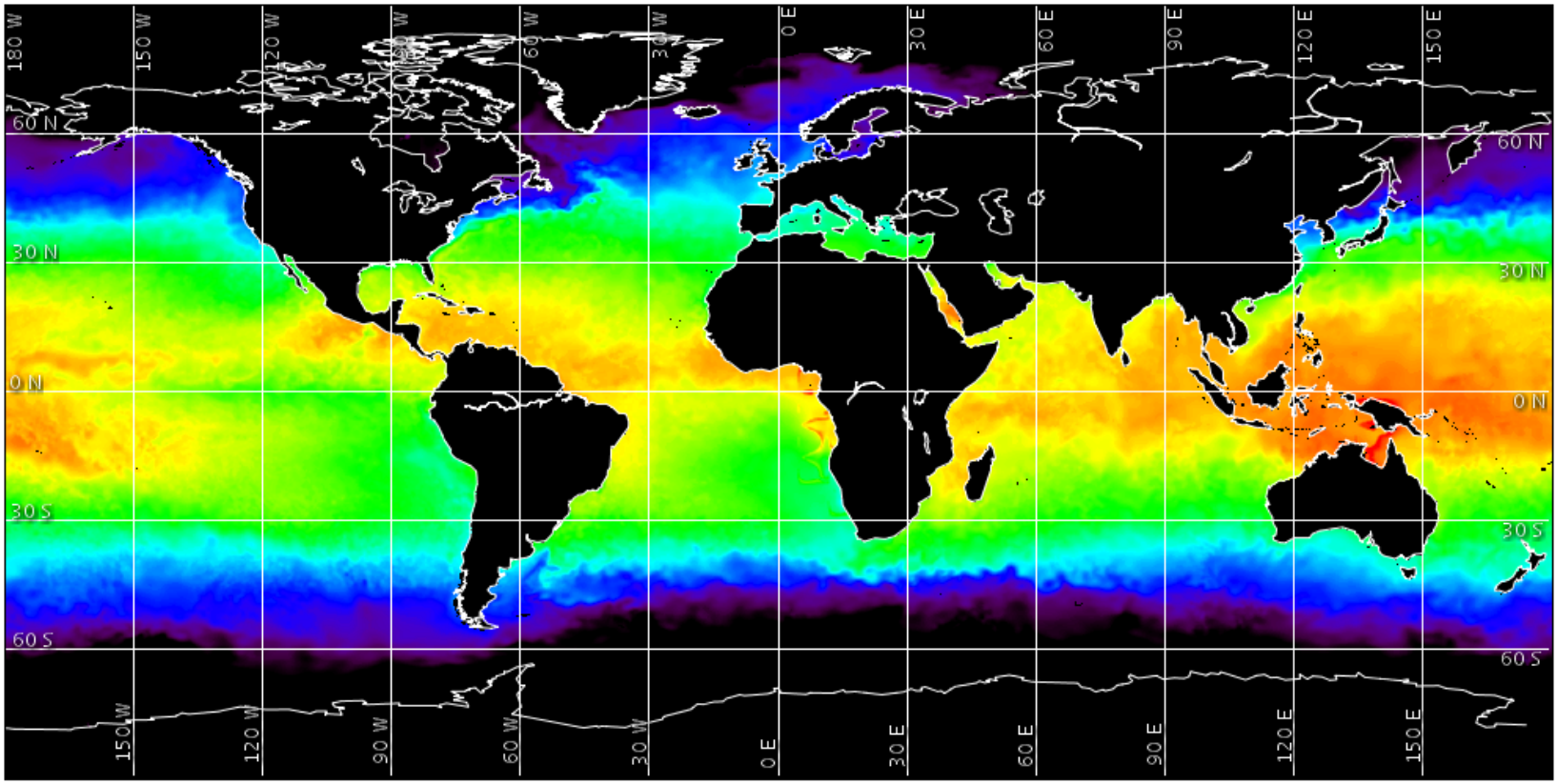
SATELLITE SEA SURFACE TEMPERATURES



NOAA CoastWatch Program
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http://coastwatch.noaa.gov

In this Lesson:

Why do we measure sea surface temperature?

What is sea surface temperature?

What causes the temperature to change?

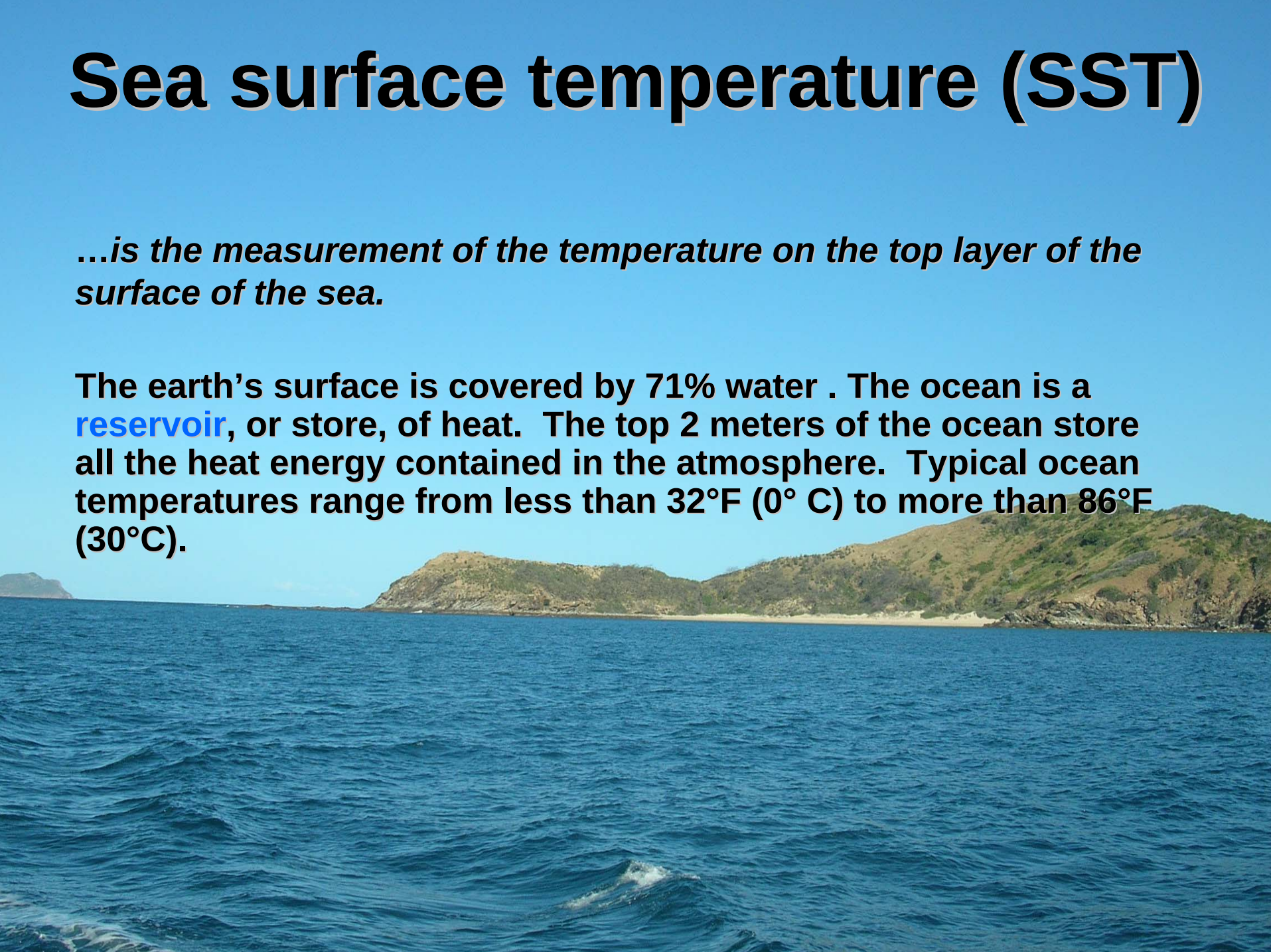
How do scientists use satellites to measure the sea surface temperature?

