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CLARIS NEWS

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A Europe-South America Network for Climate Change Assessment and Impact Studies

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EDITORIAL

Officially started in July 2004 for a 3-year period, the CLARIS project had for objectives to create a European-South American Network to address issues related to climate change in South America, to examine the feasibility of addressing climate change impacts on society and to define a set of research priorities for the region in the future. At the end of these 3 years, all the project objectives have been complied.

First, many studies on climate change in South America have been published by colleagues from the network. Indeed, the network has been effective in analysing the IPCC simulations in order to describe and understand the potential changes in the climate mean state and variability during the 21st century. Different methods have converged to very similar conclusions describing a clear increase in temperature over the entire continent (larger in the tropics than in the southern tip of the continent) and two « robust » signals in precipitation (increase in precipitation over La Plata Basin and decrease over Chile and the Andes). Moreover, a continuous effort has been made to gather daily weather stations with long historical records, realize systematic consistency checks and thus provide the CLARIS network with a set of quality-controlled daily data of major importance for extreme event studies and regional model validation. Also, for the first time in South America, different groups with expertise in dynamical downscaling have coordinated their efforts to perform similar simulations and analyse the skill of such models in simulating extreme events or interannual variability (ENSO teleconnections) in the region. Many of these results have been possible thanks to the creation and development of a CLARIS Data Archive Centre.

Second, CLARIS gathered three pilot impact projects related to climate change and pollution in megacities, Dengue epidemics or agriculture. All have demonstrated a clear impact of climate change. Especially, the regions of Dengue epidemics risk will clearly expand poleward in the future, and a risk of Dengue epidemics in Buenos Aires in the future cannot be excluded. Also, another objective was to evaluate the existence of simple (low cost) adaptation strategies for agriculture in three sites in Argentina. The conclusions highlight the sensitivity of the results to the climate scenario used to compute future yields. Indeed, the changes in the water balance resulting from changes in both precipitation and temperature can vary considerably for small changes in one of the two variables. This result demonstrates that various adaptation strategies must be proposed based on a set of possible scenarios (at least three: worst, median, best) associated to their probability of occurrence based on the IPCC model projections.

Finally, all our results led us to define new priorities of research related to climate change and impact issues (agriculture and hydrology). All these priorities are presented in the CLARIS LPB (La Plata Basin) project accepted by the European Commission in the 7th Programme Framework. The project will start in 2008 and will allow to address more in depth the physics of climate change, its consequences in terms of extremes, to provide an estimate of how decadal variability and climate change trends will interact in the region and to design adaptation strategies for specific issues related to agriculture (yields, biofuels, rural development) and hydrology (hydropower production, sediments, biodiversity in wetlands).

The CLARIS LPB project will strongly contribute to the international dynamics led by the CLIVAR/VAMOS LPB Programme and interact with other projects of IAI, GEF,… on La Plata Basin climate change and impact issues.

To conclude, I would like to specially thank all the colleagues of the CLARIS Project for making it such a success and welcome all the new colleagues participating in CLARIS LPB, with whom we will tackle motivating objectives.

Jean-Philippe Boulanger

The key objective of CLARIS was to create a network of cooperation between South American and European scientists with focus on climate change assessment and applications over South America. One of the main tools that guide us in the study of the relevant physical processes and the prediction of climate evolution and impacts are climate models. Climate models are powerful tools that accumulate long term scientific development at several first class research centres. Yet, when confronted with the monumental task of climate prediction, they regularly give conflicting views. The multi-model approach helps quantify these uncertainties based on the spread among models and thus gives an objective measure of their reliability. In this spirit, CLARIS partners performed a set of analysis projects based on the partner models and the IPCC AR4 modelling effort.

Quality of climate simulations largely depends on the models ability to capture the evolution of the slower components of the climate system (ocean, land-vegetation, ice). Given that El Niño – Southern Oscillation is a dominant mode of global climate variability and its influence on southeastern South America is well known, the evolution of simulated Niño 3 Index for current and future climates was analyzed for partner models. The difference between 2070-2100 sresA1B scenario and the 1971-2000 model climatology show a mean warming of approximately 2.7˚C for both MPI and IPSL and 2.3˚C for INGV. However, seasonal distribution of the warming is model dependent, it tends to smooth the already weak IPSL annual cycle (rendering it even weaker) and tends to accentuate it in the INGV and MPI simulations (Figure 1). Not surprisingly, a trend component dominates in all sresA1B simulations while the dominant frequencies and explained variance (once the trend components is removed), remain essentially the same as the ones obtained for the 20th century for each model.

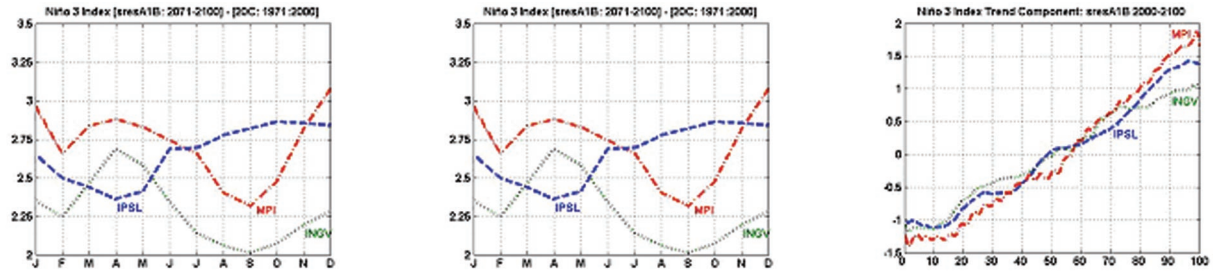


Figure 1: Observed and simulated annual cycle of Niño 3 Index for the present climate, change in the annual cycle in SRESA1B scenario and trend components, as given by Singular Spectral Analysis, for each of the models

Precipitation and temperature are the main variables of interest for climate applications (health, agriculture, water resources) and are usually required at very high spatial and temporal resolution in order to be able to evaluate the impact of climate change. Global models are not capable of directly generating reliable information at those scales and usually model data is first downscaled to the needs of the particular application. Global models performance in the present climate is, instead, evaluated based on a set of key features of South American climate that were identified at the beginning of the project: SST in surrounding oceans and mean annual circulation, low-level moisture fluxes advected into the South American continent, Southern Hemisphere low level variability modes, intrasesonal and synoptic scale patterns of variability. These same aspects are also used to describe regional climate change for various scenarios.

A subset of climate simulations of the 20th century from the IPCC-AR4 was analyzed with the aim to assess the ability of these models to reproduce the observed climatological seasonal

precipitation in South America during the period 1970-1999. Results show that models are able to reproduce the main features of the precipitation seasonal cycle over South America, although the precipitation in the SACZ region and the precipitation maximum over Southeastern South America (SESA) observed during the cold season are not well represented.

The analysis of the leading patterns of the Southern Hemisphere (SH) circulation variability from observations and model simulations shows that all models are able to reproduce the first leading pattern resembling the Southern Annular Mode (SAM), but only some of the models can reproduce Pacific South America (PSA)-like structures associated with the second and third leading patterns. It is known that precipitation year-to-year variability over extensive regions of South America experiences significant modulation by ENSO as well as by the SAM or Antarctic Oscillation. Therefore, the signature of both ENSO and SAM onto the variability of both the atmospheric circulation in the SH and the precipitation in South America was also analyzed. All models are able to represent a SAM-like structure as the leading pattern of circulation variability. Nevertheless, considerable dispersion was found among model outputs regarding the ENSO teleconnection patterns. The analysis revealed that few models are able to represent in some extent the ENSO (Figure 2) and SAM signature observed in South America hydroclimate.

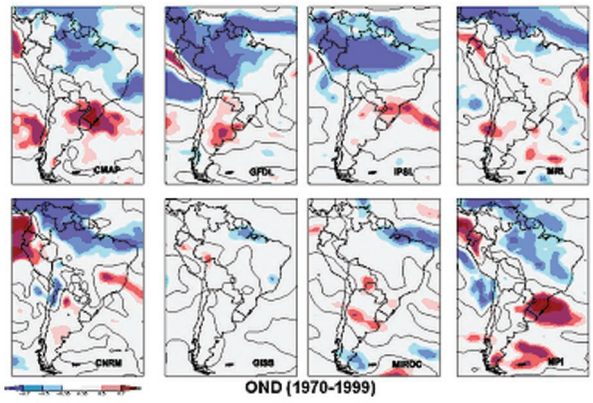


Figure 2: Correlation Maps between ENSO index (SST anomalies at EN3.4) and OND precipitation anomalies in South America for observations (CMAP, top left) and climate models

Some of the previous results have pointed to discrepancies among models or model shortcomings in reproducing the present climate. However, it interesting to highlight a considerable agreement among models in predicting the patterns of change in precipitation over South America for the SRESA2 scenario as compared to present climate. Figure 3 shows that, qualitatively, models mainly agree on the patters of change in the precipitation field. Moreover, the patterns depicted also resemble the observed recent trends in precipitation during the last decades, which suggest that the latter might be related to greenhouse forcing.

