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VEGETATION Preparatory Programme:

ABSTRACTS of the INVESTIGATIONS

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Validation of a global vegetation model using SPOT VEGETATION data

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A mechanistic plant ecophysiological model known as DOLY (Dynamical Global Phytogeography Model) has been developed by Professor F.I.Woodward at the Department of Animal and Plant Sciences, University of Sheffield and the Sheffield Centre for Earth Observation Science. This global scale model only requires data on climate and soils as input, and is primarily intended to deal with predictions of vegetation response, to changes in climate and CO_2, in terms of leaf area index, net primary productivity and evapotranspiration. Such a model is critical for inclusion in GCMs to greatly improve the treatment of climatic interactions. There are two major contributions to the model that can be provided by remotely sensed data, the first is a method for determining the opportunity for change in vegetation type in response to climate by measurement of disturbance amount and distribution. The second is a method of validating the model at a global scale. It is planned to achieve this testing by comparing simulated data from canopy reflectance models, constrained by DOLY, with simulated SPOT-HRVIR and VEGETATION data. In this way it is aimed to devise a mechanistic prediction of the radiative fluxes seen by satellites.

Component 1: Determining vegetation disturbance rates from satellite data

The change in vegetation predicted by DOLY will be modulated by the opportunity for vegetation dispersal. This is largely controlled by perturbation from various causes resulting in the creation of space for succession. Within a single biome the amount and frequency of disturbance and its spatial extent and scale will vary. The intention of this proposal is to use simulated SPOT-VEGETATION data generated from Landsat TM data, acquired as part of the BOReal Ecosystem Atmosphere Study (BOREAS) of the boreal forest, to test methods for determining for this crucial biome the amount, temporal variation and spatial distribution of gaps. These data will be used to determine the transition probabilities used in DOLY. Areas of disturbance will be detected by separating forest from non-forest within an identified forest region using: classification, image segmentation and examination of scatterometry data to provide Markov transition probabilities for a change from forest to forest gaps.

Component 2: Validation of DOLY

The validation of the DOLY model has been attempted using sparse sample records of LAI and NPP (Woodward et al. 1994) and by comparison with NPP estimated from NOAA AVHRR data (Woodward pers. comm.). Both methods have their limitations hence it is the intention of the consortium to use the DOLY predictions of LAI, chlorophyll concentration and water content in physical scattering models to predict surface reflectance. These data will be compared to the simulated and ultimately the first data from the SPOT-VEGETATION and SPOT-HRVIR. A sensitivity analysis will also be undertaken where variables from DOLY and additional variables required by the reflectance models will be allowed to vary to minimise a simple merit function. The investigation will concentrate on three specific sites which are both critical to DOLY and also have data from which to simulate HRVIR and VEGETATION. These sites comprise, the boreal forest (BOREAS), North American grasslands (FIFE) and the African savannah (HAPEX-Sahel). In addition work will be carried out on the use of ERS-1 scatterometer and ATSR-2 data for validating DOLY. The simulated optical data will also be useful as a comparison between SPOT-VEGETATION and ATSR-2.

Scaling and integration of high frequency and high resolution data : characterization of the slash and burn tropical deforestation process

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Shifting cultivation accounts for about two thirds of the tropical deforestation. To conduct a research and development strategy that provides viable alternatives to shifting cultivation on a worldwide basis, the « Alternatives to slash-and-burn » international project has been initiated. In order to identify, analyze and quantify the deforestation processes at different spatial scales, satellite data will be utilized over three distinct regions of highly degraded rainforest (Brasil, Indonesia, Cameroon). Issues given particular attention will be the time evolution and the spatial scaling of land use patterns in the slash-and-burn areas. The VEGETATION-HRVIR system specifications fully correspond to answer these issues. For this,

1. image processing techniques such as classification and use of spatial operators,
2. signal interpretation like deconvolution of the low resolution signal and temporal signature of the landscape units,

will be developed in the particular context of tropical forests. Investigators at ICRAF (Nairobi) will deal mainly with ground-truth and low resolution data processing, while the investigator at CIRAD (Montpellier) will focus on the signal interpretation.

During the pre-launch phase, SPOT-HRV, LANDSAT-TM and NOAA-AVHRR data will be utilized as simulations of the VEGETATION-HRVIR system. After the launch, these methodologic developments will be tested on actual VEGETATION data and transformed in routine procedures.

Integration of VEGETATION and HRVIR data into yield estimation approach

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The implementation of the Common Agricultural Policy at the European Community level, or even its extension to other countries, clearly involves that decision-makers must have reliable information on crop evolution at their disposal. To meet these needs, the techniques currently used are based on statistical approach or agrometeorological models using only few remotely sensed information. But their implementation remains often complex (high number of parameters and of ground surveys). Moreover the precocity, homogeneity and reliability of results are not always compatible with their utilisation for market management and setting-up of the agricultural policy.

Many research works have been carried out in these last years to investigate the contribution of remote sensing data in these fields, and in particular the possibilities of integrating information derived from radiometric measurements into agrometeorological models. Through the next availability of VEGETATION data and their related characteristics, the possibility of operating these models not only at parcel scale but also at local or regional scales is to be envisaged , as well as the use of su ch data for operational approaches of crop yield predictions (MARS-STAT project).

For this investigation on the contribution of VEGETATION data, two crops (wheat and corn) will be studied. These two crops of interest are economically important and have different agronomic growth features. For that purpose, two sites have been selected, Chartres where wheat is the main crop and Orthez which has a high percentage of corn. Moreover the analysis of these two sites is of major interest due to their climatic and agronomic specificities.

Several aspects related to the use of VEGETATION data will be investigated within this project. First, the monitoring of vegetation behaviour through VEGETATION data will be analysed in order to obtain information to be integrated into crop model, and then enabling crop yield prediction to be improved at local scale (such as the 13 French sites of MARS project). A preliminary work will deal with the possibility of retrieving individual spectral response of each main crop on the studies site from VEGETATION signal unmixing. Second, the possibility of monitoring crop growth conditions and biophysical parameters from VEGETATION data will be investigated to extrapolate the assessments made previously at IOQI scale and then carry out predictions at national scale.

Adjustments and improvement of techniques and tools will be analysed to take advantage of using both VEGETATION and HRVIR data. The development of these methodologies involves the performance and sensitivity analysis of the different approaches envisaged both at the local (MARS sites) and country levels.

Land cover/land use mapping and monitoring of Russia

Principal Investigator: E MILANOVA (Dep Geography Univ. Moscow Russia)

In order to understand environmental problems and their solutions scientists and decision makers must obtain precise and credible data on the background of vegetation, soils and land use. Detailed information on the present status and trends of evolution of natural and anthropogenic landscapes is necessary for sustainable land use, rational management of natural resources, and nature conservation.

Russia has long and eminent traditions in study of the environmental science and land use/cover mapping, with wide use of remote sensing data (space imagery from Meteor-Priroda, Cosmos, and other meteorological and resource satellites, Salyut and Mir stations, and airborne data). However, no multiscale synthetic research yet has been undertaken to summarise available data in order to study land cover dynamics, and natural and anthropogenic mechanisms, which are responsible for environmental change. There is urgent need of assessment and modelling of historical and actual trends of human impact on landscapes all over Russia.

Collection, generalisation and analyses of all currently existing data (local and regional maps, satellite imagery, detailed ground-truthing field observations in key areas) will allow preparation of basic digitised map of land cover and land use structure of Russia (status of mid-1990s), as well as a set of middle-scale and local-scale thematic maps (biodiversity, standing biomass, species composition, carbon storage, land degradation, trends of vegetation and land use changes).

Among key features and advantages of VEGETATION system, which are important for successful multiscale research is simultaneity between high spatial resolution (HRVIR) and low spatial resolution but high frequency acquisition of VEGETATION. This condition will allow multiscale studies and provide optimum combination of local observations of key areas (complemented by infield research) with regional mapping and monitoring of land cover over the whole of Russia's territory.

Application of VEGETATION data to land cover study of Russia could complete and update currently available materials. The results of proposed programme of research will have direct relevance to land management and nature conservation, and help to elaborate recommendations on rational land use strategy in Russia. Mapping, monitoring and modelling of vegetation and land use of such a vast land area could also contribute to international programmes on global and macroregional environmental change (e.g. "Land Use/ Cover Change" core project of IGBP/HDP and "Global Change and Terrestrial Ecosystems" core project of IGBP) and promote exchange of ideas and methods between western and Russian environmental and remote sensing scientists.

