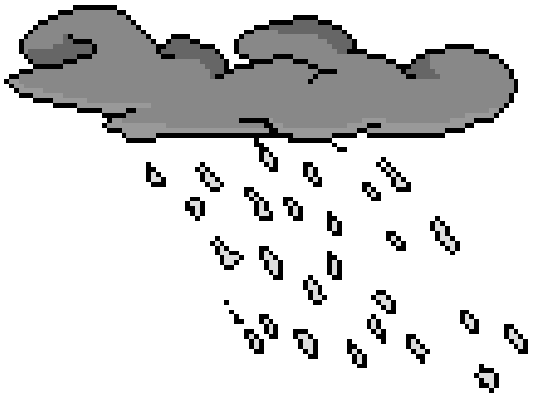
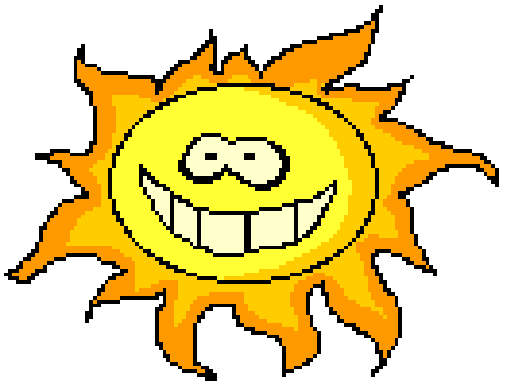
SOLAR RADIATION

Solar radiation

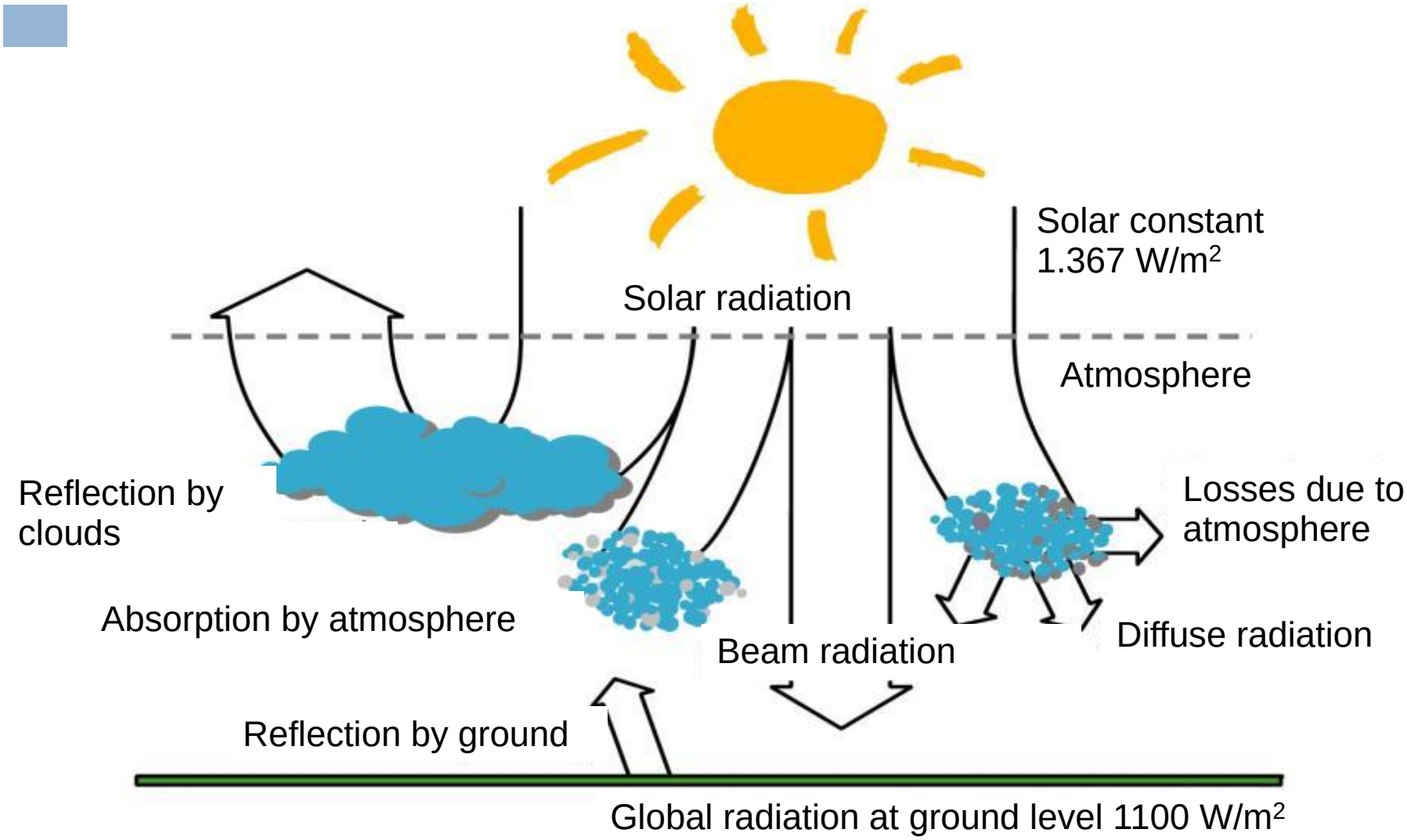
- How much solar energy reaches the ground?
- Where to find and how to read solar radiation data?
- Slope and orientation of solar collectors
- Shadow effects