What are satellite sea surface temperature images?

Sea surface temperature (SST)

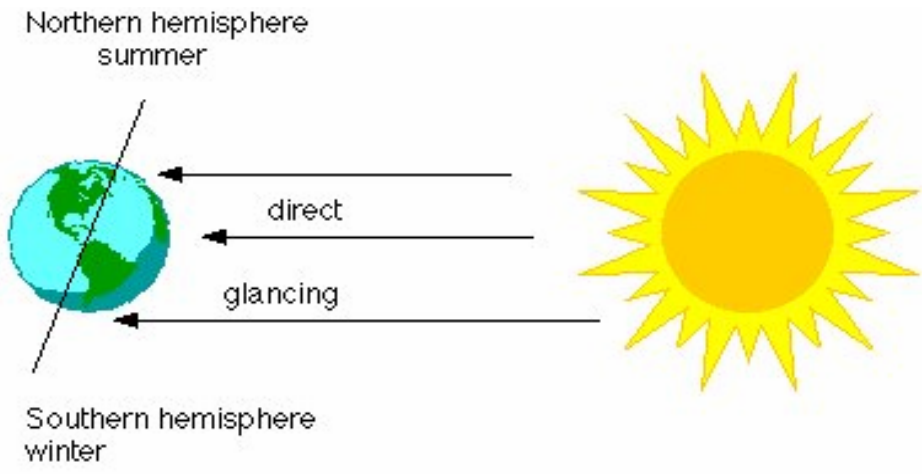
…is the measurement of the temperature on the top layer of the surface of the sea.

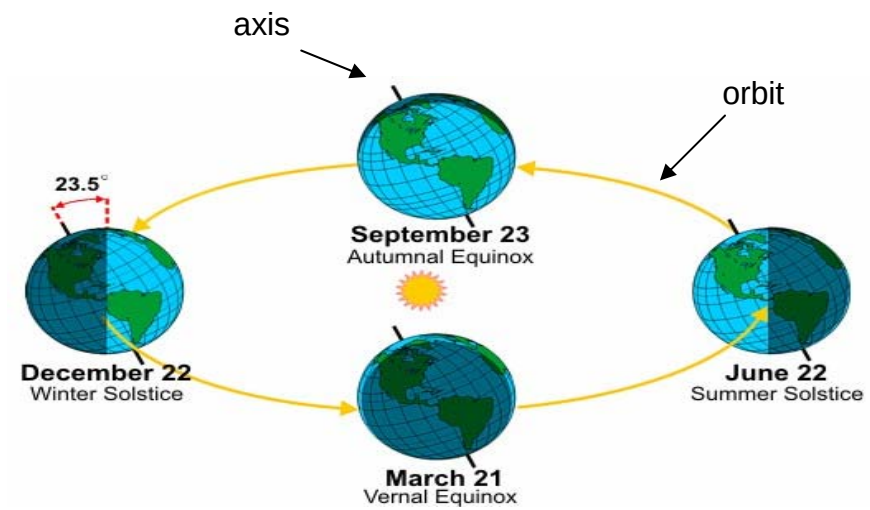
The earth's surface is covered by 71% water . The ocean is a reservoir, or store, of heat. The top 2 meters of the ocean store all the heat energy contained in the atmosphere. Typical ocean temperatures range from less than 32°F (0° C) to more than 86°F (30°C).



The sun heats the sea surface

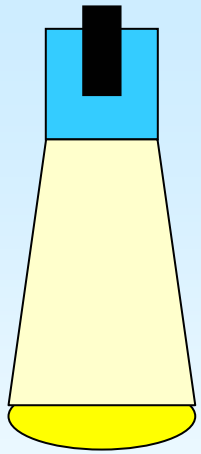
The Earth absorbs heat energy from the Sun as it revolves around the sun and rotates on its **axis**. The **orbit** of the Earth, or its path around the sun, determines where the rays of the sun are most direct. The shape of the Earth causes uneven heating. The warmest water is near the equator, while the coldest water is near the poles. This is due to the angle of the rays hitting the sun caused by the earth's **tilt** while it rotates on the axis. **Direct** rays provide heat over a smaller surface, where as **glancing** rays provide the same heat over a larger surface area.



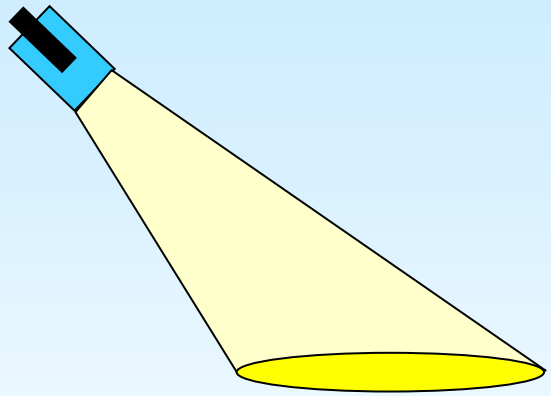


The sun heats the sea surface

Exercise: Stand five feet from a wall and shine a flashlight straight ahead. Notice the area the light covers. Now, angle the flash light to one side. Notice the change in aerial coverage of the light. This is an example of direct vs. glancing rays that hit the surface of the earth. Now, think about how hot the sun feels at noon compared to 5 PM.

