A fjord behind the town of Ilulissat in Greenland. Melting land ice accounts for about half the current rate of sea level rise, according to the latest research. Photograph: Reuters.
Lecture 01

Content Goals

• What Causes Rising Sea Level
• Numbers and Scientific Notation
• Conversion Factors
• Other Scales (Temperature)
Glacier Recession

Bear Glacier, Alaska

1980 → 2011
Glacier Recession

Pine Island Glacier, Antarctica
Thermal Expansion
Rise in Mean Sea Levels

Global mean sea level from TOPEX/Poseidon, Jason-1, and Jason-2

Change in mean sea level [mm]

Trend: $2.9 \pm 0.4$ mm/year

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Rise in Mean Sea Levels

• Increase in Ocean Mass (Fresh Water from Land)

• Melting Glaciers and Ice Sheets
  (Glacier: a slowly moving mass or river of ice formed by the accumulation and compaction of snow on mountains or near the poles.)

• Expansion of Water due to Increasing Temperature
ICLICKER QUESTION

Which of the following are believed to contribute to the rise in Global Mean Sea Levels:

a) Thermal Expansion of Water due to Increasing Average Temperature
b) Melting Glaciers and Ice Sheets
c) Increase of Ocean Mass due to Addition of Water from Land
d) All of the above
e) Just a) and c)
Numbers

Every day life:
• Most workers live within 25 miles from their job.
• Distance traveled for vacation 300-500 miles.

Outside of Earth:
• International space station is about 254 miles from the Earth’s surface.
• Average Earth-Moon distance: 238,900 miles.
• Average Earth-Sun distance: 92,000,000 miles
• Distance to nearest Star (Alpha Centauri): 26,000,000,000,000 mi
• Galactic width (Milky Way): 100,000,000,000,000 mi
• Width of the visible universe: 300,000,000,000,000,000,000,000,000 mi
Scientific Notation

Method for expressing and working with very large and very small numbers

3.45 x 10^{-2}
## Powers of 10 (Large Numbers)

### Correct but Impractical!

<table>
<thead>
<tr>
<th>Term</th>
<th>Value</th>
<th>Short-hand</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ten</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>One hundred</td>
<td>100</td>
<td>10²</td>
</tr>
<tr>
<td>One thousand</td>
<td>1,000</td>
<td>10³</td>
</tr>
<tr>
<td>One million</td>
<td>1,000,000</td>
<td>10⁶</td>
</tr>
<tr>
<td>One billion</td>
<td>1,000,000,000</td>
<td>10⁹</td>
</tr>
<tr>
<td>One trillion</td>
<td>1,000,000,000,000</td>
<td>10¹²</td>
</tr>
</tbody>
</table>

### Short-hand

- Ten = 10
- One hundred = 100
- One thousand = 1,000
- One million = 1,000,000
- One billion = 1,000,000,000
- One trillion = 1,000,000,000,000
Powers of 10 (Small Numbers)

• For numbers that have many zeros after the decimal point, we use negative powers of ten and count to the right of the decimal point (including the 1).

Examples: \(0.01 = 10^{-2}\) \(0.001 = 10^{-3}\) \(0.000001 = 10^{-6}\)

Property: Numbers with negative powers of 10 are reciprocals of numbers with the same positive powers of 10.

Example: \(\frac{1}{10^2} = 10^{-2}\)
Scientific Notation

• Write a number as the product of a number between 1 and 10 and a power of ten (positive or negative).

