WASEEM – 2
Water
<u>Air</u>
Soil
Energy
Ecosystem
Minerals

Air Pollution

Agenda, Class 18, June 6

- Reminders:
  - Tues, June 11, Due: Individual Summary for Presentation 2
  - Thurs, June 13, Quiz 3
- 1:30-2:00
  - Lecture: Air Pollution
- 2:00-3:05
  - Activity: CA Climate Change
- 3:05-3:15
  - Share with class

Class 18 Activity: Climate Change and California

OEHHA: https://oehha.ca.gov

1. What is OEHHA?

Under OEHHA's homepage, go to Environmental Topics – Climate Change – Indicators of Climate Change in California – Explore the Indicators (https://oehha.ca.gov/climate-change/2018-indicators-climate-change-california)

1. Summarize the following four sections using the Overviews: a) Climate Change Drivers, b) Changes in Climate, c) Impacts on Physical Systems, d) Impacts on Biological Systems.

2. Pick one sub-section from Impacts on Physical Systems and summarize what you learned.

3. Pick one sub-section from Impacts on Biological Systems and summarize what you learned.

4. What was the biggest take away for you personally? Why?

Consider exploring OEHHA's website for relevant information on your presentation 2 topic.

Class 18 Activity: Climate Change and California

California's Fourth Climate Change Assessment:
http://www.climateassessment.ca.gov

1. What is the Climate Change Assessment?
2. When was the Fourth Assessment released?
3. How many regional assessments are there? Which regional assessment(s) is/are relevant for you? Why?

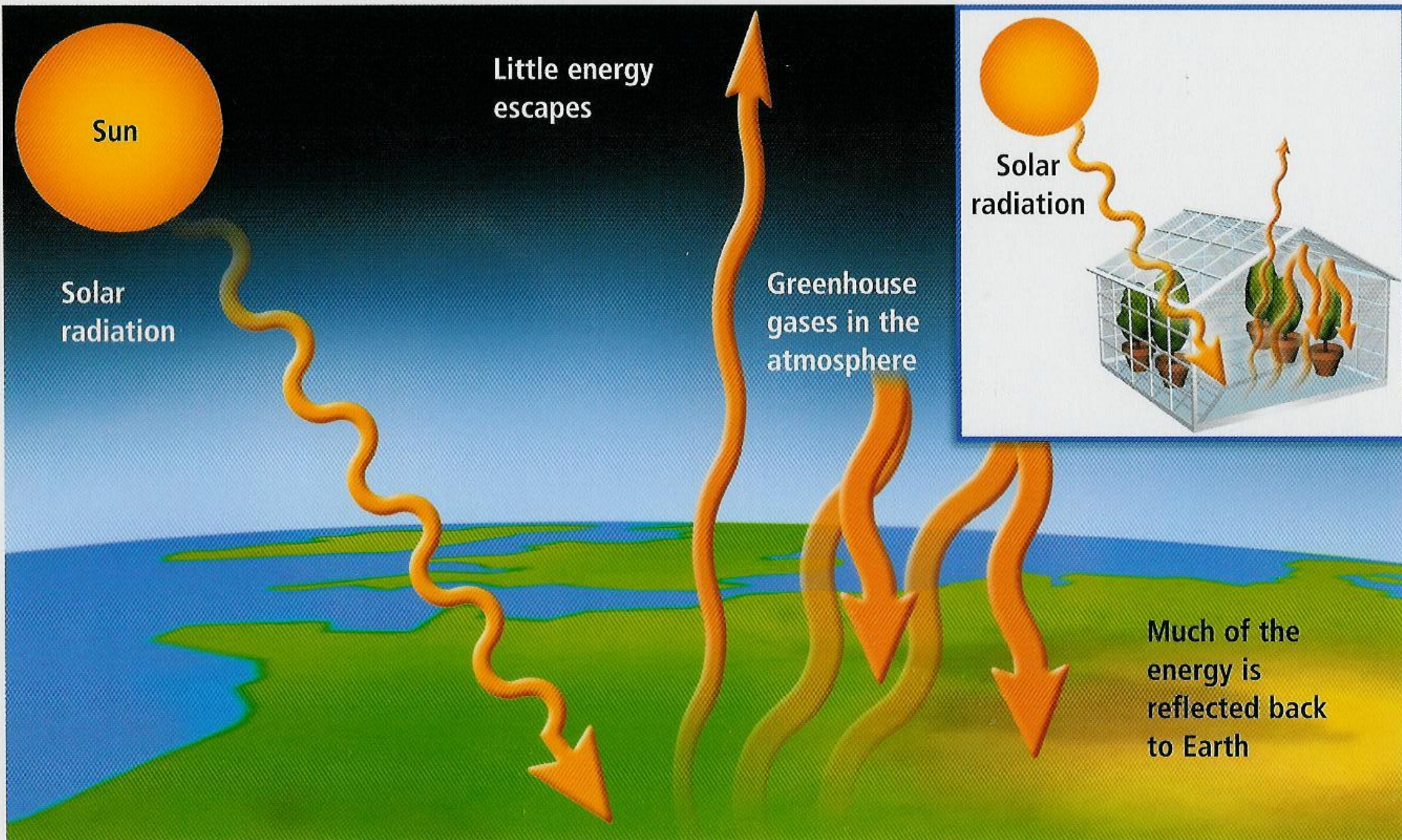*For the statewide summary, go to "Key Findings" and download the brochure and summarize the following sections*
1. Why Study Climate Change in California?
2. How is California's Climate Projected to Change?
3. Impacts of Climate Change on People
4. Impacts of Climate Change on Infrastructure
5. Impacts of Climate Change on Natural and Working Lands and Waters
6. Impacts of Climate Change on the Ocean and Coast