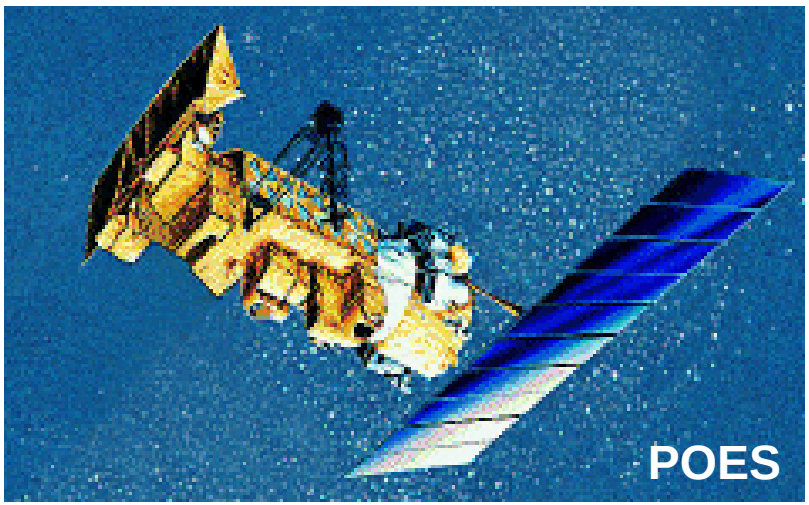


Direct (noon)



Glancing (5 PM)

NOAA Operational Satellite Instruments



POLAR ORBITING

INSTRUMENT: AVHRR

GEOSTATIONARY

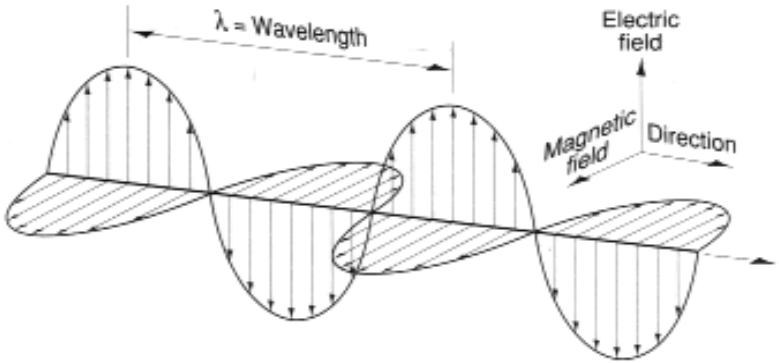
INSTRUMENT: IMAGER

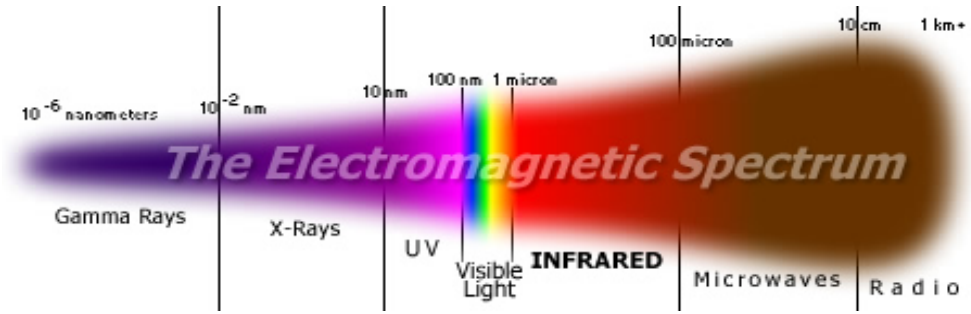
Note: There are several instruments are onboard each satellite. The instruments mentioned above are the ones used by CoastWatch for SST measurements.

Observing sea surface temperatures with satellites.

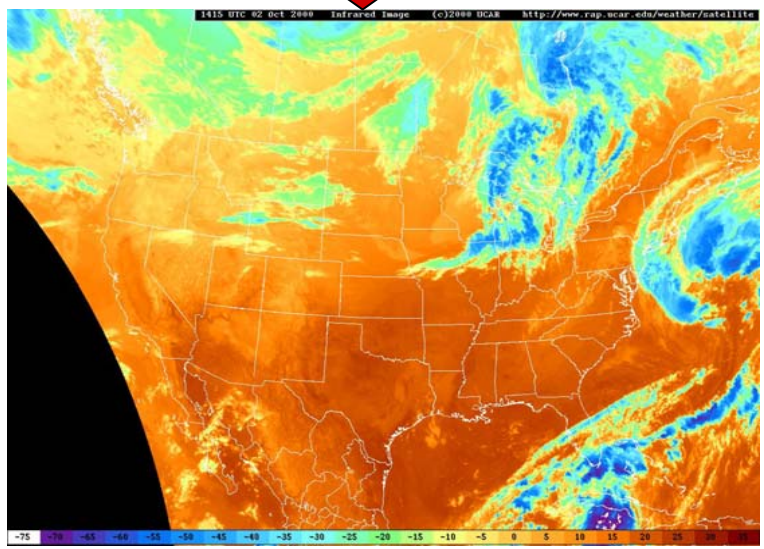
- Satellites carry instruments that detect electromagnetic radiation (another term for light).
- Instruments are designed to measure the infrared part of the electromagnetic spectrum (thermal radiation emitted by the sea surface).
- Measurements of the sea surface are generated from these instruments.
- Images are created from these measurements by computers.

