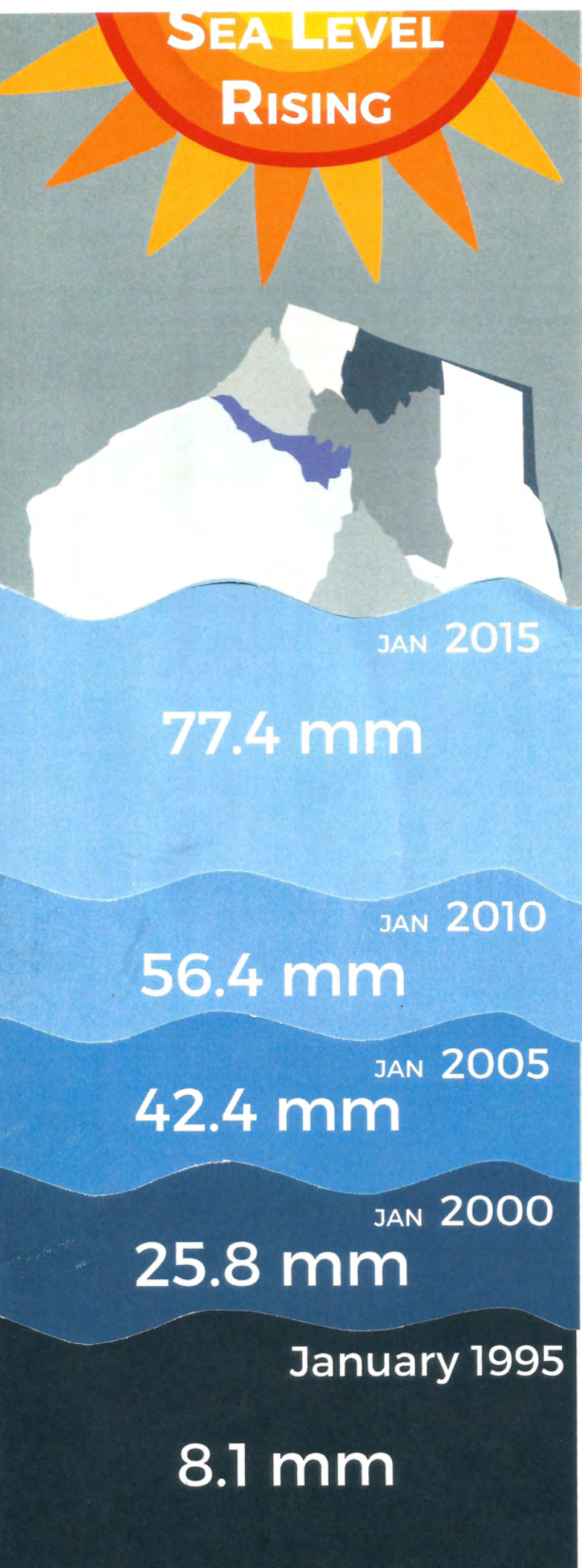

SEA LEVEL RISING
JAN 2015
77.4 mm
JAN 2010
56.4 mm
JAN 2005
42.4 mm
JAN 2000
25.8 mm
January 1995
8.1 mm

Sea Level Rising

JAN 2015

77.4 mm

JAN 2010

56.4 mm

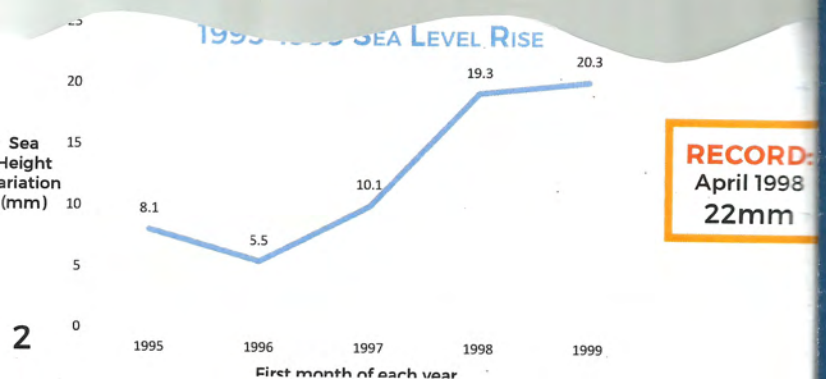
JAN 2005

42.4 mm

JAN 2000

25.8 mm

Global sea level rose about 17 centimeters (6.7 inches) in the last century. The rate in the last decade, however, is nearly double that of the last century.



