ATM 421: Tropical Meteorology
Potential Final Exam Questions

1. Tropical cyclones and the MJO have similar wind patterns in both the upper and lower levels. What are some similarities in these wind circulations and how do they differ?

2. Based on the large scale planetary circulations we learned about early in the course, as well as what we know about in the equator's vicinity, explain and illustrate why most of the desert regions of the world are in the region that they're in?

3. a) Below are two blank maps of Southeast Asia. Sketch the setup for the active phase of the Southeast Asian monsoon in the summertime on one map and the inactive phase of the monsoon in the wintertime on the other map. Be sure to include the mean wind direction, where ascent and descent are occurring, where convection is occurring, and the thermal gradient that is causing the monsoon for both cases.

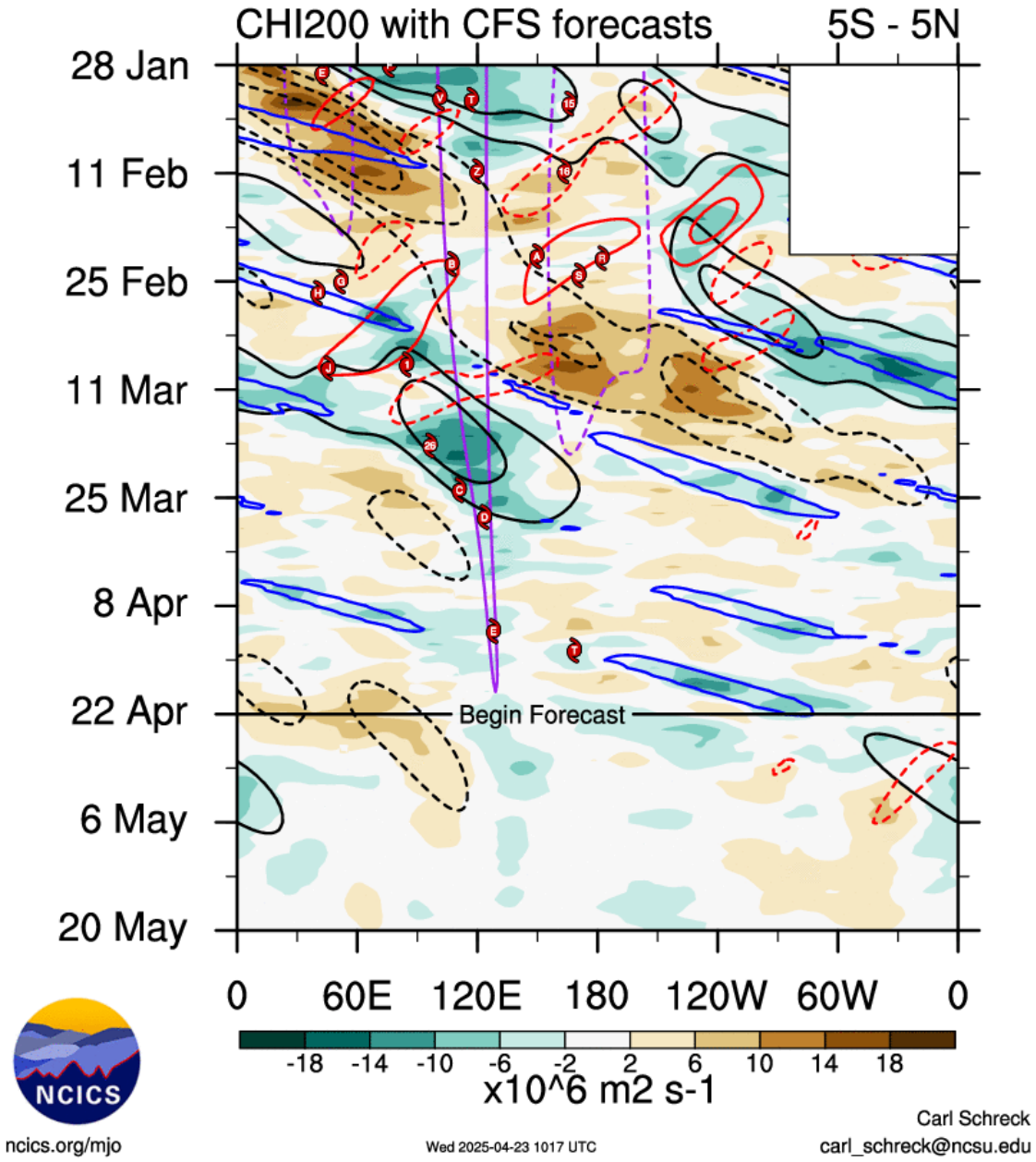
b) Explain how the thermal gradient causes the active phase of the monsoon. Be sure to link the thermal gradient to the mean flow, and thus where convection is occurring