Electromagnetic (EM) Radiation



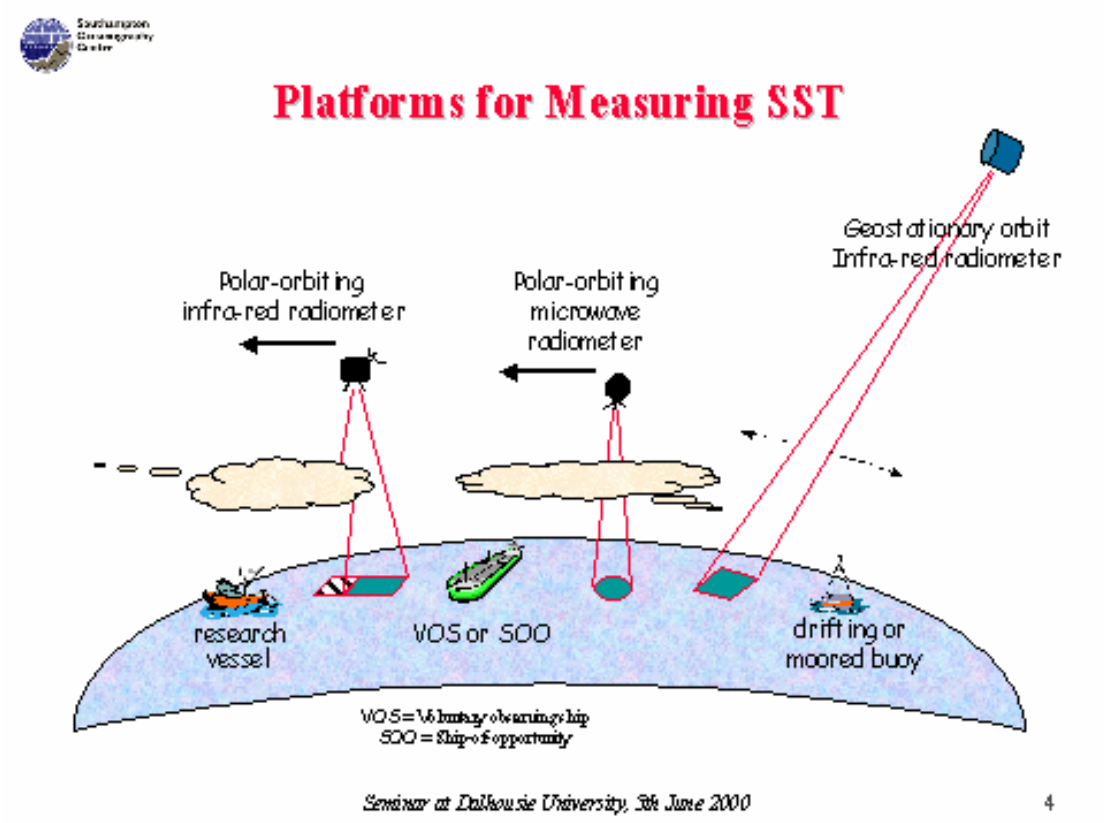


- Oscillating charges produce self-sustaining EM waves called **radiation** (e.g., light).
- All terrestrial objects emit thermal radiation.
- Higher temperatures produce shorter wavelengths of radiation.



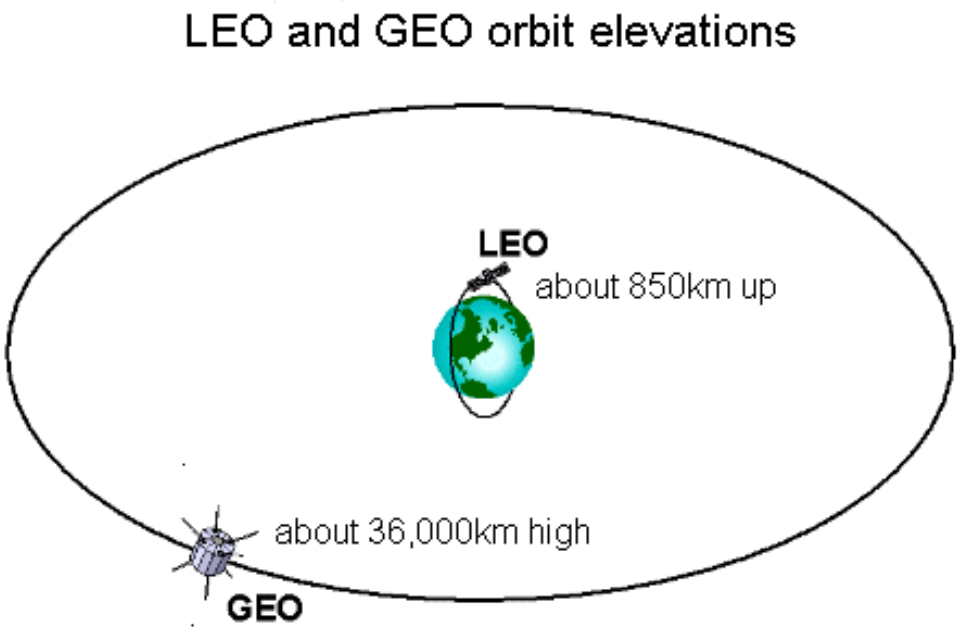
Infrared Satellite Image

Satellite Platforms for Global SST



Satellites are launched into space as “platforms” that carry instruments used to measure electronic impulses in the different parts of the electromagnetic spectrum. The satellites can see large regions of the entire globe in a short time, in contrast to ships and buoys which can see smaller areas at higher resolution.

Satellite Platforms for Global SST



Polar Orbiting or Low Earth Orbiting (LEO) Satellites

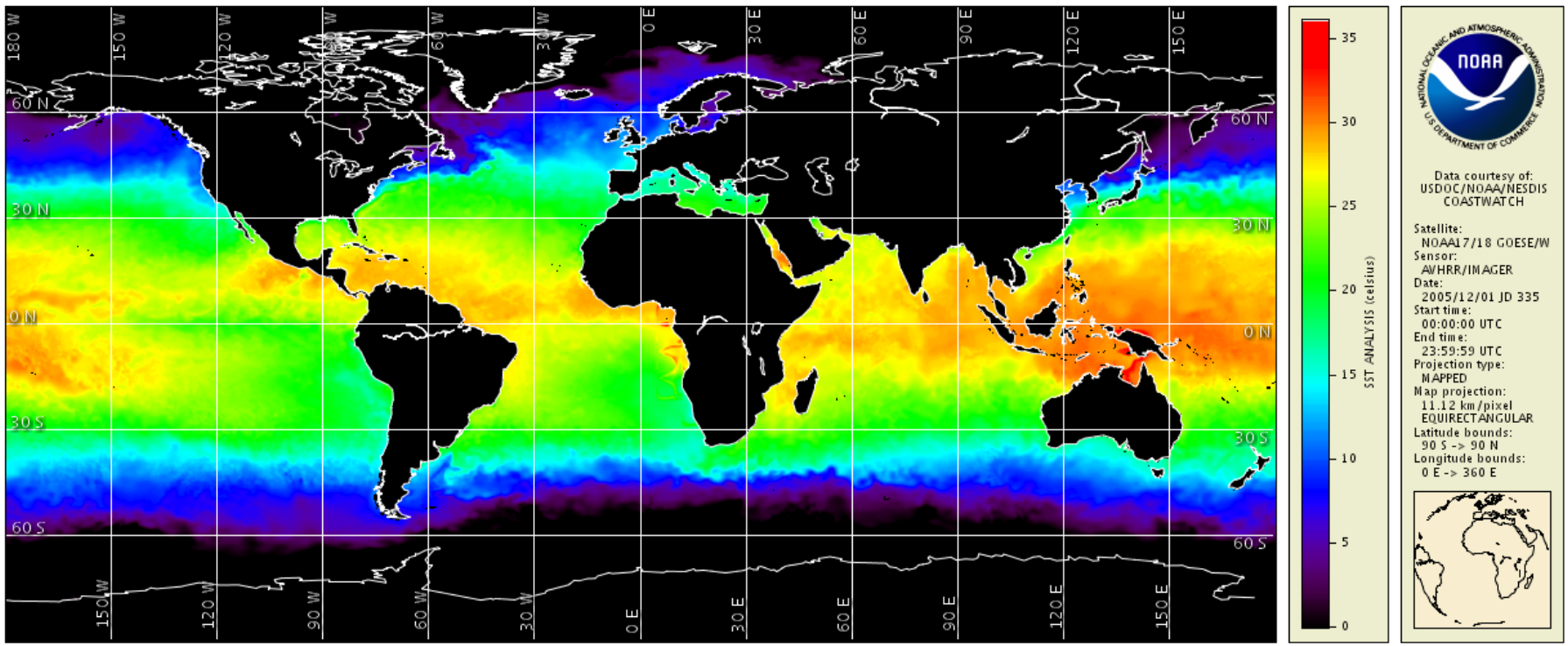
- Provide over 20 years of data
- Show 2x daily global coverage
- Have high spatial resolution (1-4 km)