Solar radiation is aleatory



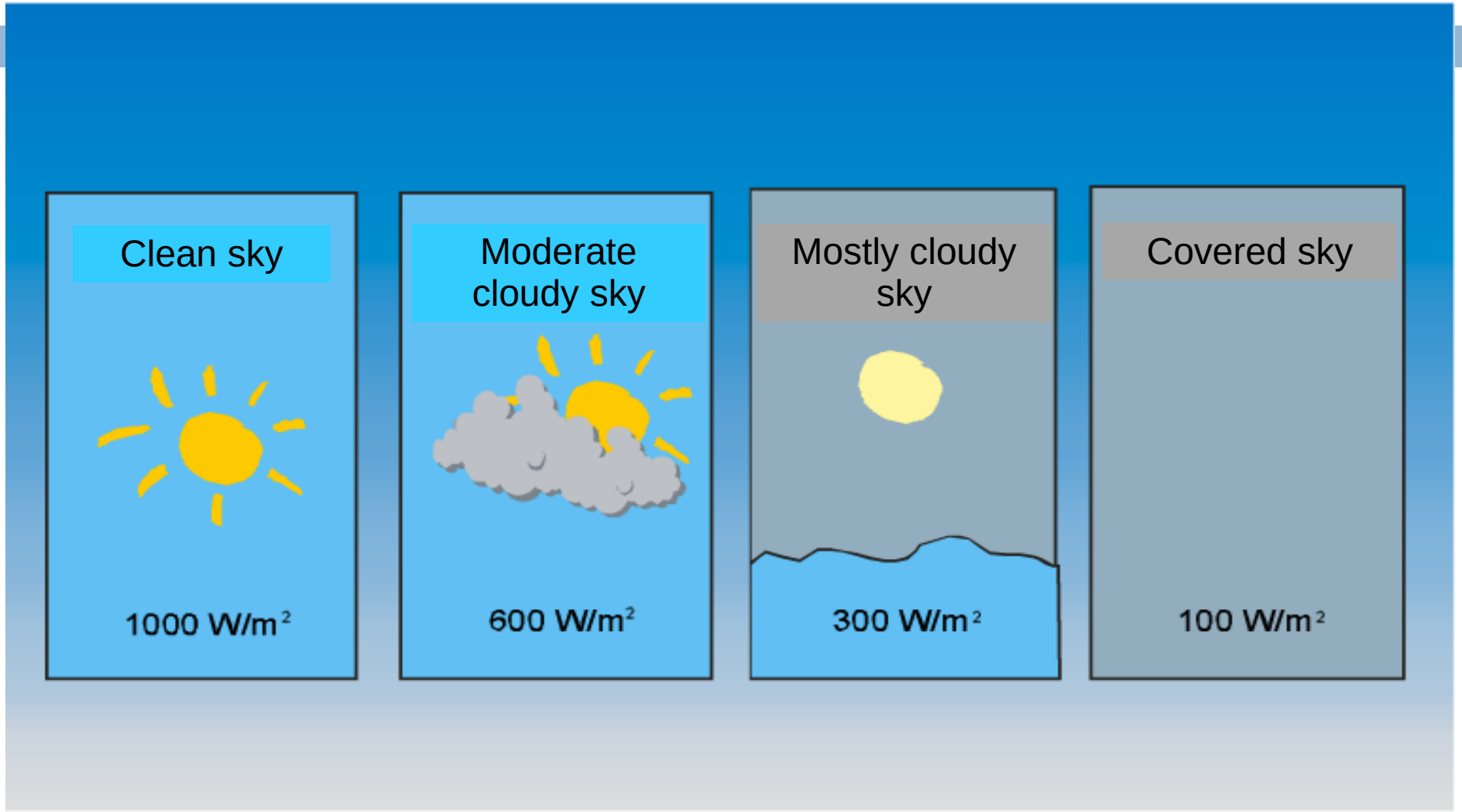


Solar radiation at ground level



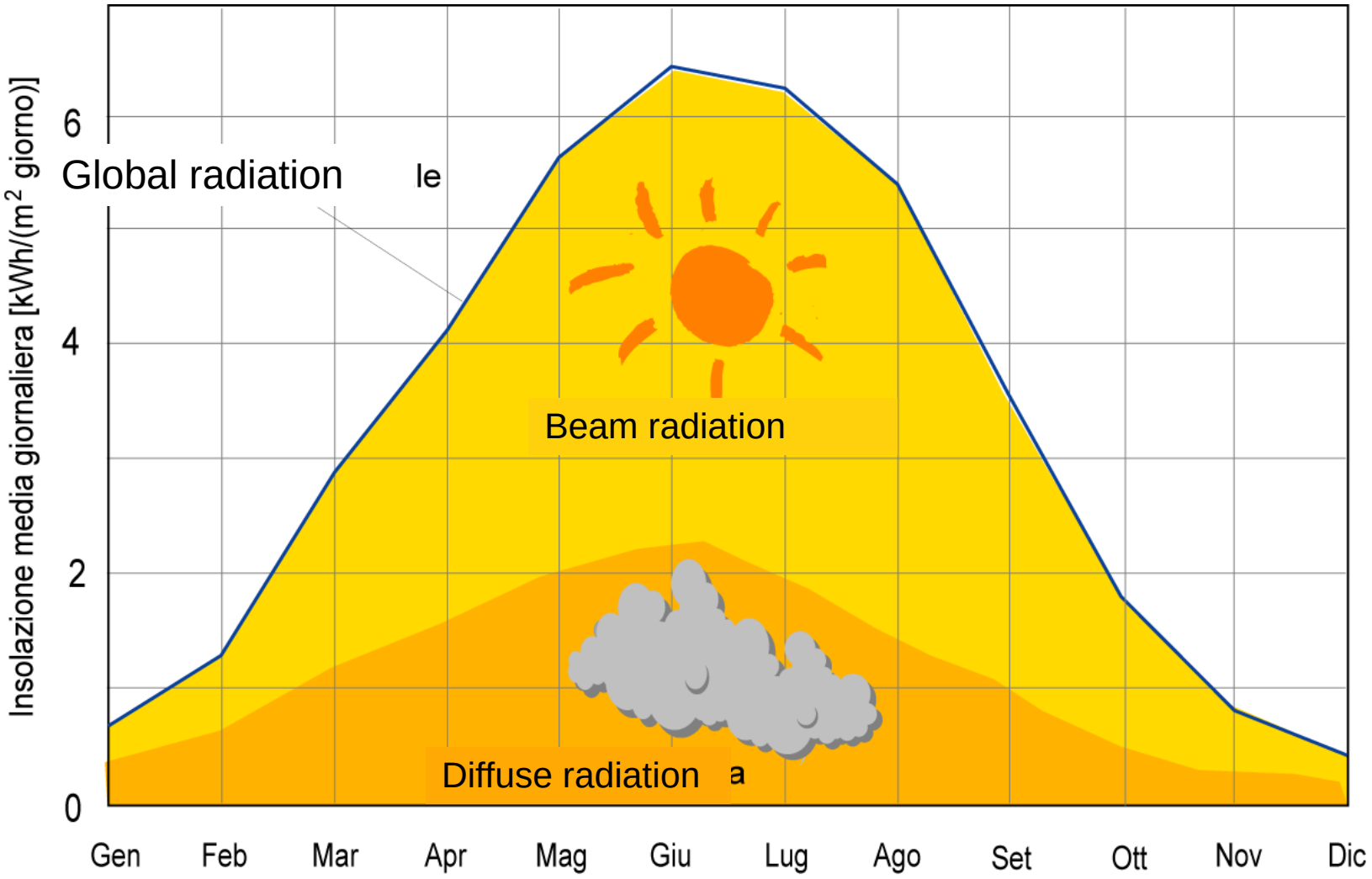
Source: Target/e.u.z.

