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COURSE MANUAL

Causes and Influences of Climate Change and Management of Weather for Sustainable Agriculture

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ICAR

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Some Basic Concepts of Meteorological Processes and Future Analytical Procedures in Agrometeorology

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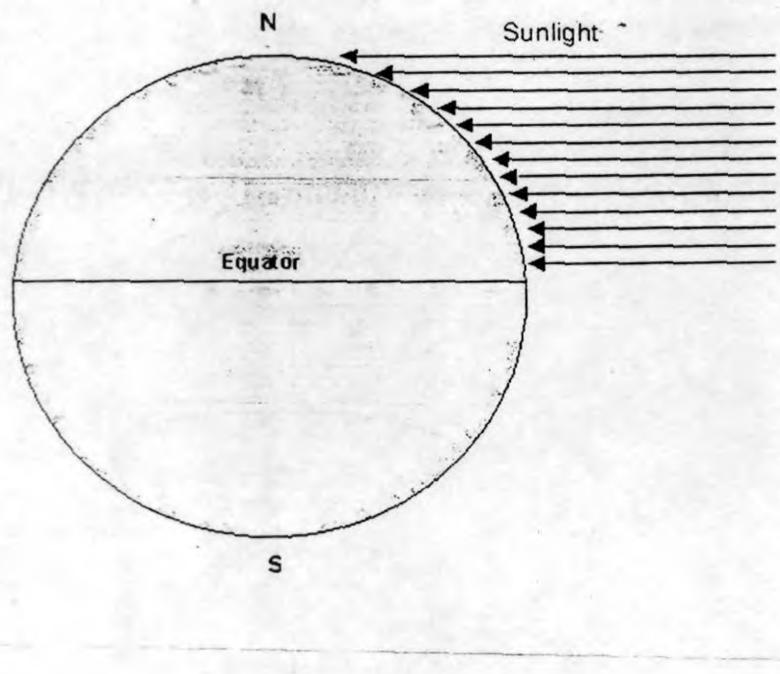
Genesis of seasons and global wind flow

- Seasons on earth are mainly caused due to the inclination of earth – 23½ degrees from the vertical and earth's revolution.
- Land constitutes of only 30% of the total global area mainly situated in the Northern Hemisphere, the rest being water.
- Differential heating of landmass and sea causes land to be heated up and also to cool faster than the sea – the reason being that land acts as a black body ie. quickly absorbs heat and releases heat quickly compared to the sea.
- Radiational heating over land causes the surface air to expand rise up and produce a low-pressure region.
- Radiational cooling over land causes the surface air to contract and descent producing a high-pressure region.

Equatorial regions get heated up more compared to polar regions



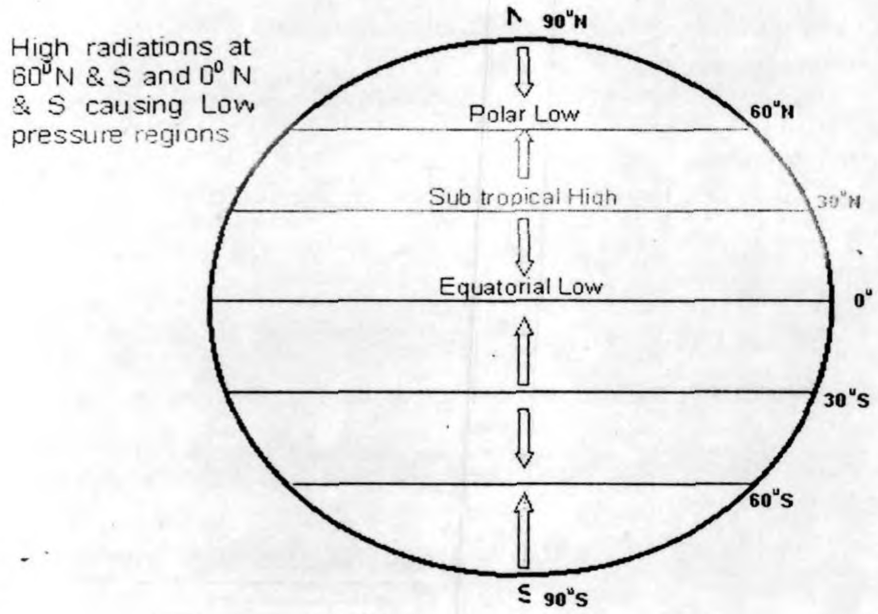
Dynamics of pressure systems

- Low pressure regions causes the surrounding air to flow into it or causes convergence of air mass – designated as 'Low'
- High-pressure regions cause the surrounding air to flow away from it causing

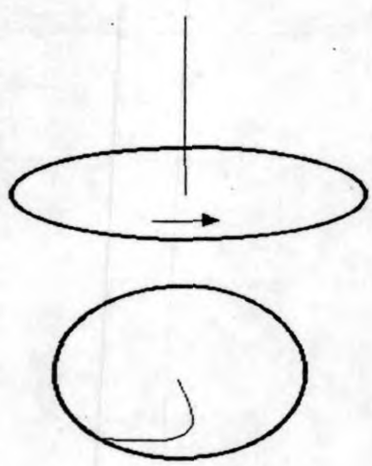
divergence of air mass – designated as 'High'.

