Towards Predicting the Impact of Climate Change on Tourism:

An Efficient Tourism Climate Index

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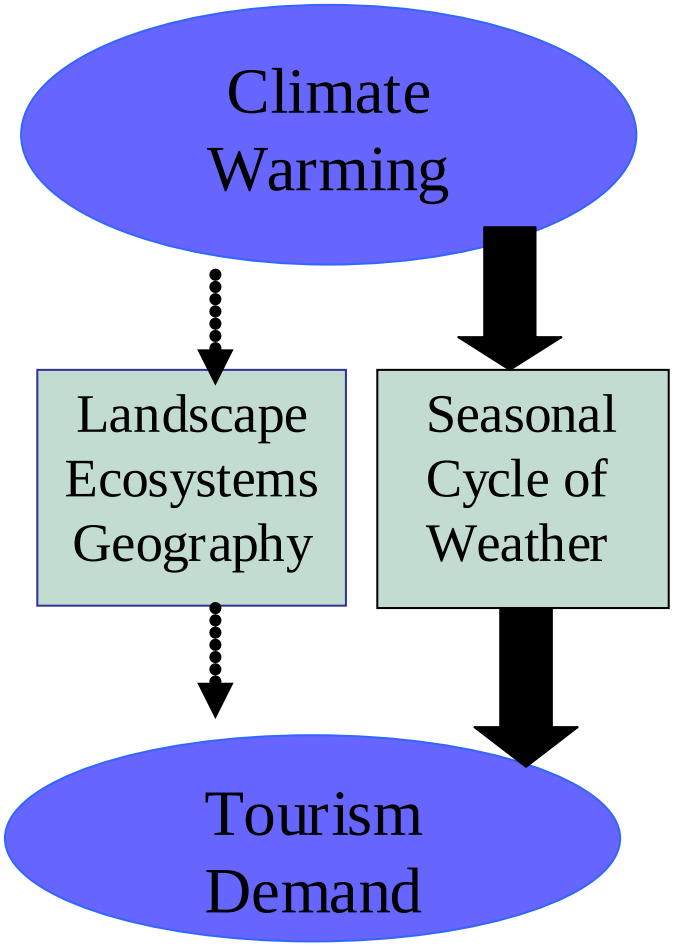
Climate Change and Tourism



BACKGROUND

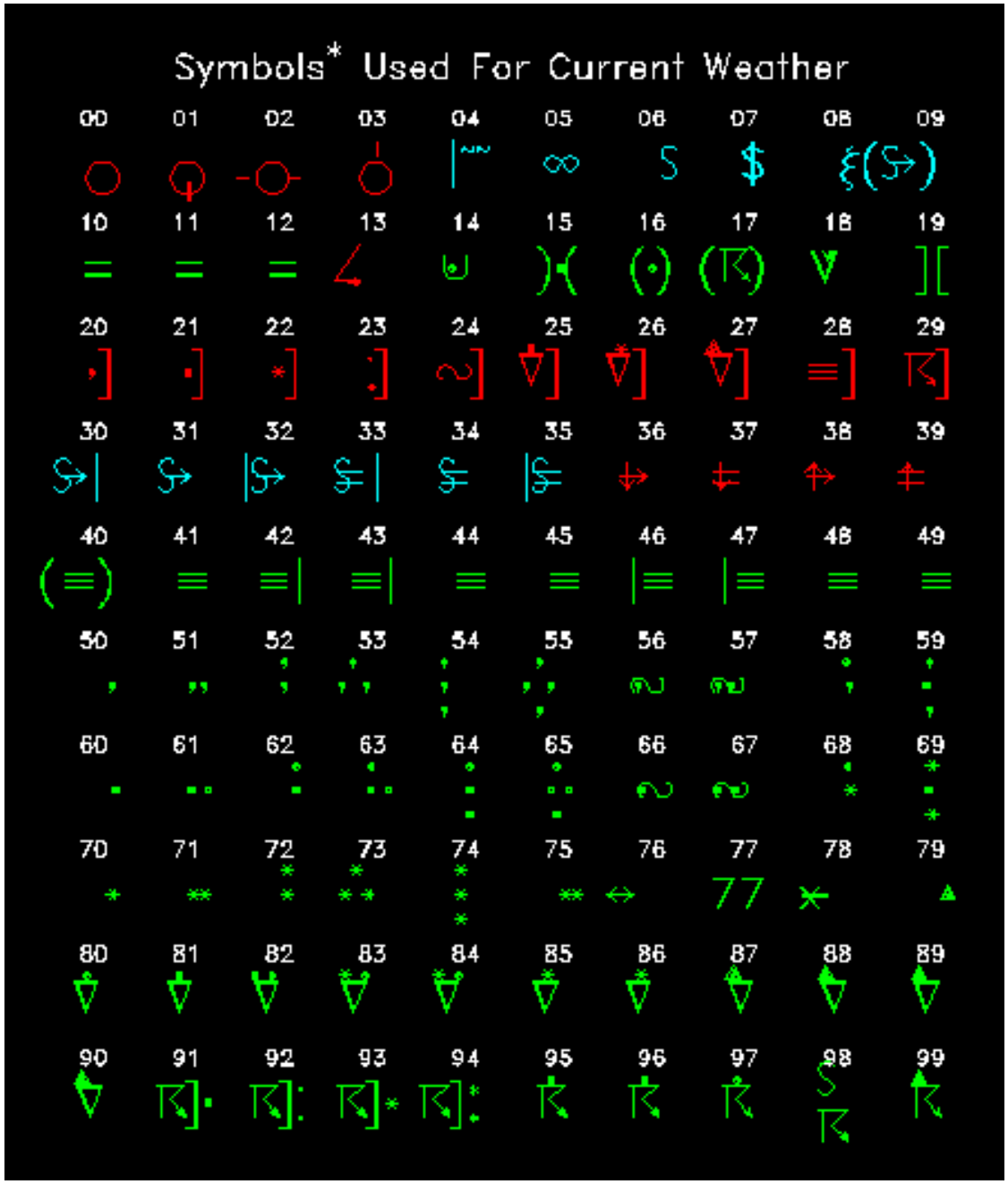
- **Tourism is affected by climate through the weather experienced by tourists**
- **Climatic averages obscure information about weather that matters to tourists**

- **Goal: Develop a tourism climate index that captures weather information relevant to specific tourist activities at a particular location**

BACKGROUND

Key weather variables, available from hourly archives of first-order weather reporting stations:

- **temperature**
- **humidity**
- **wind**
- **visibility**
- **significant “present weather”**
  (rain, snow, showers, thunder/lightning, blowing dust,…)



Symbols/codes for "Present Weather"

(from World Meteorological Organization)

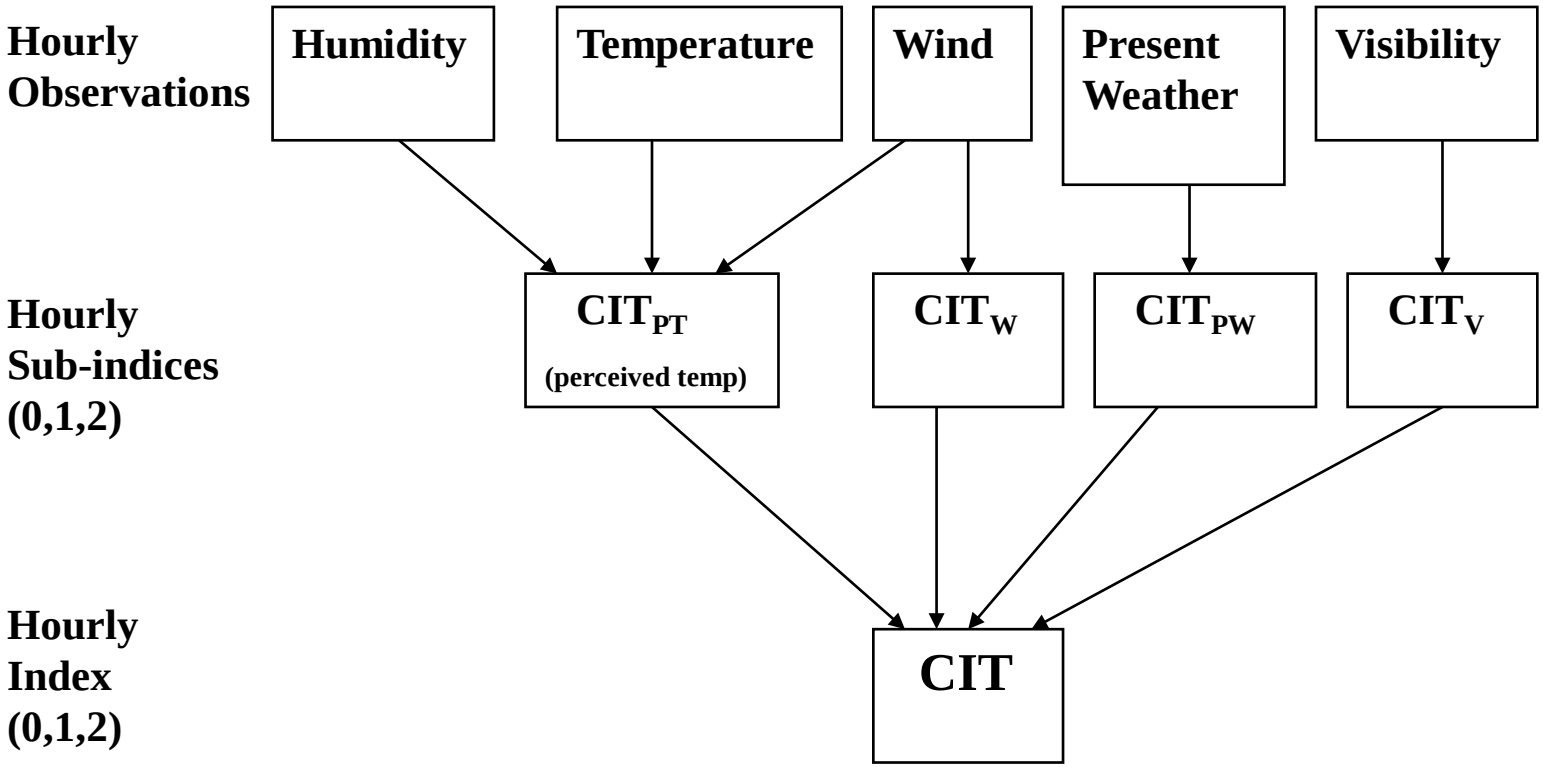
Climate Index for Tourism (CIT)