If we examine the seasonal cycle of precipitation change, there is a generalized consensus among models that the projected changes are mainly: i) an increase of summer precipitation over southeastern subtropical South America; ii) a reduction of winter precipitation over most of the continent; and iii) reduction of precipitation during the four seasons along the southern Andes.

The response of the SAM to increasing greenhouse gases (GHG) forcing was analyzed from a multi-model ensemble of simulations conducted in the framework of the IPCC AR4. Results confirms that the climate change signal in the mid- to high southern latitudes projects strongly into the positive phase of the SAM. Over the present climate time slice (1970-1999), multi-model ensemble mean reproduce the regional warming around the Antarctic Peninsula associated with the SAM. When increasing GHG (future time slice, 2070-2099), warming in the neighborhoods of

the Antarctic Peninsula and decreasing sea-ice volume in the sea-ice edge region in the Amundsen and Weddell Seas intensifies, suggesting that recent observed sea-ice trends around Antarctic Peninsula could be associated to anthropogenic forcing.

We also studied the extent to which the SAM is linked to the extreme events, assessing if the climate extremes provided by the AR4 coupled models are sensitive to the SAM and examining the projections of these extremes for the end of the 21st century for the SRES A1B scenario (period 2070-2099). We only present results related to Fd, the total number of frost days, defined as the total number of days per year with absolute minimum temperature below 0ºC. Results show significant correlations between variations in the SAM and variation in the Fd in some areas of the Southern Ocean, seemingly because changes in the SAM are associated with changes in the location and intensity of the meridional flow. The multimodel ensemble qualitatively agrees with the observed pattern for the recent decades of the 20th century of a reduced severity in temperature minima over the Antarctic Peninsula region associated with the trend in the SAM toward its high index polarity. Over South America, the number of frost days during the present

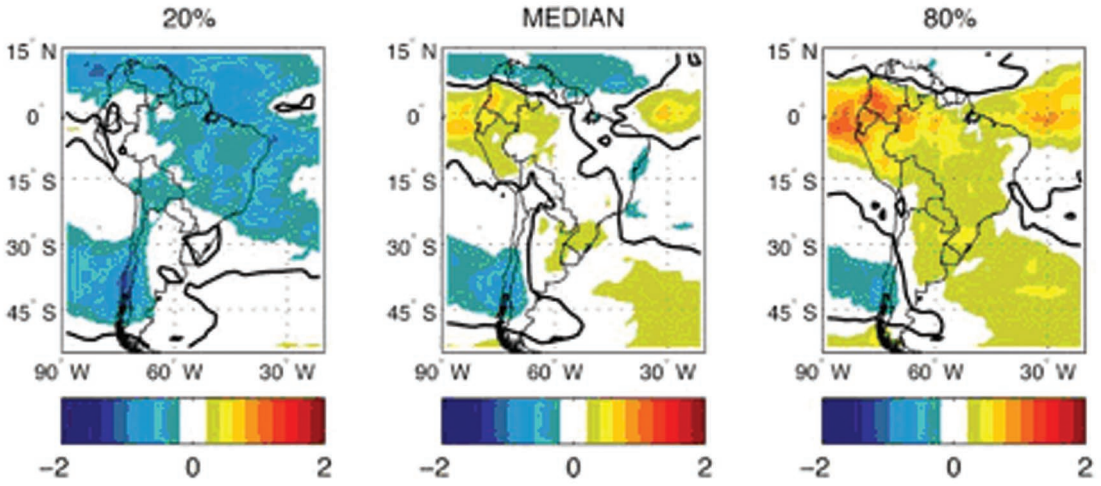


Figure 3: Mean annual precipitation changes (mm/day) between the periods 2081-2100 (SRES A2) and 1981-2000 (20c3m) based on the IPCC-AR4 ensemble. 20%, 50% and 80% cumulative probability changes are presented

climate seems to be related to the SAM along the Andes between about 20ºS and 40ºS and over central Argentina, with more frost days occurring when positive phase dominates. Associated with general increases of temperatures, in the future climate the number of frost days diminish almost everywhere, and consistently the magnitude of the differences in Fd between the positive and negative phases of the SAM is reduced (right panel of Figure 4). Finally, note that southern Patagonia is a region that shows a decrease in frost days associated with the positive phase of the SAM during both time slices.

Moving to the analysis of higher frequencies variability, the most distinctive feature that characterizes rainfall summer variability on intraseasonal timescales over South America is a dipolar pattern known as the South American Seesaw (SASS). Enhanced precipitation over the subtropics is associated with southward intensification in the South American Low Level Jet (SALLJ) and increased moisture flux from the Amazon region, while in the opposite phase of shows an enhancement in the South American Convergence Zone (SACZ). The dipolar pattern exhibits variability associated with the Madden-Julian Oscillation with periods of 30-60 days, and also on timescales around 22-28 days. The ability of 20th-century simulations of the WCRP/CMIP3 models (GFDL and MPI runs 1 and 4) to reproduce the main features of the SASS was assessed for the summers in the period 1979-1999. Simulations were compared with a climatology consisting of NCEP/NCAR's Reanalysis and NOAA's Interpolated OLR. Models are able to

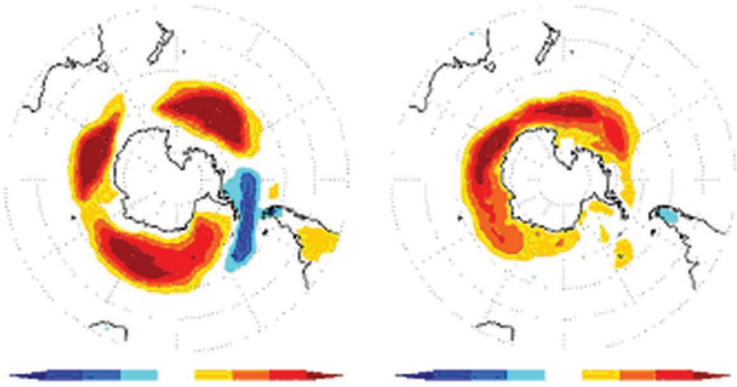


Figure 4: Composite patterns of Fd (days) during years with strong SAM positive phase minus Fd during years with strong SAM negative phase for 1970-1999 (le. panel) and 2070-2099 (right panel)

reproduce the main features of the intraseasonal variability in South America during summer. The regions of maximum variability are well represented though the models show some deficiencies in depicting the variability associated with the SACZ. Rossby-like wavetrains characterize the large-scale circulation anomalies associated with the SASS variability in both observations and simulations with some differences in the associated wavelength and anomaly life cycles. The low-level-circulation anomalies in South America, as well as the corresponding divergence patterns associated with the SASS are present in the simulations. Nevertheless, the convergence areas at subtropical regions are misplaced and stronger than the observed ones.

Additionally, the intraseasonal variability depicted by the 21st-century simulations of the WCRP/CMIP3 models was explored for the summers within 2081-2100 and emissions scenario SRESA1B. The differences between future and present climate simulations show a general decrease of the variance on intra-seasonal timescales with no significant changes in the SASS pattern and weaker associated convergence/divergence in the regional low-level circulation. While the convection anomalies in the tropical Pacific are stronger in the SRES A1B scenario, there are no clear changes in the Rossby-like circulation anomalies related with the SASS.

