Lab 1 Hulbe's short answers

1. **Where have ice sheets changed the most from the Last Glacial Maximum to the present? Where has the change been the smallest?**

   The largest changes were in North America (Laurentide and Cordilleran ice sheets), northern Europe (Fennoscandinavian, British Isles, Siberian and Barents/Kara Sea), and West Antarctica. The smallest changes are in East Antarctica and Greenland.

2. **Where are the largest continental shelves found? Why are they located in these regions? How and why are the *neritic* (or *sublittoral*) zone biomes found on continental shelves different from other ocean biomes?**

   The largest continental shelves are found at passive tectonic plate margins. These shallow areas are relatively biologically rich due to tight coupling between the surface and sediments (nutrients) on the sea floor via wind mixing and seasonal upwelling, and to proximity to terrestrial nutrient sources (river outlets).

3. **At the Last Glacial Maximum, sea level was approximately 120 meters lower than it is today. Where was that water? How might the change in sea level have affected terrestrial organisms?**

   The water was in ice sheets and glaciers. Laurentide, Cordilleran, Fennoscandinavian, British Isles, Siberian and Barents/Kara Sea, Greenland, West Antarctic, Patagonian ice sheets and ice caps, and alpine glaciers in many locations.

   Lower sea level allowed expansion of terrestrial ecosystems in regions that remained relatively warm and wet, for example the Indonesian archipelago and many coastlines. Repeated glacial to interglacial cycles promoted episodic plant dispersal.

4. **Which geographic regions experience relatively large and relatively small temperature ranges over the course of the year? Why do those regions experience such different annual cycles?**

   Higher latitude, continental regions experience relatively large seasonal temperature cycles: Siberia, Canada, and the interior of Alaska. The smallest temperature ranges are found at lower latitudes. Annual temperature cycles are smaller over ocean surfaces than over terrestrial surfaces. The causes for these patterns are the change in insolation of the course of the year, which is large at high latitudes and small at low latitudes and the contrast in heat capacity between the continents (lower) and oceans (higher). On the continents, proximity to the ocean is important because its large heat capacity moderates the seasonal cycle. Northern Europe experiences a smaller annual temperature variation than does Siberia or Canada because westerlies traveling over the north Atlantic ocean moderate temperature there.

5. **Use the data provided in this lab to predict present-day permafrost occurrence**

As a first approximation, I selected the mean annual 0 °C isotherm as a limit for permafrost viability. This is likely too warm but it is a start. I mapped that boundary using the gridded mean annual temperature and a color range with a lower limit of 0. This gives every location with a 0 or colder mean annual temperature the same color. This definition predicts permafrost throughout the Arctic, Tibetan Plateau, and northern Europe, and higher elevation mountain locations in the western US and Middle East.

This definition predicts far more extensive permafrost than is mapped in *Global Outlook for Ice and Snow*. A cooler mean annual temperature might be better. I might be able to develop a better temperature threshold using a numerical model of temperature cycles in a typical permafrost soil and the monthly mean data sets. This would require me to know something about Arctic and high elevation soils, for example, soil type and thickness.

6. **Are seasonal changes in sea level pressure in the Arctic the same or different from the seasonal cycle over the Antarctic? Why is this so?**

The wintertime high is higher over Antarctica than over the Arctic. This is due to the moderating effect of the ocean in the Arctic.

The seasonal cycle from relatively high pressure in the winter months to lower pressure in the summer months is more simple in the Antarctic than in the Arctic. This is because the distribution of land and ocean is more complicated in the Arctic than in the Antarctic. In the Arctic, winter Aleutian and Icelandic lows over the relatively warm North Pacific and North Atlantic ocean surface shift to relatively high pressure in the summer months when strong heating of the land surface produces relatively low pressure over North America and Siberia and sea level pressure over the Arctic Ocean basin is relatively low as well. SLP changes relatively less over the western part of the Arctic Ocean basin and over the Greenland Ice Sheet than elsewhere in the region and as a result, the pressure gradient across the ice sheet becomes very large during the winter months.

A pattern of relative highs and lows is observed over the southern ocean in both winter and summer, in association with the distribution of land masses. The interior of the continent experiences a large winter to summer variation while SLP changes relatively little over the circumpolar ocean surface.

