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THE REAL-TIME ARCTIC MM5 MODELING SYSTEM: CHARACTERISTICS AND PERFORMANCE FOR SHORT-RANGE ALASKA REGIONAL AD LOCAL FORECAST APPLICATIONS

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1. Introduction

Over the past year, we have initiated a collaborative effort with the National Weather Service and the Alaska Department of Transportation to develop a real-time system to ingest meteorological observations and provide a supplemental meteorological forecast capability within interior Alaska. The observations consist of not only those available routinely from National Weather Service (NWS) sites (both manned and automated), but also from supplemental networks established within Interior Alaska through a data-sharing agreement.

The design of our system makes these observations available to the general public through a Web interface design, and incorporates these observations into a multi-grid hierarchy of forecasts and forecast products generated with the aid of a modified version of the Penn State University/National Center for Atmospheric Research MM5 model (e.g., Grell *et.al.* 1994; Chen and Dudhia 2001), hereafter referred to as the "Arctic MM5". The ultimate aims of the system are as follows:

- *to provide additional weather information in terms of observations and forecast products to the ADOT, other state agencies, the general and scientific public at-large, as well as NWS forecasters throughout the Alaska Region.*
- *to serve as a source of data and information for existing specialized high latitude research efforts, including field campaigns, and to serve as a springboard to promote new research ideas and efforts.*
- *to enhance existing NWS-Advanced Weather Information Processing Systems (AWIPS) capabilities and information via an 'off-cycle' emphasis for our forecasts and a Web-based delivery system.*
- *to aid in the development and evaluation of experimental products and model developments as part of our ongoing numerical weather prediction research efforts.*

In this paper, we describe our efforts to date, including the design methodology of the system, its current configuration , some preliminary performance data, and plans for future development. While static imagery will be used for illustration in this paper, we hope to provide a demonstration of the various facets of the Web-based delivery system during the conference.

2. Collaborative Aspects

At the heart of the effort is the establishment of partnerships for the purpose of sharing and distributing various types of meteorological information. In relation to previous research projects, the authors have established working relationships with UAF's Geographic Information Network of Alaska (GINA). Primarily these relationships were for purposes of obtaining geostationary and polar orbiting satellite information for ingestion into and validation of an Alaska-specific research meteorological modeling system. The current system extends this collaboration by incorporating imagery as a part of a real-time modeling effort and as part of the entry interface.

Collaborative efforts on both research and educational fronts have been in place with the Fairbanks National Weather Service Forecast Office (Fairbanks WFO) for several years. Their contribution to this effort is the sharing of routinely collected surface observations from manned and automated land stations as well as ships and buoys.

Partnerships with a local scientific research and development company (GW Scientific) and with the Alaska Department of Transportation

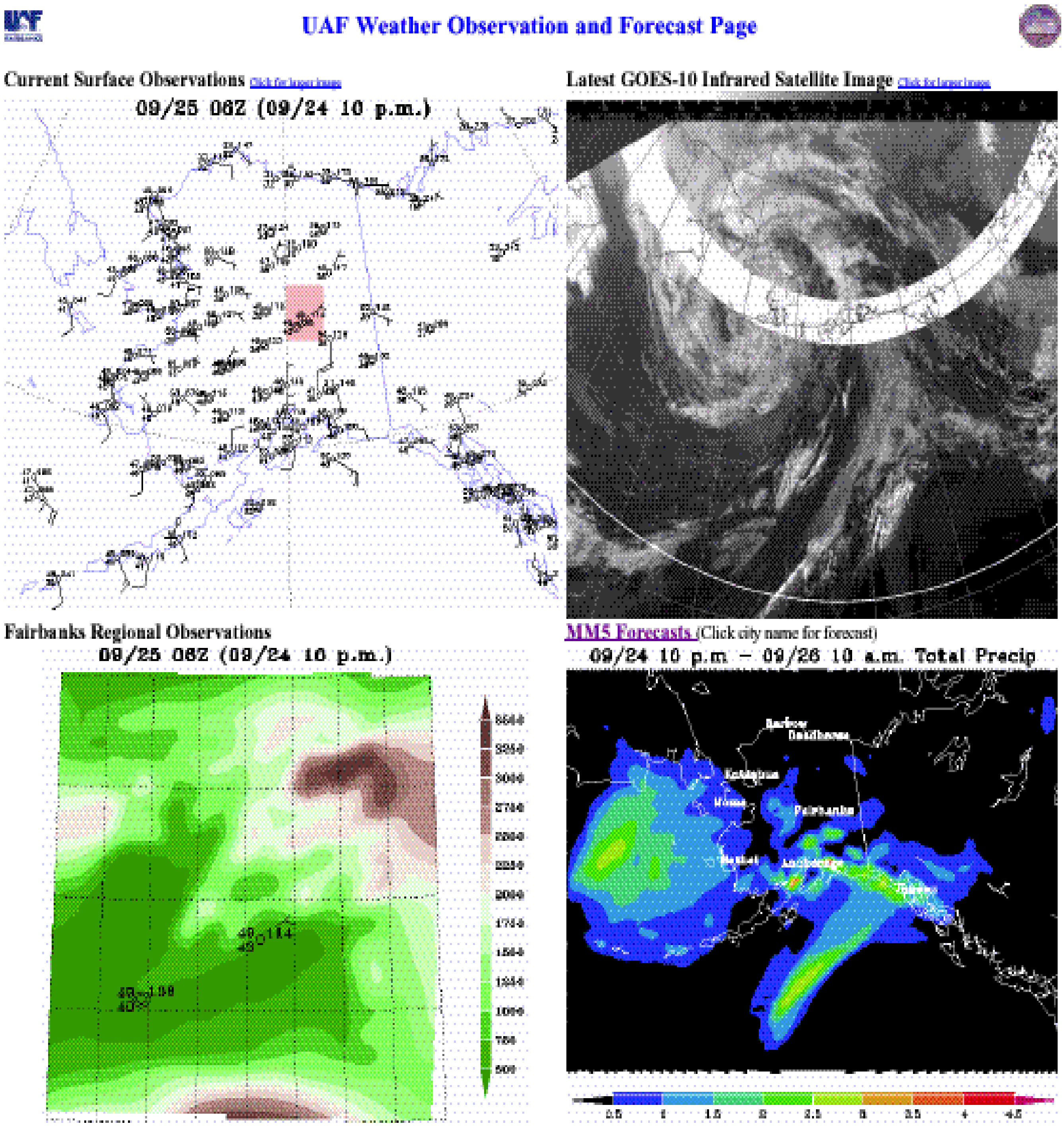


Figure 1. Entry level webpage interface for the University of Alaska Fairbanks (UAF) integrated weather observation and forecast system. The interface is divided into four primary panels beneath the title frame, which carries links back to the main UAF webpage (upper left icon) and Geophysical Institute webpage (upper right icon). The four panels are as follows: a) upper left---current surface observations for the state of Alaska and Yukon Territory, Canada; b) upper right---current satellite (visible or IR window channel) image of Alaska, obtained from UAF's Geographical Information Network of Alaska; c) lower left---local Fairbanks surface observations; d) PSU/NCAR MM5 forecast accumulated precipitation (colors, cm) for the time indicated for the statewide region, as well as links to local city forecasts and the main UAF MM5 Forecast Page, shown in Figure 2.