The changes and atmospheric circulation and moisture budget for the South American Monsoon region (SAM) [60-40W, 5-20S], and Southeast South America (SESA) [60-50W, 23-35S], as induced by anthropogenic climate change (sresA2 scenario), were also investigated based on nine coupled climate model IPCC AR4 simulations. The period 1970-2000 was analyzed and compared against observations. Analysis of future climate was performed by computing the difference between the 2070-2100 and 1970-2000 periods. There is a general agreement of decreased precipitation during October-November -the period of Monsoon onset- in SAM (6 out of 9 models) and a simultaneous increase in SESA (7 out of 9). Along with the precipitation changes, there is an increase in the vertically integrated moisture transport (VIMT) convergence over the SESA region and a slight decrease in VIMT convergence over SAM. These changes can be explained by a southward shift of the South Atlantic subtropical high, a feature that is also simulated by the models.

Another objective of CLARIS network was to facilitate the transfer of technical and scientific know-how in the field to enable partners to address the specific climate complexities of the region. In this context a training activity on practical applications for climate variability studies was conducted for scientist and graduate students from the South American laboratories. The training activities were based on MATLAB (MATrix LABoratory) applications. MATLAB is a high-level language and interactive environment that enables to perform computationally intensive tasks faster than with traditional programming languages, providing an extraordinary tool to conduct analysis of climatological datasets.

The Objectives of the CLARIS DataServer are:

- to validate the large-scale models participating to CLARIS over the SA area.
- to provide a set of agreed forcing conditions for the CLARIS regional models.
- to allow the intercomparison of regional simulations performed during CLARIS.
- to provide the data necessary for impact studies.
- to provide a shared access to project results for all participants.

The main objective was to keep the DataServer updated according to data requests from partners. To realize these objectives it was necessary to continuously define standards and to maintain contact with partners to define and to fix aspects as to the format and contents of the archives for later use by the participants. For that reason, as was defined the files stored in DataServer was NetCDF. The system consists of a RAID system (Xserve and XRaid from Apple) and one INTEL Server. There were important definitions during the project to carry on with the WP2.2 work like the following:

Localization of the CLARIS DataServer: The CLARIS DataServer is physically located at CIMA. URL: http://www.claris-eu.org

Network Common Data Form: The files are stored in the dataserver in NetCDF format whenever it is possible. NetCDF is a machine-independent, self-describing and very popular file format for scientific data.

DODS Service installed on CLARIS DataServer : The DODS server is a stable, secure, easy to use, and easy to configure system that provides subsetting and analysis services across a network. It eliminates the need for a client software to download large datasets when it only needs small amount of data. Instead, the operation is performed on the server, and the small amount of requested data is transferred over the network.
URL: http://www.claris-eu.org

Live Access Server (LAS): Highly configurable Web server designed to provide flexible access to geo-referenced scientific data. It can present distributed data sets as a unified virtual database through the DODS networking. Ferret is the default visualization application used by LAS, though other applications Matlab, IDL, GrADS can also be used.

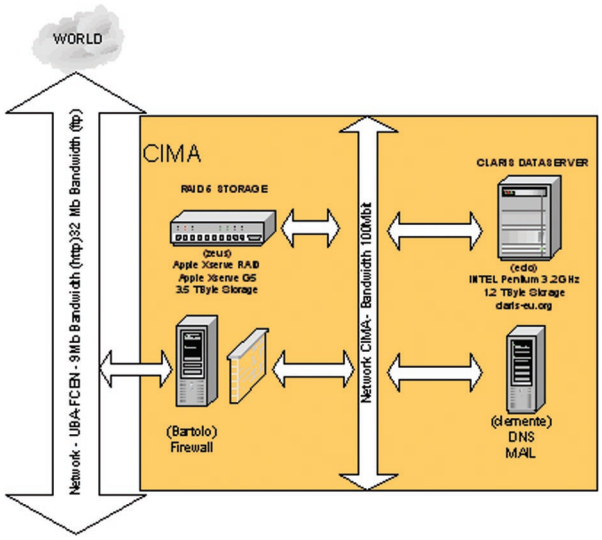
Wiki page: It is a collaborative web service to provide an easy to use tool for exchange information between workpackages. It has been used for example to exchange information for the coordinated experiment on RCM over southern South America (wp3.1) and also to publish the preliminary list of variables to allow the participants to add, modify, delete or include comments.
URL: http://www.claris-eu.org

FTP service: A tool that allows participants to downloading the files stored on CLARIS Dataserver.
URL: ftp://eolo.cima.fcen.uba.ar

MySQL database: A relational database, that will be used by WP3.2 to store data of observational data like temperature, precipitation and WP4.2 dengue data.

HTTP service: It is the main tool for exchange of documents and information between participants. The WP 4.2, on Climate and vector-borne epidemics: a pilot action on Dengue and yellow fever in Brazil will host their web site at CLARIS DataServer to access the Dengue database. This migration is under development. URL: http://www.claris-eu.org.

The final architecture of the DataServer is the following:



Another important aspect was the support to other WP's:

WP1.2: CLARIS communication and dissemination activities

CLARIS Website: maintenance and verification of the correct operation of the web site.

Mailing lists: maintenance and verification of the correct operation of the mail server and mailing lists.

Training activities: Support on the MATLAB course and support to the participants during the course.

WP2.1: Earth System Modelling

Requested IPCC model data: The data requested from participants were stored in the DS during the project time.

Requested ERA-40 reanalysis: The data requested from participants were stored in the DS during the project time.

Data INGV_SINTEX: Support to INGV to upload the INGV_SINTEX data model to the DS. Data of the SA Area were extracted from INGV_SINTEX model files and global interpolated files were produced to a resolution of 2 degrees. The amount of data processed was approx. half TByte.

WP3.1: Climate Change Downscaling

Support in the processing of the files sent by CIMA, LMD, MPI, and ULMD for the regional experiment on SA to produce standardised NETCDF files (same variable names, same grid, same units, etc) and later development of a web page summarizing the results to show the original files and the standardised files. LAS was used to show the results.

WP3.2: High-quality regional daily data base

Download global NNR 50 year data and extraction of the regional Area on SA of these variables u10, v10, sst, z, t, u, v.

WP 4.1: Climate and agriculture

Support for downloading and processing ERA40 data for statistical downscaling. Extraction of IPCC model daily precipitation and temperature time series.

WP 4.2: Climate and vector-borne epidemics

Support in the installation of the first database version in MySQL and support in the implementation of its query page to the database.

Support in the installation of a GIS in the DataServer, this task is still ongoing.

CLIMATE DOWNSCALING IN THE SUB-TROPICAL AND MID-LATITUDE SOUTH AMERICA
WorkPackage 3.1

WP3.1 has promoted the co-ordinated participation of European and South American research teams in the use, development and application of downscaling (dynamical and statistical) methods. Two kinds of activities were planned: (a) Co-ordinated experiments for dynamical downscaling and (b) Complementary research activities performed by individual partners (including climate change simulations and statistical downscaling studies). Representatives from eight institutions have participated in these activities: CIMA/CONICET (Argentina), CNRS (France), CPTEC (Brazil), INGV (Italy), LMD/CNRS (France), MPI-M (Germany), UBA (Argentina), UCH (Chile) and UCLM (Spain). In addition, the Rossby Centre/SMHI (Sweden) was invited as external collaborator.

At the starting point of the project there was little experience in the use and development of RCMs and downscaling techniques for most of South American regions. Even at present much of the work on this issue in South America remains at the level of methodological development and preliminary testing. Nevertheless, downscaled multi-year simulations and climate change projections are starting to become available for this region and a great part of the effort is being channelled through the CLARIS framework.

1. Dynamical downscaling experiments

We performed a series of co-ordinated simulations, as an endeavour to assess models' behaviour in particular month long extreme cases and in multi-year runs. A concerted approach in terms of model domain and resolution, time periods and models' forcing for all simulations was established. The regional models participating in the co-ordinated dynamical downscaling efforts include the following: MM5 (CIMA and UCH), RCA3 (CIMA and Rossby Centre/SMHI), REMO (MPI-M), PROMES (UCLM) and WRF (CIMA). An atmospheric GCM with stretched grid (LMDZ from LMD) also participates in these co-ordinated experiments. We carried out:

(i) Three simulations of about two months each of particularly anomalous months for south-eastern South America (November 25, 1970 through February 1st, 1971; October 1st, 1986 through December 1st, 1986; and May 21, 1996 through August 1st, 1996); and
(ii) Multiyear simulations of the present climate (1995-2000).

1.1. Case studies of extreme months

The last simulated months (January 1971, November 1986 and July 1996) of the three

short simulations performed with the CLARIS models were analysed. The ensemble includes one global model (LMDZ) and five RCMs (MM5, PROMES, RCA, REMO and WRF). All models were run with horizontal resolution of about 50 km over South America but varying vertical resolution. The domains of the five regional models are somewhat different from model to model but they all include southern South America and surrounding oceans.