7. Building Capacity to Address Local Impacts
8. What was the biggest take away for you personally? Why?

Global Warming Recap

- Slides 3-11 are a recap of Global Warming and Climate Change
- Things to thoroughly understand
  - Natural Greenhouse Effect
  - Greenhouse Gases
  - Human-enhanced Greenhouse Effect
  - Difference between Climate and Weather
  - Why Global Warming causes Climate Change
  - How Species are impacted by Climate Change and Ocean Acidification

Greenhouse Effect

Little energy escapes

Sun

Solar radiation

Greenhouse gases in the atmosphere

Solar radiation

Much of the energy is reflected back to Earth

Natural Greenhouse Effect Absolutely Necessary for Life on Earth

What is a Greenhouse?

- **Structure made of glass**
- **Allows light in/out**
  - **Soil and plants absorb visible and UV energy**
  - **Emit heat energy**
- **Glass keeps heat in**
  - **Does not allow emitted heat energy to get out**
  - **Gets hotter inside**
- **This is good for plants in cold climates and seasons**
  - **Makes it possible to grow fruits and vegetables in Alaska or tomatoes in winter in California**

Normal Air is a Collection of Gases:

78% Nitrogen (N_2)

21% Oxygen (O_2)

<1% Carbon Dioxide (CO_2), Argon (Ar), and other gases
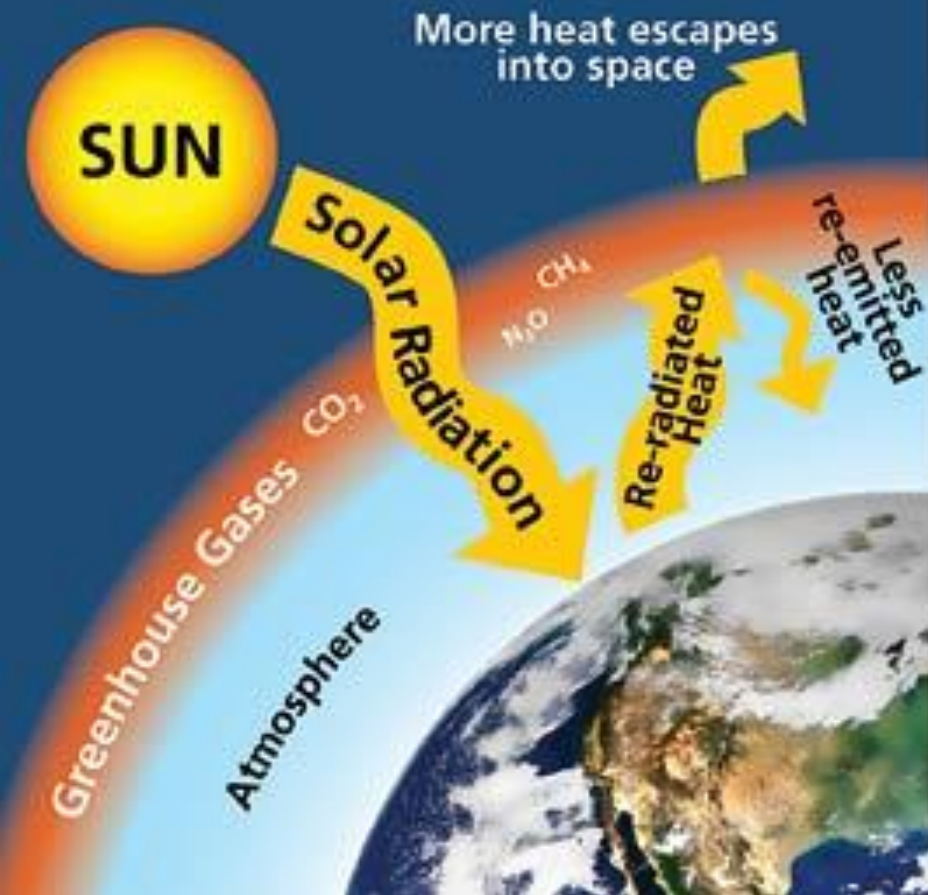
Varying amounts of Water Vapor

