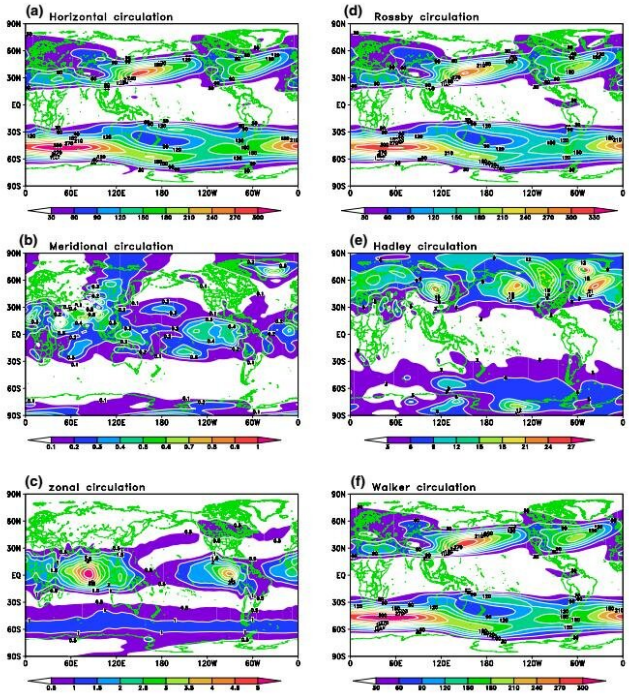
Novel theory of climate dynamics: Three-pattern decomposition of global atmospheric circulation

23 July 2020

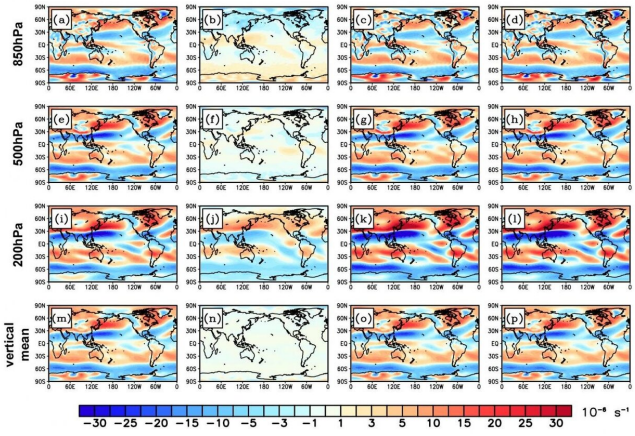


The climate characteristics of the annual mean of the kinetic energy (500 hPa, 1948~2011) (The unit is m2 s-2 1 kg, a~c are plotted by the three-pattern decomposition model, while d~f are plotted by the NCEP/NCAR reanalysis data). Credit: Science China Press

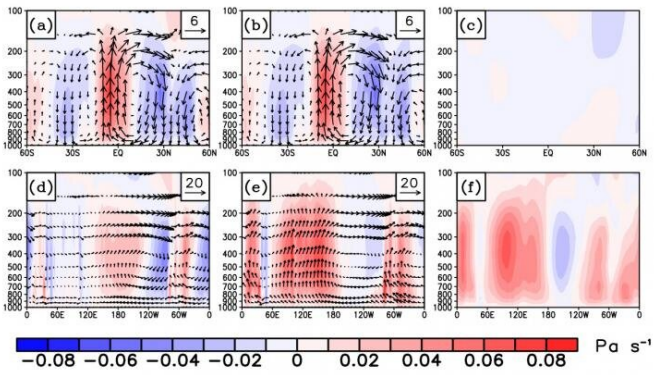
Climate change is already affecting the world on an unprecedented scale. However, there has been a lack of a complete basic theoretical system for climate prediction for a long time, which limits the accuracy of climate prediction fundamentally. A recent research development, the theory of three-pattern decomposition of global atmospheric circulation, introduces the pioneering research results in the basic theory of climate prediction.

