SERIES: 1884 TO 2015

1884

Data source: NASA/GISS
Credit: NASA Scientific Visualization Studio



COP21

PARIS2015
UN CLIMATE CHANGE CONFERENCE
COP21·CMP11

HISTORIC PARIS AGREEMENT ON CLIMATE CHANGE:

195 Nations Set Path to Keep Temperature Rise Well Below **2** Degrees Celsius buildings are responsible for **40%** of energy consumption and **36%** of CO_2 emissions in Europe.

towards Zero energy

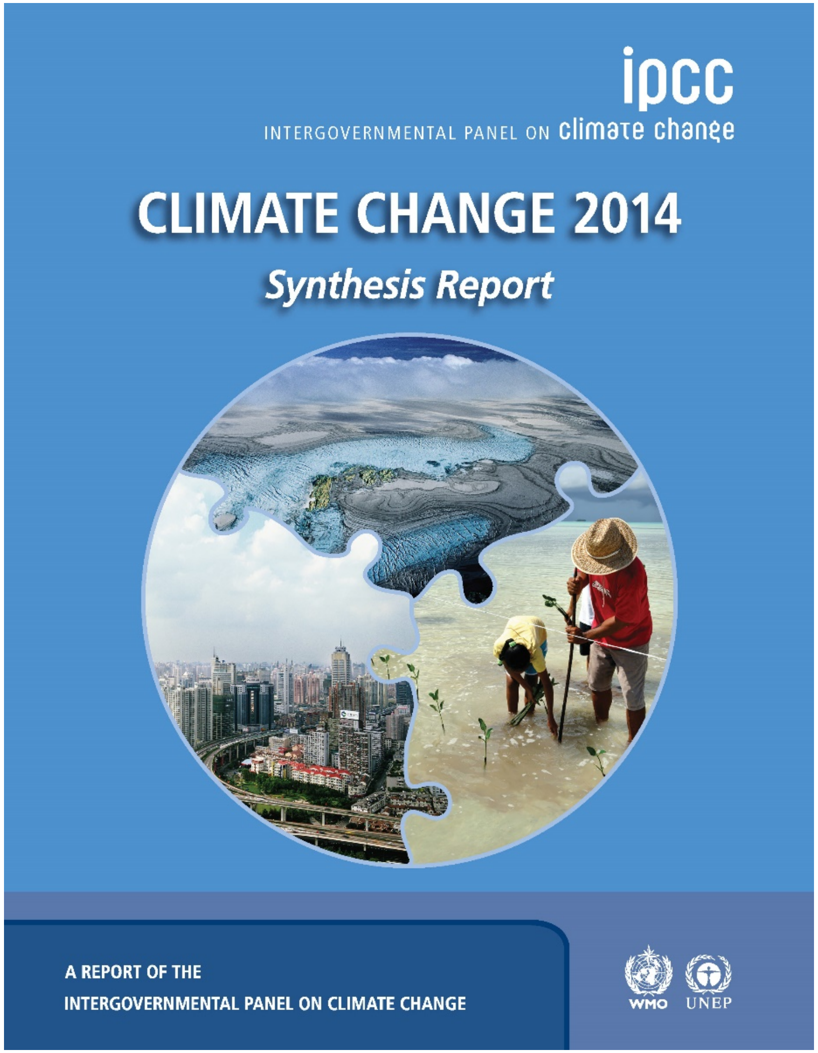
	annual energy consumption for heating	basic requirements
• low-energy houses	**<80 kWh/m2**	basic principles of environmental design
• 3 litre houses	**<30 kWh/m2**	airtightness n50≤1 ACH
• passive houses	**<15 kWh/m2**	restrictive U-values airtightness n50≤0.6 ACH ventilation+ + heat recovery system South-North orientation
• zero-energy houses		40 to 60cm thermal insulation no thermal bridges heat and electrical energy needed is entirely produced through solar energy
• energy self-sufficient houses		generate energy for heating, cooking, water heating and the operation of home appliances through active utilization of solar energy
• plus-energy houses		uses all available means of energy conservation.

IPCC is the leading international body for the assessment of climate change.

Founded in 1988 by United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO).

IPCC Fifth Assessment Report:

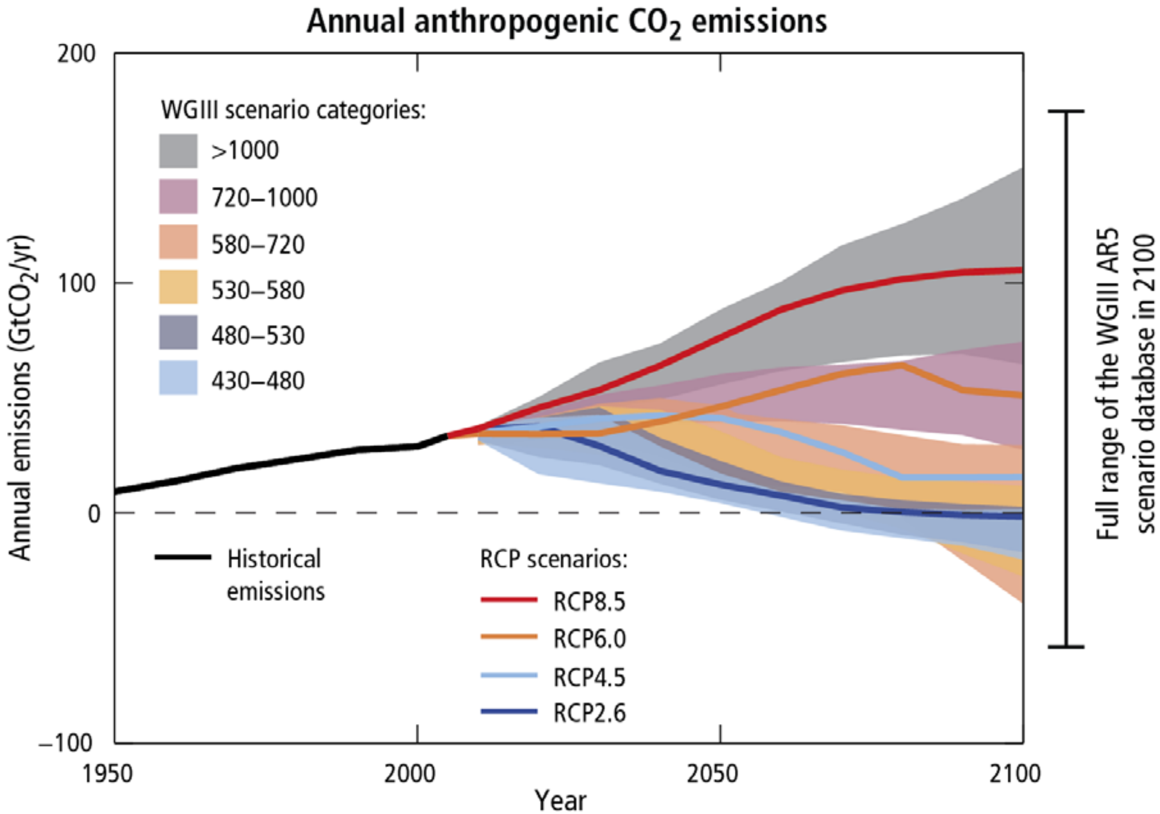
- Climate Change 2014: Synthesis Report.



http://www.ipcc.ch/pdf/assessment-report/ar5/syr/SYR_AR5_FINAL_full_wcover.pdf

IPCC

Emissions of carbon dioxide (CO2) alone in the Representative Concentration Pathways (RCPs) and the associated scenario categories used in WGIII.



RCPs scenarios

RCP8.5 very high GHG emissions

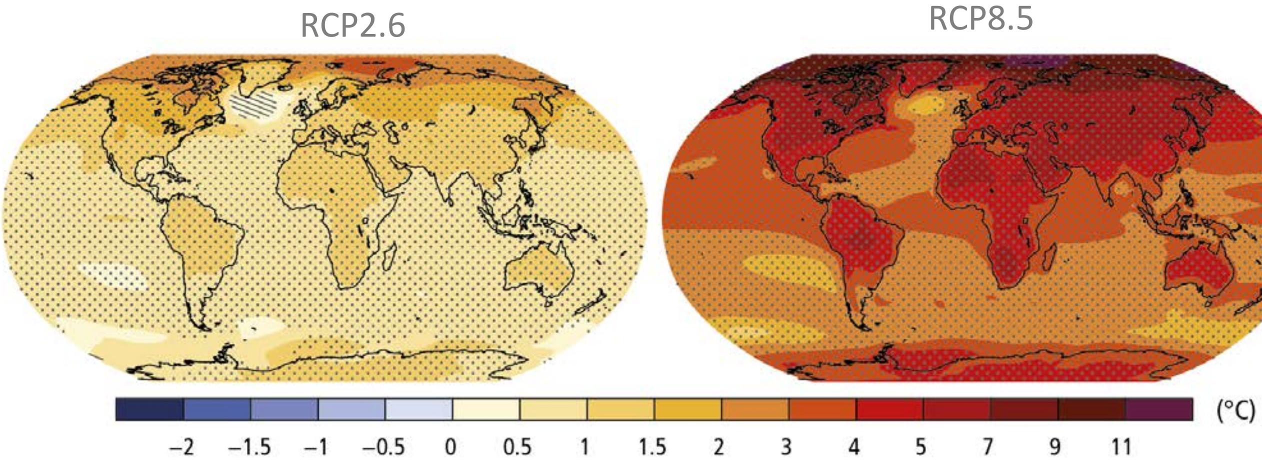
RCP6.0
RCP4.5 intermediate scenarios

RCP2.6 stringent mitigation scenario

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

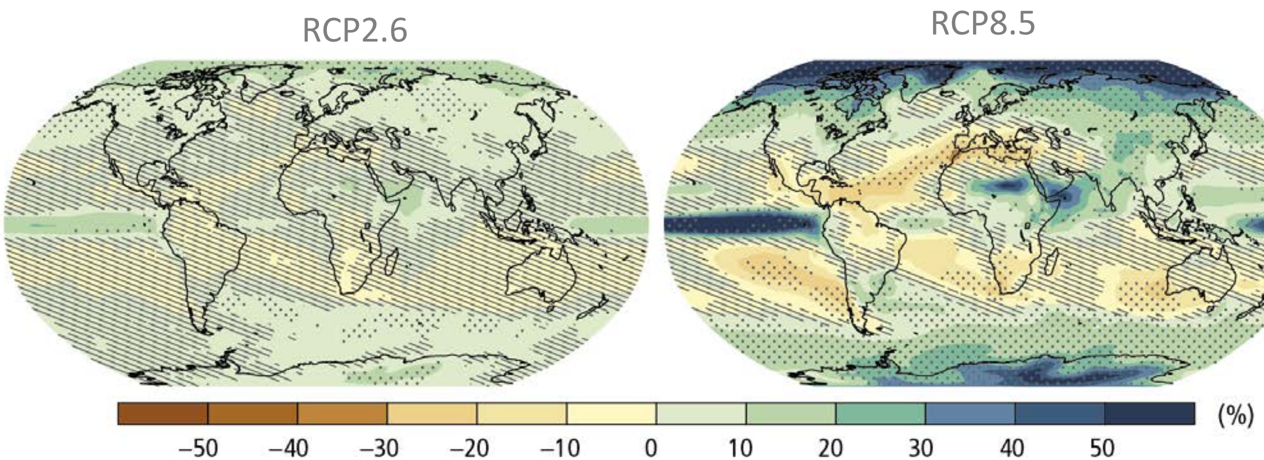
IPCC

Change in average surface temperature (1986-2005 to 2081-2100)



Projected change in average surface temperature for 2081-2100 relative to the period 1986-2005.

Change in average precipitation (1986-2005 to 2081-2100)



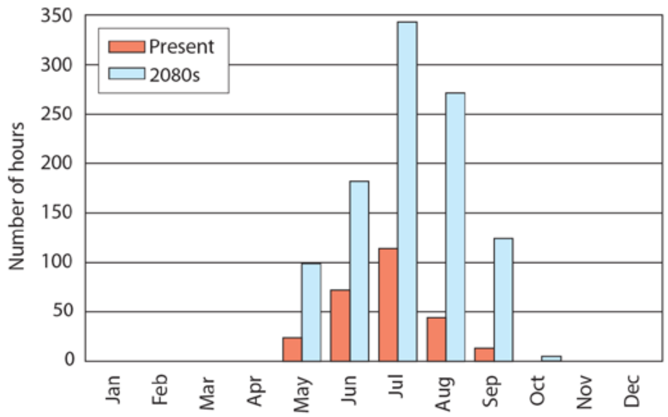
Projected change in average precipitation for 2081-2100 relative to the period 1986-2005.

IPCC, 2014: Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team, R.K. Pachauri and L.A. Meyer (eds.)]. IPCC, Geneva, Switzerland, 151 pp.

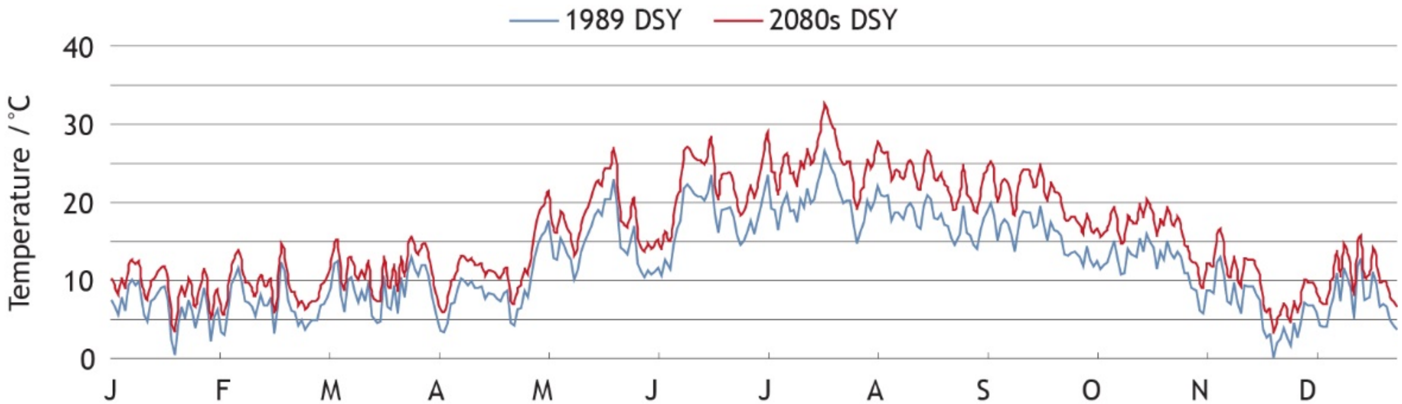
climate change

Projections of future changes in the UK:

Annual variation of hours of exceedance of 25 °C for London DSY 1989



Daily average temperature for London for 1989 and 2080s Medium-High scenario



CIBSE (2005). TM36: Climate change and the indoor environment: impacts and adaptation. CIBSE Knowledge Series KS 6. Chartered Institution of Building Services Engineers, London.