- Horizontal extent of such pressure regions are very vast compared to its vertical extent and therefore major movement of air mass is along the horizontal direction.
- Horizontal pressure gradient – Change in pressure in a unit distance in the direction of its decrease (dp/dx and dp/dy; x & y directions respectively).
- All this results in wind flowing from a high-pressure region to a low-pressure region.

Horizontal pressure distribution and wind direction of a non-rotating earth



What happens to the horizontal wind directions when the earth is rotating?



The Coriolis Force

Mark a straight line on a free rotating disk hung by a thread. Let the rotation be in the direction of the earth's rotation. After the disk stops verify the line drawn. On the disk it will be seen to have drawn a curve running towards the right. The same can be seen when the line is drawn from the centre of the disk to the periphery and vice versa.

This shows that there was actually no force (fictitious force) to tilt it in the right direction. Due to the motion of the disk it turned right. Repeating the same experiment beneath the surface of the disk it will be seen that the deflection is towards the left of the direction of mark.

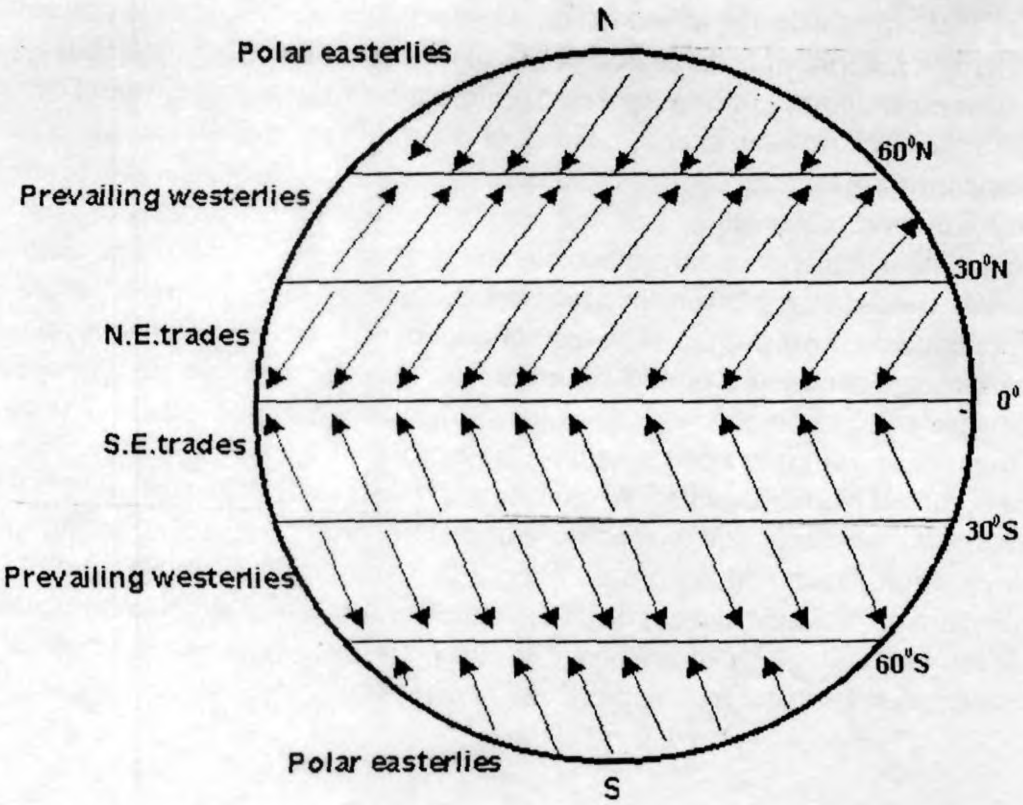
The *Coriolis force* was propounded in 1835 by the french mathematician Gustard Gustave Coriolis after the studies carried out by Laplace in rotational dynamics.

