External studies at University Jaume I

Final report

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Matriculation number 350317

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1 Introduction

During ten months I stayed as an exchange student at the University Jaume I (UJI) in Castellón de la Plana, Spain. The exchange was facilitated by the ERASMUS+ support program of the European Union. The purpose of my stay was the fulfillment of the *external studies* module of the Master's program in Geoinformatics at the University of Münster. Beyond the mandatory duration of one semester, I obtained an extension and stayed for ten months in total. The additional time allowed me to contribute further to the university's research projects and to explore possible topics of my Master's thesis.

Castellón de la Plana is the capital of the province Castellón and lies on the eastern coast of Spain. The province belongs to the autonomous community of Valencia. Official languages are Valencian and Spanish (i.e. Castilian). The city Castellón has about 170.000 inhabitants [11]. The university, henceforth abbreviated UJI, [14] was founded in 1991 and has currently about 15.000 students. I stayed at the University Institute for New Imagining Technologies (INIT), where I did project work within the Geospatial Technologies Research Group (Geotec)[8].

Professor Joaquin Huerta (huerta@uji.es) supervised me locally in his function as the director of Geotec. My supervisor at the University of Münster was professor Edzer Pebesma (edzer.pebesma@uni-muenster.de), who is also responsible for the Master's program's external studies module. Doctor Christoph Brox (broxc@uni-muenster.de) coordinates student exchanges between the Institute for Geoinformatics in Münster and the UJI. In this function, he assisted me regarding organizational matters and planning. Doctor Sven Casteleyn (sven.casteleyn@uji.es) guided my project work at the Geotec research group.

A learning agreement, created ahead of my stay, specifies the objectives of my studies. They encompass attending the *Master Thesis Seminar* that is part of the Master's program in geospatial technologies (2 ECTS), and project work equivalent to 27 ECTS. For the latter objective, I worked during the first two months for the research project *GI-N2K*[12] and dedicated the remaining time to the project *ERMES* [2, 6].

This report is structured as follows. Chapter 2 and 3 describe the GI-N2K and ERMES projects, respectively. My contributions to each project are outlined in separate subsections. Chapter 4 summarizes the results of the external studies and matches them with the requirements of the external studies module. Chapter 5 discusses the overall experience and draws a conclusion of this report.

The appendices consist of a confirmation letter from Joaquin Huerta about the project work and a transcript of records provided by the UJI that includes my grade of the 'Master Thesis Seminar'.

2 The GI-N2K project

2.1 Project description

The notion GI-N2K stands for *Geographic Information: Need to Know*[12]. It is an international research project that started in October 2013, funded by the European Commission (EC) for a duration of 36 months.

Initiators of the project identified shortcomings of the current education of geospatial professionals. Employers often have difficulties with finding well-trained employees. It is assumed that graduates of academic institutions are inadequately prepared for the demands of the European labor marked.

The project links 31 academic and non-academic partners from 25 European countries together. In a community effort, they seek a consent upon what geospatial professionals in Europe need to know and should be able to do. This consent shall manifest itself in a comprehensive *Body of Knowledge (BoK)* that describes the domain of Geographic Information Science and Technology (GI S & T). Similar works already exist, notably the *Geographic Information Science and Technology Body of Knowledge (BoK 1/e)*, published by the Association of American Geographers in 2006 [4, 5]. The GI-N2K project seeks to create an updated, dynamic version based on this work, adjusted for the European education and labor market. The existing BoK is a book that emerged from a community of US-American scientists and practitioners [5]. It seeks to be a reference and guide for infrastructures in science, education, and society. The BoK is hierarchically structured into 10 knowledge areas that contain 73 units (25 core-units). The units are composed of 329 topics, which are described by a total of 1660 education objectives.

The GI-N2K project already conducted two survey studies for the revision of the BoK. Questionnaires were sent to actively working professionals (survey of *Workforce demand in GI S & T*), and to academic institutions in Europe (survey of *GI S & T Teaching supply*). First results were published by Hofer et al. [10] and on the project's official website [4].

