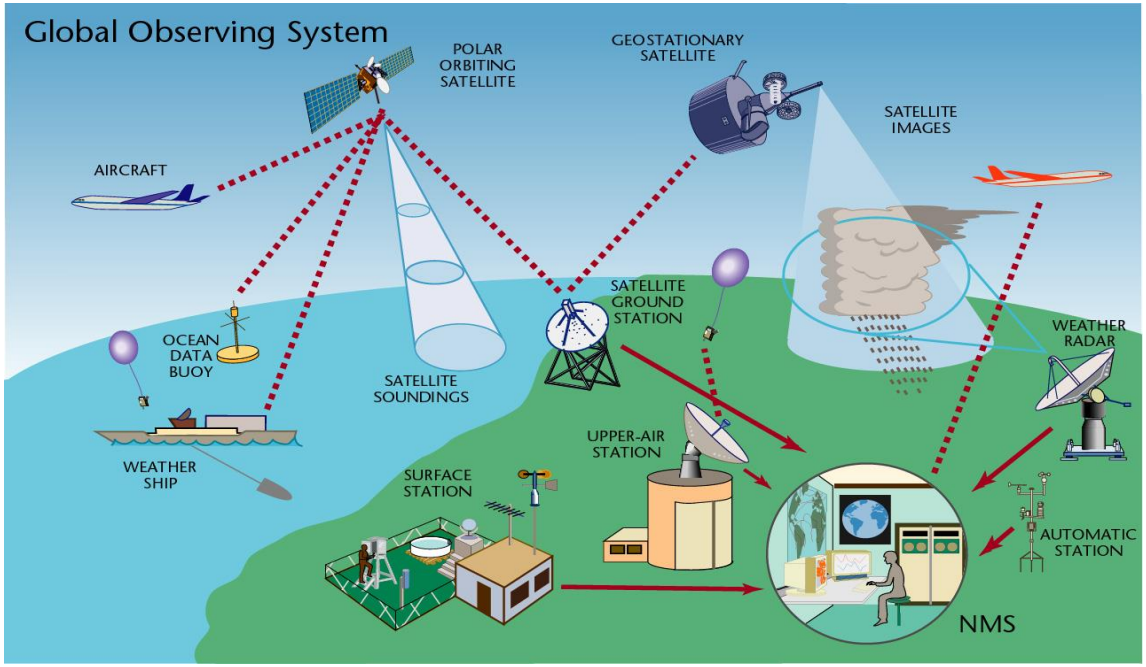
The Course of
Meteorological Instrumentation and Observations



