Embrapa

Projeto Agrogases

Potenciais Usos de Previsoes Numericas de Mudancas Climaticas

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Seminario dos Usuarios das Previsoes Numericas de Mudancas Climaticas e seus Impactos Regionais
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Agrogases network

Brazilian Corporation for Agricultural Research - Embrapa

- A set of research groups and institutions that work in an integrated and interdisciplinary approach.
- Created in 2003 to develop the project “Carbon Dynamics and Greenhouse Gas Emissions from Brazilian Agricultural, Forestry and Agroforestry Systems”, coordinated by Embrapa Environment, Jaguariuna, SP, Brazil.

Main objectives

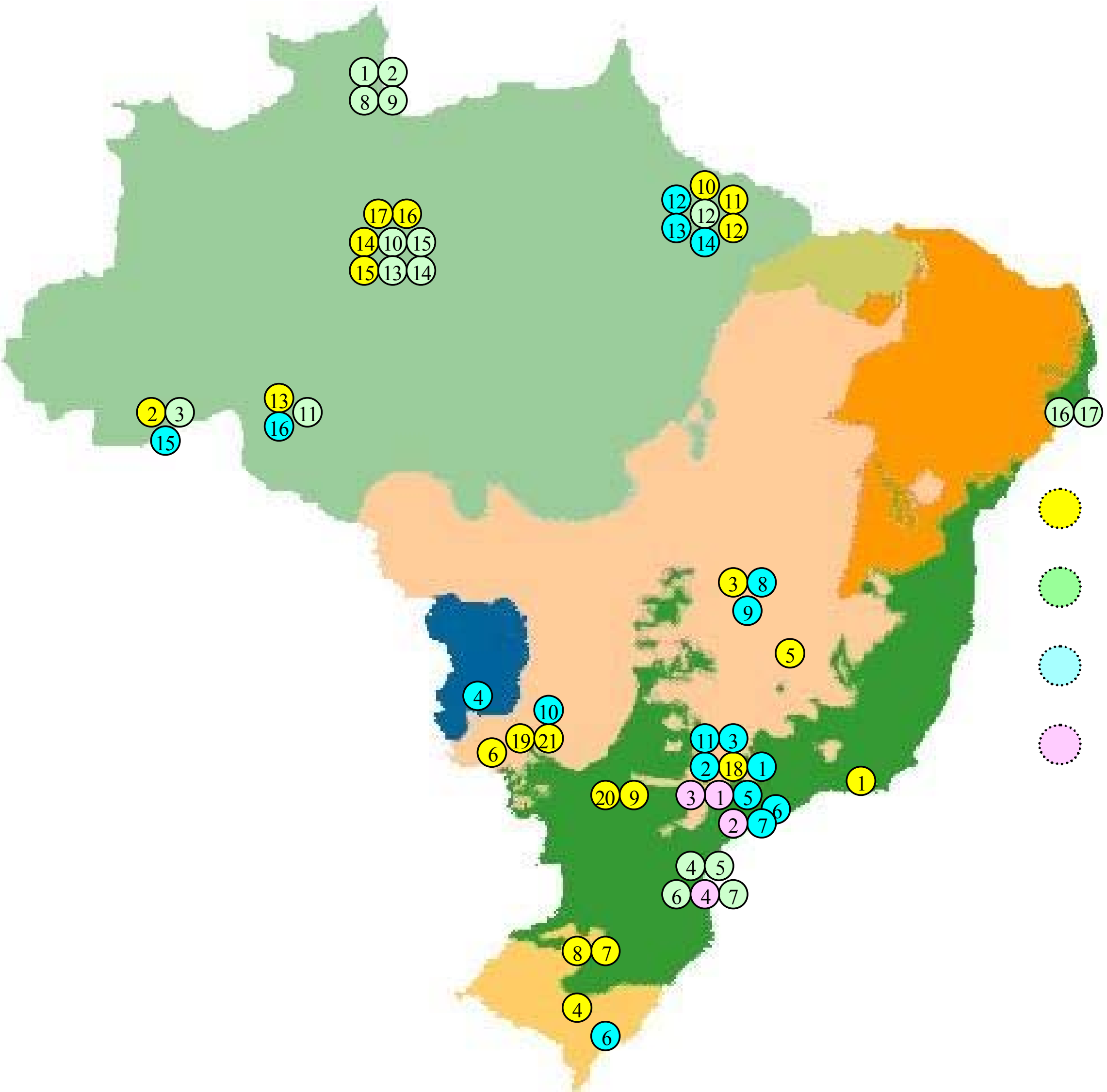
► To quantify and evaluate the carbon stocks and greenhouse gas emissions from different land use systems in Brazil.