World Map of Köppen−Geiger Climate Classification

updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000

Af Am As Aw BWk BWh BSk BSh Cfa Cfb Cfc Csa Csb Csc Cwa

Cwb Cwc Dfa Dfb Dfc Dfd Dsa Dsb Dsc Dsd Dwa Dwb Dwc Dwd EF ET

Main climates

A: equatorial
B: arid
C: warm temperate
D: snow
E: polar

Precipitation

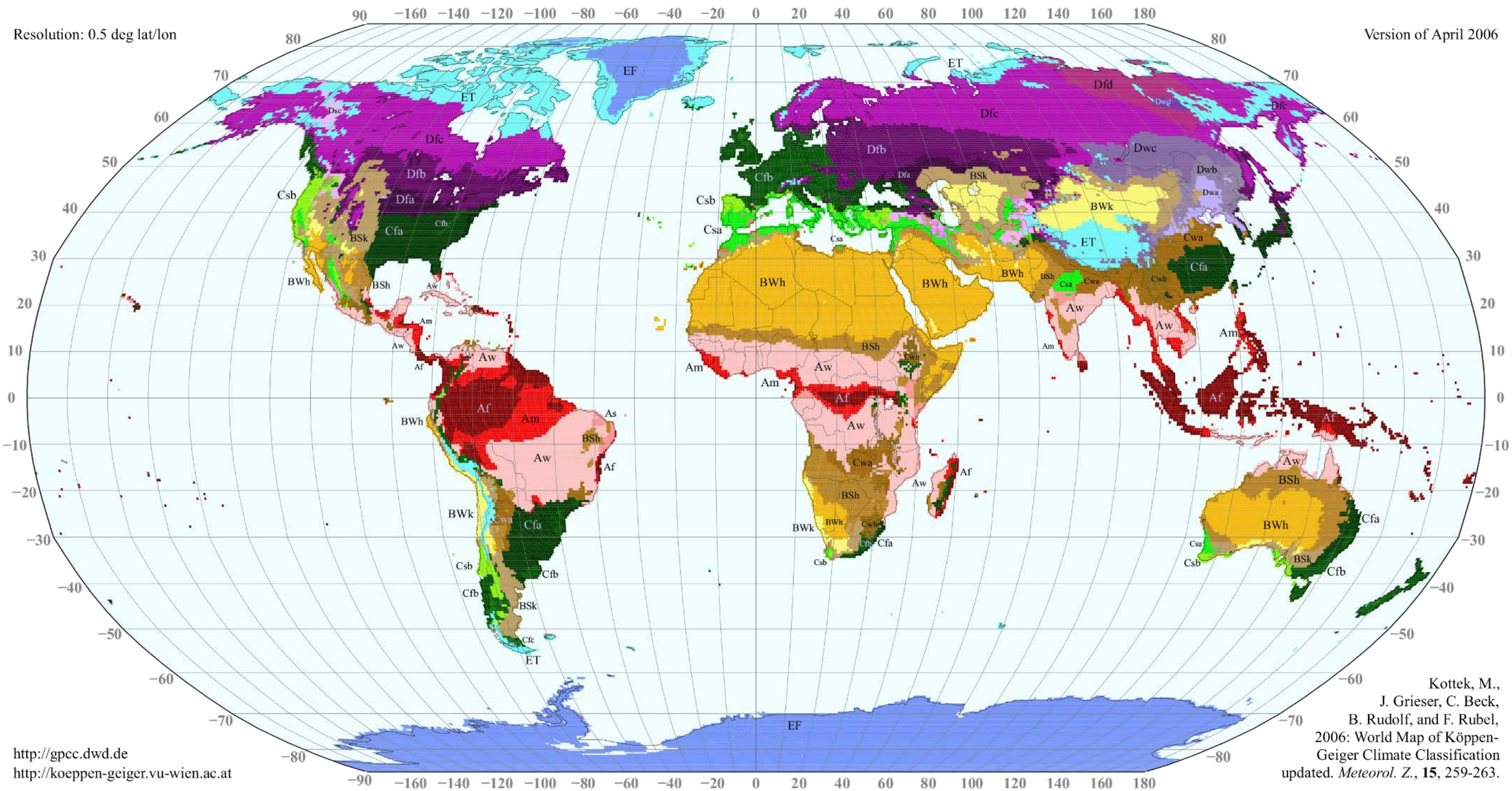
W: desert
S: steppe
f: fully humid
s: summer dry
w: winter dry
m: monsoonal

Temperature

h: hot arid
k: cold arid
a: hot summer
b: warm summer
c: cool summer
d: extremely continental
F: polar frost
T: polar tundra

Resolution: 0.5 deg lat/lon

Version of April 2006



http://gpcc.dwd.de
http://koeppen-geiger.vu-wien.ac.at

Kottek, M., J. Grieser, C. Beck, B. Rudolf, and F. Rubel, 2006: World Map of Köppen-Geiger Climate Classification updated. *Meteorol. Z.*, **15**, 259-263.

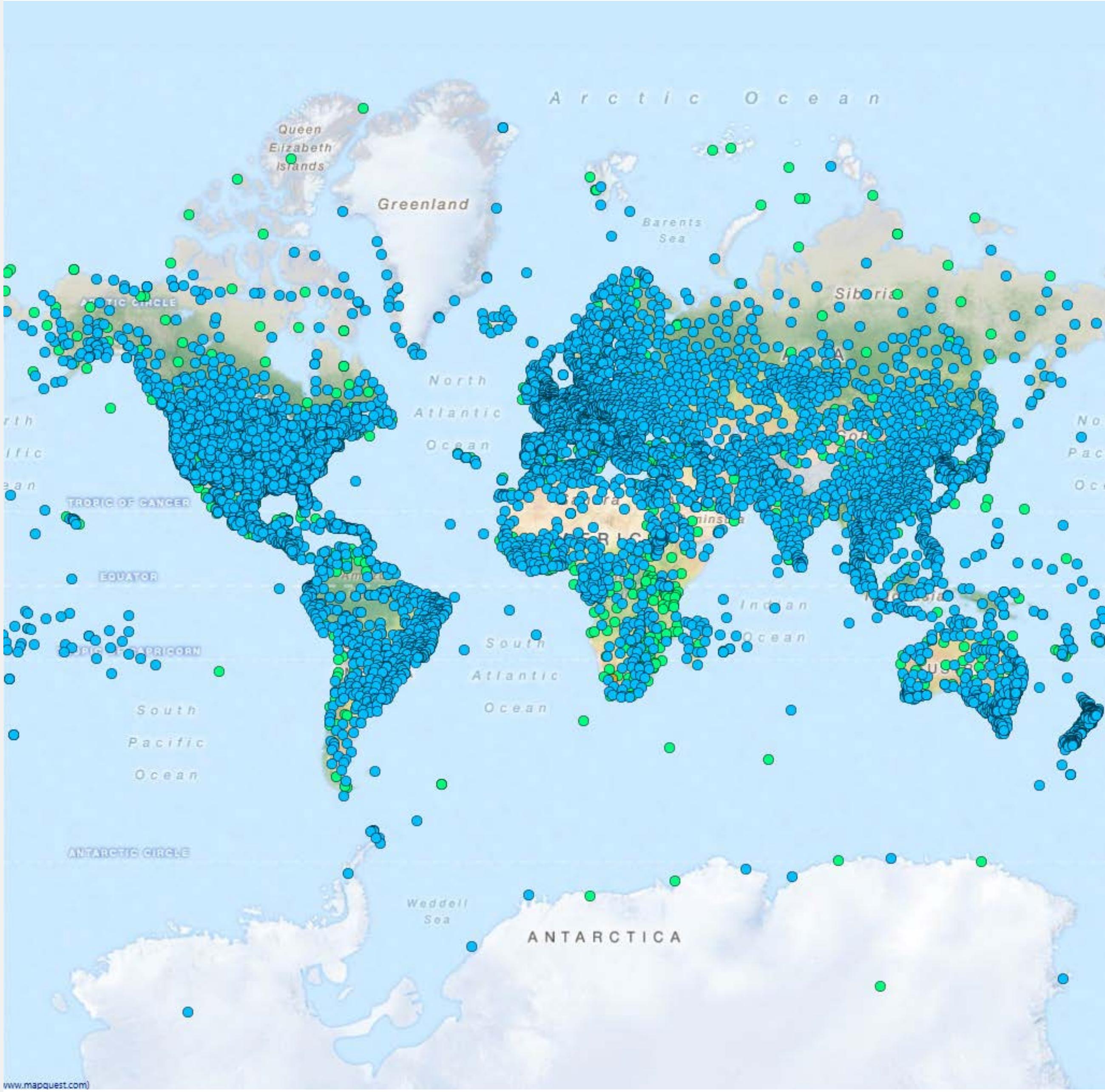
http://meteonorm.com/

Meteonorm contains worldwide weather data from 8325 weather stations

Over 30 meteorological parameters: irradiation, temperatures, precipitation, humidity, wind…

Contains several climate change scenarios

Can interpolate data for any location worldwide



meteonorm

Step by step:

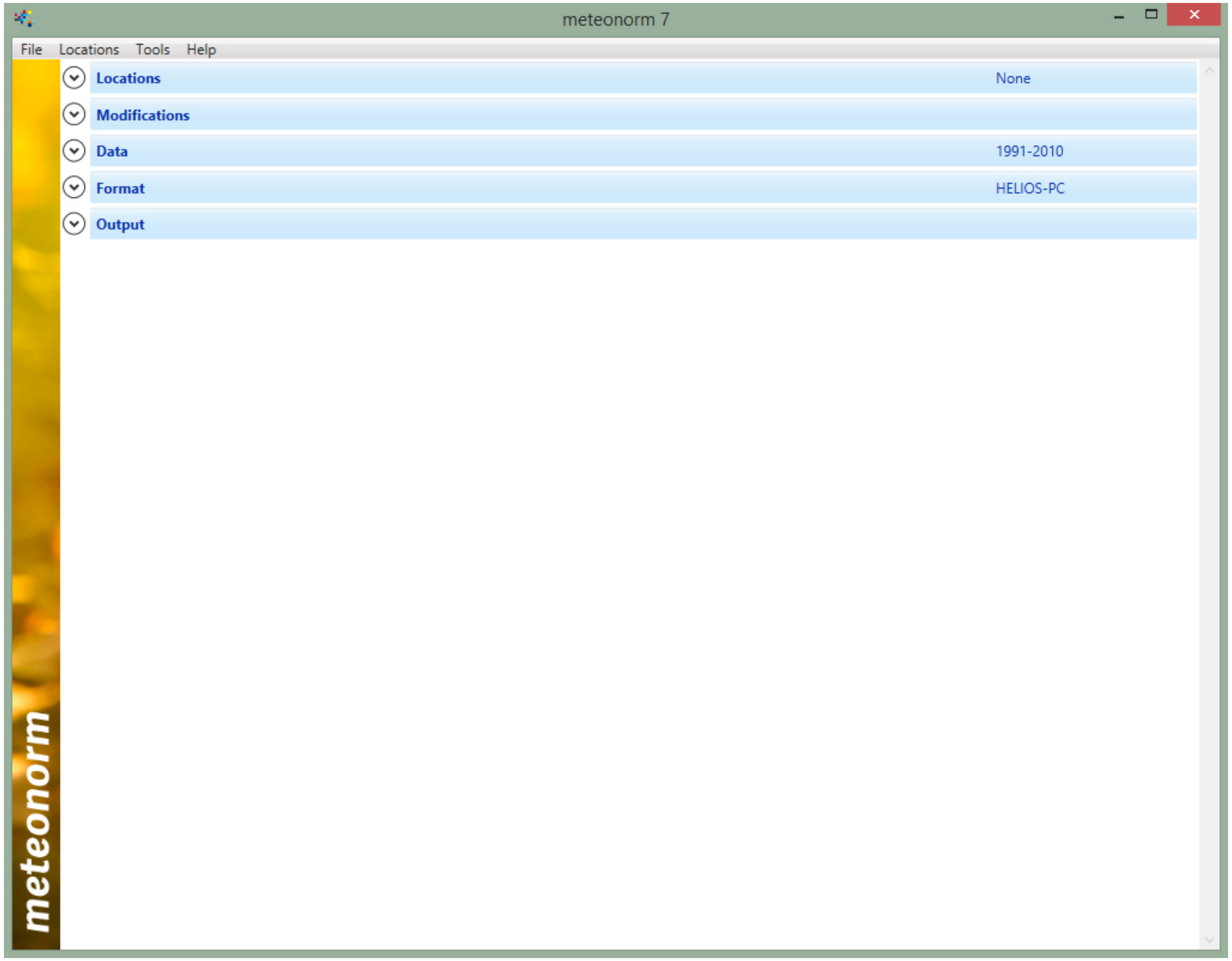
- **Locations:** Select the locations for which you want to run Meteonorm.

- **Modifications:** Modify the location specific settings.

- **Data:** Adjust data settings.

- **Format:** Set the output format.

- **Output:** Calculate and store the results

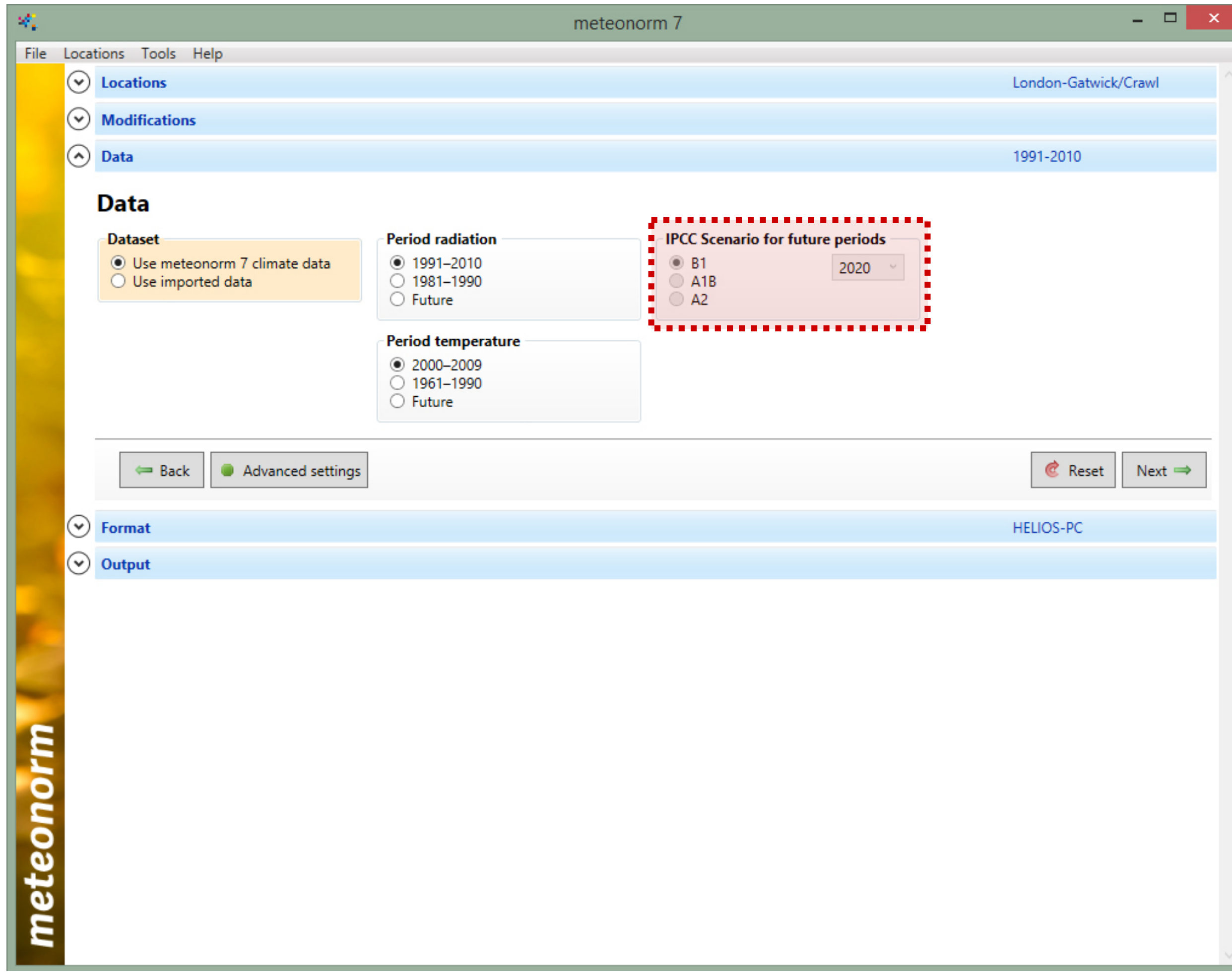


Data:

IPCC Scenarios:

- The IPCC introduced in 2014 **the Representative Concentration Pathways (RCPs)**, the third generation of scenarios.