The paper entitled "Theory of three-pattern decomposition of global atmospheric circulation", was published in *SCIENCE CHINA: Earth Sciences*, which was written by Prof. Shujuan Hu of Lanzhou University as the first author and corresponding author. This paper presented the achievements of Prof. Shujuan Hu's team in the basic theoretical research of climate dynamics over the years, and also summarized the research progress of others in the representation of global atmospheric circulation, which was a systemically important theory of climate prediction.

Under the background of global warming, major natural disasters are on the rise, causing serious economic losses and human casualties. Due to its special geographical environment, China has been seriously affected by meteorological disasters for a long time, especially drought and flood disasters. As a result, month-to-season-scale climate prediction with drought and flood forecasting as the focus has always been a major demand for national development. However, the accuracy of the existing climate prediction model is far from meeting the actual needs. The fundamental reason for the inaccuracy of climate prediction lies in the lack of basic theories of climate dynamics.



Climatological mean of vertical vorticity (d) and its decomposition: (a) vertical vorticity of horizontal circulation, (b) vertical vorticity of meridional and zonal circulations, (c) vertical vorticity of horizontal, meridional and zonal circulations at 850 hPa (1979-2013) for DJF. e~h, i~l and m~p same as a~d, but for 500 hPa, 200 hPa and the vertical mean surface, respectively. Credit: Science China Press



(a), (b)The climatic characteristics of the local (60°E, 140°E) zonally averaged meridional circulation in winter (1979~2013); (d), (e) The climatic characteristics of the local (5°S, 5°N) meridionally averaged zonal circulation. The shading and vertical velocity in wind vectors of (a) and (d) are the vertical velocities of the local (60°E, 140°E) zonally averaged meridional circulation and local (5°S, 5°N) meridionally averaged zonal circulation. The shading and vertical velocity in wind vectors of (b) and (e) are the vertical velocities of reanalysis data. (c) is the vertical velocity of the local (60°E, 140°E) zonally averaged zonal circulation. (f) is the vertical velocity of the local (5°S, 5°N) meridionally averaged meridional circulation. Credit: Science China Press

Shujuan Hu said she has been working on the dynamics of global atmospheric circulation since 2001, when she studied for her doctorate with Prof. Jifan Chou, a famous Chinese meteorologist and academician of the Chinese Academy of Science. Prof. Jifan Chou is one of the few scholars in the field of atmospheric science in China and abroad who specialize in atmospheric theory research and make important contributions. He has devoted his life to the fundamental theories and methods of long-term numerical weather forecasting and the related atmospheric and oceanic dynamics, particularly nonlinear dynamics problems. Under the leadership of Prof. Jifan Chou, the novel theory of three-pattern decomposition of global atmospheric circulation (3P-DGAC) is constructed as the systematic basic theory of the climate prediction on the month-to-season scale.

The phenomena of Rossby waves in middle-high latitudes and Hadley and Walker circulations in low latitudes were first extended to the global general circulation, and the definitions of three dimensional (3-D) horizontal, meridional, and zonal circulations were then quantified. The global atmospheric circulation was decomposed into the sum of 3-D horizontal circulation, meridional circulation, and zonal circulation; thus, the 3P-DGAC was established. Furthermore, combining the 3P-DGAC with the primitive equations of planetary-scale atmospheric motion, a new set of dynamical equations was established to directly describe the evolution mechanisms of global large-scale horizontal circulation, meridional circulation, and zonal circulation. From a global perspective, the theory of 3P-DGAC unifies the atmospheric motions in the middle-high latitudes with those in the low latitudes, which compensates for the deficiency of the partitioning of middle-high latitude atmospheric dynamics and low latitude atmospheric dynamics in the current study.

Guoxiong Wu, an academician of the Chinese Academy of Science and the famous Chinese climate dynamicist, had once paid attention to the progress of the 3P-DGAC. Prof. Guoxiong Wu commented: "3P-DGAC provides a feasible method for the study of the complex interactions between the mid-high latitude atmospheric circulation and the low latitude atmospheric circulation as well as between the horizontal circulation and the vertical circulation, which is an original and innovative research achievement with international level."

More information: Shujuan Hu et al, Theory of three-pattern decomposition of global atmospheric circulation, *Science China Earth Sciences* (2020). DOI: 10.1007/s11430-019-9614-y

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