SPECIAL PROJECT PROGRESS REPORT

Progress Reports should be 2 to 10 pages in length, depending on importance of the project. All the following mandatory information needs to be provided.

Reporting year ……2013 (started on 1 January 2013)……

Project Title: …… A general-purpose data assimilation and forecasting system ……

Computer Project Account: ……cm4……

Principal Investigator(s): ……Stefano FEDERICO……

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Affiliation: …ISAC-CNR (Istituto di Scienze dell'Atmosfera e del Clima, - Consiglio Nazionale delle Ricerche) …

Name of ECMWF scientist(s) collaborating to the project (if applicable) ……

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Start date of the project: ……1 January 2013……

Expected end date: ……31 December 2014……

Computer resources allocated/used for the current year and the previous one

(if applicable)
Please answer for all project resources (25 June 2013).

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	250.000	250.000	250.000	56.000
Data storage capacity	(Gbytes)	200	100	200	93

Summary of project objectives
(10 lines max)

The main task of this project is to improve and test a new data assimilation and forecasting system, named CRAMS (Calabria Regional Atmospheric Modelling System), which is developed at ISAC-CNR.
CRAMS is composed by two main components: an analysis package and a forecasting model. Both components are based on the RAMS (Regional Atmospheric Modelling System; Pielke, 2002), which is used since 2005 in southern Italy to produce operational weather forecasting at the mesoscale (Federico, 2011). This project mailny focuses on the development of the 3D-Var data assimilation system.

Reference:
Federico, S.: Verification of surface minimum, mean, and maximum temperature forecasts in Calabria for summer 2008, Nat. Hazards Earth Syst. Sci., 11, 487-500, doi:10.5194/nhess-11-13-487-2011, 2011.
Pielke, R. A: Mesoscale Meteorological Modeling. Academic Press, San Diego, 2002.

Summary of problems encountered (if any)
(20 lines max)

The main problems I encountered this year is the porting of the code (both RAMS and 3D-Var on cca). I'm still working on this problem, mainly with the RAMS model, which tend to develop unrealistic results in some occasions (not clearly understood). Moreover the time limit (24 h) imposed on cca is quite stringent. A time limit of 48 – 72 h would be greatly appreciated in future projects.

Summary of results of the current year (from July of previous year to June of current year)
This section should comprise 1 to 8 pages and can be replaced by a short summary plus an existing scientific report on the project

During the first year of this special project the work focused on the development of the 3D-Var component of the analysis package for the RAMS model. In this second year the attention was on the assimilation of lightning data.
However, before assimilating lightning into the model, a scheme to simulate lightning has been set-up for it and most of the work of the first semester of this year was devoted to this activity. Moreover, the comparison of simulated and observed lighting activity is an immediate and powerful tool to assess the model ability to reproduce the intensity and the evolution of the convection.
The methodology implemented to simulate the lightning in the RAMS model is inspired from the works of Dahl et al. (2011a, 2011b). The method gives the flash density at the resolution of the RAMS grid-scale allowing for a detailed analysis of the evolution of simulated lightning activity. The methodology differs from Dahl et al. (2011a, 2011b) because it is designed to account for the differences of the meteorological models used and to focus on the charge separation processes occurring in the charging zone, and it also uses a different method to spatially distribute the simulated lightning associated to the convective cells.