January 1971 and November 1986 are particularly interesting since these are two cases of monthly extreme precipitation near the Rio de la Plata region in south eastern South America. RCMs tend to be more skilful at simulating November'86 precipitation because the January'71 climate is more controlled by mesoscale and convective-scale precipitation events, which are harder to simulate. However, even in November 1986 when the maximum over Uruguay and southeastern Brazil is captured in the simulations (although with different strength), models underestimate precipitation amounts over central and eastern Brazil.

Testing these models over South America is offering a singular opportunity to share participants' expertises and to compare models' performances in a new environment. Different treatments of regional processes and feedbacks are responsible for a relatively large inter-model spread. Progress is being made for achieving a better appreciation of the sources of model errors, leading to the improvement of regional simulations.

1.2. Multi-year present-day regional simulations

The overall goal is to assess the performance of high-resolution models to reproduce the mean climate, seasonality and interannual variability in the SSA region, through comparison with coordinated regional-scale observations and analyses. The focus is put on the spread of model output related to surface temperature and precipitation and on their skill to reproduce some aspects of the hydrological budget in the region. The simulation period of this common multi-year run is 1995-1999, but some modelling groups have performed longer simulations (including such 5-y period). This multi-year simulation was carried out with four models: LMDZ, RCA3, REMO and PROMES. Results are being analysed independently by the different groups, but a collaborative research to study the regional climate as simulated by the ensemble of the four models is envisaged. For this purpose, an archive with output data from the different models needs to be created (work in progress).

2. Climate change simulations

Two different sets of climate change scenarios were generated in the WP3.1 framework:
-Regional simulations driven by global coupled models provided by WP2.1 (A1B scenario); and
-Regional simulations driven by Hadley Centre models (A2 and B2 scenarios).

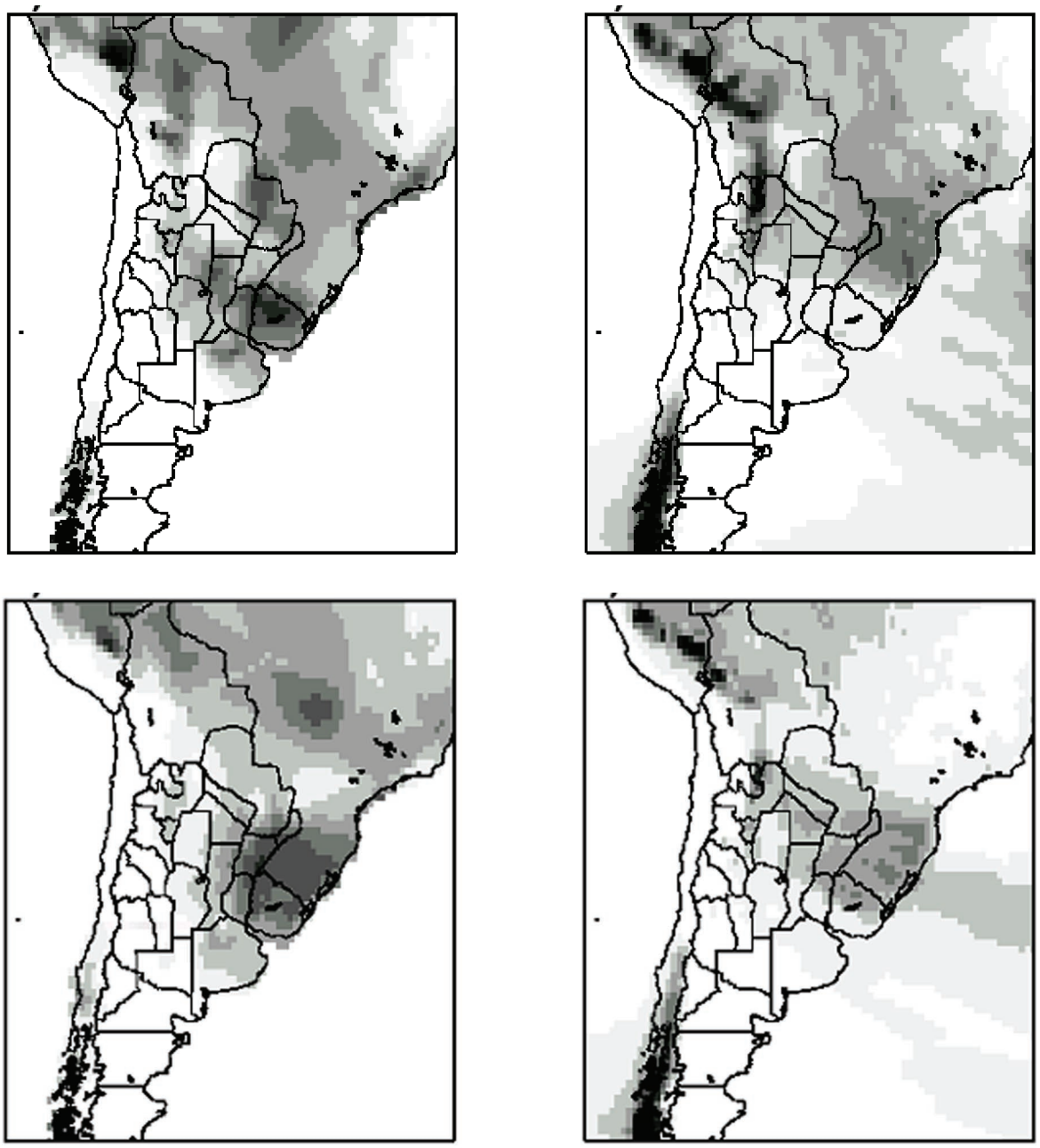
2.1. Simulations forced by boundary conditions provided by CLARIS partners

The IPCC AR4 standard (SRES A1B scenario and 20 year time slices corresponding to the last two decades of the 20th and 21st centuries) was suggested for regional climate change simulations. To this end, 6-hourly boundary condition data sets have been offered by INGV and MPI-M from two state-of-the-art global coupled models (INGV-SINTEX and ECHAM5/MPI-OM). The overall objective of this experiment is to help understanding the physical processes that underpin regional climate change and the changes in its variability through systematic intercomparisons of regional climate change simulations.

At present, only one climate change simulation has been completed. A regional climate change simulation with RCA3 driven by lateral and surface conditions from ECHAM5/MPI-OM for two 20-y time slices (1980-1999 and 2080-2099) has been carried out as part of the ongoing collaboration between CIMA and Rossby Centre. As this experiment has been accomplished recently, only a very preliminary analysis was possible. First results were discussed during the CLARIS final meeting (Sörensson et al., 2007).

2.2. Simulations forced by Hadley Centre boundary conditions

Dynamical downscaling of future scenarios has being developed by some South American groups (CIMA, CPTEC and UCH) in the framework of national funded projects (e.g. for the so-called National Communications on Climate Change), driving their models with data from other sources (Hadley Centre, UK) and considering other emission scenarios (A2, B2). Some preliminary descriptions of these pilot downscaling of climate change scenarios have been recently presented in scientific meetings (Núñez et al., 2006; Marengo, 2007). The PRECIS RCM was used at CPTEC and UCH. This RCM was forced by regional boundary conditions produced in the Hadley Centre by means of HadAM3P global atmospheric model and observed sea surface



Mean monthly precipitation (every 2 mm/day) for January 1971 (top) and November 1986 (bottom). Observational estimates (CRU, left panels) and model simulations (CLARIS ensemble, right panels)

temperatures modified with a positive trend provided by the HadCM3 coupled global model. The same boundary conditions from Hadley Centre were used at CIMA to provide surface and lateral forcing to the MM5 RCM.

However, it should be mentioned that the rainfall response of the HadCM3 model seems exaggerated over northern South America as discussed in Sörensson and Menéndez (2005) and Christensen et al. (2007). The model HadCM3 projects by far the largest annual area-average rainfall response over Amazonia, being unrepresentative of the ensemble of AR4 models for this region. It is uncertain how this anomalous behaviour of the Hadley Centre coupled model could affect the regional dynamical downscaling.

