The Catholic University of Brasília

PRO-RECTORY OF STRICTO SENSU POSTGRADUATE IN ENVORONMENTAL PLANNING AND MANAGEMENT

Master Degree

EVALUATION OF THE IMPACT OF BIOFUELS PROGRAM ON WATER AVAILABILITY OF THE CERRADO

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BRASÍLIA

2007

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EVALUATION OF THE IMPACT OF BIOFUELS PROGRAM ON WATER AVAILABILITY OF THE CERRADO

Dissertation submitted to the Post-Graduate Program Stricto Sensu in Environmental Planning and Management of the Catholic University of Brasilia, for obtaining a Master Degree in Environmental Planning and Management.

Advisor: Professor PhD. Flavio Giovanetti de Albuquerque

Brasília
2007

M188a Magalhães, Geraldo Magella Obolari de.
Evaluation of the impact of biofuels program on water availability of the cerrado/ Geraldo Magella Obolari de Magalhães. – 2008.
91 f. : il. ; 30 cm.

Dissertation (Master Degree) – The Catholic University of Brasília, 2008. Orientation: Flávio Giovanetti de Albuquerque.

1. Biomass Energy. 2. water resources. 3. oil seeds. 4. Environmental Impact. 5. Cerrados. I. Albuquerque, Flávio Giovanetti of orient. II. Title.

CDU 620.925:58

SIBI-UCB Dissertation Collection Process Coordination

THE CATHOLIC UNIVERSITY OF BRASILIA

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EVALUATION OF THE IMPACT OF BIOFUELS PROGRAM ON WATER AVAILABILITY OF THE CERRADO

Dissertation approved in December 11, 2007 for obtaining a Master Degree in Environmental Planning and Management.

Area of concentration: Water Resources

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To my wife, Maria Aparecida, friend and companion of every hour

ACKNOWLEDGEMENTS

I thank God for having granted me life with so many blessings, starting with my parents, Geraldo Magella de Magalhães and Neusa Obolari de Magalhães;

To my grandparents Eloy Obolari and Geralda Saleme Obolari (in memory), for having infused in me the love of study;

My wife, for understanding, encouragement, support and companionship in times of subtraction of our family life; and children Maria Clara, Cairo, Ariadne and Larissa for so much love;

To my friend-brother Rodrigo Silva Quintela Soares, for the presence;

To my thesis advisor, for teaching me the path of the waters;

To Mr. Joatam Lourenço dos Santos, Mayor of the Campus II of the Catholic University of Brasília-UCB, for opening the doors of the Auditorium San Francesco d'Assisi, my room during my first year in the master's degree;

All teachers and colleagues at the masters for their support and affection at various times during this hike;

To my frien Edilson Ferneda, professor at the Catholic University of Brasília-UCB, for the encouragement;

The friend Rogério Azevedo Rocha, a professor at the Federal University of Tocantins – UFT, by timely advice;

José Luiz Cabral da Silva Jr., PhD. in Agrometeorologia, Lucas Koshy Naoe, Doctor in genetics, researchers from Fundação Universidade do Tocantins, and Girlene Figueiredo Maciel, Professor at the Federal University of Tocantins, by availability and contributions;

The Coordenação de Aperfeiçoamento de Pessoal de Nível Superior-CAPES, by financial support to my research;

The Embrapa Cerrados, the information made available, in particular the Homero Chaib Son, PhD. in applied mathematics;

The National Institute of meteorology-INMET meteorologists in particular Francisco de Assis Diniz and Expedito Ronald Gomes Rebello, for classes in atmospheric circulation, and the Agricultural Engineer Luis Tomas Azevedo de Mello, for information;

To the Support Research Laboratory in Environment and Water Resources-LAMARH, the Catholic University of Brasilia, in particular to Engineer Guilherme Oliveira Ribeiro, for services rendered during this research;

The Ministry of Agriculture, Livestock and Supply and to the Ministry of Environment, through the valuable information provided.

It is said violent the river that drags everything. But nobody says it is violence to constrain its boundaries.

Bertold Brecht

RESUMO

O presente trabalho buscou avaliar o impacto do programa de Biocombustíveis na disponibilidade hídrica do cerrado. Atualmente, os recursos hídricos do cerrado, na época da seca, já sofrem um desequilíbrio porque parte da evapotranspiração da região não precipita no mesmo local, conforme estudos da circulação atmosférica apresentados pelo Instituto Nacional de Meteorologia. A hipótese concernente a esse objetivo é que a expansão das culturas para a produção de Biocombustível trará um impacto negativo à disponibilidade hídrica na região. Considerando-se o aumento de temperatura, ocasionado pelo desmatamento e/ou extração da vegetação nativa do cerrado, para o plantio das oleaginosas elegíveis, que também faz aumentar o consumo de água em todo o seu ciclo, verificou-se o impacto nos recursos hídricos da região. O estudo se deu por meio de uma revisão bibliográfica sobre a evapotranspiração da vegetação nativa do cerrado, sobre a evapotranspiração das culturas potenciais para o programa de biocombustíveis e sobre a circulação atmosférica da Região Centro-Oeste. A integração dessas informações permitiu a constatação de que a disponibilidade hídrica da região poderá ser afetada negativamente, caso se busque o cumprimento das metas de produção de biocombustíveis atualmente veiculadas pelos órgãos públicos concernentes.

Palavras-chave: Biocombustíveis. Oleaginosas. Cerrado. Evapotranspiração. Recursos Hídricos. Impacto Ambiental.

ABSTRACT

This study sought to evaluate the impact of the biofuels programme in the availability of closing water of the ecosystem, named Cerrado. Currently, the water resources of the cerrado, in the dry season, already suffering from an imbalance because of the evapotranspiration in the region do not precipitate in the same place, as the movement atmospheric studies presented by National Institute of Meteorology. The objective of this study was to evaluate the impact that the programme of biofuels can cause water availability in the cerrado, in the Midwest region of Brazil. The hypothesis concerns that the goal was: the expansion of crops for biofuel production will bring a negative impact on water availability in the region. Considering the increase in temperature caused by deforestation and / or extraction of native vegetation for the planting of oilseeds eligible, which also increase the water consumption and the demand that the alarming water use crops for their development throughout the his cycle, it checked the impact on water resources in the region. It was done a survey of information on the water demand of native vegetation, about the crop evapotranspiration potential for the biofuels program and about the movement of atmospheric Midwest Region. The integration of this information allowed the finding that the availability of water in the region may be affected adversely, if they seek compliance with the goals of producing biofuels currently served by public agencies concerning.

Keywords: Biofuels. Water Resources. Evapotranspiration. Cerrado. Oleaginous seeds. Environmental impact.

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ACRONYMS

ANEEL – The National Electric Energy Agency
B2 – Mixture of 2% biodiesel to petroleum diesel
B5 – Mixture of 5% biodiesel to petroleum diesel
B20 – Blend of 20% biodiesel to petroleum diesel
B100 – Pure biodiesel
CEI – Inter-Ministerial Executive Committee
CO_2 – Carbon dioxide
CPTEC – Center for weather forecast and Climatic Studies – INPE
DECIS – Decision Point Method
EBDA – Bahia Company for Agricultural Development
EMBRAPA – Empresa Brasileira de Pesquisa Agropecuária
ESALQ – Escola Superior de Agricultura Luiz de Queiroz
ET – Evapotranspiration
ET_o – Reference evapotranspiration
ET_c – Evapotranspiration of Culture
FBDS – Brazilian Foundation for Sustainable Development
HPa – Hectopascal (default unit of pressure and tension)
IBGE – The Brazilian Institute of Geography and Statistics
IEA – Agricultural Economy Institute
INPE – National Institute for Space Research
INMET – National Institute of Meteorology
IPCC – Intergovernmental Panel on Climate Change
JBN – Low-level Jets
K_c – Crop Coefficients
NAE – Center for Strategic Affairs of the Presidency of the Republic
NCEP – National Centers for Environment Prediction
NOS – National System Operator
ONU – United Nations Organization
PROÁLCOOL – National Alcohol Program
UNICA – Union of Sugarcane Industry
ZCAS – South Atlantic Convergence Zone

CONTENTS

INTRODUCTION

The aim of this study was to evaluate the impact that the Biofuel program may result in water availability of the Cerrado, in the Central-West region of Brazil. The hypothesis related to this goal is the expansion of crops for biofuel production:

H^o: will bring a negative impact to the water availability in the region.

H^1: will not affect the availability of water.

According to the Center for Strategic Affairs (NAE) of the Presidency of the Republic (BRAZIL 2005a, p. 11), diesel fuel can be complemented by modified vegetable oils without changing engines. According to the cited source, even if do not exist technical or regulatory obstacles to the start of the use of biofuels in addition to diesel, its use implies availability of inputs, supply security, processing capacity by the industry and final integration amongst distribution circuits.

The current scenario is to expand the acreage to meet the increase of internal and external consumption, primarily American and European. Several studies examine social, economic and financial issues, resulting from this expansion, suggesting their viability and proposing a program to expand the production of biofuels. Other studies come to do detailed analyses about the needs of the area, inputs, labor and demonstrate the availability of these resources, reinforcing the idea of expanding the already planted area. However, in the literature review performed, it was not observed any analysis of the main raw material necessary for the agricultural activity: water.

Worldwide, it is estimated that 9,000 km^3/year of water are accessible to human consumption and about 3,500 km^3 are stored in dams, adding a total of easy access of 12,500 km^3/year. The total runoff is 47,000 km^3/year, but the exploitation of the remaining 34,500 km^3/year is difficult, costly or may cause negative impacts to the environment. Currently, approximately 6,500 km^3 of water are used per year for humanity for various purposes, concentrating on the predominantly agricultural use, followed by industrial and urban (HIRATA, 2001).

The amount considered of the 119,000 km^3 per year of precipitation falling on the continents, approximately, only 72,000 km^3/year of water returns to the atmosphere through evapotranspiration, (KARMANN, 2001). The remaining 47,000 km³/year of fresh water circulating around the planet, through runoff and underground represent the water surplus, which is the difference between the volume and the evapotranspiration (HIRATA, 2001). Evapotranspiration (ET) is the process associated with the joint soil water loss by evaporation and by transpiration from plant (ALLEN et al., 1998).

Nowadays, the Cerrado native vegetation and agricultural exploitation have consumed 0.08961 km³/year (SILVA, 2003). However, plants with potential for biodiesel production (BRAZIL, 2005a, p. 38) eligible by the Federal Government would demand together the sum of 368,599 mm3.

Considering that water figures as a limiting factor for the biofuels programme, a detailed study has been developed on the impact of this programme in water resources before its implementation.

CHAPTER I – BIOFUELS

Biodiesel is a generic name for fuels produced from renewable sources such as vegetable oils and animal fats, for use in compression-ignition engines, also known as diesel engines. In addition, biodiesel can be used to generate energy instead of diesel oil and fuel oil.

Brazil for its vast territorial extension, associated with the excellent soil and climatic conditions, is considered a haven for the production of biomass for food, chemical and energy purposes. Studies released by the Department in charge of the implementation of the biodiesel in the United States claim categorically that Brazil is able to lead the world production of biodiesel, promoting the replacement of at least 60% of the diesel oil consumed in the world.

The global demand for renewable fuels will be growing and Brazil has the potential to be a major exporter in the world, especially in the current context of climate change.

1.1 Biofuels and biodiesel

As a non-renewable source of energy and due to environmental problems come from the burning of fossil fuels, the search for alternative sources of energy have been intensified. Among the most promising are biofuels, derived from agricultural products such as sugar cane, oleaginous plants, forest biomass and other sources of organic matter. As an example, one can cite the biodiesel, ethanol, methanol, methane and the charcoal (ESALQ, 2007), which can be used alone or added to conventional fuels.

Biodiesel is a biodegradable fuel derived from renewable sources, which can be obtained by different processes such as cracking the esterification or by Transesterification. Can be produced from animal fats or vegetable oils, there are dozens of plant species in Brazil which may be used, such as castor oil palm (Palm), sunflower, babassu oil, peanut, jatropha curcas and soybean, among others (NATIONAL PROGRAM for the production and use of BIODIESEL, 2007).

Biodiesel replaces all or part of the diesel oil in diesel cycle engines automotive (trucks, tractors, buses, cars, etc.) or stationary (electricity generators, heat, etc.). It can be used pure or mixed with diesel in various proportions. The mixture of 2% biodiesel to petroleum diesel is called B2, and so on, until the pure biodiesel, called B100.

According to law No. 11,097, of January 13, 2005 (BRAZIL, 2005d)[1], biodiesel is a biofuel derived from renewable biomass for use in internal combustion engines with compression-ignition internal combustion or, as regulation, to generate another kind of energy, which may partially or fully replace fossil fuels ".

Transesterification is the process currently used for biodiesel production. It consists of a chemical reaction of vegetable oils or animal fats with common alcohol (ethanol) or methanol, stimulated by a catalyst, which also extracts the Glycerin, product with various applications in the chemical industry.

Ecological fuel being biodegradable, non-toxic and essentially free of sulfur and aromatics, biodiesel brings a number of benefits associated with the reduction of greenhouse gases and other air pollutants, as well as reducing the consumption of fossil fuels (ESALQ, 2007). Many are the advantages brought by the biodiesel, as (BIODIESELBR, 2007):

- real possibility to replace almost all derivatives of oil without modification in engines, eliminating the dependence on oil;
- excellent lubricant;
- increasing the useful life of the engine;
- easy transporting and easy storage;
- unnecessary adaptation in trucks, tractors or machinery;
- provides environmental gain for the entire planet;
- collaborates to reduce pollution and greenhouse gases;
- CO2 emission rates up to 80% lower compared to petroleum diesel;
- Therefore the whole renewable CO2 emitted in burning the engine, can be captured by plants and used by them during their growth and existence.

Besides being naturally less polluting, biodiesel reduces emissions of petroleum derivatives (at about 40%, and its potential carcinogen is about 94% less than oil derivatives), has high ability to lubricate the machines or engines reducing possible damage, it is safe to store

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[1] Appendix A contains a list of Brazilian legislation on biofuels.

and transport because it is biodegradable, non-toxic and non-explosive nor flammable at room temperature, does not contribute to acid rain since it does not introduce sulfur in its composition, allows to reduce large investments in power plants or transmission lines, for local energy service in regions with little demand.

Considering so many advantages, the Brazilian Government has stimulated the production and marketing of biodiesel, being the main landmark to the publication of Decree Nº 5.488 of May 20, 2005 (BRAZIL, 2005e), which regulates law 11,097 (BRAZIL, 2005d). This Bill provides the introduction of the biodiesel in Brazilian energy matrix. Initially the allowed ratio was 2% of common diesel until 2008, 5% until 2013 and it is already being thought 20%. In the United States, cars powered with 100% biodiesel have shown amazing income.

1.2 Biodiesel production programs in the world

The European Union currently maintains the largest biodiesel program in the world. At the end of 2003, the installed capacity allowed annual production of something between 2.5 and 2.7 million tons of biodiesel, with expectation to increase in the coming years (INTERNATIONAL ENERGY AGENCY, 2004). With this program, the European Union hopes to replace 2% of diesel fuel used for transportation until 2005, with expectations to reach 20% by 2020.

Most of the vegetable oil used in this program comes from the cultivation of rapeseed. However, the vegetable oil production costs are, on average, about twice higher than mineral diesel. Nevertheless, recent analyses this program concluded that biodiesel is an alternative technically viable to the mineral diesel, since factors such as local environment, global climate, generation and maintenance of employment, balance of payments are not considered (BRAZIL, 2005a, pp. 19-20). Among benefits for biodiesel are:

- the improvement of lubricity;
- the reduction of local pollutants and emissions of greenhouse gases;
- the fact that it is non-toxic and biodegradable;
- at low concentrations, does not require changes in engines.

On the other hand, some care must be observed. For example, the large volumes of glycerin envisaged, for being one of the by-products of biodiesel production, may affect the oil-chemical market, because prices will lower considerably.

The American program of biodiesel, so much smaller than European, have soy as the main raw material, complemented by the reuse of frying oils. According to the National Biodiesel Board (BRAZIL, 2005b, p. 20-21), in 2002 were produced approximately 50 million liters of biodiesel, used basically as B20 (20% biodiesel blend). Until 2005, there were more than 12 companies producing this fuel in the United States, with a production capacity of 200 thousand tons per year.

In addition to these programs, other countries have invested in biodiesel production on a commercial scale, as China and Nicaragua. Such initiatives have the potential to become national programs for the production of biodiesel.

1.3 Biofuels in Brazil

In early 2003, in Brazil, the President of the Republic asked the NAE[2] a technical analysis on the energy issue. Studies were conducted on the production and use of biodiesel from various types of raw material and about the feasibility of its use in pure form or as a mixture with mineral diesel in various proportions. This study points to the diversity of possible raw materials and production processes as one of the great advantages of biodiesel. However, it is necessary a careful review on points such as: the total costs involved in the production, life-cycle emissions, the possibilities of job generation, availability of area and adequate manpower, among many other factors.

The Federal Government, through Decree s/n of December 23, 2003 (BRAZIL, 2003; 2006), instituted an Inter-ministerial Executive Committee (CEI) responsible for the implementation of actions directed to the production and use of vegetable oil – biodiesel – as an alternative source of energy. This Commission refers to Civil Committee of the Presidency of Republic and the Ministry of Mines and Energy as its Coordinator Executive drive. As a reflection of the work conducted by CEI, entered into force on January 14, 2005, law No. 11,097 (BRAZIL, 2005d), which provides for the introduction of biodiesel in the Brazilian

[2] http://www.planalto.gov.br/secom/nae/

energy matrix. This new legislation deals with the production, storage, distribution and sale of biodiesel in Brazil, including its use as automotive fuel.

Being considered the country of greatest potential for biofuel production by their exceptional conditions of soil, climate and, by its vast territorial extension, the Brazil pioneered the introduction of ethanol in its energy matrix and amassed an experience of more than three decades of its production and use in substitution to gasoline. The production of Brazilian sugar cane covers today a acreage totaling more than 6 million hectares, of which, 2.7 million hectares for the production of ethanol (FBDS, 2006). According to UNICA (2004, apud MOREIRA et al., 2005), for the crop year 2003/04, the production of sugar cane in São Paulo corresponded to 61.35% of the national production and 69.52% of production in the Center-South region.

In Brazil, the most widespread type of biofuel is ethanol derived from sugar cane, less polluting petroleum-derived fuels.

The Brazil had its first experience with biofuels in 1931, when the Brazilian Government authorized the use of ethanol, derived from sugarcane, mixed with gasoline in proportions between 2 to 5%, respected regional product availability. Already in 1975, there was the creation of the national alcohol Program (PROÁLCOOL) aimed at the partial replacement of gasoline by ethanol, being more a country's investment in renewable energy (BRAZIL, 2005c).

The main advantage of alcohol is the least pollution causing compared to petroleum-derived fuels (MEDINA, 2007). The cane is a complete product because it produces sugar, alcohol, bagasse and steam generates electrical energy. However, it has several disadvantages, such as the fact of not solving the problem of oil dependence.

1.4 The production of biodiesel from oilseeds

The advantage of biodiesel on diesel fossil based with regard to the emissions of pollutants, given that this is a product that is non-toxic and biodegradable is already known. In Europe, studies show that, compared to diesel, pure biodiesel produced from canola reduces greenhouse gas emissions in 40-60% (BRAZIL, 2005b, p. 31). From soybean, for example, it can be expected the same proportions of pollutant reduction.

If, on the one hand, various oilseeds can be used in biodiesel production, on the other, its production demands considerable planting area. For example, to supply 5% of B5 diesel with local oleaginous (soy, palm oil or castor oil) would require approximately 3 million hectares (BRAZIL, 2005a, p. 12). Recent studies carried on by EMBRAPA (PERES, 2003) show the regional skills for each one of them: the soy to the South, Southeast and Midwest; castor bean to the Northeast and palm oil for the Amazon region. Sunflower, peanut and others have also been considered. Also, tropical palms are always mentioned as viable and potential producers of biodiesel (BRAZIL, 2005b, p. 37).

1.4.1 Rapeseed

Rapeseed (*Brassica napus*), also known as canola, is the main plant studied and planted for biofuel production in the European Union. The grains produce approximately 38% of oil and it constitutes one of the best alternatives for the diversification of crops and income generation in winter, particularly in grain production systems, as seen in *tritícola* regions of southern Brazil (TOMM, 2003a).

Rapeseed is herbaceous, belonging to the *Cruciferae* family and, within this, the genus *Brassic*a which encompasses several species grown for horticultural uses such as forage, and for the production of oils and condiments. Also belonging to this genus are mustard, cabbage, cauliflower and turnips.

There are two species known by the designation rapeseed: *brassica napus var. oleifera* and *brassica campestres*, although it is normally associated with the first.

That is a traditional crop in many European countries (France, Germany, Poland, Sweden, Romania, etc.), North America (Canada) and it has given the first steps of implementation in southern Europe (Portugal and Spain) accompanying the growth of biodiesel.

1.4.2 Palm Oil

Known in Brazil as ‘dendê’ (*Elaeis guineensis*) the palm is originally from Africa and was introduced in our country in the Colonial period, by African slaves. The seeds were planted on the coast of the estate of Bahia, particularly in the ‘*recôncavo’* as it is known, where there were fertile soil and climate conditions for their development. For centuries has been bred only to meet the needs of regional cuisine.

Brazil is, currently, the third producer of palm oil in Latin America, being Colombia, the first, and Ecuador, in second place. The participation of Brazil in the world production of palm oil has only been 0.53%.

Among oilseeds, the culture of palm oil (*dendê*) is of greater productivity, reaching 4 to 6 tons of oil/ha. The Amazon region has the greatest potential for this palm oil plantation in the world, with estimated area of 70 million hectares, with high fitness of approximately 40% (BRAZIL, 2005a, p. 12).

1.4.3 Castor Bean

EMBRAPA has developed and released commercially, in collaboration with the Bahian Company for Agricultural Development (EBDA), two varieties of castor bean (*mamona*) available for planting in Brazil in still limited quantities: the cultivars BRS149 Northeastern and BRS 188 Paraguaçu (BRASIL, 2005a, p. 44).

Ideal for drier regions, the raw material only requires 300 ml of rain throughout its cycle of 6 months. In addition to revolutionize the economics of the Northeast, it can put Brazil in global leadership of Biodiesel, which will tend to be more competitive than today, due to future carbon credits (ECONOMIABR, 2006).

1.4.4 Peanut

According to Peres, Freitas and Gal (2005), the peanut has approximately 50% in almond oil and already constituted an important source of edible oil, before being replaced by soy. Also, in the early 1980, studies were carried out in the country, using peanut oil instead of diesel oil, with great success.

In 1972, the Brazil produced 962 thousand tons of peanuts. By virtue of a number of disincentives, the production has shrunk and, since 1987, the Brazil does not exceed the mark of 200 thousand tons. Among the factors that contributed to the downslide of the planting, the low technology used by producers; the observation of fungi that, in conditions of high humidity, produced aflatoxin which, besides attacking the pods, is carcinogenic to humans. Another important factor was the loss of vegetable oil market to competitive products, such as soybeans. Nevertheless, the opening of the energy market can provide new impetus for culture, given its high oil production capacity. Peanut allows extract twice the oil volume per unit area, compared to soybeans.

1.4.5 Soybeans

The soybean (*Glycine Max*) is the most used in the United States, where it is also common to mix with leftover waste oils for frying. The world largest exporters of soybeans and their derivatives are the United States, however they considered quite affected with a new international competitor. The reason is that in 2002/03 they lost the post for Brazil, which reached foreign exchange revenue of $ 8.1 billion against $ 7.2 billion of Americans. Brazil exported US$ 10 billion (+ 23.4%) and 36.3 mt in 2003/04.

One of the most important items of our agribusiness, soy has achieved the enviable average productivity, with projections of 2.7 thousand kilos per hectare in 2005/06.

The prominent position of soy in the Brazilian economy justifies the search for new information to improve growing conditions and reduce the risks of losses. One of the main causes of variation of productivity of soybean in Brazil has been the occurrence of water deficiency (MAR, 2006).

Water constitutes approximately 90% of the weight of the plant, working in virtually every physiological and biochemical processes. It performs the function of solvent by means of gas, minerals and, by such way other solutes enter the cells and move throughout the plant. Also it has important role in regulating the thermal plant, acting both in cooling as in maintenance and distribution of heat.

The availability of water is mainly important in two periods of development of soybean: germination-emergence and flowering-grain filling. During the first period, both the excess of water as its deficit are detrimental to obtaining a good uniformity in plant population. The soybean seed needs to absorb at least 50% of its weight in water to ensure good germination. In this phase, the water content in the soil should not exceed 85% of the total maximum of water available and not less than 50%.

The need for water in the culture of soy tends to increase with the development of the plant, reaching the maximum during flowering-grain filling (7 to 8 mm/day), decreasing after that period. Significant water deficits during flowering and grain filling, cause physiological changes in the plant, such as stomatal closure and winding of leaves and, as a consequence, causing premature loss of leaves and flowers and abortion of pods, ultimately resulting in reduction of grain yield.

The total need of water in soybean culture, for obtaining the maximum performance varies between 450 to 800 mm/cycle, depending on the climatic conditions, the management of culture and the duration of the cycle.

To minimize the effects of water deficit, it is indicated to sow only cultivars adapted to the region and to the condition of soil, that means: sowing at the time recommended and lower climate risk; with adequate moisture throughout the soil profile, and adopting practices that encourage water storage by the soil. Irrigation is effective measure, but of high cost.

1.4.6 Sunflower

The sunflower is a culture that adapts well to a variety of environments, and can tolerate low temperatures and periods of water stress. Germination is inhibited with soil temperatures below 4ºc, showing satisfactory with values greater than 8 to 10ºc. Cold temperatures during germination slow emergence and induce the formation of small seedlings.

Plants can withstand low temperatures for a short period, especially in the early stages. However, extremely cold temperatures during early development can cause leaf deformation and damage the apex of the plant, causing some anomalies, such as branching stems. The biggest visual effect of temperature is on the rate of development, resulting in smaller plants, with lower leaf area and, consequently, less productive potential. Low temperatures increase the culture cycle, delaying flowering and ripening. When they occur after the onset of flowering, they can affect the performance significantly.

High temperatures damage the plant development especially in conditions of low water availability. The temperature range of 8 to 34ºC is tolerated by the sunflower without significant reduction of production, indicating adaptation for regions with warm days and cold nights. The optimum temperature for their development is between 27 to 28°C.

Also, during the formation of the grains, high temperatures affect more seriously the fatty acid composition of oil content. There is a strong negative correlation between the content of linoleic acid and temperature increase. Temperatures above 35°C reduce the oil content.

Sunflower water needs are not yet fully defined, and there is information that indicates since less than 200 mm to more than 900 mm per cycle. However, in most cases, 500 to 700 mm of water, well distributed throughout the cycle, resulting in yields close to the maximum. Water consumption by sunflower culture varies depending on weather conditions, the duration of the cycle and the soil and crop management. Well-prepared and/or soils with high water storage capacity enable the plant to tolerate longer periods without rain and/or irrigation.

The sunflower has low efficiency in water use. Each liter of water consumed produces less than two grams of dry matter. However, under conditions of hydric deficit, such efficiency increases around 20% to 50%. Its root system is deep and well developed laterally and its maintainability of photosynthesis even under adverse conditions it tolerates short periods of drought, to ensure some income in conditions where other species produce nothing.

The need for water increases with the development of the sunflower plant. It starts from values around 0.5 to 1 mm/day during the seeding to the emergence, peaking at 6 to 7 mm/day in flowering and grain filling, decreasing after the period. An adequate availability of water during the period of germination the emergence is required to obtain a good uniformity in plant population. Phases of plant development more sensitive to water deficit are:

a) beginning of the formation of the chapter at the beginning of flowering: affects more grain yield;

b) formation and grain filling: affects more oil production. It is the largest water consumption phase by sunflower.

In a fairly practical, the most critical phase the water deficit is the period between about 10 to 15 days before the beginning of flowering and 10 to 15 days after the end of flowering. Regarding the reaction of the plant to photoperiod, the sunflower is classified as insensitive species. However, some varieties behave like short day plants and others as long day.

1.4.7 Babassu Oil

The babassu palm has a strong importance in the states of the North and Northeast regions of the country. The ample opportunities of taking advantage of the babassu oil in various activities ranging from food, clothing, until alternative energy elements. The use of this essentially extractive resource, requires to be well planned.

The babassu is considered the greatest oil plant of world resource, and one of the main products of extractive in Brazil, thereby contributing significantly to the economy of some

Brazilian states.

1.5 Water: a new paradigm

According to Rifkin (2003, p.1), at various times throughout history, the society found itself trapped between two different ways of perceiving reality, as when, on the eve of the American Revolution, James Watt patented his steam engine. This radically changed the relationship of humanity with the natural sources of energy, changing, therefore, the known lifestyle and starting what is called Industrial Age, characterized by a strong dependence on energy from fossil fuels.

Nothing really significant was done to change this model of development and to ease future consequences of the depletion of oil reserves despite already in the years 1970, at the height of American oil production, have found that half of the country's exploitable reserves had been depleted, and, despite the alert, which represented the embargo of oil producers.

According to the recent finding of a strong relationship between global warming and the burning of fossil fuels (BRAZIL, 2005b), it is pressing a new paradigm shift, seeking alternative energy sources. That, in fact, anticipated the discussions about the problem of the shortage of reserves of oil, natural gas and coal that, sooner or later, would have to be faced, strengthening the interest in alternative energy sources and renewable fuels or biofuels. Studies show that, at the current consumption rate, shortages may occur in approximately 40 years (RIFKIN, 2003, p. 5).

Since the beginning of the 20th century, water consumption has grown as a proportion twice as big as the world population grows (RIO GRANDE DO NORTE, 2007). Although most of the surface of the Earth is composed of water, only a little volume greater than 2% of all this water is sweet and more than 90% is in polar ice or in very deep underground deposits. Only 0.001% of the planet's water, which are the existing surface fresh waters (rivers, lakes and dams), are usable by man in an economically feasible and without major environmental impacts. This small portion of water is called *Water Resources*. Therefore, even in a country like Brazil, of continental dimensions, holder of the largest inventory of fresh water on the planet, the management of water resources is an imperative and urgent task.

In Brazil, the underground water reserves are estimated at 112,000 km^3 (112 trillion cubic meters) and the average multi-year contribution to the discharge of the rivers is on the order of 2,400 km³/year (REBOUÇAS, apud BORGUETTI 1988; BORGUETTI; ROSA FILHO, 2004).

In several urban centers, the groundwater is used exclusively or complementary and it constitutes the most important resource of fresh water. Many establishments use water from deep wells. Important Brazilian cities depend on groundwater in full or in part to supply, as, for example, the cities: Ribeirão Preto (SP), Mossoró and Natal (RN), Maceió (AL), the metropolitan region of Recife (PE) and Barreiras (BA). In the state of Maranhão, more than 70% of cities are supplied by groundwater. The states of São Paulo and Piauí this percentage reaches 80% (BORGUETTI; BORGUETTI; ROSA FILHO, 2004).

According to the UN, more than one billion people do not have access to safe drinking water and 2.5 billion do not have near any kind of sanitation, causing the death of approximately 8 million people per year. It is estimated that within 25 years, 4 billion people will not have water to meet their basic needs (SCOTT, 2006).