More in detail, the method assumes a plane capacitor scheme and is based on the idea that the flash rate is not only determined by the charging rate, but also by the geometry-dependent discharge strength of each lightning flash. The flash rate is given by:

$$f = \gamma j \frac{A}{\Delta Q} \qquad (1)$$

where f is the flash rate (s^{-1}), η is the lightning efficiency (0.9), A is the area (m^2) of the plane plate capacitor, j ($Cm^{-2}s^{-1}$) is the charging current, and ΔQ (C) is the averaged charge neutralized by the lightning.
For the application of this approach the geometrical properties of the capacitor need to be determined. These properties are formulated using the ice and graupel fields from the cloud resolving model and the idea underlying the parameterization is that the graupel contains the negative charge, while the ice has the positive charge. The charge is separated by the non-inductive graupel-ice mechanism (Saunders, 2008). In the formulation of the methodology, the ice field is given by the sum of pristine ice, snow and aggregates, while the graupel field is given by the sum of the graupel and hail hydrometeors.
The graupel region is identified by the region where the graupel concentration (g/m^3) is larger than 0.1 g/m^3 and the temperature is between 273 and 248 K. This limits the identification of the graupel cells into the charging zone. The ice region is identified by requiring its concentration larger than 0.1 g/m^3 and the temperature below 273 K.
In general, for an instantaneous output of the meteorological model, several ice and graupel cells are found. To identify them, the Hoshen and Kopelman (1976) labelling algorithm is used. This method, which was originally developed in the percolation theory, is an efficient way for labelling as a "cell" a continuous field satisfying some properties (for example graupel concentration larger than 0.1 g/m^3 and temperature between 273 and 248 K). The percolation theory (Stauffer and Aharony, 1994) describes the behaviour of connected clusters in a random process. In our case, the clusters are composed by contiguous model grid boxes with graupel or ice density larger than 0.1 g/m^3, while the random process is the graupel and ice field of the RAMS model.
The methodology has been tested for six-case studied occurred in central Italy in fall 2011 and fall 2012.
A detailed discussion of these cases, as well as of the methodology used to simulate lightning into the RAMS model, has been reported in Federico et al. (2014).

Reference:
Dahl, J. M. L., Holler, H., Schumann, U., 2011a: Modeling the flash rate of thunderstorms. Part I: Implementation. Mon. Wea. Rev., 139, 3093–3111.
Dahl, J. M. L., Holler, H., Schumann, U., 2011b: Modeling the flash rate of thunderstorms. Part II: Implementation. Mon. Wea. Rev., 139, 3112–3124.
Federico S., E. Avolio, M. Petracca, G. Panegrossi, P. Sanò, D. Casella, and S. Dietrich, 2014: Simulating lightning into the RAMS model: implementation and preliminary results.
Nat. Hazards Earth Syst. Sci. Discuss., 2, 3351-3395, 2014 www.nat-hazards-earth-syst-sci-discuss.net/2/3351/2014/ : doi:10.5194/nhessd-2-3351-2014
Hoshen, J., Kopelman, R., 1976. Percolation and cluster distribution. I. Cluster multiple labeling technique and critical concentration algorithm. Phys. Rev., 14B, 3438–3445.
Stauffer, D., and Aharony, A., 1994. Introduction to percolation theory. Taylor and Francis, London, 181 pp.

List of publications/reports from the project with complete references

Since the last report, a paper, using the full 3D-Var version of the analysis package, was published on AMT (http://www.atmos-meas-tech.net/volumes_and_issues.html). The paper can be downloaded at: http://www.atmos-meas-tech.net/6/3563/2013/amt-6-3563-2013.html

I have also submitted a paper which shows the implementation of the lightinig scheme into the RAMS model. The paper is open for dicussion on Natural Hazards and Earth System Sciences (NHESSD) http://www.nat-hazards-earth-syst-sci-discuss.net/2/3351/2014/nhessd-2-3351-2014-discussion.html .

The implementation of the scheme is mandatory for any data assimilation of the lightning data.

Finally I have submitted an abstract to the 8th Hymex workshop entitled: Lightning simulation of moderate-intense convective events over Italy. In this work some prelimiary results of the lightning assimilation can be found. The abstract can be monitored through the Hymex web site (www.hymex.org).

Summary of plans for the continuation of the project

(10 lines max)

The project will end this year. In the remaining part of the project I will test further the lightning-scheme and the assimilation of lightning into the RAMS model with short-term forecasts.