RECORD:
April 1998
22mm

2000-2004 Sea Level Rise

Sea Level Rising

JAN 2015

77.4 mm

JAN 2010

56.4 mm

JAN 2005

42.4 mm

The current warming trend is of particular significance because most of it is very likely human induced and proceeding at a rate that is unprecedented in the past 1,300 years.

Sea Level Rising

JAN 2015

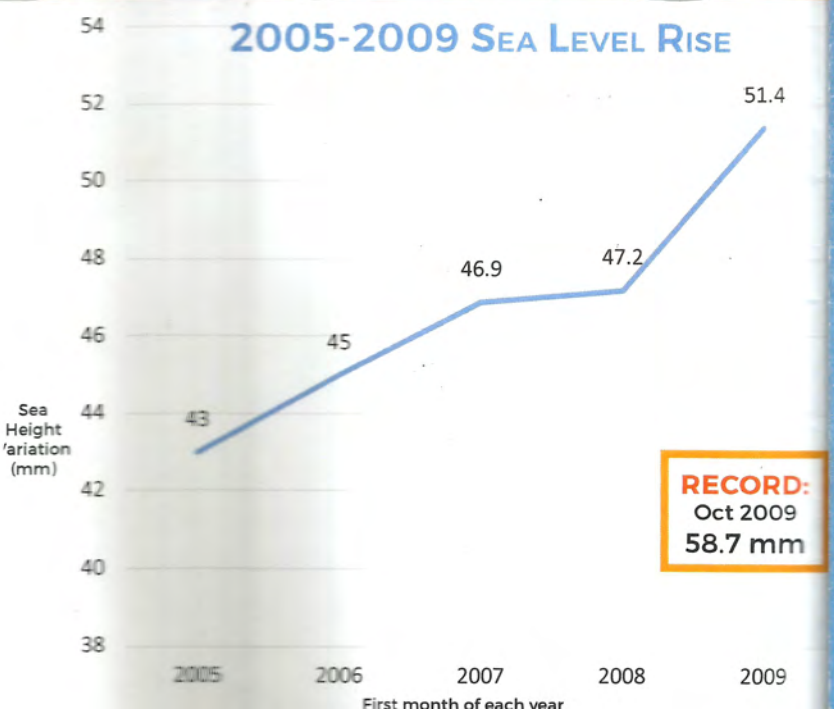
77.4 mm

JAN 2010

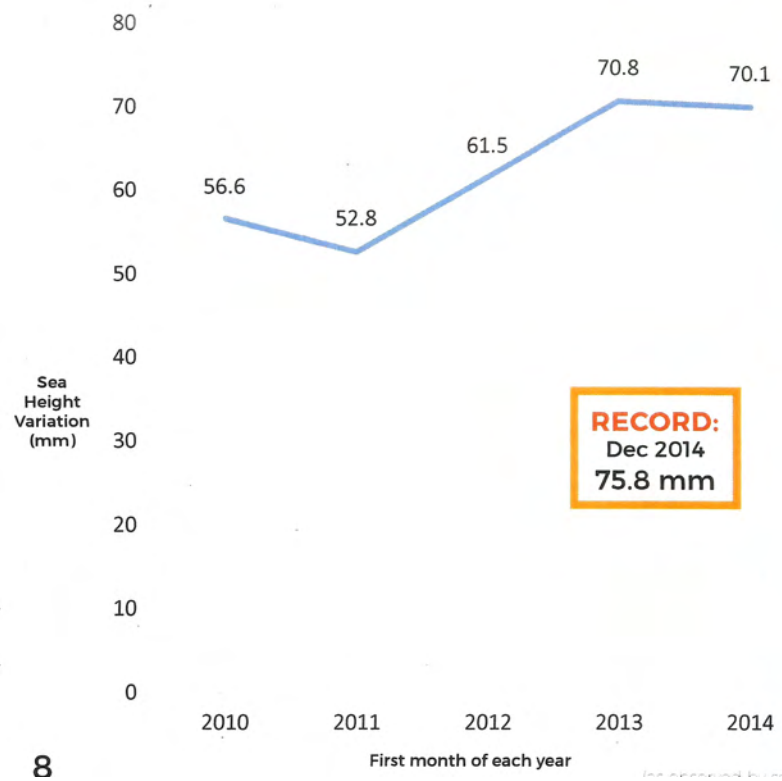
56.4 mm

Greenland & Antartica

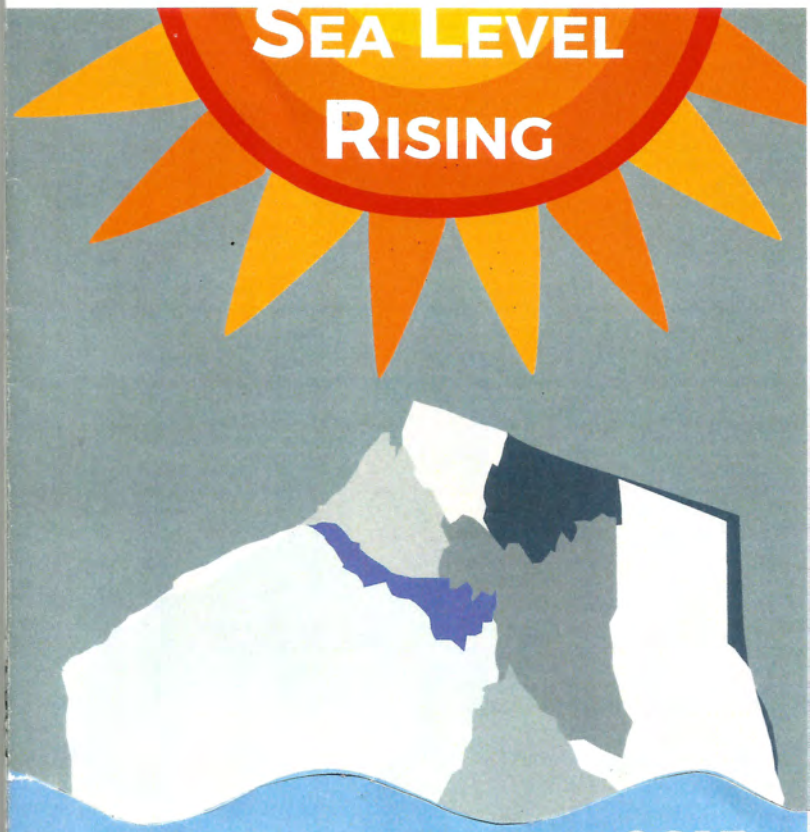