The tendency, then, is that the water will become a high-value commodity in the international market in the years to come. Developing countries, including the owners of this resource, are the ones who will suffer most as a result of the shortage, since almost all of its economy is strongly linked to exploitation of its natural resources and agricultural production for export. In order to illustrate the importance of water for agricultural production, the Table 1, below, presents the water demand for some products.

Table 1 - Water in food production

Product	**Water (in liters) needed to produce 1 Kg of the product**
Potato	500
Wheat	900
Alfalfa	900
Sorghum	900
Corn	1100
Rice	1900
Soybeans	2000

Source: CHRISTOFIDIS (2001)

Thus, more than a right, the shortage is turning the water into a valuable commodity[3]. It is up to the Governments of the countries in possession of these features the adoption of policies and standards to ensure the integrity and rational access to their reserves (SILVA, 2006).

Therefore, Brazil must remove the false idea of non-exhaustion of water resources, as well as consider its possible scarcity, despite having the greater availability of water on the planet, 13.8% of the global average runoff (AMBIENTEBRASIL, 2007).

The growth of world demand for good quality water at a rate higher than the renewability of the hydrological cycle is, by consensus, widely known in the international scientific and technical means. This growth tends to become one of the largest anthropogenic pressures on the planet's natural resources in the 21st century.

[3] Commodity is grown or mineral extraction products *in natura*, which can be stored for a time without sensible loss qualities. They are seen as one among several forms of investment. (ECONOMIABR, 2007)

CHAPTER II – METHODOLOGY

In the first stage of this research, a literature review was conducted on biofuels. This review included books, magazines, scientific articles, papers and interviews with experts. It was observed that the water was not considered in the various studies on the production of biofuel, including, in the study presented by the NAE, with regard to the predictions of impacts on water resources.

It was then performed a literature review on evapotranspiration and its use as an indicator to assess the possible impact on water resources against an expansion of the area destined to the planting of oilseeds for the production of biofuel. It was then determined the potential crop water demand for biofuels program. Finally, it was studied the atmospheric circulation in the mid-western region and its influence on regional cycle to determine if, under evapotranspiration, water is or not likely to precipitate in the region itself.

2.1 Evapotranspiration

The determination of the need for water for agricultural crops is conducted by the pattern of evapotranspiration. There are several methods for determining the evapotranspiration, and most estimates the potential evapotranspiration, i.e. when the soil does not have any disabilities that limit the use of water by plants. Due to the characteristics of each culture, the potential evapotranspiration varies from one culture to another. Thus, it was established a practice to determine a reference evapotranspiration (ET_o), used as a basis for the determination of evapotranspiration for each culture (ET_c). They can be defined as said below:

- Reference evapotranspiration (ET_o) is the evapotranspiration of a reference surface completely covered by grass or alfalfa, of uniform size, in active growth phase, with very good soil moisture conditions. The use of other denominations, as potential evapotranspiration is discouraged due to ambiguities in its definition.

- Crop evapotranspiration (ET_c) is the evapotranspiration of a culture under standard condition, free of pests, diseases and weeds, well fertilized, that develops in a wide area, with great soil and water supply that reaches full production under certain climatic conditions. Relations between the evapotranspiration of culture (ET_c) and the reference evapotranspiration (ET_o) are called crop coefficients (K_c), which are used to relate ET_c

with ET_o, namely: $ET_c = K_c * ET_o$.

This work is based on the information contained in the FAO-56 (ALLEN et al., 1998) about crop evapotranspiration estimation of oilseeds and sugarcane, where it was used ET_o = 4.8, with <K_c[initial] = 0,35, K_c[intermediary] =1,15, K_c[final] =0,35> for oilseeds and <K_c[initial] = 0,40, K_c[intermediary] =1,25, K_c[final] =0,75> for sugar cane, in the period of one year. Thus, came the following formulas for each of the life cycles of their respective cultures, whose curves are represented in the Graphs from 1 to 8:

- Non-perennial crops (castor seed, peanut, sunflower, soybeans and rapeseed):

$$ET_{c=}\begin{cases}(0{,}02758d + 0{,}32241)*ET_o,\ se\ d \in [1;30]\ \text{(initial phase)}\\ K_c*ET_o = 5{,}52,\ se\ d \in [31; LI_c]\ \text{(intermediary phase)}\\ (0{,}02758(LF_c + 1 - d) + 0{,}32241)*ET_o,\ se\ d \in [LI_c + 1; LF_c]\ \text{(final phase)}\end{cases}$$

- Where the duration of the life cycle of *LFcastor* = 240 days, *LFpeanut* = 120 days, *LFsunflower* = 150 days, *LFsoy* = 135 days and *LFcolza* = 100 days and the final day of the intermediate phase is *LIC* = *LFc*-30 since the beginning and ending cycles of these crops last, on average, 30 days.

- Perennial crops (babassu and palm oil):

$$ET_{c=}\begin{cases}(0{,}02758d_i + 0{,}32241)*ET_o,\ se\ d \in [1;60]\ \text{(initial phase)}\\ K_c*ET_o = 5{,}52,\ se\ d \in [61;365]\ \text{(intermediate phase)}\end{cases}$$

Where the duration of the life cycle of the crops, as perennial, *LFbabaçu* = *LFdendê* = 365 days and the initial cycles of these cultures lasting an average of 60 days.

- Sugar cane:

$$ET_{c=}\begin{cases}(0{,}01441d_i + 0{,}38559)*ET_o,\ se\ d \in [1;60]\ \text{(initial phase)}\\ K_c*ET_o = 6{,}00,\ se\ d \in [61;365]\ \text{(intermediate phase)}\end{cases}$$

It is known that the life cycle of sugarcane culture can last 18 months. However, in this work, it is considered only a year for calculations, there were taken 60 days for initial cycle and not considered the final phase.

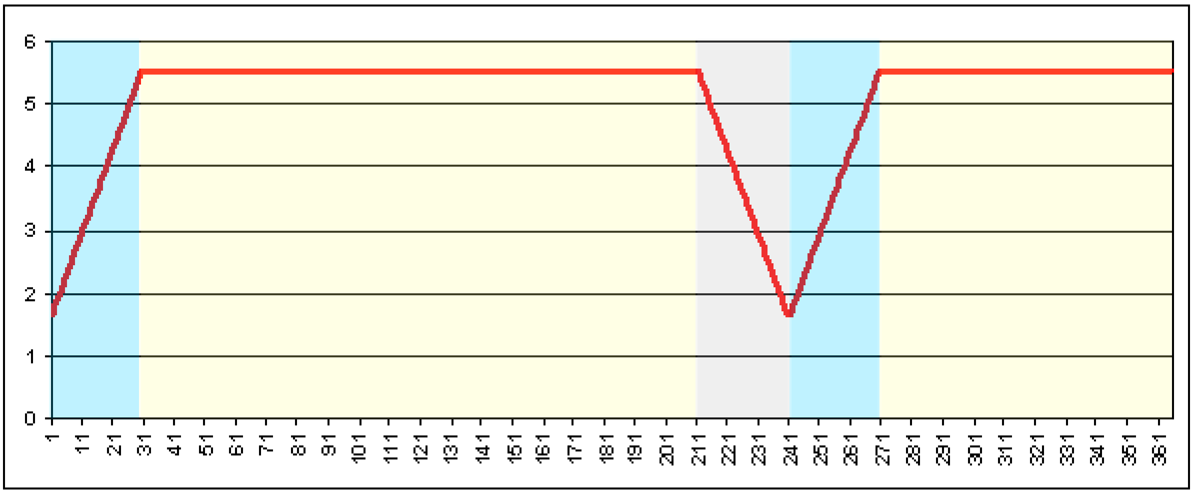


Chart 1: Estimation of evapotranspiration (in mm) of the castor oil in the period of 365 days

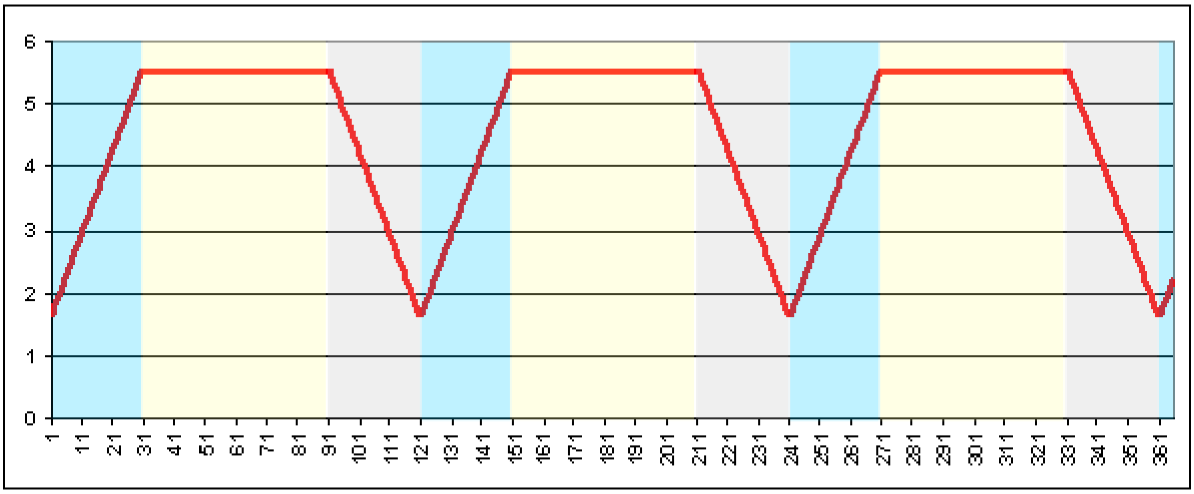


Chart 2: Estimation of evapotranspiration (in mm) of peanuts in the period of 365 days

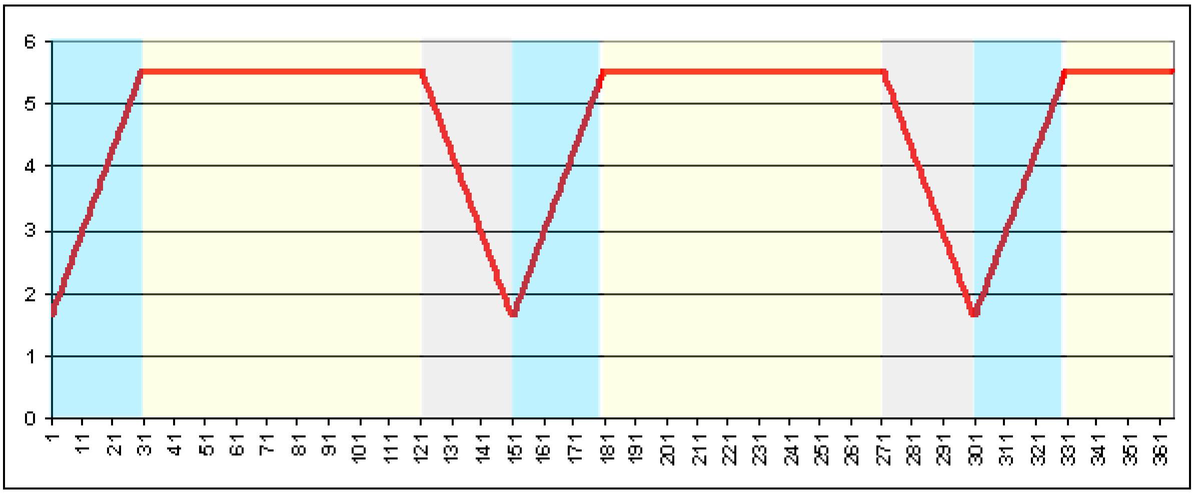


Chart 3: Estimation of evapotranspiration (in mm) of the sunflower in the period of 365 days

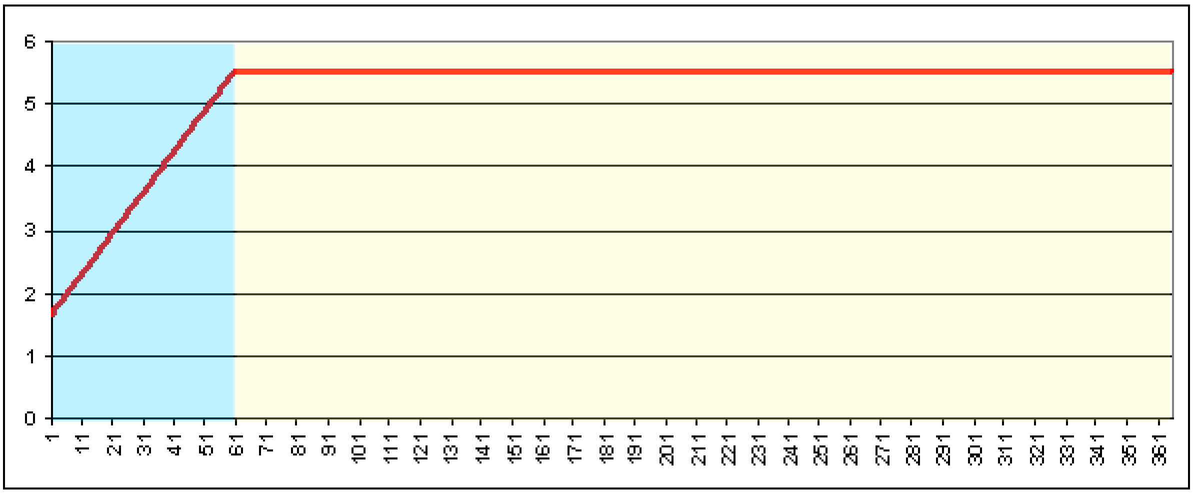


Chart 4: Estimation of evapotranspiration (in mm) of palm oil (dendê) in the period of 365 days

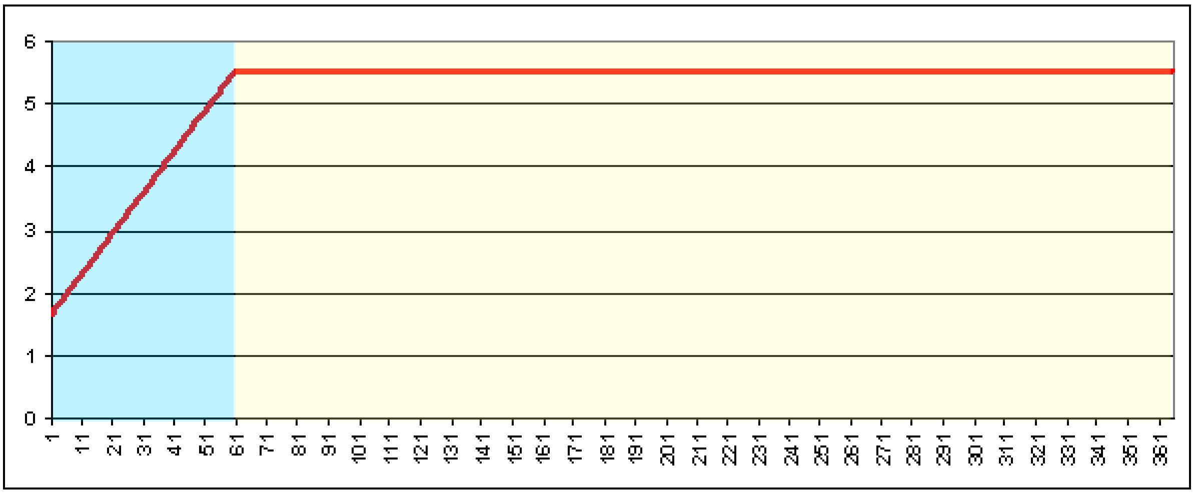


Chart 5: Estimation of evapotranspiration (in mm) of the babassu oil in 365 days period

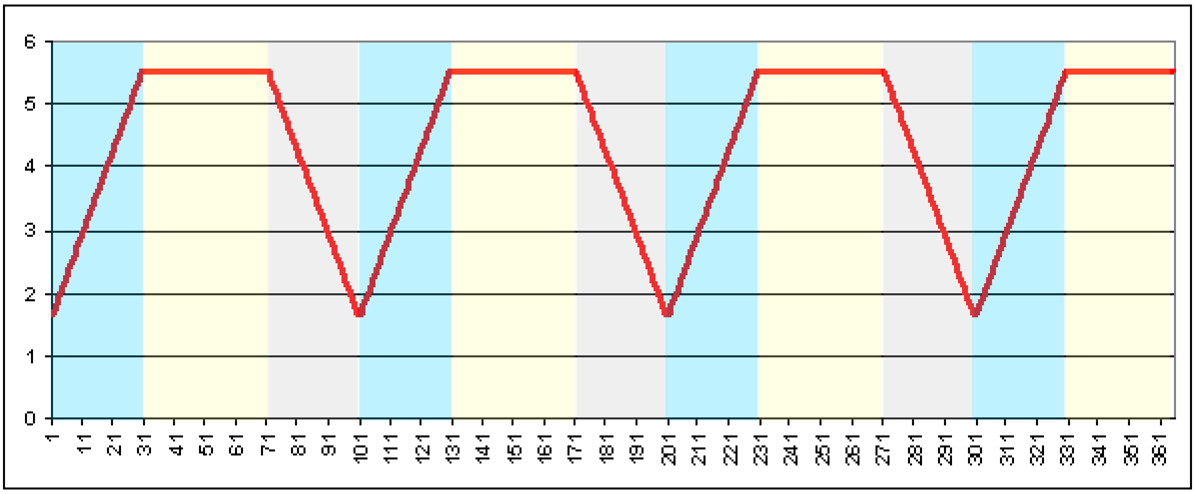


Chart 6: Estimation of evapotranspiration (in mm) of the rape in the period of 365 days

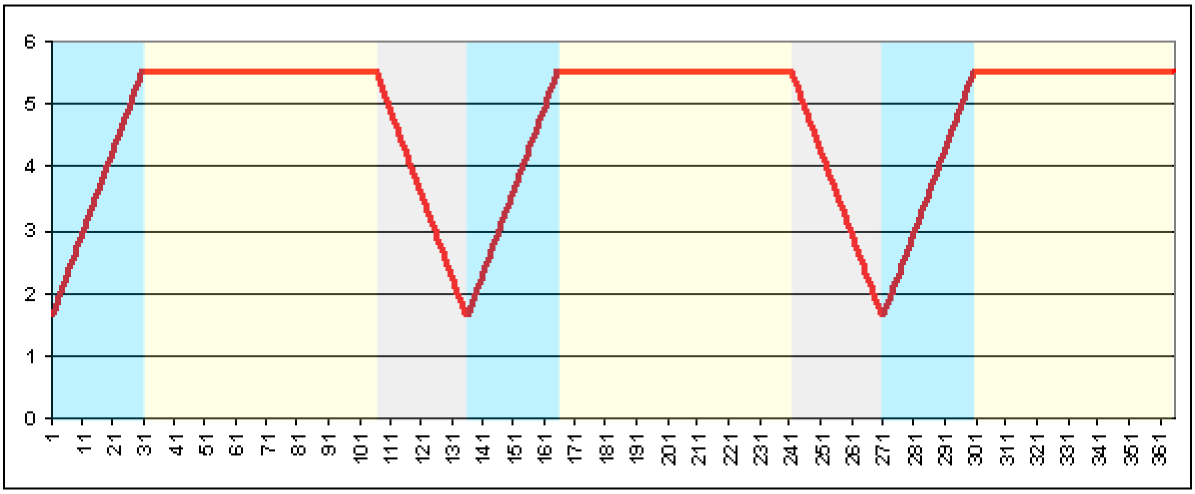


Chart 7: Estimation of evapotranspiration (in mm) of soybean in the period of 365 days

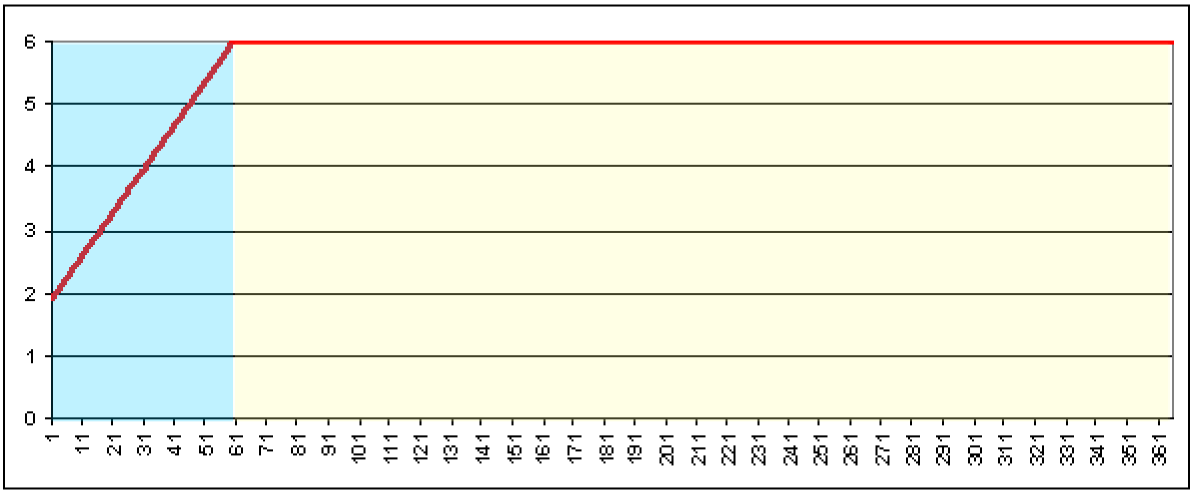


Chart 8: Estimation of evapotranspiration (in mm) of sugarcane in the period of 365 days

2.2 Calculation of evapotranspiration for oilseeds in the Midwest

Several studies have been conducted in order to determine the degree of evapotranspiration in different cultures and environments. In this paper, the focus is the evapotranspiration of oilseed made eligible by the Brazilian Government for the biofuels program, mainly as regards the region of Cerrado. Table 2 introduces water availability for plants and the evapotranspiration in dense Cerrado, *strictu sensu*, and in planted grazing (Smith, 2003). In Table 3, the calculations of evapotranspiration of oilseeds are presented in general.

Table 2 - Evapotranspiration in the Cerrado

Evapotranspiration (ETc)	(mm)/year	(m)	Demand (1000m^3)
Annual Pasture (Cerrado)	1115	1,115	33.450.000
Cerrado Stricto Sensu	924	0,924	27.720.000
Dense Cerrado	948	0,948	28.440.000

Source: SILVA (2003)

Table 3 - Calculations for evapotranspiration of oilseeds

Oleaginous	ETc (mm)/year	ETc (m)	Demand (1000m^3)
Castor Bean / 240 days	1841,96	1,841957	38.681.093
Peanut / 120 days	1536,04	1,536037	691.216.740
Sunflower / 150 days	1726,73	1,726728	259.009.200
Dendê / Perennial	1899,45	1,89945	769.277
Babassu / Perennial	1899,45	1,89945	569.835
Soybeans / 135 days	1726,73	1,726728	1.036.036.800
Sugar cane / 545 days	2067,51	2,067507	186.075.630
Rapeseed / 100 days	1611,50	1,611499	1.933.799.040

According to the report by the NAE (BRAZIL, 2005a, p. 12), the area required to supply 5% of B5 diesel with local oleaginous, and using only soy, palm oil 'dendê' and castor seed, would be about 3 million hectares, as shown in Table 4.

Table 4 - Estimated areas to produce B5

Region	Vegetable oil for B5 (1000m^3)	Raw material	Area (1000 ha)
Soutth	7.200	soybeans	600
Southeast	15.840	soybeans	1.320
Northeast	5.400	castor bean	600
North	3.240	palm oil	35
Midwest	4.320	soybeans	360
Total	36.000		2.916

Fonte: BRASIL (2005a, p. 38)

This was the area taken as a basis for the calculation of the demands. The possible expansion area for grains is of at least 90 million hectares. The areas suitable for Palm oil (dendê) strike, in the Amazon, about 70 million hectares, with high aptitude in approximately 40%.

The values shown in Table 5 relate to the evapotranspiration of oilseeds in the native vegetation in the Cerrado and refer to the first year of planting. From the second year, the values are different, because the perennial crops are already at their maximum development. That is, the coefficients (Kc) of perennial crops are already at its maximum value of 1.15 (ALLEN et al., 1998), which considerably increases the value of evapotranspiration and, consequently, water demand, as shown in Chart 9. In Table 6 and Chart 10, these data are shown in relation to the pastures.

It is evident, thus, the negative impact on water resources, caused by the oleaginous crops both in the Cerrado as in pastures. However, that would not be a problem if the evapotranspiration generated precipitations in the region itself. To answer that question, it is necessary to understand what the climatic characteristics of the region under study are.

Table 5 - Evapotranspiration of reference to the Cerrado (ETr =936 mm/year)

Culture	E.T. (mm/year)	E.T. relative (%)
Castor Bean (Mamona)	1841	196%
Peanut (Amendoim)	1536	164%
Sunflower (Girassol)	1726	184%
Palm Oil (Dendê)	1957	209%
Babassu (Babaçu)	1957	209%
Soybeans (Soja)	1726	184%

Source: BRASIL (2005a, p. 38)

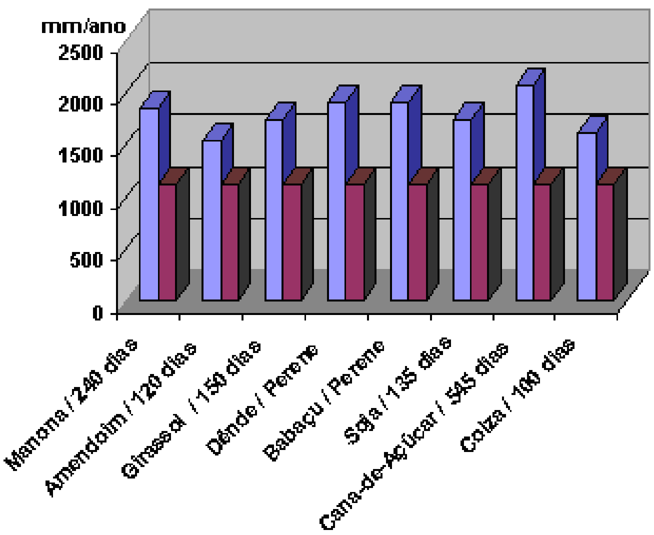


Chart 9: Crop evapotranspiration in relation to pasture
(□ = Evapotranspiration of culture ■ = Reference evapotranspiration - pasture)

Table 6: **Evapotranspiration of reference in relation to grazing in the cerrado – ETr = 1.115 mm/year**

Culture	E.T. per Culture (mm/year)	E.T. Relative (%)
Castor Bean (Mamona)	1841	165%
Peanut (Amendoim)	1536	137%
Sunflower (Girassol)	1726	154%
Palm Oil (Dendê)	1957	175%
Babassu (Babaçu)	1957	175%
Soybeans (Soja)	1726	154%

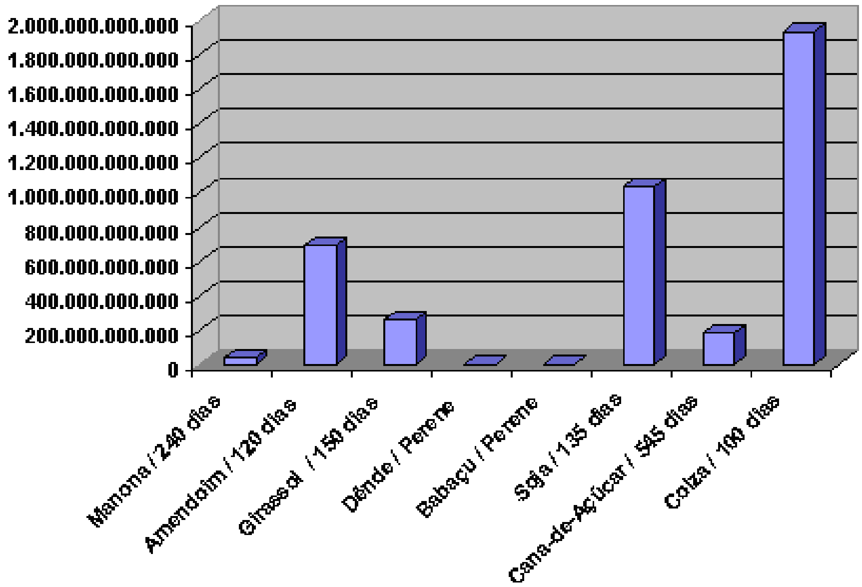


Chart 10: Volume of water for the crop evapotranspiration

2.3 Climatology of the Midwest region

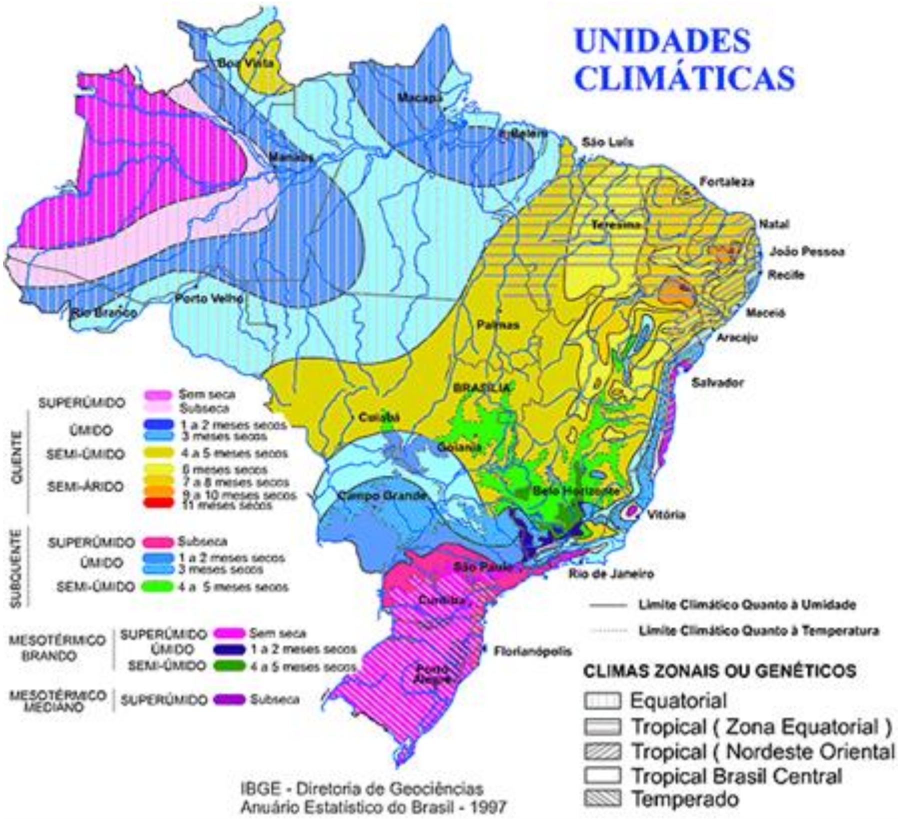
To understand the behavior of the atmosphere at different time intervals, the concepts of time and climate are indispensable. Time, in a given region can be considered as the sum of the action of various atmospheric variables, such as for example, the rain, the sun and the wind, in a short period of time. However, climate is the average behavior of the atmosphere for a long period of time, measured in months or years (INMET, 2005).

Climatic variations are the oscillations that occur in the atmospheric variables and which together affect the climate. The Earth has been going through a lot of changes, alternating periods of glaciation and inter-glaciation, where large climatic oscillations occurred.

