

Annual Progress Report Form - Oil Spill Recovery Institute

This report may be submitted by mail, fax or e-mail

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Deadline for this report: This report is due within 45 days of the anniversary of the effective date of the grant.

Today's date: 8/1/04

Name of awardee/grantee: Peter Q. Olsson, Alaska Experimental Forecast Facility, University of Alaska Anchorage

OSRI Contract Number: 03-10-15

Project title: Developing a Mesoscale Atmospheric Model for the Prince William Sound with Nowcasting/Forecasting Capability

Dates this progress report covers: 07/01/2003-06/30/2004

PART I - Progress Report on Activities

1. Non-technical Abstract or summary of project work to date that does not exceed two pages and includes an overview of the project. The abstract should describe the nature and significance of the project and progress made toward realizing project goals. It may be provided to the Advisory Board and could be used by OSRI staff to answer inquiries as to the nature and significance of the project.

The work reported on for this reporting year is a continuation of the first year's efforts on developing a mesoscale modeling nowcast/forecast system for Prince William Sound (PWS) using the Regional Atmospheric Modeling System (RAMS). We have continued to run the model in a quasi-operational mode, producing 36 hour forecasts with model output (a snapshot of predicted and diagnosed model fields) written and archived every hour.

A major achievement during this reporting year was the porting of PWS-RAMS and associated software packages to a new and much faster Beoulf computational cluster (purchased under support of the University of Alaska Anchorage). This cluster cut our model integration time by about 60%, allowing for the transfer of data to the ocean model earlier in the forecast cycle. This also has freed up computational cycles for off-line (non-forecast mode) sensitivity tests with different parameter settings and other sub-versions of RAMS. While there were several obstacles to overcome in this transition, it was seamless with regard to the mission of producing daily forecasts.

With this new capability, several sensitivity tests were undertaken. The sensitivity of simulations to sea-surface temperatures (SSTs) was explored further, and it was determined (not surprisingly) that the weekly observed SSTs provided better forecasts than using a monthly climatology of SSTs, the traditional RAMS approach. As a result these observed SSTs are now retrieved and converted into RAMS-usable format. These SST data are occasionally not available from our primary source, so we have developed an alternative means (unfortunately requiring human intervention) for this data set as well.

Other sensitivity tests included the implementation of a 5-layer snow cover in the model for winter cases. Little impact was seen in the surface winds in most cases examined. PWS-RAMS was also tested with a

smaller initial (near-surface) vertical grid spacing (20 m versus the currently- implemented 50 m spacing). This required a smaller time step to maintain numerical stability and the improvement in most cases did not warrant the increased integration time.

While every attempt has been made to make operation of PWS-RAMS an automated “hands-off” procedure, several obstacles, some foreseen and some unexpected, have prevented us from fully achieving this goal. Our primary data source for initializing the model and providing lateral boundary conditions for the integrations has been via a leased-line connection directly to the National Weather Service (NWS) Alaska Region Headquarters. Due to changes in how the NWS is reconfiguring and distributing data, this service has become less reliable and timely for our needs. As this began occurring intermittently, we used forecasts from previous Eta runs- PWS-RAMS in a sense is “nested” within a larger-scale NWS model- rather than the Eta initial analysis fields to initialize PWS-RAMS. This solution was less than optimal, since we were effectively not using the most current observations for our model initialization and integration. As the situation deteriorated, we determined that it was necessary to find an alternate back-up source of the Eta model data. Code was written to obtain the data directly from the NWS public ftp site. We still use data from NWS AK HQ when available (the fully automated version) with a hands-on intervention for days when these data are late or (occasionally) unavailable. Thus, we are still able to deliver model output to the oceanic prediction portion of the PWS Nowcast-Forecast system in a timely manner. (The importance of using the latest available data is quite significant, since the incorporation of these meteorological data are currently the chief means in which the Nowcast-Forecast system obtains and assimilates the most current observations.)

Another obstacle in this reporting period was an intermittent numerical instability in the model during cold periods in Interior Alaska. While this is outside of the grid-3 area of coverage (the 4 km grid that covers PWD and upper Cook Inlet) it caused the model integration to abort prematurely before the forecast was complete. Investigations revealed that this was a computational numerics problem involving the parallel-processing component of the PWS-RAMS code, rather than a problem with the model physics. It was ultimately resolved by using fewer than the maximum number of compute nodes (28) in the parallel processing cluster. The main impact of this “fix” was increased integration time of the model, but still within acceptable parameters for use in the Nowcast-Forecast system. As the surface temperatures warmed with the onset of spring temperatures, this problem disappeared and we were once again able to use all available compute nodes.

Both this numerical instability and the data acquisition issues mentioned above demonstrate that one cannot “black-box” a piece of software as complex as the PWS-RAMS, as expert intervention will probably always be necessary when things do not work as anticipated.

