ICC-BANYOLES 2008 CAMPAIGN IN THE FRAMEWORK OF EUROSDR RADIOMETRY PROJECT. PROJECT DESCRIPTION AND PRELIMINARY RESULTS

Roman Arbiol, Lucas Martínez
Institut Cartogràfic de Catalunya (ICC)
Remote Sensing Area
Parc de Montjuïc s/n
08038 Barcelona (Spain)
Roman.Arbiol@icc.cat, Lucas.Martinez@icc.cat

Keywords: EuroSDR, DMC, CASI, radiometric calibration, atmospheric correction.

Abstract:

In 2008 the European Spatial Data Research (EuroSDR) organisation started a new collaborative applied research project focused on Radiometric Performance of Digital Cameras. The project has these main objectives:

a) Improve knowledge on radiometric aspects of digital photogrammetric cameras.
b) Review existing methods and procedures for radiometric image improvements.
c) Compare and share operative solutions through the comparison of these techniques on the same test dataset.
d) Analyse the benefit of radiometric calibration in order to open new applications (quantitative remote sensing, change detection, etc.).

The Institut Cartogràfic de Catalunya (ICC) leads this project in collaboration with other cartographic institutions, universities and research centres in Europe. In order to share experiences with different institutions working on common and well known data sets different flight campaigns have been designed in different European areas. ICC contribution has been the Banyoles 2008 campaign. The main part of this campaign performed on July 15th 2008 has been the simultaneous acquisition of Z/I Digital Mapping Camera (DMC) and Compact Airborne Spectrographic Imager (CASI) at different orientations and flight altitudes. The flight campaign has been complemented with the measurements of different complementary sensors obtaining data of the atmosphere and the incident radiometry. All this images and complementary information will be part of a complete data set to be distributed to the institutions participating in the EuroSDR activities.

The planned contributions of ICC to these activities are:

i) Radiometric calibration of a DMC.
ii) Atmospheric correction of CASI and DMC imagery by using aerosol and water vapour contents, derived by an inversion method and subsequent validation with radiometric targets and in-field atmospheric measurements.
iii) Colorimetric calibration of sensor towards CIE standard colour space and validation with radiometric targets.
iv) Resolution studies by means of Siemens stars and edge targets. Study of the relationship between atmosphere state and resolution and comparison with computer radiative transfer simulations.

This communication is an overview of the Banyoles 2008 campaign, the measurements and a description of the airborne imagery and ground-truth data collected. The dataset from this experiment is introduced and a brief description of the expected results will be also presented.

1. The Spatial Data Research organisation

The Spatial Data Research organisation is a not-for-profit organisation linking National Mapping and Cadastral agencies with Research Institutes and Universities for the purpose of applied research in spatial data provision, management and delivery.

EuroSDR (formerly OEEPE) is a European spatial data research organisation that undertakes collaborative applied research projects, hosts focussed workshops, publishes an official series of reports, delivers an annual series of short distance learning courses, contributes to the development of specifications and standards by OGC, ISO and CEN and participates in the drafting of the INSPIRE implementing rules.

Membership consists of organisations representing national GI (Geographical Information) production and/or research throughout Europe with seventeen countries currently represented. Its strength lies in its functioning as a network of delegates, commission chairs and project leaders from production and research organisations, working together on a common research agenda. Research activities, undertaken through international co-operation, serve the European Geoinformatics community and address the whole chain of reference spatial data production, management and delivery.

Digital imaging is becoming the main photogrammetric data capture procedure. The advantage of the digital technology is the radiometric properties, including multispectral imagery, linear response, large dynamic range, great radiometric resolution, and low noise level. Radiometry opens great prospects for the utilization of the photogrammetric imagery for classical photogrammetric tasks and also in many new application areas, such as change detection, classification and environmental change monitoring. Accurate radiometric processing is necessary for both visual and quantitative applications. The rigorous treatment of image radiometry is a new issue in photogrammetric processing lines [1-18].