Solar radiation at ground level



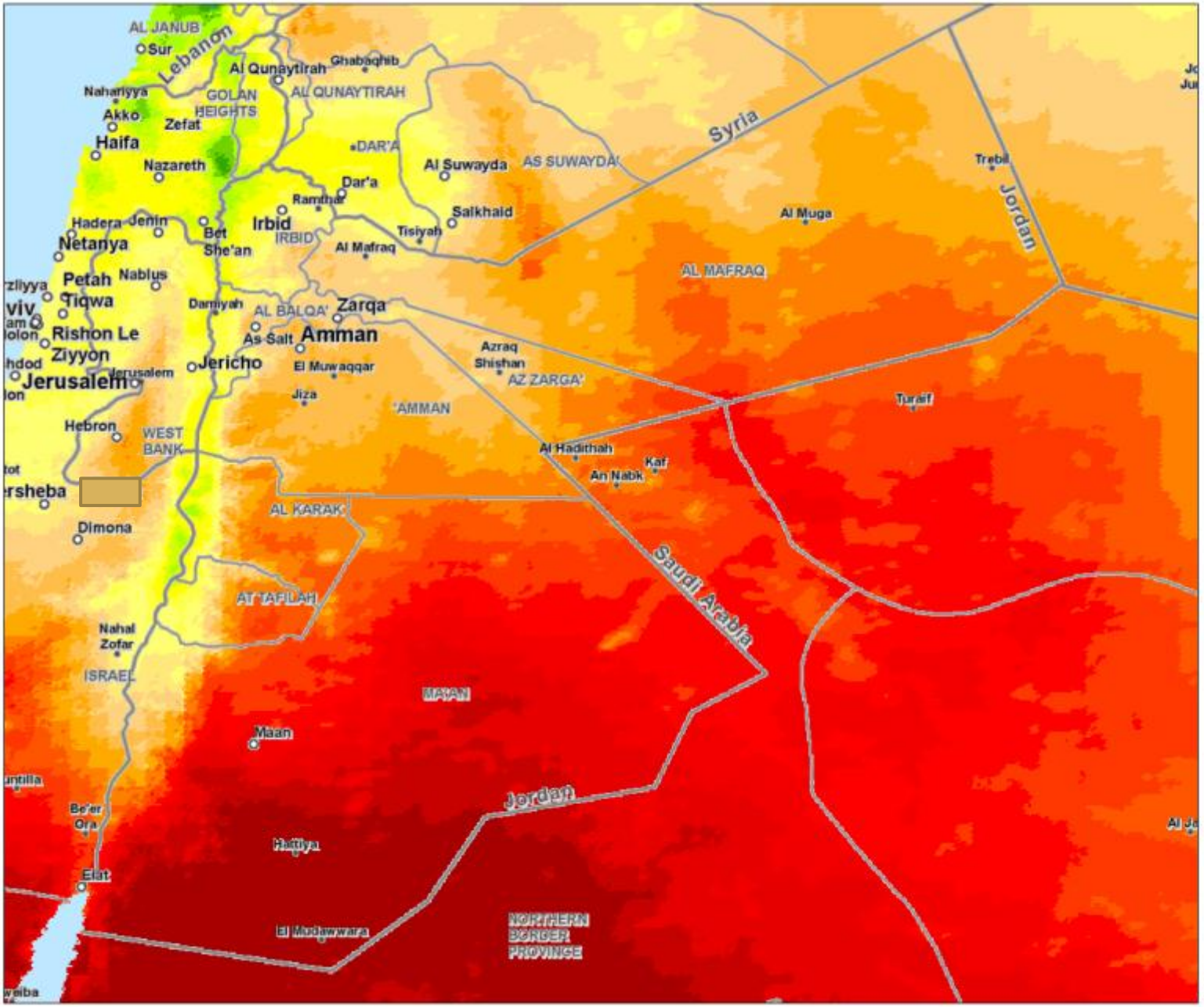
Source: ITW

Beam and diffuse radiation on horizontal surfaces



Source: Target/e.u.z.

Solar Radiation Jordan



kWh/m2

- Ocean
- 1,551 - 1,575
- 1,576 - 1,600
- 1,601 - 1,625
- 1,626 - 1,650
- 1,651 - 1,675
- 1,676 - 1,700
- 1,701 - 1,725
- 1,726 - 1,750
- 1,751 - 1,775
- 1,776 - 1,800
- 1,801 - 1,825
- 1,826 - 1,850
- 1,851 - 1,875
- 1,876 - 1,900
- 1,901 - 1,925
- 1,926 - 1,950
- 1,951 - 1,975
- 1,976 - 2,000
- 2,001 - 2,025
- 2,026 - 2,050
- 2,051 - 2,075
- 2,076 - 2,100
- 2,101 - 2,125
- 2,126 - 2,150
- 2,151 - 2,175
- 2,176 - 2,200
- 2,201 - 2,225
- 2,226 - 2,250

Where can radiation data be found?

