The impact of Rio-92 on the scientific production of USP, considering the topic of Climate Change

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Introduction

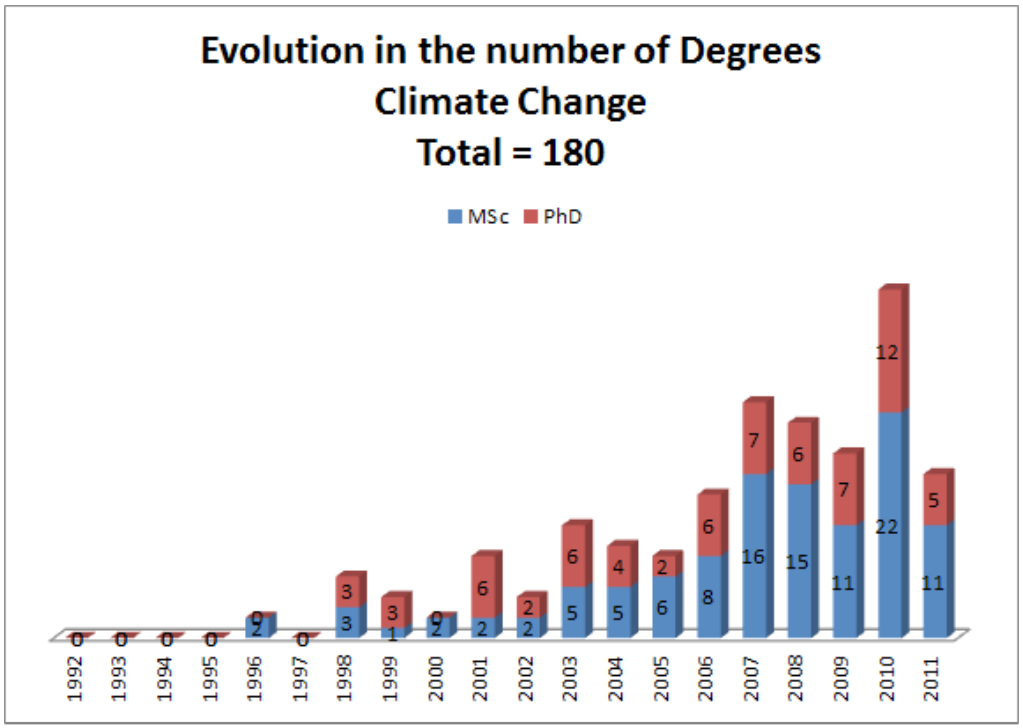
SINCE RIO-92 – a milestone in global socio-environmental history - the interest in and concern for topics related to the impact of human activity on the environment have assumed prominent proportions not only in scientific discussions, but also in people's daily lives. Currently, matters related to the environment are disseminated almost daily by the mass media such as television and the internet. The association with observed effects and the determination of some sort of cause is commonplace in any routine discussion. One of the main effects of these discussions is related to extreme weather events such as heat waves, hurricanes, tornadoes, floods, landslides, droughts and many others which, in large part, are promptly related to some type of Climate Change. Obviously, there are and there always will be great uncertainties about the topic. However, an increased understanding of the subject and the search for better explanations for the cause of major meteorological phenomena because of either their intensity of their duration is an undeniable fact. Therefore, it is only natural that the University of São Paulo should be expected, through its Graduate Programs and Research Centers, to play an extremely important role in this regard. In the area of Climate Change, this expectation has been and is being increasingly met in several fields of knowledge and is not limited only to programs directly related to atmospheric sciences. Programs in economics, social sciences, medicine, arts, engineering, philosophy, physics, mathematics, computer science, earth sciences and many others have striven to meet the demands of world society, in particular Brazilian society, by discussing and trying to better understand all aspects related to the direct and indirect effects that human activity may have caused to the Earth's climate, as described below.

Material and methods

For the purpose of this analysis two main approaches were used: response from Graduate programs of USP regarding the identification of Theses and Dissertations defended since June 1992 on the topic of Climate Change, and the two main digital collections of Theses and Dissertations in the country, the Dedalus system (Bibliographic Database of USP, which can be consulted at http://dedalus.usp.br) and the bank of Theses and Dissertations of USP (http://www.teses.usp.br /). A description of the methodology used in this survey can be found in the article by Wagner Costa Ribeiro et al. in this issue of the journal.

Results

Graph 1 shows the evolution in the number of dissertations and theses defended at USP since Rio-92.



