Environmental Physics:
Part III: Solar Energy Conversion

Lec 16	**Tues 28 Feb 10.00**	**1. The solar resource.**
Lec 17	**Thurs 2 March 10.00**	**2. Absorption of sunlight and Solar Conversion routes.**
Lec 18	**Fri 3 March 16.00**	**3. Solar Thermal energy conversion.**
Lec 19	**Tues 7 March 9.00**	**4. Thermodynamics of Solar PV**
Lec 20	**Thurs 9 March 10.00**	**5. Semiconductor background.**
Lec 21	**Fri 10 March 16.00**	**6. Solar photovoltaic energy conversion.**
Lec 22	**Tues 14 March 9.00**	**7. Implementation of Photovoltaic energy conversion.**
Lec 23	**Thurs 16 March 10.00**	**8. Solar chemical energy conversion.**

Objectives:

- To understand how solar energy can be converted into thermal, kinetic, electrical or chemical energy
- To calculate the efficiency of solar thermal and solar photovoltaic energy converters using simple models
- To be able to explain the function of a photovoltaic cell

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Dr Jenny Nelson

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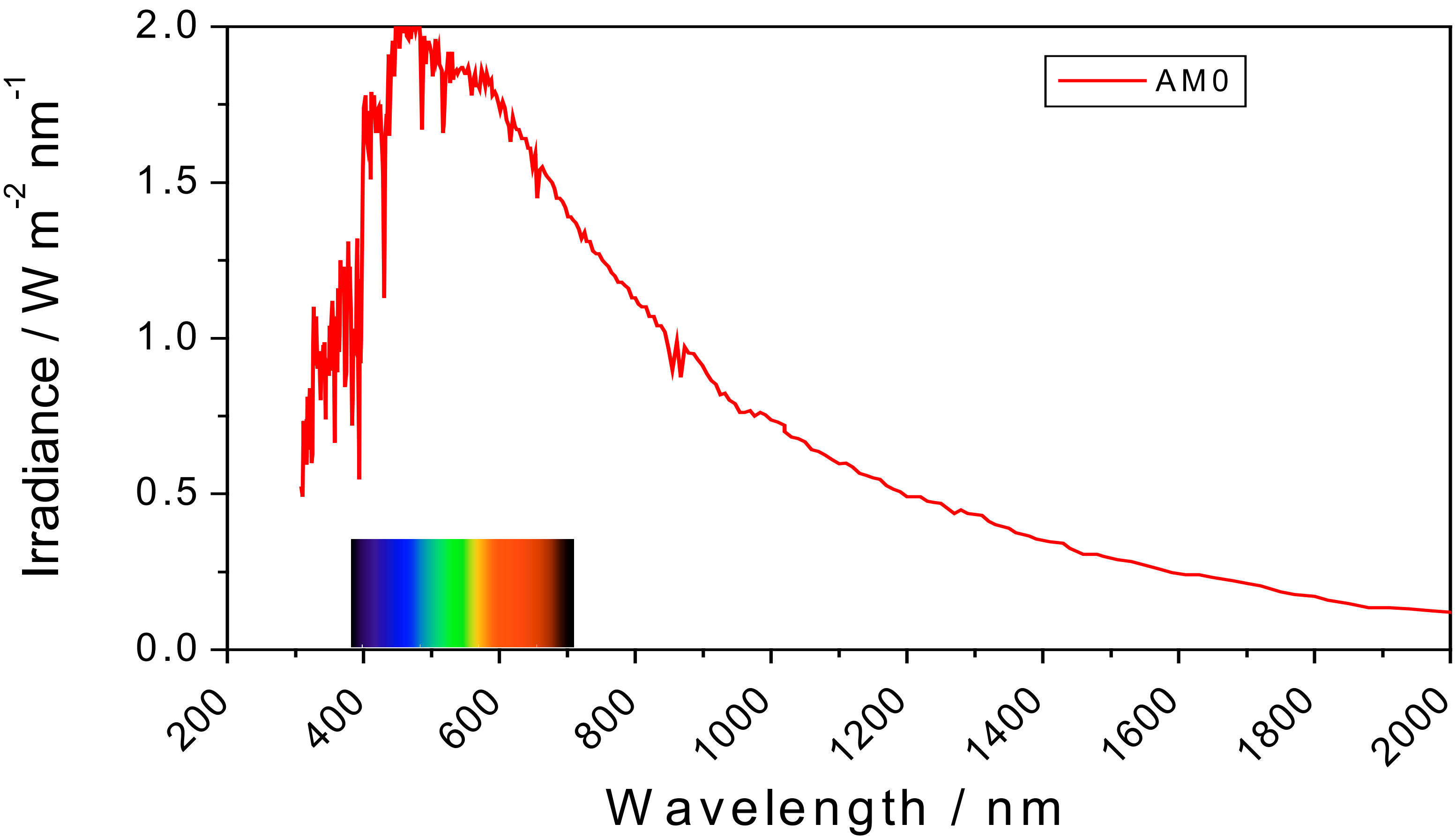
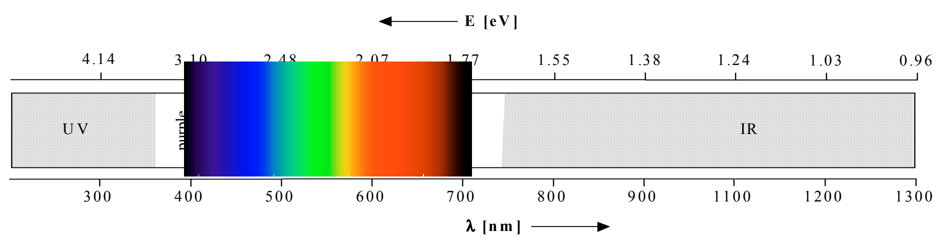
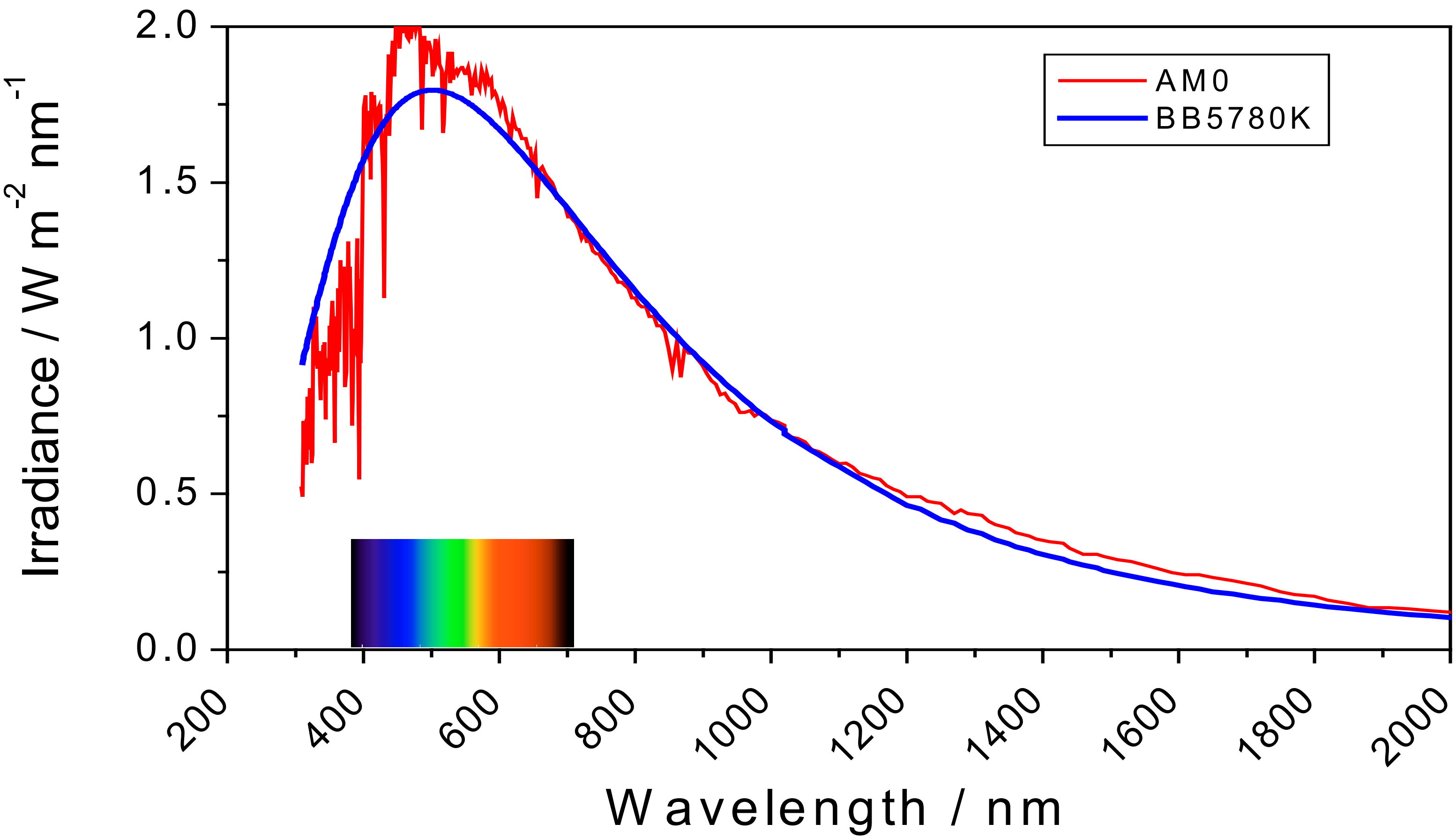
Office hours: 1-2 pm Tuesday. Room 1007 Huxley.

