

Lessons learnt from the Community Based Adaptation in Africa (CBAA)

## CLIMATE SCIENCE FOR ADAPTATION PRACTICE

**CHRIS JACK AND ANNA TAYLOR**Climate Systems Analysis Group, University of Cape Town (CSAG – UCT) &  
Stockholm Environment Institute (SEI Oxford)

### Introduction

The media is full of talk about climate change, ranging from alarmist apocalyptic stories at the one extreme, through to scandals and scepticism of the very scientific process at the other. The general public, and particularly practitioners, are often left stranded in the middle, in need of information but not sure which voices to listen to or how to navigate through the information minefield.

Here we return to some of the basic principles of climate science, including climate modelling, to consider what has been observed in the past climate, how projections for the future are constructed, and how these can be used or misused.



Monitoring the local temperature is crucial for adjusting forecasts. Climate diaries can support the recording process on farm level.



### Climate Science Basics

The Earth's climate is largely driven by radiation from the sun. The amount of radiation the earth receives from the sun varies through time according to differences in the earth's orbit. Radiation from the sun interacts with the earth's atmosphere, which is made up of a combination of gases. The main components are nitrogen, oxygen and argon, which remain the in same amounts over time and space. There are much smaller components, like carbon dioxide and water vapour, which vary considerably in amount over both space and time, but play an important role in influencing the climate.

The atmosphere:

- reflects some incoming radiation back out into space
- transmits some of the sun's radiation down to the earth's surface
- absorbs radiation coming back out from the earth's surface
- emits some of this radiation back to the surface and some of it back out to space

All this is not happening equally across the surface of the earth at any given time. Differential heating causes air to move, resulting in atmospheric circulation. Hot air rises and moves towards the poles, cool air sinks and moves towards the equator. The earth's rotation and the land mass of the continents complicate things even further. The result is the general circulation patterns that we observe.

The climate has natural variability over many time scales.

Short term variability is the weather that we see day to day, wherever in the world we are. Long term variability takes many forms and is driven by a complex set of processes, for example:

- El Nino and La Nina periods, which correspond with variations in the temperature structure in the Pacific Ocean over a few years
- Ice ages and warm "inter-glacial" periods, which correspond with cyclical variations in the orbit of the earth around the sun over many thousands of years

### **So what about global warming or human-induced climate change?**

Green-house gases (GHGs), like carbon dioxide and methane, are naturally occurring and vary 'naturally' over time and space (i.e. because of things like volcanic eruptions, which humans have little or no influence over). Changes in the amounts of these gases change the way in which radiation from the earth's surface interacts with the atmosphere, which affects the amount of heating that takes place (i.e. the temperature patterns) and the resulting movement of air. However, humans are also doing things that lead to the emission of these gases into the atmosphere, changing the concentrations to what they would otherwise have been. The scale at which this is happening has been rapidly increasing over the last few decades. This has some influence over what happens in the atmosphere and thereby what the climate is... the question is: what influence?

### **Is the planet warming?**

Observational records (measured in a variety of ways) are difficult to work with, but a huge amount of work has been done to validate these records. Paleo-records (measurements of the climate from very long ago) have large uncertainties and are often site specific. BUT, multiple temperature reconstructions using different methods seem to indicate an unprecedented rate of warming in the last 20 to 30 years.

Recent (since 1990) observed warming, measured directly, has been higher than what was projected using models. And sea level rise projections have also consistently fallen short of the levels that have been measured. That's when looking at global averages. Regional scale trends are complex, regionally dependent and difficult to produce because of short-comings in the observational records, like sparse coverage and missing data for various periods of time. Also it's important to remember that trends are statistics, so for example a drying trend in a place doesn't exclude multiple wet years (more rains than 'normal') from occurring in that same place.

### **Can humans really change the earth's temperature?**

That's a valid question! We know that the observed temperature is determined by the balance between the radiation from the sun entering the atmosphere and the Earth's radiation going out. The change in this balance is called "radiative forcing". On average, a positive radiative forcing tends to warm the surface of the Earth while negative forcing tends to cool the surface. Radiative forcing is measured in Watts per square meter ( $W/m^2$ ), which is a measure of energy. Estimates of the radiative forcing caused by human activities vary from 0.6 to  $2.4W/m^2$  (IPCC AR4). The amount of radiation being emitted from the sun varies between 0.06 to  $0.3W/m^2$ . Variations in radiation from the sun do not correspond with late 20th Century warming and



*In arid areas droughts have a serious impact on farmers harvesting rooibos tea as their livelihood strategy.*



*Climate variability and extreme weather events can have a devastating effect on livelihoods*

would not produce the vertical structure of temperature change that has been observed, so the recorded warming can't just be to do with the sun. It's very hard to explain the observed warming without factoring in the GHGs emitted by human activity. So we are confident that GHG emissions caused by human activities have an important part to play... but we don't know everything!