In 2008 EuroSDR organisation undertook a collaborative applied research project focused on Radiometric Performance of Digital Cameras. The EuroSDR radiometry project has two main stages: Review and Empirical study. The joint project leaders are Eija Honkavaara, Lauri Markelin (Finnish Geodetic Institute (FGI), Finland) and Roman Arbiol (Institut Cartogràfic de Catalunya (ICC), Spain). The project has these main objectives:

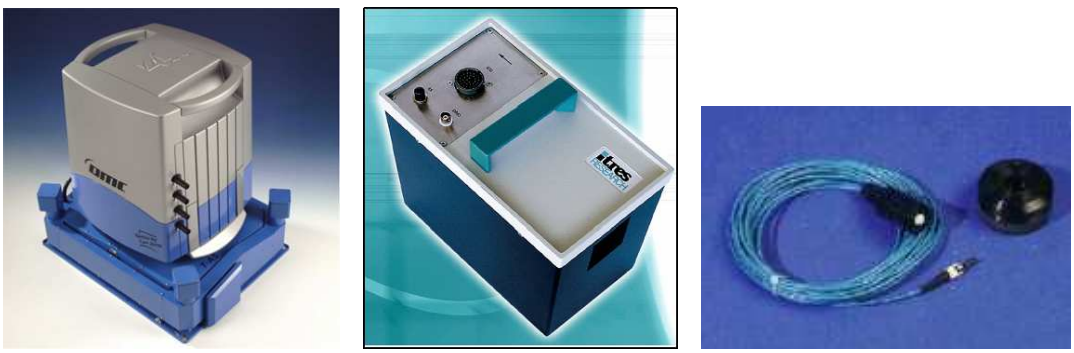
a) Improve knowledge on radiometric aspects of digital photogrammetric cameras.
b) Review existing methods and procedures for radiometric image improvements.
c) Compare and share operative solutions through a comparison of these techniques on a same test data set.
d) Analyse the befit of radiometric calibration to open new applications.

The first phase is to be completed in the first quarter of 2009, and based on these results the exact objectives for the second phase will be set. For the empirical part, several campaigns took place in summer/autumn 2008 to provide state-of-the-art image materials in Spain, Finland and Germany. In this presentation we report the results of the Banyoles 2008 campaign results and the dataset from this experiment will be also introduced.

2. Banyoles 2008 field experiment

On July 15th, 2008 a multisensor acquisition on Banyoles (Spain) ICC test field was performed. Airborne CASI and DMC images were simultaneously acquired with a Cessna Caravan B20, in the morning. The ILS (Incident Light Sensor) of the CASI system was installed on the top of the plane (Figure 1).

The airborne acquisition included flight lines at 4 different altitudes (820, 1125, 2250 and 4500 m). Lower altitude (820 m) flight lines were depicted to resolution of DMC. Therefore, the camera acquired RGB, Nir and Pan images, and several exposition time and f-numbers, with a nominal pixel size of 7.5 cm. The rest of the flight altitudes (1125, 2250 and 4500 m) were designed for the simultaneous acquisition of DMC and CASI. From these flight lines, the DMC acquired RGB, Nir and Pan images, and several exposition time and f-number, now with a nominal pixel size of 10, 20 or 30 cm. Consequently, CASI images were acquired on Enhanced Spectral Mode and 32, 74 or 144 spectral bands between 410 and 960 nm and a nominal pixel size of 1.5, 3 and 6 m, simultaneously with the camera.



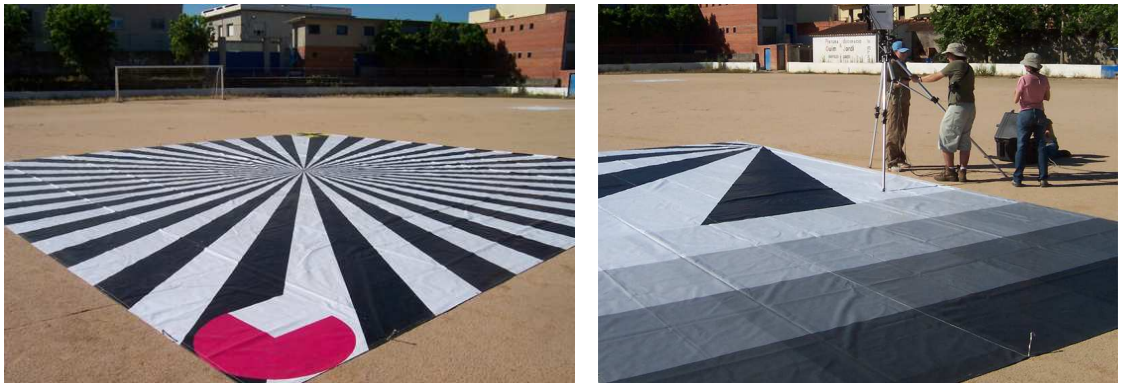
(a) (b) (c)

Figure 1. DMC sensors on board Cessna Caravan B208. (a) DMC camera (b) CASI sensor head (c) ILS sensor.