ADOT) are more recent, but show potential for becoming a focal point for the development of an enhanced statewide observational network. GW Scientific (GW) has established a series of primarily hydrologic stations in interior Alaska, with the bulk of these stations in the Fairbanks vicinity. With the addition of some sensors and a few additional stations strategically placed to supplement the existing observations, a first cut at a mesonet of stations in Fairbanks will be realized. ADOT is implementing a network of Road Weather Information Systems (RWIS) using both state and federal funds. We are contributing supplemental instrumentation to several of these stations to allow them to be more useful for ingest in and validation of the Arctic MM5 system to be discussed in the next section.

As of this writing, we are in discussions to find ways of extending these partnerships in the development of an expanded statewide mesoscale surface observation network, with the ultimate goal of developing a facility similar to MESOWEST (Horel *et al* 2002) at the University of Utah. Such a system may eventually include observations of ocean as well as atmospheric properties given the clear importance of the state of the ocean for the marine atmospheric environment that surrounds Alaska.

3. Web Interface

3.1 General Comments

Figure 1 illustrates the present entry interface for the public to the integrated observation and Arctic MM5 forecasts. This interface can be found on the Web at http://knik.iarc.uaf.edu/AtmGroup/akweather.htm. There are four main components to this interface involving observational and modeling data., each of which will be discussed briefly below. Here we note that our underlying philosophy for the interface is to be able to provide, at a glance, basic information on surface weather conditions statewide and in the Fairbanks area as well as forecast conditions over a 36-hour period on multiple scales. The interface is not intended to be comprehensive, but instead to allow for users of various levels of sophistication to obtain useful information. We expect the interface to evolve dynamically in response to feedback from various users and user groups.

In the following three subsections we touch on observational components of the initial web interface, including description of more detailed information available from deeper web levels of the facility. As appropriate, we will also describe technical aspects of the sources of information displayed. This discussion will be followed by a description of the real-time Arctic MM5 in section 4.

3.2 Statewide Surface Observations panel

The primary content of this panel of the page is a regularly updating plot of surface observations from a selected subset of all available NWS land stations, ship reports, buoy reports, and RWIS stations. Viewing a subset of the various observation types is required given that there are several regions in which observations are clustered too closely in space to allow for legible plotting. However, note that users can click on the "larger image' link at the top of the plot to obtain a larger -sized version of the plot, if desired.

Standard WMO station model conventions are adopted, and observations of temperature, dewpoint, sea level pressure and winds are plotted. Information on clouds and present weather is currently not included for the sake of legibility. To accommodate potential users not familiar with the WMO station model conventions, we are in the process of constructing an appropriate information module on the station model. This will be included on the plot as a button which, when accessed, will bring up a new window with a summary of the station model and its interpretation.

Observations are updated on an hourly frequency due to NWS communications constraints and the fact that many potential users of the site are generally accustomed to accessing NWS observations at hourly intervals, from either the NWS Alaska region office websites themselves or from a commercial provider such as The Weather Underground™. Given that much of the year special reports occur rarely and may be difficult to determine from a statewide plot, the choice was made to limit update frequency to hourly at present.

3.3 *Regional Satellite Image panel*

This panel contains the most recent geostationary infrared window channel image from the GOES-10 satellite platform, received a preexisting GOES downlinking station at the NWS Alaska Region headquarters in Anchorage. No color enhancement curves are utilized on this image and thus the approximate temperatures at a given pixel are shown in greyscale: black represents the warmest temperatures while the white areas represent temperatures colder than approximately -45^{o}C). Although the nominal resolution of the infrared window bands (4km) is coarser than that of the visible bands (1km), the overall utility of this channel is greater due to the large variability in high latitude daylight conditions over the annual cycle.

Another choice made for the interface was to utilize geostationary rather than polar orbiting imagery for the display. This choice was motivated primarily by the fact that without cloud information in the statewide surface observations panel (section 3.2), it was desirable to have a synoptic depiction of cloud cover via satellite that was temporally consistent with the surface observation plots. Although the frequency of polar orbiting satellites passes over Alaska and adjacent waters has recently increased, as yet there are no products blending NOAA-series Advanced Very High Resolution Radiometer (AVHRR) and NASA-series (i.e., "Terra" and "Aqua") Moderate Imaging Spectroradiometer (MODIS) datasets in real-time for the high latitudes. If such products do become available in real-time then it is possible that such products would replace the geostationary image currently utilized in the web interface.

3.4 Additional Mesoscale Observations: Fairbanks

Primarily to stimulate local interest in mesoscale observations from both an operational and a research perspective, the lower left panel of the web interface displays available NWS, RWIS/ADOT and other observations within approximately a 60 km radius of Fairbanks. Once the full set is implemented, initial plans call for an update frequency of 15 minutes for these observations, For display purposes in this paper, only the three active stations from the standard NWS network are plotted. By summer 2003 we will consider expanding the coverage of this panel to include the entire set of supplementary observation sites shown in Figure 2.

4. Arctic MM5 Forecasts

4.1 Web Interface Overview

The lower right panel on the web interface shows a sample precipitation forecast for Alaska and adjacent regions of Canada, Russia, the Arctic Ocean and the North Pacific Ocean. The forecast covers a 36 hour period, specifically the period listed at the top of the plot, with accumulated precipitation during the entire period, in cm, plotted according to the color scheme at the bottom of the plot.

The plot is updated according to the forecast cycles we have adopted for the Arctic MM5 real-time model. Two cycles, initiated at 06 UTC and 18 UTC, are conducted per day. The initial and boundary conditions for the model are derived from the corresponding run of the NCEP Eta model run specifically over this region for use by the NWS Alaska Region forecasters. The data is transmitted from NCEP to the Alaska Region NWS headquarters in Anchorage and reflected to each of the forecast offices as a series of netCDF files. As these files are received by the Fairbanks WFO, they are immediately reflected to our UAF Origin 2000 server and automatically converted into a suitable format via the standard MM5 preprocessor suite (e.g., Dudhia *et al,* 2002; Guo and Chen 1994). Available observations (including, in a current experimental configuration, AVHRR visible counts and brightness temperatures obtained from a UAF downlink station) are ingested into the model via automated scripts. The model is executed on the domain indicated in Figure 1 for a 36-hour period. Forecasts on a suite of nested domains, illustrated in Figure 3, are also produced. All domains utilize 41 vertical sigma-coordinate levels.

