Implementation of Modeling the Land-Surface/Atmosphere Interactions to Mesoscale Model COAMPS

Dr. Bogumil Jakubiak
Interdisciplinary Centre for Mathematical and Computational Modelling,
Warsaw University, Pawinskiego 5A, 02-106 Warsaw, Poland
phone: +48-22-8749-144 fax: +48-22-8749-115 email: jakubiak@icm.edu.pl
Dr. Teddy Holt
Naval Research Laboratory, Monterey, CA 93943-5502
phone: 831-656-4740 fax: 831-656-4769 e-mail: teddy.holt@nrlmry.navy.mil
Dr. Richard Hodur
Interdisciplinary Centre for Mathematical and Computational Modelling,
Warsaw University, Pawinskiego 5A, 02-106 Warsaw, Poland
phone: +48-22-8749-144 fax: +48-22-8749-115 e-mail: hodur@nrlmry.navy.mil
Maciej Szpindler
Interdisciplinary Centre for Mathematical and Computational Modelling,
Warsaw University, Pawinskiego 5A, 02-106 Warsaw, Poland
phone: +48-22-8749-146 fax: +48-22-8749-115 email: m.szpindler@icm.edu.pl
Leszek Herman-Iżycki
Warsaw University, ICM, Pawinskiego 5A, 02-106 Warsaw, Poland
phone: +48-22-8749-127 fax: +48-22-554-0801 email: leszek@icm.edu.pl

Award Number: N00014-09-1-1099

LONG-TERM GOALS

The long-term goal of this project is to improve the treatment of convection and the prediction of convective precipitation in the Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS®[1]), by including selected land-surface and urban canopy schemes in COAMPS, along with tools that will allow the user to choose the optimum ones for selected nested-grid configurations.

OBJECTIVES

The objectives of this project are to: (a) integrate land-surface models and urban canopy schemes into COAMPS, (b) evaluate the limitations of the proposed schemes in describing surface-atmosphere interactions during drought conditions, (c) investigate the impact of land-atmosphere interactions on Quantitative Precipitation Forecast (QPF) skill, and (d) validate the COAMPS model performance when using the land-surface and urban canopy schemes.

APPROACH

Our approach is to use COAMPS to study the impact of land-vegetation processes on the prediction of mesoscale convection over central Europe during summer months. This will be accomplished by

[1]COAMPS® is a registered trademark of the Naval Research Laboratory.

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE **2010**	2. REPORT TYPE	3. DATES COVERED **00-00-2010 to 00-00-2010**
4. TITLE AND SUBTITLE **Implementation of Modeling the Land-Surface/Atmosphere Interactions to Mesoscale Model COAMPS**		5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)		5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Research Laboratory,7 Grace Hopper Avenue,Monterey,CA,93943-5502**		8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)		10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**		
13. SUPPLEMENTARY NOTES		
14. ABSTRACT		
15. SUBJECT TERMS		

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**7**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

implementing new and more detailed surface databases into COAMPS, developing a new data assimilation system for surface parameters, and performing numerical tests with COAMPS to determine the importance of selected parameters within the land-surface model (LSM). The results of this study will be applicable to similar continental areas.

WORK COMPLETED

During FY10, we accomplished the following tasks: (a) performed a number of numerical experiments testing the effect of a land-surface model on precipitation forecasts by using the NOAH land-surface scheme in COAMPS, (b) implemented a previously-developed object-oriented verification tool specifically designed to compare precipitation forecasts with radar observations, and (c) investigated the use of operational satellite information for land and vegetation stages to improve the description of the initial conditions in the COAMPS/NOAH modeling system.