3. Statistical downscaling

3.1. Statistical downscaling of daily rainfall and temperature in La Plata Basin

A two step statistical method to estimate high-resolution surface meteorological variables (daily precipitation and maximum and minimum temperatures) in La Plata basin, from six-hourly ERA 40 reanalysis dataset has been developed and validated. Series of daily rainfall and maximum and minimum temperatures of stations within the target area were used as predictants. Both reference (surface and atmospheric) datasets expand over the period 1960-2000 (14.974 days). In the first step, the analogue technique was used to select the "n" most similar days to the "X" day. The second step involves the estimation of daily rainfall and maximum and minimum temperatures. Validation results as a whole show that the downscaling performance is good enough to allow its confident application over GCM outputs, in order to prospect possible climate evolution.

3.2. Statistical downscaling of daily rainfall and temperature using an atmospheric pattern classification method

During the second-half of the CLARIS project, we built a statistical downscaling method based on the classification of atmospheric patterns. We compared classification methods such as Kohonen maps (neural networks), k-means, k-NN (Nearest neighbours) and analogue techniques. While the K-means method gave the most satisfying results, the key of any classification method has been found to rely on:
- the choice of the variables analysed
- the criteria onto which the classification is optimised.

In order to select the variables which would optimise the simulation of the precipitation, we designed a selection method of atmospheric variables based on the entropy of the classification. Second, we tested different criteria to optimise the classification. One is the entropy based on the separation between rain and no-rain days. The second is the entropy based rain larger or lower than a specific percentile (75%; 90%).

Our results show that the system represents fairly well the distribution of rainy days and the distribution of rainfall. Moreover, it captures a large part of the interannual variability although more research efforts will have to be put on improving the simulation of extreme precipitation events. The results will be published in a CLARIS Special Issue.

4. Complementary research

4.1. Sensitivity studies with PROMES

Because of the unsatisfactory representation of monthly precipitation and temperature average obtained in the "short-period" runs with PROMES, the UCLM group considered advisable to pay preferential attention to improving the performance of this model. To do so, a set of model

experiments was accomplished after introducing diverse changes in the parameterisations of convective and land-surface processes and the soil moisture initial values, totalising over 20 short-period simulations. This sensitivity study helped to gain knowledge on which of the model characteristics should be addressed to obtain a better representation of climate extreme events in the SSA region.

4.2. Sensitivity studies with MM5

Several sensitivity experiments were performed with the CIMA version of the RCM MM5, particularly focused on the period OND 1986. Results showed that the model underestimates rainfall over La Plata basin and overestimates rainfall over tropical latitudes. Sensitivity experiments included sensitivity to the location of the northern and eastern boundaries of the domain, to the parameterisation of convection, to the parameterisation of the planetary boundary layer and to the parameterisation of radiative processes.

4.3. Surface-atmosphere interactions simulated with RCA3

Different sets of climatological integrations using RCA3 with a continental scale domain nested in reanalysis data were carried out aimed at helping to understand the variety of feedbacks between rainfall and soil moisture (work in collaboration between CIMA and Rossby Centre, see Sörensson et al., 2006 and Menendez et al., 2007). A first objective of this work was to isolate the role on the South American monsoon (SAMS) development of including a soil and rooting depth that extends as deep as 8 m in some areas of Amazonia. Another objective was to examine the influence of soil moisture initial conditions on the SAMS development. Finally, the "coupling strength" between soil moisture and precipitation was investigated.

4.4. Complementary research with WRF

A series of one-month experiments (November 1970) with the CIMA version of the RCM WRF nested in ERA40 were performed using different physical parameterisations. The following variables were tested: geopotential, temperature, sea level pressure, 2 meters temperature and wind.

References

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1. Project execution

The third objective of CLARIS is to create a South American high-quality climate database for studies in extreme events and long-term climate trends. This high-quality database is well developed and available to all CLARIS Partners trough the web page (P4). The CLARIS Daily Data Base has been incorporating new data this year. At present, we have daily maximum and minimum temperatures and precipitation from 95 stations. CLARIS partners from Uruguay (P9), Brazil (P5) and Chile (P12) have obtained the data from their Weather Services to make them available for CLARIS studies. The longest records start in 1950, the majority in the 60´s. All the data have gone through the same quality control. With these strict controls, we obtain homogeneous daily data over the region. This is the first step for the estimation of homogeneous regional indices that are the next deliverables of WP3.2.

The high-quality regional database for daily temperature and precipitation was updated by P1, P4, P5, P9, and P12. The same quality control that had been applied to Argentinean stations at the beginning of the project, was performed on all stations by P4 during this period.

Homogeneity studies were performed over Uruguay stations based on European Climate Assessment ECA methodologies. The quality control suited the one used in Argentina. The stations included and controlled stations are shown in Figure 1 with different colours depending on the country.

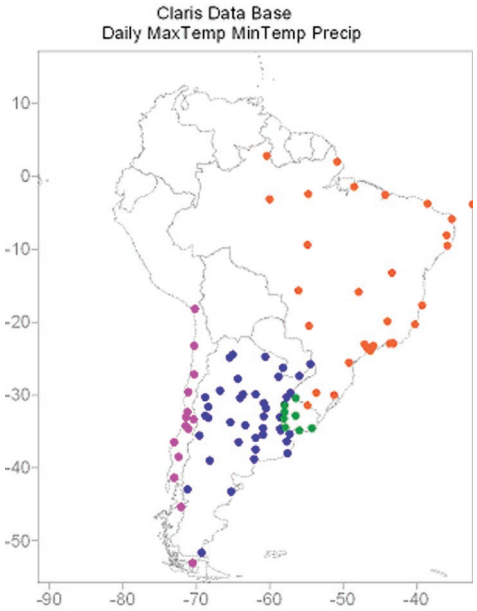


Figure 1: The Claris Data Base

The quality control includes checking for some obvious errors like Maximum Temperature cooler than the Minimum, but also comparison with an interval between the mean value for the day plus some standard deviations. The most exigent test is related to the persistence of the atmosphere, checking the differences between two consecutive days, considering that they have high probability of being within a defined interval. All these controls are saved in log files for a future use. Some other errors were found when using extreme annual values for the analysis of return values. For precipitation, the quality control is different, in general handier. Negative

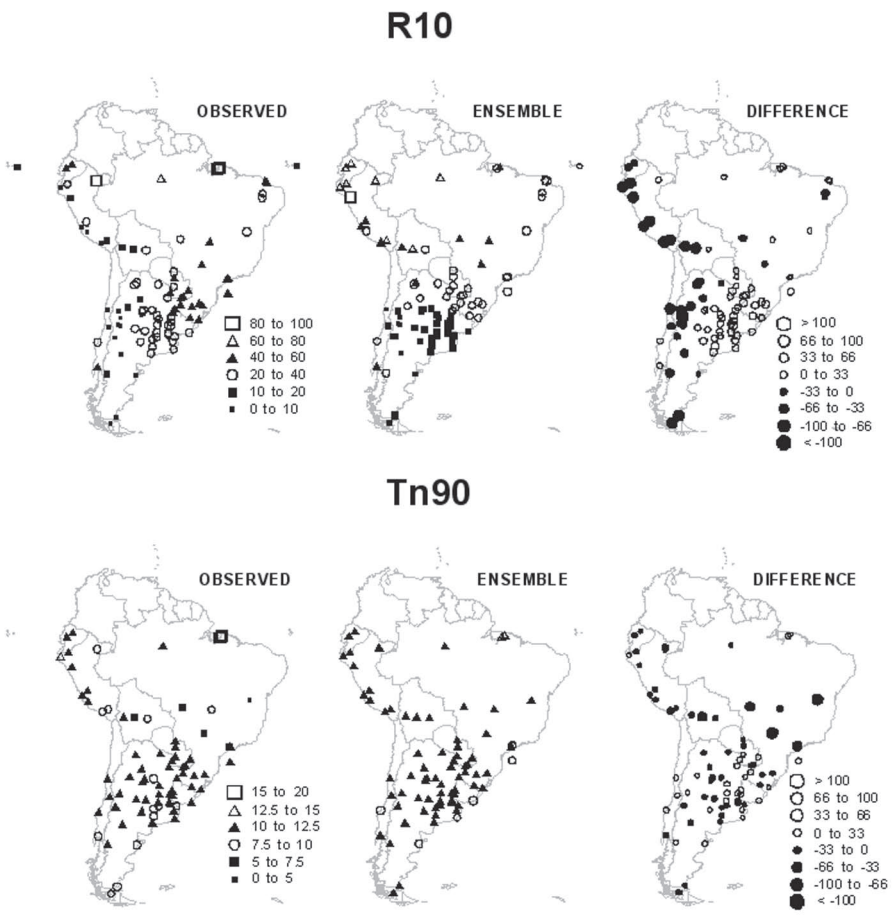


Figure 2: Indices Tn90 (annual number of days with minimum temperature above the 90th percentile) and R10 (annual precipitation from days with precipitation over 10 mm)

values are automatically rejected and longer spells of zero values are subjected to a more detailed analysis.