2.2 Contributions

The UJI aims to contribute to the GI-N2K project with a web browser-based tool for academic curriculum planning. Besides the book, a dynamic, web-based version of the Body of Knowledge already exists. It is implemented in JavaScript Object Notations

(JSON) and made available as a web service. The JSON document allows querying individual elements of the BoK using the Document Object Model (DOM). This setup enables visualizing the content dynamically and browsing interactively through knowledge areas, units, topics and their descriptions. It was my task to visualize the BoK using the service and the JavaScript library D3.js. The general approach to work with such data-driven documents was published by Bostock et al. [1].

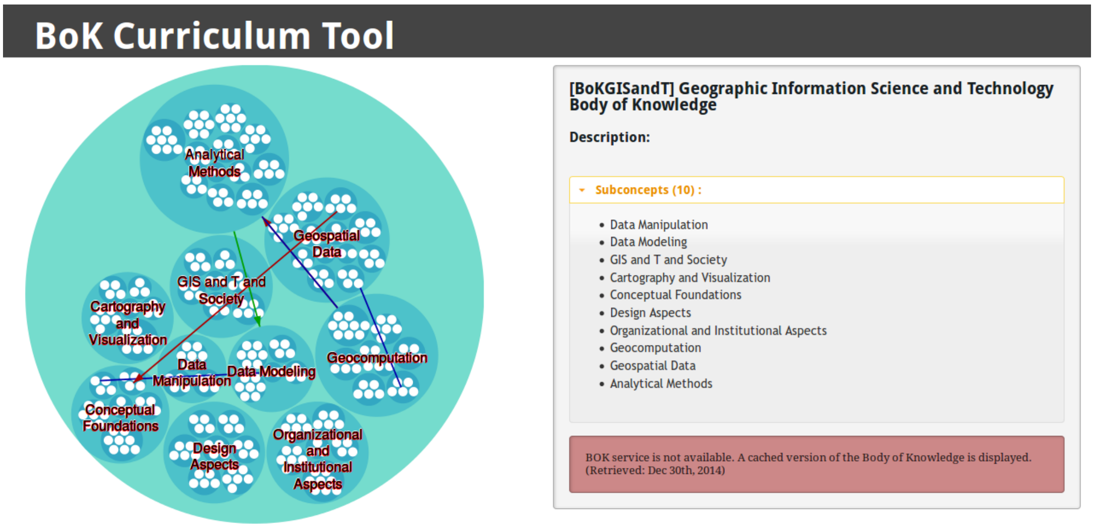

Figure 1: Browser-based visualization of the GI S & T BoK for academic curriculum planning. While users browse through concepts of the BoK with the dynamic diagram on the left, the box on the right simultaneously displays detailed information. The arrows and lines symbolize imaginary cross-relations between the concepts.

Figure 1 shows a screenshot of the implemented prototype[1]. On the left side is an interactive diagram, based on a so-called circle-packing layout[2]. The circles represent concepts of the BoK that are nested according to the hierarchy. Specifically, that means that the ten largest circles represent knowledge areas and that they contain smaller circles, representing units, which, in turn, contain circles representing topics. Users can browse through those elements by mouse interaction. Details about particular items selected by the user are displayed in the information box on the right, i.e. descriptions, dependencies, and education objectives. The box consists of a dynamic text field (for descriptions) and multiple content panels organized by collapsible tabs so that the information of interest is displayed in a concise manner without taking too much space of the screen.

[1] The source code of the *BoK curriculum tool* is online available at https://github.com/MatthiasHinz/GIN2K-BOK-Tool (Last access on Oct. 20th, 2016).

[2] D3.js and the documentation, including examples and information of the circle-packing layout, are online available at https://d3js.org/ (Last access on Oct. 20th, 2016).

Displaying cross-relations between concepts was a challenging part of the task. It was a mandatory to find suitable visualizations showing that (1) two concepts are similar to each other, (2) one concepts pre-requires another, and (3) one concept post-requires (i.e. builds upon) another. Knowing such dependencies enables modeling educational pathways. Such pathways define how students have to traverse the BoK for achieving different educational outcomes. A student, for instance, may need to complete certain units of the knowledge area *GIS and T and Society* learning about *Geocomputation.* Such cross-relations are represented by arrows and lines in different colors, as displayed Figure 1. For the prototype, the relations are set arbitrarily because real data about them was not yet available for being included. D3.js provides no means to implement such arrows in the diagram, so it required additional JavaScript programming and testing to make them display and scale correctly together with the diagram.

