Use of remote sensing for crop yield and area estimates in Southern Brazil

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Remote Sensing support to crop yield forecast and area estimates
30th November to 1st December 2006 - Stresa - Italy
General information:
Area: 8,514,204,8 km²
Population: 184,739,395 people

Main biomes:
Floresta Amazônica (Amazon Forest)
Caatinga
Cerrado (Pantanal)
Mata Atlântica (Atlantic forest)

Main crops:
Soybean (46,533,261 ton)
Maize (30,504 ton)
Rice (30,733 ton)
Wheat (4,620,679 ton)
Agricultural production
17% (grain)

Soybean, maize
(spring-summer)
Wheat
(winter)

Rice
(spring-summer)
Rangelands

Rio Grande do Sul State
• **Dimension**
  • 2,120 professors and researchers (50% PhD)
  • 2,880 technicians
  • 22,100 undergraduate students
  • 6,970 graduate students
  • 1,800 basic education students

• **Organization**
  • 54 undergraduate courses
  • 200 graduate courses
  • 376 extension courses

• Research groups - 355
Faculdade de Agronomia

Graduate courses - CROP SCIENCE
http://www.ufrgs.br/ppgfitotecnia/
CEPSRM
Centro Estadual de Pesquisa em Sensoriamento Remoto e Meteorologia

Graduate course - REMOTE SENSING
http://www.ufrgs.br/srm
Infra-structure available

- Computers and softwares (Envi, Erdas, Idrisi, SPRING, ArcGIS, SAS,...)

- Research equipments (experimental area):
  - Automatic meteorological station,
  - Micrometeorological equipments;
  - Plant equipments (LAI, photosynthesis,...)
  - Soil equipments (tensiometer, lisimeter,...)

- Radiometry Laboratory

- NOAA/AVHRR receiving station
GeoSafras Project

• Project coordinated by CONAB
  (Companhia Nacional de Abastecimento)
  and supported by UNDP

• Multi-institutional network
  UFRGS, EMBRAPA, IBGE, INMET, INPE, UNICAMP, IAC, IAPAR, SIMEPAR,...
Objective of GeoSafras

To improve Brazilian crop area and yield estimation system through a multi-institutional network for the development of methodologies, looking for an harvest forecasting system with higher objectivity.
TEAM at UFRGS:

- Ana Paula Wagner, M.Sc. (Physics)
- Anibal Gusso, M.Sc. (Physics)
- Denise Cybis Fontana, D.Sc. (Agronomy)
- Eliana Lima da Fonseca, D.Sc. (Agronomy)
- Eliana Klering, M.Sc. (Meteorology)
- Gilca Marques Alves, B.Sc. (Agronomy)
- Homero Bergamaschi, D.Sc. (Agronomy)
- Jorge Ricardo Ducati, D.Sc. (Physics)
- Laurindo Guasselli, D.Sc. (Geography)
- Moacir Antonio Berlato, D.Sc. (Agronomy)
- Mônica Tagliari Kreling, M.Sc. (Geography)
- Ricardo Wanke de Melo, D.Sc. (Agronomy)
- Rita Marques Alves, D.Sc. (Meteorology)
Methodology

Segments: estimates of crop area, estimates of crop yields and crop monitoring activities

**Remote Sensing** - measurement of the surface dynamics (imagery);
**Geoprocessing** - location and quantification;
**Agrometeorology** - crop yield modeling.

