COURSE CODE: WMA 201

COURSE TITLE: Introductory Meteorology

NUMBER OF UNITS: 3 Units

COURSE DURATION: Three hours per week

COURSE DETAILS:

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Other Lecturers: Dr. Adejuwon

COURSE CONTENT:

Water cycles in the atmosphere
Evaporation and methods of measurement
Condensation of water vapor, cloud types and cloud classification
Network of meteorological stations observation times and the transmission of information

COURSE REQUIREMENTS:

. This is a compulsory course for all students of the department of water resources management and Agrometeorology in the University. In view of this, students are expected to participate in all course activities and have minimum of 75% attendance to be able to write the final examination.

READING LIST:

1. Ayoade, J.O. Tropical hydrology and water resources
2. Duru, L .1984. Climate, Water and Agriculture in the tropics. Longman publishers. London, UK
3. Gordon, W.1981. Tropical Agriculture the Development of Production, 4th edn., Longmans, London, UK.

4. Shaw, M. 1994. Hydrology in practice. Van Nostrand Reinhold. Berkshire, UK.

Yayock, J.Y., Lombin, G., Owonubi, J.J. 1988. Crop science and production in warm climates. MacMillan publishers. London USA

LECTURE NOTES

The hydrological cycle (water cycle)

The hydrologic cycle is a continuous process by which water is transported from the oceans to the atmosphere to the land back to the sea or ocean viessman et al (1977). The components of the hydrologic cycle are:

(i) Precipitation
(ii) Evaporation
(iii) Transpiration
(iv) Infiltration
(v) Surface runoff
(vi) Ground water flow.

For a given finite region, the water budget equation is then given by

$$P-R-G-E-T=\Delta S$$

where ΔS is the change in storage.

However, difficulty in solving practical problem lies mainly in the inability to properly measure or estimate the various terms of the water budget equation. The global hydrological cycle is however not so open as there are only input and output of energy. There are no input or output of water, but rather a continually transferred from one kind of storage to another

Input (I) = output (0) $\pm$ Δstorages rainfall & inflow

Where

Input (I) includes rainfall and inflow from neighboring catchments (natural or artificial)

Output (0) includes evaporation, outflow from catchments and withdrawal by man

Δ Storages includes soil and ground water storage

EVAPORATION AND EVAPOTRANSPIRATION

Evaporation is the term used to describe water loss from water and bare ground surfaces. It is a process by which moisture is converted into water vapor and removed and transported upward into the atmosphere. On vegetated surface where transpiration is an important component of water loss the term evapotranspiration is used. Evapotranspiration is thus the combined process of evaporation and transpiration.

Process of evapotranspiration

(1) Movement of water within the soil towards the ground surface or zone of adsorption around the roots of plants.
(2) Transpiration
(3) Vaporization of the water at soil or plant surface (intercepted water) or the stomata of leaves (transpired water).
(4) Removal and transport of evaporated water, now in gaseous formal into the atmosphere.

Factors influencing the process evaporation-evapotrnapiration.

(1) Availability of moisture at given surface.
(2) Ability of the atmosphere to vaporize the water and remove and transport the vapor upwards.

If moisture is always available in sufficient qualities at the evaporating (non limiting water), then evaporation or evapotranspiration wills occur at the maximum rate possible for that environment. The concept of maximum water availability in an evaporating surface is called **Potential evapotranspiration**.

Potential evapotranspiration is the water loss that would occur from a permanently moist surface.

Factors controlling rate of evaportranspiration

(1) Climatic factors (**Major)**
  (a) Amount of energy available (solar radiation).
  (b) Atmosphere (air) humidity
  (c) Wind speed.
  others are derived from the **major** component
  (d) Sunshine duration
  (e) Temperature

(2) Non climatic factor
  (a) Characteristics of evaporating surface
  (b) Whether it is water or soil.
  (c) If soil whether vegetated or not.
  (d) Type of soil and land management
  (e) Moisture content of soil profile,
    If water surface:
  (f) Turbidity of water
  (g) Depth of water
  (h) Surface area of water body.

Methods of determination of evaporation- evaporatranspiration

- Direct method
- Indirect or estimation method

Direct method

(1) Evaporation Pan

Classes of pan

(1) sunken pans

(2) above ground pans

Common pan design

(1) United State Weather Bureau (USWB) class A pan

(2) British Meteorological Office Sunken Pans

(3) Russian GGI 3000

(4) United State Colorado Sunken Pans

Factors affecting the performance of evaporation pan

(2) Lysimeters

Types of lysimeters

(1) Weighing lysimeter

(2) Drainage lysimeters

(3) Atmometer - Piche evaporimeter

Determination of evaporation by computation (indirect method).

