

MODELING CLIMATE, SITE & PLACE ASSESSMENT TO SELECT WHERE AND HOW TO BUILD SUSTAINABLE ARCHITECTURES

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ASSESSING the PLACE a mix of interrelated aspects CLIMATE/SITE/CULTURE

the Context of intervention or, in short, the
Place as the mix of environmental aspects such
as socio-economic, cultural, regulatory, and
physical.

The architect's task is to gather these information, evaluate different aspects and alternatives and compose them in early design ideas







CLIMATE: affects physical, socio-cultural, and technological aspects





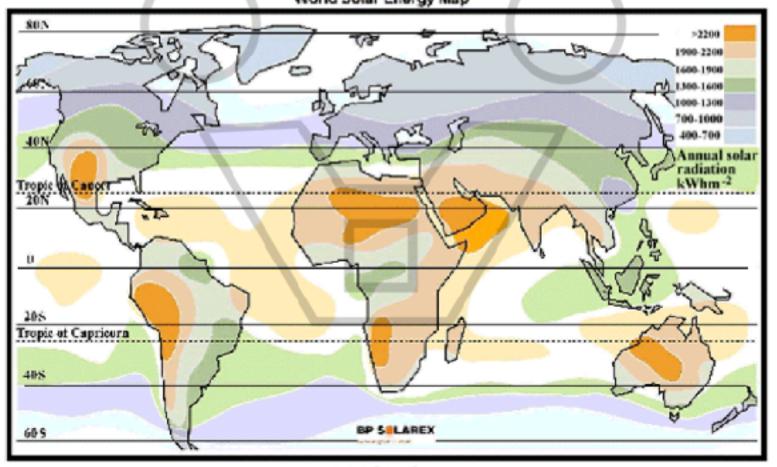
The influence of the site: GEOGRAPHICAL POSITION

Insolation is the sun's energy on a surface

Sun's energy depends on angle, sky conditions, volume and surfaces around.

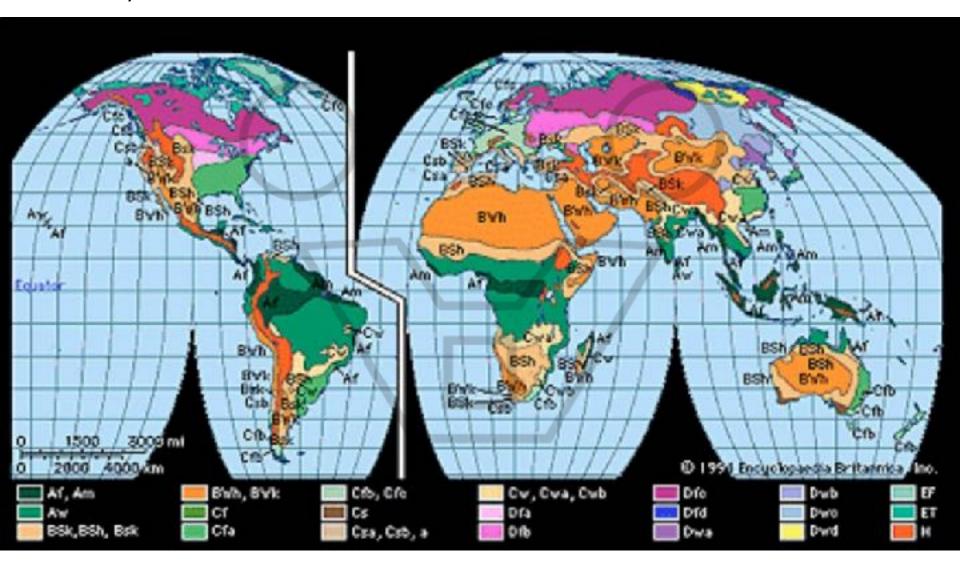
Weather files give the total amount of *direct energy* along a year measured perpendicularly to the sun direction

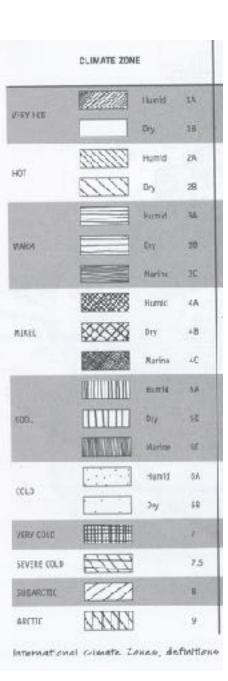
And diffuse energy measured getting all the energy and subtracting the direct energy capted, world Solar Energy Map

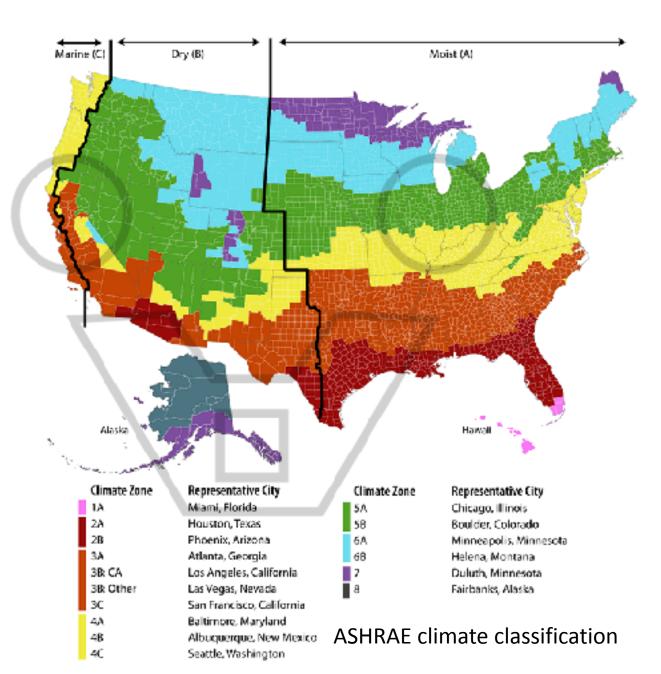




1- Find your climate zone



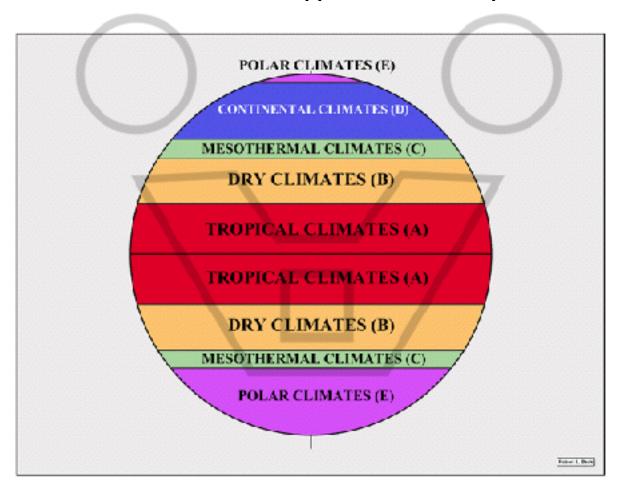




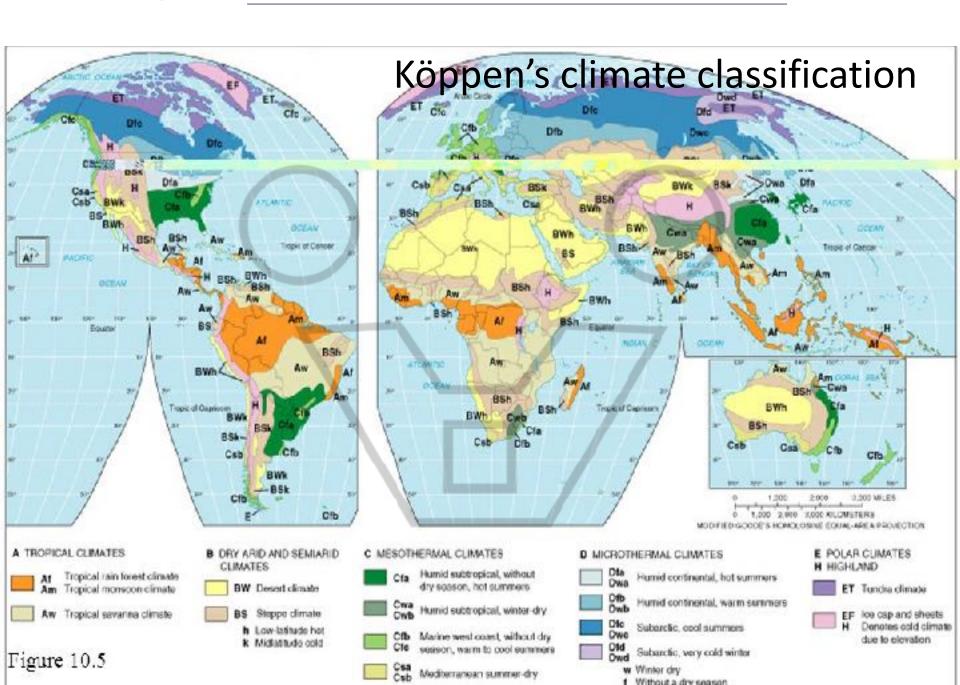
Köppen's climate classificationc

Latitudinal Model of the Köppen Climate Groups

ENVIRONMENTAL DESIGN







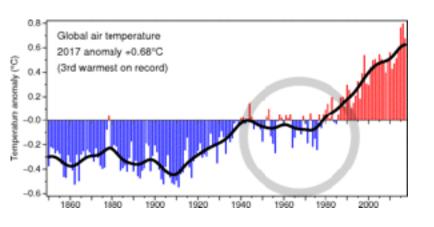


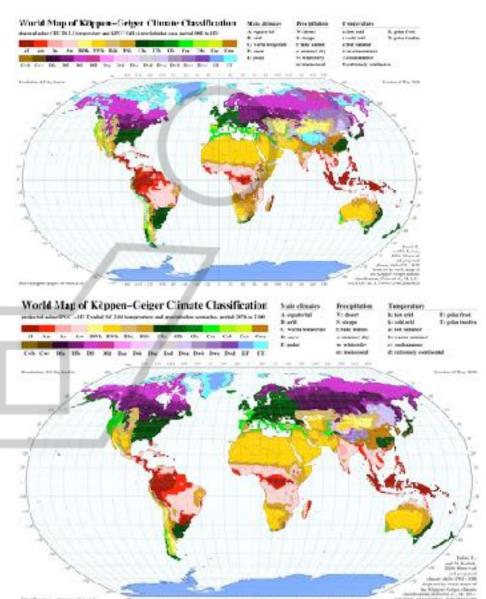
2- Tune-Up your climate conditions and zones considering the best appropriate wheather data

