



CARPE DIEM

Critical **A**ssessment of available **R**adar **P**recipitation **E**stimation techniques and
Development of **I**nnovative approaches for **E**nvironmental **M**anagement

Contract N° EVG1-CT-2001-00045

3rd Year – Annual Report
January 1st, 2004 – December 31st, 2004

EXECUTIVE SUMMARY

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<http://carpediem.ub.es>



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EXECUTIVE PUBLISHABLE SUMMARY





Contract n°	EVG1-CT-2001-00045	Reporting period:	Jan1 st , 2004 – Dec 31 st , 2004
Title	Critical Assessment of available Radar Precipitation Estimation techniques and Development of Innovative approaches for Environmental Management CARPE DIEM		

Objectives:

The key objectives of CARPE DIEM is to improve actual flood-forecasting capability through a better understanding of the processes and mechanisms that drive hydrogeological hazards.

The sensitivity of hydrological models to the errors, associated with the different input data sources, clearly reveals the need of state-of-the-art rainfall input values. To meet this goal we have worked on improving the performance of numerical prediction at short forecast times (i.e. from +6 to + 24 hours) and improving the real-time estimation of rainfall fields during severe weather events that are related to flooding and flash-flooding problems. We achieved this goal by coupling together multiparameter/polarimetric radar data and numerical weather prediction techniques (NWP). This represents the main area of innovation of the project. Another innovative aspect of the work is to exploit NWP results in order to improve the interpretation of radar observations. This exercise not only enables a general improvement in extracting information from radar but also allows the reduction of inherent radar errors, thus allowing to quality control radar measurements.

Scientific achievements:

Work was divided into three co-operative blocks.

In the first block a coordination workpackage is envisaged, where technical and financial coordination work was done.

The second block of activities is mainly devoted to research, with a definition of three areas.

Pre-processing and assimilation of radar measurements and their products in NWP is covered under **Area 1**.

Doppler wind Processing

Dual-Doppler wind extraction software programmes have been developed and used in a assimilation exercise. In addition the methodology developed has been installed in the Po Valley area and it is used in the operational analysis routine. The innovative de-aliasing algorithm developed has been tested over a number of cases covering the different climatic area analyses.

Developing and testing of a VSRF system. Analysis of severe convective episodes.

A VSRF system based on LAPS analysis system and a LAM have been implemented. The domain of analysis has been enlarged. Convective episodes have been analysed using satellite information and polarimetric radar data.

Assimilation of radar Doppler data into NWP

Software modules to pre-process and assimilate Doppler radar data have been tested. First results of the assimilation experiment are available.

Area 2 addresses the improvement of radar-derived parameters using NWP information.

Anomalous propagation

The work on beam blockage has resulted in a journal publication. The beam blockage evaluation code has been installed and tested in different areas. The work and methodology on anaprop simulation shows progress towards the implementation of a software application. The projection of DTM data into the radar grid as well as the visualisation of terrain is now available to support the analysis of anaprop cases.

Diagnosis of Overhanging Precipitation

Layers of overhanging precipitation (OP), not reaching the ground, or areas of significant evaporation are problems for any correction based on an observed VPR close to a radar. Typically positive VPR corrections at long ranges can make surface precipitation estimate less representative at the ground level in areas with overhanging precipitation than without correction at all. Prior to any VPR correction overhanging precipitation areas should be totally eliminated if we want to get the best possible surface precipitation intensity estimate. Diagnosis of overhanging precipitation can be done close to each radar applying precipitation base height field from the radar network.

The use of NWP data to diagnose OP has been tested, but it has proved to be not enough reliable to be used operationally.

Use of polarimetric radar data to improve radar rain estimates

In 2004 two work packages have been addressed. Quantitative polarimetric methods have been examined in terms of the relative advantage over conventional, reflectivity only precipitation estimates. The net outcome was that the polarimetric observables are too noisy in S-band, but might be better in C-band.