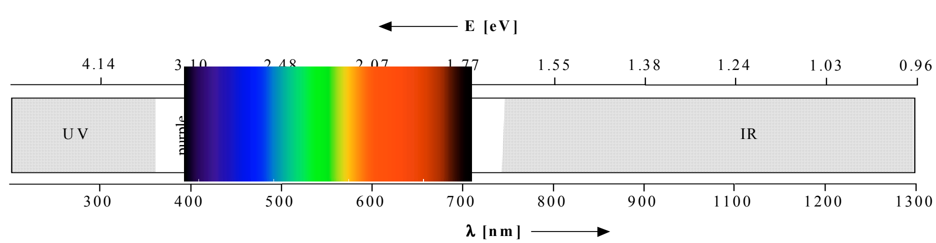
Solar power spectrum



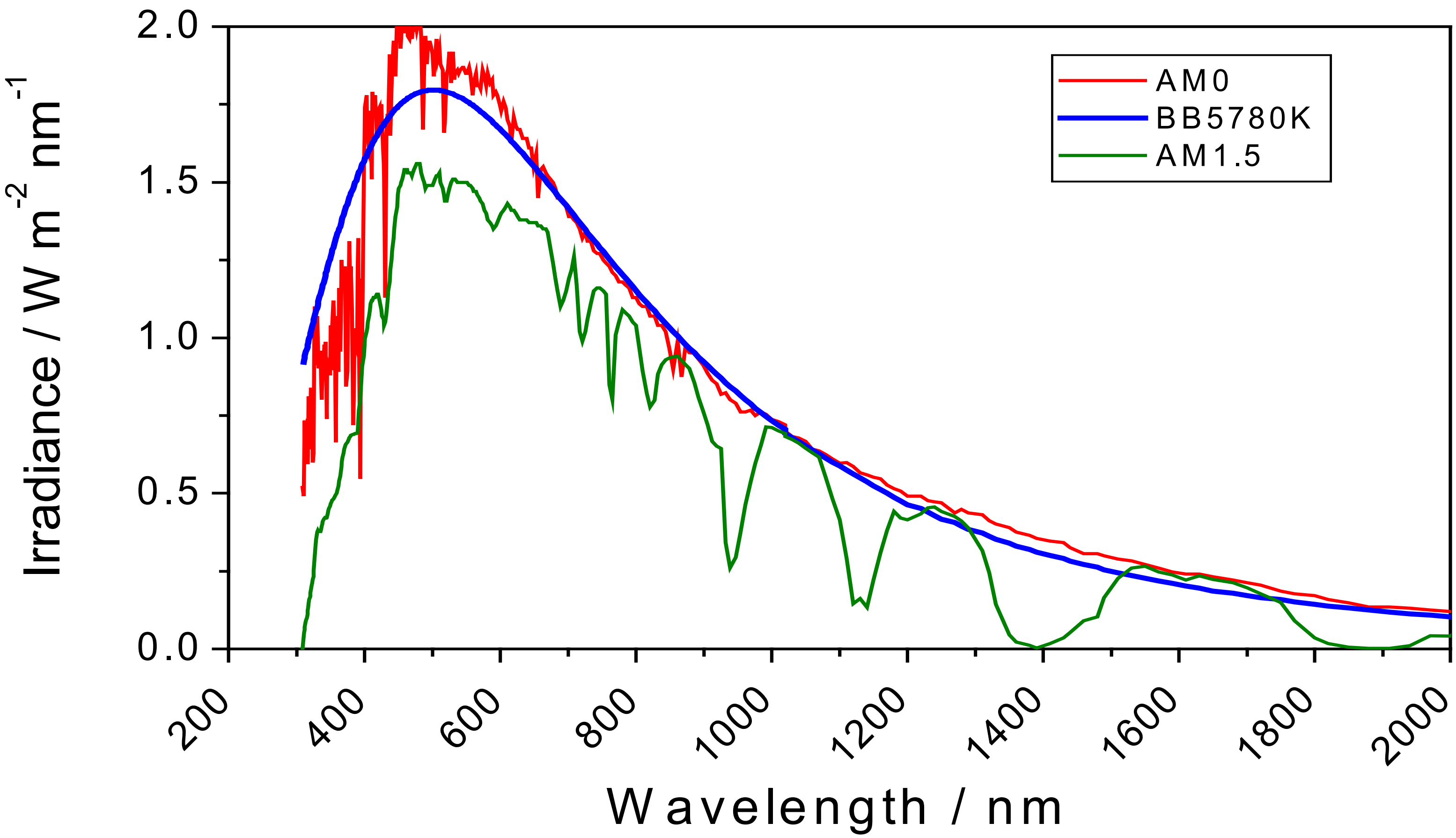


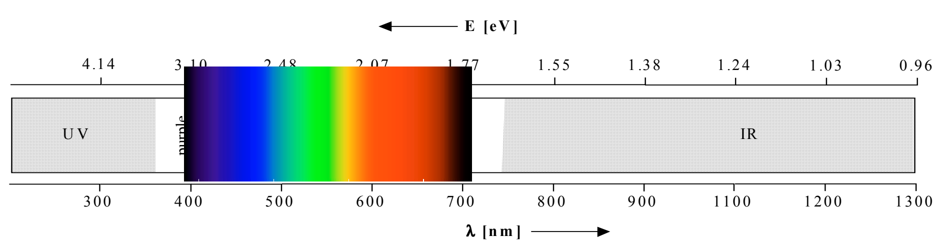
Solar power spectrum

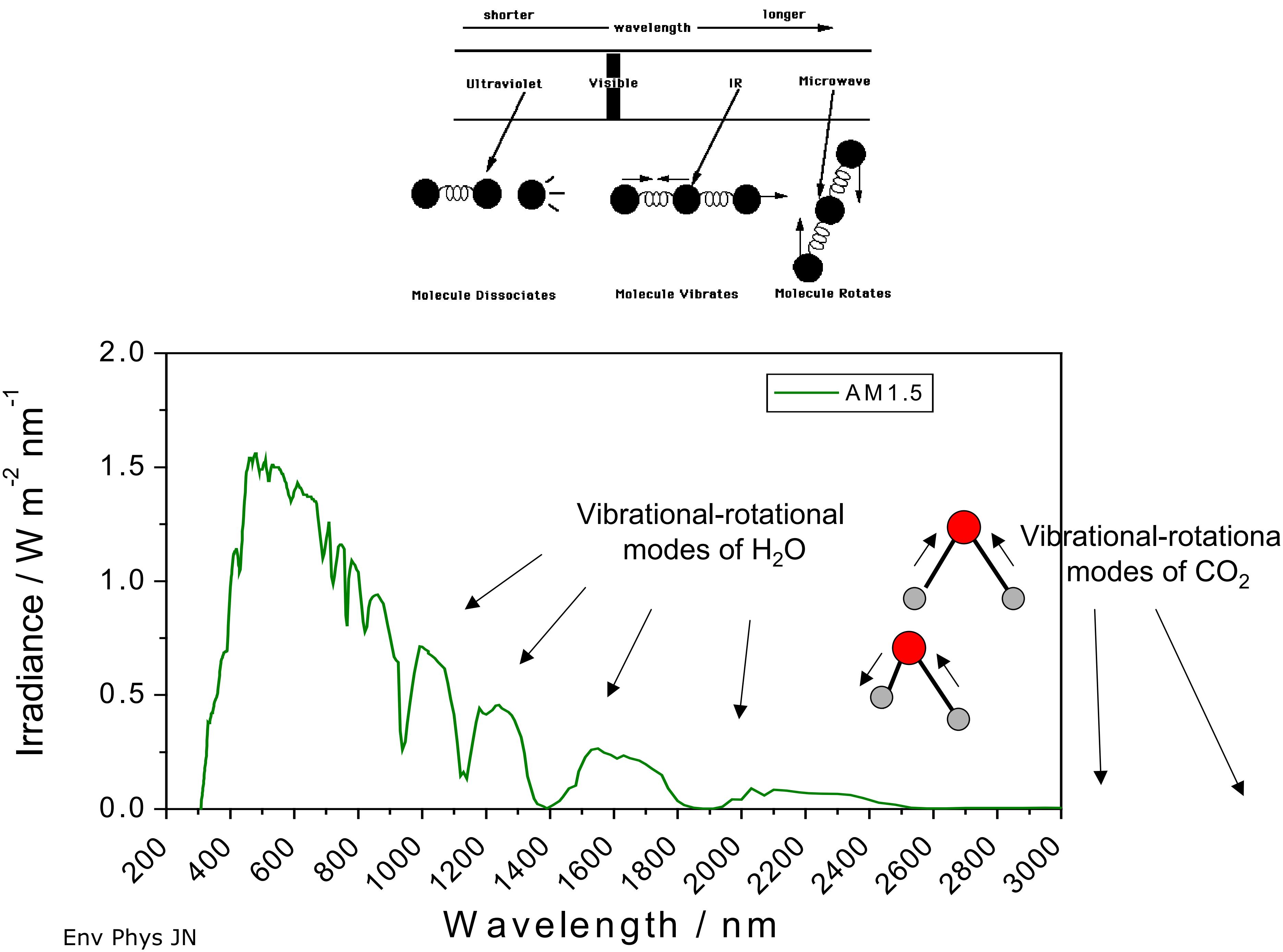




Solar power spectrum






shorter
wavelength
longer
Ultraviolet
Visible
IR
Microwave
Molecule Dissociates
Molecule Vibrates
Molecule Rotates
AM1.5
Vibrational-rotational modes of H_2O
Vibrational-rotational modes of CO_2
Irradiance / W m^{-2} nm^{-1}
Wavelength / nm
0.0
0.5
1.0
1.5
2.0
200
400
600
800
1000
1200
1400
1600
1800
2000
2200
2400
2600
2800
3000

