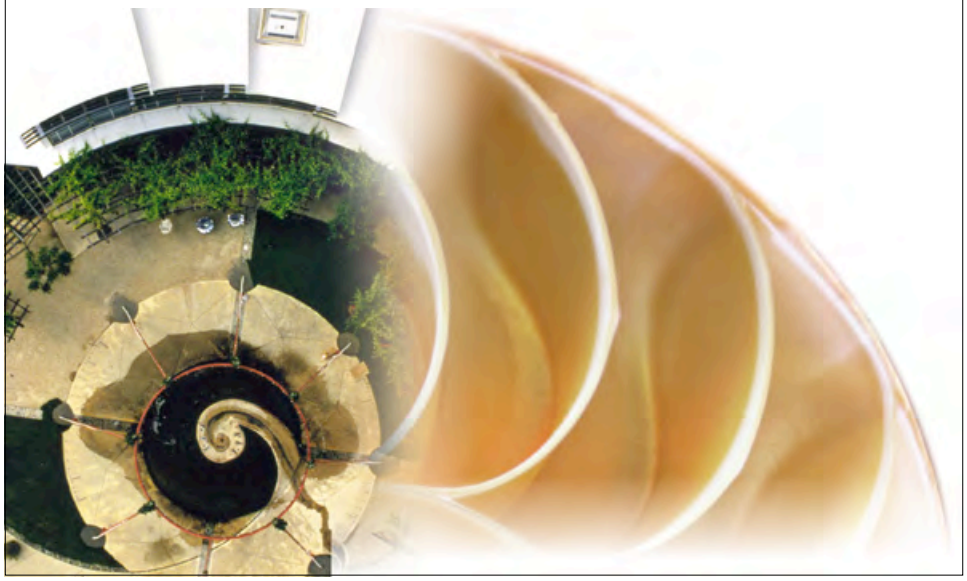
Climate Analysis

ARCH 331/431 Spring 2008
Lecture 3



announcements 4/8/08

course website:

http://courses.washington.edu/arch3431/index.shtml

Course materials (readings, assignments, lectures, references and website links) are now posted and will be updated after every lecture.

lecture slides:

PowerPoint lecture slides are now posted on the course website following lecture. They will be posted as PDF documents in two versions: 6 slides per page (for printing); 2 slides per page for viewing on your computer.

A2: Climate Analysis and References

The second assignment, along with several useful references, is now available on the course website.

Thermal Building Types

ENVELOPE DOMINATED

- typically small buildings
- low internal heat gains
- space heating determined by heat loss through the envelope.
- relatively high balance point temperature

INTERNAL LOAD DOMINATED

- typically larger buildings
- high internal heat gains
- space cooling requirements determined by heat gains from people, lights and equipment within the building
- relatively low balance point temperature

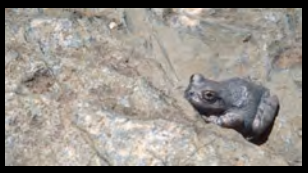
OPEN FRAME | climate accepting

CLOSED SHELL | climate rejecting

Mechanisms for Environmental Adaptation

All things in nature respond to change and to transitions from one state of the environment to another. In nature, complex interactions between organisms and the environment are structured by various adaptive mechanisms. Plants and animals use specialized strategies adapted to the particular demands of a place to survive under a broad range of global environmental conditions.

The result of adaptation in recurring conditions in nature is a remarkable array of forms that can be characterized in both static and dynamic terms.



Mechanisms for Environmental Adaptation

Reference: Ralph Knowles, Sun Rhythm Form

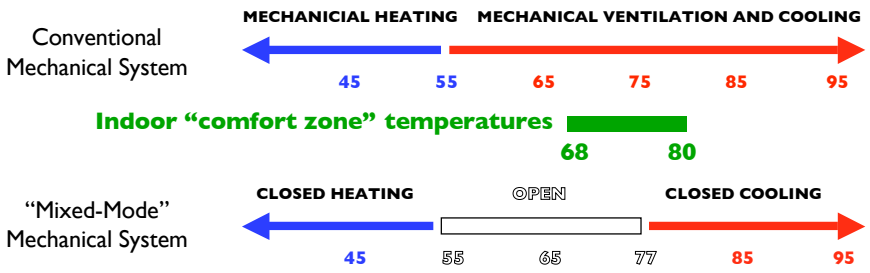
1. LOCATION
- orientation
- juxtaposition
- migration

2. FORM
- shape
- surface-to-volume ratio *(susceptibility to environmental stress)*
- envelope & openings

3. METABOLISM (chemical conversion)
- fire
- evaporation

Architectural Sailing

(a hypothetical example)



