Homework–Module 2 Name: Key

1) The length of day has steadily increased throughout the earth's history. Geological evidence[1] suggests that it was only 21.9 hours 620 million years ago (Mya). In other words, the earth rotated nearly 10% faster 620 Mya. If we assume the earth's atmosphere had the same temperature distribution then as it does now (which it did not), what changes in the geostrophic wind speeds (faster or slower) would you expect 620 Mya ago relative to today's conditions over the middle latitudes? Use concepts of chapter 6 of Ahrens to defend your answer.

We would expect slower geostrophic winds.

Because temperature differences determine the pressure field, the same temperature distribution would produce the same horizontal pressure gradient force (PGF) and require the same Coriolis force to balance the PGF as today too. Recall that the geostrophic wind results from a balance between the pressure gradient force and the Coriolis force, and that the Coriolis force is defined as the product of the earth's rotation rate and the wind speed. This implies wind speeds slower than today would produce the same Coriolis force 620 Mya. Hence, geostrophic winds would be slower.

The most recent assessment from International Panel on Climate Change (IPCC 2103) states that during the next 20 years (2016-2036; see Fig. 11-10 of AR5-WG1), the average surface temperatures over high latitudes of the wintertime Northern Hemisphere are expected to 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 temperature projections materialize, it follows that features of the global circulation during northern hemisphere winter could change too. Answer the last two 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 chapters 6 and 7 of Ahrens should prove especially useful.

We would expect a slowing of the jet stream.

Greater warming of the polar regions relative to the tropics would decrease north-south temperature differences, which in turn would decrease the north-south PGF. A weaker PGF requires a smaller Coriolis force to balance it, and a smaller Coriolis force could only be produced by slower winds.

3) What changes in the intensity and frequency of extratropical cyclones during winter would you expect if average tropics-to-pole temperature difference decreases by 2˚C? Again, explain your answer using concepts of module 2. Material in chapter 8 of Ahrens should prove quite valuable.

We would expect a decrease in the intensity and frequency of cyclones.

Because horizontal temperature differences are the energy reservoir from which extratropical cyclones form, a weaker north-south temperature gradient would mean that there is less energy to develop extratropical cyclones. It follows that cyclones in 2036 would likely be weaker and fewer in number because the temperature gradient is smaller.

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1 https://www.scientificamerican.com/article/earth-rotation-summer-solstice/