c) Suppose there is no thermal gradient over the region. Would this cause the monsoon to intensify or weaken? Please explain why.

4. Why do the strongest winds within a tropical cyclone occur at lower levels, but not at the surface? Explain your reasoning using the structure of a tropical cyclone.

5. Explain the role of vertical wind shear in tropical cyclone formation and intensification. You must include in your answer how wind shear can both inhibit and enhance tropical cyclone development under different atmospheric conditions.

6. Define the ER and Kelvin wave using a Hovmöller. What are the two main factors that make these waves different from each other?



7. What causes the seasonal reversal of winds during the South Asian monsoon? Explain how the difference in heating between land and ocean, rising air, and the movement of the Intertropical Convergence Zone (ITCZ) help start and strengthen the monsoon. Also, describe how latent heat and winds in the upper atmosphere help support the heavy rain and storms during the monsoon season.

8. Equatorial Kelvin waves move eastward along the equator and are often associated to areas of enhanced convection. What are the main features of a Kelvin wave's wind and pressure patterns, and how can these features help support the organization of tropical convection?

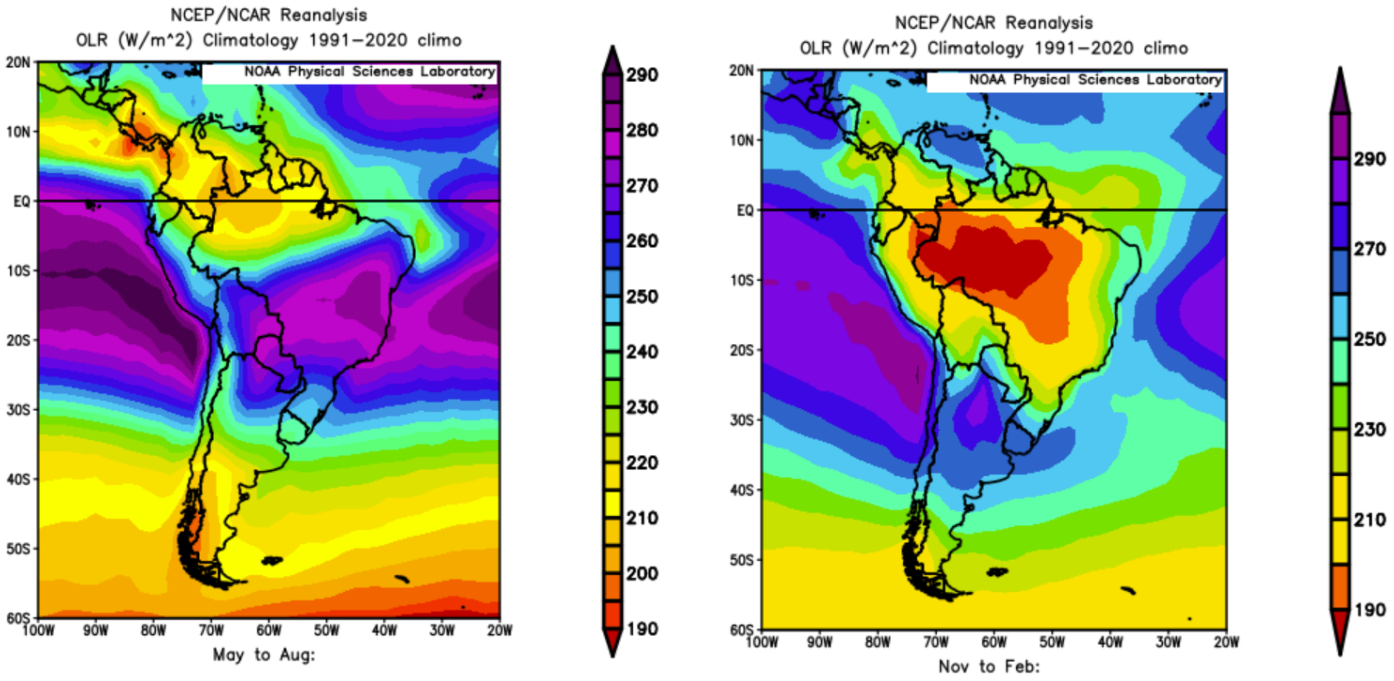
9. What controls θ_{eb}?

