BALANCED FLOW IN ATMOSPHERE

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OUTLINE

- Balanced Flow
- Natural Co-ordinates
- Geostropic Flow
- Inertial Flow
- Cyclostropic Flow
- Gradient Flow

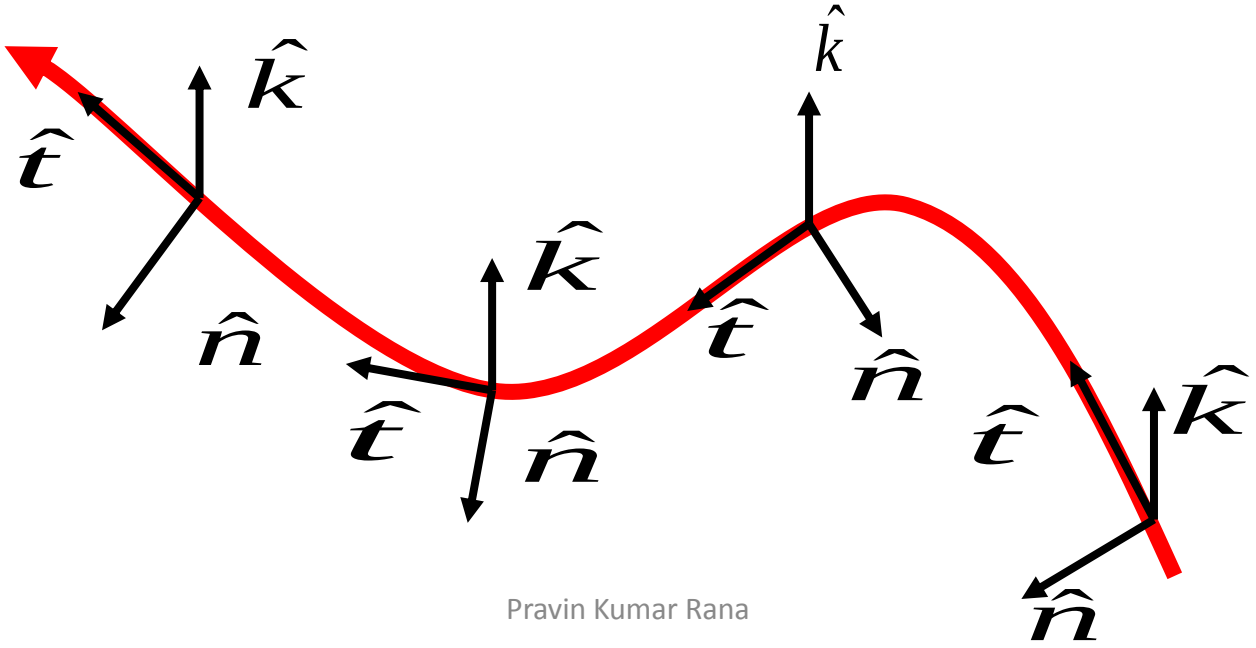
BALANCED FLOW

- The pressure and velocity distributions in atmospheric systems are related by simple, approximate force balances

- To explore these balanced flow conditions, it is useful to define a new coordinate system, known as natural coordinates

NATURAL CO-ORDINATES

- Natural coordinates are defined by a set of mutually orthogonal unit vectors whose orientation depends on the direction of the flow



Components of horizontal momentum equation (isobaric) in natural coordinate system

