The IPCC Reports

• Intergovernmental Panel on Climate Change (IPCC) established in 1988 by WMO and UNEP
  → assess available scientific and socio-economic information on climate change and its impacts and on the options mitigation and adaptation
• Compiled by hundreds of scientists, reviewed by scientists, governments and experts
Key questions about the climate system and its relation to humankind
Surface Temperature Measurement Stations

GHCN v2.0 Mean Temperature Stations
• Increase in global-average surface temperature over the 20\textsuperscript{th} century by about 0.6\textdegree C
• 1990s warmest decade and 1998 warmest year in instrumental record since 1861
Proxy Temperature Data

- Historical records from farmers logs, travellers diaries, etc.
- Oxygen isotopes in corals and glaciers
- Patterns in tree ring width, density, and isotopic composition
- Fossils in ocean and lake sediments
- Pollen grains in sediments
Reconstructed Temperatures in NH over last 1000 years

- 20th century increase largest in any century over last 1,000 years
- 1990s and 1998 warmest decade and year of the millenium
Regional pattern of warming

- Near global increase in temperatures
- Largest increases in mid- and high-latitudes over continents in Northern hemisphere
Changes in precipitation and moisture

• Precipitation increases by 0.5-1%/decade at mid- and high latitudes in Northern Hemisphere over land

• Water vapor has increased by several percent per decade in NH

• Increase in cloud cover by 2% since beginning of 20th century
Changes in snow and ice cover

• 10% decrease in snow extent since 1960s
• Snow melt starts 2 weeks earlier
• Widespread retreat of mountain glaciers
• 40% decline in Arctic sea-ice thickness in summer
Changes in sea level

- Global average sea level rose by 0.1-0.2 meters during the 20th century (~1.5 mm/year: 10 times higher than average over last 3000 years)
- Global ocean heat content has increased

Factors causing sea-level change:
- Thermal expansion, as ocean water warms it expands: main reason for change over last century and for coming few centuries
- Melting of ice on land (glaciers and ice sheets): main reason for change in sea-level between glacials and interglacials (~120m since 20,000 years ago)
Changes in atmospheric and oceanic circulation

- Unusual El-Nino behaviour since mid-1970s. More frequent and warmer El-Niños and shorter La Niñas.
"Taken together these trends illustrate a collective picture of a warming world"

(a) Temperature Indicators

<table>
<thead>
<tr>
<th>OCEAN</th>
<th>LAND</th>
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<tbody>
<tr>
<td>LOWER STRATOSPHERE **lower stratosphere: 0.5 to 2.5°C decrease since 1979</td>
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<tr>
<td>TROPOSPHERE Upper * Little or no change since 1979</td>
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<tr>
<td>Low- to Mid- ** 0.0 to 0.2°C increase since 1979 - satellites &amp; balloons</td>
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<td>* 0.2 to 0.4°C increase since ~1960</td>
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NEAR-SURFACE

* 1990s warmest decade of the millennium and 1998 warmest year for at least the N.H. ** marine air temperature: 0.4 to 0.7°C increase since late-19th century

*** sea surface temperature: 0.4 to 0.8°C increase since the late 19th century. * global ocean (to 300m depth) heat content increase since 1950s equal to 0.04°C / decade

*** massive retreat of mountain glaciers during 20th century * land night time air temperature increasing at twice the rate of daytime temperatures since 1950 ** lake and river ice retreat at mid and high latitudes since the late 19th century (2 week decrease in ice duration) *** land air temperatures: 0.4 to 0.8°C increase since late 19th century

* Arctic sea ice: sumer thickness decrease of 40% and 10 to 15% decrease in extent during spring and summer since 1950s

? Antarctic sea ice: no significant change since 1978

** Virtually certain (probability > 99%)
* Very likely (probability > 90% but < 99%)
* Likely (probability > 66% but < 90%)
* Medium likelihood (probability > 33% but ≤ 66%)
## Hydrological and Storm related Indicators

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<tr>
<td><strong>LOWER STRATOSPHERE</strong></td>
<td><em>20% water vapour increase since 1980 (above 18 km)</em></td>
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</table>
| **TROPOSPHERE** | | *no significant global trends since 1980; 15% increase in tropics (10°N to 10°S)*
| | | *many regions with increases since about 1960*
| | *2% increase in total cloud amount over the ocean since 1952* | |
| **NEAR-SURFACE** | *no systematic large-scale change in tornadoes, thunder-days, hail* | |
| | *2 to 3% decrease in sub-tropics* | *20th century land surface rainfall*
| | *2 to 3% increase in tropics* | |
| **no widespread changes in tropical storm frequency / intensity during the 20th century** | **5 to 10% increase in N. Hemisphere mid-to-high latitude precipitation since 1900, with much of it due to heavy / extreme events** | *widespread significant increases in surface water vapour in the N. Hemisphere, 1975 to 1995*

**Likelihood:**

*** Virtually certain (probability > 99%)
** Very likely (probability > 90% but ≤ 99%)
* Likely (probability > 66% but < 90%)
? Medium likelihood (probability > 33% but ≤ 66%)