Record-Breaking Christmas Heat Clinches Record Warm December For Hundreds of Cities

Map from @SERCC is truly incredible. All the "1s" are locations setting a record warm December. Many others top 3.

3:23 AM - 1 Jan 2016

Snowstorm Deaths Reach 41 as East Coast to Dig Out

By EMILY KNAPP and MEGHAN KENEALLY • Jan 25, 2016, 11:54 PM ET

Deadly Snowstorm Breaks Records; 80 Million Affected

The East Coast is digging itself out after near-record snowfall forced a shutdown of major public transportation and the shuttering of businesses and government offices and left at least 41 dead.
Record breaking in Hawaii!

RECORD EVENT REPORT
NATIONAL WEATHER SERVICE HONOLULU HI
437 PM HST MON JAN 25 2016

...RECORD HIGH TEMPERATURE SET AT HILO HI...

A RECORD HIGH TEMPERATURE OF 88 DEGREES WAS SET AT HILO HI TODAY. THIS BREAKS THE OLD RECORD OF 87 SET IN 1977.

$$
Sudden freezes in Asia

Hong Kong hit by coldest temperatures in nearly 60 years

Morning temperatures dropped to 3.3°C in urban areas of the southern Chinese city, where most buildings lack central heating, and below freezing in the hills.

Record-breaking cold freezes 90 percent of China

By Wu Yan (chinadaily.com.cn/Xinhua)

Updated: 2016-01-22 16:18

Sudden freezes in Asia

East Asia Hit by Record Snowfalls and Cold Weather

Mark Rivett-Carnac @mrivettcarnac Jan. 25, 2016

50 cold-related fatalities were recorded in Taiwan

Extreme cold weather pushed through East Asia this weekend, causing deaths and crippling transportation, according to multiple news sources.

The sudden drop in temperature led to 50 deaths in Taiwan, where many victims were elderly people.
How will predicted climate changes affect the biosphere?

Direct effects of increased CO$_2$ on organisms
<table>
<thead>
<tr>
<th>Time or Response</th>
<th>CO$_2$ concentration (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ice-age levels</td>
<td>0.018-0.022</td>
</tr>
<tr>
<td>Preindustrial levels</td>
<td>0.026-0.028</td>
</tr>
<tr>
<td>Current levels</td>
<td>0.038-0.040</td>
</tr>
<tr>
<td>Predicted 2100 levels</td>
<td>0.05-0.10</td>
</tr>
<tr>
<td>Exhaled from lungs</td>
<td>5.3-5.9</td>
</tr>
<tr>
<td>Loss of mental acuity</td>
<td>2.0-7.5</td>
</tr>
<tr>
<td>Loss of consciousness</td>
<td>5.0-10.0</td>
</tr>
<tr>
<td>Loss of life</td>
<td>20.0-30.0</td>
</tr>
</tbody>
</table>
Direct Effect of CO$_2$ on Plants

• Availability of energy
• Availability of water
• Acquisition of nutrients
Photosynthesis

\[ \text{CO}_2 + \text{water} + \text{light} \rightarrow \text{carbohydrates} + \text{oxygen} \]

Converts ATP + NADPH into sugars (carbohydrates)
Rubisco enzyme is a catalyst
Rubisco enzyme is a catalyst
Photorespiration
No net production of energy (ATP, NADPH or sugar)
Photorespiration
No net production of energy (ATP, NADPH or sugar)
Photosynthesis or Photorespiration?

- Depends on relative amounts of CO$_2$ and O$_2$ in the atmosphere around the plant
- Currently, 2 – 3 cycles of photosynthesis for every 1 cycle of photorespiration
Photosynthesis or Photorespiration?

With a rising concentration of CO$_2$, photosynthesis favored over photorespiration.

—Higher efficiency in converting light into sugars
Direct Effect of CO$_2$ on Plants

- Availability of energy
- **Availability of water**
- Acquisition of nutrients
Water and Plants

$\text{CO}_2$ enters leaves and $\text{H}_2\text{O}$ vapor exits them through openings called stomata
Plants control how wide the stomata open with environmental cues

- Relative humidity
- Light level
- CO$_2$ concentration
- Soil H$_2$O availability

Goal: minimize amount of H$_2$O lost per CO$_2$ taken in
Most plants lose 500-1000 molecules of H\textsubscript{2}O for every molecule of CO\textsubscript{2} they assimilate—Cacti lose only about 50 H\textsubscript{2}O molecules per CO\textsubscript{2} assimilated.
Plants and Water

Rising CO$_2$ concentration will increase the amount of CO$_2$ assimilated per H$_2$O lost.

—Plants can decrease width of stomal openings to conserve water but still maintain similar CO2$_2$ concentration

—Or, they can keep the openings the same and lose water at similar rates, but increase CO$_2$ assimilation
What will plants do?