► To establish an integrated information network that will subsidize the generation of sustainable technology for reducing greenhouse gas emissions, as well as to support to the formulation of public politics.

Specific objectives

- Quantification of GHG fluxes in agricultural production systems, forestry and agro-forestry;
- Characterization of C dynamics under cerrado vegetation, crops management systems, pastures, native and planted forests, and agroforestry;
- Evaluation of the effect of agricultural and forestry production practices on gas emissions and atmospheric carbon absorption;
- Improvement of the GHG national inventory;
- Evaluation of the options for mitigating greenhouse gas emissions by improving sustainable land use from the social, economic and environmental standpoints

Study areas



C stock and dynamic in soils

C stock and dynamic in vegetation

Measurement of GHG

GHG Inventories and Social-Economical analysis

Agrogases Network
Carbon Dynamics and Greenhouse Gas Emissions in Brazilian Agricultural, Agroforestry and Forestry Systems

Project Part 1 – Project Management

- **Project Part 2 – Soil Stock and Dynamics**
  - PA 2.1. C stock and Soil Basic Unities
  - PA 2.2. Brachiaria pastures
  - PA 2.3. Conventional and no-tillage systems
  - PA 2.4. Agroforestry systems in Amazon
  - PA 2.5. Estability of OM in soil and vegetal residues
- **Project Part 3 – Carbon Stock in Natural Forestry / Permanent Plantations**
  - PA 3.1. Tropical Primary Forest
  - PA 3.2. Planted forest
  - PA 3.3. Tradicional forests and alternatives in Amazon region
  - PA 3.4. *Caatinga*
  - PA 35. Atlantic Forest
- **Project Part 4 – Estimation of GHG in Land Use Systems**
  - PA 4.1. Methane emission by ruminants
  - PA 4.2. Methane emission from flooded soils
  - PA 4.3. N_2O from agricultural areas and pastures
  - PA 4.4. CO_2, CH_4 in Amazon agric. sytems
  - PA 4.5. CO_2 balance in sugar cane crops

Project Part 5
National Inventories of GHG / Analysis of strategies to GHG mitigation under actual social economical conditions
Future scenarios for simulation

