I. Naturally occurring cyclical change in global circulation patterns.
   A. Two endpoints of oscillation, La Nina and El Nino
   B. Shifts from one state to another occur on temporal scale larger than seasons, approximately 2-7 years
   C. Global warming does not cause the Southern Oscillation, but there may be interactions between the two.
   D. Southern Oscillation is driven by feedback between trade wind intensity and sea surface temperatures. Under normal (or intermediate) conditions, the trade winds pile up warm surface water in the western Pacific while upwelling colder water in the east Pacific from below the surface. The resulting east-west surface temperature contrast reinforces an east-west air pressure difference across the Pacific that in turn drives the trade winds. With El Nino, this basic pattern is reversed. With La Nina, this pattern is amplified.

II. La Nina
   A. Cooler than normal SST’s in east Pacific
   B. Dry stable conditions from subtropical Pacific High in east Pacific
   C. Peru and California current well-defined
      1. These cold currents stabilize atmosphere
      2. Cold surface water inhibits air from rising
   D. Trade winds blow east to west
      1. Carry evaporative moisture to west Pacific
      2. Water piles up in west Pacific
      3. Enhanced cold water upwelling occurs in east Pacific in response
   E. Effects of La Nina
      1. Increased hurricane activity in eastern Pacific and Atlantic/Caribbean.
         a. 3-to-1 greater likelihood of a major Atlantic hurricane striking the United States during La Niña versus El Niño years, with correspondingly higher economic losses during La Niña years. With La Nina, subtropical jet stream shifts further north, allowing hurricanes to experience less wind shear in the upper levels.
      2. Coral bleaching on the Great Barrier reef and Indo Pacific region

III. El Nino
   A. Warmer than normal SST’s in east Pacific
   B. Wet and unstable conditions develop in east Pacific as Pacific High weakens
   C. Trade winds slow and reverse to blow west to east
      1. Carry evaporative moisture to east Pacific
      2. Instability and low pressure dominate in east Pacific
      3. Warm water piles up in east Pacific, up to 14 degrees F warmer. Warm water may extend from the coast of South America to the International Date Line, a large swath of the central and eastern Pacific
      4. Cold water upwelling occurs in west Pacific in response
   D. Anomalies in SST, wind fields, and air pressure are greatest during El Nino events.
   E. Effects of El Nino
      1. Flooding/landslides in normally dry regions of California and South America
      2. Drought in west Pacific
      3. Coral bleaching in central and eastern Pacific
      4. Decreased Atlantic hurricane activity: subtropical jet is further south, this creates an upper level environment that favors more shearing off of the tops of hurricanes.
5. Changes in the patterns of primary production that in turn ripple through marine and terrestrial trophic webs.
   a. Decreased upwelling along eastern Pacific and subsequent declines in phytoplankton erode the food base for marine fisheries and the sea mammals and sea birds that depend upon them.
   b. Changes in the abundance of animals that are reservoirs for zoonotic diseases that can infect humans.
      (1) 1992-1993 Hanta virus outbreak in Four Corners region of US indirectly caused by increased ENSO rains, which caused increased vegetation cover and habitat for the mammals that carry Hanta virus

IV. There are other natural oscillations in our climate system:
   A. Modoki El Nino
   B. Madden-Julian Oscillation
   C. North Atlantic Oscillation
   D. Arctic Oscillation
   E. Pacific Decadal Oscillation