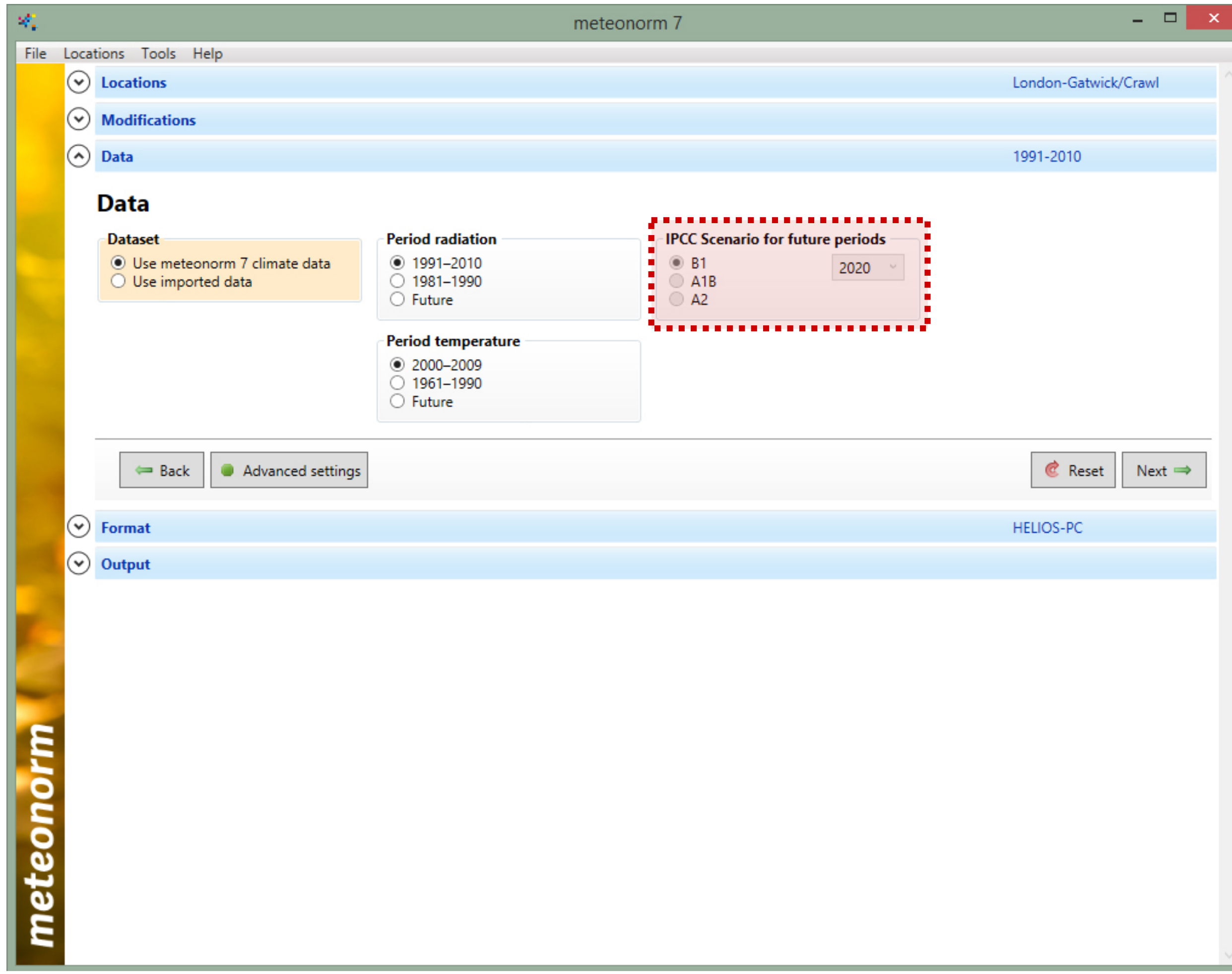
- Meteonorm includes three **Special Report on Emissions Scenarios (SRES),** the second generation of scenarios introduced by the IPCC in 2000.



Data:

IPCC Scenarios:

- Three different scenarios are available:
  - **B1** (low GHG emissions)
  - **A1B** (intermediate scenario)
  - **A2** (high GHG emissions)

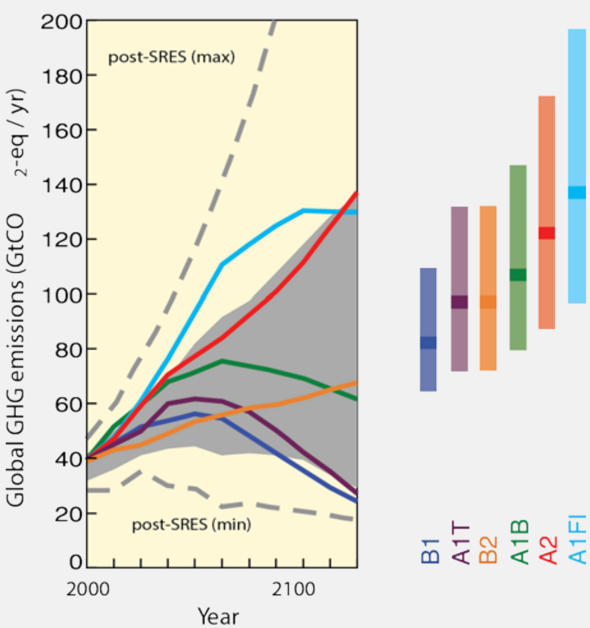


meteonorm

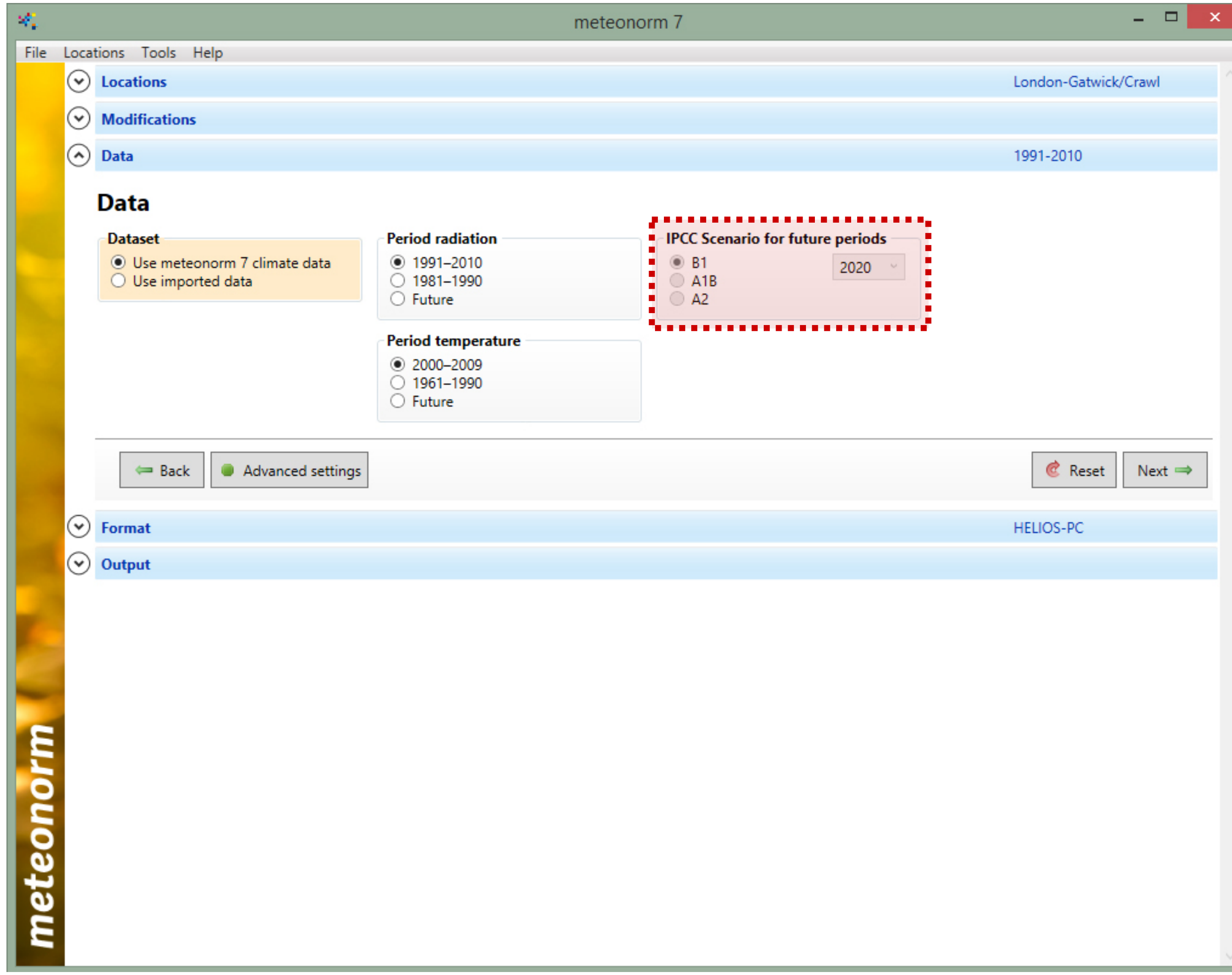
Data:

IPCC Scenarios:

Scenarios for GHG emissions



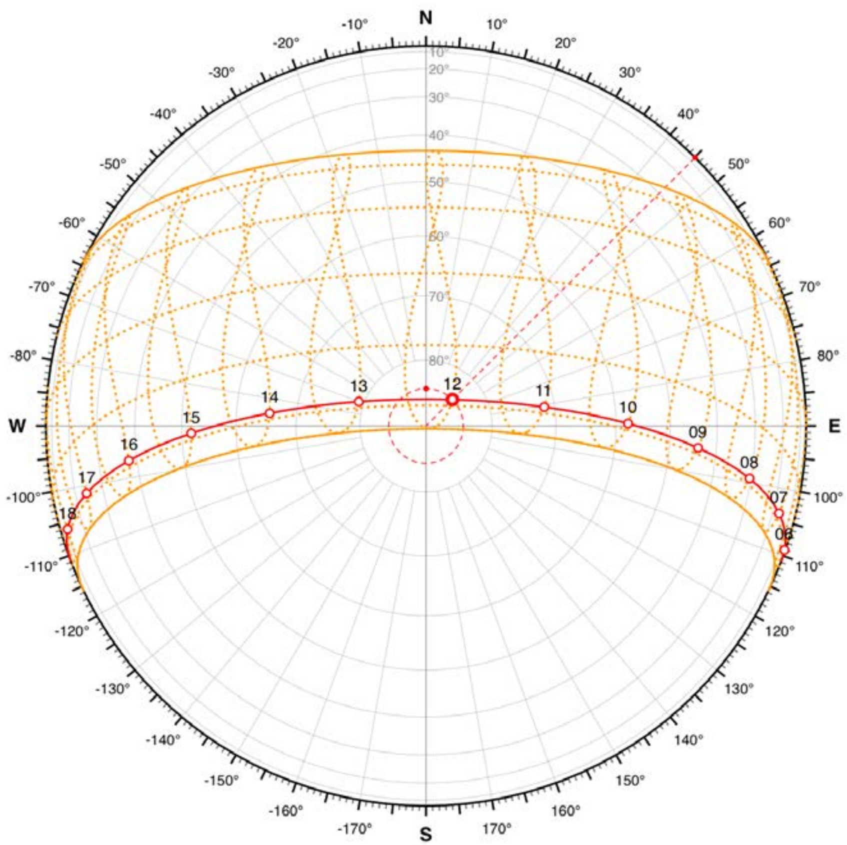
IPCC, 2007: Climate Change 2007: Synthesis Report.



solar radiation

sun path diagram

Represents the seasonal-and-hourly positional changes of the sun over the sky dome.



http://andrewmarsh.com/apps/releases/sunpath2d.html

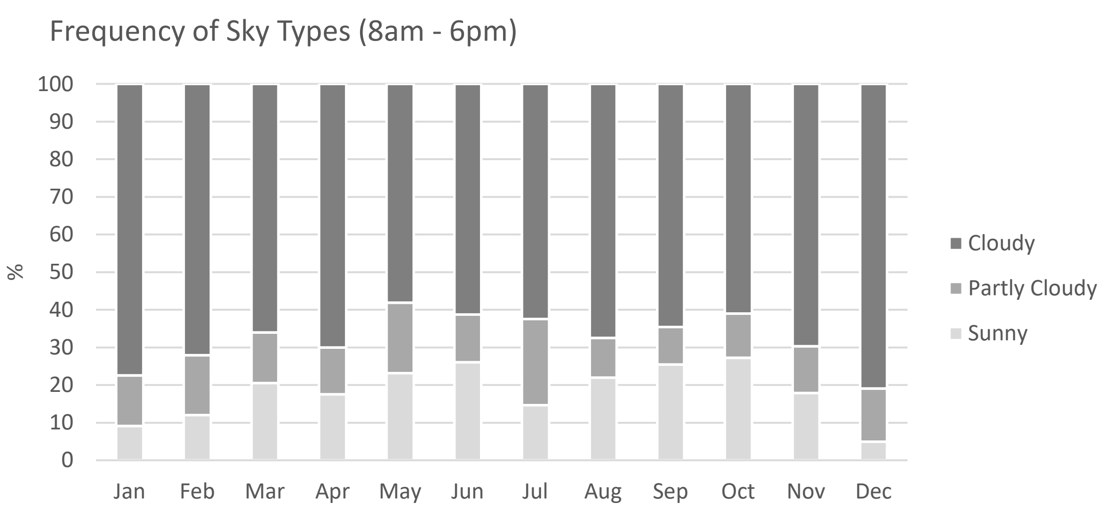
frequency studies

Benefits of performing frequency climatic analysis:

- A frequency study of the climatic conditions will help to understand the impact of the results obtained in your analysis over the year.

- Will help to define the level of intervention that best suits your project requirements.

- Will inform about the potential and the applicability of different passive strategies in your project. The results can be filtered considering a defined schedule in order to obtain more precise information.



processing weather data

Benefits of performing frequency climatic analysis:

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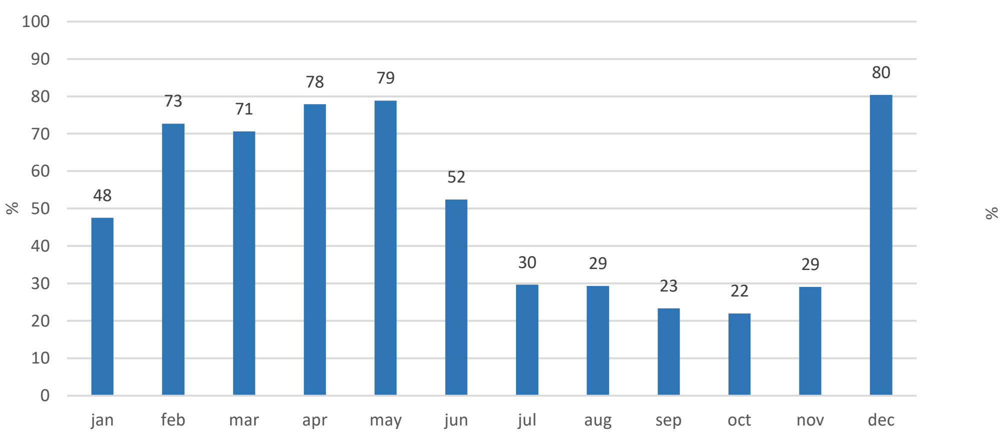
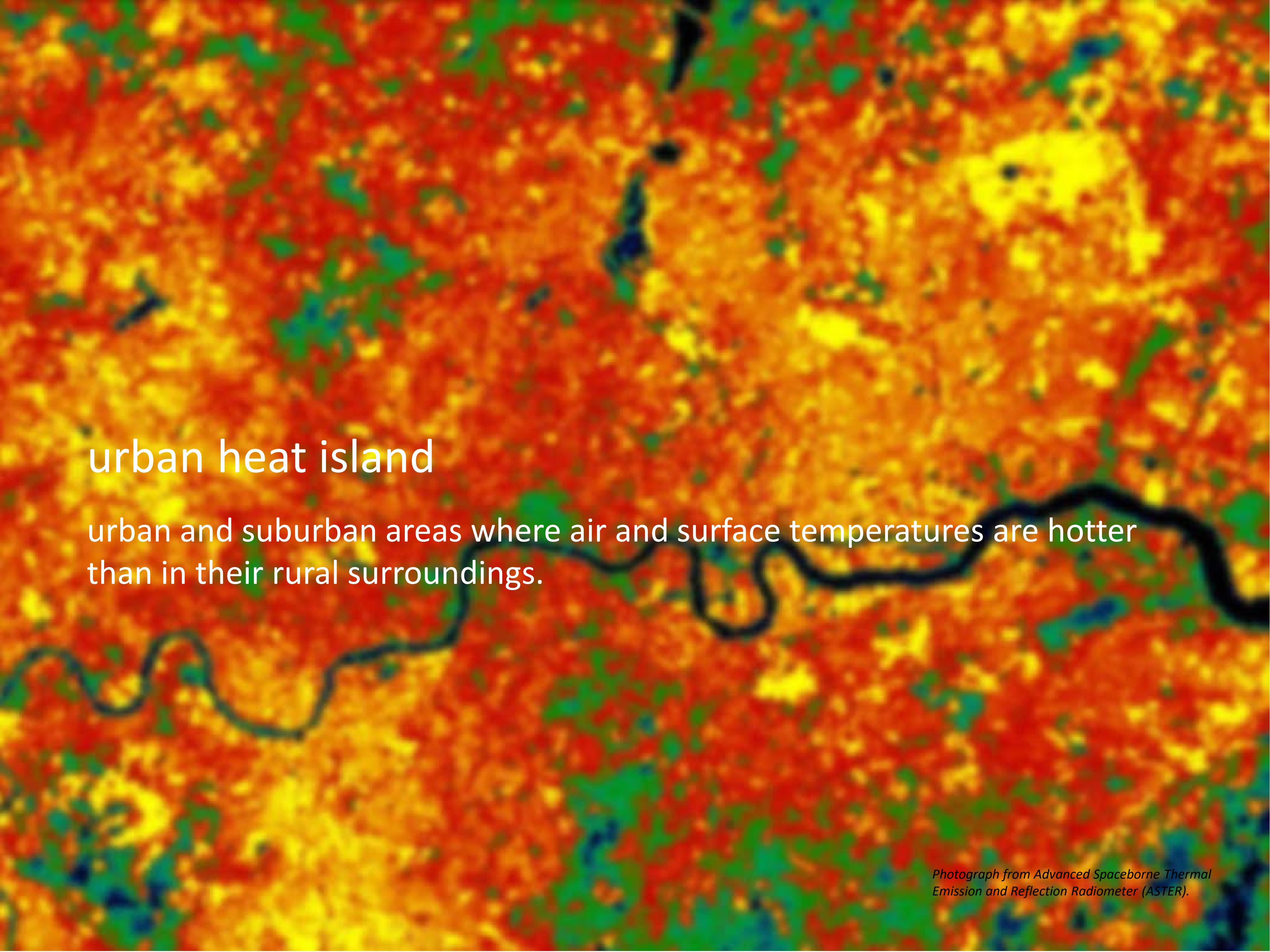
Dry bulb temperature – **Natural ventilation**