Geostationary (GEO)

- Only show hemispherical coverage
- Have high temporal resolution (1-3 hourly)

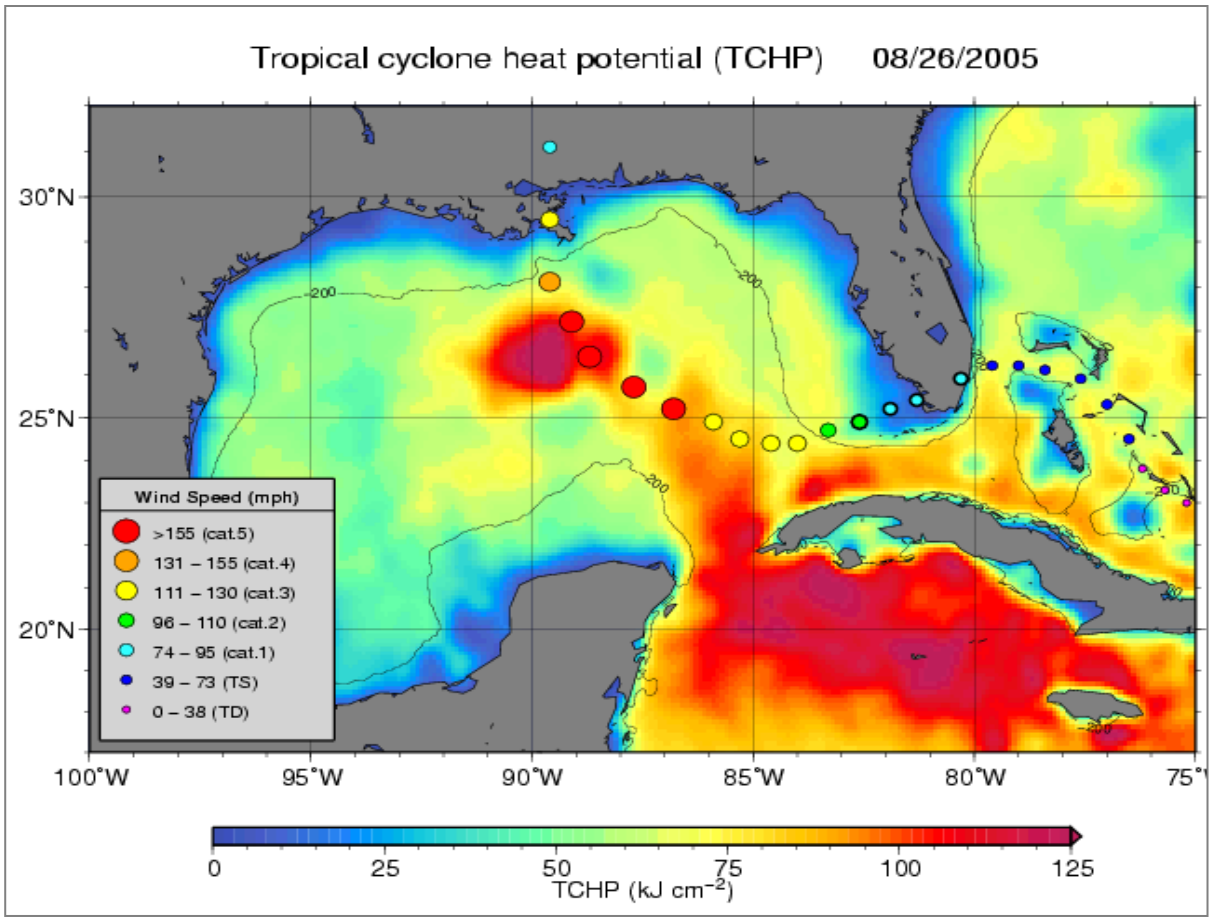
APPLICATIONS OF SST

Since the oceans contain a lot of heat, and heat is a big part of global climate, measuring these sea surface temperatures becomes a key component to climate studies. Tracking SST data, long-term, is very important for the prediction of weather forecasts, climate change, and natural resource management, as well as tracking ocean currents and monitoring the **El Niño-La Niña** cycles.



Weather

The ocean provides a significant amount of latent heat to storms passing over its surface. The amount of heat available is one factor in the formation of hurricanes. Sea surface temperatures are used in deriving the Tropical Cyclone Heat Potential.



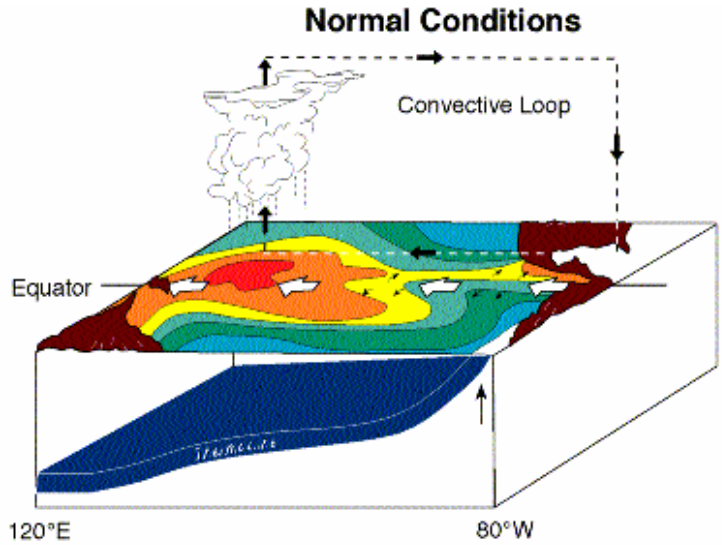
More accurate and precise coastal evacuation prediction information based on Tropical Storm Predicted Paths and Tropical Cyclone Heat Potential (TCHP) provides coastal zone managers tools to make informed life-saving decisions.