The ICC test field is a flat uniform football dirt field inside Banyoles (Spain), located at 42º 07’ 14’’ N 2º 45’43’’ E (WGS84) where man-made covers were already installed in 2005 for a previous radiometric data acquisition (Figure 2).

Figure2. ICC Banyoles (Spain) ICC test field with man-made covers and Siemens stars deployed (15 July 2008).

Now, Siemens stars were also deployed for resolution measurement (Figure 3). Besides, many artificial and natural stable covers with spatial homogeneity and spectral reflectance range are available around the test field including a lake. Almost simultaneously to the flight, a field campaign was developed to install man-made radiometric and geometric covers to perform the field 400-1000 nm reflectance measurements using handheld radiometers. In addition, the atmosphere was scanned with an atmospheric Lidar, a Sun-photometer a GPS temporal station and a meteorological station.



(a) (b)

Figure 3. Resolution targets deployed on test field for Banyoles (Spain) campaign.
(a) 10*10 meters full Siemens star. (b) 10*5 10x5m quarter of Siemens star plus grey scale.

Two groups from Centre de Recerca Ecològica i Aplicacions Forestals (CREAF) and Instituto de Desarrollo Regional (IDR) from Universidad de Castilla-La Mancha (UCLM) performed radiance and reflectance measurements with PPSystems Unispec and GER VIS-NIR radiometers. Atmospheric state was measured by several groups, instruments and techniques from the test field. An atmospheric Lidar developed by Universitat Politècnica de Catalunya (UPC) provided aerosol profiles while an automatic suntracking photometer CE-318 (AERONET like) provided column integrated values of Aerosol Optical Thickness (AOT) for the optical spectrum. Additionally a temporal GPS station deployed by ICC on the adquisition day measured GPS data to derive Zenital Troposheric Delay that is used to measure atmosphere moisture (Figure 4). Atmospheric profiles and meteorological data were provided by Servei Meteorològic de Catalunya (SMC).

(a) (b) (c)

Figure 4. Atmospherical measurements from the test field for Banyoles 2008 campaign. (a) UB Sunphotometer (b) UPC atmospheric Lidar (c) ICC GPS temporal station.

2.1 Digital Mapping Camera, Airborne Compact Airborne Spectrographic Imager and Incident Light Sensor

The CASI, ILS and DMC sensors performed a total of 12 flight lines at different altitudes. From these flight lines, the total amounts of DMC acquisitions were 156 pan and VIS-Nir images and 12 CASI images. Regarding the optical characterization of the DMC acquisitions the pan images have f-numbers 11.3 or 16, the Nir images have f-numbers 7.8 or 5.5 and the RGB always works using the f-numbers triplets: “5.4, 6.2, 5.5” or “7.7, 8.7, 7.8”. The CASI images were calibrated with laboratory coefficients to radiance units. All the images were orthorectified with DGPS and INS data, with a nearest neighbour procedure in order to maintain the original radiometry.

2.2 Field reflectance ground-truth data

In order to test the atmospheric correction of CASI images, to develop and test the algorithms that enhance the radiometric performance of the DMC and geometric characteristics of the CASI data, the UCLM and CREAF groups performed radiance and reflectance measurements with handheld radiometers along the acquisition data day (15th July) almost concurrently the flight-time the flight-time. The target sites consisted of invariant surfaces for the acquisition time as well as five man-made covers deployed by ICC. The selected invariant surfaces were: bare soil and man-made covers, vegetable green cover, still water, cereal stubble, fine gravel bed and asphalt. The measuring sequence included a Spectralon reference surface to obtain the solar spectrum. This way, the spectral radiance was calibrated into 400 – 1000 nm spectral absolute reflectance.

2.3 Atmosphere data acquisition

A UB sunphotometer measured sun and sky radiance to derive total column water vapor, ozone and aerosols properties using a combination of spectral filters (440, 675, 870, 936, 1020, 340 and 380 nm). The sunphotometer data yield the optical mass, the aerosol optical depth for each wavelength, the Angstrom parameters and total column water vapour for the beginning of the airborne images acquisition. The aerosol optical depth show low values. The air mass during the campaign was a polar air mass characterized by low turbidity. This means that the day had good conditions for optical remote sensing [20].