The prototype makes use of the HTML/CSS framework Yaml[3] for implementing a simple grid-based website layout. The information box is implemented using the JavaScript library JQuery UI[4], which enables the collapsible content panels (Accordion). The layout of the tool was adjusted and tested with different browsers, screen resolutions and operating systems.

It was planned to enhance the prototype with an editor for curricula, where users can drag and drop concepts from of the BoK to the target document. This task was passed on to other developers. The source code of the tool includes extensive comments and a readme file with developer notes, which assures that the software can be understood and modified by others.

I carried out the work on this contribution on my own, i.e. as the only developer. The development was accompanied with weekly meetings with Dr. Sven Casteleyn. We discussed the approach, milestones, and technical issues that occurred during the work.

3 The ERMES project

3.1 General project description

ERMES [2, 6] is an EC-funded, international research project of three years duration (2014-2016) and dedicated to the European rice economy[2]. The acronym ERMES stands for *an **E**arth obse**R**vation **M**odel-based ric**E** information **S**ervice.* Coordinator of the project is the *Institute for Electromagnetic Sensing of the Environment* that belongs to the *National Research Council of Italy* (CNR-IREA). The project aims to make rice cultivation more economical, efficient and sustainable by providing analyses and forecasts of crop conditions. The challenge is, on the one hand, that negative impacts of agriculture must be minimized, for instance, by economizing the use of natural resources, pesticides, and fertilizers; on the other hand, we need efficient ways to produce stable food for nourishing the growing word population.

[3]The YAML framework and documentation are online available at http://www.yaml.de/ (Last access on Oct. 20th, 2016).

[4]The JQuery UI library and documentation are online available at http://jqueryui.com/ (Last access on Oct. 20th, 2016).

Rice is one of the most important crops on the global food market. Data of the *Food and Agriculture Organization of the United Nations* (FAO)[7] indicate that in 2014 about 0,4% of the world's rice production (circa 2.9 million tons) originated from the European Union. Of this amount, 48.3% were produced in Italy, 30.1% in Spain, and 9.4% in Greece. Hence these countries are the biggest rice producers in the EU. ERMES brings together partners from each of these countries and from Swiss. Consequently, three regions of the top-producing countries were selected as study areas: the Piedmont-Lombardy district in Italy, the Valencian rice district in Spain, and the Thessaloniki / Serres rice districts in Greece. The primary objective of ERMES is to gather data about these regions, to perform crop modeling, and to provide thus obtained information as web services to stakeholders of the European rice economy. Those stakeholders are rice farmers, private companies, regional authorities, and agro-environmental policymakers.

The ERMES system [2], which is the core of the project, shall encompass two services; the *Regional Rice Service* (RRS) shall allow regional authorities to monitor and oversee the rice planting of a larger region, and the *Local Rice Service* (LRS) shall provide farmers and local rice businesses with detailed information at farm-scale, including high-resolution maps of the area of interest. A web-based geoportal shall make these services accessible. Rice farmers, in addition, shall be provided with a smart app for phones and tablets that enables them to obtain in-situ observations and receive location-based information, for instance, risk alerts. On the long run, it is aimed to expand solutions developed in ERMES to the global rice marked, in particular, to Africa and Asia.[2]

3.2 Activities at the UJI

The ERMES project is structured into 12 work packages (WP) [6]. Responsibilities for the packages are divided among the project partners. Therefore the UJI leads work package 7 – *geo-services for information management: integration and communication*, with Sven Casteleyn as the package leader. The package targets establishing a state-of-the-art Spatial Data Infrastructure (SDI) (Task 7.1) that incorporates ERMES data products from different partners and sources and exposes them as services. The data includes Earth Observation (EO) products, meteorological data, and in-situ observations (from the smart app). Derived products (e.g. yield estimations and risk predictions) are obtained, amongst others, from the WARM rice model [3]. Based on this SDI, the UJI develops the above-mentioned geoportal for visualizing and exploring ERMES data products (Task 7.2) and also develops the smart app for rice farmers (Task 7.3).