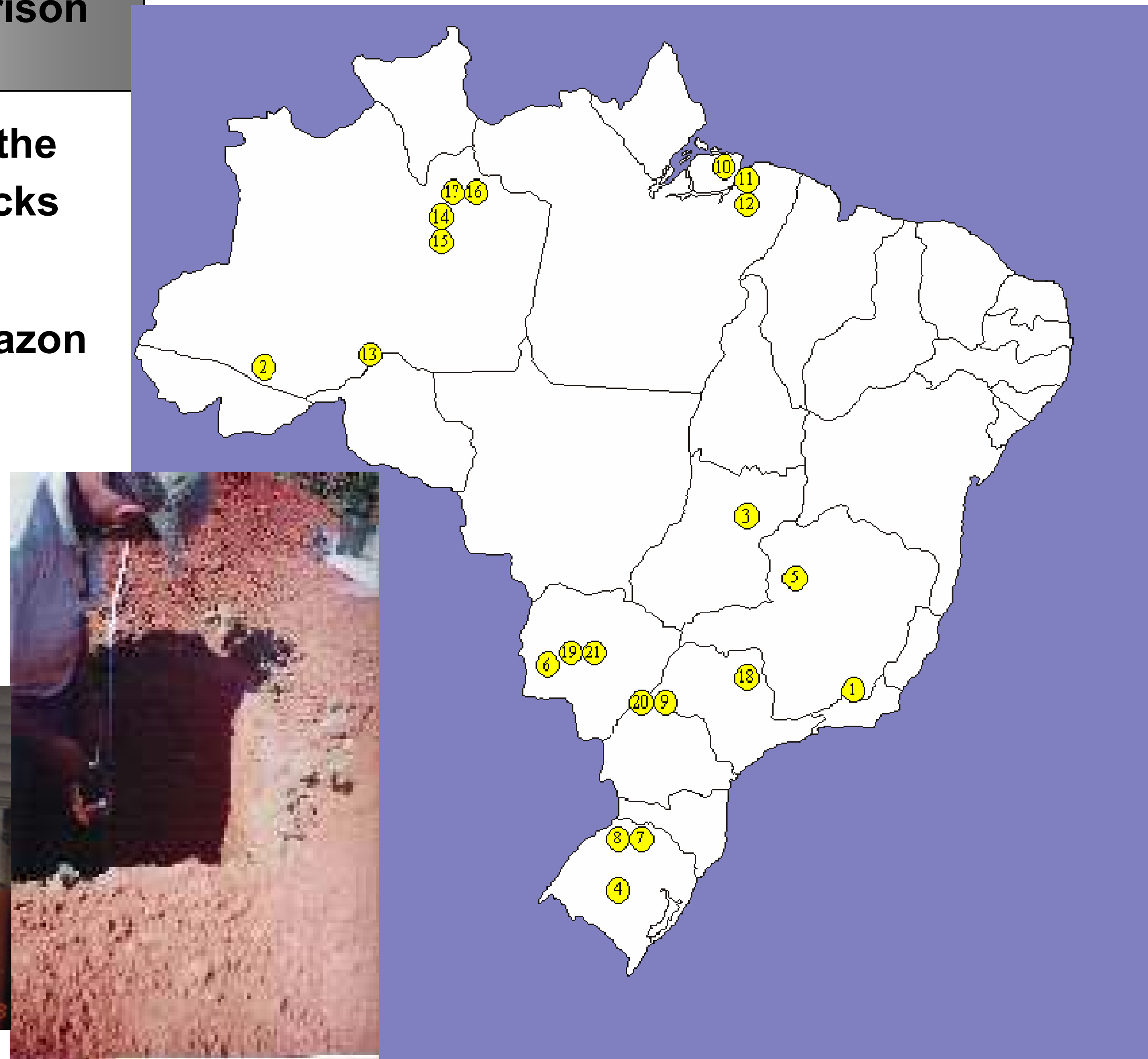
AP 2.1. Assessing of Soil C stock in Comparison Basic Unities

2.1.1. **Systematization of the information on soil C stocks in Brazil (data base)**

2.1.2. **Soil C stock in Amazon**

2.1.3. **Soil C stock in Cerrados region**

2.1.4. **Soil C stock in the South region of Brazil**



AP 3.2. Assessing of Carbon stock in Permanent Plantations

- Estimation of Carbon stock of vegetation, soils and litter
- Forest inventory
- Database using RS and GIS
- Survey of available inventories
- Modeling of C stocks

***3.2.1.* Development of modeling of C stock and dynamics per compartment of individual trees**

***3.2.2.* Remote sensing applied to the assessment of biomass of planted forests**

***3.2.3.* Study of C dynamics in relation to forestry management practices**

***3.2.4.* C stock related to scenarios of reduction or increment of reforested areas and the final use of forestry production**

***3.2.5.* Study of C fixation in comercial plantations under different stages of initial growth in areas of Cerrado region in Roraima**