- -find detailed statistical data of your site
- -consider climate condition of similar sites In terms of:
- •altitude,
- •locations (by the sea, hill, urban,...)
- •type of soils
- terrain morphology,
- •winds exposition,



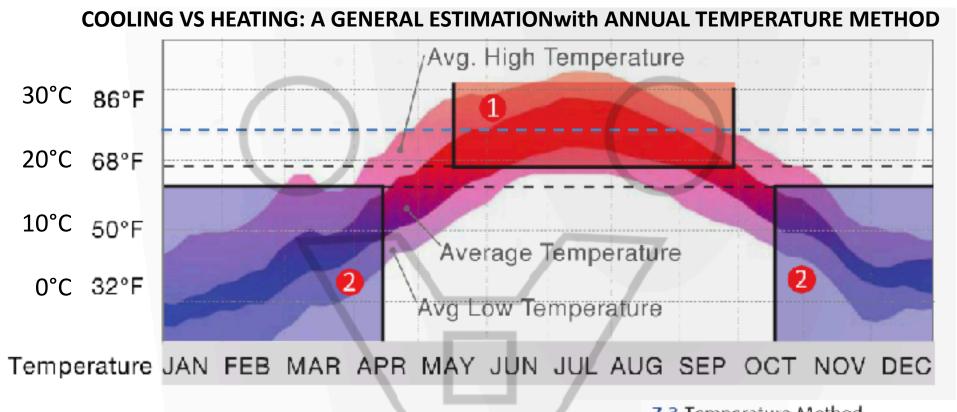
2- Tune-Up your climate zone considering the climate evolution and site





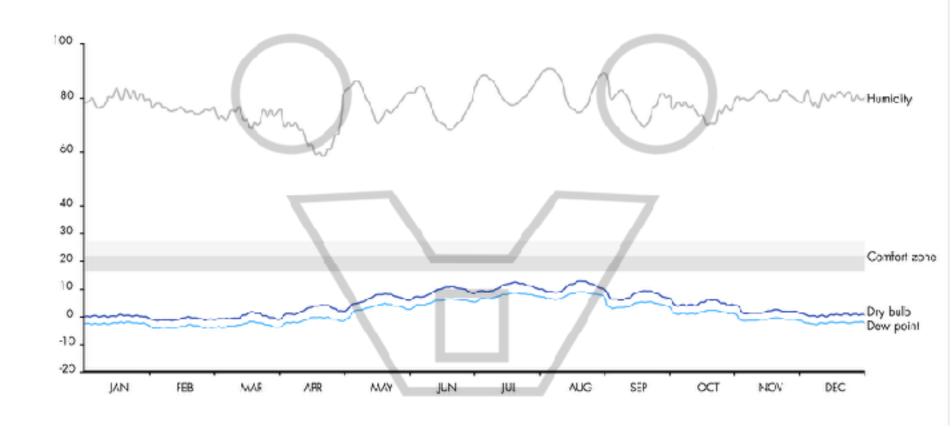
2. Confirm the main energy behaviour using Annual Temperature Profile

ENVIRONMENTAL DESIGN



7.3 Temperature Method. Annual temperature profile, with estimated heating and cooling. seasons highlighted.

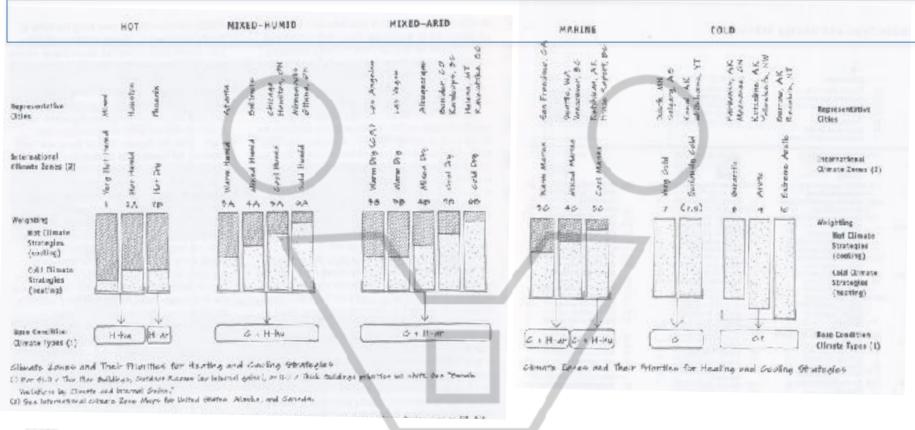
Source: Ecolect outputs of annual weather data from Central Park in New York City.





