SEASONAL TEMPERATURE AND PRECIPITATION DEPENDENCIES IN SOUTHEAST ALASKA

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Abstract

The climate of southeast Alaska is primarily influenced by moist maritime air from the adjacent Pacific Ocean that is occasionally modified by drier continental air from Canada. This battle between maritime and continental air masses can also have implications in terms of the relationships between temperature and precipitation in this region. In order to gain a better understanding of this relationship, linear regression was used to determine the correlation between seasonal temperature and precipitation values at four locations in southeast Alaska. In addition, mean 700-mb and 500-mb height composites were calculated for seasons with anomalous mean temperature and precipitation values at the same four locations. Comparisons of these composites helped identify flow characteristics conducive to the anomalous conditions.

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1. Introduction

Southeast Alaska has very unique geographic features that contribute to the climatic relationship between temperature and precipitation. It consists of an archipelago of both islands and mainland with a network of channels that make up the inside passages. Numerous glaciers flow down the Coast Mountains to the east and other mountain ranges to the north. Southeast Alaska is the boundary that divides the Pacific Ocean to the west and the Canadian interior to the east. It is often the battleground between wetter maritime and drier continental air masses resulting in a climate that is primarily maritime with occasional continental influences.

Since these two competing air masses have differences in both temperature and precipitation, it may be possible to: 1) identify and quantify the seasonal relationship between temperature and precipitation, 2) evaluate the mean upper level height patterns that would be conducive to significant departures from normal for these parameters.

Thus, by compositing upper level heights in seasons with mean temperature and precipitation values considerably above or below normal, the flow patterns that lead to these significant anomalous conditions can be identified and classified. These patterns should help forecasters understand the impacts of long wave features for improved long-term climate forecasts.

Recently, studies have shown that tropical sea surface temperatures (SSTs) can be correlated to the seasonal weather in the tropics and mid-latitudes (e.g., Mestas-Nunez and Enfield 2001; Lupo et al. 2006; Kung and Chern 1995; Mokhov et al. 2004). These studies demonstrated that there is some promise in using tropical SSTs to forecast on the seasonal timescale. The analysis of Hurrell (1995) suggests that El Niño Southern Oscillation (ENSO) -related SST (sea surface temperature) anomalies would have a substantial impact on the seasonal character of temperatures and precipitation in the study region. However, the impact of mid-latitude SSTs on seasonal mid-latitude weather is still in question (e.g. Kushnir et al. 2002).

Recognition of the upper-level flow types associated with SST anomalies could yield a better understanding of the seasonal temperature and precipitation anomalies that would be expected over southeast Alaska. Early detection of flow regimes associated with anomalous conditions could increase forecast skill for the Alaskan panhandle.

2. Data and Methods

a. Data

1) Southeast Alaska

Four stations (circled in Fig. 1) in southeast Alaska were selected for this study. Yakutat is positioned on the coast of Yakutat Bay, unprotected from storms in the Gulf of Alaska. The St. Elias Mountains are on the opposite side of Yakutat Bay with the huge Malispinia glacier flowing down the mountain to the water. Juneau is the most inland of the four stations, located on the mainland between the Coast Mountains and the inside passages. Sitka is situated in Sitka Sound on the west-central side of Baranof Island. The western coastline of Baranof Island lies exposed to the Pacific Ocean. Sitka is predominantly maritime, but can experience modified continental air in strong offshore flow. Annette rests north of the Dixon Entrance, east of Prince of Wales Island, and approximately 22 miles

Fig. 1. A map of the southeast Alaska study region (Alaska Information Services).

south of Ketchikan. Annette is partly protected from open coastal waters but is adjacent to the Dixon Entrance, a large strait to the south. A maritime air mass predominantly influences this location, but it can also experience continental air during offshore flow.

2) Data sets

The temperature and precipitation for the years 1950 to 2005 came from the National Oceanic and Atmospheric Administration's (NOAA) National Climatic Data Center (2006); however, 1997 and 1998 were eliminated from Sitka because of a significant quantity of missing data. For each chosen site, the average temperatures and precipitation amounts were determined for each month of the 55-year data set. The days of precipitation, excluding days that yielded a trace, were also calculated. With the calculated monthly averages, seasonal values were computed.

The months used for each season were: December, January and February for winter; March, April and May for spring; June, July and August for summer; September, October and November for fall. The seasonal reanalysis of composite mean geopotential heights were generated by the NOAA Climate Diagnostics Center. Information on ENSO phases and PDO (Pacific Decadal Oscillation) phase were obtained from the NOAA Climate Prediction Center.

b. Methods

To determine the measure of correlation between the temperature and precipitation, a standard linear regression was found for each season at each location. The slope of the line illustrated the direction of the relationship. An increasing slope, for example winter at Yakutat (Fig. 2), suggested that seasons with warmer mean temperatures are likely to have more precipitation. A decreasing slope, for example summer at Juneau (Fig. 3), indicates that seasons with warmer mean temperatures are more likely to have less precipitation. The correlation values, as well as directional and non-directional null probabilities were calculated to determine the significance of the relationship (Tables 1-2).

The second part of the study classified seasons in relation to their deviation from mean conditions. If both the temperature and precipitation values were one or more standard deviation away from the mean, that season of that particular year was chosen for a case study. Case studies were then classified as: warm and wet, warm and dry, cold and wet, or cold and dry. For example, warm and wet seasons were at least one standard deviation above the mean for both temperature and precipitation.

Geopotential height composites at 500-mb and 700-mb for the selected years were grouped accordingly to the stated classifications above. These levels were chosen to avoid flow interference with the complex terrain of southeast Alaska. Analysis of these composites allows identification of dominant synoptic patterns associated with each condition. Tables 3 and 4 list winter and summer case studies used in this analysis.

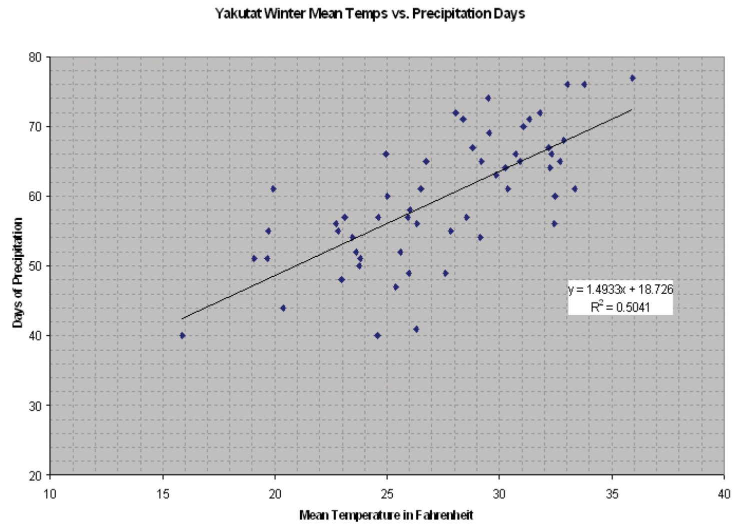

Fig. 2. Positive Temperature-Precipitation Correlation for the Winter Seasons from 1950-2005 for Yakutat.

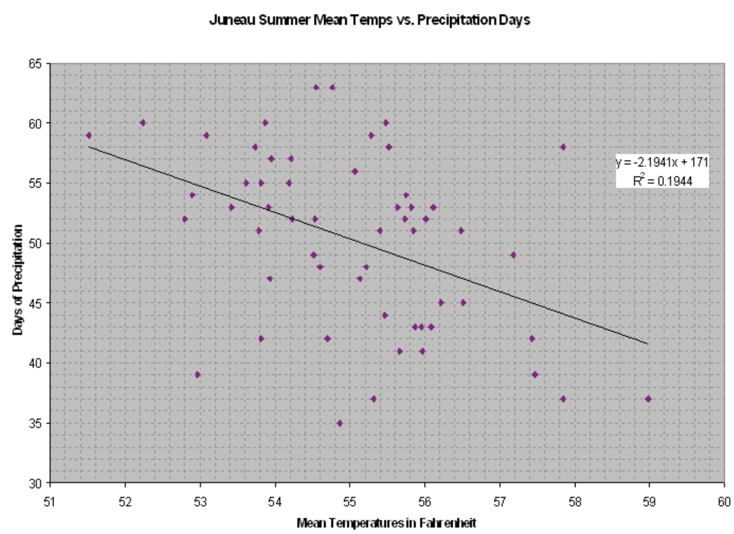

Fig. 3. Negative Temperature-Precipitation Correlation for the Summer Seasons from 1950-2005 for Juneau.