Weather events do not occur in isolation, where several events can be explained by others, as for example, the intensity of rain in several regions of the country can be explained by the temperature of the surface waters of the Pacific Ocean in accordance with the scientific observation (ESCHWEILER-HASTENRATH; HELLER, 1977; HANSTENRATH, 2006). These connections, i.e. tele - connections of phenomena can modify the local, regional and global climate, and, therefore, the hydrological cycle (runoff and underground, precipitation, evaporation, etc.).

There is evidence and several scientists around the world agree that human activities, in search of economic development, the comfort and the facilities of modern life, are causing climate changes so unnatural, whether by the emission of pollutant gases, either by replacement of natural vegetation for cultures related to farming activities (NOBLE; SAMPAIO; SALAZAR, 2007; MARENGO, 2006; GLEICK; KIPARSKY, 2004).

In the Midwest, where the Cerrado ecosystem is concentrated, cultures related to farming activities have ostensibly been happening since the '70 (MARENGO, 2006). In the current Brazilian climatic units map (Map 1) it is noted that the Midwest offers a regular distribution of rainy and dry periods well defined. The dry season varies from 4 to 5 months, between the months of May to September.

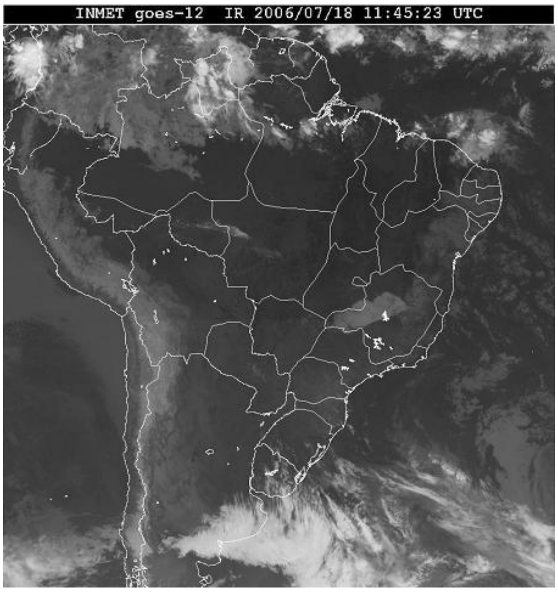


Map 1: **Map of climatic units of Brazil**
Source: Brazilian Institute of Geography and Statistics (1997)

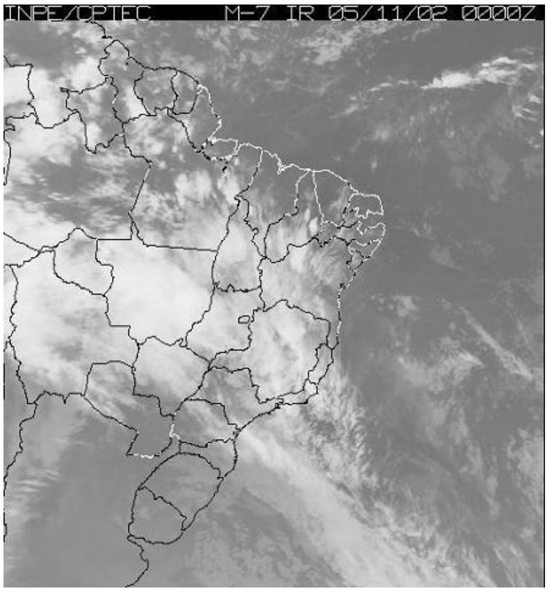
2.3.1 Winter- dry season

In the Midwest, the winter season is characterized by drought and with low levels of relative humidity. Climatology explains that there is a decrease in rainfall due to the invasion of cold air (high pressure of polar origin), as shown in Map 2 and a subsidence (descending movement of the winds), removing moisture from the region. From mid-July to mid-September, starts the predominance of hot and dry air mass in the Centre of Brazil, leading to a drier atmosphere.

In that period, it is also noted the absence of the flow of the winds of the low levels of West to East, on the transport of moisture (opposite situation from November to March), which contributes to the absence of rain. The Image 1 presents the images of GOES-12 satellite, the infrared channel, where completely opposite situations are observed between the period of drought (dark areas without cloud cover) and the rainy season (white areas with a lot of clouds).



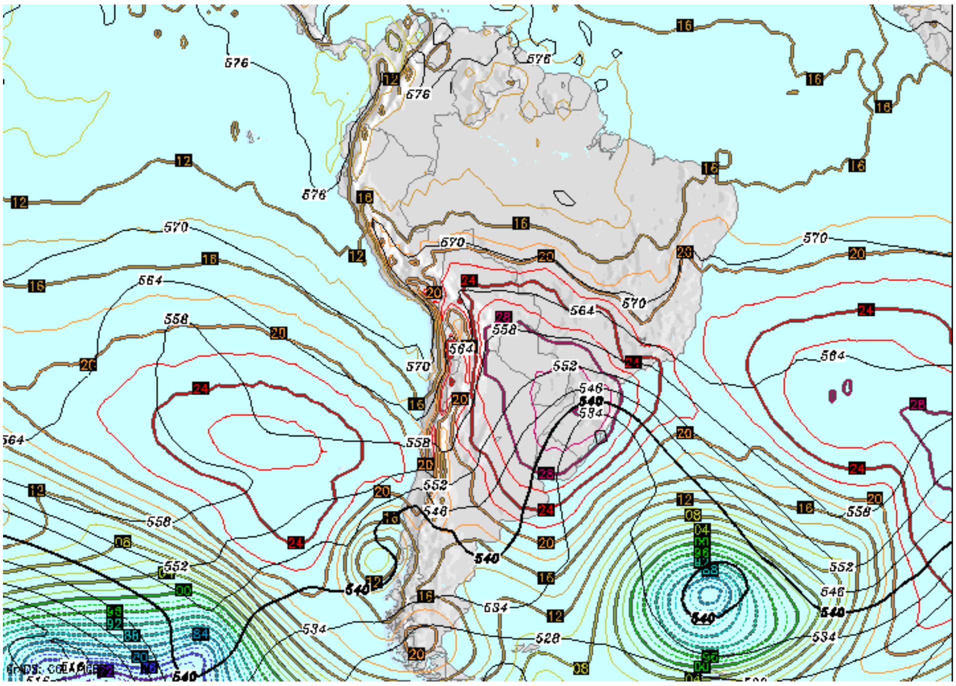
(a)



(b)

Image 1: Images from the GOES-12 Satellite, the infrared channel: (a) in July 19, 2006, to 11:45 Hours, without cloud cover; (b) in November 5, 2002 at 12:00 am (CPTEC), with plenty of cloud cover (DINIZ; REBELLO, 2001)

In July, the precipitation values are from 20 mm to 60 mm in the center and northern of the State of Mato Grosso do Sul, from 10 mm to 20 mm in Southern Goias, south and northwest of Mato Grosso and below 10 mm in other areas of the region. In August, the rainfall is between 40 mm and 60 mm in the south and center of the Mato Grosso do Sul and between 20 mm and 40 mm in southern Goiás and in western and southern Mato Grosso. In the rest of the region these values are 10 mm. in September, rainfall is between 60 mm and 120 mm in the west and northern Mato Grosso, east-central and southern Mato Grosso do Sul. In the east and northeast of Goiás and in Brasília, the Federal District, the values oscillate between 10 mm and 20 mm. In Eastern and southern Mato Grosso, north, west and central-eastern Mato Grosso do Sul, and in other areas of the State of Goiás, the rainfall is between 20 mm and 40 mm. According to Climatologist, in winter period, there is a greater frequency of cold air mass (high pressure Polar) which contributes to the absence of precipitation, as shown in Map 2.



Map 2: The atmospheric pressure at sea level, with validity of 72 hours, at 00:00 am, of July 14, 2000 – polar high pressure Centre (cold front) reaching much of the Midwest, carrying cold air with low temperatures and sharp subsidence on the region (DINIZ; REBELLO, 2001)

During the period of drought, the second fortnight of May through September, the concentration of the haze causes low levels of relative humidity, caused by the following climatic factors:

1. distance from the coast;
2. influence of cold air masses to reach the Midwest region;
3. predominance of subsidence systems that operate in the Midwest (descendants of the winds moves), preventing the formation of clouds in the Mato Grosso do Sul, Goiás, Mato Grosso, Tocantins and the Federal District, West of Minas Gerais. These systems are characterized by the descent of the air in the higher levels of the atmosphere to the

surface and makes the atmosphere more drought.

Moreover, in the years in which the drought begins in may, drought is sharper. It can be affirmed that, at that time, one of the aggravating elements of the climate are the fumes from cars, burning and the consequent concentration of lit meteors (air/dust mixtures). The climatic condition with haze predominates in much of the Midwest, reaching the west of São Paulo and the Triângulo Mineiro, important rural mesoregion located at the southwest of the State of Minas Gerais.

2.3.2 Summer-rainy season

In the Midwest, the summer is characterized by the rainy season due to the arrivals of cold fronts along with the moisture from the Amazon, which is transported by low-level Jet-JBN, and counterclockwise circulation of winds in the upper atmosphere around 12 km of altitude. The cold front joint combination with the interaction of the Amazon moisture mass, form a weather system known as the South Atlantic convergence zone – ZCAS. This system, when formed, offers a high support in the rains of the Midwest and Southeast regions for several days, weeks, or more, being what most contributes to the rains in the Midwest.

Part of the South-East rainfall is due to the Midwestern evapotranspiration as a function of the low-level Jet-JBN, carrying moisture to the Southeast.

2.3.3 Considerations for anomalies of precipitation in Central-Western Brazil

According to Diniz and (2002) Rebello, extreme climatic fluctuations on seasonal scale in the Tropics (geographical parallel distant 23 degrees 27 minutes and above and below the equator, respectively, called the Northern Tropic of Cancer and the South Tropic of Capricorn) and high variability in precipitation with negative anomalies have caused large consequences in the sectors of water supply in urban centers, in agriculture and hydropower planning of the country. The Southeast region concentrates most of the hydropower generation, with 55% of production, with the largest energy consumer market, with 47.2 million units, is in the Southeast and South of Brazil. In this way, the impact is larger due to the high concentration of population and economic wealth. A positive example applied to hydroelectric is the Salto Santiago plant, on the Iguaçu River, where the La Niña event of 1996 unleashed a yield increase and decrease environmental impact (MOURA, 2000, etc.

High temporal variability in the position and intensity of the ZCAS, was observed by Kousky (1988, apud DINIZ; REBELLO, 2006) and Casarin and Kousky (1986, apud DINIZ; REBELLO, 2006) and, more recently, during summer 1999/2000, in January and February.

The counterclockwise circulation activity of wind flow in 200 HPa, over South America confirms the presence of the ZCAS about Southeast region, as studied by Vargas et al. (2000, apud DINIZ; REBELLO, 2006).

Bastos and Fernando (2000, apud DINIZ; REBELLO, 2006) observed along 1978-1997, in the months of December to February, that the wind field and the associated velocity at 850 hPa, suggest the presence of convergence alongside the ZCAS.

Some configurations of atmospheric blocking in the runoff on the South America, with drought in the southern region are known for Casarin (1982, apud DINIZ; REBELLO, 2006). In practice, what is observed by the climatology are spells (although in the summer, refers to a dry period, when it would be expected more rain) of the order of 8 to 15 days of drought, on the southeast of the country and the eastern part of the Midwest in the period from January to March.

Diniz and Rebello (2002) check and compare the totals of rainfall that occurred with the normal monthly, for the months of January and February, of INMET 90 network of weather stations. INMET also examines the negative anomalies patterns maps of monthly rainfall, using *decis* intervals through 1961 to 2000.

With that, it was found the strong reduction in rainfall over the southeastern region, states of Goias and Distrito Federal and the impact on hydroelectric. Diniz and Rebello (2002) using the annual chart of the last five years about the capacity of reservoirs in the region, provided by the national system operator – ONS.

According to Diniz and (2006), Rebello for the examination of the causes of these anomalies of precipitation, the climatic wind fields were used and analyzed for the months of January and February, the average monthly circulation anomalies in the levels of 850 and HPa 200 global model generated from the National Centers for Environment Prediction (NCEP), about South America, for the determination of the deficiencies of the wind flow patterns on both levels. At 200 HPa, atmospheric blocking situation was observed on the SE, GO and DF and absence of the ZCAS. In low levels, at 850 HPa, it was verified the existence of stronger jets responsible for the transport of moisture to the South as proposed by Vargas et al. (2000, apud DINIZ; REBELLO, 2006) and the absence of moisture in the State of Goiás as shown in Figure 1, letters c and f.

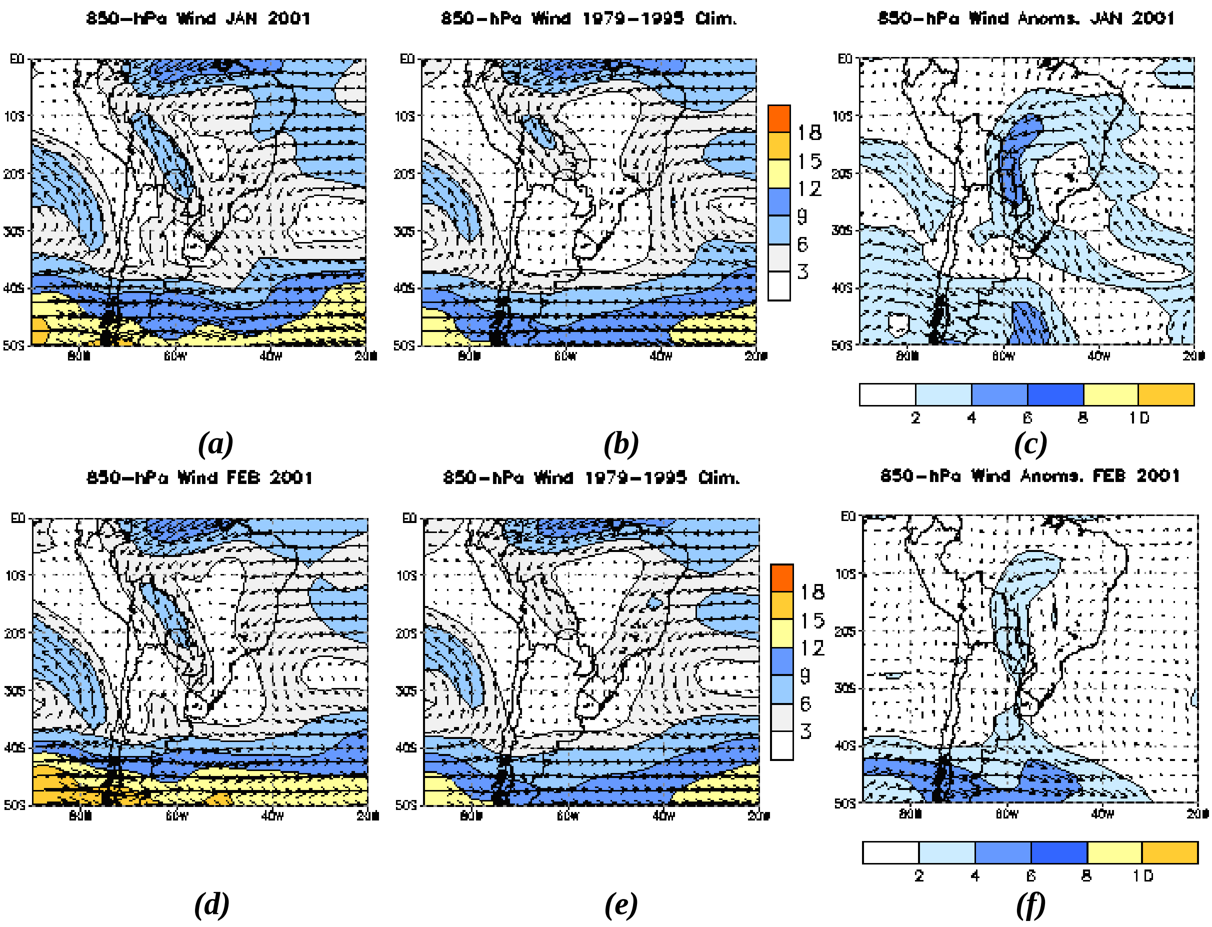
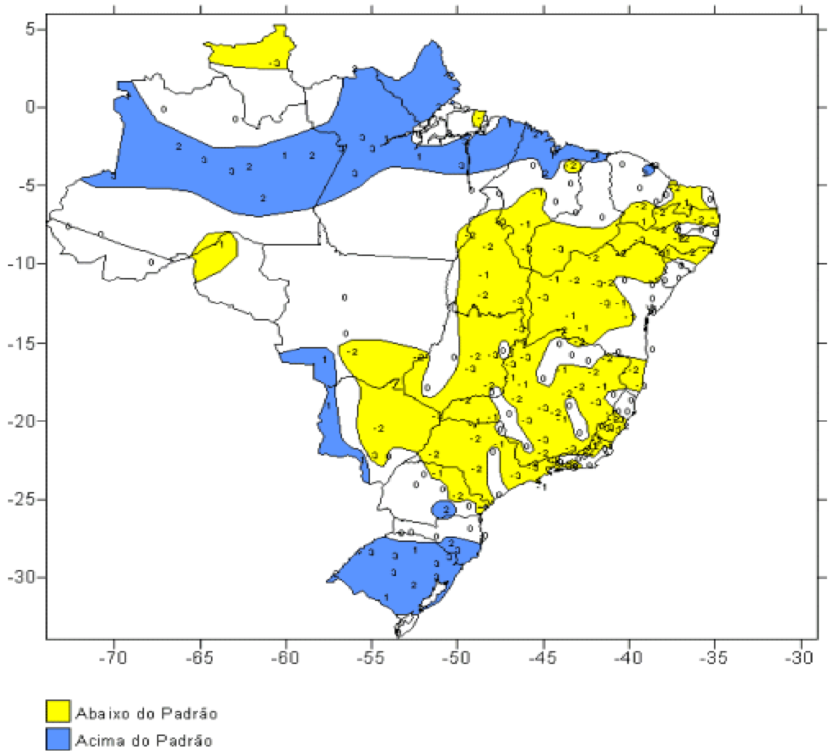
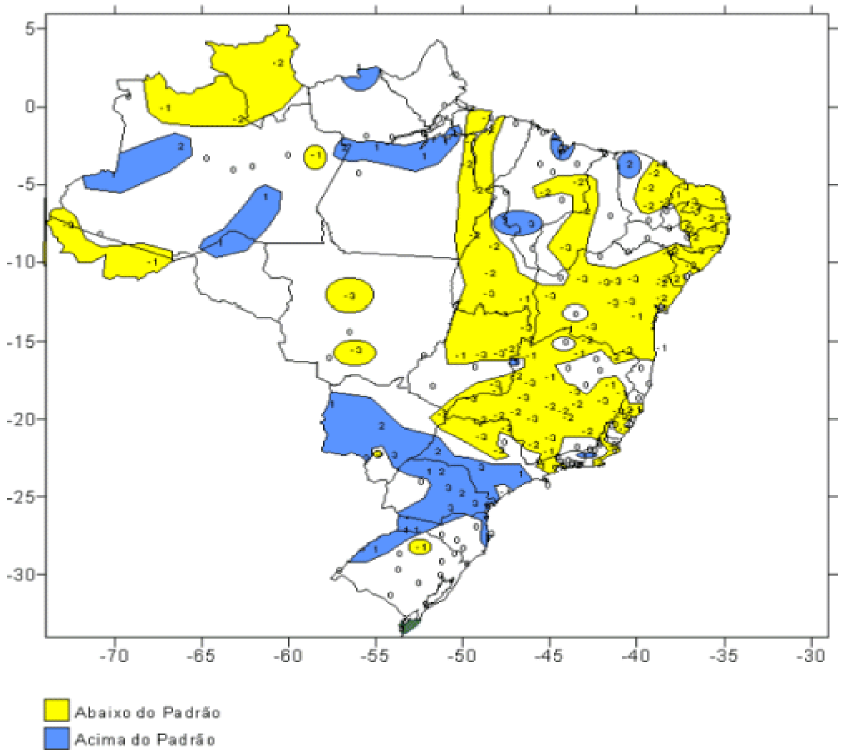


Figure 1: Wind fields at 850 hPa, in January and February 2001, regarding the data between 1979 to 1995 (DINIZ; REBELLO, 2001)

During the months of January and February, it was observed high temporal and spatial irregularity in rainfall and on the position of the ZCAS. In this evaluation, using the defaults of the negative anomalies of monthly precipitation, calculated by means of the *decis method* intervals, which show a strong reduction in rainfall in much of the region, with very low negative pattern (-3), considered the severe drought in relation to the deviation from the normal drought (Maps 3 and 4). In monthly charts (Graphs 11 and 12), there were compared totals rainfall occurred (blue line) with the monthly normal (red line), to 90 meteorological stations, showing differences considerably high in these precipitations by localities, ranging from 45 to 60% reduction in rainfall in the regions of the basins.



Map 3: Deviation of precipitation in '*decis method*', indexes (-3) yellow, very low precipitation patterns: January 2001 (DINIZ; REBELLO, 2001)



Map 4: Deviation of precipitation in '*deci*s method', indexes (-3) yellow, very low precipitation patterns: February 2001 (DINIZ; REBELLO, 2001)

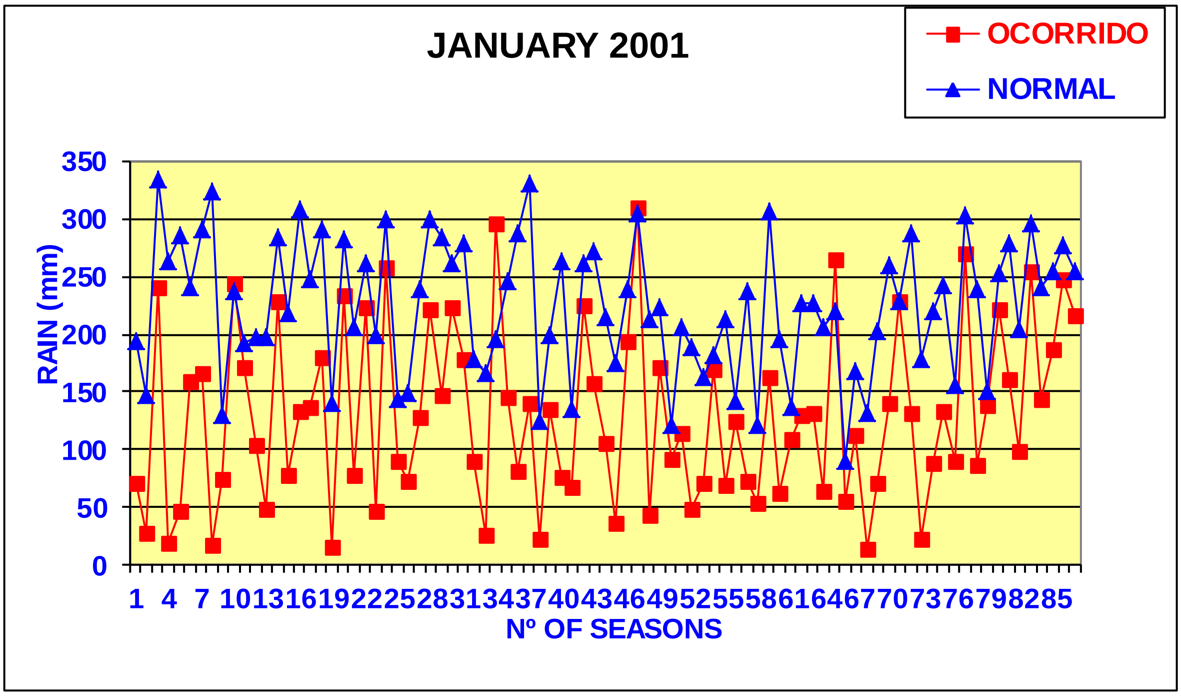


Chart 11: Rainfall totals **occurred** compared with the **normal** in January 2001 (DINIZ; REBELLO, 2001)

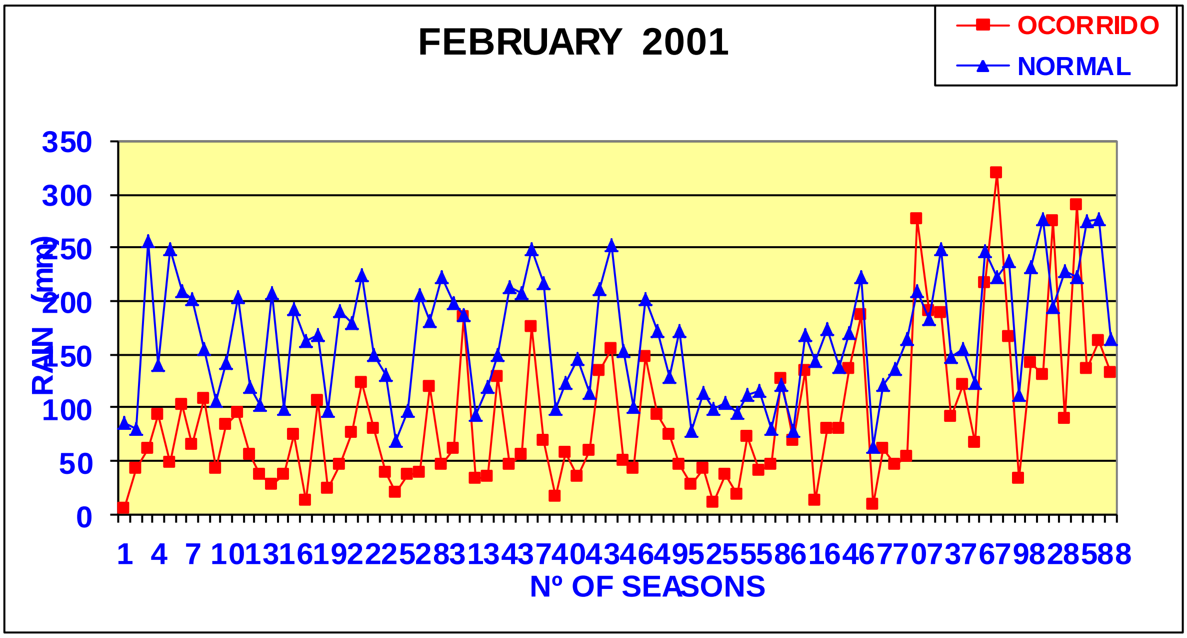


Chart 12: Rainfall totals **occurred** compared with the **normal** in the month of February 2001 (DINIZ; REBELLO, 2001)

The activity of the movement of winds at 200 HPa, counterclockwise about South America, confirms the presence of the ZCAS on the Southeast and Midwest, as studied by Vargas et al. (2000, apud DINIZ; REBELLO, 2002). Therefore, according to Diniz and Rebello (2002), the opposite situation or weakening of the High of Bolivia should be associated with the absence of the ZCAS on the Southeast and Midwest, evidence in the month of January 2001, in the field of wind anomalies at 200 HPa, where counterclockwise circulation was weaker (cyclonic anomalies) that climatology over the tropics throughout much of South America (Figure 2, letter f). Another situation observed by Diniz and (2002), Rebello is the characteristic of this movement that prevented the movement of cold fronts (blocking) hit the Southeast and Midwest, remaining between Argentina and the southern region, as described by Kousky (1988, apud DINIZ; REBELLO, 2002). In February, the high of Bolivia went further south of its position when climatological persisted the strongest winds from West the mid-latitude and subtropical latitudes in anticyclone anomalies, with a closed circulation off the coast of the state Rio Grande do Sul. This pattern favors the convective activity in the South and the absence of convection between the Southeast and the Midwest. In low levels, 850 hPa, Figure 2 shows, in the months of January and February, the Jets presence stronger than usual, from Northwest to South of the continent (Amazon South region), responsible for the transport of moisture from the Amazon, described by Vargas et al. (2000, apud DINIZ; REBELLO, 2002). This setting favored the increase of rainfall in the South and left the Southeast and the eastern part of the Midwest drier.

Diniz and Rebello (2006) observed that the change in large-scale atmospheric patterns over South America, without the appearance of the ZCAS can remain for the medium-term period (10 days), with the absence of precipitation.

Map 5 to Map 61 illustrate that there are monthly precipitation anomalies in rainy periods in the years 2001/2002; 2002/2003; 2003/2004; 2004/2005; 2005/2006; 2006/2007 and at the beginning of 2007/2008. It was noted a variability in rainfall that can be related to various global systems that influence directly in the mechanisms that produce rains and spatial-temporal distribution in the regions. It becomes apparent the uneven distribution of rainfall in the last three years, with average deficits in the periods considered around 450 mm, and at the beginning of the rainy season of 2007/2008 a deficit around 250 mm, showing the anomalous behavior of the atmosphere.

