IV MODELLING WEEK UCM

Master in Mathematical Engineering - UCM

Madrid, June 14-22, 2010

http://www.mat.ucm.es/momat/2010mw/2010mw.htm

Newsletter 2
June11, 2010

Contents

Welcome

On behalf of the Organizing Committee, we welcome you to the IV Modelling Week UCM.

This event is organized, within the framework of the Master in Mathematical Engineering at Universidad Complutense de Madrid, by the Faculty of Mathematical Sciences, the Research Group "Mathematical Models in Science and Technology: Development, Analysis, Numerical Simulation & Control" (MOMAT) and the Interdisciplinary Mathematical Institute (IMI).

The aim is to promote the use of Mathematics as a tool to solve problems arising from the industry. The presentations and exhibitions will take place on June 14nd and 22th and attendance is free for all interested people.

The event will build on the success of the previous editions, while incorporating new features to enhance your experience.

The conference venue is in the heart of Madrid, Spain. In June, Madrid weather is at its finest. Please join us at the IV Modelling Week and enjoy the beauty of Madrid. We look forward to seeing old friends and meeting new ones.

Juan Tejada
Facultad de Ciencias Matemáticas, UCM

Ángel Manuel Ramos
MOMAT Research Group

Marta Arregi
Interdisciplinary Mathematics Institute

2. Collaborators, problems, programme, participants

Universities

UNIVERSITY OF OXFORD

UNIVERSIDAD DE ZARAGOZA

UNIVERSITAT POLITÈCNICA DE CATALUNYA

USC UNIVERSIDADE DE SANTIAGO DE COMPOSTELA

UAB Universitat Autònoma de Barcelona

CMB Mathematical Institute 24-29 St Giles' Oxford OX1 3LB UK — Centre for Mathematical Biology

Università degli Studi di Firenze

Instituto de Matemática Interdisciplinar

UNIVERSIDAD COMPLUTENSE MADRID

Companies

Santander

inge heart of pure water

podoactiva® CENTROS DE PODOLOGÍA Y BIOMECÁNICA

neometrics

Public administration

GOBIERNO DE ESPAÑA MINISTERIO DE CIENCIA E INNOVACIÓN

Research teams/projects

momat

Modelos Matemáticos en Biología y Medicina
MTM2008-01867

Others

i-math ingenio mathematica

Programme

The event will have 4 parts:

- PRESENTATION OF THE PROBLEMS: by problem coordinators and by companies representatives, on June, 14, Monday.
- WORK GROUPS: each group of students, coordinated by one or various coordinators, will work on a problem from 16:00 h. to 21:00 h. until June 21, Monday.
- PRESENTATION OF RESULTS AND CONCLUSIONS: each group will deliver a report describing the results and conclusions reached and one or more of its members will make a public presentation on June, 22, Tuesday.
- WRITTEN REPORTS: each Working Group will write a paper setting out the results and conclusions reached.

Monday 14-06-2010

- 16.00 - 16.10h Introduction and opening of the IV Modelling Week, UCM
- 16.10 - 16.30h Exposition of Problem 1. Dr. Iacopo Borsi. Dept. of Mathematics "U. Dini" - Università degli Studi di Firenze.
- 16.35 - 16.55h Exposition of Problem 2. Dr. Etelvina Javierre. CIBER-BBN - Universidad de Zaragoza
- 17.00 - 17.20h Exposition of Problem 3. D. Jorge Juan Sueiras Revueltas. Director of Analytical Solutions - Neo Metrics.
- 17.25 - 17.45h Exposition of Problem 4. Dr. Miguel Carrión Álvarez. Risk Analyst - Department of Methodology - Banco de Santander.
- 17.50 - 18.10h Exposition of Problem 5. Dr. Heike Gramberg. University of Oxford.
- 18.25 - 21.00h Working Groups at the laboratories.

Tuesday 15-06-2010 to Monday 21-06-2010

- 16.00 - 21.00h Working Groups at the laboratories

Tuesday 22-06-2010

- 16.00 - 16.45h Preparing final details of each group in the laboratories
- 17.00 - 17.20h Presentation of Results and Conclusions of Group 1
- 17.25 - 17.45h Presentation of Results and Conclusions of Group 2
- 17.50 - 18-10h Presentation of Results and Conclusions of Group 3
- 18.15 - 18-35h Presentation of Results and Conclusions of Group 4
- 18.40 - 19-00h Presentation of Results and Conclusions of Group 5
- 19:00h Closing of the IV Modelling Week, UCM

PROBLEM 1:

Mathematical modelling of a water filtration process based on membrane filters.