Ice loss near the poles is one of the most critical changes pushing sea levels higher, a conclusion supported by data of increasing weight and accuracy. Greenland's contribution to global sea-level rise is the largest, and increases every decade. Studies suggest that its melt grew from 0.09 millimeters per year between 1992 and 2001, expressed as the global sea-level rise equivalent, to 0.59 millimeters per year between 2002 and 2011 [Velicogna et al, 2014].



2010-2014 Sea Level Rise



Sea Level Rising



JAN 2015

77.4 mm

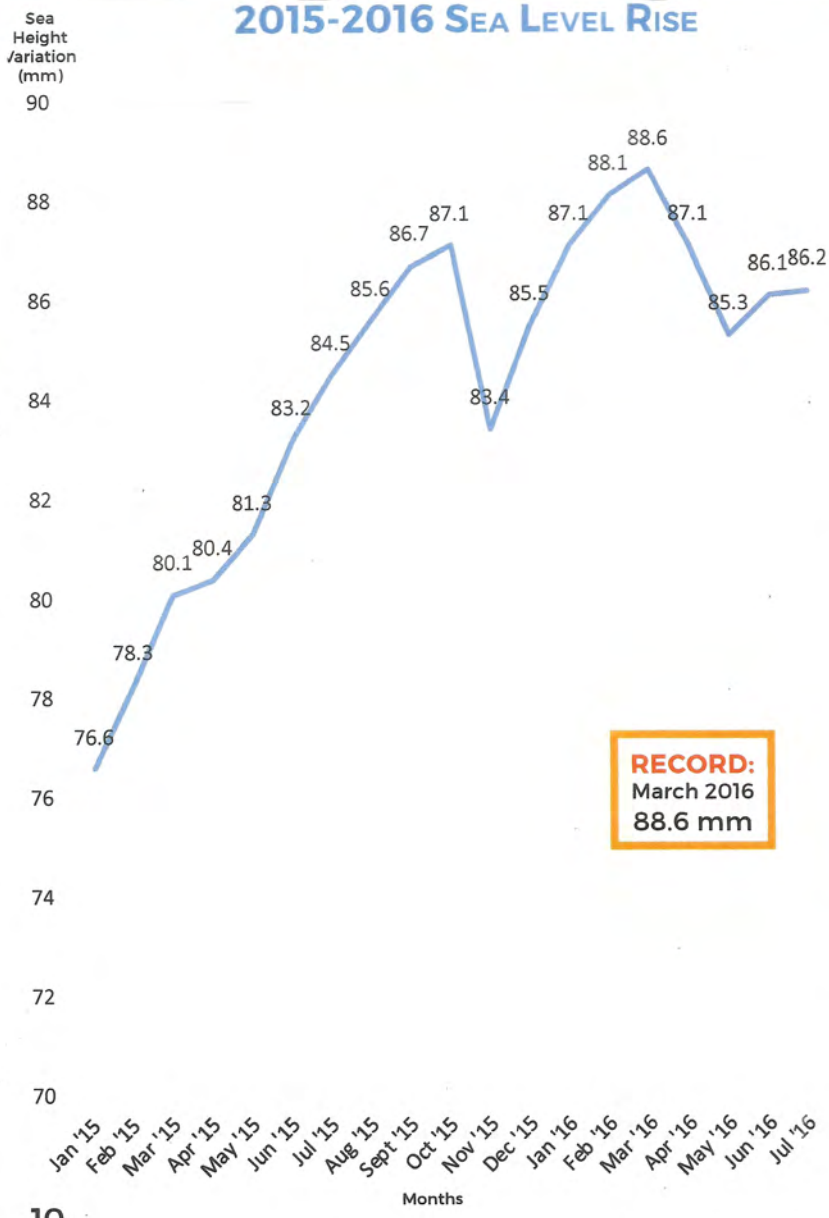
Greenland & Antartica continued...