3. Results

c. Relevance of the linear correlations

The charts in Figs. 4 and 5 summarize the results of the regression study for all four seasons. Figures 4a and 4b depict slope and correlation values (r) that result for temperature and total precipitation, while Figs. 5a and 5b depict the same values for temperature and days of measurable precipitation. The value of the appropriate regression line slope can also be used to determine the change in total precipitation or rain days for each 1°F change in mean temperature.

The slope of the regression line for the winter and fall seasons was positive at all locations indicating that warmer temperatures usually resulted in higher precipitation and more rain days (Figs. 4-5). This reflects the fact that winter temperatures in southeast Alaska are warmer and wetter under the maritime influence and colder during dry arctic offshore flow. Fall trends were similar to winter. Relative to winter, the lower correlation values for total precipitation and mean temperature during the fall found at most sites, Juneau being the lone exception, reflects the transitional nature of the fall season.

In contrast to winter and fall, summer is characterized by a negative slope at all locations (Figs. 5a and 5b), meaning that warmer summers were usually drier and cooler

Linear Regression Statistics

Temperature vs. Total Precipitation				
Winter				
	slope of equation	r value	Significance (Null Probability)	
			Directional	Non-Directional
Yakutat	1.9455	0.622415	less than .0001	less than .0001
Juneau	0.4942	0.5029	less than .0001	less than .0001
Sitka	1.3024	0.5386	less than .0001	less than .0001
Annette	1.201	0.432	0.0004955	0.000991
Spring				
Yakutat	0.5118	0.1425	0.149723	0.299446
Juneau	-0.1099	-0.0872	0.263423	0.526846
Sitka	-0.7113	-0.2345	0.045487	0.090974
Annette	-0.8591	-0.255	0.0121085	0.024217
Summer				
Yakutat	-0.0029	-0.0004	0.498708	0.997416
Juneau	-0.5809	-0.2585	0.028377	0.056754
Sitka	-0.6686	-0.1597	0.1266925	0.253385
Annette	-1.0139	-0.2775	0.020128	0.040256
Fall				
Yakutat	2.7102	0.3571	0.00373	0.00746
Juneau	1.4137	0.5574	less than .0001	less than .0001
Sitka	1.909	0.4265	0.000725	0.00145
Annette	0.4672	0.0927	0.250345	0.50069

Table 1. Linear regression statistics based on temperature and total precipitation.

Temperature vs. Days of Precipitation				
Winter				
	slope of equation	r value	Significance (Null Probability)	
			Directional	Non-Directional
Yakutat	1.4933	0.71	less than .0001	less than .0001
Juneau	1.01094	0.6283	less than .0001	less than .0001
Sitka	1.7028	0.5632	less than .0001	less than .0001
Annette	1.2896	0.4748	0.000125	0.00025
Spring				
Yakutat	-0.095	-0.0265	0.423974	0.847948
Juneau	0.4505	0.209	0.0628	0.1256
Sitka	-0.9623	-0.1685	0.168523	0.227717
Annette	-0.762	-0.1852	0.087917	0.175834
Summer				
Yakutat	-1.8461	-0.3914	0.001564	0.003127
Juneau	-2.194	-0.4409	0.000377	0.000754
Sitka	-2.3476	-0.3766	0.002725	0.00545
Annette	-1.9766	-0.3912	0.001574	0.003148
Fall				
Yakutat	1.3291	0.3541	0.003996	0.007991
Juneau	2.2211	0.2927	less than .0001	less than .0001
Sitka	1.566	0.3579	0.004253	0.008506
Annette	0.7694	0.183	0.090524	0.181047

Table 2. As in Table 1, except for temperature and days of measurable precipitation.

summers were typically wetter. Note that the summer correlation values for "total precipitation" are smaller than for "days of measurable precipitation" (Figs. 4a and 5b), suggesting that a few large precipitation events could skew the total precipitation values toward the high side during years that would otherwise be dry.

Summer months in southeast Alaska are normally warm when high pressure dominates and skies are generally clear. Dry conditions with less cloud cover allow more solar heating and warmer daytime temperatures. Also, the sea remains cooler than the land due to the sea's larger heat capacity. The role played by the upper level flow patterns with respect to the relationship between mean temperature and "total precipitation" and "days of measurable precipitation" is described in the following sub-section.

b. Upper- level composites

Upper-level composites of the mean geopotential heights at 500-mb and 700-mb were examined for seasons that were at least one standard deviation from the mean in both temperature and precipitation in order to classify the type of upper-level long-wave pattern that would lead to seasonal extremes. The 700-mb level was chosen because it was the lowest standard height that remained above the influence of the mountain ranges. The 500-mb level was useful in providing a nearly frictionless surface.

Fig. 4a. **Fig. 4b.**

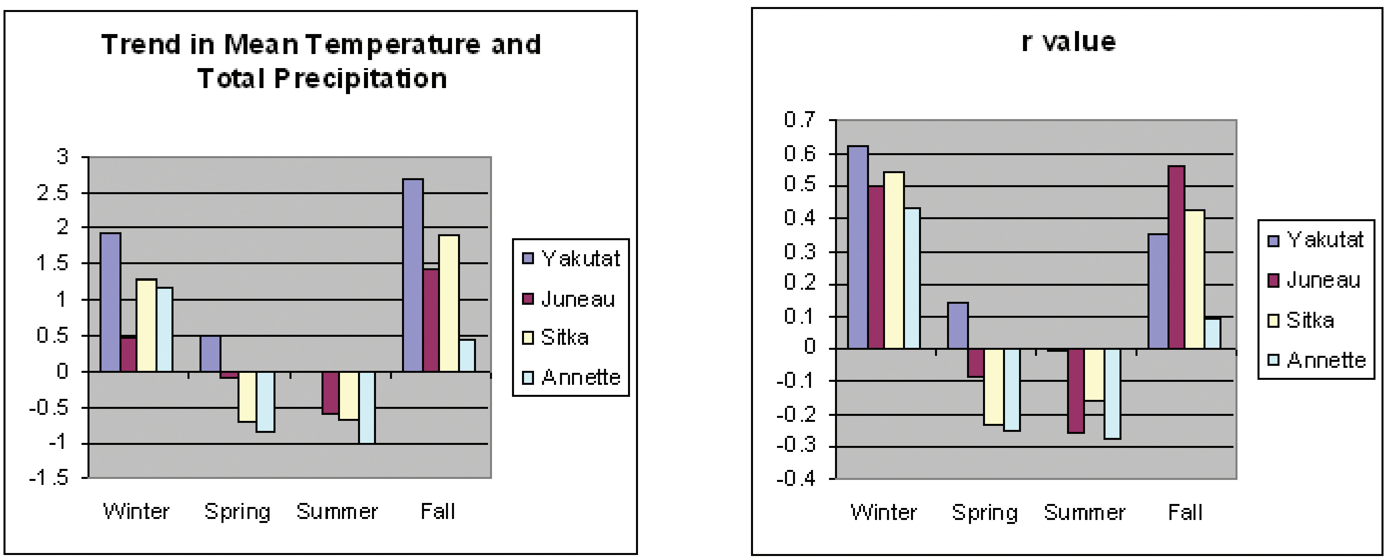

Fig. 4. Linear regression results for total precipitation and mean temperature. a) Slope and b) Correlation coefficient.