In anticipation of the upcoming (ongoing as of this writing) PWS Field Experiment, a very high resolution fourth grid (at 1 km grid spacing) was generated for use in research using data from the experiment. It was determined that using this fourth nested grid was not feasible for the experiment, since integration time for the model with this grid increased from about 1.5 hours to 8+ hours. It will prove useful however as we explore the results of the Field Experiment.

Also in support of the Field Experiment, we implemented a longer forecast time (out to 48 hours) at the request of other modelers. While the ultimate utility of a forecast out to this time for such a limited domain is questionable (in other words the predictive skill at such high resolution) this was done to suit others’ modeling needs.

While not strongly emphasized in the original proposal, a considerable effort has also been put into model verification since this is how we learn how to produce better simulations and forecasts. Point-wise verification has been undertaken and statistics are being compiled to determine model performance at

point locations.

It should also be noted that we are archiving all the data from the model simulations since we began quasi-operational daily runs. This provides a valuable resource for future research in PWS, since observations are sparse and the gridded PWS-RAMS data sets are excellent spatially-integrated and physically consistent data sets for the area.

Finally, work was begun on determining the geographical extent of the PWS watershed, with an eye towards using PWS-RAMS precipitation forecasts to get a handle of the hydrologic input to the watershed. Fresh water input into the Sound is important in ocean modeling and is a largely unaddressed question at this point.

2. Brief review of the objectives as described in original proposal and progress report related to these objectives.

a) Develop a nowcast/forecast version of a mesoscale model (RAMS) for use in PWS.

While a first pass at this goal was largely accomplished in the first year of the proposal, the long and arduous task of improving model performance continues as noted in the summary above. The effort for this year has been to produce a *better* nowcast/forecast version of RAMS. We have tested several versions of RAMS 4.3 as implemented by researchers at other locations and have incorporated some of their modifications to our modeling efforts. Also noted in the summary above has been an effort to develop alternative sources for model initialization to make the PWS-RAMS package less vulnerable to “data blackouts” from primary sources. As noted, this comes at the expense of human intervention to determine when to “go to Plan-B”.

These efforts make the PWS-RAMS system more robust in the operational forecasting environment.

b) Develop model forecast graphics and display on web.

We have continued our efforts of last year to produce graphics for the web. Several of the graphics were “tuned” for operational use, better utility, and more pleasing presentations. Winds at constant height levels (2000ft, 4000 ft, and 6000 ft) were added to assist general aviation in the Sound region. These are also used by avalanche forecasters in the greater PWS region. This is an example of how the data produced primarily for use in driving an ocean model can be used for ancillary purposes for a variety of user interests.

We have also developed a masking approach to graphics at fixed geometric levels. Previously, levels that were below the surface (for example 2000 ft winds, sea-level pressure, in the mountains north of PWS) were extrapolated from higher levels, providing spurious and often physically inconsistent features where these levels were below the terrain height. Now, we mask out all data points below the terrain surface for these plots, providing more physically realistic plots at the expense of data voids in regions of high terrain. (This is not really a problem, other than visually, since there is no “correct” value for 2000 ft. winds in terrain above 2000 ft.)

c) Create an archive of of model output data and graphics

We continue to archive data of both the model runs and graphics. We have developed two RAID (redundant array of independent disks) arrays to store the increasing volume of data. (This equipment to

make this possible was purchased with funds from the University of Alaska Anchorage.) Having the data “on-line” rather than on magnetic tape facilitates the efforts of in-house research on past events and developing long-term statistical measurements of model performance. We still continue to also archive the model results on magnetic tape as well, and hope to also make a DVD-based library as an alternative backup source.

In addition, we are storing model data at the Arctic Region Supercomputing Center (ARSC) at the University of Alaska Fairbanks. The ARSC has a huge data storage facility and is well suited to this type of task. This off-site storage is added back-up protection for the data. The data is being stored in its native RAMS-style format, since we do not know for sure who else besides the AEFF will be using the data, and it is most useful to us in this form.

d) Provide model output to other researchers in Prince William Sound.

We continue to provide delivery of data in real time to researchers at the University of Miami, OPEL, running real-time PWS-POM, another of the components of the PWS nowcast/forecast system. Currently, the data is automatically pushed to OPEL at the end of each model run, thus providing an upper boundary forcing for the ocean model. We anticipate that in the future, other researchers will want to take advantage of this unique data source for PWS and have developed software to provide real-time data services to others as well. (Even though other researchers may not have the time demand for data in real time, this is the easiest way for us to provide this kind of service).

e) Verify the model with observations.