Measurements by the twin GRACE satellites (Gravity Recovery and Climate Experiment) show that most of the losses between 2003 and 2013 were coming from the southeast and northwest portions of the island, while the southwest is responsible for more than half of the acceleration of ice loss. The estimated total loss is in the range of more than 200 to more than 300 gigatons per year (1 gigaton is approximately 264 billion gallons of water.

Antarctica's contribution to sea-level rise increased from 0.08 millimeters per year between 1992 and 2001 to 0.40 millimeters per year between 2002 and 2011 [Velicogna et al, 2014]. Together, Greenland and Antarctica contribute about one third of pres-

THE SEAS OF THE EARTH ARE RISING, A DIRECT RESULT OF A CHANGING CLIMATE. OCEAN TEMPERATURES ARE INCREASING, LEADING TO OCEAN EXPANSION, AND AS ICE SHEETS AND GLACIERS MELT, THEY ADD MORE WATER. AN ARMADA OF INCREASINGLY SOPHISTICATED INSTRUMENTS, DEPLOYED ACROSS THE OCEANS, ON POLAR ICE AND IN ORBIT, REVEALS SIGNIFICANT CHANGES AMONG GLOBALLY INTERLOCKING FACTORS THAT ARE DRIVING SEA LEVELS HIGHER.

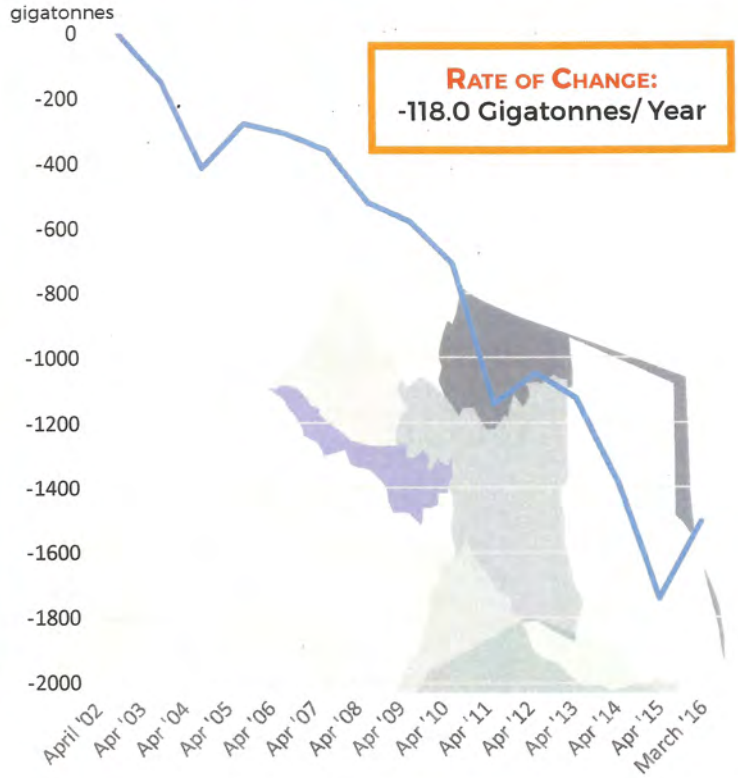
2015-2016 Sea Level Rise



(as observed by satellites)