RESULTS

A series of experiments were performed using the research version of COAMPS both with, and without, the NOAH land surface model. The first set of experiments we did is a simulation of a heavy rain event in Poland in May 2010. COAMPS was initialized at 0000 UTC 7 May 2010 with fields from the Global Forecast System (GFS) from the National Centers for Environmental Prediction (NCEP). These fields served as the initial conditions for two 24-hour forecasts: the first using the COAMPS/NOAH system, the other (control run) using COAMPS without the NOAH LSM. For these runs, the coarse mesh (9 km) grid covered most of the Central European area, the medium mesh (3 km) covered all of Poland, and the fine grid (1 km) covered an area roughly corresponding to the area covered by one radar site inside north-central Poland. The model grid domains are shown in Fig. 1. The model used 40 vertical levels. Fig. 2 shows the results of the simulated surface reflectivity fields at 14 hours and 45 minutes into the forecast (1445 UTC) on the medium and fine grids for the COAMPS/NOAH run. The patterns for both grids show very good qualitative agreement in the shape and intensity of the precipitation with the 1500 UTC observed precipitation pattern, shown in Fig. 3. There are striking similarities between the forecast and observed precipitation patterns, particularly with the 1 km grid forecast.

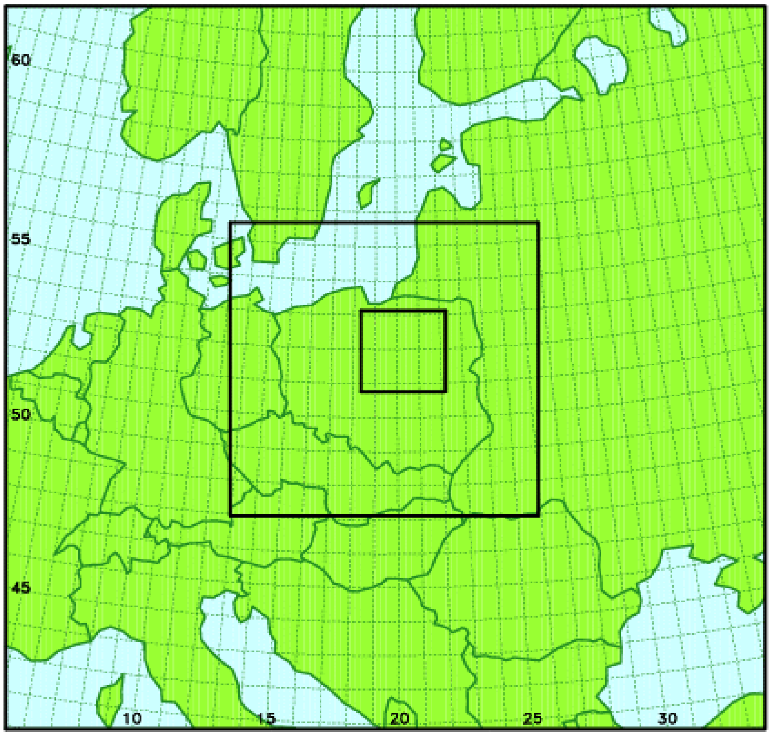

Figure 1. Triply-nested COAMPS grid structure for the COAMPS/NOAH experiments, showing the extent of the coarse (9 km), medium (3 km), and fine-mesh (1 km) grids.