A link is located as part of the panel name for the MM5 forecasts on the entry Web interface. This link takes the user to a separate MM5 Forecast Products web page (http://knik.iarc.uaf.edu/AtmGroup/ForcastGraphics.htm)from which more detailed forecast information is available via a variety of output forecast products. Further discussion on these products is given in section 4.2.

In addition, a small set of Alaskan localities are indicated on the precipitation plot. While this information provides some geographic context, the city or town names are actually clickable objects which, when activated, will produce a pop-up window with a text forecast for that location for the next 36 hours. These text forecasts are derived solely from the Arctic MM5 model outputs. In their initial implementation they will be fairly simple algorithms; over time we intend to gradually increase the level of sophistication as an area of active forecast research.

The Arctic MM5 model configuration, in terms of physical parameterizations and options utilized in the real-time modeling system has been undergoing steady revision since the system was brought on-line in May 2002. Changes to the model configuration that have occurred since that time reflect work done by researchers at UAF, the National Center for Atmospheric Research, Ohio State University and the Air Force Weather Agency to improve MM5 performance for cold season and/or high latitude applications. Most notable in the Arctic MM5 is the inclusion of not only a coupled land surface model (the NOAH model; Mitchell et al, 2002), but also coupled ocean mixed layer (Kantha and Clayson, 1994)and thermodynamic sea ice (Zhang and Zhang, 2001) models , making the Arctic MM5 a true earth system mesoscale forecast model. Table 1 summarizes the current configuration of the model as of this writing (February 2003), and additional details on the ocean mixed layer and thermodynamic sea ice models can be found in Zhang *et al* (2003, this volume), Zhang and Tilley (2002b) and the aforementioned references.

In addition to this standard configuration, which is the standard for all real-time runs, we also have implemented an experimental Arctic MM5 system which includes a AVHRR-based cloud initialization scheme (Fan and Tilley 2002) and experimental incorporation of MODIS data within our integrated in-flight icing algorithm, described in the next section and also in Tilley *et al*. (2002). The experimental version of the model and icing algorithms are being validated in a similar fashion as to be discussed in section 5; if the changes prove beneficial, we anticipate incorporating them into the standard version during the late spring to early summer 2003 timeframe.

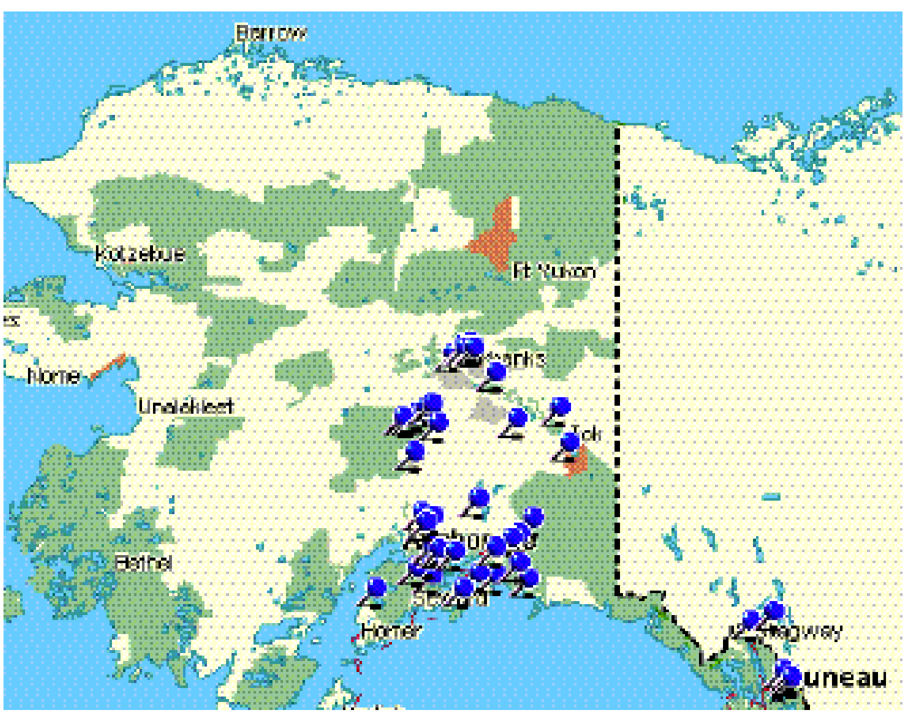


Figure 2. Spatial distribution of supplementary surface observation stations (blue push-pin symbols) to be obtained through data partnerships with GW Scientific and the Alaska Department of Transporation and Public Facilities. Note that the network is primarily confined to areas accessible from the Alaska road system.