Closed Heating Mode Strategies

MECHANICAL	ARCHITECTURAL
• Active Solar	• Thermal Mass: Heat
• Furnace/Boiler	• Direct Gain: Sun

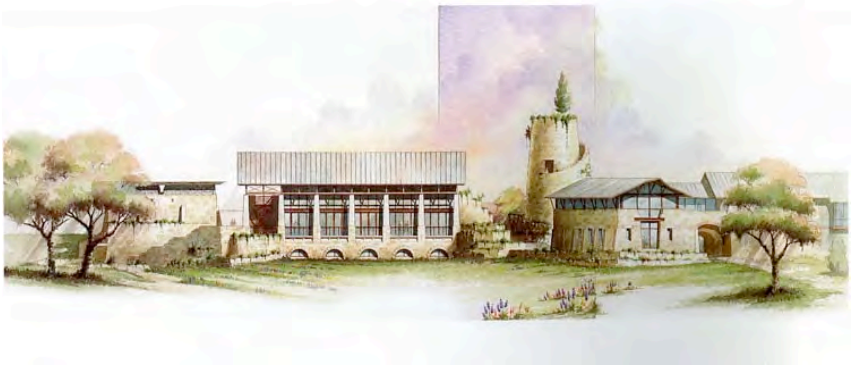
Closed Cooling Mode Strategies

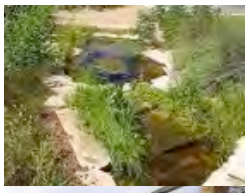
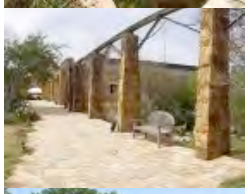
ARCHITECTURAL	MECHANICAL
• Thermal Mass: "Coolth"	• Ceiling Fans
• Evaporation: Water	• Chillers

Lady Bird Johnson Wildflower Center

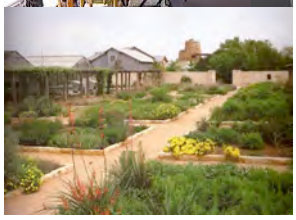
Austin, Texas

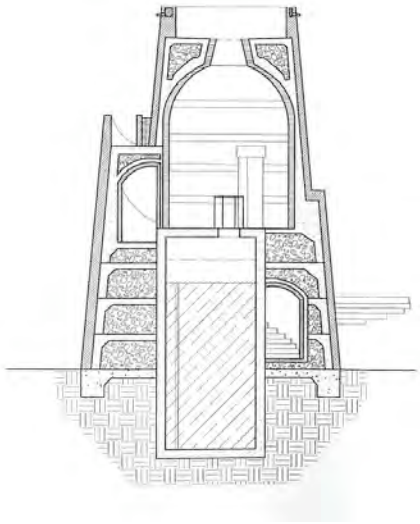
Overland Partners • San Antonio, Texas







Monterey Bay Aquarium

Monterey, California

EHDD • San Francisco, California

Longitudinal sectio-

Climate Analysis

Ecological design begins with an intimate understanding of *Place*

When coming to an understanding of place, we should ask these questions:

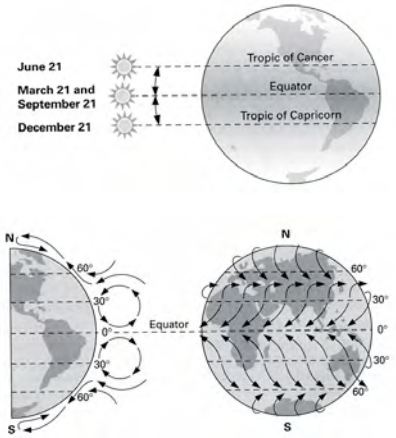
- *What is here?*
- *What will nature **allow** us to do here?*
- *What will nature **help** us do here?*

1. ***Collect** relevant climate, weather and solar data;*
2. ***Analyze** and articulate this information in clear, graphic form;*
3. ***Synthesize** a set of climate priorities and architectural strategies.*