The Entropy-Alpha decomposition, based on Pauli-matrices, has been tested to classify radar echos. The



statistical fluctuations of scattering vectors in random media problems (such as clouds or rain cells) lead to the possibility of analyzing the hermitian coherency matrix; the diagonalisation of this matrix yields two scalar observables, i.e. entropy H and alpha-angle α . Using the entropy-alpha plane it is possible to define various areas for the classification of scattering processes.

The main objectives of the **Area 3** are the development of procedures for combining radar and rain-gauge estimates of rainfall with numerical weather predictions (NWP) and the assessment of the quality of the predicted rainfall field in terms of discharge forecasts in urban and rural catchments.

Analysis of different precipitation estimates

The work has identified rather complex spatio-temporal error characteristics in precipitation estimates from various sources, and thereby highlighted the importance of careful quality control when designing algorithms for combining estimates. Furthermore, the runoff modelling experiments clearly demonstrated the sensitivity of a hydrological model to precipitation errors. Especially the impact of the timing of the errors was revealed. The overestimated precipitation by HIRLAM in spring had a dramatic impact on the spring flood, as it coincided with the snow melt period. An even more pronounced overestimation by RADAR in autumn, however, had virtually no effect on modelled discharge as the period was characterized by near base flow conditions (further, the overestimation was most pronounced in an upstream part of the catchment).

The application of combined MW-IR satellite rainfall techniques have shown that problems arise when trying to keep the MW-IR histogram matching for a long time. Precipitating systems obviously modify very fast and matching is lost quite rapidly, especially in convective situations. For this reason the constellation of polar satellites with MW sensors onboard needs to be enlarged and this is planned in the future Global Precipitation Measurement (GPM) Mission.

MW rainfall estimation algorithms show strong deficiencies over land due to different soil reflection and emission properties. Screening procedures used to discard non-rainy pixels or to assign rain to certain areas are often applied blindly and tend to cause underestimation of the total rain area, as in the Algerian case. The study shows unambiguously that better screening procedures help in correcting such errors. At the same time, and especially at mid latitudes, a finer calibration with radar data is to be attempted in the near future.

Assessment of rainfall-runoff model

The TOPKAPI model has been applied to the Dargle catchment in Ireland. The model can be applied, using existing topographical, soil and land-use data, without calibration and gives physically realistic outputs. However, when gauging data is available, the model performance can be improved by manually adjusting some of the parameters. The sensitivity analysis confirms the appropriateness of the simple manual calibration for matching flow peaks. While the overall fit is quite good, there is some systematic structure in the residuals and, for the Dargle, the fitted TOPKAPI model underestimates discharge peaks and overestimates recessions and base flows. This may be partly due to the lack of a groundwater component and its influence on the model calibration. The modelled soil depth has a large influence on the performance, for instance a depth of 1 m produces a model which tends to over-estimate the number and magnitude of peaks and under-estimate recessions. Where sufficient data is available for calibration, simpler semi-distributed or lumped models may be better for flood forecasting application only.

The end-users activities and project results dissemination form the third block.

End Users Workshop

The 6th Carpe Diem Project partners meeting was held at the Unitas Conference Center, Helsinki, Finland on the 22nd and 23rd June 2004 and was jointly organised with the MUSIC and the Mantissa projects. There were five sessions (1) The European Context; (2) Observational Techniques; (3) Meteorological and Hydrological Modelling; (4) End-Users round table and (5) End-Users needs, applications and perspective. A total of 84 persons attended the meeting.

International School on Hydro-geological Risk Prevention and Management - Session one Rainfall estimation and forecast.

As an important part of the final meeting a session of the "International School on Hydro-geological Risk Prevention and Management" was organised. The school lasted for an entire week with the participation of about 50 students.