Perceived temperature (PT) –

summer: heat index (temperature, humidity)

winter: wind chill (temperature, wind)

Climate Index for Tourism (CIT)



Climate Index for Tourism (CIT)

- **Each subindex is assigned an hourly value:**

  2 = ideal for particular activity
  1 = marginally suitable for the activity
  0 = unsuitable for the activity

- **Hourly value of Climate Index for Tourism (CIT) is based on the four hourly subindices**

- **If all four subindices are 2, then CIT = 2**
  If any of the four subindices is 0, then CIT = 0
  Otherwise, CIT = 1

Climate Index for Tourism
Threshold table for outdoor sightseeing

	Perceived Temperature (CIT_{PT})	Wind (CIT_W)	Visibility (CIT_V)	Present Weather (CIT_{PW})
0	<20, or >95 (F)	>20 (mph)	<1 (km)	9,17,19,25,26,27,28,29,32,35,36,37,38,39,46,47, >51 and <100
1	≥20 and <40, or >85 and ≤95	≥13 and ≤20	≥1 and ≤4	6,7,8,15,16,18,20,21,22,23,24,30,31, 33,34,40,41,42,43,44,45,48,49,50,51
2	≥40 and ≤85	<13	>4	0, 1,2,3,4,5,6, 10,11,12,13,14

Climate Index for Tourism: Threshold table for skiing

	Perceived Temperature (CIT_{PT})	Wind (CIT_W)	Visibility (CIT_V)	Present Weather (CIT_{PW})
0	<-20 or >40 (°F)	>20 (mph)	<1 (km)	Same as outdoor sightseeing, except for 70, 71, 85-89
1	≥20 and <0, or >32 and ≤40	≥13 and ≤20	≥1 and ≤4	6,7,8,15,16,18,20,21,22,23,24,30,31, 33,34,40,41,42,43,44,45,48,49,50,51, 70, 71, 85-89
2	≥0 and ≤32	<13	>4	0, 1,2,3,4,5,6, 10,11,12,13,14

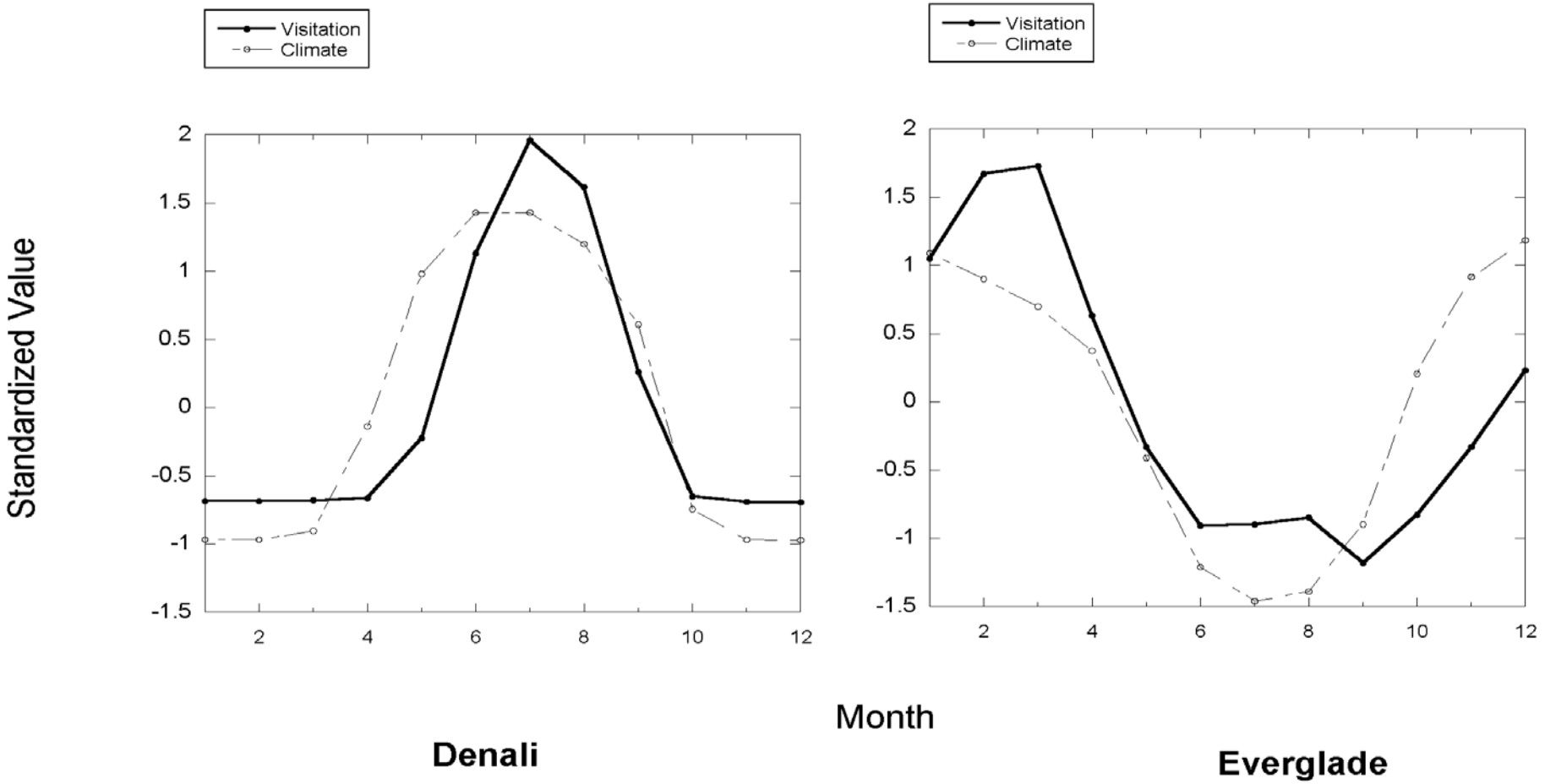
Climate Index for Tourism (CIT)

- **Sites used for prototype examples of index:**

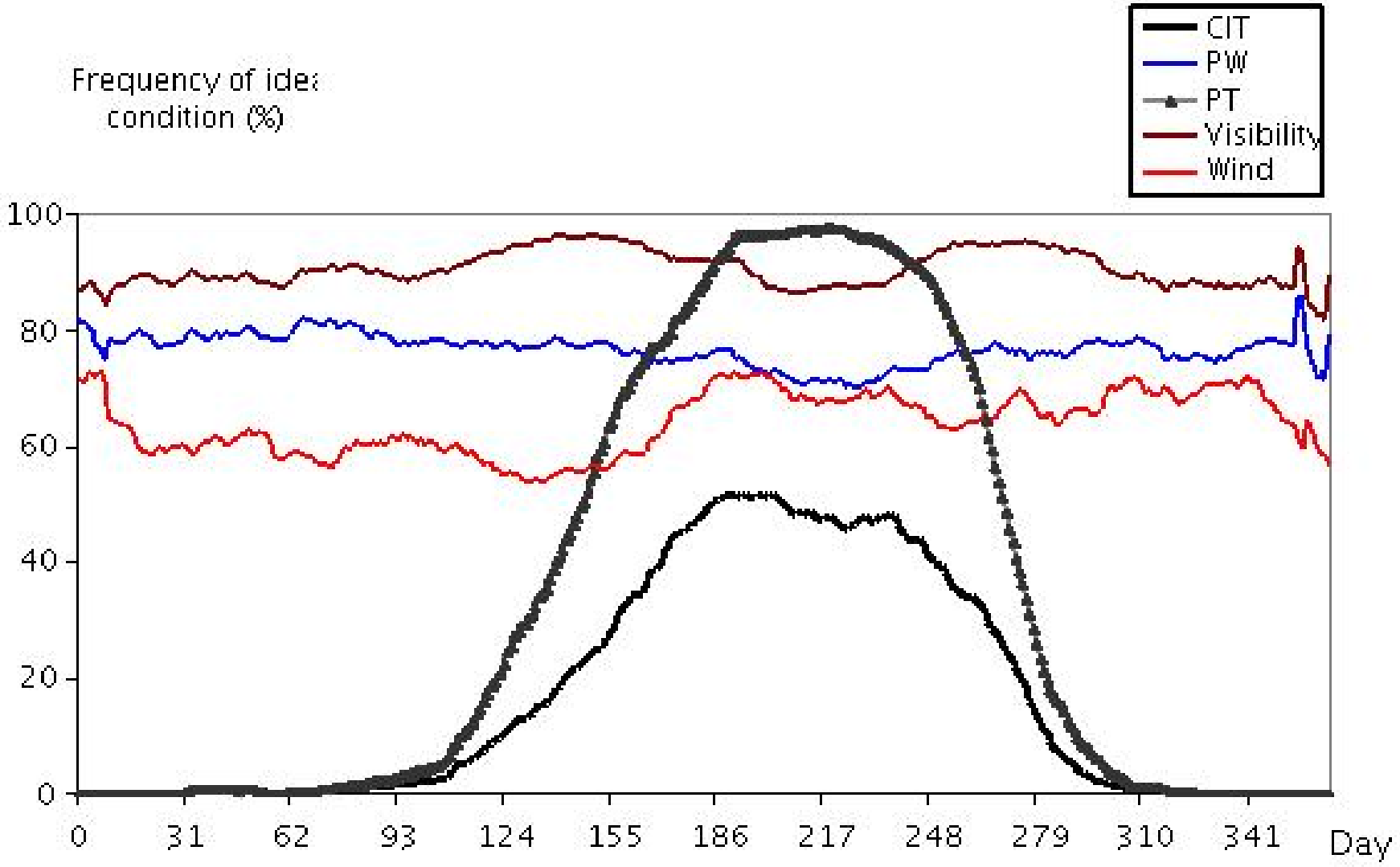
  -- **Alaska: King Salmon and Anchorage**