In view of the difficulties of accurately measuring evaporation and evapotranspiration accurately in the field attempts have been made to estimate them indirectly using meteorological data. There are now dozens of formulae available for estimating values of evaporation.

There are two major approaches that may be adopted in calculating evaporation from open water. The mass transfer method sometimes called the vapor flux method, calculate the upward flux of water vapour from the evaporating surface. The second or energy budget method considers the heat sources and sinks of the water body and air adisolates the energy required for the evaporating process. A third method uses a combination of the two physical approaches.

Among the popularly used methods

(1) Mass transfer methods

(2) Energy budget method

(3) Penman formula (combination method)

(4) Empirical formulae method

(5) Water budget method or the water balance method.

CONDENSATIONS OF WATER VAPOUR

The moisture of the atmosphere, although it is a small proportion of the earth's water storage is the most vital source of fresh water.

*****The formation of precipitation for the water as it exists in the air is a complex and delicately balanced process. If the air was pure, condensation of the water vapor to form liquid water droplets would occur only when the air became greatly supersaturated called aerosols provides nuclear around which water vapor in normal saturated air can condense.

These are two types of condensation nuclear.

(1) Hygroscopic particles

(2) Non- hydroscopic particles.

Hydroscopic particles: these are particles which have affinity for water vapor and condensation begins on these particles before the air becomes saturated. Example of hydroscopic particle is the salt particles from oceans.

Non hydroscopic particles: these are particles which need some degree of super saturated, depending on the size before attracting condensation. Examples are products of industrial activities, soot and ash particles and natural dust on land surface.

Condensation nuclear vary in scale form the radius of 10^{-3} μm for small ions to $10\mu m$ for large salt particles. Large hydroscopic salt nuclear are normally confined to maritime regions but tiny particle called Aitken nuclear can travel across continents and even circumnavigate the earth. Although condensation nuclear are essential for wide spread condensation water vapor, only a small fraction of the nuclear present in the air takes part in cloud droplets formation any one time.

There are other conditions that must be fulfilled before precipitation can occur:

(1) Moist air must be cooled to near dew point, this can be achieved by Adiabatic expansion of rising air. A volume of air may be forced to rise by an impending mountain range. The reduction in pressure causes lowering of temperature without any transfer of heat.
(2) By emitting of two very different air masses e.g when warm moist mass of air converges with a cold mass of air, the warm air is forced to rise and may cool to dew point. Any mixing of the contrasting mass of air would also lower the over all temperature.
(3) By contact between a moist air mass and a cold object such as the ground.

GROWTH OF CLOUD DROPLETS

Once cloud droplets are formed their growth depends on

(1) Hydroscopic and surface tension forces.
(2) Humidity of the air
(3) Rate of transfer of water vapor to water droplets.
(4) Latent heat of condensation released.

A large population of droplets competes with the rate depend on their origin and on the cooling rate of air providing the supply of moisture.

The mechanism of growth of cloud droplets becomes complicated when the temperature reached boiling point pure water can be super cooled to about 40^0 C temperature before freezing. On the other hand cloud droplets do not freeze in normal air conditions until cooled below – 10^0C. they freeze only in the presence of small particle called ice nuclear retaining their spherical shape and becoming solid ice crystals.

Water vapour may then be deposited directly on the water surface. The crystals grow into various state depending on temperature and degree of super-saturation of air with respond to ice.

Considered water vapour appear in the atmosphere as cloud in various characteristic forms. (cloud are tiny droplets of water vapour , suspended and floating in the air.)

Clouds are tiny droplets of water vapour suspended and floating in the air. Their forms, shapes, hits admouts indicate the sky and weather conditions of a particular place. On maps plans joined by lines of equal degree of cloudness are called isonephs leading to the formation of water droplets. Cloud can also be formed by temperature inversion. Cloud cover is also known to

(1) aid formation rain

(2) reflection of shortwave and radiation

(3) reduce solar radiation.

CIRRUS CLOUDS

They occur in the upper troposphere, they consist of fine ice crytal and have a delicate silky appearance without shadow. Other forms are cirrus-stratus (a thin white sheet) and cirrus cumulus (small white flakes arranged in a pattern resembling lambs wool). They are often called mackerel cloud.

Altocumulus differ from cirru-cumulus in that the cloud sheets are lower and the flakes larger and often shows large shadows. They are both of white patch, sheet on layer of cloud generally with shading, composed of laminae rounded masses which are sometimes partly fibrous or diffuse and which may or may not be merged.

Altostratus : is a dense sheet of grey or bluish cloud color, often showing a fibrous structure and of uniform appearance, totally or partially covering the sky. They are present in the medium tropospheric and are usually followed by precipitation of a continuous type.
Stratocumulus : is a low cloud layer consisting of large lumpy (rounded) masses or roles of dull grey colour with bright interstices. They are non fibrous may or many not merged.