Fig. 5a. **Fig. 5b.**

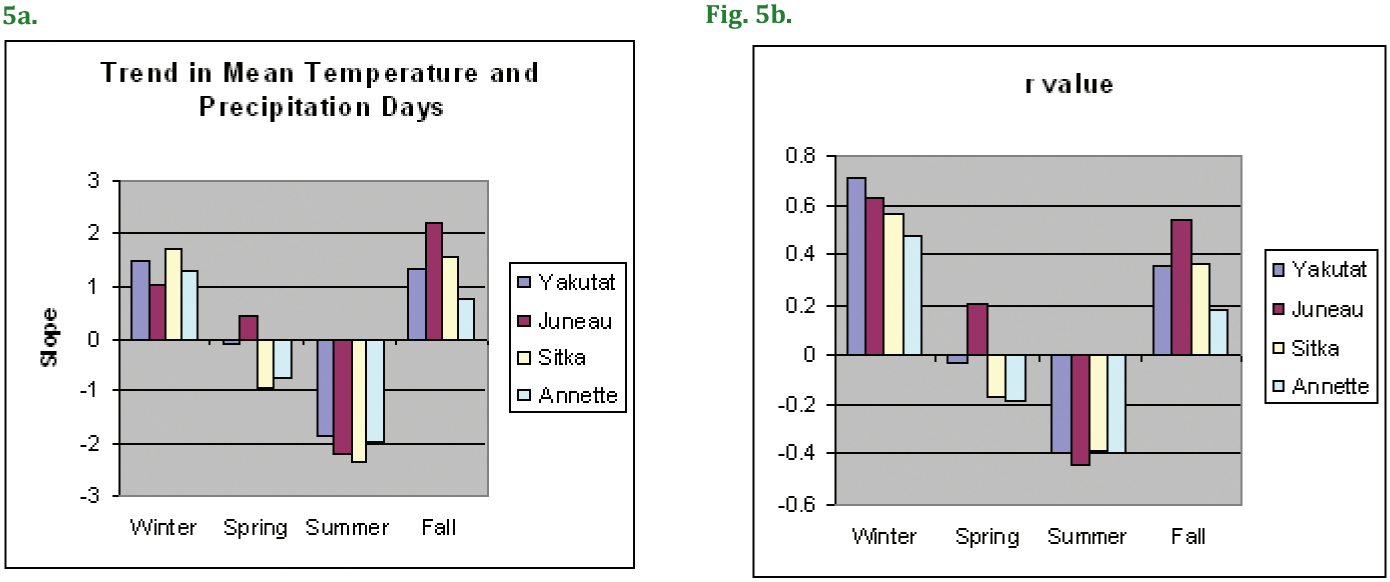

Fig. 5. As in Fig. 4, except for days of measurable precipitation. a) Slope and b) Correlation coefficient.

1) Winter season

a) Cold and dry

All locations were colder and drier when the upper ridge became established along the western coastline of Alaska. Figure 6 shows the typical pattern aloft (winter of 1950) that allowed such conditions. When the ridge was strong and reached north into the Arctic Ocean, cold air moved into southeast Alaska as it curved around a positively-tilted trough over western Canada. Most of the flow came from the interior while some had very brief exposure over the water. Strong flow near a positively-tilted trough became diffluent south of the panhandle, which also led to drier conditions below 700-mb.

The 1969-1970 winter season had height patterns that were unlike the others for cold and dry seasons. Figure 7 shows that the ridging shifted eastward, positioned more over western interior Alaska. Tight gradients resulted in strong northwest flow on the west side of a negatively-tilted trough, which became oriented southeast to northwest over the Gulf of Alaska. The cold air mass was more maritime-modified, due to a longer residence time over the water. Most of these systems followed the 500-mb flow

Continued page 101

Table 3 Code

WW	Warm and Wet	CD	Cold and Dry	CN	Cold and Normal
WD	Warm and Dry	NN	Normal and normal	NW	Normal and Wet
CW	Cold and Wet	WN	Warm and Normal	ND	Normal and Cold

Winter	*Yakutat*	*Sitka*	*Juneau*	*Annette*	*ENSO*	*PDO Phase*
1950	CD	CD	CN	CD	La	2
1952	ND	CN	CD	NN	N	2
1955	NN	NW	NN	NW	La	2
1956	CN	CN	CN	CD	La	2
1958	NN	NN	NN	WW	El	2
1960	NN	NN	NN	NW	N	2
1961	WN	WW	WN	NN	N	2
1963	NN	WW	NW	WW	N	2
1964	NW	NW	NW	NW	El	2
1965	CN	CN	CN	CW	La	2
1969	CD	CD	CD	CD	El	2
1972	CN	CD	CN	CN	La	2
1977	WW	WN	WN	WN	El	1
1979	NN	CN	CD	CN	N	1
1982	ND	CD	CD	ND	N	1
1985	NW	NW	NW	NN	La	1
1986	WW	NN	WW	NN	N	1
1987	WW	WW	WN	WN	El	1
1992	WW	WW	WW	WW	El	1
1993	NN	NN	NW	NN	N	1
2003	WN	WD	NN	WN	El	2
2005	NN	NN	NW	NN	El	2

Table 3. Classifications for winter and summer cases based on total precipitation

Fig. 6a.

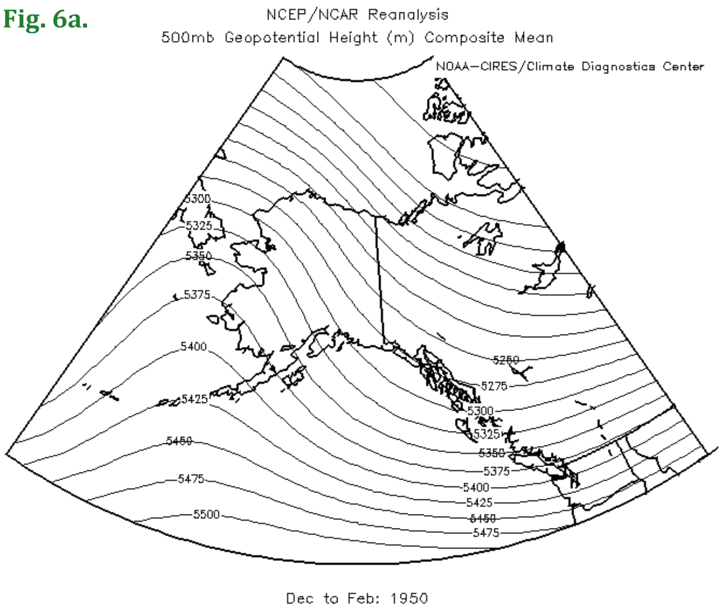

Fig. 6b.

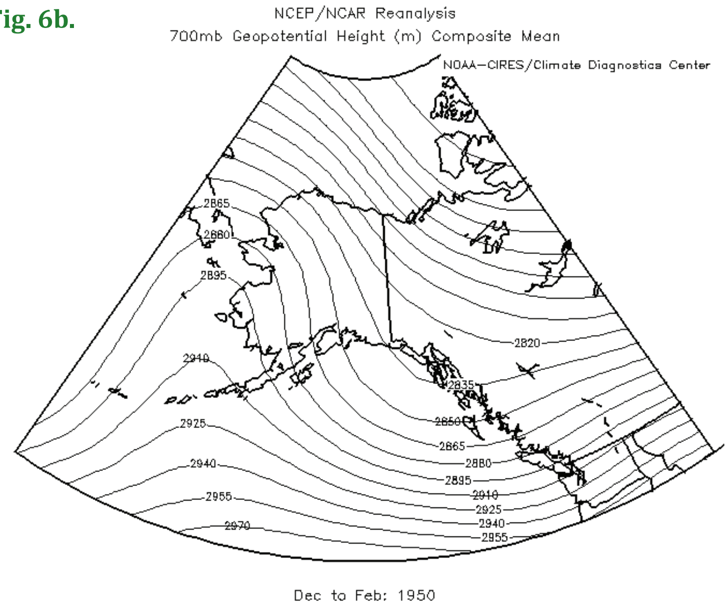

Fig. 6. Geopotential height composites for winter 1950 (Cold and Dry), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Summer	*Yakutat*	*Sitka*	*Juneau*	*Annette*	*ENSO*	*PDO Phase*
1955	CN	CN	CN	CW	La	2
1956	NN	NW	CW	CW	La	2
1957	WD	NN	ND	NN	La	2
1958	NN	WW	NN	WW	El	2
1961	NW	NW	NW	WN	N	2
1965	CW	CN	CN	NN	La	2
1969	CD	NN	NW	WN	El	2
1970	NN	CN	CN	NN	El	2
1973	CN	CN	CN	CN	El	2
1977	WD	WD	NN	NN	El	1
1983	WN	WW	NN	NN	El	1
1984	NN	NW	NW	CW	La	1
1989	NN	ND	WD	WD	La	1
1990	WW	WN	WN	WN	N	1
1991	NW	CN	NW	NN	N	1
1993	WN	WD	WN	WD	N	1
1994	WN	NN	WD	WN	N	1
1997	WN	---	WW	NN	N	1
2004	WD	WD	WD	WD	N	2
1993	NN	NN	NW	NN	N	1
2003	WN	WD	NN	WN	El	2
2005	NN	NN	NW	NN	El	2

Table 3. Continued from previous page.

