Transnational Access project
HyMedEcos-Gradients

1. General information

Project acronym HyMedEcos-Gradients

Project title Hyperspectral monitoring of Mediterranean ecosystems: gradients of land degradation

Type Scientific project

Scientific theme Assessment of the use of hyperspectral remote sensing data for monitoring spatial and temporal transitions in Mediterranean ecosystems.

Main scientific field and Specific discipline Earth Sciences & Environment / Ecosystems & Biodiversity

Participants undertaking research

<table>
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<tr>
<th>Name + link to id card</th>
<th>Research status</th>
<th>Email</th>
<th>Institution</th>
<th>Institution country</th>
<th>CV</th>
<th>Letter of reference</th>
<th>Publication</th>
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</thead>
<tbody>
<tr>
<td>HOSTERT Patrick</td>
<td>Experienced researcher</td>
<td><a href="mailto:patrick.hostert@eo.hu-berlin.de">patrick.hostert@eo.hu-berlin.de</a></td>
<td>Humboldt Universität zu Berlin</td>
<td>Germany</td>
<td>CV</td>
<td>Publication (4)</td>
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<tr>
<td>ALCAZAR Rita</td>
<td>Post-Graduate</td>
<td><a href="mailto:rita.alcazar@lpn.pt">rita.alcazar@lpn.pt</a></td>
<td>LPN - League for the Protection of Nature</td>
<td>Portugal</td>
<td>CV</td>
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<tr>
<td>FREYALDENHOVEN Andreas</td>
<td>Post-Graduate</td>
<td>reyalデン<a href="mailto:hoven@geographie.uni-bonn.de">hoven@geographie.uni-bonn.de</a></td>
<td>Universität Bonn</td>
<td>Germany</td>
<td></td>
<td></td>
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<tr>
<td>GUERREIRO Isabel</td>
<td>Technician</td>
<td><a href="mailto:guerreiro@esabipbeja.pt">guerreiro@esabipbeja.pt</a></td>
<td>Escola Superior Agrária</td>
<td>Portugal</td>
<td>CV</td>
<td></td>
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</tr>
<tr>
<td>KAUFMANN Hermann</td>
<td>Experienced researcher</td>
<td><a href="mailto:charly@gfz-potsdam.de">charly@gfz-potsdam.de</a></td>
<td>GFZ</td>
<td>Germany</td>
<td>Publication (2)</td>
<td></td>
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<tr>
<td>LEITAO Pedro</td>
<td>Experienced researcher</td>
<td><a href="mailto:p.leitao@geo.hu-berlin.de">p.leitao@geo.hu-berlin.de</a></td>
<td>Humboldt-Universität zu Berlin</td>
<td>Germany</td>
<td>CV</td>
<td>Publication (3)</td>
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</tr>
<tr>
<td>MILTON Edward</td>
<td>Experienced researcher</td>
<td><a href="mailto:e.j.milton@soton.ac.uk">e.j.milton@soton.ac.uk</a></td>
<td>University of Southampton</td>
<td>United Kingdom</td>
<td>CV</td>
<td></td>
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<tr>
<td>MOREIRA Francisco</td>
<td>Experienced researcher</td>
<td><a href="mailto:moreiraisa@sapo.pt">moreiraisa@sapo.pt</a></td>
<td>Instituto Superior de Agronomia</td>
<td>Portugal</td>
<td>CV</td>
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<tr>
<td>OSBORNE Patrick</td>
<td>Experienced researcher</td>
<td><a href="mailto:peo1@soton.ac.uk">peo1@soton.ac.uk</a></td>
<td>University of Southampton</td>
<td>United Kingdom</td>
<td>CV</td>
<td>Publication (4)</td>
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<tr>
<td>PATANITA Manuel</td>
<td>Post-Graduate</td>
<td><a href="mailto:mpatanita@ipbeja.pt">mpatanita@ipbeja.pt</a></td>
<td>Instituto Politécnico de Beja</td>
<td>Portugal</td>
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<tr>
<td>PINTO Manuel</td>
<td>Technician</td>
<td><a href="mailto:mjpinto@fc.ul.pt">mjpinto@fc.ul.pt</a></td>
<td>University of Lisbon</td>
<td>Portugal</td>
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<tr>
<td>SCHMIDTLEIN Sebastian</td>
<td>Experienced researcher</td>
<td><a href="mailto:schmidtlein@kit.edu">schmidtlein@kit.edu</a></td>
<td>Karlsruhe Institute of Technology (KIT)</td>
<td>Germany</td>
<td>Publication (1)</td>
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<tr>
<td>SEQUEIRA Eugnio</td>
<td>Post-doctoral researcher</td>
<td><a href="mailto:eugenio.sequeira@sapo.pt">eugenio.sequeira@sapo.pt</a></td>
<td>LPN - League for the Protection of Nature</td>
<td>Portugal</td>
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<tr>
<td>SUSS Stefan</td>
<td>Post-Graduate</td>
<td><a href="mailto:stefan.suess@geo.hu-berlin.de">stefan.suess@geo.hu-berlin.de</a></td>
<td>Humboldt-Universität zu Berlin</td>
<td>Germany</td>
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<tr>
<td>VAN DER LINDEN Sebastian</td>
<td>Experienced researcher</td>
<td><a href="mailto:sebastian.linden@geo.hu-berlin.de">sebastian.linden@geo.hu-berlin.de</a></td>
<td>Humboldt-Universität zu Berlin</td>
<td>Germany</td>
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Lead scientist's background
(scientific and aircraft measurements background and experience, English level)Physical Geographer with an MSc in GIS and a PhD in Remote Sensing; experience on remote sensing and environmental analysis in semi-arid, urban and forest ecosystems; focus on LULCC and hyperspectral data analysis; member of the
While remote sensing