STEM-VGT : Satellite measurements and terrestrial ecosystem modelling using VEGETATION instrument

Principal Investigator: G. DEDIEU (LERTS/ CESBIO Toulouse France)

Co investigators: JC Gérard (LPAP / IAL Liège),
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Our general objective is to develop process models of vegetation functioning that can be used at regional and global scale for predicting carbon and water exchanges between land surface and the atmosphere. Vegetation functioning refers to the temporal development of vegetation such as carbon uptake, phenology, carbon pools, biomass and its allocation within the various plant components. In a first step, we will focus on the assessment of fluxes at the seasonal time scale. The specific objective of this sub-project is to develop and validate VEGETATION based methods for calibrating such vegetation process models.

We plan to address the following topics :

- development, assessment, improvement of assimilation techniques of SPOT-4 HRVIR and VEGETATION measurements (actual or simulated, including SWIR band) in vegetation models;
- most of vegetation processes strongly depend on water availability. We plan to couple vegetation process models with a SVAT model in order :
  - to improve soil moisture estimates
  - to supplement satellite measurements in the optical domain (HRVIR, VEGETATION) by thermal infrared data to add more constraints on the models through multispectral assimilation
- investigation of the use of combined high and low space resolution to account for sub-grid surface (vegetation, soil) heterogeneity
- assessment and improvement of "ecological rules", combined with assimilation techniques to further constraint the system or provide parameters which cannot be derived from satellite measurements.

Therefore, the prelaunch phase will be devoted to investigating at three differents scales these four topics :.

- Test sites : method developement and investigation of sub-grid processes will be analysed using satellite and in-situ data over three test sites : the Hapex Sahel site (Niger), the Murray Darling Drainage Basin in Australia, the San Pedro Basin, over Mexico and the USA, where the SALSA-MEX experiment should take place.
- Continental scale : spatial extrapolation of the methods and models developed over the three test sites will be carried out over the whole Australian continent.
- Global scale : global runs for NPP estimate will to integrate the improved methods developed over the three test sites and Australia.

VEGETATION data will be simulated by using NOAA/AVHRR, ERS-2/ATSR2, ADEOS/OCTS measurements. The post launch phase will test the methods developed during the pre-launch phase with actual HRVIR and VEGETATION data. The above mentionned test sites, as well as regional and global studies, will be used and supplemented by others SALT sites located on a south-north transect.

VEGETATION/SPOT for Northern Applications

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We have selected a team of eight experienced and productive scientists and academics specialized in the various fields of remote sensing to utilize the combined VEGETATION and HRVIR data for monitoring northern ecosystems. The main objective of this investigation is to explore the usefulness of the additional blue and shortwave infrared bands and the narrow near infrared band in deriving biophysical parameters and estimating net primary productivity of northern ecosystems (cropland, grassland, boreal forest, wetland and tundra). The advantages of the radiometric precision and stability and the fixed orbit of the VEGETATION instrument over the existing NOAA AVHRR will be explored in the preprocessing of the data including corrections for bidirectional reflectance distribution effect and pixel screening. This study draws upon the experience attained by our team members in previous and on-going projects such as FIFE (First ISLSCP Field Experiment), BOREAS (Boreal Ecosystem-Atrnosphere Study), NBIOME (Northern Biosphere Observation and modelling Experiment) and others. The experience and data sets from these project will allow us to exploit the VEGETATION data without incuring high expenses. Intensive study areas will be located in central and eastern Canada. Algorithms will be developed using VEGETATION data to retieve leaf area index (LAI) and the photosynthetically active radiation absorbed by vegetation (APAR). A Photosynthetic Efficiency model (PEM) and the Regional HydroEcological Simulation System (PHYSSYS) capable to incorporating VEGETATION data will be used to stuty spatial and temporal variations in carbon budget and productivity of northern ecosystems. Algorithms, models and scientific principles to be developed and improved in this study are expected to be applicable for boreal ecosystems worldwide.

The Suitability of VEGETATION for Mediterranean Land Degradation and Desertification Monitoring

Principal Investigator: W. MEHL (EMAP/ IRSA/ JRC Ispra Italy)

Co investigators: J. Hill (RS Dep. Trier),
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S. Sommer(EMAP/IRSA/JRC Ispra)

For the observation of land degradation and desertification processes with spaceborne imaging instruments we need a standardised methodology which is capable to provide information on soil conditions and vegetation cover. We believe to have identified in "Spectral Mixture Analysis" (SMA) a methodological framework which permits to derive consistently such information across different data acquisitions and different sensors.For operational monitoring of land degradation a multi-stage sampling strategy must be developed where low resolution sensors will provide the contextual information both in space and in time for a correct and statistically significant evaluation of status and processes as observed by high resolution earth observation instruments. As VEGETATION system parameters offer both daily coverage and a higher spectral resolution than current sensors with short revisiting cycles (the latter property being a prerequisite for successful application of SMA), we shall evaluate the function that system can fulfil in an operational setup for monitoring of land degradation in the Mediterranian basin. In particular we shall investigate the portability of SMA and the compatibility of results derived from that methodology with those obtained at high resolution, and the portability of topography related corrections to VEGETATION scale. That part of the study will be carried out mainly during the prelaunch phase on simulated data sets. During the post-launch phase we shall study in addition indicators derived from VEGETATION which can be used to evaluate a priory the statistical significance of data samples gathered at high resolution, and the potential of observing and measuring phenomena which in our area of interest may be rare but highly significant for risk estimation and quantification of erosion (vegetation peaks and river plumes after rain fall events).

Monitoring seasonal Dynamics of North America Grasslands using VEGETATION

Principal Investigator: D. MEYER (EDC/USGS Sioux Falls SD USA)

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The grasslands of the Great Plains in North America are comprised of ecological, climatic, and agricultural systems on a scale well-suited for study by medium resolution sensors such as the VEGETATION instrument. For many years, this biome has been observed by the Advanced Very High Resolution Radiometer (AVHRR) to monitor land cover and vegetation dynamics. However, limitations on calibration, geometry, orbital drift, resistance to atmospheric effects, limited spectral coverage and lack of concurrent high-resolution data have restricted its utility by introducing substantial errors into all stages of processing and analysis. The VEGETATION instrument provides an opportunity to overcome these restrictions.

The proposed study will evaluate the VEGETATION instrument for two important classes of remote sensing problems: (1) direct estimation of surface physical parameters, and (2) indirect measures of surface characteristics. The first problem is the estimation of surface albedo, which requires precise scene geometry and radiometry, in addition to measurements across a broad portion of the solar spectrum. This part of the experiment is designed to test the capabilities of VEGETATION in an application that has proven difficult to solve with existing sensors. The second problem is the computation of seasonal metrics, based on time series composites of the normalized difference vegetation index (NDVI) as surrogate measures of plant phenology. This part of the study is designed to test VEGETATION's performance in a biome-scale monitoring application.

This study will monitor surface conditions over the Great Plains using multi-temporal analyses, and multi-scale techniques for validation. Four to six grasslands preserves, administered and maintained by The Nature Conservancy, will serve as test sites for the validation. On-site staff will make routine ground observations of plant phenology and atmospheric conditions, while more detailed measurement campaigns, designed to measure plant spectra, biomass, chlorophyll content, and related parameters, will occur three to five times per year for the years 1995-1998. Parallel to the detailed surveys, SPOT/XS and Thematic Mapper data will be acquired and degraded to 1-kilometer resolution to determine the loss of information that occurs between these different scales. Relationships will be established between surface and satellite measurements to determine the limits of discrimination of surface parameters from medium resolution imagery. For the pre-launch phase, the AVHRR will be used as the operational instrument to determine albedo and vegetation metrics.

After launch, data collected simultaneously by the VEGETATION and SPOT/HRVIR instruments will provide an unprecedented opportunity to study multi-scale and multi-temporal relationships from spectrally consistent medium- and high-resolution sources. It is anticipated that VEGETATION will provide substantial improvements over present systems for conducting both direct and indirect measurements of the grasslands ecosystem.

Vegetation dynamics in the southern Amazon basin, Brazil, by SPOT 4 imagery

Principal Investigator: E DE MIRANDA (Ecoforce Sao Paulo Brazil)

This project will provide a better understanding of the vegetation dynamics in the Southern Amazon Basin. The proposal is the result of a multi-institutional agreement between ECOFORCE and NMA/EMBRAPA, with the support of INPE and PRTFAS-CTRAD. The investigation was therefore planned to value, in a complementary and synergetic way, the existing facilities, human and financial resources of the participant institutions. The experimental objectives of this proposal is to evaluate the potential use of SPOT4/VEGETATION imagery for estimating the extent of burned areas in the Southem Amazon Basin, Brazil.