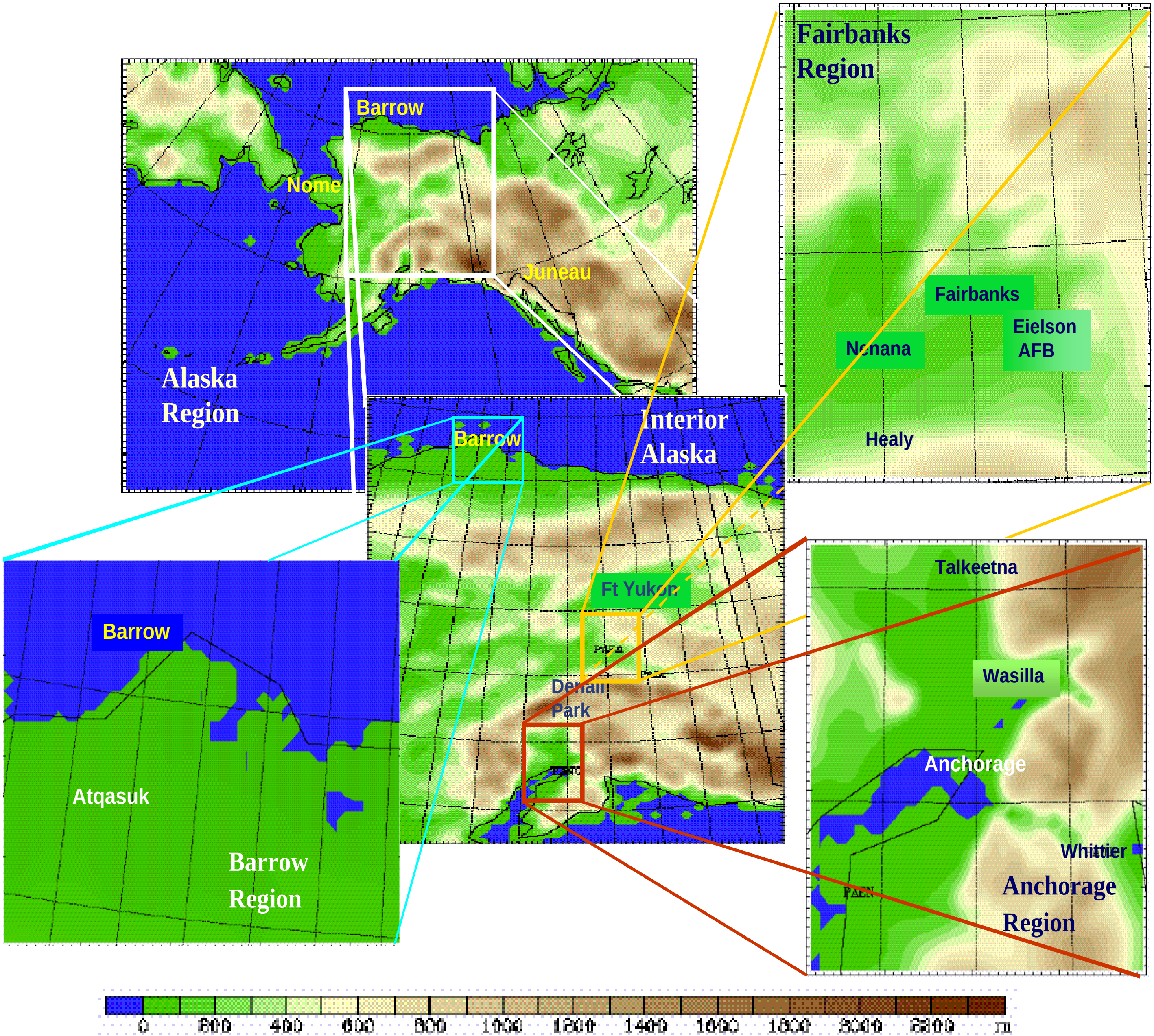


Figure 3. Domain configurations and terrain utilized in the real-time MM5 modeling system. The outermost domain (Alaska Region) resides on a 45km horizontal grid and is executed for 36 hours. The Interior Alaska donain , with a grid resolution of 15 km begins execution at 6 hours into the forecast cycle and continues until 30 hours. The Interior Alaska Domain is the mother domain for the remaining three nested domains: the Fairbanks Region, Anchorage Region and Barrow Region domains. All of the innermost domains reside on a 5 km horizontal grid and begin execution at 9 hours into the forecast period, ending at 24 hours. The color scale indicates the elevation of a grid box, in meters. 2-minute USGS terrain data are utilized for all domains.

4.2 Sample Arctic MM5 Products

If a user clicks on the link "MM5 forecasts on the Web interface, the user is taken to a separate page which lists the various Arctic MM5 forecast products which are available. Figure 4 illustrates a sample of such a page. Forecast products are organized by product name and the domain of interest (e.g., Alaska Region, Interior Alaska, Fairbanks, Anchorage, Barrow). In addition, near the top of the page information is provided on the time stamp of the latest forecast cycle available and, through a separate freeware widget available from Weather Underground, Inc., the current Fairbanks time and temperature.

Each of the names of the various forecast products (really MM5 native or postprocessed fields) is a clickable link. When activated, a new pop-up window will appear containing an information file in PDF format. These files are intended to help general scientific users of the site to better understand the nature of the particular forecast product in question. They should also be useful for members of the general public with some scientific background. The authors welcome feedback on these files and will make appropriate modifications as deemed appropriate from such feedback. One change that was made in direct response to such feedback was the inclusion of a direct link to Adobe Systems, Inc. site where a user who does not already have access to Adobe's Acrobat Reader™ product can download a freeware version of the product in order to read the informational files.

It is also important to note that the domain designations on the MM5 Forecast Graphics page are also clickable links. Activating a link will result in the creation of a new pop-up window that shows a graphical depiction of the topography of the domain chosen, and, for all but the Alaska Region domain, a representation of the relative position of that domain with respect to the others, through a numerical key. The Alaska Domain is designated Domain 1 while the Interior Alaska domain is Domain 2. The Fairbanks Domain is designated Domain 3, and so on.

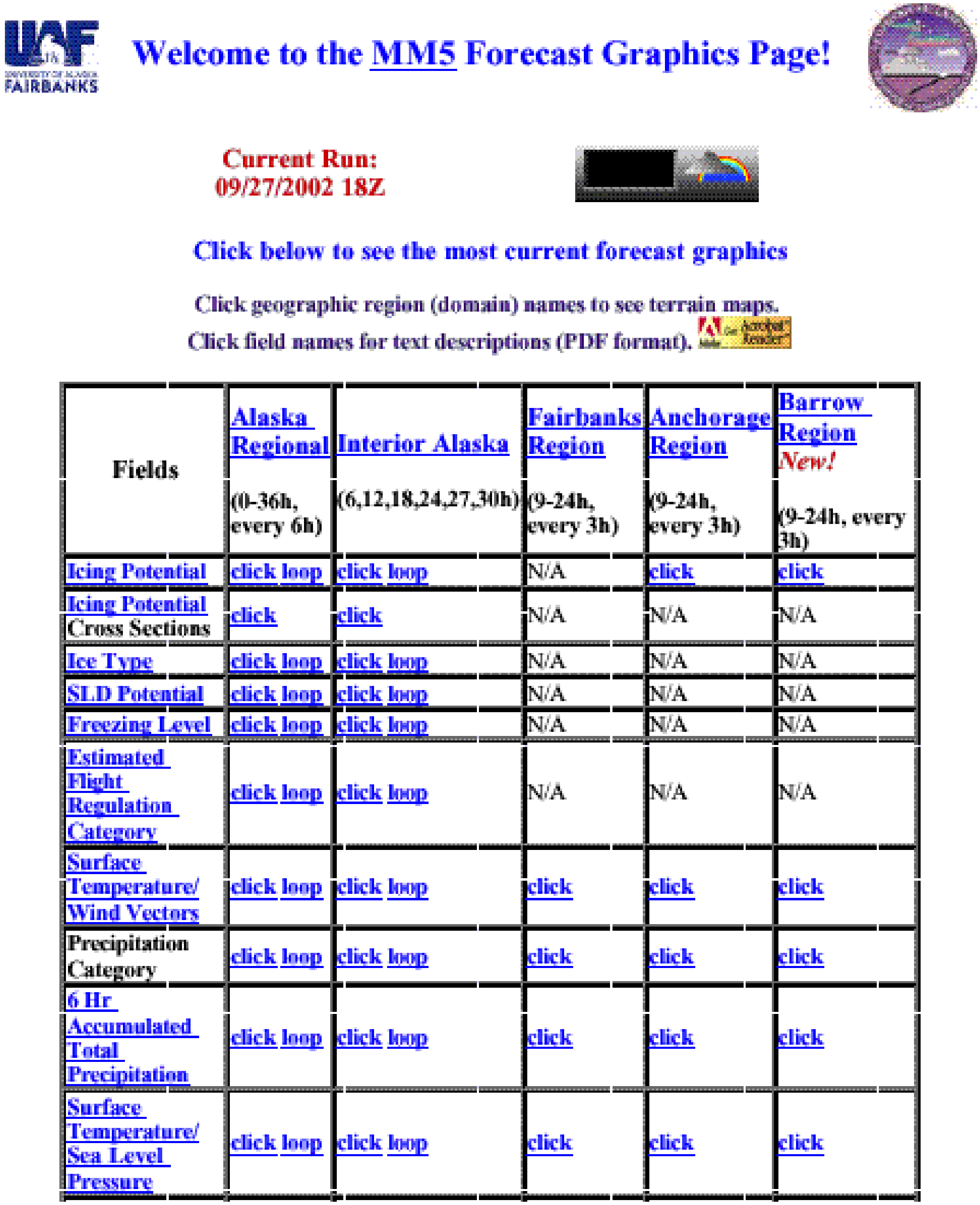
The hours that forecast products are available for a given domain are listed at the top of each column. All products are available as a series of plots, one for each forecast time listed, and can be accessed by clicking on the "click" link for the particular product/domain combination desired. Some products are also available as animated loops by activating a "loop" link. In both cases, link activation results in a pop-up window being generated that contains either the series of graphical images or the animated loop. All graphical images available from this page are generated using the MM5 postprocessor *RIP* (Read, Plot, Interpolate) written by M. Stoelinga