The aircraft’s core remote sensing instruments, namely its

2/7

HyMedEcos: The climatic regime of the Mediterranean region typically causes

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vegetation and soils will be estimated. The strategies and approaches that were applied to generate these maps, as well as the subsequent

other geo-/biophysical variables that will serve as inputs for ecosystem and ecological models. Additionally, carbon storage potential in

The primary output of the project will be thematic digital maps of land cover, soil quality, biomass, steppe bird distribution and biodiversity and

other geo-biophysical variables that will serve as inputs for ecosystem and ecological models. Additionally, carbon storage potential in

vegetation and soils will be estimated. The strategies and approaches that were applied to generate these maps, as well as the subsequent

analyses and respective results will be published in international, peer-reviewed journals.

References: De Jong, S. M. & Epema, G. F. 2006 Imaging spectrometry: basic principles and prospective applications, Kluwer Academic
Weather conditions. Preferably clear sky conditions, although up to 10% cloud cover is also acceptable.

Time constraints. Time of data acquisition would be preferably within 1.5 hours before local solar noon, though acceptable anytime 2.5 hours before or after local solar noon. In order to answer our research questions, the imagery should be collected during the first half of April, corresponding to the vegetative peak of both annual and perennial vegetation, as well as to the steppe birds’ breeding season. This timing is thus the most appropriate for quantifying all variables relating to vegetation and agricultural use, which are central to the processes being investigated.

Location(s) and reason for that choice. The study area includes the transition from a protected to a non-protected area with distinct land use regimes. The area close to Castro Verde is a Special Protection Area for birds (SPA), with a bespoke agri-environmental scheme aimed at maintaining the traditional cereal farming system to promote steppe bird populations, which are of international importance for some threatened species. However, this farming system also inadvertently promotes soil erosion, which is considered a major threat to the long-term sustainability of the cereal steppe of Castro Verde, which makes the area an interesting case study. At the same time, land abandonment can counteract some negative impacts on ecosystem services on the medium- to long-term time scale, e.g. based on natural succession in abandoned areas and related carbon sequestration. Additionally, the data collection in 2011, in a region partially overlapping with an existing dataset from 2006 (EUFAR project “STEPPEBIRD”), will also allow for a temporal analysis of e.g. vegetation cover patterns and steppe bird populations.

Number of flights / flight hours and flight patterns. We estimate a flight time of c. 2.5 hours duration. The study area should be covered by four (4) parallel flight lines at 4500m altitude, re-flown at 1500m (see uploaded file HyMedEcos_Grade_Flightdesign.pdf for more details). Additionally, one (1) short flight line perpendicular to and crossing the previous lines should be flown at 4500m altitude, to allow for BRDF effects correction.