$$\frac{dV}{dt} = -\frac{\partial \Phi}{\partial s}$$

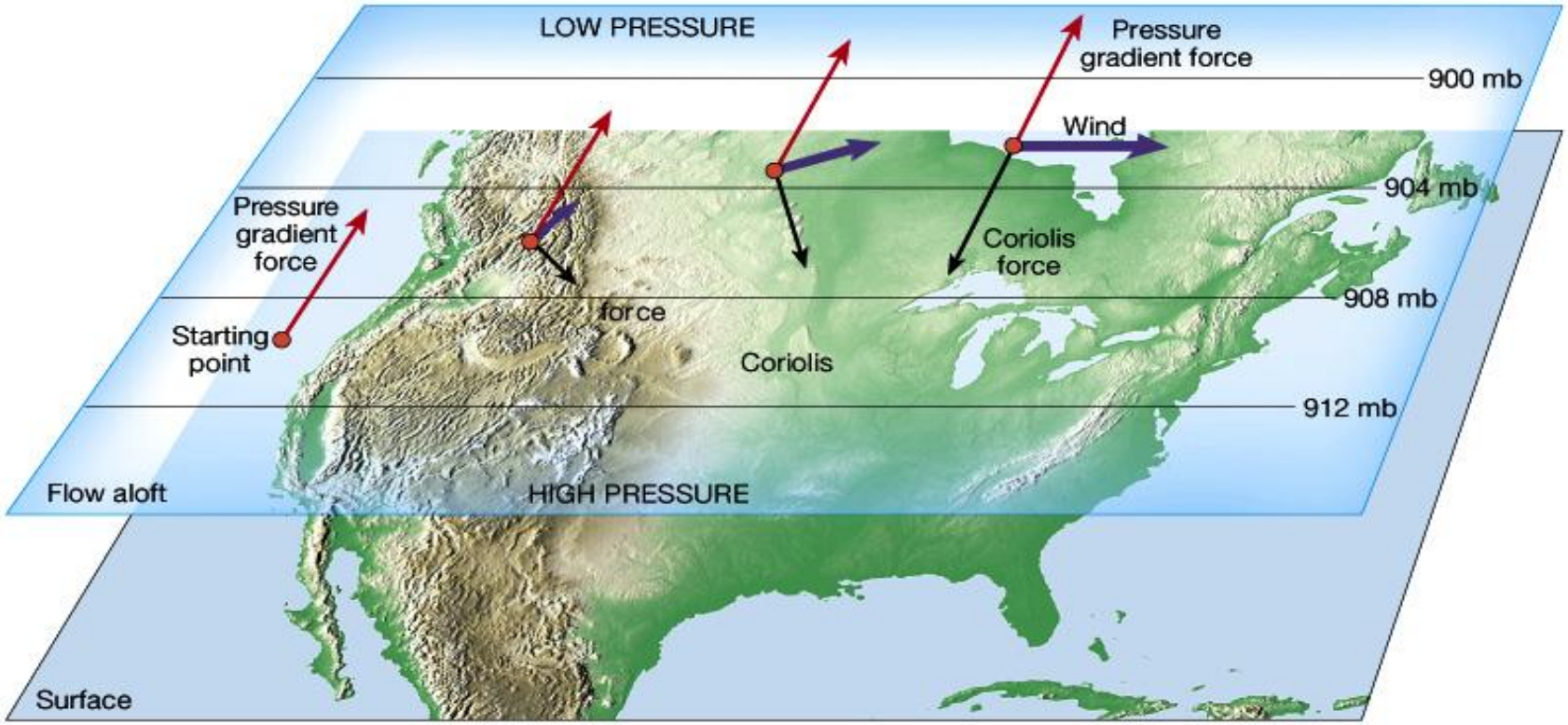
$$\frac{V^2}{R} + fV = -\frac{\partial \Phi}{\partial n}$$