Problem proposed by Inge GmbH

Coordinator

Dr. Iacopo Borsi (Università degli Studi di Firenze, Dept. of Mathematics "Ulisse Dini").

Exposition of the problem

The use of polymeric membranes to filter waste waters is a technique widely applied by industry and municipal companies devoted to the control of the water quality.

In our context, we deal with a filtration module consisting in a pressure vessel housing some *multi-bore* fibres, namely a polymeric porous fibre holed by 7 bores along its length. The water to be filtered pass within the bores and flow through the membrane, due to the applied pressure gradient between inner and outer part of the fibre. The pollutant particles larger than the membrane pores diameter are cut off inside the channel, so that the water collected outside the fiber is cleaned.

The main problem in these filtering systems is the membrane *fouling,* namely the process making the membrane dirty. As a the matter of fact, a part of the filtered particles can attach on the inner surface of the membrane, forming a thin layer (the so-called *cake*) which eventually soils the medium and reduces the filtration efficiency. To remove this material, periodically a back wash process is imposed to the system, inverting the flux and let the clean water flow through the membrane.

Therefore, in defining a model describing the whole filtration process one has to to take into account: (i) the hydrodynamic problem, referred to the water flowing in the porous medium; (ii) the diffusion/reaction problem, referred to the particles suspended in water and attaching on the membrane.

Scheme of the work to be done

1) Introduction of the general problem, also providing a raw analysis of experimental data. Such preliminary part is useful to focus the most important parameters to be simulated (according to the technical specifications given by the company).

2) Set up of the set of equations, and of boundary conditions, in the simplified 1D case.

3) Scaling procedure: study of the order of magnitude of the main parameters in order to: (A) introduce further simplifications to the model (if possible); (B) calculate the time scales characterizing the different processes.

4) Numerical solution of the dynamic problem referred to a single cycle filtration + back wash.

5) Provide an *average* procedure (w.r.t. spatial variables) in order to reduce the model to a system of ordinary differential equations: application of the averaged model to simulate several cycles of filtration + backwash.

PROBLEM 2:

Mathematical modelling of wound healing processes to help the treatment of chronic wounds.

Problem proposed by Podoactiva, Centros de Podología y Biomecánica

Coordinators

Dr. Etelvina Javierre (CIBER—BBR, Universidad de Zaragoza, Spain).

Exposition of the problem

Wound healing is a highly orchestrated process that goes by three partly overlapping phases (inflammation, granulation tissue formation and remodelling) which involve a high number of biological events. Miscommunication between cells, substrate and biochemical and biomechanical signals leads to delayed or impaired wound healing. Examples of chronic wound are keloids (benign fibrotic tumours due to overgrowth of granulation tissue), pressure ulcers (lesions caused by unreleased pressure due to prolonged long-term bed rest or inadequate footwear) and venous ulcers (lesions caused by insufficient blood supply due to venous hypertension). Mathematical modelling can help to understand the biophysical interactions behind successful wound healing and help in the search for new and personalized treatments. This problem proposal arises from the collaboration of the Structural Mechanics and Material Modelling Group of the University of Zaragoza and the company Podoactiva, Centros de Podología y Biomécanica in the field of biomechanical behaviour of pressure ulcers in diabetes patients and falls within the scope of the National Project DPI2009-07514 granted by the Ministry of Science and Innovation.

The aim of this problem proposal is to familiarize the students with several well-established diffusion-reaction equations describing the progress of several processes in wound healing, and their numerical resolution through finite element formulations. In more detail, the students will work on models of re-epitheialization (i.e. repair of the dermis-epidermis connexion), angiogenesis (i.e. repair of the vascular system) and contraction (i.e. reduction of wound size due to cellular traction). Since wound edge can be seen as a moving boundary, the students will be introduced to these specific numerical techniques to capture moving interfaces as part of the solution.

Scheme of the work to be done

1) Introduction of the problem, reduction to the simplified 1D models, and description of the finite element subroutines to be used.