Other constraints or requirements. None

3. Key measurements required to achieve science aims

Parameter / measurement required. Essential parameters for the achievement of our science aims are detailed surface reflectance, collected by image spectrometer instruments and terrain and vegetation structure data, collected by laser scanning. All these parameters should be collected at two spatial scales (see uploaded file HyMedEcos_Grade_Flightdesign.pdf for more details).

If applicable, specify TA instrument required. None

Instruments to be provided by hosting aircraft operator. (basic instrumentation owned by the aircraft operator described on EUFAR website only) Specim Eagle Hyperspectral Sensor

Specim Hawk Hyperspectral Instrument

Leica ALS50 (II)

Instruments to be provided by scientific group. (Have already been flown. On which aircraft? Do the instruments have their own data acquisition system?) Part of the study area has already been flown (by NERC ARFS’s Dornier 228 in 2006 – EUFAR “Steppebird” project), and CASI-2 imagery and ALTM-3033 data has been collected.

Instrument operators onboard. Comprehensive ground activities will be conducted for the collection of data for the calibration and validation of the airborne data. Spectroscopic measurements of the land surface will be taken throughout the study area, by use of three ASD Field Spectrometers provided by the HU Berlin and the U Bonn. Soils will be sampled for subsequent laboratory analysis for measuring several parameters, indicators of soil erosion, such as moisture, pH, phosphorous, potassium and organic matter. Vegetation parameters to be measured include vegetation type and agricultural use (including fraction cover), floristic composition and species abundance, phenological condition, chlorophyll content (measured with a Minolta SPAD 502 supplied by the HU Berlin), biomass and succession stage. Also, pasture forage quality will be assessed by the estimated amount of crude protein and the in vitro digestibility, as measured by the modified Hohenheimer gas test. Finally, bird survey data will be collected for assessing bird community changes along the gradients of land degradation and use (see uploaded file HyMedEcos_Grades_Sciencecase.pdf for more details).

4. Data processing and analysis

Methodology for handling the data and analysis of output. Flights at two different altitudes – relatively low (1500 m) and high (4500 m) – are planned, which will be used to assess the cross-scale transferability of the developed algorithms. Moreover, the two datasets may be used for cross validation of results, especially with regard to quantitative results, e.g. classification results at 2 m resolution may well be used for validating regression outputs at 6 m resolution. Spectroscopic measurements of land surface will be collected throughout the study area, following a standardised methodology which also accounts for heterogeneity. Field data on soils, vegetation and birds will be collected (see above). Algorithmic development and data analysis for describing the region’s gradual patterns (such as succession state or shrub encroachment, biomass estimation, soil quality, etc.) will focus on two aspects: parameterisation of kernel-based approaches, such as Support Vector Regression and Import Vector Machine models, for image data at both spatial resolutions, for evaluating absolute accuracy and effects of scale. The overall best results will be used for subsequent analysis. The synergies between hyperspectral and laser scanning data and the surplus of such information will be tested. All derived parameters, e.g. relating to vegetation cover, density, biomass, will be incorporated into ecological models, and the respective
ecosystem gradients and transitions quantified. At this stage, novel approaches such as Boosted Regression Trees, Maximum Entropy models and Support Vector Machines will be applied and evaluated.

Resources available to support the project beyond the flying/data acquisition period (funding, cooperation with other projects, manpower for analysis of results and preparation of user report, availability of laboratory facilities…) All equipment and computer facilities necessary for field data collection and for data processing are available within the eight institutes involved. Moreover, the experiment will be linked with several approved projects:
- “EnMAP Core Science Team: Monitoring ecosystem transitions” (BMWi/DLR);
- “Assessment of feeding value of pasture grasslands with hyperspectral remote sensing” (EnMap preparation call, BMWi, Section Agriculture);
- “Practice - Prevention and Restoration Actions to Combat Desertification: An Integrated Assessment” (FP7-ENVIRONMENT / 226818);
- “RuralValue - Sustainable Development of threatened extensive farming systems” (EEA Grants of the European Financial Mechanism / PT0041);

Through these projects, funding is available for personnel and working costs. BSc and MSc students at the various institutions will also use and analyse the data within their study projects.