Nimbo- stratus is a denser shapeless and ragged layer of cloud from which precipitation usually form. It is often connected with altostratus at higher level. They are grey cloud layer often dark the appearance of which is rendered diffuse by move or less continuosly falling rain or show which in most cases reaches the ground. It is thick enough throughout to blot the sun.

Cumulus : is a thick cloud whose surface is domed shape often of a cauli-flower structure and whose bases more or less horizontal. They are normally divided into three groups.

(1) Cumulus humilis- flat weather cloud
(2) Cumulus conpestus- they are like column. They reach a considerable height without producing precipitation
(3) Cumulombus – grey mass of cloud rising like mountain.

They are generally accompany by thunder storm and sometimes hail in pronounced case, they produces tornadoes and winds (hurricanes)

Stratus : is a uniform layer of low for cloud which does not touch the ground. Fog and smog are low cloud that touch the ground. In the case of fog visibility is reduced by cloud that have absorbed water.
Haze : consist of dry dust and sots which reduce the visibility and affect the coloring of distant objects.

Types of conventional stratus

(1) Synoptic weather station
(2) Agricultural weather station
(3) Cumatological weather station
(4) Rainfall station.

Weather elements

It recorquises 10 weather element to be measured.

(1) Past and present weather
(2) Wind direction and speed (mile/hr, knot, km/hr)
(3) Amount and form of cloud (oktas)
(4) Height of cloud (cloud height search light)
(5) Visibility (observation of object fixed at know distant or use of visibility meter)
(6) Temperature
(7) Air humidity
(8) Barometer pressure (barometer)
(9) Precipitation
(10) Sunshine duration (cambell storke sunshine recorder).

Methods of weather observation measurement

(1) Instrumental
(2) Non-instrumental

(1) Instrumental : are general of two types
   (1) Registering = automatic
   (2) Non-registering
   (3) Non- instrumental: depends on the skill and value judgment the observation should be determined from the relevant topographical map if available and the height above sea level established from the

nearest ordinance survey benchmark. Particular attention should be paid to noting the exact orientation of the enclosure since the setting up of the anemometer and sunshine recorder is dependent on direction.

Design considerations

(1) There are several well defined stages in the design of network of gauging station for measurement if hydrological variable.

(2) Recognizance background research on the location and known characteristic of area to be studied.
    - Size of the area
    - Check whether It is a political entity or a natural drainage basin.
    - However when assessing the design problem it is advisable to think in terms of natural catchment areas even if the total area is defined by political boundaries.
    - Physical features of area should be studied. (drainage pattern , the surface relief, geological structure vegetation).
    - Climatic conditions (seasonal difference terms of temperature precipitation).

(3) Practical planning: existing measuring station should be identified, visited for inspection and to determine observational practices and all available data assembled. Plot the station sites on topographical map of area.

(4) To locate weather station the condition that must be fulfilled are.

(1) Stations must be in a leveled ground about 10m by 7m in exetent covered grass, should not be sited near a hill, depression or step slope. (3) although a certain amount of shelters is required for rain gauges a very open site is desirable for sunshine recorder and anemonited. If enclosure not satisfactory for particular

instrument, they may be installed elsewhere according to their requirements

(2) Far from objects like buildings trees etc.

(3) A recommended plan for the instrument enclosure is as shown below. The geographical coordinates of the station latitude and longitude.

Density and characteristics of weather station

The density and distribution of weather station to be established on a network within a given area depends on.

(1) The meteorological elements to be observed.
(2) Topography of area.
(3) Purpose of location of weather station. i.e
(4) Availability of resources
(5) Availability
(6) Man-power.

Air burn instrument

(1) Radiosonde – explore the atmosphere. It is a radio transmitted equipped to measure temperature, pressure, relative humidity windspeed and direction. It comprises of balloon, small radio-transmitted. The balloon is filled with hydrogen or helium and ascends into 16-20 km of the atmosphere. It can be found at ikeja.

   Beyond 20km- met rocket are used. This provides information about element at that distance.

(2) Weather radar- system of detection and location of targets which are capable of reflecting high frequency radio waves

(micro-wave), it consists of a transmitter, receiver antennal, indication or scope. The range is about 80km. there are two ways of displaying information on the scope.

(1) Plan position indicator (PPI); It presents a plane view of echoes that enable us to read up both range bearing of target (cloud).

(2) Range – height indication (RHI); It gives a plot of the echo height and range. To do this a vertical. It advantage is that it shows level and distance.

(3) Weather satellite

Tiros was the first satellite lunched (April 1960 in America). There are some improvement in weather satellite in many countries. There are two types of weather satellites based on orbital configuration.

(1) Polar orbital satellite : it goes from pole to poles

(2) Geo-stationary satellite: moves around the equatior.