MUSTANSIRIYAH UNIVERSITY
COLLEGE OF SCIENCES
ATMOSPHERIC SCIENCES DEPARTMENT

2019-2020

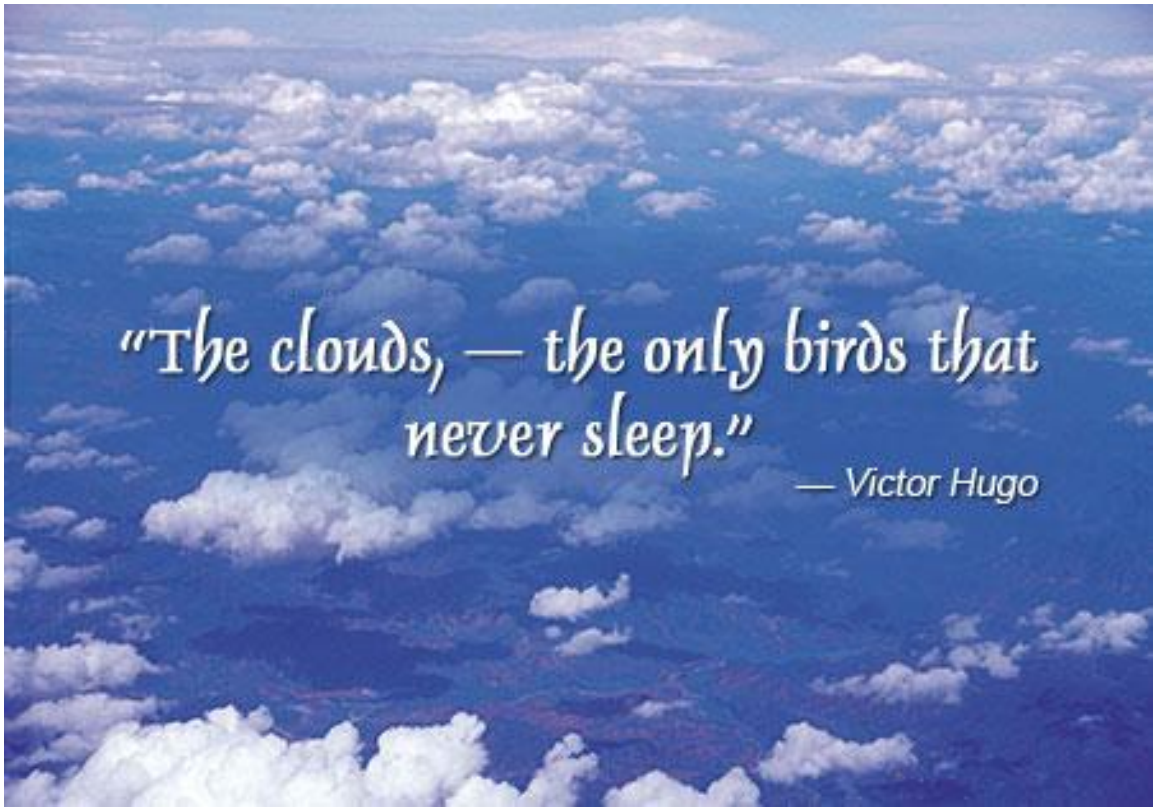
Dr. Ali alhafiz

SECOND STAGE

Welcome Students! ☺

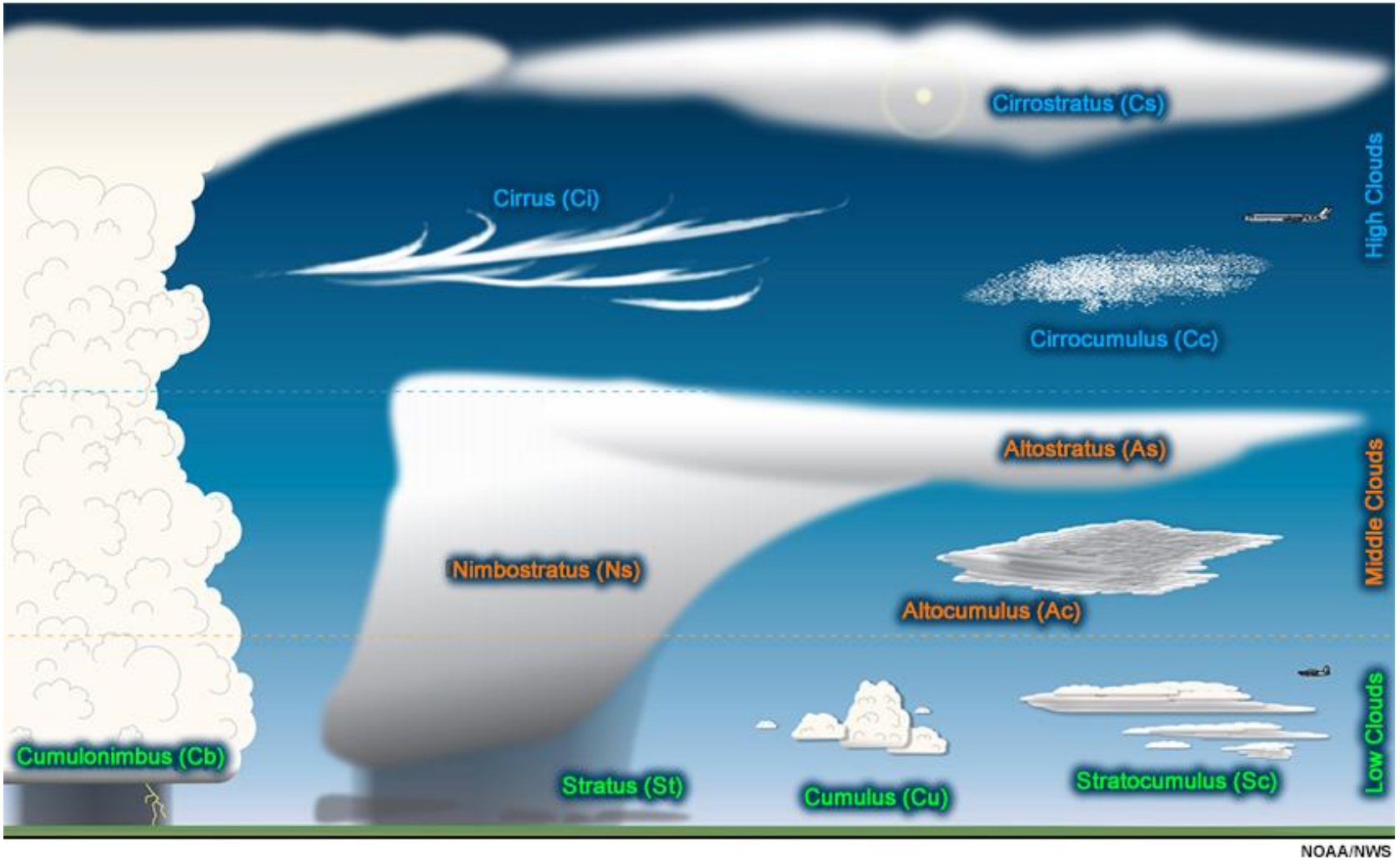
TO LECTURE FIVE

CLOUDS



A **cloud** is a visible collection of billions of small water and/or ice particles suspended in the atmosphere above Earth's surface. Clouds form when water vapor condenses.

Clouds come in all shapes and colors, and exist at all levels of the troposphere. Their unique features can tell us something about the atmospheric processes that led to their formation, or indicate impending weather changes.



Clouds is found in the lower part of the atmosphere "troposphere". Some clouds are formed in the stratosphere, too

The **shape and the position of the clouds** tell the direction and speed of the wind in the sea, and clouds tells how much water vapor is in the air

CLASSIFICATION OF CLOUDS

- The French naturalist Lamarck (1744–1829) proposed the first system for classifying clouds in 1802; however, his work did not receive wide acclaim.
- One year later, Luke Howard, an English naturalist, developed a cloud classification system that found general acceptance. In essence, Howard's innovative system employed Latin words to describe clouds as they appear to a ground observer. In Howard's system, there were the four basic cloud forms.

Other clouds could be described by combining the basic types. For example, nimbostratus is a rain cloud that shows layering, whereas cumulonimbus is a rain cloud having pronounced vertical development.

Root	Meaning
cirro-	high
alto-	mid
strato-	layer
cumulo-	heap
nimbo-	precipitation

In 1887, Abercromby and Hildebrandsson expanded Howard's original system and published a classification system that, with only slight modification, is still used today. Ten principal cloud forms are divided into four primary cloud groups. **Each group is identified by the height of the cloud's base above the surface**: high clouds, middle clouds, and low clouds. *The fourth group* contains clouds showing more vertical than horizontal development. Within each group, cloud types are identified by their appearance. The table below lists these four groups and their cloud types.