Fig. 7a.

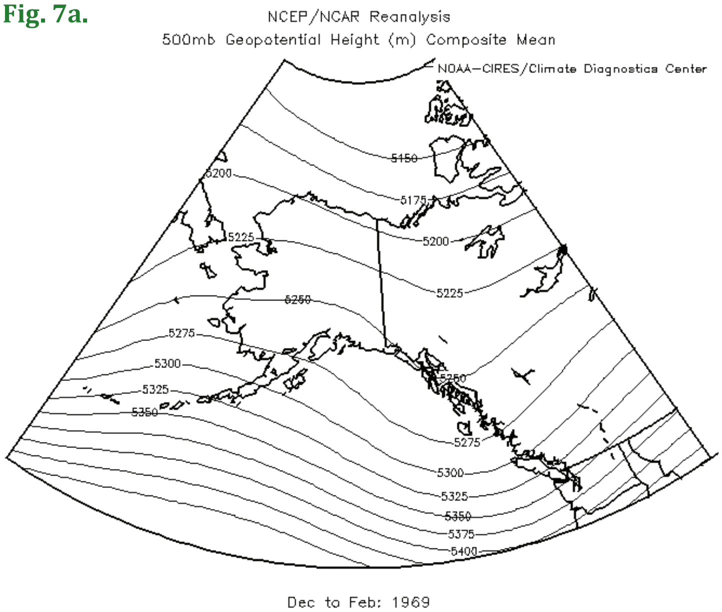

Fig. 7b.

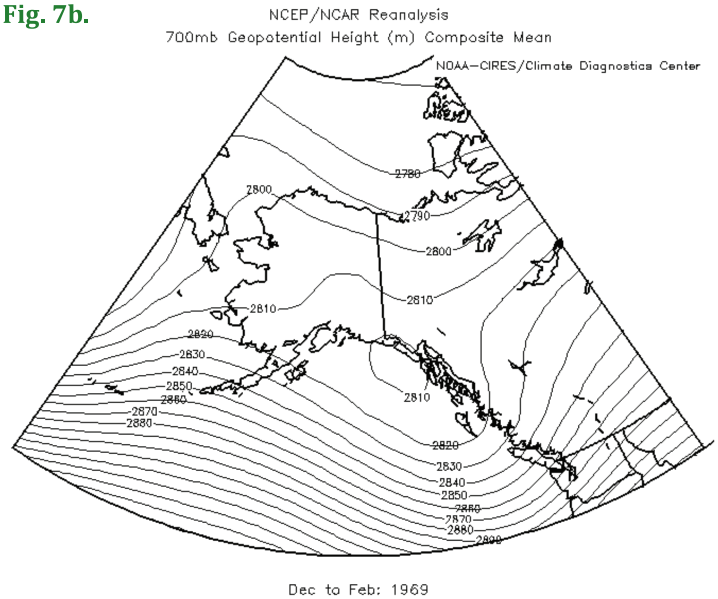

Fig. 7. Geopotential height composites for winter 1969 (Cold and Dry), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Winter	*Yakutat*	*Sitka*	*Juneau*	*Annette*	*ENSO*	*PDO Phase*
1950	CD	CD	CD	CD	La	2
1954	NN	NN	NN	NN	N	2
1955	NW	NW	NW	NW	La	2
1956	CN	CD	CD	CD	La	2
1957	ND	ND	ND	CD	La	2
1958	NN	NN	NN	WW	El	2
1964	NW	NW	WW	NW	El	2
1965	CN	CN	CN	CN	La	2
1966	CN	NN	CD	CN	El	2
1967	CN	NN	NW	NW	N	2
1969	CD	CD	CD	CD	El	2
1970	NN	WD	NN	NN	El	2
1972	CN	CN	CN	CN	La	2
1973	NN	ND	CN	NN	El	2
1976	NN	NN	NN	NW	La	2
1977	WW	WW	WW	WN	El	1
1978	ND	ND	ND	ND	El	1
1982	ND	CN	CD	NN	N	1
1983	WW	WN	NN	WW	El	1
1987	WW	WW	WN	WN	El	1
1992	WW	WW	WW	WW	El	1
1996	ND	NN	NN	NN	La	1
1998	WN	---	WN	WW	El	1

Table 4. Classifications for winter and summer cases based on days of measurable precipitation

into southern British Columbia, suggesting the presence of a blocking pattern. Blocking in the Alaska sector tends to divert the storm track away from the study region as high pressure generally is established over Alaska or the Yukon forming the familiar "Omega" or "dipole" configuration. For a more thorough description of blocking, see Wiedenmann et al. (2002) and references therein.

b) Cold and wet

No location experienced this pattern for days of measurable precipitation, so this condition applied only to the total amount of precipitation. Figure 8 shows a strong blocking ridge along the western coastline of Alaska over the Bering Sea which reached far into the Arctic Ocean. A strong positively-tilted trough extended from the Yukon into interior Alaska, with a tight gradient over the Gulf of Alaska. Cold air was pumped into southeast Alaska and mixed with maritime systems which moved through southern portions of the Alaskan panhandle.

c) Warm and dry

Sitka was the only location that met criteria defined for this condition. Figure 9 shows a large negatively-tilted trough centered over the Aleutian Islands with tight height gradients over the Gulf of Alaska in a southwest-to-northeast orientation. A very strong ridge extends from western Canada into the Arctic Ocean. With the ridge axis closer to the Alaskan panhandle, diffluent flow was present aloft helping to weaken the cool and moist southwesterly maritime flow.

d) Warm and wet

In general, a negatively-tilted trough was positioned offshore from southwestern Alaska into the western Gulf of Alaska and ridging stretched

Summer	Yakutat	Sitka	Juneau	Annette	ENSO	PDO Phase
1952	NN	ND	NN	CD	N	2
1953	ND	WD	NN	NN	N	2
1955	CN	CN	CW	CN	La	2
1956	NN	NW	CN	CW	La	2
1957	WD	ND	ND	NN	La	2
1960	NN	CW	CN	NN	N	2
1965	CN	CN	CD	ND	La	2
1968	NN	ND	ND	NN	La	2
1970	NW	CW	CW	NN	El	2
1973	CW	CW	CW	CW	El	2
1983	WW	WW	NN	NW	El	1
1984	NN	NN	NW	CW	La	1
1988	NW	NN	NW	NW	El	1
1989	ND	ND	WN	WD	La	1
1990	WN	WD	WD	WN	N	1
1993	WD	WD	WD	WD	N	1
1994	WD	NN	WN	WN	N	1
1997	WD	---	WW	NW	N	1
1999	NN	CN	NN	CW	La	1
2000	NW	NW	NW	NW	La	2
2004	WD	WD	WD	WN	N	2
2005	WN	WN	NN	NN	El	2

Table 4. Continued from previous page.

past the Beaufort Sea into the Arctic Ocean as shown in Fig. 10. The steering flow between this trough and ridge was from the southwest, bringing numerous maritime systems through southeast Alaska. This maritime air mass kept the southeast warmer and wetter.

Composites in Fig. 9 were warm and dry, while those in Fig. 10 were warm and wet. The factor that could account for this difference is that in Fig. 9 the upper-level low to the west is further south (over the Aleutians) for the warm/dry case, and further north (over Seward Peninsula) for the warm wet case. Both have the warm southwest flow over the panhandle, but in the dry case, because of the more southerly low position, the jet would also be more to the south and systems would be in their weakening phase by the time they reached the panhandle.

Fig. 8a.

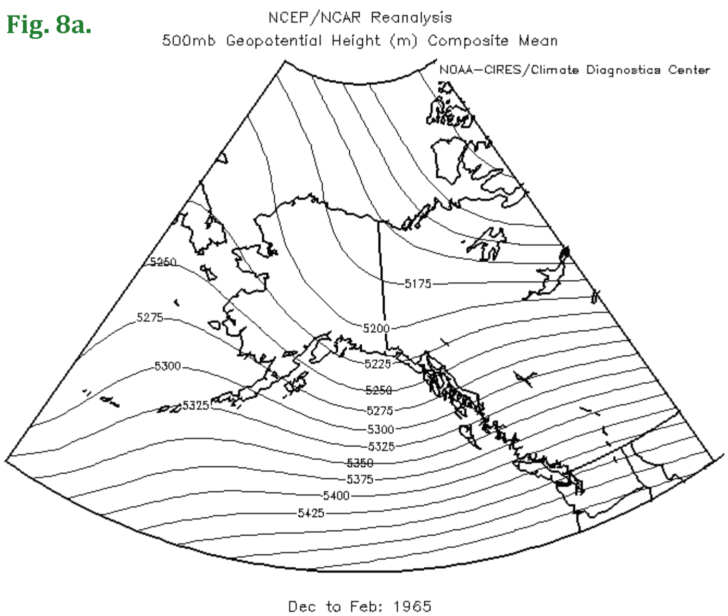

Fig. 8b.