Climate Analysis

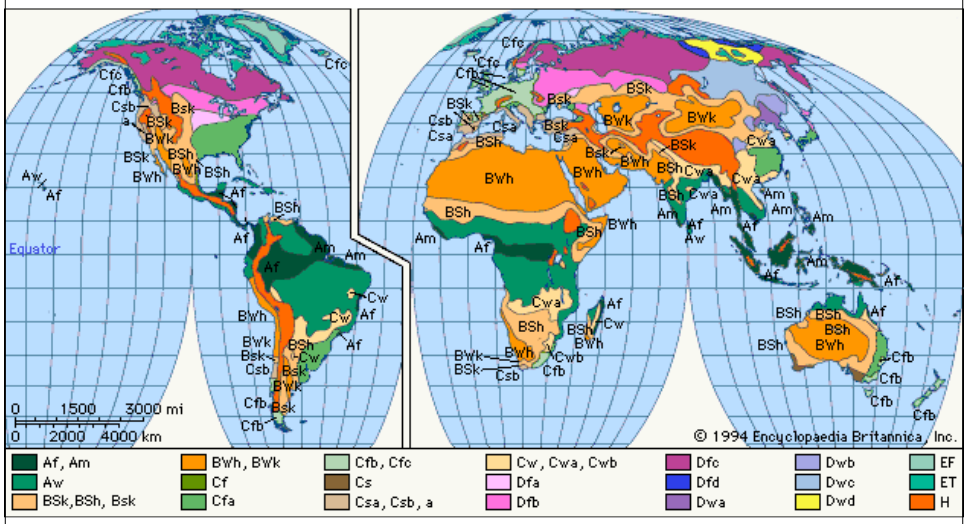
Global Climate: Cause and Effect

Uneven heating and cooling of the Earth's surface combined with rotation produce large scale wind, temperature and precipitation patterns



Climate Analysis

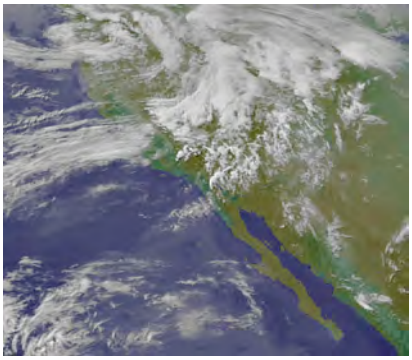
Global Climate: Classification Systems



Köppen World Climate Types		**Simplified Climate Types**	
A	hot, tropical rainy	**A**	**hot humid**
B	dry	**B**	**hot arid**
C	temperate rainy	**C**	**temperate**
D	snowy forest	**D**	**cold/variable**
E	arctic/alpine		

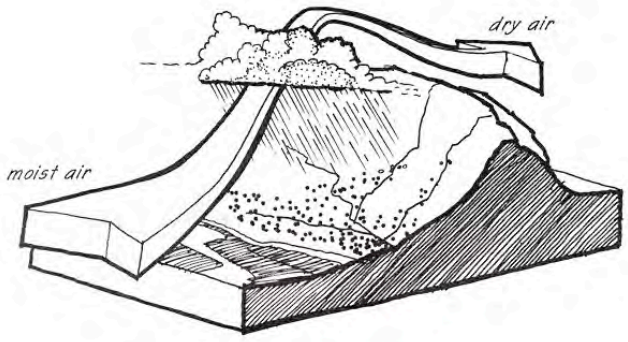
A, C, D, *and* ***E*** *differ by temperature.*

