Dynamical Different between West and East Portion of Upper Anticyclone

Wan-Li Wang (w.-l. Wang) 1,2 Ying-Qi Xie (y.-q. Xie) 3 Hua Xu 4

1 China Meteorological Administration, Wuhan Regional Climate Centre, Wuhan, China, zipcode, 430074
2 School of Resource and Environmental Science of Wuhan University, Wuhan, China, zipcode, 430079
3 College of Earth Science, Yunnan University, Kunming, China, zipcode, 650091
4 Wuhan Polytechnic, Wuhan, China, zipcode, 430074

Without any exaggeration it is said that in free atmosphere General Circulation is mainly made of Anticyclone and Cyclone. Upper Anticyclone is a system of winds that clock-wisely rotates around a center of high atmospheric pressure (at 850hPa, 700hPa, 500hPa, 200hPa etc) in the northern hemisphere; the warm pole-ward flow forms at western boundary current of it; the cool equator-ward flow forms at eastern boundary current of it, but what dynamical different between west and east flank of Anticyclone, even why and how like this, have not be recognized well unanimously so far, an new analysis from perspective of geopotential height changes is employed below: there is an image line in Anticyclone’ middle which divides anticyclone into east portion of equator-ward flow and west portion of pole-ward flow, Anticyclone’ east (west) part is generally associated with descending (ascending) air as its east (west) part generate positive(negative) planetary vorticity advection due to equator(pole)-ward flow which just balances its east(west) negative(positive) relative vorticity advection in the troposphere; but if more deeper researching performed, it is disclosed that there are some other significant and more obvious dynamical different features between east flank and west flank of it, for example, there is one southward (northward) biggest (maximum) south-north component of jet in east (west) of Anticyclone, respectively, this phenomena is important quality, southward (northward) maximum south-north component of jet is also the pronounced boundary to separate the negative vorticity area from positive vorticity area of the east (west) of Anticyclone; the strongest descending(ascending) center just locates between southward (northward)biggest component of south-north jet and a center of high (low) pressure of its west, as well as just in the place being most approaching to southward (northward) biggest component of jet from its west; in addition, although east side of southward biggest component of the jet of east part of anticyclone is in area of positive vorticity, but this part still pervades descending air due to southward wind whose geostrophic vorticity(Coriolis parameter) lessen when air moves southward. then this area geopotential height becomes greater, similarly, although west part of anticyclone is in area of northward wind, but east flank of northward biggest component of the jet of west of Anticyclone also pervades descending air due to this location being just in negative vorticity area; therefore, it is very vital for diagnosing for monsoon and desert that geopotential height changes in to greater (smaller) ,therefore, geopotential height becomes slight (large) while air of pole(equator)-ward moves. Here Ζ the vertical coordinate, x the zonal coordinate, γ being the acceleration of gravity, f is Coriolis parameter, R is gas constant (287m/°K), (T_L-T_H)/Δx is vertical temperature gradient,(T_L-T_H)/Δx is east-west temperature gradient, γΔf=γΔv is different gravitational potential from high level to low level. v_H−v_L is meridian wind vertical shear, more important, (R(T_L-T_H)/Δx)/γ is the static stability(non-dimensional number), standing for the ratio of perpendicular thermal expansion force to gravity. (R(T_L-T_H)/Δx)/γ/γ is east-west thermal expansion force to current east-west Coriolis force. Here Ζ represents approximately thermal wind.

1. Two Dimension Larger-Scale Stability Index (w.-l. wang, 2009)

\[ v_H - v_L = R^2 (T_L - T_H) / (T_L - T_H) / f g \Delta x \]

If it was supposed that \( R^2 (T_L - T_H) / (T_L - T_H) / f g \Delta x = const (m^2 s^{-1}) \), this means thermal wind balance, then \( f g \Delta x = f \Delta \Phi = \Delta f = const (m^2 s^{-1}) \) which is very useful to interpret why west (east) section of Anticyclone usually is consistent to uplifting (descending) motion due to \( f \) of west (east) of Anticyclone changes into greater (smaller) ,therefore, geopotential height \( \Phi \) there becomes slight (large) while air of pole(equator)-ward moves. Here \( Z \) the vertical coordinate, \( x \) the zonal coordinate, \( \gamma \) being the acceleration of gravity, \( f \) is Coriolis parameter, \( R \) is gas constant (287m/°K), \( (T_L-T_H)/\Delta x \) is vertical temperature gradient, \( (T_L-T_H)/\Delta x \) is east-west temperature gradient, \( \gamma \Delta f=\gamma \Delta v \) is different gravitational potential from high level to low level. \( v_H − v_L \) is meridian wind vertical shear, more important, \( (R(T_L-T_H)/\Delta x)/\gamma \) is the static stability(non-dimensional number), standing for the ratio of perpendicular thermal expansion force to gravity. \( (R(T_L-T_H)/\Delta x)/\gamma/\gamma \) is east-west thermal expansion force to current east-west Coriolis force. Here \( \Phi \) represents approximately thermal wind.

2. Absolute Vorticity Balance

\[ f + (\partial \psi / \partial x - \partial \psi / \partial y ) = const \]

Here \( f \) is Coriolis parameter. \( (\partial \psi / \partial x - \partial \psi / \partial y ) \) is relative vorticity, obviously, its east (west) part of Anticyclone generate positive(negative) planetary vorticity advection due to equator(pole)-ward flow take place which just balances its east(west) negative(positive) relative vorticity advection in troposphere, so Anticyclone’ east (west) part is generally related to descending (ascending) air.