Graph 1 – Evolution in the number of MSc Dissertations and PhD Theses defended in Graduate Programs at the University of São Paulo between June 1992 and September 2011

Graph 1 shows clearly that the approach to the topic of Climate Change by Graduate Programs at USP was only perceived from 1996 as a possible reflection of the discussions held at Rio-92, which motivated the scientific community to discuss and study the topic. The first PhD Theses were defended only in 1998, and the number of such Theses has been fairly steady over the years,

hovering around six Theses defended per year. In contrast, the number of Master's Dissertations has increased significantly, totaling 22 dissertations defended in 2010. Interestingly, that the same year also showed a significant increase in PhD Theses defended, totaling 12 – a twofold increase over previous periods. Another important year, with a number of papers slightly lower than in 2010, was 2007, when 16 Master's Dissertations and seven PhD Theses were defended. Much of this increase can be explained by the publication of the IPCC Third Assessment Report – TAR in 2001. This report is one of the most mentioned documents to date, due to the fact that one of its chapters discusses in detail the scientific basis of Climate Change (IPCC, 2001). After the publication of this important report, aspects such as the carbon cycle, burning of fossil fuels, global warming, deforestation, extreme events and many others began to be studied from a broader and correlated perspective. What used to be studied by an individual area began to be considered in an interdisciplinary manner, giving rise to a large number of Inter-Unit Graduate Programs at the University of São Paulo and in other important universities in the country.

At USP, the distribution of studies related to Climate Change is quite heterogeneous and comprehensive. Altogether, this survey has shown that the topic is addressed by 28 different Units, as seen in Table 1.

Table 1 – USP units with theses and dissertations defended on topics related to Climate Change

Unit	Acronym	Unit	Acronym
School of Communications and Art	ECA	Institute of Electrotechnics and Energy	IEE
Nursing School	EE	São Carlos' Institute of Chemistry	IQSC
Science Teaching of the Physics Institute	Enscienc	Medicine School of Ribeirão Preto	FMRP
School of Architecture and Urbanism	FAU	Engineering School of São Carlos	EESC
School of Economics and Business Administration of Ribeirão Preto	FEARP	Law School	FD
Institute of Mathematics and Computer Science	ICMC	Inter-Units Program in Energy EP/IEE/FEA/IF	Inter Energia
Inter-Units Program in Biotechnology USP/IPT/ Butantan Institute	Inter Biotec	Inter-Units Environmental Science Program	PROCAM
Institute of Energy and Nuclear Research	IPEN	School of Philosophy, Sciences and Letters of Ribeirão Preto	FFCLRP
Institute of Chemistry	IQ	Oceanography Institute	IO

Latin American Integration Program	PROLAM	Polytechnic School	EP
School of Economics and Business Administration	FEA	Center of Nuclear Energy in Agriculture	CENA
School of Public Health	FSP	Institute of Biosciences	IB
School of Philosophy, Letters and Humanities	FFLCH	Institute of Astronomy, Geophysics and Atmospheric Sciences	IAG
Institute of Geosciences	IGC	School of Agriculture Luiz de Queiróz	ESALQ

Chart 2 shows the number of Dissertations/Theses defended in each of the units listed in Table 1.

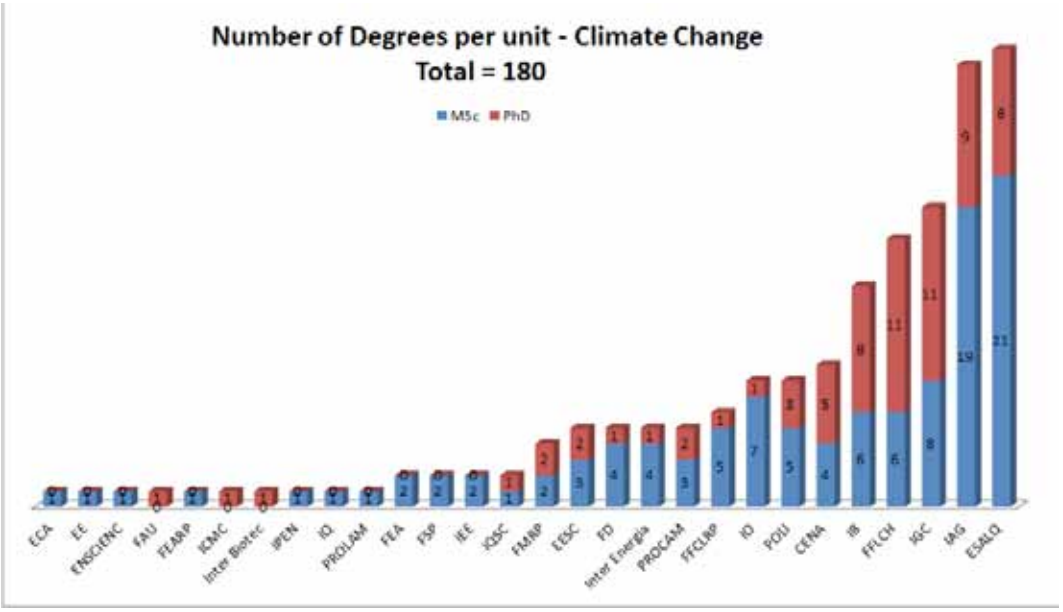


Chart 2 – Number of MSc Dissertations and PhD Theses defended in Units with Graduate Programs at the University of São Paulo on topics related to Climate Change between June 1992 and September 2011