## Climate Modelling

Basically, climate modelling involves converting theories of atmospheric physics, solar radiation, phase state physics, etc., into mathematical formulas that can be solved by a computer. The relevant values are worked out for discrete areas (called grid cells) across the whole world, over a number of time steps. The result is a simulation of the climate – a simplified 'copy' of the climate system, worked out on a computer (so that lots of equations can be included and calculated relatively quickly).

But it's not that easy, in fact it's not easy or simple at all. Not all theories are fully developed or understood. Lots of important processes that affect the climate in a given part of the world happen at scales smaller than the grid cell, like the interaction of air with mountains, the formation and dissipation of clouds, rainfall, etc. All these things are therefore captured in the models by 'parameterisations' (simplified representations), and this is where the major differences between models stem from. The influence of clouds is most likely the biggest source of uncertainty when it comes to projecting the climate.

## Climate Projections

The basic procedure is to take a climate model, run it using actual measured 20th Century GHG concentrations, and

compare the results with the observed 20th Century climate, in order to establish what biases the model has built into it (as a result of the way things are parameterized). Then run the climate model using projections of future GHG concentrations (linked to scenarios of how development will take place). Compare the results for future climate with those simulated for the 20th Century, to calculate the differences or 'anomalies' (the amount of expected change). This expected change can then be added onto the current observed climate.

But there are lots of climate models out there, developed by different research groups around the world, which one is best to use? If a model is good at simulating the 20th century, is it accurate for the future? All models have strengths and weaknesses associated with them, and represent some aspects of the climate better than others. For this reason it's worth reviewing the outputs from a range of models when considering what the climate might be doing in your area of interest, and don't forget that each model has certain biases built in. If the models disagree about the kind of changes expected for a certain area, it's important to consider why. The reality is however, that in most cases, the model resolution (the area for which it gives one result) is not very useful for answering people's pressing questions on the ground.

## Downscaling

The climate in a specific place is a function of large scale climate state and local drivers, like features in the surface of the landscape (e.g. mountains), the land cover (e.g. forest versus cereal crop versus concrete), and the interactions with any large bodies of water nearby. Downscaling is an effort to determine the local response to a large scale climate state for a given location. There are two main types of downscaling, each with different strengths and weaknesses. Dynamical



downscaling, which uses a limited area model to simulate the physical processes at the regional scale, captures local feedbacks but is difficult to validate. Statistical downscaling (sometimes called empirical downscaling), which uses statistically derived relationships that describe the local scale response to the large scale climate state, doesn't have built in biases but doesn't capture extreme conditions well.

When trying to develop a picture of what the climate is doing and might do in the future for a given place, it is important to combine many sources of relevant information. Firstly make sure that you have some clear questions in mind, and that climate models are suitable tools for trying to answer those questions. If so, it is advisable to look at the outputs from a number of global climate models, as many as possible, bearing in mind that each one produces an answer, not the answer. Look at an analysis of observed historical data from your area of focus, and then at downscaled projections (keeping in mind the strengths and weaknesses of the different methods used to do the downscaling). Be careful and considered about what conclusions you can confidently draw in order to take a decision.

### Seasonal forecasting

One specific use of some climate models is to generate a forecast of what we might expect the conditions to be like in the next season, the coming 3 months. Alternatively these forecasts can also be generated using statistical methods. Seasonal forecasts however, are often not very good, because not all of the regional and local processes influencing the climate are well understood and/or represented in the model. Models tend to be better at capturing longer term and larger scale changes in the climate.



*The management and monitoring of water resources should go hand in hand with climate monitoring*



*A weather station in the Suid Bokkeveld: involving farmers in monitoring the climate and discussing strategies*



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Nieuwoudtville, South Africa

info@indigo-dc.org

www.indigo-dc.org