3. Sverdrup Balance

\[ \beta v = f \omega \Delta \psi \]

Here \( f \) is Coriolis parameter. \( v \) south-north wind, \( \beta \) Rossby Parameter ( \( \beta = \partial f / \partial y \) ).\( \omega \) is upward velocity of air, easily understood, the vertical column of air is squashed (stretched) when air moves toward the equator (pole), thus, descending (uplifting)motion take place as well as vertical column of air is squashed (stretched) when air moves toward the equator (pole).

4. Centripetal Force and Centrifugal Force

Corresponding author: Wan-Li Wang (w.-l. Wang), Main research field: Climate Dynamics, Meteorology Dynamics and the L probability distribution function. China Meteorological Administration, Wuhan Regional Climate Centre, School of Resource and Environmental Science of Wuhan University.

Email: xiaowen2002@yahoo.com, xiaowen2@aliyun.com.cn, xiaowen2@yahoo.com.cn
The equator (pole)-ward flow of the Anticyclone' east (west) portion usually is accompanied by increasing (decreasing) size of earth rotation radius meanwhile the centrifugal force of rotation of earth and its projection calculated upon perpendicular direction (at z coordinate) increase (decrease), respectively, when air move forward to equator(pole), thus the centripetal force also increase (decrease), so there pressure increase (decrease) and air descend (ascend) during equator (pole)-ward flow moves due to the centripetal force balances the centrifugal force on surface of rotation earth, in others words, the more the centrifugal force is, the more the centripetal force is also, vice versa. In all, small (bigger) the centripetal force is preferable to ascend (descend) of air.


If east-west wind $u=\text{const}(\text{ms}^{-1})$ (so-called zonal balance), then relative vorticity is equal to $\partial\nu/\partial x$, therefore on leeward standing, the left side of southward and northward biggest component of south-north jet all correspond positive vorticity, in contrast, right side of southward and northward biggest component of south-north jet all correspond negative vorticity, respectively.

$$f \cdot \Phi = \text{const} \quad \Phi \frac{\partial f}{\partial x} + f \frac{\partial \Phi}{\partial x} = 0$$

$v > 0$

$v < 0$

$$\frac{\partial v}{\partial x} < 0 \quad f \rightarrow \text{small} \quad \Phi \rightarrow \text{big} \quad \frac{\partial v}{\partial x} > 0 \quad f \rightarrow \text{big} \quad \Phi \rightarrow \text{small}$$

$$\frac{\partial f}{\partial x} < 0 \quad \frac{\partial \Phi}{\partial x} > 0 \quad \frac{\partial f}{\partial x} > 0 \quad \frac{\partial \Phi}{\partial x} < 0$$

Obviously, Maximum equator-ward flow and maximum pole-ward flow is just the boundary to separate negative vorticity area at its right side on leeward standing from positive vorticity area at its left side also leeward standing, meanwhile, Maximum descending (ascending) motion is just located in negative (positive) vorticity area and is in the place very closest to Maximum equator-ward (pole-ward) flow approaching from its right (left) side upon leeward standing. In other words, the right (left) side of Maximum equator-ward (pole-ward) flow corresponds to Maximum descending (ascending) motion area, respectively.

### 6. Diagnosis for Existence of Monsoon and Desert Using This Theory

- **t**: averaged over May to Aug.
- **lev**: 0
- **Long Term Mean precip mm/day**

![Map of Long Term Mean precip mm/day](image)
It is easily seen from four figure above that East-Asia and South Asia monsoon just locate within area of pole-ward flow of west flank of Anticyclone (such as West Pacific subtropical High) and its long term mean precipitation (mm/day, averaged 5-8 month from 1979 to 2000 year) is very conspicuous, more than 2mm/day, the value of long term mean OLR(Wm-2) is less than 230(Wm-2) (long term averaged value in 5-8 month), in contrast, south Mediterranean, Sahara Desert, Arabian Peninsula just locate within area of equator-ward flow of east flank of Anticyclone (such as Azores subtropical High) and its long term mean precipitation (mm/day) is very rare there, less than 2mm/day, the value of long term mean OLR(Wm-2) is more than 290(Wm-2). There is prominent characteristics that the majority place of equator-ward (pole-ward) flow of long term averaged usually is desert (monsoon) climate, for instance, East-Asia and South Asia is in monsoon, and South Mediterranean, West Africa and West Asia is in desert, among them, The most drought place in world is Alexandria in Egypt of north Africa, there is only 3mm rain in whole 51 years from 1889 to 1940 (Hoskins, 1996); Alexandria is approximately closest to right side of Maximum equator-ward flow at east part of Anticyclone (such as Azores subtropical High) when leeward standing, however, Cherrapunji in north of Bay of Bengal is most moist place in world whose annual rain account is 11000mm (Hoskins, 1996) so-called "rain center of world", in fact, Cherrapunji is approximately closest to left side of Maximum pole-ward flow at west part of Anticyclone (such as West Pacific subtropical High) also when leeward standing.

Key words: Absolute Vorticity Balance, Thermal Wind Balance, Desert, Monsoon, Two Flank of Meridian Jet Axis