2) Variation of the model parameter values to analyze the interactions between cells, growth factors and the mechanical environment through computer simulation. Determination of pharmacological and biomechanical strategies that yield a reduction in the healing time.

3) Study of the effect of wound shape in the healing process. Introduction of the 2D models. Description of the finite element subroutines to the used and mesh generation tools. Simulation of the healing process for different wound shapes.

PROBLEM 3:

A mathematical model for fraud prediction and control planning of electrical company clients.

neometrics

Problem proposed by Neometrics.

Coordinators

Dr. Benjamin Ivorra (Universidad Complutense de Madrid).
Dr. Juan tejada (Universidad Complutense de Madrid).
Fernando Fernandez (Neometrics).
Jorge Juan Sueiras Fernandez (Neometrics).

Exposition of the problem

During this work we will be interested in developing and studying a mathematical model that predicts the possible client frauds of a particular electric company in order to help this company to plan efficient control campaigns.

Indeed, currently, this kind of fraud is relatively common and consists in modifying physically the electric meter in order to reduce the displayed amount of energy consumed. However, this fraud can be easily detected by a simple control *in-situ* which is, unfortunately, expensive. So it is interesting for the considered company to establish whose clients should be visited and the organization of those controls. The model developed during this project will intend to answer to those questions.

More precisely, we will consider a typical binary predictive model, the binary component modelling the *fraud/no fraud* state of the clients. First, we should classify the clients (single person, small/big size companies, industrial area, geographical zone...) and their associated fraud motivation (duration, amount, *modus operandi*...). Then, we will use a real database to determine for each client, considering their characteristics, a risk fraud measure. According to previous risk estimation, we will intend to solve a multi-objective optimization problem in order to plan an *optimal* control campaign (cost of the campaign vs. economical gain for the company). Finally, using databases of real control campaigns, we will validate and check the efficiency of the obtained results.

Scheme of the work to be done

1) Identify the principal client characteristics associated to frauds by using the given bibliography and database.

2) Develop a predictive model in order to establish for each client a fraud risk measure. Model coefficients will be calibrated using real data.

3) Formulate an interesting optimization problem associated to control campaign planning and determine the way to solve it (global optimization, direct methods...).

4) Validate the obtained results by developing numerical experiments considering data obtained during previous control campaigns.

PROBLEM 4:

Calibration of single-factor HJM models of interest rates.

Problem proposed by Banco Santander.

Coordinators

Dr. Miguel Carrión Álvarez (Banco Santander)
Dr. Gerardo Oleaga (Universidad Complutense de Madrid)

Exposition of the problem

The Heath-Jarrow-Morton model provides a framework for discussing arbitrage-free evolution of interest rate curves. Here we propose to explore a few issues around the calibration of interest rate models for risk management purposes.

The HJM framework is rich enough to encompass any interest-rate dynamics. However, for the purposes of fitting a model to historical data a sufficiently parsimonious model should be chosen. It can be argued that a single-factor HJM model (one with a single Brownian generator) is already rich enough for most practical purposes. Such a model is equivalent to a certain "short-rate" model, which has a more intuitive interpretation than the full curve dynamics it encodes. It can also be shown that a sufficiently rich variety of interest rate curves are possible under such a model - in particular, curves of the form proposed by Nelson and Siegel, while preserving the ability to interpret the short rate model intuitively.

Though the choice of single-factor models limits the possibility of overfitting, one can make Nelson-Siegel type curves arbitrarily complex and so one has to be careful not to introduce more parameters into the model than can be fitted reliably from actual data. Finally there is the issue of how much of the variance of historical data is explained by the model.

Scheme of the work to be done

(Any or all of the following topics can be developed and taken as motivation for further work - throughout, issues of implementation and efficiency can be discussed)

1) Discussion of the difference between the asset pricing problem and the risk/portfolio management problem. Price of risk.
2) Discussion of the single-factor HJM model, and the relationship between the term volatility structure and the equivalent short rate model. Role of initial conditions and price of risk. Relationship with the Nelson-Siegel parametrization.
3) Descriptive statistics of a sample history of an interest rate curve. Stationarity, independence, normality, principal component analysis.
4) Fitting a single-factor model to the data. Choice of the number of parameters of the model. Goodness of fit and avoiding overfitting. Discussion of drift estimation, in particular statistical significance and stationarity.
5) Back-testing of fitted model: comparison with historical data using descriptive statistics (qualitative and quantitative).
6) Forecasting and scenario analysis with fitted model: simulation of future histories (Monte Carlo simulation); estimating price and risk (e.g VaR) of simple interest-rate instruments and/or portfolios.

