第5次作业

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关键词：关键词1，关键词2

Homework 5

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# Question 1

Draw [Fig. 6.7](https://www.sciencedirect.com/science/article/pii/B9780123285317000062?via%3Dihub#f0035) for the Southern Hemisphere using the same coordinate axes. Make sure that what you draw transports heat and momentum toward the South Pole. ([Hartmann, 2016, p. 192](#_ENREF_1))

## Solution



**Figure 1.1** **Schematic of the streamlines (black with arrows) and isotherms (colors) associated with a large-scale atmospheric disturbance in mid-latitudes of the Southern Hemisphere.** Arrows along the streamline contour indicate the direction of [wind velocity](https://www.sciencedirect.com/topics/earth-and-planetary-sciences/wind-velocity). The streamlines correspond approximately to lines of constant pressure, since the winds are nearly geostrophic. The signs of the deviations of the wind components and temperature from their zonal average values are shown with asterisks to illustrate that the NW–SE tilt of the streamlines indicates a southward zonal momentum transport, and the westward phase shift of the temperature wave relative to the pressure wave gives a southward heat transport. ([Hartmann, 2016, p. 169](#_ENREF_1))

# Question 2

Derive [(6.19)](https://www.sciencedirect.com/science/article/pii/B9780123285317000062?via%3Dihub#e0110) from [(6.15)](https://www.sciencedirect.com/science/article/pii/B9780123285317000062?via%3Dihub#e0095) and [(6.13)](https://www.sciencedirect.com/science/article/pii/B9780123285317000062?via%3Dihub#e0075). ([Hartmann, 2016, p. 192](#_ENREF_1))

## Definitions and Basic Properties of Time- and Zonal Average

时-空场的（有限）时间平均定义为

故当取定时，时间平均算子是线性算子. 定义对其时间平均的偏移量

则有

本来，定义式 (2.1) 不能保证不依赖于时间，但若物理量存在某个稳态值，或存在周期，则适当选取可能使得与时间无关. 故在本题中，我擅自假定不依赖于时间，从而有

由 (2.2) 至 (2.4) 得

时-空场的纬向平均定义为

故纬向平均算子是线性算子. 定义对其纬向平均的偏移量

则有

与有限时间平均的情况不同，纬向平均的定义式 (2.6) 保证了不依赖于经度，从而

假定时间平均算子与纬向平均算子可交换次序，即

则有

即与可交换次序，与可交换次序.

## Solution

由上一节的结果，有

取，则，代入 (2.13) 立得

References

Hartmann, D. L. (2016). Chapter 6 - Atmospheric General Circulation and Climate. In D. L. Hartmann (Ed.), *Global Physical Climatology (Second Edition)* (pp. 159-193). Elsevier. <https://doi.org/10.1016/B978-0-12-328531-7.00006-2>