Deliverables of each work package consist of extensive reports, which are enlisted at the project's official website [2]. One core achievement of the UJI's team during my stay was the prototype of the geoportal for the Regional Rice Service, called the regional geoportal. Therefore I co-authored the corresponding *Deliverable 7.4 - Report on Regional Service Geoportal V0*[9]. The prototype was first demonstrated at the annual project meeting held in May 2015 in Valencia, which I also attended.

Figure 2 is a screenshot of the presented prototype. The depicted map shows the vegetation index NDVI derived from MODIS satellite imagery of the Italian Lombardy. Green color indicates large amounts of chlorophyll and therefore locations where live green plants carry out photosynthesis. Shades of yellow indicate moderate to small amounts and red color absence of chlorophyll. The NDVI maps are used for monitoring the development and distribution of vegetation. Other maps indicate, for instance, the presence of rice plants or potential abiotic risks.

Users of the portal can choose between different data products (weekly NDVI maps, in the example) and between dates. All ERMES products have a spatial and a temporal dimension, i.e. they mostly consist of periodically updated, consecutive series of maps. Besides the map, figure 2 also shows a time-series of all NDVI values over the course of the year 2014 for a selected pixel location, from which seasonal changes become apparent. A slider widget of the prototype (not depicted herein), allows users to do a side-by-side comparison between two maps from different times or even different products.

Current prototypes of the ERMES geoportal and smart app are available online[5].

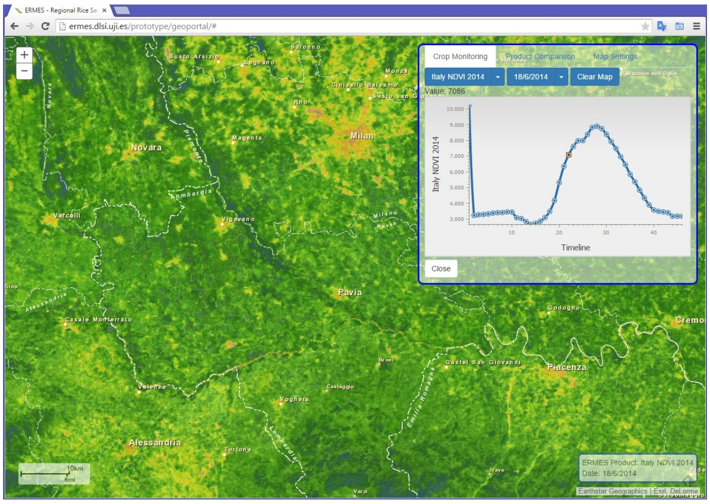

Figure 2: Screenshot of the Regional Geoportal with an NDVI map of the Italian Lombardy and a time series showing seasonal changes of local vegetation

The development team of the UJI started working in December 2014 and consisted of about six people. We began setting up a basic SDI and then prioritized the regional geoportal, which had to be fully operational, although with minimal functionality, until the annual meeting in May. Afterward, the focus shifted towards the Local Rice Service. We extended the geoportal with a *local profile* that shows farm-scale maps of high resolution and also prioritized the development of a smart app prototype.

The project work was organized according to the principles of Scrum [13], a methodology of agile software development. The schedule was divided into so-called sprints that last for one month. Each sprint began with a planning meeting and ended with a review meeting. In the meantime, development work was conducted on a daily basis. In the planning meeting, the project requirements were assessed and compared with current

[5]The website of the ERMES prototypes:
http://ermes.dlsi.uji.es/ (Last access on Oct. 22th, 2016).

state of work. As a result, we defined a set of features targeted during the sprint. During the review meeting, we discussed achievements as well as issues that occurred. A temporal log documents each sprint with its main activities and the achieved milestones. In periodic Skype meetings, the progress was also discussed with the project partners. Feedback from stakeholders and end-users was obtained during project meetings and local workshops (e.g. the during the annual meeting in Valencia).

Team members met on a daily basis in the office for working and swiftly exchanging information. Members who were temporarily absent reported via E-Mail or Skype to the others. Issues and problems were frequently discussed in E-Mail correspondences that often involved fellow researchers and project partners from other countries and institutions. The source code of client applications was stored in a collection of online repositories[6] on the web platform GitHub, and thus accessible to all project members.

