Advanced Building Science

- Design Conditions
  - Interior (based on thermal comfort, etc.)
  - Exterior (based on macro & micro climate)
  - Unconditioned spaces (somewhere in between)

- Readings
  - HF: Chapter 14
  - BSBE: Chapter 3

Design Conditions

- Indoor design conditions
  - physiological principles
  - moisture and humidity
- Outdoor design conditions
  - heating design conditions
  - cooling/dehumidification design conditions
  - mean daily range
- Unconditioned spaces
  - predicting temperatures

Design Conditions

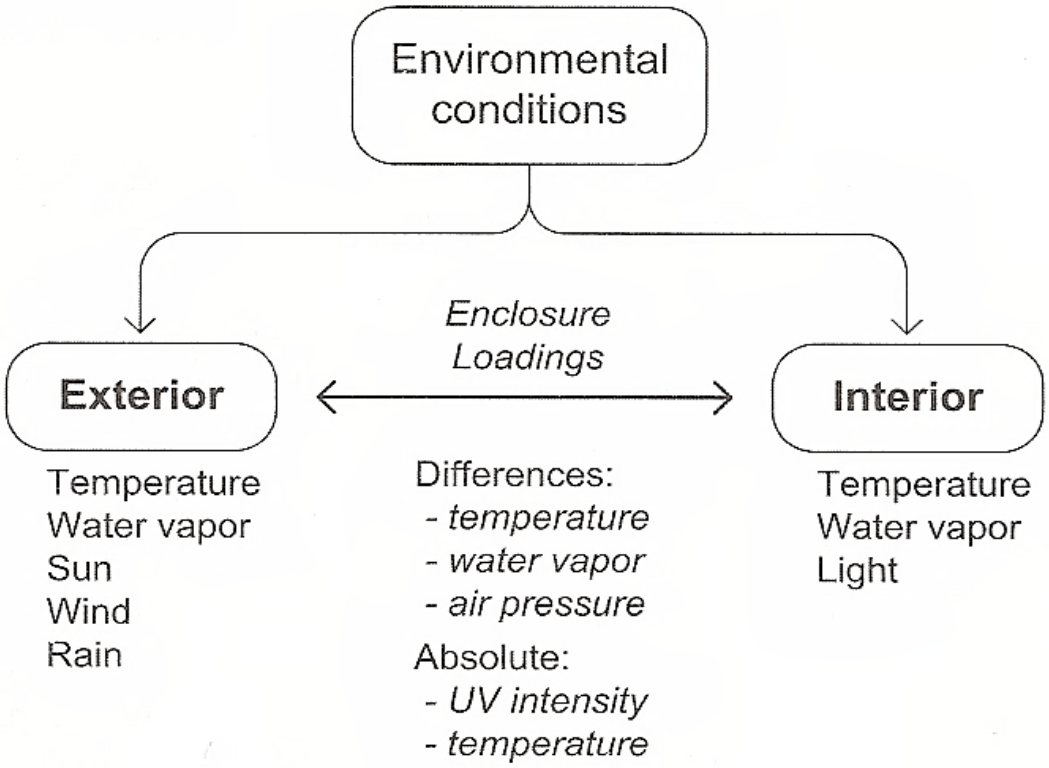

Figure 3.2: Environmental conditions and enclosure loadings

Source: Straube & Burnett, Building Science for Building Enclosure, Chapter 3

Indoor Design Conditions

- Building Conditioning Types
  - Temperature
  - Humidity
  - Pressure

- Residential
  - Winter temperature: 65 to 70 degrees
  - Summer temperature: 72 to 78 degrees

Indoor Design Conditions

Table 3.4: Types of conditioning for buildings

Type	Temperature Control	Humidity Control	Pressure Control	Examples
I a	●			Heated house, warehouse
I b	●	○		Heating and normal A/C
I c	●		○	Heating + exhaust fans
I d	●	○	○	Heating+ A/C + exhaust fans
II a	●	●		Museum, fruit storage
II b	●	●	○	Pressurized + controlled
III	●	●	●	Special labs, chip fabrication
IV	●		●	Dust sensitive manufacturing
V		●	●	Special food storage
VI			●	Cement factory