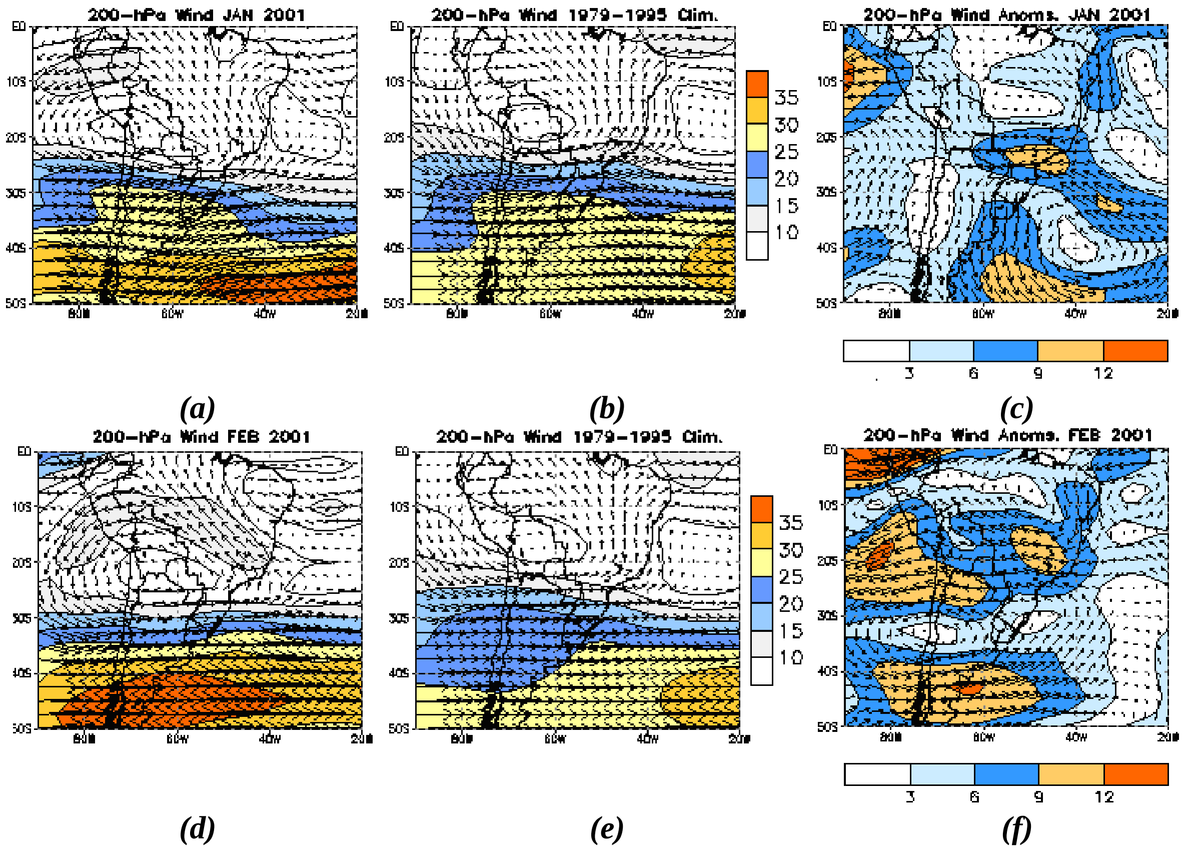
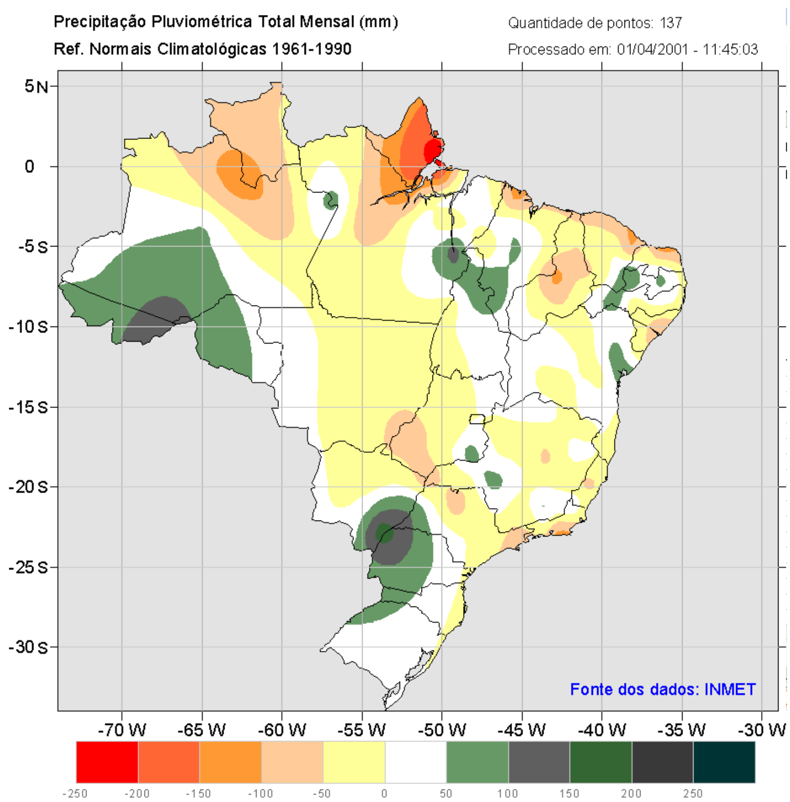
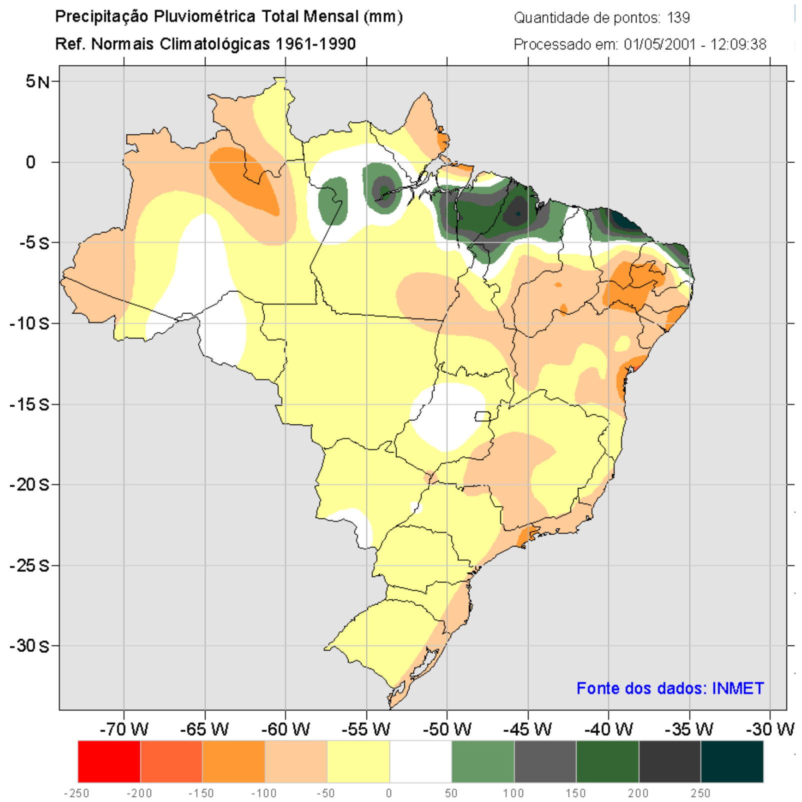


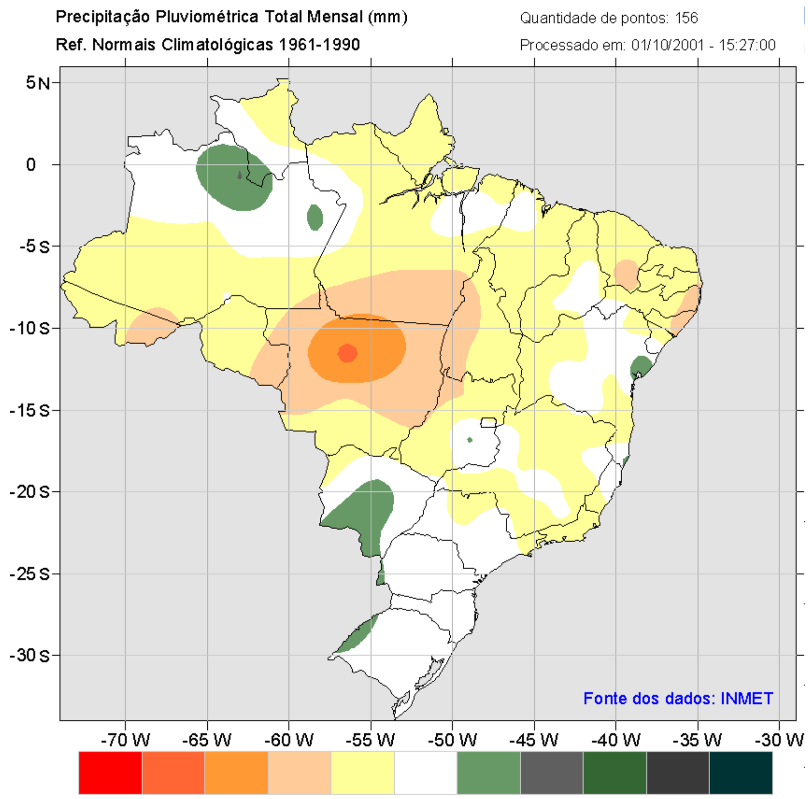
Figure 2: Wind fields at 200 HPa, in January and February 2001, regarding the data between 1979 to 1995 (DINIZ; REBELLO, 2005)



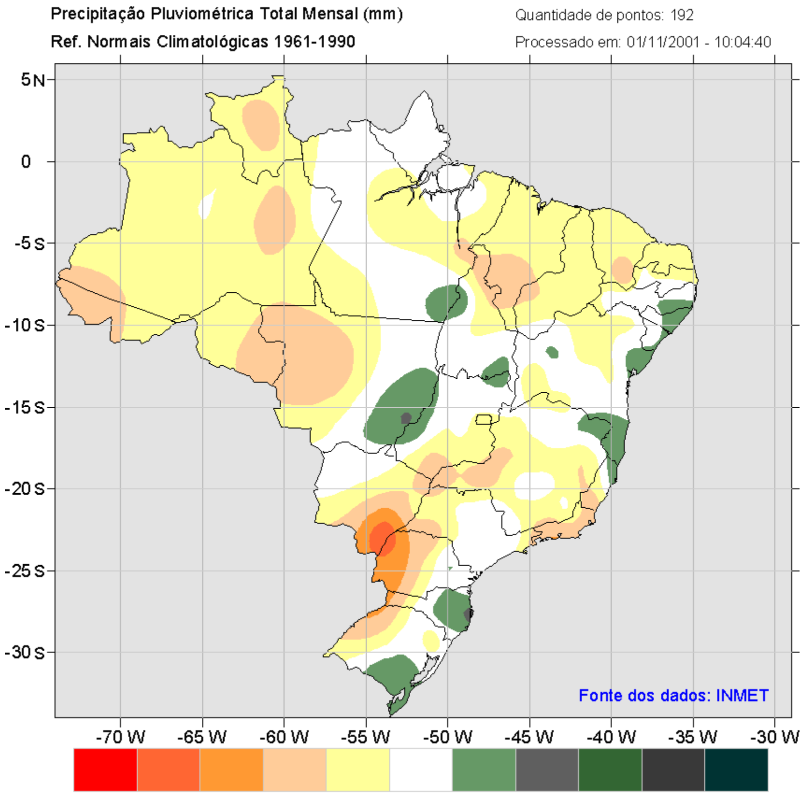
Map 5: Deviation of monthly total rainfall (mm)-March/2001 (REF. Climatological Norms 1961-1990)



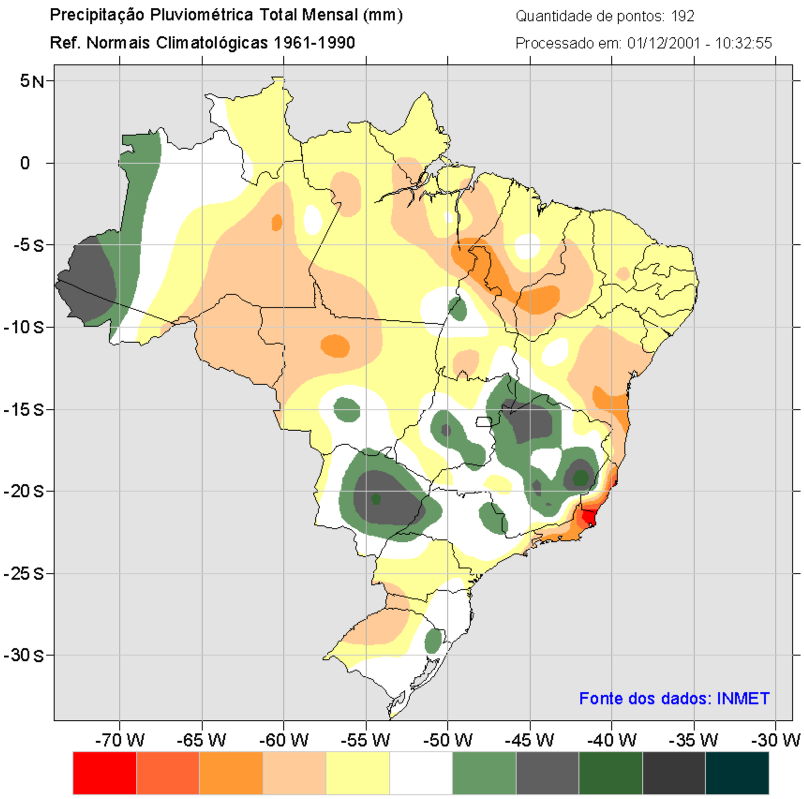
Map 6: Deviation of monthly total rainfall (mm) – Apr/2001 (REF. Climatological Norms 1961-1990)



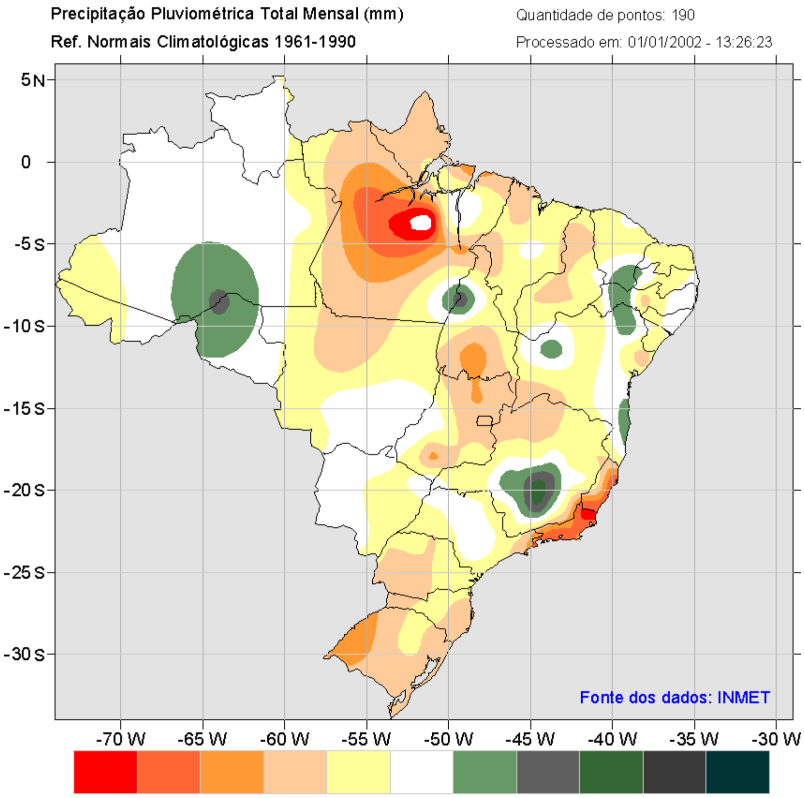
Map 7: Deviation of monthly total rainfall (mm) – September/2001 (REF. Climatological Norms 1961-1990)



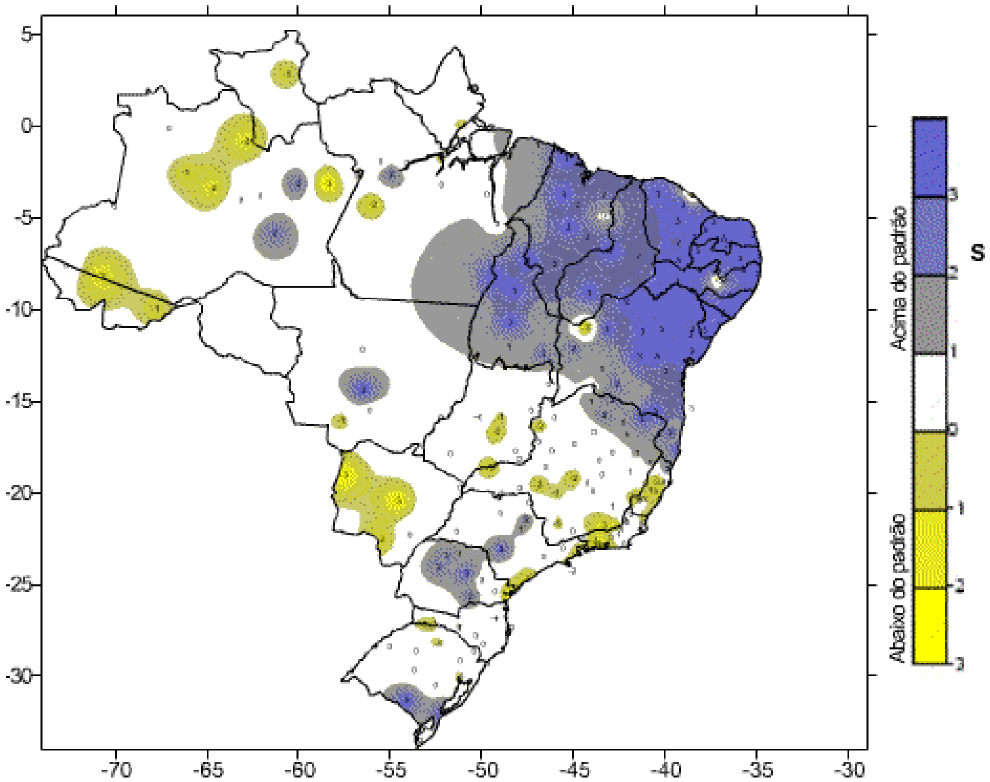
Map 8: Deviation of monthly total rainfall (mm)-October/2001 (REF. Climatological Norms 1961-1990)



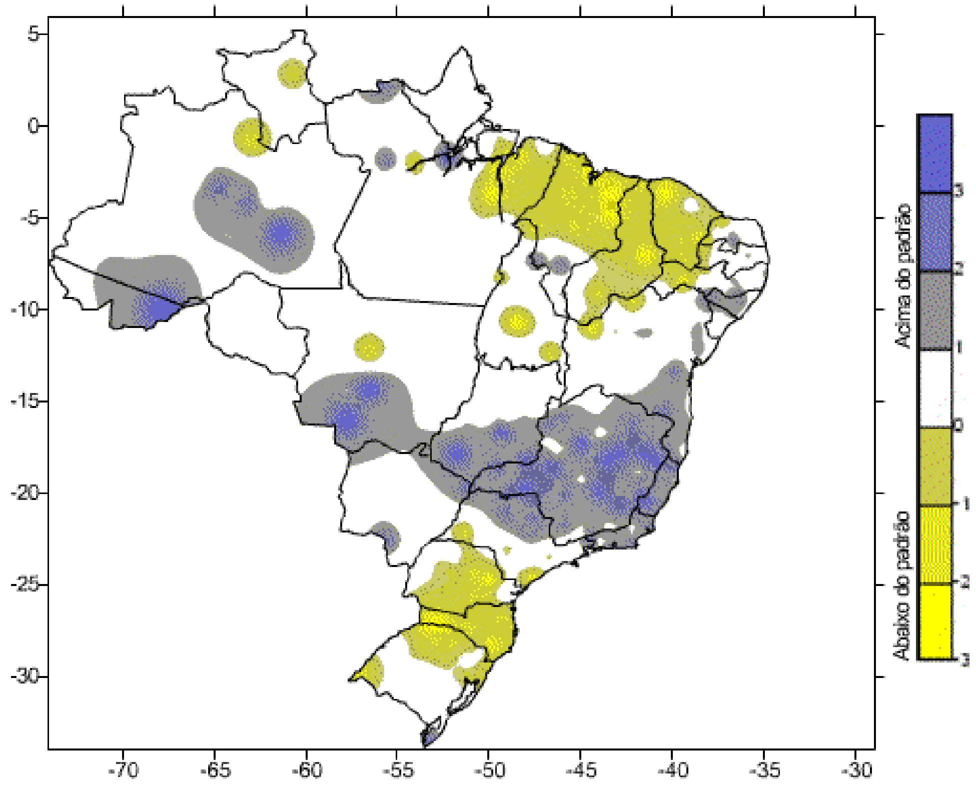
Map 9: Deviation of monthly total rainfall (mm)-Nov/2001 (REF. Climatological Norms 1961-1990)



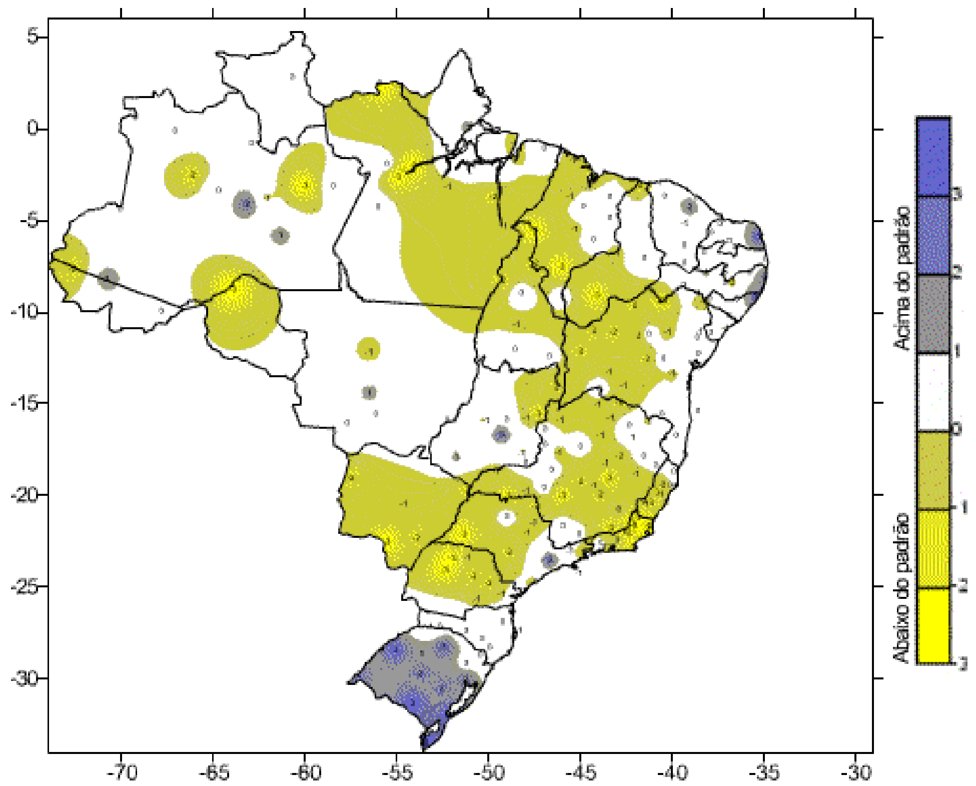
Map 10: Deviation of monthly total rainfall (mm) – December/2001 (REF. Climatological Norms 1961-1990)



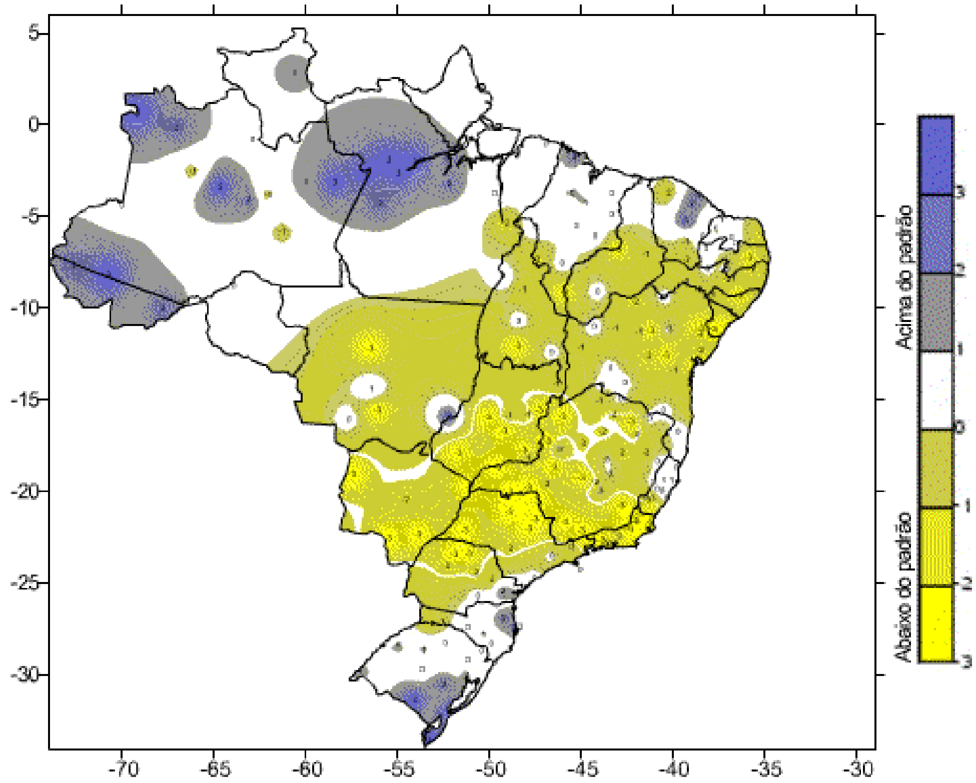
Map 11: Study of deviations of monthly precipitation in Brazil – 'decis method' -January Deviation/2002 (source: INMET)



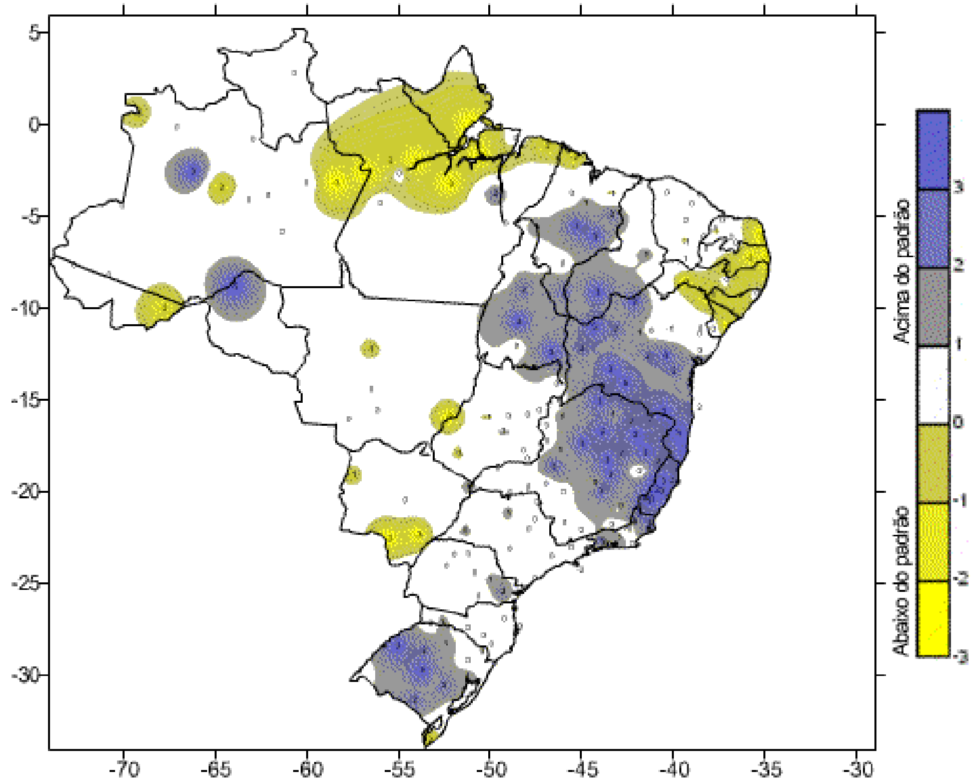
Map 12: Study of deviations of monthly precipitation in Brazil – 'decis method' - February/2002 Deviation (source: INMET)



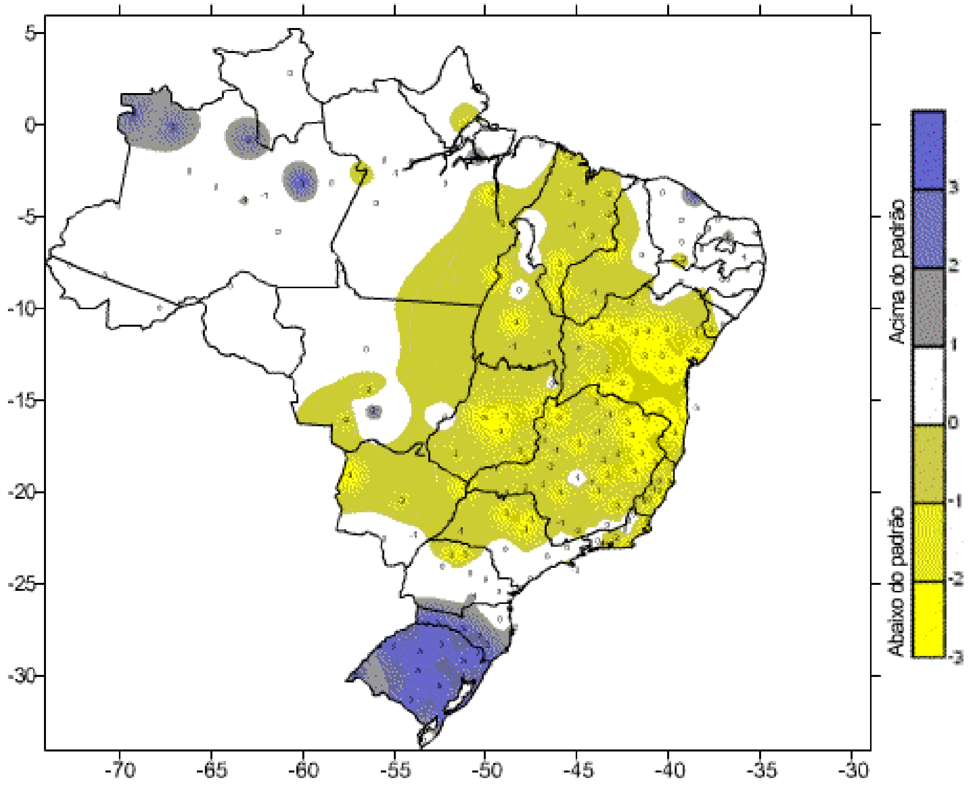
Map 13: Study of deviations of monthly precipitation in Brazil – 'decis method' -March Detour/2002 (source: INMET)



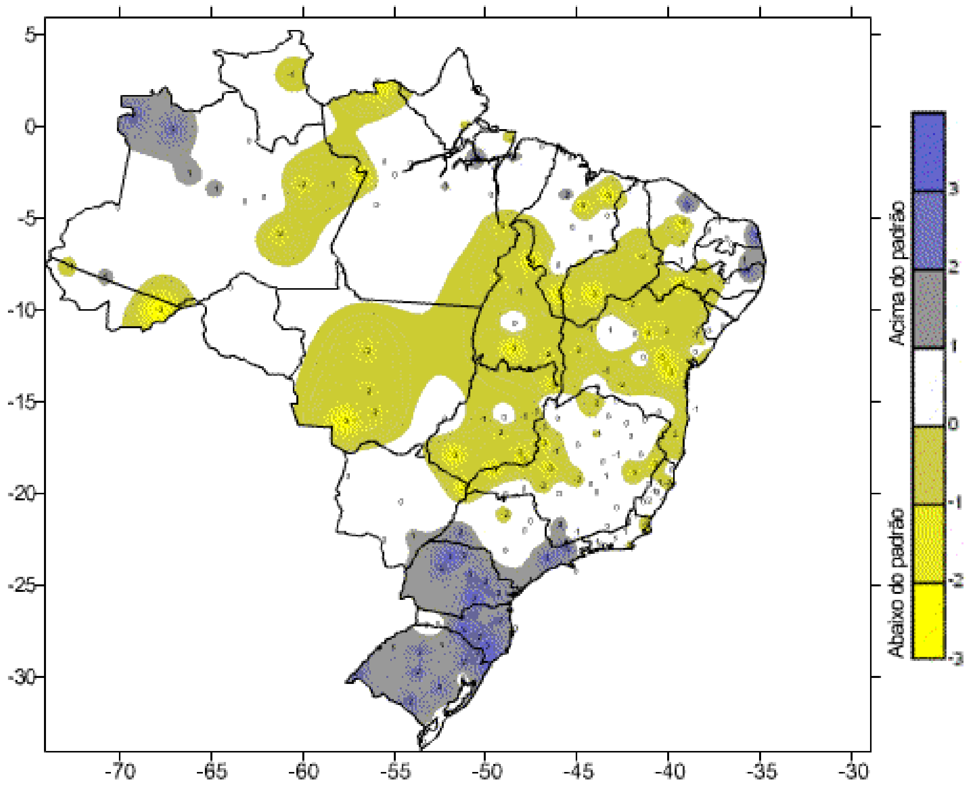
Map 14: Study of deviations of monthly precipitation in Brazil –'decis method' -April/2002 Deviation (source: INMET)