Aerosol vertical distribution over Banyoles site during plane overpasses was derived from LIDAR. Extinction and backscatter coefficients computed by UPC elastic LIDAR single scattering equation and Single inversion algorithms. Measurements were realized at 532 and 1064 nm for 30 min integration time periods. Results show a stable atmosphere at the beginning and some more variability by the end, in concordance with sunphotometer measurements and considerations [21-25].

Total column water vapour related parameter was also measured with a temporal ICC - GPS station installed for the acquisition day. The GPS data recorded at a temporal frequency of 1Hz were processed with the Canada Centre for Remote Sensing online global Precise-Point-Positioning service. Estimated Troposheric Zenith Delay calculated from the data ranges from 2.34 to 2.4 m. These values are useful to characterize atmospheric water vapour during the airborne acquisition [26].

Additionally, a near automatic SMC weather station provided temperature, moisture and atmospheric pressure for the airborne acquisition interval. This data was completed by SMC forecasted vertical profiles of the temperature, moisture and atmospheric pressure for the test site.

3. Banyoles 2008 main goals and expected results

Banyoles 2008 experiment is depicted to serve the campaign participants and any other additional group interested in the objectives of EuroSDR radiometry project. In this frame, Banyoles 2008 participant's main goals and expected results are described next.

First objective is the spectral characterization of a Compact Airborne Spectrographic Imager (CASI) regarding bandwidth and smiling effect. Comparison with on laboratory results will be also done. Atmospheric correction will be performed taking advance of airborne mult-height acquisition strategy and radiometric radiometric homologous areas [27]. Atmospheric correction of CASI imagery (Figure 5) with aerosol distribution and load, and water vapour derivation by an inversion method will be validated with radiometric targets and atmospheric measurements.

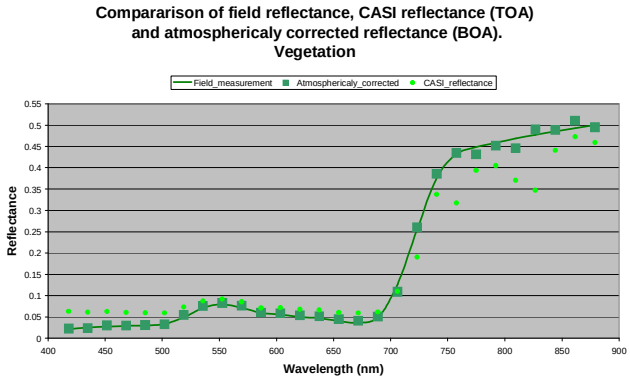


Figure 5. CASI atmospheric correction example from [27]

Next objective is the study of resolution by means of Siemens star and edge targets [28]. Study of the relationship between atmosphere radiative transfer simulations and resolution lost is expected. DMC resolution will be extend to pan and multispectral bands along and across the CCD axes thanks to the lower flight lines configuration.

Following objective is the radiometric calibration of a Z/I Digital Mapping Camera (DMC) by the radiance and the reflectance methods. Radiance method will be performed thanks to the simultaneous acquisition of DMC and CASI data. As DMC images are not radiometrically calibrated in absolute terms, they will be processed to derive a simple relationship between DMC digital numbers and CASI well calibrated digital numbers, so DMC data could be read in terms of physical units (radiance) [29]. See an example of the relationships at Figure 6 and some calibrated images using the described procedure at Figure 7.

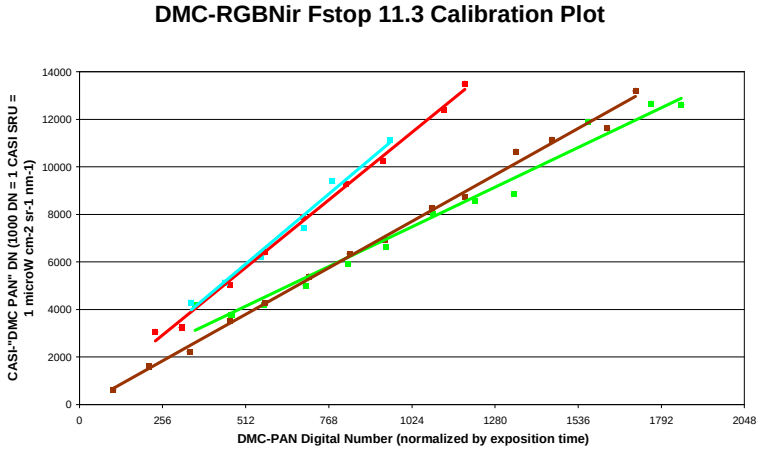


Figure 6. DMC radiometric cross calibration with CASI example from [29]