Meteonorm: http://www.meteonorm.com/media/maps_online/gh_map_africa.pdf

PV GIS: http://re.jrc.ec.europa.eu/pvgis/countries/afr/4-gs13.png

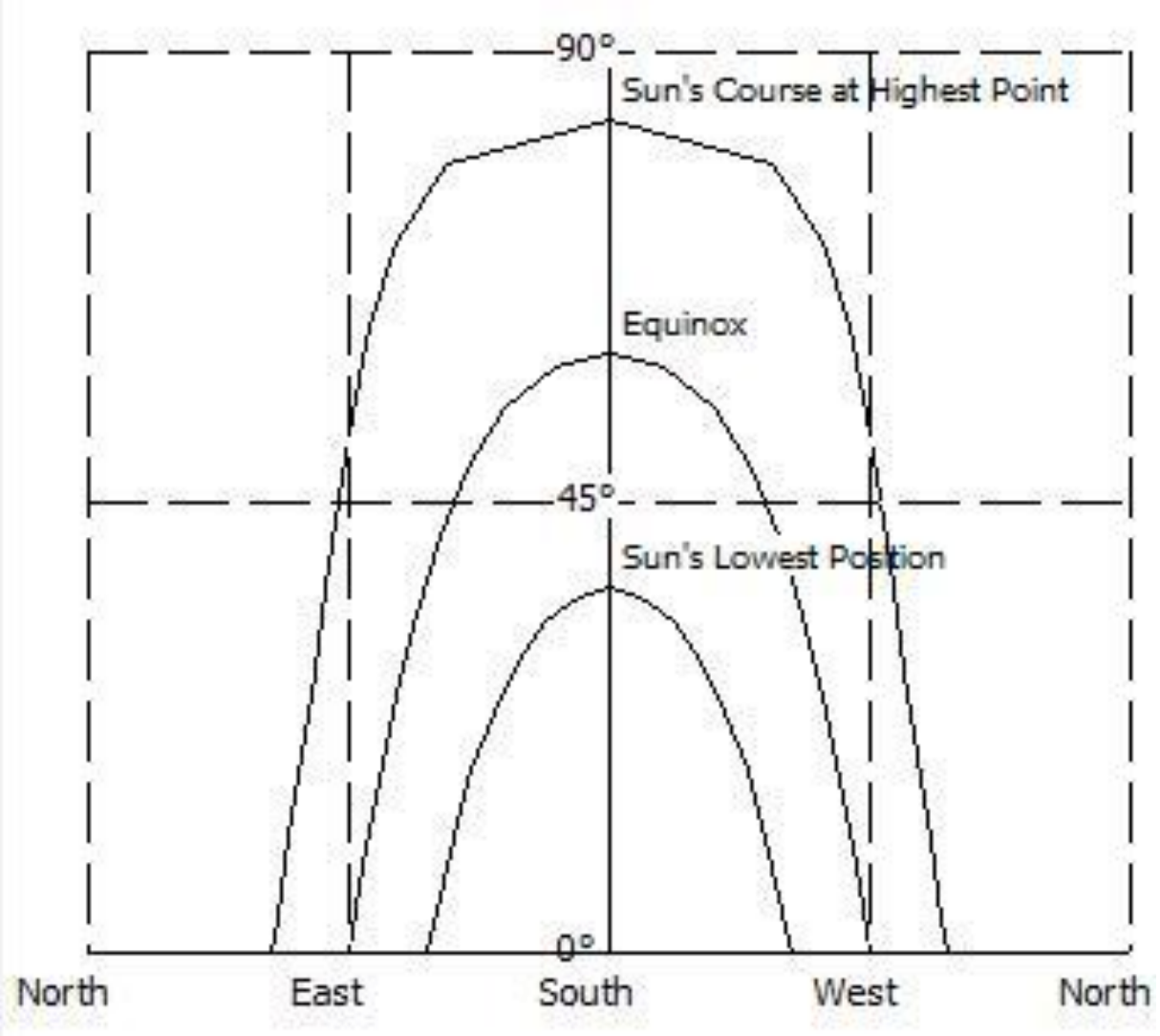
NASA: http://swera.unep.net/index.php?id=wms_compliant