B *distinguished from others by low precipitation.*



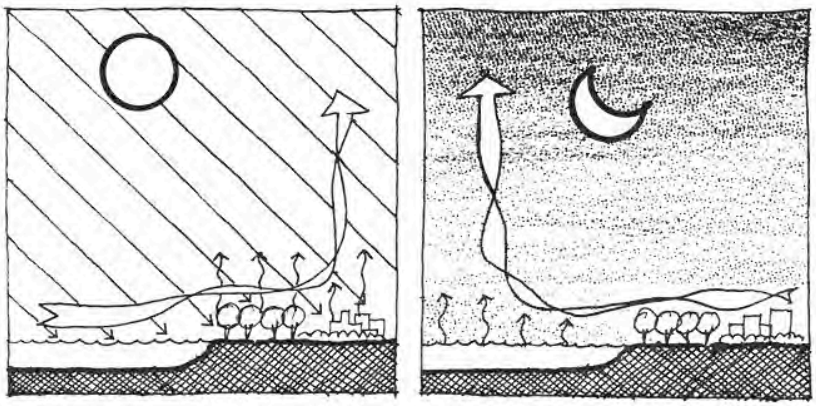
Climate Analysis

Climate Mechanisms: **Rain Shadow**



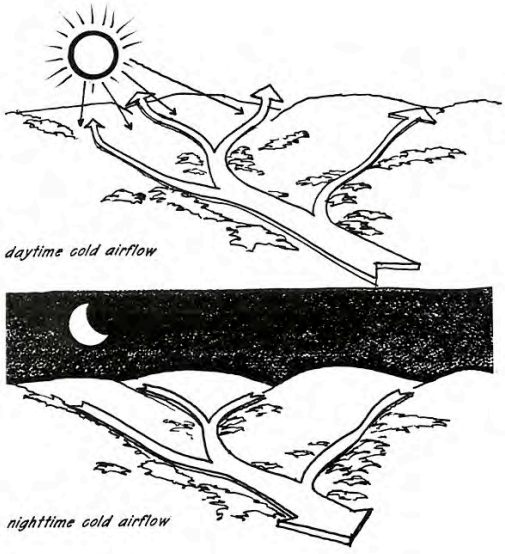
Climate Analysis

Climate Mechanisms: **Land-Sea Breezes**



Climate Analysis

Climate Mechanisms: **Valley Winds and Air Drainage**



Climate Analysis

Climate Mechanisms: **Biological Factors**

Climate Analysis

Objectives

I. Collection: Finding Relevant Climate Data

Challenges:

• finding temperature, relative humidity, wind speed and direction, and sky cover, for your location.

II. Analysis: Understanding & Graphic Articulation of the Data

Challenges:

*• too much information; making sense of the data available, and selecting the most important, **architecturally relevant**, information;*

• effectively telling the story of the climate in your location in a clear graphic manner and a climate narrative in plain language.

III. Synthesis: Identifying Climate Priorities & Architectural Strategies

Challenges:

• correctly identifying what the most important priorities are for a particular building type and program in a particular place.

Climate Analysis

Obstacles to reliable site-specific climate data

- dependence on airport or agricultural data sets remote from actual building site
- not all data collected at every station
- topography and land cover are major determinants of local climate
- human impacts are changing climate

Climate Analysis

1. Data Collection for Architectural Design

- **Temperature:** monthly normal high & low
- **Relative Humidity:** monthly normal high & low
- **Wind:** normal monthly normal velocity and direction
- **Sky Conditions:** clear, partly cloudy, cloudy
- **Climate Narrative:** description of climate
- **Character/Sense of Place:** images
- **Solar Radiation:** energy incident on a surface

Climate Analysis

1. Data Collection for Architectural Design: **sources**

Reference

Online Resources: Climate Data & Analysis (available on course website)

Western US:

Western Regional Climate Center

www.wrcc.dri.edu/climsum.html

USA:

NOAA

www.ncdc.noaa.gov/oa/ncdc.html

International:

ICSMS International Meteorological Data

- Each instructor will have at least one CD.
- This disk runs only on PC's, and operates in DOS.
- Instructions are in A2: Climate Analysis, on the course website.

sources

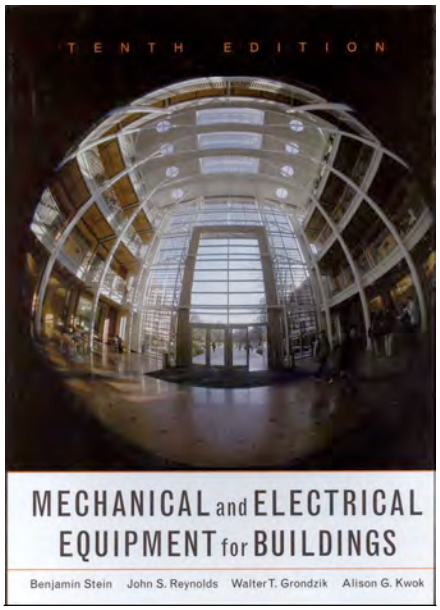
MEEB 10th edition

Appendix B:

Climate Conditions for the United States, Canada and Mexico

Appendix C:

Solar Data



sources

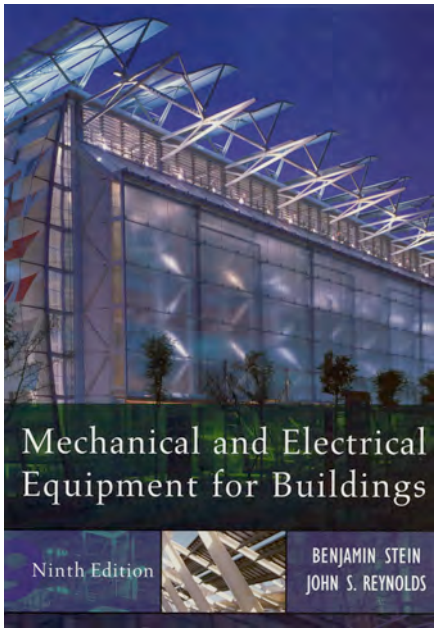
MEEB 9th edition

Appendix A:

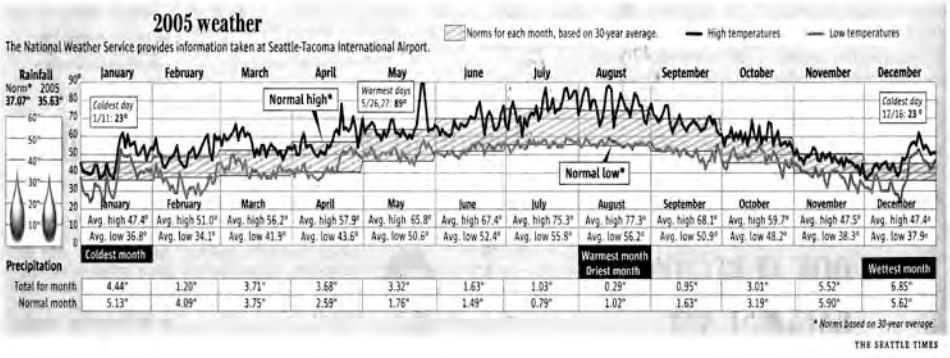
Climate Conditions for the United States, Canada and Mexico

Appendix B:

Solar Data



sources



sources

CLIMATES OF THE STATES

National Oceanic and Atmospheric Administration
Narrative Summaries, Tables, and Maps
for Each State
with
Overview of State Climatologist Programs

Second Edition

New Material by
James A. Ruffner

Volume 2

Ohio -- Wyoming
Puerto Rico and U.S. Virgin Islands
Atlas of State Climates
Hurricane Data
The State Climatologist Program 1954-1973
Guide to Current Information Sources
Appendixes

GALE RESEARCH COMPANY • BOOK TOWER • DETROIT, MICHIGAN 48226

CLIMATOGRAPHY OF THE UNITED STATES NO. 60

Climate of Washington

TOPOGRAPHIC FEATURES - The location of the State of Washington on the windward coast in mid-latitudes is such that the climatic elements combine to produce a predominantly marine-type climate west of the Cascade Mountains, while east of the Cascades, the climate possesses both continental and marine characteristics. Considering its northerly latitude, 46° to 49°, Washington's climate is mild.

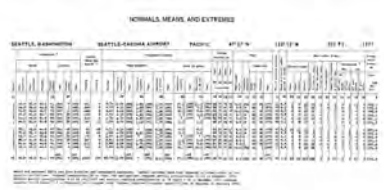
There are several climatic controls which have a definite influence on the climate, namely: (a) terrain, (b) Pacific Ocean, and (c) semi-permanent high and low pressure regions located over the north Pacific Ocean. The effect of these various controls combine to produce entirely different conditions within short distances.

Washington's western boundary is formed by the Pacific Ocean. The seasonal change in the temperature of the ocean is less than the seasonal change in the temperature of the land, thus the ocean is warmer in winter and cooler in summer than the adjoining land surfaces. The average temperature of the water along the coast and in the Strait of Juan de Fuca ranges from 45° in January to 57°F in July; however, during the summer, some of the shallow bays and protected coves are five to ten degrees warmer.