This effort has been recognized by the GCOS (Global Climate Observing System) /WCRP Atmospheric Observation Panel for Climate, in its XII and XIII sessions, who included some references in their lists of conclusions.

"The AOPC commended the progress being made in the CLARIS (Europe-South America Network for Climate Change Assessment and Impact Studies) project to assemble data from a number of countries in South America. It encouraged additional countries to contribute data to this effort and to make them openly available for climate monitoring purposes:"

"The AOPC noted the update on the Climate Change Assessment and Impact Studies (CLARIS) project in South America and welcomed the progress being achieved, particularly in the area of improved coordination and capacity-building in the region. It also noted, however, the considerable difficulty in assembling the required database for studies of extreme events and climate trends in the South America region. The Panel strongly urged nations to make their daily historical climate data openly available to the CLARIS project and to the GSN Archive. The AOPC also noted the proposal to the European Union 7th Framework Programme (FP7) to continue the CLARIS project beyond 2007, with a focus on the La Plata basin, and expressed its strong support for this initiative"

Some long-term stations over central and northern Argentina, southeastern Brazil and Uruguay are being analysed to obtain trusted long-term trends and variability.

Indices of extreme temperature and precipitation has been calculated for the region. These

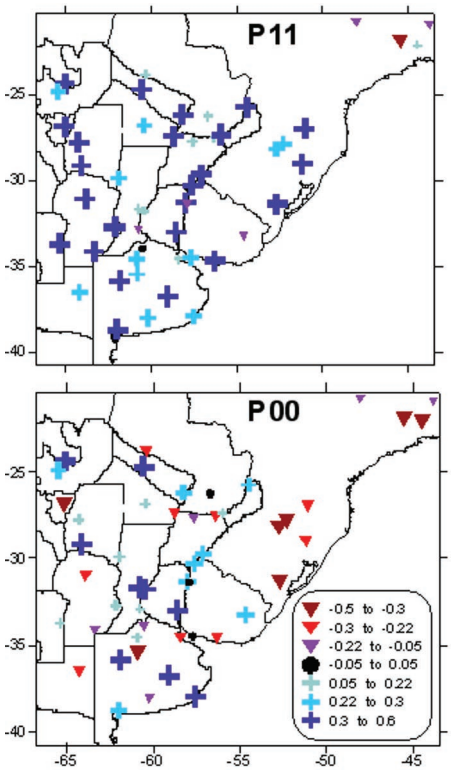


Figure 3 Sign of the trend in persistences as measured by Kendall's tau. '+' indicates rises, and 'Д' drops. Values greater than (-0.22; + 0.22) indicate significance at p<0.05.

indices has been compared to the global climate models from the IPCC AR4 model intercomparison to assess their reliability (P4, P5, P9). Two examples are shown in the Figure 2, for the Indices Tn90 (annual number of days with minimum temperature above the 90th percentile) and R10 (annual precipitation from days with precipitation over 10 mm). The 1961-2000 mean observed values (from station data), the 1961-2000 8-model ensemble mean, and the difference between them, expressed in percentage. These results are presented to show the performance of the models to better represent the temperature extremes over the precipitation ones.

To determine the most characteristic features of the rainday and no rainday the temporal evolution of P11 and P00 is analysed. Figure 3 shows the sign of the annual trends for all the stations in the common period 1961–2000. It is interested to observe the spatial coherence in the sign and the significance of the annual trends of P11 (Figure 3, up), showing that the probability of rainday when the day before was a rain day increase in the whole region. The probability of no rainday when the day before was a no rainday shows a greater spatial variability (Figure 3, down). Two coherence regions in the sign and significance of the annual trends with opposite characteristics are observed; one in southern Brazil (negative trends) and the other over Mesopotamia region (positive trends). The sign of the trend in the rest of the region will depend on the location of the station.

CLIMATE AND AGRICULTURE: A PILOT ACTION IN THE ARGENTINEAN PAMPA HUMEDA
WorkPackage 4.1

Agriculture production has significant social and economic implications in the humid pampa, located north of 40°S and east of 65°W. Climate variability, and more specifically extreme climate events, remains a major risk factor for this activity.

This Workpackage has two main objectives: a) Identify a range of spatial and temporal scales common to climate models and agricultural needs for which the role of climate on crop productions can be evaluated; and b) Assess current agricultural systems with respect to a changing climate scenario in order to evaluate the physical and economical performance of innovative production systems.

To progress successfully towards these objectives, four tasks were planned:

- **Task 1**. *Create a common climate and agricultural database including high-quality detailed data at some selected sites for evaluate an integrated climate, cropping and economic modelling system, and to assess the vulnerability of agricultural systems to external shocks*

Three sites (Pergamino: 33.90 °S, 60.57 °W, Anguil: 36.50 °S, 64.02 °W and Marcos Juárez: 32.68 °S, 62.10 °W) were selected to characterize the different climate types in the humid pampa, particularly in the transition zone. The four major crop species grown in this region were studied: corn, wheat, soybean and sunflower.

The database of climatic information consists of daily information on maximum and minimum temperatures, radiation, estimated from heliophany and rainfall. Because crop diversification and production depend not only on total precipitation, but also on the distribution of precipitation during the growing season, different properties of rainfall were also analysed.

A database of agronomic information was created: a) Percentage of clay, silt and sand for different depths (0-15; 15-27; …. ; 200 cm); b) Thermal time for maize planting 23/09 and Wheat: Planting 13/06; c) The crop sequence for the three locations; and d) Fertilization in maize, wheat and soybean.

• **Task 2**. *Perform crop model simulations under various past climate scenarios at various selected validation sites*

The estimation of agricultural systems production and externalities under different weather-soil-agromanagement scenarios can be done using crop/cropping systems models. Such models simulate at field scale the biophysical processes most relevant to estimate the non-linear interaction of crops-soil systems as affected by weather and agricultural management. Models are deterministic and are run in a stochastic fashion using samples of weather.

Simulations were run reproducing the environmental drivers to agricultural production at the three locations. Current and innovative cropping systems were evaluated and the system performance was evaluated using the mean value and variability of yield, phenology, water and nitrogen crop stress, nitrogen leaching. Estimating the sensitivity of agricultural production to weather is a very broad topic even when limiting the evaluation to biophysical aspects.

The simulations run must be considered a first approach to system evaluation which will be better tuned when contrasting them against simulations using climate change scenarios. These simulations are primary base for evaluation of simulation settings by local expert knowledge.

Irrigation has proved to be a support to production for some crops to buffer rainfall variability as projected from the data used to generate weather. It can be assumed that the value of irrigation would increase in regimes of either increased temperature (i.e. increased evapotranspiration demand) or rainfall variability. In such conditions, as a qualitative estimate, some production systems may easily become unsustainable in ¨Anguil¨. The estimates produced via simulation, to be considered a first approach to cropping system simulation in the environments under evaluation, indicate a modest risk of nitrogen leaching except for maize grown in the location with the highest yearly rainfall, “Pergamino”.

• **Task 3**. *Apply downscaling methods of climate change scenarios to the region of interest in order to provide future climate conditions at local scale, useful to force the cropping system*

• **Task 4**. *Downscale climate change scenarios in the CLARIS pilot region to characterize the potential impacts on agricultural activities and productions, and to generate management scenarios (crop species and maturity class choice, sowing time, irrigation, fertilization, etc.) to design cropping adaptation strategies taking into account the impact on the natural resource base (e.g. soil organic matter)*. An assessment of the farmer decision process under changing climate conditions will be made.

Special procedures are needed to deduce regional-scale parameters from large-scale climate simulations. In this WP, two downscaling statistical method were analysed:

a) clustering method of atmospheric variables in order to simulate the daily precipitation. The

method used 17 variables from the ECMWF ERA40 Reanalysis. In a first stage, it automatically estimated an optimum set of variables in order to simulate the occurrence of rainfall and in a second stage, it does the same to simulate the amount when it rains.

b) analogue technique: A two-step statistical method to estimate high-resolution surface meteorological variables (daily precipitation and maximum and minimum temperatures), from six-hourly ERA 40 reanalysis dataset has been developed and validated. In the first step, the analogue technique was used in order to select the "n" most similar days to the "X" day. The second step involves the estimation of daily rainfall and maximum and minimum temperatures.