***3.2.6.* Study of C fixation in experimental forestry areas in Roraima**

***3.2.7.* Modeling and determination of C stock and fixation in the forestry production in Central Amazon**

Project Part 4
Estimation of GHG emissions from different land use systems

PA 4.1. Estimation of methane emissions from ruminantes

4.1.1. Evaluation of methane emission from the rumen of dairy cattle

4.1.2. Evaluation of methane emission from the rumen of beef cattle in the Southeast region

4.1.3. Evaluation of methane emission from the rumen of crossbreed dairy cattle with controled ingestion of forage

4.1.4. Evaluation of methane emission from the rumen of beef cattle in the Pantanal region

4.1.4. Methane analysis and sulfur

PA 4.2. Estimation of GHG from flooded areas

4.2.1. Evaluation of methane emission from flooded rice crops in the southern and southeast regions

4.2.2. Simulation of methanogenic processes in flooded rice crop systems (Huang et al. 1998)

4.2.3. Sazonal evaluation of methane and CO_2 fluxes in humid fields in Cerrado region

PA 4.3. Estimation of N_2O e CH_4 emissions from agricultural soils

4.3.1. Avaliação dos fluxos de N_2O e metano em solos agrícolas sob plantio direto na região dos Cerrados

4.3.2. Avaliação da emissão de N_2O e CH_4 em solos sob pastagens de *Brachiaria* no Cerrado

PA 4.4. Measurement of CO_2 fluxes in sugarcane crop systems

4.4.1. Observações de longo prazo dos fluxos turbulentos de CO_2 no sistema solo-planta-atmosfera em plantação de cana-de-açúcar no Estado de São Paulo

4.4.2. Determinação de C e N potencialmente mineralizáveis no solo sob plantação de cana-de-açúcar em São Paulo

PA 4.5. CO_2, CH_4, N_2O e NO emissions from sequential agroforestry systems in the East Amazon

4.5.1. Emissão de GEE em sistema de corte-e-queima e pousio espontâneo

4.5.2. Emissão de GEE em sistemas de corte-e-mulch associados a pousio melhorado

4.5.3. Emissão de GEE em cronoseqüências de florestas secundárias

4.5.4. Emissão de GEE e fixação de N em diferentes sistemas de uso da terra

4.5.5. Emissões de GEE em sistemas de uso da terra em solos de baixa fertilidade natural na Amazônia

A.P. 4.1. Evaluation of methane emission from ruminants

4.1.1. Evaluation of methane emission from the rumen of dairy cattle

4.1.2. Evaluation of methane emission from the rumen of beef cattle in the Southeast region

4.1.3. Evaluation of methane emission from the rumen of crossbreed dairy cattle with controled ingestion of forage

4.1.4. Evaluation of methane emission from the rumen of beef cattle in the Pantanal region

4.1.4. Methane analysis and sulfur hexafluoride by gas chromatography

A.P. 4.2. Evaluation of methane emission from flooded areas

4.2.1. Evaluation of methane emission from flooded rice crops in the southern and southeast regions

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4.2.3. Sazonal evaluation of methane and CO_2 fluxes in humid fields in Cerrado region

Climatic data:
Temperature, solar radiation, rainfall

Approach: GIS and modeling integration

Modeling GHG emission from agricultural activities

1- better understand the process involved in GHG emissions and C dynamics

2- improve our ability to predict GHG emissions for different conditions and environments

3- study “ what if” scenarios and optimal solutions in order to analyze mitigation strategies

4- forecast potential effects of climate change to agricultural systems, (specially grazing systems)

Modeling in the Agrogases project

Examples:

1- Soil Carbon Dynamics (Based on the Century Model)

2- Fluxes of CO_2 (SIB2 model)

3- Methane Emissions from flooded rice crop systems (Huang et al., 1998)

3- Methane Emissions from animal production systems (Dijkstra’s Rumen Model, Whole Farm Model, GRASP)

Daily totals of CO_2 Net Ecosystem Exchange observed in a sugarcane plantation

- Observed by the eddy correlation method and estimated by SiB2 model (Simple Biosphere Model)

