ME4252 Nanomaterials for Energy Engineering

Introduction to Nanomaterials

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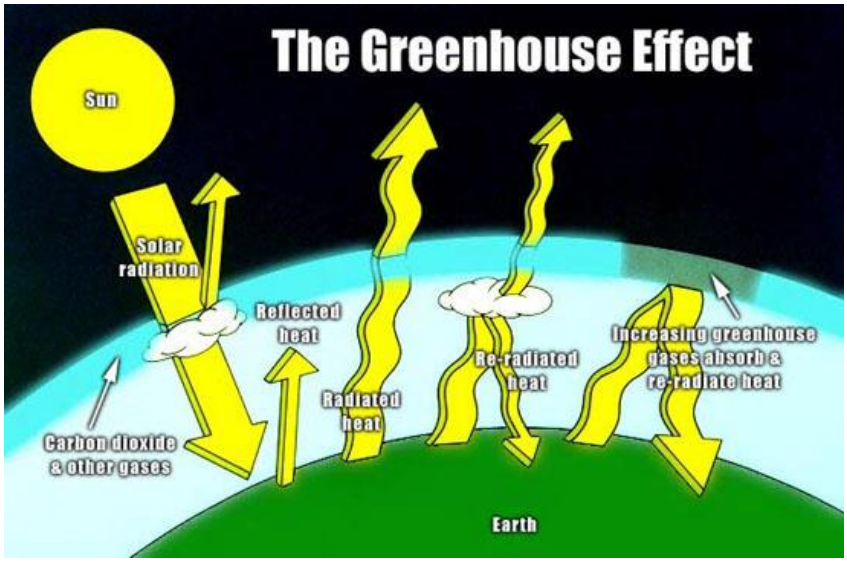
Climate Change - Global Warming



http://www.odec.ca/projects/2005/stro5c0/public_html/greenhouse_effect.jpg

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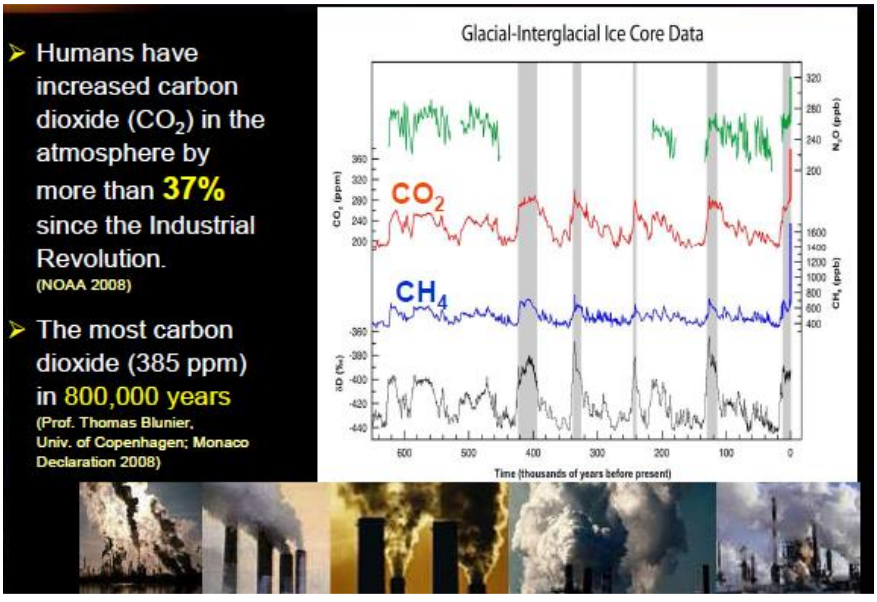
CO_2: Most Significant Greenhouse Pollutant



AR4, IPCC 2007

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What do these pollutants do?
Global fever!

Greenhouse gases make the earth too hot - just like sleeping under a thick blanket in summer time

Our atmospheric "blanket" is over 37-45% thicker than it was used to be..