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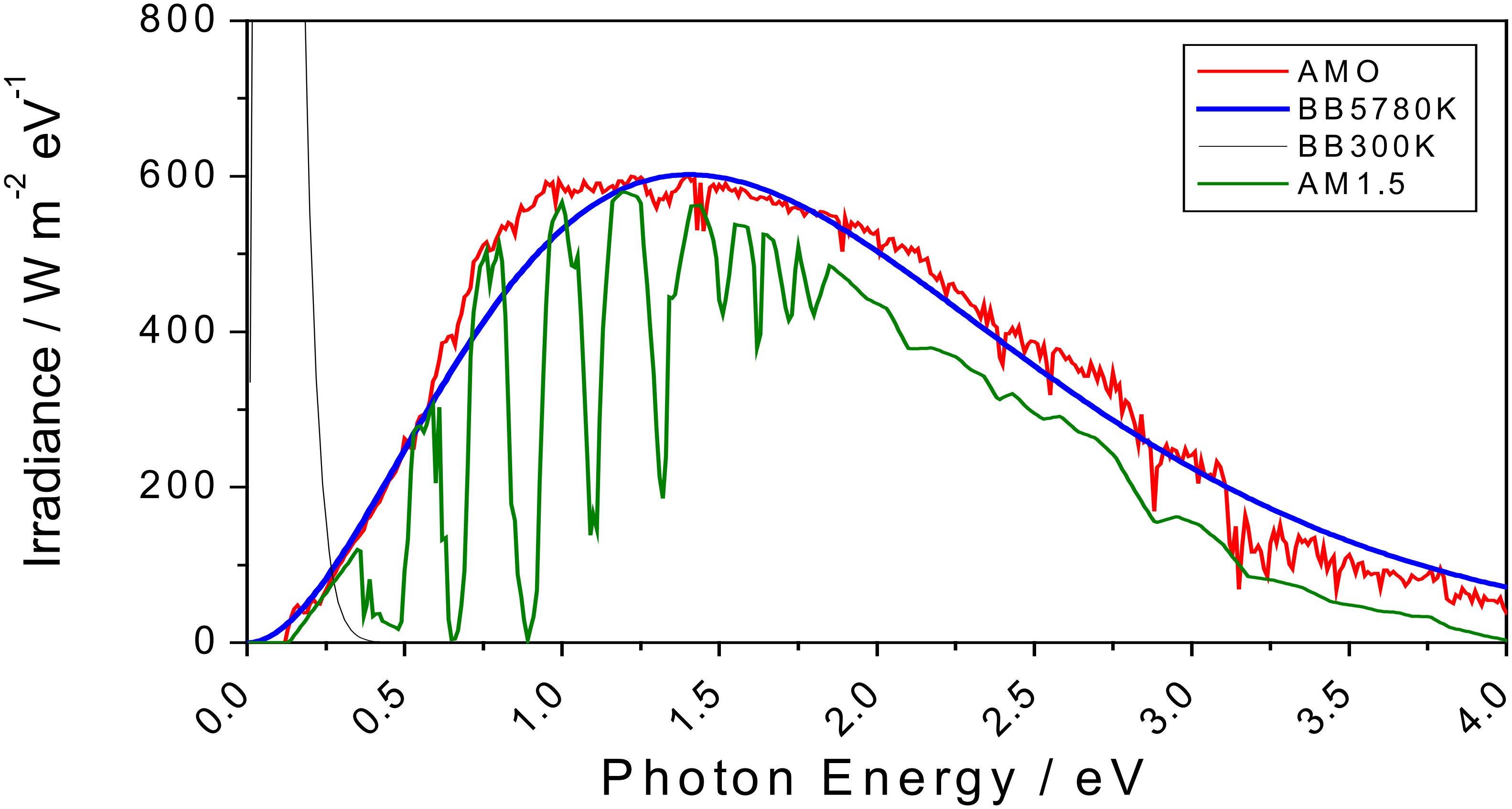
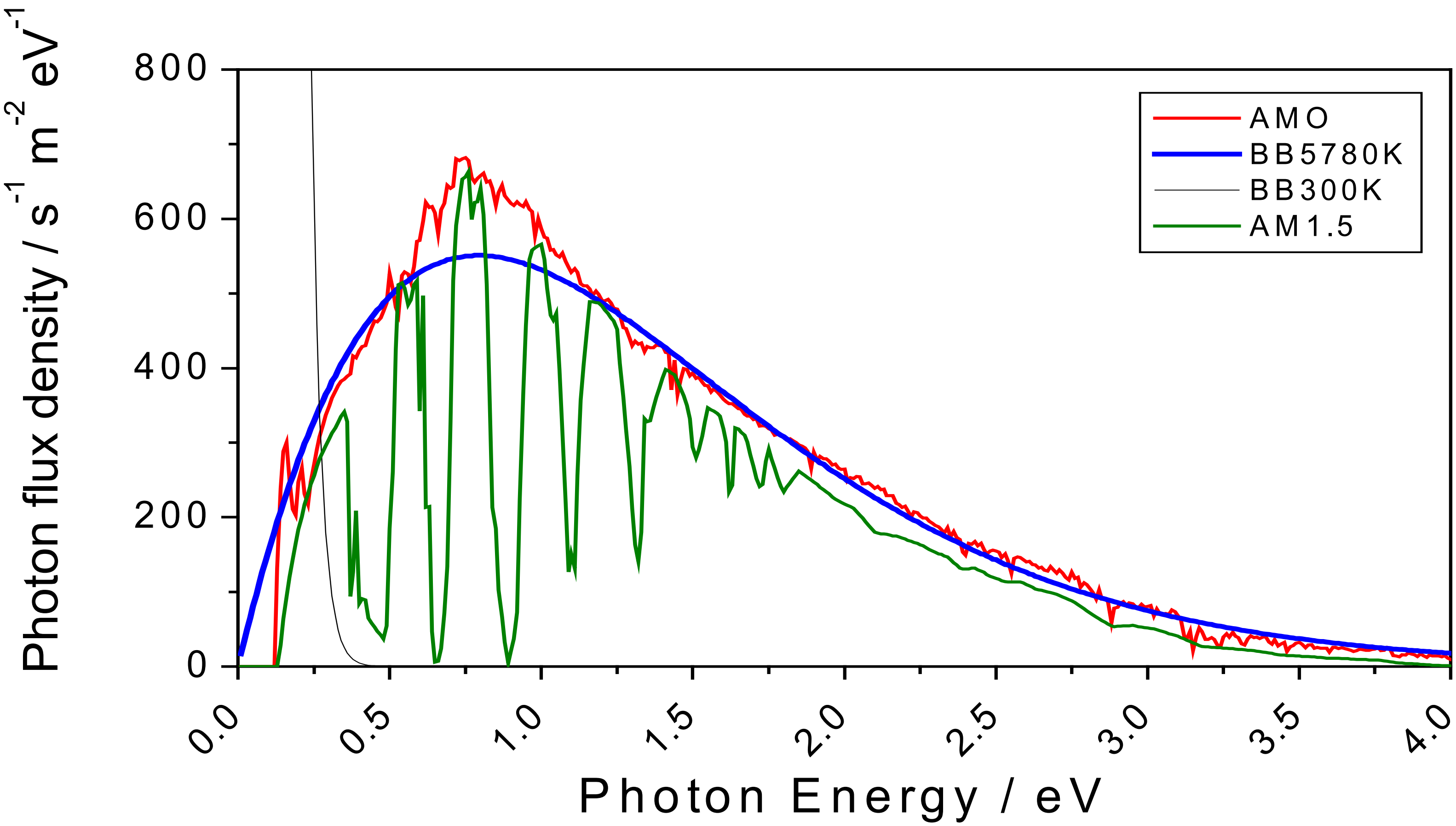
Solar power spectrum