Rocha et al., 2000, Atmospheric CO_2 fluxes and soil respiration measurements over sugarcane in southeast Brazil. In: Global Climate Change and Tropical Ecosystems. R. Lal, J.M. Kimble, B.A. Stewart eds., CRC Press, Boca Raton, 405-414

Sugarcane crop system

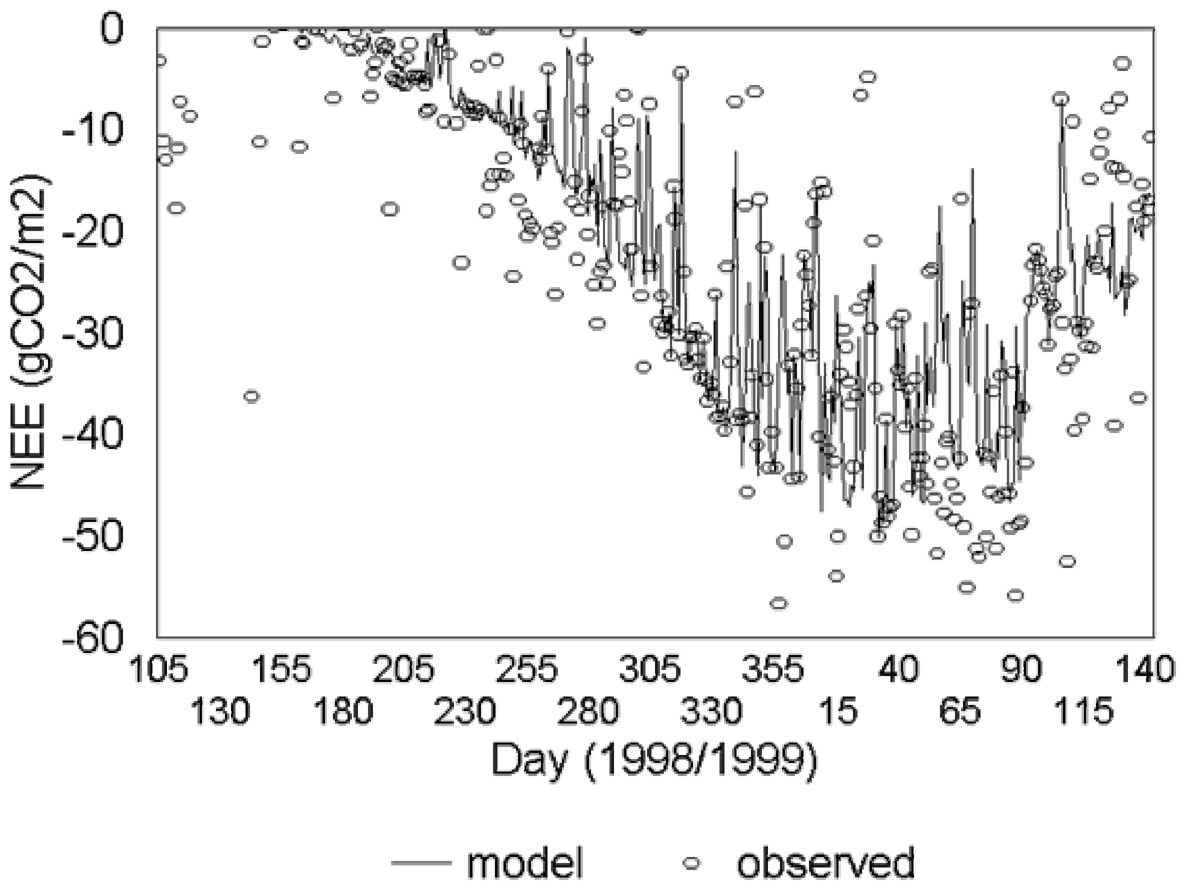
- Long term observations of energy balance, CO_2 and soil moisture were undertaken in a sugarcane plantation in Sertaozinho, SP, Brasil, during the years 1997-1999.

