2. Climate (Outdoor)

**Weather** - General atmospheric conditions at a given place to a given time with respect to:
- Temperature
- Humidity
- Rain (precipitation)/snow
- Wind/air movement
- Radiation

It is a dynamic process from moment to moment, from day to night and from season to season.

**Climate** - The characteristic weather conditions of an area arranged over an extended period of time. Climate is defined by:
- Latitude
  - angle of solar radiation
  - Amount of solar energy
- Altitude
  - Density of the atmosphere
- Distance from the ocean
  - Store/release heat
- Conditions of the ocean
Climate interaction between a building and its environment
Wind

Wind is the motion of the air due to:

- Solar radiation
- Differential absorption of sun light between land and bodies of water
- Large ocean currents
- Temperature and pressure differences between air masses

Wind speed is a function of:

- Location
- Elevation
- Topography
- Surface roughness
- Exposure/surrounding
Wind Effects
Basic Wind Speed Map of the US

- Note that high wind is concentrated in the east coast. In Philadelphia area wind speed is around 100 mph.
**Wind Pressure**

- Wind, when obstructed by buildings, creates pressure (see map)
- (static) \( q = 0.00256 V^2 \) (wind speed depending on location - see map)
- Design pressure, as defined in building codes, is expressed in terms of the static pressure and other factors
Wind Pressure and Suction
Climate Zones in the US
Precipitation

**Forms**
- Rain
- Mist
- Dew
- Snow
- Sleet
- Hail

**Process**
- Hydrologic Cycle

Water evaporates

Precipitation dependent on temperature and wind

Ground water
Precipitation - continued

Rain

- Expressed as average annual rainfall varies from 10” or less to 80-100 inches (see map)

Rain and Wind

- Is most critical in rain penetration through building envelope. Expressed as *Driving Rain Index*. 
Driving Rain Index (DRI)

It reflects the effect of amount of rain and wind speed.

DRI is the product of annual precipitation less 1/10 of snow, hail, sleet in mm and average annual wind speed in m/sec divided by 1000. A measure of the ability of rain to penetrate the building envelope.
Precipitation and Rain Index in the US
Mechanics of rain penetration

1. Wind momentum to raindrops ----> water will get into holes and gaps (driven rain by wind through holes and gaps).
2. Capillarity - surface tension will draw water through cracks or holes (>1.0mm).
3. Surface Absorption - such as in brick, stucco and wood -- evaporation reduces surface absorption.
4. Thermal Pumping - (pressure differential) High temp ---> lower temp
   High pressure ---> lower pressure
   Airflow with moisture
Snow

- An important form of precipitation, particularly for horizontal surfaces/roofs
- 8-10” of snow = 1” of water
- Wind can blow snow and increase its effect on roofs
- In the US average annual snowfall varies from 0 to 6 feet max (see map)
Cycles of freezing and thawing can be destructive to envelope materials that are absorbent to water. Quality of material has to increase with the increase of # of cycles -- varies from 0 ---> 130 (see map)
Annual Freeze-Thaw Cycles

Impact the choice of the quality of the cladding material.

Ex. For brick veneer brick types:

- SW SW NW
- Severe
- Mod.
- Negligible

This classification is mainly dependent on # of F-T cycles.
Climate (Indoor)

Why ? need to control

2. Comfort to people
   1. Temperature 68-72°F
   2. RH 25-75%

3. Building contents - particularly RH
   1. Art galleries/museums

4. Doors/windows

5. Envelope design/condensation
Indoor water vapor

Sources
2. Human breath
3. Cooking
4. Combustion
5. Washing/laundry
6. Planting

Quantities, see table in text

Example: for 1000ft house (cavity, cons floor, pitched tile roof) may contain 750-1000 gallons of water. A fully exposed house should evaporate 50%.
Approach

In humid climates - indoor vapor pressure must be able to drop towards the outdoor level within 1/2 a day.

In dry climates - indoor vapor pressure needs to be retained and the aim then becomes a vapor-tight envelope.
Vapor Diffusion

**Natural**
- Ducts/openings/mat-absorption
- Stack power (like in chimney)
- Wind (infiltration/exfiltration)

**Forced**
- Fans
- Dehumidifiers
- Air-conditioning
Orientation

In temperate climate, such as the US, orientation significantly affects microclimate, so that each side of a building has its own unique set of conditions.

Examples:

- South facing building envelope are much warmer than those facing north.
- Southern exposures can develop summer surface temperatures of 120-140°F even in mild climates. Has adverse effect on material, durability, sealant, coatings, etc.
- Southern exposure can be warm and dry in winter while the north side is damp and shady.
- Southern exposure walls will experience more cycles of freeze-thaw then the north wall because of the longer range of temp, fluct, see graph.
# Sources of indoor vapor/humidity

<table>
<thead>
<tr>
<th>Source</th>
<th>Quantity of water (litres)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Human Breath</strong></td>
<td></td>
</tr>
<tr>
<td>resting or sleeping</td>
<td>.04 per/h/person</td>
</tr>
<tr>
<td>sedentary</td>
<td>.05 per/h/person</td>
</tr>
<tr>
<td>heavy work, sweating</td>
<td>Upwards of 0.1 per/h/person</td>
</tr>
<tr>
<td><strong>Family cooking</strong> (but excluding vapor from gas if cooking fuel)</td>
<td>0.9-3.00 per day</td>
</tr>
<tr>
<td><strong>Combustion</strong> (flueless appliances)</td>
<td></td>
</tr>
<tr>
<td>Gas (typical)</td>
<td>0.65 per hour</td>
</tr>
<tr>
<td>Gas, basic rate, heaters</td>
<td>0.80 per m$^3$</td>
</tr>
<tr>
<td>Paraffin heaters</td>
<td>1.00 per litre of fuel</td>
</tr>
<tr>
<td><strong>Household washing and laudering</strong></td>
<td></td>
</tr>
<tr>
<td>clothes washing indoors</td>
<td>0.5-1.8 per day</td>
</tr>
<tr>
<td>clothes drying indoors</td>
<td>5.0-14.0 per day</td>
</tr>
<tr>
<td>Bath, shower, dishwasher (per person/house)</td>
<td>0.75-1.5 per day</td>
</tr>
<tr>
<td><strong>Planting</strong></td>
<td></td>
</tr>
<tr>
<td>Large pot plant, watering and transpiration</td>
<td>Up to .85 per day</td>
</tr>
</tbody>
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