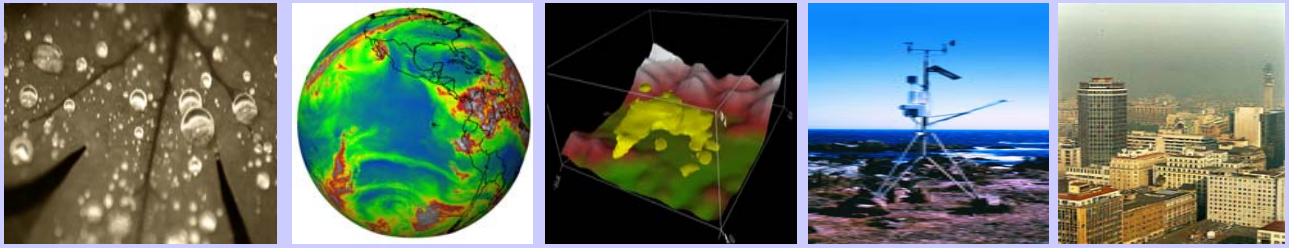
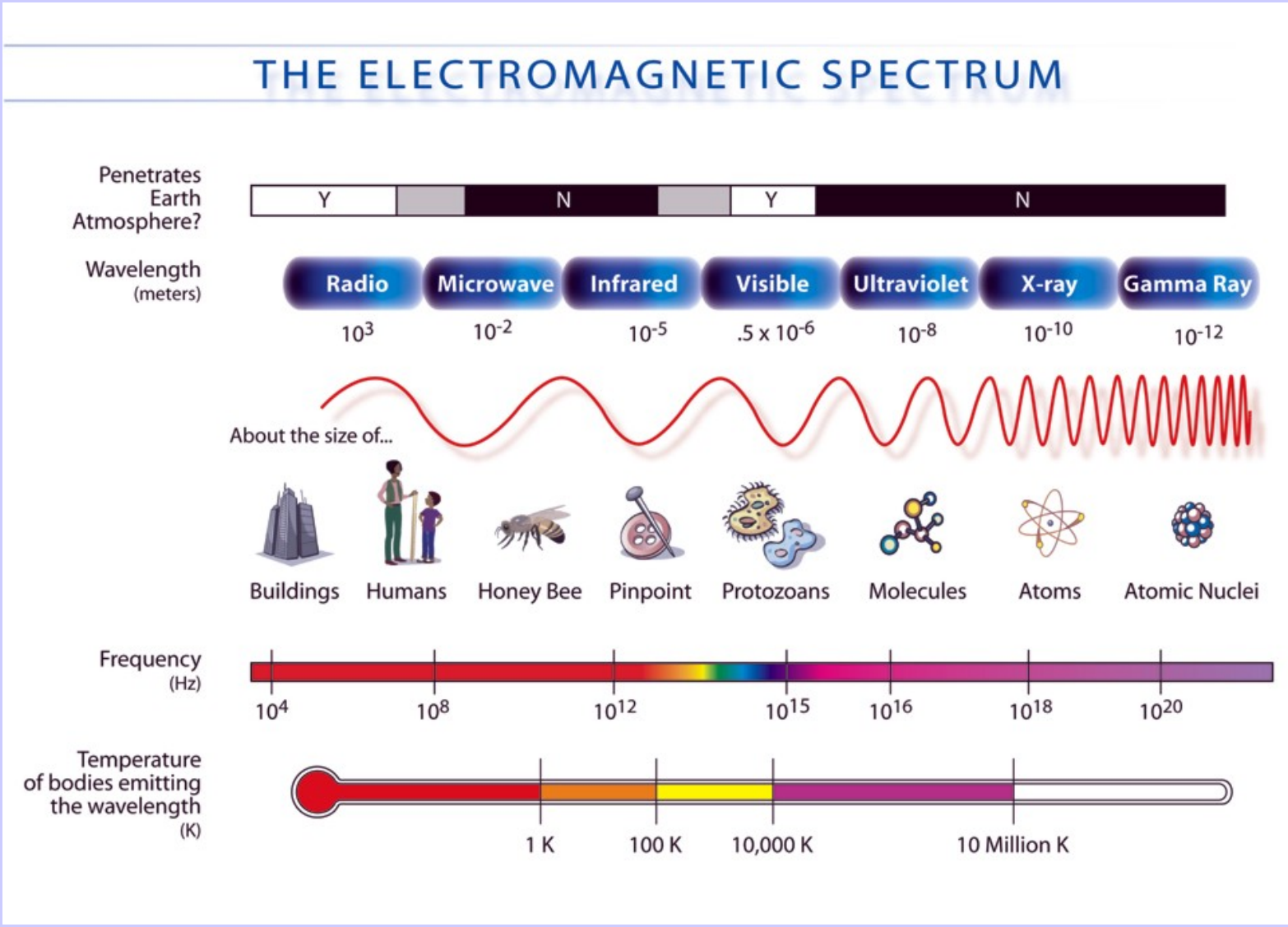


Universidad de Chile
Departamento de Geofísica

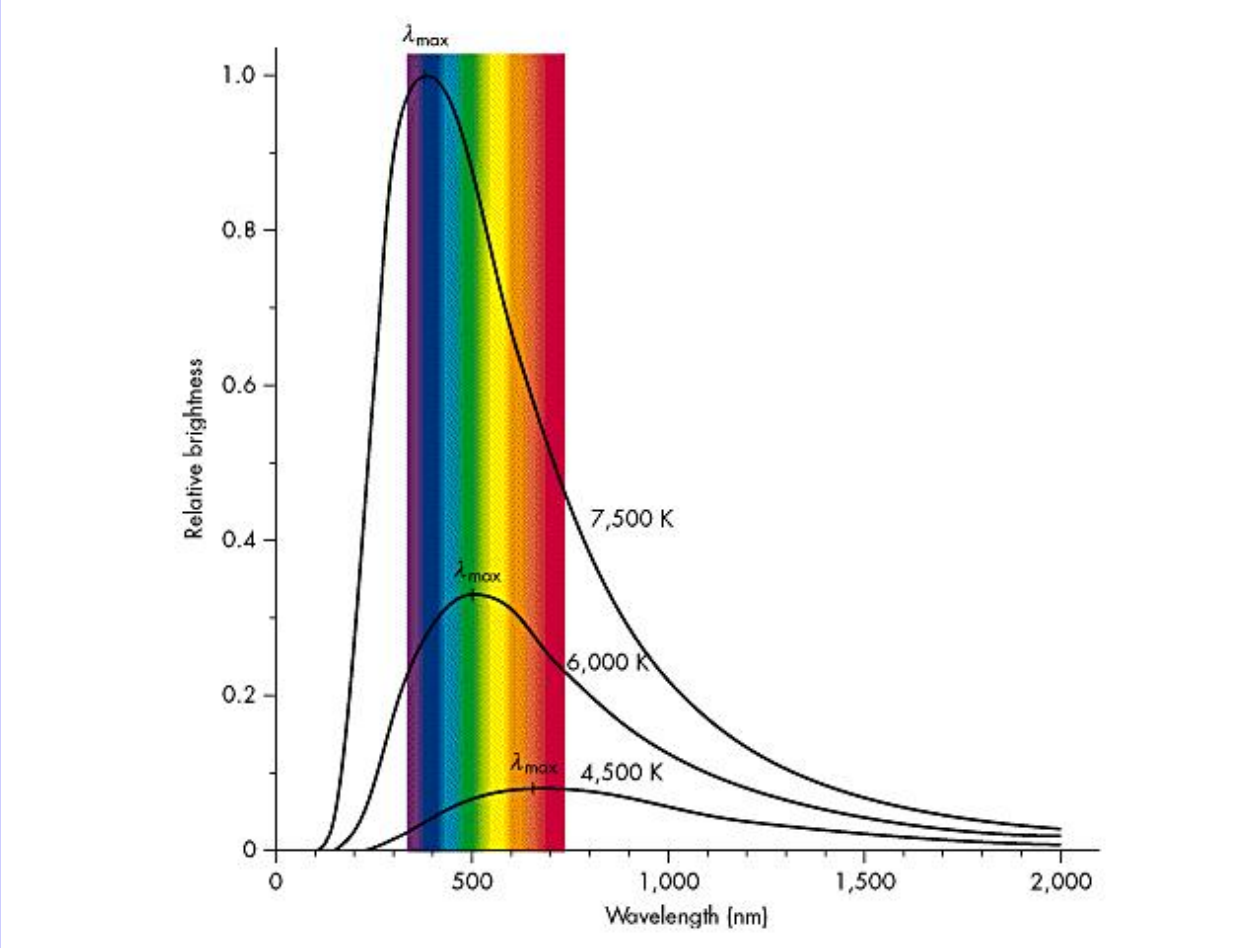
Introducción a la Meteorología y Oceanografía (2011)