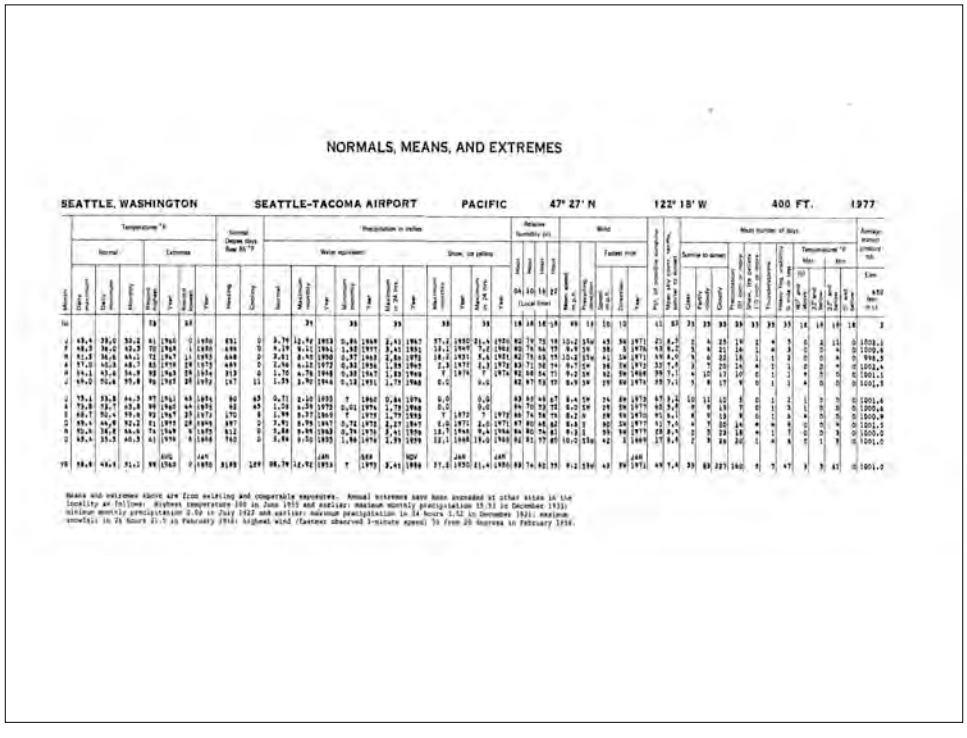
There are two ranges of mountains parallel to the coast and athwart to the prevailing direction of moist air moving inland from over the ocean. The first orographic lifting and major release of moisture occurs along the western slope of the Coastal Range. The second area of heavy orographic precipitation is along the windward slopes of the Cascade Range. The Cascade Mountains, 90 to 125 miles inland and 4,000 to 10,000 feet in elevation, are a topographic and climatic barrier separating the State into eastern and western Washington. The higher, wider and more rugged sections are in the northern part of the State. Some of the highest isolated volcanic peaks are Mt. Rainier (14,408 ft.), Mt. Adams (12,307 ft.) and Mt. Baker (10,730 ft.). These and other high peaks are snowcapped throughout the year. The only break in the Cascade Range is the narrow and scenic Columbia River gorge.

CLIMATIC FEATURES - Warming and drying of air as it descends along the lee (eastern) slopes of the Cascade Range results in near desert conditions in the lowest section of the Columbia Basin. Another orographic lifting of the air occurs as it flows eastward from the lowest elevations of the Inland Basin toward the Rocky Mountains. This lifting of air results in a gradual increase in precipitation from the lowest section of the basin to the higher elevations along the eastern border of the State.

The location and intensity of the semi-permanent high and low pressure areas over the north Pacific Ocean have a definite influence on the climate. Air circulates in a clockwise direction around the semi-permanent high pressure cell and in a counter-clockwise direction around



NORMALS, MEANS, AND EXTREMES



NORMALS, MEANS, AND EXTREMES

SEATTLE, WASHINGTON — SEATTLE-TACOMA AIRPORT — PACIFIC — 47° 27' N — 122° 18' W — 400 FT. — 1977

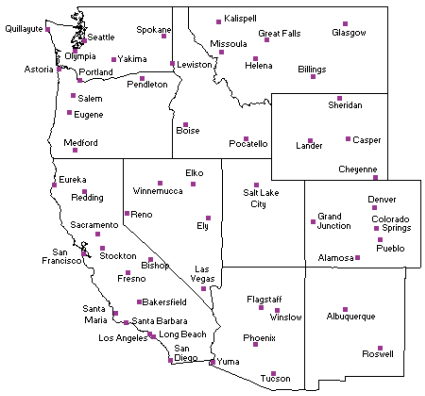
Means and extremes above are from existing and comparable exposures. Annual extremes have been extended at other sites in the locality as follows: Highest temperature 100 in June 1915 and earlier; maximum monthly precipitation 15.51 in December 1933; minimum monthly precipitation 0.02 in July 1922 and earlier; maximum precipitation in 24 hours 5.52 in December 1921; maximum snowfall in 24 hours 21.0 in February 1916; highest wind (fastest observed 1-minute speed) 76 from 28 degrees in February 1958.

Climate Analysis

1. Data Collection: **sources**

Western Regional Climate Center:

www.wrcc.dri.edu/summary/lcd.html



SAN FRANCISCO, CALIFORNIA, INTERNATIONAL AIRPORT
NORMALS, MEANS, AND EXTREMES

LATITUDE: 37 Deg. 37 Min. N LONGITUDE: 122 Deg. 23 Min. W ELEVATION: FT. GRND 8 BARO 90 TIME ZONE: PACIFIC WBAN: 23234

	(a)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	YEAR
TEMPERATURE (Deg. F)														
Normals														
-Daily Maximum		55.6	59.4	60.8	63.9	66.5	70.3	71.6	72.3	73.6	70.1	62.4	56.1	65.2
-Daily Minimum		41.8	45	45.8	47.2	49.7	52.6	53.9	55	55.2	51.8	47.1	42.7	49
-Monthly		48.7	52.2	53.3	55.6	58.1	61.5	62.7	63.7	64.5	61	54.8	49.4	57.1
Extremes														
-Record Highest	68	72	78	85	92	97	106	105	100	103	99	85	75	106
-Year		1948	1930	1952	1969	1984	1961	1988	1993	1971	1987	1967	1958	Jun-61
-Record Lowest	68	24	25	30	31	36	41	43	42	38	34	25	20	20
-Year		1928	1929	1929	1929	1929	1932	1928	1935	1929	1929	1931	1932	Dec-32
NORMAL DEGREE DAYS														
Heating (base 65 Deg. F)		505	358	363	287	218	121	92	68	79	135	306	484	3016
Cooling (base 65 Deg. F)		0	0	0	5	0	16	21	28	64	11	0	0	145
% OF POSSIBLE SUNSHINE														
MEAN SKY COVER(tenths)														
Sunrise - Sunset	54	6.2	6.2	5.8	5.2	4.5	3.7	3	3.3	3.2	4	5.4	6	4.7
MEAN NUMBER OF DAYS:														
Sunrise to Sunset														
-Clear	68	8.5	7.8	9.6	10.8	13.5	16.1	20.6	19	18.1	15.5	11.1	9.4	160.1
-Partly Cloudy	68	7.6	7.4	8.6	9.3	9.7	8.6	7.6	8.7	8.3	8.9	8.3	7.5	100.4
-Cloudy	68	14.9	13.1	12.9	9.9	7.8	5.3	2.8	3.3	3.6	6.5	10.6	14.1	104.8
Precipitation														
.01 inches or more	68	10.8	9.6	10	5.9	2.9	1.2	0.3	0.5	1	3.5	7	9.9	62.5
Snow, Ice Pellets, Hail														
1.0 inches or more	68	0.*	0	0	0	0	0	0	0	0	0	0	0.*	0.*
Thunderstorms	68	0.4	0.4	0.3	0.2	0.1	0.1	0.1	0.1	0.2	0.3	0.1	0.2	2.5
Heavy Fog Visibility														
1/4 mile or less	58	3.5	2.6	0.4	0.1	0.1	0.*	0.*	0.2	0.6	1.3	2.1	3.2	14.2
Temperature Deg. F														
-Maximum														
90 Deg. F and above	36	0	0	0	0.1	0.3	1	0.7	0.3	1.2	0.4	0	0	4
32 Deg. F and below	36	0	0	0	0	0	0	0	0	0	0	0	0	0
-Minimum														
32 Deg. F and below	36	1	0.1	0.	0	0	0	0	0	0	0	0	0.8	1.9
0 Deg. F and below	36	0	0	0	0	0	0	0	0	0	0	0	0	0
AV. STATION PRES. (mb)	23	1019.1	1018.1	1016.8	1016.9	1015	1014.3	1014.2	1013.9	1013.6	1015.8	1018.5	1019.6	1016.3
RELATIVE HUMIDITY (%)														
Hour 04	36	86	85	82	82	84	85	86	87	84	82	84	85	84
Hour 10 (Local Time)	36	79	76	71	65	64	63	65	67	66	68	72	77	69
Hour 16	36	67	65	63	60	60	58	59	61	59	59	63	67	62
Hour 22	36	81	79	77	77	79	80	82	83	80	77	77	80	79
PRECIPITATION (in.)														
Water Equivalent														
-Normal		4.35	3.17	3.06	1.37	0.19	0.11	0.03	0.05	0.2	1.22	2.86	3.09	19.7
-Maximum Monthly	68	11.26	9.52	9.01	6.36	3.81	0.86	0.35	0.66	2.3	7.3	7.94	12.3	12.3
-Year		1993	1958	1958	1958	1957	1967	1977	1976	1959	1962	1973	1955	Dec-55
-Minimum Monthly	68	0.24	T	T	T	T	0	0	T	T	T	0	0.01	0
-Year		1991	1953	1934	1977	1992	1928	1930	1995	1995	1978	1929	1989	Jul-30
-Maximum in 24 hrs	68	5.71	2.64	2.46	2.66	1.54	0.83	0.35	0.36	2.3	3.74	2.43	3.33	5.71
-Year		1982	1987	1982	1958	1957	1967	1977	1976	1959	1962	1994	1955	Jan-82
Snow, Ice Pellets, Hail														
-Maximum Monthly	68	1.5	T	T	0	0	0	0	0	0	0	0	1	1.5
-Year		1962	1994	1995									1932	Jan-62
-Maximum in 24 hrs	68	1.5	T	T	0	0	0	0	0	0	0	0	1	1.5
-Year		1962	1994	1995	1987								1932	Jan-62
WIND														
Mean Speed (mph)	68	7.2	8.6	10.5	12.2	13.4	14	13.6	12.8	11.1	9.4	7.5	7.1	10.6
Prevailing Direction														
through 1964		WNW	WNW	WNW	WNW	W	W	NW	NW	NW	WNW	WNW	WNW	WNW
Fastest Mile														
-Direction(?)	46	16	22	17	18	31	28	28	27	28	25	20	22	16
-Speed(mph)		58	55	41	47	41	44	40	36	38	44	47	54	58
-Year		1963	1900	1995	1992	1984	1969	1993	1974	1968	1950	1953	1995	Jan-63
Peak Gust														
-Direction(?)	12	S	S	S	NW	NW	W	W	W	NW	S	S	SW	SW
-Speed(mph)	12	61	69	64	54	58	51	52	45	44	58	60	74	74
-Date		1995	1986	1995	1984	1984	1984	1987	1992	1994	1989	1984	1995	Dec-95

(a) - Length of Record in Years, although individual months may be missing.
0.* or * - The value is between 0.0 and 0.05.
Normals - Based on the 1961 - 1990 record period.
Extremes - Dates are the most recent occurrence.
Wind Dir. - Numerals show tens of degrees clockwise from true north. "00" indicates calm.
Resultant Directions are given to whole degrees.

SAN FRANCISCO, CALIFORNIA, INTERNATIONAL AIRPORT
NORMALS, MEANS, AND EXTREMES

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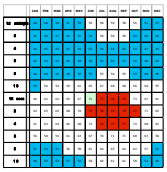
-Cloudy	68	14.9	13.1	12.9	9.9	7.8	5.3	2.8	3.3	3.6	6.5	10.6	14.1	104.8
RELATIVE HUMIDITY (%)														
Hour 04	36	86	85	82	82	84	85	86	87	84	82	84	85	84
Hour 10 (Local Time)	36	79	76	71	65	64	63	65	67	66	68	72	77	69
Hour 16	36	67	65	63	60	60	58	59	61	59	59	63	67	62
Hour 22	36	81	79	77	77	79	80	82	83	80	77	77	80	79
PRECIPITATION (in.)														
Water Equivalent														
-Normal		4.35	3.17	3.06	1.37	0.19	0.11	0.03	0.05	0.2	1.22	2.86	3.09	19.7
WIND														
Mean Speed (mph)	68	7.2	8.6	10.5	12.2	13.4	14	13.6	12.8	11.1	9.4	7.5	7.1	10.6
Prevailing Direction														
through 1964		WNW	WNW	WNW	WNW	W	W	NW	NW	NW	WNW	WNW	WNW	WNW

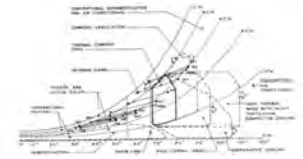
Climate Analysis

II. Analysis and Graphic Articulation

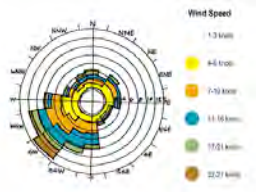
1. Temperature:
2-hour temperature map



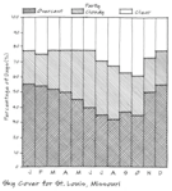
2. Temperature + Rel. Humidity:
Psychrometric Chart



3. Wind Direction & Velocity
Wind rose



4. Sun & Shade
Sky Cover Chart



1. Temperature: 2-hour temperature map

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
12 midnight	37	40	42	45	50	56	60	60	56	49	42	38
2	37	39	40	43	49	54	58	58	54	48	42	37
4	36	38	39	42	47	53	56	57	53	47	41	36
6	35	37	39	41	46	52	55	56	52	46	40	36
8	36	39	40	43	48	54	57	58	54	47	41	37
10	41	44	47	51	57	62	67	67	62	54	46	41
12 noon	44	48	51	55	61	67	72	72	67	58	49	44
2	45	50	53	57	64	70	75	75	69	60	51	45
4	44	48	52	56	62	68	74	74	68	59	50	44
6	42	46	48	52	59	64	69	69	64	55	47	42
8	40	43	45	48	54	60	64	64	60	52	45	40
10	38	41	43	46	52	57	61	62	57	50	43	39

8am to 6pm

CLOSED/Heating: 55%

OPEN/"Sailing": 42%

CLOSED/Cooling: 3%

Seattle 2-hour temperatures

Balance Point = 55° F

Change-over Temperature = 75° F