Assimilation of remotely-sensed data of high repetitivity in process models

ICPA Bucharest - ICPPT Fundulea
contribution to the ADAM Project
(2000-2002 period)

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According to a feasibility study made in 2000 by the European Remote Sensing Service (ERSIS), agriculture in relation with the emergence of precision farming represents the largest share of the Earth Observation (EO) accessible market, that is up to 30% (assessed today at 300 MEUR).

Assuming the availability of new quality data and related services, the EO accessible market for agriculture is supposed to increase to 2,000 MEUR in 2015.
**The “ADAM” PROJECT**

Assimilation of Spatial Data by AgroModeling

A French-Romanian co-operation project for 4 years (2000-2004) initiated by the French Space Agency (CNES)

**Main Objective**

To elaborate a methodology for the assimilation of the remote sensing data of high spatial-temporal resolution within agro-physiological models coupled with radiative models, in order to produce the information needed in a farm (at the “field scale”)

The “ADAM” PROJECT

Assimilation of Spatial Data
by AgroModeling

Long Term Objective

To produce space systems dedicated to agriculture at the field scale, capable of monitoring and warning, similar to those already operational in meteorology and oceanography.
The “ADAM” PROJECT

**French Partners**
- The French Space Agency (CNES)
- The Institute for Agronomy Research (INRA-Avignon)
- The College of Agriculture Purpan (ESAP-Toulouse)

*Responsibility: global co-ordination, satellite data acquisition and pre-processing, research*

**Romanian Partners**
- The Romanian Space Agency (ASR & CRUTA)
- The Institute for Soil Science and Agrochemistry Research (ICPA-Bucharest)
- The Institute for Cereals and Industrial Crops Research (ICCPT-Fundulea)

*Responsibility: ground survey, research*

- InterGIS srl - private company  
  *Responsibility: GPS support*
Specific Objectives of ICPA - ICPPT to be achieved in “ORIZONT 2000” Program

• Contribution to the development and validation of a methodology for the assimilation of the remote sensing data of high spatial-temporal resolution in agro-physiological models coupled with radiative models & the spatialization of the assimilation procedure results

• Development of a processing strategy for the optical and radar remote sensing data in order to extract the maximum of information on soil and vegetation
Remote Sensing Data (e.g. Vegetation Index)

Model State Variables (e.g. Leaf Area Index, Chlorophyll)

Estimations at the model time step

PRINCIPLES OF SPATIAL DATA
ASSIMILATION
BY AGROMODELING

RADIATIVE MODEL

AGRO - PHYSIOLOGICAL MODEL
(BIOMASS PRODUCTION)

RESULTS SPATIALIZATION

Fitted spectral profile
BASIC INPUT DATA TYPES (1)

(1) meteorological data
(2) soil data
(3) crop data
(4) agricultural practices
(1) meteorological data
- temperature
- rainfall
- global and diffuse radiation
- wind speed
- potential evapotranspiration, ...

(2) soil data
- organic matter
- total Nitrogen, Pa, Ka
- texture
- bulk density
- field capacity
- wilting point
- moisture profiles
- mineral Nitrogen profiles, ...

(3) crop data
- phenological stages
- leaf area index
- total above biomass
- height
- biomass partitioning
  (green leaves, senescent leaves, stems, ears)
- yield components
- grain quality
- total Nitrogen in leaves, ...

(4) agricultural practices
- sowing date
- seed treatment
- irrigation
- fertilizers application
- pesticides application
- harvest date, ....
BASIC INPUT DATA TYPES (II)

(5) multitemporal remote sensing data

(6) yield monitoring system data

The frequency of acquisition is related to the crop phenological cycles
SUPPORT INPUT DATA

BASED ON GEOREFERENCING, INPUT AND PROCESSED DATA ARE MANAGED WITHIN A GEOGRAPHIC INFORMATION SYSTEM

GPS DATA
THE MONITORING OF THE FIELDS AND OF THE SAMPLING UNITS IN 3 AREAS WITHIN THE FUNDULEA SITE

GPS measurements
1st group: submetric accuracy (Odyssey Javad system)
- Control points for the rectification of the satellite images
- Position of the sampling units
- Position of the corner reflectors (installed for the calibration of the radar data)
GPS Measurements
1st Group

Accurate location of the corner reflectors
(installed on the ICCPT building roof)

Positioning for

descendent radar satellite orbit

ascendant radar satellite orbit
**GPS Measurements**

**1st Group**

Control points for the rectification of the satellite images

Example of the overlay control

between

an optical image (SPOT XS) and a radar image (ERS 2)
GPS Measurements

1st Group

Location of the sampling units

Example of two sampling units positioned on a SPOT XS image

Example of soil measurements (for moisture and roughness) on a sampling unit
GPS Measurements
2nd Group

Combine machines equipped with yield monitoring systems (YMS)

- LandStar (differential GPS)
- Yield sensor
- Moisture sensor

The spatial accuracy of the YMS measurements is compatible with the spatial resolution of the multi-temporal remote sensing data.
**GPS Measurements**  
2nd Group

**Harvest strategy**

*Harvest the greatest possible number of fields of a minimum area (several hectares) in order to map the variability within fields*

*Cover the most possible part of the site in order to map the variability among fields*
During the campaign 2001, about 650 ha of winter wheat have been harvested with 3 equipped combine machines, from a total of 1,500 ha within Fundulea site.

About 80% of the raw data are of good quality and yield maps have been produced based on them.

YMS data are used for the spatialization of the assimilation results and for validation.
EXAMPLE OF YIELD MAPS

Yield map for “Flamura 85” wheat cultivar

Yield (in quintals)

- 10 - 20
- 20 - 30
- 30 - 40
- 40 - 50
- 50 - 60
- 60 - 70
- 70 - 80
- 80 - 90
- 90 - 100
- No Data
Challenge for the future

Internet servers
where
crop models assimilate remote sensing data
in order to give information about fields in real time

Model initialization

Data about
• fields coordinates
• cultivar characteristics
• permanent soil characteristics
• agricultural practices

AGRICULTURAL SYSTEM
AT FIELD SCALE
Information on
• water stress
• mineral nutrition stress
• weed infestation
• pest attack ...

FARMS

Information during
the phenological cycle

THIS SYSTEM SHOULD BE ECONOMICALLY VIABLE!