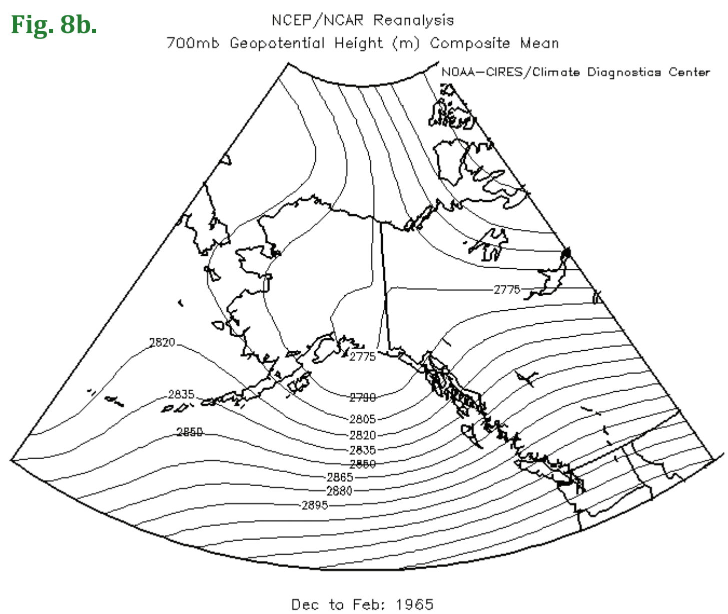

Fig. 8. Geopotential height composites for winter 1965 (Cold and Wet), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Fig. 9a.

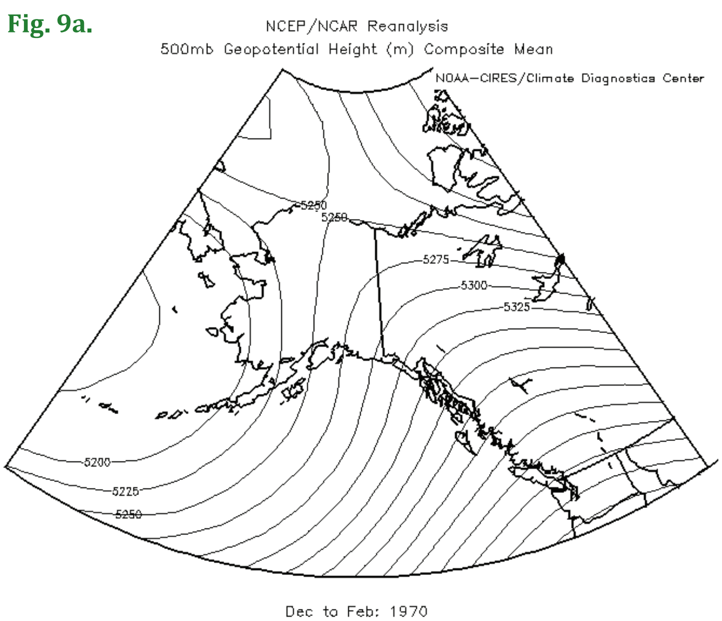

Fig. 9b.

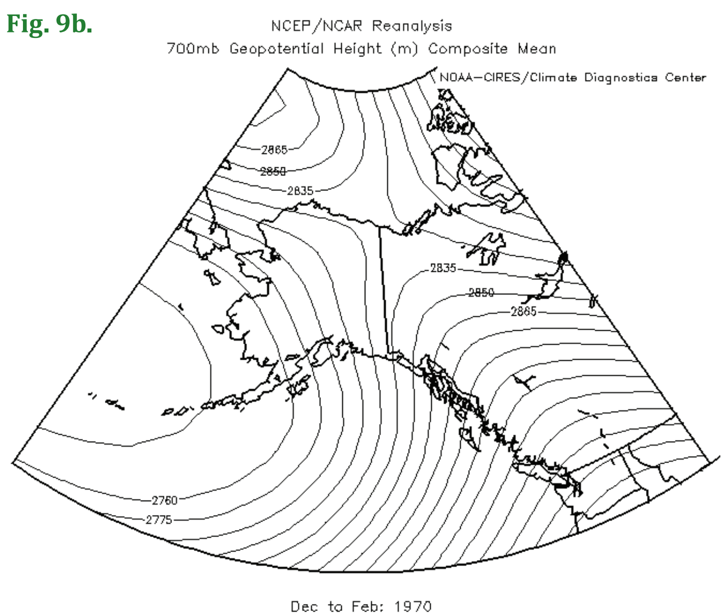

Fig. 9. Geopotential height composites for winter 1970 (Warm and Dry), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

2) Summer patterns

a) Cold and dry

Figure 11 shows a positively-tilted trough over the Bering Sea with another weak trough positioned near the southern British Columbia and Washington coastline. A moderate ridge extended from western Canada into the interior of Alaska to the Arctic Ocean. Strong southwesterly flow aloft became diffluent near northern and central portions of southeast Alaska. Cold but modified southwesterly flow aloft became diffluent and slowed as it encountered the ridge where it then came onshore over the southern Alaskan panhandle. Juneau experienced similar conditions (Fig. 12), when the trough extended from the Bering Sea into the northern Pacific Ocean. The ridge only reached the interior of Alaska. Nearly zonal flow over the Gulf of Alaska curved north, directing storms into the central section of southeast Alaska.

Fig. 10a.

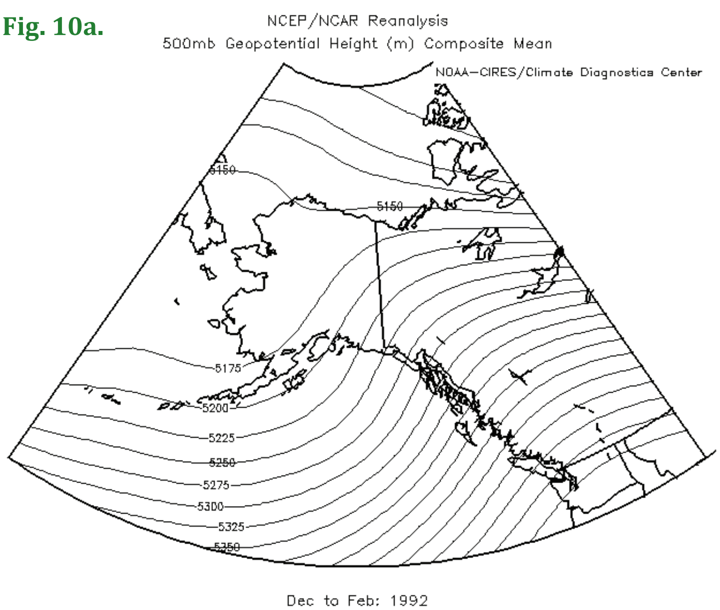

Fig. 10b.

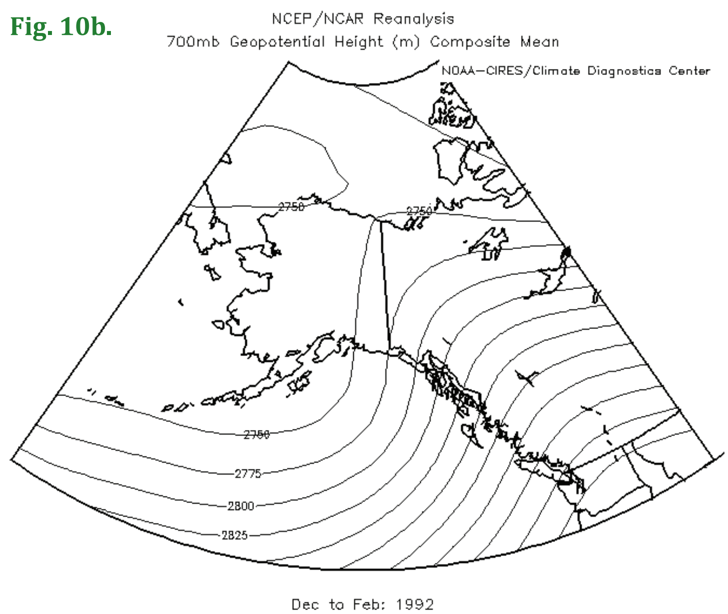

Fig. 10. Geopotential height composites for winter 1992 (Warm and Wet), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Fig. 11a.