Design Software: T*Sol, Transol, Polysun

NREA solar atlas

Solar radiation – regular variations

Daily and monthly variations



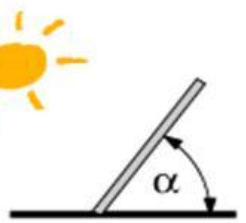
Source: www.solaritaly.enea.it

Example of monthly values

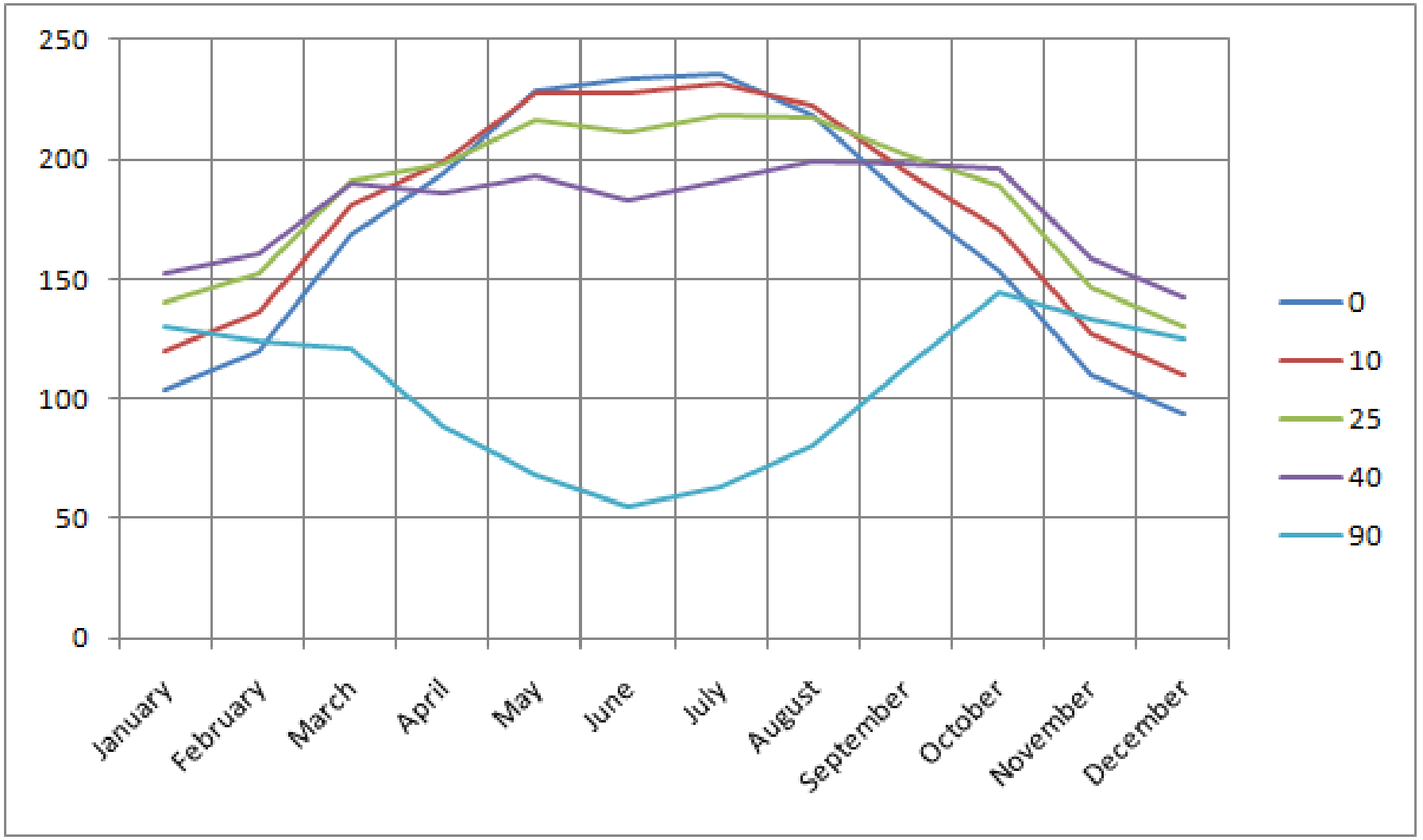
	G Horizontal
	[kWh/m²]
January	103
February	120
March	168
April	194
May	228
June	233
July	235
August	219
September	184
October	153
November	109
December	94
Year	**2040**

Source: T Sol

Radiation on sloped surfaces

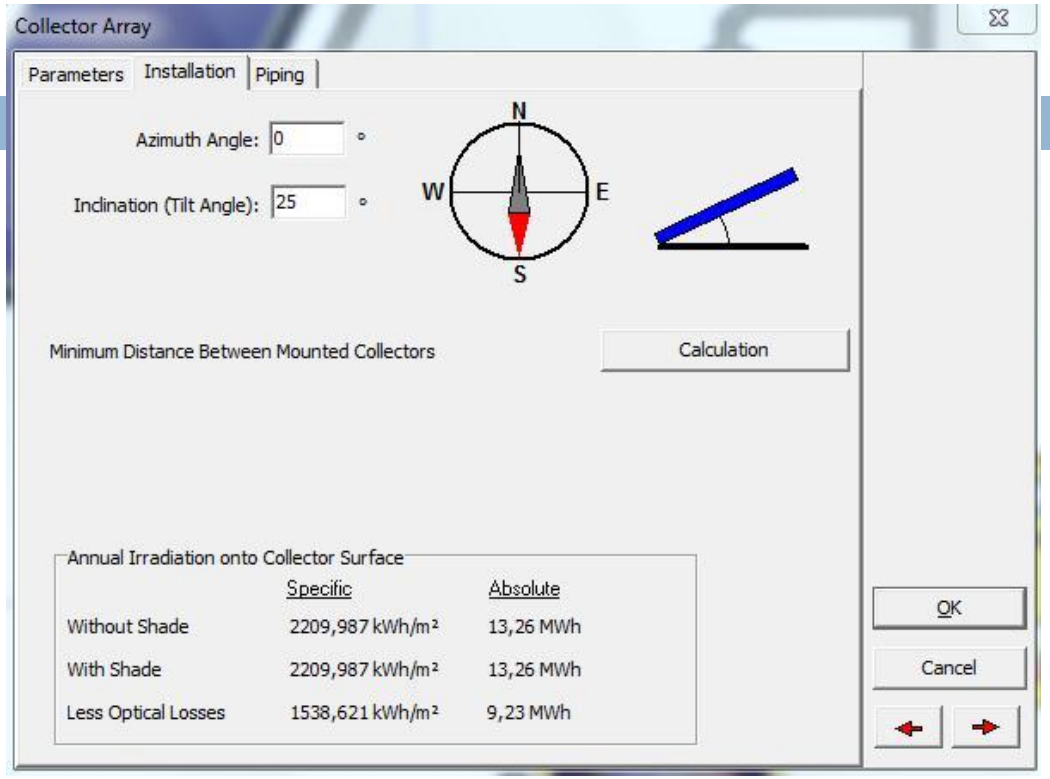


[kWh/(m^2 month)]



Optimal slope angle

slope [°]	kWh / (m2 a)
0	2040
10	2145
20	2200
25	**2210**
30	2200
40	2150
50	2050
60	1900
70	1715
80	1490
90	1250