  -- **Florida: Orlando and Everglades**

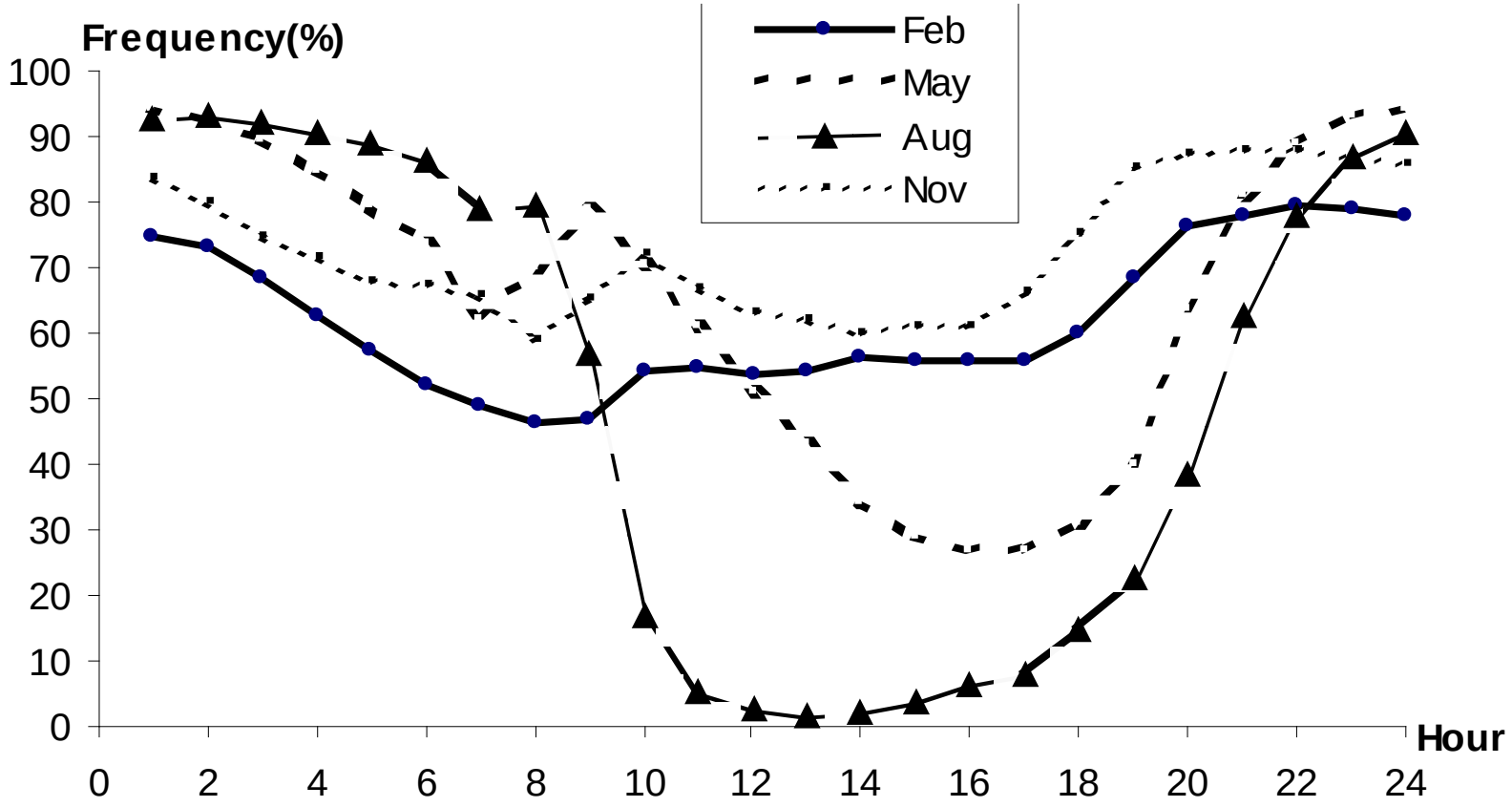
Seasonal Patterns: Monthly CIT vs Visitations Denali and Everglades National Parks



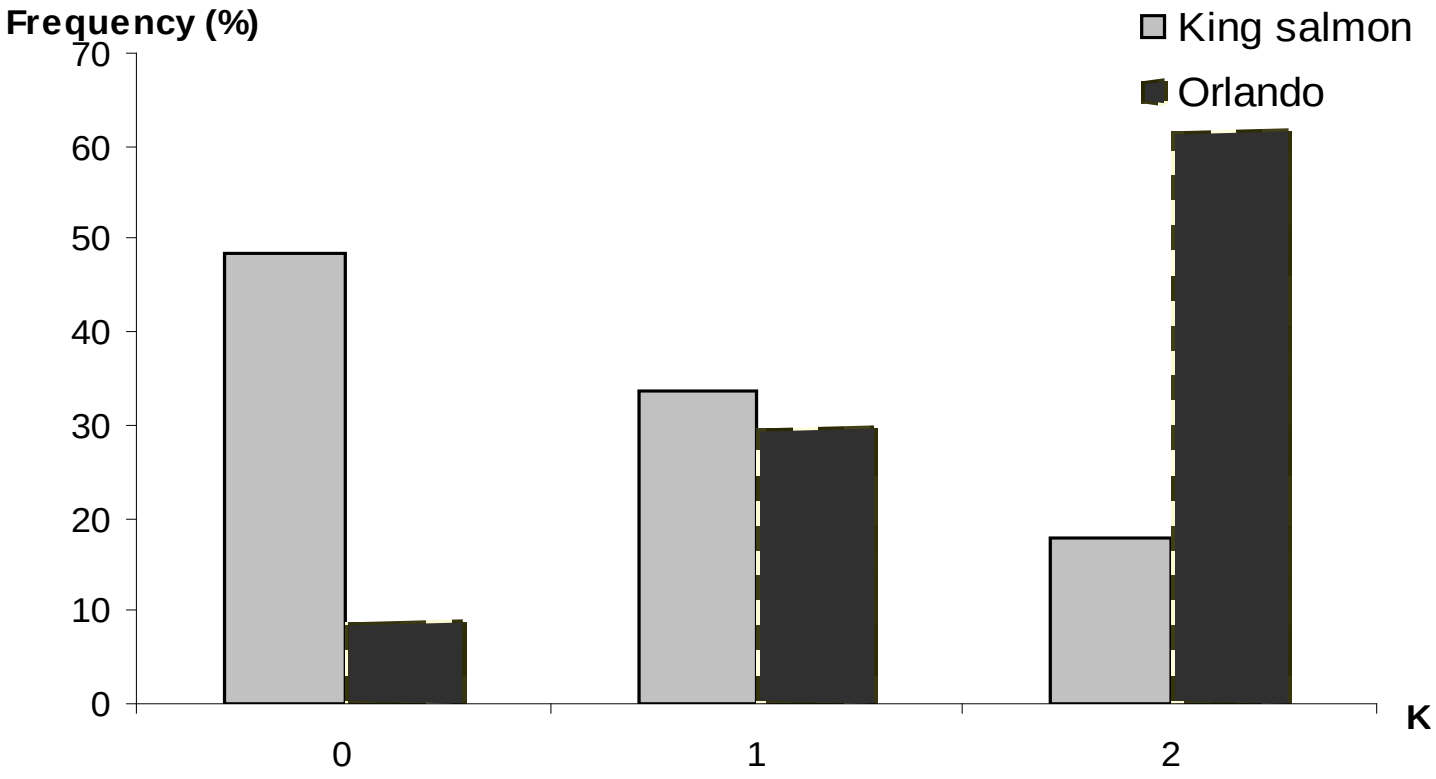
Contributions of different weather elements to overall CIT frequency of ideal sightseeing conditions (King Salmon)



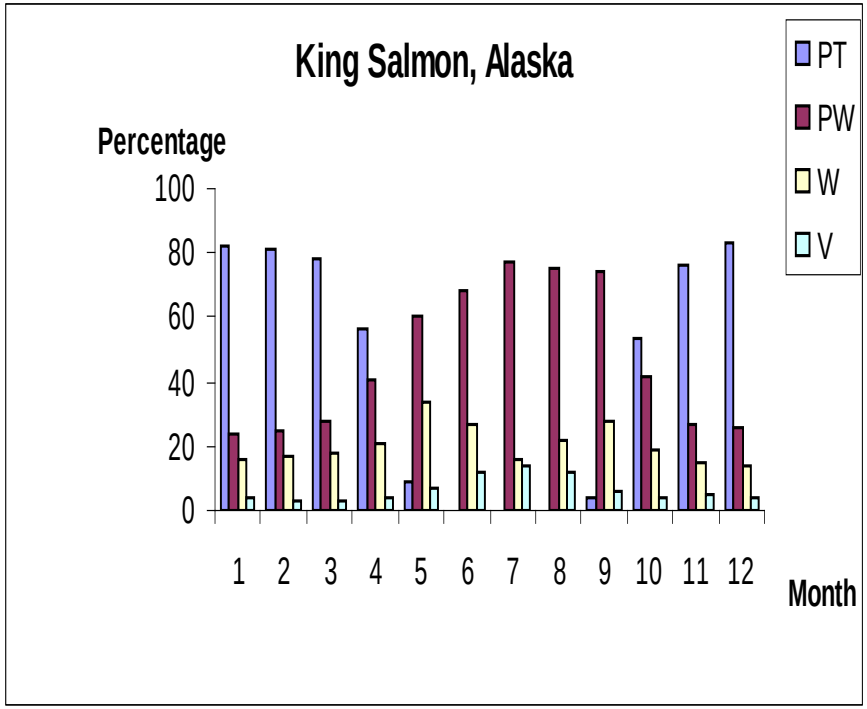
Diurnal cycle of Perceived Temperature subindex at Orlando