The main study site is located in the State of Mato Grosso and has an area of about 250,000 sq. km. It is a climatic transition area between the savanna and the rain forest. The use of fire in grass and shrublands and the practice of deforestation followed by burnings to open new agricultural fields and pastures are very common. The continuous changes in the land use and the large size of farms are favorable in principle to the classification of the SPOT4/VEGETATION data. Since 1991, the ECOFORCE and NMA's research teams have been working with daily data from NOAA/AVHRR to monitore vegetation burnings, during the dry seasons, with INPE's collaboration. The main expected outcomes of this investigation proposal are:

- The multispectral measurements, to obtain a cartography of the detected burning sites (NOAA/AVHRR) and the burned areas (SPOT4/VEGETATION), that will improve the "Multi-Institutional Integration System for Monitoring the Burnings in Brazil";
- The multitemporal analysis of the vegetation indexes related to the dynamics of the surface processes that influence the`vegetation development (water availability, soil type, topographic situation, land use and land management), in a transition area between the rain forest and the savanna woodlands.

Method to monitor characteristics of boreal forests using SPOT VEGETATION data

Principal Investigator: K. ANDERSSON (VTT Finland)

Co investigators: T. Häme, A. Salli, M. Holm (VTT),
R. Kaliola, K. Syrjänen (Univ. Turku)

The purpose of this study is to develop an operative methodology to monitor resources of boreal forests over extensive areas by using SPOT VEGETATION data as the primary information source. The resources include tree biomass (or organic matter), tree species groupings distribution, and major forest site types. The methodology will be actualized in a software package. Some of the elements of the methodology already exist. They have been developed during recent or ongoing studies at VTT or elsewhere. The elements of the methodology include:

- atmospheric and geometric corrections
- image mosaicing
- computation of the models for stand characteristics estimation using ground truth and high resolution satellite data
- application of different models on the mosaic
- quantitative estimation of spatial structure of forests using mathematical morphology

The scientific objectives of this project are:

1. to test and further develop methodology to apply models, developed using high resolution satellite data and ground truth, to the low resolution data mosaic
2. to test and further develop methodology to correct the atmospheric effect using natural targets

Data sets for simulation of the pre launch phase, will be generated from SPOT and AVHRR data. Images are needed from Sweden, Finland and possibly from Russia.

Evaluation of MIR data from SPOT4/VEGETATION for the monitoring of climatic phenomena impact on vegetation

Principal Investigator: I. PONS (GEOSYS Toulouse France)

A country struck by a climatic phenomena such as drought needs to be able to measure the gravity of the situation.

Since 1989, GEOSYS has satisfied such requirements by setting up a specific Geographic Information System (GIS). This system uses space-derived, repetitive, low resolution satellite data (NOAA/AVHRR) in conjunction with other types of information (mainly land use, agro-climatic data and crop calendars). It enables the effects of drought to be measured globally, objectively and rapidly.

The impact evaluation method is based on a multi-temporal comparison of a series of images acquired during a normal year (considered as the reference year), and those acquired during the current year. The differences observed and mapped enable a zoning and hierarchical organization of the impact to be established.

The launching of VEGETATION/SPOT 4 with a Short Wave Infra Red (SWIR) channel will surely be a means of obtaining more information on vegetation for global, low resolution studies.

The objective of the investigation proposed is to study the interest of VEGETATION data for impact zoning and to prepare to the integration of the se ne w data in the information system of evaluation.

The study will be made up of three progressive phases which will go from the evaluation of the gains brought about by SWIR to the definition of a drought impact monitoring system.

These three phases are as follows:

• Preliminary study for evaluating the information provided by the SWIR band and integrating it into the impact evalutation. The study will be conducted on low resolution simulations using LANDSAT TM images and on a fairly limited area.

• Extention, specification and validation of the method on a larger area covered by ATSR2 data. Once these two phases have been carried out, the monitoring system is totally defined on simulated data (pre-launch phase).

• Carrying OUt of a study for monitoring vegetation impact in a real context using VEGETATION data.

The site chosen is in Spain, where drought problems come about regularly year after year, and where the gravity of the phenomenon is monitored every year by the current system.

In addition to the innovative nature of the integration of SWIR in order to obtain more comprehensive information on the biomass and soil caracteristics and therefore for monitoring drought impact, the advantage of this study is to propose a concrete application for the VEGETATION data.

VEGETATION data in the monitoring of disturbance patches and postdisturbance succession in natural vegetation in South Africa

Principal Investigator: H. GULINCK (Institute for Land and Water Management, Leuwen, Belgium)

In a recent EC-DGVIII project a baseline dataset and methodology was elaborated concerning vegetation patterns and changes at medium scale level (1/50000-1/100000) in the natural parks of northern Botswana, using Landsat-MSS and Landsat-TM as source information. The project was linked to problems such as overgrazing and fire. The introduction of VEGETATION information will be helpful in reconstructing the short term history of individual region, especially for ephemeral features in natural landscapes. Secondly VEGETATION data will help in providing information on atmospheric interferences, often local as smoke plumes. Thirdly, a synergy between low resolution VEGETATION data and high resolution Landsat or SPOT data may greatly enhance the operational success of satellite based vegetation monitoring, in providing multiscale data on parameters of the environment such as standing green biomass.

The objectives of this new proposal are the following:

1. Adding a monitoring component for high frequency, ephemeral and localised ecological phenomena such as fire to the research described here above.
2. Contribute to the methodology of interpretation of VEGETATION data, more specifically :
   - 2a. Define frequency thresholds for VEGETATION data
   - 2b. Estimate contrast thresholds for detection of disturbances in VEGETATION data
   - 2c. Estimate pixel composition thresholds for detection of disturbances.

The methodology in the pre-launch phase comprises the selection of Landsat MSS, TM and SPOT images as source data for simulation, including a multiyear series, a one season set and a single date resolution set. This data is already available for a great part. A supporting field survey is envisaged as well. This project will apply the most straightforward technique for simulation possible and acceptable, but not specifically search for optimal algorithms, as the emphasis lays on the spatial and temporal domain.

During the second, postlaunch phase, the simulation will be repeated for comparison with real VEGETATION data. In the early and later stage of this phase, a ground truthing mission is envisaged.

The expected results are the following :

- Feasability of VEGETATION for recording fires and other disturbances
- Methodology for the interpretation of VEGETATION in the selection of SPOT-HRVIR
- Improved interpretation methodology for high resolution images

A workplan design for implementation high and low resolution satellite images in wildlife habitat mapping and monitoring

Determination and validation of Land Surface Biophysical properties using SPOT 4 VEGETATION and HRVIR

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A. Strahler (Boston University, USA)

This investigation is concerned with the development of a number of new algorithms (and validation of the resultant data products) appropriate to the VEGETATION and HRVIR instruments that will be launched on board SPOT 4. In particular, the proposal focuses on the use of VEGETATION to acquire multiple view/illumination angle data to characterise the Bidirectional Reflectance Distribution Function (BRDF) of different Earth surface materials and, hence, to derive estimate values for a number of key biophysical properties of the land surface, including the albedo and Leaf Area Index (LAI).

Derivation of surface spectral albedo involves either numerical or analytical integration of the surface BRDF which, in turn, requires the use of either an empirical or physical model of bidirectional reflectance at the Earth surface. Depending on the parameterization of this model, estimates may also be obtained for various biophysical parameters (e.g.. the LAI of vegetation canopies). We propose to examine the applicability of a number of different BRDF models in this context. This will involve a consideration of their relative computational requirements, the robustness of the inversion procedures used, the sensitivity of the model inversions of the number and angular distribution of the available directional reflectance measurements, and the physical meaning of the derived model parameters at different spatial scales.

Although VEGETATION will be capable of observing any point on the Earth surface over a range of viewing and illumination angles from different orbital overpasses. the angular distribution of these measurements, particularly with respect to the viewing hemisphere will be relatively restricted. Thus, we intend to examine the combined use of data from VEGETATION with that from other current and proposed 'medium' resolution satellite sensors (e. g.. MERIS, MISR and MODIS) to provide a more complete sample of the BRDF and hence to derive still more accurate estimates of land-surface albedo, LAI etc.

To ensure that the derived data products are accepted and widely employed by the relevant user communities, we have proposed a rigorous data validation scheme based on established geostatistical techniques. This will be used, in conjunction with multi-resolution (multi-scale) data sets, to scale up from a controlled set of detailed point measurements at the Earth surface, through contemporaneous airborne and high spatial resolution satellite sensor data (including HRVIR on SPOT 4), to the grid scale of VEGETATION and other medium resolution sensors. This will be used to provide accuracy estimates for each of the derived data products.

The algorithms will be developed, tested and refined prior to the launch of VEGETATION using a range of existing data sets from five test sites, namely (i) HAPEX-Sahel, Niger, West Africa (semi-arid), (ii) FIFE, Konza prairie, Kansas, USA (grassland), (BOREAS, Canada (coniferous woodland), (iv) Chang-Ping/Tang-Shan, near Beij ing, China (woodland/agriculture), and (v) La Crau, southern France. The La Crau test site w ill be used additionally as a post-launch test site.