Table 1: UAF Real-Time MM5 Configuration

Physical Process	Scheme Utilized
Cumulus Convection	Grell (1993)
Explicit Microphysics	Reisner *et al* (1998) mixed phase modified following Cassano *et al* (2001)
Radiative Transfer	CCM2 scheme modified following Cassano *et al* (2001)
Land Surface	NOAH-LSM (Koren *et al* 1999) implemented as in Zhang and Tilley (2002a)
Ocean	Kantha/Clayson (1994 mixed layer model)
Sea Ice	Zhang and Zhang (2001) thermodynamic sea ice scheme
Boundary Layer	MRF (Hong and Pan 1996) scheme
Data Assimilation	MM5 standard Newtonian Nudging (Stauffer and Seaman 1990)
Initialization	Operational Alaska version of the NCEP Eta Model with surface observation ingest
Postprocessing Algorithms	UAF IIDA (Tilley *et al* 2002); Skill score-based verification

of the University of Washington (Stoelinga, 2001). Figures 5a though 5d illustrate plan view plots created by this package for standard MM5 output variables on the Alaska Region and Interior Alaska domains. We have not only included variables such as temperature, winds and precipitation that have direct forecast value to the public-at-large, but also some additional variables (integrated cloud water, omega vertical motion, heights/vorticity) that have been deemed as potentially useful to the NWS forecasters in the Alaska Region.

In addition to standard MM5-type output variables, we have the capability of producing further diagnostics using a variety of algorithms,



Welcome to the MM5 Forecast Graphics Page!

Current Run:
09/27/2002 18Z

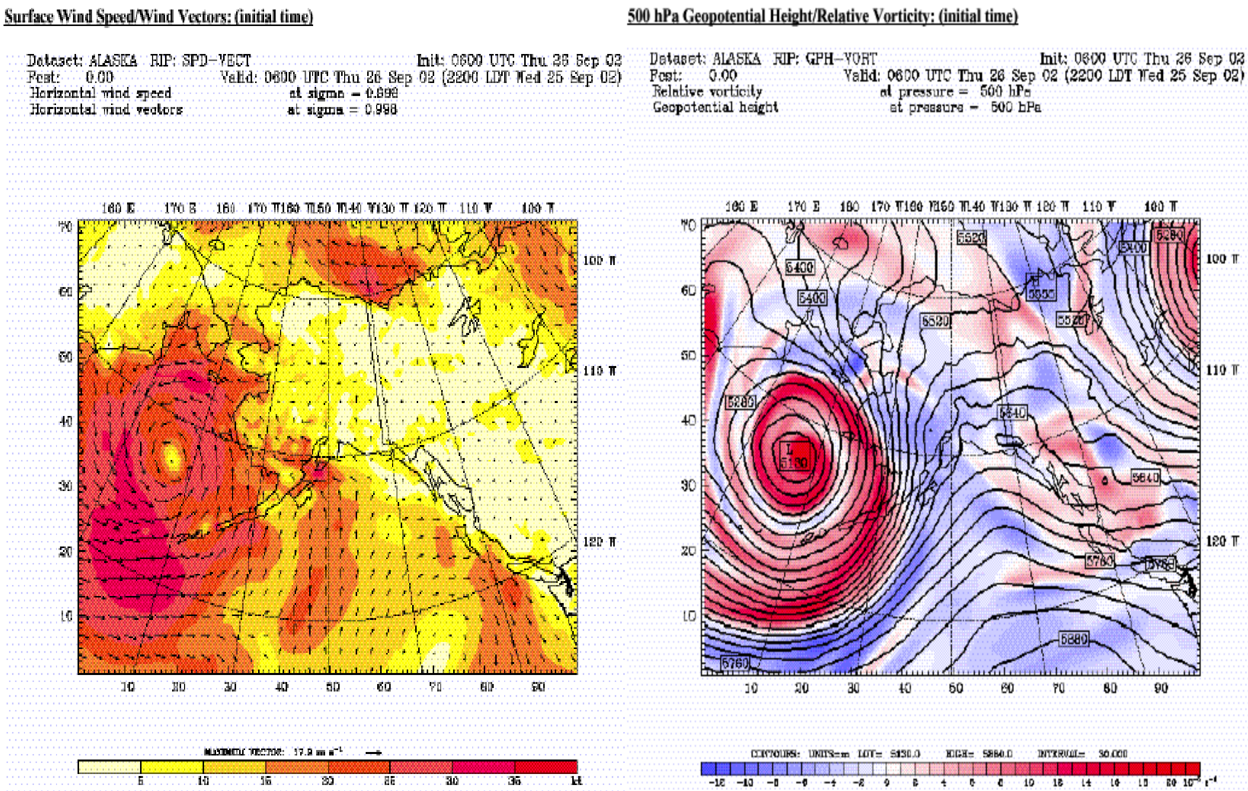
Click below to see the most current forecast graphics

Click geographic region (domain) names to see terrain maps.
Click field names for text descriptions (PDF format).