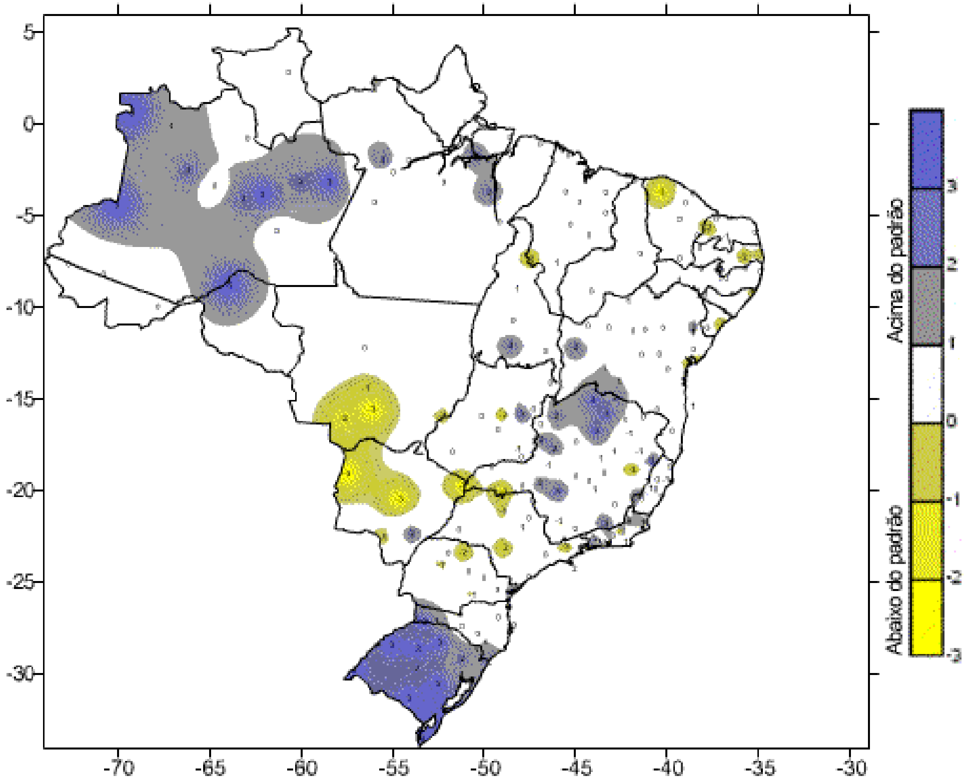
Map 15 Study of deviations of monthly precipitation in Brazil – 'decis method' -September Deviation/2002 (source: INMET)



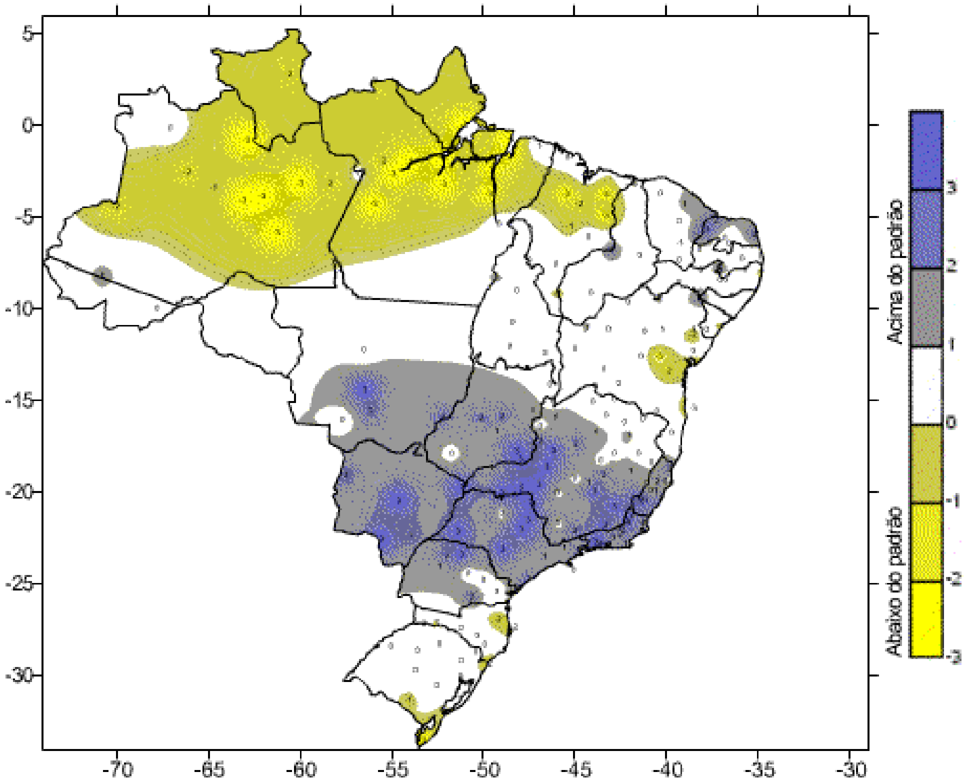
Map 16: Study of deviations of monthly precipitation in Brazil – 'decis method' - October/2002 Deviation (source: INMET)



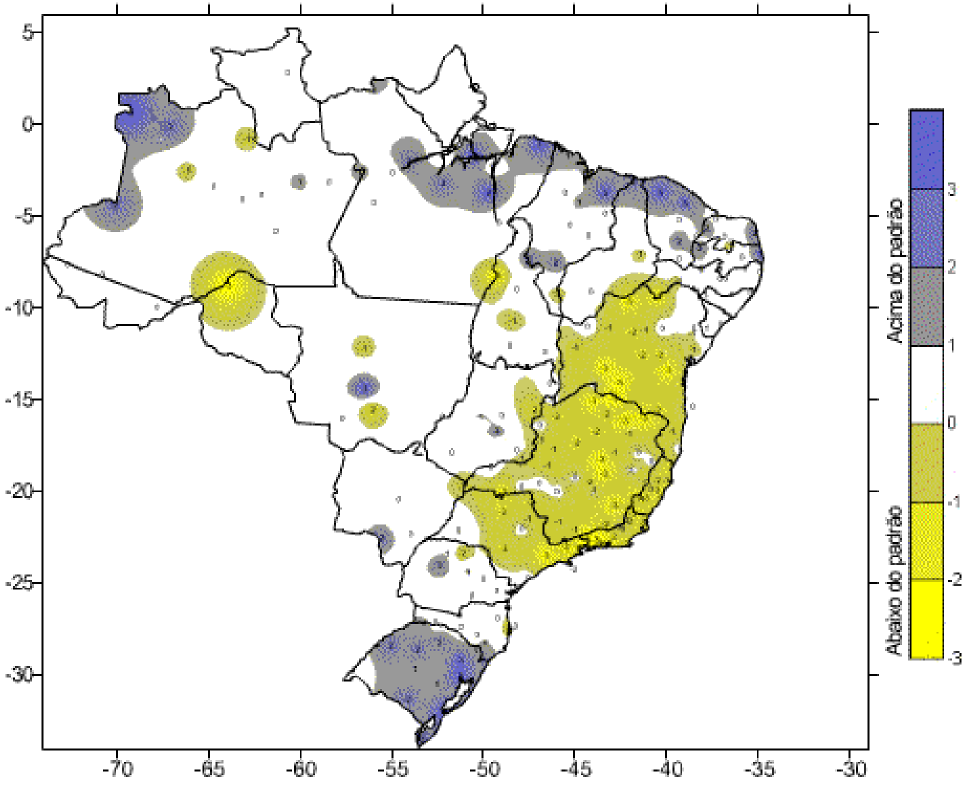
Map 17: Study of deviations of monthly precipitation in Brazil – 'decis method' - November/2002 Deviation (source: INMET)



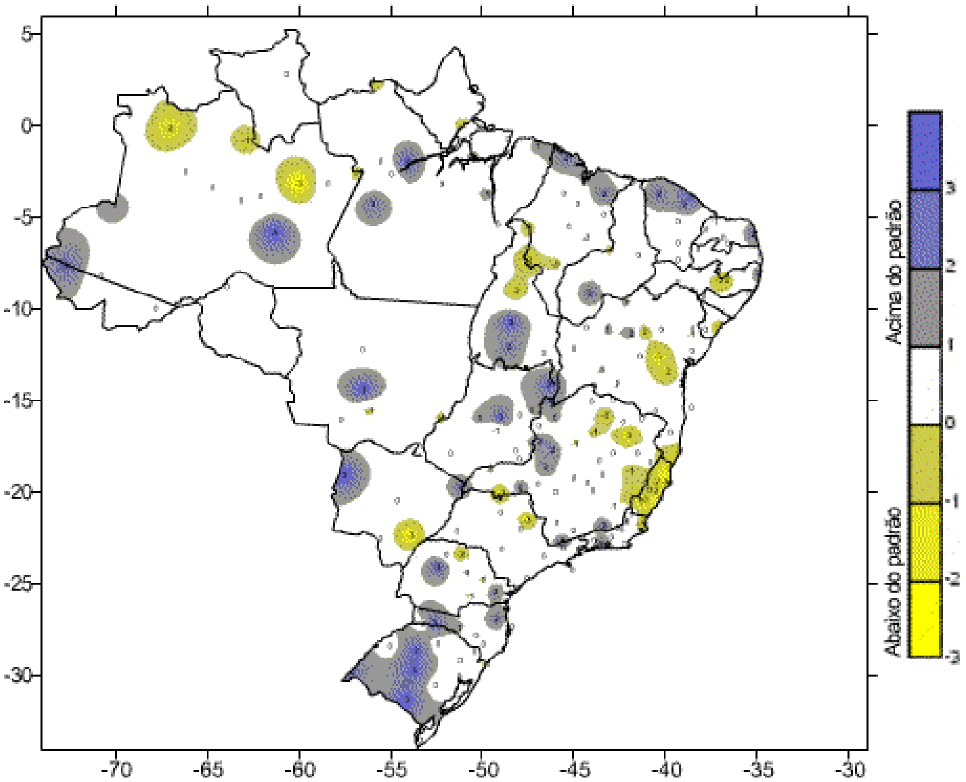
Map 18: Study of deviations of monthly precipitation in Brazil – 'decis method' -December Bypass/2002 (source: INMET)



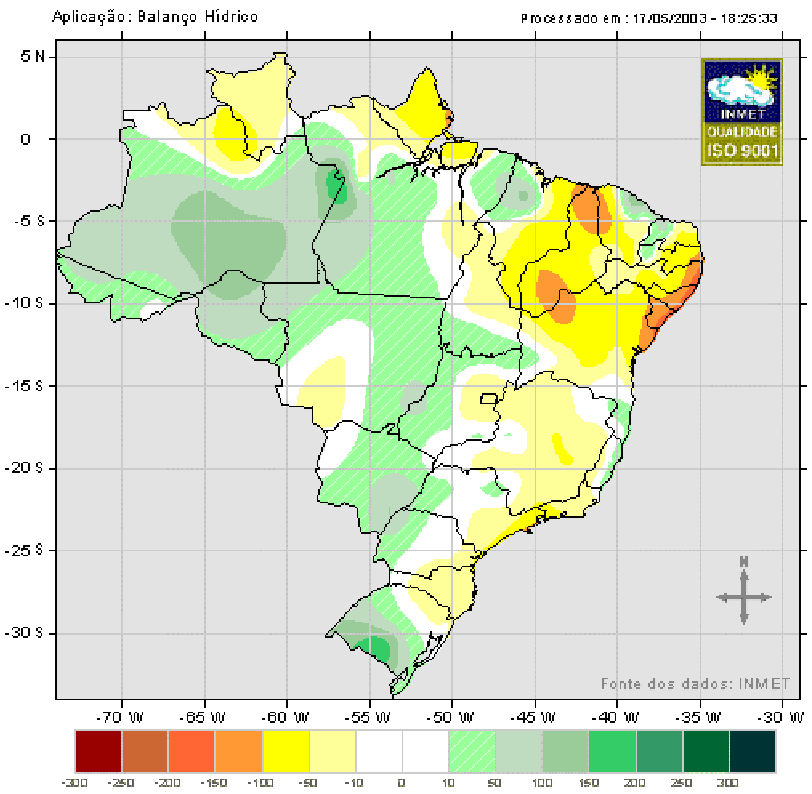
Map 19: Study of deviations of monthly precipitation in Brazil – 'decis method' -January Deviation/2003 (source: INMET)



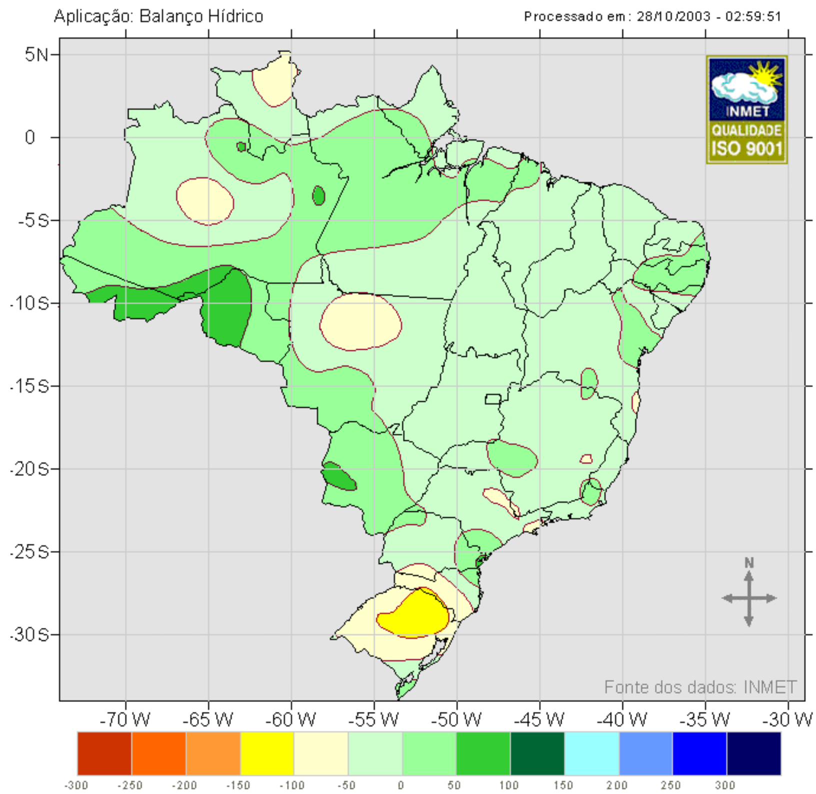
Map 20: Study of deviations of monthly precipitation in Brazil – 'decis method'-February Deviation/2003 (source: INMET)



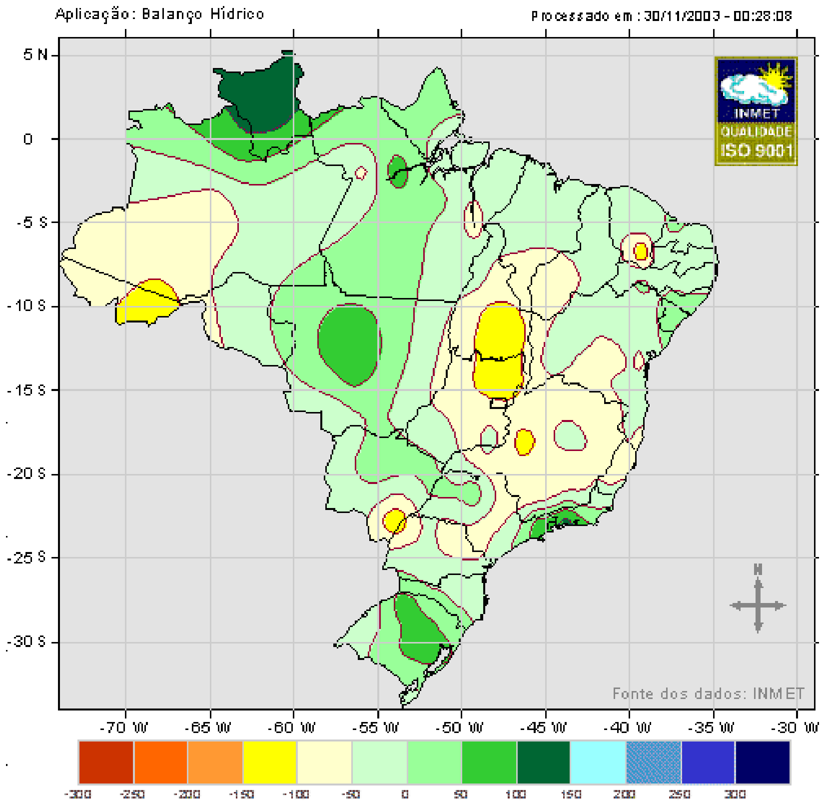
Map 21: Study of deviations of monthly precipitation in Brazil – 'decis method' -March Detour/2003 (source: INMET)



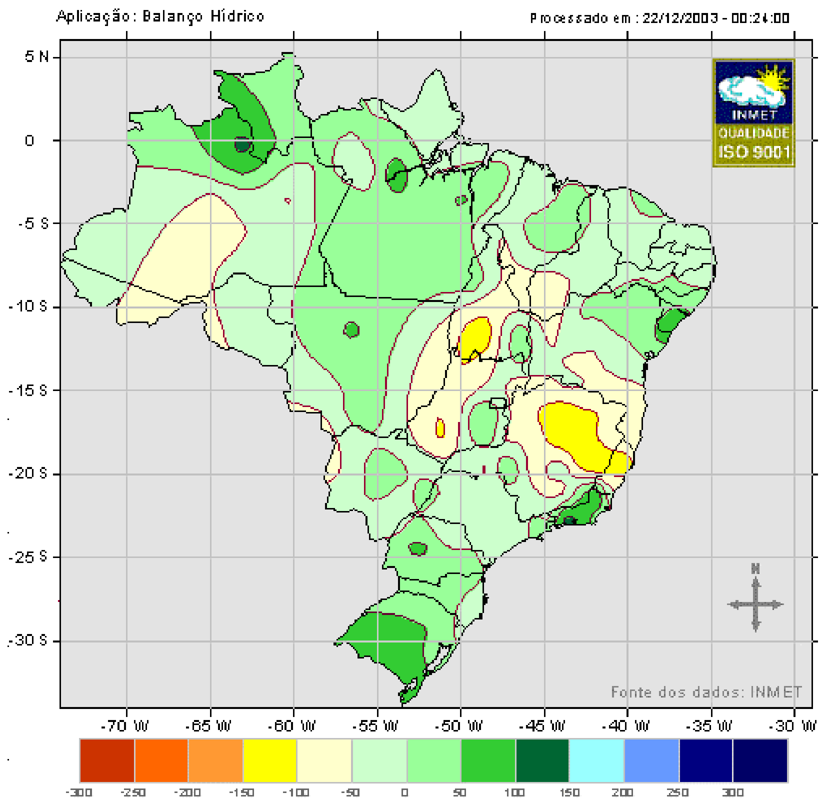
Map 22: Deviation of monthly total rainfall (mm)-April/2003 (REF. Climatological Norms 1961-1990)



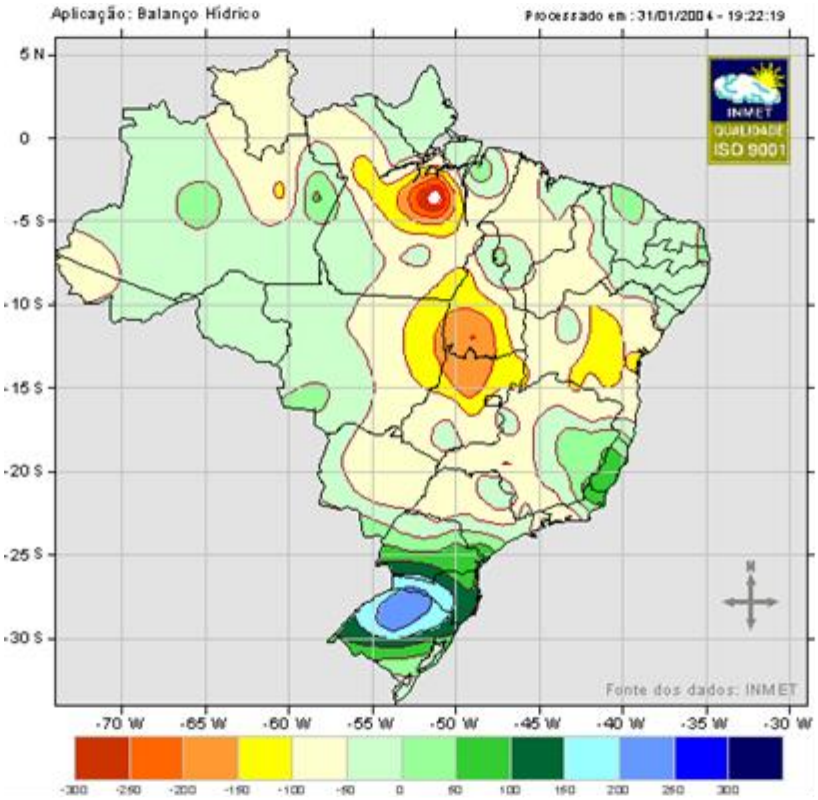
Map 23: Deviation of monthly total rainfall (mm) – September/2003 (REF. Climatological Norms 1961-1990)



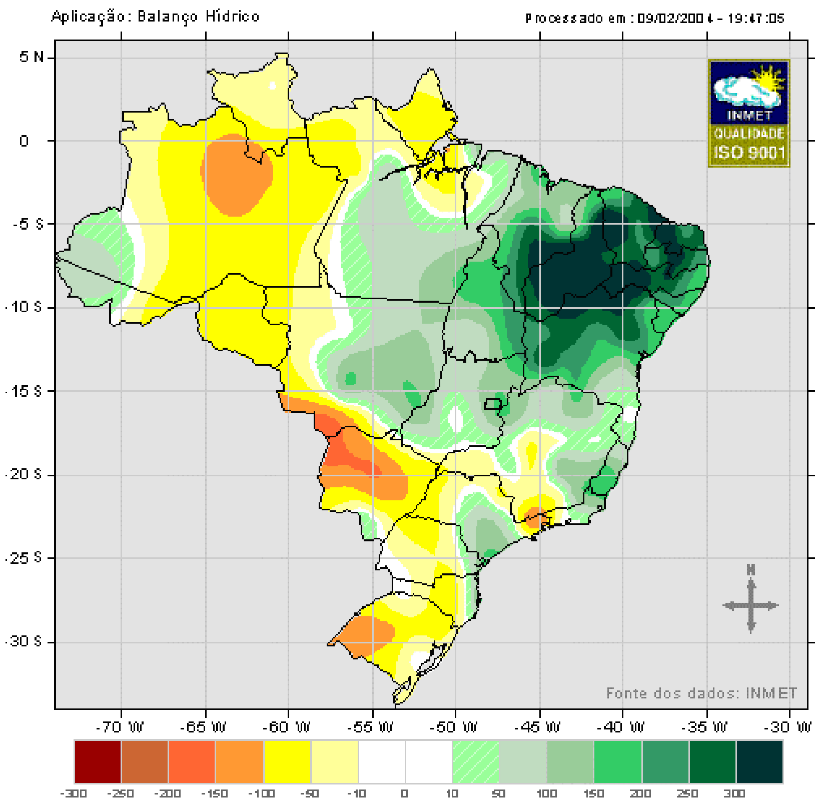
Map 24: Deviation of monthly total rainfall (mm)-October/2003 (REF. Climatological Norms 1961-1990)



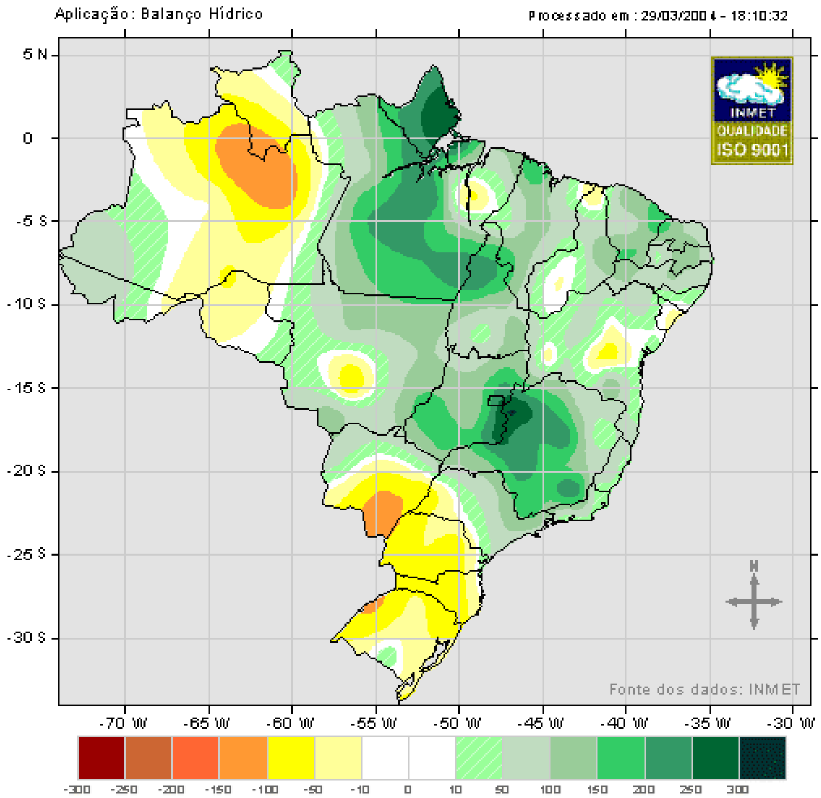
Map 25: Deviation of monthly total rainfall (mm) – November/2003 (REF. Climatological Norms 1961-1990)



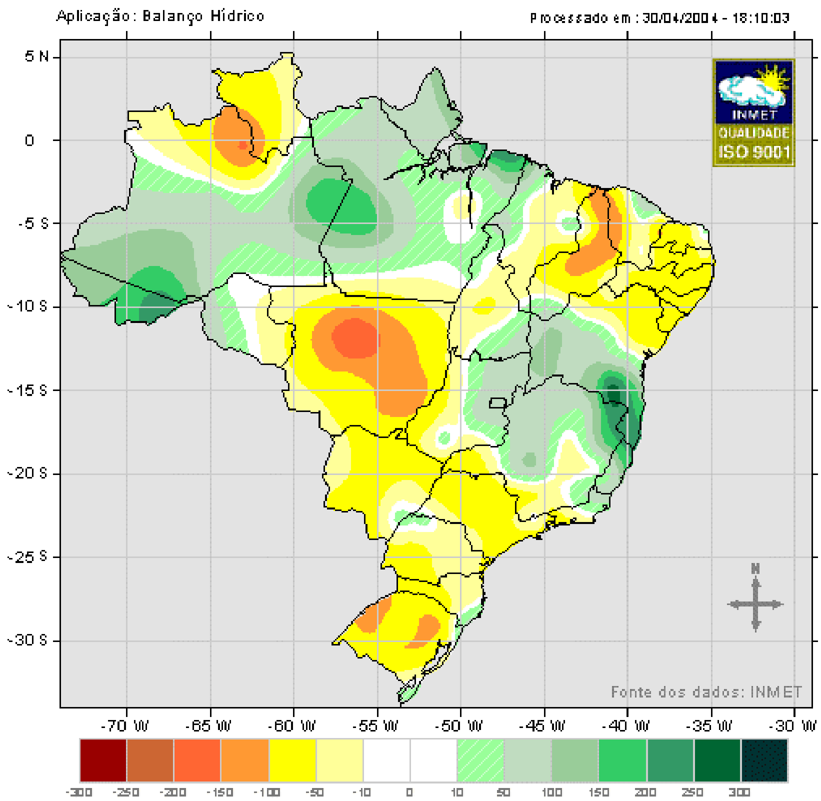
Map 26: Deviation of monthly total rainfall (mm)-December/2003 (REF. Climatological Norms 1961-1990)



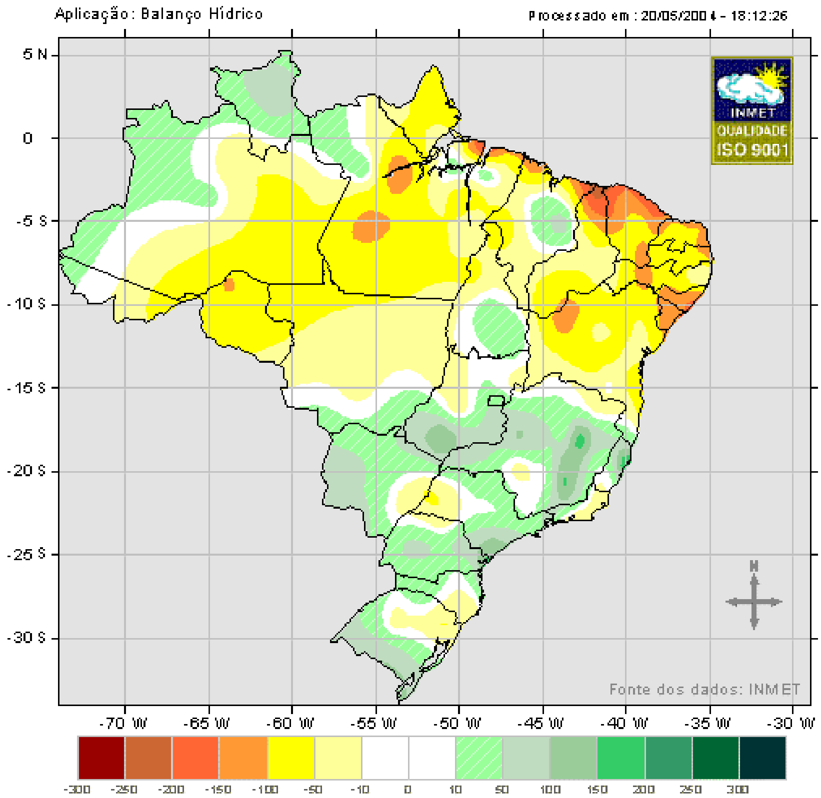
Map 27: Deviation of monthly total rainfall (mm) – January/2004 (REF. Climatological Norms 1961-1990)



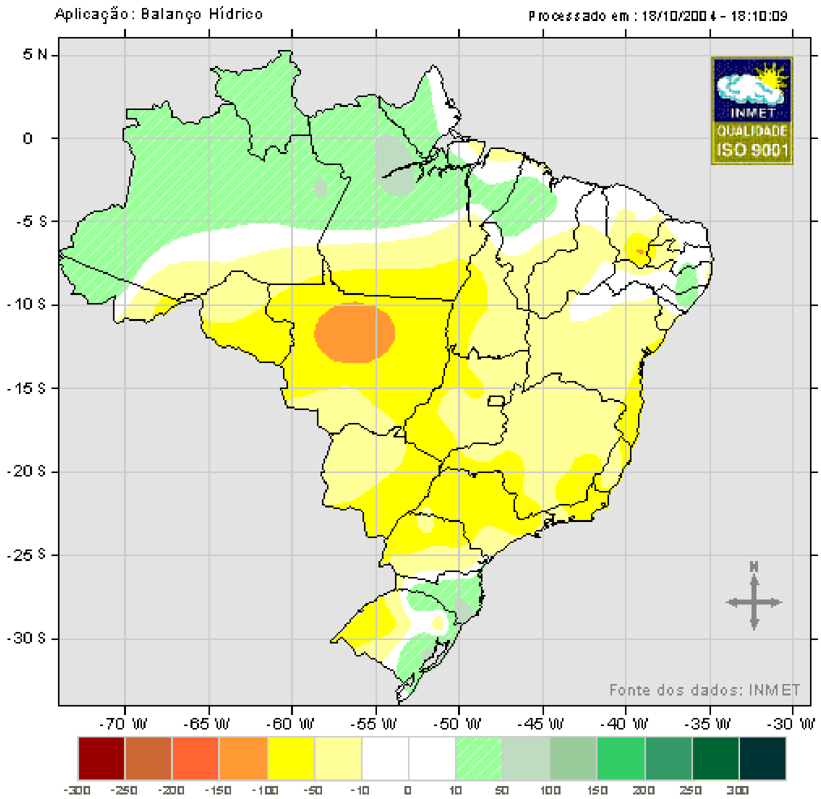
Map 28: Deviation of monthly total rainfall (mm) – February/2004 (REF. Climatological Norms 1961-1990)