Note: ● Directly controlled ○ - Incidental Implicit

Source: Straube & Burnett, Building Science for Building Enclosure, Chapter 3

Exterior Design Conditions

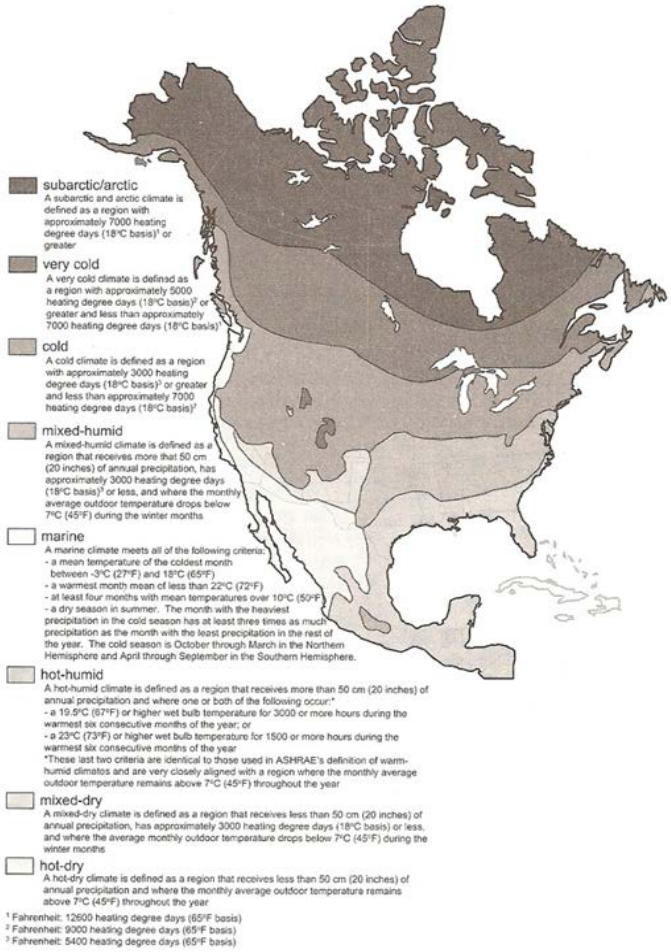

Figure 3.4: Lstiburek's climate zone classification [Lstiburek 2005]

Source: Sraube: Straube & Burnett, Building Science for Building Enclosure, Chapter 3