  • Examples:
    • $12000 = 1.2 \times 10^4$
    • $0.000033 = 3.3 \times 10^{-5}$

• To write a number in scientific notation:
  1) Move the decimal point to the first non-zero digit
  2) Count the number of positions you moved the decimal point;
     • if to the left, the power of 10 is positive
     • if to the right, the power of 10 is negative.
Multipliers

- $p = 10^{-12}$ (pico)
- $n = 10^{-9}$ (nano)
- $\mu = 10^{-6}$ (micro)
- $m = 10^{-3}$ (milli)
- $1 = 10^0$
- $k = 10^3$ (kilo)
- $M = 10^6$ (mega)
- $G = 10^9$ (giga)
- $T = 10^{12}$ (tera)
ICLICKER QUESTION

One million can be written as:

a) 100,000
b) $10^8 / 10^2$
c) 1,000,000,000
d) $10^4 \times 10^8$
e) $10^3 \times 10^4$
One million can be written as:

a) 100,000
b) $10^8 / 10^2 = \frac{10^8}{10^2} = 10^{8-2} = 10^6 = 1,000,000$
c) 1,000,000,000
d) $10^4 \times 10^8$
e) $10^3 \times 10^4$
Some Conversion Factors

Length:
• 1 $mi = 1.609 km = 1609 m$
• 1 $in = 2.54 cm$
• 1 $ft = 12 in$

Time:
• 1 $year = 365 days$
• 1 $day = 24 hr$
• ...
Example:

Using the data below determine what is a marathon in miles (mi).

• 1 Marathon = 42.195 km
• 1 mi = 1.609 km

\[
\frac{1 \text{ mi}}{1 \text{ mi}} = 1 \quad \frac{1}{1} = \frac{1 \text{ mi}}{1.609 \text{ km}} \quad 1 = \frac{1.609 \text{ km}}{1 \text{ mi}}
\]

\[
42.195 \text{ km} \times \frac{1 \text{ mi}}{1.609 \text{ km}} = 26.22 \text{ mi}
\]

1 Marathon = 26.22 mi
Temperature Scales

• What is the freezing temperature of water in both Fahrenheit and Celsius?

\[ 32°F = 0°C \]

• boiling temperature?

\[ 212°F = 100°C \]

• Celsius-to-Fahrenheit

\[ T_F = \left( \frac{9}{5} \right) T_C + 32 \]

• Fahrenheit-to-Celsius:

\[ T_C = (T_F - 32) \left( \frac{5}{9} \right) \]
In Class Activity

• A typical gasoline vehicle produces about 4.8 metric tons of CO\(_2\) (carbon dioxide) per year.
  (This assumes average fuel economy of about 21 miles per gallon and driving about 12,000 per year. We will do this calculation later in the semester.)

• The average car lifespan in the USA is about 8 years.

• 1 mile = 1.6 km, 1 Metric ton = 1.0 \times 10^6 g

• CO\(_2\)e/km \rightarrow Carbon Dioxide Emissions Per kilometer.
### Electric Cars' Carbon Emissions: g CO₂e/km

<table>
<thead>
<tr>
<th>Country</th>
<th>Emissions</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>370</td>
</tr>
<tr>
<td>South Africa</td>
<td>318</td>
</tr>
<tr>
<td>Australia</td>
<td>292</td>
</tr>
<tr>
<td>Indonesia</td>
<td>270</td>
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<tr>
<td>China</td>
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<tr>
<td>Iceland</td>
<td>70</td>
</tr>
<tr>
<td>Paraguay</td>
<td>70</td>
</tr>
</tbody>
</table>

**Power Source**
- Coal Based
- Fossil Heavy
- Broad Mix
- Fossil Light
- Low Carbon

Note: Results include emissions for vehicle manufacturing, direct grid emissions, indirect grid emissions and losses. Based on national averages for 2009.

Sources: DEFRA, GHG protocol, IEA, EPA, GREET, LCA literature

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In Class Activity Data

• A typical gasoline vehicle produces about 4.8 metric tons of CO₂ (carbon dioxide) per year.
  (This assumes average fuel economy of about 21 miles per gallon and driving about 12,000 per year. We will do this calculation later in the semester.)

• The average car lifespan in the USA is about 8 years.

• 1 mile = 1.6 km, 1 Metric ton = 1.0 × 10⁶ g

• CO₂e/km → Carbon Dioxide Emissions Per kilometer.

• E-car’s carbon emissions in the US: 202 CO₂e/km