Earth's Atmosphere is a Natural Greenhouse

Beneficial to Earth's Ecosystems
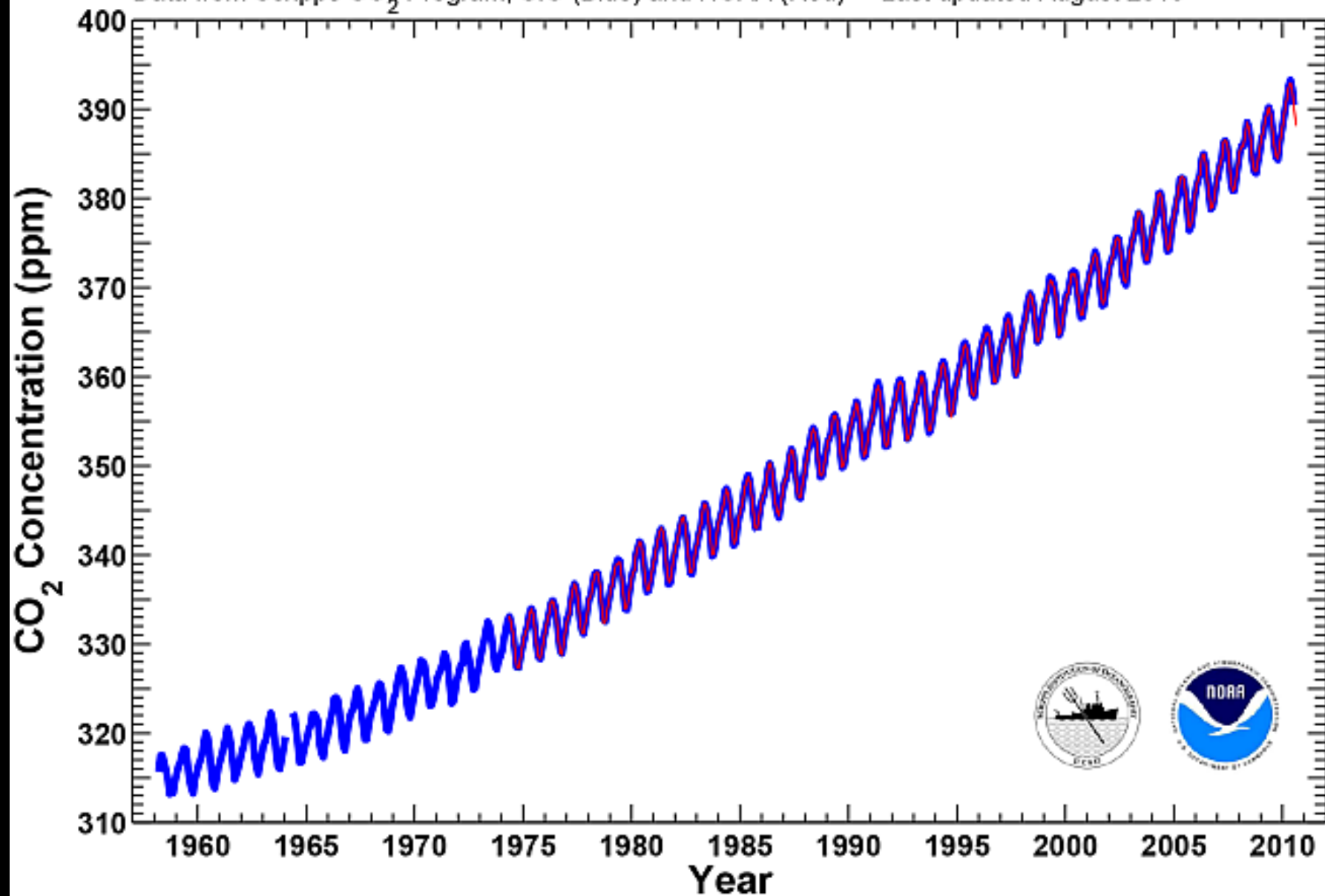
Damaging to Earth's Ecosystems