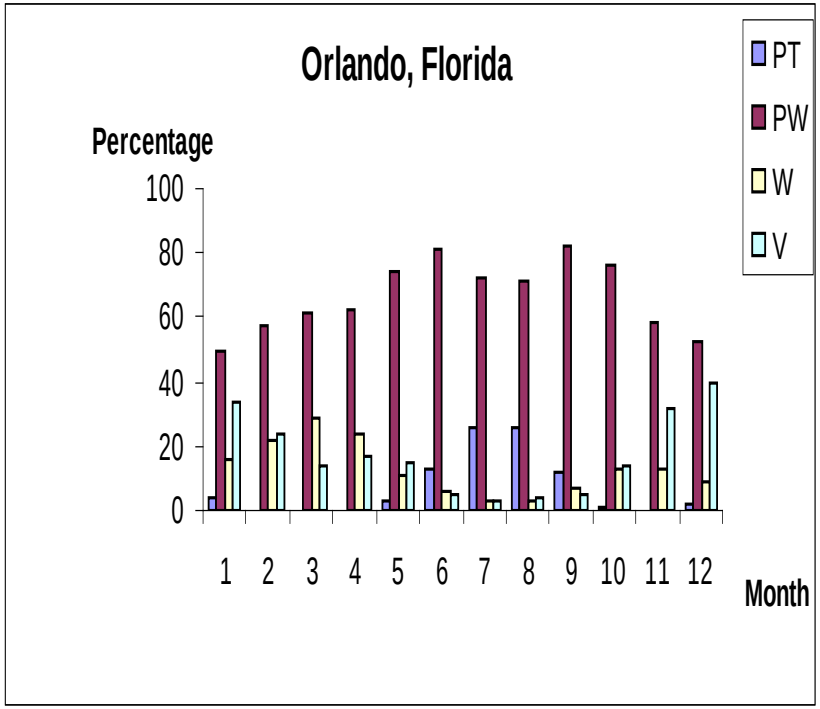


All-season Frequency Distribution of Perceived Temperature, CIT_{PT}



CIT contributions: % of unsuitable cases attributable to each subindex





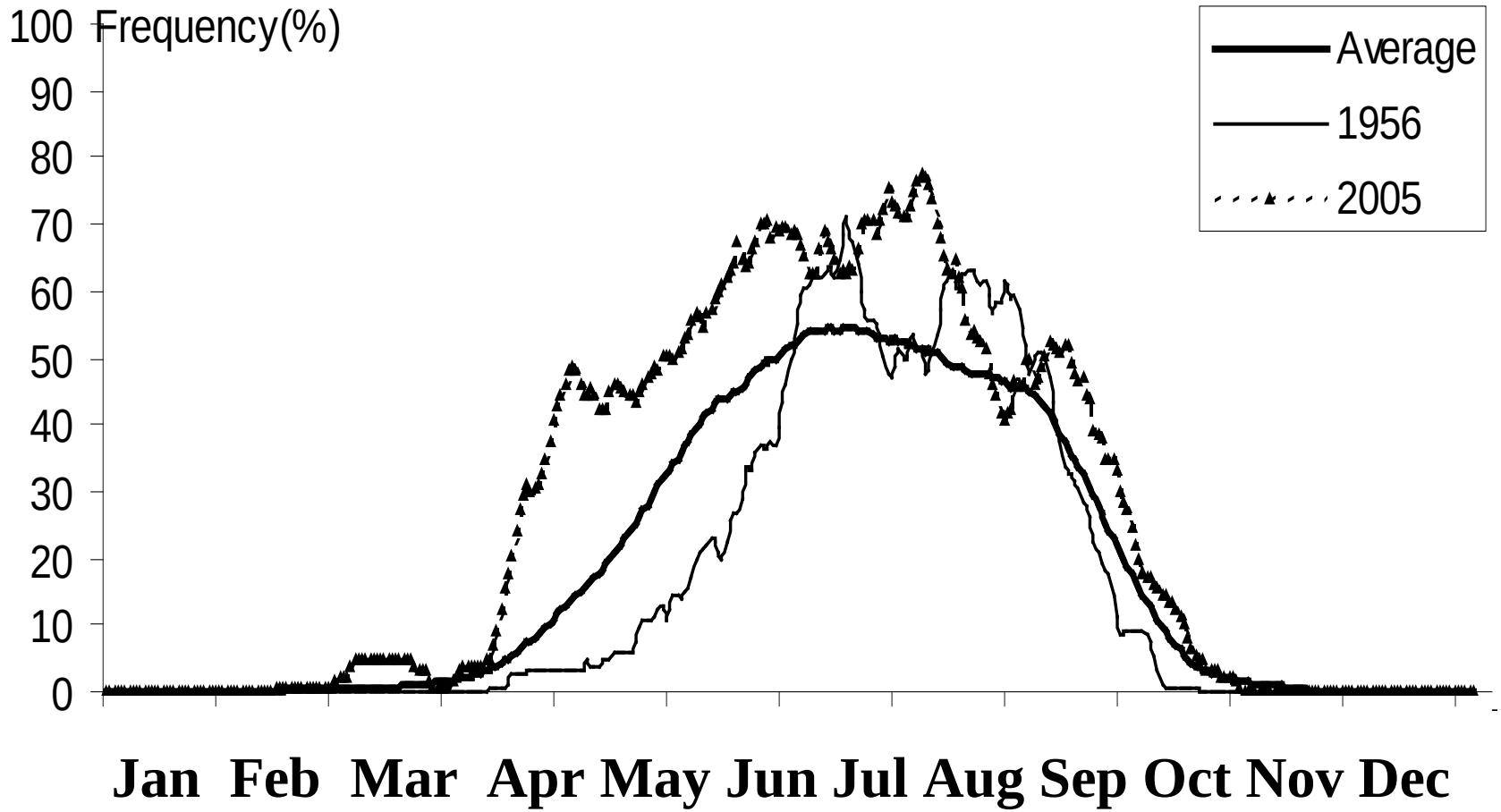
Hours of $CIT_{sub}(0)$ / Hours of CIT(0)

Changes of annual and seasonal temperatures in Alaska: 1949-2006

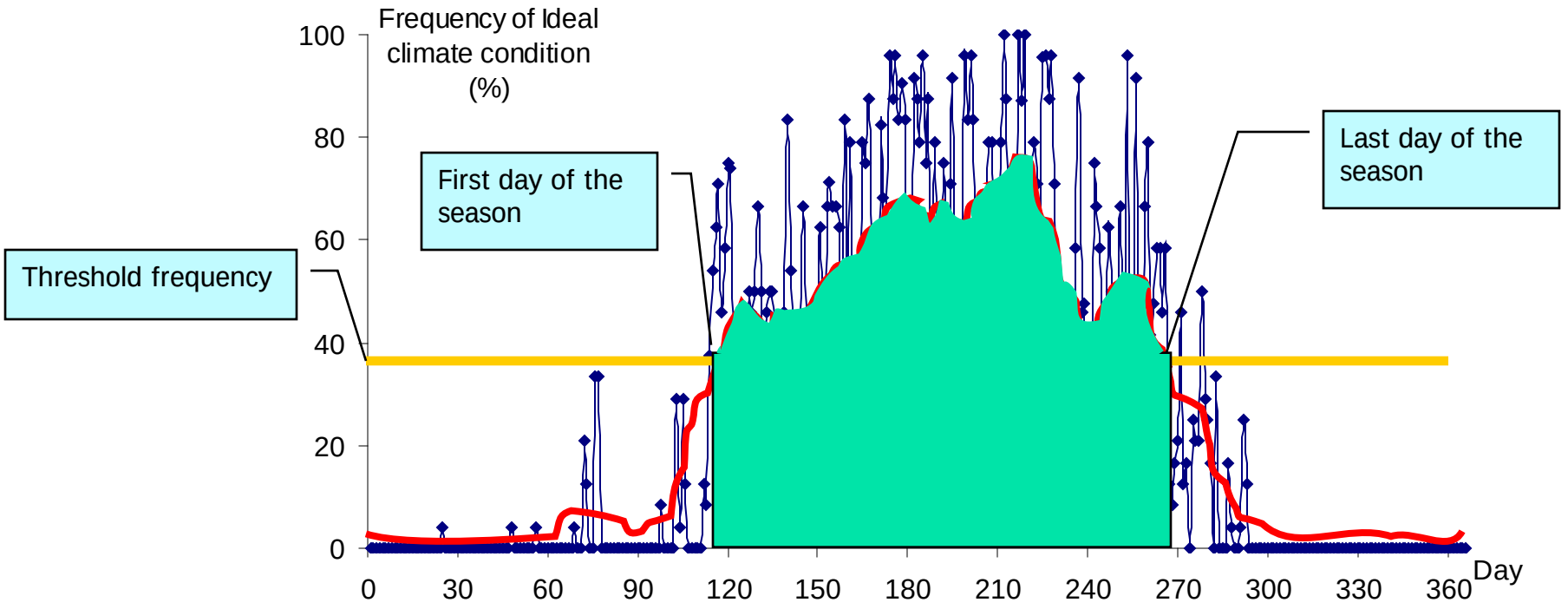
	Total change, °F (1949 - 2006)				
Location	Annual	Spring	Summer	Autumn	Winter
Arctic					
Barrow	3.8	4.2	2.5	2.1	6.1
Interior					
Bettles	4.0	4.8	1.8	0.9	8.5
Big Delta	3.7	3.9	1.3	0	9.7
Fairbanks	3.6	4.2	2.2	-0.2	8.1
Gulkana	3.0	2.7	1.0	-0.3	8.3
McGrath	4.0	5.0	2.8	0.6	7.6
West Coast					
Bethel	3.7	5.3	2.4	0.3	6.9
Cold Bay	1.9	2.6	2.1	1.1	2.0
King Salmon	4.3	5.5	2.0	0.7	9.2
Kotzebue	3.2	2.1	2.4	1.4	6.8
Nome	3.0	4.0	2.5	0.7	4.9
St. Paul	2.3	3.3	3.2	1.5	1.5
Southcentral and Southeast					
Anchorage	3.4	4.1	2.0	1.0	7.2
Annette	2.4	2.9	1.9	0.3	4.1
Homer	4.3	4.6	3.7	1.8	7.0
Kodiak	1.5	3.1	2	-0.1	1.5
Juneau	3.6	3.5	2.4	1.4	6.8
Talkeetna	5.3	5.7	3.3	2.2	9.3
Yakutat	2.8	3.5	2.0	0.2	5.1
Average	*3.4*	*3.9*	*2.3*	*0.8*	*6.3*

