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 (10 June 2013).

		Previous year		Current year	
		Allocated	Used	Allocated	Used
High Performance Computing Facility	(units)	/	/	150.000	110.000
Data storage capacity	(Gbytes)	/	/	200	45

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 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)

Few problems occurred at the start of the project. Most of them were caused because I was new to c2a , while I used ecgate mainly to retrieve data from MARS. Most of the initial problems referred to the use of the xlf90 compiler and ar command on c2a. I was aided by the ECMWF staff to compile the RAMS model, which uses both C and Fortran routines. Moreover, RAMS uses HDF5 and some work was done to fix few problems with HDF5 routines (the version I used was not the same installed on c2a).
The main problem, however, is the limited space on the permanent area, which sometimes slow down my activity on c2a, because files need to be uploaded to the scratch area and then simulations can be performed.

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

The aim of this special project is to implement and test a 3D-Var data assimilation system suited for the RAMS (Regional Atmopsheric Modeling System, Pielke, 2002) model. This model doesn't have a variational data assimilation system, while it has several tailored ad hoc methods like nudging and dynamical adaptation.
It is important to mention that a 4D-Var data assimilation system is already in use for RAMS (Zupanski et al., 2005; Polkinghorne et al., 2009). Nevertheless, this code is not available to the RAMS community, and the aim of this project is to realize a simple but effective variational system, suitable for applications and operational implementation in small meteorological centres. The 3D-Var, indeed, requires less computational resources compared to 4D-Var (Rabier et al., 2000) or Ensemble Kalman filters (Anderson, 2001); it does not require the adjoint model and is simpler to implement. Of course there are drawbacks because of this "simplicity", the most important being the use of a constant forecast error covariance matrix.
To better define the framework of thus special project, it should be mentioned that a version of the RAMS model is maintained at ISAC-CNR and is operational in southern Italy (Federico, 2011). So, this project is an effort to establish a 3D-Var analysis system to be used with this model.
At the time of writing a 2D-Var system was implemented and was tested using radiosoundings and wind profilers over central Europe. The data were downloaded from MARS (Meteorological Archive

and Retrieval System) and the whole process activity is described in detail in Federico (2013). This paper is attached to this report and is a part of the report.
Results show the validity of the analyses because they are closer to the observations, consistently with the settings of the data assimilation system. Moreover, using the analysis effectively reduces the error for the one- and two hours forecast, with some improvement for the three-hours forecast.
Even if it is acknowledged that 2D-Var is a rough approximation of the 3D-Var, it is stressed that this is a first step toward the implementation of the 3D-Var code.
Compared to the paper attached to this report, an important functionality was added to the analysis system: the possibility to use the same horizontal coordinate system as RAMS. RAMS uses a rotated polar stereographic projection, whose pole is near the centre of the domain to minimize the projection distortion (Pielke, 2002). In the vertical direction, RAMS uses the sigma-z terrain following coordinate (Pielke, 2002), while the analysis uses pressure.
The possibility to run the analysis on the same horizontal coordinate system as RAMS, eventually with coarsened horizontal resolution to speed-up the analysis, is an important feature because it simplifies the interpolation between the RAMS and analysis grids. The option to run the analysis on a regularly spaced longitude-latitude grid, as shown in Federico (2013) is still available to use the ISAN (ISentropic Analysis) package, which is the standard method to initialize RAMS (see the RAMS technical manual available at http://www.atmet.com/html/docs/rams/rams_techman.pdf).
Finally, the analysis package and RAMS model were completely integrated in a cycling mode.

Reference:
Anderson, J.: An ensemble adjustment Kalman filter for data assimilation. Mon. Wea. Rev., 129, 2884–2903, 2001.
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.
S. Federico. Preliminary Results of a Data Assimilation System. Atmospheric and Climate Sciences (ACS), 2013, Vol.3, 61-72.
Pielke, R. A: Mesoscale Meteorological Modeling. Academic Press, San Diego, 2002.
Rabier, F., H. Järvinnen, E. Klinker, J.-F. Mahfouf, and A. Simmons: The ECMWF operational implementation of four-dimensional variational assimilation. I: Experimental results with simplified physics. *Quart. J. Roy. Meteor. Soc.,* **126,** 1143–1170, 2000.
Polkinghorne, R., Vukicevic, T., Evans, K. F.: Validation of Cloud-Resolving Model Background Data for Cloud Data Assimilation. Mon. Wea. Rev., 138, 781-795, 2009.
Zupanski, M., D. Zupanski T., Vukicevic, K. Eis, and T. Vonder Haar: CIRA/CSU four-dimensional variational data assimilation system. Mon. Wea. Rev., 133, 829–843, 2005.

List of publications/reports from the project with complete references

I have published one paper (which refers to the 2D-Var implementation of the analysis code) showing the prototype of the analysis system. In particular using the radiosoundings over Europe and the European Wind profiler network is shown in detail. The complete reference is:
S. Federico. Preliminary Results of a Data Assimilation System. Atmospheric and Climate Sciences (ACS), 2013, Vol.3, 61-72.
Note that the paper still uses two different grid projections, in the horizontal, for the analysis and forecasting model. In the current state of development the analysis package and RAMS model can share the same horizontal grid projection.

There is a second paper, using the 3D-Var version of the analysis package, submitted to Atmospheric Measuements Techniques (http://www.atmos-meas-tech.net/volumes_and_issues.html), but it is under review.

Summary of plans for the continuation of the project

(10 lines max)

I will work on the extension of the variational analysis system from 2D-Var to 3D-Var. Some results in this direction were already obtained; nevertheless there is still work to do (optimize the minimization algorithm, better constraint of recursive filters, etc.). I believe that the rest of this year will be devoted to this activity.
A second direction of development, starting at the beginning of 2014, will be the use of AMDAR data in the analysis, to show their impact on the short-term forecast (1-6 h) of the CRAMS model.