# Alterations in Amazonia

**Drs Bart Kruijt** and **Carlos Nobre** are coordinators of a new research project which aims to forecast the effects of deforestation and climate changes in Amazonia over the coming decades and develop an Early Warning System concept for detecting substantial and irreversible losses

**To begin, can you outline the main research objectives of the AMAZALERT project?**

AMAZALERT is examining how global and regional climate change, deforestation and other land use changes will have an impact on Amazonia and how these impacts feed back to the climate. Models of the processes involved will be improved and stakeholders will participate in generating scenarios for Amazonia's future, including consideration of necessary policies and their implementation. Finally, bringing all this information together, we aim to develop a blueprint for an 'Early Warning System' to detect early signs of tipping points involving loss of Amazonian ecosystem services and degradation of its forests.

**How do you plan to model or measure anthropogenic effects on land use and land cover change?**

AMAZALERT will project several future scenarios for land-use change, based upon a range of socioeconomic scenarios running up to 2050. For the forthcoming decade or two, these scenarios will be developed based upon the views of stakeholders from the region, and will serve as input into a land use change model. We include important drivers such as road construction, (inter)national demand for agricultural products, and land tenure in our study. Additionally, we will study the effect of planned or possible hydropower dams and new water ways, in combination with climate change, on river discharge and navigability.

**The project proposes an Early Warning System for detecting loss of Amazon ecosystem services. How do you intend to develop this and what would the applications of this system be?**

We intend to develop a blueprint of what an Early Warning System could look like. We aim to develop both a theoretical framework and tools that help to detect irreversible loss or early warning signals of loss. We will also develop a plan for bringing together indicators from climate observations, river conditions, state of the forests and socioeconomic metrics. Such a system would enable policy makers to be reliably alerted if and when Amazonia, or substantial areas in the region are heading towards big changes.

**You are closely linked with other research projects such as ROBIN (see p83), which explores the role of biodiversity in climate change mitigation. How does this research link in with your own research into the future of the Amazon in a changing climate?**

ROBIN covers not only Amazonia, but Central America as well, and its focus is more on biodiversity. The insights provided by ROBIN on the drivers and consequences of land use changes will be highly complementary to AMAZALERT because their focus will be on smaller-scale interactions but over a larger study area. Elucidating the role of forests and biodiversity in, particularly, climate change mitigation will help the assessments of degradation risk by

AMAZALERT, and vice versa. Finally, we hope to be able to link in the role of biodiversity in resilience towards irreversible changes in the Amazon system, addressing an additional factor in the complex climate-vegetation-people-waters system that may or may not contribute to non-linear and abrupt change.

**Have you faced any major challenges over the course of the research? Is there anything that you foresee as an on going challenge in the research and if so how do you aim to approach this?**

It will be a complex task to couple the results of climate, vegetation, and hydrology models and scenarios from stakeholder workshops, and to distil from this the patterns and causes that point to forest degradation. To identify potential tipping points in these patterns will be the ongoing challenge, which is why we do not aim to actually build an early-warning system but merely to design a blueprint for this.

**The project is still in its early stages. Have you made any important findings in the research so far?**

From the onset of the project, we have investigated which ecosystem services of the Amazon region are considered most significant, including the opinion of a large range of stakeholders. We therefore already have a good insight into which are the most important functions and services, which we should consider in our studies.

# AMAZALERT

An international collaboration of scientists and researchers is embarking on **AMAZALERT** – an ambitious project which is investigating critical feedbacks between climate and long-term land use change in the Amazon

**AMAZONIA IS ONE** of the world's greatest natural resources, performing several important functions, including representing a major stock and buffer for global carbon and carbon dioxide, maintaining the regional water cycle, affecting global climate and biodiversity. These functions help to conserve important resources for the Amazonian people and the economy: soils, rainfall, natural flooding regime, hydropower and waterways.

Amazonia is under threat in two main ways: deforestation and climate change. In the Brazilian Amazon, deforestation rates are currently rapidly decreasing as a consequence of many factors including rigorous governance, voluntary moratoria on land use such as soy bean expansion and, to a lesser extent, the global economic crisis. Government ambitions are to reduce deforestation by 80 per cent by 2020, but it is not certain what the impacts will be of new legislation such as the Brazilian forest code, or possible adoption of the international Reducing Emissions from Deforestation and Forest Degradation (REDD+) mechanism. Research shows that the main factors that drive deforestation rates outside protected areas are the demands from and availability of markets for agricultural, bio-energy or mining products, and infrastructure such as roads and hydropower. An agricultural policy to put sustainable intensification as a top priority, even though there are more than 750,000 $km^2$ already deforested with much less than optimal agricultural productivity.

Furthermore, some model simulations have suggested that under scenarios of continued climate change (more than 3.5 °C warming) and extensive deforestation (more than 40 per cent) the forests of the Amazon may be vulnerable to some form of dieback, the exact nature of which is uncertain. Models suggest that forests may possibly degrade into savannah-like ecosystems, but the sensitivity of forests strongly varies and also depends on the presence of fire.