Percentage of occupied hours when External DBT is within the Ashrae-55 comfort band (90% acceptability) - Dakar, Senegal



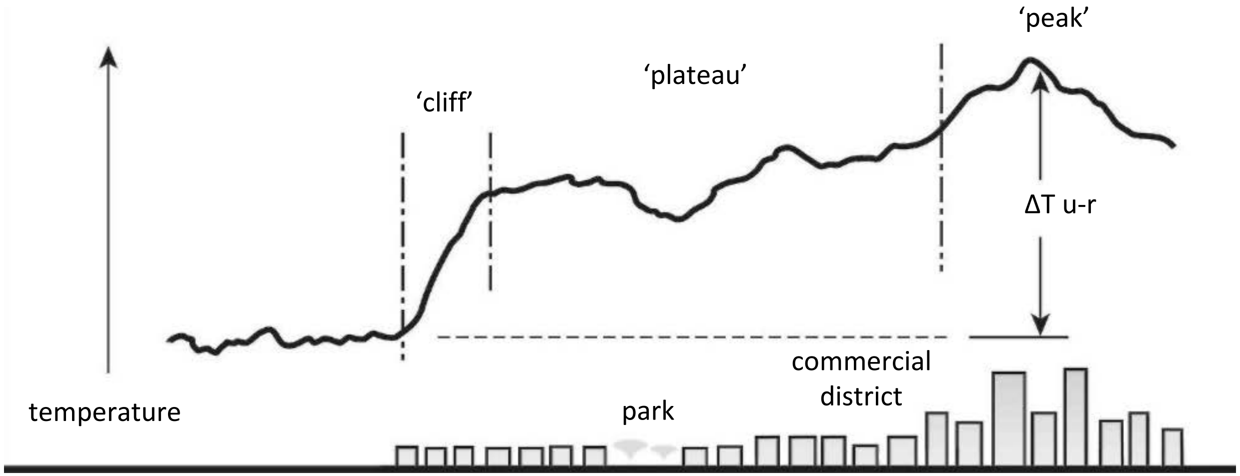
urban heat island

urban and suburban areas where air and surface temperatures are hotter than in their rural surroundings.

Photograph from Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER).

urban heat island

generalized cross-section of a typical UHI.



the conventional measure of the intensity of the urban heat island is the temperature difference between an 'urban' location and a 'rural' one.

Erell, (2010).

types of urban heat island

surface heat island (SHI)

temperature of urban surfaces is greater than that of the surrounding rural (natural) surfaces.

urban SHIs are largest during the daytime, especially in sunny conditions with little wind, and are generally weaker at night.

canopy-layer heat island (CLHI)

is observed in the layer of air closest to the surface in cities.

It is typically observed at night in stable atmospheric conditions and is weaker or non-existent during the daytime.

boundary-layer heat island (BLHI)

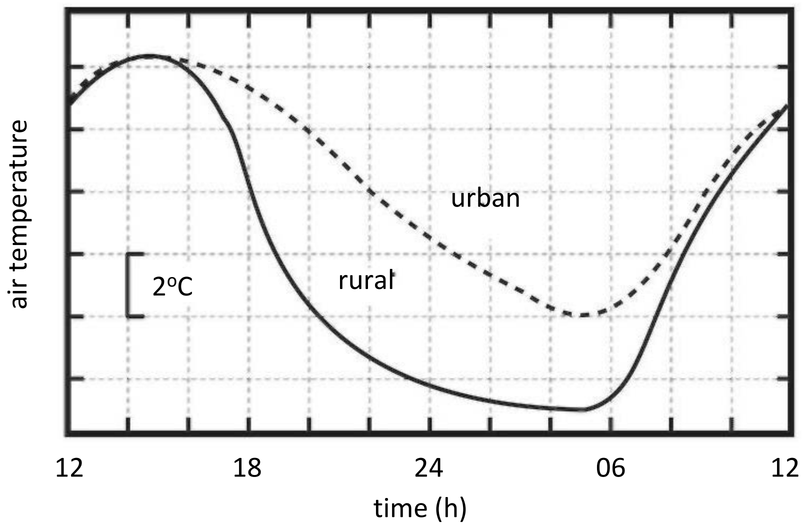
forms a dome of warmer air that extends downwind of the city.

it is sensitive to wind changes.

Erell, (2010).

urban heat island

typical diurnal variation of urban and rural air temperature.

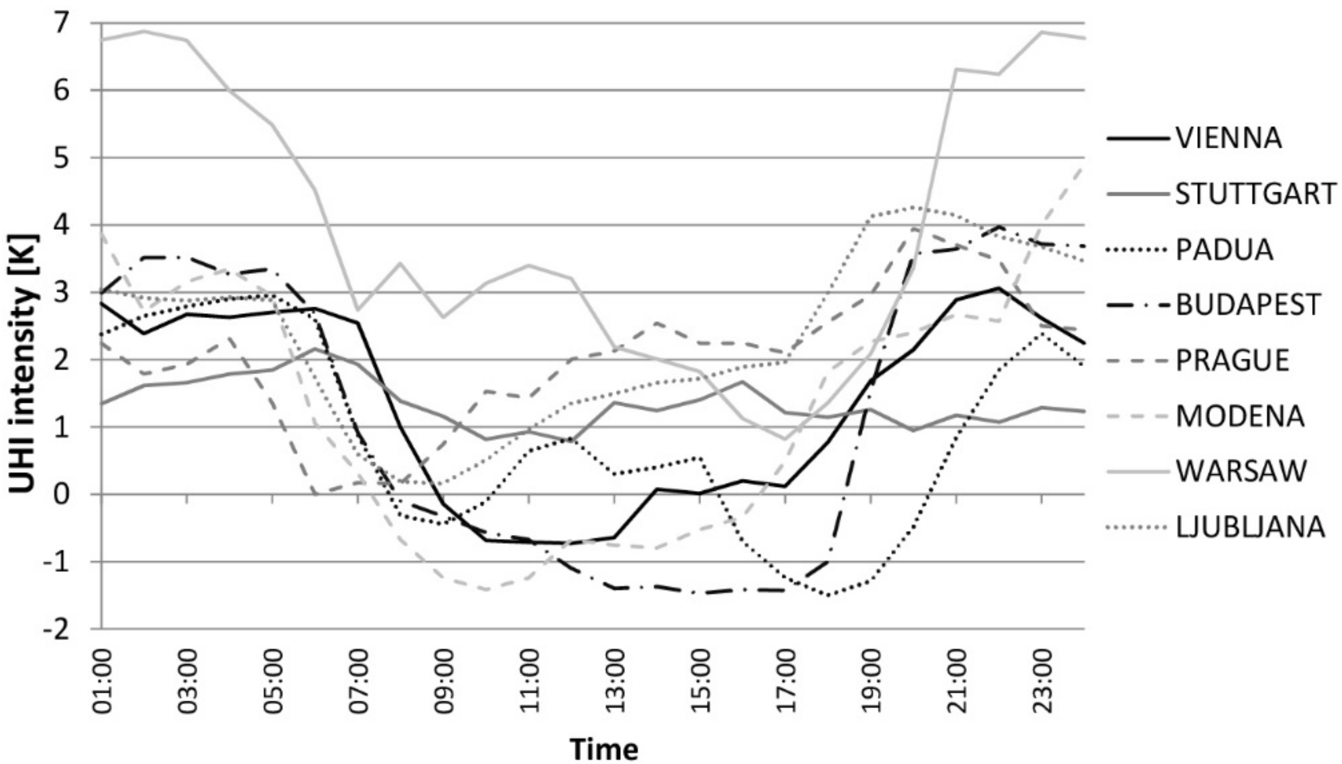


the nocturnal UHI is formed as the result of relatively rapid cooling in rural areas in the late afternoon and early evening, compared with slower cooling in the city.

Erell, (2010).

urban heat island

hourly UHI intensity distribution for a reference summer day in eight European cities.

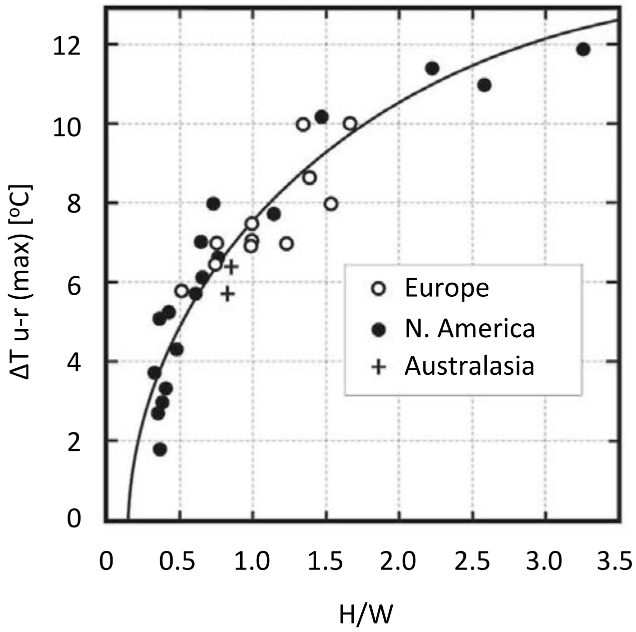


Ardeshir Mahdavi, PhD, (2014).

factors affecting urban heat island intensity

building density

relation between maximum observed heat island intensity and the H/W ratio.



a dense matrix of buildings promotes the creation of urban heat islands through a variety of processes.

Erell, (2010).

factors affecting urban heat island intensity

building density

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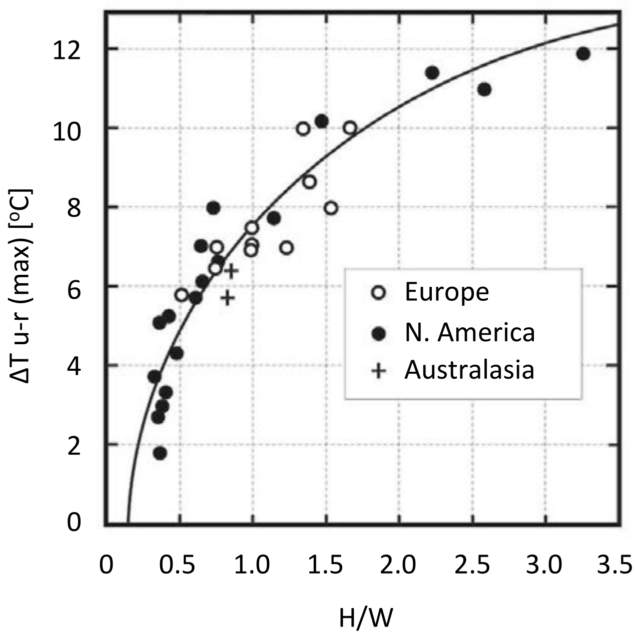


- solar energy is trapped due to multiple reflection and absorption within urban canyons.

- restricted SVF inhibits the net emission of long-wave radiation to the sky .

a dense matrix of buildings promotes the creation of urban heat islands through a variety of processes.

Erell, (2010).

factors affecting urban heat island intensity

urban materials

surface	Albedo (α)	Emissivity (ε)
man-made		
asphalt	0.05–0.20	0.95
concrete	0.10–0.35	0.71–0.90
brick	0.20–0.40	0.90–0.92
corrugated iron	0.10–0.16	0.13–0.28
fresh white paint	0.70–0.90	0.85–0.95
clear glass (normal incidence)	0.08	0.87–0.94
natural		
forest	0.07–0.20	0.98
grass	0.15–0.30	0.96
soil (wet)	0.10–0.25	0.98
soil (dry)	0.20–0.40	0.90–0.95

the intensity of SHIs is higher with highly absorptive materials such as asphalt or dark-coloured roof tiles.

evaporation of soil moisture leads to a reduced sensible heat flux and hence to lower air temperatures.

Erell, (2010).

factors affecting urban heat island intensity

vegetation

- intercepts solar radiation (thus shading the surface).
- it blocks incoming longwave radiation (from the sky) and outgoing radiation emitted by the ground.
- reduces air speed when wind is blowing.
- provides moisture through evapotranspiration.

Erell, (2010).

factors affecting urban heat island intensity

weather

heat island magnitudes are largest under calm and clear weather conditions.

geographic location

regional or local weather influences, such as local wind systems or coastal cities may impact heat islands.

human activity

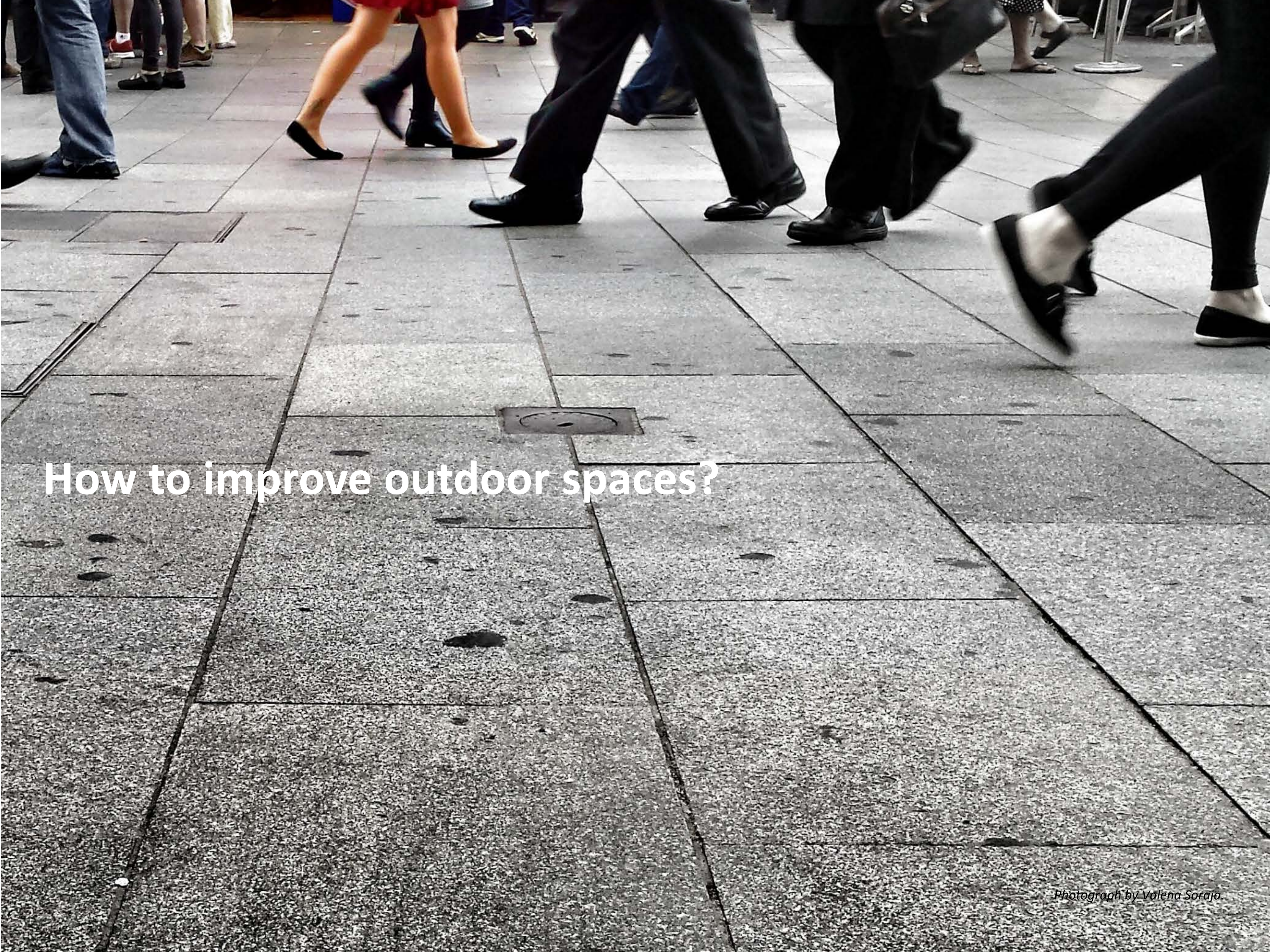
modifies the urban atmosphere in various ways, including the emission of industrial pollutants and exhaust fumes from vehicles.