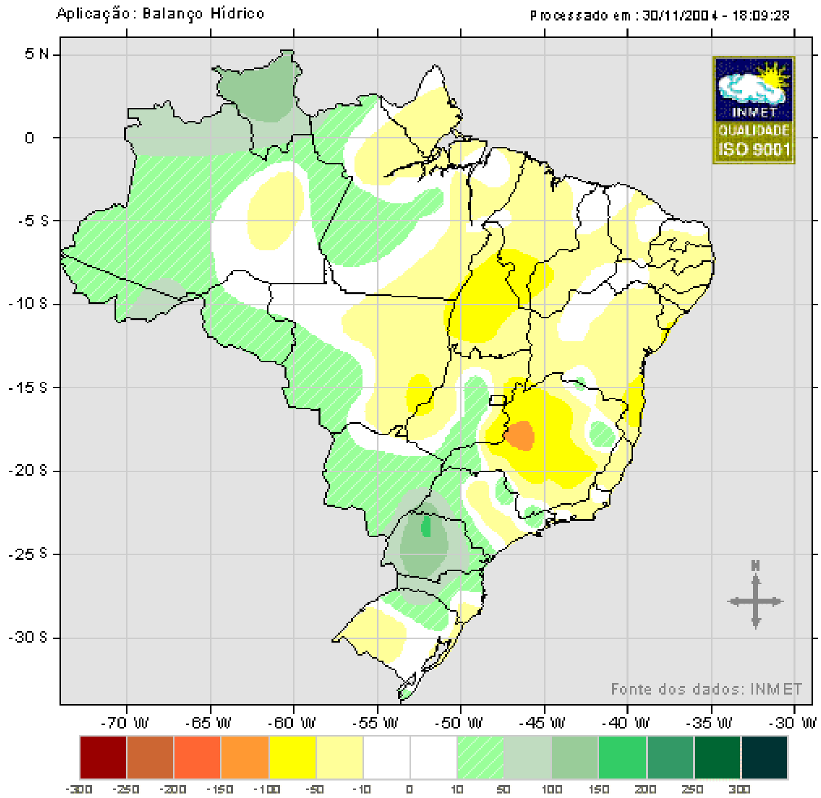
Map 29: Deviation of monthly total rainfall (mm)-March/2004 (REF. Climatological Norms 1961-1990)



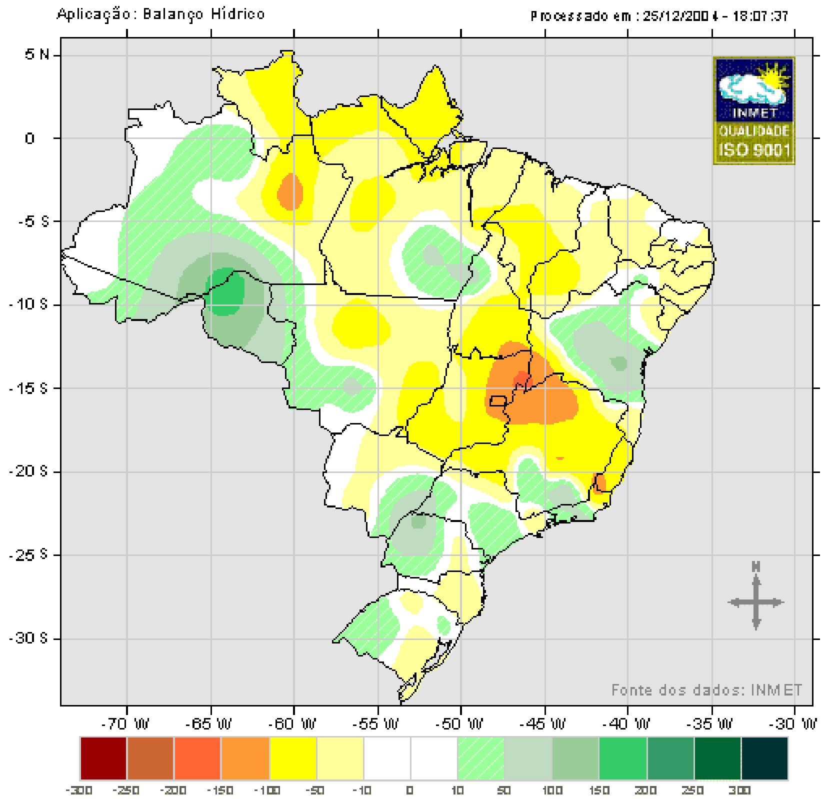
Map 30: Deviation of monthly total rainfall (mm)-April 2004 (REF. Climatological Norms 1961-1990)



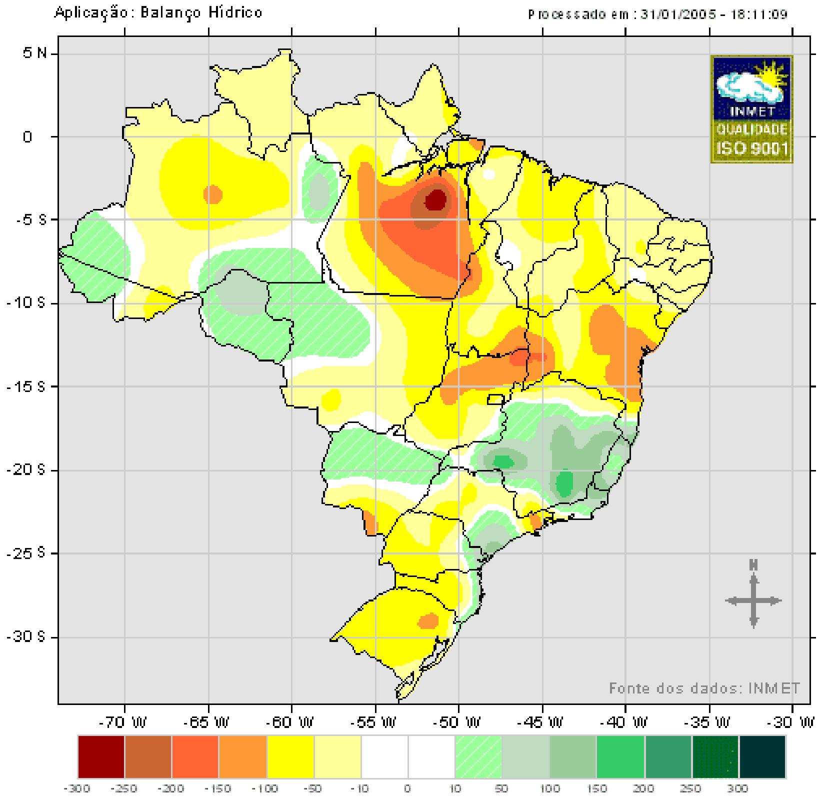
Map 31: Deviation of monthly total rainfall (mm)-September/2004 (REF. Climatological Norms 1961-1990)



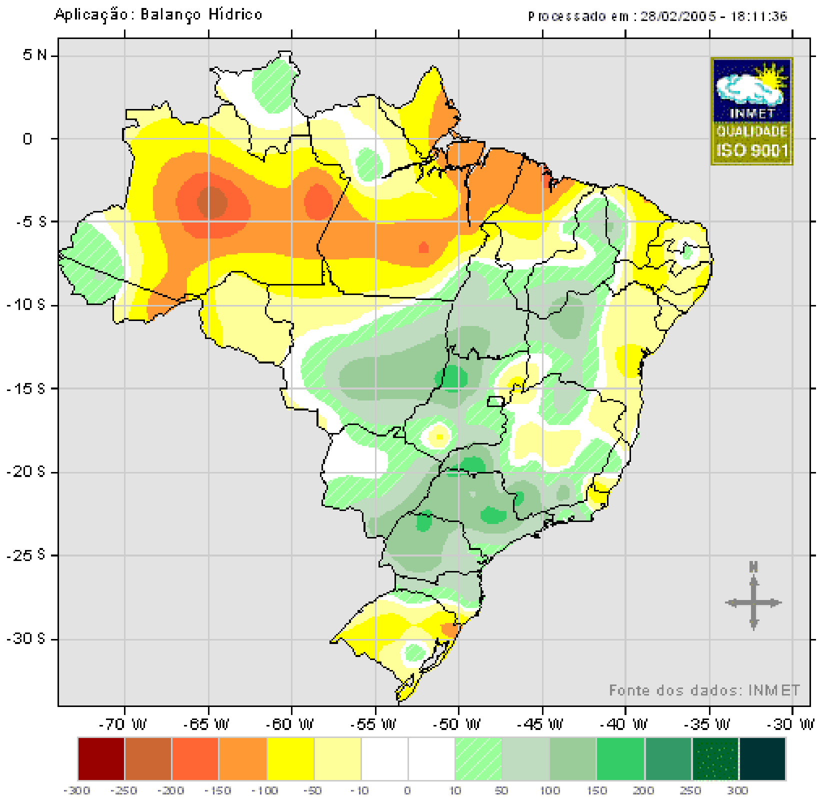
Map 32: Deviation of monthly total rainfall (mm)-October/2004 (REF. Climatological Norms 1961-1990)



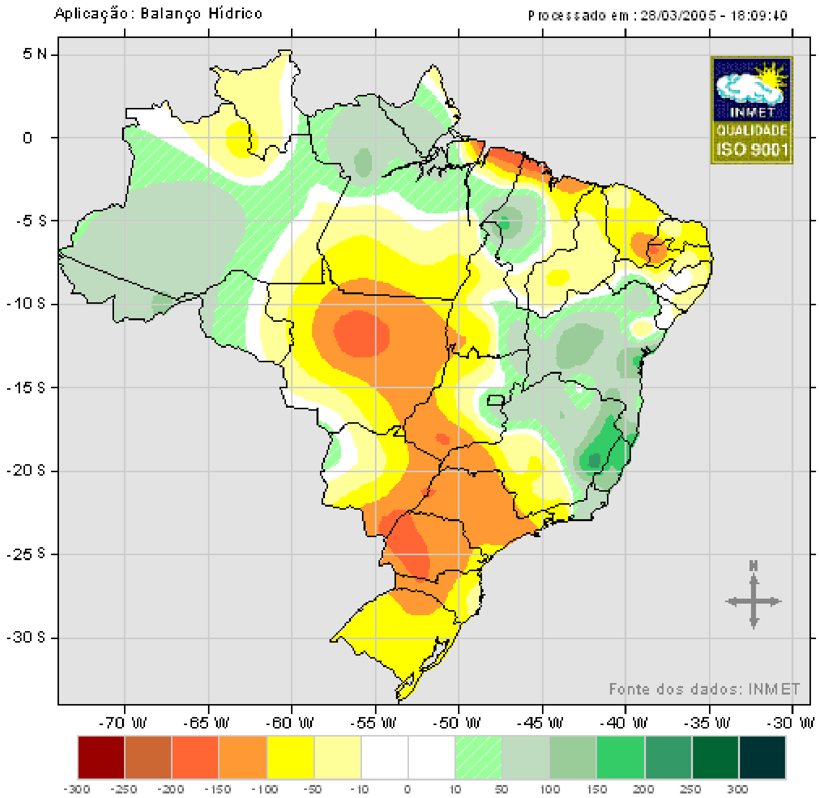
Map 33: Deviation of monthly total rainfall (mm) – November/2004 (REF. Climatological Norms 1961-1990)



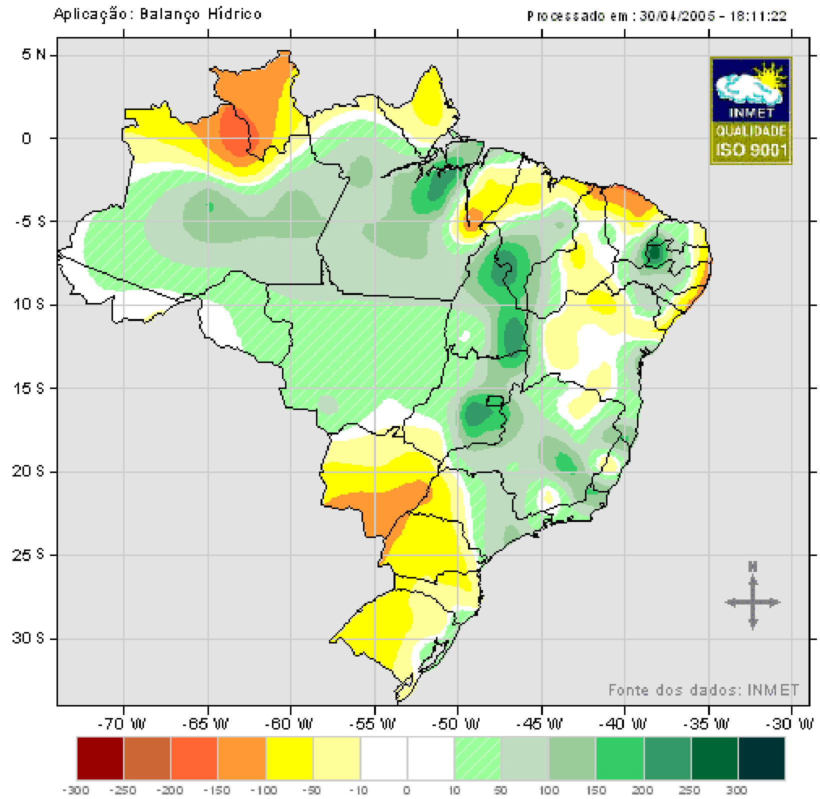
Map 34: Deviation of monthly total rainfall (mm)-December/2004 (REF. Climatological Norms 1961-1990)



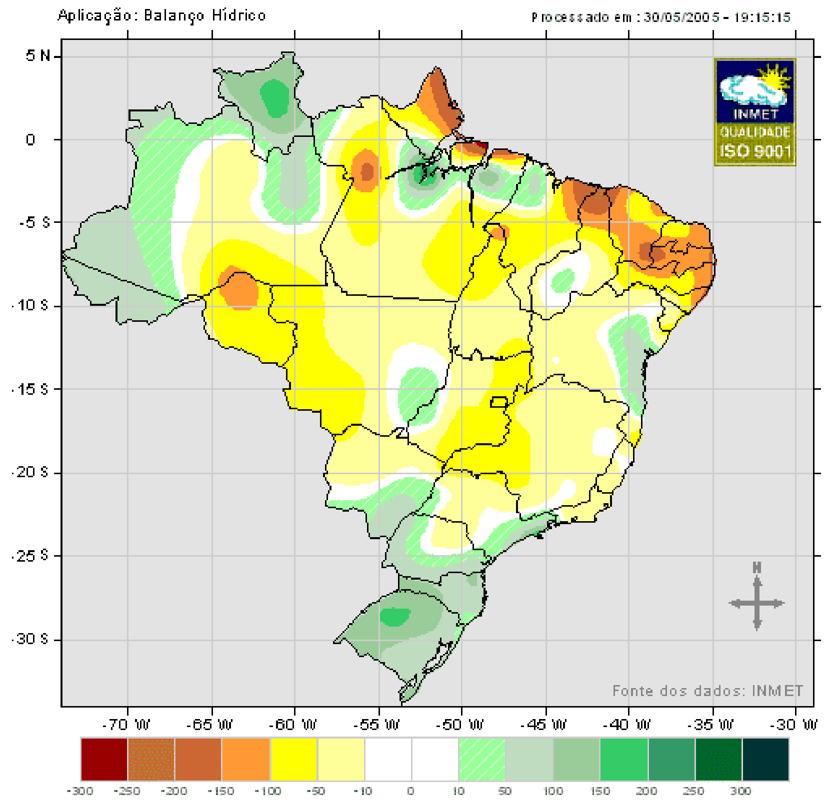
Map 35: Deviation of monthly total rainfall (mm) – January/2005 (REF. Climatological Norms 1961-1990)



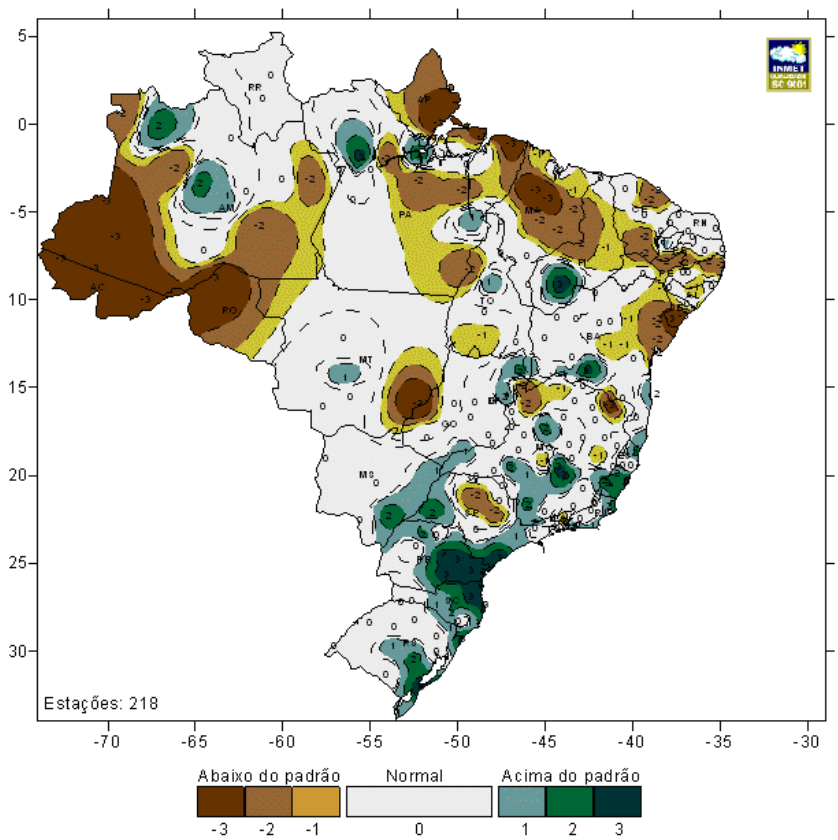
Map 36: Deviation of monthly total rainfall (mm) – February/2005 (REF. Climatological Norms 1961-1990)



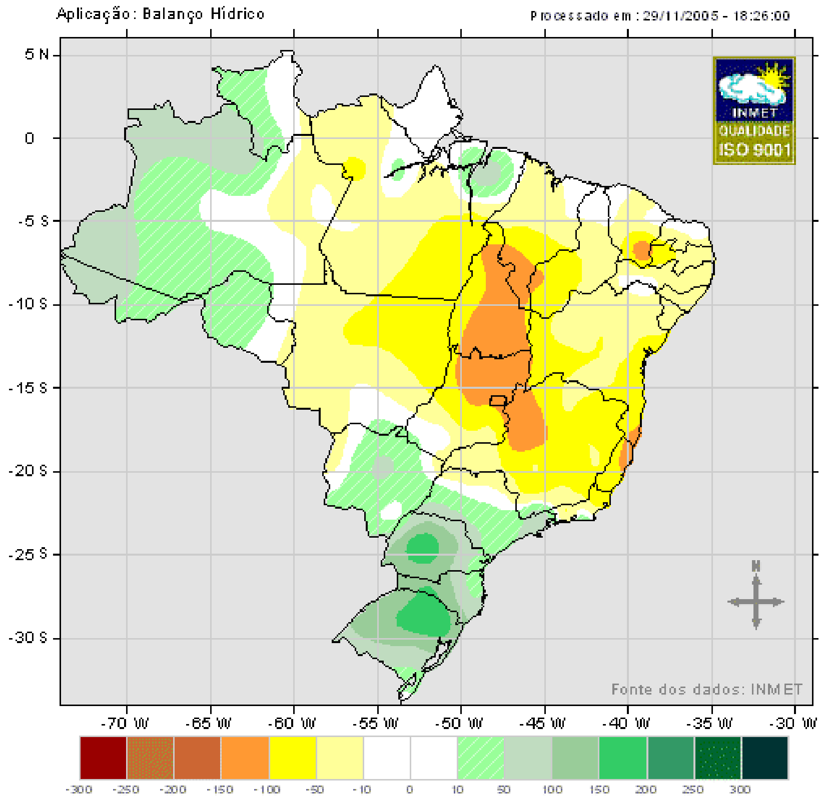
Map 37: Deviation of monthly total rainfall (mm)-March/2005 (REF. Climatological Norms 1961-1990)



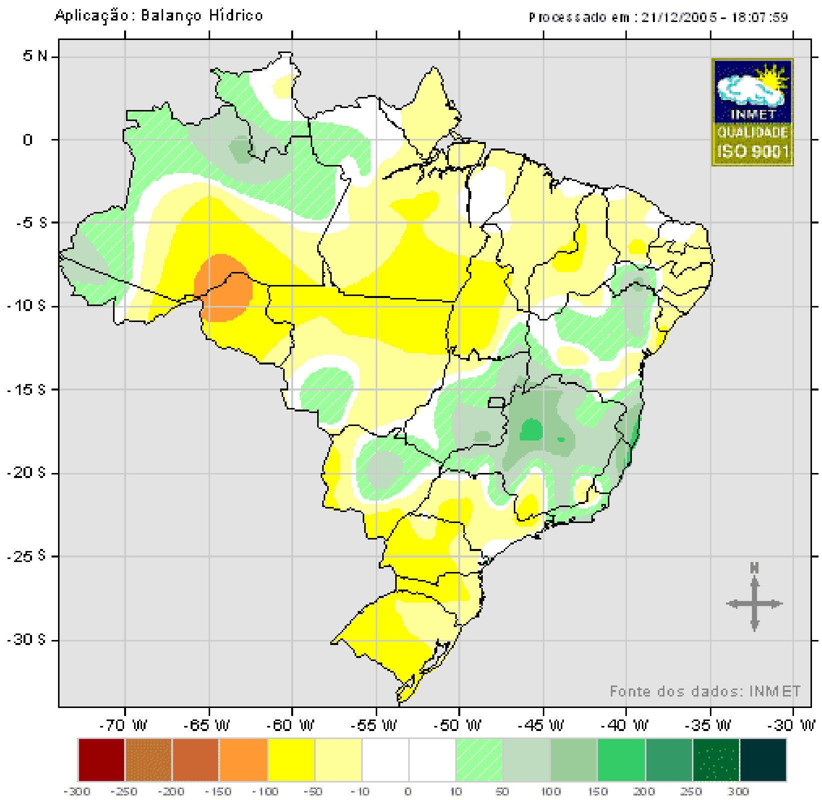
Map 38: Deviation of monthly total rainfall (mm)-April/2005 (REF. Climatological Norms 1961-1990)



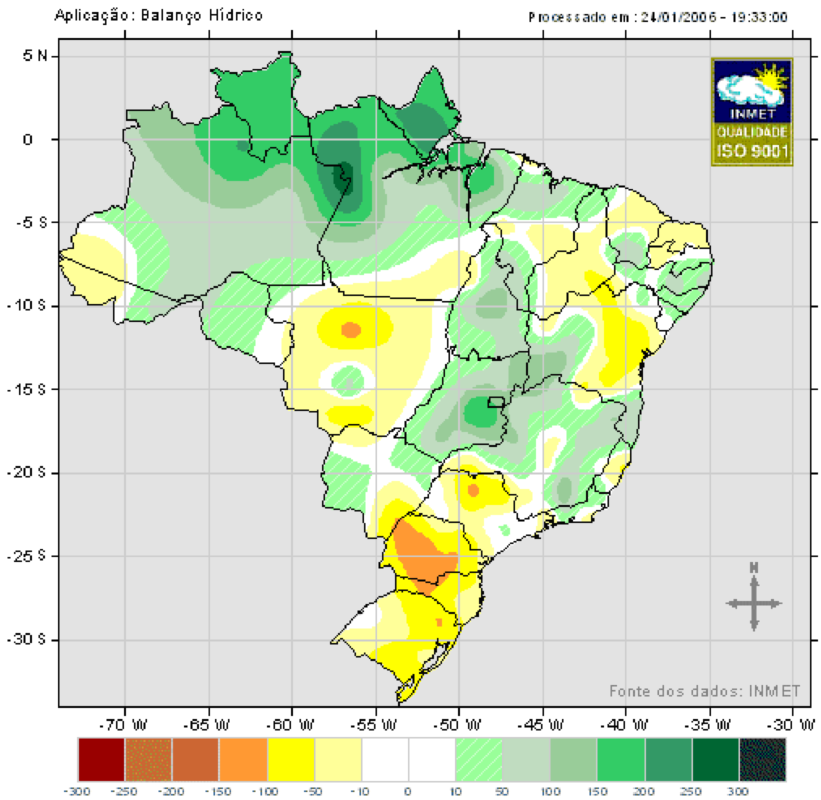
Map 39: Deviation of monthly total rainfall (mm) – ‘decis method’ -September/2005



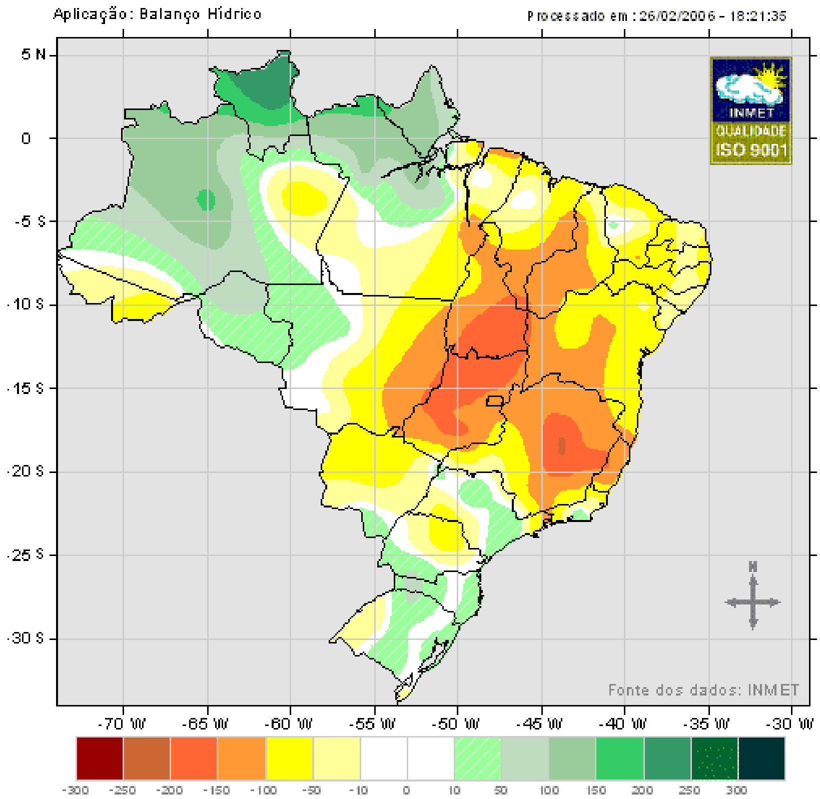
Map 40: Deviation of monthly total rainfall (mm)-October/2005 (REF. Climatological Norms 1961-1990)



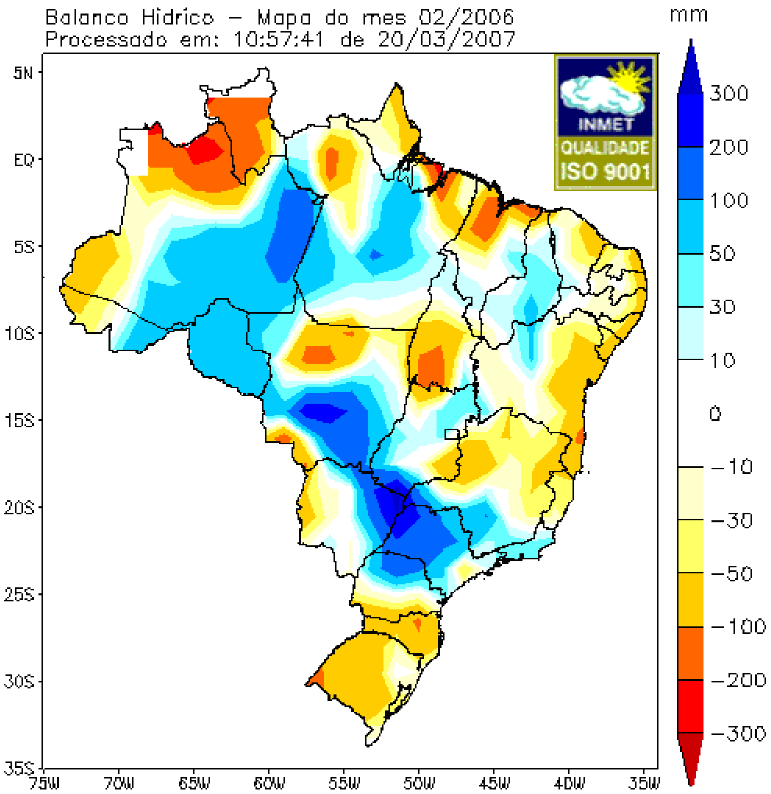
Map 41: Deviation of monthly total rainfall (mm) – November/2005 (REF. Climatological Norms 1961-1990)



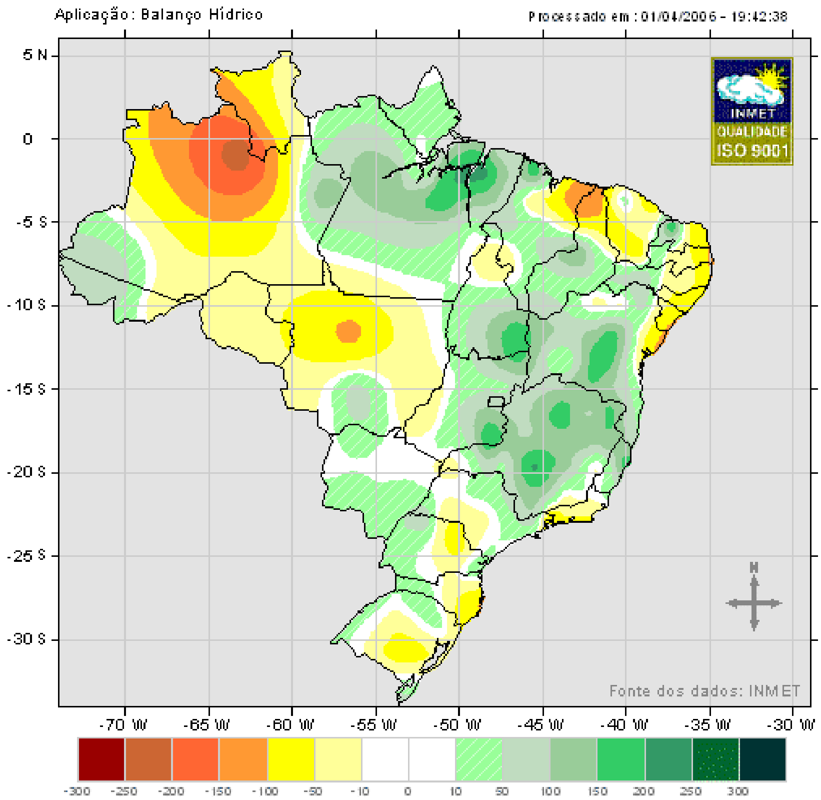
Map 42: Deviation of monthly total rainfall (mm) – December/2005 (REF. Climatological Norms 1961-1990)