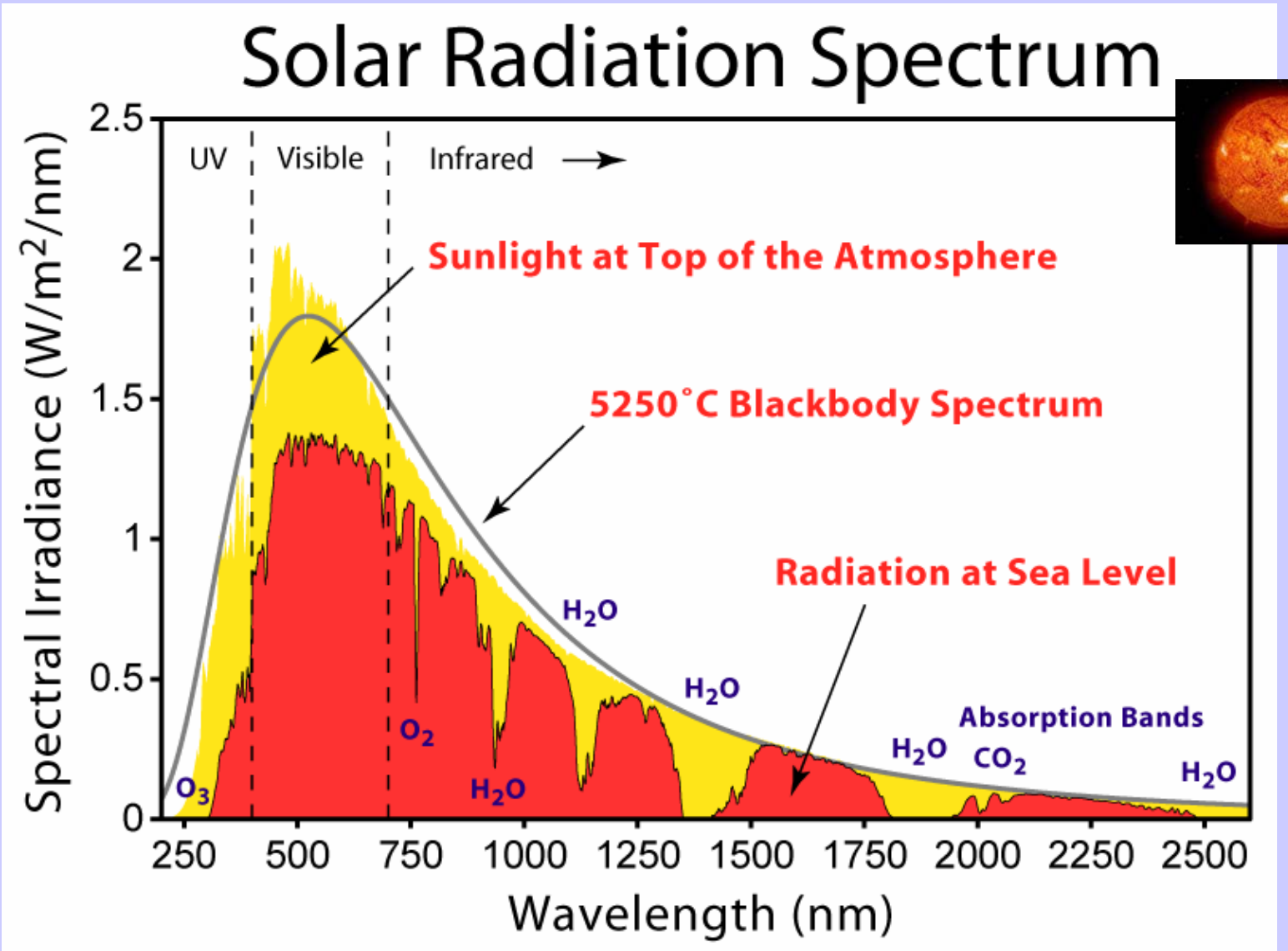
Transferencia Radiativa I (Radiación Solar)

Prof. René Garreaud
www.dgf.uchile.cl/rene

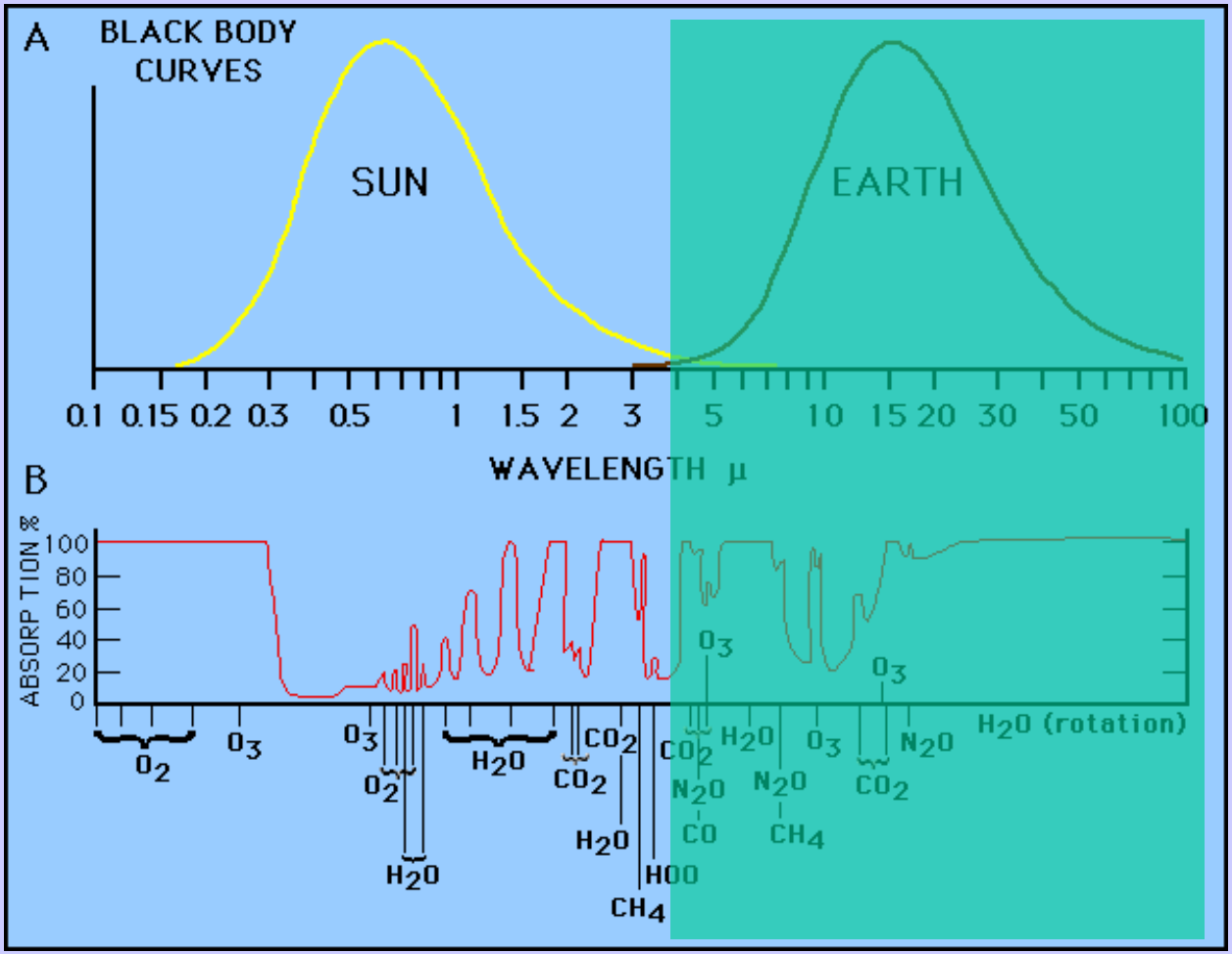


http://mynasadata.larc.nasa.gov/images/EM_Spectrum3-new.jpg


λmax
1.0
0.8
0.6
0.4
0.2
0
Relative brightness
7,500 K
λmax
6,000 K
λmax
4,500 K
0
500
1,000
1,500
2,000
Wavelength (nm)



http://physweb.bgu.ac.il/COURSES/Astronomy1/Graphics/solar_spectrum.png



En su paso por la atmósfera, la radiación solar sufre absorción y dispersión debido a las moléculas de aire y aerosoles. En promedio, la absorción de la RS es solo de un 20%, pero muy efectiva en el rango de los rayos gama y UV.

Constante Solar: Cuanta energía recibimos del sol

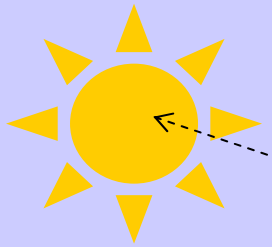
La energía emitida por el sol por unidad de area

$$E = \sigma T_s^4$$

Energía total que emite el sol

$$I = 4*\pi*R_s^2*E$$

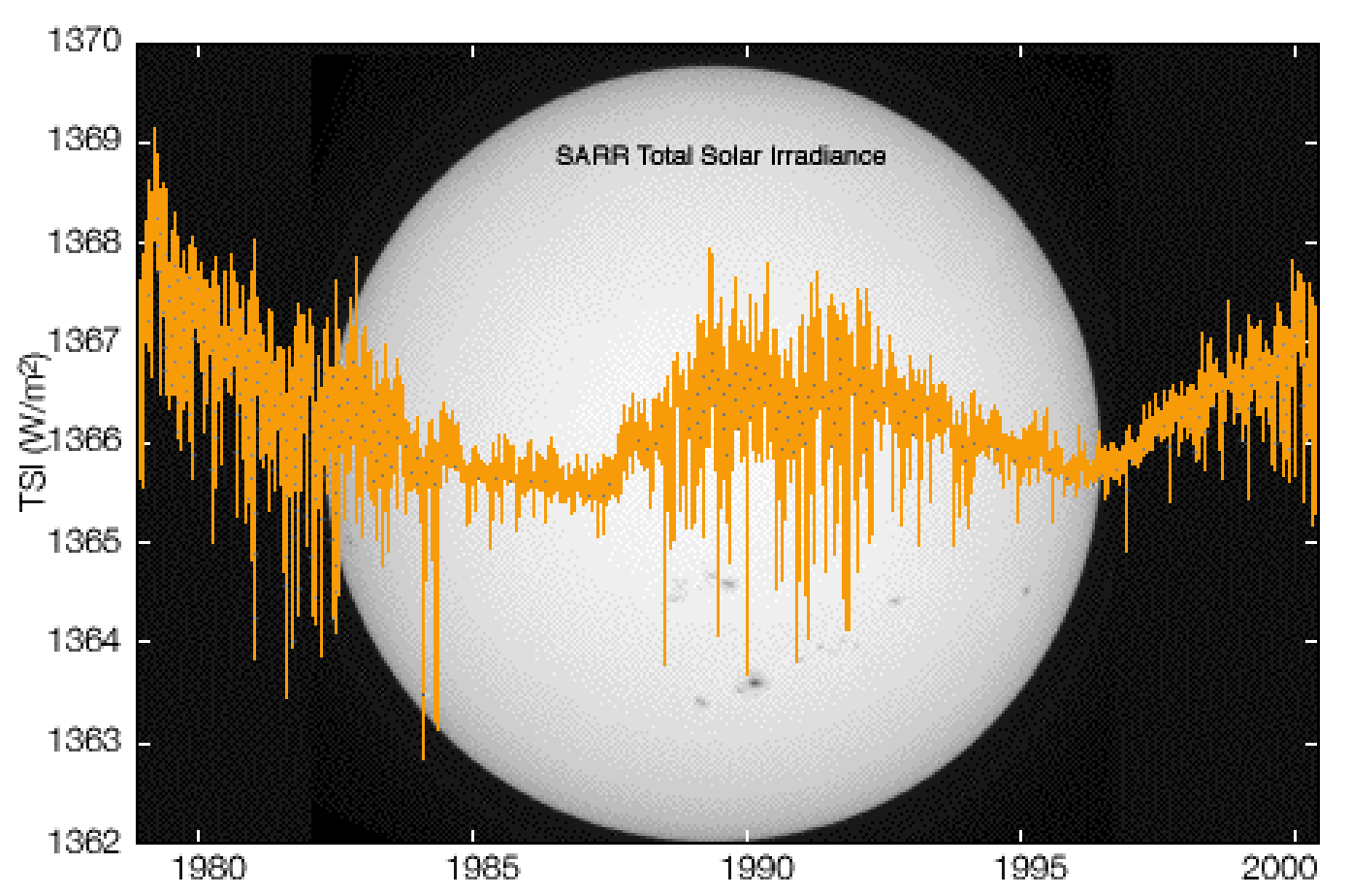
Energía por unidad de area a la distancia de la tierra:

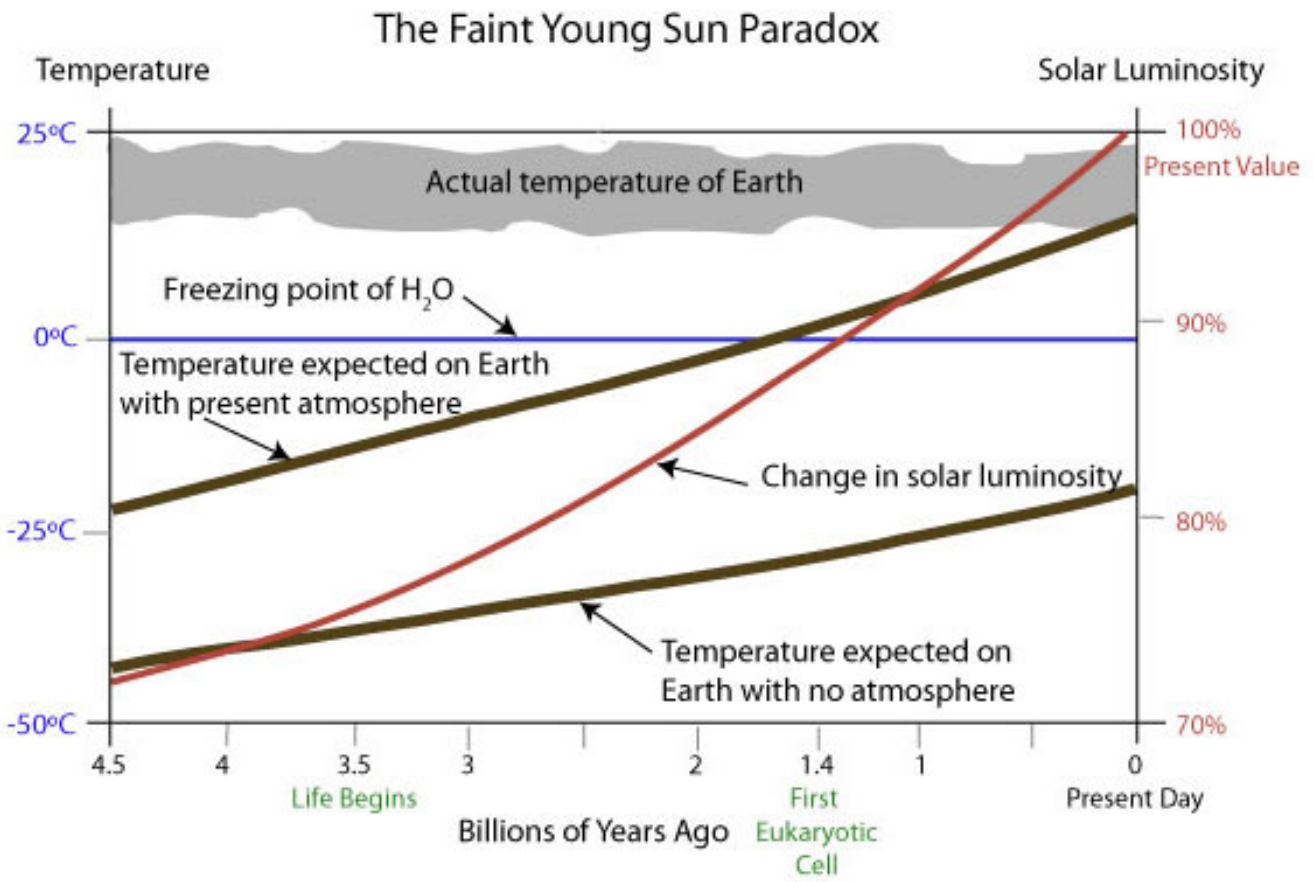


$$CS = I / (4*\pi*D_{t-s}^2) = 1397\ W/m^2$$

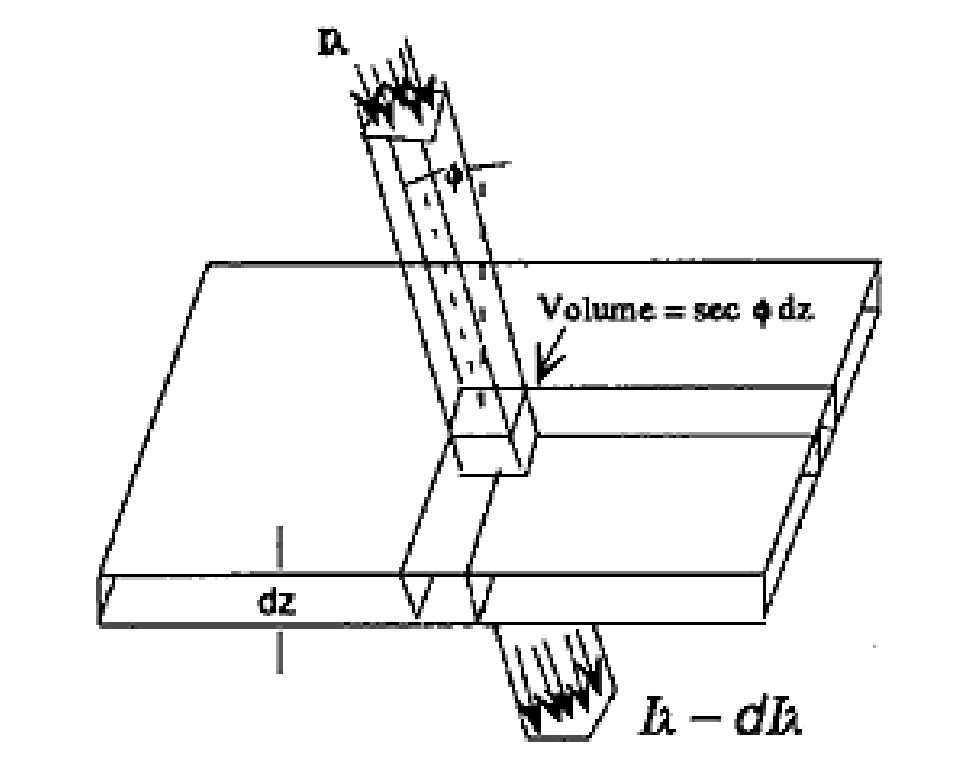
D_{t-s}

Tarea: Determinar CS para cada planeta


SARR Total Solar Irradiance
TSI (W/m²)
1370
1369
1368
1367
1366
1365
1364
1363
1362
1980
1985
1990
1995
2000



Even though the Sun was about 30% dimmer than it is now, the temperature on Earth has been more or less stable.



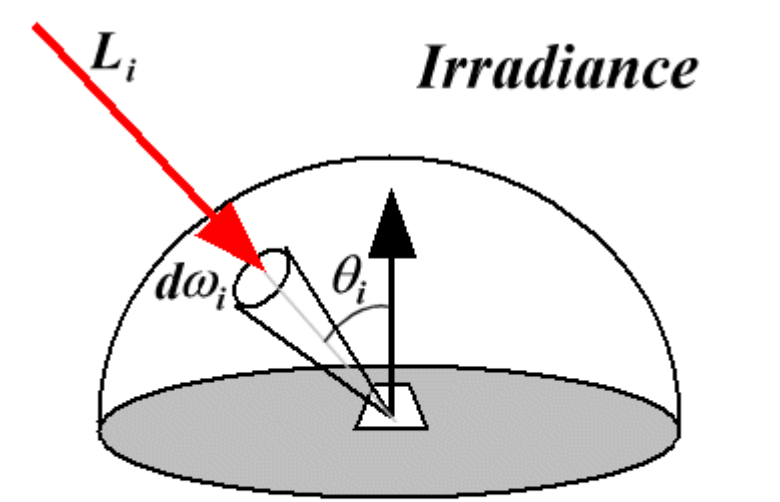
$$dI_\lambda = -I_\lambda \rho k_\lambda ds$$