- The eddy covariance method was used to measure the fluxes of energy and CO_2 and a neutron probe provided the soil moisture data.

- The sugarcane soil-vegetation-atmosphere system was modelled with SiB2 (Simple Biosphere Model), which utilized as driving forcings the meteorological variables measured on the top of a tower at the plantation area.

Results

- Total evaporation simulated for the 1998/1999 cycle was 1,027 mm, 9% greater than the observed.
- The measured above-ground biomass was 7.3 kg CO_2 m^{-2}, which coefficient of variation was about 30% higher, and the simulated assimilation was 9.9 kg CO_2 m^{-2}, although 35% higher, it shows the same order



Daily totals of CO_2 balance between sugar cane plantation and the atmosphere (Net Ecosystem Exchange)

Century model applied to simulation of soil organic carbon of an Acrisol under no-tillage and disc-plow systems

- Experimental monitoring and application of Century Model

Leite, L.F.C., Mendonca, E.S., Machado, P.L.O., Fernandes Filho, E.I., Neves, J.C.L. 2004. Simulationg trends in soil organic carbon of an Acrisol under no-tillage and disc-plow systems using the Century model. Geoderma, p. 283-295.

No-tillage system in Brazil:

- Is widely used over an area of 14 million ha (Pereira, 2002)
- Combined with crop rotation involving cover crops, no tillage favors the accumulation of plant residues of soil surface
- Represents a potential contribution to the atmospheric C fixation

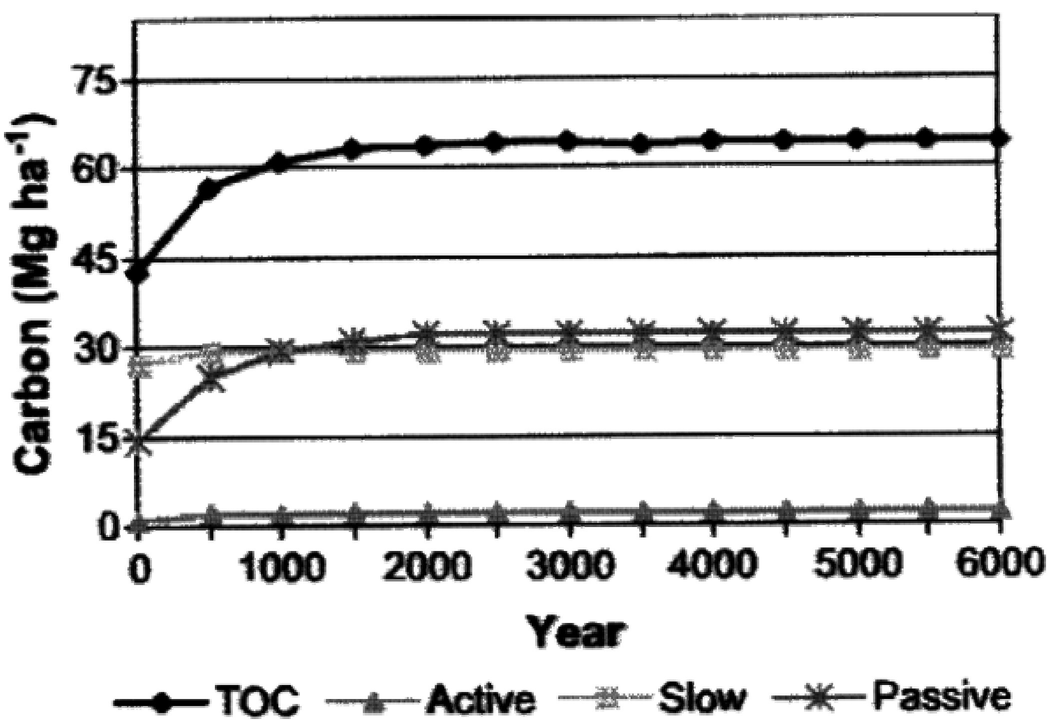
Model input for simulation of tillage using v. 4 of the Century Model (Leite et al., 2004)