GEOSTROPHIC FLOW

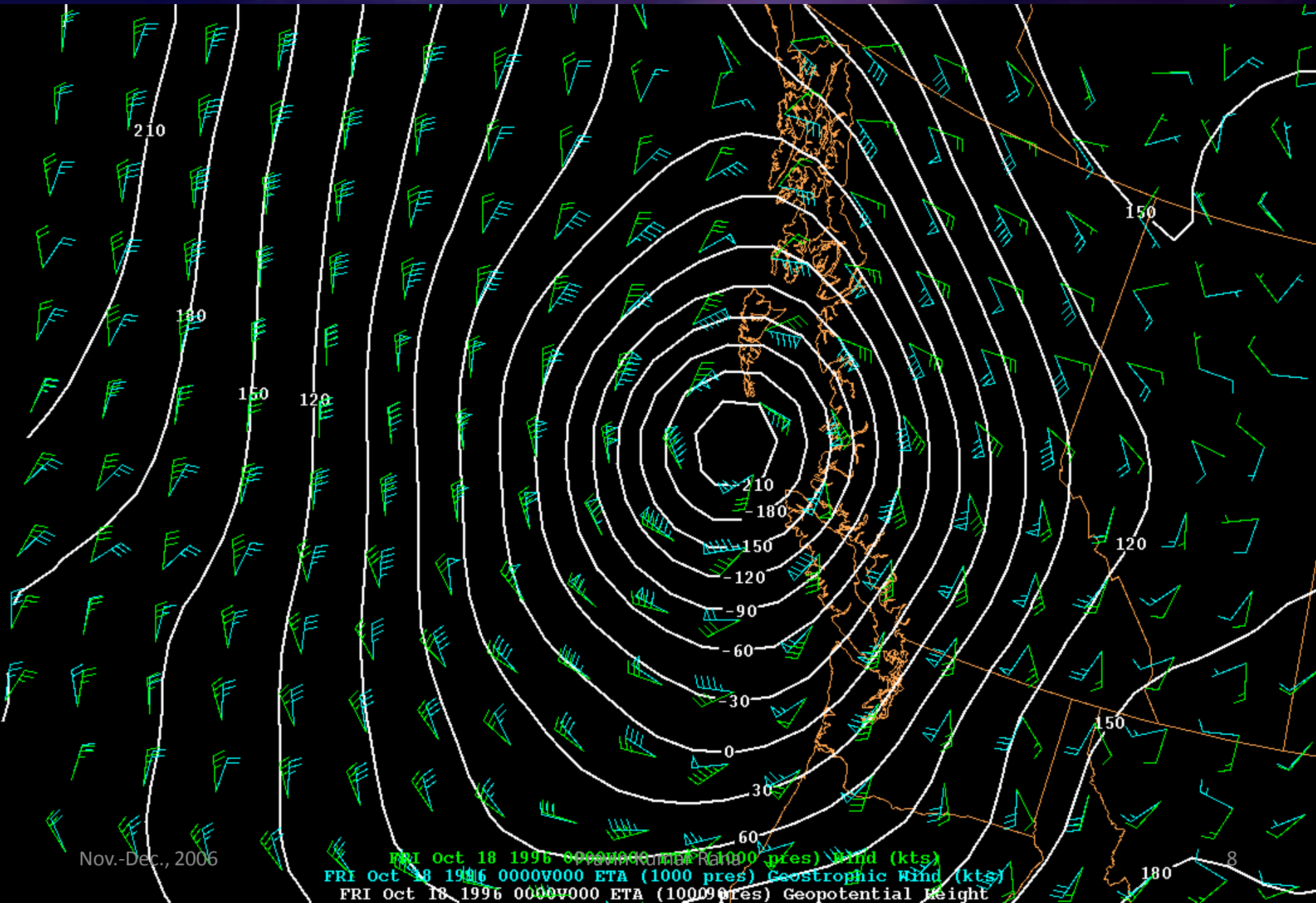
- A state of motion of air in atmosphere in which the horizontal Coriolis force exactly balances the horizontal pressure gradient force at all points of the field

- The geotropic wind is directed along the isobars with low pressure to the left in the Northern Hemisphere and to the right in the Southern Hemisphere