Members of the consortium represented here have extensive experience working together on related satellite sensor programmes, notably NASA's MODIS and MISR instrument teams and have developed prototype code for MODIS that could be applied directly to VEGETATION. Consortium skills include detailed in situ measurement of land surface biophysical parameters (including the 3-D structural properties of vegetation canopies), geostatistical theory and spatial sampling methods, and in BRDF modelling and inversion.

Development of a synthetic algorithm for vegetation monitoring

Principal Investigator: F. BARET (INRA Avignon France)

Co investigators: JM Nakache(Aérospatiale Cannes),
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MD Steven (Dep of Geography Univ. Nottingham)

The objective of this proposal is to develop an algorithm devoted to the monitoring of vegetation. The algorithm is expected to represent our current understanding of the biophysical processes governing canopy reflectance and radiative transfer in the atmosphere. Further, we will explicitly use the directional and spectral characteristics of VEGETATION to retrieve the maximum information on the vegetation and minimise the effects of confounding factors well identified such as the atmosphere, soil background, bi-directional and scaling effects.

The vegetation will be monitored through a pertinent biophysical variable directly related to radiative transfer in the canopy: the gap fraction (probability to see the soil from a given direction). This variable can be easily measured at ground level, and used to compute canopy cover (gap fraction observed from nadir), canopy light interception or absorption efficiency (APAR) as well as albedo.

The spatial scale addressed in this proposal will correspond to VEGETATION spatial resolution that allows an exhaustive coverage of large areas. The temporal scale will correspond to short time periods during which the bi-directional properties are sufficiently sampled while the vegetation did not change significantly. It corresponds to 10 or 15 days periods.

We will mainly focus on agricultural landscapes because simulation and validation are more easy to complete. However, potential successful applications to natural ecosystems are expected. The algorithm developed will hopefully provide also a way to synthesise the spectral, temporal and directional data recorded by VEGETATION but also by other systems such as NOAA AVHRR, POLDER, MERIS, MODIS, MISR, ATSR, METEOSAT...This will allow both to compare the performances of VEGETATION to those of other sensors, but also to investigate a way to use concurrently all these sources of information.

The approach envisioned is based on existing models describing the physical processes involved in light transfer in the atmosphere and canopies. The study will be split in four successive parts.

Construction of the data base made of several scenes representative of typical landscapes. The optical (spectral and directional) properties of each object in the scene will be simulated using either canopy functioning models coupled to canopy reflectance models or to archive data when models are not available. The VEGETATION pixel response will then be simulated by summing the contribution of each object in the pixel, after accounting for the effect of the atmosphere. We will in parallel simulate the gap fraction at VEGETATION scale as well as the reflectance of a " black " pixel for atmospheric corrections. The data base, initially built with VEGETATION pecifications, can be adapted to match other sensors such as NOAA AVHRR. This will allow to study the potential complementary between these systems.

Relating the temporal string of radiometric data to the gap fraction. The algorithm will consist to relate the input data (reflectance as a function of time and configuration, and the associated " black " pixel value) and output data (the gap fraction). We propose to exploit the efficient capabilities of neural networks to establish the relationship.

Validation of the algorithm on airborne and satellite data. We will evaluate the approach developed using airborne POLDER data acquired in 1995 during a 2 months experiment concurrently to NOAA AVHRR data.. The test site will be the Crau site, south east of France, that will be also shared as a test site for other proposals.

Evaluation of VEGETATION performances and synergy with other sensors. The algorithm developed for VEGETATION will be compared to actual compositing algorithm used in the VGT-S products. Because the approach can be adapted to any sensors, we will be able to compare VEGETATION performances to those of other sensors (NOAA AVHRR, ...). We will also evaluate the interest of specificities such as VEGETATION's blue band. However, more important is the possibility to provide an integrated algorithm that could assimilate data from different optical sensors to increase the bi-directional/temporal/spectral sampling of the targets. In this study we will investigate the complementary between VEGETATION and NOAA AVHRR.

Potential of VEGETATION data used in combination with other sensors for the monitoring of forests at a regional scale.

Principal Investigator: JP LAGOUARDE (INRA Bordeaux France)

Co investigators: D Guyon, Y Brunet, P Berbigier (INRA Bordeaux),
Y Kerr (LERTS/CESBIO Toulouse)

Two experimental objectives are followed in this proposal which focusses on global monitoring of forests.

The first objective is to study the signification of the VEGETATION channels and especially SWIR at 1 km resolution as it will be provided by the VEGETATION instrument. A part of the work will consist in generating simulated VEGETATION data over different types of coniferous forests using degradation techniques on a TM archive available at the laboratory. The experimental site is the Landes forest in the southwestern France, and particularly the Nezer forest which has been a test site for the laboratory since 1984. An important database of ground information is available on this site. The variability induced at 1 km¨ by the forest structure (mixture of stands, clearings and thinnings) will be analysed, using geostatistics. SWIR ATSR2 data -as soon as available- in the prelaunch phase, and combined VEGETATION/HRVIR scenes in the post-launch phase, will be used to validate the results against actual data. The expected results deal with the evaluation of improvements brought by the SWIR channels for large scale characterization of forest types and global monitoring at regional scale. In this phase, the study of the spatial integration processes at 1 km¨ scale is privilegiated. The expected results should contribute to a better understanding of the complementarity between VEGETATION (high temporal/low spatial resolution) and SPOT/HRVIR (high spatial/low temporal resolution) data.

The second objective of the proposal is devoted to the global monitoring of forests (deciduous as well as coniferous) at the regional scale. In this case, the temporal evolution aspects will be clearly privilegiated. The evolution troughout time of the visible and IR channels is related to both phenological and vegetation growth, as well as to hydric factors. The simultaneous temporal variations of VEGETATION channels and indices (NDVI...) with hydric conditions (characterized by the way of surface temperature) will be analysed. For this purpose, a NOAA-AVHRR archive of 5 day-scale synthesis of NDVI and Ts (archive built by the CNES over the period 1988-1990) will be analysed first: we shall evaluate the interest of agrometeorological indices such as ð(Ts-Ta) combining the surface temperature with the air temperature at a few tenths of meters above the vegetation for assessing the water status of the forests. The acquisition of a ATSR2/AVHRR data set on a daily basis will allow to improve the proposed methods. Especially, in this part of the work, estimations of actual evapotranspiration will be made using deterministic models. Moreover the potential of several indices possibly integrating the SWIR channel will be studied. The last step will be a validation performed on a VEGETATION set of data. The assimilation of measurements at a regional scale of visible and infrared (NIR, SWIR) channels, and derived indices combined with estimations of evapotranspiration derived from TIR are expected to improve production models in the future.

Utilization of VEGETATION data to extract effective vegetation parameters of heterogeneous surfaces

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Co investigators: Y Kerr (LERTS/CESBIO Toulouse),
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Vegetation is a key parameter in the functioning of hydrological processes occurring within the earth-atmosphere interface and is, therefore, a sensitive indicator for environmental and global changes. Continuous monitoring of vegetation variation at regional to global scale would provide useful clues concerning our changing environment. Remote sensing provides a means to monitor changes in the amount of vegetation in a qualitative manner for homogenous surfaces. Quantitative estimates of vegetation of especially heterogeneous surfaces are to be established in order to fully understand and predict the future trend of our changing environment. The VEGETATION instrument to be included on board the SPOT 4 satellite would provide a unique data set due to its frequent and large spatial coverage, sensitive spectral bands for vegetation and atmosphere, and particularly its multidirectional capability. The VEGETATION data will consequently provide scientists an opportunity to fully investigate the feasibility of quantitatively extracting physical or biophysical properties of terrestrial land surfaces. In this project, we propose an investigation that utilizes the VEGETATION data to quantitatively estimate surface physical parameter such as vegetation percentage cover and leaf area index (LAI) and develop an operational approach to monitor vegetation at regional to global scales. We will use well-controlled ground data sets and satellite data to first quantify the noise levels from atmosphere and soil background, and BRDF models to quantify the bidirectional effect. In a second step, we will define effective surface physical parameters at regional to global scales and establish a quantitative relationship between the effective surface physical parameters and VEGETATION data by modeling physical processes of radiation regime within the earth-atmosphere interface. The approach will be simple and within a reasonable noise level, to allow an operational use of VEGETATION data products for vegetation monitoring. The outcome of this project will be three-fold: generation of an operational algorithm specifically designed to quantitatively extract surface (heterogeneous) physical parameters with the VEGETATION data sets; definition of effective surface parameters retrievable with VEGETATION data; and quantification of noise levels.