**Crops:** wheat (winter)
soybean and rice (spring-summer)
SOYBEAN
(Spring-summer crop; Non-irrigated)

Brazil 23.6%

World
Brazil

Production (million ton)

Harvests
2000 2001 2002 2003 2004 2005 2006

BR RS

14.58 18.34 13.32 18.45 11.18 4.78 14.44
Remote Sensing at UFRGS (GeoSafras)

The use of a combination of satellite images with different resolutions:

- LANDSAT/TM (30m, 16 days)
- TERRA/MODIS (250m, 2 days or MVC 16 days)
- NOAA/AVHRR (1100m, 1 day or MVC 15/30 days)
LANDSAT/TM
Crop area mapping

2006 Harvest
Soybean area estimation: 11 Landsat/TM images
TERRA/MODIS
Crop area - mapping and monitoring

OCT

NOV

DEC

JAN

FEB

MAR

NDVI

-0.5 ≤ 0.3
0.3 ≤ 0.4
0.4 ≤ 0.5
0.5 ≤ 0.6
0.6 ≤ 0.7
0.7 ≤ 0.8
0.8 ≤ 1.0
TERRA/MODIS – Soybean mapping

November Image (boolean)

February Image (boolean)

November Image (boolean)

Landsat image

Resultant Image: Mapping and quantification of the soybean area
TERRA/MODIS - Soybean Mapping 2006
TERRA/MODIS – Soybean Mapping 2006

Counties 100% covered by images without clouds

$R^2 = 0.9545$
NOAA/AVHRR
Crop monitoring and yield estimations

Temporal NDVI profiles

www.ufrgs.br/srm
NOAA/AVHRR

Agrometeorological-Spectral Model

- **Agrometeorological Term**
  Water and temperature conditions

- **Spectral Term**
  Water and temperature conditions and others: management, diseases, pests, and other stress.
Rio Grande do Sul state and meteorological stations

Argentina

Uruguay

Santa Catarina

Oceano Atlântico

Meteorological stations
Agrometeorological-spectral Model

Bianchi et al. (2006)

\[ Y = Y_m \times (a \cdot AT + b \cdot ST) \]
Soybean yield estimates

Yields (kg.ha⁻¹)

<table>
<thead>
<tr>
<th>Year</th>
<th>IBGE</th>
<th>Agrometeorological-spectral model</th>
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<tbody>
<tr>
<td>2003</td>
<td>2743</td>
<td>2310</td>
</tr>
<tr>
<td>2004</td>
<td>1427</td>
<td>1219</td>
</tr>
<tr>
<td>2005</td>
<td>589</td>
<td>753</td>
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<tr>
<td>2006</td>
<td>1935</td>
<td>1603</td>
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</tbody>
</table>
Problem to crop yield estimations

Lack of meteorological data to feed the model

Alternative

Simulation meteorological data
Results presented in JRC workshop
Montevideo - October 2006

Melo e Fontana (2006)

Objective:

a) to compare ECMWF simulated data to observed data at surface meteorological stations;

b) to evaluate the use of simulated data in the soybean yield model in Rio Grande do Sul State, Brazil
Meteorological data:

- Maximum Temperature (°C)
- Minimum Temperature (°C)
- Mean Temperature (°C)
- Rainfall (mm)
- Evapotranspiration (mm)

10-days periods from 2003/01/01 to 2005/12/31
Simulated ECMWF data
Observed meteorological data

Geosafiras

Meteorological stations
EVAPOTRANSPIRATION

ET (mm) - ECMWF

ET (mm) - Meteorological station
Soybean yield estimations using ground and ECMWF data
Meteorological data

Mean Yield

- **GeoSafras**: 2310 kg.ha\(^{-1}\)
- **ECMWF**: 2359 kg.ha\(^{-1}\)
Meteorological data

Mean Yield

Geosafras

2004

Mean Yield 1219 kg.ha\(^{-1}\)

ECMWF

Mean Yield 1379 kg.ha\(^{-1}\)
Meteorological data

Mean Yield

2005

GeoSafras

Yields Kg.ha$^{-1}$

Mean Yield

753 kg.ha$^{-1}$

ECMWF

Mean Yield

920 kg.ha$^{-1}$
Final Considerations

• Success of the Geosafras project (UFRGS - CONAB)

• Objectivity, accuracy, low cost and practicility of the estimations

• Need of continued improvement

• Experience exchanges are welcome
Thanks!