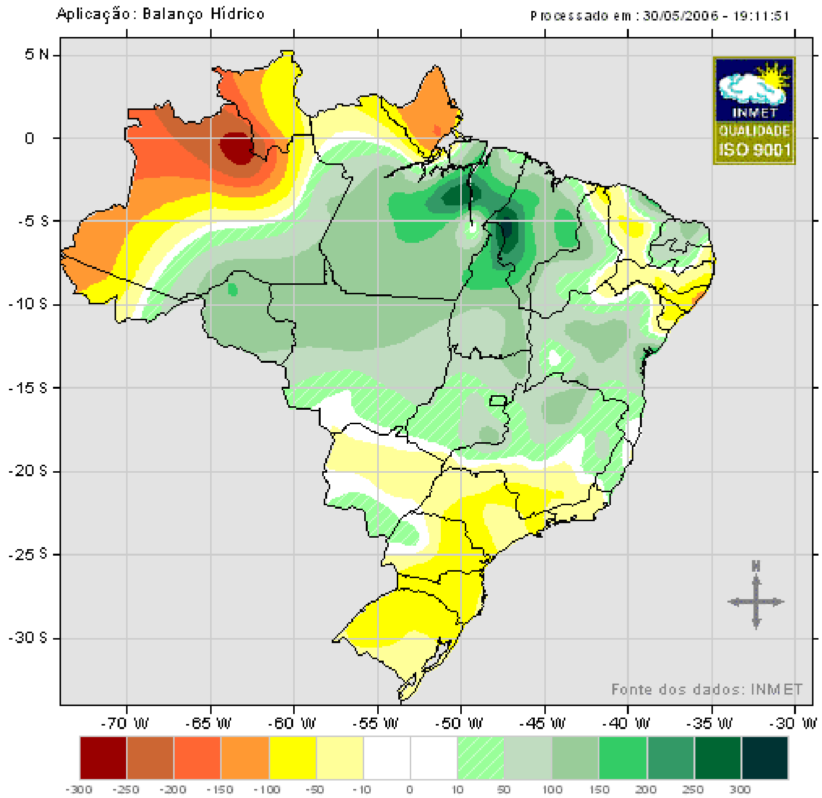
Map 43: Deviation of monthly total rainfall (mm) – January/2006 (REF. Climatological Norms 1961-1990)



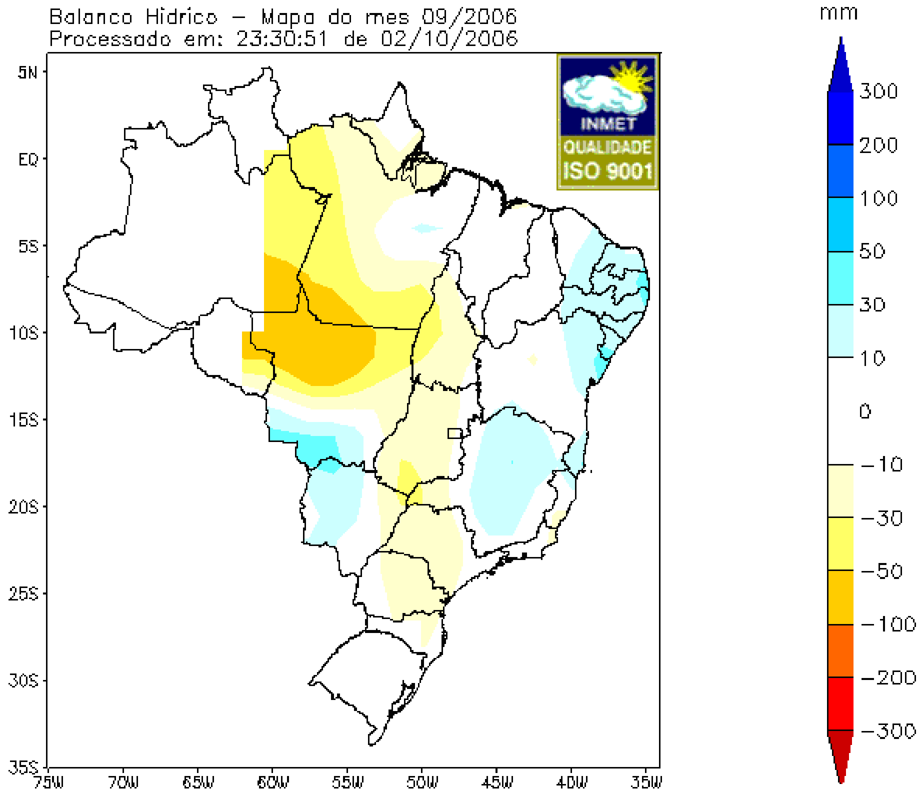
Map 44: Deviation of monthly total rainfall (mm) – February/2006 (REF. Climatological Norms 1961-1990)



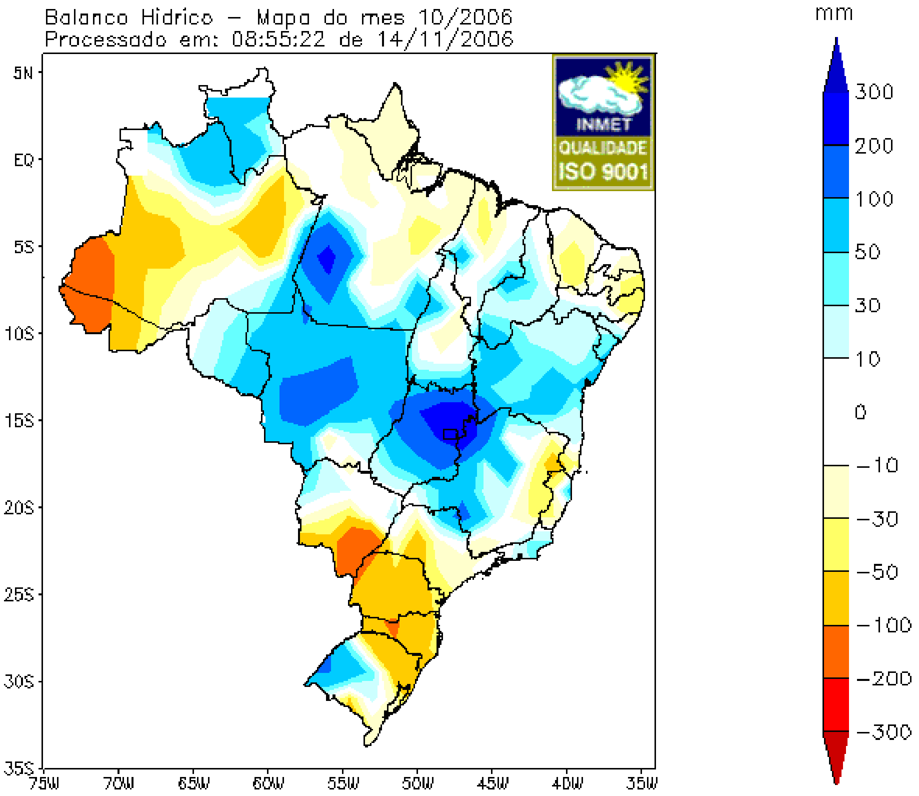
Map 45: Deviation of monthly total rainfall (mm)-March/2006 (REF. Climatological Norms 1961-1990)



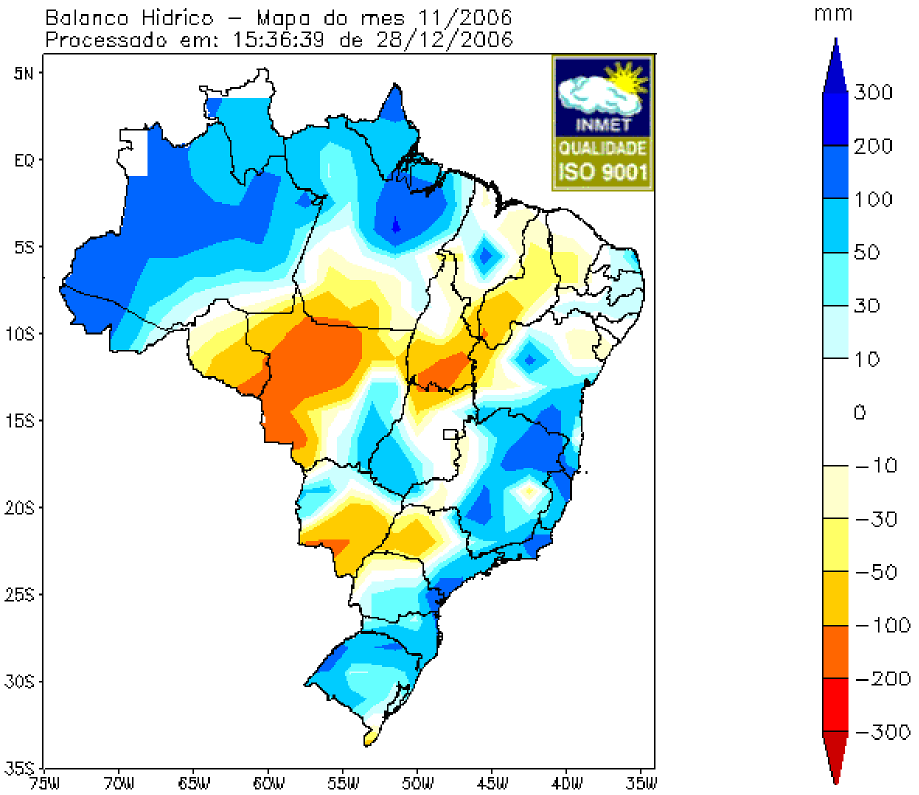
Map 46: Deviation of monthly total rainfall (mm) – April/2006 (REF. Climatological Norms 1961-1990)



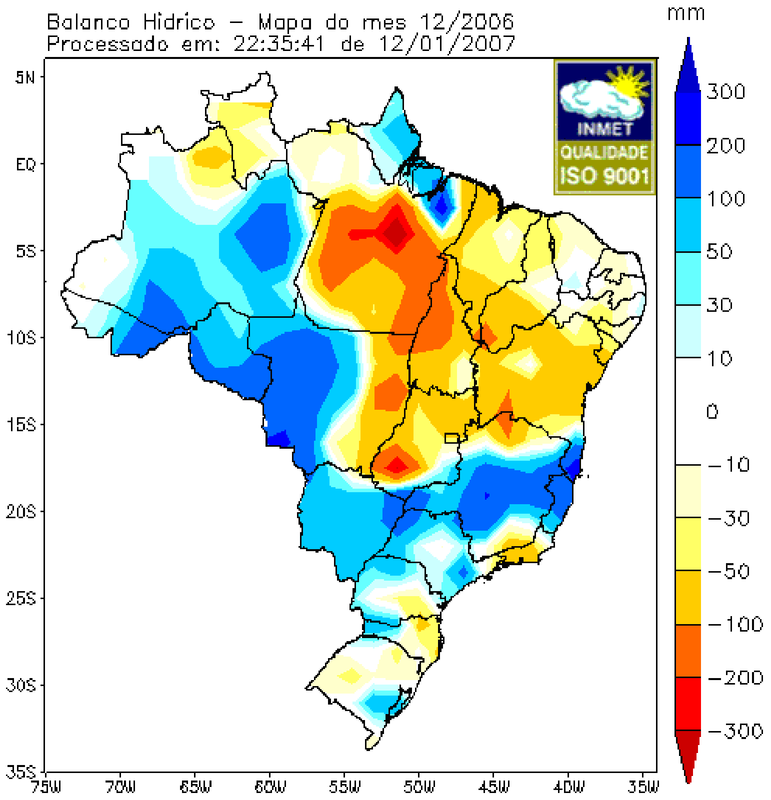
Map 47: Deviation of monthly total rainfall (mm) – September/2006 (REF. Climatological Norms 1961-1990)



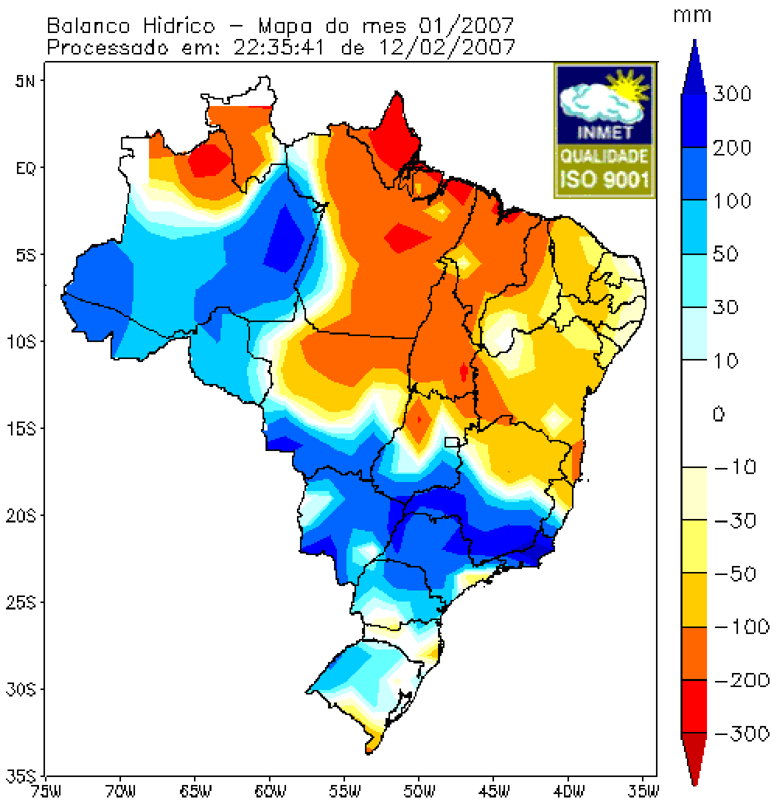
Map 48: Deviation of monthly total rainfall (mm)-October/2006 (REF. Climatological Norms 1961-1990)



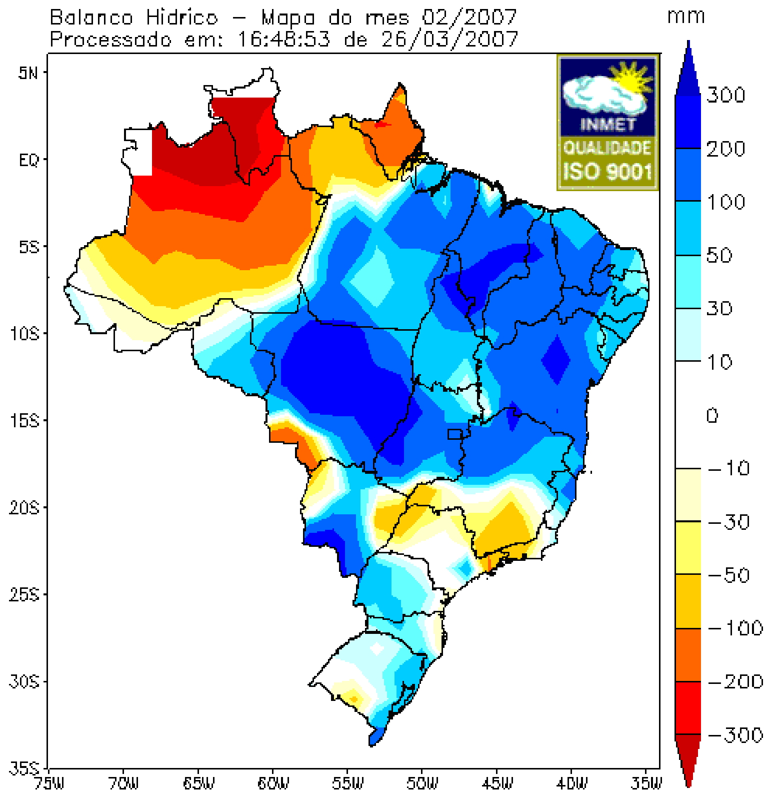
Map 49: Deviation of monthly total rainfall (mm) – November/2006 (REF. Climatological Norms 1961-1990)



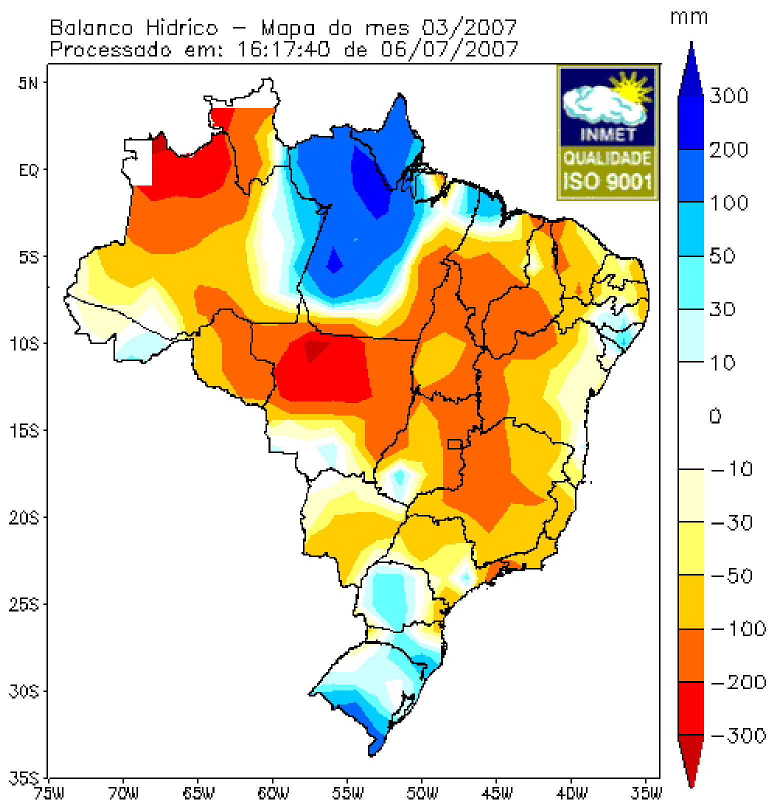
Map 50: Deviation of monthly total rainfall (mm) – December/2006 (REF. Climatological Norms 1961-1990)



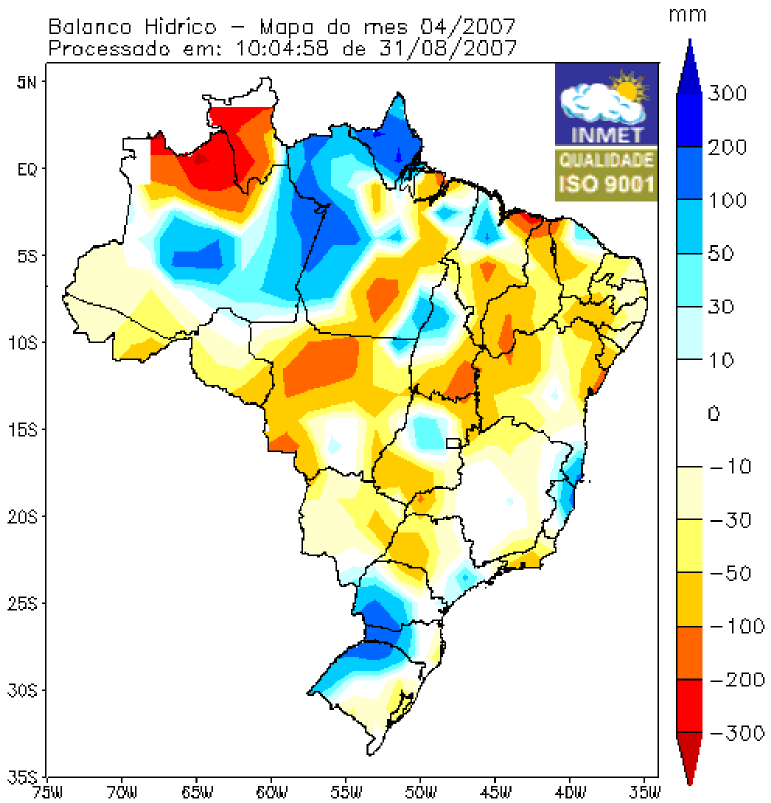
Map 51: Deviation of monthly total rainfall (mm) – January/2007 (REF. Climatological Norms 1961-1990)



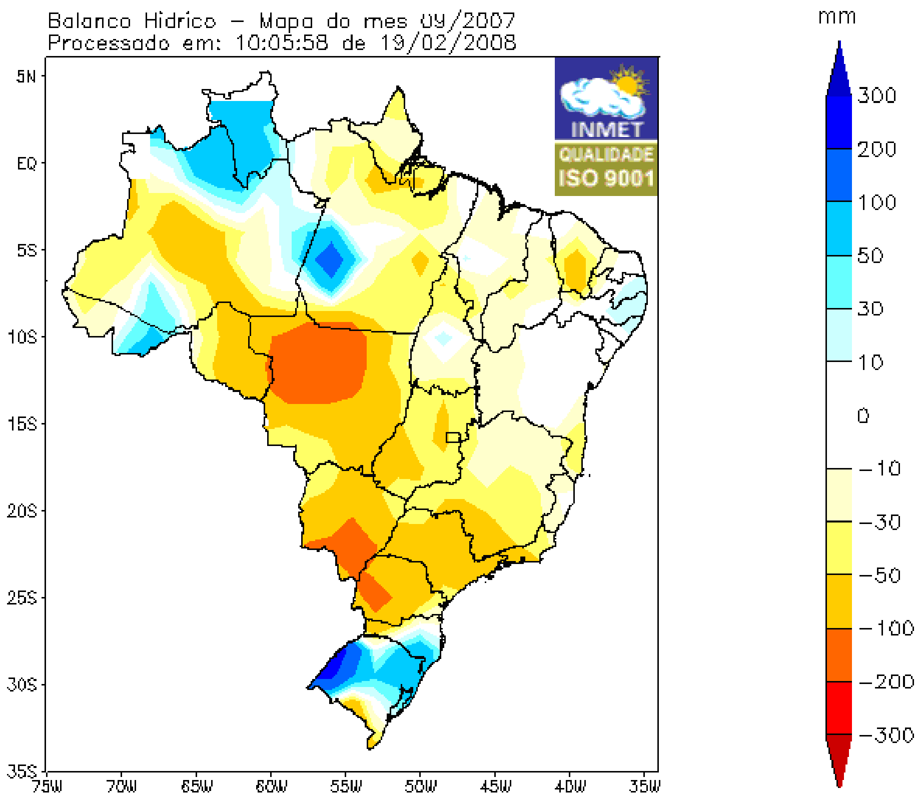
Map 52: Deviation of monthly total rainfall (mm) – February/2007 (REF. Climatological Norms 1961-1990)



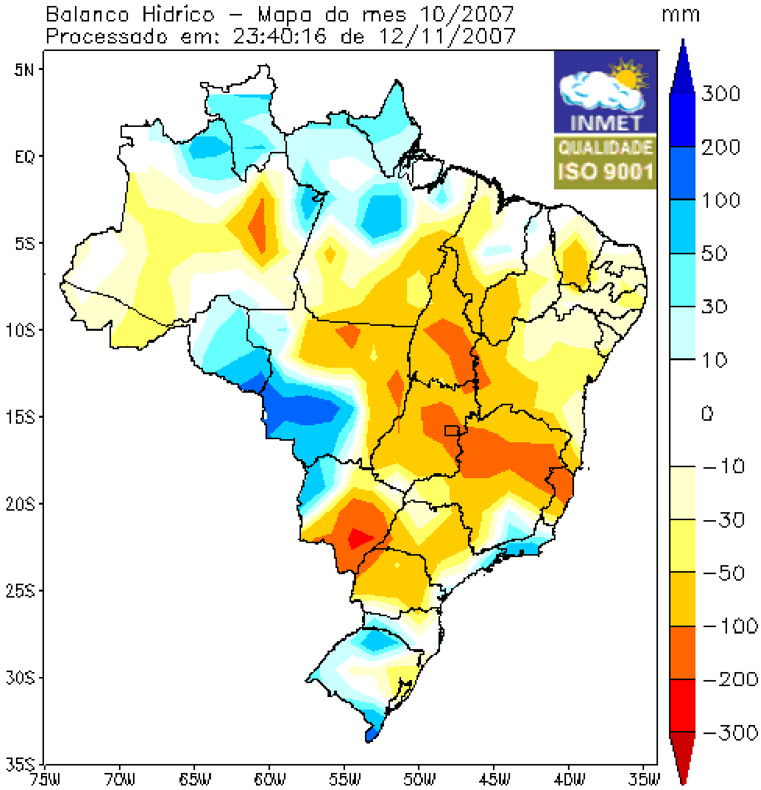
Map 53: Deviation of monthly total rainfall (mm)-March/2007 (REF. Climatological Norms 1961-1990)



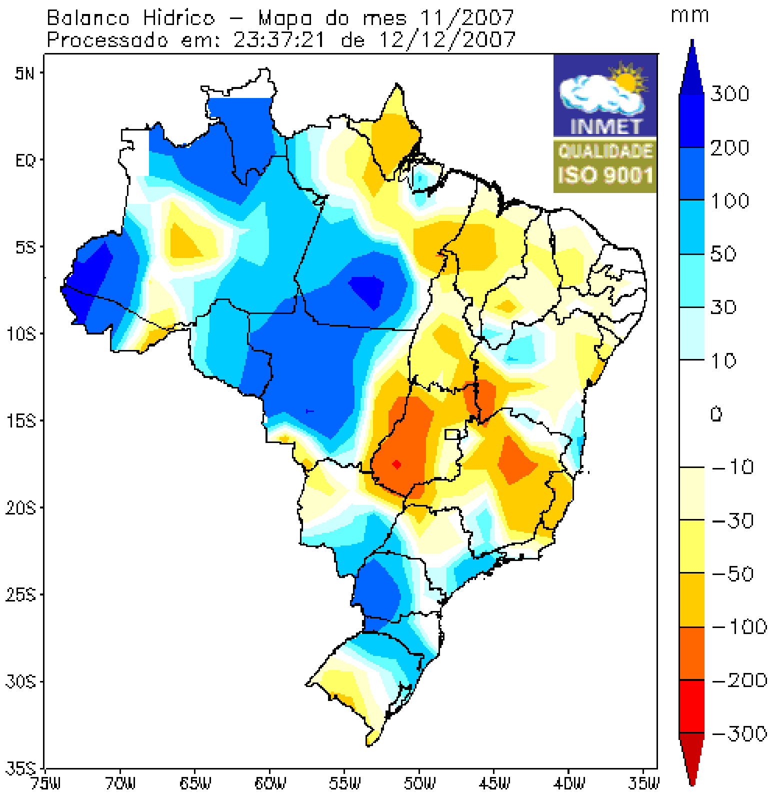
Map 54: Deviation of monthly total rainfall (mm) – April/2007 (REF. Climatological Norms 1961-1990)



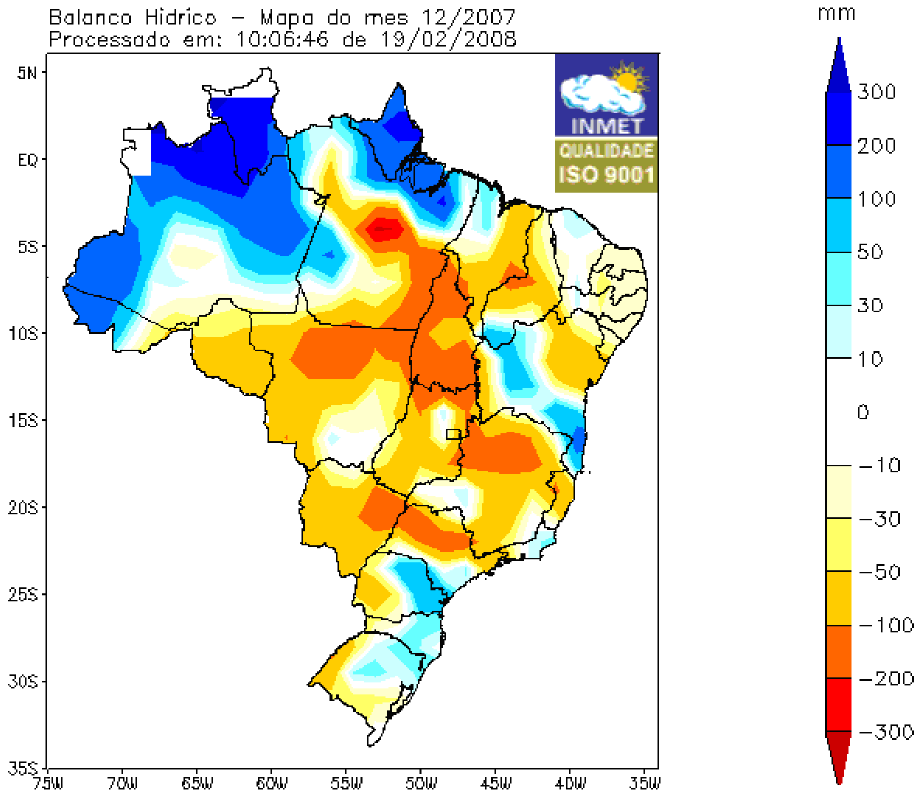
Map 55: Deviation of monthly total rainfall (mm) – September/2007 (REF. Climatological Norms 1961-1990)



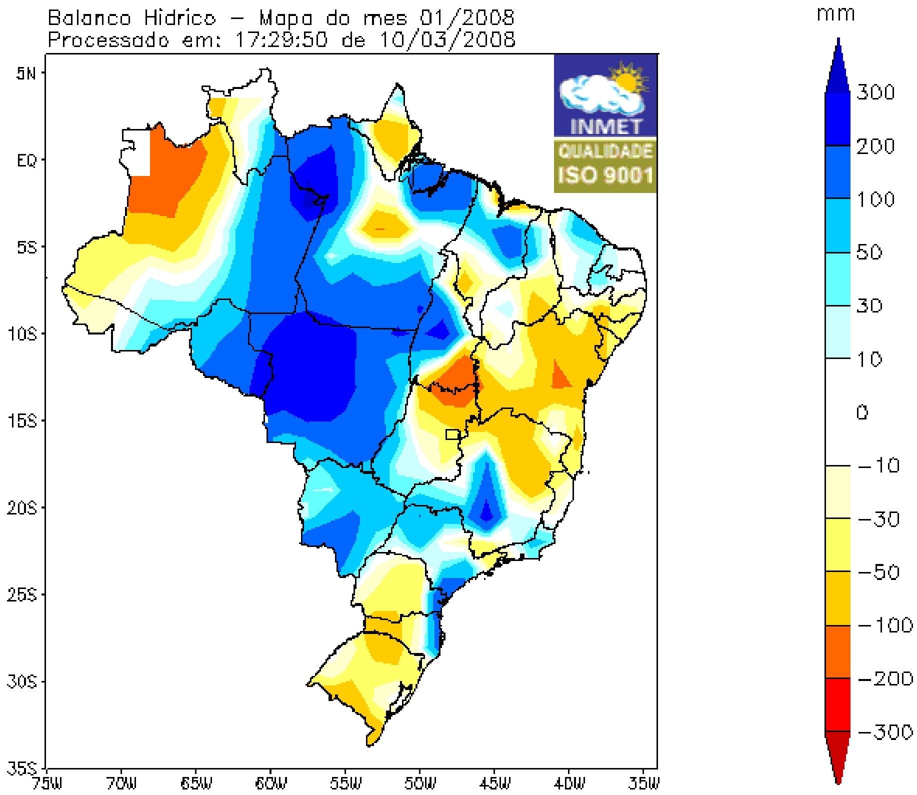
Map 56: Deviation of monthly total rainfall (mm)-October/2007 (REF. Climatological Norms 1961-1990)