Green House Effect

Occurs in the troposphere, with gases able to absorb heat

- **N_2 (Nitrogen) and O_2 (Oxygen), not greenhouse gases**
  - Do not absorb heat, hence do not contribute to the greenhouse effect
- **Greenhouse Gases: H_2O, CO_2, CH_4 (Methane), N_2O (Nitrous Oxide), SO_2 (Sulfur Dioxide), CFCs (ChloroFluoroCarbons)**
  - Absorb heat, trap some of it making the troposphere warmer
  - Amount of water vapor (H_2O) depends on climate and weather. The others are present in trace amounts
  - CFCs do not occur in nature. The others occur naturally and also by human activity
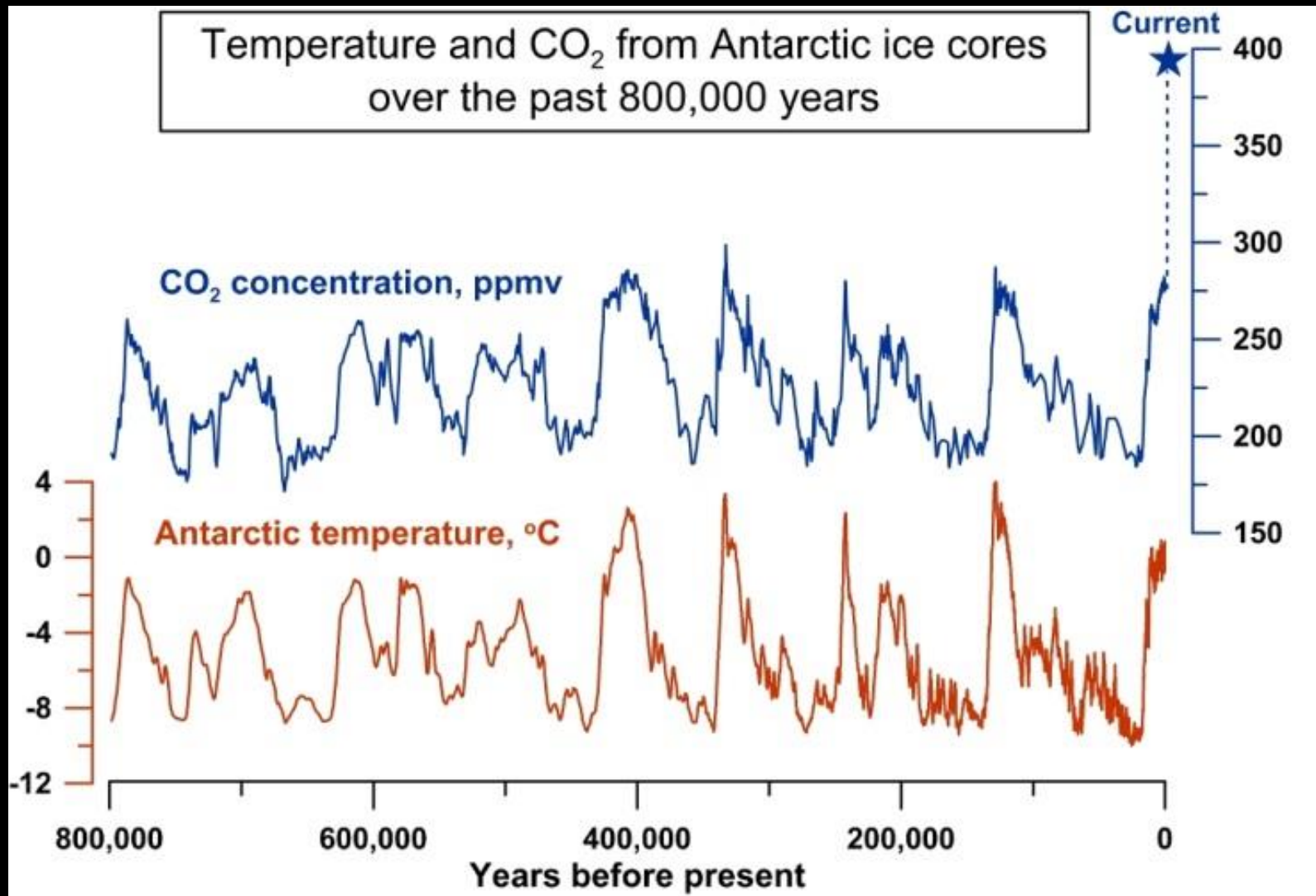 - CO2 is the longest living, nearly a century. CH4 is dissipated faster, but it contributes more to warming