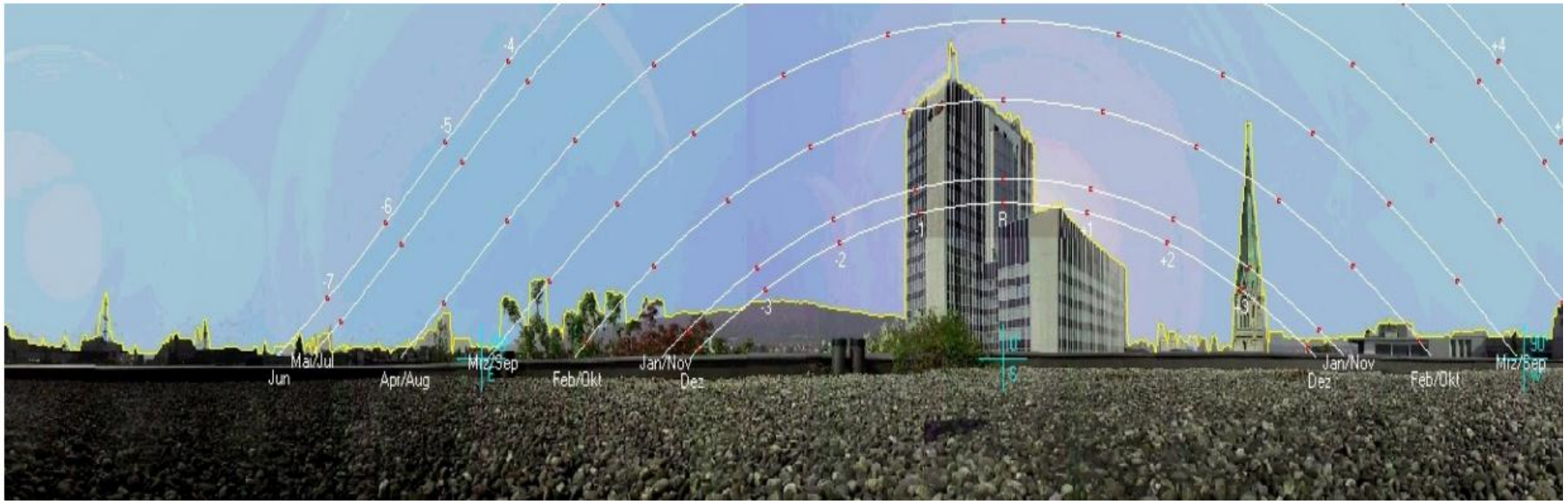


Losses due to different slope and orientation

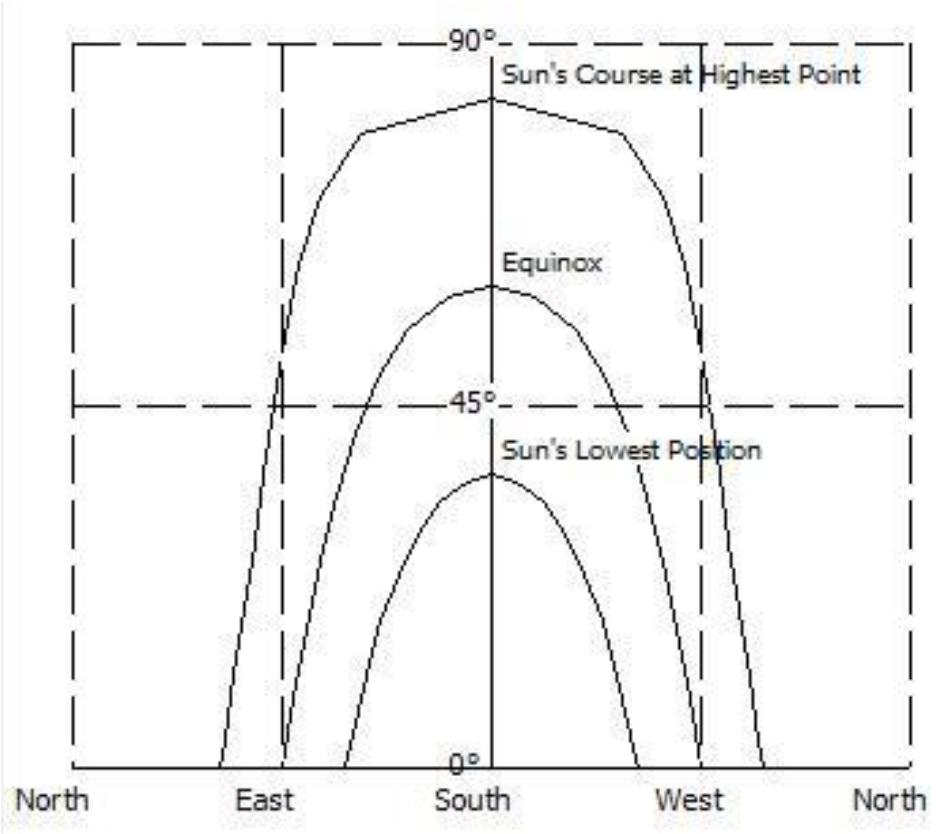
	West						East
	90	60	30	0	-30	-60	-90
0	92	92	92	92	92	92	92
10	91	94	96	97	96	94	91
20	89	94	98	99,6	98	94	89
25	87	94	98	100	98	94	87
30	85	93	98	99,7	98	93	85
90	51	57	58	56	58	57	51

