Meteorology 433

Radiation Measurement
Spring 2022

Methods

- Thermal detectors: respond to heat gain or loss due to absorption of incoming or emission of outgoing radiation.

- Photovoltaic detectors: convert absorbed radiation to a voltage.

- Radiation instruments can be classified according to their use.

- Radiometer: generic term for all radiation.

Devices

- Pyranometer: global solar radiation
  - Direct and diffuse radiation from the whole hemisphere.
  - Sensing element must be on a horizontal flat surface.

Devices

- Pyrheliometer: measures direct solar beam.
  - Sensing element must be kept normal to the beam, or pointed directly at the sun.
  - Equatorial mounting or automatic tracker required.
  - Must be kept aligned with the sun within 0.25º.

Devices

- Net Radiometer: measures the difference between incoming and outgoing radiation.

Devices

- Four Component (or stream) Net Radiometer: measures each component (shortwave and longwave) of the incoming and outgoing radiation.
  - Pyrgeometer: measures longwave Earth radiation.

Four Componet Net Radiometer

Pyranometer

Pyrgeometer

Pyrgeometer

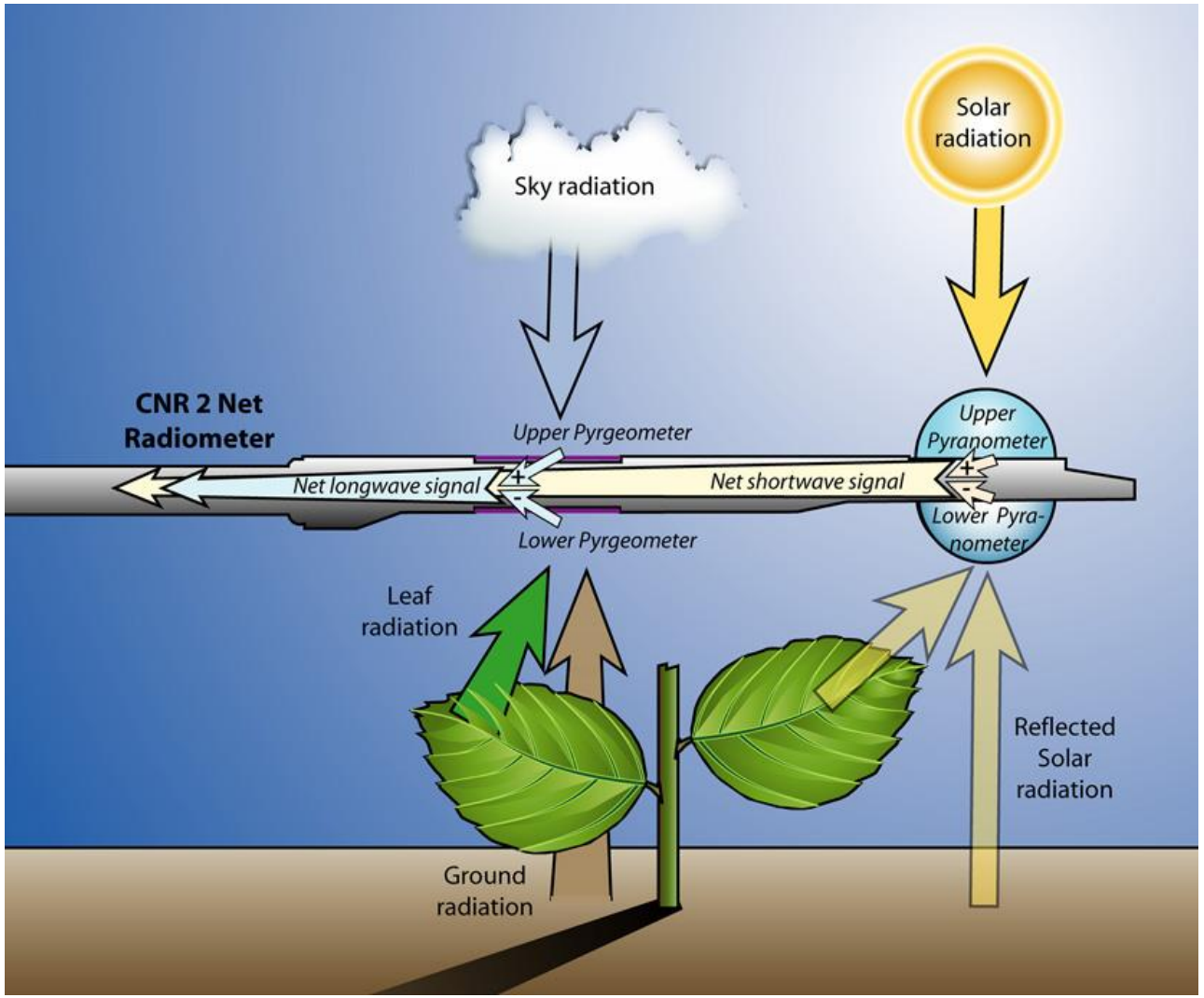
Pyranometer

Pyrgeometer

Pyranometer

Pyrgeometer

Pyranometer


Solar radiation
Sky radiation
CNR 2 Net Radiometer
Upper Pyrgeometer
Upper Pyranometer
Net longwave signal
Net shortwave signal
Lower Pyrgeometer
Lower Pyra-nometer
Leaf radiation
Reflected Solar radiation
Ground radiation

Measurement Errors

- Absolute calibration error
  - Imperfect reference sensor in calibration.
  - Best bet: Send it to NIST for calibration.
- Spectral response error
  - Sensor not conforming to the ideal spectral response.
- Cosine error
  - Error due to inaccurate cosine correction that produces errors at low solar elevation angles.
- Hysteresis error
  - Increasing input response differs from decreasing input response.
- Azimuth error
  - Due to lack of symmetry.

More Errors

- Linearity error
  - Sensor output is not linearly proportional to input.
- Temperature coefficient error
  - Sensor ends up being sensitive to temperature as well as radiation.
- Response time error
  - Input is changing rapidly and the sensor cannot respond.
- Long-term stability error
  - Sensor characteristics change with time.
- User setup and application errors
- Wind Speed errors
  - Can be caused by wind heating or cooling the dome of the instrument.

Exposure - Common

- Instrument must be kept clean.
  - A first-class station requires daily cleaning.
- Condensation must never occur inside the instrument.
- Site must be free from shadows.
- Site must be free from reflections.
- Instrument must be kept level.

Exposure - Other

- Instruments that “look down”
  - Footprint should contain ground cover representative of the area.
  - $R = Z \tan(\sin^{-1} \mathrm{sqrt}(f))$
    - f = fraction of total radiation received by the sensor.
    - Z = height of sensor.
    - If Z = 3m, 95% of the radiation comes from a circle of radius 13.1m about a point just below the sensor.