3. Analize thermal condition in order to establish design priorities

heating/cooling





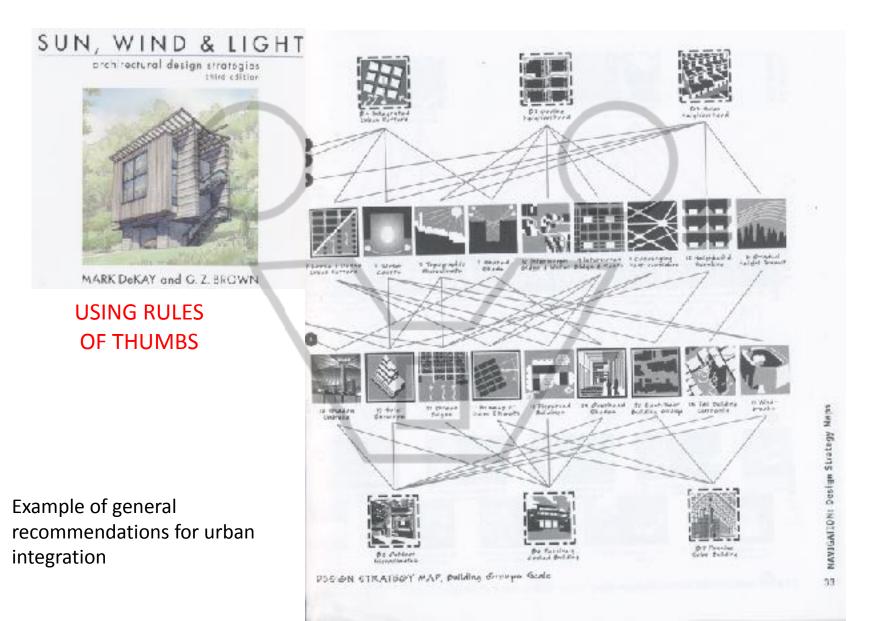
To be cooled



To be heated

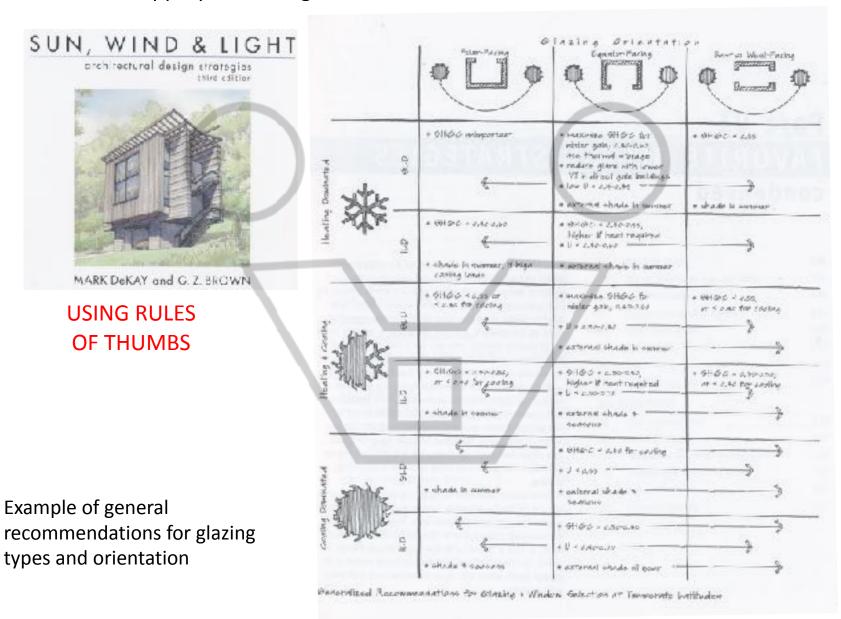


4. Find & define appropriate design criteria & recommendations





4. Find & define appropriate design criteria & recommendations





MODELING CLIMATE, SITE & PLACE ASSESSMENT TO SELECT WHERE AND HOW TO BUILD SUSTAINABLE ARCHITECTURES

USING COMPUTATIONAL APPROACH





Temperature
Humidity
Winds



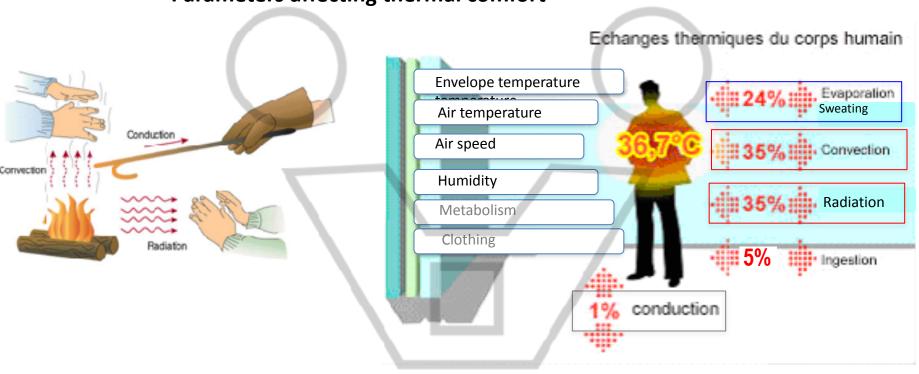


TEMPERATURES & HUMIDITY



THERMAL COMFORT

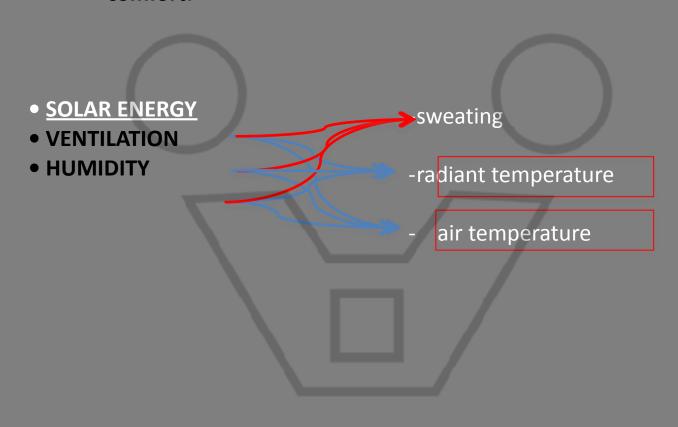
Parameters affecting thermal comfort



RADIANT TEMPERATURE+AIR TEMPERATURE

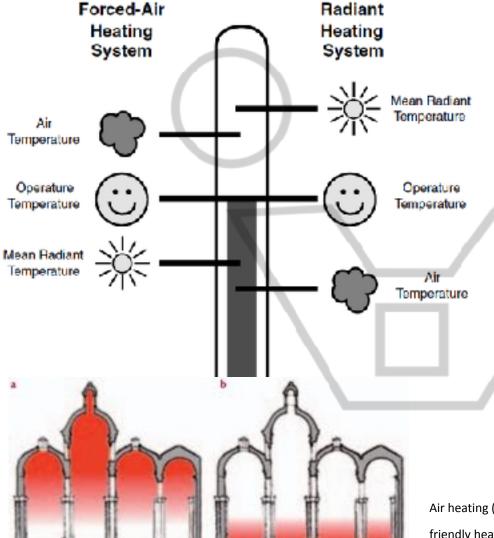


Environmental Parameters affecting thermal comfort:





OPERATIVE TEMPERATURE



Radiant heating systems compensate a lower air temperature with a higher radiant temperature, while air heating systems compensate a lower radiant temperature with a higher air temperature. The operative temperature -- a weighted average of both -- can be the same. Source: Radiant Heating & Cooling Handbook, Richard Watson, 2008.

Air heating (left) versus radiant heating (right) in a church building. Source: Fabric-friendly heating, Dario Camuffo.



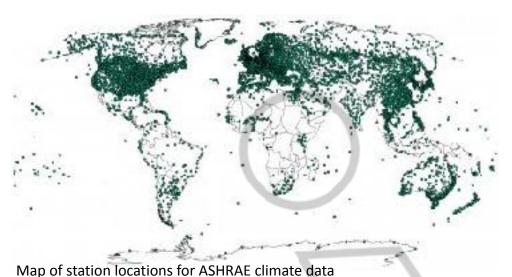
TEMPERATURE



(altitude, context, sun radiation, wind, humidity, sky)

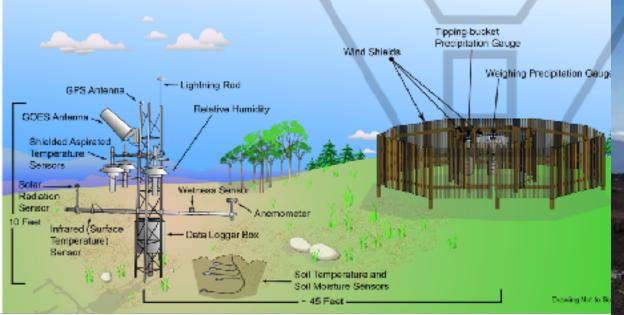
Climate data

HOW TO COLLECT CLIMATE DATA: WEATHER STATIONS



Wheather data includes:

- geographical coordinates
- •Annual weather files (8760 hours of the year) used to compute Energy Use Intensity (EUI)
- •TMY (Typical metereological year) that is encapsulated in the .epw files mantained by Energy Efficiency and Renewable Energy (EERE)
- •Peak condition files used to dimension mechanical







https://energyplus.net/weather

e	EnergyPlus	Downloads	Documentation	Support & Training	Licensing	Weather +	Feachacx	Log in
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Weather Data

Weather data for more than 2100 locations are now available in EnergyPlus weather format — 1942 locations in the USA, 71 locations in Canada, and more than 1900 locations in 190 other countries throughout the world. The weather data are arranged by World Melecrological Organization region and Country.

View Weather Data Select a region below to view weather data. Arrica (WMO Region 1) Asia (WMO Region 2) South America (WMO Region 3) North and Central America (WMO Region 4) Southwest Pacific (VMO Region 5)

Browse Weather Data

Europe (WMC Region 6)

Dlick on the markers in the map below to access weather data.



.ddy .stat .epw

Environmental parameters affecting thermal comfort: SOLAR ENERGY

Site Inventory: Physical Attributes 121

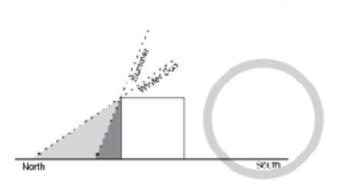
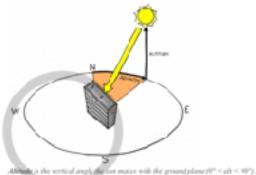


Figure 5:15 Schematic clagram of the seasonal variation in shade cast by a building in the northern hemisphere. Solar exposure in cutdoor spaces near a building varies not only with weather conditions but also with time of day, day of year, and location of the space in relation to both the building and the sun.



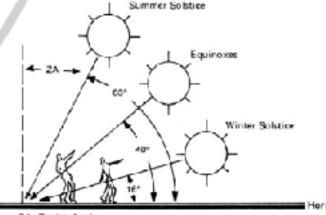
SOLAR ENERGY

les 24 heures Solaines

an soleth

si la totalité des constitions necessaires et suffisantes n'est pas arquise, il y a l'exequible, insuffisance — malhem chaque jour et ... toute la vie !

Figure 5-14 Diagram of seasonal changes in the maximum daily sun angle for a mid-latitude location in the Northern Hemisphere. Source: Marsh, Londscope Pienning. Third Ed., copyright © 1998, p. 290, Figure 15-3-Reprinted by permission of John



2A-Zenith Angle



HOW TO MEASURE SOLAR ENERGY?

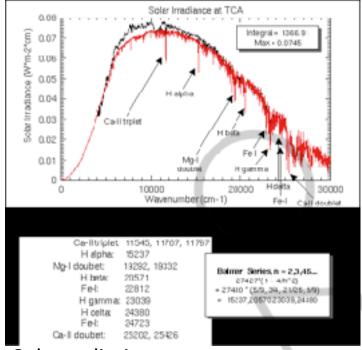
RADIATION=W/m2

BTU vs KW

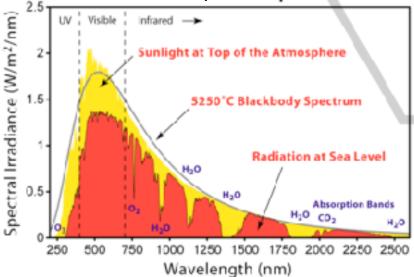
Ft2 > m2

1 Btu=0,293071 W/h

1 ft2=0,092903 m2



Solar radiation spectrum



Environmental parameters affecting thermal comfort: SOLAR ENERGY

Solar radiation* at the top of the atmosphere.

*) *Radiation* occurs when an object emits electro magnetic energy.

Irradiation is the energy absorbed by an object/surface

1366 W/m² (solar costant)

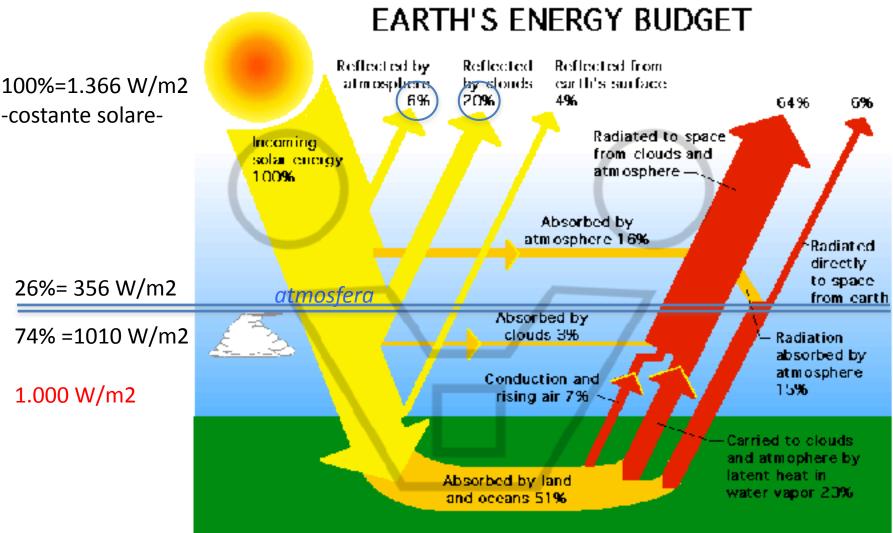
1 W = 3,416 Btu.