PROBLEM 5:

Mathematical Modelling of the mobility of Trypanosomes

Problem proposed by Centre for Mathematical biology, Oxford.

Coordinators

Dr. Heike Gramberg (Univesity of Oxford)
Dr. Antonio Brú (Universidad Complutense de Madrid)

Exposition of the problem

Trypanosomes are a group of kinetoplastid one-celled organisms. All members in this group are parasitic, and are primarily found in insects, although some species have a secondary host. There are several species in the group of Trypanosomes that can infect humans, causing major diseases such as sleeping sickness in Africa and Chagas disease in South-America
Trypanosomes are characterized by having one single flagellum. They move around by beating this flagellum back and forth similar to for example sperm cells, with this difference that the flagellum of Trypanosomes is pointing in the direction of the flow so that it is pulling itself through the fluid instead of pushing. The movement of the flagellum is driven by an internal sliding force between pairs of inextendible fibres along the length of the flagellum causing local bending of the flagellum. The sliding force is balanced by a bending force due to the bending stiffness of the flagellum and the viscous shear forces acting on the surface of the flagellum and the cell body.
The aim of this problem proposal is to derive the equations of motion, and to investigate the motion of the Trypanosomes by varying the material properties of the flagellum such as the bending stiffness and the profile of the sliding force along the length of the flagellum.

Scheme of the work to be done

1) Introduction of the general problem..

2) Derivation of the differential equations and boundary conditions describing the displacement of the flagellum. Use an appropriate scaling to derive a set on non-dimensional equations.

3) Study the simplified case where the displacement of the flagellum is small compared to the length of the flagellum. This leads to a set of linear equations for which there exists an analytic solution. Study the influence of the material properties of the flagellum on this solution.

4) Numeric solution of the full problem.

2. Collaborators, problems, programme, **participants**

Dr. Iacopo Borsi
Università degli Studi di Firenze
Dipartimento di Matematica Ulisse Dini
Italy

Dr. Benjamín Ivorra
Universidad Complutense de Madrid
Facultad de Ciencias Matemáticas
Spain

Etelvina Javierre
Department of Mechanical Engineering
Mecánica
Universidad de Zaragoza
Spain

Dr. Juan Tejada
Universidad Complutense de Madrid
Facultad de Ciencias Matemáticas
Spain

Dr. Miguel Carrión Álvarez
Banco Santander
Risk Analyst
Department of Methodology
Spain

Dr. Heike Gramberg
University of Oxford
United Kingdom

Dr. Gerardo Olega
Universidad Complutense de Madrid
Facultad de Ciencias Matemáticas
Spain

Dr. Antonio Brú
Universidad Complutense de Madrid
Facultad de Ciencias Matemáticas
Spain

Jorje Juan Sueiras
Neometrics
Spain

Fernando Fernández
Neometrics
Spain

2. Collaborators, problems, programme, **participants**

Confirmed Participants:

Name	Nationality	Institution
Barontini, Sara	Italy	Università degli Studi di Firenze
Bello, José M.	Spain	Universidad Complutense de Madrid
Bruni, Camilla	Italy	Università degli Studi di Firenze
Bueno Alonso, Antonio	Spain	Universidad Complutense de Madrid
Caroccia, Marco	Italy	Università degli Studi di Firenze
Desiró, Flavia	Italy	Università degli Studi di Firenze
Espinoza Bernardo, Herbert Moisés	Perú	Universidad Complutense de Madrid
Gancedo Cobreros, María Dolores	Spain	Universidad Complutense de Madrid
García Siles, Javier	Spain	Universidad Complutense de Madrid
Von Glehn, Ingrid	Germany	University of Oxford
Hennessy, Matt	Canada	University of Oxford
Hurtado Encinar, Jesús	Spain	Universidad Complutense de Madrid
Ilyanova Ivanova, Siana	Bulgaria	Universidad Complutense de Madrid
Jargalsaikhan, Bolor	Mongolia	Universidad Autónoma de Barcelona
Ji, Senshan	China	Universidad Autónoma de Barcelona
Kesamoon, Chainarong	Thailand	Universidad Autónoma de Barcelona
Levitt, Antoine	France	University of Oxford
López Vizcayno, Santiago	Spain	Universidad Complutense de Madrid
Luque Fernández, María Loreto	Spain	Universidad Complutense de Madrid
Loureiro Brañas, Juan	Spain	Universidade de Santiago de Compostela
Nowzohour, Christopher	Germany	University of Oxford
Parra Gimeno, Carlos	Spain	Universidad Complutense de Madrid
Passarella, Diego Nicolás	Argentina	Universidade de Vigo
Pérez Alegre, Aranzazu	Spain	Universidad Complutense de Madrid
Pérez de Mercado, Elisa	Spain	Universidad Complutense de Madrid