$$I_\lambda(z) = -I_\lambda(\infty)\exp(-\tau_\lambda \sec\phi)$$

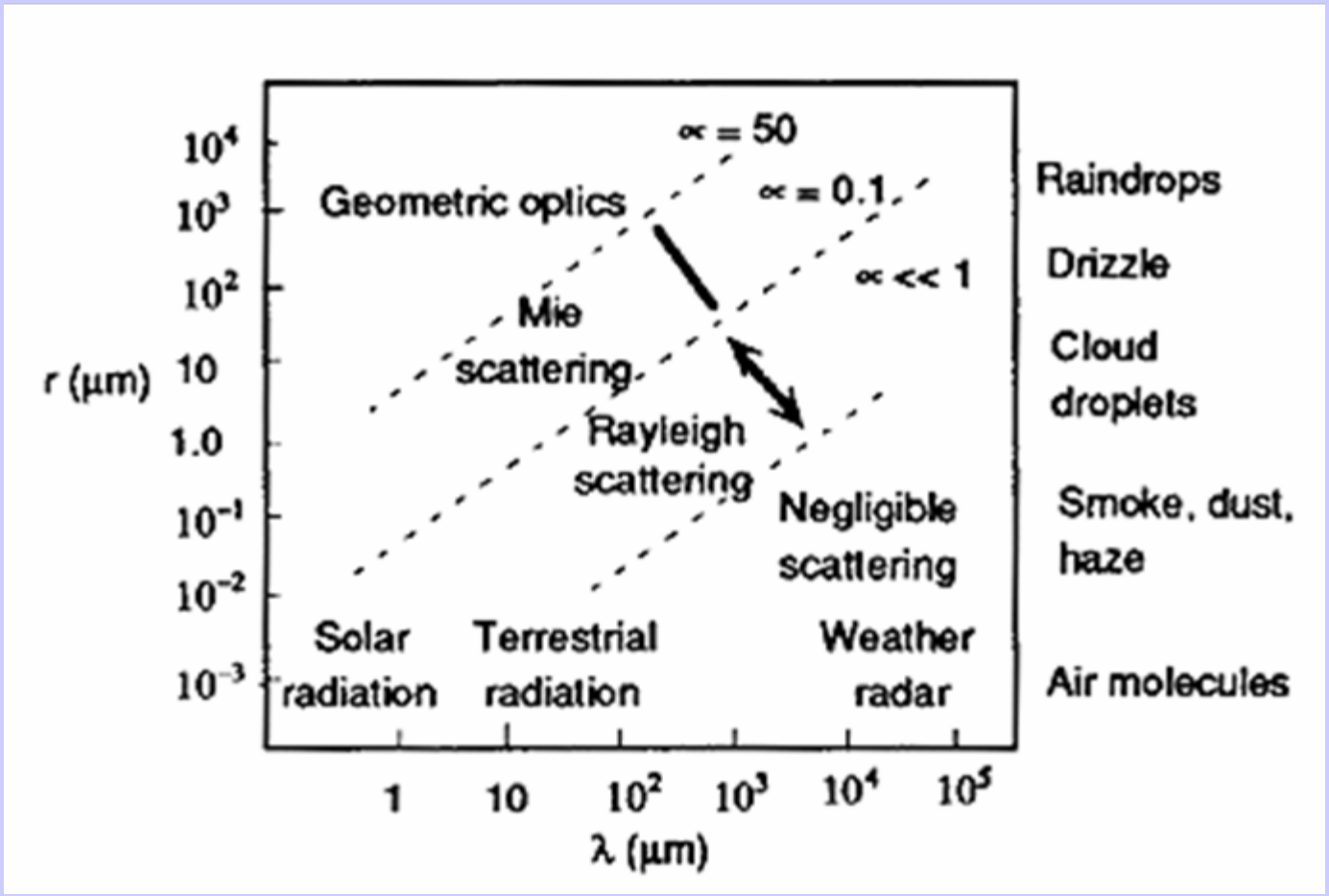
$$\tau_\lambda = \int_z^\infty k_\lambda \rho dz$$

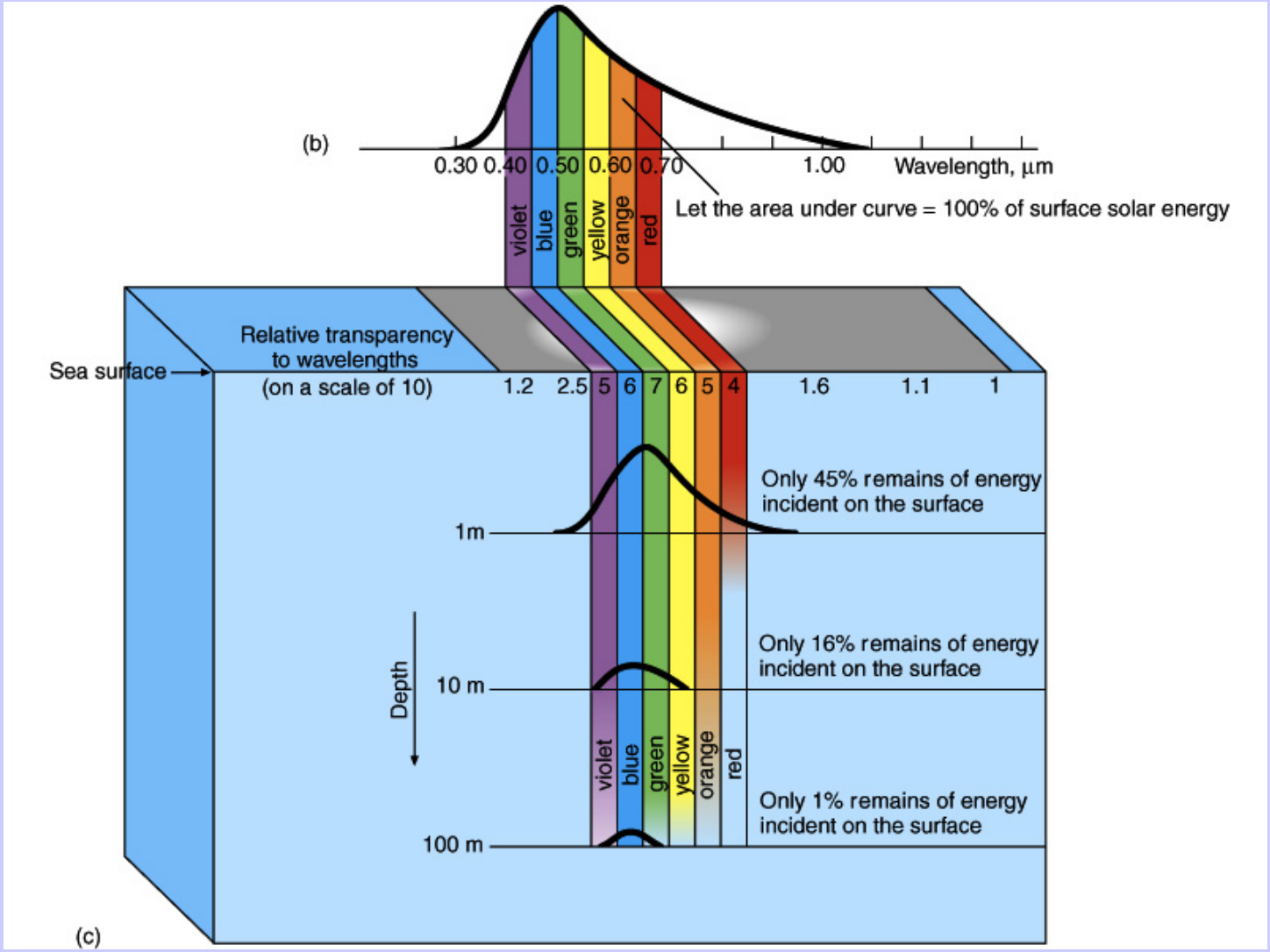
Conceptos claves

L, I = Intensidad o radianza [$Wm^{-2}sr^{-1}$]
E, F = densidad de flujo o irradianza [Wm^{-2}]



$$E_i = \int_{\Omega_i} L_i \cos\theta_i d\omega_i$$


10^4
10^3
10^2
10
1.0
10^{-1}
10^{-2}
10^{-3}
r (μm)
∝ = 50
∝ = 0.1
∝ << 1
Geometric optics
Mie scattering
Rayleigh scattering
Negligible scattering
Raindrops
Drizzle
Cloud droplets
Smoke, dust, haze
Air molecules
Solar radiation
Terrestrial radiation
Weather radar
1
10
10^2
10^3
10^4
10^5
λ (μm)


(b)
0.30 0.40 0.50 0.60 0.70 1.00 Wavelength, μm
violet
blue
green
yellow
orange
red
Let the area under curve = 100% of surface solar energy
Sea surface
Relative transparency
to wavelengths
(on a scale of 10)
1.2 2.5 5 6 7 6 5 4 1.6 1.1 1
Only 45% remains of energy
incident on the surface
1m
Depth
10 m
Only 16% remains of energy
incident on the surface
violet
blue
green
yellow
orange
red
100 m
Only 1% remains of energy
incident on the surface
(c)

El Planeta Tierra es (aprox) esférico e inclinado respecto al plano orbital (23.5º actualmente)