Outdoor Design Conditions

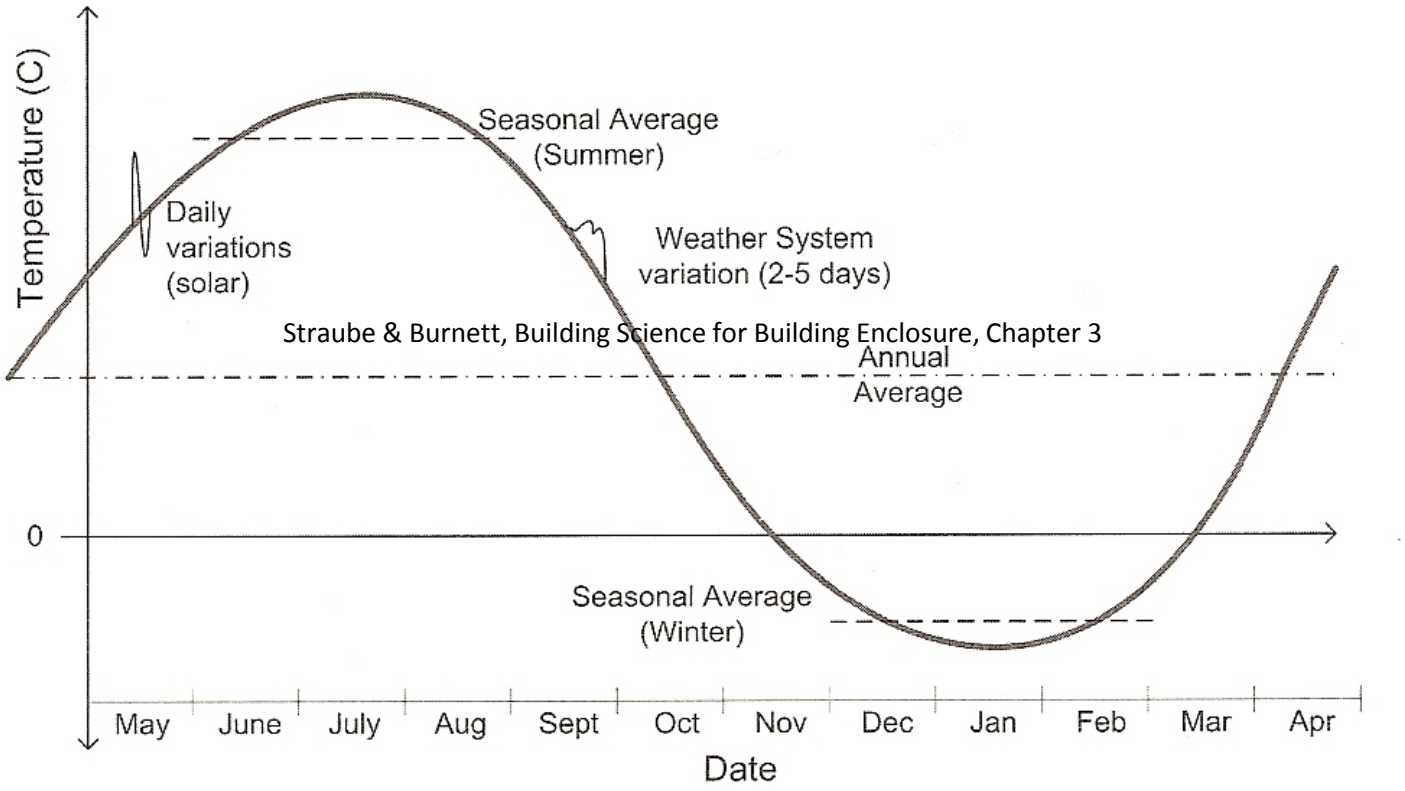

Figure 3.11: Temporal variations in weather

Source: Straube & Burnett, Building Science for Building Enclosure, Chapter 3

Outdoor Design Conditions

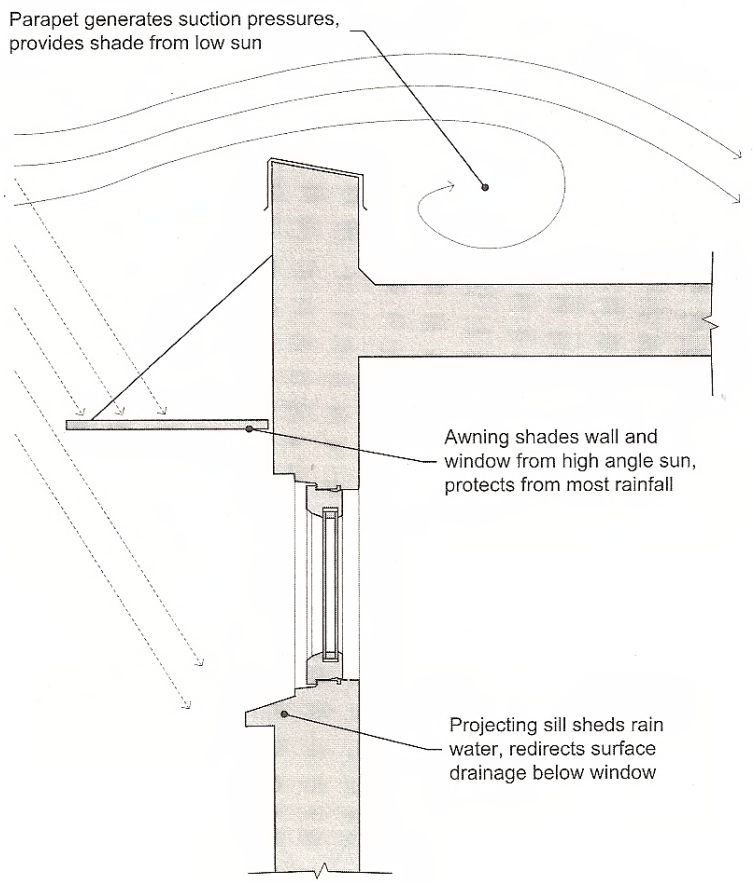

Figure 3.9: Enclosure-specific microclimate

Source: Straube & Burnett, Building Science for Building Enclosure, Chapter 3

Outdoor Design Conditions

Weather Data

- Heating design conditions*
  - generally occurs between 6:00 and 8:00 a.m. (suntime)
- Cooling/dehumidification design conditions*
  - generally occurs between 2:00 and 4:00 p.m. (suntime)
- Mean daily range
  - useful for summer cooling
- Heating degree days
  - useful for energy estimating
  - sometimes used in below grade approximations