7. **definition for "the Arctic region"**

The 10°C mean maximum isotherm lies south of the Arctic circle (66° 33' N) in the north Pacific, and in the western north Atlantic, the adjacent Canadian archipelago, and southern Greenland. The ice-free continental sites experience strong summer warming, moving the 10°C isotherm north. The east-west contrast in the north Atlantic must be related to circulation in the shallow ocean and the path of the jet stream

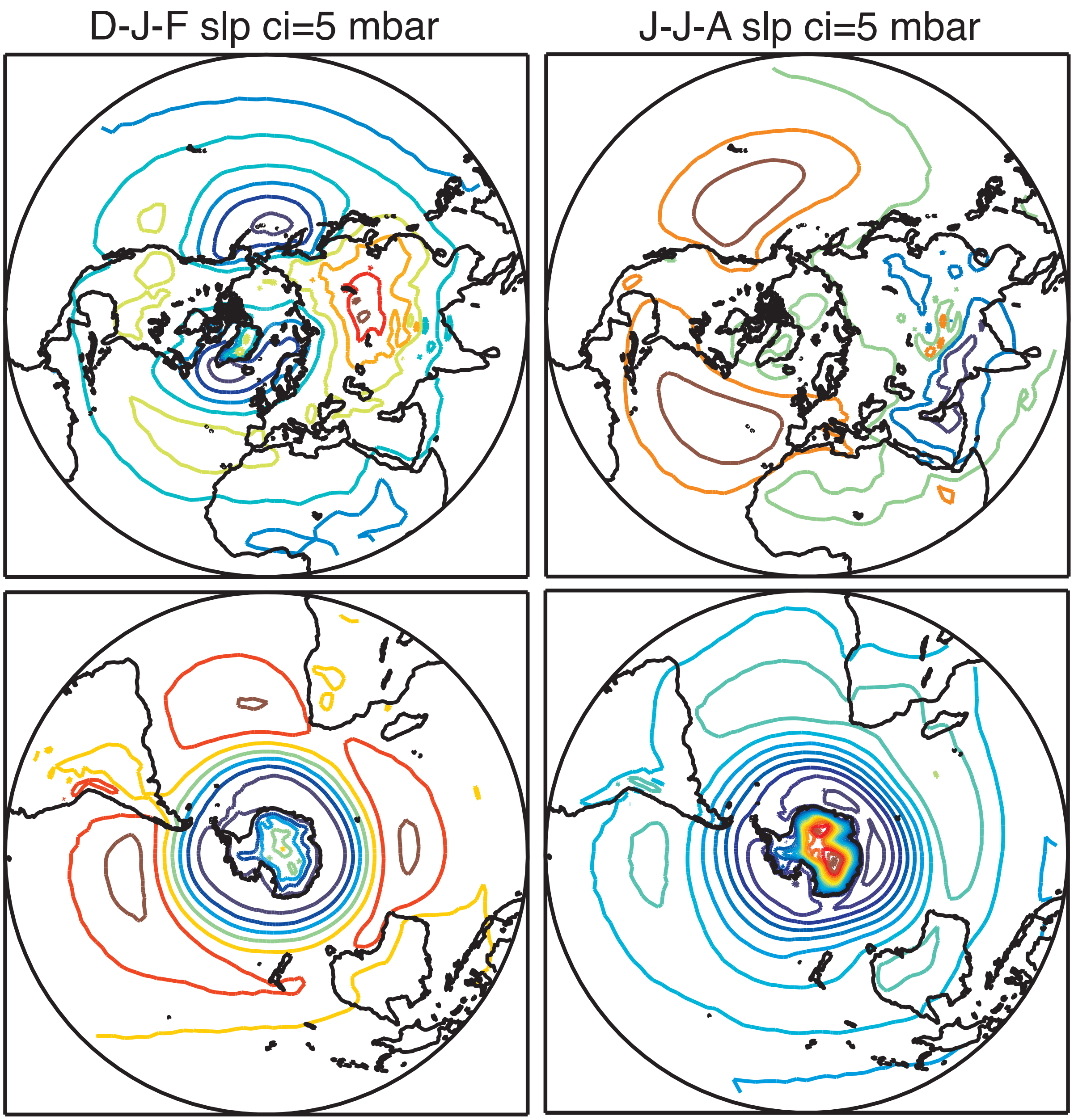

Figure 1: Mean December-January-February and June-July-August sea level pressure from the lab data sets. Warmer colors are relatively higher and cooler colors are relatively lower SLP.