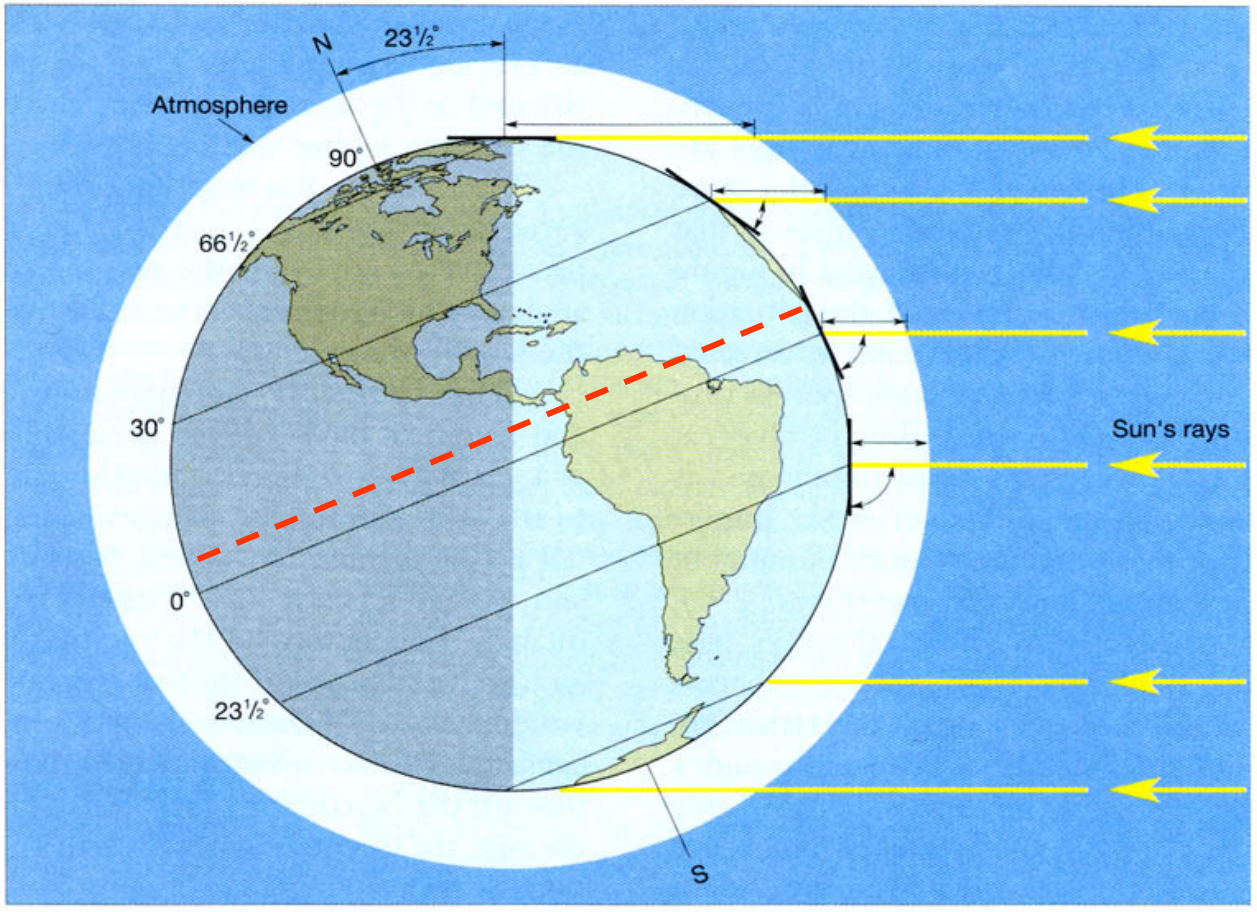


Figure 2•2 Rays striking the earth at a low angle must traverse more of the atmosphere than rays striking at a high angle and thus are subject to greater depletion by reflection and absorption.

La inclinación de la tierra, combinado con el movimiento de traslación de la tierra produce la alternancia de las estaciones: máxima energía solar en HS o HN. Factor de segundo orden: excentricidad de la orbita terrestre (4% menos que el promedio en Enero, actualmente)

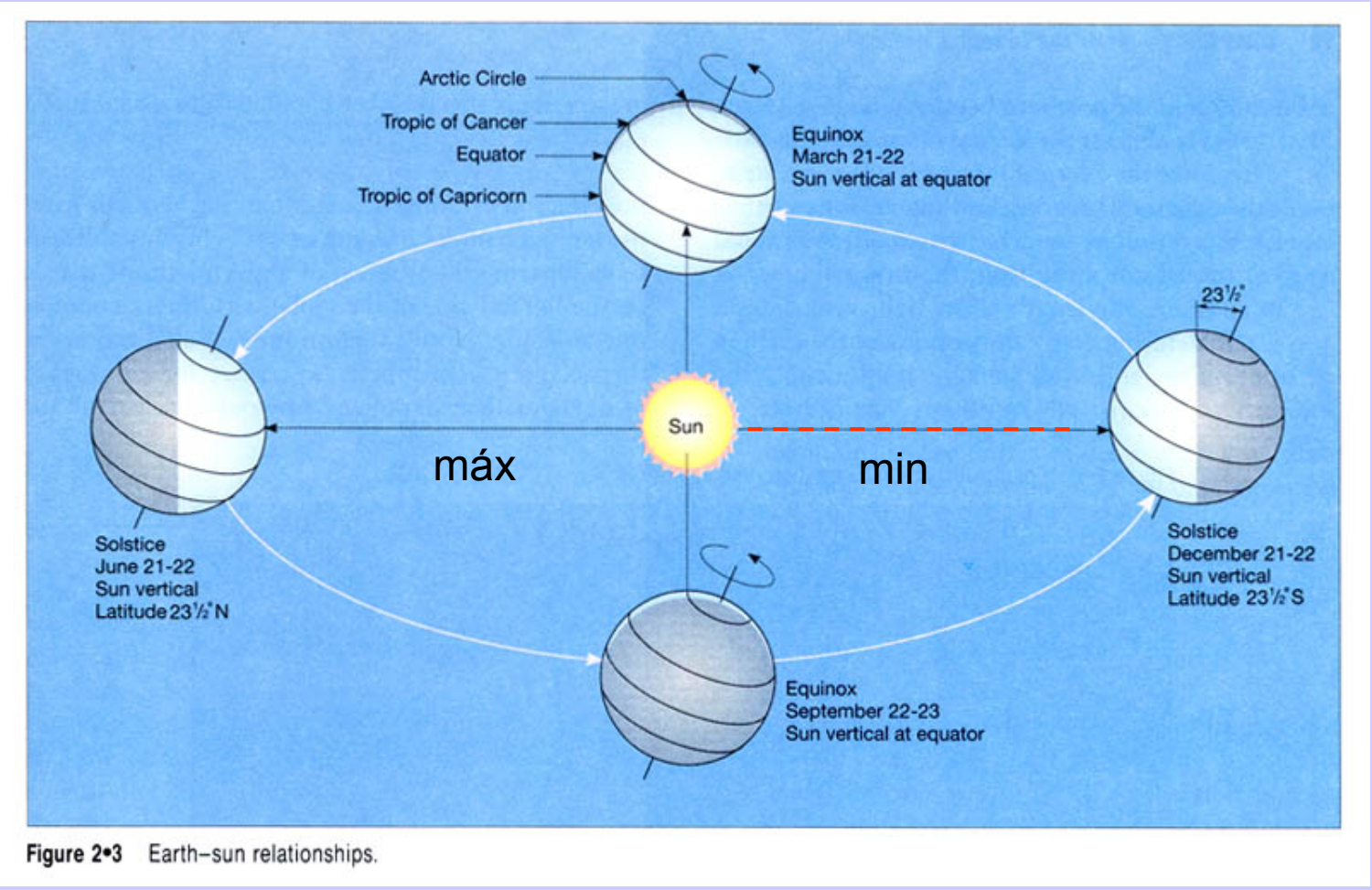
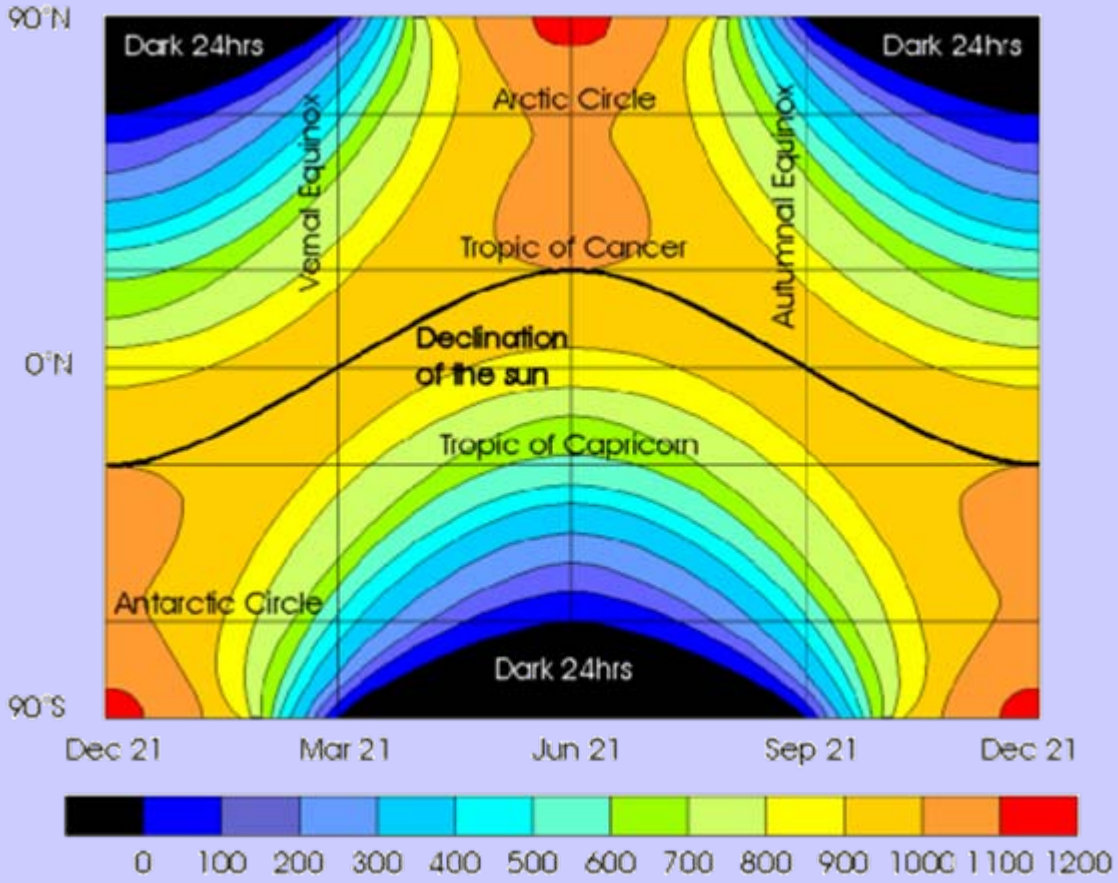