Mauna Loa Observatory, Hawaii
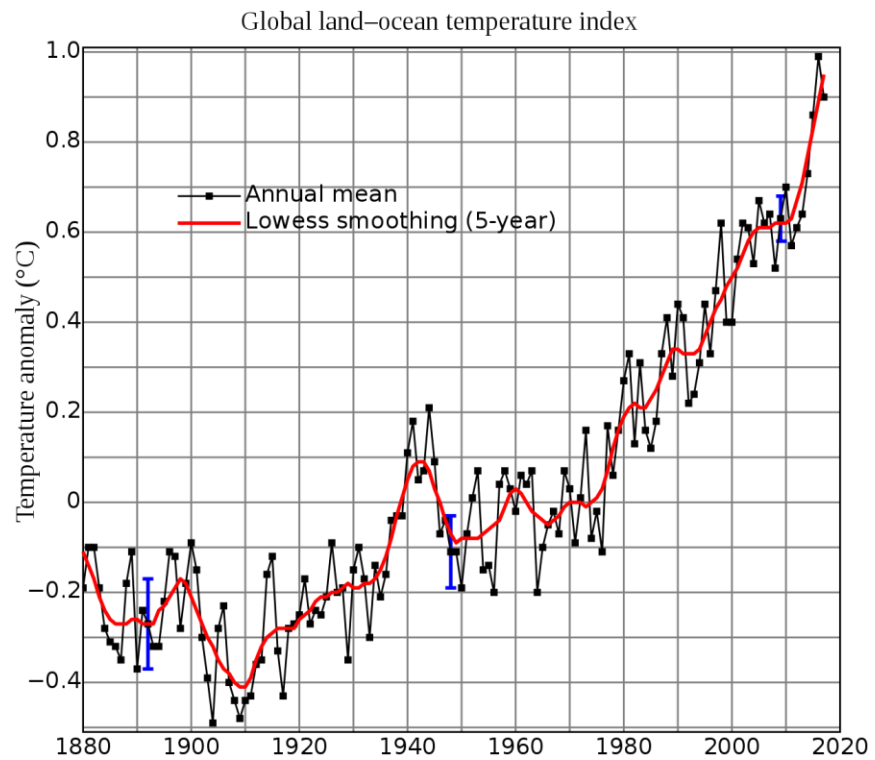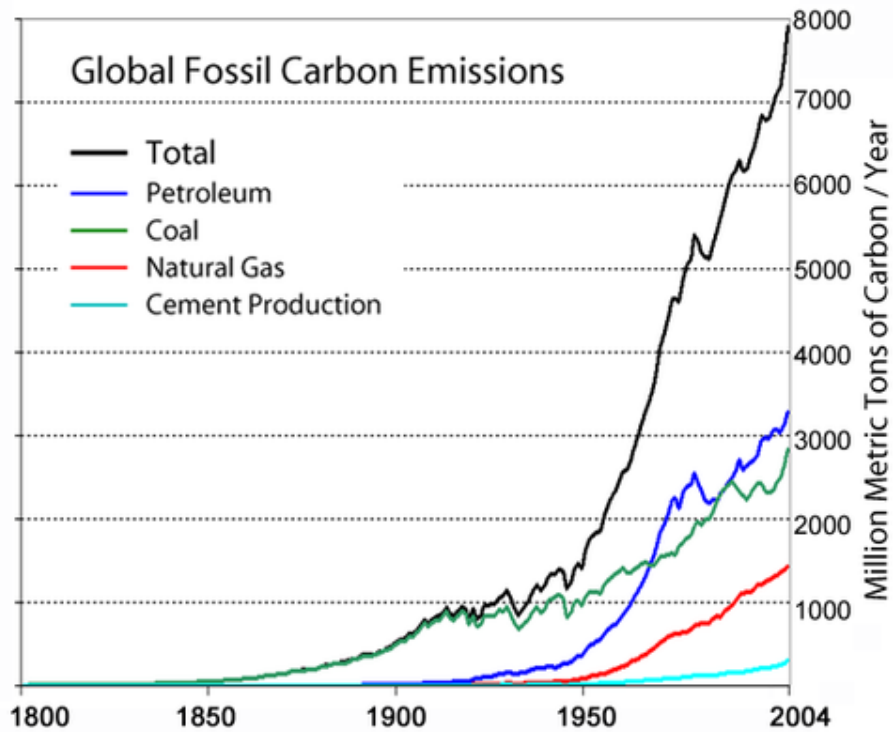Monthly Average Carbon Dioxide Concentration
Data from Scripps CO_2 Program, SIO (Blue) and NOAA (Red)   Last updated August 2010