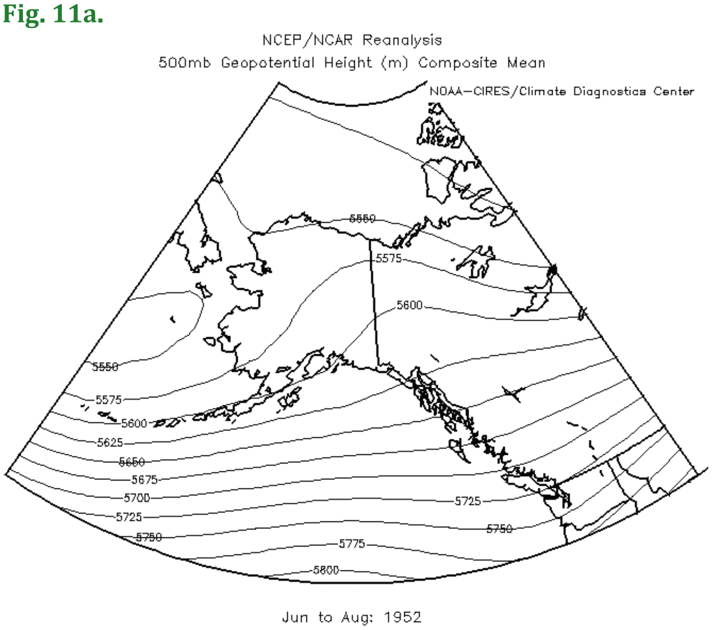

Fig. 11b.

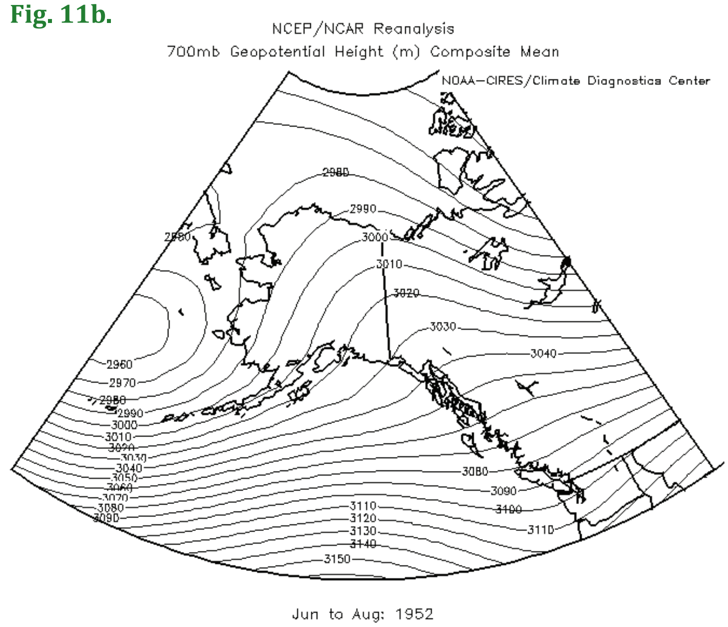

Fig. 11. Geopotential height composites for summer 1952 (Cold and Dry), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

b) Cold and wet

Figure 13 generally shows that the cold and wet conditions were triggered by a negatively-tilted trough in the Gulf of Alaska. Cold air from the Bering Sea mixed with maritime flow over the Pacific Ocean. This modified air mass followed the nearly zonal storm track before moving inland and bringing with it, moist surface systems. The flow became southwesterly over the eastern Gulf of Alaska and into northwest Canada. The ridge over western Canada was very weak and had little effect over the flow that approached the Alaskan panhandle. As a result, numerous maritime low pressure systems tracked into the study region bringing relatively cold and wet conditions.

c) Warm and dry

The flow pattern shown in Fig. 14 resulted in warm and dry conditions. A negatively-tilted trough extended from the Bering Sea into the

Fig. 12a.

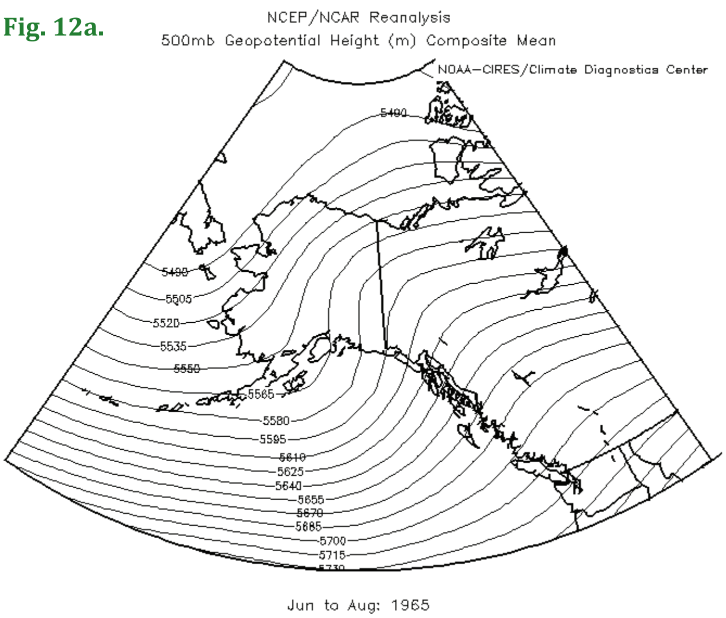

Fig. 12b.

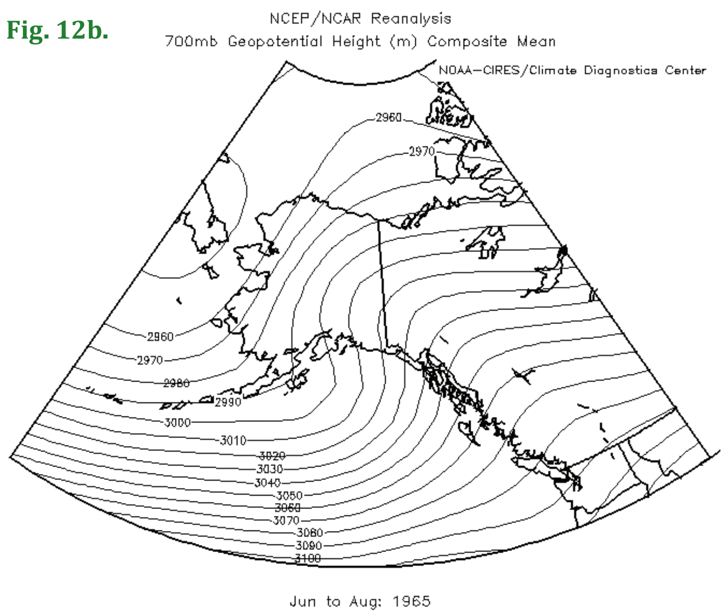

Fig. 12. Geopotential height composites for summer 1965 (Cold and Dry), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Fig. 13a.

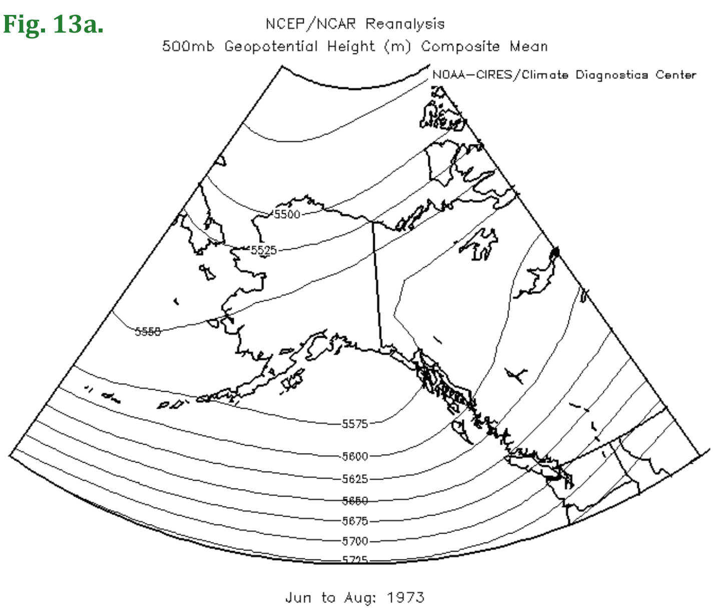

Fig. 13b.