Balance of forces for geostrophic equilibrium



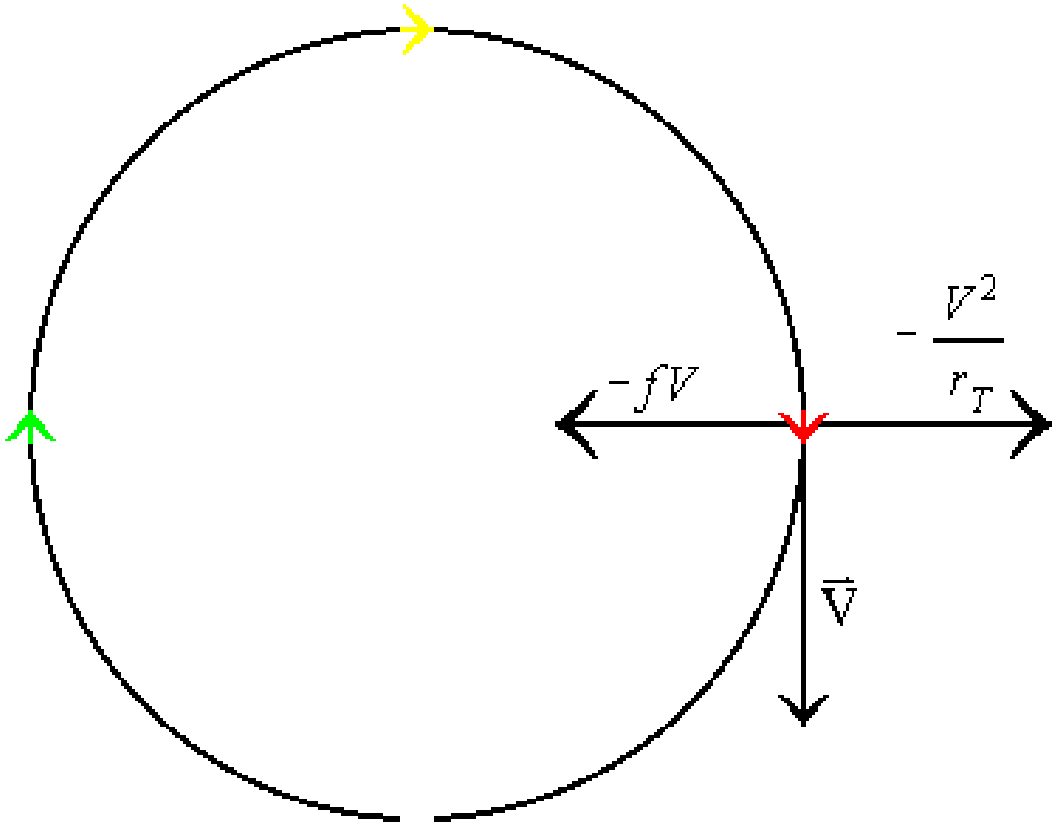
Geostrophic and observed wind 1000 mb (ocean)



INERTIAL FLOW

- In horizontally uniform pressure field, inertial flow is due to exact balance between Coriolis force and centrifugal force

- In inertial flow, the air parcels follow circular paths in clockwise in Northern Hemisphere and anticlockwise in Southern Hemisphere (Neglecting the latitudinal dependence of Coriolis force)