CO$_2$ Concentration in Atmosphere and Temperature Correlate!

Temperature and CO$_2$ from Antarctic ice cores over the past 800,000 years

CO$_2$ concentration, ppmv

Antarctic temperature, $^{\circ}$C

Current

Years before present

Global Fossil Carbon Emissions
- Total
- Petroleum
- Coal
- Natural Gas
- Cement Production

Global land–ocean temperature index
- Annual mean
- Lowess smoothing (5-year)

The Other GHG - Methane

- More potent (causes more warming), but short lived
- Source 1: Leaks from oil and gas facilities
  - Can be controlled with RACT (Reasonable and Available Control Technologies)
- Source 2: Sources related to Climate Change
  - Small but non-zero probability of
    - Quick release of huge amounts of methane from thawing permafrost
    - Release of methane from underwater methane "hydrates" from warming Ocean floor
  - Referred to as "Methane bomb"
  - Could trigger **extinction-level warming**
  - http://earthsky.org/earth/global-methane-levels-hitting-new-highs

How Should Humans React?

- Mitigation
  - Lower global temperature = reduce GHG emissions
- Adaptation
  - How to help countries like Maldives?
  - How should California prepare for the future?
- Who pays for Mitigation and Adaption?
- If we don't act now, who will be affected?
  Find out during In-class activity

Other Impact of Fossil Fuels

- **Visible air pollution**
  - **Extremely hazardous to human health**
  - **Burning fossil fuels for industry and heating**
    - *US Cities air quality worsened by car emissions*
    - *CA Central Valley worsened by spraying of fertilizers and "-icides" (aerosols)*
    - **Geographical Valleys and Basins fare worse**
  - **Much better since passage of Clean Air Act and amendments from the 50's through 90's**
  - **Regulated by EPA and regional Air Quality Management Districts**
    - *E.g., Bay Area Air Quality Management District*
    - *Air quality monitored by National Ambient Air Quality Standards (NAAQS)*

Telegraph.co.uk

Air Pollutants

Solid or gas particles not part of natural air and are unhealthy

1. Primary Air Pollutants

   – Directly emitted from a source (e.g., CO, CO_2, NOx, VOC)

