

Name:

Date:

TEACHER VERSION: Suggested student responses included

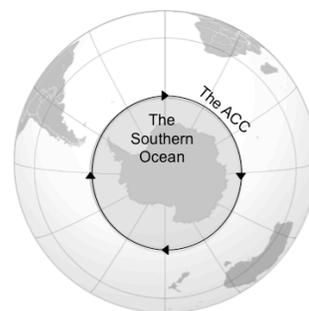
The Southern Ocean

Guiding Question:

- What are the seasonal environmental characteristics of the Southern Ocean?

Introduction

The Southern Ocean surrounds the continent of Antarctica, and has been recognized as an independent 'ocean' since 2000 due its unique features. One important defining feature of the Southern Ocean is the Antarctic Circumpolar Current (the ACC), which is the world's biggest ocean current, and flows eastward.



Due to the pattern of circulation of the ACC, the Southern Ocean is somewhat isolated from the waters of the Atlantic, Pacific, and Indian Oceans. At the same time, it acts as a connecting link in the circulation of the world oceans. In terms of area, the Southern Ocean is the fourth largest ocean after the Pacific Ocean, Atlantic Ocean, and Indian Ocean, but before the Arctic Ocean.

In the Southern Ocean, sea surface temperature (SST) varies from about ten degrees Celsius to about two degrees Celsius. Storms travel eastward around the Antarctic continent and frequently are intense due to the temperature contrast between ice and open ocean. The area from the edge of Antarctica to the Antarctic Circle has, on average, the strongest winds found anywhere on Earth. In the winter the ocean freezes outward in the Pacific and Atlantic sectors. Although the air temperatures goes below zero degrees Celsius, some coastal areas are kept ice-free throughout the winter because of the intense and persistent winds from the interior of Antarctica.

The Southern Ocean has several different patterns of variability. Distinct "fronts" (areas in which variables change rapidly) can be seen in both SST and chlorophyll data. The chlorophyll concentration is a measure of the growth of phytoplankton (microscopic ocean plants), or their productivity. The seasonal patterns are also quite distinct, due to the large differences in the amount of sunlight the area receives between winter and summer, and partly due to the movement of the sea-ice boundary.

Part 1: Reading questions

Where is the Southern Ocean?

The Southern Ocean surrounds the continent of Antarctica.

What is the ACC?

The ACC is the Antarctic Circumpolar Current. This is the world's largest ocean current, which flows eastward around Antarctica.

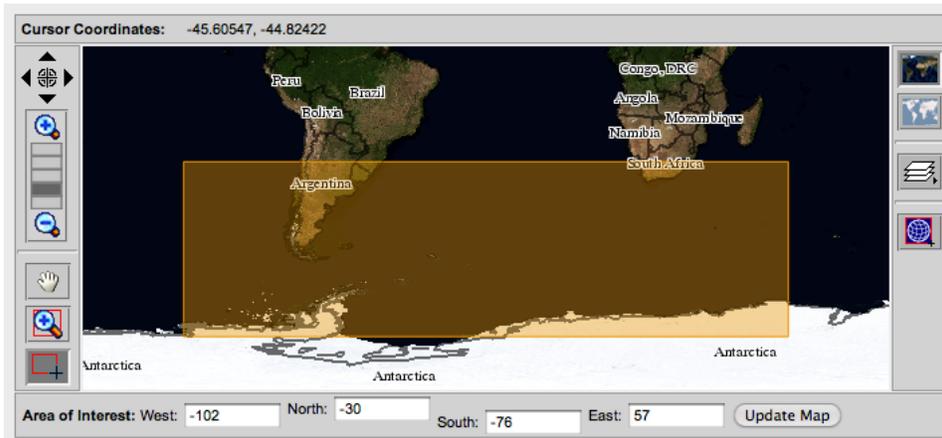


What causes seasonal patterns in sea surface temperature and chlorophyll concentration?

There are two main factors in the seasonal patterns in sea surface temperature and chlorophyll. One is the difference in the amount of sunlight between the summer and winter. The second is the movement of the sea ice boundary.

Part 2: Temperature patterns

1. From the Student Climate Data website (<http://studentclimatedata.unh.edu>), click on the 'Ocean Data' tab at the top of the page.
2. Under 'Tools and Data' in the left panel, click 'DICCE Portal' to bring you out to the NASA DICCE data portal.
3. Click on the map, and drag your mouse across the screen, or use the Area of Interest box, to create a box that encompasses the Southern Ocean in the Atlantic zone.