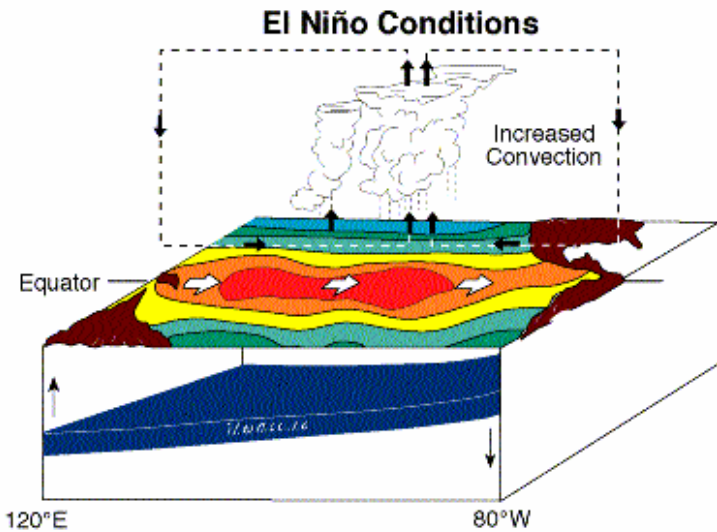
El Niño & La Niña

El Niño and La Niña coupled with the Southern Oscillation are global climatic phenomena caused by changes in air pressure.

During El Niño, weakening of the trade winds cause warm water to shift from the western Pacific Ocean to the eastern Pacific Ocean increasing the warm surface layer, preventing upwelling of nutrients to fisheries off the coast of Peru. The onset of El Niño reduces fish populations and creates a strain on the fishing economy.

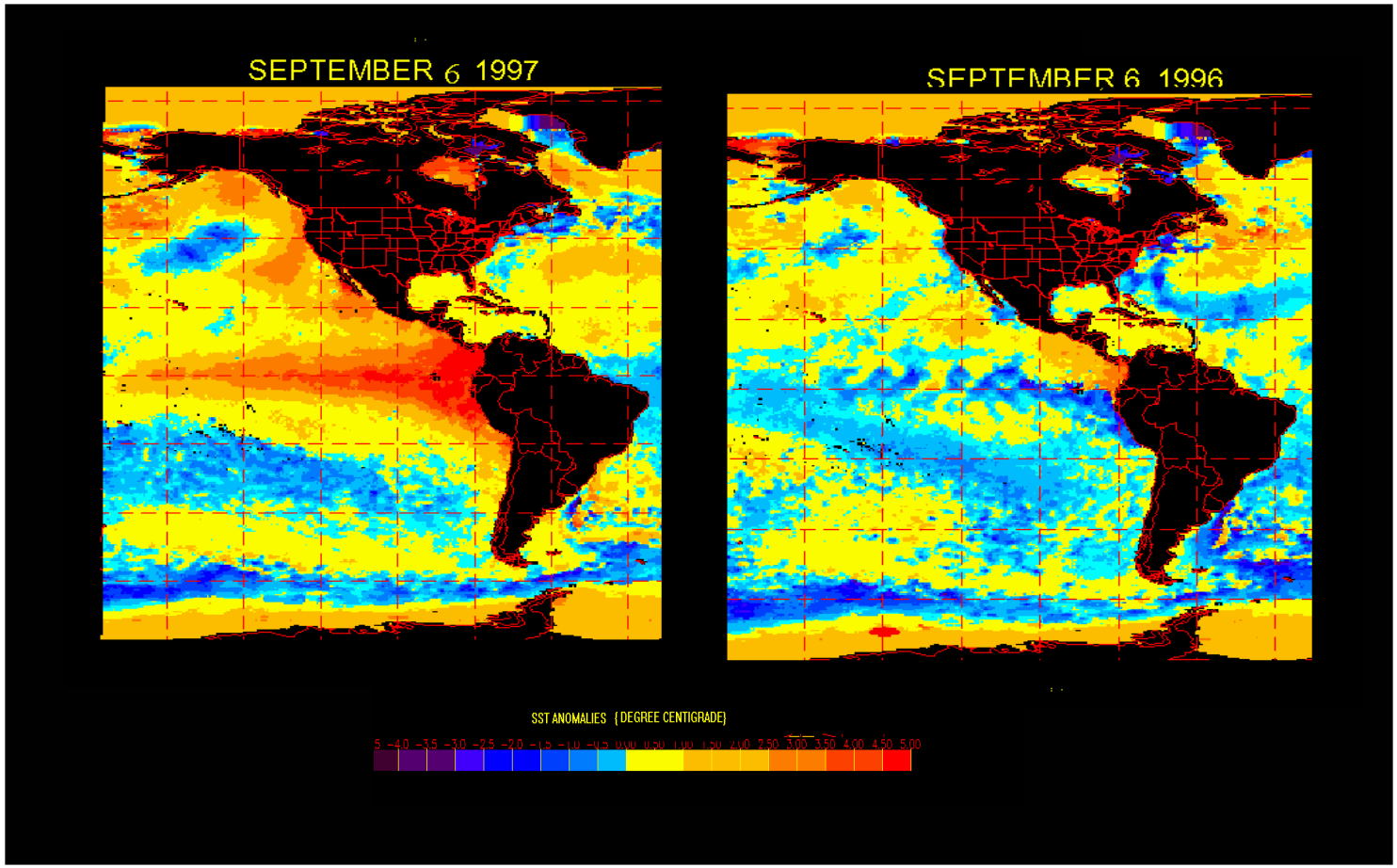
La Niña is the opposite effect, with increased upwelling to produce higher nutrient levels for the food chain. SST anomalies are used to track both events.





NOAA/PMEL/TAO

El Niño



Comparison of El Niño conditions (left) with normal conditions (right).

Coral Reefs

Scientists use SST to provide coastal managers with advance warning of coral bleaching events, which helps them to manage valuable resources. Coral reefs are as significant to the ocean as rainforests are to land.