Erell, (2010).

mitigating urban heat island

Category	Measure	Expected benefit
Buildings	Cool roofs	High solar reflectance and thermal emissivity.
	Green roofs	Shading (intensive green roofs) and evapotranspiration.
	Green facades	Reducing ambient air temperature, shading properties, natural cooling, control airborne pollutants, energy efficiency.
	Façade construction and retrofit	Reducing cooling/heating load, reducing ambient air temperature, improving building envelope quality.
	Geometry of urban canyon (new projects)	Fresh air advection cool air transport into the city.
Pavements	Cool pavements	Decreasing ambient air temperature.
	Pervious pavements	Storm water management.
Green areas	Planting trees within the urban canyon	Shading (in case of trees) and evapotranspiration lower peak summer air temperatures, reducing air pollution.
	Parks, green areas	

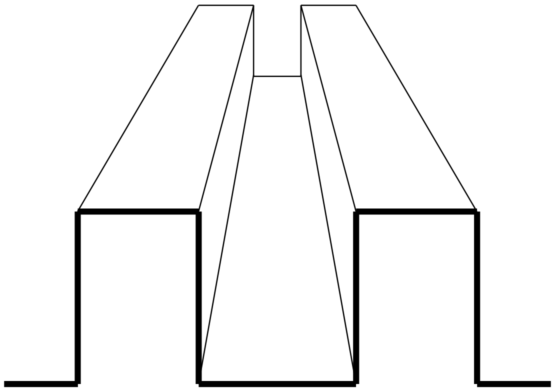
Ardeshir Mahdavi, PhD, (2014).


How to improve outdoor spaces?
Photograph by Valena Soraja


urban fabric
Granada (Spain) Google Maps.

urban canyon

urban canyon is one of the most widely used model to describe the fabric of buildings and open spaces.



sky view factor (SVF) & height-to-width ratio (H/W)

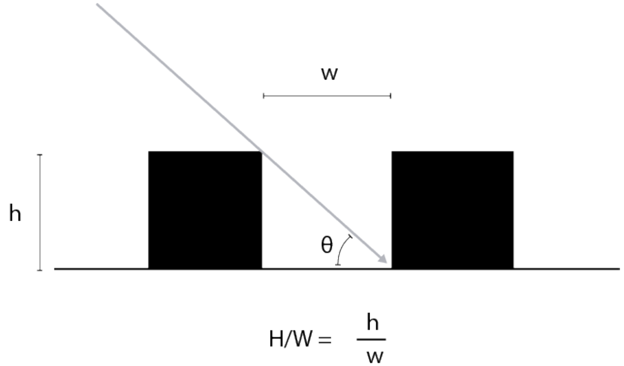
- Used to describe the urban density, urban canyons, courtyards…

SVF

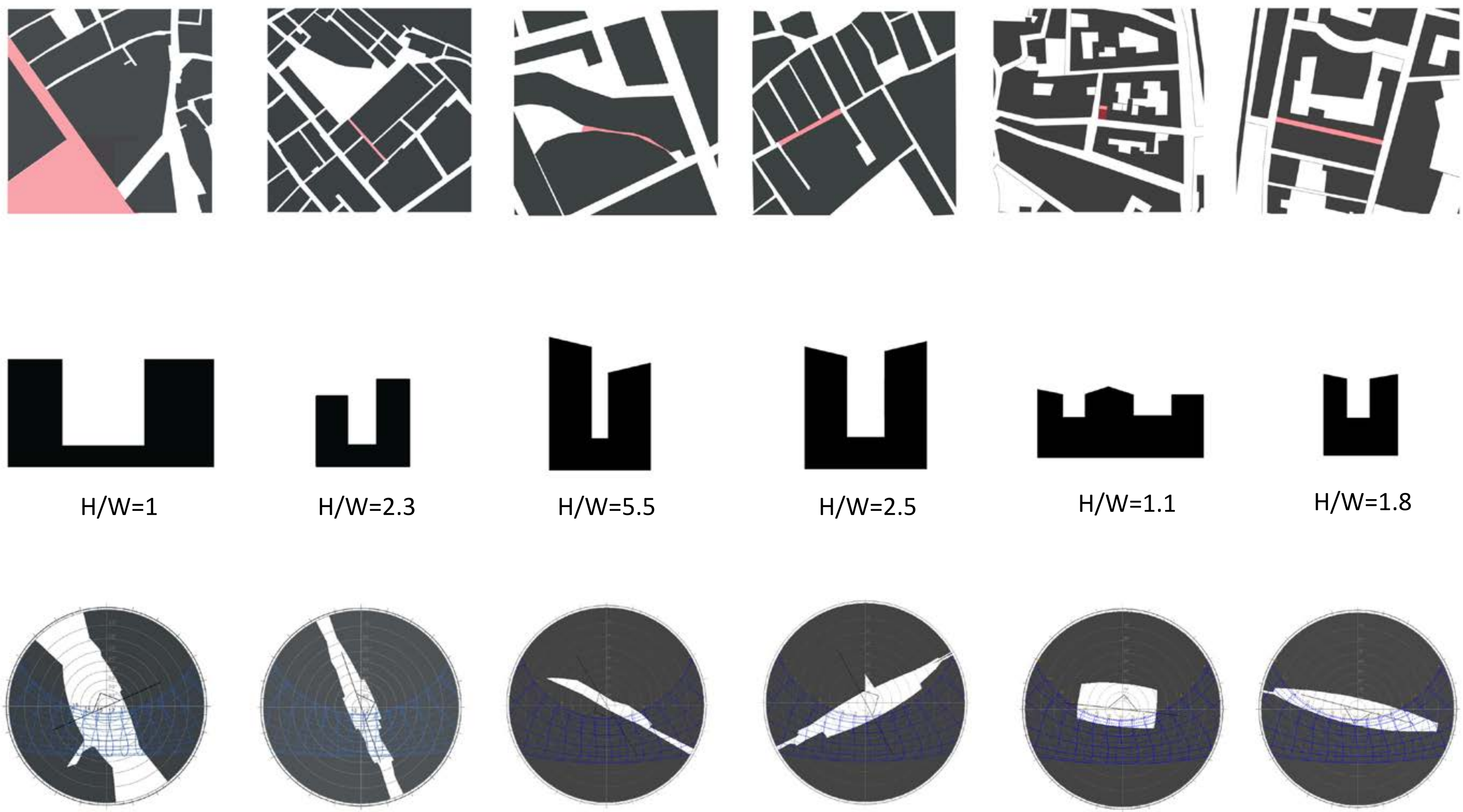
- The proportion of the sky dome that is ‘seen’ by a surface, either from a particular point on that surface or integrated over its entire area

H/W

- Describes the sectional proportions of the urban layout. It is defined as the ratio between the average height of adjacent vertical elements (such as building facades) and the average width of the space.

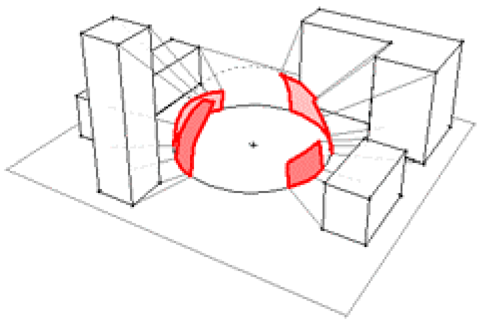


sky view factor (SVF) & height-to-width ratio (H/W)

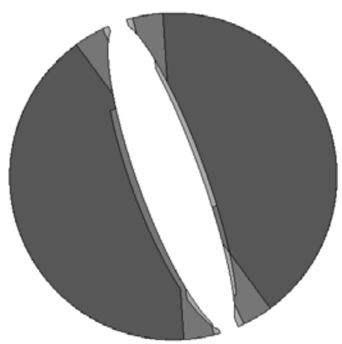


shading mask

- There are a large variety of tools to estimate the SVF and plot shading masks for more complex and irregular geometries, which are characteristic of most real urban settings.

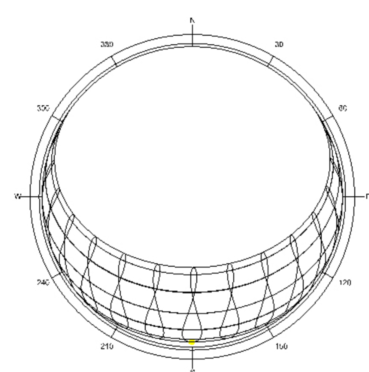


http://andrewmarsh.com/blog/2011/05/03/real-time-site-analysis



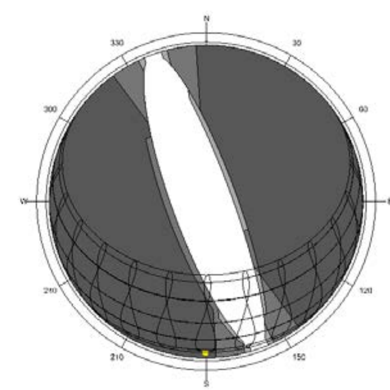
SVF

+



Sun path diagram

→



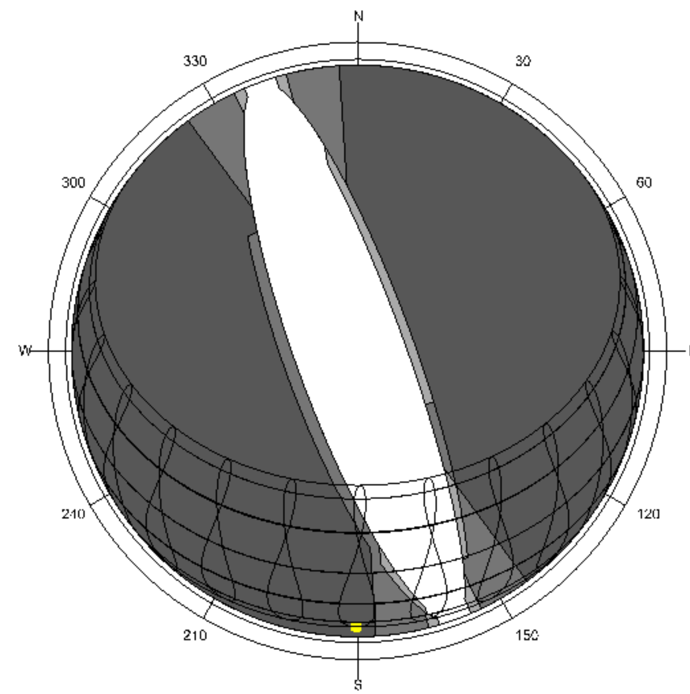
Shading mask

shading mask

- Shading masks allow you to determine the extent of overshadowing for selected objects on a sun-path diagram

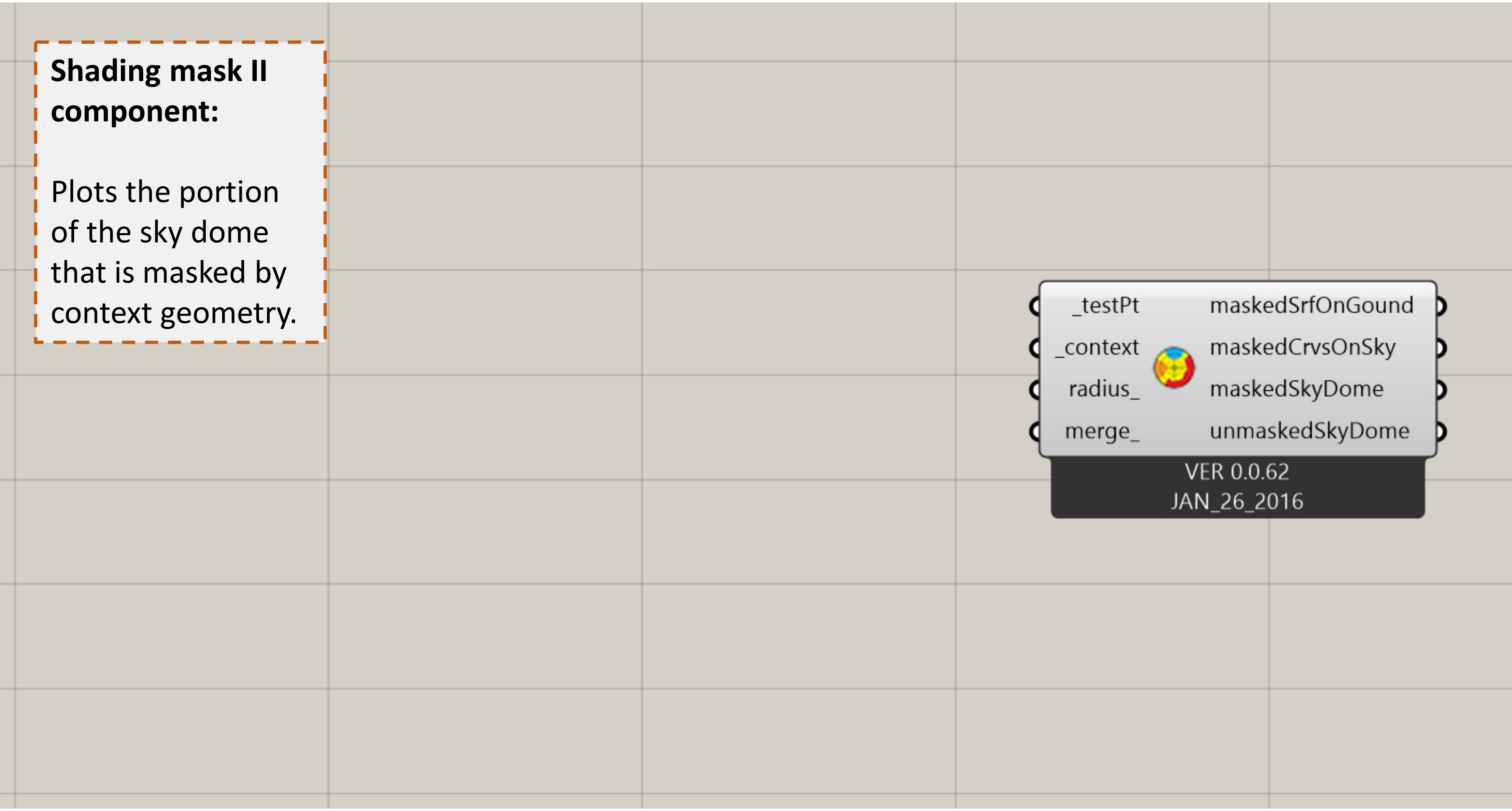
- This diagram is constructed with a point, and the result is always a hard-edged shading block. The point is either in shade or it is not.

- Considering the overshadowing of a surface (a wall, window, or roof) is more complicated than just a single point. There will be times when it is only partially in shade.

