Current Ocean Studies
11:

Near Real-Time Views: Gulf Stream and Tropical Oceans

1. Print this file.
2. Print the *Weekly Ocean News* file and answer the two *Concept of the Week* questions in the *Weekly Ocean News* File.
   (**Note:** Check the DataStreme Ocean website during the week as breaking ocean news stories may have been added.)

To Do Investigation:

1. Read Chapter 11 in the *DataStreme Ocean* textbook and respond to the *Chapter Progress Questions* in the *DataStreme Ocean Study Guide* binder. [Do **not** complete the *Questions for Review* and *Critical Thinking Questions* appearing in the *Ocean Studies* text].
2. Complete Investigations 11A and 11B in the *Ocean Studies Investigations Manual*.
3. Go to the *Current Ocean Studies* link on the course website to complete this investigation.

After completing Investigation 11B in the *Investigations Manual*, use the ***¡El Niño!-¡La Niña!*** slide chart provided in the *Study Guide* to answer the following questions.

1. Examine ***¡El Niño!-¡La Niña!*** with the slide insert pushed all the way into the device so that Neutral Conditions appears in the indentation along the bottom of the large window. (Note: If La Niña appears when fully inserted, pull the slide out, flip it to the other side, and reinsert.) Look at the large window. It displays a schematic of the Pacific Ocean along the equator (greatly exaggerated in the vertical). The scene depicts the ocean surface with atmosphere above and a vertical cross-section of the ocean below. The smaller windows below the large window provide ocean information.

   Arrows in the **Surface Currents** window indicate that during neutral conditions, surface water flows towards the **[(*east*)(*west*)]**. According to the values reported in the windows, the highest sea surface temperatures (SSTs) during neutral conditions occur in the **[(*eastern*)(*western*)]** tropical Pacific. This SST pattern is caused by relatively strong Trade Winds pushing sun-warmed surface water **[(*eastward*)(*westward*)]**, as evidenced by the direction of surface currents.

2. Warm surface water transported by the wind away from the South American coast is replaced by cold water rising from below in a process called *upwelling*. Upwelling of cold deep water results in relatively **[(*high*)(*low*)]** SSTs in the eastern Pacific compared to the western Pacific.

3. Slowly pull the insert out of ***¡El Niño!-¡La Niña!*** while watching the changing scene in the large window. Note that the stormy conditions move eastward. Continue pulling until the **El Niño** label is lined up in the large window indentation. Now you are viewing atmospheric and oceanic conditions that are expected during a typical ***El Niño***. While no

two ***El Niño*** episodes are exactly alike, all of them exhibit most of the characteristics described in ***¡El Niño!-¡La Niña!***.

As seen in the **Surface Currents** window, the surface water currents during ***El Niño*** flow toward the **[(*east*)(*west*)]**. As evident in the appropriate **Sea Surface Temperature** window, this causes SSTs in the eastern tropical Pacific to be **[(*higher*)(*lower*)]** than during neutral conditions. (Neutral conditions are denoted by the black marks along the sides of the windows. Differences of the current value from the neutral conditions is an *anomaly*, positive if higher, negative if lower.)

4. In response to surface currents, sea surface heights in the eastern tropical Pacific are **[(*higher*)(*lower*)]** than during neutral conditions. At the same time, the arrival of the warmer water causes the surface warm-water layer to thicken. Evidence of this is the **[(*shallower*)(*deeper*)]** depth of the thermocline compared to neutral conditions.

5. The tropical Pacific at times experiences trade winds stronger than during neutral conditions with SSTs lower than usual in the eastern tropical Pacific and higher than usual in the western tropical Pacific. Associated with these ***La Niña*** conditions are anomalies generally opposite those occurring during ***El Niño***. Remove the slide insert from the sleeve and turn it to the other side. Slide the insert back into the sleeve until **Neutral Conditions** appears in the indentation along the bottom of the large window. (Note that the Neutral Conditions on both sides of the insert are identical.) Then continue pushing the insert in until **La Niña** appears in the indentation.

   During ***La Niña***, the Trade Winds drive surface currents toward the **[(*west*)(*east*)]**, resulting in sea surface temperatures in the western tropical Pacific that are slightly **[(*higher*)(*lower*)]** than during neutral conditions while the eastern tropical Pacific experiences **[(*positive*)(*negative*)]** SST anomalies. The **La Niña** wind and current patterns produce a thermocline depth in the eastern tropical Pacific that is **[(*deeper*)(*shallower*)]** than the neutral value, leading to **[(*weaker*)(*stronger*)]** upwelling than average (note the large curved arrows).