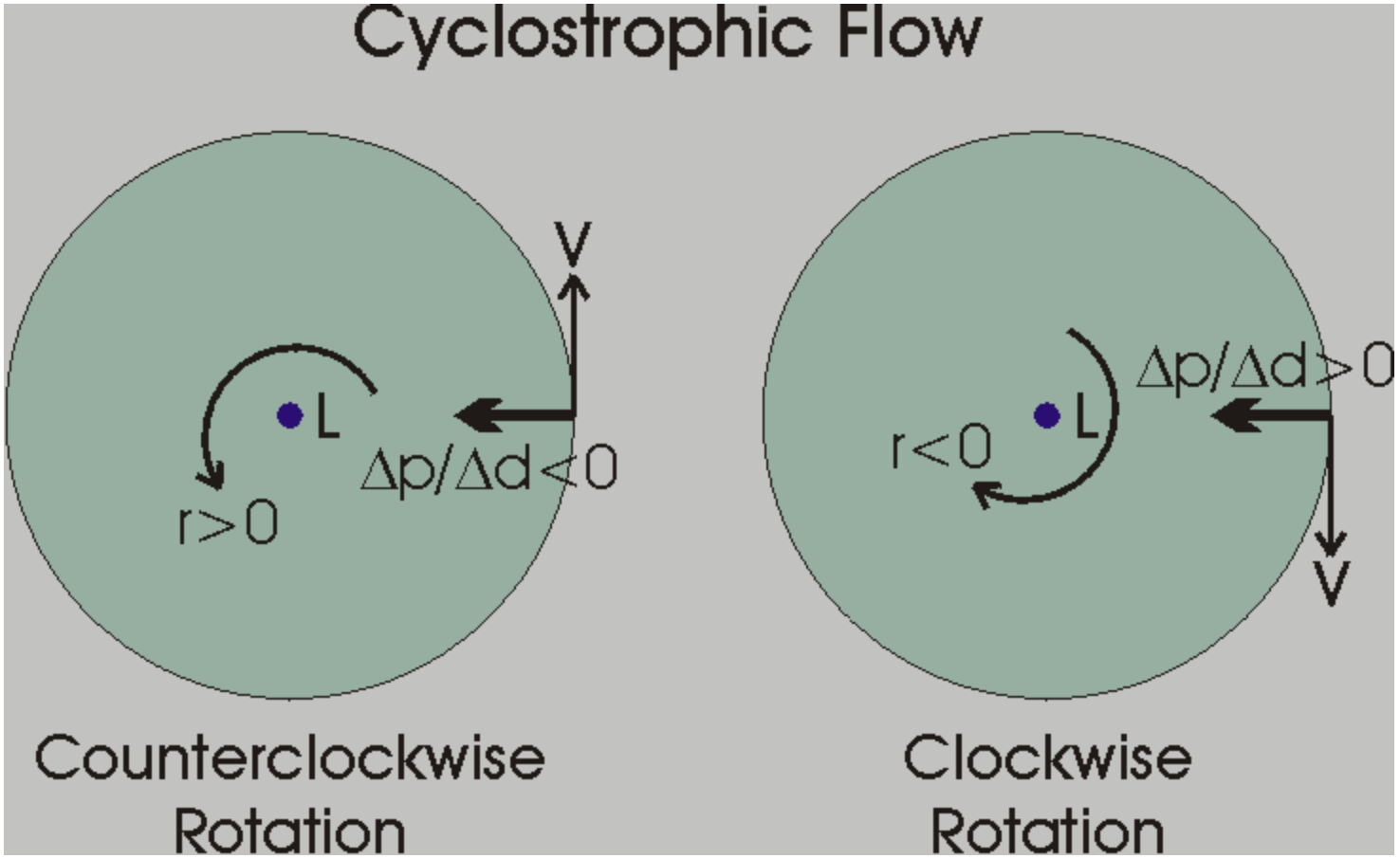
Inertial flow may occur at the poles due to strong Coriolis force