5. Planning

Starting date: 07-04-2011
Ending date: 07-04-2011

Preferred and acceptable dates (season / time windows) Preferred dates: 01-04-2010 to 08-04-10
Acceptable dates: Anytime between late March and mid-April

Agreement to share aircraft time (project clustering, cost sharing) Yes

6. Other useful comments

Training benefit of the project (e.g. spread potential of airborne research to a wide scientific community; training of research students in experimental planning, methodology, data analysis and applications, etc) This experiment includes a large cooperative network across eight institutions (universities, research institutes and one environmental NGO, including two local institutions) and three countries, which will promote the dissemination to the wider scientific community. Knowledge transfer will occur both within institutions (including the participation of PhD students and several other partners who are inexperienced in airborne research) and between institutions through attendance at scientific conferences. In addition, the collected data will be used in teaching within the academic institutions involved. In particular, BSc and MSc students will process and analyse the collected datasets and thus learn the developed methodologies for handling such data. Moreover, this experiment will be open for receiving students willing to join the field campaigns for the acquisition of ground measurements.

If possible, 3 scientific reviewers that EUFAR may contact Prof. Dr. Manfred Ehlers, Institute for Geoinformatics and Remote Sensing, Universität Osnabrück, manfred.ehlers@uos.de
Dr. Christopher Small, Lamont-Doherty Earth Observatory, Earth Institute, Columbia University, small@ldeo.columbia.edu
Dr. Bogdan Zagajewski, Department of Geoinformatics and Remote Sensing, Faculty of Geography and Regional Studies, Warsaw University, bogdan@uw.edu.pl

Sources of funding of the project and of related projects (if clustering with existing projects supported either by national or other EC funding, how the project add additional or complementary aims to the already funded experiments) The data collected within this experiment will allow the achievement of the objectives of the “EnMAP Core Science Team” project by providing an inter-disciplinary characterisation of ecosystem transitions/gradients in a semi-natural area, including soils, vegetation and birds. Within this project, a further hyperspectral campaign (with the HyMAP sensor / HyEurope 2011 campaign) will also take place, however, this campaign will only allow us to investigate a limited number of processes, as all annual plants will have ended their vegetative period and the bird communities will have ended their breeding season. Thus, the present experiment will greatly improve the project’s research. The project “Assessment of feeding value of pasture grasslands with hyperspectral remote sensing” will also greatly benefit from these data by providing a further study area (with region-specific plant communities) where to test its methodological developments. For all the other projects linked with this experiment, these data will provide a unique opportunity to access remotely sensed data, which will allow the quantification of many parameters which would otherwise remain unstudied.

Scientific training provided by lead scientist to other EUFAR sponsored scientists within the fields of the proposed experiments and analysis Yes

Number of students 15

Number of days recommended 6

Knowledge about EUFAR opportunities from From your colleagues

Related documents
You may need to login to the EUFAR Back Office to see all the documents.

- Project HyMedEcos-Gradients: Flight Design
- Project HyMedEcos-Gradients: Science Case

Comments
From HOSTERT Patrick on 13/12/2010:
Dear TA Coordinator,

The supplementary information provided here directly addresses the questions raised by the reviewers of our initial proposal.

Additionally, the "HyMedEcos_Gradients_Sciencecase.pdf" has been revised and updated, to incorporate the changes suggested by the reviewers.

1. Rev. A: Satellite data could be a good solution for a pre-reconnaissance of the researches.
   Full orthophoto coverage of the study area has been purchased by the Humboldt-Universität zu Berlin. These data were collected by the IGP (Portuguese Geographical Institute) in 2009, with a spatial resolution of 0.5m, and with spectral information in four channels (Visible and Near Infra Red). These data will be used for pre-reconnaissance of the area, as well as for sorting the field-sampling points according to a stratified random scheme.

2. Rev. B: Too many sub-objectives; possibly organize hierarchically.
   Rev. C: Specific objectives are not explicitly stated; too many objectives.
   This was a clear issue as two reviewers mentioned it. We have thus re-structured the proposal's foci into two main components: above ground biomass and carbon storage in natural vegetation; and biodiversity (steppe birds and their habitats). By doing this we have excluded some components, such as the characterisation of afforestations and the soil component (see reply to comment 4, below), making the study more focused and with more clearly defined objectives.