Socio-economic relevance and policy implications:

The main objective of the CARPE DIEM project is to improve flood forecasts in small urban and rural catchments by means of improved rainfall estimation and prediction. This is an extremely important problem of which the socio-economical relevance is very high and its policy implications relate to the



possibility of improving the decision process, during emergency situations, particularly in densely populated urban areas.
 Natural End-users of CARPE DIEM outcomes are civil protection and ground defence agencies, as well as hydrological and weather services. Furthermore as the CARPE DIEM End-Users panel demonstrates improvements in rainfall detection, estimation and prediction will benefit a much wider audience, such as sewage management agencies, hydro-electric power industries and highway management agencies, e.g. for snow clearance etc.

Conclusions:

The project has developed advanced methodologies to increase the operational exploitation of radar information. This will have a direct feedback in the quality and availability of rainfall estimation and prediction fields. Advancement in understanding of basic processes and mechanisms that drive hydrogeological hazards is a natural consequence of the work done. The forecasting quality assessment will be based upon end-user requirements that will be called to specifically suggest their needs and to verify the effectiveness of the results. The end-users community has been greatly involved within the project activities through the realisation of project workshops and a school.

Keywords:

radar meteorology, rainfall, data assimilation, weather forecasting, dual Doppler, polarisation, vertical reflectivity profile, hydrological modelling, flood forecasting.

1.1. Publications (cumulative list)¹

1.1.1. Peer Reviewed Articles:

Authors	Date	Title	Journal	Reference
Haase, G., and Landelius, T.	2004	De-aliasing of Doppler Radar Velocities Using a Torus Mapping.	J. Atmos. Oceanic Technol.	21, 1566-1573
Lindskog, M., Salonen, K. Järvinen, H. and Michelson, D. B.	2004	Doppler radar wind data assimilation with HIRLAM 3D-Var.	Mon. Wea. Rev.	5, 1081-1092
Orlandi, A., A. Ortolani, F. Meneguzzo, V. Levizzani, F. Torricella, and F.J. Turk	2004	Rainfall assimilation in RAMS by means of the Kuo parameterisation inversion: method and preliminary results	J. Hydrology	288, 20-35
M. Galletti, P.P. Alberoni, V. Levizzani and M. Celano	2004	Assessment and tuning of the behaviour of a microphysical characterization scheme	Advances in Geosciences	submitted
Fornasiero, A.; Amorati, R.; Alberoni, P.P.; Ferraris, L.; Taramasso, A.C	2004	A method to remove effects of radar beam interaction with the ground in various propagation conditions. impact on data quality	Advances in Geosciences	submitted
Fornasiero, A.; Alberoni, P.P.; Picciotti, E.; Vulpiani, G.; Marzano, F.S.	2004	Reconstruction of reflectivity vertical profiles and data quality control for C-band radar rainfall estimation	Advances in Geosciences	submitted

¹ Two copies of publications issued during reporting period should be annexed to the report, specific cases should be agreed by the Project Officer



1.1.2. *Non refereed literature:*

Authors / Editors	Date	Title	Event	Reference	Type²
Haase, G., Landelius, T. and Michelson, D. B.	2004	A novel de-aliasing algorithm for radar radial wind velocities profiles.	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden		Conference proceedings.
Olsson, J., Johansson, B., and S. Fogelberg	2004	Tests of radar-observed precipitation in the HBV model	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden		Abstract
Koistinen, J. and H. Pohjola	September 2004	Diagnosis of precipitation detection range	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of 3rd European Conference on Radar Meteorology and Hydrology (ERAD), Vol 2, pp. 438-439	Poster and extended abstract
Pohjola H. and J. Koistinen	September 2004	Identification and elimination of overhanging precipitation	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of 3rd European Conference on Radar Meteorology and Hydrology (ERAD), Vol 2, pp. 91-93	Oral presentation and extended abstract
Saltikoff, E., J. Koistinen and H. Hohti	September 2004	Downburst identification using Doppler shear in FMI radar network	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of 3rd European Conference on Radar Meteorology and Hydrology (ERAD), Vol 2, pp. 41-44	Oral presentation and extended abstract
Saltikoff, E., U. Gjertsen, D. Michelson, I. Holleman, J. Seltmann, K. Odakivi, A. Huuskonen, H. Hohti, J. Koistinen, H. Pohjola and G. Haase	September 2004	Radar data quality issues in Northern Europe	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of 3rd European Conference on Radar Meteorology and Hydrology (ERAD), Vol 2, pp. 212-215	Oral presentation and extended abstract
Goh, Y. K. and A. R. Holt	Dec 2004	Analysis of Three Dimensional Wind Field from Two Operational Doppler Radars	2004 UWERN Annual Conference, Salford		Poster

