



Measurement of solar radiation, air velocity, air temperature

The methods for calculating evapotranspiration from meteorological data require various climatological and physical parameters. Some of the data are measured directly in weather stations. Other parameters are related to commonly measured data and can be derived with the help of a direct or empirical relationship.

Meteorological data can be expressed in several units. Conversion factors between various units and standard S. I. units. Climatic parameters, calculated by means of the equations presented in this chapter are tabulated and displayed for different meteorological conditions.

Solar radiation

The evapotranspiration process is determined by the amount of energy available to vaporize water. Solar radiation is the largest energy source and is able to change large quantities of liquid water into water vapour. The potential amount of radiation that can reach the evaporating surface is determined by its location and time of the year. Due to differences in the position of the sun, the potential radiation differs at various latitudes and in different seasons. The actual solar radiation reaching the evaporating surface depends on the turbidity of the atmosphere and the presence of clouds which reflect and absorb major parts of the radiation. When assessing the effect of solar radiation on evapotranspiration, one should also bear in mind that not all available energy is used to vaporize water. Part of the solar energy is used to heat up the atmosphere and the soil profile.

Air temperature

The solar radiation absorbed by the atmosphere and the heat emitted by the earth increase the air temperature. The sensible heat of the surrounding air transfers energy to the crop and exerts

as such a controlling influence on the rate of evapotranspiration. In sunny, warm weather the loss of water by evapotranspiration is greater than in cloudy and cool weather.

Air humidity

While the energy supply from the sun and surrounding air is the main driving force for the vaporization of water, the difference between the water vapour pressure at the evapotranspiring surface and the surrounding air is the determining factor for the vapour removal. Well-watered fields in hot dry arid regions consume large amounts of water due to the abundance of energy and the desiccating power of the atmosphere. In humid tropical regions, notwithstanding the high energy input, the high humidity of the air will reduce the evapotranspiration demand. In such an environment, the air is already close to saturation, so that less additional water can be stored and hence the evapotranspiration rate is lower than in arid regions.

Wind speed

The process of vapour removal depends to a large extent on wind and air turbulence which transfers large quantities of air over the evaporating surface. When vaporizing water, the air above the evaporating surface becomes gradually saturated with water vapour. If this air is not continuously replaced with drier air, the driving force for water vapour removal and the evapotranspiration rate decreases.

The combined effect of climatic factors affecting evapotranspiration is illustrated in Figure 10 for two different climatic conditions. The evapotranspiration demand is high in hot dry weather due to the dryness of the air and the amount of energy available as direct solar radiation and latent heat. Under these circumstances, much water vapour can be stored in the air while wind may promote the transport of water allowing more water vapour to be taken up. On the other hand, under humid weather conditions, the high humidity of the air and the presence of clouds cause the evapotranspiration rate to be lower. Consequently, the wind speed affects the evapotranspiration rate to a far lesser extent than under arid conditions where small variations in wind speed may result in larger variations in the evapotranspiration rate.

Solar radiation

Measurement

Solar radiation can be measured with pyranometers, radiometers or solarimeters. The instruments contain a sensor installed on a horizontal surface that measures the intensity of the total solar radiation, i.e., both direct and diffuse radiation from cloudy conditions. The sensor is often protected and kept in a dry atmosphere by a glass dome that should be regularly wiped clean.

Net longwave and net shortwave radiation can be measured by recording the difference in output between sensors facing upward and downward. In a net radiometer, the glass domes are replaced by polyethylene domes that have a transmission range for both shortwave and longwave radiation.

Where pyranometers are not available, solar radiation is usually estimated from the duration of bright sunshine. The actual duration of sunshine, n , is measured with a Campbell-Stokes sunshine recorder. This instrument records periods of bright sunshine by using a glass globe that acts as a lens. The sun rays are concentrated at a focal point that burns a hole in a specially treated card mounted concentrically with the sphere. The movement of the sun changes the focal point throughout the day and a trace is drawn on the card. If the sun is obscured, the trace is interrupted. The hours of bright sunshine are indicated by the lengths of the line segments.

The quantity of heat conducted into the soil, G , can be measured with systems of soil heat flux plates and thermocouples or thermistors.

Wind direction and velocity

Measurement

Wind is characterized by its direction and velocity. Wind direction refers to the direction from which the wind is blowing. For the computation of evapotranspiration, wind speed is the relevant variable. As wind speed at a given location varies with time, it is necessary to express it as an average over a given time interval. Wind speed is given in metres per second (m s^{-1}) or kilometres per day (km day^{-1}).

Wind speed is measured with anemometers. The anemometers commonly used in weather stations are composed of cups or propellers which are turned by the force of the wind. By counting the number of revolutions over a given time period, the average wind speed over the measuring period is computed.

Wind profile relationship

Wind speeds measured at different heights above the soil surface are different. Surface friction tends to slow down wind passing over it. Wind speed is slowest at the surface and increases with height. For this reason anemometers are placed at a chosen standard height, i.e., 10 m in meteorology and 2 or 3 m in agrometeorology. For the calculation of evapotranspiration, wind speed measured at 2 m above the surface is required. To adjust wind speed data obtained from instruments placed at elevations other than the standard height of 2m, a logarithmic wind speed profile may be used for measurements above a short grassed surface: