University:

Name of University Researcher Preparing Report:

NWS Office: Anchorage Forecast Office

Name of NWS Researcher Preparing Report:

Type of Project (Partners or Cooperative): Partner

Project Title: Anchorage Alaska significant snowfall events associated with low pressure centers in Prince William Sound
UCAR Award No.: S08-71435

Date:

Section 1: Summary of Project Objectives

Objectives

To improve forecasts for significant winter snow events in the Anchorage Bowl by examining the relationship between significant snowfall events in Anchorage and the presence of a PWS low.

Objective 1 Compile a climatology of Anchorage significant snowfall events for the last 10 years (January 1997-December 2006).

Objective 2 Create a climatology for Anchorage significant snowfall events with associated PWS lows for the period January 1997 - December 2006.

Objective 3 Case study of an Anchorage significant snowfall event associated with a PWS Low.

Section 2: Project Accomplishments and Findings

Describe the research/development activities and accomplishments carried out to date. These accomplishments may relate specifically to the original project objectives, or they

may be ones that arose during the course of the project (e.g., development of an innovative method for accomplishing the objective or insight into a related problem). Highlight any major changes to the scope of work. If the project involved separate research topics, please list each separately

2.1 In cooperation with the NWS the climatology of Anchorage significant snowfalls for the period of January 1997 - December 2009 has been compiled and identification of significant snowfall events associated with a center of surface low pressure in Prince William Sound was completed for the same period.

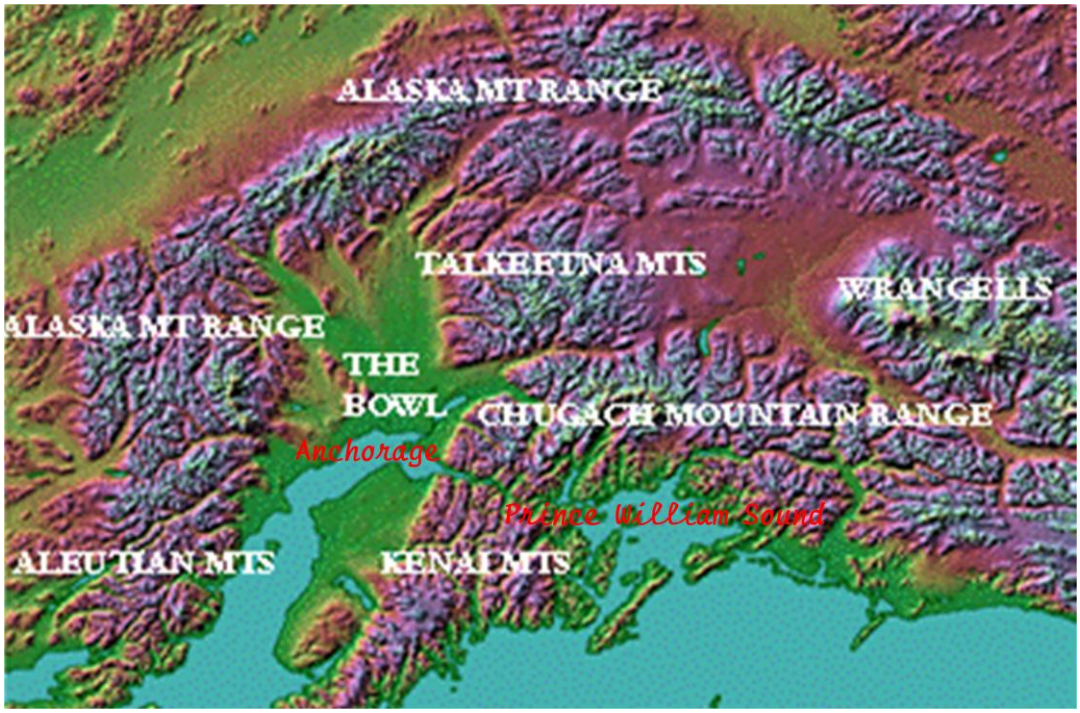

Figure 2-1 South central Alaska, Anchorage and Prince William Sound

Considering the length of the winter season and the area's proximity to several ice-free water sources, the Anchorage area sees relatively few very large snowfalls. Many storm systems that impact the surrounding area yield little in the way of precipitation for Anchorage itself. Events that do significantly impact the public are often associated with light precipitation rates over extended periods. We found that snowfall is often low density with snow

water density typically in the range of 3-10% and an average for the period of study of 5.5%.