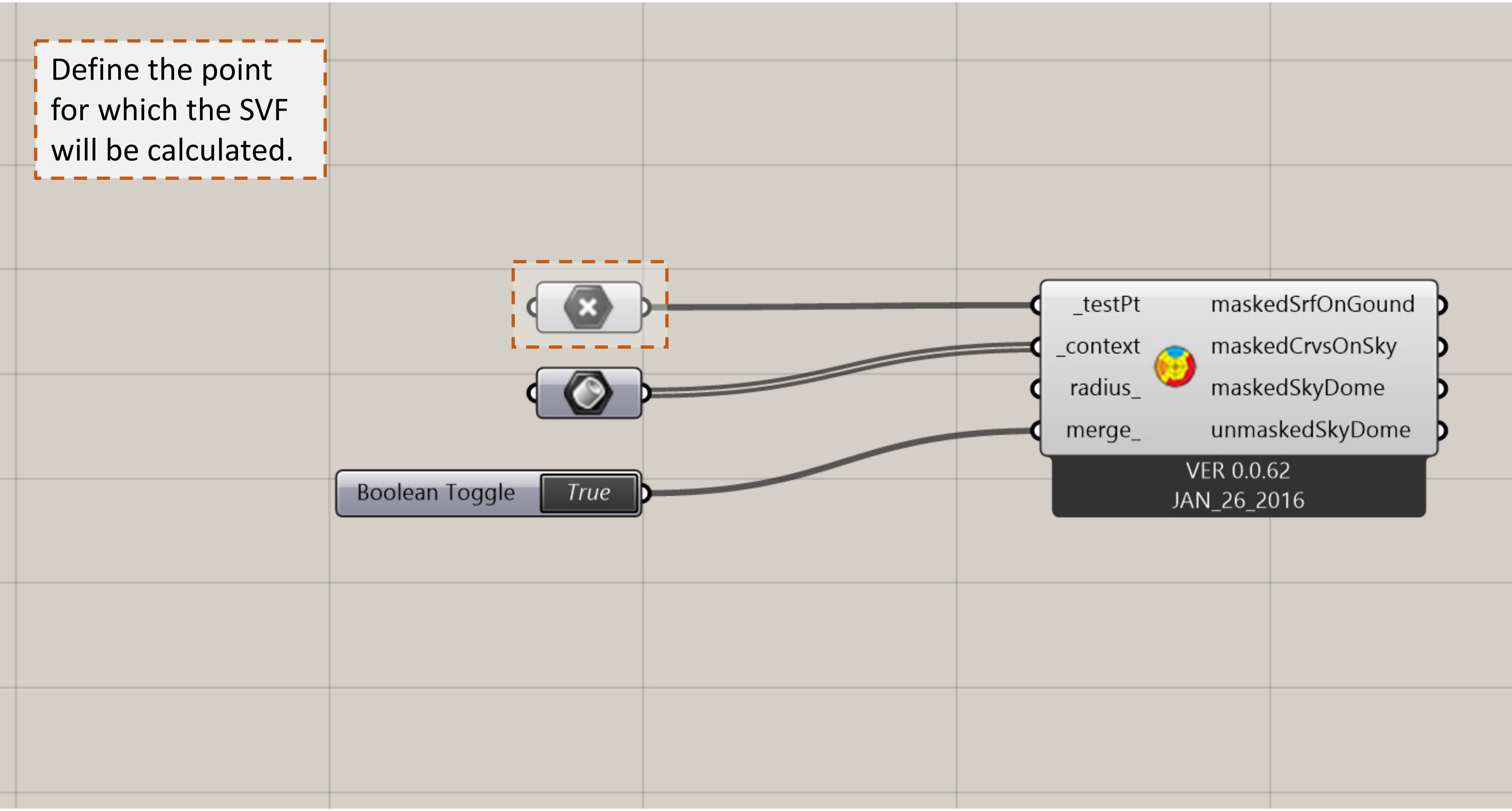


Sun-Path Diagram - Latitude: 51.517
21 DEC 12:00, ALT = 15.05, AZM = 180.29

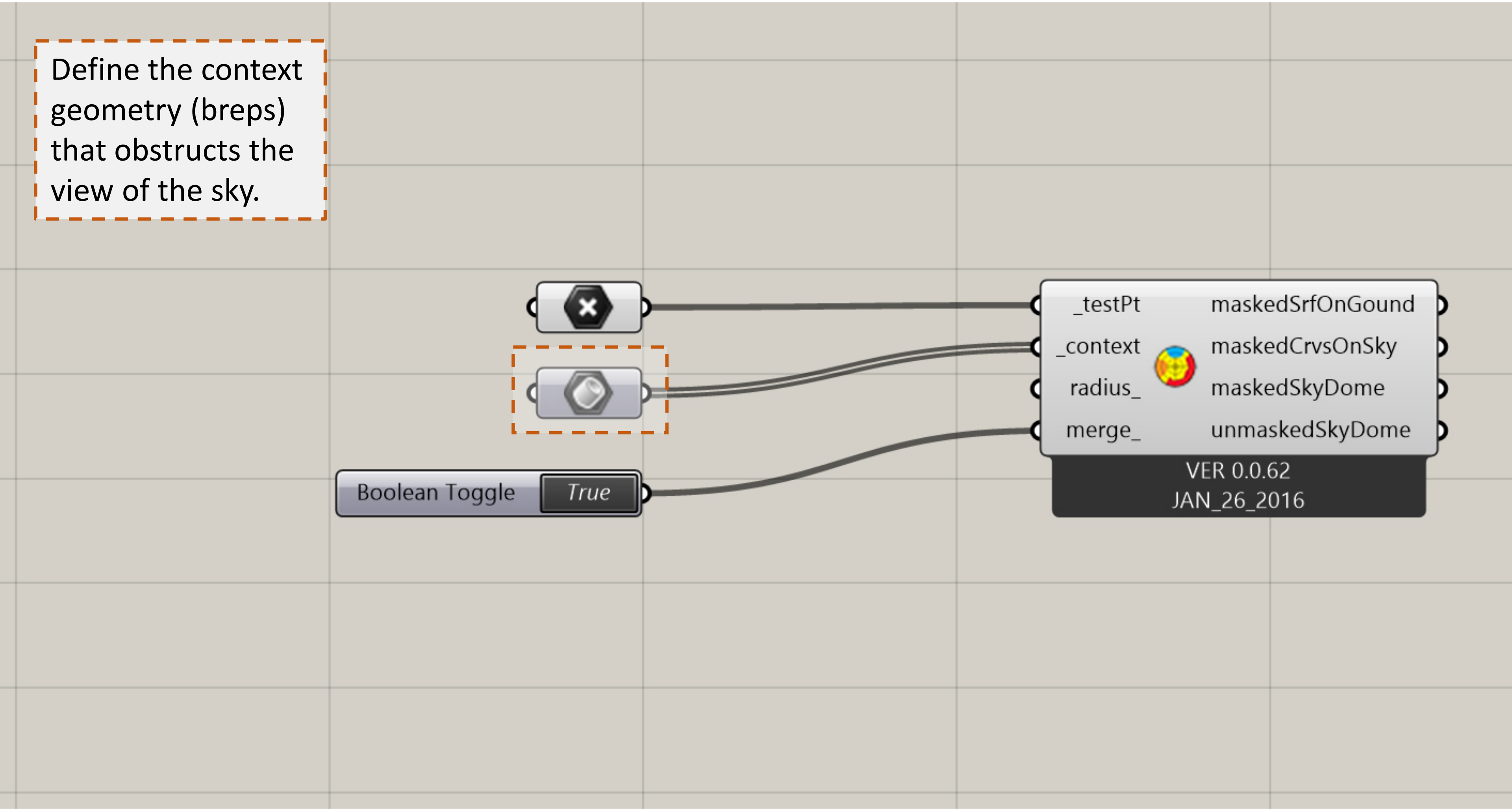
shading mask



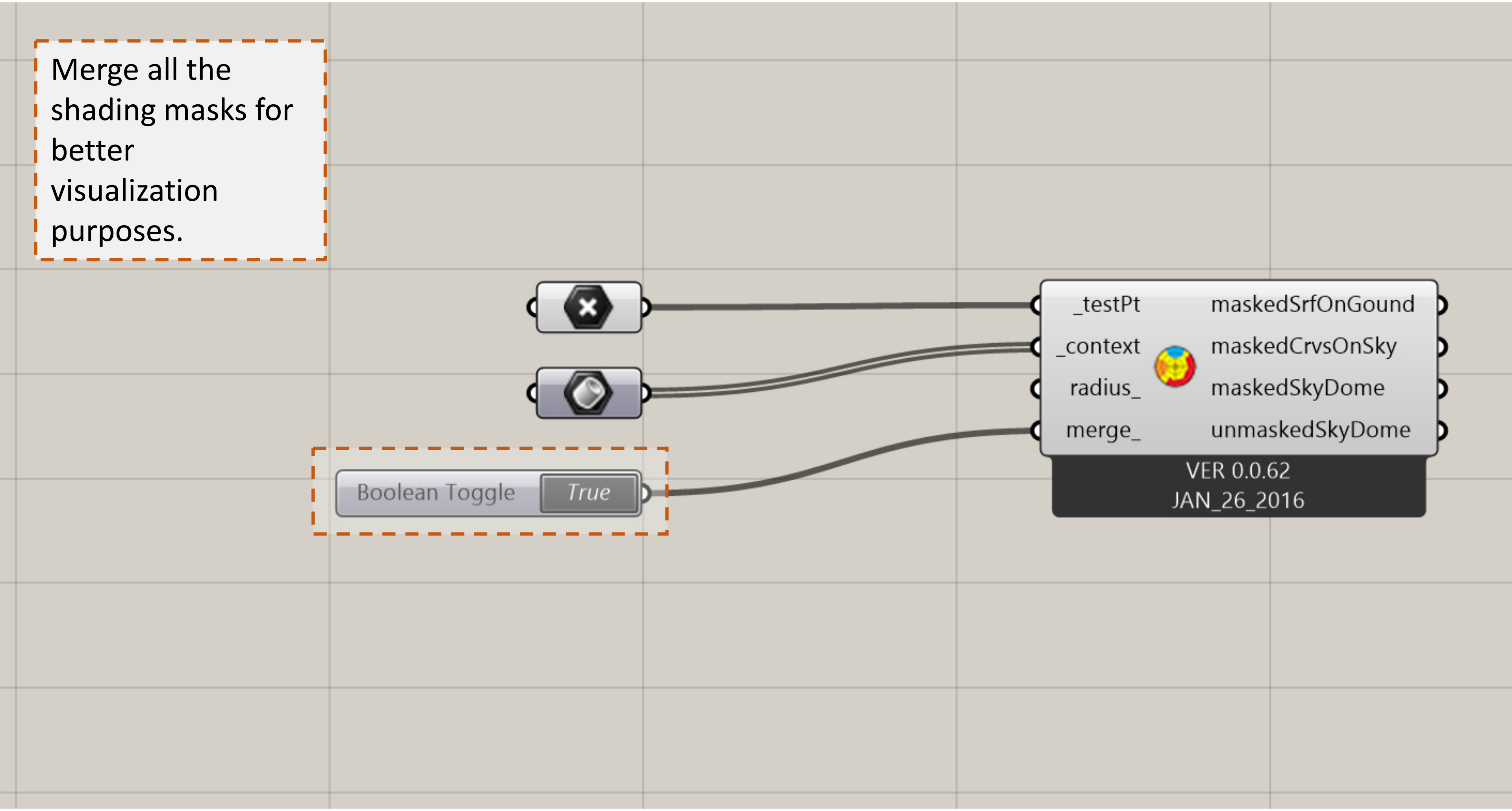
shading mask



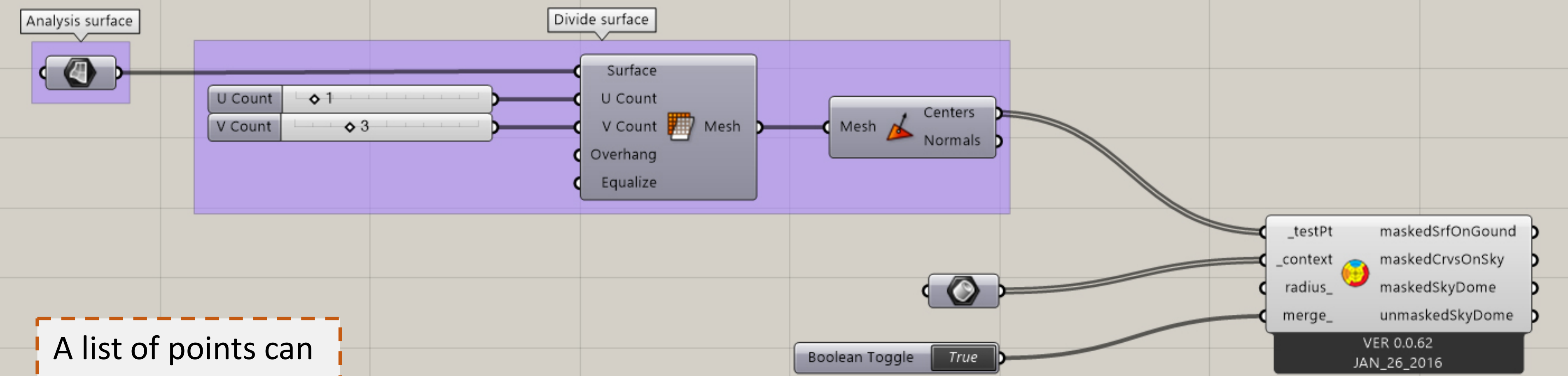
shading mask



shading mask



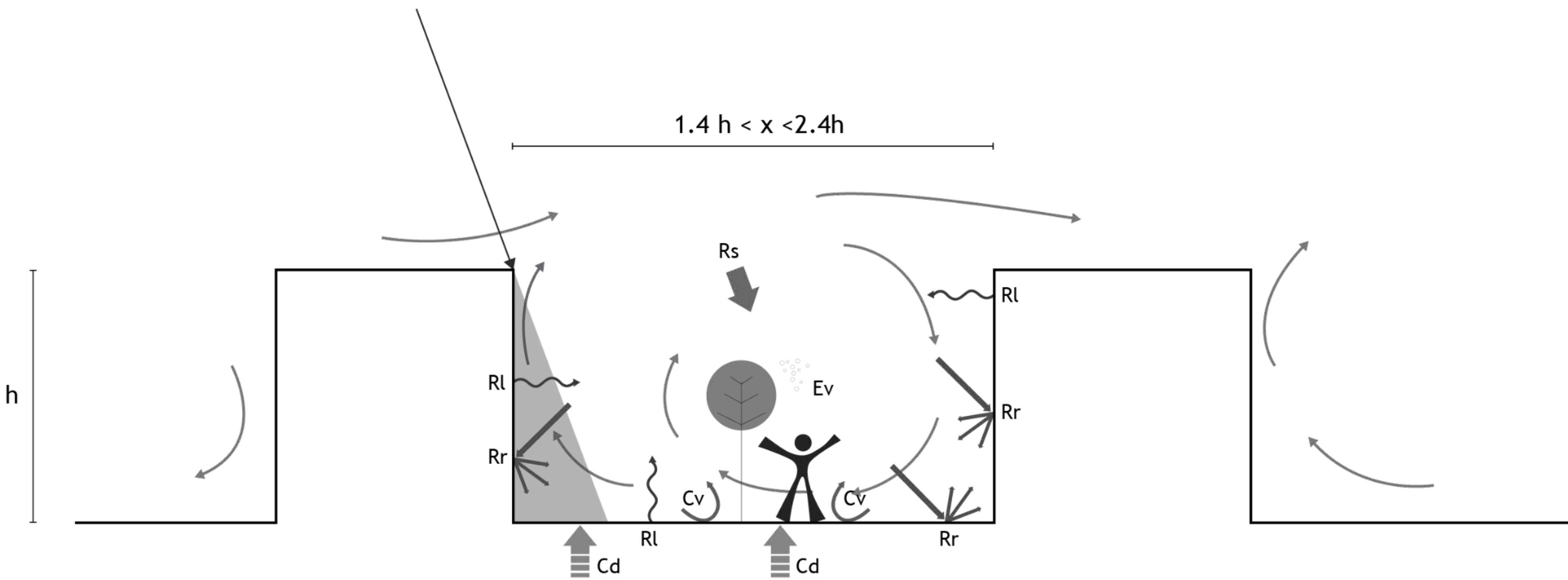
shading mask



A list of points can also be used to evaluate overshadowing of surfaces.

environmental thermal factors in an urban space

- air/surface temperature
- humidity
- longwave/shortwave/reflected radiation
- convective/conductive fluxes
- wind flow
- evapotranspiration

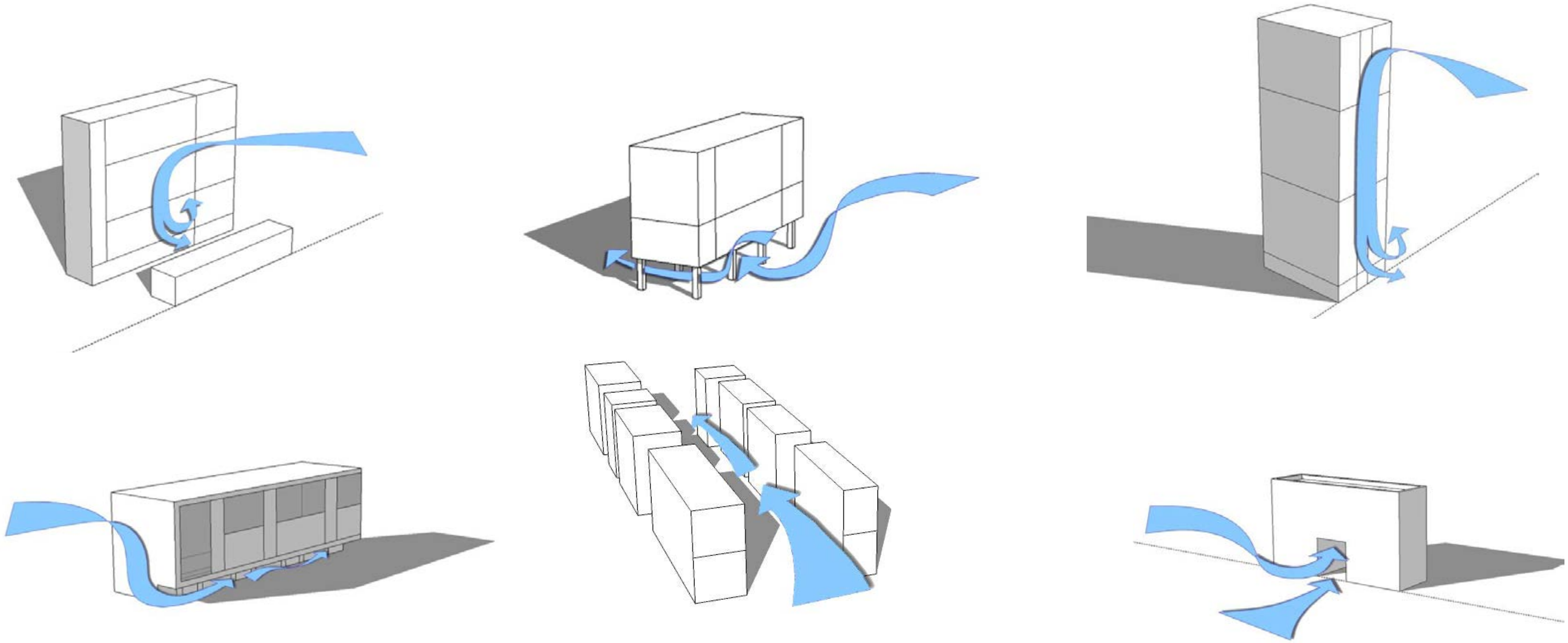


wind flow

Photograph by Peter Wood.