² Type: Abstract, Newsletter, Oral Presentation, Paper, Poster, Proceedings, Report, Thesis



Authors / Editors	Date	Title	Event	Reference	Type ²
Goh, Y. K., and A. R. Holt	Sept. 2004	Analysis of Three Dimensional Wind Field from Two Operational Doppler Radars	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden		Proceeding/Oral presentation
Haase, G., T. Landelius, and D. B. Michelson	Sept 2004	Impact of a novel de-aliasing strategy on the quality of Doppler radar wind profiles and super-observations used for data assimilation	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden		Proceeding/Oral presentation
Goh, Y. K.	June 2004	Improving radar Doppler wind information extraction	European workshop on New Tools for Flood Forecasting and Warning, Helsinki		Oral presentation
Jarmo Koistinen, Heikki Pohjola, Joan Bech & David Bebbington	June 2004	Improving radar reflectivity information extraction	European workshop on New Tools for Flood Forecasting and Warning, Helsinki		Oral presentation
Picanyol M., J.R. Miró, B. Codina, X. Saenz de Buruaga	2004	A comparison experiment between nudging and incremental analysis updating in a mesoscale model	EGU - 1st General Assembly, Nice, France, 25 - 30 April 2004	EGU04-A-07442	Poster
Bebbington, D.; Rae, A.; Bech, J.; Codina, B.; Picanyol, M	2004	Modelling of weather radar echoes from anomalous propagation using a hybrid parabolic equation method and thermodynamic fields derived from a numerical weather prediction model	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	European Conference on Radar in Meteorology and Hydrology (ERAD) - COST 717 Final Seminar. Abstracts Book, Copernicus GmbH (c) 2004, p. 29	Oral presentation
Bech, J.; Toda, J.; Codina, B.; Lorente, J.; Bebbington, D.	2004	Using mesoscale NWP model data to identify radar anomalous propagation events.	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	ERAD Publication Series Vol 2. Copernicus GmbH (c) 2004 ISBN 3-936586-29-2, pp. 310-314	Poster
Bech, J.; Vilaclara, E.; Pineda, N.; Rigo, T.; López, J.; O'Hora, F.; Lorente, J.; Sempere, D.; Fàbregas, F. X.	2004	The weather radar network of the Catalan Meteorological Service: description and applications	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	ERAD Publication Series Vol 2. Copernicus GmbH (c) 2004 ISBN 3-936586-29-2, pp. 416-420	Poster