Need to do experiments!

Grow plants in CO$_2$ enriched environments

– Controlled environment chambers
– Open top chambers
– Free Air CO$_2$ Enrichment (FACE) plots
Controlled environment chambers

Open top chambers
What will plants do?

They compromise

– Close stomata by 22% to conserve water
– Increase CO₂ assimilation, 32% faster
CO₂ Acclimation

Plants in increased CO₂ assimilate CO₂ faster through photosynthesis
–Stimulates faster growth
CO₂ Acclimation

After days, weeks, or months of exposure to increased CO₂ levels, net CO₂ assimilation slows.

– In long term, growth rates at elevated CO₂ only 8% faster

The decline of the stimulation of CO₂ over time is called CO₂ acclimation
Thank you Alyssa Temple!

Many large companies pledged to take measures to address climate change to contribute to a United Nations climate agreement between 195 nations sealed last month in Paris.

While they’re setting targets to cut their own fossil-fuel pollution, the report shows their suppliers, which are responsible for as much as four times as much greenhouse gas emissions, are out of sync.

72% of suppliers said climate change risks could significantly impact their operations, sales or costs. Nearly two-thirds said climate policies, such as carbon taxes, posed a risk to their business.

But less than half of respondents set a target to cut carbon emissions and only 34 percent reduced emissions in the past year.
• "Emissions are not reducing at the rate required to meet the Paris goals, nor are suppliers building the resilience they need to deal with the climate impacts they will inevitably face."

• Companies should work with suppliers to encourage greater action on climate change.

• Lego started hosting "innovation camps" in the hope of creating joint projects with suppliers that could reduce carbon emissions collaboratively. Other companies have threatened to drop suppliers that fail to comply with their environmental policies.
Direct Effect of CO$_2$ on Plants

- Availability of energy
- Availability of water
- Acquisition of nutrients
Nitrogen nutrition of plants

Nitrogen (N) is the mineral that plants require in the greatest amount.

– Nitrogen fertilizers stimulate nearly all agricultural and natural ecosystem growth
– Nitrogen availability is a major limiting factor for plant growth
Nitrogen fertilizers applied in the United States

N applied (Mt yr\(^{-1}\))

Amount spent ($ billions)

Power costs (¢ kw-h\(^{-1}\))

Year

N applied
Amount spent
Power costs

2010

Nitrogen fertilizers applied in the United States
Nitrogen in the atmosphere can not be used by plants

–Bond between Nitrogen atoms too strong to break (inert)
Biological Fixation: some microorganisms in the soil convert $N_2$ into a useable form: ammonia ($NH_3$)

- $NH_3$ dissolves in water to form ammonium ($NH_4^+$)
- Nitrate ($NO_3^-$) is produced through biological fixation or decomposition in soil

Plants use these forms of nitrogen (ammonium and nitrate) for growth.
Nitrogen nutrition of plants

- Most plants acquire nitrogen through root absorption of ammonium and nitrate.
- Plants convert these forms of nitrogen into amino acids and energy (ADP).
Nitrogen and plants in elevated CO$_2$

Earlier, we saw that energy and water availability for plants increase with CO$_2$ concentration

— This stimulates growth.

But, nitrogen availability might not keep up
Plants initially grow faster and release more carbohydrates into the soil

• Microorganisms use these carbohydrates and become more active.
  – Respire 18% faster than under normal CO₂ conditions

• As microorganism growth increases, they remove mineral nitrogen and other nutrients from the soil
Nitrogen and plants in elevated CO$_2$

As extraction of nitrogen from soil by microorganisms increases, nitrogen availability to plants decreases under CO$_2$ enrichment.
Food Quality

Nutritional value of plant material will decline
   – Protein concentrations decline
   – Concentration of phenolics increase. Makes plants hard to digest.

Herbivores might have to eat more plants to get the same nutrition
Carbon Dioxide Sensing Organisms

Lots of organisms measure the CO$_2$ concentrations of their surroundings
Ants, bees, and termites detect location and activity of hives by CO$_2$ concentration gradients
Mosquitoes, ticks, and tsetse flies find blood meals by following the trail of CO\textsubscript{2} to their prey.
Rising $\text{CO}_2$ concentrations will interfere with $\text{CO}_2$ sensing.

Other climate changes may expand ranges!
Climate change will affect the following factors

- Carbon Dioxide levels
- Temperature
- Precipitation
- Salinity
- pH (acid level)
Temperature

Average global temperatures have warmed about 0.6°C over the last 150 years.

Likely to warm an additional 2° to 6°C by the end of this century.
Temperature patterns have changed: increased nighttime minimum temperatures

Frost defines the growing season for some plants