Shadows

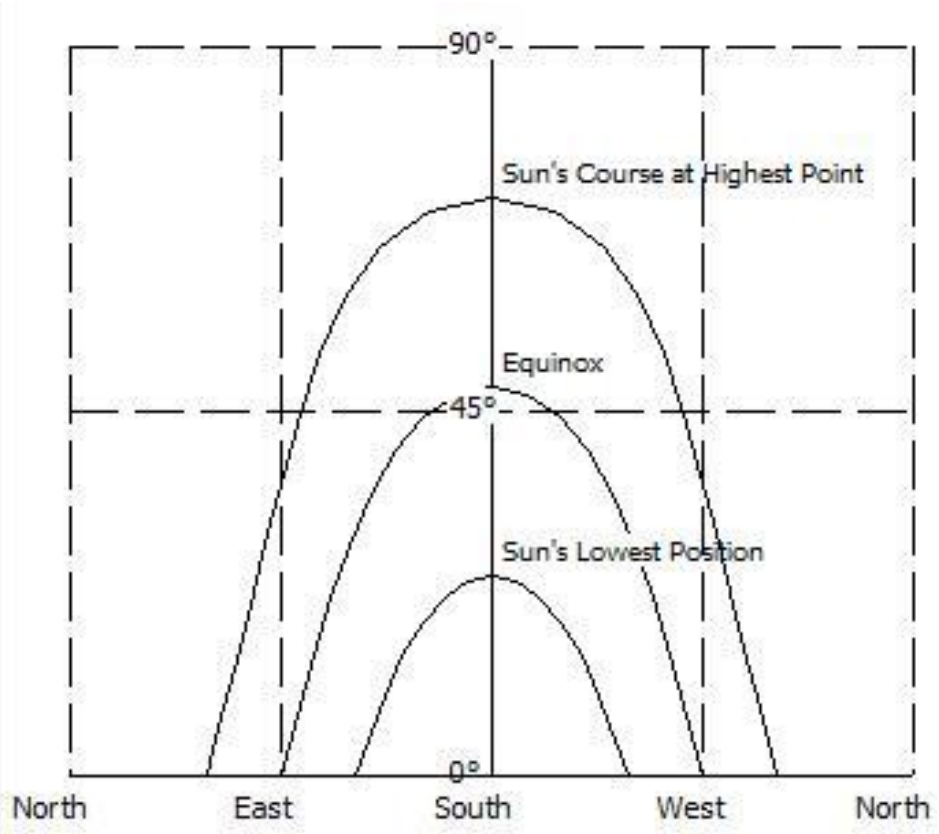
- thumb estimation
- evaluation of obstacles’ coordinates
- compass and clinometer
- sofwares (evaluation of basic obstacles’ geometric data)


-4
-5
-6
-7
-3
-2
-1
+1
+2
+4
Mai/Jul
Jun
Apr/Aug
Mrz/Sep
Feb/Okt
Jan/Nov
Dez
Jan/Nov
Dez
Feb/Okt
Mrz/Sep