3. Rev. B: Data sampling scheme (for calibration and validation) not specified.
   An additional paragraph has been added to the revised Science Case document, with some further description of the field data sampling scheme, as well as additional information being added in the respective sub-sections. On each of the specific project components, model validation will be performed by cross-validation procedures, thus avoiding the need for extra data sampling.

4. Rev. B: Soils study is not capable of meeting the aims: seasonal problems (difficult to relate soil properties with vegetated surface particularly critical during the peak vegetative period of vegetation); no method to derive soil quality specified; lack of soil erosion studies to determine local pedotransfer functions.
   Rev. C: Lack of soil texture measurements.
   This component was identified as a weak (and diverting) element in the original proposal. Indeed, in order to allow for full characterisation of the gradients in soil erosion, we acknowledge that it would be necessary to conduct further experiments and soil analyses, which would move the study too far from our main aim. We have therefore re-structured the proposal into two main foci (above ground biomass and carbon, and biodiversity), omitting the soil component. This approach sharpens the focus on the key questions of interest.

5. Rev. C: How to estimate carbon storage from collected data?
   The above ground carbon can be directly estimated from the above ground biomass values. For example, according to Navarro Cerrillo & Blanco Oyonarte (2006), in Mediterranean shrubs, ca. 50% of the biomass corresponds to carbon. In this way, the above ground carbon storage can be estimated for the whole of the area, and the changes in storage potential along the environmental gradients monitored.

6. Rev. C: The proposed airborne data collection is not adequate to analyse phenological gradients.
   The use of the term phenology was probably misleading as we did not intend to analyse phenological gradients, for which much more data collection campaigns would be necessary.
   On one side, we are interested in investigating the spatial gradients in vegetation conditions, in relation to land degradation. For example, it is expected that the development patterns of grassland vegetation on top of the hills (most degraded, with shallower soils) to be quite different from those on the valley bottoms, particularly in what regards to biomass and cover.
   In respect to perennial (shrub) vegetation, temporal changes in the species spectral behaviour are expected between the spring and summer (Calvão & Palmeirim, 2004). In order to derive methods of estimation of shrubland biomass/carbon based on spectral measurements (relevant for future monitoring by airborne or spaceborne sensors), these changes need to be incorporated.

With best regards,

Patrick Hostert

7. Reporting

Campaign dates: From 29-03-2011 to 27-04-2011

Participants

<table>
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<tr>
<th>Name</th>
<th>First time flying this aircraft</th>
<th>Participation in the campaign</th>
<th>Number of visits to campaign</th>
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<td>FREYALDENHOFV N Andreas</td>
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<td>GUERREIRO Isabel</td>
<td>Yes</td>
<td>Remotely</td>
<td>0</td>
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<td>KAUFMANN Hermann</td>
<td>Yes</td>
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Pre-processing of hyperspectral data was concluded. Digital Surface Models (DSM) and Digital Terrain Models (DTM) were produced for all LiDAR data acquired. The TOC and 1148 individuals of 45 different species recorded. Data analysis: All analogue data has been digitised and all acquired data is being processed so far, the data do not include boresight information, which will hinder the geographic rectification of these data. Finally, the spectral metadata and supplementary data provided were partly inconsistent and erroneous, particularly the data at the higher altitude. Comparing several reflectance spectra with field spectra collected in our test site in the town of Castro Verde, white targets show to be systematically underestimated, while those of black targets were rather overestimated. Additionally, a large majority of all data points (99.43% and 99.92% in the data collected at the low and high altitude, respectively) has information from only a single return. Although this does not affect the calculation of the digital surface, digital terrain and canopy height models, it can possibly compromise the calculation of a vegetation density model, potentially useful as supplementary data for the shrub biomass estimations. While the aerial photography data has not been processed so far, the data do not include boreight information, which will hinder the geographic rectification of these data. Finally, the spectral metadata and supplementary data provided were partly inconsistent and erroneous, particularly the data at the higher altitude.