TABLE 4.2 The Four Major Cloud Groups and Their Types

1. High clouds
   - Cirrus (Ci)
   - Cirrostratus (Cs)
   - Cirrocumulus (Cc)
2. Middle clouds
   - Altostratus (As)
   - Altocumulus (Ac)
3. Low clouds
   - Stratus (St)
   - Stratocumulus (Sc)
   - Nimbostratus (Ns)
4. Clouds with vertical development
   - Cumulus (Cu)
   - Cumulonimbus (Cb)

Approximate Height of Cloud Bases above the Surface for Various Locations

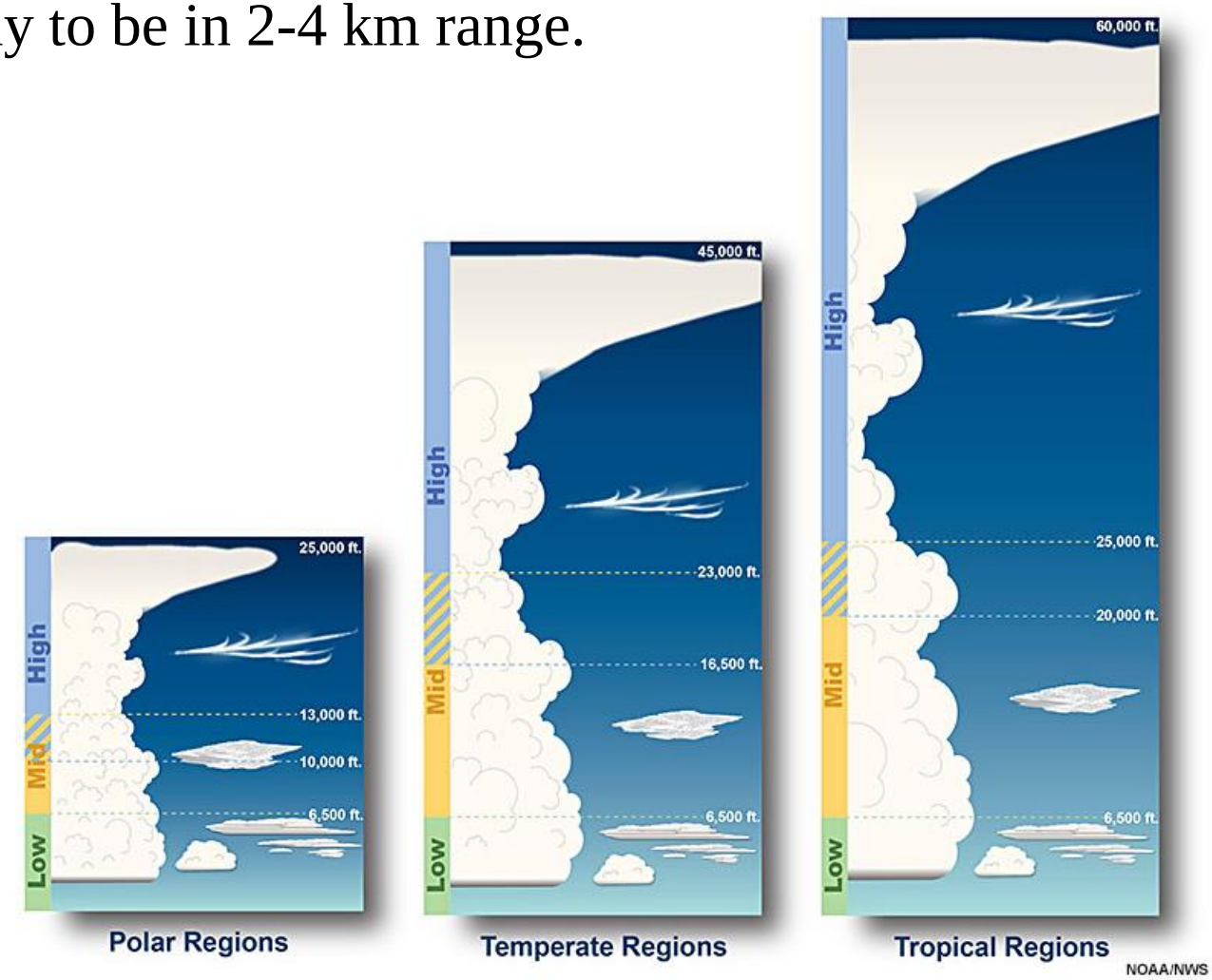
Cloud Group	Tropical Region	Middle Latitude Region	Polar Region
High Ci, Cs, Cc	20,000 to 60,000 ft (6000 to 18,000 m)	16,000 to 43,000 ft (5000 to 13,000 m)	10,000 to 26,000 ft (3000 to 8000 m)
Middle As, Ac	6500 to 26,000 ft (2000 to 8000 m)	6500 to 23,000 ft (2000 to 7000 m)	6500 to 13,000 ft (2000 to 4000 m)
Low St, Sc, Ns	surface to 6500 ft (0 to 2000 m)	surface to 6500 ft (0 to 2000 m)	surface to 6500 ft (0 to 2000 m)

