Global Warming and Climate Change

The Greenhouse Effect
- Solar Radiation Powers the Climate System
  - Carbon dioxide, Water vapor, Methane, Nitrous oxide

Industrial Pollution
- CAFO, Agribusiness

Deforestation
Some scientific conclusions have been so thoroughly examined and tested, and supported by so many independent observations and results, that their likelihood of being found wrong is vanishingly small. Such conclusions are then regarded as settled facts. This is the case for the conclusions that the Earth system is warming and that much of this warming is very likely due to human activities.

very likely = 90-99% probability

...strong evidence on climate change underscores the need for actions to reduce emissions and begin adapting to impacts.

Advancing the Science of Climate Change – National Academies: http://americasclimatechoices.org/
Weird weather-added heat in the Arctic (sea ice retreat) influences the jet stream and may make extreme weather and climate events more likely.

July, 2012 was the hottest month on record in the contiguous U.S. June-August hottest global land temperature ever recorded.

Drought of historic proportions – 4/5ths of U.S. On July 11, 2012 the U.S. Department of Agriculture announced more than 1000 counties in 26 states qualified as natural disaster areas – largest natural disaster in U.S. history.

Northern Hemisphere Temperature Anomalies, 1951-2011

"Extremely hot" summer temperatures have grown from occurring on 1% of the land area to 19% of the land area. 75% of land area experienced summers in the "hot" category during the past decade, compared to only 4% during the 1951 to 1980 base period.

Seasonal mean temperature 1951-1980 plotted at top of the curve. Decreasing in frequency to the right are "hot" anomalies (1-2σ), "very hot" (2-3σ), "extremely hot" (>3σ).
Global Winds Accelerating

Tropics expanding

Extreme rainfall events are more frequent

Extreme warm events in winter more prevalent than cold events


Hawai‘i Temperature Index

30-yr change = +0.9°F

30-yr change = +1.4°F

The Orographic Cloud

Condensation Inversion

Precipitation Trends (% per decade)


The world's ice is melting. In the past decade, the annual difference of melting and snowfall on Greenland tripled. 2010 set a record for melting on July 8, about 40 percent of the ice sheet had undergone thawing at or near the surface. In just a few days, the melting had dramatically accelerated and an estimated 97 percent of the ice sheet surface had thawed by July 12. Satellite Altimetry – global average 3.2 mm/yr

Regional MSL trends from Oct-1992 to Mar-2010 (mm/year)

Melting of glaciers 23 cm sea level rise by mid-century

http://www.youtube.com/watch?v=Vl4afq8Q5tg

Satellite Altimetry – global average 3.2 mm/yr

Antarctica losing 24 cubic miles of ice per year since 2002

Greenland is losing mass at about five times the rate today as it was in the early 1990s. Antarctica is losing mass at 50% higher rate today than it was in the early 1990s.

Semi-Empirical Models
IPCC Economic Scenarios, Population decline
A2Fi – Fossil fuel intensive
A2 – Balanced energy
B1 – Environmental emphasis

Last interglacial was warmer than today and Greenland partially melted

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National Research Council, 2012

- 8-23 cm (6 in) by 2030
- 18-48 cm (1 ft) by 2050
- 50-140 cm (3 ft) by 2100

Eemian Temperature and Sea Level
Red dots – temperature (sea surface, ice cores, pollen)
Green line – model of temperature data
Blue – B1, 2100 scenario

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National Research Council, 2012

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Sea level was +6.6 m (95%) higher than today.

Groundwater Inundation

Sea level, water table, and freshwater-saline water interface

Marine and Groundwater Inundation
At 0.66 m, 69% of total flooded area is due to groundwater inundation

Sea level +3 ft

Coastal erosion
New wetlands
Saltwater intrusion
Drainage problems
Isolated communities
Coastline displacement
Wave overtopping
Evacuation routes and shelters
Flash flooding
Saltwater intrusion
Intergovernmental Panel on Climate Change

The blue band shows how global average temperatures would have changed due to natural forces only, as simulated by climate models. The red band shows model projections of the effects of human and natural forces combined. The black line shows actual observed global average temperatures. As the blue band indicates, without human influences, temperature over the past century would actually have first warmed and then cooled slightly over recent decades.


http://www.ted.com/talks/james_hansen_why_i_must_speak_out_about_climate_change.html
IPCC, 2007 – Intergovernmental Panel on Climate Change

Future warming?

CO₂ Production

CHANGE IN PRECIPITATION BY END OF 21ST CENTURY
inches of liquid water per year

as projected by NOAA/GFDL-CM2.1
Surface salinity change over the period 1950–2000. Rainfall and evaporation changes are making the oceans less salty in vast regions (blue) and more salty elsewhere (red). Research shows that while the surface warmed 0.5°C, the water cycle sped up roughly 4%, twice as fast as predicted by most climate models. These results also indicate that in general, wet areas got wetter and dry areas got drier.

Red and Orange Arrows
- Hundreds of millions of people exposed to increased water stress
- 30–40% of species at risk of extinction around the globe
- About 30% of global coastal wetlands lost
- Increased damage from floods and storms
- Widespread coral mortality
- Many ecosystems severely damaged
- Reduction in food production
- Increased mortality from heat waves, floods and droughts

Mitigation – human intervention to reduce the sources or enhance the sinks of greenhouse gases
- Alternative energy sources
  - Renewable
- Energy efficiency and conservation
  - Transportation/Urban Design
  - Reforestation (land preservation)
  - Mass transit
- Geoengineering
  - Bio energy
  - Carbon capture and storage
  - Radiation management

Alternative energy sources
Renewable, Electric/Hybrid mass transit

Geoengineering
Bio energy with carbon capture and storage, Carbon Air capture, Carbon capture and storage, Radiation management
Adaptation – actions to tolerate the effects of warming

- Enhancing adaptive capacity
  - Improving access to resources
  - Improving education
  - Improving infrastructure
  - Community-based planning

- Agriculture during drought
  - Improve emergency response
  - Drought tolerant crops
  - Rainwater storage

- Coastal communities
  - Retreat and abandon
  - Stay and defend
  - Combination, phased adaptation

King Tides: Pacific Islands have special needs and important skills