3.3 Contributions

This section highlights some of my main contributions to the ERMES project. My primary task was server-side development and server administration, therefore providing web services for the geoportal and smart app. In this context, I worked closely together with Carlos Granell, the task responsible for setting up the SDI and the ERMES regional service (tasks 7.1 and 7.2)[6].

My first task was to configure a virtual machine on the UJI's internal server cloud, to install all required software and to create a documentation of the setup for all team members. The machine has the following components and functions: (1) An FTP-server that allows data providers to push geodata to the server, (2) an HTTP-server for deploying and hosting the prototypical geoportal and smart app, (3) Software for managing the geodata and setting up geospatial web services, i.e. ArcGIS for Server and ArcGIS Desktop 10.3, as well as a PostGIS database.

The server machine acts as a centralized data repository for the ERMES system and thus implements the so-called *GIS subsystem*. The subsystem mediates between the data and metadata- providers (the EO subsystem) and the web-based *client applications*; ERMES products are created and processed by different project partners and regularly uploaded to the server via FTP. The data is thus centralized on the server in order to ease the maintenance and for setting up geospatial web services based on local files. Importantly, this system design avoids performance penalties on client applications due to needless data transfer within distributed systems.

The data repository on the server is a file-based system that follows a strictly specified folder structure and file naming conventions. Most of the data products are series of raster data files (i.e. 1-band GeoTIFF files), stored in folders named after the product and product parameters. For instance, the daily maximum temperatures in northern Italy are stored under the path `..\IT\Regional\IT_EP_R4_Meteo\2014\TMax` and consists of 365 GeoTiff-files named `IT_Meteo_TMax_2014_ddd.tif`, while 'ddd' is an incremental number. Few data was also given in vector format, notably auxiliary data like

[6]The ERMES source code repositories are online available at https://github.com/ermes-fp7space/ (Last access on Oct. 22th, 2016).

administrative areas and parcels of rice fields dedicated to the local rice service.

A significant amount of my work consisted of setting up geospatial web services using different data structures, map projections, and service parameters. The results were then discussed within the team, especially in terms of performance. We often ran into technical issues and limitations when implementing new features and thus had to explore different solutions and workarounds. Some of the most important points were the services' speed/performance and how to properly visualize them. On the client side, we had to find methods for obtaining pixel-wise values and time series from a stack of raster values (the solution was to set up an ESRI image service based on a mosaic dataset and then to use the 'identify'-method of the client API). To reduce long-term maintenance costs, we worked on automatically setting up and updating services by running scheduled Python scripts on the server. Given a large amount of data from different datasets, it was difficult to decide which and how many services we need to set up on the long run. Also, there was great concern about the usability and understandability of our services, i.e. end-users of the system are usually not GIS experts and might repel an overburdened geoportal with many services and non-intuitive functionality.

Issues also occurred when working on the smart app. It is one objective of the app that it should be operable in offline mode because it dedicated to rice farmers that may use it in rural areas where mobile internet is not available. It was decided to use a basemap service with aerial imagery, upon which a grid of rice field parcels is overlaid. The map tiles shall be downloaded for a particular area of interest before the user goes offline. The challenge was to keep the amount of data small while at the same time providing images of high resolution. Furthermore, we struggled with technical limitations of the client-side map library and it turned out being difficult to customize third-party basemap services for our purposes. In consequence, I created a set of custom basemaps services based on local files. Therefore I combined the existing auxiliary data with freely available geodata from the web, for instance, Landsat-8 satellite imagery provided by the NASA and USGS[7], as well as place names and locations from the GeoNames geographical database [8]. These basemaps finally worked together with the smart app as intended, but the team criticized that the imagery appears too blurry when zooming in. The reason is that Landsat-8 images have a maximum resolution of only 15 m per pixel, which was to our knowledge, the highest resolution of any freely available file-based remote sensing imagery that covers the study areas completely. The development group then decided to request commercial satellite images of higher resolution and to keep the basemap services as a temporary solution.