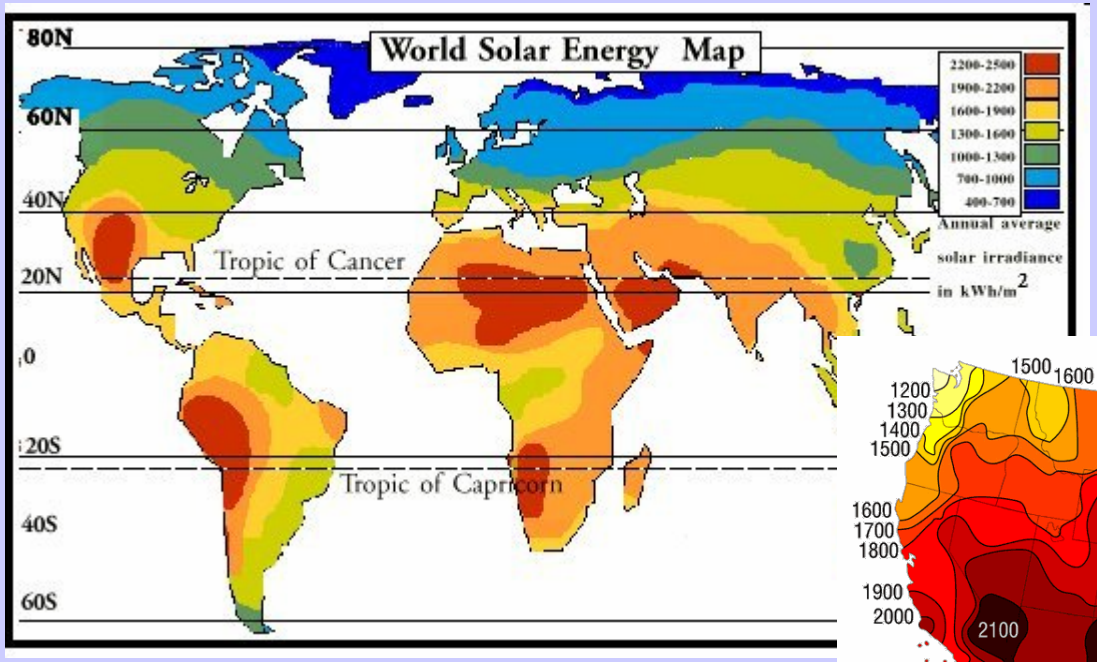
Figure 2•3 Earth–sun relationships.

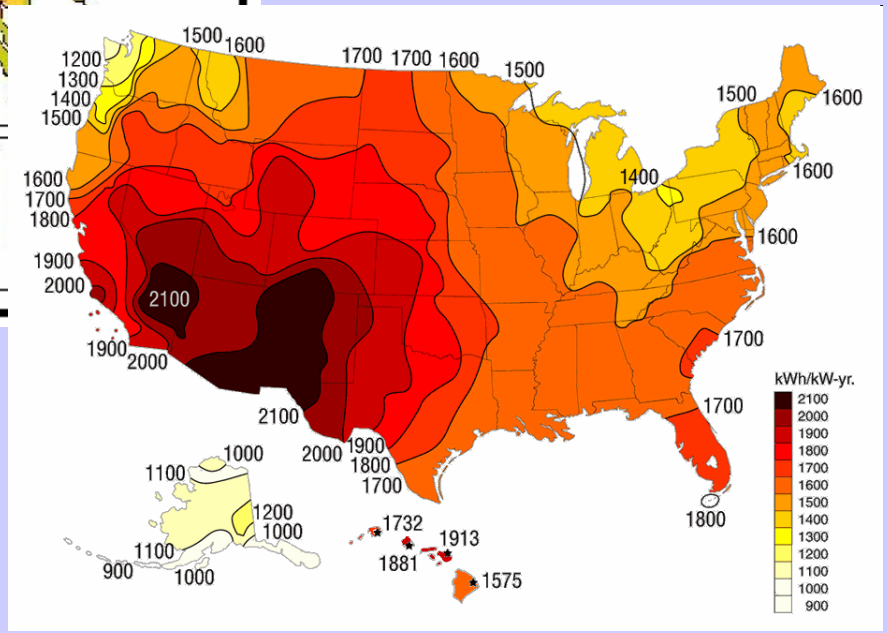
Alternancia de estaciones produce cambios en la energía solar (al tope de la atmósfera) que reciben distintas latitudes a lo largo del año



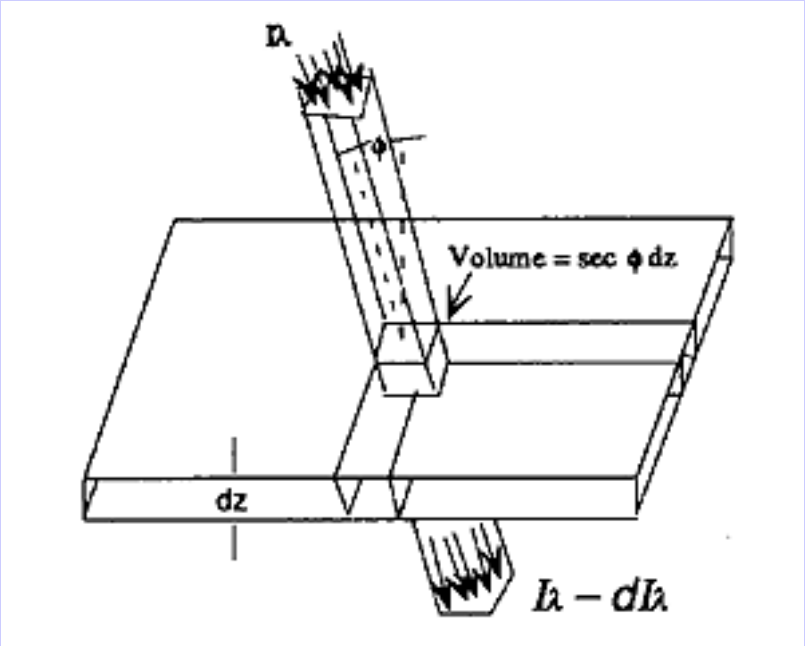
Aplicación importante: energía solar - Conceptos claves:

* Radiación solar global (directa + difusa)
* Insolación diaria
* Mediciones versus simulaciones





Para Chile, ver el explorador de Energía solar y eolica en:
http://quique.dgf.uchile.cl/EnergiaRenovable/Explorer2/



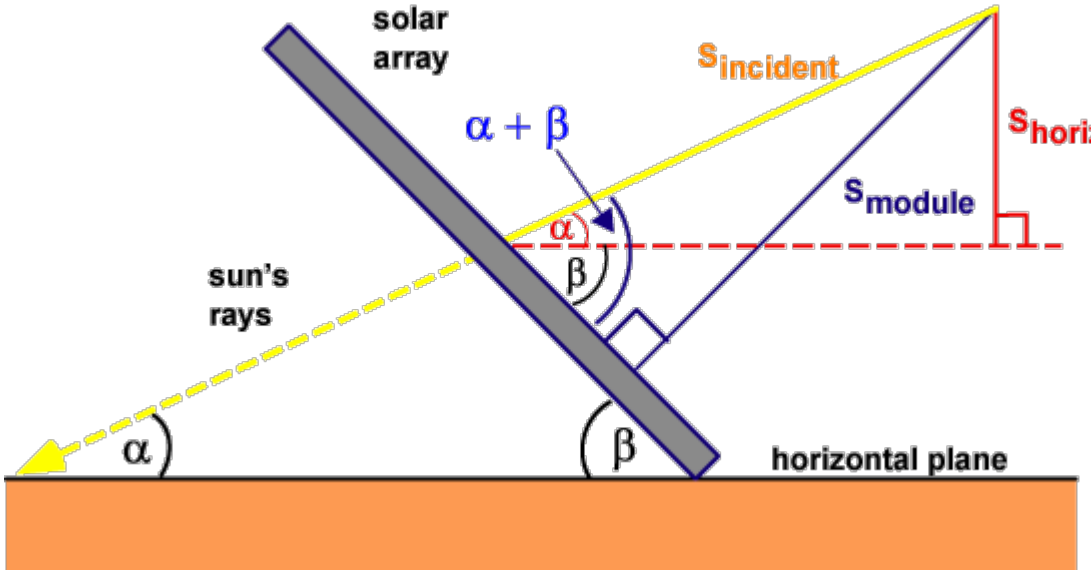
$$OC\downarrow = CS'\cos(\chi)T_N$$ Radiación incidente en plano horizontal

$$\cos(\chi) = \sin\varphi\sin\delta + \cos\varphi\cos\delta\cos(h)$$

$$T = T(\chi, nubes, altura, etc.....)$$

Todo lo que necesita saber sobre calculo de RSOL:

http://pvcdrom.pveducation.org/index.html

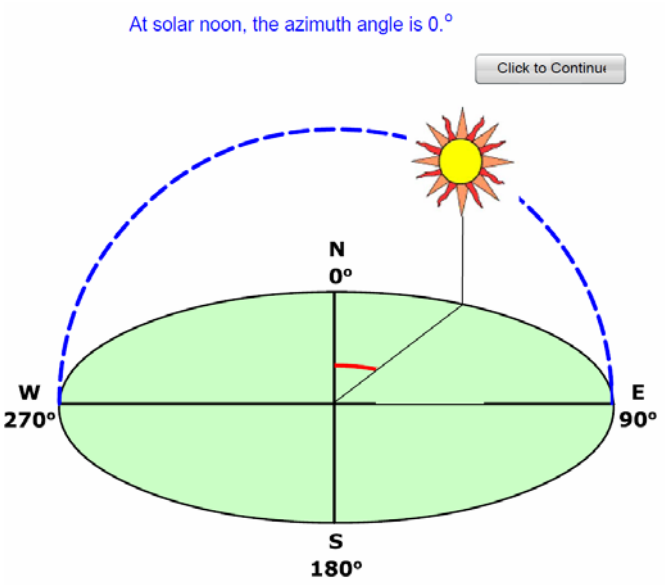


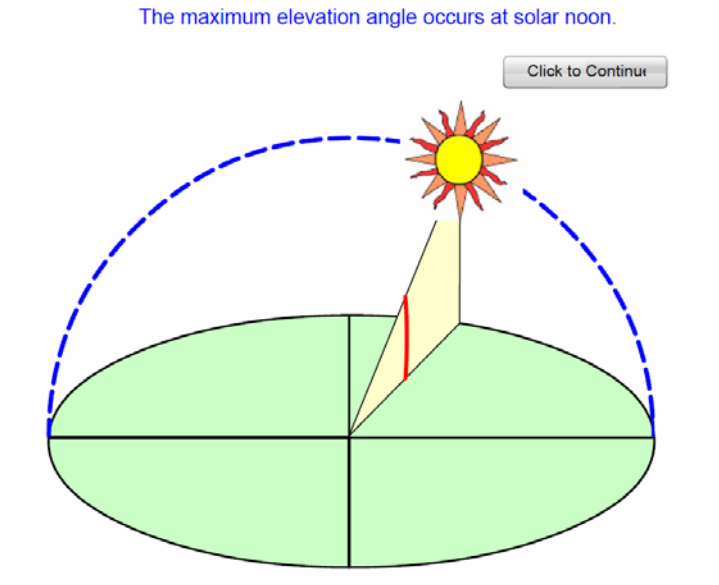
$$Elevation = \sin^{-1}[\sin\delta \sin\varphi + \cos\delta \cos\varphi \cos(HRA)]$$

$$Azimuth = \cos^{-1}\left[\frac{\sin\delta \cos\phi - \cos\delta \sin\phi \cos(HRA)}{\cos\alpha}\right]$$

Todo lo que necesita saber sobre calculo de RSOL:

http://pvcdrom.pveducation.org/index.html





$$Elevation = \sin^{-1}[\sin\delta \sin\varphi + \cos\delta \cos\varphi \cos(HRA)]$$

$$Azimuth = \cos^{-1}\left[\frac{\sin\delta \cos\phi - \cos\delta \sin\phi \cos(HRA)}{\cos\alpha}\right]$$

2.18. Sun Position Calculator

Using the equations on the previous page, the position of the sun in the sky can be determined from the observer's location and the time of day. In the top blue squares, enter the observer's location and time of day.

Time and Date

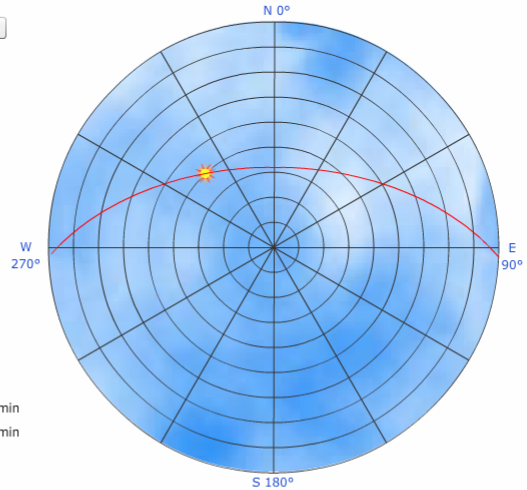
The time is given as 24 hour time and the minutes are entered separately. Thus for 5:15 pm, enter 17 in the hour box and 15 in the minute box.

Longitude, Latitude and Time Zone (GMT)

Longitude, latitude and time zone of locations throughout the world are available at www.timeanddate.com. Minutes of longitude and latitude are entered as fractions, so 17° 30' becomes 17.5. Enter locations with an east longitude as negative. For daylight saving (summer time), subtract 1 hour from the given values. Generally speaking, locations east of Greenwich (UK) are positive and locations west of Greenwich are negative. There are other services that will determine your approximate latitude and longitude from your IP address. For example ip2location.com.

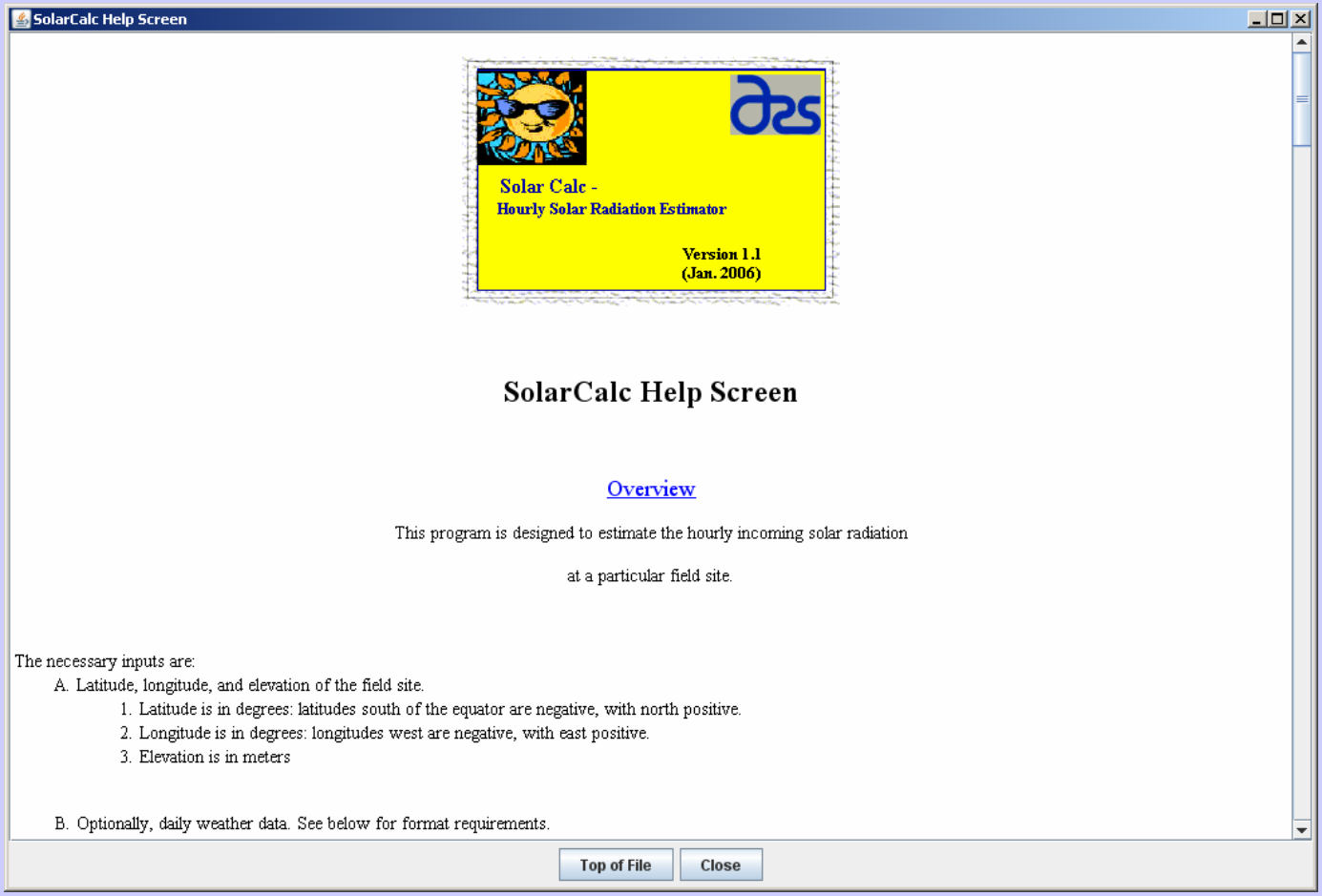
Month	March
Day	17
Hour	15
Minute	33
Latitude	-34
Longitude	140
GMT Offset	11

day number	76	days
EoT	-9.06	min
Time Corr.	-109.06	min
declination	-2.02	deg.
hour angle	25.98	deg.
altitude	49.86	deg.
azimuth	317.22	deg.
sunrise	7:44	hour:min
sunset	19:55	hour:min



The graph on the right shows the position of the sun's azimuth and elevation angles projected onto a two-dimensional plane. An elevation angle of 90° corresponds to the stage when the sun is directly overhead and appears in the centre of the graph. An elevation angle of 0° corresponds to the point when the sun is on the horizon, and appears on the outer edge of the graph. The azimuth angles are marked around the graph's edge, so an azimuth angle of 0° is at the top of the graph. The graph is best understood by trying a number of times and locations and seeing where the azimuth and elevations are plotted.