Rodríguez-Miñón Sala, Santiago	Spain	Universidad Complutense de Madrid
Sánchez, Alejandra	Colombia	Universidad Complutense de Madrid
Silva Torres, Juan José	Spain	Universidad Complutense de Madrid
Sueiras Revueltas, Jorge Juan	Spain	Neometrics
Vara Martín, Carlos Alberto	Spain	Universidad Complutense de Madrid
Vélez Serrano, Daniel	Spain	Universidad Complutense de Madrid
Verdes-Montenegro, Daniel Neira	Spain	Universidad Complutense de Madrid
Villar Marco, Clara	Spain	Universidad Complutense de Madrid

3 Participation costs

The organization will cover, for agreed participants

Travel. For non UCM participants whose costs are covered by UCM, flight ticket has been bought by the organization and sent to the participant by e-mail.

Accomodation. For non UCM participants whose costs are covered by UCM: in shared double rooms for students and single room for instructors, at Residencia Galdós (see below).

Meals: For non UCM participants whose costs are covered by UCM: at Residencia Galdós, breakfast, lunch and dinner included (arrival day, dinner; departure day, breakfast).

Residencia Galdós

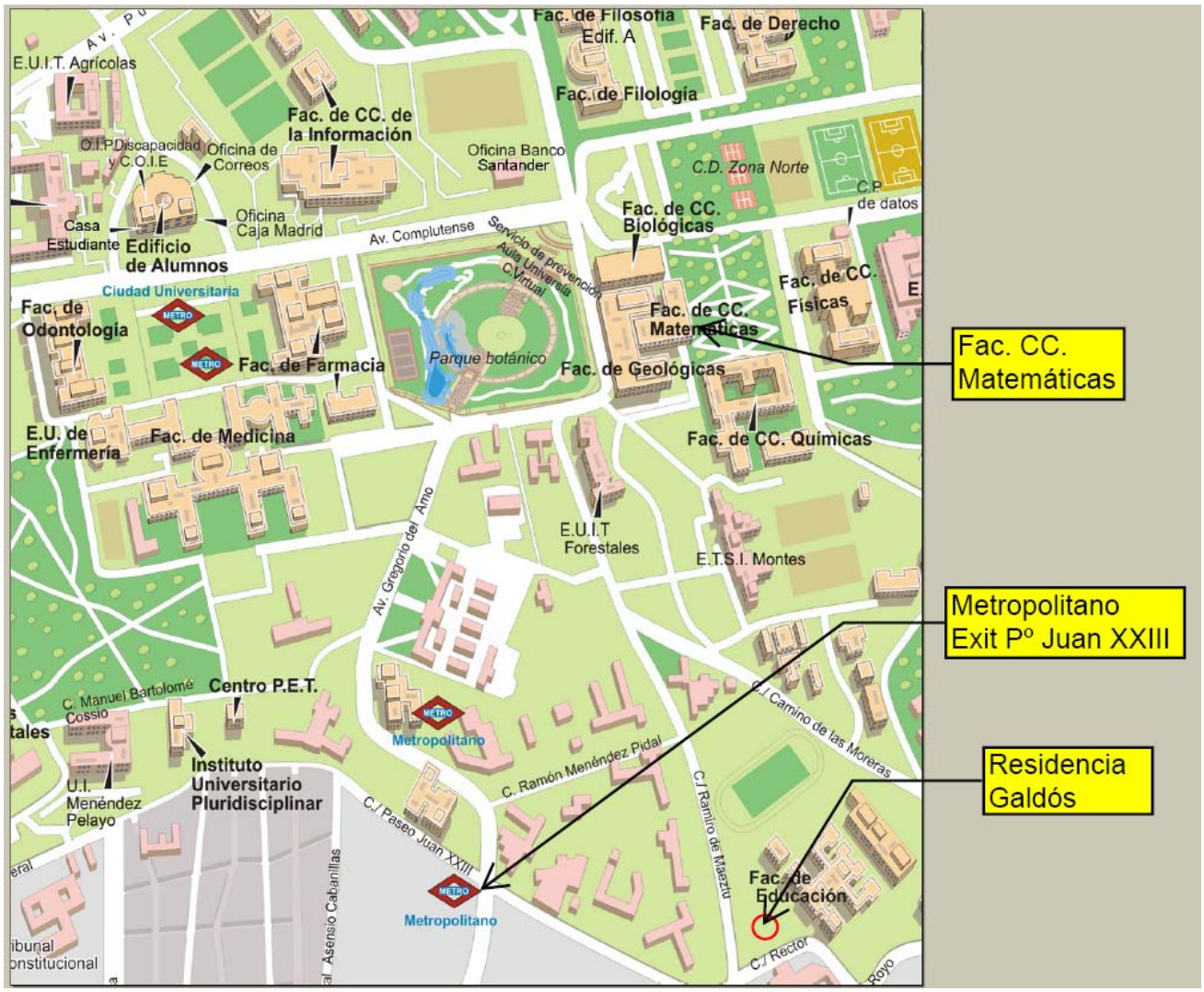
The residence is located at the campus of the University. The address is Ramiro de Maeztu, number 2, and telephone number is (+34) 912062900. The closest underground stop is Metropolitano. Buses connect the residence with Moncloa (132 and C), many points in the University campus (132 and F), Cuatro Caminos and Guzmán el Bueno metro stops (C and F), ...
The webpage of the residence is www.residenciagaldos.com