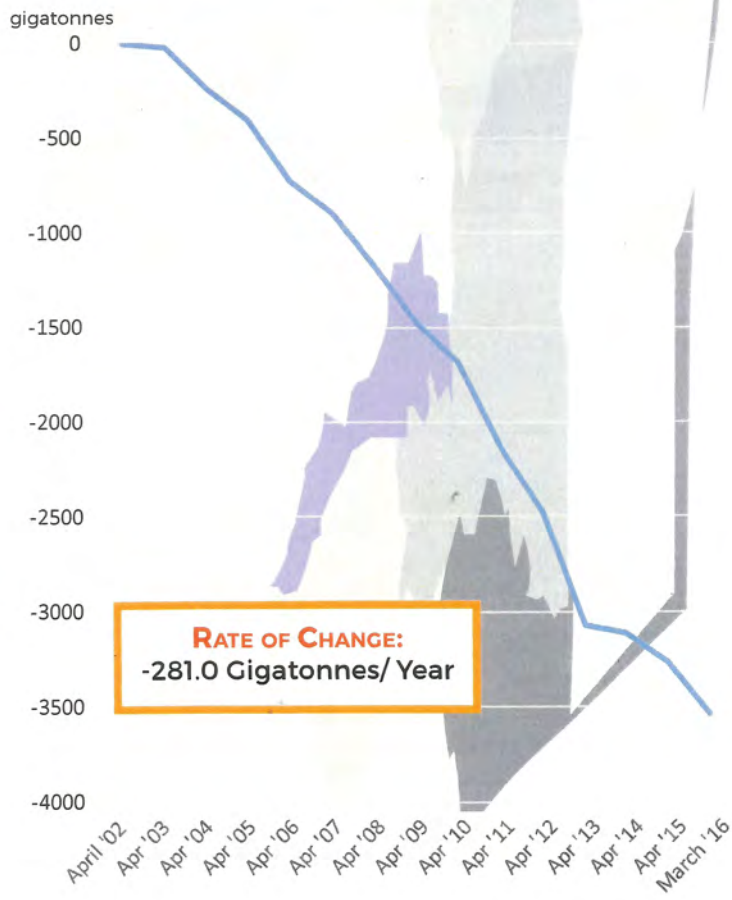
Antartica Mass Variation since 2002

Data source: Ice mass measurement by NASA's GRACE satellites.



Greenland Mass Variation since 2002

Data source: Ice mass measurement by NASA's GRACE satellites.