## TRANS-ATLANTIC RESEARCH COMMUNITY

Now, scientists from 14 European and South American research institutes are undertaking an ambitious research project called AMAZALERT to examine how likely these predictions are, and to improve the ability to forecast where and when changes may occur and how big they may be. Coordinated by Dr Bart Kruijt at Wageningen University and Research Centre in The Netherlands, and Dr Carlos Nobre at the Ministry of Science, Technology and Innovation of Brazil, AMAZALERT brings together three leading global climate modelling institutions; four leading dynamic vegetation and hydrology modelling groups; first-hand knowledge and expertise on developing land use change scenarios; and strong expertise on policy analysis.

AMAZALERT is also closely linked with other research projects such as ROBIN (see p83), which is focused on investigating the mitigating role of biodiversity in relation to climate change in Latin America, and whose research will complement that of AMAZALERT. The collaborative combination is necessary to develop an integral view on the likelihood of irreversible changes in the Amazon. The project is developing a strong, trans-Atlantic research community that is uniquely positioned to tackle

# AMAZALERT

## OBJECTIVES

To provide better understanding of the linked processes that drive changes, to reduce uncertainties in predictions, and to lay the groundwork for an Early Warning System.

## PARTNERS

**Dorian Frieden**, Joanneum Research, Austria • **Tim Baker**, University of Leeds, UK • **Philippe Ciais**, French National Centre for Scientific Research, France • **Han Dolman**, Association for Christian Higher Education Research and Patient Care, The Netherlands • **Patrick Meir**, The University of Edinburgh, UK • **Gillian Kay**, Met Office, UK • **Hans Verbeeck**, Ghent University, Belgium • **Kirsten Thonicke**, Potsdam Institute for Climate Impact Research, Germany • **Kasper Kok**, ALTERRA, The Netherlands • **Celso von Randow**, National Institute for Space Research (INPE), Brazil • **Mateus Batistella**, Brazilian Enterprise for Agricultural Research (EMBRAPA), Brazil • **Humberto Rocha**, The University of São Paulo, Brazil • **Germán Poveda**, National University of Colombia, Colombia • **Daniel Larrea**, Friends of Nature Foundation, Bolivia

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**DR BART KRUIJT** has long-term experience researching the functioning of forests in Amazonia and elsewhere. He previously led research concerned with the quantification of the rainforests' carbon cycle and interactions with the atmosphere.

**DR CARLOS NOBRE** obtained his PhD in meteorology from MIT. For almost 30 years, he has been involved with Amazonian science and has participated in many field experiments in that region, studying local, regional and global impacts of Amazonian deforestation based on observations and modelling.

these complex, international environmental problems and the team hopes that this will enable their work to have a maximum impact on European climate goals and international and South American sustainable development strategies, including REDD+.

## CHANGE IN AMAZONIA

The AMAZALERT team is analysing uncertainties in biogeochemistry, land cover (vegetation), land use change and regional hydrology, as well as nonlinear responses and feedbacks, using models in which land surface is coupled to global climate. The way in which policies and possible future response strategies of policy makers, trade and economy will affect land use change will also be modelled. Kruijt explains that there are many potential feedbacks and unexpected side effects of changes in vegetation, climate and socioeconomic developments: "Such complex interactions carry the risk of tipping points in Amazonia, and it is these risks that AMAZALERT aims to quantify through integrated analysis".

The researchers are using detailed climate simulation results from three of the best available global climate models: the UK Hadley Centre's newest climate and Earth system model; the new Brazilian global climate model at Brazilian Institute for Space Research (INPE); and the climate model, run by the French National Centre for Scientific Research. Although these are state-of-the-art simulations, which have been cross-validated and compared to a suite of other similar climate models, the outputs are only as accurate as the information that is currently available on the Amazonian climate and forests. Therefore, AMAZALERT is also aiming to reduce inaccuracies through new model validation and development, focusing particularly on the land surface and vegetation components of the models using existing data sets. They also plan to improve vegetation models through collecting new field data on the sensitivity of the forests to temperature and drought conditions, and are developing an integrated simulation of forest fire sensitivity: "We know that the future of the forests also crucially depends on whether their growth will be stimulated by increasing atmospheric carbon dioxide, and we are investigating how we can better quantify this effect," Kruijt adds.

## DEVELOPING POLICY RESPONSES

AMAZALERT is in its early stages, but the team has already made a good start by establishing the state of the art in the climate and vegetation models they are using, and defining a range of scenarios for socioeconomic development in Amazonia. An upcoming challenge for the project is to involve stakeholders in developing land use change scenarios through working with communities in the areas they are studying. The project will interact in particular with stakeholders at institutional and municipality level to collect information on likely socioeconomic developments and deforestation scenarios. These groups will work jointly in interactive workshops to develop views on the future, including information about how people will respond to climate and forest changes as predicted by the AMAZALERT models. This will allow the researchers to study some degree of feedback in socioeconomic processes as well.

One of the groups main aims is to propose an 'Early Warning System' for detecting any imminent irreversible loss of Amazon ecosystem functions together with policy response strategies to prevent such loss. The team is therefore keen for decision makers to take their findings into account and these will be involved in the stakeholder-based scenario development as much as possible. This process means that they will be provided with first-hand information on the results of AMAZALERT, whilst informing the project about likely policy responses to regional environmental change as forecasted by the AMAZALERT models. Kruijt is hopeful about the outcomes: "If, at the end of the project, we have a clear idea about the likelihood of Amazonian tipping points and the effectiveness of policies, we will have succeeded," he states.

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