Introduction:

The ***AMS Ocean Studies Investigation Manual***'s Investigation 11A and 11B explored the close coupling of the ocean and atmosphere. The first examined the Gulf Stream and the second ***El Niño*/*La Niña***. Here, we will visit recent views of the Gulf of Mexico/North Atlantic and tropical Pacific to update ourselves with present sea surface conditions. Also, we will describe the newly created **Global Tropical Moored Buoy Array** that spans the equatorial regions of the Pacific, Atlantic and Indian Oceans.

The Gulf Stream:

In Investigation 11A, the U.S. Naval Oceanographic Office's Gulf Stream map for 1 May 2009 that was presented in Figure 5 was analyzed. For an update, **Figure 1** displays near

real-time information for 9 November 2009 covering the same area as the southern map segment in Figure 5. Compare the maps for the May and November dates.

6. Compare the May and November positions of the Gulf Stream (labeled "GS") east of mid-Florida to east of Cape Hatteras, NC. The positions are **[(*within two or three*) (*beyond several*)]** latitude/longitude degrees of each other.

7. According to the sea surface temperatures (SST) appearing on the maps in the same Gulf Stream segment, it appears SST values are generally higher in early **[(*May*)(*November*)]**.

8. Tropical cyclones (e.g., hurricanes) require a sea surface temperature of at least 26.5 °C (80 °F), among other requirements, to form. Compare Gulf of Mexico, Caribbean Sea and Atlantic Ocean SSTs south of about 30 degrees N on the May and November maps.