* Used to be winter/summer percentiles, now annual percentiles

Solar Radiation

2009 ASHRAE Handbook—Fundamentals

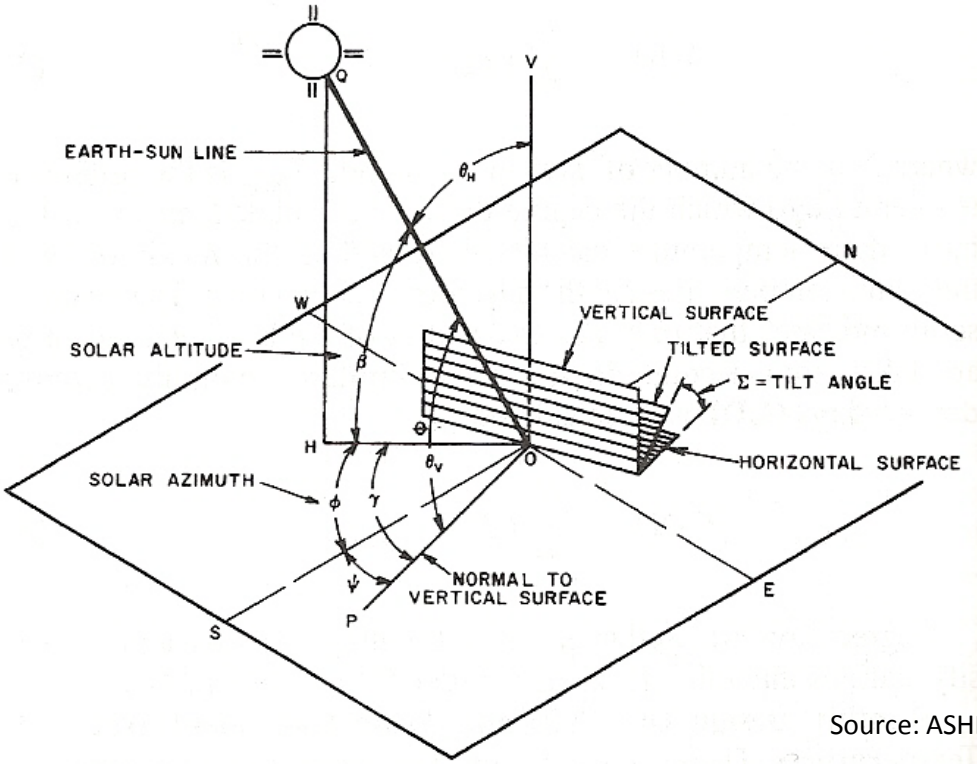

Fig. 3 Solar Angles for Vertical and Horizontal Surfaces

Source: ASHRAE Handbook of Fundamentals 2009, Chapter 14

Solar Radiation

Solar Gains by Surface

- July 21st
- @ 45° N. Latitude

Hour	North Wall	East Wall	South Wall	West Wall	Roof
1	0	0	0	0	0
2	0	0	0	0	0
3	0	0	0	0	0
4	0	0	0	0	0
5	32	71	5	5	9
6	**117**	472	38	38	119
7	83	651	68	63	286
8	87	**679**	107	82	454
9	97	606	209	97	595
10	107	457	318	107	704
11	114	252	394	114	772
12	116	126	**420**	126	**795**
13	114	114	394	252	772
14	107	107	318	457	704
15	97	97	209	606	595
16	87	82	107	**679**	454
17	83	63	68	651	286
18	**117**	38	38	472	119
19	32	5	5	71	9
20	0	0	0	0	0
21	0	0	0	0	0
22	0	0	0	0	0
23	0	0	0	0	0
24	0	0	0	0	0
TOTAL	1390	3820	2698	3820	6673