BLEACHED CORALS

HEALTHY CORALS

Coral reefs are important to the ocean ecosystems because they…

…provide protection to reef organisms;

…provide a source of nutrients for the ecosystem and nourishment for humans;

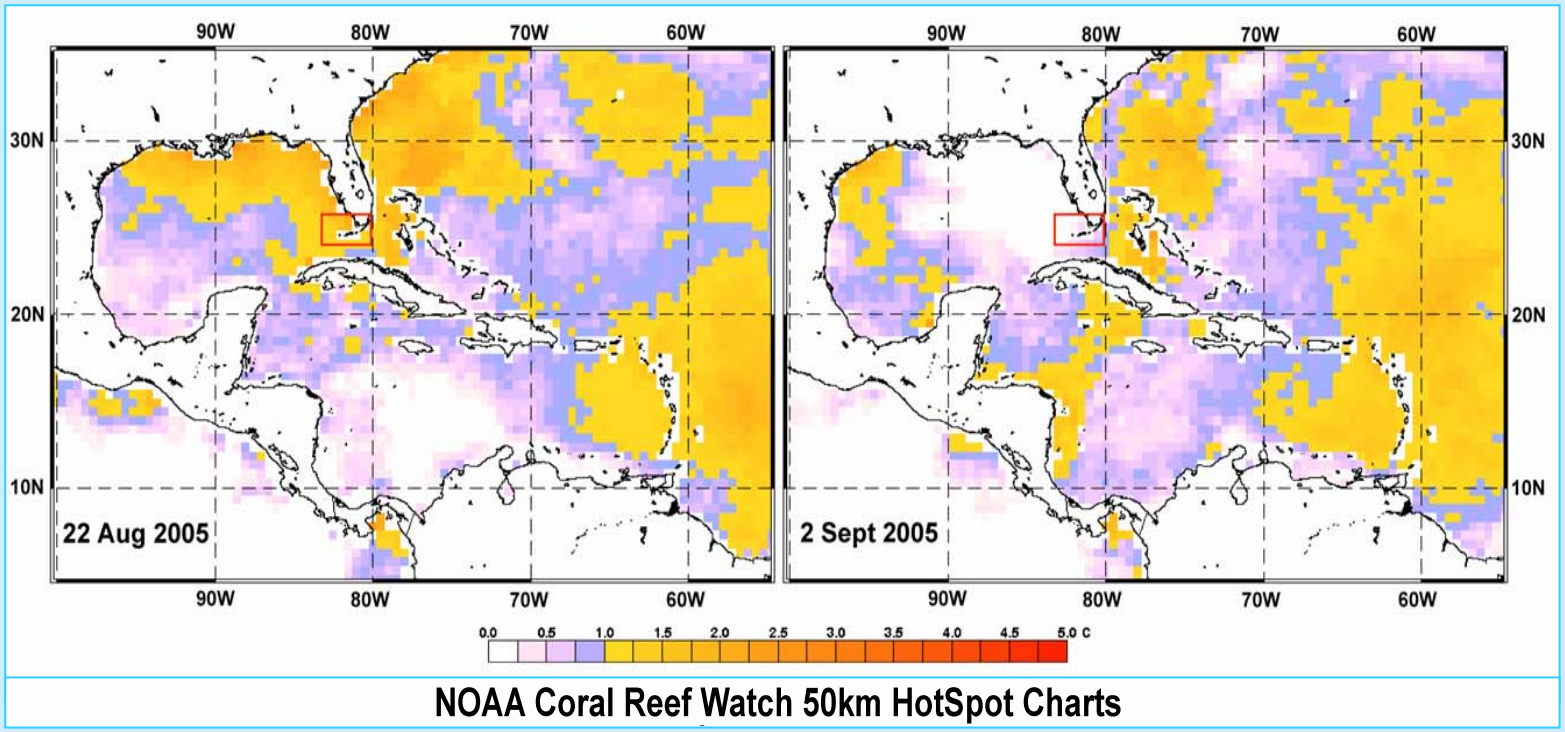
…are indicators of climate change;

…and provide income through tourism, fishing, building materials, coastal protection, and new drugs and bio-chemicals.

Coral Reefs

Corals have a symbiotic relationship with zooxanthellae, in which the zooxanthellae receive nutrients from corals in return for food via photosynthesis. Zooxanthellae are sensitive to changes in water quality and temperature, therefore minimal temperature differences may have a detrimental effect on them. These temperature changes cause corals to lose the zooxanthellae leaving it a bleached white (top left). Persistent bleaching causes corals to die.

Coral Reefs



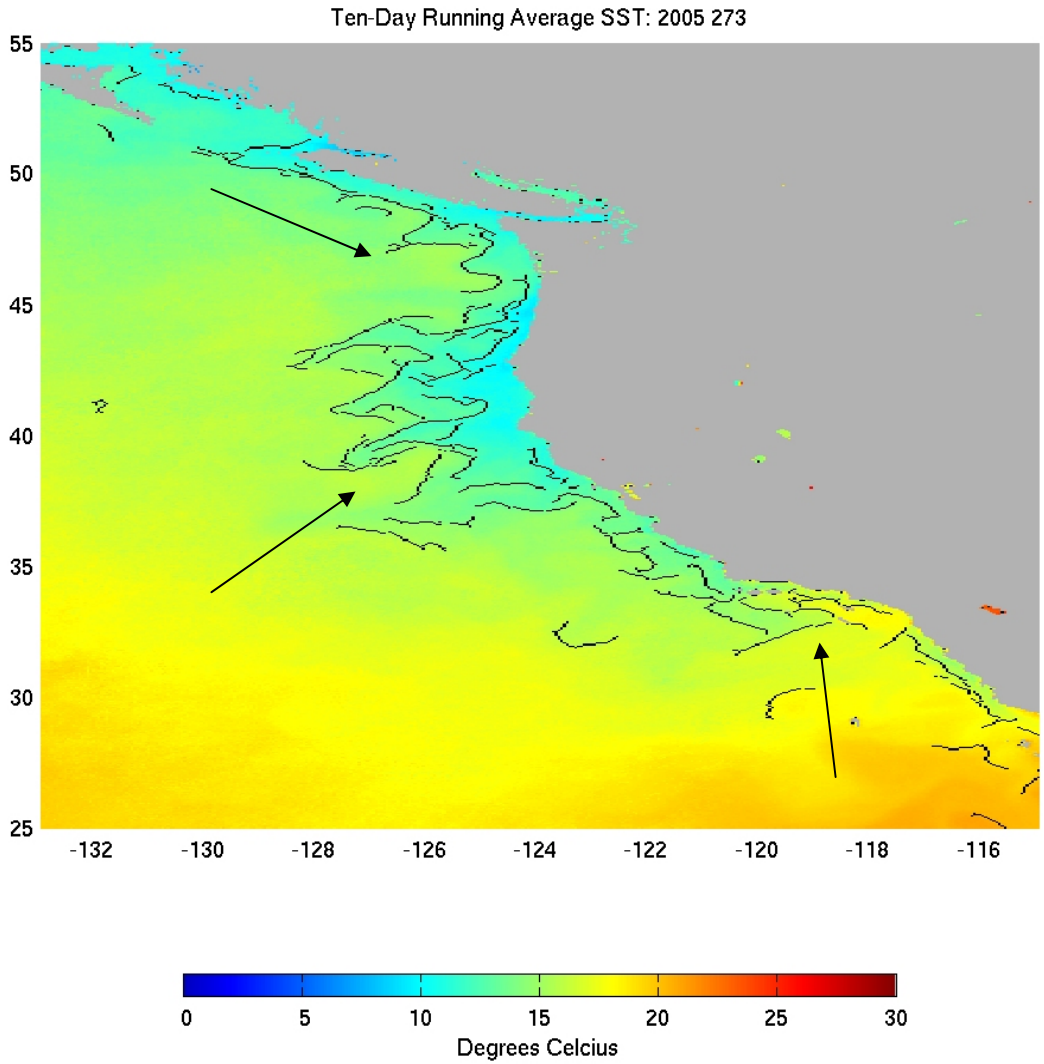
NOAA Coral Reef Watch 50km HotSpot Charts

