CLIMATE CHANGE AND SHORT-TERM FORECASTING FOR ALASKAN NORTHERN COASTS

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1. INTRODUCTION

Global climate models project that the Arctic is an area where changes to the climate due to warming are likely to be the largest in the world. Alaska, as part of the Arctic, is already experiencing significant climate change. Observed data indicate that over the last 30 years, annual global surface temperatures have increased 1-2 degrees Celsius, with some of the largest increases occurring in Alaska (Fig. 1) (see //climate.gi.alaska.edu/). Sea ice is showing an approximate 8 percent decrease in areal extent since 1954, with winter freeze-up and spring melt arriving about three weeks later and earlier, respectively (Hassol, 2004; Overland and Stabeno, 2004). The waters around Alaska are also showing an increase in sea level (Leuliette, et al., 2004). On land, increased seasonal thaw depth of the active layer is causing accelerated permafrost thaw (Serreze, et al., 2000).

John Lingaas (Fairbanks Weather Forecast Office, personal communication) has shown an increase in frequency for Arctic storms since 1997, as well as a change in the origin and tracks for these storms (Table 1). During the 8-year period from 1997 through October, 2004, twelve storms occurred that caused damage along the arctic coast. Five of these events were generated in the Arctic Ocean, not the Bering Sea, which bears directly on the impact of the storms on the northern shores. This contrasts with the period 1980 through 1996, when only 10 damaging storms occurred, and all but one of those had their origins in the Bering Sea, not the Arctic Ocean.

2. ADVERSE IMPACTS ALONG NORTHWESTERN ALASKAN COASTS

The interaction of the impacts from climate change described above has resulted in Alaskan northwestern coastal villages becoming more susceptible to flooding and erosion. The coastal shoreline generally features large areas of relatively low topographic relief, although this varies from natural beaches, dunes, bluffs and rocky shores. Another unique feature of the shoreline north of the Bering Sea is the presence of permafrost. Three coastal Alaskan villages have been identified in a Government Accounting Office report (2004) as in imminent danger from flooding and erosion from rising water and large waves to the point they must soon relocate: Kivalina, Shishmaref, and Newtok. Four other villages are in various stages of serious erosion and/or flooding: Barrow, Kaktovik, Point Hope, and Unalakleet (Fig. 2).

There are numerous sites along the Alaskan coast that are susceptible to episodic events, such as Nome, where a recent storm event inflicted major damage. For this paper Shishmaref, Point Hope, and Nome will be examined in more detail to look at the effects of climate change on these sites. The implications of climate change on short-term forecasts and warnings will also be discussed using a case study of the recent storm that impacted Nome.

2.1. Effects on Shishmaref

Shishmaref is a traditional Inupiaq native subsistence community of 600 located on a barrier island about 80 km northeast of the Bering Strait. The barrier island is approximately 0.4 km wide and 5 km in length. The soil under Shishmaref is a fine, silty sand. Permafrost is generally found at a depth of 1 m. Recent melting of the permafrost breaks the binding that keeps the moist sand together. Increased storms are producing large waves that are easily eroding the sandy beach and exposing permafrost underpinnings, increasing melting. On average, the island is losing 1.5-3 m of coastline each year, with some episodes (i.e.1997) causing losses in excess of 30 m. According to Clifford Weyiouanna (personal communication), a life-long resident of Shishmaref, the problem isn't only that storms are getting more frequent with stronger winds, but the water level is higher and sea ice, which normally protects the island during the winter months, is freezing-up later. Normal freeze-up off Shishmaref occurs the third week of October. Freeze-up has increased to more than three weeks later over the last 10 years. In 2002 freeze-up didn't occur until Christmas.

2.2. Effects on Point Hope

Point Hope is another traditional subsistence Inupiaq native coastal village and the oldest continually inhabited community in Alaska. It is located 483 km southwest of Barrow. The village, inhabited by 850 residents, occupies the tip of Point Hope Peninsula on the coast of the Chukchi Sea. The peninsula is a low lying gravel

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spit that forms the western most extension of the northwest Alaskan coast. With the lack of sea ice to protect the shoreline, fall storms are having much greater impact. Flooding occurs from strong winds blowing out of the west and northwest producing large waves that bombard the north and south beaches. The north beach is 19 km long; the south beach 29 km long. The most vulnerable areas to flooding are the airport runway which floods on its north end, and the only road that extends to the mainland from the peninsula also goes underwater cutting off the only evacuation route. Wave action during strong storms can create ocean surges 2.4 m or more along a coast that is only a meter or two above sea level.

2.3. Effects on Nome from the Storm of 18-20 October, 2004

The city of Nome, population 3,500, lies on the southern shores of the Seward Peninsula and is exposed to storms moving northeast in the Bering Sea. Between 0000 UTC, 18 October and 0000 UTC, 19 October, 2004 a cyclone in the northern Bering Sea deepened approximately 50 mb…from a 990 mb elongated trough to a 940 mb super storm dominating the circulation. At the height of the storm the radius of gale force or stronger winds was on the order of 480 km, dominating conditions in the Bering and the southern Chukchi Seas. Kivalina (Fig. 2) suffered major beach erosion and flooding with 0.8 m of standing water around the local school and the village septic system was washed away. Point Hope and Shishmaref suffered shoreline erosion and flooding, but Nome was hardest hit by the storm. A storm surge of 3 m was observed by the local tide gauge at 1800 UTC, 18 October. Superimposed on the surge were seas estimated to 6 m and winds to 31 m s^{-1}. Major damage occurred to a number of beach front buildings, debris washed inland for more than two blocks, power lines were torn down and serious erosion took out the road south of town. An estimate of damage in Nome is more than 5 million dollars. However, most important, no lives were lost.

3. IMPLICATIONS OF CLIMATE CHANGE ON SHORT-TERM FORECASTS

One of the most significant impacts of changing climate for the NWS in Alaska is on the short-term forecast and warning processes. With more arctic coastal communities in Alaska at greater risk than ever from coastal storms, forecasters must provide high quality forecasts and warnings with greater lead time to emergency managers and decision makers prior to the storm. With the low coastal relief, emergency managers and community officials must be able to mitigate the impacts of the storms on the community prior to its arrival. Such activities frequently include erecting physical barriers to high surf and storm surge, moving small boats used for subsistence, boarding up windows of buildings near the shore, and even evacuating the public. Given the isolation of these communities, all of whom lie outside of any road system, evacuations require a great deal of time and resources to accomplish. All of these actions translate directly into lead time required before the onset of storm conditions.

The storm that occurred along the western Alaskan coast 18-20 October, 2004, highlights the positive impact that high quality forecasts and warnings with several days' lead time can provide to these coastal communities. The storm had its origins several weeks earlier as Typhoon MA-ON which caused six deaths in Japan. Re-curving to the northeast, the storm moved into the north central Pacific Ocean as a rather innocuous low pressure trough. Encountering colder air and favorable upper-air winds, the storm began to rapidly intensify as it moved into the western Bering Sea. Rapid deepening and strong winds, combined with a long over-water fetch, created a very dangerous storm surge aimed directly at the community of Nome, Alaska. Sea ice extent was approximately 13 percent below the climatological normal for October, 2004.

For this storm, the numerical models developed by the NWS National Centers for Environmental Prediction, and the storm surge models developed by the NWS Meteorological Development Laboratory, accurately predicted the general track, intensity, and timing of the storm and its attendant storm surge, especially in the Bering Sea coastal areas. The consistency of the models from one run to the next gave forecasters at the NWS Weather Forecast Office in Fairbanks, Alaska, which has forecast and warning responsibility for Nome, greater confidence in the model's diagnosis of the unfolding event. Fairbanks forecasters issued their first products warning of this event early on the morning of 16 October, 2004: nearly 60 hours in advance of the storm. Over the next three days, forecasters would issue hundreds of watches, warnings, advisories and statements related to this event. Staff at the NWS Weather Service Offices in Nome and Kotzebue spent considerable time coordinating these products and services with the local and state emergency management officials, assisting with the interpretation of the information and aiding the decision-making process.

4. SUMMARY

Records of increasing temperatures, thawing permafrost, rising sea level, and reduction in sea ice extent and thickness are all physical evidence of warming in Alaska. In the north these rising temperatures are causing the protective nearshore ice to form later in the year and melt sooner, leaving the coastal villages vulnerable to greater impacts from the waves and surge associated with Fall storms.

In order to provide sufficient time for villages to take disaster mitigation prior to storms there is a greater need than ever for high quality, consistent numerical model guidance such as that which was provided to forecasters during the storm of 18-19 October, 2004. Since these numerical models rely on observational data, there is also a need for increased number and quality of arctic atmospheric and oceanic observations, both in-situ and remotely-sensed. The challenge for the forecaster will be to recognize the increasing number of extreme events under changing climatic conditions so that he/she can issue accurate forecasts and warnings with sufficient lead time to arctic coastal communities.

5. REFERENCES

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1980 – 1996				
	Storm Origin	Arctic Ocean	Russia	Bering/Pacific
	Number of Events	1	3	6
1997 – 2004				
	Storm Origin	Arctic Ocean	Russia	Bering/Pacific
	Number of Events	5	1	6

Table 1. Origin of storms that produced coastal damage in northern Alaska during the periods of 1980-1996 and 1997-2004.

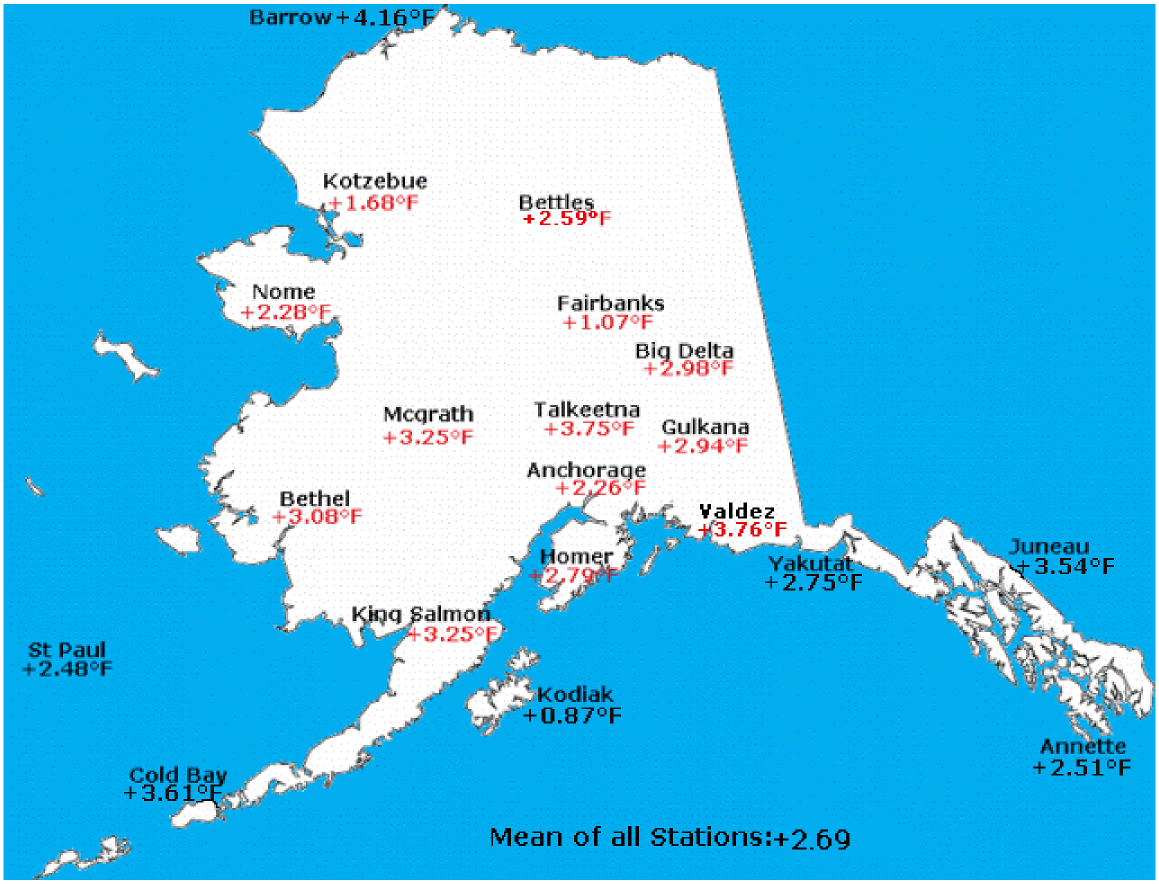

Fig.1. Mean annual temperature change for stations in Alaska 1971-2000 (Figure provided courtesy of the Alaska Climate Research Center).

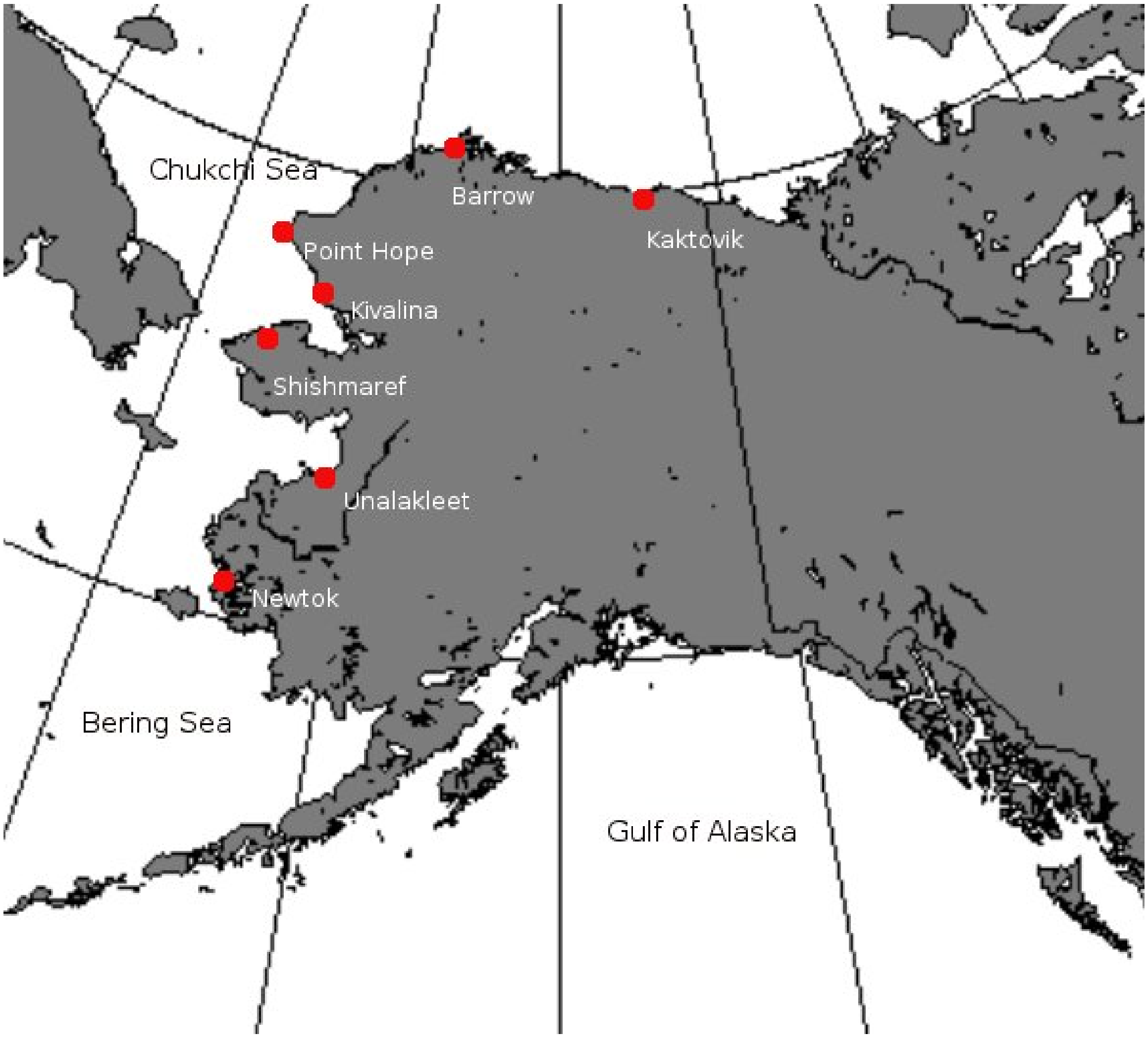

Fig. 2. Map of Alaska northern coastal villages and towns discussed in this paper.