Model input for simulation of tillage systems using version 4 of the Century model

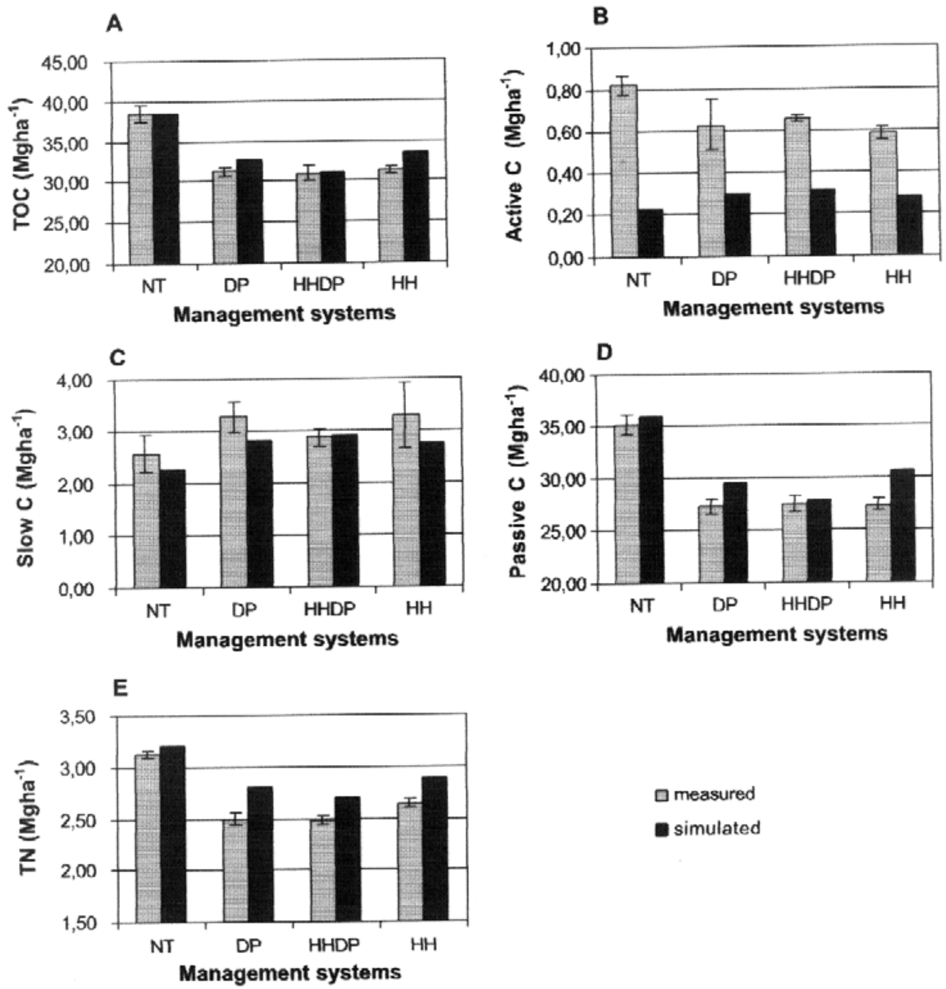
	Value
Soil variables	
Texture (% sand, % silt, % clay)	38, 16, 46
Bulk density (mg m^{-3})	1, 13
Initial SOM (g C m^{-2}; C/N)	
Active surface	50, 12,5
Active soil	159, 9
Slow soil	1776, 22
Passive soil	4460, 12
Monthly weather variables	
Mean total precipitation (cm $month^{-1}$)	14
Mean maximum temperature (°C)	14.8
Mean minimum temperature (°C)	26.4
Cultivation variables	
Multiplier for increased decomposition	
Active pool	1.0 (NT); 1,8 (DP); 2.0 (HHDP); 1.6 (HH)
Slow pool	1.0 (NT); 4.0 (DP); 5.0 (HHDP); 3.0 (HH)
Passive pool	1.0 (NT); 1.8 (DP); 2.0 (HHDP); 1.6 (HH)

Carbon pool values were obtained from direct method. NT: no tillage; DP: disc plow; HHDP: heavy disk harrow + disk plow; HH: heavy harrow.