Fields	Alaska Regional (0-36h, every 6h)	Interior Alaska (6,12,18,24,27,30h)	Fairbanks Region (9-24h, every 3h)	Anchorage Region (9-24h, every 3h)	Barrow Region New! (9-24h, every 3h)
Icing Potential	click loop	click loop	N/A	click	click
Icing Potential Cross Sections	click	click	N/A	N/A	N/A
Ice Type	click loop	click loop	N/A	N/A	N/A
SLD Potential	click loop	click loop	N/A	N/A	N/A
Freezing Level	click loop	click loop	N/A	N/A	N/A
Estimated Flight Regulation Category	click loop	click loop	N/A	N/A	N/A
Surface Temperature/ Wind Vectors	click loop	click loop	click	click	click
Precipitation Category	click loop	click loop	click	click	click
6 Hr Accumulated Total Precipitation	click loop	click loop	click	click	click
Surface Temperature/ Sea Level Pressure	click loop	click loop	click	click	click

Figure 4. Sample of the upper half of the MM5 Forecast Graphics page discussed in text. Several fields are omitted from the lower part of the figure for clarity and legibility. See discussion in section 3.5.2 for details.

some of which are standard features of the *RIP* package (e.g., the Flight Regulation category) and others which have been developed locally (e.g., precipitation category) or in conjunction with other investigators. The prime example of this latter type of product can be seen in the products designated *Icing Potential, Ice Type and SLD Potential.* These products are the result of recent work at UAF to adapt, for high latitude application, the NCAR/RAP icing algorithm (e.g.,



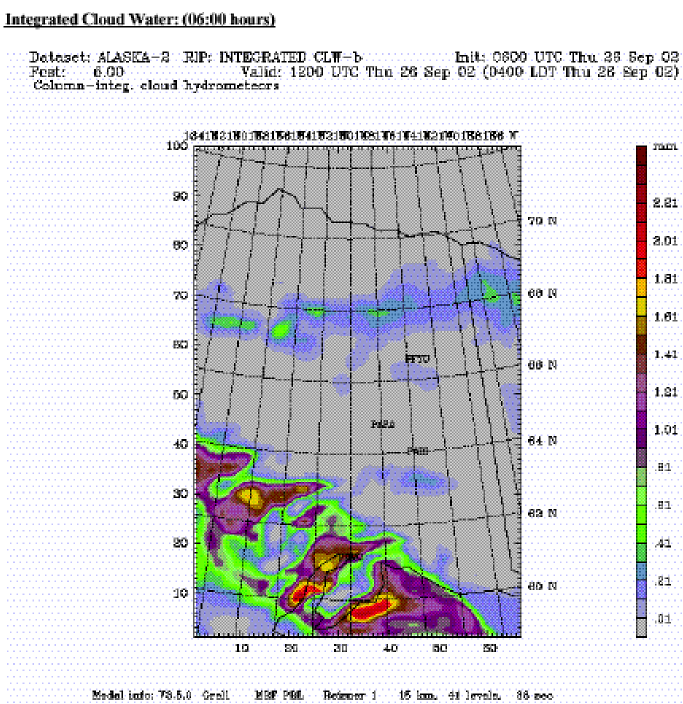


Figure 5. Samples of forecast products reachable from the MM5 Forecast Graphics page a) Surface wind speed (colors; kts) and direction (vectors) at the model forecast initial time (06 UTC 9/28/02) on the Alaska Region domain; b) Geopotential height (contours; m) and relative vorticity (colors; s^{-1}) at the 500 hPa level for the same time and domain as part a; c) Vertically-Integrated Cloud Liquid Water (colors; mm) for a 6 hour forecast (12 UTC 9/28/02) on the Interior Alaska domain, initiated as part of the same forecast cycle as parts a) and b).

McDonough and Bernstein 1999) now utilized as CIP (current icing potential) by the Aviation Weather Center in Kansas City (M. Politovich, per. comm.). A description of our work to adapt the CIP as it is utilized here, as the so-called UAF Integrated Icing Diagnostic Algorithm (UAF IIDA) can be found in Tilley *et al* (2002). Here we summarize by noting that the UAF IIDA, in its diagnostic mode, incorporates surface observations and satellite observations from the GOES

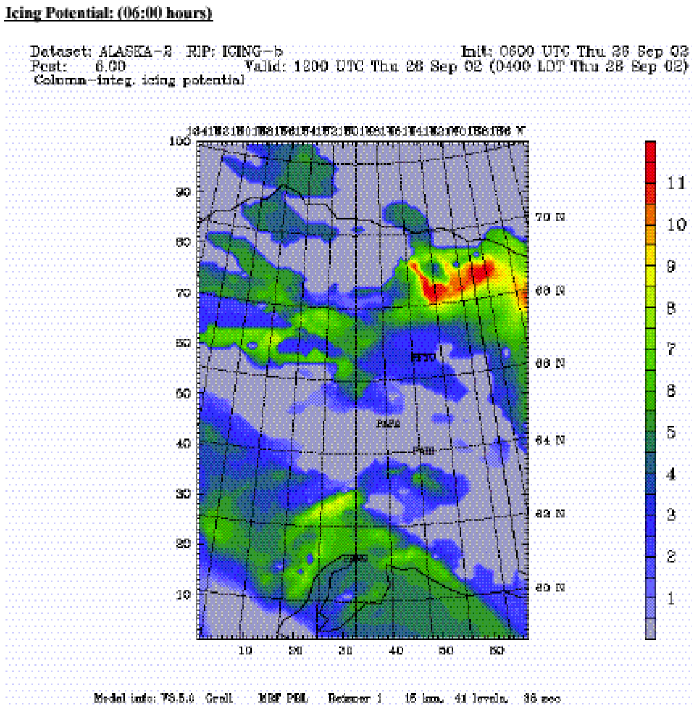


Figure 6. Sample Plot of UAF IIDA Icing Potential Forecast/Diagnostic Product on the Interior Alaska (15km) domain. While the Icing Potential itself is a 3-dimensional quantity, for economy of presentation we utilize a vertically-integrated form of the Icing Potential derived by summing the Icing Potential through the grid column. Maximum value for the vertically-integrated field is 20. Field shown is for a 6 hour forecast valid at 12 UTC 26 Sept 2002) from the forecast mode of the UAF IIDA. In forecast mode the Icing Potential field is derived essentially from the MM5 model simulation alone.