Considering the earth surface, the total solar energy is= 174 PW Peta= million of billions

Ricordiamo che: 1 Kcal = 4.186 J = 1,16 x 10-3 kWh = 1×10-7 TEP

1joule=1 Nm=0.000278Wh=0,0009478 Btu



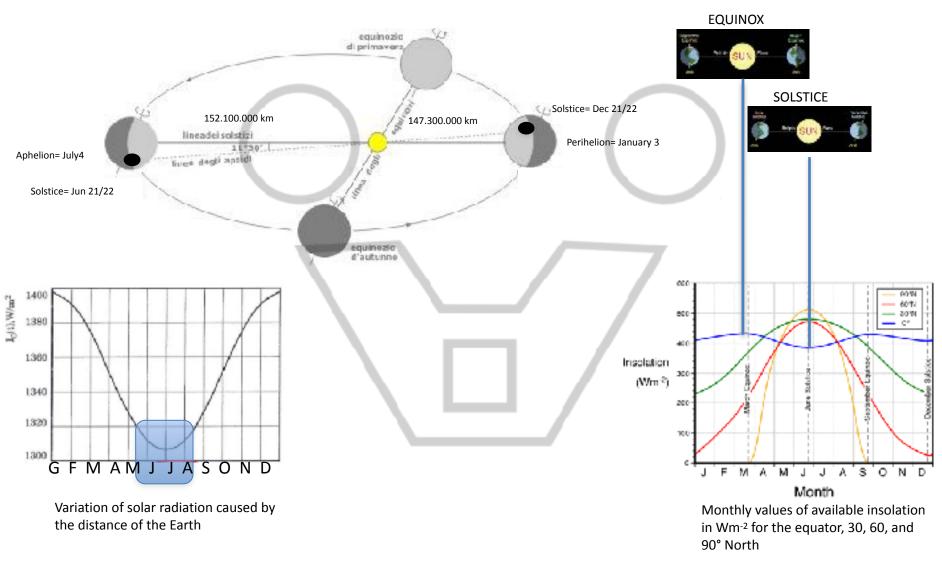


Radiazione assorbita

Detratte tutte le perdite per riflessione e retrodiffusione da parte di atmosfera e superficie terrestre, l'energia incidente che rimane è assorbita dalla superficie terrestre e contribuisce così al suo riscaldamento, in maniera <u>variabile a seconda della latitudine e del tipo di superficie</u>

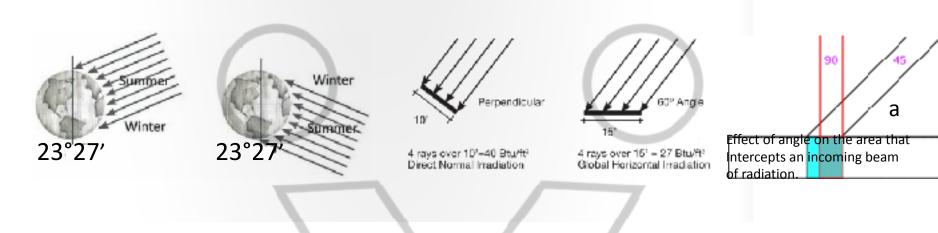


VARIATION OF SOLAR RADIATION DUE TO ANNUAL PERIOD AND LATITUDE



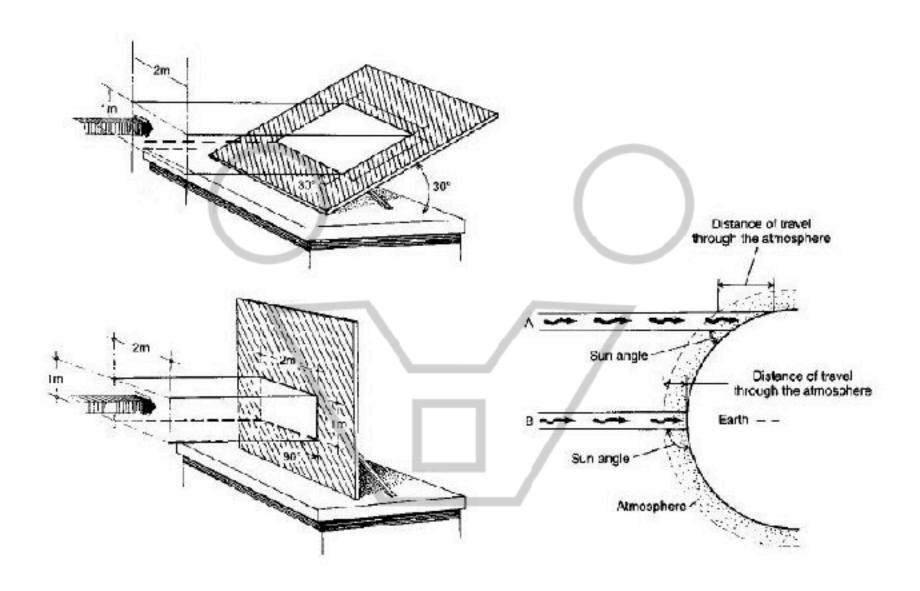


The influence of the site: GEOGRAPHICAL POSITION

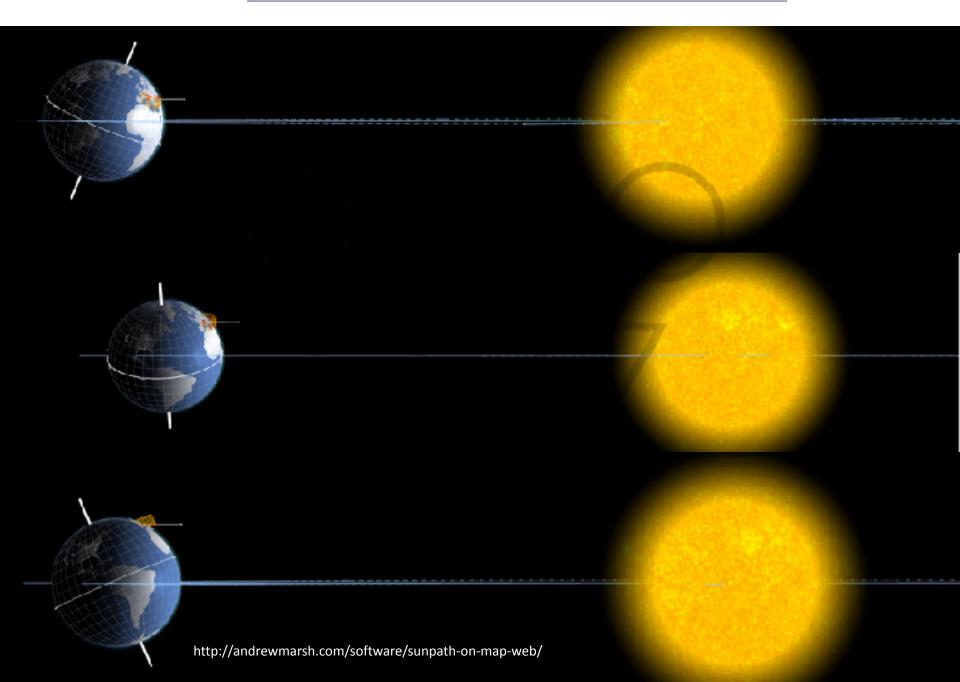


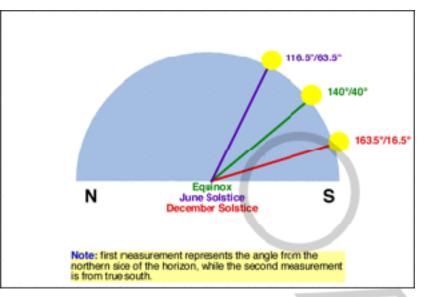
Intensity = SIN (a)



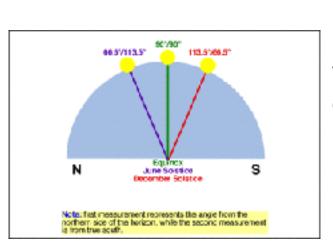


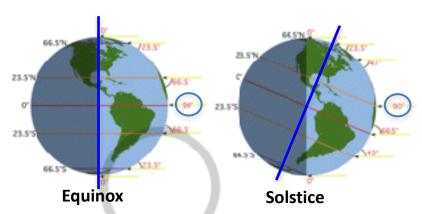






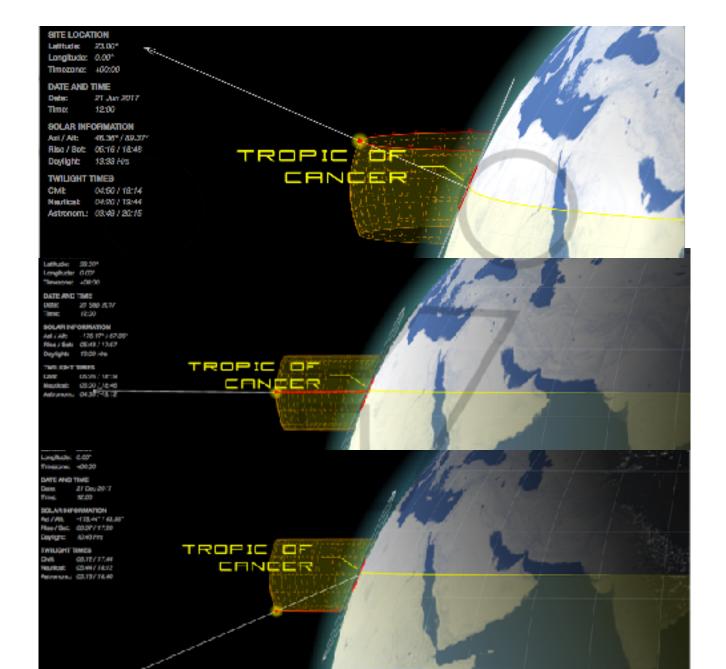
solar noon for 50 degrees North during the June solstice, equinox, and December solstice.