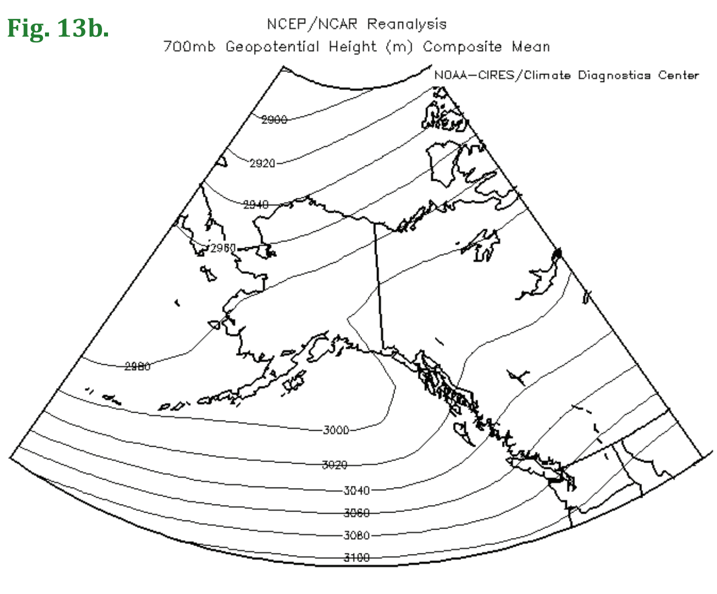

Fig. 13. Geopotential height composites for summer 1973 (Cold and Wet), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Pacific Ocean. Northwest flow moving over the Gulf of Alaska near the base of the trough quickly weakened as it streamed toward the ridge-influenced southeast Alaska. In contrast to the weak ridge associated with cold and wet conditions, the flow pattern for this warm and dry case shows a prominent ridge over Alaska and western Canada. The ridge had a strong influence over the temperatures and weakened the majority of maritime systems that approached the Alaskan panhandle. Moreover, the persistent ridge diverted moisture away from the study area while high pressure led to subsidence across southeast Alaska.

d) Warm and wet

The pattern in Fig. 15 shows a negatively tilted trough centered near Kodiak Island, Alaska and a ridge aligned parallel to the coast over western Canada. With the trough extended into the

Fig. 14a.

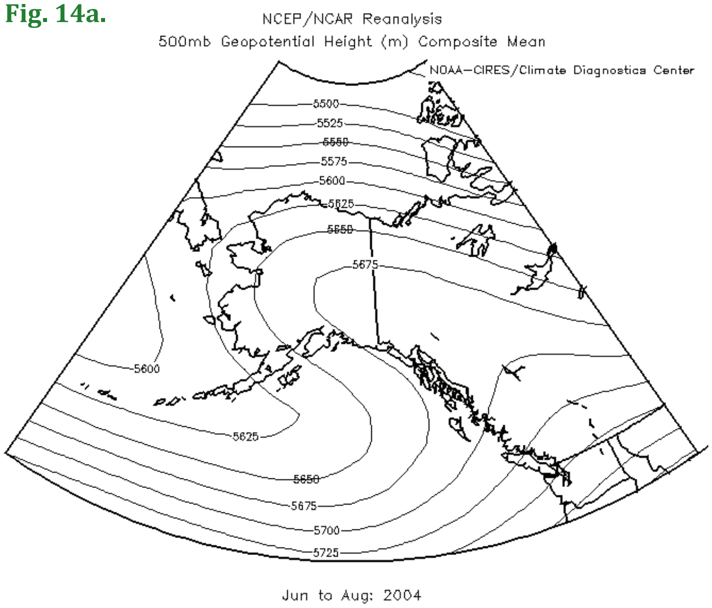

Fig. 14b.

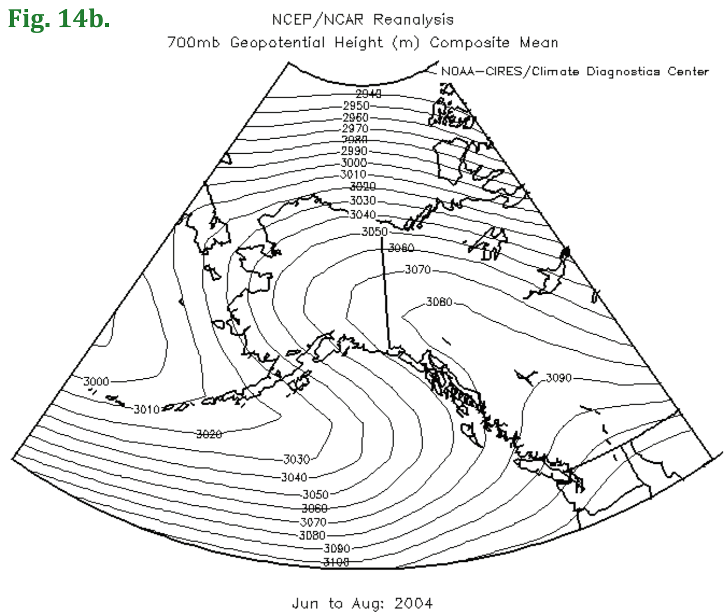

Fig. 14. Geopotential height composites for summer 2004 (Warm and Dry), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Fig. 15a.

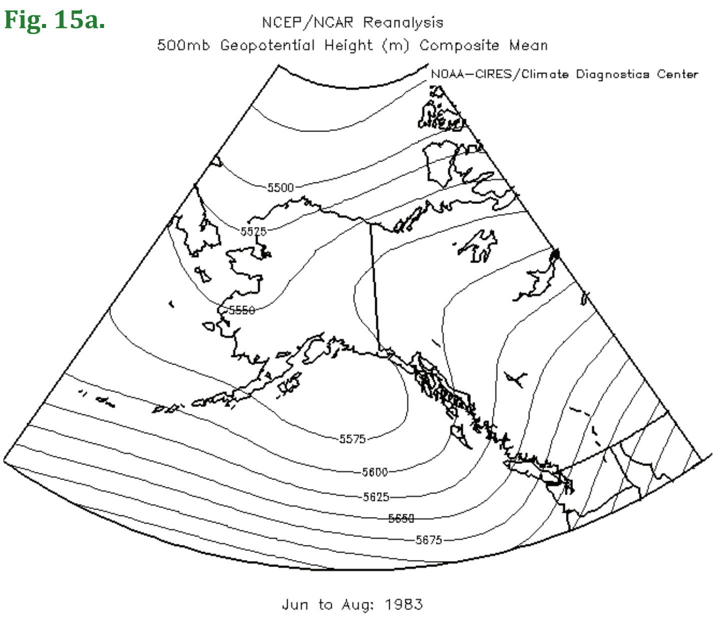

Fig. 15b.

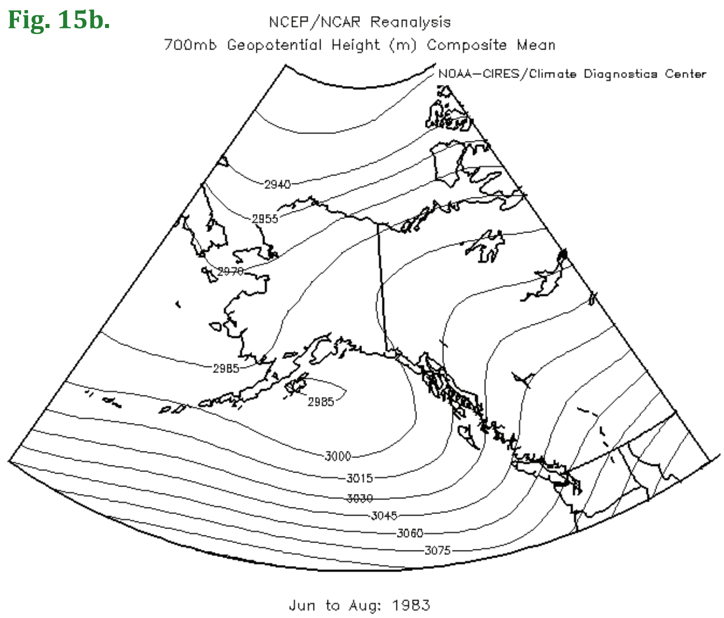

Fig. 15. Geopotential height composites for summer 1983 (Warm and Wet), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

Pacific Ocean, maritime systems moved along the northwest track and entered diffluent flow aloft near southeast Alaska. Western portions of the Alaskan panhandle had precipitation that was above the mean.