2. Secondary Air Pollutants

   – Formed from reactions of primary air pollutants under certain conditions (e.g., ground level O_3)
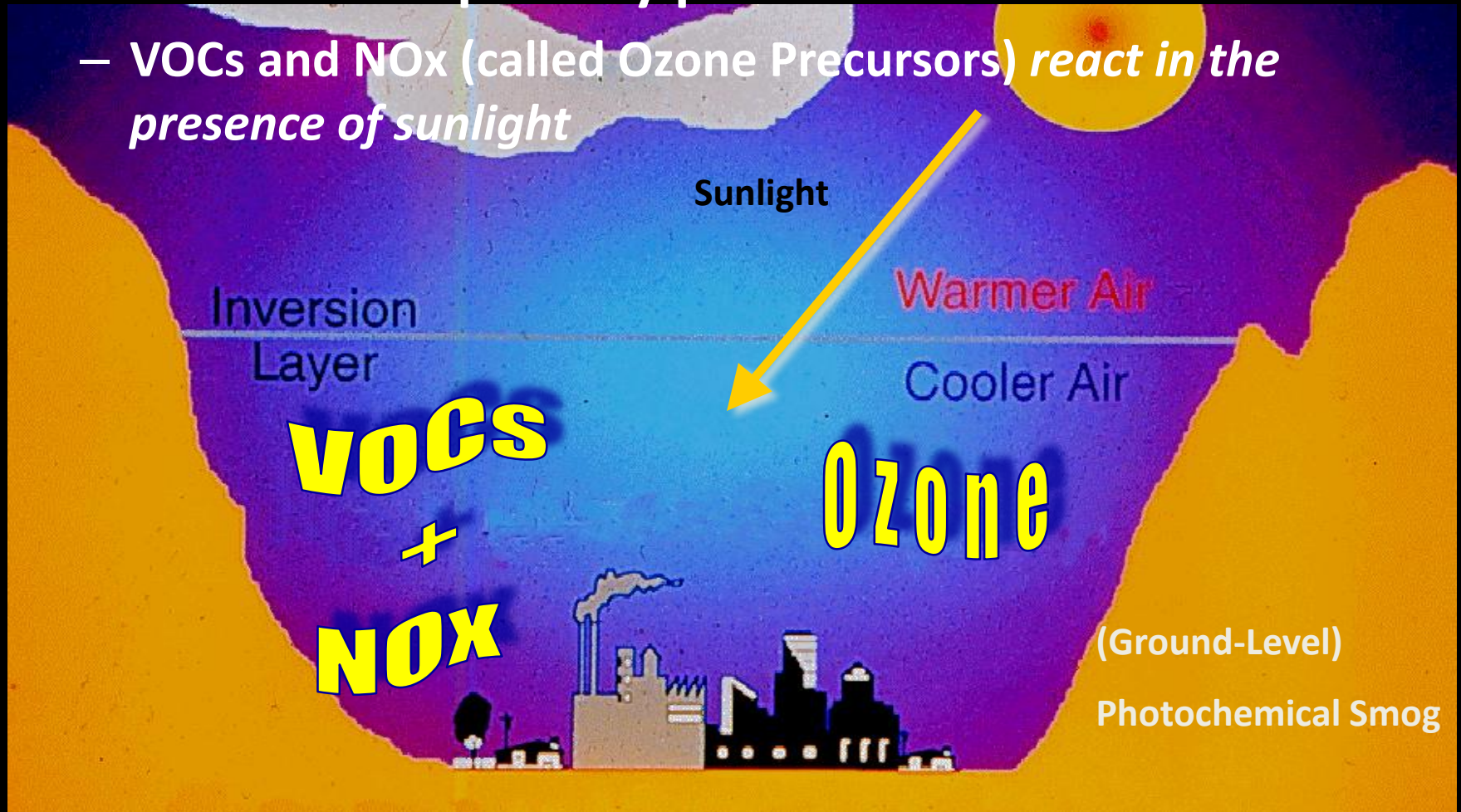
**Primary Air Pollutants
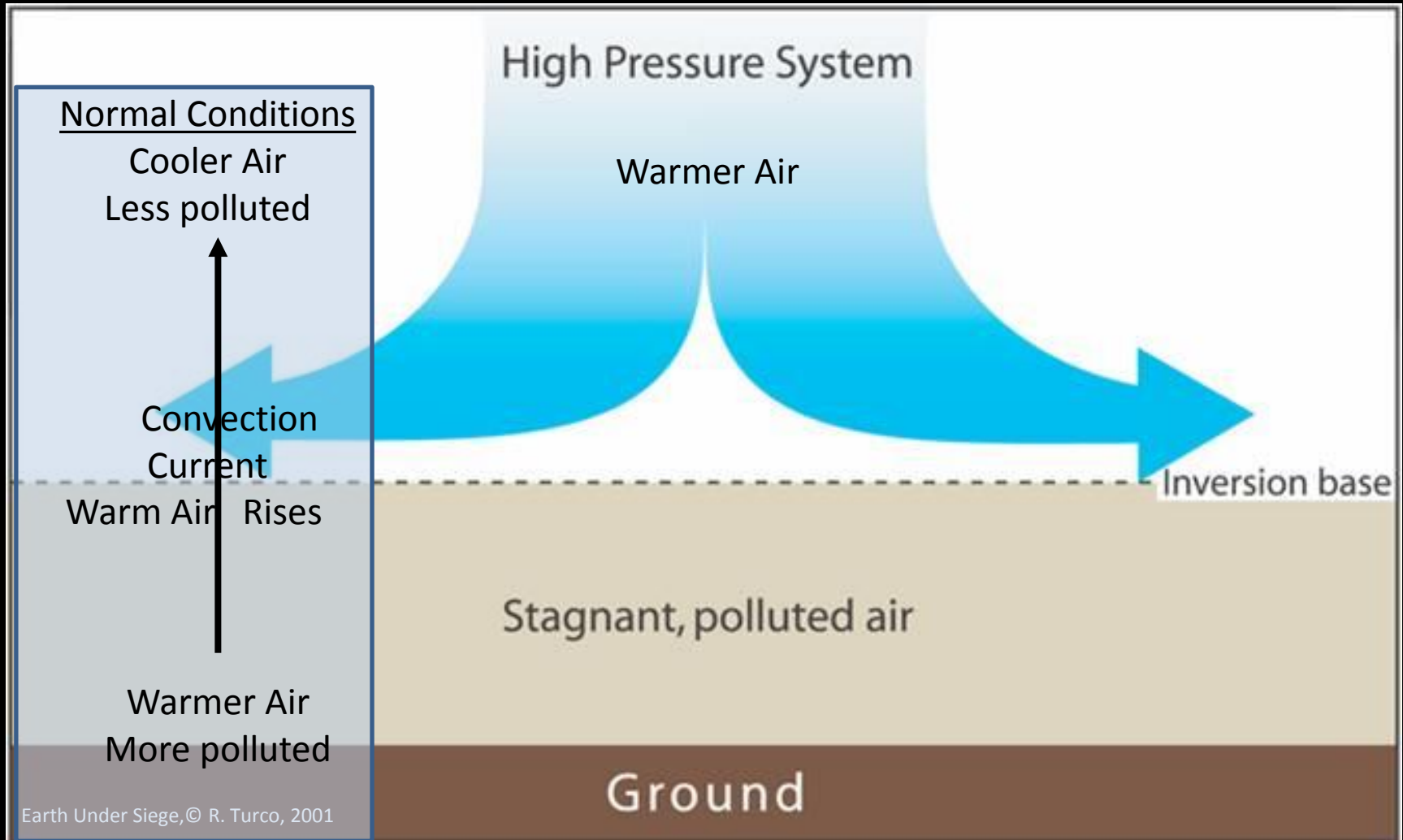VOCs (Volatile Organic Compounds)**