Sun trajectory in Cairo and Rome

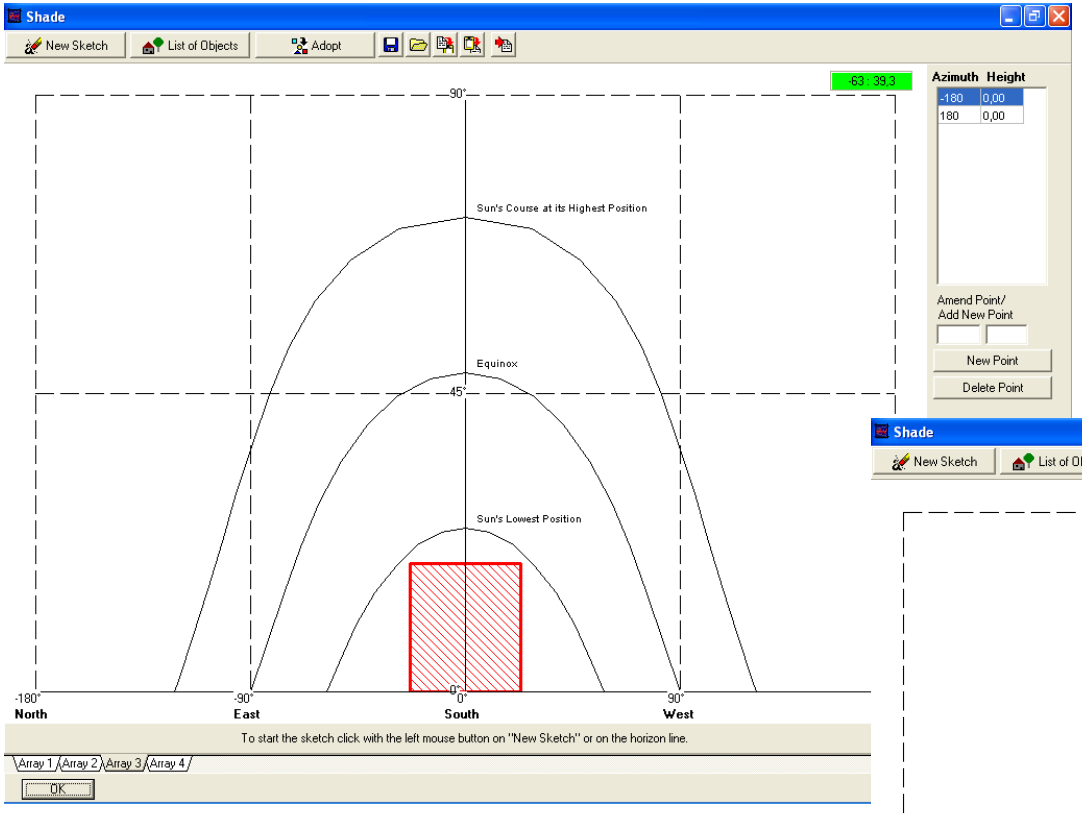


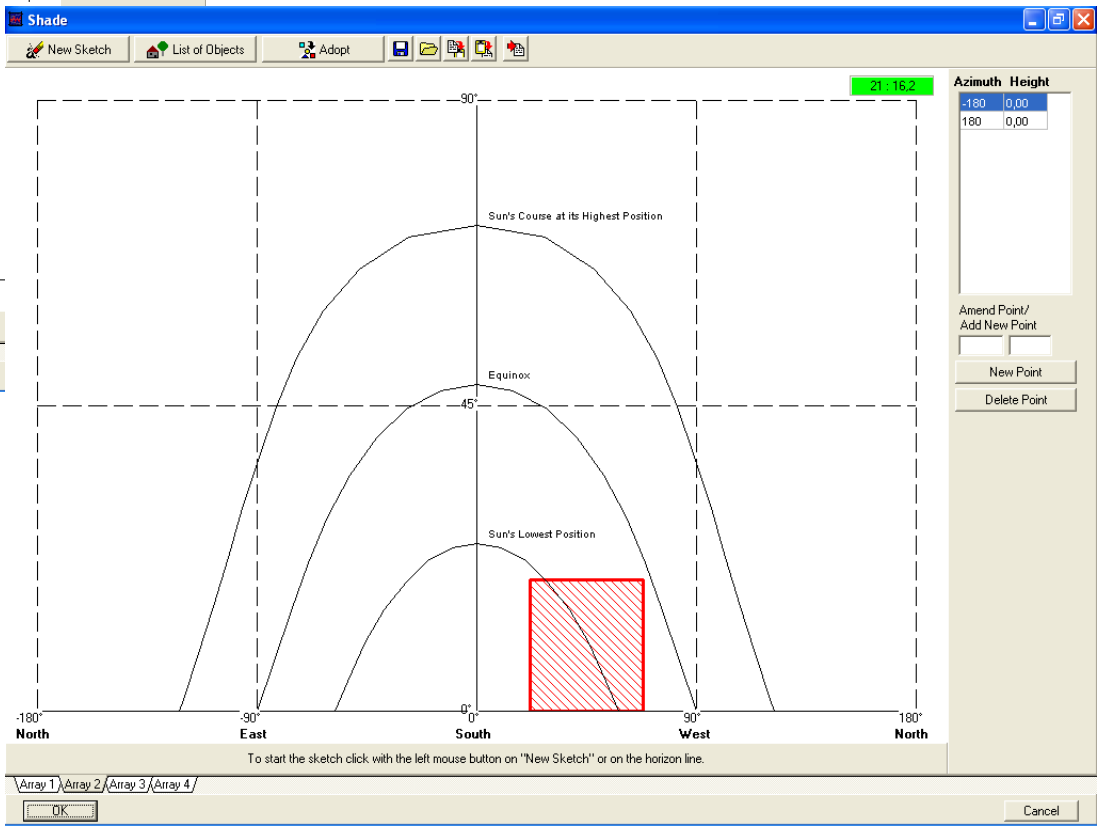
Cairo



Rome

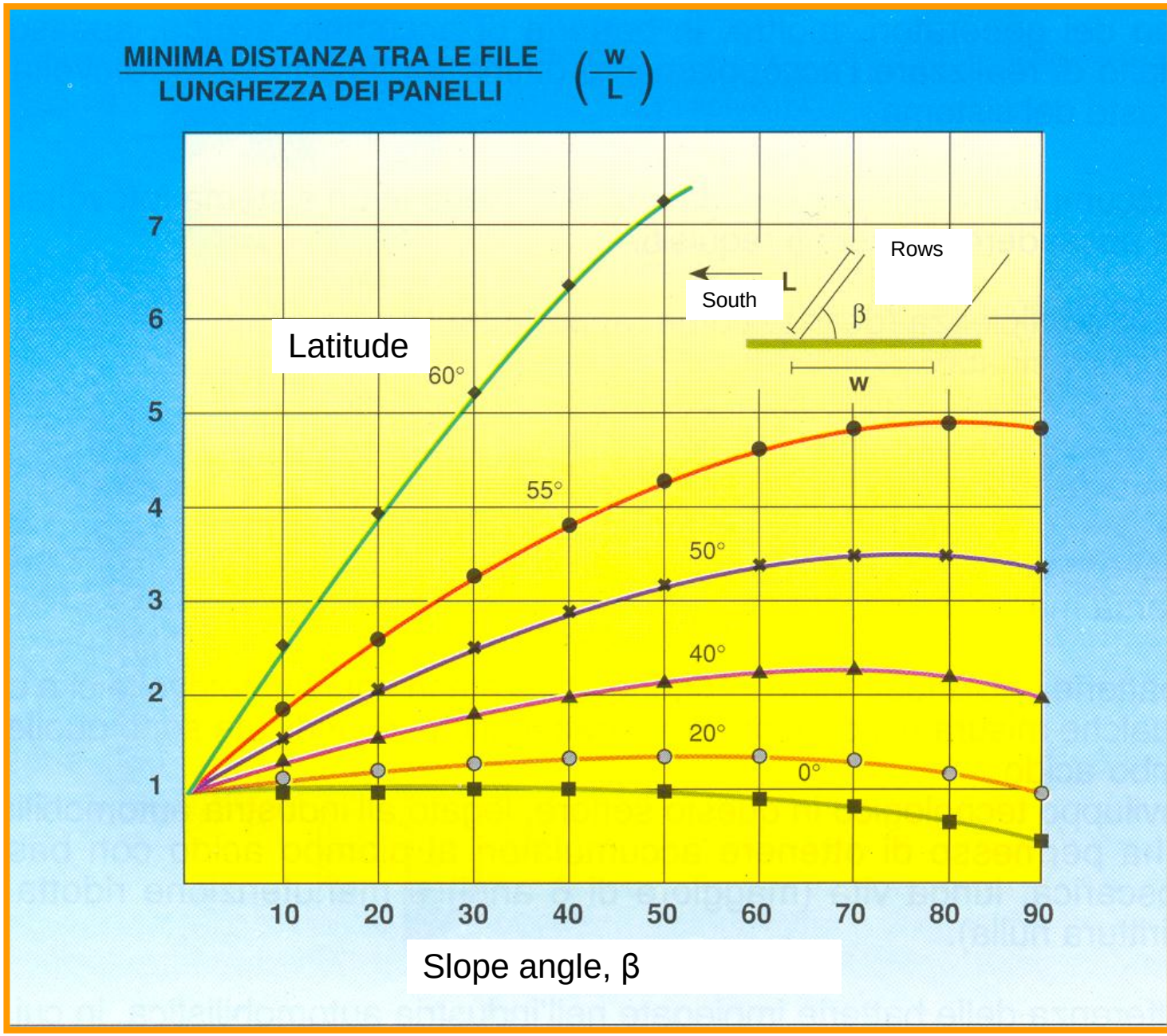
Same obstacle in different positions





Shadow effect between collector rows

$$\frac{\text{Min. distance between rows}}{\text{Collector's lenght}} = \frac{W}{L}$$



Source: ENEA