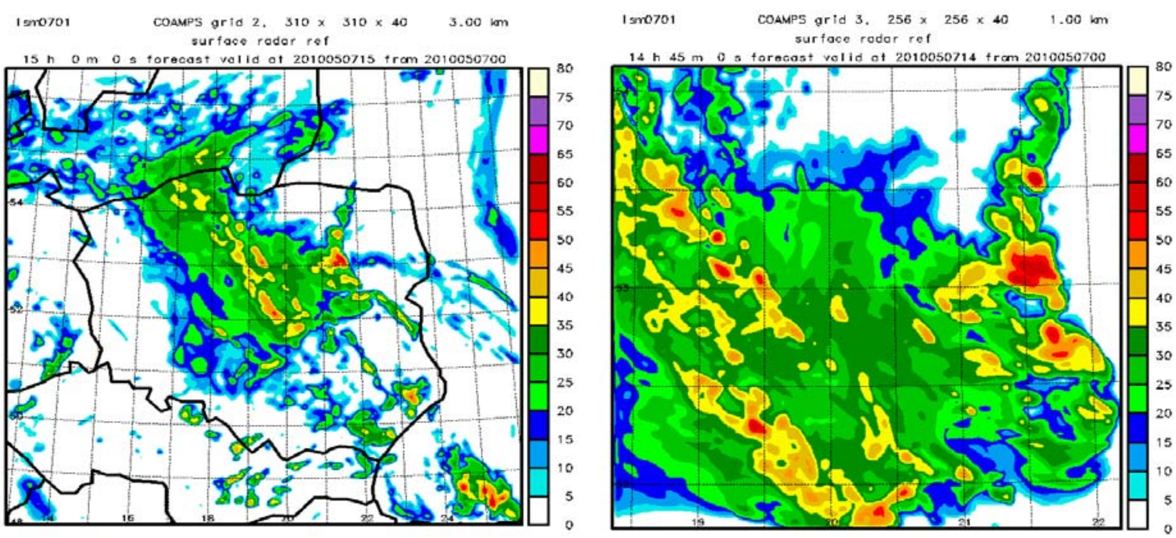

Figure 2. COAMPS-simulated radar reflectivity patterns on the 3 km grid (left panel), and on the 1 km grid (right panel).

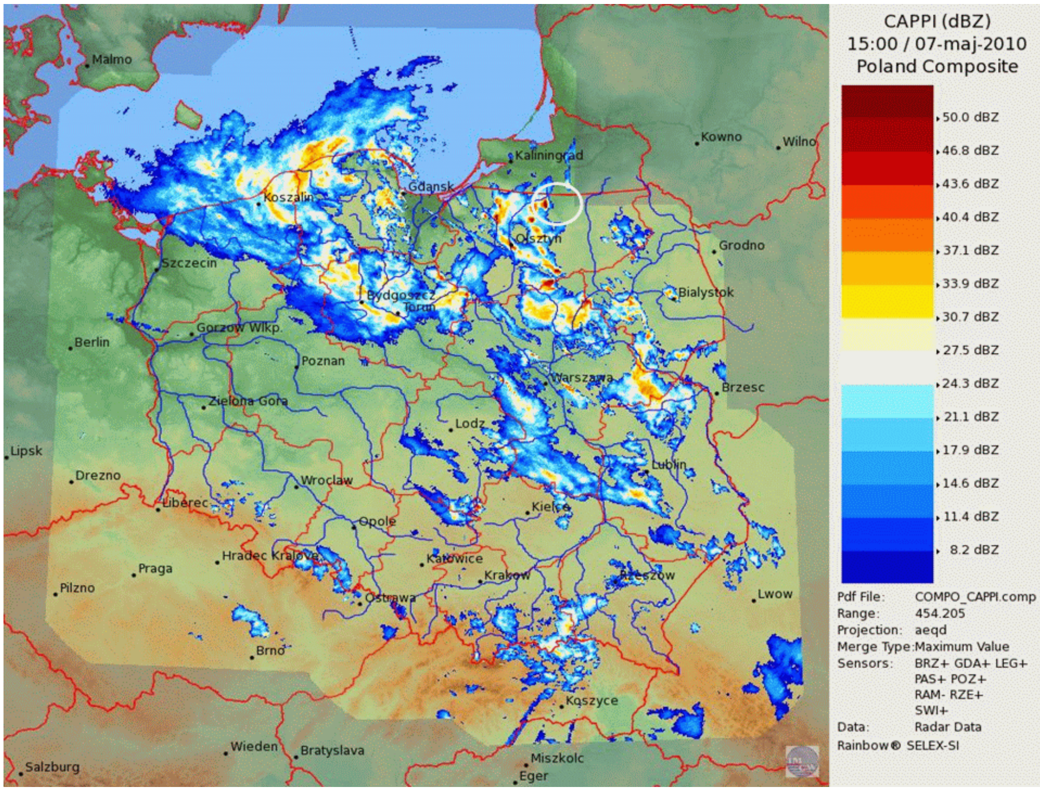

Figure 3. Composite of the surface reflectivity field observed over Poland at 1500 UTC 7 May 2010.