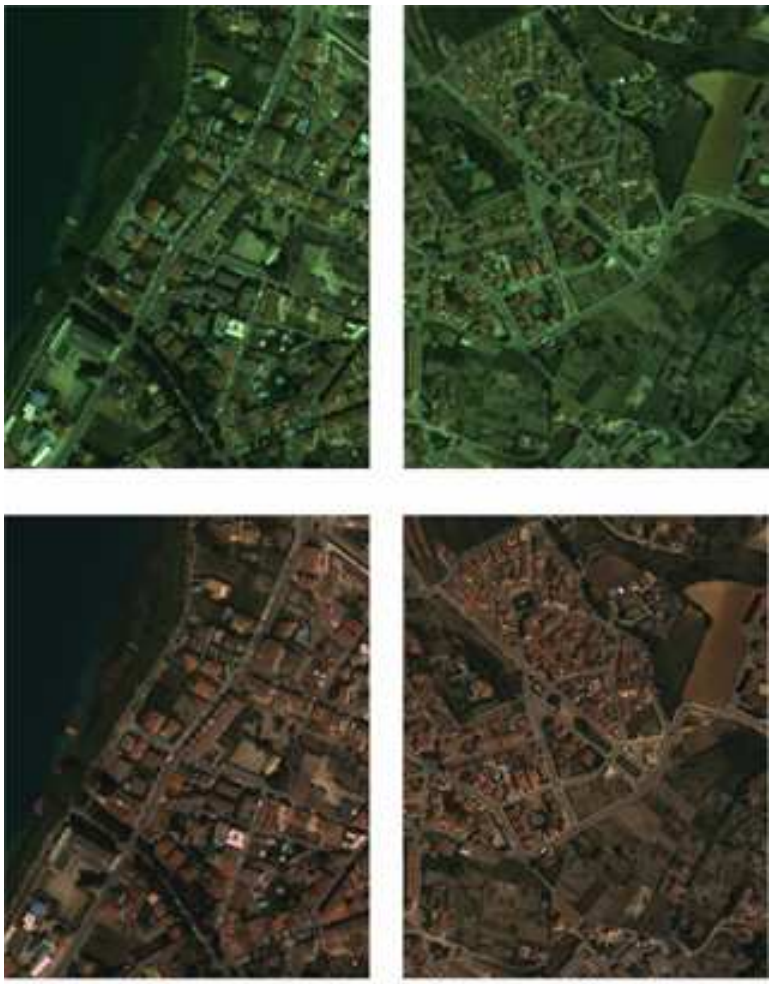


Figure 7. DMC radiometric calibration example on Banyoles area from [30]. (Up) DMC images after sensor radiometric calibration. (Down) DMC images after absolute calibration derived from simultaneous CASI images.

Next objective is the colorimetric calibration of DMC sensor towards CIE standard colour space. Photomaps products are desired to reproduce the proper tones and physical models and hypotheses [30] that improve empirical radiometric normalizations of the images will be developed and applied to the images. See an example of colorimetric calibrated images using the described procedures at Figure 8.

Finally, the last objective is the Atmospheric correction of DMC images by using CASI derived atmosphere parameters. Radiometric targets will help to validate the results yield by the methodologies. DMC images atmospheric correction will enhance the number of applications for DMC radiance and reflectance images for remote sensing studies such us land use and classification, change detection, water quality, forest and vegetation analysis, etc

Banyoles 2008 is part of a collaborative applied research project. All the collected data is fully offered to all the experiment participants. Moreover, any other additional group interested in the use or the participation in the process and analysis parts of the experiments are invited to collaborate. In order to do it, an application (ask for a digital form) might be submitted by email to Banyoles 2008 experiment management (authors of this communication) with a brief description of the research group, and an extended abstract of the objectives, procedures and expected results. Results are expected to be presented at EuroCow Workshop to be held in January 2010.