interaction between buildings

wind exposure

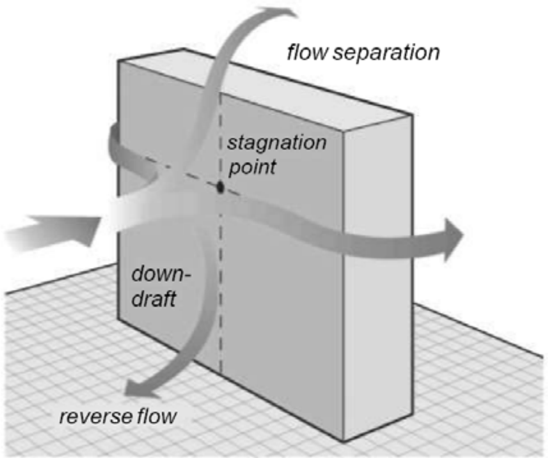


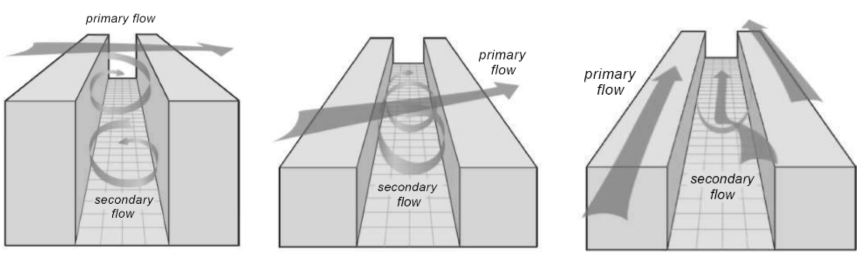
wind enhances natural ventilation, but also infiltration.

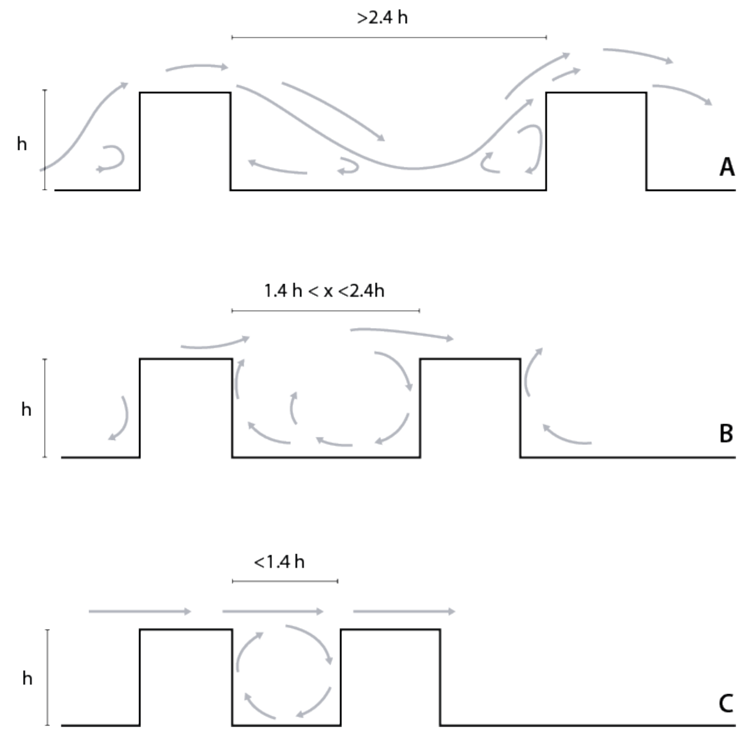
it also improves comfort perception and expands comfort band to higher temperatures.

in a dense urban environment, air movement between buildings can be blocked.

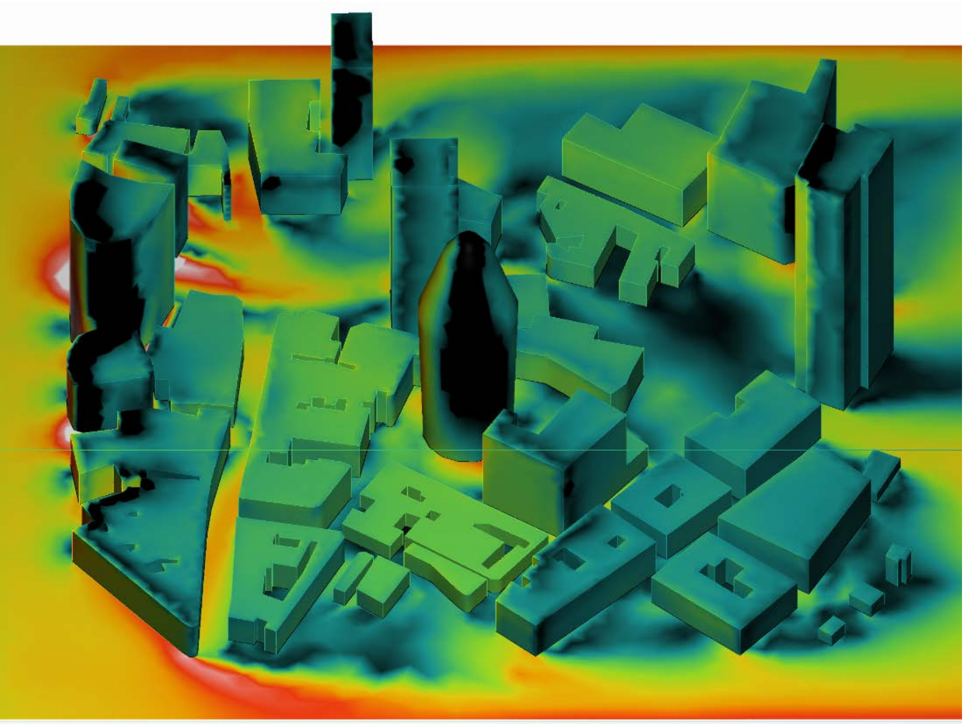
wind flow

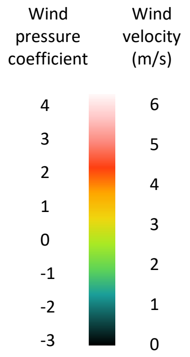

flow separation
stagnation point
down-draft
reverse flow

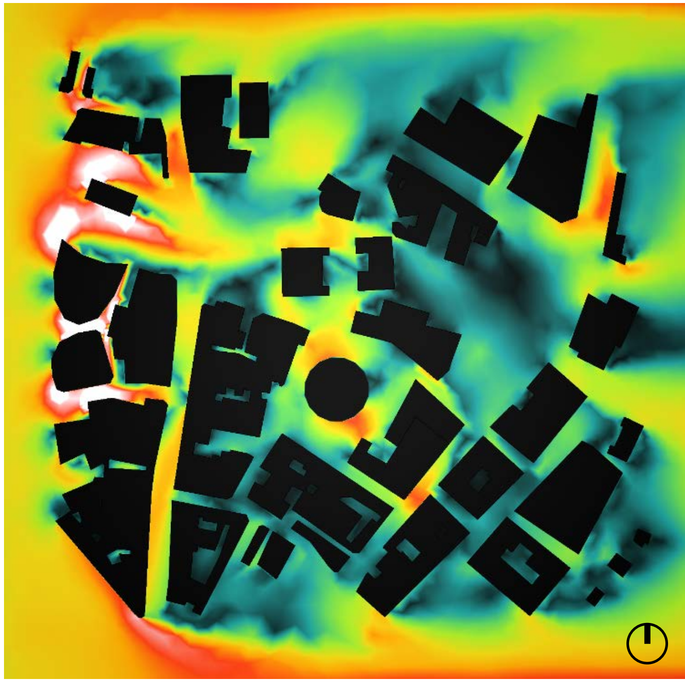

primary flow
secondary flow
primary flow
secondary flow
primary flow
secondary flow


>2.4 h
h
A
1.4 h < x <2.4h
h
B
<1.4 h
h
C

wind flow







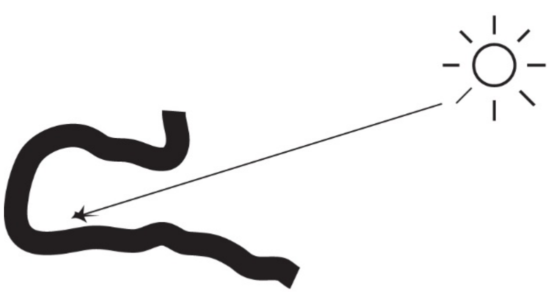
wind direction: W

Photograph by Paul rafter.

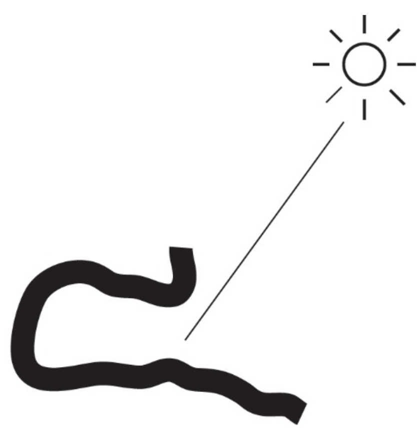
solar access

solar access in the urban fabric mainly depends on the existing obstructions, space orientation and sun altitude.

in some occasions, solar shading is a valuable strategy for protecting from direct solar radiation and therefore improving outdoor comfort conditions.



winter season



summer season

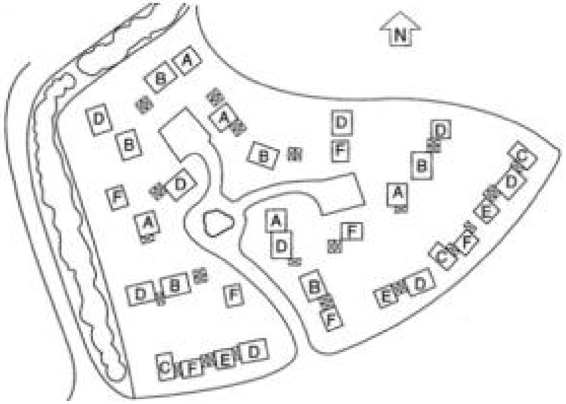
Littlelfair, (2000).

solar access

orientation

-10% energy

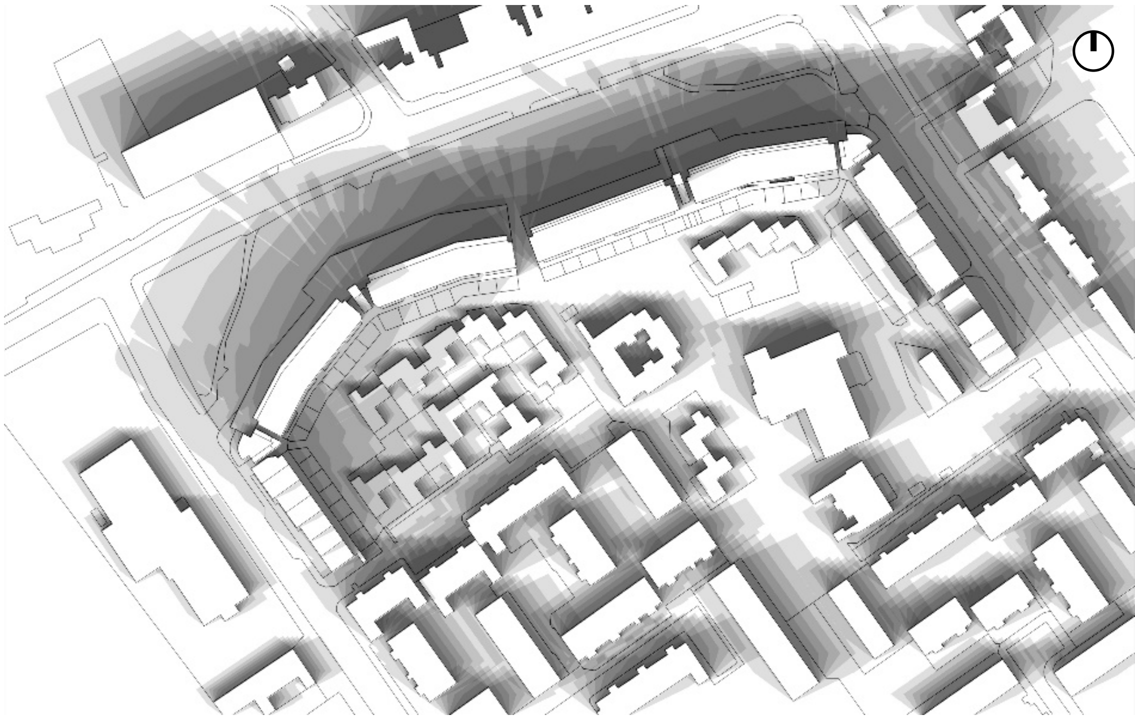
8.900 kWh/year



7.900 kWh/year

Littlelfair, (2000).

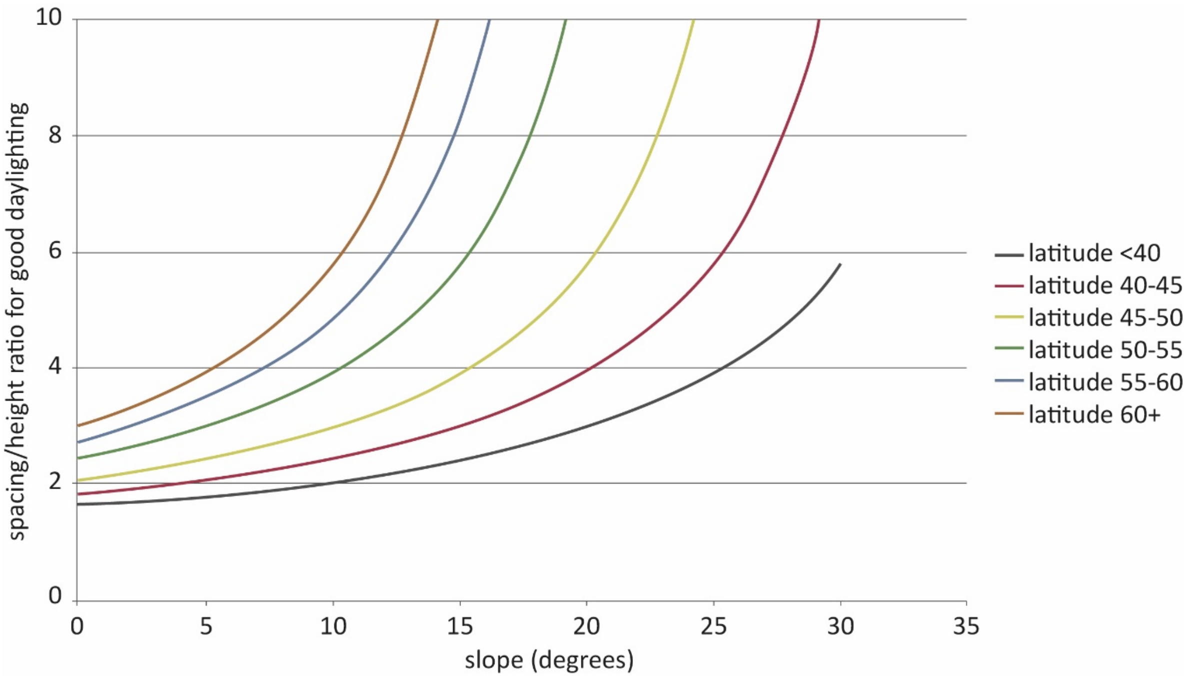
solar access

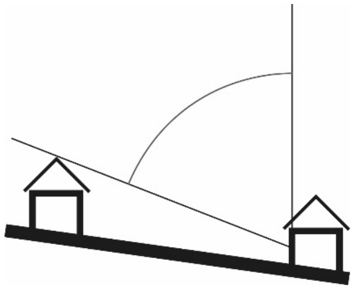


solar access

daylight

height ratios for rows of houses to achieve good access to daylight.





