

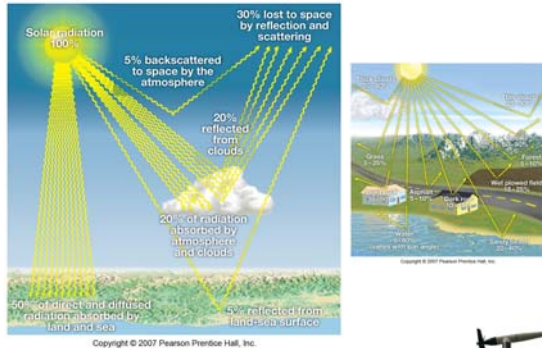
Radiation



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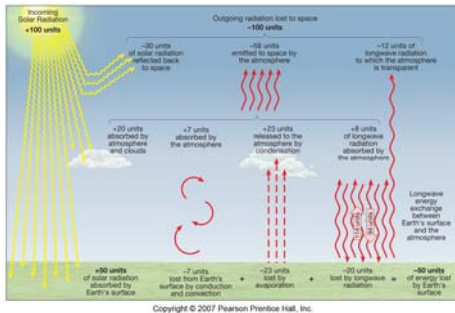
Solar (Shortwave) Radiation



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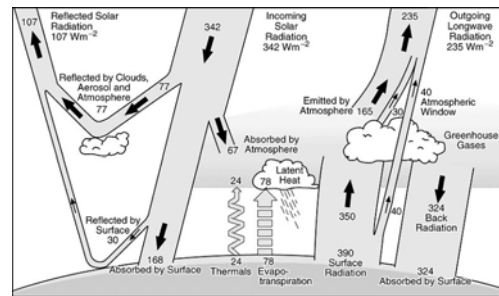
What happens to solar radiation?



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Earth's Radiative Equilibrium

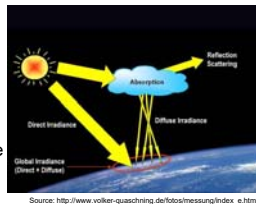


You will learn more about radiation in physical meteorology

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Solar Radiation Measurements

- We distinguish between direct and diffuse solar radiation
- Direct solar radiation
 - Radiation emitted from a solid angle of the Sun's visible disk, received on a surface perpendicular to the beam (the angle matters!)
 - At the top of the atmosphere, this is the solar constant ($S_0 = 1367 \text{ W m}^{-2} \pm 3\%$)
- Global solar radiation
 - Sum of diffuse and direct radiation



Source: http://www.volker-quaschnig.de/fotomeasurement/index_e.html

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Solar Radiation Measurements



- Pyrheliometer
 - Measures direct solar radiation
 - Points at the Sun and is perpendicular to solar beam
 - A blackened plate with a temperature sensor resides inside a long tube so that the viewing angle is $\sim 5^\circ$

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Solar Radiation Measurements

- Pyranometer
 - Measures global solar radiation
 - All solar radiation received on a horizontal surface
 - Sum of direct and diffuse solar radiation
 - Two types
 - 1) Measure ΔT between two surfaces with different absorption properties using thermopiles. Assume ΔT results from different absorption of solar radiation.
 - 2) Photovoltaic sensor: Functions like a miniature solar cell. Radiation creates electric current.

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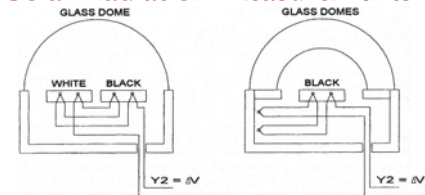
Solar Radiation Measurements

Kipp & Zonen CMP3 Pyranometer



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Solar Radiation Measurements

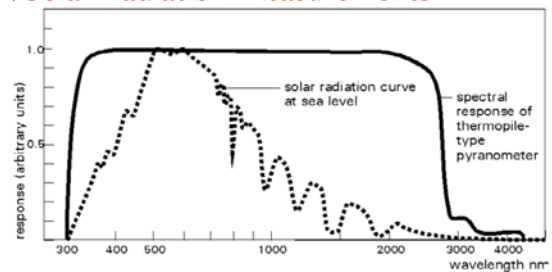


Above: Two styles of thermopile pyranometers showing only two pairs of thermocouples instead of the more usual 10–100 pairs.