Color code: *-1 - 0* *0 - 1* *1 - 3* *3 - 5* *5 - 7* *7 - 9* *> 9*

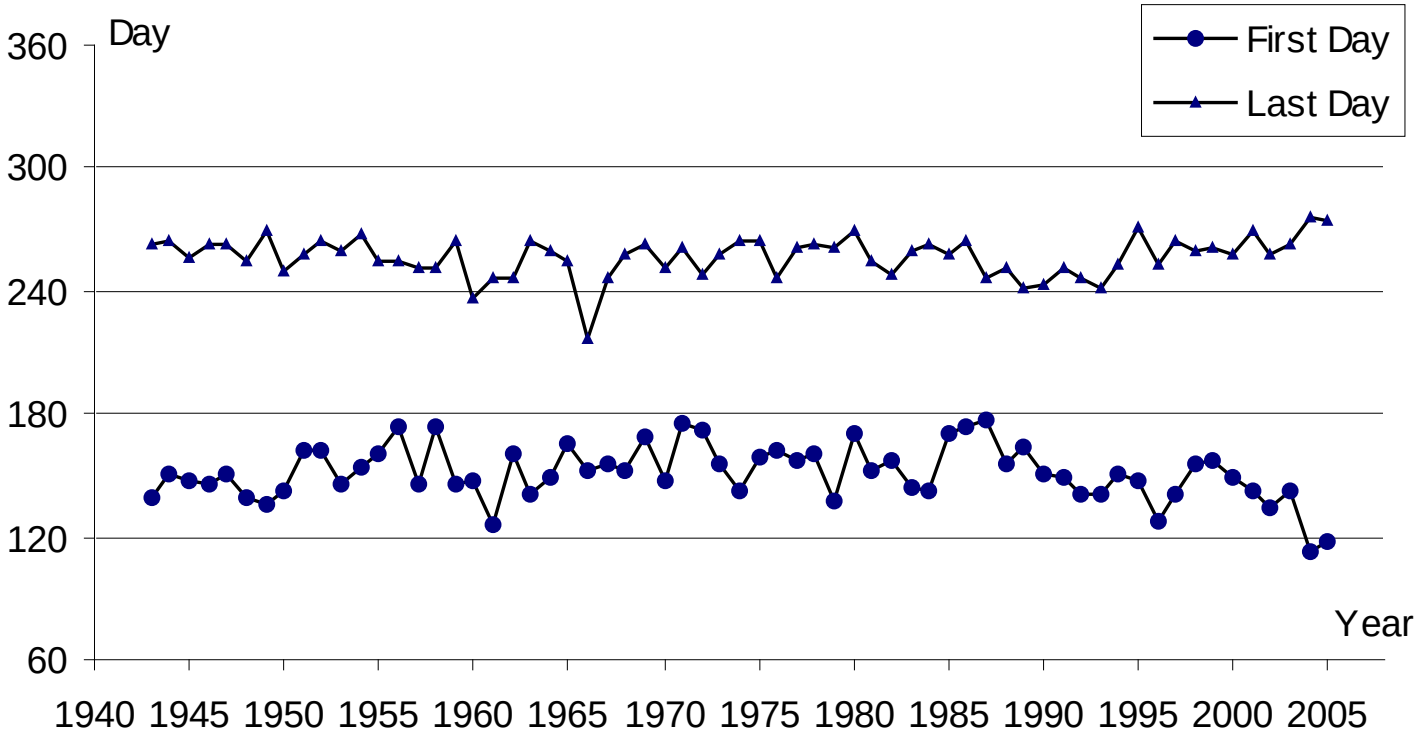
Frequency of ideal conditions: 1956, 2005 and mean (King Salmon sightseeing)



Can use CIT to quantify tourism climate season length at daily resolution

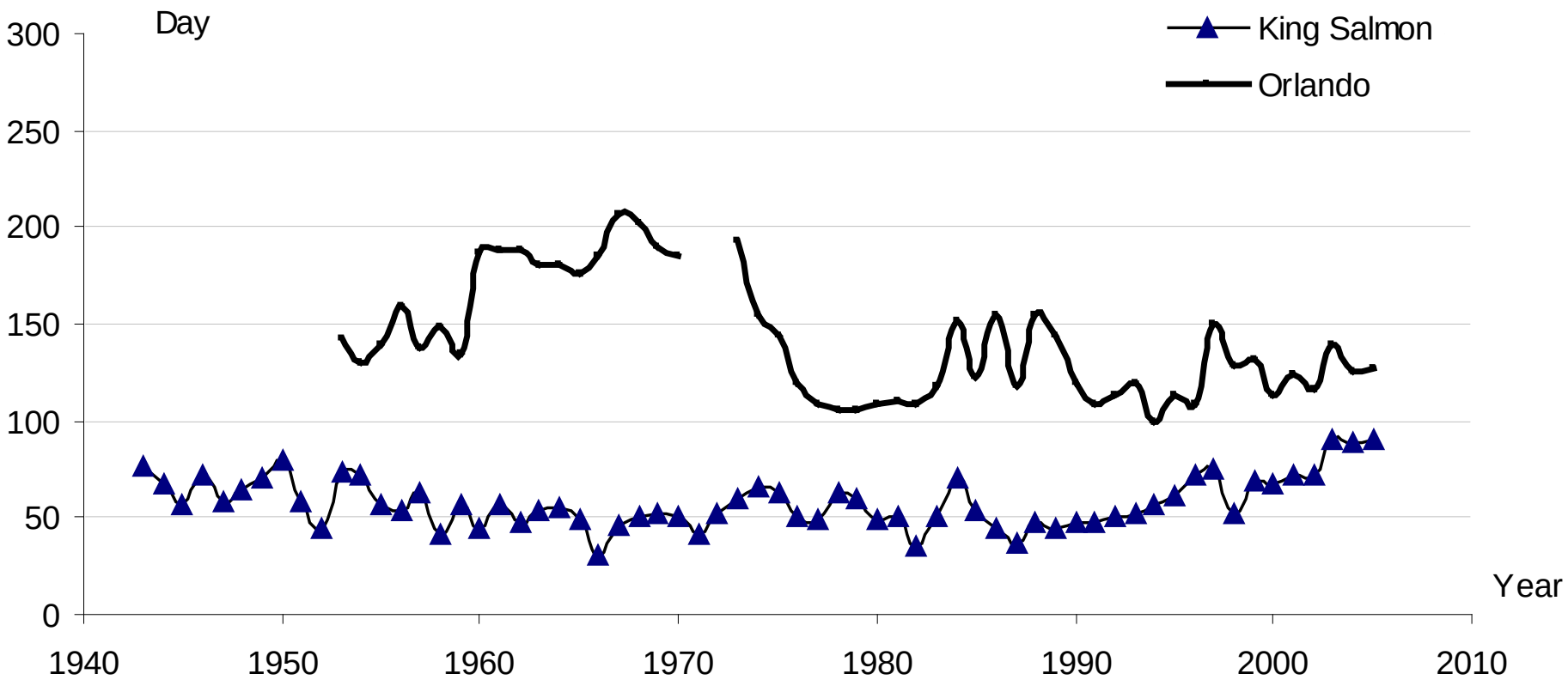


Variation of Julian dates of 1st day, last day of sightseeing season at King Salmon, AK



Variation of start, end date of the sight seeing season at King Salmon, AK

Number of days each year with at least six consecutive hours of ideal sightseeing conditions

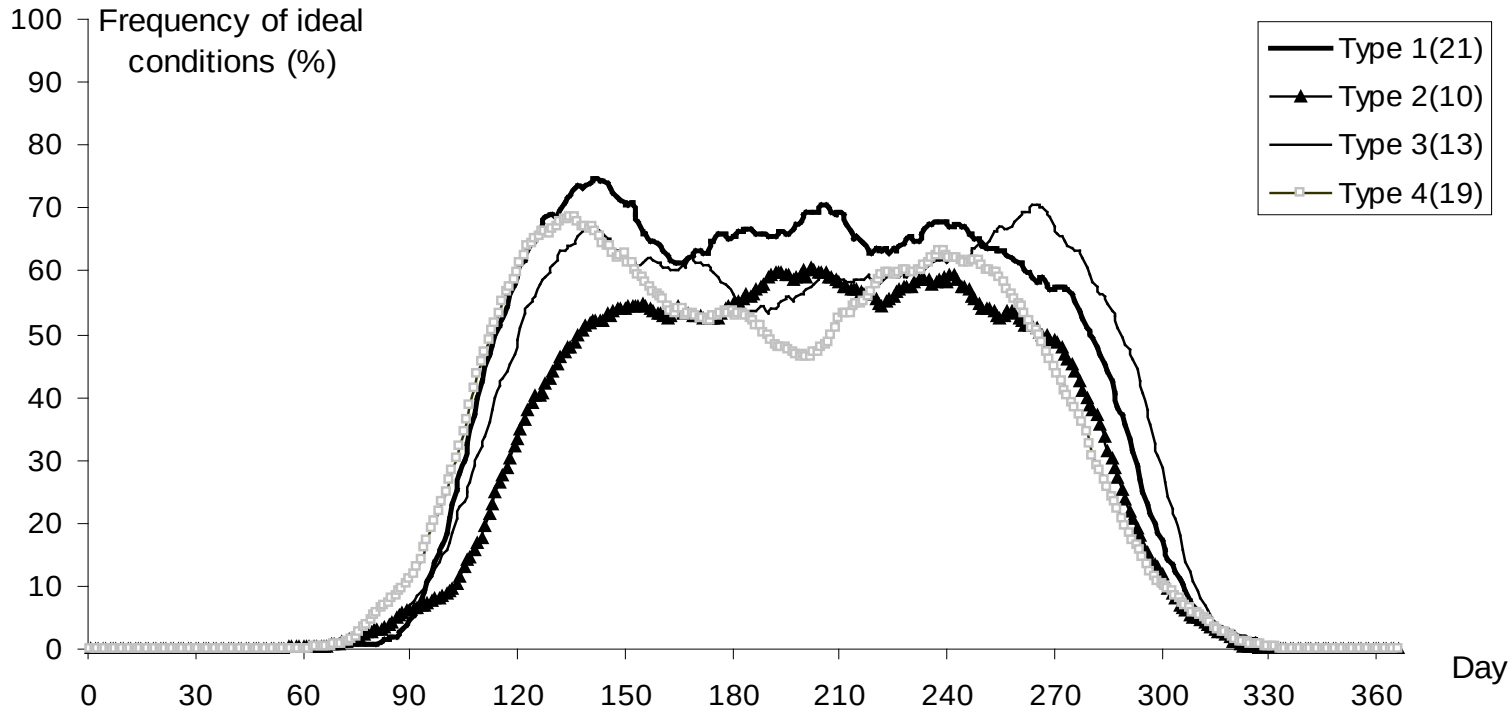


Linear trend and statistical significance of Perceived Temperature and Frequency (by month)