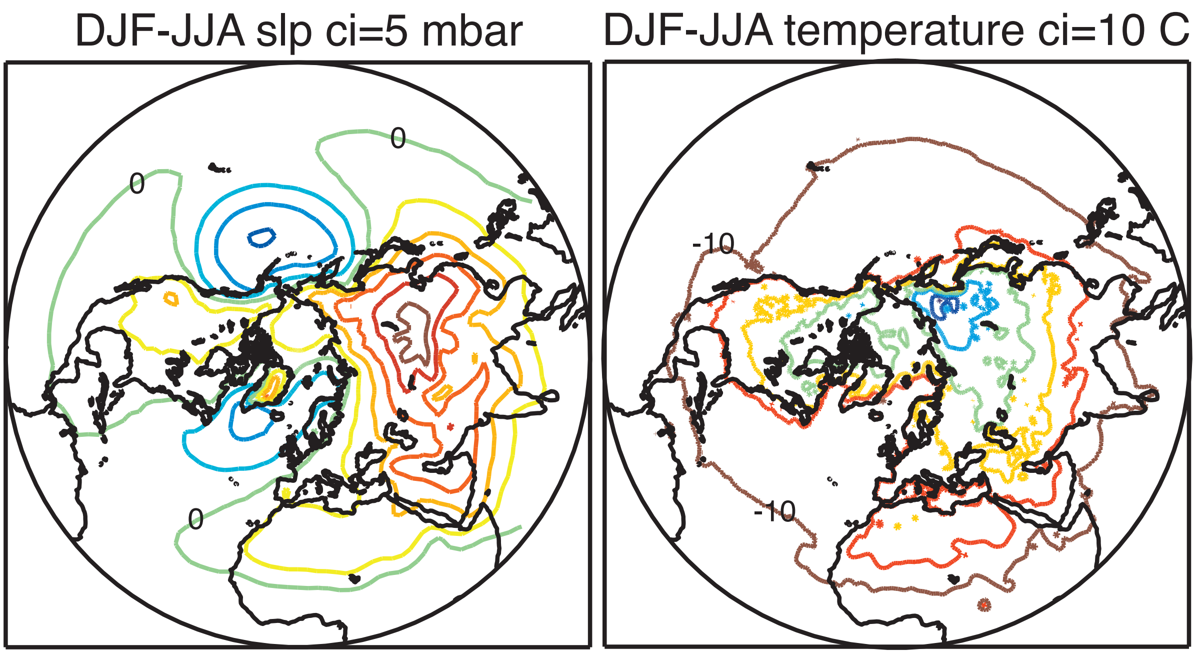

Figure 2: Mean December-January-February minus mean June-July-August sea level pressure and temperature from the lab data sets. Warmer colors are relatively higher and cooler colors are relatively lower SLP. The contour intervals are 5 mbar and 10°C.

along the polar front. Warmer waters move east across the north Atlantic, entering the Arctic east of Greenland while cooler, Arctic waters move south through Davis Strait and along the west coast of Greenland.

8. **seasonal sea level pressure**

   (a) **Compare the winter/summer contrast over the Arctic basin with the same seasonal contrast over the north Atlantic and north Pacific.**

   The winter/summer contrast in SLP over the Arctic Ocean basin looks more like the change over the adjacent land masses than change over the north Atlantic and north Pacific. This is the case for both SLP and temperature. Winter sea ice expansion over the ocean surface isolates the ocean from the atmosphere, limiting heat exchange and allowing near-surface air to cool as if it were over the snow-covered land surface.

   (b) **Describe, in general, the pressure gradient from the interior of Antarctica to surrounding ocean surface.**

   The pressure gradient from the interior of the Antarctic continent to the coast is always from relatively higher to lower pressure but the gradient is larger in winter than in summer due to the development of a strong winter high. This should result in persistent anticyclonic (counter-clockwise here in the southern hemisphere) circulation around the high and persistent off-shore winds.

   (c) **Use your answer to part to speculate about how the pressure field and low-level winds over north America would have been different at the last glacial maximum.**

   The large Laurentide Ice Sheet would have created a similar situation over North America. The interglacial seasonal cycle would have been replaced by a persistent high and anticyclonic circulation (clockwise in the north). This would have moved cold, dry air down off the ice sheet and out over Alaska the continental United States.