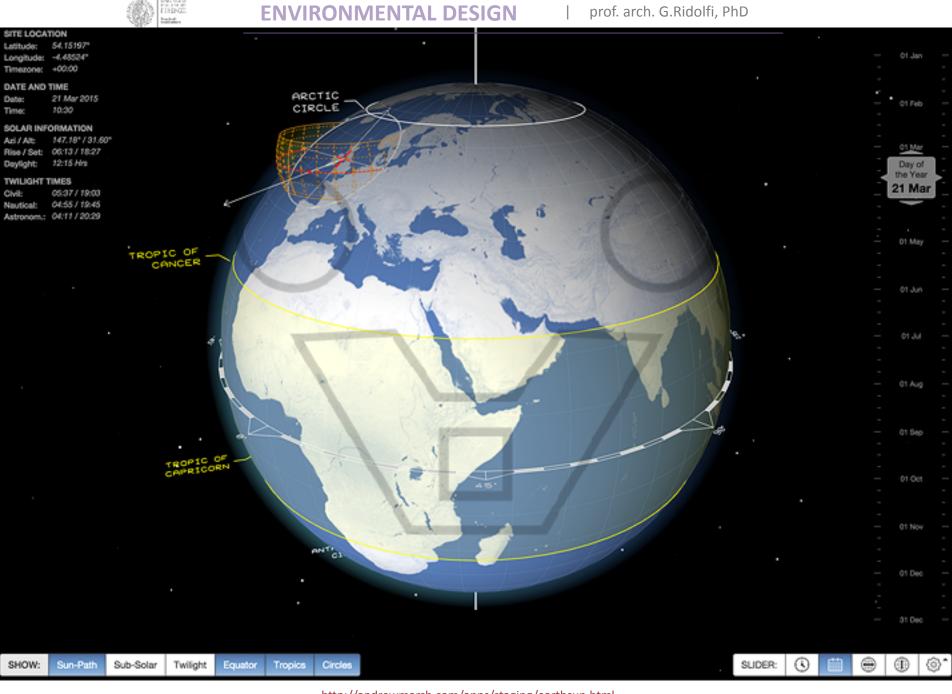




Relationship of maximum Sun height to latitude for the equinox (left) and June solstice (right). The red values on the right of the globes are maximum solar altitudes at solar noon. Black numbers on the left indicate the location of the Equator, Tropic of Cancer (23.5 degrees N), Tropic of Capricorn (23.5 degrees S), Arctic Circle (66.5 degrees N), and the Antarctic Circle (66.5 degrees S). The location of the North and South Poles are also identified. During the equinox, the equator is the location on the Earth with a Sun angle of 90 degrees for solar noon. Note how maximum Sun height declines with latitude as you move away from the Equator. For each degree of latitude traveled maximum Sun height decreases by the same amount. At equinox, you can also calculate the noon angle by subtracting the location's latitude from 90. During the summer solstice, the Sun is now directly overhead at the Tropic of Cancer. All locations above this location have maximum Sun heights that are 23.5 degrees higher from the equinox situation. Places above the Arctic Circle are in 24 hours of daylight. Below the Tropic of Cancer the noon angle of the Sun drops one degree in height for each degree of latitude traveled. At the Antarctic Circle, maximum Sun height becomes 0 degrees and locations south of this point on the Earth are in 24 hours of darkness.

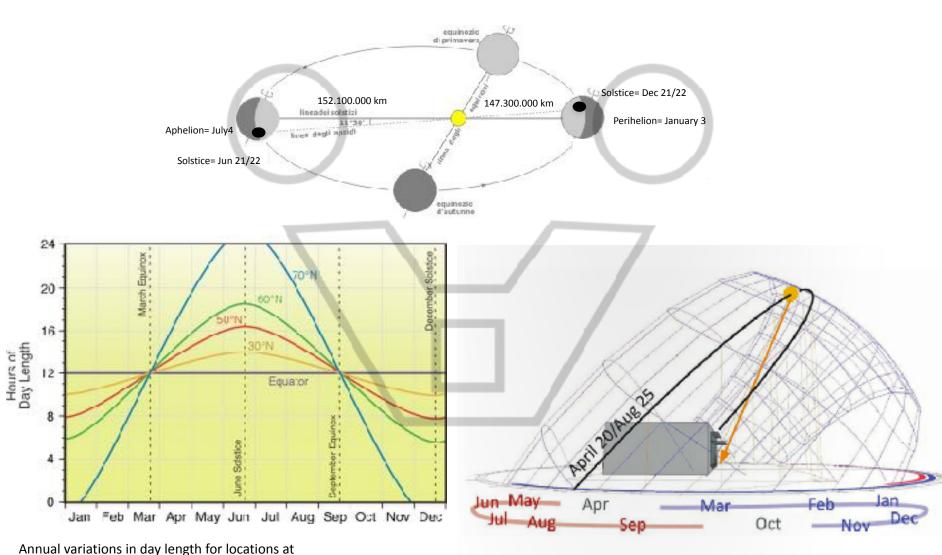
Variations in solar altitude at solar noon for the equator during the June solstice, equinox, and December solstice





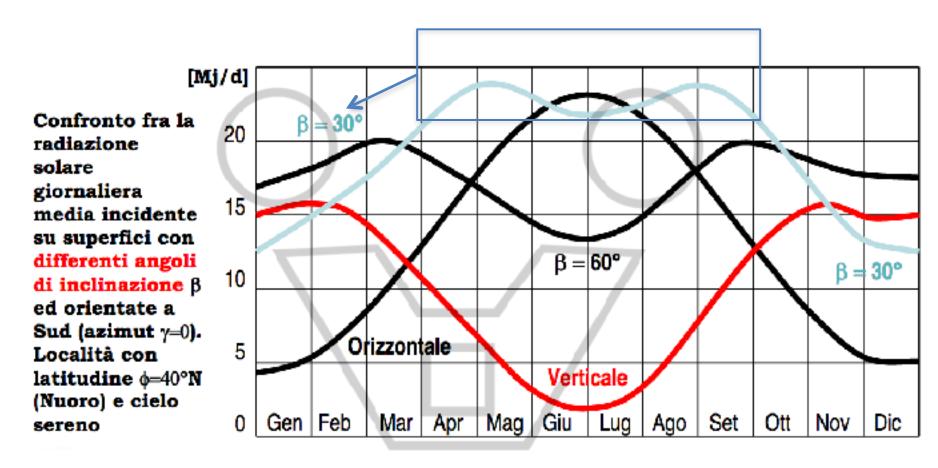


VARIATION OF SOLAR RADIATION DUE TO ANNUAL PERIOD AND LATITUDE



Annual variations in day length for locations at the equator, 30, 50, 60, and 70° N

The influence of the site: GEOMETRY





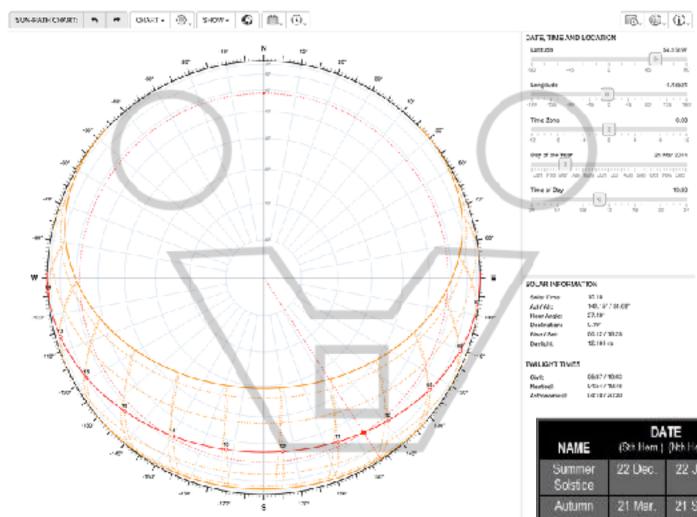
The influence of the site: GEOGRAPHICAL POSITION



SOLAR GEOMETRY http://andrewmarsh.com/software/sunpath-on-map-web/



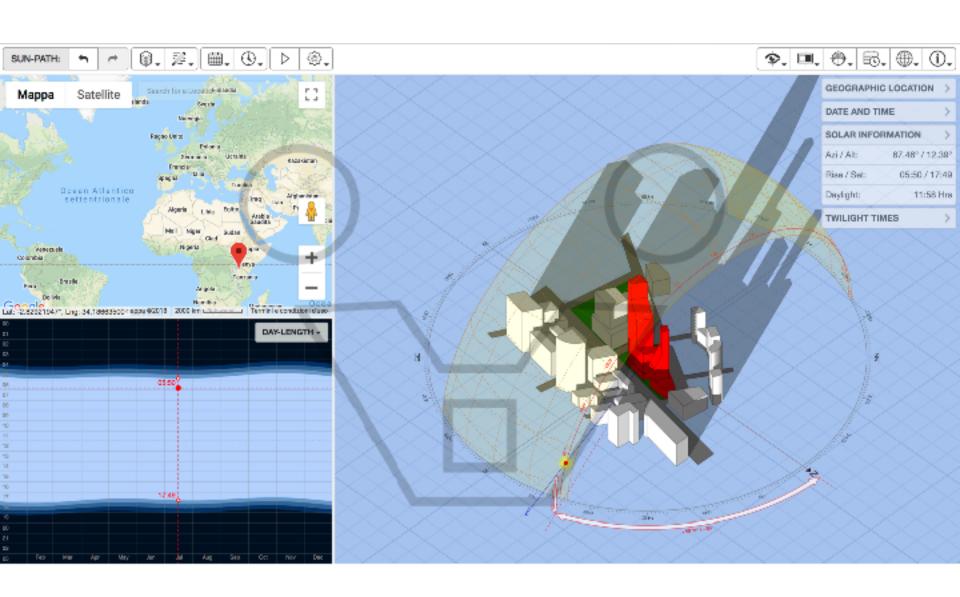
The influence of the site: GEOGRAPHICAL POSITION