$$\boxed{E\,/\,\mathrm{eV} = 1240\,/\left(\lambda\,/\,\mathrm{nm}\right)}$$

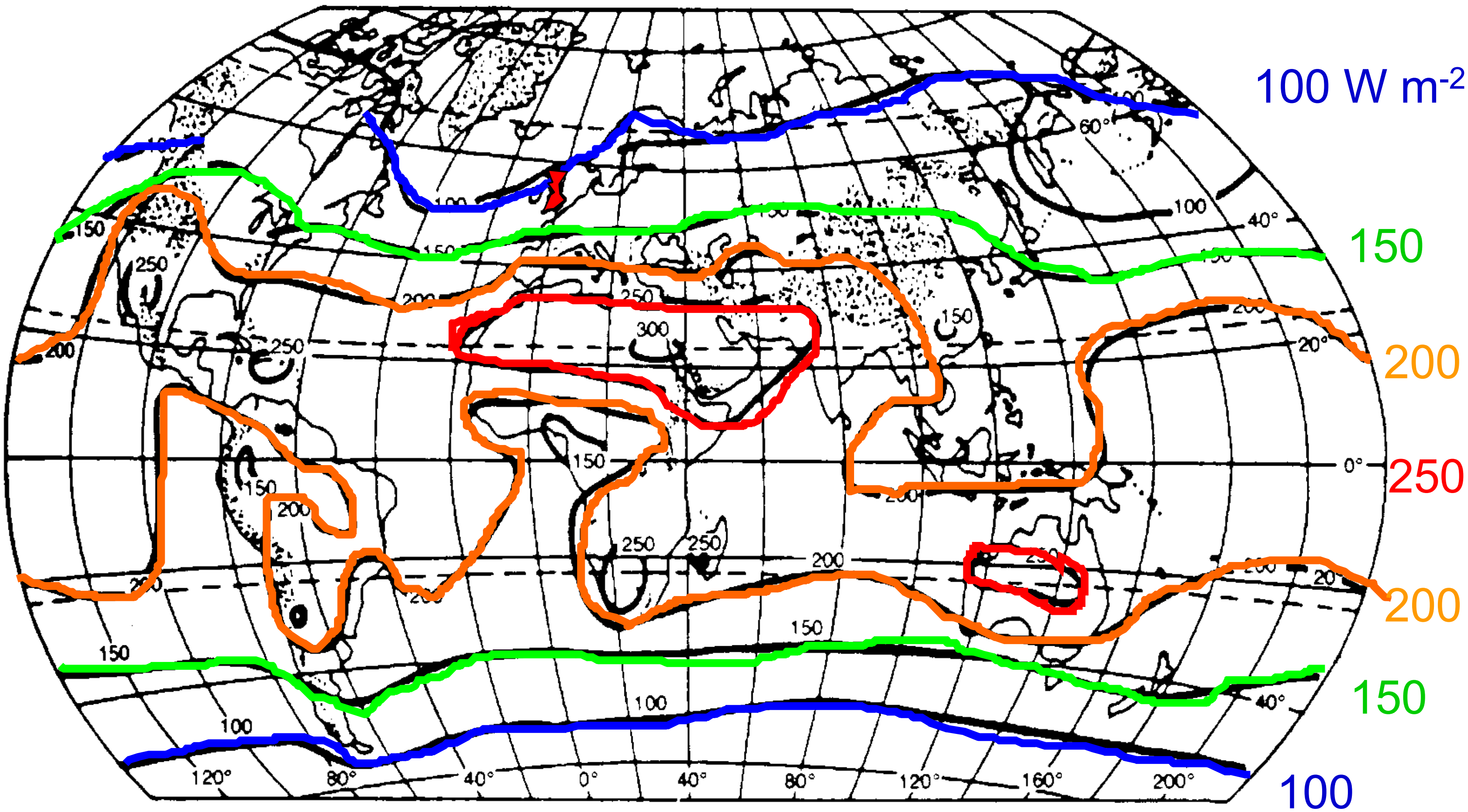


visible

Solar photon flux spectrum



Average ~ 200 Wm^{-2} (5 peak sun hours)



Southern Britain ~ 125 Wm^{-2} (~3 peak sun hours)

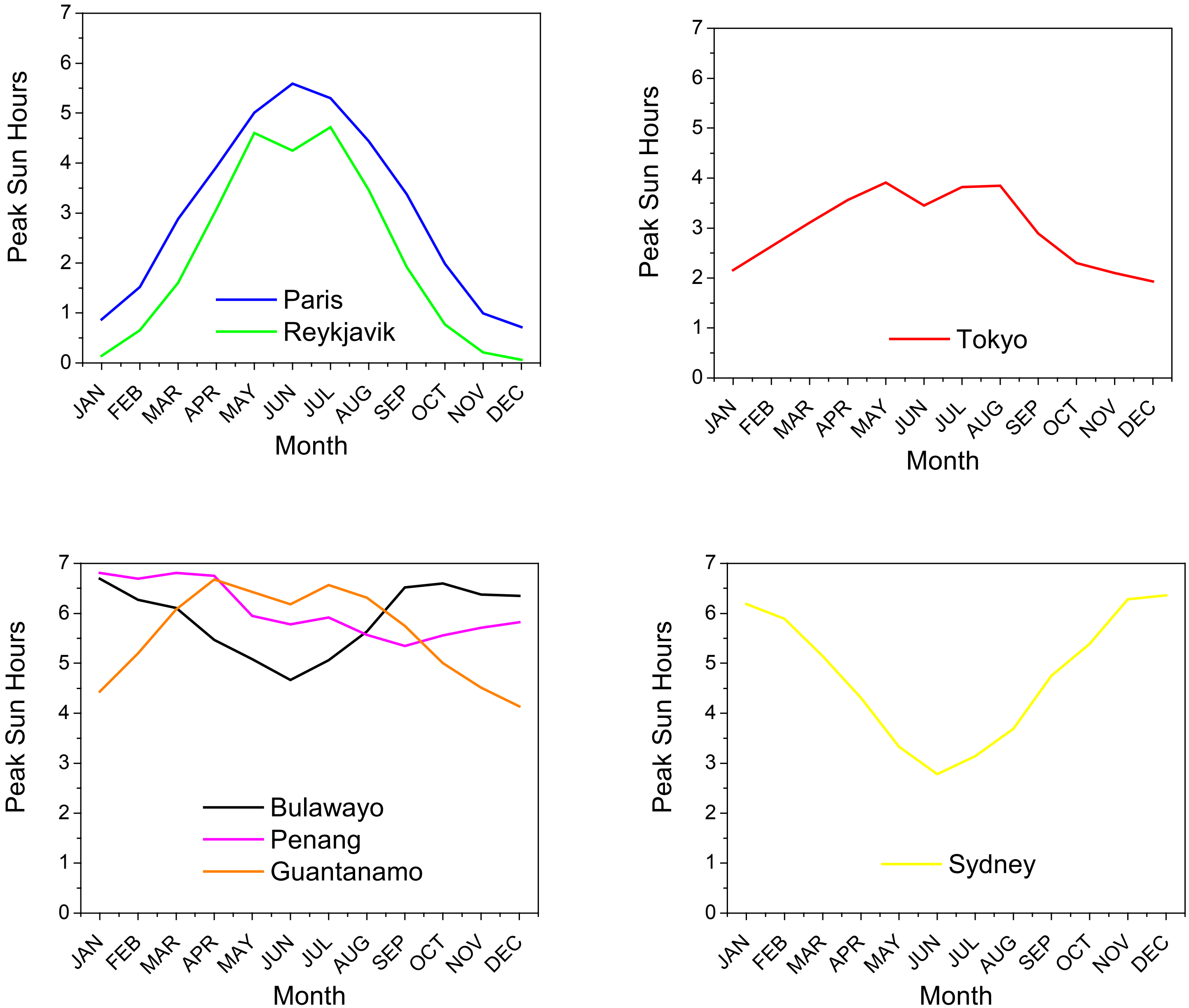
Energy consumption per capita in Western Europe ~ 5 kW

Mean solar irradiance in Southern Britain ~ 125 W m^{-2}

What land area is needed to supply the energy needs of a city of 10 million people using solar irradiation:

(a) with conversion efficiency of 50%?