Main achievements / Further plans for analysis
The flight campaign was joined by comprehensive ground activities including the acquisition of field spectra for image data calibration and for model validation / calibration, of shrub and grassland vegetation data at the plot level, and of data on the bird communities at the landscape level. The flight campaign thus took place from 29th of March to 27th of April in 2011, as described below. Land cover mapping: During the campaign, large areas of the study region were mapped according to a purposely-defined hierarchical mapping scheme. Field spectroscopy: Field spectroscopic measurements were taken for two main purposes: reference spectral measurements of selected targets were collected for image data calibration (and validation); and spectroscopy data of different land cover types (with particular focus on the dominant shrub species and on fallow pasture vegetation) were collected for further data analysis. The measurements were collected using two Analytical Spectral Device (ASD-3) full range field spectrometers. A total of 174 shrub spectra and 293 spectra of non-shrub features (mostly grassland vegetation) were collected. All spectral measurements were acquired within nine days after the overflight to guarantee comparability to the airborne imagery. Plot vegetation sampling: In total, 90 shrub plots and 32 grassland plots within the flight lines, and 34 grassland plots around the flight lines, were sampled. In the shrub plots, top-of-canopy photography (at a height of ca. 4.5m above ground) was acquired, for the estimation of shrub vegetation fractional cover. Also, allometric measurements (maximum crown height, and both larger and smaller crown diameters) were taken on all shrubs within a sampled plot, in order to estimate plot shrub biomass. Additionally, we collected an extra sample of ca. 60 young shrub plants of both Cistus shrub species, in order to complement the existing allometric formulas. In the grassland/pasture plots, 3 representative vegetation samples were collected per plot for the forage quality analysis. For estimating grassland biomass, 15 plate meter measurements were taken for each grassland plot within the flight lines. Bird community sampling: In order to guarantee a representative sampling scheme, we defined five different land cover configuration classes with distinct shrub coverage, which characterises the shrub encroachment gradient observed in the study area. The bird sampling was constituted of 10 minute duration counts on circular plots representative of the shrub biomass estimations. While the aerial photography data has not been processed so far, the data do not include boreight information, which will hinder the geographic rectification of these data. Finally, the spectral metadata and supplementary data provided were partly inconsistent and erroneous, particularly the data at the higher altitude.

### Field spectroscopy
Field spectroscopic measurements were taken for two main purposes: reference spectral measurements of selected targets were collected for image data calibration (and validation); and spectroscopy data of different land cover types (with particular focus on the dominant shrub species and on fallow pasture vegetation) were collected for further data analysis. The measurements were collected using two Analytical Spectral Device (ASD-3) full range field spectrometers. A total of 174 shrub spectra and 293 spectra of non-shrub features (mostly grassland vegetation) were collected. All spectral measurements were acquired within nine days after the overflight to guarantee comparability to the airborne imagery. Plot vegetation sampling: In total, 90 shrub plots and 32 grassland plots within the flight lines, and 34 grassland plots around the flight lines, were sampled. In the shrub plots, top-of-canopy photography (at a height of ca. 4.5m above ground) was acquired, for the estimation of shrub vegetation fractional cover. Also, allometric measurements (maximum crown height, and both larger and smaller crown diameters) were taken on all shrubs within a sampled plot, in order to estimate plot shrub biomass. Additionally, we collected an extra sample of ca. 60 young shrub plants of both Cistus shrub species, in order to complement the existing allometric formulas. In the grassland/pasture plots, 3 representative vegetation samples were collected per plot for the forage quality analysis. For estimating grassland biomass, 15 plate meter measurements were taken for each grassland plot within the flight lines. Bird community sampling: In order to guarantee a representative sampling scheme, we defined five different land cover configuration classes with distinct shrub coverage, which characterises the shrub encroachment gradient observed in the study area. The bird sampling was constituted of 10 minute duration counts on circular plots with 125m distance limit, and all visual and auditory bird observations were registered. The sampling locations were purposely chosen in the study area. The sampling locations were purposely chosen in the study area. The sampling locations were purposely chosen in the study area. The sampling locations were purposely chosen in the study area.