Land cover changes in Africa : Multitemporal change vector analysis at coarse scale and change processes categorisation with high spatial resolution data

Principal Investigator: E LAMBIN (Lab Télédétection, Univ Catholique Louvain Belgium)

Co investigators: J Wilmet (Univ Catholique Louvain)

A change detection technique based on the comparison, pixel by pixel, of the time trajectory of remotely sensed variables (e.g. vegetation indices, surface temperature, spatial structure), was developed recently by Lambin and Strahler (1994 a, b) as part of NASA's MODIS program. This technique requires high temporal frequency data. Detecting change in land-cover is important for a number of applications - e.g. agricultural change, tropical deforestation, desertification, urbanisation, ecological impact of climatic change. However, in most cases, the simple detection of areas subjected to change must be followed by an accurate measurement of the rate of change and a characterisation of the processes of change. These latter tasks are much better performed with fine rather than coarse spatial resolution data. The future SPOT/VEGETATION system has the potential to allow a permanent, global scale monitoring of land-cover change at a coarse resolution accompanied by a detailed analysis of the magnitude and spatial aspects of change processes at a fine resolution, wherever an area of important change has been detected. In this project, it is proposed to: (i) test and adapt the multitemporal change-vector method to the VEGETATION data; (ii) explore the complementarity of the low resolution data - for change detection - with the high resolution data - for change measurement and categorisation.

These techniques will be tested over West Africa. This research will be linked to on-going research activities by a research network ("Human Capital Mobility") which includes the investigators. The objective of this network is to build a regional ecosystem model for West Africa to relate land-cover changes to climate changes by quantifying the fluxes between the surface and the atmosphere. The research will also be linked to current MODIS Land research activities on the development of the "Land-cover change" product.

This research will build on the unique opportunity for land-cover change analysis to collect, from the same satellite system, frequent low resolution data with a global coverage and fine resolution data well focused over the zones where significant processes have been detected.

Estimation of surface variables at the subpixel level for use as input to climate and hydrology models

Principal Investigator: JP FORTIN (INRS Eau Sainte Foy Québec Canada)

Co investigators: M Bernier (INRS Eau Sainte Foy)

The general objectives of the study are (a)estimation of surface variables using data from a medium spatial resolution and high frequency remote sensing sensor in orbit and (b) increase accuracy of spatial positioning for multitemporal analysis of data.

Derived from those are the following specific objectives: (a) estimation of the percentage of various land covers within each pixel; (b) estimation at the sub-pixel level of the spatial distribution of snow cover on the ground and other physical variables of the surface, corresponding to each land cover within the pixel, the albedo for example; (c) as accurate as possible positioning of the images for multitemporal input into an spatially distributed hydrological model using geocoded data.

For the pre-launch phase, the proposed investigation will consist in simulating first VGT and HRVIR data from TM data, the differences in bandwidth being acceptable for our purposes. Then, after radiometric correction of the simulated data for atmospheric and directional effects, the analysis of data will consist first in the estimation of sub-pixel land-cover characteristics like albedo, using a procedure developed at INRS-EAU and similar to the approach used in the spectral mixture method. The same procedure allows better positioning of medium resolution data and this increase accuracy will be studied. Also, using the spectral mixture methodology, the percentage of each land covers on mixed pixel will be estimated, with regards for the types of land covers that lead to significantly different hydrological effects. Finally, the spatial distribution of snow cover will be estimated with the same methodology, with particular emphasis on forested areas.

The same type of analyses will be performed on actual VGT and HRVIR data during the post-launch phase. Also, a comparison will be made with AVHRR data to assess the advantages of VGT data over AVHRR data.

The expected results are: (a) a much better positioning accuracy of the pixels of a medium resolution sensor like the VGT, which will be very important for multiscale, multitemporal studies; (b) a better multitemporal estimation of the evolution with time of surface characteristics (albedo, ,...) of various land covers for mixed pixels, because of increase positioning accuracy; (c) a better multitemporal estimation of the percentages of each land cover on each mixed pixel; (d) a better monitoring of the variation in the spatial distribution of snow cover with time, during the Spring melt.

It should be possible to use the results in projects related to the objectives of the mission, namely surface mapping of surface parameters and monitoring of their dynamics for the estimation of their seasonal and long-term variations as well as a better understanding of these processes for their use in hydrological and general circulation models.

Improved Atmospheric Corrections and Data Compositing for Surface Reflectance Retrieval

Principal Investigator: M.LEROY (LERTS/CESBIO Toulouse France)

Co investigators: G. Dedieu (LERTS),
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D Tanré (LOA Lille)

This investigation aims at an improvement of the products delivered by the VEGETATION system, and falls in the category of proposals entitled "development of new procedures or techniques for handling and analysis of multispectral, multitemporal or multiscale data acquired by VEGETATION and other sensors". The foreseen improvement of products concerns the algorithms of atmospheric corrections and of the temporal compositing of successive sensor acquisitions.

Atmospheric corrections: Inaccuracies of atmospheric correction procedures lead to significant errors on surface reflectances retrieved from the sensor measurements. The nominal VEGETATION products are corrected from atmospheric effects using the SMAC code (Rahman and Dedieu, 1994), in which the water vapor, ozone and aerosol contents are given by a climatology or by some prescribed value. It is clear that any error on these contents translates into a corresponding error on retrieved surface reflectances. In this proposal, we will seek to improve the accuracy of these atmospheric contents. One of the issues concerns the choice of sources for the water vapor and ozone concentrations. We will compare simulated TOA (Top Of the Atmosphere) reflectances using as input climatologic or ECMWF data for water vapor, and using as input climatologic or TOVS/NOAA data for ozone content. We will also investigate the possibilities of use of the B0 VEGETATION blue channel, using simulations of TOA reflectances with as an input various statistical distributions of aerosol loading , in order to set thresholds on the blue TOA reflectance above which sensor data should be discarded (suspected to be contaminated by aerosols). These various studies will be used to recommend specific procedures and algorithms of atmospheric corrections at the end of the prelaunch phase. In the post launch phase, these procedures will be tested on VEGETATION data on well documented specific sites for which atmosphere data from the PHOTONS sunphotometer network are available. We will also evaluate during this phase the possibility of operational use of atmospheric products delivered by the spaceborne POLDER/ADEOS system, such as water vapor concentration, and aerosol optical thickness and phase function in the VEGETATION Ground Processing Segment .

Compositing method : The nominal VEGETATION products will use the Maximum Value Composite (MVC) technique as a compositing method of temporal series of data. This compositing tends to attenuate undesirable effects due to cloud contamination of pixels, and atmospheric and directional effects. This method, however, suffers a number of drawbacks. Several authors have attempted to overcome these drawbacks and proposed methodological improvements of various approaches, based on either appropriate filtering and selection of data, such as in the BISE method (Viovy et al., 1992), or on the correction of directional effects using a modelling of the bidirectional angular signature of reflectances, such as in Leroy and Roujean, 1994. We propose to evaluate and test these various possibilities. Several alternative "selection/filtering" methods will be tested using global GVI data derived from AVHRR temporal series. A partial validation will be provided by the degree of smoothness of restituted temporal profiles of vegetation indices, and by their level of realism using some a priori knowledge of phenology in various sites distributed worldwide. Next, we plan to study methods based on the correction of directional effects using airborne POLDER data acquired on well documented sites (HAPEX 1992, BOREAS 1994, Alpilles). A variety of analytical directional models will be tested with these data. The assumption that no temporal variability of pixel reflectances occurs during the compositing period will be tested using the results of the forthcoming airborne POLDER campaign on the Alpilles site. A simulation of the effect of possibly severe cloud conditions on the retrieved composited reflectance can easily be performed with these data. The validation of all investigated data composition methods can only be indirect, and will be performed on AVHRR time series on the same sites as those of the airborne POLDER campaigns. Validation criteria include the following : (1) When using a directional model, the size of regression residues must be as small as possible, (2) One should obtain essentially the same reconstructed bidirectional reflectance in the compositing process by using different subsets of data with differing viewing configurations, (3) Eliminated data by selection/filtering should correspond to hazy or cloudy days. This work will be performed in the prelaunch phase and will lead to a recommendation

of choice of compositing procedure for VEGETATION. The latter procedure will be tested with VEGETATION data on the same sites as for AVHRR and airborne POLDER. The validation will be basically the same as for AVHRR; some additional verifications will be possible with spaceborne HRV/SPOT4 and POLDER data.

Research on extracting of BRDF information of ground target from simulated VEGETATION data and validation of BRDF models

Principal Investigator: X. LI (IRSA Beijing PRC)

Co investigators: Qijiang Zhu (Dept Geography Beijing),
Chongguang Zhu(IRSA Beijing)

In this proposal, our main experimental region will be set in Sanxia Area (3-Gorge Area) at Yangtze River which ranges E106° -E113° and N28.5° -N33.5° . And our main interests focus on new methods and techniques of processing multitemporal, multiscale, and multiangle data, especially on those that can fit for VGT data. In order to establish the Satellite-Flight-Field 3-level VGT simulation data and validate the BRDF models, we will need three kinds of VGT simulation data VGT simulation data from the 30-meter high tower, airborne VGT simulation data, and the large scale and multitemporal NOAA/AVHRR data. From the 30-meter high tower, we will use spectral radiometer SE-590 to measure the information of the ground targets and take advantages of the changes of solar zenith and azimuth to simulate the multi-angle VGT data. As to the airborne VGT simulation data, wideangle CCD bi-camera system will be used.