As seen in Chart 2, several units addressed the issue of Climate Change in their Graduate Research Program, with an emphasis, in particular, on those related to biology, agriculture and earth sciences. The number of Dissertations/Theses defended at Esalq, IAG, IGc, FFLCH, IB, Cena and Poli is probably related to the impacts of Climate Change on events such as drought, excessive rainfall, variations in the availability of solar energy, CO_2 concentration in the atmosphere, and other factors related to the soil-vegetation-atmosphere system, in which agriculture is one of the sectors most susceptible to any change in weather patterns, besides its economic importance to our country. The disser-

tations/theses defended at the various units of USP covered different aspects of Climate Change, based on specific definitions of the topic, including impact on society, health, and economy, media actions, technological development, and actions to mitigate the possible adverse effects of increased greenhouse gas emissions (GHG) and its impact on global warming. An interesting example of multiplicity of subjects covered by the various scientific studies surveyed in the graduate program of USP is shown in Figure 1, through a "cloud of terms" based on the titles of the 180 Theses and Dissertations defended on the topic of Climate Change and related subjects.

Figure 1 – Cloud of terms based on the titles of Theses and Dissertations defended at USP between June 1992 and September 2011 on topics related to Climate Change, with an emphasis on the words most frequently used.

Figure 1 shows the multidisciplinary nature of the topic Climate Change, since words such as precipitation and temperature may indicate impacts on the climate of different regions such as the Amazon (forest), *Cerrado* and other municipalities and states in Brazil. The presence of terms such as emissions, greenhouse gases, and implications is also observed. Aspects more targeted at mitigation policies such as the Kyoto Protocol and the environment are also shown.

Global warming caused by increased concentrations of greenhouse gases in the atmosphere as a result of anthropogenic actions, influences temperatures and atmospheric and oceanic circulations, which in turn modify the hydrological regime, with an impact on rainfall in various regions of the globe. Water management in general will be affected, with an impact on agriculture, energy production and socioeconomic activities in large cities. All this interaction has a cost that can be assessed and subsequently associated with the vulnerability of the populations.

An example of the contributions that the scientific studies conducted at the graduate programs of USP is a doctoral thesis defended at ESALQ in 2010 (MORAES, 2010). The research highlights how climate change is especially

important for the agricultural sector, since it is an activity that depends on natural cycles. The aim of the thesis was to assess the economic impacts of climate change scenarios for Brazilian agriculture. The effects on the areas of eight crops (beans, corn, soybeans, cotton, rice, sugarcane, cassava and coffee) were assessed using a computable general equilibrium model, The Enormous Regional Model for Brazil (TERM-BR), and scenarios were provided by the Brazilian Agricultural Research Corporation (EMBRAPA) based on the Intergovernmental Panel on Climate Change (IPCC). Two scenarios were simulated with different time spans, one for 2020 disregarding social and economic changes (2020/A2), and one for 2070 with economic and social adaptations in the IPCC projections (2070/B2). For 2020/A2, the negative effects are concentrated in the Northeast, as a consequence of the region's semi-arid climate and production profile, in addition to the states of Mato Grosso and Mato Grosso do Sul, as a result of impacts on the area suitable for soybeans. In contrast, in this scenario the Southeast region was benefited because sugarcane showed yield increases under mild climate warming. The net result pointed to a slight reduction in economic activity (GDP), an increase in foodstuff prices and a shift in regional labor from the Northeast and Central-West to the other regions. For the second scenario, 2070/B2, the Northeast and Central-West regions were again the most affected. However, economic activity gains in the Southeast were smaller, since the beneficial effect on sugarcane disappears in more severe climate change scenarios. As a result, the national decrease in economic activity was higher than in the previous scenario. With respect to labor market, the trends regarding labor migration from the Northeast and Central-West to the other regions remained. However, this migration was concentrated, proportionately, in the more skilled strata of the labor market. Climate Change, in the absence of tougher adaptation and mitigation measures, may pose a risk to historically underdeveloped or recently developed regions. In particular, it was shown that the economic impacts in Brazil are heterogeneous among the large regions and the states they comprise.