Meals hours at Residencia Galdós:

	Monday to Friday	Saturday and Sunday
Breafkast	7:00 to 10:00	7:00 to 11:00
Lunch	13:00 to 16:00	13:00 to 17:00
Dinner	20:00 to 22:00	20:00 to 23:00

4 Practical info

Facultad de Ciencias Matemáticas and Residencia Galdós at Moncloa Campus:



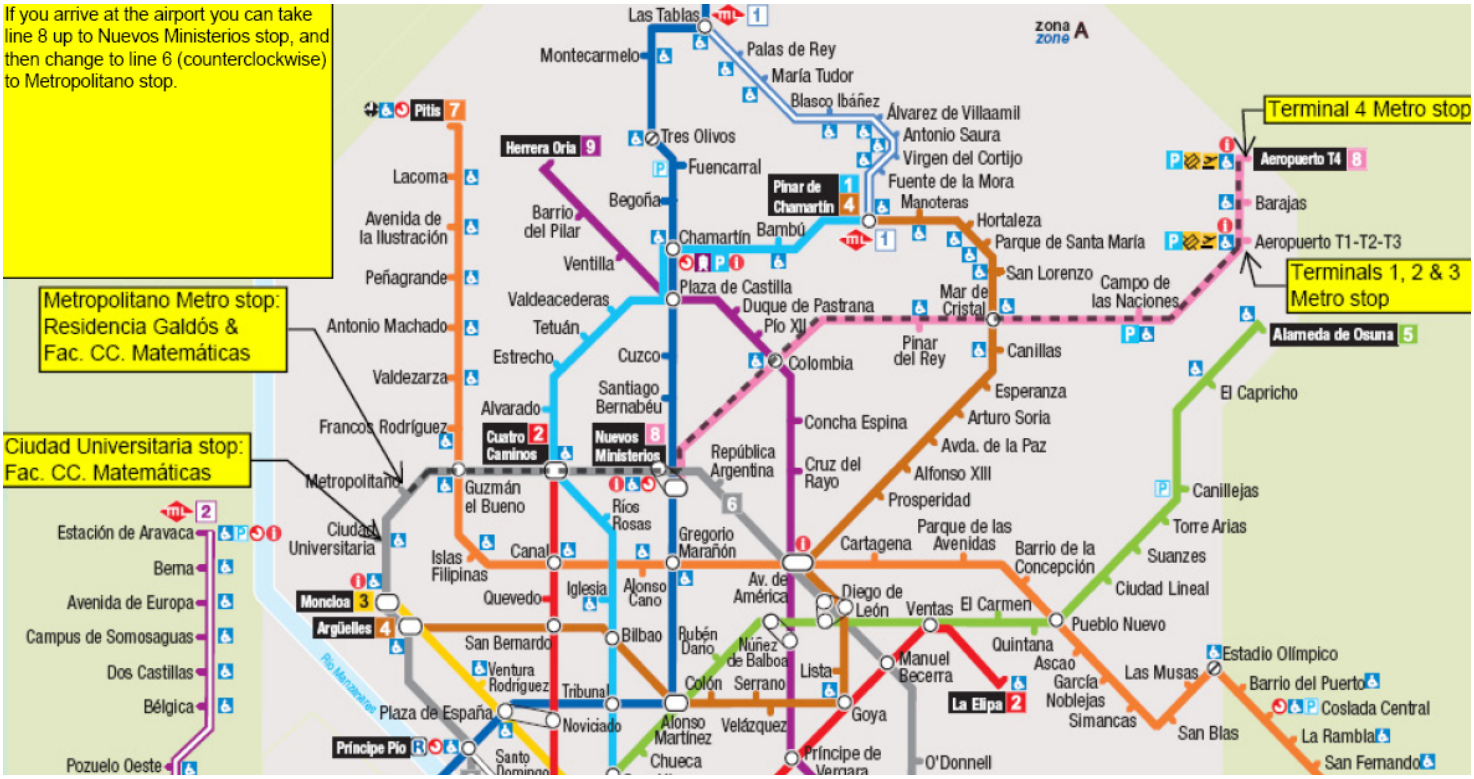
(Attention: this map is not north oriented)