Techniques for preprocessing the simulation data consist of radiative and atmospheric corrections, resampling, geometric registration. However, the key elements in extracting BRDF information from AVHRR simulation VGT data will be accurate registration acquired in sequent dates, appropriate atmospheric corrections for different illumination and viewing geometry, selection of BRDF models and inversion algorithm. We will remove the influence of the atmosphere by means of image restoration getting necessary atmosphere references from the multiangle images, perfecting the transfer functions with the image-processing and singal-handling techniques, and finally using Wiener filter to get image restored. For the accurate image registration, such preprocessing procedures as mean value removal, linear sampling, and geometric correction are needed to generate an image of high resolution tower structure, then search for the mathching points with the correlative algorithm based on grey values of the images, and finally, determine the local-adaptive position and grey value for each pixel by double bilinear interpolation method and then produce the registered images. To extract the BRDF information and the 3-dimensional structure information of the vegetation, we will apply algorithms developed for BRDF products of MISR/MODIS of EOS.

Development of Correction Strategies for Spectral Time Profiling of Boreal Forest Reflectance

Principal Investigator: P. SYREN (RS Dep . U. Stockholm Sweden)

Co investigators: G. ALM (RS Dep Stockholm)

The reliability of an estimated environmentally induced spectral change between two or more observations is largely dependent on several steps of radiometric corrections. These corrections are connected to sensor related errors, atmospheric conditions and sun-target-sensor geometry, but also the target condition at the time of observation.

Atmospheric correction of satellite images is a necessary step in multitemporal image analysis and synthesis. Changes in ground reflectance must be correctly interpreted even if the changes are small. Atmospheric modelling using transfer code programs need correct input about the atmosphere at the time of registration of the satellite data. One has often to rely on standard atmospheric descriptions within the transfer code programs in the absence of measured atmospheric parameters. This project addresses the question of estimation the aerosol optical depth from easily obtained measurements of the direct solar irradiance for calculating the Ångström Beta coefficient. The Beta coefficient is a wavelength independent factor that can give the aerosol optical depth, but only under the assumption that aerosol particle size distribution is constant. During the project, the validation of this assumption will be performed.

Other critical atmospheric parameters are water vapour content and ozone concentration. These are also measured and used as input to the atmospheric correction model. The usefulness of the blue and SWIR bands of VEGETATION for estimation of the aerosol and water vapour will be tested. Due to the large scan angle of the VEGETATION sensor, the side looking effect in the backward scattering direction is also a part of the project.

The need of radiometric correction is closely connected to the purpose for which the spectral comparison is made. In such cases where the expected spectral change is of a great magnitude, the scheme for radiometric corrections may be more generalised, compared to a situation where the change is close to the radiometric resolution of the sensor. Vegetation targets, as coniferous boreal forest, is characterised as a low reflectance object. Some typical reflectance values are 0.01, 0.15, 0.07 in the red, NIR and SWIR band respectively. For Swedish conditions the annual spectral variation range is on the order of 10 DN's in Landsat TM band 4, primarily depending on the phenological stage. The range in annual fluctuations is greatest in the NIR wavelength band and decrease through the SWIR and red band. In a long time perspective the spectral evolution with age is strong up to a stand-age of c. 50 year, after which the reflectance remains essentially stable. This general outline of the spectral dynamics may be interrupted by natural events such as forest fire or storm felling, but also by forest management activities as thinning and cleaning-cutting. To extract these components, that influence the forest canopy reflectance, in order to estimate an accelerated spectral trend a far-reaching strategy for radiometric corrections together with a statistically sufficient amount of data is a prerequisite.

To accomplish reliable estimates of spectral change, three major objectives of the proposed research programme are emphasised. On a regional basis, the spectral characterisation of boreal forest in respect to reflectance and anisotropic response is most important. Secondly, a better knowledge of the meteorological influence on canopy reflectance will improve the accuracy of multitemporal analyses.

Development of spectral indices optimized for the VEGETATION instrument

Principal Investigator: M VERSTRAETE (MTV/IRSA/JRC Ispra Italy)

Co investigators: B Pinty (Univ. Clermont-Ferrand)

Vegetation indices have traditionally been used to interpret satellite remote sensing data, for example in terms of land cover types or to estimate simple vegetation characteristics. To the extent that the radiances measured by the sensors at the top of the atmosphere are affected not only by the plant cover but also by the atmosphere and the underlying soil, these indices may be significantly affected by these undesirable perturbations. One approach would be to correct the data to take these effects into account, but this requires access to considerable additional data sets *(e.g.,* the analysis of large amounts of weather data). An alternative approach consists in developing new indices designed to remain sensitive to the presence of vegetation, but also to be less sensitive to these perturbing factors. The first phase of the work described in this research proposal aims at defining a spectral index optimized to monitor vegetation on the basis of the radiometric data which will be produced by the VEGETATION instrument. In the second phase, this new index will be evaluated and compared to existing indices. This evaluation will be based on spatially degraded SPOT data, which exhibit similar spectral characteristics, unless simulated VEGETATION data can be obtained to perform this task. Finally, an assessment of the proposed index after the launch of the VEGETATION instrument will be performed to demonstrate the strengths and weaknesses of this new tool in actual applications.

VEGETATION instrument and MODIS : a joint research and development project on terrestrial monitoring

Principal Investigator: E VERMOTE (Geography Dep. Univ. Maryland, College Park USA)

Co investigators: JC Roger (Geography Dep. Univ. Maryland),
CJ Tucker(NASA GSFC),
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The purpose of this investigation is first to verify the VEGETATION on-board calibration using vicarious calibration methods developed by PI and CO-I's for existing satel]ite platforms. The second part of the study is to apply operational atmospheric correction procedures to the VEGETATION dataset over land. The algorithms for this correction are being deve]oped by PI and CO-I's for the MODerate resolution Imaging Spectroradiometer (MODIS) instrument on-board the EOS platform. The MODIS instrument includes all the VEGETATION channels. The third part of the study is to take advantage of the unique multi-resolution characteristics of the SPOT4 platform, developing and testing appropriate mixture modelling approaches using the both low (Ikm-VEGETATION) and high (20m-HRV) resolution data.

Similarities in the spatial and spectral resolution of VEGETATION and MODIS instruments present important opportunities for development of algorithms and procedures suitable for both instruments. The earlier launch of the VEGETATION instrument provides the means for testing the MODIS algorithms prior to the launch of the first EOS platform. The MODIS algorithm development work in turn will strengthen the utility of VEGETATION data. The calibration of the VEGETATION instrument will be performed on-board by a calibration lamp system. The first point of the proposed study is to validate this calibration with various vicarious calibration methods. These methods use ocean and cloud views both for absolute and relative calibration. The absolute method was first designed for SPOT-4/VEGETATION, then, adapted and coupled with an interband calibrati on as an operati onal method for the NOAA-AVHRR sen sor seri es, and selected by the POLDER science team for the calibration of the POLDER instrument. The intent is to use the lessons learnt on existing systems and adapt the procedures for VEGETATION in order to meet the user driven calibration requirements .

The I km global land dataset with the blue channel provided by VEGETATION will be very useful as a MODIS test dataset. Similarly the algorithms designed for MODIS can enhance the utility of the data provided by VEGETATION. Monitoring of vegetation can be done using individual channels and general indexes such as the Normalized Difference Vegetation Index (NDVI). Such indexes are sensitive to the effects of variable atmosphere. Thus the best way to produce a good quality vegetation index is to incorporate atmospheric correction in the procedure. Methods proposed for the atmospheric correction of VEGETATION data stem from the heritage of several studies which have converged to an operational method. The retrieval of aerosols is a key parameter for atmospheric correction. This inversion is based on finding dark targets. The procedure has been successfully demonstrated for test-case studies and has been selected for MOD1S for development as an at-launch product.

VEGETATION will provide the means to develop and use spectral mixing/unifying analysis for information extraction for a variety of environments. This is expected to be particularly useful in arid and semi-arid areas, where the 4 VEGETATION bands will enable better characterization of soil background effects in areas of sparse vegetation cover. Our intent is to explore the formation of coarse resolution composite images, and then to use high resolution mixing/unmixing analysis to extract more information from these locations .