Authors / Editors	Date	Title	Event	Reference	Type ²
Bech, J.	2004	Observational Analysis and Numerical Modelling of Atmospheric Propagation Conditions of Weather Radar Echoes.		COST Working Document WDF_02_200406_1 , 27 pp. Available at http://www.smhi.se/cost717	Internal report.
Galletti, M., P. P. Alberoni, and V. Levizzani	2004	Assessment and tuning of the behaviour of a microphysical characterization scheme based on radar polarimetric variables	14th Int. Conf. on Clouds and Precipitation, Bologna, 18-23 July.	Proc. 14th Int. Conf. on Clouds and Precipitation, Bologna, 18-23 July, 771-774	Proceedings
Levizzani, V., and A. Mugnai	2004	Rainfall measurements from space: Where are we?	14th Int. Conf. on Clouds and Precipitation, Bologna, 18-23 July.	Proc. 14th Int. Conf. on Clouds and Precipitation, Bologna, 18-23 July, 1123-1126	Proceedings
Toricella, F., V. Levizzani, and V. Poli	2004	Applications of PMW rainfall algorithms to Mediterranean area events.	14th Int. Conf. on Clouds and Precipitation, Bologna, 18-23 July.	Proc. 14th Int. Conf. on Clouds and Precipitation, Bologna, 18-23 July, 1171-1174	Proceedings
Bruen, M & Parmentier, B	2004	A systematic approach to assessing the value of radar estimates of precipitation for hydrological models used in flood forecasting in rural catchments.	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden		Oral presentation
A. Fomasiero, R. Amorati, P. P. Alberoni, L. Ferraris, and A. C. Taramasso	Sept. 2004	Impact of combined beam blocking and anomalous propagation correction algorithms on radar data quality.	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of the 3rd European Conference on Radar Meteorology (ERAD) together with the COST 717 Final Seminar, Visby, Island of Gotland, Sweden, 6 - 10 September 2004, 216 – 222.	Oral Presentation
F. S. Marzano, G. Vulpiani, P. P. Alberoni, L. Ferraris, L. Provenzale, and N. Rebora	Sept. 2004	Spatial characterization and classification of rainfall fields derived from operational c-band weather radar data.	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of the 3rd European Conference on Radar Meteorology (ERAD) together with the COST 717 Final Seminar, Visby, Island of Gotland, Sweden, 6 - 10 September 2004, 223 – 229.	Poster



Authors / Editors	Date	Title	Event	Reference	Type ²
R. Cremonini, R. Bechini, P.P. Alberoni, and M. Celano	Sept. 2004	Which hydrometeor classification scheme is realistic using ZH, ZDR and temperature in complex orography? A study based on operational C-band polarimetric weather radar in northern Italy	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of the 3rd European Conference on Radar Meteorology (ERAD) together with the COST 717 Final Seminar, Visby, Island of Gotland, Sweden, 6 - 10 September 2004, 393 – 397.	
Silvestro, F.; Rebora, N.; Ferraris, L.; Alberoni, P.P.; Fornasiero, A.	Sept. 2004	Clutter and anomalous propagation identification using doppler-polarimetric measurements and vertical reflectivity profile.	3rd European Conference on Radar in Meteorology and Hydrology, 6-10 September 2004, Visby, Sweden	Proceedings of the 3rd European Conference on Radar Meteorology (ERAD) together with the COST 717 Final Seminar, Visby, Island of Gotland, Sweden, 6 - 10 September 2004.	
Chandra, M.; Galletti, M.; Alberoni, P. P.; Bebbington, D.; Hagen, M.	April 2004	Comparison between radar rainfall estimates obtained from Z-R and PhiDP-R relationships.	EGU - 1st General Assembly, Nice, France, 25 - 30 April 2004		Oral presentation
Galletti, M.; Alberoni, P.P.; Levizzani, V.	Oct. 2004	Assessment and tuning of the behaviour of an microphysical characterisation scheme.	Plinius Conference on Mediterranean Storms, 17-24 October 2004		Oral presentation
Fornasiero, A.; Amorati, R.; Alberoni, P.P.; Ferraris, L.; Taramasso, A.C.	Oct. 2004	A method to remove effects of radar beam interaction with the ground in various propagation conditions. impact on data quality.	Plinius Conference on Mediterranean Storms, 17-24 October 2004		Oral presentation
Fornasiero, A.; Alberoni, P.P.; Picciotti, E.; Vulpiani, G.; Marzano, F.S.	Oct. 2004	Reconstruction of reflectivity vertical profiles and data quality control for C-band radar rainfall estimation.	Plinius Conference on Mediterranean Storms, 17-24 October 2004		Poster
Silvestro, F. ; Ferraris, L.; Rebora, N.; Morando, M.; Alberoni, P.P., Fornasiero, A.	Oct. 2004	Clutter and rainfall discrimination by means of doppler-polarimetric measurements and vertical reflectivity profile analysis	Plinius Conference on Mediterranean Storms, 17-24 October 2004		Poster



1.1.3. Others: (Patents, CD ROM's, videos,...)

CD-ROM – Proceedings of “European workshop on New Tools for Flood Forecasting and Warning” held in Helsinki, Finland, 22-23 June, 2004. Available at ARPA – SIM.