(b) with conversion efficiency of 5%


Peak Sun Hours
Month
JAN FEB MAR APR MAY JUN JUL AUG SEP OCT NOV DEC
0 1 2 3 4 5 6 7
Paris
Reykjavik
Tokyo
Bulawayo
Penang
Guantanamo
Sydney

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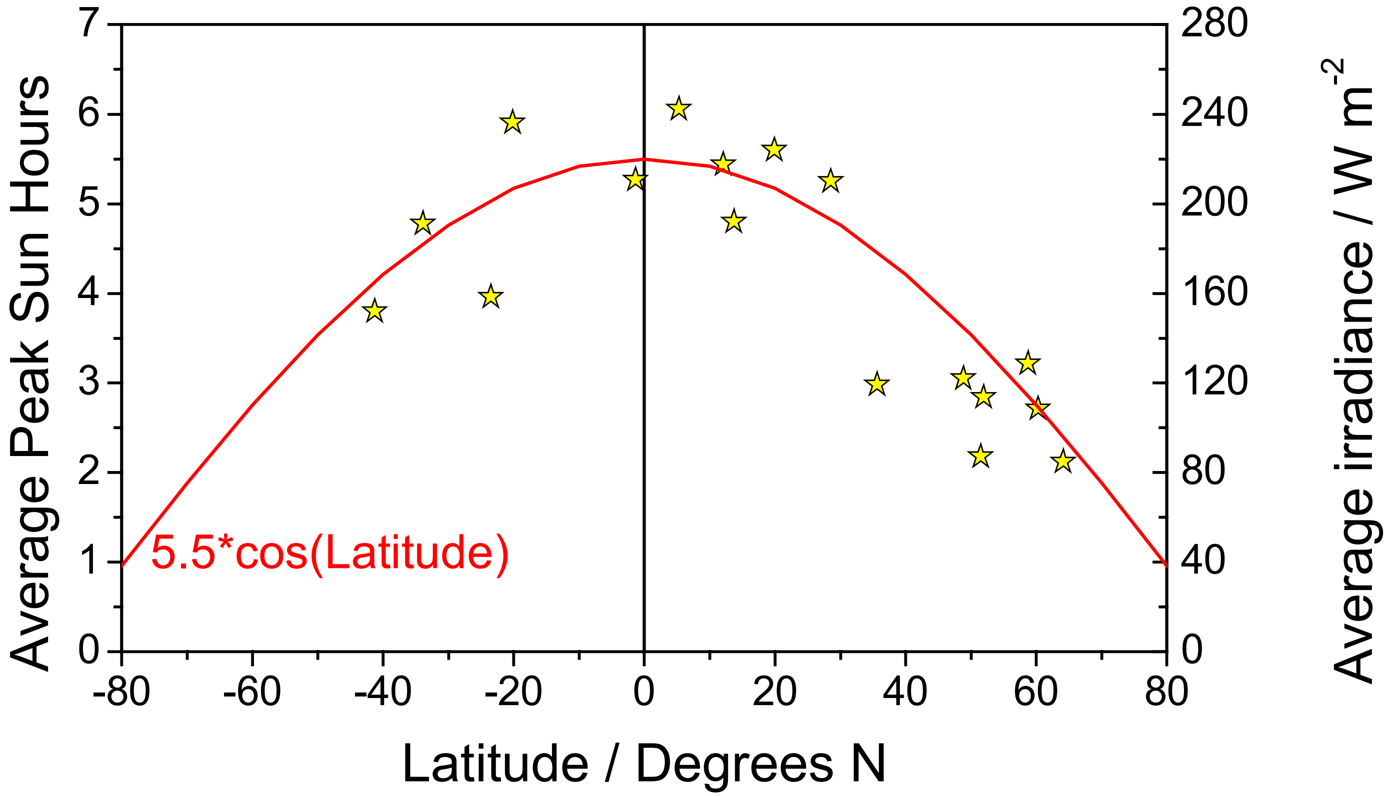

Average Peak Sun Hours
Average irradiance / W m-2
Latitude / Degrees N
5.5*cos(Latitude)
0
1
2
3
4
5
6
7
0
40
80
120
160
200
240
280
-80
-60
-40
-20
0
20
40
60
80

Summary of Lecture 16

- Sun radiates like a black body at T_{sun} = 5780 K, diluted by f_{sun}= $2.16.10^{-5}$
- Solar power spectrum: $$u(E)dE = \frac{2\pi}{h^3c^2}\frac{E^3dE}{e^{E/kT}-1}$$
- Solar photon flux spectrum: b(E) = u(E) / E
- Earth's atmosphere reflects, absorbs and scatters solar radiation
- Irradiance sensitive to latitude, climate, daily and seasonal cycle
- Solar radiation is an abundant but intermittent and low density resource (average ~ 200 W m^{-2})