Source: <http://www.uk.ac.uk/agnel/408/instruments/shortad.html>

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Solar Radiation Measurements



Spectral sensitivity of a thermopile pyranometer in combination with the spectrum of the sun under a clear sky.

Source: Kipp & Zonen CNR 1 net radiometer instruction manual. The CNR1 uses, among other things, a thermopile pyranometer.

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Solar Radiation Measurements

LI-COR LI200X-L Silicon Pyranometer



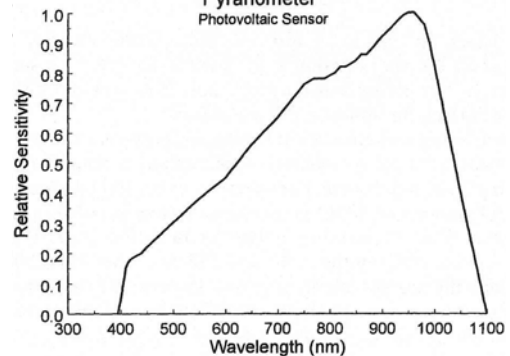
Photo: C. Godfrey

- Measures sun plus sky radiation
- Measurement waveband: 400 to 1100 nm
- Uses a silicon photovoltaic detector

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Solar Radiation Measurements

Pyranometer Photovoltaic Sensor



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Solar Radiation Measurements

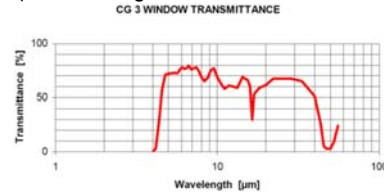
- Diffuse solar radiation:
 - Pyranometer with a shadowband
 - Shadowband requires adjustment (manual or automatic) for solar azimuth and elevation



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Terrestrial Radiation Measurements

- Pyrgeometer
 - Measures terrestrial (Earth) radiation
 - Requires a temperature correction
 - Typically, a flat silicon window measures 3 μm to 50 μm wavelengths



Source: Kipp & Zonen CNR 1 net radiometer instruction manual. The CNR1 uses, among other things, a silicon pyrgeometer with an interference filter to block solar radiation.

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Why do pyrgeometers need a temperature correction?

- Pyrgeometer signal represents the exchange of far infrared radiation between the sensor and the object it's facing
- Sensor generates:
 - A positive voltage output when it faces an object that is hotter than its own sensor housing
 - A negative voltage output when it faces a colder object
- We must therefore account for the sensor temperature:

$$E = \frac{V}{C} + \sigma T_{\text{sensor}}^4$$

- Where:
 - V = voltage output
 - C = calibration coefficient
 - σ = Stefan-Boltzmann constant

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Net Radiation

- Net radiometer
 - Measures the difference between incoming and outgoing total radiation
 - Kipp & Zonen CNR1
 - 2 pyranometers (up and down)
 - 2 pyrgeometers (up and down)



With the CNR1, we can derive net solar radiation, net far infrared radiation, total net radiation, albedo, sky temperature, and ground temperature. How might we do this?

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Net Radiation—A Cheaper Option

Kipp & Zonen NR-Lite



- Two Teflon-coated black surfaces
- Spectral response: 0 to 100 μm

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Solar Radiation Measurements

- Radiometer
 - Generic term for all radiation measuring devices
- Pyrheliometer
 - Measures direct solar beam
 - Sensing element must be normal to solar beam
- Pyranometer
 - Measures global solar radiation
 - Must respond to direct solar beam and diffuse sky radiation from the whole hemisphere
 - Sensing element must be a horizontal flat surface
- Pyrgeometer
 - Measures global terrestrial (longwave) radiation
- Pyrradiometer
 - Measures total global, longwave, and shortwave radiation
- Net Pyrradiometer
 - Measures difference between incoming and outgoing radiation

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Exposure Requirements

- Formation of fog, smoke, and airborne pollution should be typical for the surrounding area
- Instrument windows must be clean
 - A good station is cleaned daily from dust, rain, dew, and bird droppings
 - Aspirators should be used to avoid formation of dew and to promote drying of the domes after rain
- For all sun angles over the entire year, shadows should not be cast over the instrument and light should not be reflected toward the instrument
- Instrument must be kept level
- Pyrheliometers must be kept aligned within 0.25° of the Sun



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