http://www.ars.usda.gov/services/software/



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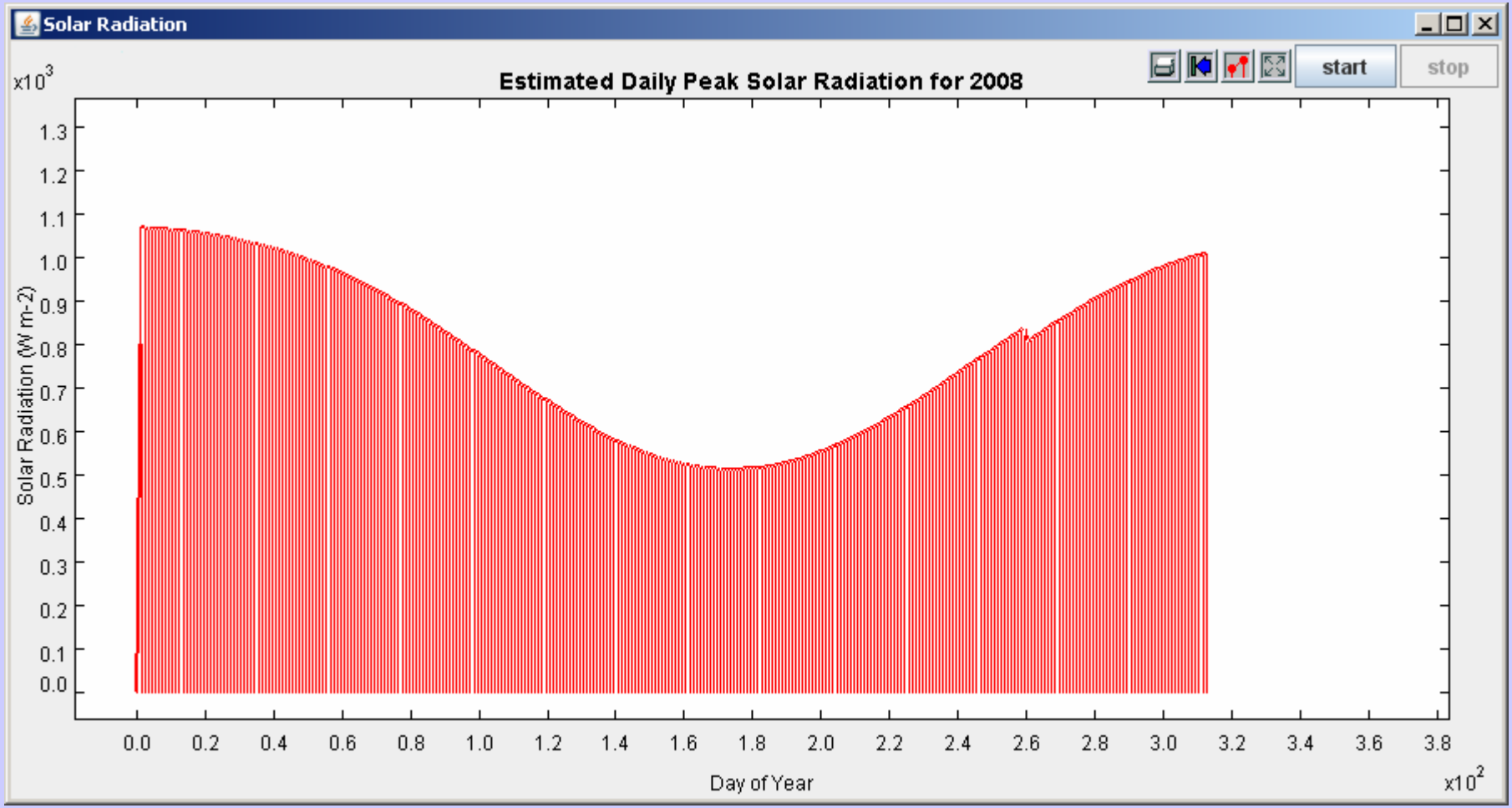
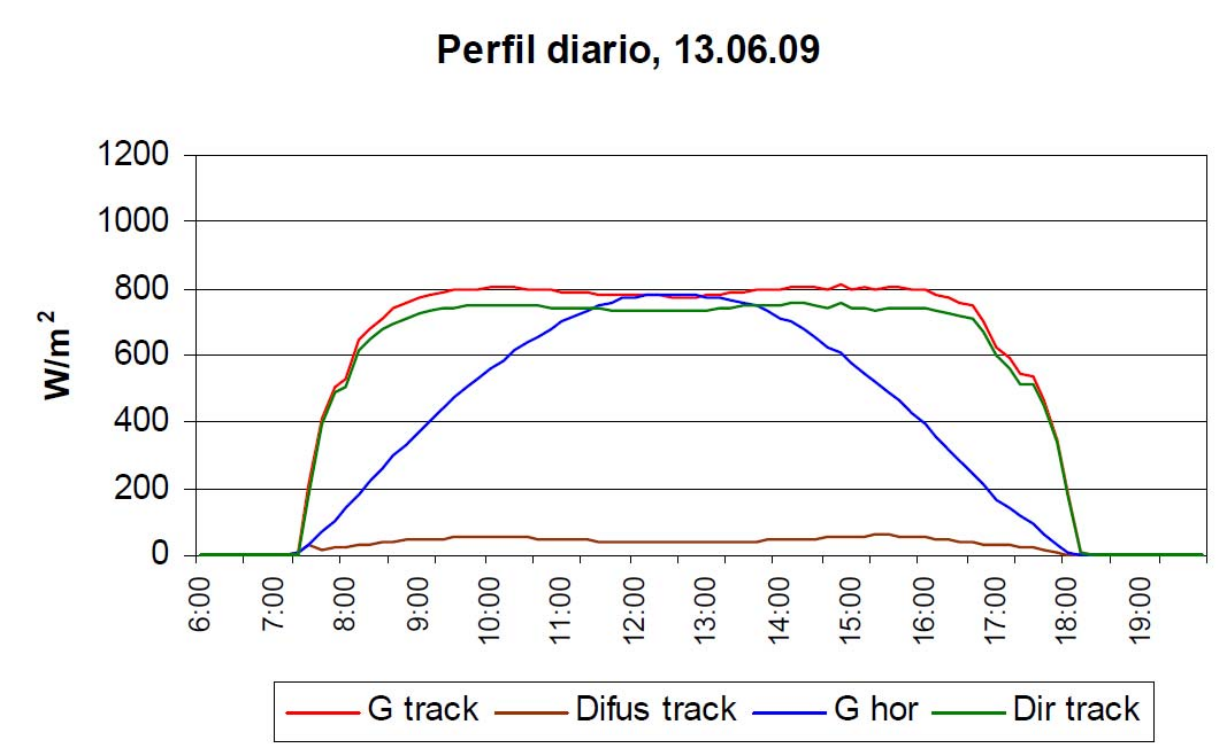


Figura 1: Vista completa de la estación



Radiación global horizontal:	5.17	kWh/m^{2}día
Radiación global en seguimiento:	7.72	kWh/m^{2}día
Radiación difusa en seguimiento:	0.44	kWh/m^{2}día
Radiación directa en seguimiento:	7.27	kWh/m^{2}día

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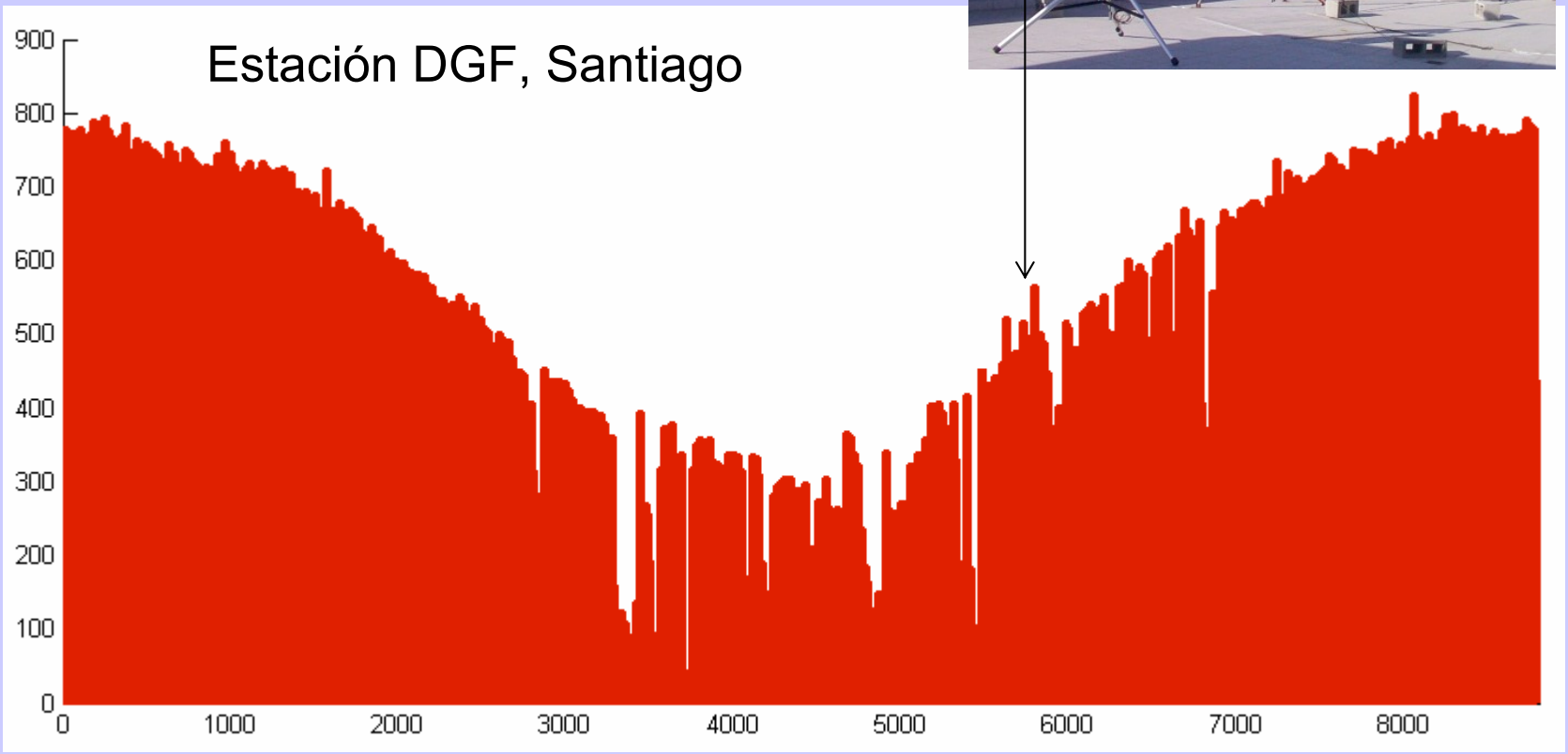

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