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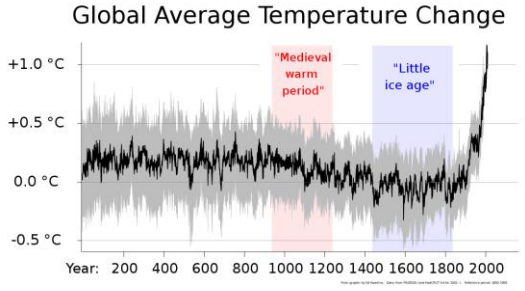
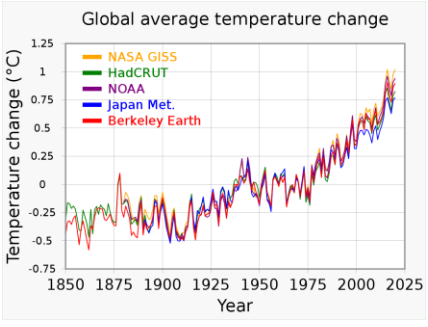
Global Warming





Global temperature record - Wikipedia

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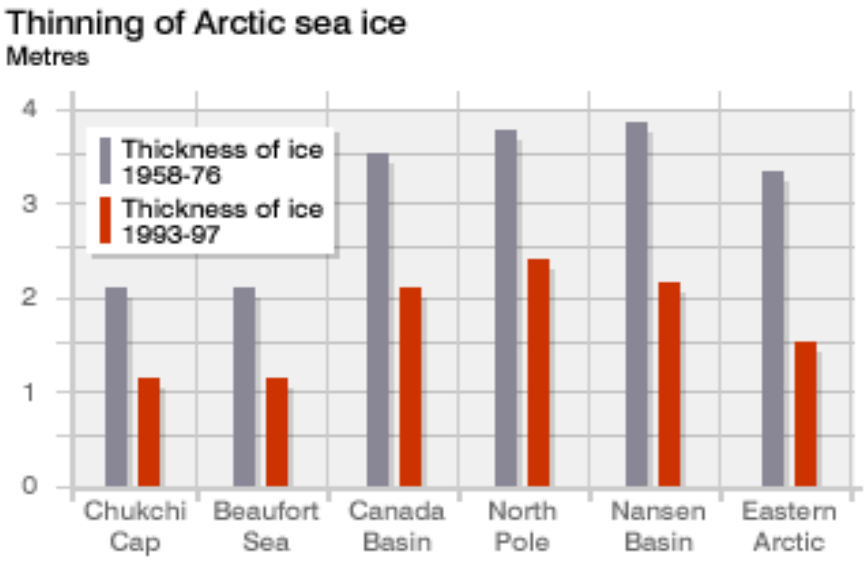
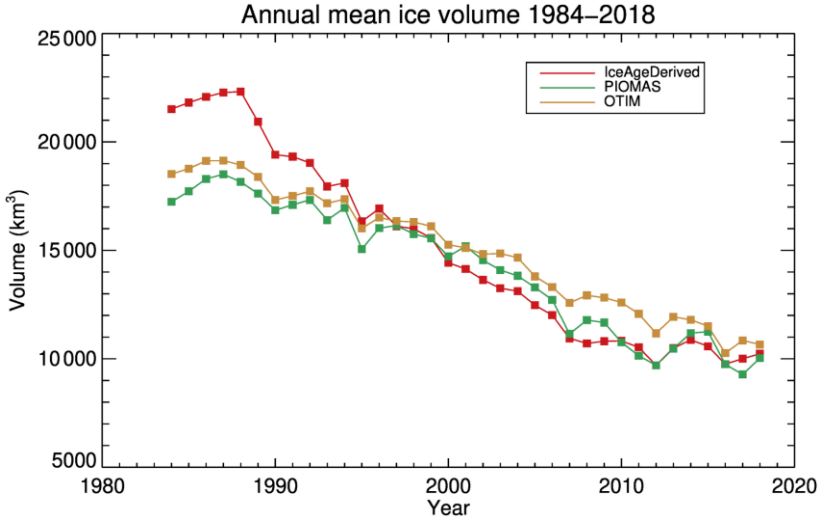
Thinning Ice



