AGROMETEOROLOGICAL RESEARCH AND APPLICATIONS NEEDED TO PREPARE AGRICULTURE AND FORESTRY TO 21ST CENTURY CLIMATE CHANGE

VICTORINE PERARNAUD¹, BERNARD SEGUIN², ERIC MALEZIEUX³, MICHEL DEQUE⁴ and DENIS LOUSTAU⁵

¹Météo-France-Direction de la Production, 42 avenue Coriolis, 31057 Toulouse, Cedex, France
E-mail: victorine.perarnaud@meteo.fr

²Institut National de Recherche Agronomique, Unité Agroclim Site Agroparc, domaine St-Paul, 84914 Avignon, Cedex 9, France
E-mail: seguin@avignon.inra.fr

³Centre de Coopération Internationale en Recherche Agronomique pour le Développement, Cirad-DS, TA 179/01, avenue Agropolis, 34398 Montpellier, Cedex 5, France
E-mail: malezieux@cirad.fr

⁴Météo-France- Centre National de Recherches Météorologiques, 42 avenue Coriolis, 31057 Toulouse, Cedex, France
E-mail: michel.deque@meteo.fr

⁵Institut National de Recherche Agronomique, Recherches Forestières, BP 45, 33611 Gazinet, France
E-mail: Denis.Loustau@pierroton.inra.fr

Abstract. The adaptation of agriculture and forestry to the climate of the twenty-first century supposes that research projects will be conducted cooperatively between meteorologists, agronomists, soil scientists, hydrologists, and modellers. To prepare for it, it is appropriate first of all to study the variations in the climate of the past using extensive, homogenised series of meteorological or phenological data. General circulation models constitute the basic tool in order to predict future changes in climate. They will be improved, and the regionalisation techniques used for downscaling climate predictions will also be made more efficient. Crop simulation models using input data from the general circulation models applied at the regional level ought to be the favoured tools to allow the extrapolation of the major trends on yield, consumption of water, fertilisers, pesticides, the environment and rural development. For this, they have to be validated according to the available agronomical data, particularly the available phenological series on cultivated crops. In addition, climate change would have impact on crop diseases and parasites, as well as on weeds. Very few studies have been carried out in this field. It is also necessary to quantify in a more accurate way the stocks and fluxes of carbon in large forest ecosystems, simulate their future, and assess the vulnerability of the various forest species to a change in climate. This is all the more important in that some propagate species choices must be made in the course of the next ten years in plantations which will experience changed climate. More broadly speaking, we shall have not only to try hard to research new agricultural and forestry practices which will reduce greenhouse gas emissions or promote the storage of carbon, but it will also be indispensable to prepare the adaptation of numerous rural communities for the climate change (with special reference to least developed countries in tropical areas, where malnutrition is a common threat). This can be accomplished with a series of new environmental management practices suited to the new climatic order.
1. Introduction

To prepare agriculture and forestry for the climatic change forecast for the twenty-first century, particular efforts must be made in research, based on the knowledge on climate data currently available, for the development of the most up to date applied management techniques. This development must be accompanied by efforts in agronomic research which take climatic change into account for research in plant genetic improvement and development of sustainable cropping systems to attain operational applications for adaptation strategies. It then becomes indispensable to single out two ways of adaptation depending on the final user: those which can be implemented by the farmer (for example modification of sowing dates, varietal choice or use of seasonal forecasts) and those of decision-makers (e.g. land and natural resource managers) which necessitate investment in infrastructures (particularly water resource projects). Thus, in operational terms, the results of research will have to contribute to the implementation of durable construction and management options which enable the adaptation of agrosystems and forest ecosystems to climate change. This will include identification of sensitive areas, choice of new crops, understanding mechanism of species replacement, calculation of future water needs and collection, visualisation of geographical species area and potential changes in impact of pests and diseases.

To the scientific and technical problems raised by adapting agriculture and forestry to climatic variability and change must also be added socio-economic considerations which will not be covered in this article but which will have to be borne in mind. Hence, any significant modification in local production will necessarily affect the global organisation of markets and economic and social systems. Conversely, agriculture and forestry are likely to make a significant contribution to climatic change dynamics through the emission of greenhouse gases (GHG) or, on the contrary, the storage of CO₂. The combination of these elements will be analysed in the text below, supported equally by climatic research in relation to agricultural and forestry production issues.

Our arguments will rely principally upon examples relating to France, a temperate region, but we have tried to extend their scope by broadening our considerations to semi-arid and tropical zones. In these areas, the precariousness of ecological and social systems combined with the impact of climate change is likely to have a major effect on the productivity and balance of cultivated ecosystems (reduction of biodiversity due to an increased drought, irreversible erosion of land linked to flooding). This may lead in some cases to the migration of human populations if food safety is affected. Indeed, even though the simulations show a higher elevation of temperature in polar and temperate latitudes, in relation to the tropical latitudes, tropical crops are today much closer to their thermal optimum and hence more likely to suffer from thermal excesses in the future. Insects and diseases, already very active in tropical zones, could proliferate and widen their area of influence. The combination of these factors, to which must be added the dependence of less developed