Clouds can be categorized based on other factors such as altitude, composition, and temperature (see table below).

Altitude		**Composition**	**Temperature**
Cumuliform	**Stratiform**		
significant vertical development	high	ice crystals	cold
	middle	supercooled water droplets	cold
	low	water droplets	warm

Cloud Altitude Observations

Because the troposphere is much warmer in the tropics than at higher latitudes, the cloud base height differs for mid and high clouds across these regions. For instance, mid-level clouds near the equator generally have heights between 2 km and 7.5 km, while closer to the poles, these cloud heights are likely to be in 2-4 km range.



Cloud Identification

High clouds in middle and low latitudes generally form above 6000 m. Because the air at these elevations is quite cold and "dry," high clouds are composed almost exclusively of ice crystals and are also rather thin. High clouds usually appear white, except near sunrise and sunset, when the unscattered (red, orange, and yellow) components of sunlight are reflected from the underside of the clouds.

- The most common high clouds are the **Cirrus (Ci),** which are thin, wispy clouds blown by high winds into long streamers called mares' tails. They can look like a white, feathery patch with a faint wisp of a tail at one end. Cirrus clouds usually move across the sky from west to east, indicating the prevailing winds at their elevation. They predict fair to pleasant weather.

- **Cirrocumulus clouds (Cc)**, seen less frequently than cirrus, appear as small, rounded, white puffs that may occur individually, or in long rows. When in rows, the cirrocumulus cloud has a rippling appearance that distinguishes it from the silky look of the cirrus and the sheet like cirrostratus. Cirrocumulus seldom cover more than a small portion of the sky. The dappled cloud elements that reflect the red or yellow light of a setting sun make this one of the most beautiful of all clouds. The small ripples in the cirrocumulus strongly resemble the scales of a fish; hence, the expression “mackerel sky” commonly describes a sky full of cirrocumulus clouds.

Ripples of altocumulus resemble the skin of King Mackerel

- The thin, sheet like, high clouds that often cover the entire sky are **Cirrostratus(Cs)**, which are so thin that the sun and moon can be clearly seen through them. The ice crystals in these clouds bend the light passing through them and will often produce a halo. In fact, the veil of cirrostratus may be so thin that a halo is the only clue to its presence. Thick cirrostratus clouds give the sky a glary white appearance and frequently form ahead of an advancing storm; hence, they can be used to predict rain or snow within twelve to twenty-four hours, especially if they are followed by middle-type clouds.

Middle Clouds The middle clouds have bases between (2000 and 7000 m) in the middle latitudes. These clouds are composed of water droplets and when the temperature becomes low enough they have some ice crystals.

- **Altocumulus, Ac** clouds appear as gray, puffy masses, sometimes rolled out in parallel waves or bands. Usually, one part of the cloud is darker than another, which helps to separate it from the higher cirrocumulus. Also, the individual puffs of the altocumulus appear larger than those of the cirrocumulus.

- The **Altostratus, As,** is a gray or blue-gray cloud that often covers the entire sky over an area that extends over many hundreds of square kilometers. In the thinner section of the cloud, the sun (or moon) may be dimly visible as a round disk, which is sometimes referred to as a “watery sun”.