Figure 8. DMC colorimetric calibration example on Banyoles area from [30]. (Up) DMC images after absolute calibration derived from simultaneous CASI images. (Down) DMC images after colorimetric calibration.

4. Conclusions.

In the frame of European Spatial Data Research (EuroSDR) radiometry project ICC-Banyoles 2008 experiment was scheduled and developed on July 2008. Airborne images, atmospheric measurements and ancillary radiometric data were acquired on Banyoles test field. The dataset from this experiment was introduced and a description of the expected results was also presented. Finally, an offer to all the research groups that share the EuroSDR objectives is done to join the initiative and exploit the dataset.

Acknowledgements

The authors are very grateful to the participants of Banyoles 2008: Finnish Geodetic Institute, Centre de Recerca Ecològica i Aplicacions Forestals, Instituto de Desarrollo Regional (Universidad de Castilla La Mancha), Universitat Politècnica de Catalunya, Universitat de Barcelona and Servei Meteorològic de Catalunya.

The authors very much appreciate all the cooperation and help provided by the Banyoles Council and CD Banyoles for the use of the “Camp Vell” football playground.

Banyoles 2008 is an activity in the project “Radiometric Aspects of Digital Photogrammetric Images” also aligned with the EuroSDR project “Medium Format Digital Cameras” under leadership of Görres Grenzdörffer, Universität Rostock (University of Rostock) and the EuroDAC initiative on digital camera certification, headed by Michael Cramer, Universität Stuttgart (University of Stuttgart).

References

[1] Hinz, A., 1997. Design concepts of digital phtogrammetric cameras, Photogrammetric Week 1997, (Fritsch, D., D. Hobbie, Eds.), Wichmann Verlag, pp. 43-48.

[2] Fricker, P., Sandau, R., Walker, A.S., 1999. Digital photogrammetric cameras: possibilities and problems, Photogrammetric Week 1999, (Fritsch, D., R. Spiller, Eds.), Wichmann Verlag, pp. 71-82.

[3] Spiller, R.H., 1999. Z/I Imaging: A new system provider for photogrammetry and GIS, Photogrammetric Week 1999, (Fritch,. D., R. Spiller, Eds.), Wichmann Verlag, pp. 35-42.

[4] Hinz A., Dörstel, C. and Heier, H., 2000. Digital Modular Camera: System concept and data processing workflow, International Archives of Photogrammetry and Remote Sensing, 33(B2), unpaginated CD-ROM, 6 p.

[5] Diener, S., Kiefner, M. and C. Dörstel, 2000. Radiometric normalisation and colour composite generation of the DMC, International Archives of Photogrammetry and Remote Sensing, 33(B1): 82-88.

[6] Tang, L., Dörstel, C., Jacobsen, K., Heipke, C. and Hinz, A., 2000. Geometric accuracy potential of the Digital Modular Camera, International Archives of Photogrammetry and Remote Sensing, 33(B4/3): 1051-1057.

[7] Read, R. and Graham, R., 2002. Manual of Aerial Survey – Primary Data Acquisition, first ed. Whittles Publishing, UK.

[8] Cramer, M., 2005. Digital airborne cameras - Status and future, Proceedings of ISPRS Hannover Workshop 2005: High-Resolution Earth Imaging for Geospatial Information, unpaginated CDROM, 8 p.

[9] Cramer, M., 2006. Calibration and validation of digital airborne cameras, International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 36(B1), unpaginated CDROM, 6 p.

[10] Hefele, J., 2006.Calibration experience with the DMC, Proceedings of EuroSDR Commission I and ISPRS Working Group 1/3 Workshop EuroCOW, 25-27 January 2006, unpaginated CD-ROM, 6 p.

[11] Honkavaara, E., Ahokas, E., Hyyppä, J., Jaakkola, J., Kaartinen, H., Kuittinen, R., Markelin, L. and Nurminen, K., 2006. Geometric test field calibration of digital photogrammetric sensors. ISPRS Journal of Photogrammetry & Remote Sensing, Special Issue on Digital Photogrammetric Cameras, 60(6): 387-399.

[12] Honkavaara, E., Jaakkola, J., Markelin, L. and Becker, S., 2006. Evaluation of resolving power and MTF of DMC. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 36(A1), unpaginated CD-ROM, 6 pages.