Sensitivity analysis of compositing strategies : modeling and experimental investigations

Principal Investigator: P. DEFOURNY (Dep Environmental Sciences Univ. Louvain, Belgium)

Co investigators: F Veroustraete (VITO Mol)

The observation of the earth by optical satellite sensors is limited by the interference of clouds and other atmospheric phenomena. When several images are available over a short period of time, individual images can be composited to reduce the atmospheric perturbations. Many algorithms to select the most suitable pixel value for a temporal composite out of a set of measurements obtained at different dates, have been developed to create a mosaic of pixels. First tested for NDVI composites, they are now used for compositing individual reflective channels. These procedures have shown strong radiometric artefacts in the spectral bands. This proposal aims at investigating systematically, the main issues related to the temporal synthesis production using modelling and experimental approaches based on actual data, first derived from a similar sensor and then subsequently from the VEGETATION sensor.

The specificity of the study is to test the sensitivity of the compositing process to the different factors, not only for the NDVI composite but also for the single-channel composite images. A two-step strategy is planned to highlight and quantify the main perturbating factors (anisotropic effects, atmospheric effects, cloud cover type, registration accuracy and radiometric calibration) which affect the consistency of temporal synthesis. Then the objective is to assess the performance of various composite procedures regarding these wellidentified issues. The first step focusing on the characterisation of the perturbating factors to the VEGETATION data, is based on both a bi-directional reflectance model and on empirical observations. This includes a review of the main theoretical issues as well as a systematic observation of the respective factor influences for different land covers and different illumination conditions. For the modelling approach, a physically-based bi-directional reflectance model is selected to carry out the sensitivy analysis. For the empirical approach, VEGETATION simulated time series over Northern Europe.and West Africa provide different land cover types and the seasonal variation insures a sufficient variability in illumination conditions. The conclusions from the modelling studies will be compared and discussed swith the results from the actual data analysis. The second step consist in a performance assessment of the compositing algorithms available from the literature or specifically proposed for VEGETATION. The core of these investigations consist in empirical observations and statistical comparisons of different composites from simulated data for the pre-launch phase and from actual VEGETATION data during the post-launch phase. The goal of our compositing procedure is to approximate with the composite image, as much as possible a single-date cloud free image with constant near-nadir geometry. The limitations of the investigation using only simulated data have to be discussed in the light of the theoretical and modelling contributions.

The perspective of the production environment and the global coverage will be taken into account for the selection of alternative algorithms for compositing. Any appropriate modification or a new strategy for compositing proposed for VEGETATION based either on results of the sensitivity analysis or on the experimental approach, will also be tested. The expected outputs result in clear recommendations for the compositing strategy and statements about the compositing consequences for the land applications.

Mapping and modeling of temporal and bio-physical phenomena of the sahelian wetlands environment using VEGETATION data

Principal Investigator: Pr R. De WULF Dep. of Forest and Water Management University of Gent, Belgium

Wetlands often are at the heart of regional rural economies, and at the same time have very high conservation value. Africa supports some of the worlds largest swamps and some of these occur within the Sahelian zone : the Interior Niger Delta and the Chad Basin (comprising Lake Chad and adjacent floodplains). The last few decades the increase of the human population and the associated increased demand for irrigation water and arable land has put ever greater pressure on these ecosystems. Large-scale hydro-agricultural projects are being planned, comprising large dams and extensive irrigation schemes. Some of these have already been implemented and eventually two-thirds of the wetlands could disappear.

The availability of a baseline data set, providing an accurate picture of current land use, would be an extremely important tool for conservation purposes. In order to improve the insight into the functioning of these ecosystems, it would be interesting to study various environmental parameters. Finally, considering the very dynamic nature of these wetlands, the dataset should preferably include a temporal dimension.

The research will consequently deal with two topics :

- Mapping of land cover of the Sahelian wetlands environment : the mapping will be focused on land cover types, such as open water (permanent and seasonal), aquatic macrophytes, cultivated and natural floodplains, dryland and irrigated agriculture, natural semi-arid grassland and acacia grassland,... From the scientific point of view, special attention will be paid to the dynamic aspects of the response pattern of the respective VEGETATION channels. A second focus will be the assessment of the mapping accuracy by referring to SPOT HRV data.
- Dynamic modeling of temporal bio-physical phenomena of the Sahelian wetlands environment : the methodological aspects consist of the assessment of a one year cycle of the dynamic phenomena within the ecosystems. This will enable the establishment of a framework for further modeling. By using ancillary data mathematical models will be constructed in order to describe the annual dynamic phenomena. Temporal samples will be simulated in order to reconstruct the temporal trajectories of these phenomena. Finally, the long term temporal dynamics will be assessed. This will allow the evaluation of the feasibility of long term monitoring of change patterns by means of VEGETATION data.

The results will have both an operational and a scientific significance. Operationally they will fit within several ongoing projects, such as WCMC's Wetland Digital Map Database, WWF and IUCN's wetland restoration programmes, and the European Community Wetland Programme. Scientifically it is anticipated that the project will provide substantial improvements over present systems for temporal profiling of land features, in particular for wetlands.

VEGETATION data for monitoring woody vegetation in European landscape frameworks

Principal Investigator:	H. GULINCK Institute for Land and Water Management, Leuwen, Belgium
Co investigators	Pol Coppin, Martin Hermy (Katholieke Universiteit Leuwen)

This project seeks to assess the possibilities of implementing VEGETATION data in information databases helpful to European policies concerning rural areas, forestry, green space and environment in general. The basic problem is to find out how the coarse resolution VEGETATION data react to target features in a highly fragmented cultutal landscape.

The work hypothesis is that the VEGETATION signals, and different indices derived from these, can be modeled as functions of the areal contribution of

- relatively stable land cover and landscape categories,
- predictable seasonal variations
- residual characteristics that are due to environmental and other anomalies.

Emphasis will be put on the signal contribution of woody vegetation cover. Furthermore, it is important to present the information content of VEGETATION data in terms familiar to the end user community of planners and of production and protection ecologists.

High resolution remote sensing data (SPOT, Landsat TM) will be used in two ways in this research. Firstly, they will serve as information basis for the resampling to VEGETATION data, concentrating on three seasonal periods. Secondly, the SPOT and Landsat data will be classified and combined with external data sets in order to create land classes and landscape types according to proven methods. These classes and types are a stratification basis for field surveying, enabling the refinement of both the VEGETATION simulation and the basic land cover classification.

Statistical techniques will be used to correlate simulated VEGETATION data to land cover and landscape variables. This will be applied over a study area covering a substantial part of Belgium and parts of the Netherlands and France, an area with contrasting landscape features.

It is expected that such a stepwise approach encompassing the analysis of stable, predictable and residual components will permit an evaluation of the applicability of VEGETATION for different potential users operating in the field of rural and ecological planning.

Disturbed ecosystems dynamics in the Aral sea region by remote sensing and GIS methods

Principal Investigator: Dr R RESSL German Aerospave Research Centre (DLR-DFD) Germany

The main objective of the project is the monitoring of the present state and dynamics of vegetation in the Aral sea region and particularly in the Amu-Dar'ja amd Syr-Dar'ja deltas. The most important parameters are biodiversity and biological productivity of agricultural and non-agricultural lands. For the evaluation of these parameters intra-annual multispectral VEGETATION data will be examined. The collected information will be incorporated in the existing GIS of the Aral sea region. This includes the updating of thematic data layers of the GIS and modeling of future developments of local ecosystems. There is a high need of forecast modeling as the future of irrigation, environment, economic stability and population health is in grave doubt.

VEGETATION data have primary importance to provide monitoring and modeling of degradation processes in the Aral sea region due to several remarkable features, such as simultanity between high resolution data (HRVIR) and low resolution data and a high frequency of data aquisition.

The VEGETATION system allows frequent observation of all study areas, which will be essential to study seasonal conditions and variations and short time phenomena.

Thus the VEGETATION imagery will be important to investigate the current ecological situation and to develop an environmental rehabilitation plan and sustainable development projects in the region.

The application of VEGETATION data and the implementation in the existing Aral sea GIS will have direct relevance to land management and nature conservation. In addition the data will assist to elaborate recommendations on rational and sustainable strategies for further development of the Aral sea region.

The results of the research will be used by local decision makers and planners as well as by several international missions working in this region (e.g. UNESCO, UNDP, etc.)

Mapping, monitoring and modeling of vegetation could contribute to international programs, such as 'Ecological Research and monitoring in the Amu-Dar'ja and Syr-Dar'ja deltas at the Aral sea as a basis for restoration' by UNESCO-BMFT (509/RAS/40), or 'System of observation and monitoring of environmental degradation and desertification in the Aral sea' by the Institute of Geography RAS and others.