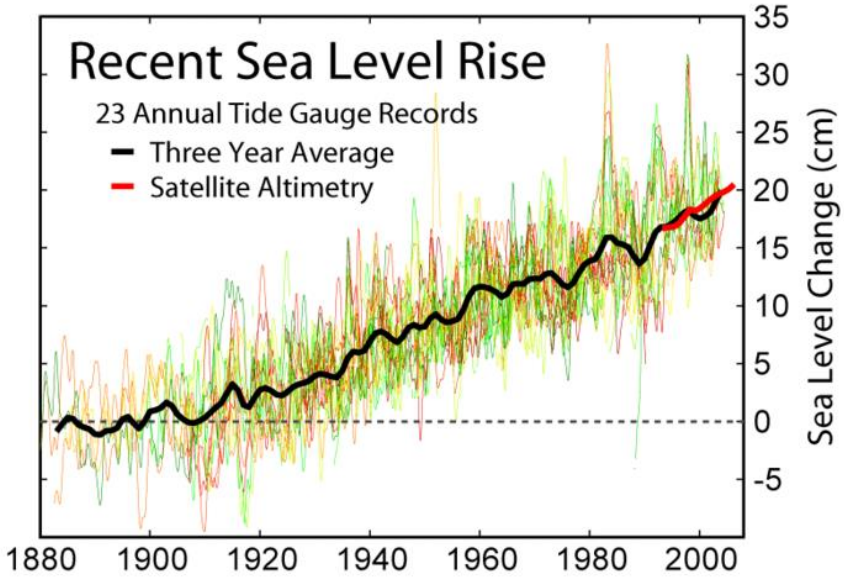
SOURCE: UNEP

Thinning Ice



Y. Liu et al., The Cryosphere, 14, 1325–1345, 2020

Sea Level Rise



http://wildwildweather.com/forecastblog/2008/09/

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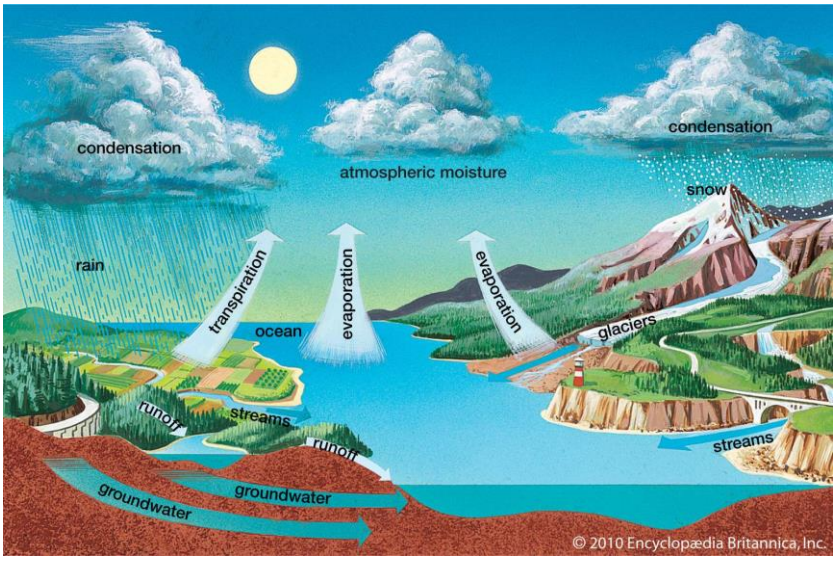
Global Warming



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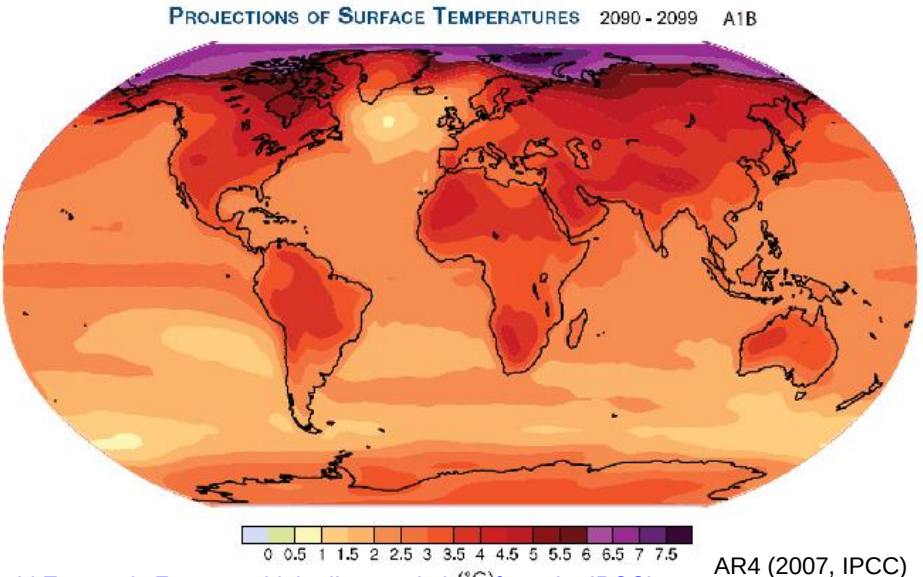
A Warmer Future



AR4 (2007, IPCC)

World Economic Forum on LinkedIn: 5 red alerts from the IPCC's latest report. Find more vital information | 259 comments

What is Nanomaterial?