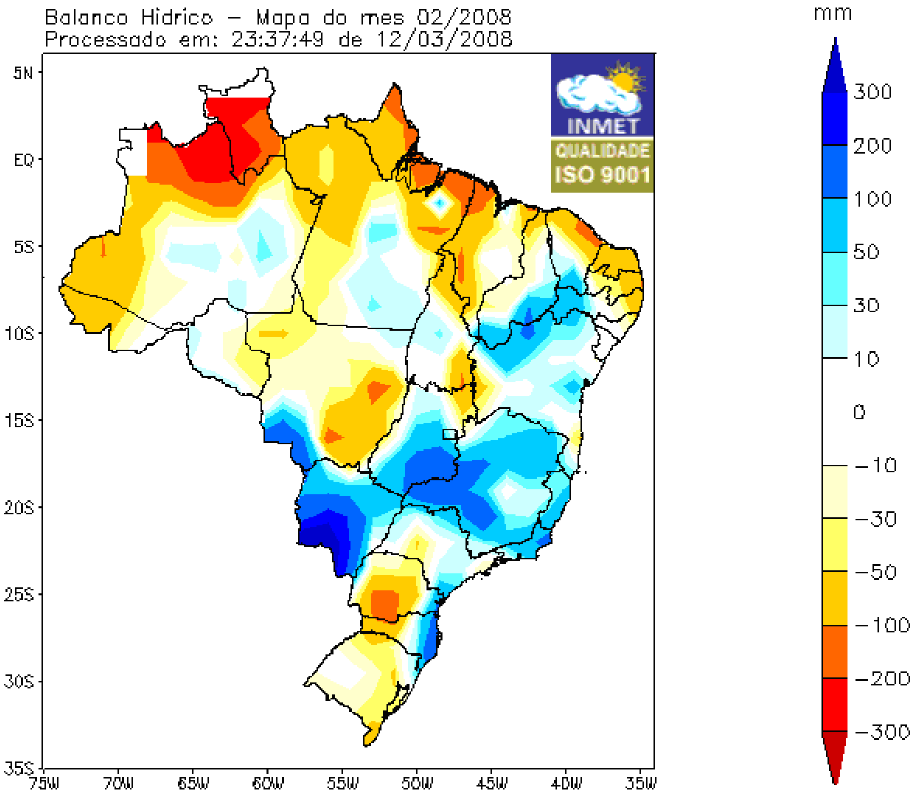
Map 57: Deviation of monthly total rainfall (mm) – November/2007 (REF. Climatological Norms 1961-1990)



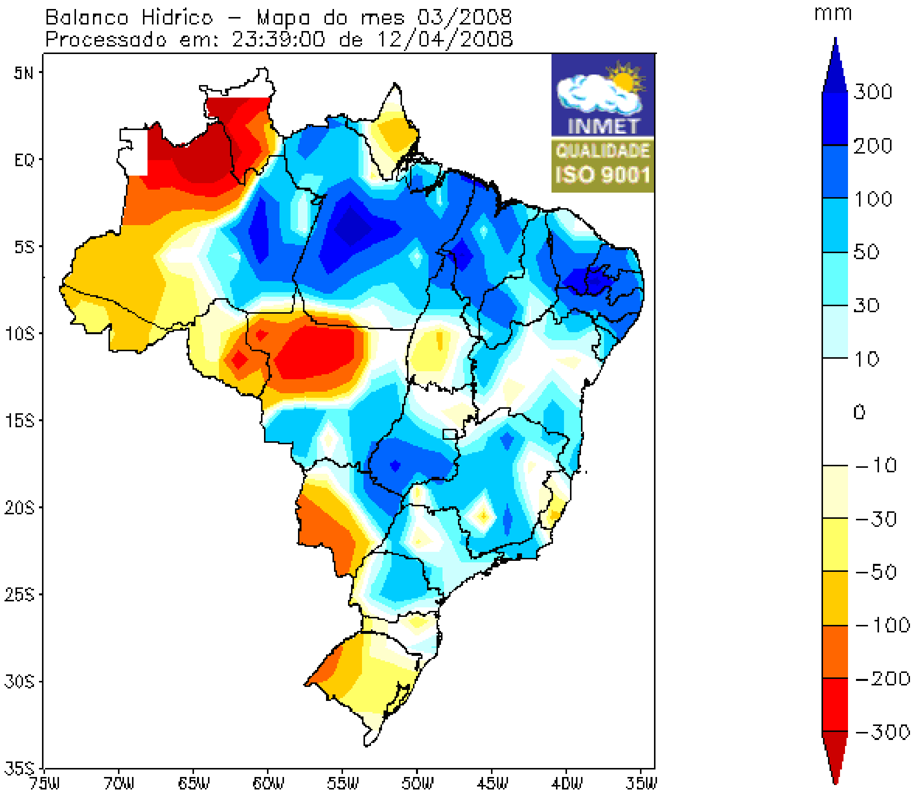
Map 58: Deviation of monthly total rainfall (mm) – December/2007 (REF. Climatological Norms 1961-1990)



Map 59: Deviation of monthly total rainfall (mm) – January/2008 (REF. Climatological Norms 1961-1990)



Map 60: Deviation of monthly total rainfall (mm) – February/2008 (REF. Climatological Norms 1961-1990)



Map 61: Deviation of monthly total rainfall (mm)-March/2008 (REF. Climatological Norms 1961-1990)

Marengo (2006) comments that the Brazilian Pantanal is with atypical behavior of floods in recent years and, the main causes are probably the low rainfall volumes recorded and alternating rainy periods and droughts in the region. Specifically in the period October 2004 to March 2005 the lowest peak occurred during the period from 1974 to 2004.

Noble, Sampaio and Salazar (2007) make a relevant relationship regarding the changes of land use and hydrology, showing that the effect of deforestation and climate change directly affects the hydrological cycle at all scales of time: on time scales of days to months lead to changes in the incidence of floods; in seasonal to amongst annual time scales, changes in the characteristics of drought is the main hydrological manifestation; and, in years to decades, the interconnections in global atmospheric circulation patterns, caused by ocean-atmosphere interaction, affect the hydrology of some regions.

Studies reveal that occurrences of rains in South America are related to meteorological phenomena belonging to various temporal and spatial scales, ranging from the global scale (El Niño-La Niña), 30-60 day Oscillation (Madden& Julian Oscillation) and the South Atlantic convergence zone (ZCAS) as well as the local weather conditions (rain located) that affect mainly in Midwestern regions precipitation, Southeast, Northeast and North South sector of southern region (GRIMM; PSCHEIDT, 2001; CARVALHO et al., 2002a; CARVALHO et al., 2002b; MADDEN; JULIAN, 1994).

2.3.4. Climate variability of low humidity of the air in the Midwest

According to Diniz and Rebello (2002), extreme values of low relative humidity of the air is the main meteorological parameter in weather that has caused many problems and discomfort to the population during the period from June to September in the Midwest. The relative humidity of the air in the atmosphere is subjected to the air temperature. Thus, this humidity is the reason of the ratio of the partial pressure of vapor and saturation pressure, submitted at the same temperature. That is why it is expressed as a percentage: the higher the temperature, the lower the air humidity. Air humidity can also be defined as being the reason for the amount of water vapor mixture in relation to the amount of mixture required to saturate water steam under the same conditions of pressure and temperature.

Under the view of Climatology, during the dry season (winter), from June to mid-September, the Midwest region receives influence of the masses of cold air, which in turn are under the dominion of a subsumed movement of the winds in the atmosphere, active in the region. These systems are characterized by the descent of the air in the higher levels of the atmosphere toward the surface and prevent the formation of clouds, leaving the drier atmosphere. During the months of August to early September, extended period of drought, with the highest number of days without rain and higher incidence of solar radiation. This characteristic atmospheric pattern causes a considerable increase in air temperatures in the Central-West region of Brazil, with greater predominance of hot and dry air mass and, in the lower layer of the atmosphere, the highest concentration of haze (dust in suspension, fumes from cars, as well as vegetation burnings) leading to low relative humidity.

Climate change, in part, shows a change in the trajectory of climate behavior in a region or part of the world. This change should not be temporal or transient, but, a process that has been established through the climate data of temperature, air humidity, evapotranspiration and precipitation patterns.

Diniz and Rebello (2006) used the smallest monthly extreme values of the parameter of the relative humidity for a period of 44 years, from 1961 to 2004, database series of INMET. Generally, the minimum air humidity values occur around the 3:0 pm GMT. Consideration of these extreme values comes monthly to verify occurrences and frequencies of extremes of moisture from the air, as well as their variability. Therefore, there were not considered the daily minimum values of relative air humidity. Graphics of the 5-year moving average of the extreme values of yearly minimum air humidity are also prepared. Graphics with the averages of minimum values of monthly air humidity extremes, during the period from 1961 to 1990, with the period of 1991 to 2004 and compared to low air humidity variation by the curves of each chart are also set.

Localities studied were the cities of Brasília-DF, Campo Grande-MS and Goiania-GO. The climatology in the period showed that the driest months of the year are August and September, in which the average values of the relative air humidity extreme monthly minimum are respectively 20% and 20%: in Brasília-DF; of 22% and 24% in Campo Grande-MS; and 20% and 20% in Goiania-GO. The lowest indexes of relative humidity in these localities observed during the period under study were recorded on the following dates:

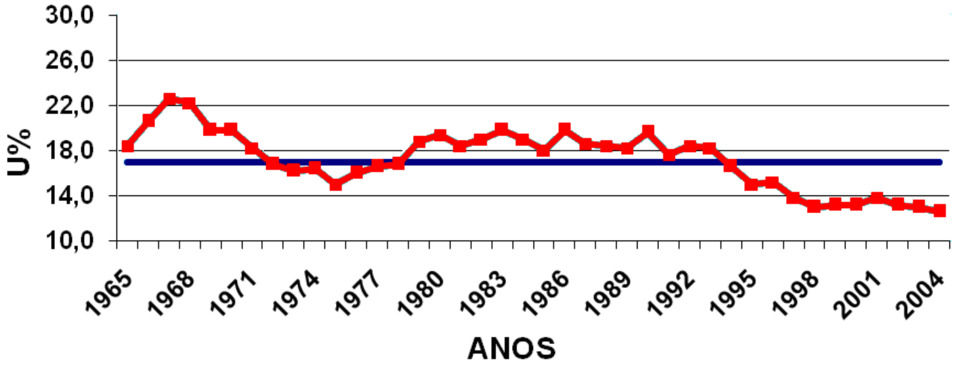
- Brasília, 10% on August 7th /2002 and September 4th /2004;
- Campo Grande-MS, 11% on September 2nd and 6th /2004;
- Goiânia-GO, 11% on September 4th and 6th /2004.

For Brasilia-DF, data were used for three periods: from 1971 to 1979, in which the air humidity minimum annual indices presented below the minimum annual average value; from 1980 to 1992, when the air humidity minimum annual indices presented above the minimum annual average value; and the third period, **considered the largest and most critical**, from 1992 to 2004, with indices of air humidity, around 12%, well below the average annual extreme value.

Campo Grande-MS, there were considered two distinct periods: from 1975 to 1982, in which the air humidity behaved with annual minimum values well above the minimum annual average value, and 1986 to 1993, when there was a break in the information, and therefore, you cannot obtain a better definition of the behavior of the moisture from the air, but the range of 1994 to 2004, shows a greater period of low rates of annual air humidity, around 16% compared with the average annual extreme, which tends to rise between 2000 and 2002 and falls again.

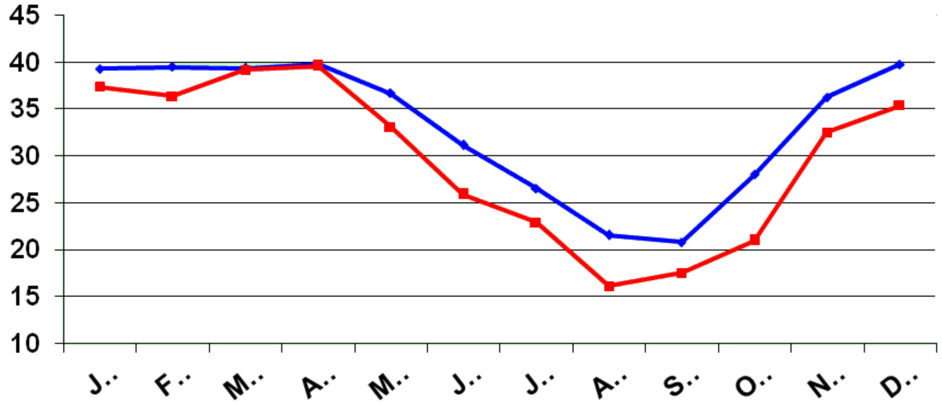
Goiânia-GO, there were considered two periods: from 1978 to 1987, in which the air humidity presented annual minimum values above the line of the minimum annual average value; and the period of 1987 to 2004**, considered the largest and most critical** where air humidity decreased to values around 15%, with a slight increase between 2000 to 2002, returning to decrease again.

This information is represented in the Charts 13 to 18.



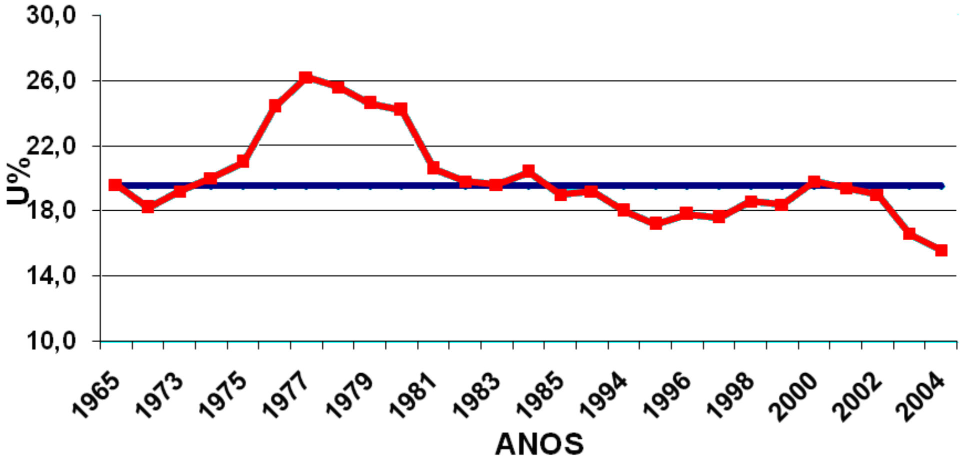
[Red = extreme annual moving average; Blue = minimum average annual extreme]

Chart 13: Relative air humidity of Brasília-DF [1965-2004] (DINIZ; REBELLO, 2006)



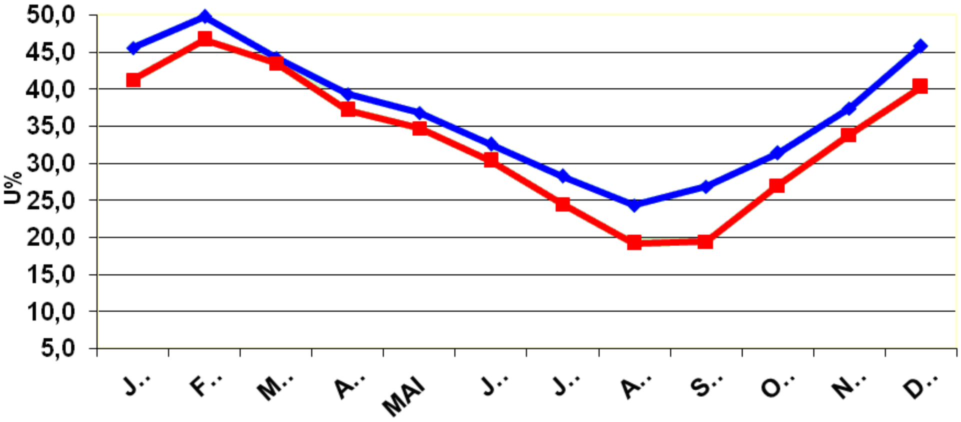
[Blue = average minimum monthly [1961-1990]; Red = minimum monthly average [1961-2004]]

Chart 14: Variation of relative air humidity of Brasília (DINIZ; REBELLO, 2006)



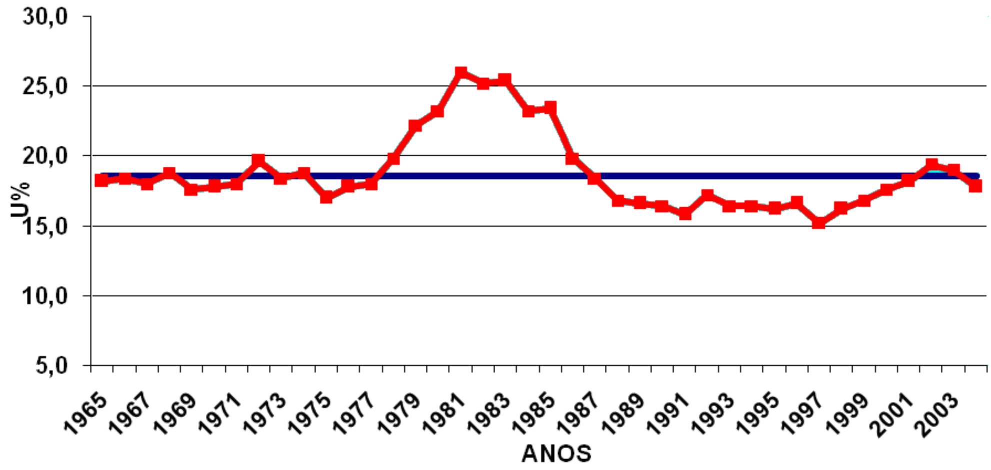
[Red = extreme annual moving average; Blue = minimum average annual extreme]

Chart 15: Relative humidity of Campo Grande-MS [1961-2004] (DINIZ; REBELLO,2006)



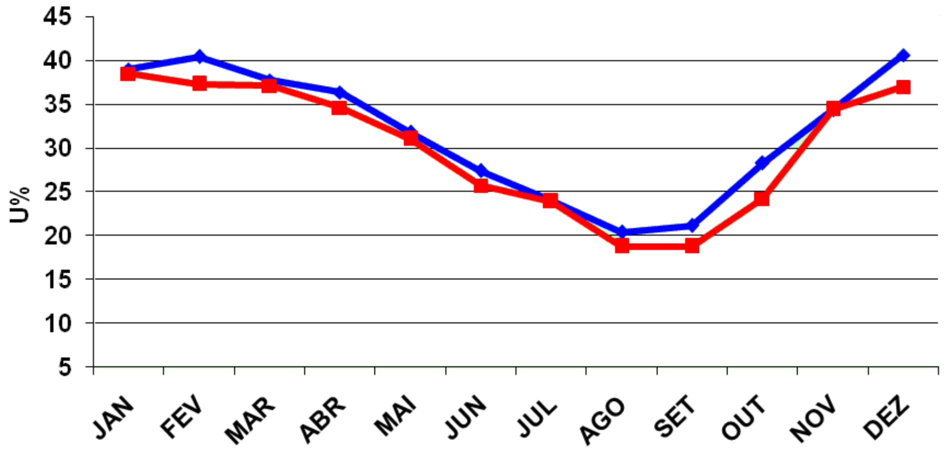
[Blue = average minimum monthly [1961-1985]; Red = minimum monthly average [1993-2004]]

Chart 16: Variation of relative humidity of Campo Grande (DINIZ; REBELLO, 2006)



[Red = extreme annual moving average; Blue = minimum average annual extreme]

Chart 17: Relative humidity of Goiânia-GO [1961-2004] (DINIZ; REBELLO, 2006)



[Blue = average minimum monthly [1961-1985]; Red = minimum monthly average [1991-2004]]

Chart 18: Variation of relative humidity of Goiânia- GO (DINIZ; REBELLO, 2006)

Extreme averages were calculated monthly minimum relative humidity and plotted for the period 1961 to 1990, (period of climatic normal) curve in blue, and for the period 1991 to 2004, red curve. There were checked the average minimum monthly moisture variability in each locality in the two periods.

In Brasilia-DF, it was observed a decrease in the average minimum monthly air humidity around **5 percentage points** (26% to 21%) during the period of drought for the transition with the rains (June to October); in the second period from 1991 to 2004, the red curve illustrates. This variability in air humidity demonstrates that critical values with low rates of air humidity are occurring with greater frequency in Brasília-DF. Maybe this situation is related to the demographic increase, with deforestation, with the increase in the amount of automobiles and asphalted areas.

In Campo Grande-MS, there was also a decrease in the average minimum monthly air humidity around **5 percentage points** (29% to 24%) and in the months of June to October, during the period from 1991 to 2004; in relation to the period of 1961 to 1985. 30 years have not been used for this location due to lack of data.

Goiânia-GO was the only location that showed lower difference in decrease in the average minimum monthly air humidity, around **2 percentage points** (24% to 22%) during the months of June to October, in the period from 1991 to 2004, compared to the previous period, as shown in Chart 6. Despite little difference, it was observed that in this location, on average, the climate has become drier than in other cities in the study.

Diniz and Rebello (2006) conclude that, in spite of the study has been started with data from the years 1960s, all localities showed extreme relative humidity minimum monthly average and a decrease in the period from 1991 to 2004. This situation in reduction of moisture from the air, more precisely in the dry period, which might be related to climate variability and the global warming the planet is going through in the last three decades. However, one of the indications of climate change is the increased frequency of extreme events and, according to all the maps of the extreme minimum monthly averages show; there is a high variability of air humidity in the second period.

One cannot relate this variability of extreme values of average monthly low levels of moisture from the air checked, with the existence of a periodicity of atmospheric variability or statistical climatology, because the higher frequency of extreme values of air humidity, have been measured (calculated) in the last decade, and not in previous decades.

In terms of micro-climate, as enhanced by Diniz and Rebello (2006), one cannot dismiss the demographic increase in cities and from deforestation, factors that contribute, in a long, to the variability of moisture from the air.

CONCLUSION

The theme of biofuels is current and has been constantly emphasized by writing and television media throughout these past few months. The information transmitted to the public, in general, have been almost always imprecise, especially as regards the demand for natural resources such as water, for all purposes of production. In this sense, not only the public, but mainly the decision-makers agents do not always have managed to discern the certainties and uncertainties regarding the sustainability of the present program and, especially, the future. This research is intended to contribute to the studies and projections of environmental impact from biofuels program on water availability of the Cerrado, considering the demand of water resources needed for the production of oilseeds elected.

It is known that both the pastures as the existing cultures in the region under study have scary amounts of water demand, considering the current data and climate surveys of the Intergovernmental Panel on Climate Change – IPCC. This work found that the demand for water for the sustainability of the programme will be, for some oilseeds, practically doubled up.

Currently, the water resources of the Cerrado, in the dry season, already suffer an imbalance on the basis of evapotranspiration in the region do not precipitate in the same location as the atmospheric circulation studies presented by the National Institute of Meteorology-INMET. Considering the increase in temperature caused by deforestation and/or extraction of native vegetation to plant oilseeds eligible – which also increases water consumption – everything leads us to believe that the impact on water resources in the region should be negative.

All of these factors justify future works that seek to further study about the variables here exposed and their interrelationships. This can, for example, be approached from techniques of modeling and simulation of environmental systems.

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APPENDIX A - LEGISLATION AND STANDARDS ON BIODIESEL

Laws

- **Lei nº 11.116, de 18 de maio de 2005**[4]: Dispõe sobre o Registro Especial, na Secretaria da Receita Federal do Ministério da Fazenda, de produtor ou importador de biodiesel e sobre a incidência da Contribuição para o PIS/Pasep e da Cofins sobre as receitas decorrentes da venda desse produto; altera as Leis n os 10.451, de 10 de maio de 2002, e 11.097, de 13 de janeiro de 2005; e dá outras providências.
- **Lei nº 11.097, de 13 de janeiro de 2005**[5]: Dispõe sobre a introdução do biodiesel na matriz energética brasileira; altera as Leis 9.478, de 6 de agosto de 1997, 9.847, de 26 de outubro de 1999 e 10.636, de 30 de dezembro de 2002; e dá outras providências.
- **Lei nº 10.848, de 15 de março de 2004**[6]: Dispõe sobre a comercialização de energia elétrica, altera as Leis nºs 5.655, de 20 de maio de 1971, 8.631, de 4 de março de 1993, 9.074, de 7 de julho de 1995, 9.427, de 26 de dezembro de 1996, 9.478, de 6 de agosto de 1997, 9.648, de 27 de maio de 1998, 9.991, de 24 de julho de 2000, 10.438, de 26 de abril de 2002, e dá outras providências.

Decrees

- **Decreto Nº 5.457, de 06 de junho de 2005**[7]: Reduz as alíquotas da Contribuição para o PIS/PASEP e da COFINS incidentes sobre a importação e a comercialização de biodiesel.
- **Decreto Nº 5.448, de 20 de maio de 2005**[8]: Regulamenta o § 1 o do art. 2 o da Lei n o 11.097, de 13 de janeiro de 2005, que dispõe sobre a introdução do biodiesel na matriz energética brasileira, e dá outras providências.
- **Decreto Nº 5.298, de 6 de dezembro de 2004**[9]: Altera a alíquota do Imposto sobre Produtos Industrializados incidente sobre o produto que menciona.
- **Decreto Nº 5.297, de 6 de dezembro de 2004**[10]: Dispõe sobre os coeficientes de redução das alíquotas de contribuição para o PIS/PASEP e da COFINS, incidentes na produção e na comercialização de biodiesel, sobre os termos e as condições para a utilização das alíquotas diferenciadas, e dá outras providências.
- **Decreto de 23 de dezembro de 2003**[11]: Institui a Comissão Executiva Interministerial encarregada da implantação das ações direcionadas à produção e ao uso de óleo vegetal - biodiesel como fonte alternativa de energia.
- **Decreto de 02 de julho de 2003**[12]: Institui Grupo de Trabalho Interministerial encarregado de apresentar estudos sobre a viabilidade de utilização de óleo vegetal - biodiesel como fonte alternativa de energia, propondo, caso necessário, as ações necessárias para o uso do biodiesel.

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4 http://www.biodiesel.gov.br/docs/Lei11.116_18mai2005.PDF
5 http://www.biodiesel.gov.br/docs/lei11097_13jan2005.pdf
6 \\Ibictlab\wwwroot\biodiesel\docs\lei10.848_15mar2004.pdf
7 http://www.biodiesel.gov.br/docs/Decreto_5.457_07jun2005.doc
8 http://www.biodiesel.gov.br/docs/Decreto_5.448_20mai2005.pdf
9 http://www.biodiesel.gov.br/docs/Decreto_%205.298_6dez2004.pdf
10 http://www.biodiesel.gov.br/docs/Decreto_5.297_6dez2004.pdf
11 http://www.biodiesel.gov.br/docs/Decreto_Casa_Civil_23.12.03.pdf
12 http://www.biodiesel.gov.br/docs/Decreto_Casa_Civil_02.07.03.pdf

Norms

- **Portaria MME 483, de 3 de outubro de 2005**[13]: Estabelece as diretrizes para a realização pela Agência Nacional do Petróleo, Gás Natural e Biocombustíveis - ANP de leilões públicos de aquisição de biodiesel de que trata o art. 3 o, da Resolução do Conselho Nacional de Política Energética - CNPE n o 3, de 23 de setembro de 2005.
- **Portaria ANP 240, de 25 de agosto de 2003**[14]: Estabelece a regulamentação para a utilização de combustíveis sólidos, líquidos ou gasosos não especificados no País.

Resolutions

- **Resolução ANP n º 31, de 04 de novembro de 2005**[15]: Regula a realização de leilões públicos para aquisição de biodiesel.
- **Resolução CNPE n º 3, de 23 de setembro de 2005**[16]: Reduz o prazo de que trata o § 1º do art. 2º da Lei nº 11.097, de 13 de janeiro de 2005, e dá outras providências.
- **Resolução ANP nº 42, de 24 de novembro de 2004**[17]: Estabelece a especificação para a comercialização de biodiesel que poderá ser adicionado ao óleo diesel na proporção 2% em volume.
- **Resolução ANP nº 41, de 24 de novembro de 2004**[18]: Institui a regulamentação e obrigatoriedade de autorização da ANP para exercício da atividade de produção de biodiesel.
- **Resolução BNDES Nº 1.135 / 2004**[19]: Trata do Programa de Apoio Financeiro a Investimentos em Biodiesel no âmbito do Programa de Produção e Uso do Biodiesel como Fonte Alternativa de Energia.

Normative Statements

- **Instrução Normativa MDA nº 02, de 30 de setembro de 2005**[20]: Dispõe sobre os critérios e procedimentos relativos ao enquadramento de projetos de produção de biodiesel ao selo combustível social.
- **Instrução Normativa MDA nº 01, de 05 de julho de 2005**[21]: Dispõe sobre os critérios e procedimentos relativos à concessão de uso do selo combustível social.
- **Instrução Normativa SRF nº 526, de 15 de março de 2005**[22]: Dispõe sobre a opção pelos regimes de incidência da Contribuição para o PIS/Pasep e da Cofins, de que tratam o art. 52 da **Lei nº 10.833**[23], de 29 de dezembro de 2003, o art. 23 da **Lei nº 10.865**[24], de 30 de abril de 2004, e o art. 4º da **Medida Provisória nº 227**[25], de 6 de dezembro de 2004.

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13 http://www.biodiesel.gov.br/docs/PortariaMME483-2005.pdf
14 http://www.biodiesel.gov.br/docs/P240_2003.PDF
15 http://www.biodiesel.gov.br/docs/ResolucaoANPn31de2005Leilao.pdf
16 http://www.biodiesel.gov.br/docs/ResolucaoCNPEn3de28092005.pdf
17 http://www.biodiesel.gov.br/docs/Resolucao_42.pdf
18 http://www.biodiesel.gov.br/docs/Resolucao_41.pdf
19 http://www.biodiesel.gov.br/docs/resolucao1135bndes.pdf
20 http://www.biodiesel.gov.br/docs/IN%2002%20proj%20com_social.pdf
21 http://www.biodiesel.gov.br/docs/Minuta1.pdf
22 http://www.biodiesel.gov.br/docs/INSRF_526-2005.pdf
23 http://www.biodiesel.gov.br/docs/Lei10.833_29dez2003.pdf
24 http://www.biodiesel.gov.br/docs/Lei10.865_30abr2004.pdf
25 http://www.biodiesel.gov.br/docs/MedidaProvisoria227.pdf

- **Instrução Normativa SRF nº 516, de 22 de fevereiro de 2005**[26]: Dispõe sobre o Registro Especial a que estão sujeitos os produtores e os importadores de biodiesel, e dá outras providências.

[26] http://www.receita.fazenda.gov.br/Legislacao/Ins/2005/in5162005.htm