CYCLOSTROPHIC FLOW

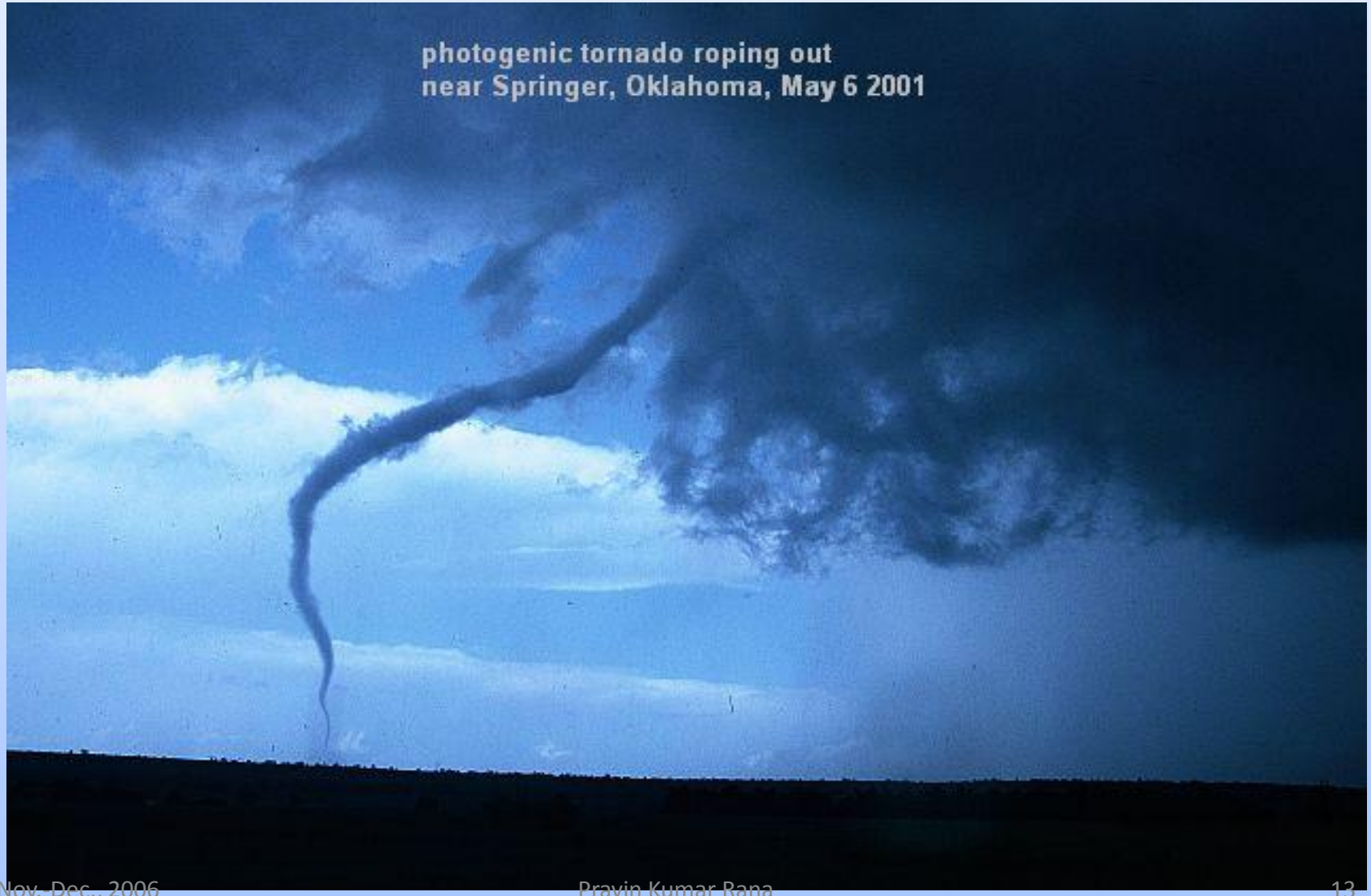
- For small horizontal scale of a disturbance, the horizontal pressure gradient force and centrifugal force are in exact balance gives Cyclostrophic flow

- Cyclostrophic balance approximation is valid provided that the ratio of the centrifugal force to the Coriolis force is large

Cyclostrophic flow may be either cyclonic or anti-cyclonic



Example Of Cyclostrophic Flow: **TORNADO**



GRADIENT FLOW

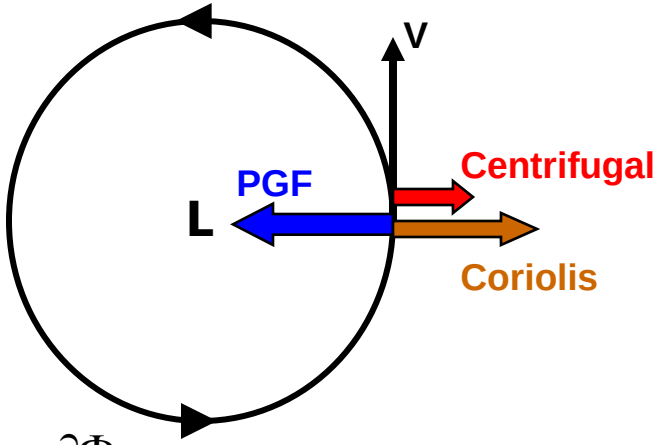
- Gradient flow is horizontal frictionless flow which is parallel to the isobars (isobars are not parallel) so that the tangential acceleration vanishes