4. Under the 'Physical Ocean' parameter section, click the box next to 'Sea Surface Temperature.'

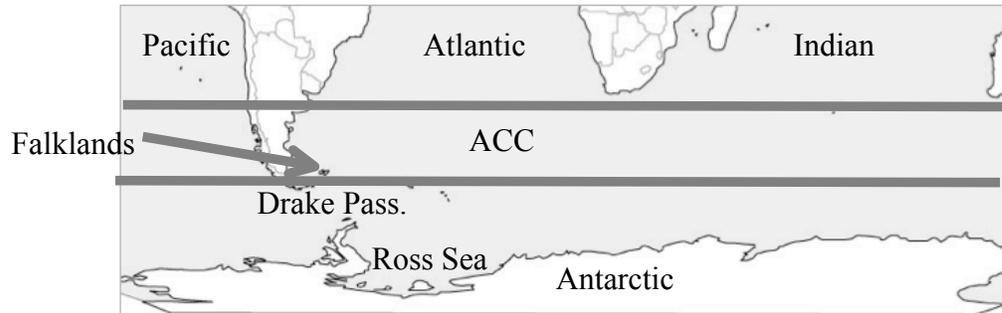


5. In the 'Temporal' section, set both the Begin and End Date years to '2003' and months to 'Jan.'



6. Using the 'Select Visualization' drop-down menu, select 'Lat-Lon map, Time-averaged.'
7. Click [Edit Preferences](#) and under the **Color Bar** section click 'Custom.' Set the **Min value** to 4 and the **Max value** to 20.
8. Click [Generate Visualization](#)

- As the image is loading, use a map, atlas, or online tool (such as Google Maps) to label the following landmarks on the map below: Cape Town, the Falkland Islands, Antarctica. Identify the following ocean-marks: the Atlantic Ocean, the Pacific Ocean, the Indian Ocean, the Drake Passage, the Ross Sea, the ACC.



- Observe the pattern of sea surface temperature from South America (left side of the image) to Africa (right side of the image). At what latitude range (remember, latitude lines run east-west, or horizontally) do you see the biggest temperature change? (*This would be the approximate boundary between the Southern Ocean and the Atlantic*). What are the values above and below this range?

The biggest temperature change is between the latitudes 40 S and 50 S. Above this range the temperature is greater than 20°C, below this range the temperature is less than 4°C.

- Return to the data portal page by clicking the [Home](#) tab on the top-left of the page.
- Keep all parameters the same, except in the **Temporal** section, change the end month to 'Dec' (leaving the starting month as 'Jan').
- Using the '**Select Visualization**' drop-down menu, select 'Animation'. Check Edit Preferences to see that the Color Bar Min is set to 4 and the Max to 20.
- Click [Generate Visualization](#)
- How does sea surface temperature change over the course of a year?
Sea surface temperature changes as the ACC position moves. As the ACC moves northward, the area of water that is less than 4°C increases during June to September.

- Does the position of the ACC change? How can you tell?

Over the course of the year, the ACC moves northward, reaching its highest latitude in August, then moving southward until December. I can tell because the boundary of waters that is greater than 4°C and less than 20 °C shifts.

Part 3. Patterns of chlorophyll

- Return to the data portal page by clicking the [Home](#) tab on the top-left of the page.
- Click *off* the Sea Surface Temperature box, and click *on* the box next to 'Chlorophyll a concentration.'

Ocean Biosphere(1997/09/01 - 2014/12/31)		
Parameter	Data Product Info	
<input checked="" type="checkbox"/> Chlorophyll a concentration	SWFMO_CHLO.CR	SeaWIFS
<input type="checkbox"/> Chlorophyll a concentration	MAMO_CHLO_9km.CR	MODIS-Aqua

3. Keep Animation selected, and under [Edit Preferences](#) set the **Color Bar Min** to 0.05 and the **Max** to 1.5.
4. Repeat the animation generation for 2003 for chlorophyll.
5. Describe the chlorophyll pattern in January. How does this compare with the patterns for SST in January?

The highest chlorophyll concentrations are at the ACC and below (off the coast of Antarctica). The values range from about 0.34 to greater than 1.5 mg/m³. The highest chlorophyll values correlate with the lower sea surface temperature values.

6. As you progress through the months, what is happening to the pattern of chlorophyll in the images? What do you think is causing this?

Chlorophyll values are lowest in June and July, and highest in the December and January. This could be because the Antarctic summer (November-January) might provide phytoplankton with more sunlight for photosynthesis.

7. Which months do you see the highest values of chlorophyll in the Southern Ocean?

The highest values of chlorophyll concentration occur between November and January

Part 4. Light

1. Return to the data portal page by clicking the [Home](#) tab on the top-left of the page.
2. Click *off* the Chlorophyll a concentration box, and click *on* the box next to 'Photosynthetically Available Radiation' (PAR, or sunlight) under 'The Energy and Radiation System'.
3. Repeat the animation generation for 2003 for PAR. **Note: Ocean areas that are white represent areas with no data available.*
4. Describe the patterns in light intensity for January.

January has PAR values that range from 28 to 69 Einstein/m²/day. The higher PAR values are at the higher latitudes, and the low PAR values are near the coast of Antarctica.

5. What are the brightest months? When are the darkest months?

The brightest months are December and January; the darkest months are June and July.

6. Is there a relationship between patterns in PAR and chlorophyll concentration? If so, why?

Yes, there is a relationship between PAR and chlorophyll. The chlorophyll concentrations are highest when PAR values are highest. Without favorable PAR (sunlight), phytoplankton cannot photosynthesize, leading to low chlorophyll concentrations.