A smaller contribution to the project emerged from my initiative; as one of the study areas with rice fields is located not far from Castellón, I decided to travel there and explore it by myself. The fields are located at the Albufera Natural Park, in the surroundings of the Albufera freshwater lagoon. On May 31st, 2015, I took 290 photos of rice fields and the landscapes nearby the village Sollana. The collection is freely available on the internet and permitted for free use, in particular for the ERMES project. I used a

[7]http://earthexplorer.usgs.gov/ (Last access on Oct. 22th, 2016).
[8]http://www.geonames.org/ (Last access on Oct. 22th, 2016).

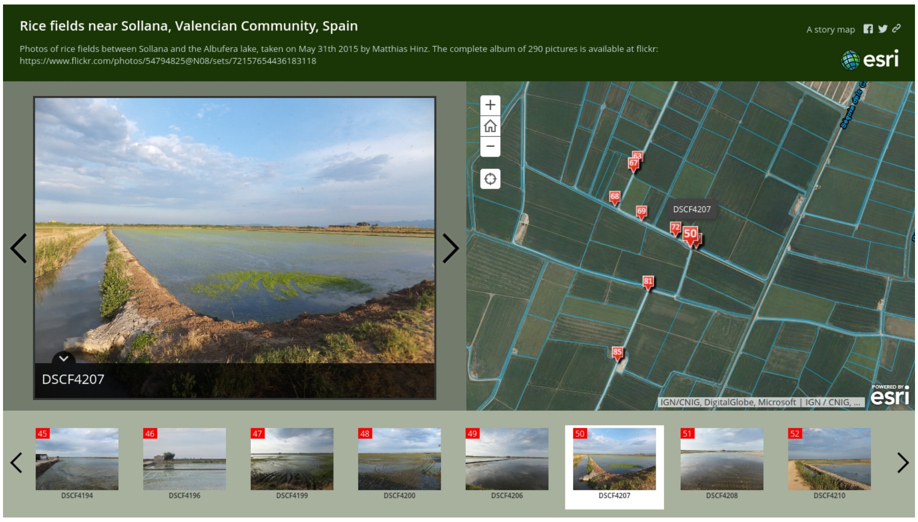

Figure 3: Geotagged photos, taken from the Valencian rice district and a map of corresponding the rice field parcels of the study area, marked by blue lines.

GPS-enabled so that all photo are geotagged and can be related to a particular location of the study area. I made a selection of 99 images and integrated them in an *ESRI Story Map*[9], a browser-based widget made for presenting series of geotagged photos side by side with a map (see Figure 3). Furthermore, I customized the basemap and included a map layer that shows the parcels of all rice fields located in the study area, denoted by blue lines.

4 Results

The main objective of the external studies is working with Geoinformatics competencies in larger projects and teams. Within the period of my stay, I worked for two international research projects: the GI-N2K project and the ERMES project. For the former project, I worked autonomously on one single task. For the ERMES project, in contrast, I solved a multitude of different tasks that required much collaboration within the Geotec research group. I was also required to follow discussions with the international project partners and occasionally communicated directly with them (i.e. via E-Mail, Skype or at the annual project meeting). The joint work was documented in official project reports, notably for the regional geoportal. The project work allowed me to improve soft skills like networking and multi-cultural awareness. I could develop competencies like handling GIS and SDIs, as well as web programming. Also, I gained practical experience in handling and visualizing remote sensing data.

Significant improvements I have made by learning in English and Spanish. A mandatory online test for the ERASMUS+ program during my stay indicated, although in-

[9]The Story Map is online available at http://arcg.is/2dwVa8s (Last access on Oct. 22th, 2016).

formally, an overall proficiency of C2 - the highest level of proficiency according to the Common European Framework of Reference (CEFR). During my stay, I also learned to express myself in Spanish in most situations of everyday life. A cloze-based language assessment (C-Test) at the University of Münster, taken shortly after my stay, indicated with 50 / 100 points that I reached an intermediate level of proficiency.

The external study period required a high amount of self-dependent organizational work, for instance, initiating contact with the geotec research group and the UJI for negotiating about the activities during my stay and thereby addressing the formalities of the ERASMUS grant and the external semester (i.e. formal application, grant agreement, learning agreement and other documents). I had to organize all journeys, accommodations, and everyday necessities by myself and had to get accustomed to a surrounding that is different in terms of climate, culture, and language. These tasks were not trivial, but elaborating them in detail would exceed the scope of this report.