SOLAR GEOMETRY

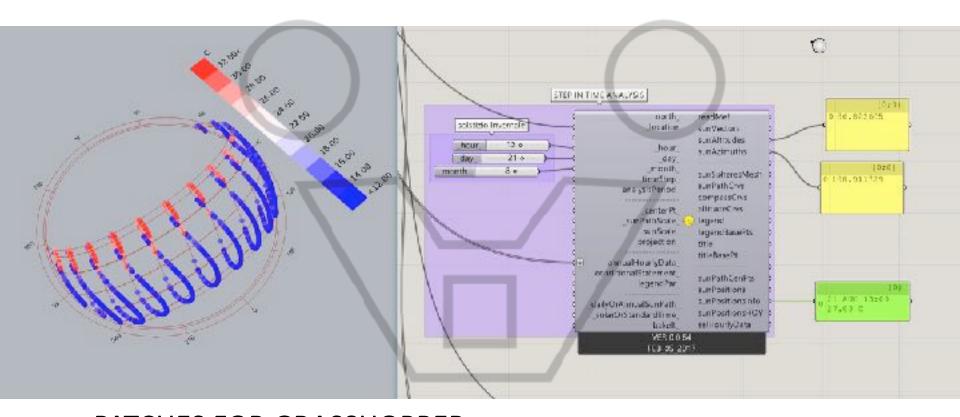
http://andrewmarsh.com/apps/releases/sunpath2d.html

NAME		(Nth Hem.)	DESCRIPTION
Summer Solstice	22 Dec.	22 Jun.	Sun at its highest noon altitude
Autumn Equinox	21 Mar.	21 Sep.	Sun rises due east, sets due west
Winter Solstice	21 Jun	21 Dec	Sun at its lowest noon situade
Spring Equinox	21 Sep	21 Mar.	Sun rises due east, sets due west



http://andrewmarsh.com/apps/staging/sunpath3d.html

SOLAR GEOMETRY WITH LADYBUG



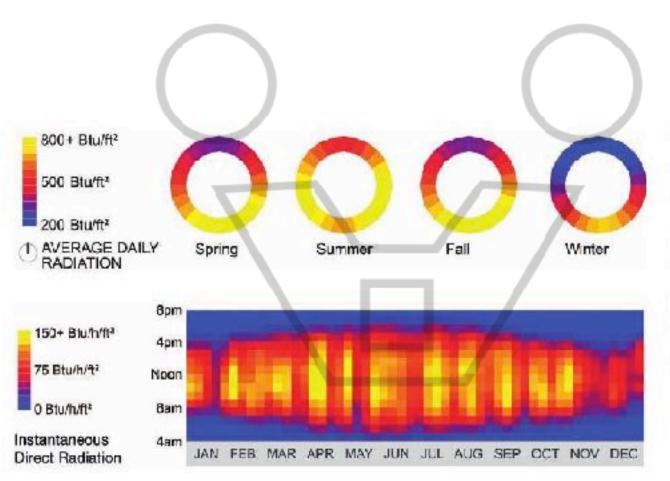
PATCHES FOR GRASSHOPPER

HYDRA WEB PLATFORM https://hydrashare.github.io/hydra/index.html?keywords=LBExampleFiles

MAILAB http://www.mailab.biz/category/environmental-design/



AVERAGE DAILY RADIATION



4: CLIMATE ANALYSIS

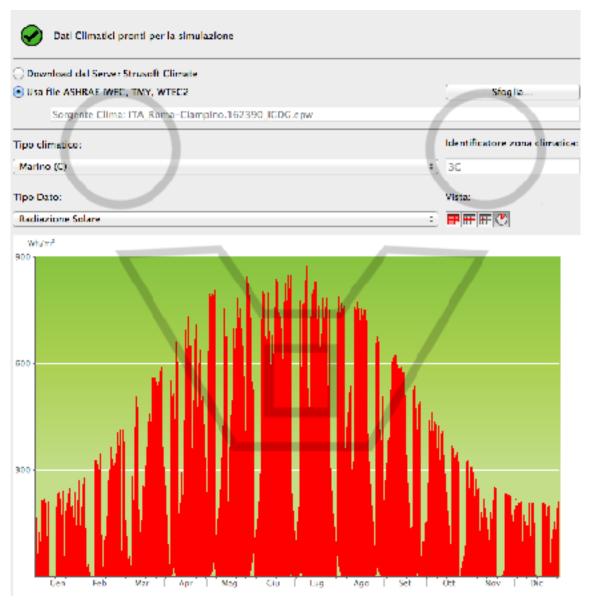
4.10 and 4.11

Solar roses from Central Park in New York City show the average daily amount of solar energy on each vertical segment of a cylinder. Since solar angles are symmetrical about the solstices, each season was centered on an equinox or solstice. The lower images show radiation on a horizontal surface for each four and day of the year from the same weather file.

Source: Autodesk's Ecotect output. Courtesy of Calliton.