- In gradient flow, there is a three-way balance between the Coriolis force, the centrifugal force, and the horizontal pressure gradient force

- There are four possibilities of geostrophic winds

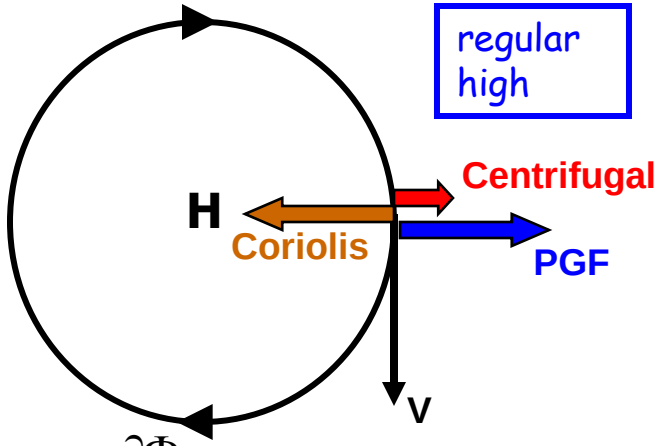
Gradient Wind Possibilities

regular low



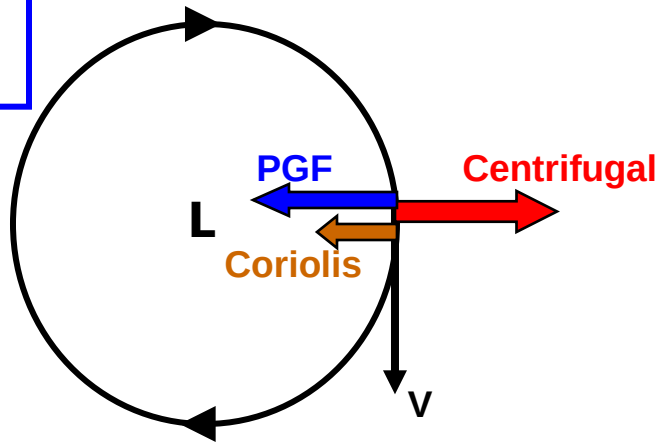
$R > 0, \quad \frac{\partial \Phi}{\partial n} < 0,$ negative root

regular high



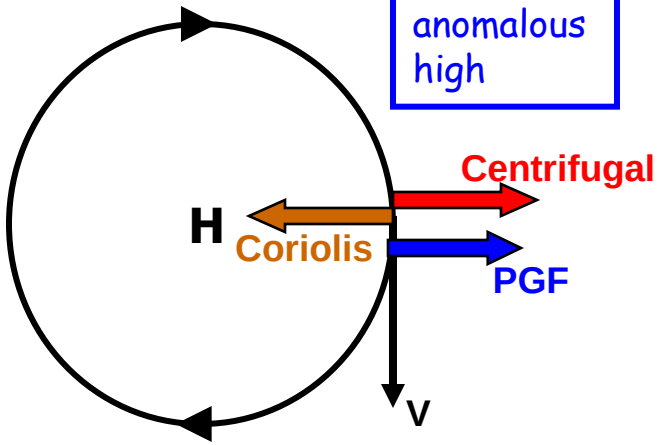
$R < 0, \quad \frac{\partial \Phi}{\partial n} < 0,$ positive root

anomalous low



$R < 0, \quad \frac{\partial \Phi}{\partial n} > 0,$ negative root

anomalous high



$R < 0, \quad \frac{\partial \Phi}{\partial n} < 0,$ negative root

Thank You