(red = increase, blue = decrease)

	Dep. variable	1	2	3	4	5	6	7	8	9	10	11	12	1-12
Alaska	T	.25 *	.246	.32 **	.34 **	.34 **	.242	.34 **	.283 *	.118	-.04	.12	.287 *	.50 **
	CIT (2)	0.00	0.20	0.19	.29 *	0.24	0.22	0.15	.35 *	0.06	0.19	0.11	0.13	.3 *
	CIT (0)	-0.22	-.38 **	-.40 **	-.26 *	-.29 *	-0.19	-0.03	-0.23	-0.0	0.02	-0.10	-.30 *	-.47 *
Fla.	T	0.11	0.20	0.21	0.09	0.19	0.26	.37 **	.29 *	.32 *	.35 *	.28 *	0.15	.46 **
	CIT (2)	0.01	-0.04	-0.24	-0.27	-.30 *	-.45 **	-.69 **	-.47 **	-.47 **	-.41 **	-0.27	-0.01	-.42 **
	CIT (0)	-.33 *	-0.26	-0.15	-0.17	-.39 **	.29 *	.35 *	.32 *	-0.13	-0.16	-0.05	-0.21	-0.13

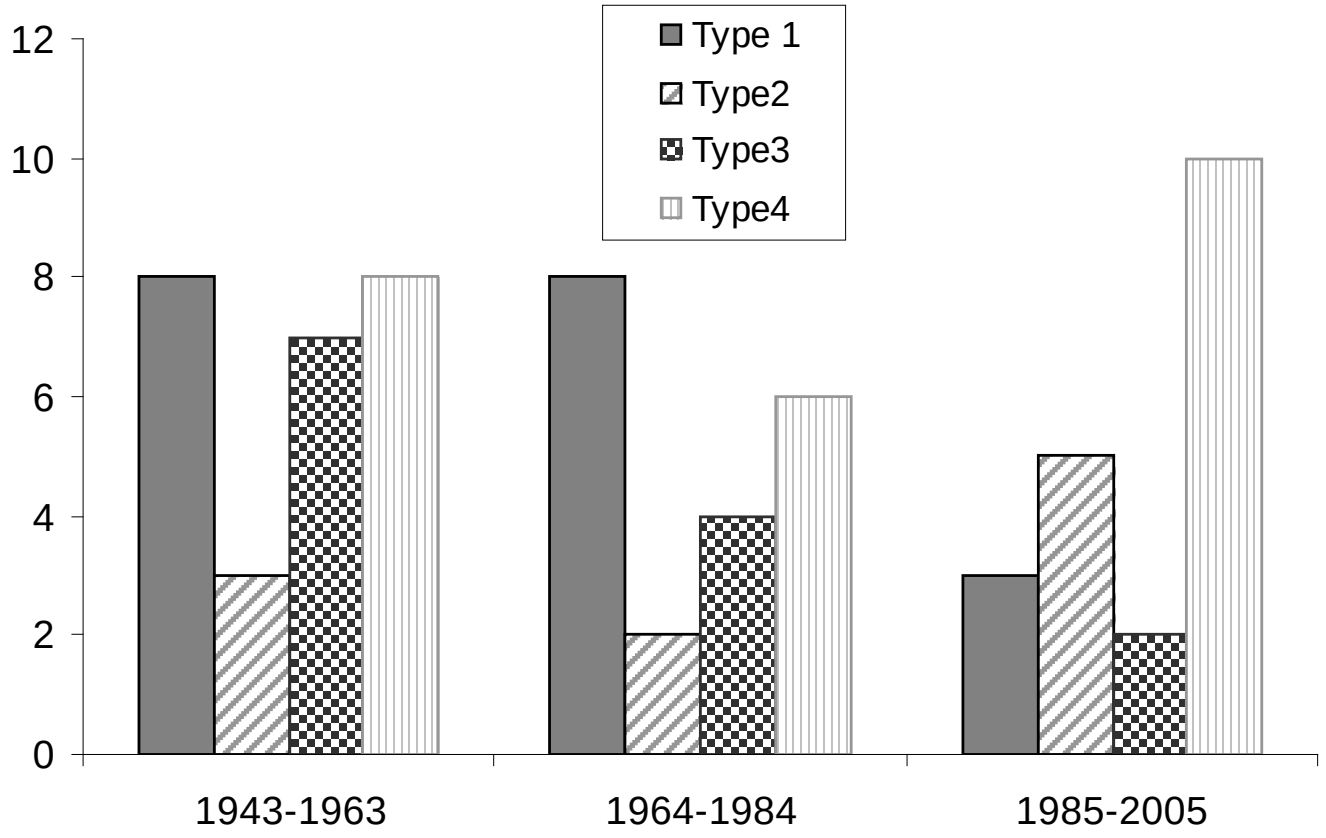
Objective typing of seasonal variations (K-means cluster analysis for Anchorage skiing)



Four types seasonal patterns for Skiing in Anchorage
Day 0: July 1

Changes over time in Anchorage ski season types:

Type 1 = long season, Type 4 = short season

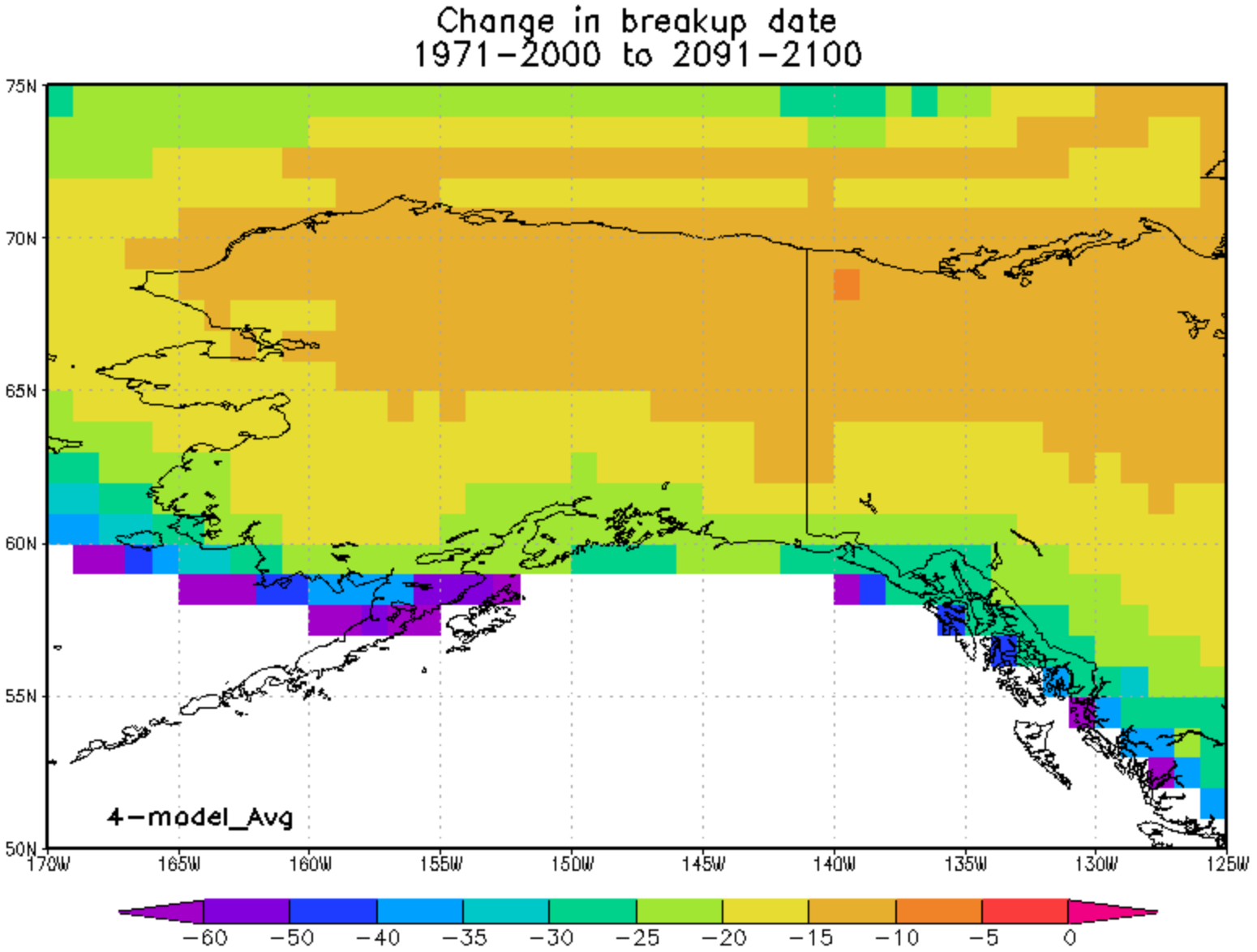


What about future changes ?