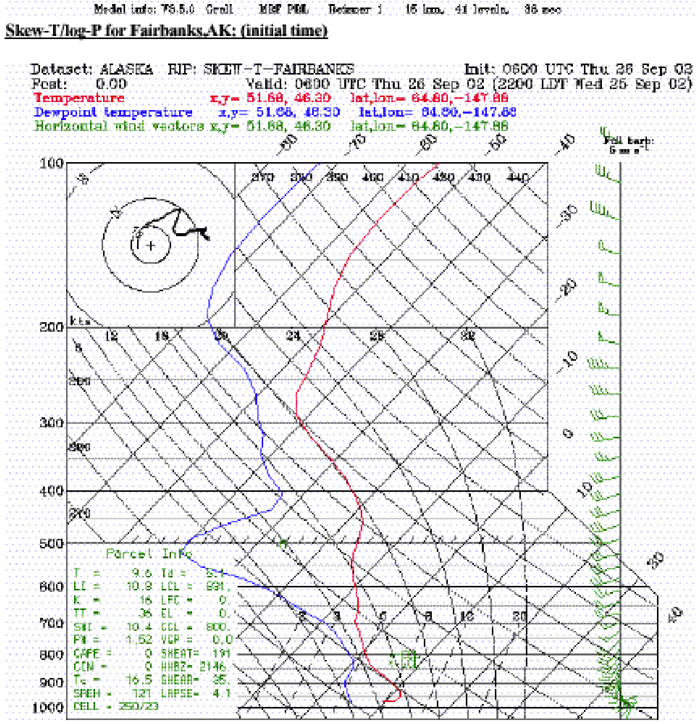


Figure 7. Sample vertical sounding plot for the MM5 45 km (Alaska Region domain) model gridpoint centered on the location of the Fairbanks International airport. The sounding is plotted on a standard skew-T/log P thermodynamic diagram. The temperature profile is shown by the red line while the dewpoint profile is shown by the blue line. Wind barbs are plotted in green, with a wind hodograph in the upper left corner. Note that the system allows for sounding plots to be derived from any of the applicable model domains, in this case the Alaska Region, Interior Alaska and Fairbanks Region domains. Since the grid boxes corresponding to the Fairbanks airport for the three domains vary in resolution by a factor of nine, some differences in the sounding representations from the three grids is expected and can be used as a means of better understanding the impacts of mesoscale topography on the vertical profile.

Imager and AVHRR sensors in addition to the MM5 output fields. In its forecast mode, the UAF IIDA is based solely on MM5 output. A sample plot of an *Icing Potential* product is shown in Figure 6.

Besides the plan view type of plots discussed above, we also have the capability through the RIP package of plotting fields to show their vertical structure. A common application in this regard is model forecast vertical soundings of temperature, wind and dewpoint on Skew-T/log-P thermodynamic diagrams. An example of such a plot for Fairbanks is illustrated in Figure 7; the plot follows standard Skew-T/log-P plotting conventions for the temperature, dewpoint and wind fields, but also includes a a)

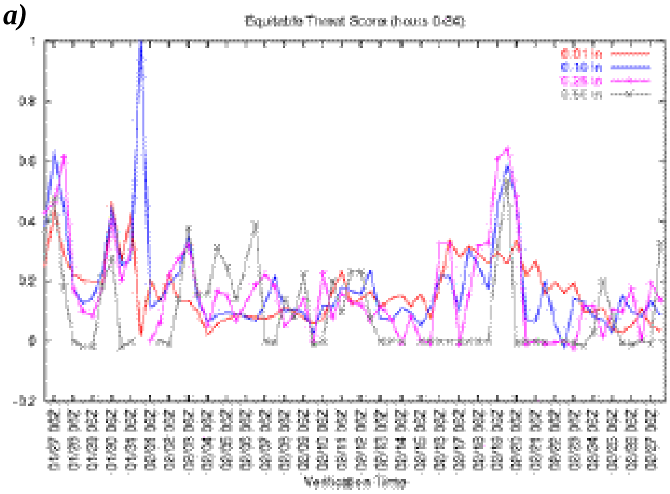
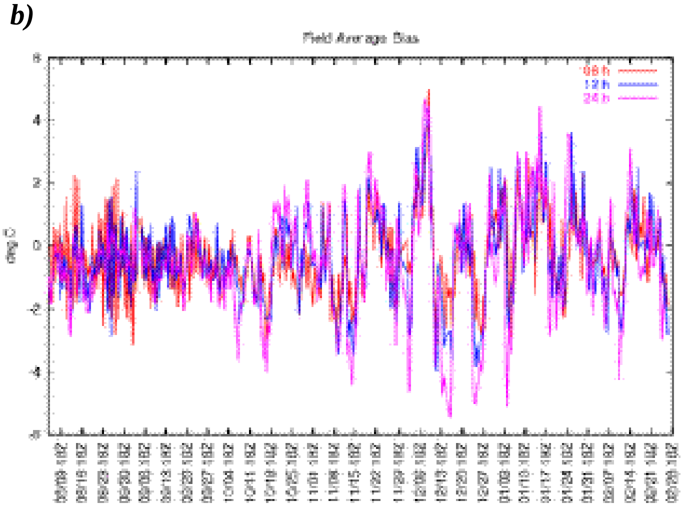


Figure 8. a) Equitable Threat Scores for24-hour accumulated precipitation on the 45 km domain. Precipitation thresholds of 0.01, 0.10, 0.25 and 0,50 inches are evaluated with this skill score. The period 25 January -28 February 2003 is shown . Higher scores imply a better forecast.

b)



b) Domain-averaged bias score for near-surface (lowest model computational level) air temperature (K), for the 15 km domain. Scores are shown for 6-hour, 12-hour and 24-hour forecasts. The period 9 August 2002- 28 February 2003 is shown.

hodogram of the winds in the upper left of the figure. Further, the plot provides information on the possibility of convective activity through a variety of computed convection diagnostic indices, including the commonly used computation of convective available potential energy (CAPE). During the warm season we also provide plan view plots of CAPE for the various domains as an aid to forecasters and more sophisticated aviation users who are experienced at interpreting horizontal distributions of CAPE.

In addition to the ability to plot variables in vertical profiles at a point, the RIP software also provides the ability to plot fields in vertical cross section. In our present implementation, we have elected to limit such plots to the UAF IIDA Icing Potential diagnostic. This is partly because aviators have expressed a desire for this type of information in an icing diagnostic, and partly for intercomparison purposes with a slightly different Alaska-specific algorithm developed at NCAR.

