# Supporting Text: Doing Climate and Environmental Sciences

*Keywords: landscape, reconstruct, record, cores, sample.*

**What do climate and environmental sciences look at?**

Climate and environmental sciences attempt to study and reconstruct landscape changes over time and space, often focusing on larger time frames than those provided through qualitative data sources.

Scientists do this to model past environmental phenomena and patterns.

**Where can we look for information on El Niño?**

Evidence of the cyclical patterns of El Niño phenomena can be found in the natural world. Different physical features, or indicators, are combined as pieces of the puzzle that makes up the complex story of the El Niño phenomenon.

We are going to look at the different sources of primary data, or evidence directly from the field, to see what these different indicators are.

**How do we do climate and environmental sciences?**

For the research conducted on the El Niño phenomenon in northern Peru, the following four instrumental and natural measures were used (among others):

1. Precipitation
2. Geographic Information Science (GIS)
3. Cores
4. Tree rings

Each of these provides information on how El Niño impacts the landscape and can be brought together for a more accurate understanding of the phenomena.

**1. Precipitation**

The El Niño phenomenon centres around water. Because of this, the most prominent data collected relates to the abundance of precipitation that occurs with an event.

Identifying levels of precipitation will help scientists to determine whether an El Niño event is occurring or has occurred and can also help model and predict future events.

There are many ways to measure rainfall, from basic measurement containers placed outside, to more complex rain radars.

**Rain radars**

A rain radar collects large scale measurements on rainfall by emitting waves which bounce back information. Let's look at the one used in northern Peru.

| **Video** |
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*This video shows the use of rain radars to collect data about the El Niño phenomenon in northern Peru. The process of data monitoring and collection is quite complex, so the level of depth addressed and required here should be discussed with students.*

**Transcript**

RAIN RADAR
Science Station “Ramón Mugica”, Piura Campus
Dr Rodolfo Rodriguez, Director of the “Ramón Mugica” Science Station

*What is the rain radar installed in UDEP used for?*
The rain radar installed in the University of Piura is used for the detection and monitoring of pluvial precipitation which occurs on the coast and in some parts of the highlands of the Piura region, within a reach of 100km of distance. This is made possible through the emission of radiofrequency waves from an antenna. These waves impinge on the mass of water precipitated and return a signal towards the antenna which is then processed in the processing cabin and shown on screens, as we are seeing here.

*How is the information registered on the radar during summer rains used?*
The radar’s information is used for the monitoring of precipitation occurring during the rainy season in our region, which is determined with a high resolution in time and space, in such a way that it is possible to distinguish the geographical location of the precipitation, be it district, basin, or micro-basin.

*Does this radar belong to an international network?*
The University of Piura’s rain radar is part of a chain of rain radars which have been installed in the south of Ecuador and in the north of Peru, and which are currently functioning simultaneously, in a synchronised manner.

*What is the importance of the radar for the international scientific community?*
For the international scientific community, the observations being made with this rain radar are very important because it is the first time these are being made with such a high resolution in space and time.

*This rain radar is the first of its kind working permanently in Peru. It can be used as an early warning system, it is useful for ecoclimatic research, and it helps the agriculture of Piura, the region most impacted by El Niño.*

*It is co-financed by Innóvate Perú, in collaboration with Petroperú, the Peruvian Association of Producers and Exporters of Mango (Asociación Peruana de Productores y Exportadores de Mango, APEM), and the University of Marburg (Germany).*

**What have we learnt from Dr Rodriguez?**

1. Rain radars work by emitting waves which bounce off water, as shown in the image on the left. When these waves hit the water, they return to the radar which then collects information about quantity, place, and time.
2. These radars are therefore very accurate for determining the time and place of measures of precipitation.
3. This radar is part of a network of radars which work together to collect regional data.

**Why are rain radars useful?**

1. They can be used for early warning systems. This means they can detect when rainfall is above average and can warn people about potential floods before they occur.

2. Measures of rainfall can help with ecoclimatic research, to study the environment and the climate of the area.
3. Information of rainfall can also help with agricultural production, for example indicating when there may be water shortages or excess.

**2. Layers of evidence: cores and sediments**

| **Video** |
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| *This video is from the University of Utrecht, which shows palaeoecologist Dr Timme Donders gathering core samples from a mountain lake in Ecuador to study the El Niño phenomenon.* |

**The coring process**

The video showed us how mud collected from lakes – known as cores – can indicate when an El Niño event has happened. This graphic shows us how scientists go about collecting cores from a lake.