10. Suppose TC Tam is moving over the Pacific Ocean where SSTs are warm (greater than 26°C), but vertical wind shear is about 40 kt. Based on what you know about TC formation, predict whether the storm will strengthen significantly, weaken, or stay about the same. Explain your reasoning with reference to the environmental conditions provided.

11. Given are two plots of outgoing longwave radiation (OLR) over South America during two periods of the year, November–February and May–August:

a) Describe the associated wind patterns east of South America for both the periods.

b) Describe the expected precipitation over the region during these two periods. What causes this pattern?



12. In September of 2022, Hurricane Ian rapidly intensified into a Category 5 hurricane over the eastern Gulf of Mexico before devastating the state of Florida.

a) Define equivalent potential temperature and explain how high values in the lower troposphere contribute to tropical cyclone intensification. Use Hurricane Ian as an example.

b) Given a cross-section of equivalent potential temperature from the Caribbean during Ian's intensification, what patterns would you expect to see in the vertical and horizontal distribution? How would these patterns indicate favorable conditions for intensification?

c) If Hurricane Ian were to have interacted with a deep, digging trough on its impact to Florida, how would you expect the motion of the hurricane to be affected?

13. Explain how through using radar imagery and a Hovmöller diagram, a forecaster can tell the difference between an Equatorial Rossby wave, Kelvin wave, and the Madden–Julian Oscillation.