Significant snowfall events were identified on the basis of a storm total greater then 6” measured at the NWS Anchorage Forecast Center. A “storm total” was identified as continuous snowfall or intermittent snowfall occurring over a 36 hr period. This definition of a storm is similar to that used by other researchers Changnon and Branick in their studies of significant snowfall events for the contiguous 48. (Branick 1997) (Changnon 1969) (Changnon S.A.. and Changnon 1978) More importantly the criteria were selected in consultation with NWS Anchorage operations staff on the basis of types of storms that most seriously impact the public in Anchorage.

The period of record for the study was confined to the period post 1997. (The location of the official Anchorage snowfall measurement site has remained the same since that point in time.)

Table 1 shows the annual snowfall measured by the NWS in Anchorage, the number of storms per season identified as having significant snowfall and the contribution of these events to the seasonal snowfall total. The number of significant storms is highly variable from season to season. The mean number of significant events per year is 3.7 with a standard deviation of 2.3. These events on average contribute 41% of the seasonal total and 43% of the snowfall measured during the period.

The Anchorage area sees few very large snowfalls of greater than 12”. During the period of study the municipality recorded 3 of the 5 largest, 24-hour snowfalls since observations began. The largest of these events was 22 inches (with an event total of 26.7”) but of the 44 events studied only seven had a storm total greater than 12 inches.

year	annual in	total # sig snowfalls	total sig (in)
1997-1998	58.6	0	0
1998-1999	79.3	4	44.7
1999-2000	76.2	3	26.6
2000-2001	63.5	2	17.7
2001-2002	81.5	3	47.6
2002-2003	36.8	2	15.2
2003-2004	113.9	8	65.4
2004-2005	76.6	4	32.6
2005-2006	69.8	1	10.3
2006-2007	84.3	5	47.8
2007-2008	109.1	7	66.9
2008-2009	93.4	5	34.1
Total	943	44	408.9

Table 2-1 Significant snowfall events Anchorage AK 1997-2009

2.2 The second objective of the study was to identify significant snowfall events associated with the presence of an area of low pressure to the east of Anchorage in Prince William Sound. The presence of a PWS low has been anecdotally associated with Anchorage snowstorms.

The significant snowstorms from the significant snowfall climatology were analyzed for the presence and duration of an analyzed low pressure center in Prince William Sound. For each event a time series of the North American Regional Reanalysis data were plotted for the region. The surface pressure reduced to MSL, were contoured at 1 mb and 3 hr intervals for each event. Events in which a center of an area of low pressure was identified to fall within a region 2 degrees in the N-S direction and 3 degrees in the E-W direction, centered on PWS, were considered to be events associated with a "PWS Low".

Events characterized by the presence of PWS Lows comprised just over half of all significant storms for Anchorage for the period of October 1997 – September 2009. The percentage contribution of inches of significant snow due to PWS low events was very close to the period number percentage of significant events (Table 2). The contribution of PWS low events to the total snowfall for the period was 24% (226").

year	total no. significant snow events	no. PWS significant snow events	annual percent of PWS storms	annual % sig snowfall from PWS lows
1997-1998	0	0	0.00	0.00
1998-1999	4	4	1.00	1.00
1999-2000	3	1	0.33	0.29
2000-2001	2	1	0.50	0.63
2001-2002	3	1	0.33	0.18
2002-2003	2	0	0.00	0.00
2003-2004	8	4	0.50	0.61
2004-2005	4	3	0.75	0.72
2005-2006	1	1	1.00	1.00
2006-2007	5	5	1.00	1.00
2007-2008	7	1	0.14	0.16
2008-2009	5	3	0.60	0.56
1997-2009	44	24	0.55	0.54

Table 2-2 Contribution of PWS Lows to Anchorage significant snowfall 1997-2009

Interesting to note is the distribution of snowfall events by month. With no significant snowfalls in the months of May – September during the period of the study, we found an odd distribution of storms across the winter months. The number of storms occurring in December was much higher than any other month, in fact, a greater number occurred in December than any three other months combined (Table 3). The effect of two very large storms, which occurred in the months of March and April, appear to have biased average storm totals for the two spring months to be much larger than the mid-winter average storm totals.