Visualization of sun energy radiation



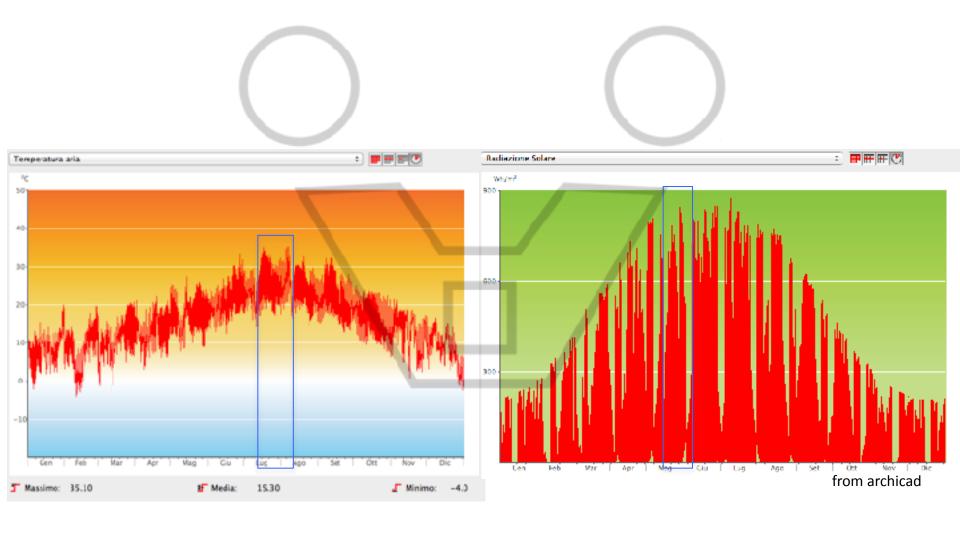


Visualization of sun energy radiation

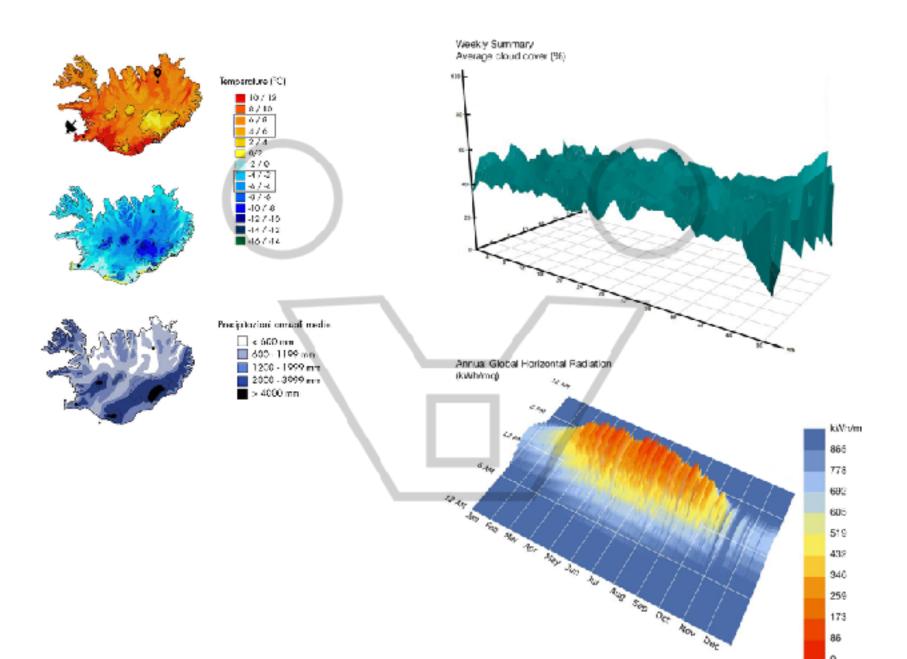




Visualization of air temperature in relation with solar radiation

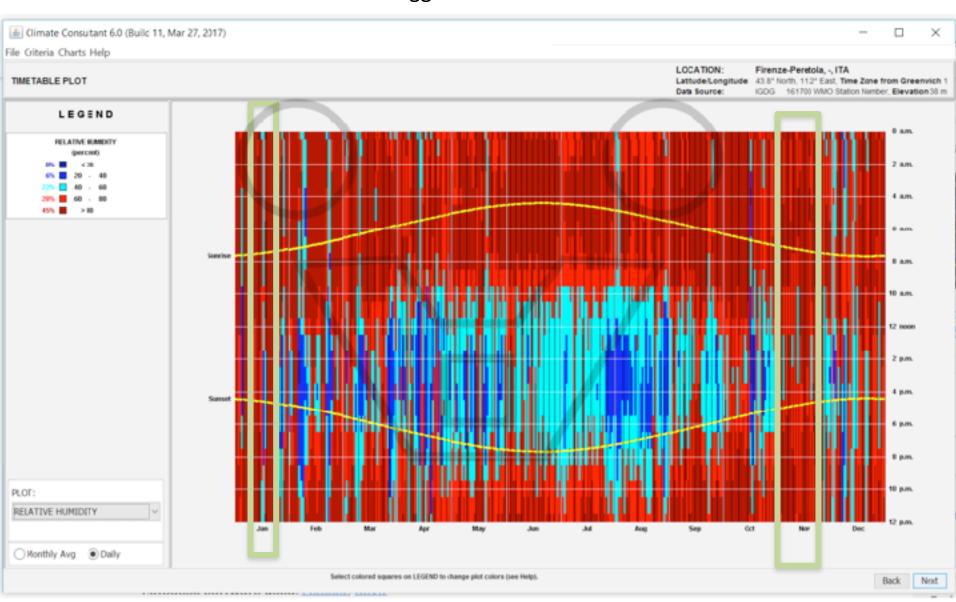






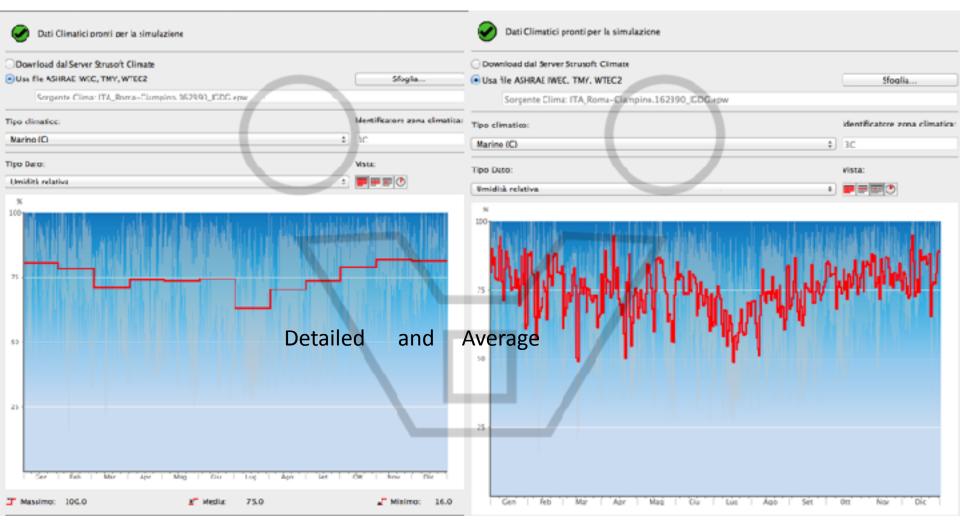


Perché UR è maggiore di notte?





Visualization of Relative Humidity



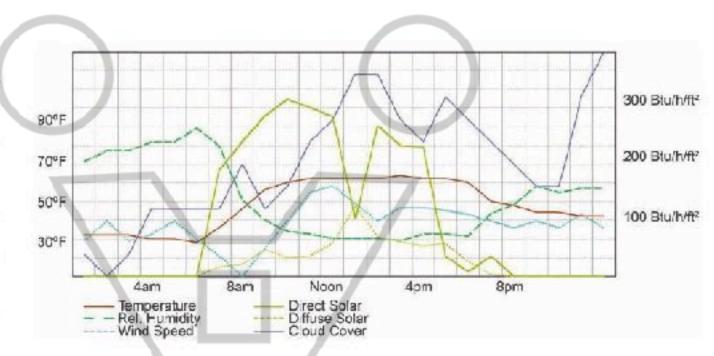


Inverse relationship between Temperature and Humidity

4.5

A 24-hour period set of data from a weather file shows the interaction of the dry bulb temperature, the relative hundridity, the direct solar, diffuse solar, wind speed and cloud cover. Note the inverse relationship of temperature and hundridity, direct and diffuse solar irradiation; and the inconsistent relationship between cloud cover and direct solar.

Source: Autodesk Ecotect Suite output of EnergyPlus weather data. Courtesy of Callison.



Apparent Temperature (AT)

ENVIRONMENTAL DESIGN



The **AT** is defined as the temperature, at the reference humidity level, producing the same amount of discomfort as that experienced under the current ambient temperature and humidity.

Basically the **AT** is an adjustment to the *ambient* temperature (**T**) based on the level of humidity.

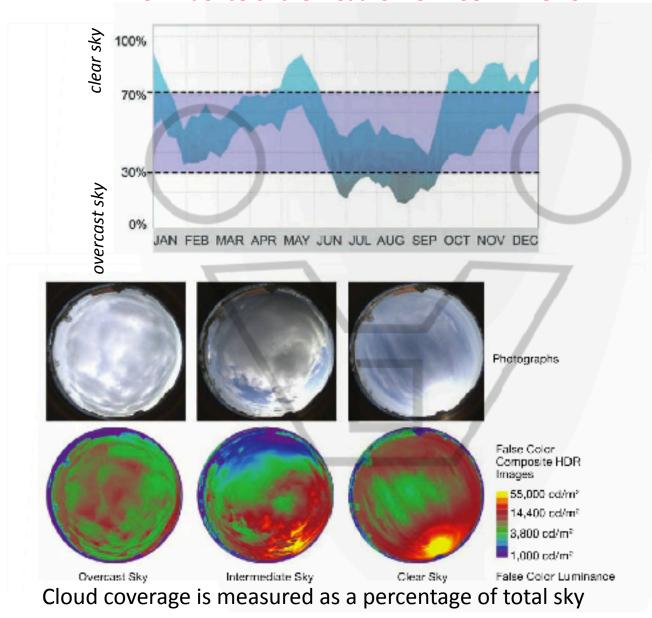
	26%	30%	35%	40%	45%	60%	66%	60%	65%	70%	75%	80%	86%	90%	95%	100%
42°	48	50	52	55	57	59	62	64					75			82
41°	46	48	51	53	55.	57		61	64			70	72	74		79
48°	45	47	49	51	63	55		59	61		65			71		
325	43	45	47	49	51	53	55	57	59	61						72
381	42	44	45	47	49	51	53	55	56		60	62	64		67	69
37°	40	42	44	45	47	49	51	52	54				61			
360	39	A.C.	42	44	45	47	49	50	52	-54	55	57	59			63
35°	37	39	40	42	44	45	47	48	50	51	53	54				61
341	36	37	39	40	42	43	45	48	48	49	51	62	54	65		
330	34	36	37	3	40	41	43	44	46	47	48	50	51	53	54	55
32"	33	34	36	37 35	W	40	41	42	44	45	46	48	49	50	52	53
310	32	33	34	35	37	38	39	40	42	43	44	45	47	48	49	50
380	30	32	33	34	35	36	37	39	40	41	42	43	45	46	47	48
29°	29	30	31	32	33	35	36	37	38	39	40	41	42	43	45	46
281	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43
27*	27	27	28	29	30	31	32	33	34	35	38	37	38	39	40	41
260	26	26	27	26	29	30	31	32	33	34	34	35	36	37	38	39
25°	25	25	26	27	27	28	29	30	31	32	33	34	34	35	36	37
242	24	24	24	25	28	27	28	28	29	30		32	33	33	34	35
21	23	23	23	24	25	25	26	27	28	28	29	30	31	32	32	33
22°	22	22	22	22	23	24	D	25	20	27	27	28	29	30	30	31
I mur d	29 C°	N	iessun d	disagio												
Da 30	a 34 C	C° SI	ensazio	ne di d	disagio											
										che pù						

Da 40 a 45 C° Forte sensazione di malessere. Pericolo: evitare gli sforzi

Pericolo grave: interrompere tutte le attività fisiche Pericolo di morte: colpo di calore imminente



The influence of the weather: SKY CONDITIONS



8.2

Cloud cover in Allen. Texas, varies from intermediate and overcast in winter, to intermediate and clear in summer. The CIE defines clear skies as >70% cloud cover, overcast skies as <30% cloud cover, and other skies as intermediate.

Source: Madiñed autput fram Autodesk Ecatect Suite. Courtesy of Callison.

8.3

Actual sky conditions that correspond to overcast, intermediate, and clear skies are shown using high dynamic range (HDR) fish-eye photographs and false color images. While most daylight simulation uses synthetic, averaged sky conditions, actual sky conditions vary by the minute. HDR skies can be used in daylighting simulations, see Case Study 8.6.

Source: Inenici (2016). Images & Illuminating Engineering Society, vrww.iec.org.



The influence of the weather: SKY CONDITIONS

				Condizioni a	tmosferiche			
Radiazione solare	Cielo sereno	Nebbia	Nuvoloso	Disco solare giallo	Disco solare bianco	Sole appena percettibile	Nebbia fitta	Cielo coperto
	0	0	-0.	0/	0	0		
globale	1000 W/m ²	600 W/m ²	500 W/m ²	400 W/m ²	300 W/m ²	200 W/m ²	100 W/m ²	50 W/m ²
diretta	90%	50%	70%	50%	40%	0%	0%	0%
diffusa	10%	50%	30%	50%	60%	100%	100%	100%

http://www.sunsim.it/

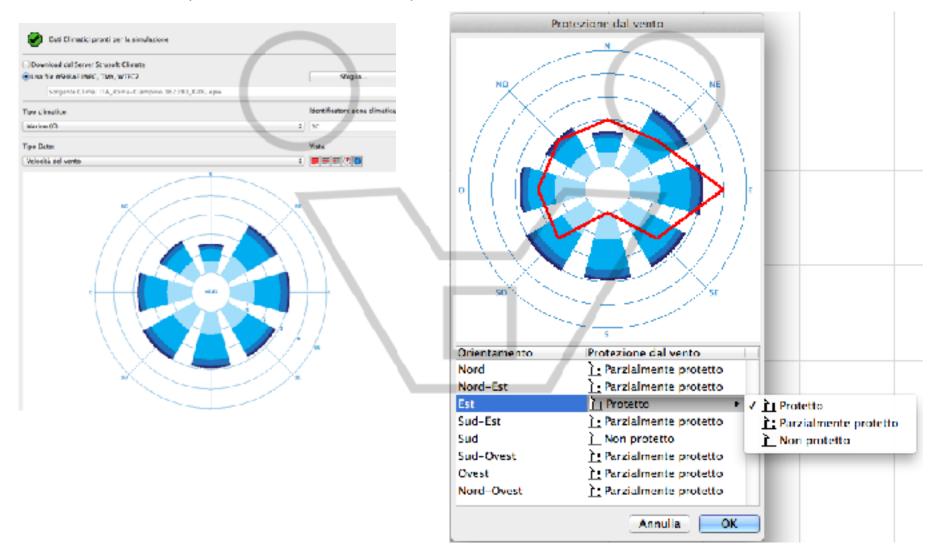






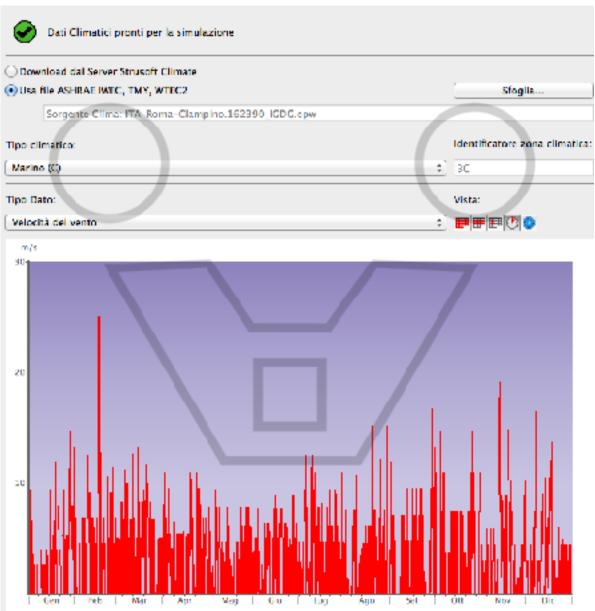


- 1- determine the coldest and the hottest seasonal period and hours
- 2- for that periods find the most frequent wind directions