Monitoring Boreal Forest Resources in Northern Europe

Principal Investigator:	B. PINTY (LAMP Clermont Ferrand)
Co investigators	Dr H Johnsen & O Engelsen (NORUT-IT) Dr M Verstraete & Y Govaerts (SAI/JRC)

SPATEM: Spatial-temporal integration of satellite data: an image segmentation approach for the improvement of environmental monitoring and modeling with the VEGETATION instrument

Principal Investigator: Dr. Agustín Lobo Instituto de Ciencias de la Tierra "Jaume Almera" (C. S. I. C.) Barcelona SPAIN

Coarse spatial resolution imagery of high temporal frequency has proved to be of great value for the study of terrestrial ecosystems. Several research approaches are being conducted to simulate terrestrial ecological processes with models that use this imagery as a fundamental information. Such models based on coarse spatial resolution (> 1 Km2) appear to be promising at global and continental scales.

Nevertheles, there is an increasing concern on the regional value of predictions produced by models based on coarse spatial resolution imagery.

This is particularly critical for areas (such Iberia) that contain major ecotones and are thus candidates to major environmental impacts in case of global warming. Also, the regional accuracy of models based on coarse spatial resolution imagery is more questionable in Iberia (and the European Mediterranean Region) because the core of landscape fragmentation occurs at an spatial scale similar to the size of the coarse pixel, thus producing a large number of ("mixed") pixels that contain different types of landscape units. On the other hand, high spatial resolution imagery (HRV, TM) that can be used for more appropriate landscape mapping, lacks the essential temporal information.

We propose in this project to integrate the high spatial resolution of the HRVIR sensor with the high temporal resolution of the VEGETATION instrument taking advantage of the simultaneous presence of these two types of sensors in the future SPOT platforms. To accomplish this goal we will use an image segmentation approach (IMORM, Iterative Mutually Optimum Region Merging) developed by the authors. A segmentation-based processing will delimit landscape units in the high spatial resolution imagery and fully inscribed (= "pure") coarse spatial resolution pixels will be selected to provide the temporal dynamics information.

Our objectives are: (i) to give a quantitative phenological description (based on "pure" coarse spatial resolution pixels) of landscape units defined with the high spatial resolution imagery; (ii) to evaluate the improvement introduced by this "pure" phenological signals on satellite-based primary production models; and (iii) to evaluate the improvement introduced by the "pure" phenological signal of VEGETATION over Mediterranean communities versus the AVHRR-NDVI "pure" phenological signal.

This project will use Iberia as a convenient area of study due to its high environmental diversity and its strong climatic gradient. In particular we will focus in a heterogeneous region in which other current environmental and satellite-based research is being conducted by members of the research team.

This research will improve our monitoring and predictions of vegetation properties at a regional scale. As such, it will be relevant for the operational use of VEGETATION in the assessment of the impact of climate dynamics on ecosystems (both natural and agricultural ones) at a regional scale. By selecting an Iberian region as area of study we focus on an area that is particularly threatened from the point of view of global warming and negatively affected by the European Common Agricultural Policy.

This project will complement, take advantage of and contribute to two other current research projects (funded by the Government of Spain and the E.C. respectively) and one more submitted project.

Applications of VEGETATION data to resources management in Arid and semi-arid rangelands

Principal Investigator:	Dr Agnes BEGUE CIRAD-CA MONTPELLIER France
Co investigators	Dr J. Qi & P Heilman (USDA6ARS, US) Dr B IMAM (U. of Arizona, US) Dr G Chehbouni (ORSTOM, Mexico) Dr R Escadafal (ORSTOM, JRC./Ispra, Italy) Dr B Mougenot (ORSTOM, Niger) Dr A Royer & B Djaby (AGRHYMET, Niger) Dr C Watts & H Abias (CIDESON, Mexico)

Arid and semi-arid regions compromised one third of the terrestrial earth surfaces and are vulnerable to environmental changes induced by natural events and human activities. Redistribution of biodiversity and land degradation, as a consequence of environmental changes, directly impact the sustainability of the arid ecosystems. It is, therefore, scientifically and societally imperative to study arid ecosystems as a function of managemental practices and hydrological processes related to the environmental changes.

In this proposal, we propose an investigation of using the data to be acquired with the VEGETATION sensor to seek some practical and operational solutions to these science and societal problems. Two steps will be undertaken in this investigation. The first step will be to use the blue and MIR spectral channels available on VEGETATION sensor to obtain (i) a better quality vegetation indicator by correcting for the soil effects and (ii) information on the soil characteristics, and second step will be to investigate an operational strategy to use the VEGETATION data, after soil corrections, to provide resource managers with critical information on vegetation and soil to help them in making management decisions. The algorithm development and calibration will be carried out with existing ground and satellite data at US, Mexico and Niger sites to ensure generalization capability.

Antarctic snow characteristics from POLDER and VEGETATION data

Principal Investigator:	Dr M FILY Laboratoire de Glaciologie et Geophysique de l'Environnement Saint MARTIN d'Heres France
Co investigators	Dr B Schmitt & C Genthon (LGGE)

The main objective of this proposal is to use VEGETATION with POLDER data to study the albedo of snow in Antarctica. Two main factors which can modify the albedo are the roughness and the grain size, the pollution is negligible in Antarctica. Those factors are changing upon space and time over the ice sheet, they will be studied on a large scale. This study will help the parameterization of the albedo in GCM (Global Climate Models) depending on climate parameters such as the snow accumulation rate, the temperature or the wind.

This proposal is closely linked to 3 other projects which are already accepted and funded:

- Antarctic snow characteristics from POLDER on ADEOS (M. Fily, PI) POLDER data will provide the necessary information on the BRDF that are necessary to interpret the directional VEGETATION measurements
- Investigation and modeling of the physical characteristics and properties of snow at the surface of polar ice sheets (Project Polar Snow accepted by EC, C. Genthon from LGGE is PI) The surface grain size and the snow albedo are important input and output of the metamorphism model we use. VEGETATION measurements will be used to get the spatial and temporal variations of the grain size over the ice sheet.
- Development of a spectro-goniometric system in a cold laboratory for the snow BRDF measurements (coordinated by B. Schmitt from LGGE) The BRDF of smooth snow is necessary to be able to get the roughness and the surface slopes from POLDER measurements. Those measurements will also be used for the reflectance model validation.

VEGETATION is an adequate instrument because:

- it provides images on a large enough scale to study the complete ice sheet
- the middle infrared channel (MIR) depends strongly on the grain size
- MIR channel will help cloud detection

Many studies are presently under development in our laboratories which are directly related to the future interpretation of VEGETATON data:

- development of a snow bidirectional reflectance model
- study of the effect of the snow geometry (size and shape) on the reflectance
- study of the effects of topography and roughness on satellite images.

We are associated to many scientific traverses which are planned in the next years on the Antarctic Ice Sheet. Remote sensing related studies will be done along these traverses for validation, in particular concerning the roughness and the grain size.

A comparative and synergistic study of ATSR2's and the VEGETATION System's response to changes in VEGETATION cover

Principal Investigator: Pr D Llewellyn-Jones University of Leicester UK

Co investigators Pr A Millington, Dr J Wellens, F Gemmel, G. Mackay (Univ. of Leicester)
Dr C Mutlow (Rutherford Appleton Laboratory)

This proposal is to carry out a comparative study of the response of data from the ATSR-2 and the VEGETATION system space-borne sensors to reflected signals from land surfaces with large variationsin vegetation cover. The results will be used initially (Phase 1) to evaluate and simulate the response of the VEGETATION system instrument to changes in vegetation cover; and secondly (Phase 2) to exploit the multi-angle sampling geometries of the two instruments in order to develop synergistic applications of the data to determine the multi-directional properties of the reflected signal from the Earth's surface.

The work draws together two separate observation and analysis programmes using ATSR-2 data to monitor and analyse the characteristics of vegetation in widely contrasting geographic regions, and also draws together the scientific exploitation programmes of two important and innovative satellite sensors, namely ATSR-2 and the VEGETATION system.

The sensor to be used exclusevely in the initial parts of the programme, the ATSR-2, has four reflected VIS/NIR channels (at 1.6, 0.86, 0.67 and 0.55 microns) whose widths and cetre-wavelengths are close to those of the VEGETATION system sensor. A comparative assessment will be carried out on the main characteristics of the two sensors, concentrating on their band-pass characteristics (which are very similar) and on their viewing geometries and sampling characteristics (which are different at the edges of the VEGETATION system swath).

An assessment will also be carried out of the main characteristics of the ATSR-2 channel response to small changes in vegetation cover. As with the VEGETATION system, the sensitivity of ATSR-2 data to vegetation changes is expected to be superior to that of data from sensors such as AVHRR where the bands are relatively broad with respect to the spectral features of the reflected signal from vegetation. Subsequently, data acquired from both sensors will be used to investigate the multi-directional characteristics of remotely-sensed signals from vegetation.