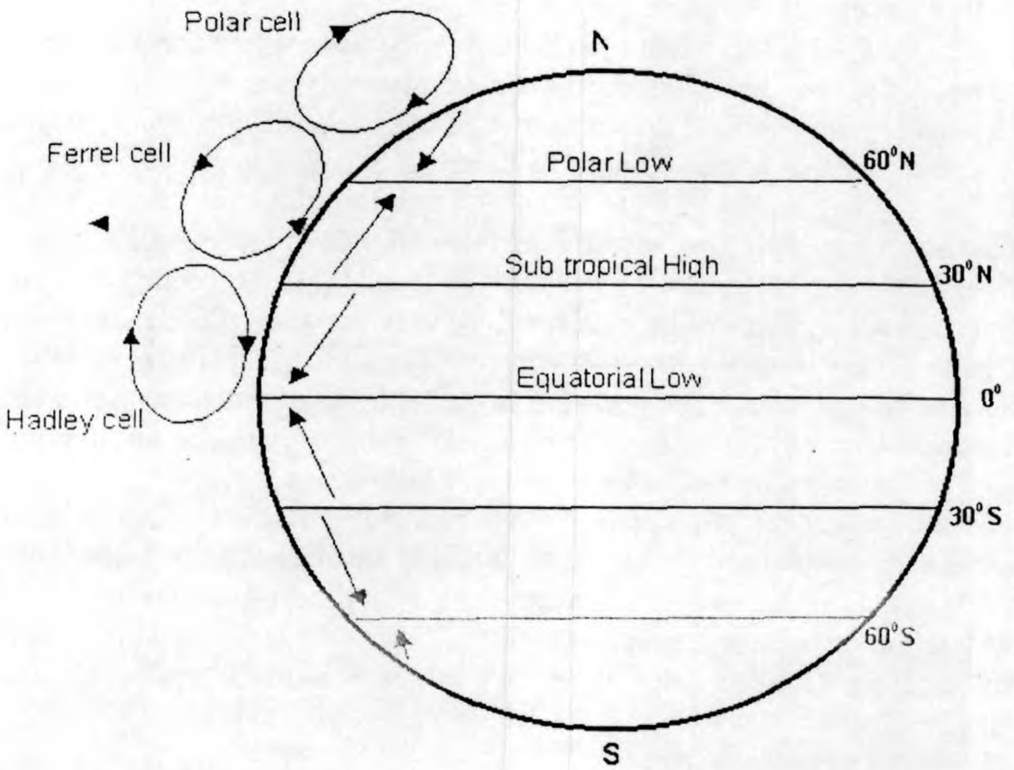
It can be defined as a fictitious force which has a tendency to deflect any motion on the earth's rotating surface (or any rotating surface) at right angles to the direction of the motion and acts towards the right in the northern hemisphere and towards the left in the southern hemisphere.

The force per unit mass = $2\Omega \sin\theta \times V$ where θ is the latitude and Ω the angular velocity.

$\Omega = 2\pi/T$ where T is the time taken for 1 rotation= 24 x 60 x 60 sec
$= 7.27 \times 10^{-5}$ radian/sec
V is the velocity of the mass of air
$2\Omega \sin\theta$ is the *Coriolis parameter*.

Horizontal surface wind patterns of the rotating earth





The motion over the earth as a whole – The General Circulation

Inter Tropical Convergence Zone (ITCZ)

The low pressure system with rising air and convergence at the equator produces a calm at about 5^0N and 5^0S latitude. This low pressure area of a large extent is known as the ITCZ otherwise known as Doldrums.

Role of ITCZ in the formation of monsoons

The ITCZ shifts with the march of the sun especially when the sun crosses the equator towards the northern hemisphere. So, during he month of May the ITCZ also shifts from the equator with intense heating in the north of the equator, where more land mass comes under intense heating. This low pressure region pulls the SE trades from the southern hemisphere.

Once the wind crosses the equator, it will deflect due to the Coriolis force and flow as SW winds. These moisture laden winds gets blocked by the W-E aligned Himalayas and the Tibetan plateau, expands cools and condenses moisture over he Indian sub-continent causing the SW monsoon rainfall. By around the last week of June the whole sub-continent will be covered. This will last till the first week of September when it will start to recede with the sun's position a the equator. The SW monsoon completely withdraws by the middle of October.

The complete withdrawal of SW monsoon is followed by the beginning of the NE monsoon. This is mainly due to the return of the NE trades over India during this period with moisture laden winds from the Bay of Bengal bringing copious rainfall to the southern parts of the continent. The ITCZ closely follows the sun's position but onto the southern hemisphere its presence is not very distinct. The NE monsoon rainfall will complete its cycle by the middle of December.

Other causes of rainfall

- Orography
- Convective
- Fronts & Cyclones

Forces governing surface horizontal winds

a) Pressure Gradient force
b) Coriolis force
c) Centrifugal force
d) Frictional force

Balance between these forces creates

1) Geostrophic wind - Pressure gradient vs Coriolis force
2) Gradient wind - Pressure gradient vs Coriolis and Centrifugal force
3) Surface wind - Pressure gradient vs Coriolis and frictional force

Analysis of spatial variability in a geographic location

Somewhere In the 1930s a mining engineer named Danie W. Krige propounded a mathematical procedure to estimate unknown data in a 2D space for finding out gold deposits. The procedure was then refined by a mathematician A. Matheron in 1950. This procedure which gave a surprisingly good estimation is today known as Kriging and is widely used in Geostatistics.

This procedure employs the use of calculating the semivariogram of a set or all of the points considered in a field along with an unknown and then estimating this value. For this to be effectively used, the use of a computer is necessary. Many types of Kriging processes are in use. Spatial Kriging can be used to find out climatic as well as soil variables and a holistic dimension can be obtained with a 2D contour plot. This can also be used for agroclimatic crop specific zonation. Concurrence can then be verified with RS data. GIS based analysis uses this technique.