	Significant snowfalls	Significant snowfalls w/ PWS low	Monthly inches from sig. snowfall	Average inches from sig. snowfall
October	**4**	**3**	**33.8**	**8.45**
November	**5**	**4**	**42.2**	**8.44**
December	**17**	**9**	**144.4**	**8.49**
January	**5**	**3**	**45.2**	**9.04**
February	**7**	**3**	**63.1**	**9.01**
March	**4**	**2**	**54.3**	**13.57**
April	**2**	**0**	**25.9**	**12.95**
Total	**44**	**24**	**408.9**	**9.29**

Table 2-3 Distribution of Anchorage significant snowfall events by month for period 1997-2009

2.3 In the course of reviewing significant snowfall events to determine which events were associated with PWS lows, a number of cases were analyzed on the basis of surface observations of wind speed and direction, temperature and precipitation intensity. The precipitation onset and intensity from the observations were compared to operational forecast grids from the NAM model to find a case where boundary conditions for a high-resolution simulation could be expected to produce measurable precipitation for Anchorage.

The case chosen for simulation was an event occurring during the period between 12Z February 9, 2005 and 12Z February 11, 2005. The storm was typical in that the NARR indicated a surface low-pressure system centered in western PWS for a 12-hour period between 12Z February 10 2005 and 00Z February 11, 2005. This event produced 7.2” of snow and .3” of an inch of snow water equivalent (SWE) for Anchorage.

The event was simulated using the WRF-NMM (NWS) and WRF ARW (UAA) dynamic cores with NCEP NAM operational grids for initialization and boundary conditions. The results of the simulation were verified against observations from Anchorage, Merrill Field and Kenai (Figure 2-1).

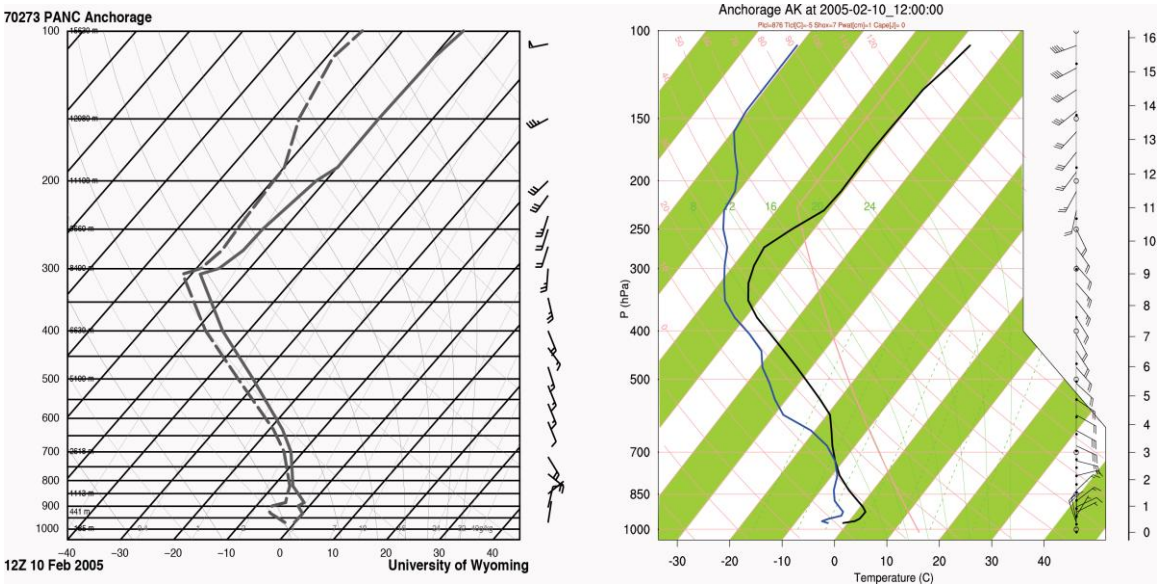

Figure 2-2 PANC sounding (left), WRF sounding (left) 12Z February 10, 2005

Although the WRF simulation did indicate the presence of a low-pressure system centered in western PWS, and the winds were qualitatively similar during the period, the model overproduced precipitation by a factor of 5 (Figure 2-2). The precipitation results from the simulation are so unrealistic; we feel that it would be unreasonable to draw conclusions from the model results regarding real dynamics for this event.