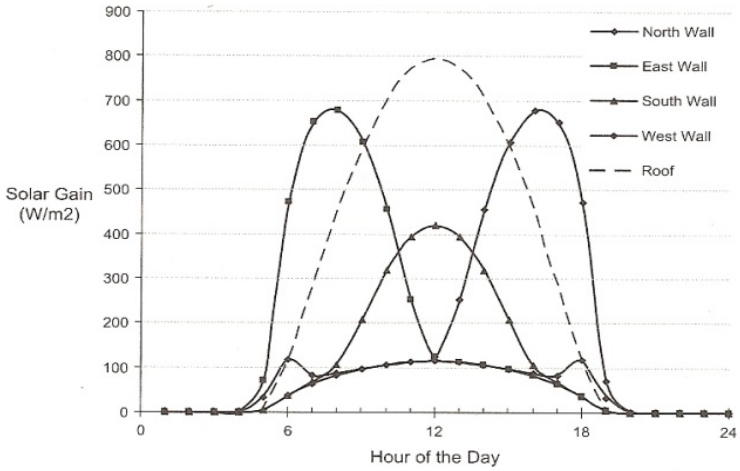

Figure 3.18: Solar gains - clear day values on July 21 at 45°N (W/m²)

Source: Straube & Burnett, Building Science for Building Enclosure, Chapter 3

Annual Rainfall

Climate Zones

– North America

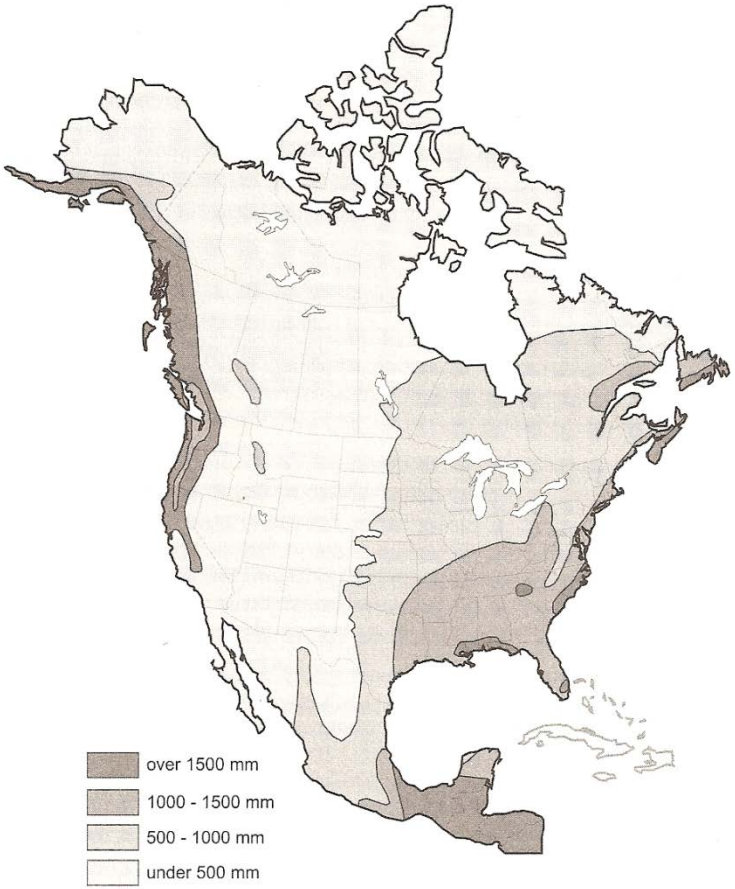

Figure 3.24: Average annual rainfall in North America

Source: Straube & Burnett, Building Science for Building Enclosure, Chapter 3

Unconditioned Spaces

Predicting Temperatures

- Generally between indoor and outdoor conditions
- Function of heat gain from conditioned space relative to heat loss to outdoors

- Rule of thumb
  - cooling mode: $t_u = t_i - 0.667(t_i - t_o)$
  - heating mode: $t_u = t_i - 0.50(t_i - t_o)$

In Summary

Questions and Discussion

Preview for Next Class

- Intro to Air Exchange
  - Basic concepts
  - Terminology

- Readings
  - HPE: Chapter 3.2
  - HPE: Appendix B.11