We strongly stress that all UAF IIDA-related products are still considered quasi-experimental at this stage and should not be relied on as official guidance. Such guidance is properly obtained from the Alaska Aviation Weather Unit (AAWU) in Anchorage. This fact is clearly stated on all our UAF IIDA-related pages, including direct hyperlinks to the AAWU site (http://aawu.arh.noaa.gov).

5. Arctic MM5 Performance and Validation

Although a more thorough discussion of the real-time Arctic MM5 performance during its first year will be presented at the conference, here we provide a sample of the types of validation activities we conduct as well as how they are used in evaluating the Arctic MM5 performance.

Figures 8 and 9 depict typical verification

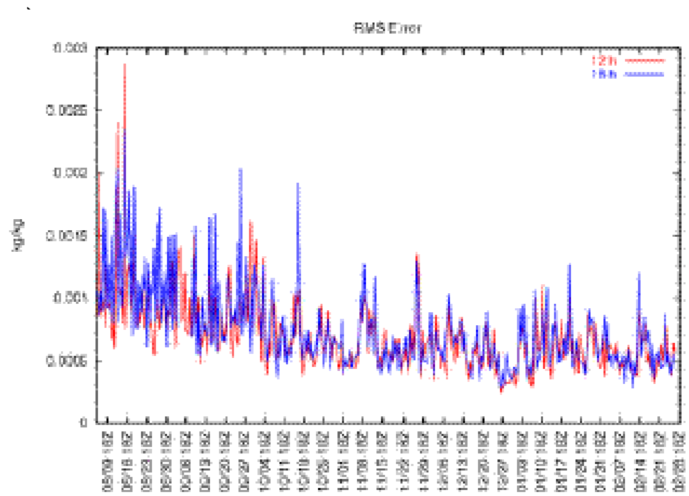
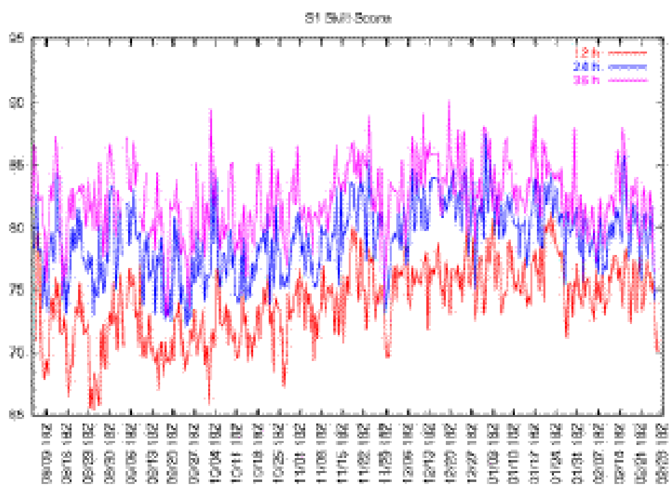


Figure 9. a) Root-mean-square error of the water vapor mixing ratio (kg/kg) for the 5-km Anchorage regional domain (see Figure 3 for location). RMSEs for 12-hour and 18-hour forecasts are shown for the period 9 August 2002- 28 February 2003.



b) Domain-average S1 skill score for the near-surface (lowest computational level) zonal (U) component of the wind on the 45 km domain. The S1 score is a measure of the ability of the forecast to represent analyzed gradients of the geophysical variable. Lower scores indicate a better forecast. Scores for 12-hour, 24-hour and 36-hour forecasts are shown covering he period 9 August 2002- 28 February 2003.

plots produced automatically within the course of a typical Arctic MM5 run cycle. Figures 8a and 8b show time series plots of the equitable threat score (ETS; e.g., Wilks, 1995) for precipitation on the 45 km domain and the near-surface (actually lowest model level) temperature bias on the 15 km domain. Figures 9a and 9b show the root-mean-square (RMS) error for the near-surface water vapor mixing ratio on the Anchorage regional domain, and the S1 skill score (e.g., Teweles and Wobus, 1954) for the near-surface zonal wind component, again on the 45 km domain.. These four plots represent four of the different metrics which we use to continuously evaluate the real-time model on an ongoing basis. In addition to these metrics, we also conduct verification on the UAF IIDA icing diagnoses (not shown) utilizing pilot reports (PIREPs) in a contingency-table based approach (e.g., Brown *et al* 1997).

Figure 8a shows the time series of the daily 24 hour ETS since late January 2003, when this latest addition to the verification suite was added, for the thresholds of .01, .1, .25, and .5 inches. Over this time period, the model has shown to be fairly consistent, with each of the three lowest thresholds verifying consistently in the 0.15-0.25 range. During drier periods, the model tends to perform a bit better.

In Figure 8b, we see that the model tends to have a consistently slight cool bias over time and for all forecast hours. This is a characteristic which is more pronounced on the larger grids (domains 1 and 2) than on the smaller 5 km grids (domains 3, 4, and 5).

Figure 9a shows that the RMS error for the "surface" vapor mixing ratio has been on a steady decline since we started compiling statistics in August 2002. This is to be expected, as in addition to declining variance of environmental water vapor amounts during the winter months, the real-time model has also been undergoing enhancements over this period. A major addition has been the inclusion of the NOAH land surface model, which has helped with near-surface forecasts.

In Figure 9b, it is clear that the skill score for this variable is less (and therefore the forecast is better) for shorter-term forecasts. This is of course to be expected, though is an effect which is most pronounced on the large domain. On the others, the model tends to produce rather consistent quality forecasts for all forecast periods

6. Future Development

Over the next 6 months we anticipate additional development on several aspects of our system. Most notable will be the addition of the remaining observational station locations seen in Figure 2 that are not yet available within our real-time system. The increase in station density will allow for an improved depiction of mesoscale conditions in the Fairbanks vicinity as well as interior Alaska.

Second, we are continuing research into improving our initial conditions via dynamic initialization of cloud cover and moisture information from satellite (see Fan and Tilley, 2003, this volume, for details). We are also investigating the utility of conducting the real-time runs on a newly acquired platform at UAF's Arctic Region Supercomputing Center. If such a move proves feasible, it would remove a hardware-related constraint on the types of model improvements that can be incorporated in the real time system, since each improvement we make to the real-time system carries a computational cost. With current in-house computing resources, we find that we are near the point of weighing the benefits of the incorporation of new features against their relative computational cost and the associated increase in wall clock time (and corresponding decrease in timeliness of information) for a real-time run.

Finally, as news of our system spreads and the user base increases, we anticipate making cosmetic and/or informational content changes on the series of web pages and graphical products available, based upon feedback from the users. It is our hope that through such feedback we can develop a system that provides a true service to the general public within Alaska as well as to the Alaskan aviation community, NWS forecasters, scientific researchers and the numerical forecast community at-large.

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