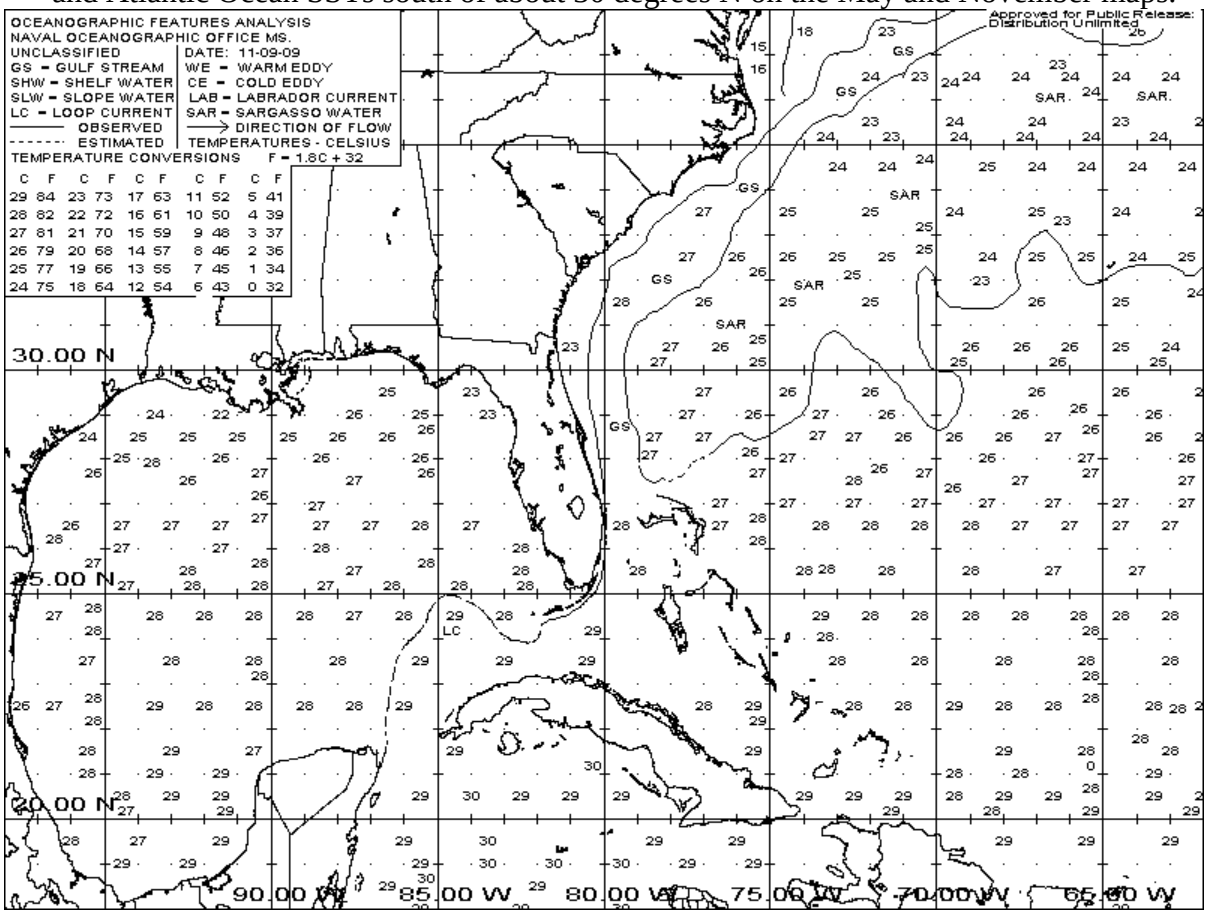

Figure 1. U.S. Naval Oceanographic Office's southern portion Gulf Stream map for 9 November 2009.

Based on temperature alone, you would expect a higher probability of a hurricane occurrence in early **[(*May*)(*November*)]**.

We recommend that you track the Gulf Stream over time to see its changes. Directions for retrieving the latest Gulf Stream map are given in the ***AMS Ocean Studies Investigation***

Manual's Investigation 11A after Item 25. Once at the U.S. Naval Oceanographic Office's site, you can also acquire similar maps in a color-coded version. If you look at the colorized versions, be sure to note that the two segments of the map have different color-coded temperature scales.

El Niño/*La Niña*:

In the ***AMS Ocean Studies Investigation Manual***'s Investigation 11B, Figure 5 displays the 5-day average surface wind and temperature conditions across the tropical Pacific from the TAO/TRITON array for the time period ending 11 May 2009. For an update, **Figure 2** displays information for 8 November 2009, about six months later. Compare the maps. [Remember that isotherms are drawn at intervals of 0.5 Celsius degrees.]

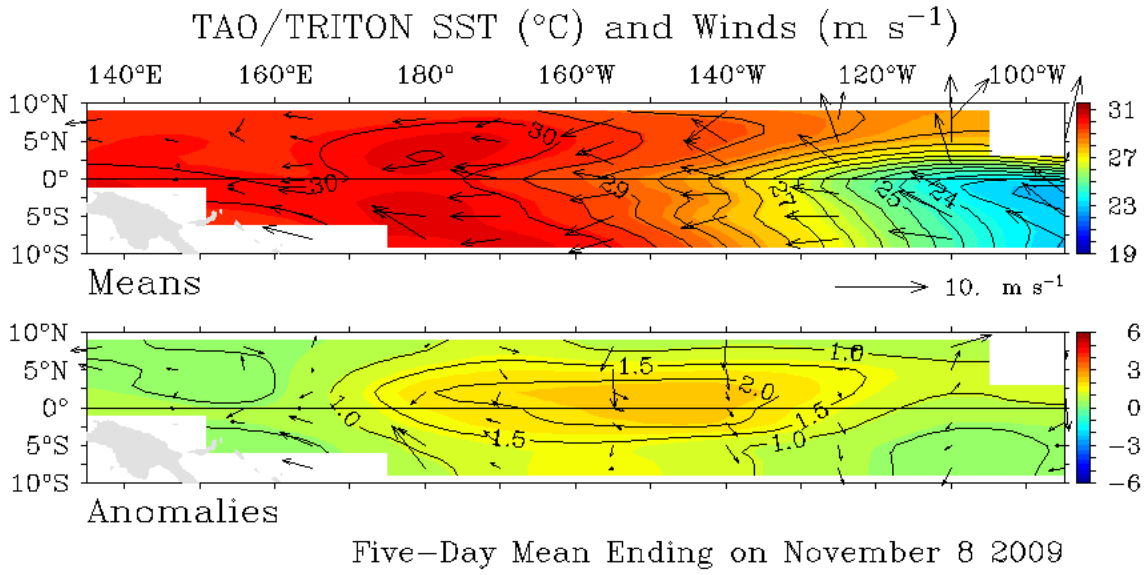

Figure 2. TAO/TRITON array tropical Pacific surface wind and temperature conditions for 8 November 2009.

9. Comparison of the two upper-panel "Means" views show that the lowest mean SST values in early May 2009 were slightly less than 26.5 °C near 95 degrees W, while in early November 2009 the lowest means SST values were slightly less than **[(*23.0*) (*25.0*)(*27.0*)]** °C near 95 degrees W.

