## Homework–Module 2

**Name:** Key

1) The length of day has steadily increased throughout earth's history. Geological evidence[1,2,3] suggests that the length of day was 21.9±0.4 hours 620 million years ago (Mya) and 18.7±0.25 hours billion years ago (Gya). In other words, the rotation rate of Earth was about 10% faster 620 Mya and 28% faster 1.4 Gya. If we assume the earth's atmosphere had same horizontal pressure distribution then as it does now (which it did not and will overlook for this question), what changes in the geostrophic wind speeds (faster or slower) would you expect relative to today's conditions over the middle latitudes? Explain your answer using concepts of module 2. (Hint: consider how the Coriolis force changes with the earth's rotation rate.)

There is a 600-character limit for all questions.

Thought progression:
-Same temperature distribution would yield the same pressure field and PGF.
-Same PGF 620 Mya as today would require the same Coriolis force as today to establish geostrophic balance.
-Since Coriolis force is the product of earth's rotation rate times wind speed, a 10% faster rotation rate would require a 10% slower wind to produce the geostrophic balance.
-Hence, one would expect slower wind speeds.

[1] https://www.scientificamerican.com/article/earth-rotation-summer-solstice/
[2] http://adsabs.harvard.edu/abs/2000RvGeo..38...37W
[3] http://www.pnas.org/content/early/2018/05/30/1717689115

The most recent assessment from International Panel on Climate Change (IPCC 2103) states that during the 20 year period of 2016 to 2036 (see Fig. 11-10[4] of IPCC report AR5-WG1), the average surface temperatures over high latitudes of the wintertime northern hemisphere will warm by 3˚C, which is more than any other region of the world. On the other hand, the tropics are expected to warm the least, 1˚C or less. If the IPCC surface temperature projections materialize, it follows that features of the global circulation during northern hemisphere winter could change too. Answer the remaining questions based on the IPCC projections.

2) What changes in the intensity (i.e. average speed) of the polar jet stream (increase or decrease) would you expect if the polar troposphere warms 2˚C more than the tropics? Explain your answer using concepts of module 2. Material in sections 8.1 to 8.5 and 9.1 of H&P could prove especially useful.

Thought progression:
-More warming in polar regions than the tropics would decrease the north-south temperature difference.
-Weaker N-S temperature gradient would yield a weaker N-S pressure gradient.
-Weaker PGF requires a smaller Coriolis force to establish geostrophic balance.
-Smaller Coriolis force means slower winds.

3) What changes in the intensity of extratropical cyclones during winter would you expect if the average tropics-to-pole temperature difference decreases by 2˚C? Again, explain your answer using concepts of module 2. Section 10.3 of H&P is particularly relevant to the question. (Ignore the impact that changes in temperature would have on atmospheric moisture content.)

Thought progression:
-Horizontal temperature differences are the energy reservoir from which midlatitude cyclones form.
-A weaker N-S temperature means that less potential energy would be available to develop cyclones.
-It follows that cyclones in a world of weaker temperature gradients would be, on average, also weaker (ignoring the impact of changes in moisture!).

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[4] http://www.ipcc.ch/report/graphics/images/Assessment Reports/AR5 - WG1/Chapter 11/Fig11-10.jpg