IV MODELLING WEEK UCM Madrid, June 14-22 , 2010

http://www.mat.ucm.es/momat/2010mw/2010mw.htm

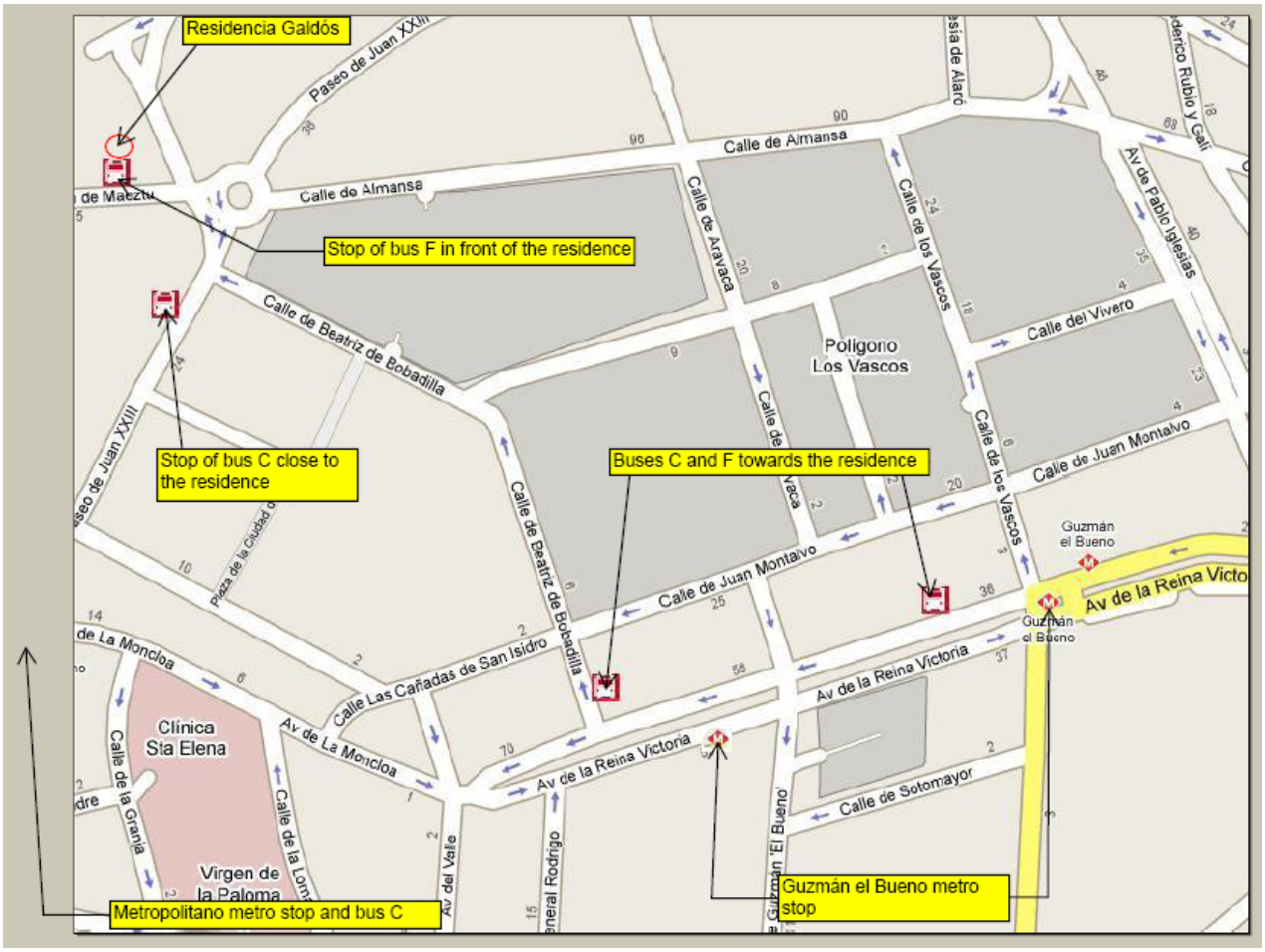
How to arrive from the airport

There are two underground (Metro) stops at the airport, depending on the terminal. A single trip costs 2 euro from the airport to the city:



A taxi would cost around 25 euro from the airport to the residence. Tipically the taxi driver will not know how to find the street, so you could print the map to show them.
Handicapped people should not use Metropolitano metro stop since it's not very accessible. They can use Guzmán el Bueno metro stop instead, and then take bus F or bus C (map in the next page):

Bus stops near Residencia Galdós:



Moving around

You can find some information at:

Transport Information System: http://www.ctm-madrid.es/
and
Metro de Madrid (underground): www.metromadrid.es/en/index.html
EMT (local buses): http://www.emtmadrid.es/index.html?lang=eng
Cercanías (regional train): http://www.renfe.es/cercanias/madrid/

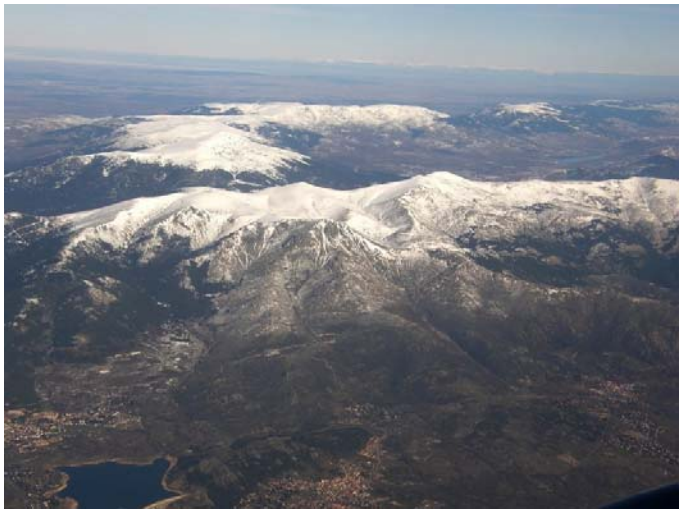
Tourism

Madrid City: http://www.esmadrid.com/en/portal.do
Madrid City and Region: http://www.turismomadrid.es/index_INGL.aspx

The University

Universidad Complutense de Madrid: www.ucm.es
Faculty of Mathematics: www.mat.ucm.es
Instituto de Matemática Interdisciplinar: www.mat.ucm.es/imi/IMI_english.htm

Communication Tower and Cuatro Torres Business Area, Madrid



Mountains, Madrid