CD-ROM – “Proceedings of International School on Hydro-geological Risk Prevention and Management – Session one – Rainfall estimation and forecast.” Held in Bologna, Italy, 29 November – 3 December, 2004. Available at ARPA – SIM.

1.1.4. Planning of future publications: (type, date, contents, ...)

Preparation of a special issue on “Recent Advances in Measurements, Modelling and Uncertainty Assessment in Real Time Flood Forecasting – Vol 1-2” for HESS. List of papers prepared by the CARPE DIEM team:

Haase, G., Salonen, K., Källberg, P. Lindskog, M., Goh, K. and Alberoni P.P. Processing and assimilation of Doppler Radar Wind data: A comparison case study.

Källberg, P. and Landelius, T, and . A case study carried out with two different NWP systems.

J. Olsson, B. Johansson and G. Grahn, Comparison of areal precipitation estimates and their performance in runoff modelling: a case study for a central Swedish catchment.

Goh, Y. K., A. R. Holt, and P.P. Alberoni, 'Analysis of Three Dimensional Wind Field from Two Operational Doppler Radars'.

Alberoni, P.P., M. Celano, V. Levizzani, and A. R. Holt, 2005: Analysis of severe convective events from two operational dual polarisation Doppler radars.

Levizzani, V., F. Torricella, and F. J. Turk, 2005: Rainfall measurement from space: science and technology.

Torricella, F., V. Levizzani, A. Ortolani, S. Melani, A. Antonini, and F. J. Turk, 2005: Rapid update satellite rainfall estimations for the Mediterranean.

Koistinen, J., H. Pohjola and H. Hohti. Accuracy of quantitative radar based precipitation measurements applying an operational VPR correction method

Pohjola, H. and J. Koistinen. Statistical comparison of attenuation due to rain, sleet and snow in C-band radar measurements

Riccardo S., Lindskog M., Todini E., Gustafsson N. A methodology for estimation of forecast error variations into the HIRLAM 3-dimensional variational data assimilation system

Joan Bech, Bernat Codina, Jeroni Lorente. Improved Forecasts of Weather Radar Propagation Conditions

David Bebbington, Stephen Rae, Joan Bech, Bernat Codina, Miquel Picanyol. Modelling Of Weather Radar Echoes from Anomalous Propagation Using A Hybrid Parabolic Equation Method And Thermodynamic Fields Derived from A Numerical Weather Prediction Model

Anna Fornasiero, Pier Paolo Alberini. Statistical analysis and modelling of the radar beam propagation condition in the Po valley.

Y. Kheng Goh, Anthony R. Holt and Pier Paolo Alberoni. Analysis of Three Dimensional Wind Fields from Two Operational Doppler Radars

Thomas Börner. A first approach to unsupervised entropy-alpha-classification of full-polarimetric weather-radar data.

B. Vehviläinen, M. K. Cauwengerghs, J.-L. Cheze, A. Jurczyk, R. J. Moore, J. Olsson, M. Salek, and J. Szturc, Evaluation of operational flow forecasting systems that use weather radar, submitted as COST 717 report.

Michelson, D., Einfalt, T., Holleman, I., Gjertsen, U., Friedrich, K., Haase, G., Lindskog, M. and Szturc., J. Weather Radar Data Quality in Europe: Quality Control and Characterization. Submitted as COST 717 report.



Proceedings of 32nd International Conference on Radar Meteorology (AMS) in Albuquerque, USA October 2005.

A peer reviewed article in Journal of Atmospheric Meteorology.

Bruen, M. & Parmentier, B. A comparison of different types of catchment model for flash flood forecasting in steep catchments using either rain or rain-gauge precipitation inputs. Accepted for presentation at the General Assembly of the European Geosciences Union, April 2005.



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