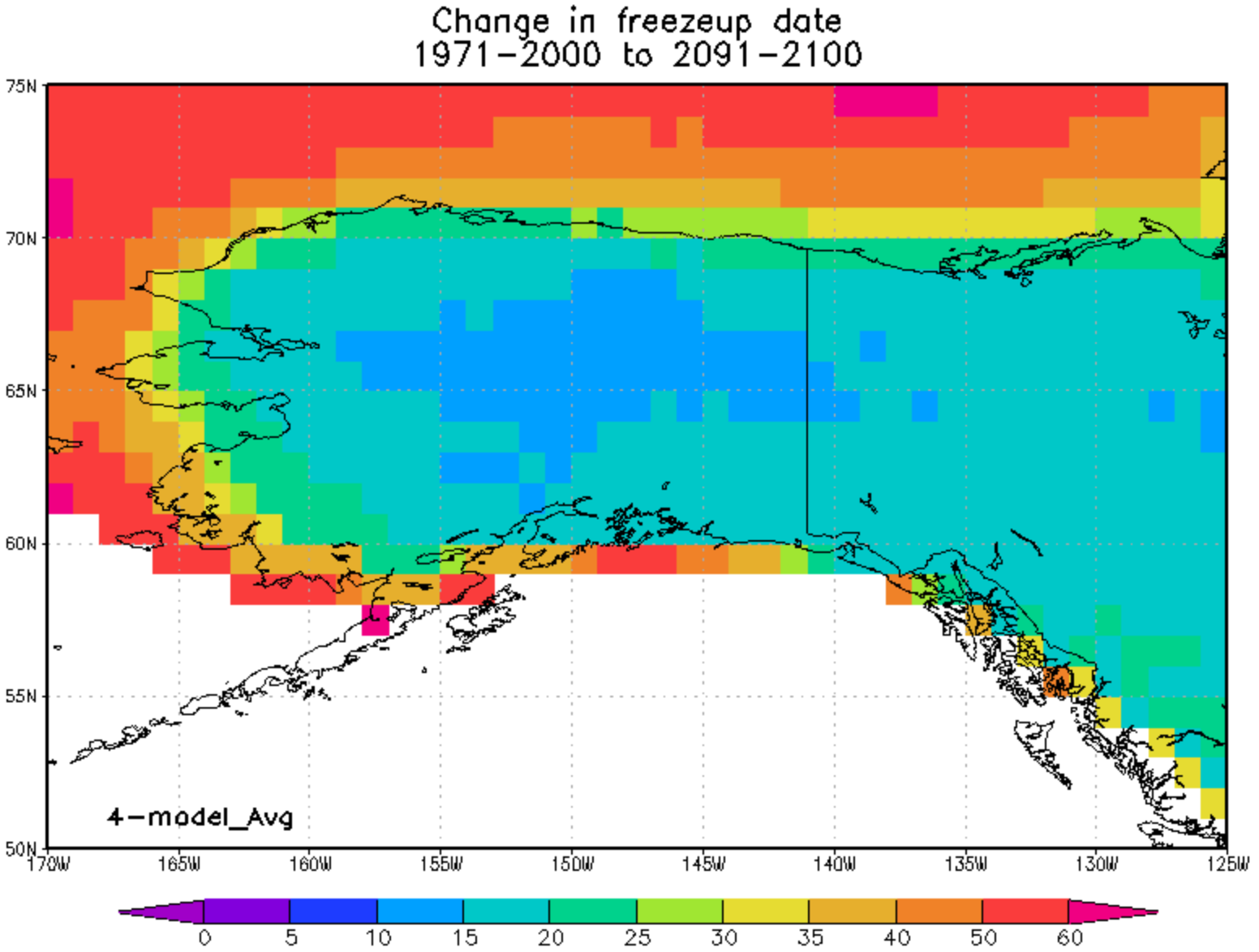
- **Use made of IPCC climate model projections**
- **Four "best" models selected on basis of simulation of seasonal cycle of Alaska climate, 1980-2000**
- **Daily output for Alaska extracted for mid- and late-21st century**
- **First look: Changes in length of warm season**

  (10-day running mean Temperature > 0°C)

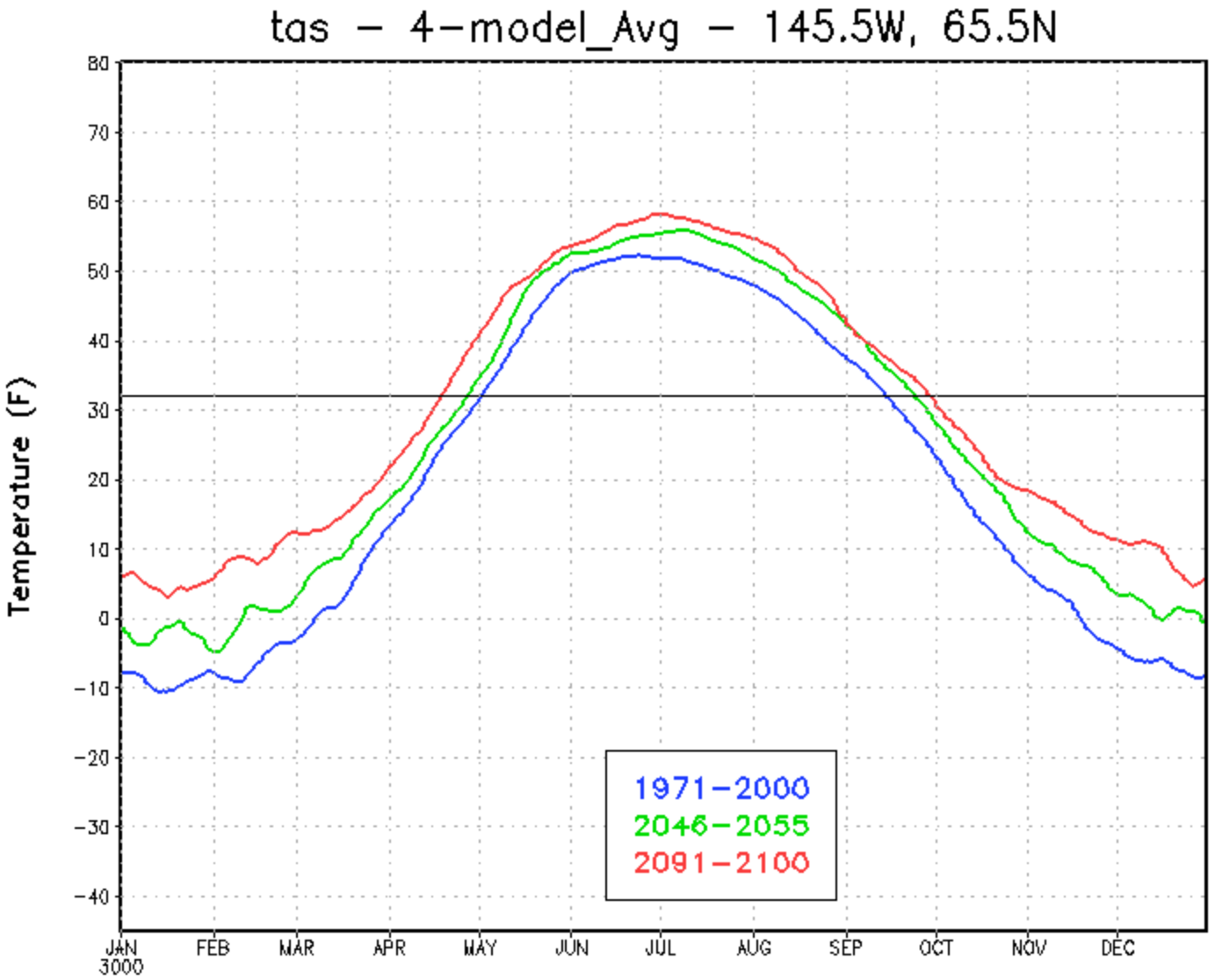
IPCC model projections of change in thaw date by 2091-2100



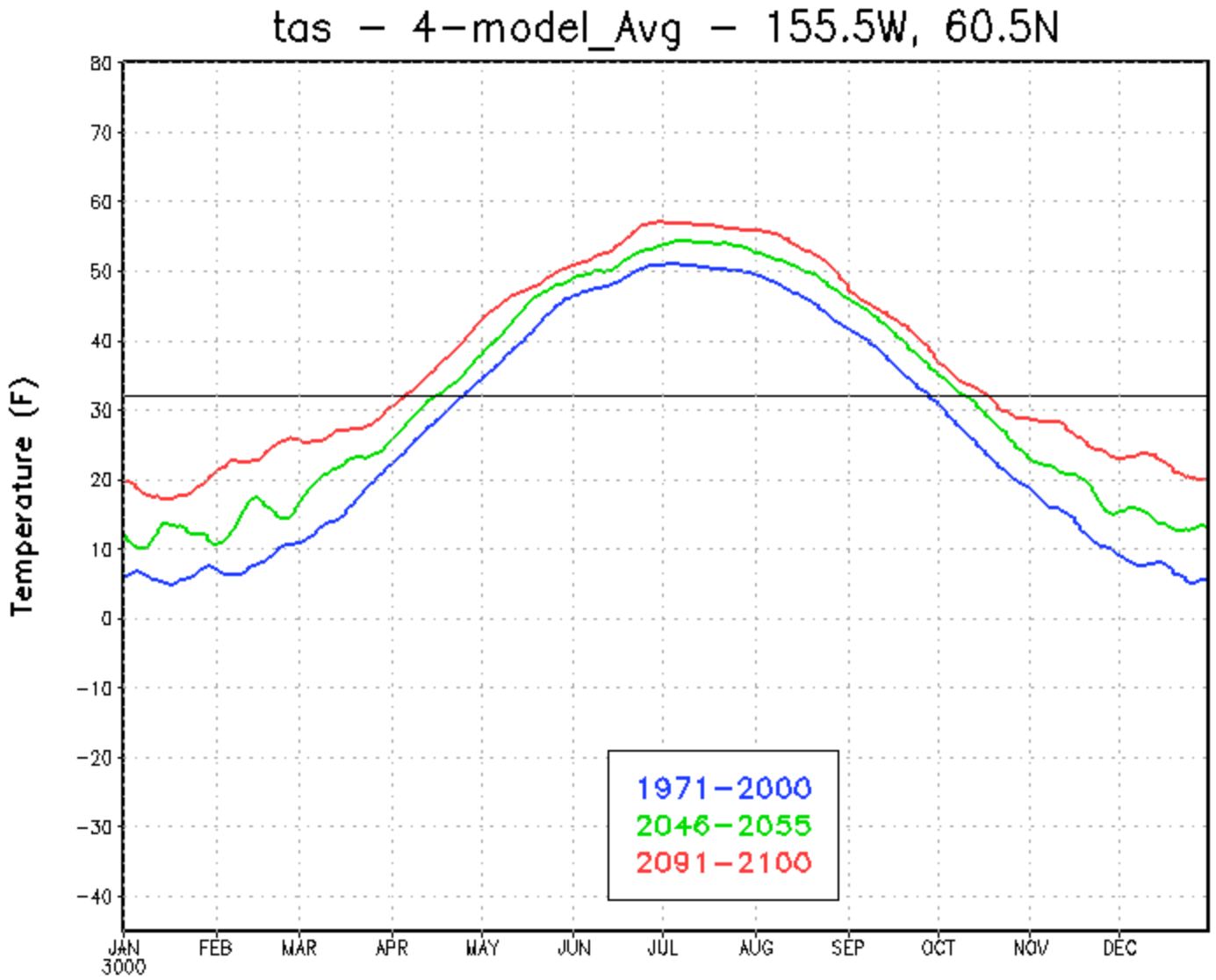
IPCC model projections of change in freeze-up by 2091-2100