Secondary Air Pollutants

- **E.g., Ground-Level Ozone (O_3), "The Bad Ozone"**
- **Main component of photochemical smog**
- **Produced from primary pollutants**
  - **VOCs and NOx (called Ozone Precursors)** *react in the presence of sunlight*

Sunlight

Inversion Layer

Warmer Air

Cooler Air

VOCs + NOx

Ozone

(Ground-Level)

Photochemical Smog

Inversion Layer

High Pressure System

Warmer Air

Normal Conditions
Cooler Air
Less polluted

Convection
Current
Warm Air   Rises

Warmer Air
More polluted

Earth Under Siege,© R. Turco, 2001

Inversion base

Stagnant, polluted air

Ground

Learn more during Presentation 2

Inversion Layer

- Normal
  - Air at higher altitudes cooler than air at lower altitudes
  - Convection occurs
    - Warmer ground level air will rise, and cooler air will fall
- Pollution is generally produced at ground level
  - Dissipated to upper atmosphere through convection
- Inversion Layer
  - Warmer Air at High Pressure in higher altitudes due to Weather conditions
  - Convection is less effective because the air above is already warmer
  - So there is less mixing of air between altitudes.
  - Traps the pollution at ground level.

Can We Predict Future Climate?

- Models used for predicting future climate
  - **Models are Mathematical equations**
  - **Validated (how do we know they are correct?)**
    - By predicting temperatures in the past
    - Checking if they match data on past temperatures
- Many inputs used in the model
  - **Some are data that can be obtained (measurements)**
  - **Some are guesses**
    - E.g., human behavior and policy
    - How much will CO_2 emissions reduce?
    - So model-based predictions have uncertainty, different from being wrong!