14. Why is the MJO relevant for TC genesis?

15. Why can we describe a tropical cyclone as a heat engine?

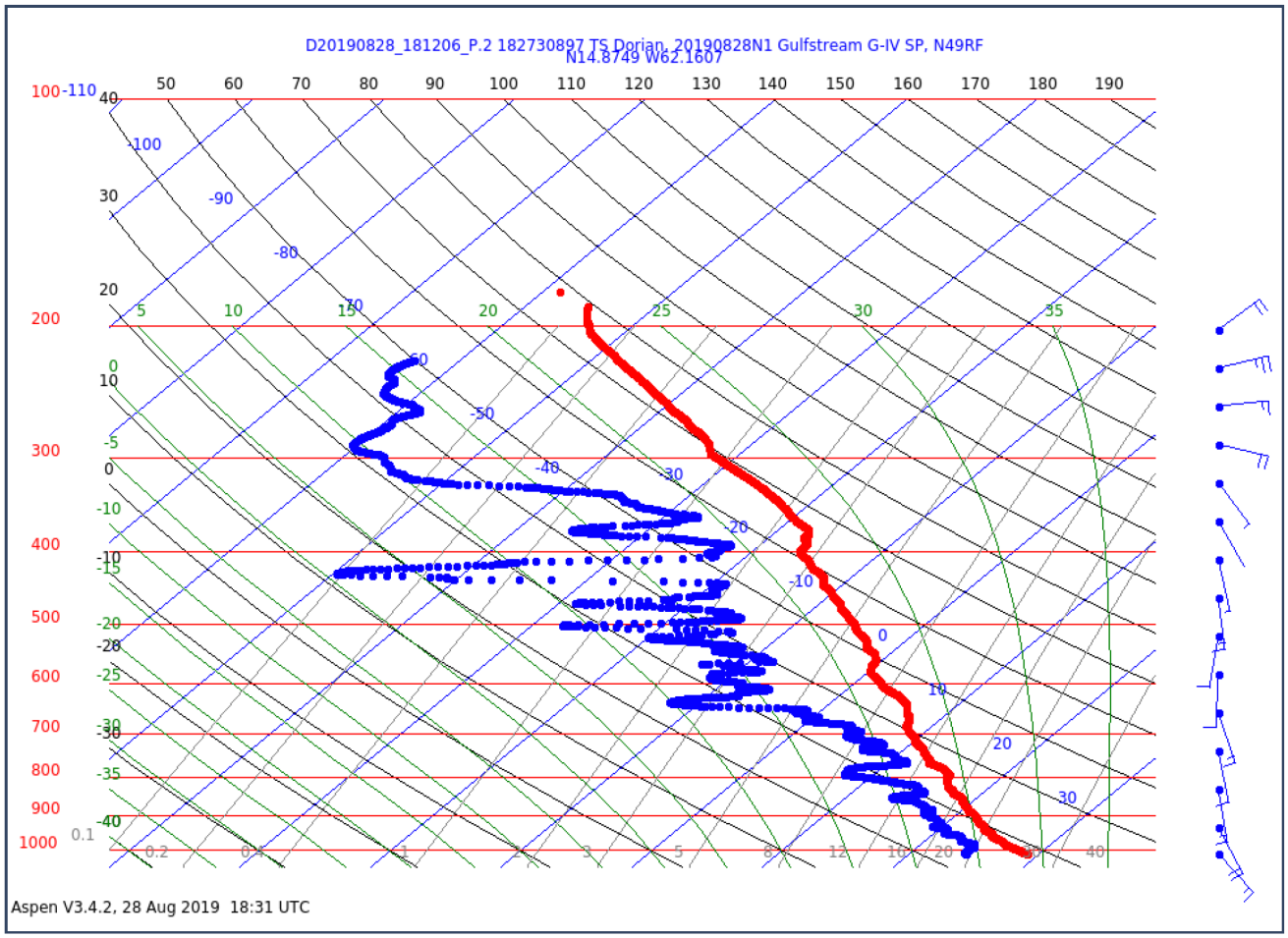
a) Explain how the structure and processes within a tropical cyclone that support this analogy.

b) With this in mind, a tropical cyclone moves over an ocean region with uniformly warm sea surface temperatures but experiences an increase in outflow-layer temperature due to nearby upper-level warming (from a ridge for example). Based on the thermodynamic structure of a tropical cyclone, will the storm be more likely to intensify, weaken, or remain steady?

16. The skew-T diagram below shows an atmospheric sounding taken on 28 August 2019 during the early intensification phase of Hurricane Dorian, collected by a NOAA Gulfstream IV aircraft. Using this sounding answer, the following:

a) Explain how the WISHE mechanism operates and how the conditions in this sounding either favor or hinder this process.

b) Identify levels of high theta-e. How does this vertical theta-e structure relate to the efficiency of WISHE in the tropical environment?



17. What is the primary energy source for tropical disturbances?

18. List and explain three different ways a tropical cyclone could rapidly intensify. List and explain two different ways a tropical cyclone could rapidly de-intensify.

19. Thinking about the process for TC intensification through sea surface and atmospheric interaction, created by the modern father/grandfather Kerry Emmanuel, answer the following:

a) Name this process.

b) Describe the aforementioned process and how it benefits TC development and maintenance through the sea interactions.

c) Explain how interactions between the sea surface and low levels of the atmosphere help to move/enhance the theta e profile in the atmosphere.