[13] Honkavaara, E., Jaakkola J., Markelin L., Nurminen K. and Ahokas E., 2006. Theoretical and empirical evaluation of geometric performance of multi-head large format photogrammetric sensors. International Archives of Photogrammetry, Remote Sensing and Spatial Information Sciences, 36(A1), unpaginated CD-ROM, 6 pages.

[14] Dörstel, C., 2007. DMC – (R)evolution on geometric accuracy, Photogrammetric Week 2007, (Fritsch, D., Ed.), Wichmann Verlag, pp. 81-88.

[15] Fricker, P., 2007. Raising the bar for the multi-band high-resolution airborne imagery, Photogrammetric Week 2007, (Fritsch, D., Ed.), Wichmann Verlag, pp.71-79.

[16] Honkavara, E. and Markelin, L, 2007. Radiometric Performance of Digital Image Data Collection - A Comparison of ADS40/DMC/UltraCam and EmergeDSS. Photogrammetric Week 2007. Institute for Photogrammetry, University of Stuttgart.

[17] Honkavaara, E., Peltoniemi, J., Ahokas, E., Kuittinen, R., Hyyppä, J., Jaakkola, J., Kaartinen, H., Markelin, L., Nurminen, K. and Suomalainen, J., 2008. A permanent test field for digital photogrammetric systems. Photogrammetric Engineering & Remote Sensing, 74(1): 95-106.

[18] Markelin, L., Honkavaara, E., Peltoniemi, J., Ahokas, E., Kuittinen, R., Hyyppä, J., Suomalainen, J. and Kukko, A., 2008. Radiometric calibration and characterization of large-format digital photogrammetric sensors in a test field. Photogrammetric Engineering & Remote Sensing (in press).

[20] Draxler, R.R. and Rolph, G.D., 2003. HYSPLIT (HYbrid Single-Particle Lagrangian Integrated Trajectory) Model access via NOAA ARL READY Website (http://www.arl.noaa.gov/ready/hysplit4.html). NOAA Air Resources Laboratory, Silver Spring, MD.

[21] Comerón, A., Rocadenbosch, F, López, M. A., Rodríguez, A., Muñoz, C., García, D. and Sicard, M., 2004. Effect of noise on lidar data inversion with the backward Klett algorithm, Applied Optics, 43, 1-6.

[22] Pérez, C., Sicard, M., Jorba, O., Comerón, A. and Baldasano, J. M., 2004. Summertime re-circulations of air pollutants over the north-eastern Iberian coast observed from systematic EARLINET lidar measurements in Barcelona, Atmos. Environ., 38, 3983-4000.

[23] Rocadenbosch, F. and Comerón, A., 1999. Error analysis for the lidar backward inversion algorithm, Applied Optics, 38 (21), 4461-4474.

[24] Rocadenbosch, F., Comerón, A., and Albiol, L., 2000. Statistics of the slope-method estimator, Applied Optics, 39 (33), 6049-6057.

[25] Sicard, M., Pérez, C., Rocadenbosch, F., Baldasano, J.M. and García-Vizcaino, D. 2006. Mixed-layer depth determination in the Barcelona coastal area from regular lidar measurements: methods, results and limitations, Boundary-Layer Metorol., 119 (1), 135-157.

[26] CSRS-PPP (Precise Point Positioning) Service. Canada Centre for Remote Sensing. Website (http://ess.nrcan.gc.ca/2002_2006/gnd/csrs_e.php)

[27] Martínez, L., Palà, V., Arbiol, R, Pérez, F. and Tardà, A., 2006. Atmospheric correction algorithm applied to CASI multi-height hyperspectral imagery, 2nd International Symposium on Recent Advances in Quantitative Remote Sensing: (RAQRS'II). 25 – 29 September. València.

[28] Soler, M. E., Pérez, L.F., Palà , V. and Arbiol, R., 2007. Experiencias en medidas de resolución de imagen en el ICC. 7th Geomatic Week.. Barcelona, 20-23 february.

[29] Martínez, L., Arbiol, R., Palà, V. and Pérez, F., 2007. Digital Mapping Camera radiometric and colorimetric calibration with simultaneous CASI imagery to a CIE Standard Observer based colour space. IEEE International Geoscience and Remote Sensing Symposium. Barcelona, 23-27 Juliol.

[30] Martínez L. and Arbiol R., 2008. ICC experiences on DMC radiometric calibration. International Calibration and Orientation Workshop EuroCOW 2008. Castelldefels, 30 gener-1 Febrer.