Regarding my Master's thesis, the external studies were a good preparatory research exercise, particularly the 'Master thesis seminar'. In hindsight, though, I chose a thesis topic that is very different from my activities at the UJI. Although it often suggests itself to base a Master's thesis on the external studies, it can be argued that such switching between research fields and topics fosters a more versatile professional qualification profile.

5 Discussion and Conclusion

Living in a foreign country and organizing my stay was as much a challenge as getting involved in project work at the UJI. A number of incidents occurred, for instance, during my outgoing flight my luggage was held back at the airport so that it arrived in Spain with delay. Property (shoes, money) was stolen from me in two incidents. For organizational matters, I had to address four academic institutions: The international offices at the UJI and the University of Münster as well as the Institute for Geoinformatics and the university institute INIT. Each of these institutions had their own requirements, and sometimes it was hard to determine responsible persons and supervisors, as well deadlines and deliverables. Some of these matters appeared intransparent to me. Nevertheless, my confusion was outweighed by the cooperativeness of many persons involved.

In conclusion, my external study semester was a unique and transformational experience that posed many personal and professional challenges to me. It was the first time for me to live in a foreign country over a longer period and also to participate in research projects on this scale. The work helped me to gain soft skills as well as expertise in the fields of geoinformatics. I think that the additional effort compared to an external semester in Germany or directly at the university pays off in experience, and I would recommend it to fellow Master's students.

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Castellón de la Plana, July 14th, 2015

Dear Sir or Madam,

As director of the Geotec Research Group at University Jaume I, I confirm that exchange student Matthias Hinz participated in our research projects and classes from October 1st 2014 until July 14th 2015. The amount of performed work includes 870 h of self-studies at least.

The student mainly worked for the *ERMES project*, which is set out to build a Geographic Information System dedicated to rice farmers and authorities of the rice sector. Furthermore he contributed to the GI-N2K project with a browser widget visualizes the *Geographic Information Science & Technology Body of Knowledge* and attended the *Master Thesis Seminar* of the Master's program for Geospatial technologies.

The student worked in a scientific team and attended group meetings. Thereby he practiced skills in verbal and written communication. By living in Castellon de la Plana and staying at the local university, the student could improve his intercultural competencies and foreign language skills in English and Spanish.

I fully support to take into account the above achievements by the student for the first course of the "External Studies" – module of the Master of Geoinformatics at the University of Münster, as far as it complies with the specific requirements.

Best regards,

Dr. Joaquín Huerta
Geotec Research Group Director http://www.geotec.uji.es
UBIK Geospatial Technologies http://www.ubikgs.com
Universitat Jaume I, Castellón, Spain

UNIVERSITAT JAUME·I

José Luis Blasco Díaz, Secretary-General of the Universitat Jaume I,

CERTIFIES:

That Hinz, Matthias Markus, with Passport/Identity Card number C7CT0K48J, has taken the following subjects in the

Erasmus Mundus University Master's Degree in Geospatial Technologies (R.D. 1393/2007)

Subject	Type	Cred.	Year	Exam period	Grade	
SIW012 - Master Thesis Seminar	CS	2	2014/15	1st Ordinary	Very Good	9.00

Credit summary	Needed	Passed
Compulsory credits	90	2
Optional credits	0	0

Average grade (1): 9
Average grade (2): 3

(1) Grades are between 0 and 10: Fail: 0-4,9; Pass: 5-6,9; Good: 7-8,4; Very good: 8,5-10; Excellent with honours: 8,5-10;

From the academic year 2003/04 onwards and following Royal Decree 1125/2003, the grading scale is the following: Fail: 0-4,9; Pass: 5-6,9; Good: 7-8,9; Very good: 9-10; Excellent with honours: 9-10

(2) Equivalences to harmonise grades from different universities (RD 1267/1994):
Fail: 0 Pass: 1 Good: 2 Very good: 3 Excellent with honours: 4

(3) Subject studied in another university on an exchange programme.

***CS:** compulsory subject, **OP:** optional subject*

The Secretary-General

Castellón de la Plana, 29 July 2015

UNIVERSITAT JAUME·I

The head of the Teaching and Student Office
María del Carmen Falomir del Campo