A more quantitative evaluation shows that all our experiments performed so far show a slight improvement in the convective precipitation forecasts by the COAMPS/NOAH system over the control runs. Table 1 presents the results of this evaluation. Here, we bin the precipitation values into 3 categories: (1) Correct (the observed and forecast events have comparable values), (2) Overestimated (forecast values of precipitation are higher than the observed values), and (3) Underestimated (the forecast values are lower than observed). In all categories, the COAMPS/NOAH system outperformed the control run. The fact that the number of underestimated precipitation objects is at least two times higher that the number of overestimated precipitation objects suggests that COAMPS is too dry.

Table 1. Precipitation validation for the COAMPS/NOAH (LSM) and COAMPS (NOLSM) experiments.

Case	Class	Counters
LSM	Correct	651
	Overestimated	177
	Underestimated	496
NOLSM	Correct	511
	Overestimated	211
	Underestimated	393

Our second set of experiments is an evaluation of the surface wetness model (SWEB), a model we plan on incorporating into the COAMPS/NOAH system in the future to better predict leaf wetness duration.

Leaf wetness duration is one of the most critical variables in the development of plant diseases, and it is extremely significant in the management of crop protection activities and the use of weather-related disease forecasting models. In our preliminary work, we implemented the simulation model based on agro-meteorological variables. This is a physical model which uses the energy balance principle. The main problem in using leaf wetness duration is that most sensors measure leaf wetness duration indirectly, have different physical properties from leaves, and they require calibration to represent a specific crop. The current literature contains a number of the simulation models, both empirical and physical. We have decided to use SWEB for the simulation of the leaf wetness duration. The SWEB model is based on the "big leaf" concept. The model consists of four parts: (a) a description of the water distribution on leaves, (b) the water balance on a canopy, (c) an energy balance to calculate the leaf wetness duration, and (d) the wind impact on the wetting (or drying) of leaves. The agro-meteorological data were taken from a station in the fruit fields in Pomiarki, Poland. Radar rainfall data from the Swidwin radar (in northern Poland) were used to integrate the values of leaf wetness. Since spatial rain data from point measurements (gauges) are more sparsely distributed than measurements derived from radar rain estimates, we prefer to use radar rain data to produce detailed maps of leaf wetness duration.

The SWEB model can be adapted to the physical characteristics of any particular crop by adjusting four plant parameters: (a) leaf area index (LAI), (b) maximum fraction of canopy allowed as wet surface area, (c) crop height, and (d) maximum water storage per unit area. Magarey et al. (2006) reported on a series of simulations to estimate the relative importance of these parameters. The observed fraction of canopy wet surface area is the amount of plant parts that are wet in a canopy. This can be compared with the simulated index fraction of canopy wet surface area, which was estimated from the relative volume of water stored in the canopy and change in surface area to volume ratio during drying. Another variable used for describing the surface wetness was the canopy surface wetness. The units are yes (1) or no (0) at an hourly sampled frequency. The total number of hours a canopy is wet is the leaf wetness duration.