Modeled stocks of SOC (TOC) and organic carbon pools of an Acrisol (0-20 cm) under Atlantic Forest (Leite et al., 2004)



Measured and simulated total organic carbon (TOC) (A), active (B), slow (C) and passive (D) carbon pool, and total nitrogen (TN) (E) in different soil management systems. NT= no-tillage, DP= disk plow and light harrowings, HH= heavy disk harrowing (n=4 for measured values) (Leite et al., 2004)



Conclusions (*Leite et al., 2004*)

- Both active and slow C pools were more sensitive to soil management systems than total organic carbon pool.
- The Century model simulated changes in the total organic carbon content and obtained a good fit to measured data.
- Underestimation of the stocks of slow and active C pool, so that other processes must be included in the Century model for acid tropical soils.

Métodos para estimar taxas de emissão de metano proveniente de fermentação entérica

- Experimentos com animais (SF$_6$ technique, camaras controladas, metodos micrometeorologicos)
- Modelos empíricos
  - Blaxter and Clapperton (1965)
  - Moe and Tyrrell (1979)
  - Kirkgebner et al. (1995)
- Modelos mecanísticos
  - Modelo de Dijkrsta (1992)
  - MOLLY (Baldwin, 1995)

Application of the Dijkstra' rumen model to evaluate dietary effects on methane emissions by dairy and beef cattle under tropical conditions

Objective: to simulate whole animal methane emissions for a range of dietary inputs, aiming to verify the potentiality of methane mitigation and the increment of production efficiency

Dijkstra, J., Neal, H.D.St.C., Beever, D.E.,.France, J. 1992. Simulation of nutrient digestion, absorption and outflow in the rumen: model description. *Journal of Nutrition* 122, 2239-2256.

Principais fatores que influenciam emissão de metano em ruminantes

- Tipo do animal (espécie, raça)
- Peso
- Fase de desenvolvimento
- Ingestão diária
- Composição do alimento (fibra, carboidratos solúveis, ácidos orgânicos, pectina, hemicelulose e celulose)

WFM – Whole Farm Model (Bright et al., 2000)

- Modela eventos num sistema de produção de gado de leite em escala diária;
- É constituído de um “framework” ao qual são acoplados sub modelos para os processos de crescimento da pastagem e metabolismo dos bovinos;
- Utiliza informações de clima e manejo.

Variáveis climáticas x produtividade e qualidade de pastagens

- Mudanças na composição da pastagem (espécies predominantes, presença de plantas daninhas);
- Produtividade (kg de matéria seca/hectare)
- Taxa de acúmulo de matéria seca;
- Qualidade da pastagem – composição da matéria seca (fibra, carboidratos solúveis, ácidos orgânicos, pectina, hemicelulose e celulose).

Variáveis climáticas utilizadas em modelos de simulação de sistemas de produção animal

Exemplos:

- GRASP – Grass and Animal Production Model – utiliza dados diários de chuva, temperatura, umidade, evaporação e radiação solar (Day et al., 1997)
- Whole Farm System – dados diários de temperatura máxima e mínima, radiação, velocidade do vento, precipitação, horas de brilho solar e evaporação (Bright et al., 2001)

Outras aplicacoes

- Avaliacao do efeito do incremento de concentracao de CO_2 atmosferico e de temperatura sobre plantas C3 e C4 (dados simulados e observados atraves de experimentos de campo)
- Investigacao do efeito de variaveis climaticas sobre o balanco de carbono, fluxos de gases de efeito estufa, volatilizacao da urea
- Obtencao de cenarios de fluxos de gases traco provenientes de atividades agricolas

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Obrigado!