CLIMATE AND VECTOR-BORNE EPIDEMICS: A PILOT ACTION ON DENGUE AND YELLOW FEVER IN BRAZIL WorkPackage 4.2

1. 1. Workpackage objectives

The project objectives were:
1) To create an epidemiological relational database to include data on Yellow fever (YF) cases (human and monkeys) and Dengue human cases in Brazil; this database should be freely accessible on the CLARIS public web site.
2) To determine which climate parameters are key to explain the spatial and temporal distribution of YF and Dengue cases.
3) Generate epidemiological scenarios for Dengue transmission, according to various climate change scenarios.

1. 2. Contractors involved

IRD, France, with the following external collaborators: SVS-MH, Brazil; FUNCEME-IRD "CATIN" project, Brazil; CNRS, France; FIOCRUZ, Brazil.

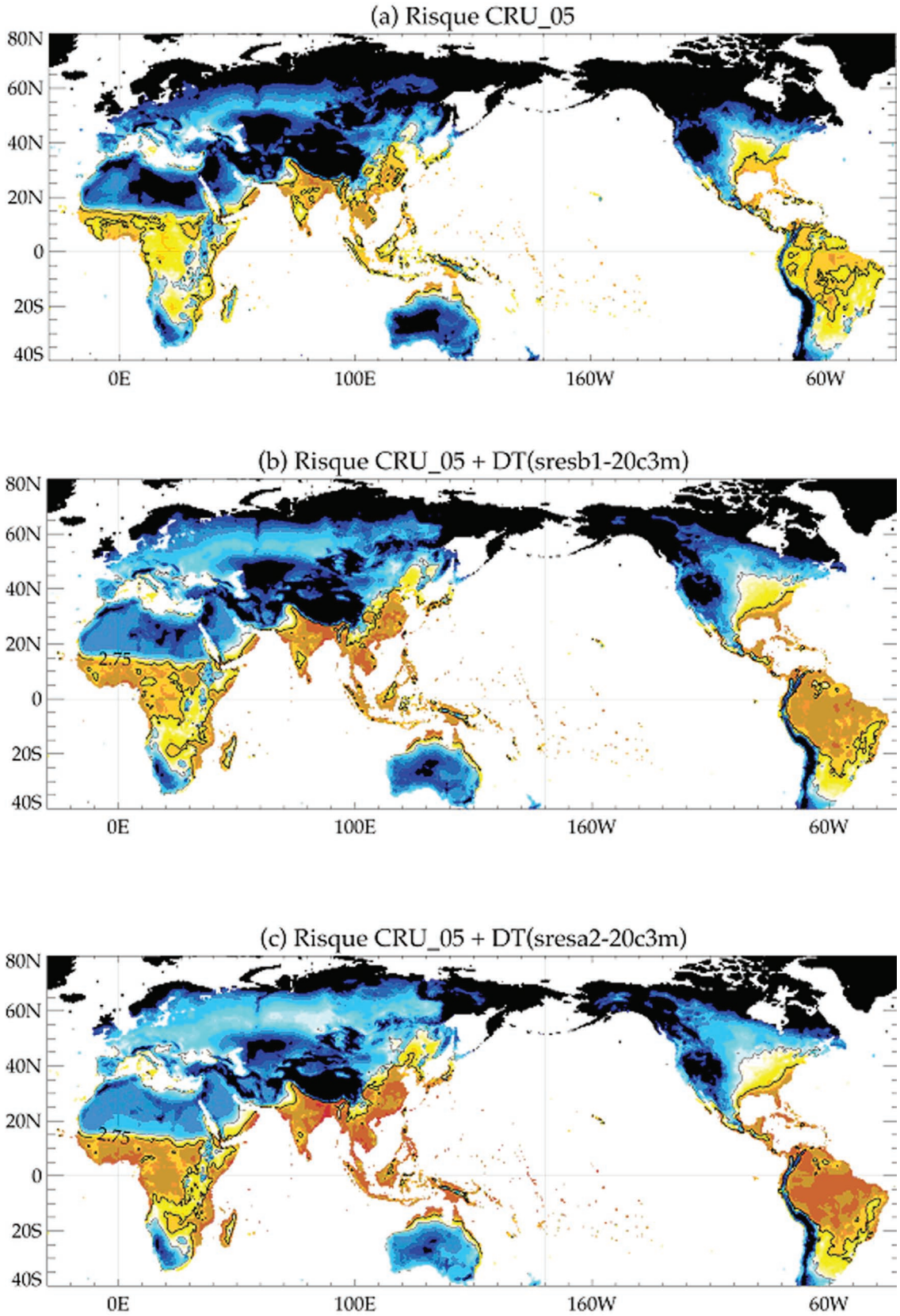
1. 3. Methodologies

Various Aedes aegypti-Dengue models described in the literature were compared, in terms of availability of data types and applicability for our objectives. It was concluded that none of the existing models was totally suitable for our project and that it was necessary to elaborate a new model combining different aspects from existing ones. One main constraint to conceptualise the model was its final suitability to be validated by field data relatively easy to be collected by the Health services in the SA countries.

The analysis of some historical series of Dengue epidemics was done, in order to look for a means to estimate the vectorial capacity (R0) or basic reproduction rate, directly from the initial curve of daily increase of the number of cases. We would be thus able to compare it with the same figure as estimated by the model: yet another validation method.

To construct a relational database, many languages exist but we concentrated on free ones which would be adapted to data mining in databases on the web, and to dynamically build maps to show the results of queries. PHP, PostGreSQL and MapServer were chosen as suitable for these objectives.

To evaluate the impacts of climate change on the risk of dengue transmission, we used as input to the risk model the output of 12 IPCC models, calculated for the period 2070-2100. The increasing of earth surface under risk was estimated by difference with the actual climate (1960-1990 period) calculated by the same models.



Figs. a-c: Maps of risk of Dengue transmission, estimated by the risk model. Up: present climate; middle: present + increase deduced from B1 GCM scenario; below: same with A2 scenario. The yellow and orange colours show the limits of the endemic and epidemic transmission risks, respectively

1. 4. Results

The WP 4.2 database has been populated by data from the Brazilian national databases SINAN and FAD, for Dengue and YF cases and mosquito prevalence, respectively. The original data have been adapted by Walter Ramalho and a data mining system has been developed by Régilo Souza (both collaborators from SVS-MH, Brazil) under the free licensed programming languages PHP, MySQL and MapServer, later updated with PostGreSQL. With such tools, the results of searches in the database may be visualized on maps, created dynamically. Such a system allows any member of the civil society to be aware of passed events or future risks. It will allow stakeholders to take decisions for control and prevention of epidemics.

Two activities were carried out to validate the risk model: comparison of risk maps with the actual distribution of Dengue and experimental studies to explore the sensibility of the model to variations in the entomological parameters. Christophe Menkes, Matthieu Lengaigne and Jean-Philippe Boulanger (LOCEAN, France) collaborated to provide the climate data from 12 IPCC models which served both to compare the actual risk (mean climate for the 1960-1990 period) with the Dengue distribution on a 0.5° x 0.5° world grid. Thus, the endemic and epidemic risk took values of 100 and 200, respectively. Thereafter, the risk was estimated according to the standard B1 and A2 scenarios (figs. 1-3), and % augmentation of surface at risk was evaluated for each continental area. As the vector survival is one of the main parameters which influences the vectorial capacity (and thus the risk), experiments were initiated to check the thoroughness of the functions used in the model to estimate it from the temperature and relative humidity. The results of the experiments which are ongoing as part of the project CATIN (collaborative work with FUNCEME, SESACE and CNPq, Fortaleza, CE, Brazil; coordinator Jacques Servain), showed that non-negligible variations may occur in mosquito survival between proximate places in the same town. This suggested that future studies at finer scales are needed to better understand the distribution of dengue cases during epidemics. During the project, it has also been possible to publish some important work on the ecology of the vector of Dengue, Aedes aegypti in Brazil. This paper presents a new index for quantify the relative risk of different types of mosquito breeding containers. This container risk factor would complement the more general climate-associated risk of the model for decision-making during prevention and control campaigns.