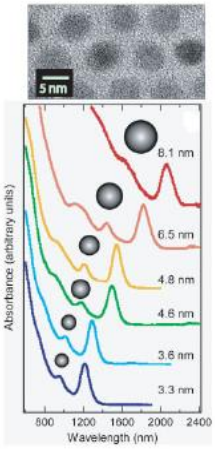
Nanomaterials are commonly defined as materials with an average grain size **less than 100 nanometers**

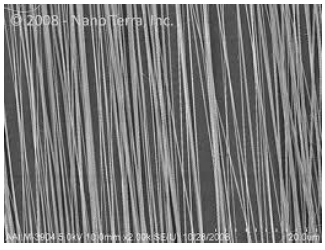
1 nm = 10^{-9} m

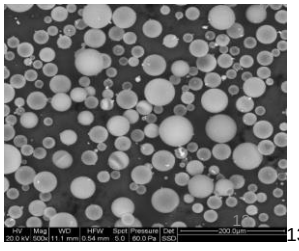
- The average width of a **human hair** is on the order of **100,000 nanometers**
- A single particle of **smoke** is in the order of **1,000 nanometers**

Nanomaterial Shapes

- Nanomaterials can be nanoscale in **zero dimensions** (quantum dots for solar cells)
- **One dimensions** (nanowire or nanofibers)
- **Two dimensions** (graphene sheets etc.,)
- **Three dimensions** (particles etc.,)







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Why Nanomaterials ?

Nanotechnology exploits benefits of ultra small size, enabling the use of particles to deliver a range of important benefits or properties:

- Thermodynamics
- Electrical conduction
- Thermal conduction
- Mechanical properties

Energy systems:

Energy harvesting (solar cells, fuel cells and thermo-electrics)

Energy storage (lithium-ion batteries and supercapacitors)

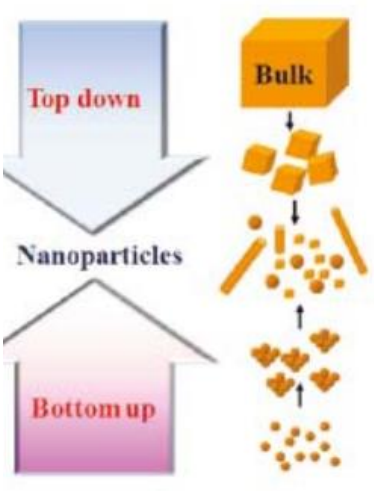
Why?

Surface/interface contributions become enormously important.

- Behavior of nanomaterials may depend more on **surface area** than particle composition itself.
- Relative-surface area is one of the principal factors that enhance its reactivity, strength and electrical properties.

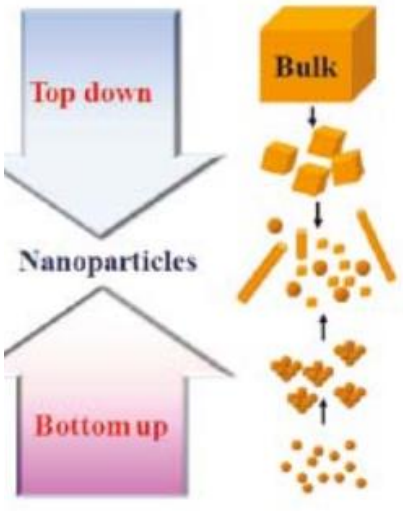
Approaches

- **Top-down** – Breaking down matter into more basic building blocks. Frequently uses chemical or thermal methods.
- **Bottoms-up** – Building complex systems by combining simple atomic-level components.



Methods for Creating Nanostructures

- **Mechanical grinding** example of (top-down) method
- **Wet Chemical** example of both (top-down) & (bottom up)



Topics to be covered (only for guidance)

Weeks 1, 2 and 3

1. Introduction to nanomaterials, semiconductor, ionic conductor and mixed conductor; Measurement of transport properties (impedance spectroscopy).

Week 4

2. Nanomaterials synthesis: solid state and solution approaches, calcination and sintering; characterization of nanomaterials.

Weeks 5 and 6

3. Physical properties of nanostructured materials
3.1 Thermodynamics
3.2 Electrical conductivity

Weeks 7, 8, 9 and 10

4. Energy conversion and storage using nanostructured materials
4.1 Solar Cells
4.2 Fuel cells
4.3 Thermo-electrics (Guest Lecture)
4.4 Rechargeable batteries
4.5 Supercapacitors

Weeks 11 and 12

5. Engineering aspects and challenges to be faced
5.1 Designing miniaturized devices: fuel cells and batteries
5.2 Safety issues

Weeks 13: Revision

Total Assessment: 100%

- **CA: 40%** (two quizzes)
- **Final Examinations: 60%**