10. At the same time, the lower panels reported anomalies (departures from the long-term average or normal conditions) for early May 2009 and early November 2009. They showed that the departures from the long-term average conditions were **[(*greater*) (*less*)(*the same*)]** in early November 2009 compared to early May 2009.

11. In early November 2009, the greatest temperature anomalies were larger than **[(*+2.0*) (*+1.0*)(*-2.0*)]** Celsius degrees.

12. Go to the following to determine the most current ***El Niño*/*La Niña*** forecast: http://www.cpc.noaa.gov/products/analysis_monitoring/enso_advisory/ensodisc.pdf . According to the synopsis presented, **[(*El Niño*)(*La Niña*)]** is currently occurring and is expected to continue strengthening and last through at least the Northern Hemisphere winter 2009-2010. [Note: The "**El Niño/Southern Oscillation (ENSO)**" terminology used in the diagnostic discussion at this website is synonymous with ***El Niño*/*La Niña***.]

[Reminder: You can access the latest TAO/TRITON map displays by going to http://www.pmel.noaa.gov/tao/index.shtml, and clicking on the map that appears.]

The Global Tropical Moored Buoy Array:

In recognition of the extremely important roll the tropical ocean plays in climate research and forecasting, a multi-national effort has been established to provide environmental data in near real-time. **Figure 3** displays the full Array.

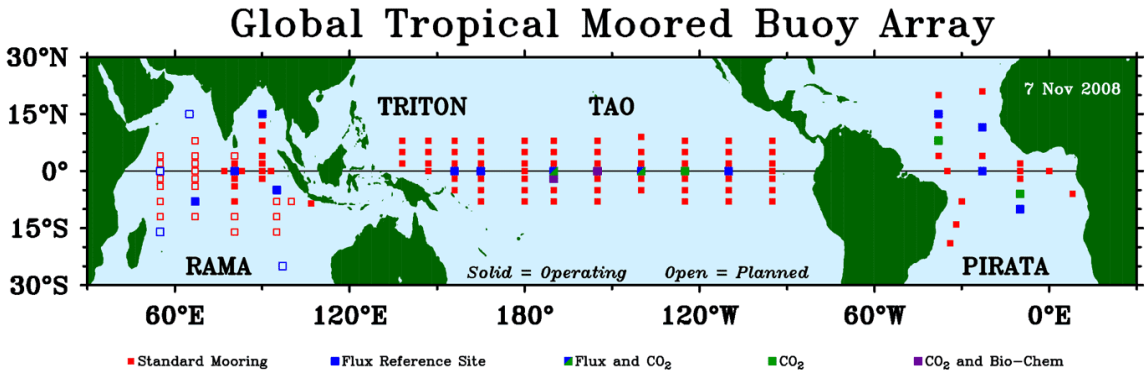

Figure 3. The Global Tropical Moored Buoy Array. [NOAA/PMEL]

13. Figure 1 shows that the Global Tropical Moored Buoy Array includes the Pacific Ocean's TAO/TRITON array, the Indian Ocean's array and the Atlantic Ocean's array. The name of the Atlantic's array is **[(*RAMA*)(*PIRATA*)]**.

To find out more about the Global Array, go to: http://www.pmel.noaa.gov/tao/global/global.html. To focus in on the individual moored buoy arrays in the different oceans, click on the acronyms appearing in the lead paragraph.

The Global Tropical Moored Buoy Array is a contribution to the Global Ocean Observing System (GOOS), Global Climate Observing System (GCOS), and the Global Earth Observing System of Systems (GEOSS).

Record your responses to items in DataStreme Ocean Investigations 11A and 11B on the Investigations Answer Form and responses for Current Ocean Studies items on the Current Ocean Studies Answer Form for transmission to your course mentor.

Instructions for Communications with Mentor:

After completing this week's applications, transmit the following work to your LIT mentor by Monday, 23 November 2009, or as coordinated with your mentor:

1. Chapter 11 Progress Response Form from the DataStreme Ocean *Study Guide* binder, or the DataStreme Ocean website.
2. Investigations 11A and 11B Investigations Answer Form, from the DataStreme Ocean *Study Guide* binder, or the DataStreme Ocean website.
3. Current Ocean Studies 11 Current Ocean Studies Answer Form.

Return to *DataStreme Ocean website*