### Main achievements / Further plans for analysis
The flight campaign was joined by comprehensive ground activities including the acquisition of field spectra for image data calibration and for model validation / calibration, of shrub and grassland vegetation data at the plot level, and of data on the bird communities at the landscape level. The flight campaign thus took place from 29th of March to 27th of April in 2011, as described below. Land cover mapping: During the campaign, large areas of the study region were mapped according to a purposely-defined hierarchical mapping scheme. Field spectroscopy: Field spectroscopic measurements were taken for two main purposes: reference spectral measurements of selected targets were collected for image data calibration (and validation); and spectroscopy data of different land cover types (with particular focus on the dominant shrub species and on fallow pasture vegetation) were collected for further data analysis. The measurements were collected using two Analytical Spectral Device (ASD-3) full range field spectrometers. A total of 174 shrub spectra and 293 spectra of non-shrub features (mostly grassland vegetation) were collected. All spectral measurements were acquired within nine days after the overflight to guarantee comparability to the airborne imagery. Plot vegetation sampling: In total, 90 shrub plots and 32 grassland plots within the flight lines, and 34 grassland plots around the flight lines, were sampled. In the shrub plots, top-of-canopy photography (at a height of ca. 4.5m above ground) was acquired, for the estimation of shrub vegetation fractional cover. Also, allometric measurements (maximum crown height, and both larger and smaller crown diameters) were taken on all shrubs within a sampled plot, in order to estimate plot shrub biomass. Additionally, we collected an extra sample of ca. 60 young shrub plants of both Cistus shrub species, in order to complement the existing allometric formulas. In the grassland/pasture plots, 3 representative vegetation samples were collected per plot for the forage quality analysis. For estimating grassland biomass, 15 plate meter measurements were taken for each grassland plot within the flight lines. Bird community sampling: In order to guarantee a representative sampling scheme, we defined five different land cover configuration classes with distinct shrub coverage, which characterises the shrub encroachment gradient observed in the study area. The bird sampling was constituted of 10 minute duration counts on circular plots with 125m distance limit, and all visual and auditory bird observations were registered. The sampling locations were purposely chosen in the study area. The bird sampling was constituted of 10 minute duration counts on circular plots with 125m distance limit, and all visual and auditory bird observations were registered. The sampling locations were purposely chosen in the study area. The bird sampling was constituted of 10 minute duration counts on circular plots with 125m distance limit, and all visual and auditory bird observations were registered. The sampling locations were purposely chosen in the study area.
allometric formulas for estimating shrub biomass is in progress, which will result in plot shrub biomass estimations. Approximately half of the grassland vegetation samples have been analysed for forage quality. The Import Vector Machine (IVM) model routines have been implemented and test runs have been conducted on the field spectra. Further plans for analysis: Some of the next steps in the analysis include: - the spectral data post-processing (such as absorption bands removal, data mosaicking and EnMAP-simulation); - IVM models for estimating shrub fraction of cover, applied to all scales of analysis (field spectra, airborne and EnMAP-simulated data) and cross-scale comparisons; - Support Vector Regression (SVR) / Partial Least Squares Regression (PLSR) models for estimating shrub biomass from the plot to the EnMAP scale; - PLSR models for estimating grassland biomass at the EnMAP scale; - Grassland forage quality estimation at the EnMAP scale; - Further processing of the LiDAR data for producing Vegetation Height Models (VHM) and possibly Vegetation Density Models (VDM); - Synergistic uses of hrsi and LiDAR data for estimating shrub biomass; - PLSR / Generalized Dissimilarity Modelling (GDM) models for estimating shrub and bird community transitions; - Publication of all methodological developments and results in peer-reviewed international journals.

Difficulties encountered
Although the service providers supplied a software tool for the geometric correction of the hrsi (APL), after extensive tests on the data, we decided to use a third-party software (PARGE). PARGE is not only a standardly accepted software for remote sensing imagery pre-processing, but it showed to be the most suitable platform for integration with the ATCOR software package for atmospheric correction. Particularly the data formats and products (e.g. DEM-derived products) produced/required by APL were not directly compatible with ATCOR. Additionally, the processing of large amounts of data was not possible in APL thus requiring a tiling routine to split the data into small samples of spectral bands (10 to 30 bands, depending on the data size), which slowed down greatly the processing workflow during the test runs. Also, processing large amounts of data in APL sometimes resulted in erroneous image artefacts. Finally, the delivered data had an uncorrected spectral smear problem which concerns the brightest surfaces, including all white targets in our reference sites, thus severely constraining the radiometric calibration of the data.

Publications linked to the project

Website of the project