Low clouds, with their bases lying below 2000 m are almost always composed of water droplets; however, in cold weather, they may contain ice particles and snow.

- The **nimbostratus Ns** is a dark gray, “wet”-looking cloud layer associated with more or less continuously falling rain or snow. The intensity of this precipitation is usually light or moderate. it is never of the heavy, showery variety. Thin nimbostratus is usually darker gray than thick altostratus, and you cannot see the sun or moon through a layer of nimbostratus. Visibility below a nimbostratus cloud deck is usually quite poor because rain will evaporate and mix with the air in this region.

- A low, lumpy cloud layer is the **stratocumulus,** Sc. It appears in rows, in patches, or as rounded masses with blue sky visible between the individual cloud elements. Often they appear near sunset as the spreading remains of a much larger cumulus cloud. The color of stratocumulus ranges from light to dark gray. It differs from altocumulus in that it has a lower base and larger individual cloud elements. Rain or snow rarely fall from stratocumulus.

Notice that the rounded masses are larger than those of the altocumulus.

Stratus St is a uniform grayish cloud that often covers the entire sky. It resembles a fog that does not reach the ground. Actually, when a thick fog “lifts,” the resulting cloud is a deck of low stratus. Normally, no precipitation falls from the stratus, but sometimes it is accompanied by a light mist or drizzle. This cloud commonly occurs over Pacific and Atlantic coastal waters in summer.

Clouds with large vertical extending

- The puffy **Cumulus, Cu** cloud takes on a variety of shapes, but most often it looks like a piece of floating cotton with sharp outlines and a flat base. The base appears white to light gray. The top of the cloud often in the form of rounded towers denotes the limit of rising air and is usually not very high. These clouds can be distinguished from stratocumulus by the fact that cumulus clouds are separated (usually a great deal of blue sky between each cloud) whereas stratocumulus usually occur in groups or patches.

If they continues to grow vertically, it develops into a giant **cumulonimbus**, a thunderstorm cloud. Its top may extend upward to the tropopause. A cumulonimbus can occur as an isolated cloud or as part of a line or “wall” of clouds. Massive amounts of energy are released by the condensation of water vapor within a cumulonimbus and result in the development of violent up- and downdrafts, which may exceed fifty knots. fast winds at these higher altitudes can reshape the top of the cloud into a huge flattened anvil.

Other appearances

Kelvin-Helmholtz Wave

halo

sun dog

haze

lightning

aurora borealis

rainbow

dawn

Measurement of cloud height using a balloon

Cloud height may be measured in daylight by determining the time taken by a small rubber balloon, inflated with hydrogen or helium, to rise from ground level to the base of the cloud.

The base of the cloud should be taken as the point at which the balloon appears to enter a misty layer before finally disappearing.

The rate of ascent of the balloon is determined mainly by the free lift of the balloon and can be adjusted by controlling the amount of the gas in the balloon.

The time of travel between the release of the balloon and its entry into the cloud is measured by means of a stop-watch. If the rate of ascent is n metres per minute and the time of travel is t minutes, the height of the cloud above ground is $n * t$ metres, but this rule must not be strictly followed.

Care should be taken if there is eddies, precipitation.

This method can be used at night by attaching an electric light to the balloon.

Cloud Height and Remote Sensing

Weather satellites orbiting Earth carry instruments that sense radiation in the infrared wavelengths (10.2 to 11.2 micrometers). This radiation is essentially heat radiated back to space from Earth's surface, atmosphere, and clouds. Clouds typically have the coldest temperatures compared to the surface and the atmosphere.

Because infrared measurements are based on sensing heat, the infrared imagery is a useful tool for estimating the temperatures of cloud tops. These temperatures can then be translated to cloud height. High altitude clouds have colder cloud-top temperatures than lower altitude clouds. These different cloud-top temperatures mean that low and high clouds appear differently in the infrared imagery.