Regarding preliminary difficulties in obtaining epidemiological data on YF, the studies have been more oriented on the selvatic vectors, during a collaborative work with FIOCRUZ institute in Rio de Janeiro. Studies have been done and results published on the systematics and ecology of two main vectors of selvatic YF in Brazil. These studies, done as part of a doctorate thesis (Jeronimo Alencar; "Bioecological, genetic and taxonomical aspects of Haemagogus (Diptera: Culicidae) selvatic vectors of yellow fever virus in Brazil") will contribute to better understand the biology of these species and the risk of their contact with non-vaccinated people.

1. 5. Discussion

The main objectives of the WP were accomplished, i.e. elaborating an epidemiological database to be fed and consulted by any people with concern in Dengue and YF in SA, with the long term objective to strengthening collaboration between SA countries in their fight against these mosquito-borne emerging diseases. Another important objective was the production of a tool (model) giving a risk index, to enable stakeholders and health officers to anticipate the consequences of climate change or seasonal variability as affected by ENSO, or even extreme climate events. Some by-products of the project were the following (some already disseminated in international reviews and/or meetings): design of a new method to estimate directly the value of R0 from the beginning of an epidemic; design of a new risk index specific to container type; stimulate two external collaborators (Brazilian) to begin a thesis in relation with these two diseases.

However, much work remains to be done, mainly to study the behaviour of human populations at risk, in order to propose a methodology which may serve as a base for future prevention activities. We emphasize thus the need for interdisciplinary studies with sociologists.

CONTINENTAL-SCALE AIR POLLUTION PRODUCED BY SOUTH AMERICAN MEGACITIES
WorkPackage 4.3

The objective of WP 4.3 of CLARIS was to develop a tight cooperation between South American and European scientists in order to assess:

· The impact of mega cities on air quality at the sub-continental scale (e.g: São Paulo and Santiago)
· The impact of land-use changes on air quality at the local and regional scales
· The relative effects of anthropogenic versus biogenic emissions on atmospheric oxidants and aerosol abundances at the continental scale
· The regional climate forcing resulting from changes in aerosols and tropospheric ozone concentrations in the past and in the future.

We summarize here the major accomplishments towards the objectives of the Project.

Development of an emission database for urbanized and industrialized regions at high spatial resolution

The University of Chile has developed an inventory of trace gas emissions in relation to vehicle traffic for the following 4 South American mega-cities: Santiago, Chile, Lima, Peru, São Paulo, Brazil, and Bogotá, Colombia.

The impact of mega cities on the chemical composition of the atmosphere has been assessed in cooperation and in support of the 4-year project on "South American Emissions Mega cities and Climate" (SAEMC) supported by the Inter-American Institute for Global Change Research (IAI). This South American project is established in support of CLARIS' objectives. It provides accurate regional emissions and climate change scenarios for South America with emphasis on the impacts of and on mega cities. New or revised mobile emission inventories are now available for various cities, including Buenos Aires, Santiago, Bogotá, São Paulo, and Medellín (See saemc.cmm.uchile.cl). In the case of Santiago, inverse modelling has been used to improve the emissions in terms of spatial and temporal distribution.

Development of a model for emission of chemical compounds by forest and savannah fires in South America

A detailed fire model that provides chemical emissions by forest and savannah fires in the South American continent has been developed, and used to assess the impact of biomass burning on air quality in the region. The key emissions under consideration are those of carbon monoxide, nitrogen oxides (two ozone precursors) as well as aerosol particles. The location of the fires and their intensity are derived from space observations and fed into the fire model. The release of carbon dioxide from biomass burning is used to derive the emissions of other compounds such as CO and NO. These emissions release the chemical species at the surface as well as in altitude, since fire-clouds can reach the middle or even the upper atmosphere.

Global model simulations for the atmospheric composition for present and future conditions (based on emission scenarios)

The MOZART-2 global chemical transport model was run for 10-year periods in 1890, 2000, and 2100 with meteorology from the ECHAM atmospheric general circulation model. Runs were made with fixed climate and with climate changing from year 2000 to 2100 as predicted by the ECHAM-OM coupled climate model for the IPCC A2 scenario. The results for the region of South America were analysed specifically, showing that climate change in the region will affect air quality in South America.

Regional Chemical Transport Modelling

Different European and South American regional chemical transport models have been developed to assess the impact of human activities, and specifically of mega city emissions and biomass burning on the air quality in the region. Specifically, these coupled chemical dynamical models have been used to assess the impact of South American Mega-Cities on the regional climate, the effects of anthropogenic emissions versus biogenic emissions, the level of air quality, and the impact of chemistry on climate forcing (including aerosol direct/indirect effects).

Models have been developed at INPE/CPTEC in Brazil (CATT-BRAMS), at the University of Chile (two regional models), and at the Max Planck Institute for Meteorology in Hamburg, Germany.

The Brazilian model (CATT-BRAMS) is a regional chemical transport model able to simulate at high horizontal and vertical resolution the dispersion of fire plumes into the atmosphere. It includes a detailed formulation of biomass burning emissions, as well as ventilation of the boundary layer and vertical transport of fire products in the free troposphere. The dispersion of the chemical compounds produced by the burning fields depends on the wind fields as well as from convective activity. This regional model provides the three-dimensional distribution of species like CO, NOx and aerosol particles. Calculations have been performed for 2 specific horizontal resolutions of the model: 40 and 200 km.

The Chilean model, based on the WRF/CHEM regional climate-chemistry model, has been modified and extended at the University of Chile. It covers a limited spatial domain, but uses a grid at very high resolution. It has been designed to perform studies of urban pollution, and has been used to study air quality in Santiago, Chile. The emissions are those provided by the Comisión Nacional para el Medio Ambiente (CONAMA). The model accounts for gas as well as liquid phase. Data from chemical field campaigns have been used for validation and emission evaluation purposes. The model runs for Santiago de Chile in operational forecast mode. A nested set-up has been designed for the Santiago Metropolitan area. Boundary conditions are provided by a global modelling system such as MOZART or MATCH. Further software has been developed, which allows the automatic execution of climate runs. Within this software, the model can be executed on a consecutive daily basis using restart conditions. This system is currently used for climate runs within the project "Climate variability in Chile: evaluation, interpretation, and projections" financed by CONICYT and supported by CLARIS.

The implementation of a regional-scale climate model (RCA) is now complete at the Centre for Mathematical Modelling (CMM UCH) and is used, combined with air quality models, to study the impact of climate change scenarios on air quality in mega cities in the western coast of South America. The model was evaluated over the South East Pacific region against observed data, covering Santiago and Lima.

The regional climate model, REMO, developed at the Max Planck Institute for Meteorology, includes a chemical scheme describing the ozone formation and destruction. This hydrostatic model operates currently with the following horizontal resolutions: 1/2°x1/2° (ca. 55 x 55 km²) or 1/6°x1/6° (ca. 18 x 18 km²). Lateral forcing is provided by one of the following reanalysis data: (ERA15, ERA40, NCEP/NCAR) or by the meteorological fields provided by the ECHAM5 general circulation model. REMO has been extended to include chemical processes, and has been applied to the South American area. A major improvement to the tracer-convection scheme of the model has been made. The model produces the distribution of ozone and its precursors, and assesses how emissions from fires and urban emissions affect air quality at the regional scale. The model is coupled "online" with a dynamical module and treats therefore fully climate-chemistry interactions at the regional scale.

These different models have been used extensively to perform sensitivity studies and validation tests at the regional scale. This approach helps to better understand the performance

of the models, and to gain confidence on the performance of the model for prediction studies.

Exchanges of Visitors

Two PhD students of the University of Sao Paulo visited for 3 months the Max Planck Institute for Meteorology in Hamburg. These students are developing a regional chemical transport model to study the pollution in the region of Sao Paulo.

· Leila Droprinchinski Martins and Jorge Alberto Martins from Sao Paulo, Brazil, visited the MPI and worked on the preparation of their theses. Jorge Alberto Martins worked on "Aerosols and air quality in the region of São Paulo" and Leila Droprinchinski Martins worked on "Chemical atmosphere and air quality in the region of Sao Paulo". Both completed their theses in São Paulo.

· Laura de-Simone-Borma from the University of Tocantins visited the MPI for one and a half month and worked on the hydrology in the Tocantins basin in South America. She is now teaching courses on Earth System Modelling in her university.

CONTENTS

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