When considering total precipitation, a similar pattern arose. Figure 16 shows that the strong trough was shifted west and the closed low was near the Aleutian peninsula. The ridge was stronger as well and extended into the Arctic Ocean. Southwest, maritime flow was directed towards western and southern portions of the Alaskan panhandle.

3) Cold and warm phases of the Pacific Decadal Oscillation (PDO)

There are two phases that make up the PDO (Mantua 1999) the cold phase and the warm phase. The warm phase (also known as PDO 1) consisted of the years 1977-1998 when El Niño events were more frequent, stronger and more persistent. During this period, there were six El Niño events and five La Niña events. The cold phases (also known as PDO 2) occurred during 1947-1976 and from 1999 to present. These phases experienced nine longer and stronger La Niña events as well as nine weaker El Niño events (Gershunov and Barnett 1998).

ENSO is an oscillation of SSTs across the equatorial Pacific. It is an inter-annual and inter-decadal oscillation that dominates near the tropics and occurs every 3-7 years (Lupo et al. 2006). These oceanic temperature oscillations affect height patterns, which in turn, affect temperature and precipitation for a given region. During the PDO 2, cold and dry conditions were more prevalent during the winter season while cold and wet conditions were more frequent during the summer. La Niña events were stronger and more frequent. PDO 1 had more persistent and intense El Niño events (Gershunov and Barnett 1998). During PDO 1 periods, warm and wet patterns were recurrent for winters, but summers had many warm and dry years. Blocking patterns did play a role in some of the composites, which resulted in altered precipitation and temperatures in portions of southeast Alaska (Wiedenmann et al. 2002).

4. Conclusions and Future Research

This paper has presented a synoptic climatology of seasonal temperatures, precipitation, and measurable precipitation days for southeast Alaska. After determining the correlation between temperature and precipitation at four stations in southeast Alaska, the average temperature and precipitation for each station was determined for each season. Seasons that featured temperature and precipitation more than one standard deviation from the average were then selected as case studies for further review and classified based upon their temperature and precipitation anomalies. Seasonal mean heights at 500-mb and 700-mb were then examined for each of these case studies.

Fig. 16a.

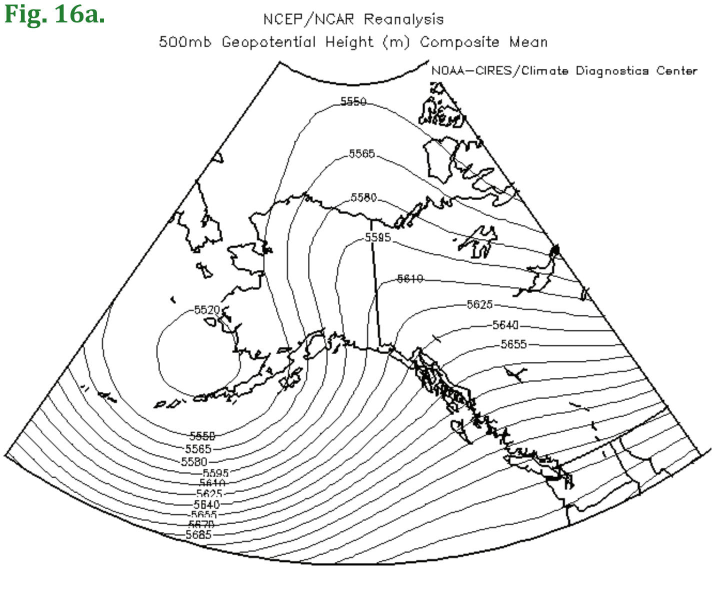

Fig. 16b.

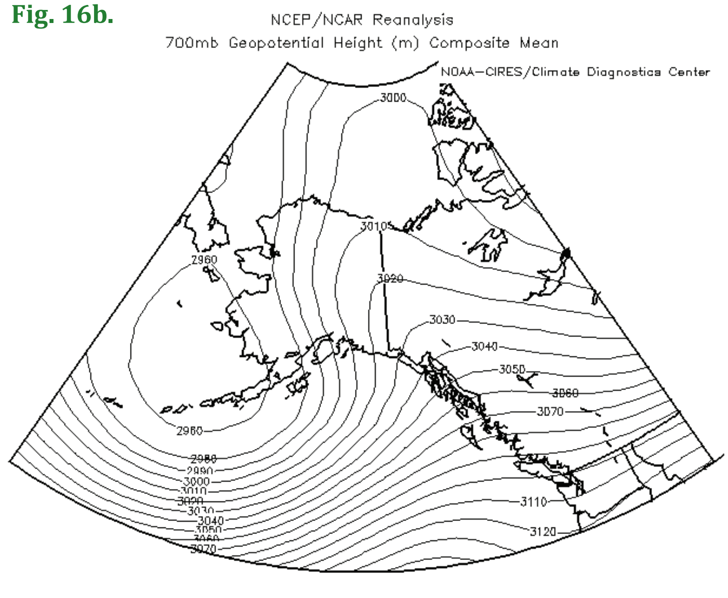

Fig. 16. Geopotential height composites for summer 1958 (Warm and Wet), where a) is the 500-mb heights (m) and b) is the 700-mb heights (m).

A significant positive relationship in the winter season between temperature and precipitation was demonstrated. Warmer winters tended to be wetter, and colder winters tended to be drier. The upper-level composites showed that warm and wet winters were driven by a dominance of onshore maritime flow aloft.

The summer season had a negative relationship between temperature and precipitation. Warmer summers tended to be dry which is typically caused by ridging or diffluent flow aloft that diminishes cloud cover and increases solar heating. "Total precipitation" did not correlate as well as "days of measurable precipitation", most likely because the former could be affected by a few heavy precipitation events.

The two predominant conditions that took place during the winter season were: (1) warm and wet, and (2) cold and dry. The majority of the cold and dry seasons occurred during La Niña events in the PDO 2 (cold) phase. The associated upper level flow patterns had the ridge near the western coastline of Alaska and the trough over the eastern Gulf of Alaska into the southeast portion of the study area. The PDO 1 (warm) phase was associated with El Niño events, all of which had warm and wet conditions. These patterns had the ridge over western Canada and the trough over the western Gulf of Alaska. The two major patterns for the summer months were: (1) cold and wet, and (2) warm and dry. Cold and wet patterns had the upper level trough centered in the Gulf of Alaska with a weaker ridge over western Canada. These conditions mostly occurred during the La Niña events of PDO phase 2. Warm and dry conditions were more frequent in the neutral years of PDO 1. These patterns had a strong upper level ridge over the western Canada and Alaskan border and a strong trough in the northern Pacific Ocean. The results found from this study provide supplementary guidance to the NCEP long-range forecasts, specifically, the three month outlook for temperature and precipitation issued by the Climate Prediction Center (2006). They also provide guidance for new forecasters in southeast Alaska who may not be familiar with this region.

A possibility for future research is to produce additional composites of moisture that may provide a better understanding of how flow direction impacts precipitation. A layer of relative humidity from 700-mb to 500-mb would be the best for composites, since values below 700-mb would be affected by terrain.

Through feedback mechanisms, changes in the tropical SSTs trigger pressure heights to fluctuate and therefore generate fronts. Compiling SST composites for the selected years could help to locate warm anomalies. Height patterns can then be compared to SST composites to determine if there is a direct relation this far north. If so, then early recognition of these anomalies may lead a forecaster to expect similar patterns that have previously occurred. One might consider other influences such as the Arctic and North Atlantic Oscillations (AO, NAO) (Mitchell 2000 and Hurrell 1995) as well as Pacific North American Pattern (PNA) (Sheng 1999) that may influence temperatures or precipitation tendencies.

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