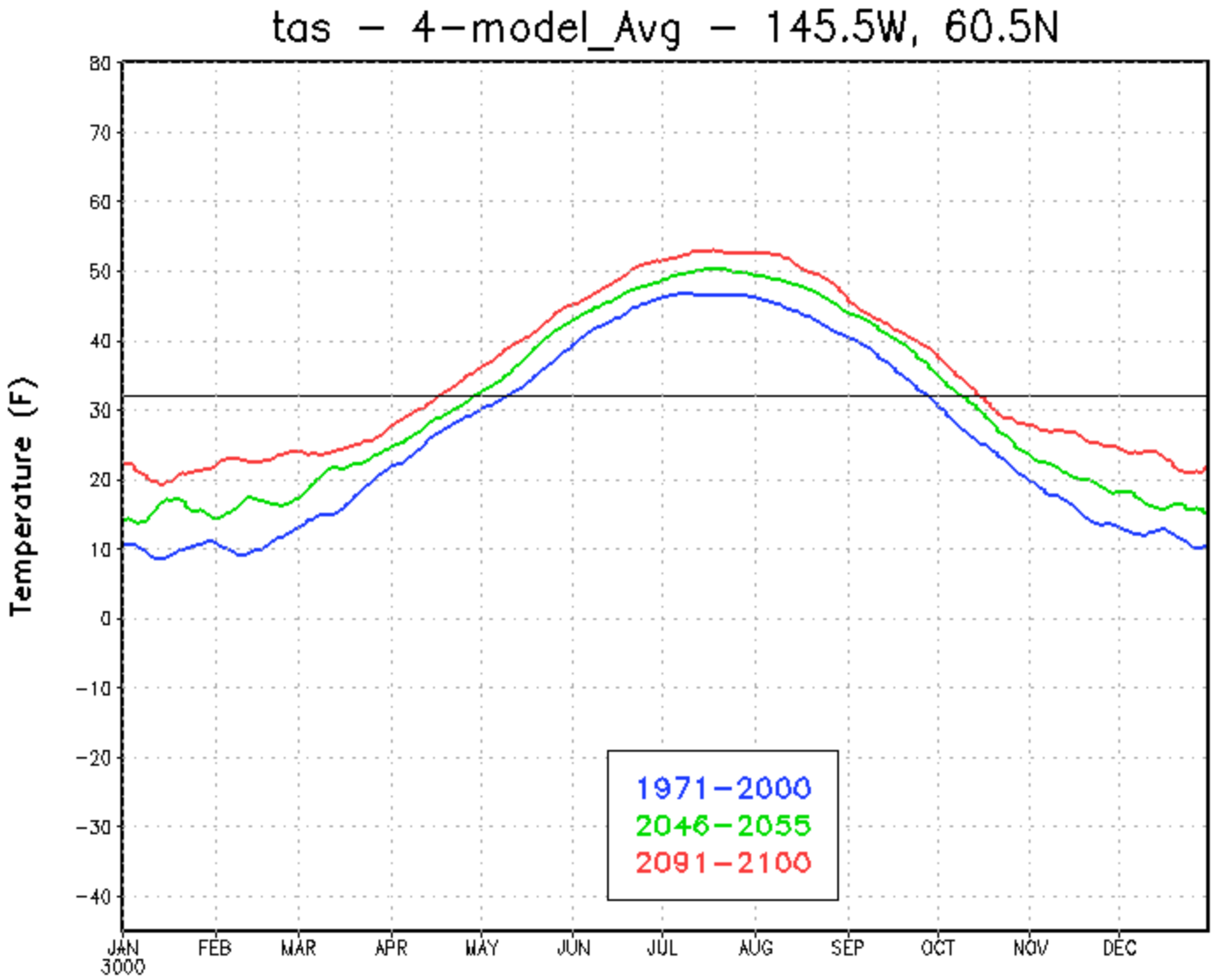
Mean seasonal cycle of surface air temperature (Fairbanks grid cell)



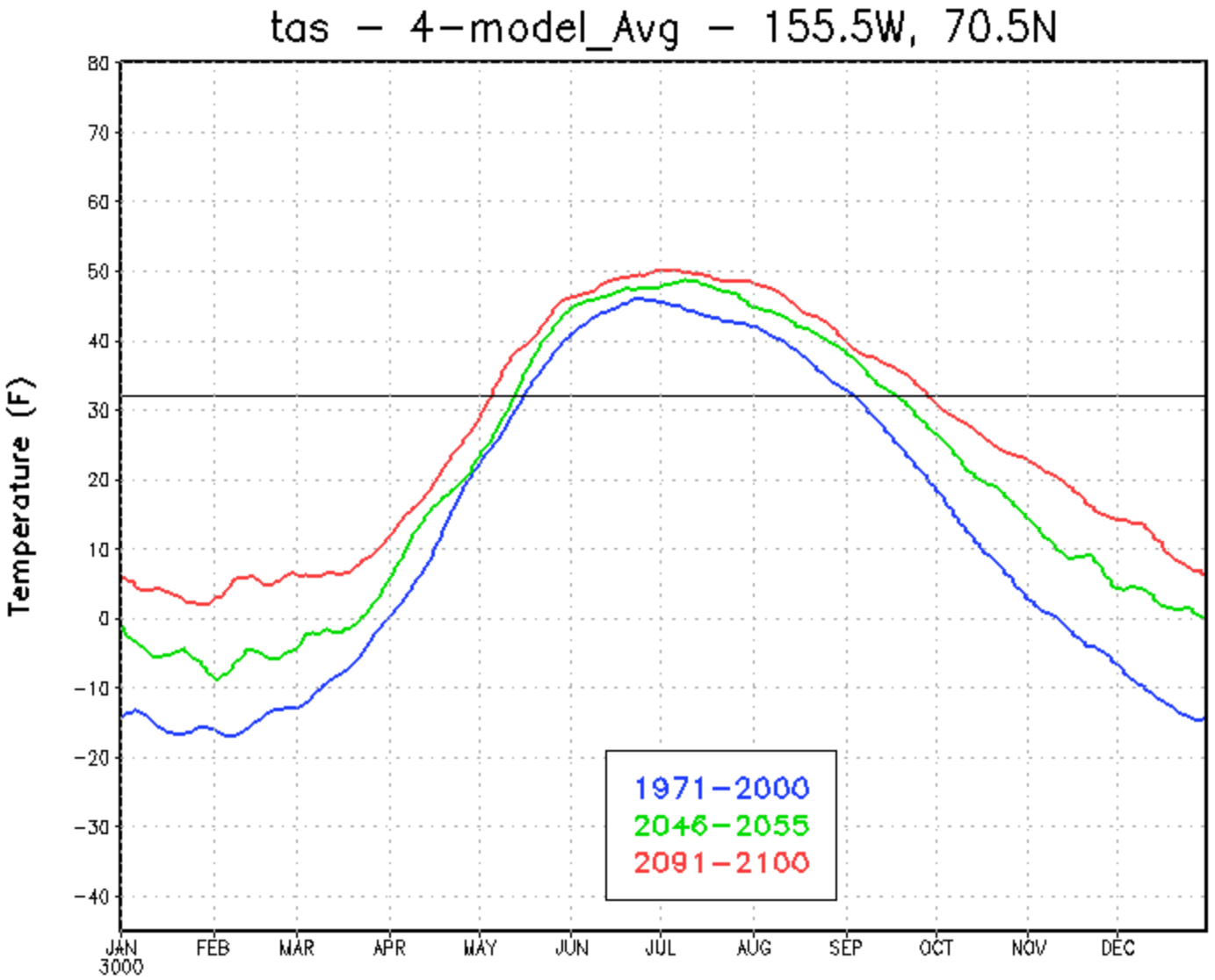
Mean seasonal cycle of surface air temperature (King Salmon)



Mean seasonal cycle of surface air temperature (Anchorage)



Mean seasonal cycle of surface air temperature (Barrow)



Conclusions

- **The hourly index captures variations of climate-driven tourism weather for various activities, locations, seasons and times of day**
- **The index shows that ideal tourism weather exhibits temporal trends -- favorable for some activities/locations, unfavorable for others**
- **The lengthening of the summer season is the prominent signal in the recent and projected changes in Alaska**

Future Research

- **Determine optimum thresholds of suitability for different weather elements and different activities**
- **Link the CIT to more direct evidence of tourist participation and satisfaction**
- **Evaluate sensitivity of the CIT to climate *change* in destinations with different climate characteristics**