Littlelfair, (2000).


albedo
the fraction of solar energy (shortwave radiation) reflected from the Earth back into space.
Photograph by Konstantin Kalishko

solar radiation

urban materials

surface	absorptance (a)	albedo (α)	emissivity (ε)
man-made			
asphalt	0.80-0.95	0.05–0.20	0.95
concrete	0.65-0.90	0.10–0.35	0.71–0.90
brick	0.60-0.80	0.20–0.40	0.90–0.92
corrugated iron	0.84-0.90	0.10–0.16	0.13–0.28
fresh white paint	0.10-0.30	0.70–0.90	0.85–0.95
clear glass (normal incidence)	0.20	0.08	0.87–0.94
natural			
forest	0.80-0.93	0.07–0.20	0.98
grass	0.70-0.85	0.15–0.30	0.96
soil (wet)	0.75-0.90	0.10–0.25	0.98
soil (dry)	0.60-0.80	0.20–0.40	0.90–0.95

Erell, (2010).


vegetation
Photograph by Konstantin Kalishko

vegetation

evapotranspiration

the major effects in vegetation are due to evapotranspiration of plants and trees that regulate their foliage temperature.

the process to estimate air temperature reduction by evapotranspiration is very complex, and computational calculations are required.

evapotranspiration = f(CO_2 fixation, plant type, albedo of the plant leaf, height of the plant, leaf area density…)

use your own measurements to understand the potential of green areas in outdoor spaces.

vegetation

other benefits

- shading effects due to trees: mitigation of the solar heat gain.
- reduction of surface temperatures: decreasing convective and conductive heat loads.
- reduction of short-wave and long-wave radiation from soil to environment or to building by ground cover plants or water films.
- windbreak effect or insulation effect: wind speed and infiltration mitigation in winter.

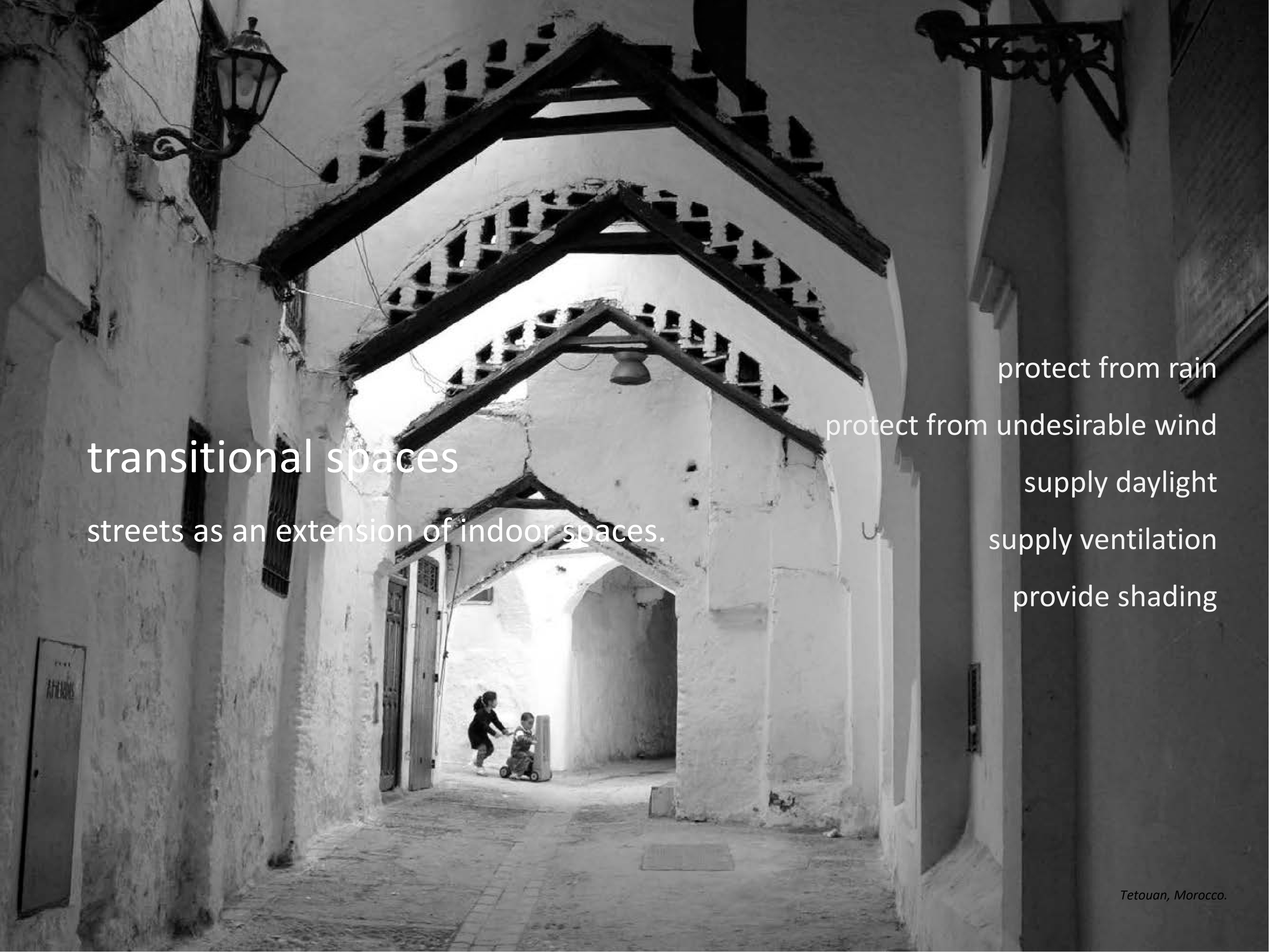
Alhambra, Granada

water

water has much higher thermal capacity than any of the other material in the urban tissue.

a large body of water (sea, river, lake, fountain) has a moderating influence on the air temperature in its vicinity.

water evaporation has a cooling effect on surrounding air when exposed to air movement.



Tetouan, Morocco.


outdoor comfort

predicting outdoor comfort

since Fanger's method is the 1970s, many thermal indices have been proposed to evaluate outdoor comfort conditions.

PMV	1970s
PET	1990s
PT	1990s
PST	1990s
OUT_SET	2000s
UTCI	2010s

environmental factors

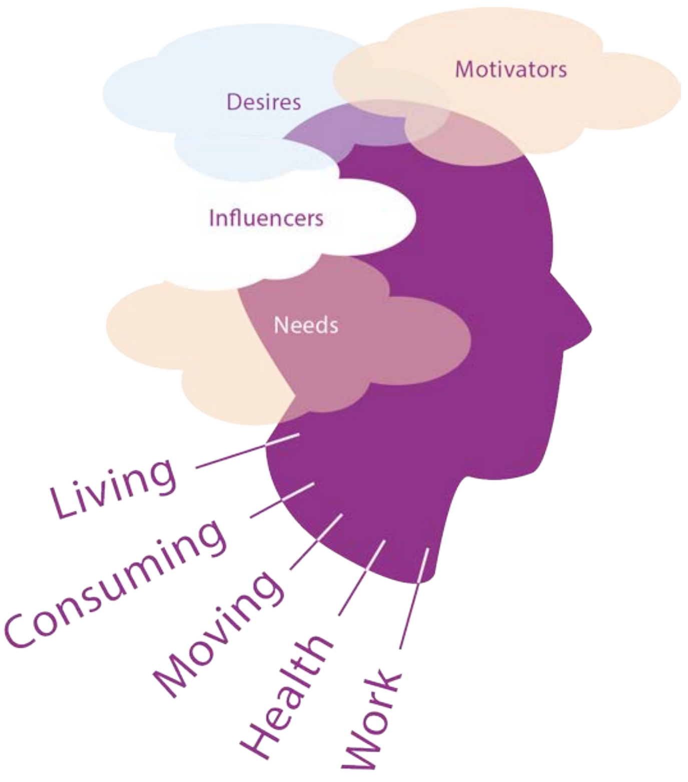
DBT	(^{o}C)
RH	(%)
MRT	(^{o}C)
v	(m/s)

physiological factors

met

clo

OUR LIFESTYLES ARE
AT THE CENTRE OF OUR
SUSTAINABLE FUTURE



Sustainable lifestyles

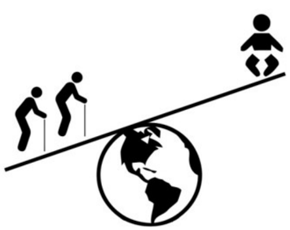
Sustainable lifestyles aim to ensure that everything we do, have, use and display meets our needs and improves our quality of life while minimising the consumption of natural resources, emissions, waste and pollution and ensures that resources are safeguarded for future generations.

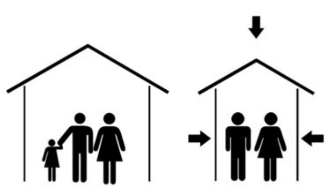
ENVIRONMENTAL SOCIAL ECONOMICAL

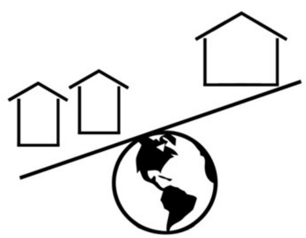
future trends

Megatrends and European Lifestyles

- Global population growth
- Increasing living standards
- Ageing of the EU population
- Average household size in Europe has decreased from 2.8 to 2.4 people
- More than 86% of the population in developed regions is expected to live in cities by 2050.







future trends

Challenges and opportunities for sustainable lifestyles

- Increasing awareness and **behaviour change** for energy and water conservation.
- Community and city action demonstrates the success of participatory approaches to sustainable, long-term living and mobility options such as **ecotowns**.
- Sustainable neighbourhoods, **communities** and cities are emerging through **co-creation** and participation.
- **Sharing:**

*"A big shift from the **20th century hyper-consumption**, to a **21st-century age of collaborative consumption** is under way. The convergence of social technologies, a renewed belief in the importance of community, pressing environmental concerns, and cost consciousness are moving us away from the old forms of consumerism toward one of **sharing, aggregation, openness, and cooperation.**"*

Rachel Botsman, Author and Founder, Collaborative Consumption,
SPREAD project advisor

future trends

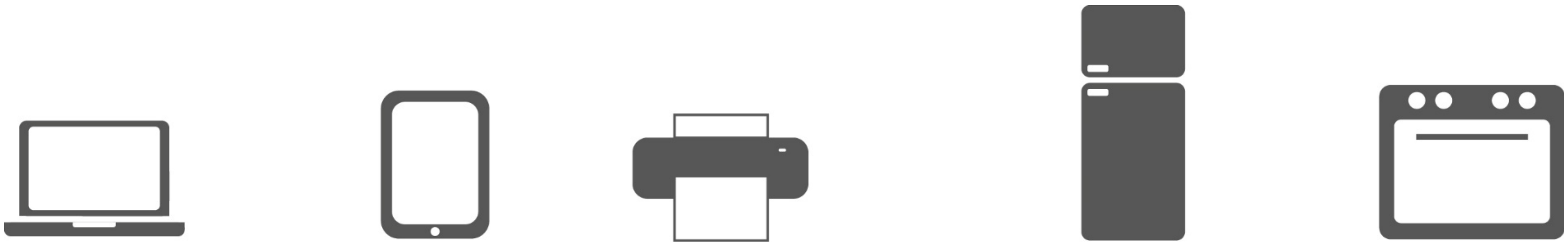
Cultural background

The cultural background influences on people's **lifestyles**, **habits**, **requirements**, **schedules**, **adaptability and comfort conditions.**



future trends

Equipment result in heat gains to the room equal to the total power input.



Laptop	Tablet	Printer	Fridge	Oven
45 W - 240 W (Idle - CPU max)	3 W (display on)	2 W- 20 W (Idle - printing)	36 W - 60 W (A-rated – C-rated)	1400 W

Benchmark allowances for equipment gains in typical buildings:

Offices: 15 W/m^2
Teaching spaces: 10 W/m^2
Restaurants/bars: 5 W/m^2

Equipment gains from office to drop significantly from 25 W/m² in 2015 to 10 W/m² in 2080.

Portability of electronic devices:

Wireless networks and portable electronic devices reduce the number of specific areas considered as main heat emitters.

future trends

Lighting heat gains are also dependent on daylight availability and efficacy of the light source:

Traditional Incandescent
60W

Halogen Incandescent
43W

Compact Fluorescent Lamps (CFLs)
15W

Light Emitting Diodes (LEDs)
12W

The above graph compares 60 watt (W) traditional incandescent with energy efficient bulbs that provide similar light levels.

Recommended illuminance at the appropriate working plane & benchmark allowances for lighting gains in typical buildings:

Offices:	300-500 lux	8-12 W/m2
Teaching spaces:	300 lux	12 W/m2
Restaurants/bars:	100-200 lux	10-20 W/m2

`sustainable' methodology

Understanding prospective users requirements (energy and environmental profile of life-style, needs and potentials within building typology).

1. Research on the future trends and population requirements
2. Define the users' profiles

3. Learn from their cultural background, dressing code, habits, vernacular architecture…
4. Define the user behaviour, the occupancy and energy consumption pattern

`sustainable' methodology

4. Defining the user behaviour, the occupancy and energy consumption patter:

a) **Hourly schedule of internal gains** for the different **periods of the year** (weekdays, weekends, cold season, mid season, cold season) and for each **occupied space** (living room, bedroom, kitchen, office, communal space…).

- Occupancy gains
- Equipment gains
- Lighting gains

b) **Hourly schedule** of different **user behaviours** and **adaptive opportunities** provided for the different **periods of the year** (weekdays, weekends, cold season, mid season, cold season) and for each **occupied space** (living room, bedroom, kitchen, office, communal space…).

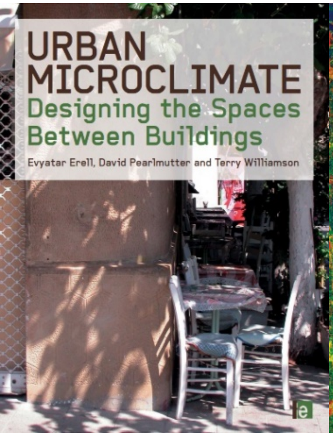
- Openable windows
- Solar control
- Shutters
- etc

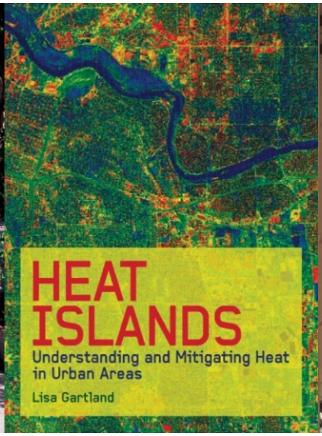
`sustainable’ methodology

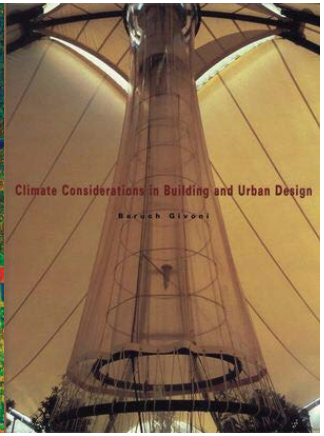
4. Defining the user behaviour and the occupancy and energy consumption pattern for Energy Modelling

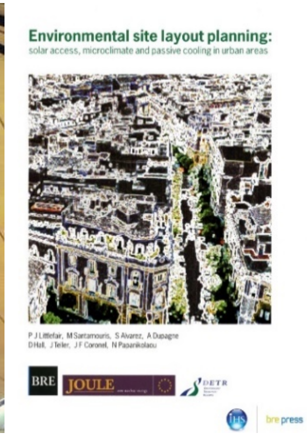
c) Define (hourly) the **internal heat gains** considering **future sustainable lifestyles**, the improvements in **equipment** energy **efficiency**, the **portability of electronic devices** and the **efficacy of future luminaries.**

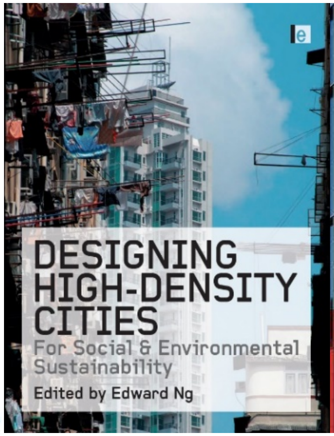
recommended reading list

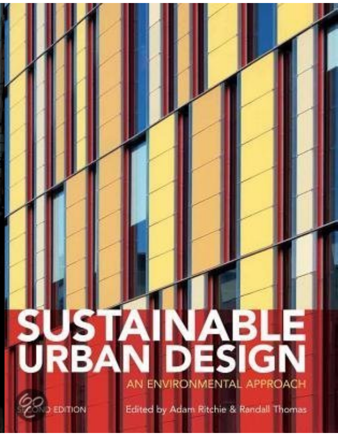












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Q&A session

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