Over time, river discharge and flood sediments enter the lake, settling at the bottom.

Scientists then ride out onto the lake, dropping a corer – an instrument which collects the sediment, into the water. This corer collects a core – a 90cm long sample of different sediment layers, from the bottom of the lake. This is known as gravity coring.

Once collected, scientists take the cores back to a laboratory to analyse them. They pick apart different sediment layers by looking at the particles in each of these.

**Lake cores**

El Niño events can be read from the mud cores in two ways:

1. The quantity and type of sediment will indicate when floods transport sediment from other areas into the lake, so larger layers with unusual sediment types may indicate a flooding event.
2. This sediment carries many biological indicators of floods which reveal ecosystem conditions. These can include pollen which indicates vegetation in the area or species of fish present in the lake. This is particularly indicative in areas where the lakes created by El Niño events are temporary, where the presence of fish can be directly related to a flooding event.

**(Advanced) Deeper lake sediments: sub-bottom profiling**

Sub-bottom profiling is used to access deeper sediment layers that are not reachable through coring.

A *profiler* is a machine which emits waves to collect information about these deeper sediment layers. It is kept on a boat on top of the water, and travels around the lake to collect the data – for example, the pathways shown in the bottom left image. The waves hit the sediment and are bounced back to the profiler, which then gathers information about the thickness and components of the layers. It recreates an image of the sediments that looks like the bottom right image.

**Sediment layers**

In the same way, other sediment layers that accumulate on landscapes also indicate the movement of soil that is transported during floods, carrying natural indicators of flooding events.

Floods can be read through the increased amount of sediment deposited and by looking at the composition of the sediment, where the breakdown of different soil types or organisms within can indicate larger volumes of water or show where it travelled from.

**3. Tree rings**

These vary depending on external conditions, providing information about the climate at the time of growth, such as temperature, whether it was a dry or rainy season, or even indications of forest fires.

These environmental indicators can be dated, as each tree ring indicates the growth of a tree over a year.

Thicker rings indicate better growth conditions in terms of water availability and temperature and, in this case, can indicate an El Niño event.

We can see an example of this in the image on the right. Both brackets indicate one year of growth, but the lower one is much larger. From this, we can hypothesise that the larger tree ring growth is related to higher levels of water available, potentially due to flooding.

**4. Geographic Information System (GIS)**

GIS is a form of software which allows you to analyse and visualise geographic data.

An example of this is the use of satellite imagery. In these images, you can see the La Niña lagoon, located in northern Peru. The top image is from February 2017 and the bottom is from March 2017. These images demonstrate how the floods of an El Niño event fill up the lakes temporarily.

**Remote sensing**

One form of GIS is remote sensing, which finds data of the earth's surface from a distance by emitting waves and recording their reflection.

To measure agriculture, we used satellite data about vegetation which tells us how green the surface is. This was done using free online images from a satellite, and then processed through different software to quantify vegetation levels.

**Step 1: Satellite images**

On the right are three satellite images that were downloaded from the Internet for free. They show the same location in northern Peru in August of 2016, 2017, and 2018.

The first image represents the landscape before an El Niño event, the second one is a few months after the flooding, and the third one is a year after an El Niño event.

**Step 2: Analysis**

These images are then run through a software to determine the levels of vegetation in them. The darker greens here represent higher levels of vegetation.

We can see that the second image, right after an El Niño event, shows both more vegetation and higher levels present. However, this does not last as it decreases the following year.

From this, we can determine that El Niño increases vegetation levels in this desert area, benefitting agriculture fields temporarily.

**Altogether now**

Multiple measures create a more accurate picture of the environmental conditions.

It is more accurate because, when put together, you can draw parallels between data calculations which support a hypothesis.

For example, if we think an El Niño event is starting, we can correlate increased rainfall detected with a rain radar with higher levels of vegetation calculated through GIS. This will strengthen the hypothesis that an El Niño event will occur.

These measures can reconstruct past landscapes, explain present ones, or help us to prepare for future ones.

| **Activity** |
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| *Ask the students to summarise the main points learned throughout the lesson before taking them through to the conclusions.* |

**Conclusions**

1. There are many ways to obtain primary data for climate and environmental sciences.
2. To study El Niño, some of these include measures of precipitation; natural records such as lake cores, sediment layers, and tree rings; and remote sensing.
3. When we group the different data, we can piece together the long-term history of El Niño in a specific area.
4. This is useful to predict and prepare for future El Niño events.