Another specific and interesting example relating GHG emissions, economy and industrialization was developed in a doctoral thesis at the EP (LIMA, 2009). This study demonstrated how the construction sector contributes to CO_2 emissions in the production of materials, and even suggests the importance of developing policies in this area. The study aimed to obtain indicators related to CO_2 emissions in the domestic segment of concrete, for the assessment of its relation to climate change. The results showed that emissions in the range of 195-231 $kgCO_2$/ton of concrete (about 88 percent) are associated with cement. In the scenarios chosen for the study, if there is no change in CO_2 emissions from the cement industry, total emissions in 2030 will be equal to 3.0 and 4.5 times higher than in 1990, the reference year used in the scenarios related to the evolution of factors linked to climate change. At these levels, the increase in emissions will be greater than those required for inclusion in any mitigation

scenario currently considered worldwide, thus showing the challenges that the cement industry will face in the coming decades. The construction sector can also contribute to improving technological control in the production of concrete, and with a greater share of ready-mix concrete in the segment. This study is part of a more general topic: sustainability of the construction materials chain, which is becoming increasingly important. In this chain, it is difficult to find sectorial organization in some segments. Therefore, the use of tools that enable identifying and studying relevant problems with a proper degree of reliability and a good cost-benefit ratio for research is very important. Over the past few years, the Amazon has been the focus of discussions in all sectors of society, particularly because of the increased deforestation and consequent climate impacts it has experienced. However, a doctoral thesis defended in 2001 at the FFLCH (ZAMPARONI, 2001) already clearly demonstrated the process of land degradation and urbanization in some regions of Brazil. This study examined climate change in the Amazon region of Mato Grosso arising from the colonization that started in the 1970s, taking as sample the municipalities of Sinop, Sorriso and Vera, located in the Basin of the Middle Teles Pires river. In the context of space appropriation, occupation and transformation in the Amazon region of Mato Grosso, data on the temporal/spatial evolution of deforestation in the area studied were mapped and quantified, resulting in percentages of occupied areas and areas with vegetation remnants. The data resulting from population increases in the study area and growing urbanization in rural areas in the Amazon region of Mato Grosso were treated in light of the rural/urban migration resulting from the modernization of agriculture in southern Brazil. The analysis of trends in climate variables reviewed in the period 1973-1998 supported the verification of possible Climate Change stemming from the process of occupation and transformation of the area studied. While in the municipality of Vera total deforestation was 31 percent and in Sinop, 47.0 percent, in Sorriso it had reached 66 percent in 1997, since the area occupation process started in the late 1970s. The urbanization process of rural areas was seen in the three municipalities addressed in the study, since most of the migrant population is concentrated in urban areas. The study also evinced an increase in the annual maximum and minimum average temperatures, a decrease in the values of annual average rainfall and increases in the annual averages of relative humidity and evaporation. The study concluded that changes in climate variables are related to both the deforestation and the urbanization of rural areas in the municipalities of Sinop, Sorriso and Vera, located in the Amazon region of Mato Grosso.

As seen here, and based on several other studies, local Climate Change due to human activities may contribute to Global Climate Change. What is being discussed now is how this feedback between both occurs, since various meteorological indicators considering future scenarios show changes in average global circulations and particularly in weather systems. A master's dissertation

defended in 2009 at the IAG (KRÜGER, 2009) showed interesting results in this direction. The research examined the possible impacts of climate change scenarios in the climatology of tropical cyclones in the South Atlantic. The study used a numerical model to analyze regional cyclones in the present climate (1975-1989) and future climate (2071-2085-scenarios A2 and B2). First, the climatology simulated by the model was evaluated in terms of precipitation and temperature in the present climate. For both variables, the regional model simulated the spatial and seasonal pattern similar to that observed, although with different intensities. For future scenarios, the model simulated positive anomalies in air temperature, which were higher over the North and Northeast of Brazil for A2, coinciding with the greatest reductions in rainfall. An automatic cyclone-tracking scheme was used to obtain the climatology of cyclones simulated by the model. The simulated cyclones were weaker than those observed in the present climate (1975-1989). However, the spatial distribution of the cyclogenetic density was closer to what was observed. The climatology projected for future scenarios (A2 and B2) showed a reduction in the total number, average lifetime, average initial intensity and average travel speed of cyclones. The biggest changes occurred in the A2 scenario. The three regions of cyclone formation on the east coast of South America (south coast/Southeastern Brazil, Southeastern Uruguay and Southern Argentina) remained active in the simulations of future climate, with minor differences in the intensity and position of the maximum core density. Furthermore, the region of generation of cyclones with higher initial intensities shifted toward the South Pole. These results suggest that the climate in the South and Southeast regions of Brazil may be quite different from what we observe today. An evaluation of adaptations and a definition of vulnerabilities in these areas may therefore be necessary.

Conclusions

In general, it is clear that over the last few years the research developed at the University of São Paulo has contributed to increase the knowledge of all the implications of human activities in changing the climate as we have known it in the past centuries. Some of the examples presented, clearly show that the Graduate area of USP not only conducts basic research, but is also attentive to the needs of society for advancing in the knowledge of important topics.

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