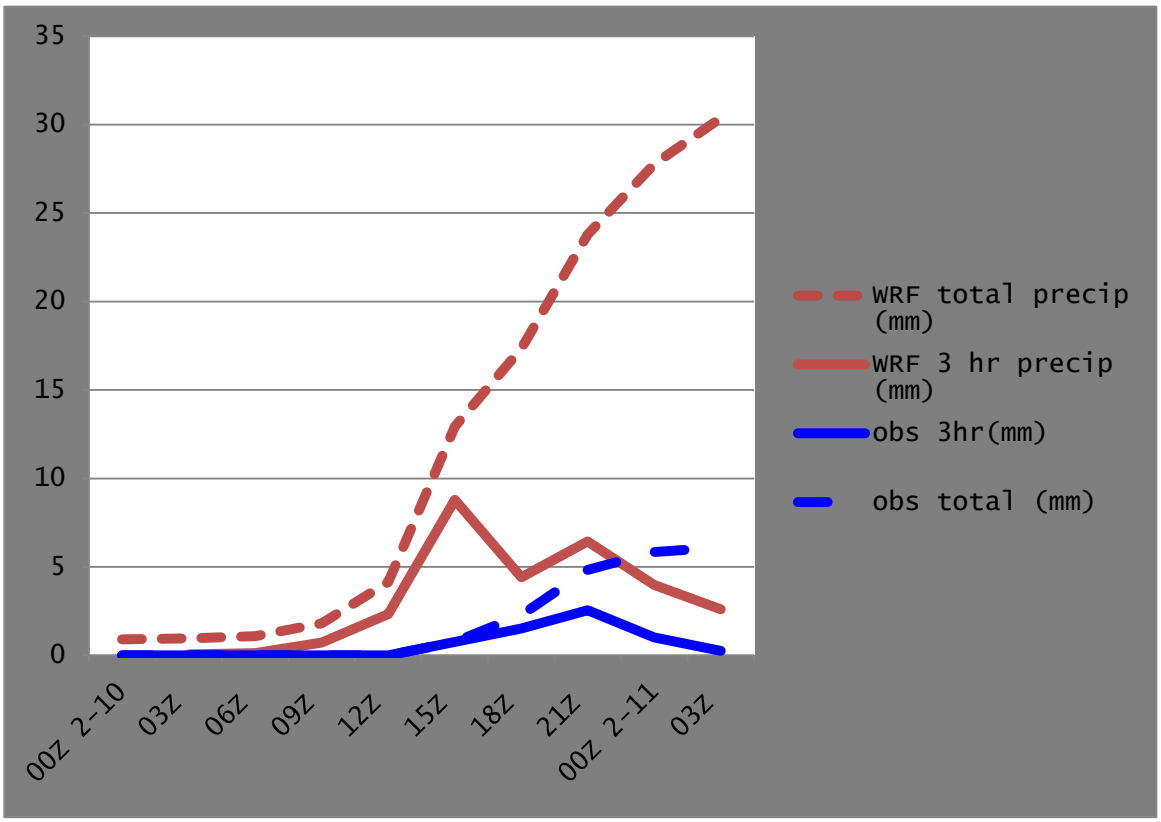

Figure 2-2 WRF ARW simulation vs. observed precipitation for Anchorage Int'l Airport, February 10 -11, 2005.

Section 3: Benefits and Lessons Learned: Operational Partner Perspective *List the benefits to the NWS office from the collaboration and any significant lessons learned during the study. Please be as specific as possible, particularly in regard to any improvements in forecasting resulting from the COMET project (**see examples**). Identify any major problems encountered and describe their resolution.*

This project has provided a foundation for the National Weather Service Forecast Office in Anchorage understanding of Prince William Sound Lows and their potential to produce significant snowfall for the Anchorage area. The climatological research of these events has pointed out the relative portion of the annual snowfall that accompanies Prince William Sound Lows. It has also pointed out the mean snow ratio for PWS Lows. The research has also pointed out the features that are present in most storms. For instance, we are now able to delineate the onset of snowfall at Anchorage based upon guidance. The belief is that this study will allow forecasters to better forecast the PWS snowfall events with greater accuracy in timing the onset and also the amount of precipitation. This will provide hopefully result in providing better customer service to local officials on snow removal efforts.