Wind Velocity



from archicad



- 3- define wind speed for the hottest and coldest periods
- 4- reduce the speed according to altitude and roughness of the site

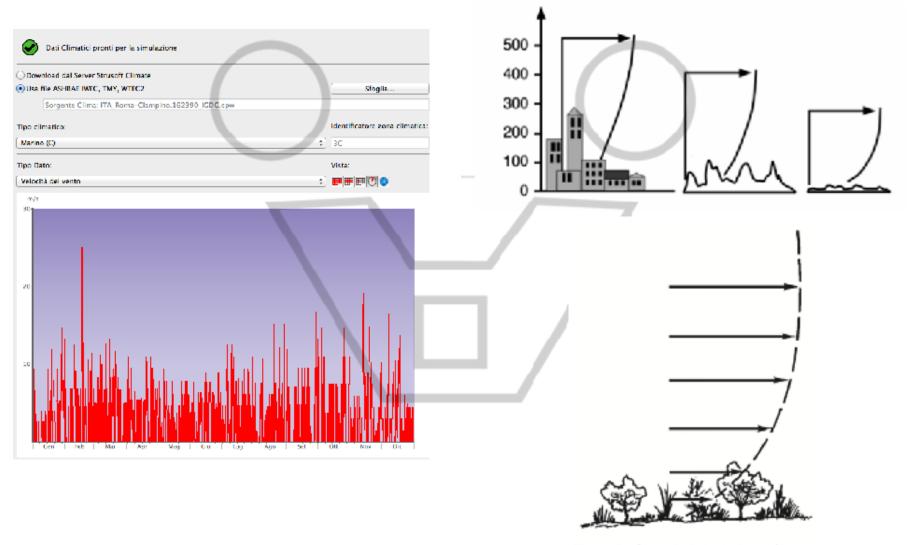


Figure 1—General wind velocity profile near surface (from Rothermel 1983).



Effect of Wind on Temperature

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HOW TO VISUALIZE WINDS – Airflow Modeling

Understanding the air flow and distribution patterns for buildings.

The building form and shape can affect how air flows through the building and across neighboring developments into the building.

This is an important consideration for natural ventilation and can significantly reduce costs of air-conditioning provisions. There are Computational Fluid Dynamics (CFD) tools available that can help simulate the air-flow patterns within built-spaces as well as for whole building estates

Basic software tool:

Flow Design http://www.autodesk.com/education/free-software/flow-design (student version available)

Other popular software tools:

Fluent by Ansys: http://www.ansys.com/. (student version available)

FloVent from Mentor Graphics: http://www.mentor.com/.

Comsol Multiphysics modeling software: https://www.comsol.com/.

References

AIA (The American Institute of Architects) (2012) An Architect's guide to integrating energy modeling in the design process ERI@N (Energy Research Institute @ NTU) (2013) Nanyang Technological University (NTU), Singapore NREL (2009) A handbook for planning and conducting charrettes for high-performance projects, National Renewable Energy Laboratory (NREL), Sept 2009

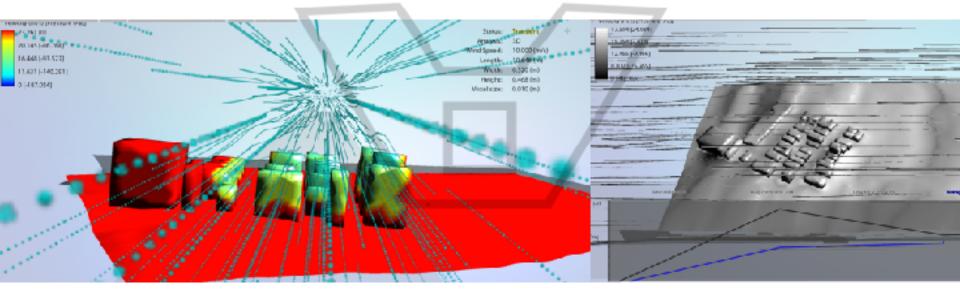
prof. arch. G.Ridolfi, PhD

Air movement: WIND ANALYSIS

5- Orient the model according to the wind direction

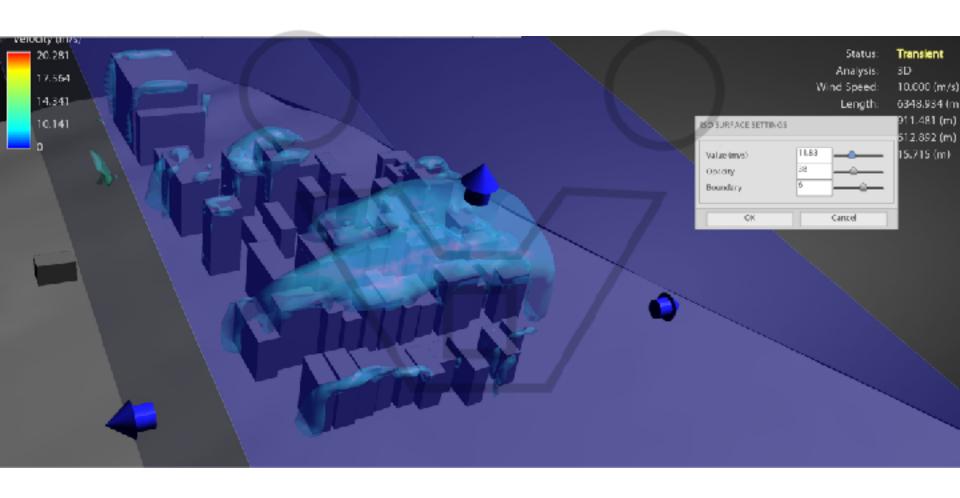


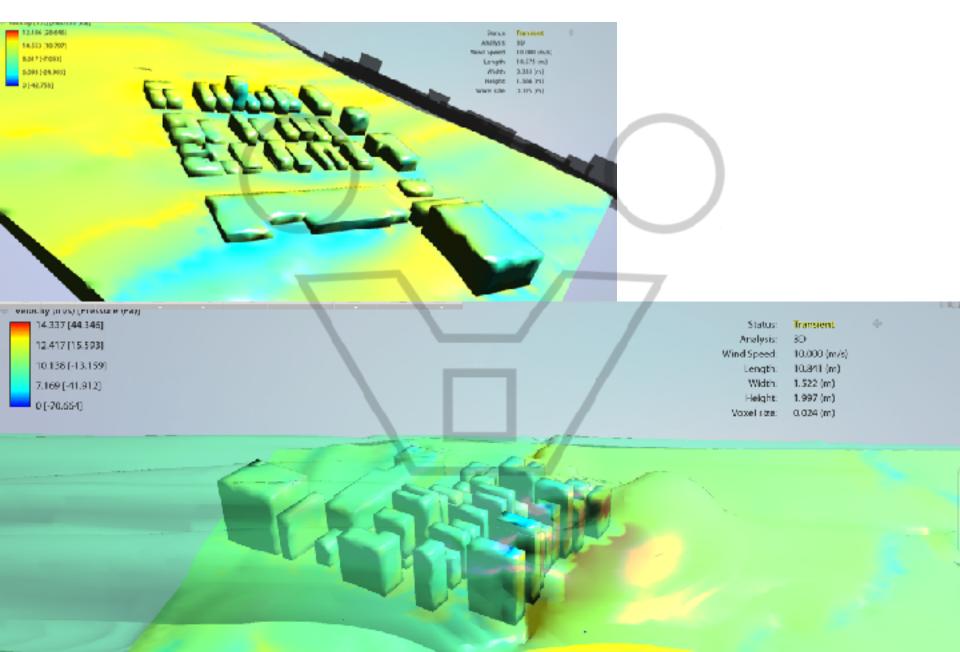






6- Set the wind velocity & analyze results (low, high pressure zones)







SOFTWARE DOWNLOAD http://www.energy-design-tools.aud.ucla.edu/climate-consultant/request-climate-consultant.php

VIDEO TUTORIAL

https://www.youtube.com/watch?v=OsWm8dfhP U

SHORT MANUAL

https://www.researchgate.net/publication/

266571240_CLIMATE_CONSULTANT_30_A_TOOL_FOR_VISUALIZING_BUILDING_ENERGY_IMPLICATIONS_OF_CLIMATES

LINKS

Climate Analysis

Solar Position

The Solar Envelope

Reading Sun Path Diagrams [video]

Sun and Shadow Studies in BIM

Sun and Shadow Studies in BIM -Workflow [video]

The difference between source and site energy

Revit Tutorials: Conceptual Massing

Revit Tutorials: Design Options

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Building Performance Analysis in Revit 2016 R2 with Autodesk Insight 360

examples

Italian Nursery School: Conceptual Design Analysis

Sustaining Modernity: An Analysis of The Gropius House