As noted in the summary, we have put more effort in to this area of the project. We have been hampered to some degree by the unavailability of the mid-Sound buoy for much of this last cold season and also the unavailability of data from the PWS met stations, many of which are off line and not reporting. We have implemented point statistics tests for wind speed and wind direction from those sites that are available, and will continue this routinely as part of our validation studies. These statistical measures will become more useful as we continue to accumulate forecast data.

We are also exploring methods of verifying the model on a grid-wise (as compared to point-wise) level. This is difficult at this point due to the spatial infrequency of the observations, but with the return of the availability (hopefully) of the PWS meso-network of meteorological observations we can produce meaningful objective analyses of surface weather fields (pressure, winds, temps, precipitation, etc) for comparison purposes.

3. Describe problems or roadblocks encountered in project implementation.

Most of the significant roadblocks were discussed in the summary above. Most significant was the problem of model stability (Courant number stability) on the new cluster. As noted, this was remedied (after exhaustive trouble-shooting) by using a smaller number of compute nodes in the effective computational cluster until surface temperatures in the Alaska interior warmed to spring-time values and the numerical problem became a non-issue.

Porting the model code to the new cluster went well, all in all, with some minor glitches in producing consistent runs between the new and old clusters.

The data availability problem discussed above became more of an issue as the reporting year progressed. By developing redundant sources in initialization data sets we have hopefully got this problem covered. During some of the initial data blackout periods we were unable to make the runs in real time, but do to

the efforts of AEFF staff, we were able to go back and make these simulations after the fact, maintaining continuity of the time series of data sets of PWS-RAMS output.

4.Highlight accomplishments, whether or not they were part of the original proposal.

Our most significant accomplishment (and the primary deliverable of this funded project) has been to maintain a complete series of simulations for the time period covered by this proposal, with over 95% of these being done in the forecast “real-time” mode. RAMS has a vast number of configuration options from grid-spacing to cloud and surface models to turbulence closure schemes. It is desirable to find a selection of these choices that will work over different seasons with their differing types of weather, and to a large extent we have found a good combination of parameters. (There are enough configurable parameters that several million realizations would have to be considered to try every combination).

We have also been able to maintain the high success rate at real-time forecasting in the face of unforeseen events, as discussed above. This is largely due to the dedication of AEFF staff to do what it takes to overcome unforeseen hurdles in a timely manner. This has required creative thinking and insight as to what are the causes and likely solutions to the problems.

5.Conclusions to date.

Our main conclusion to date is that it is possible to model routinely the atmosphere over PWS. We have shown that, using a nested grid approach, we can simultaneously simulate the atmospheric processes that occur on the synoptic or continental scale (Grid 1) and capture the local effects these processes have in the mountainous PWS. This approach has been successful throughout a full season (with a few hiccups), suggesting that the nowcast/forecast system is robust.

Preliminary evaluation of statistics suggest that PWS-RAMS simulates some situations better than others. We are now trying to identify those situations where the model has a tendency to perform poorly, and determine what might be done to improve model performance.

RAMS does a creditable job with wind speed and direction in the presence of significant synoptic forcing (strong pressure gradients) and does more poorly when the large-scale pressure gradients are weak. This is possibly due to poor resolution of SSTs in the 1 degree square input data set and might be remedied by a closer coupling of the ocean and atmospheric models. It is also possible that higher resolution grids may help in these situations, since topographic forcing (in narrow channels for example) would likely be better resolved. This is to be determined through sensitivity tests.

6.Appendix including copies of all written reports or publications completed or in progress, resulting from the project work. This also includes abstracts of papers presented at conferences. Please note the acknowledgment of OSRI support stated in Section 10.3.4 of the Grant Policy Manual.

The following conference paper/presentation is an outcome of the work funded by this project:

An assessment of the response of coastal ocean model (EPWS-POM) to forcing by a regional atmospheric model in Prince William Sound, Alaska. C.N.K. Mooers, I. Bang, and P.Q. Olsson, *American Geophysical Union Meeting*, Jan, 2004.

The following journal manuscript in preparation is an outcome of research funded by this project:

A climatology of simulated low-level wind jets over Cook Inlet, Prince William Sound, and Shelikof Strait, Alaska. H. Liu, P.Q. Olsson, H. Yi, and K. P. Volz.

Part II - Annual Financial Statement

<u>Budget Category</u>	Year-to-date	Balance <u>Budget Expenses</u> <u>Remaining</u>
Direct Costs		
Personnel	\$86,134.99	(\$1,266.99)
Travel	\$ 304.40	\$1,195.60
Contractual	\$ 0.00	\$ 0.00
Commodities	\$ 184.98	\$1,300.02
Equipment	\$ 0.00	\$ 0.00
Subtotal Direct Costs	\$86,624.37	\$1,228.63
Indirect	\$26,767.05	\$ 378.95
Project Total	\$113,391.42	\$1,607.58