In addition, staff at the Forecast Office has started to research more forecast problems and looks forward to future collaboration with the University of Alaska – Anchorage.

Section 4: Benefits and Lessons Learned: University Partner Perspective *Describe the benefits to the University resulting from the collaboration and any significant lessons learned during the study. Identify any major problems encountered and describe their resolution*.

The NWS and COMET contacts have been uniformly reasonable and helpful throughout the process of application and administration of the project. The local representatives of the

NWS both at the local and regional level have been very supportive of the partnership between UAA and the NWS. Despite the demands of shift work placed on schedules of NWS personnel, the study has moved forward smoothly.

Considerable effort was put into setting up the WRF ARW to run in research mode for a domain centered on Anchorage. The investment in pre- and post- processing scripts will make it simpler to run additional cases with little time investment. Future modeling efforts will likely consist of multiple runs on multiple cases to try to guarantee a more realistic and useful simulation.

In the course of the composing the significant snowfall climatology, university researchers became familiar with accessing NARR data and plots from NCEP. The university staff has also become significantly more adept at using NCL to produce quality analysis products from WRF output. Although not particularly helpful in this case because of the poor results, the university was able to gain experience using the VAPOUR package for visualization of the data from the case study. The combination of access to regional datasets and new analysis tools will allow the university to approach a variety of research questions using tools and datasets accessible to local NWS partners.

The feedback to the university on the details of forecasting problems *other than* significant snowfall events, for the Anchorage Forecast Center has, perhaps been, the most significant benefit from the collaboration between the two parties. It appears that there is a great deal of interest in pursuing research projects on numerous mesoscale phenomena including high wind events and conditions producing wind shears and turbulence in the ANC forecast area.

The university grants and contracts process was very slow to process the agreement between UCAR and UAA. The administrative process on the UAA side was stifling and did not represent a reasonable expenditure of university resources

relative to the grant funding. It is hoped that future cooperative agreements would move through the university more quickly now that an initial contract has been approved. Future efforts should be hampered less by administrative hurdles.

Section 5: Publications and Presentations *Provide complete citations using the AMS bibliographic format for each thesis, dissertation, publication or presentation prepared as part of this project.*

Presentations:

Volz, K.P., P.Q. Olsson and H. Liu, 2008: The Prince William Sound Low and Associated Impact on Anchorage Significant Snowfall Events. *Little Alaska Weather Symposium*, Fairbanks, Alaska, May 12-13.

Olsson, P.Q., and K.P.Volz, 2009: Anchorage Significant Snowfall Associated with a Low Analyzed in Prince William Sound. *2009 Alaska Weather Symposium*, Fairbanks, Alaska, March 10-12.

Section 6: Summary of University/Operational Partner Interactions and Roles *Describe the responsibilities of the various project participants over the course of the entire project.*

NWS partners and UAA participants met three times during the project.

- To scope project and allocate research responsibilities
- To review initial findings on number of events and select case for WRF simulations
- Finally to review findings from WRF ARW simulation by UAA
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Operational Partner Responsibilities

- Identify storms with snowfall greater than 6" for period 1997-2007.
- Run WRF NMM for case study February 10, 2005.

University Partner Responsibilities

- Create climatology of significant snowfall events for period 1997-2009.
- Identify significant snowfall events associated with PWS Lows for period 1997-2009.
- Identify event for numerical simulation.

- Run WRF ARW for case study February 10, 2005.
- Verify and analyze model results for UAA, WRF ARW simulation.

Bibliography

Branick, M.L. "A climatology of significant winter-type weather events in the contiguous U.S.: 1982-1994." Weather and Forecasting 12 (1997): 193-207.

Changnon S.A.. and Changnon, D. "Record Winter Storms in Illinois:1977-1978." Report of Investigation 88 1978: 68pp.

Changnon, S.A. "Climatology of Severe Winter Storms in Illinois." Bulletin 53 1969.

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Branick, M.L. "A climatology of significant winter-type weather events in the contiguous U.S.: 1982-1994." Weather and Forecasting 12 (1997): 193-207.

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