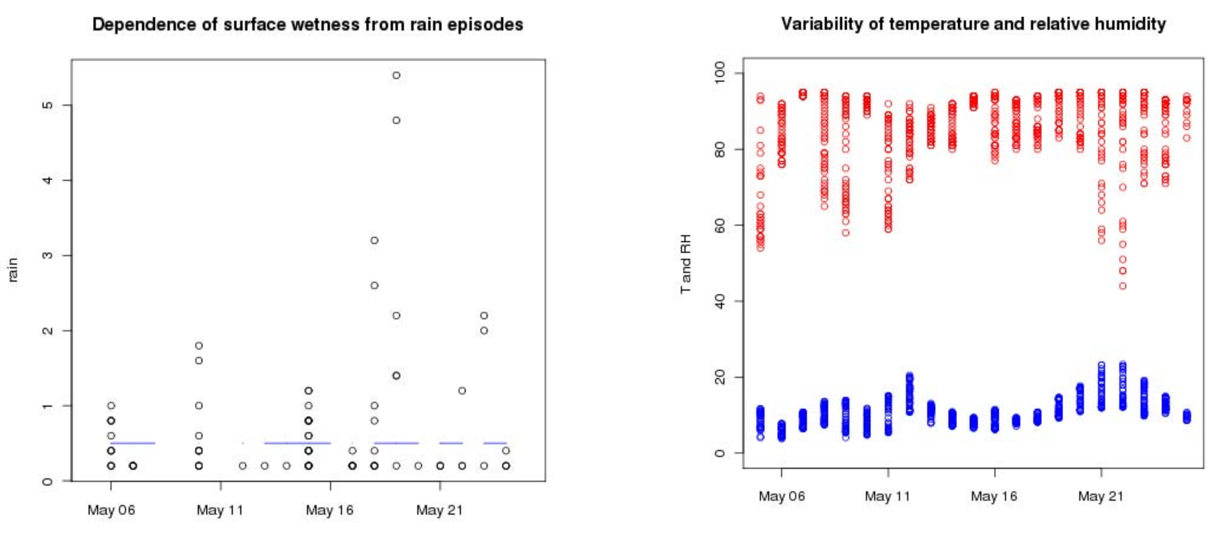

Figure 4. Observed dependence of leaf wetness duration from rain events (left panel) and variability of temperature and relative humidity on canopy height, Pomiarki, May 2010.

The dependence of leaf wetness duration from the rain episodes is presented in the left panel of Fig. 4. Short precipitation events during the day are marked by open circles, and the periods of leaf wetness duration are marked by short horizontal lines. The right panel of Fig. 4 shows a variability of the temperature (blue circles, °C) and relative humidity (red circles in percent). Hourly values of all meteorological parameters are presented for each day. The smaller amplitude of the temperature and higher values of humidity on rainy days are most visible features in this picture, giving us a baseline to use for the validation of the SWEB model.

Within this project, the continuous rain area (CRA) object-oriented verification method has been developed. We presented the development of that method during the COST Action ES0905 workshop in Toulouse, 18-19 Oct 2010.

PERSONNEL EXCHANGES AND TRAVEL COMPLEMENTED

Richard Hodur, University of Warsaw, ICM, working for ICM in US – visited ICM, University of Warsaw, Poland during a period 16-27 May 2010, working on development of the COAMPS system.

Bogumil Jakubiak, University of Warsaw – participated in EGU General Assembly in Vienna in a period giving one poster presentation.

Bogumil Jakubiak, University of Warsaw – participated in ERAD conference in Sibiu, Romania, 6-10 Sep 2010, giving one poster presentation.

Bogumil Jakubiak, University of Warsaw – participated in COST Action ES0905 workshop in Toulouse, 18-19 Oct 2010, giving one oral presentation.

IMPACT/APPLICATIONS

This improvement in the treatment of convective processes in COAMPS will be useful for improving precipitation forecasting.

TRANSITIONS

None.

RELATED PROJECTS

COST Action 731 project – Propagation of uncertainty in advanced meteo-hydrological forecast systems. Within this action, we started to develop a radar data assimilation scheme using the ensemble Kalman filter approach.

COST ESSEM Action ES0905 – Basic Concepts for Convection Parameterization in Weather Forecast and Climate Models

REFERENCES

Hodur, R.M., 1997: The Naval Research Laboratory's Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS). *Mon. Wea. Rev.*, 125, 1414-1430.

Jakubiak, B., R. Hodur L. Herman-Izycki and M. Sierzaga, 2010: Dependence of the convective precipitation forecasts from details of the land-surface model. Geoph. Res. Abstr. v. 12, EGU2010-14031-1.

Jakubiak, B., K. Starosta, and Z. Czaczyk, 2010: Modeling the leaf wetness duration using agro-meteorological and radar precipitation data. Poster presentation on the Sixth European Conference on Radar in Meteorology and Hydrology, Sibiu, Romania, 6-10 Sep 2010.

Jakubiak, B., and M. Sierzega, 2010: Implementation of the continuous rain area method to the verification of precipitation forecasts. Oral presentation on WG4's Meeting for ES0905 Workshop, Toulouse, France, 18-19 Oct 2010.

Magarey, R.D., Russo, J.M. and Seem, R.C., 2006: Simulation of surface wetness with a water budget and energy balance approach, Agro and Forest Meteorology, 139, 373–381.