NOAA Coral Reef Watch's HotSpot product measures sea surface temperature anomalies in excess of 1°C above maximum monthly mean. An anomaly is an abnormality in the regular trend of data. By targeting anomalies, scientists can locate the positions of suspected coral bleaching. http://coralreefwatch.noaa.gov

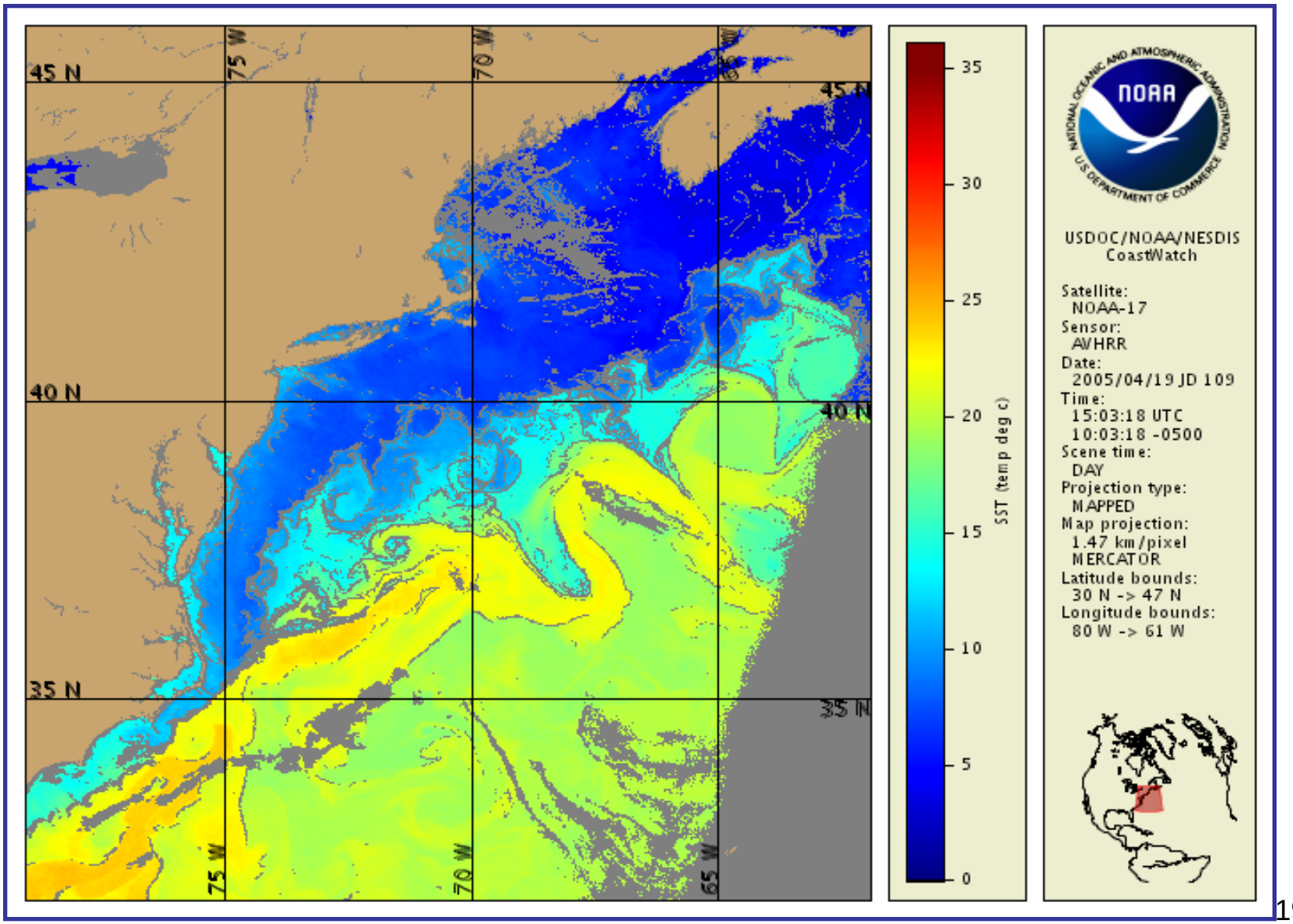
Fronts

(derived from Ten-Day running Average GOES SST)

Fish prefer to be in areas of boundaries, (e.g. fronts and ice edges) because high levels of food reside in these areas. Fisherman use SST data products such as the **fronts** (shown above) to track changes in temperature conditions, which aids in predicting where fish are most likely to be found.



CoastWatch Sea Surface Temperature



Questions

How is sea surface temperature measured?

Why do scientists measure SST?

How does the ocean surface warm up?

Name a few applications for SST. Can you think of others not listed here?

Key Acronyms

- **AVHRR** - advanced very high resolution radiometer
- **EM** - electromagnetic
- **GEO** - geosynchronous orbit
- **GOES** - geostationary operational environmental satellite
- **IR** - infrared
- **LEO** - low earth orbit
- **NOAA** - National Oceanic and Atmospheric Administration
- **POES** - polar operational environmental satellite
- **SST** - sea surface temperature

Thank you for taking the time to review this tutorial. Please forward any comments and suggestions to Shawna Karlson at Shawna.Karlson@noaa.gov

For more information on CoastWatch, please visit the website at http://coastwatch.noaa.gov