CAUSES

Glasiers & Icecaps

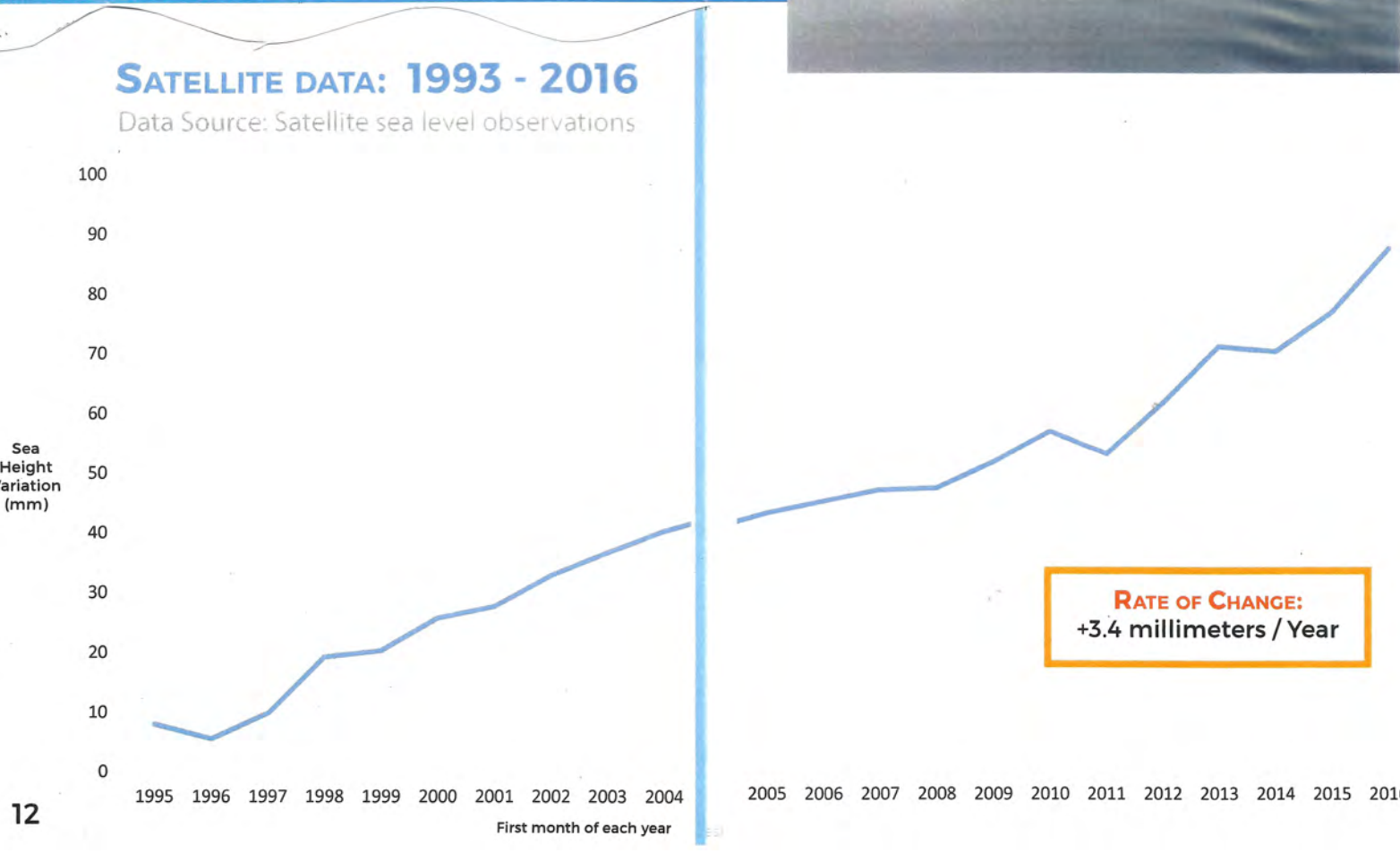
Measurement of the Earth's many glaciers and ice caps—smaller ice masses that are not a part of the Greenland or Antarctic ice sheets— show accelerated retreat. Together, they also account for about a third of the present sea level rise planet-wide (between 2.6 and 2.9 millimeters per year over at least the past 20 years).

That places these smaller ice masses in the top three contributors to sea level rise, along with the warming of ocean water, which causes it to increase in volume, and the melting of the great ice sheets of Greenland and Antarctica.

The largest losses are from Arctic Canada, Alaska and coastal Greenland, but with significant contributions from other regions, such as the Andes in southern Chile, Argentina or the Himalayas.

Yet here, too, we encounter unexpected nuance as we move from bigger to smaller scales. While these smaller ice masses will remain among the dominant contributors to sea level rise through the next two centuries, their contribution likely drops to insignificance beyond the 200-year mark.

Despite their outsized effects at present, glaciers and ice caps represent only about one percent of the Earth's ice total (about 0.7 millimeters of equivalent sea level rise per year). So, once they are depleted, the great ice sheets become the overwhelmingly dominant contributors to ice loss.



Thermal Expansion

Most climate scientists agree the main cause of the current global warming trend is human expansion of the "greenhouse effect"1 – warming that results when the atmosphere traps heat radiating from Earth toward space.

Certain gases in the atmosphere block heat from escaping. Long-lived gases that remain semi-permanently in the atmosphere and do not respond physically or chemically to changes in temperature are described as "forcing" climate change. Gases, such as water vapor, which respond physically or chemically to changes in temperature are seen as "feedbacks."

Gases that contribute to the greenhouse effect include:

Water vapor: The most abundant greenhouse gas, but importantly, it acts as a feedback to the climate. Water vapor increases as the Earth's atmosphere warms, but so does the possibility of clouds and precipitation, making these some of the most important feedback mechanisms to the greenhouse effect.

Carbon dioxide (CO2): A minor but very important component of the atmosphere, carbon dioxide is released through natural processes such as respiration and volcano eruptions and through human activities such as deforestation, land use changes, and burning fossil fuels. Humans have increased atmospheric CO2 concentration by more than a third since the Industrial Revolution began. This is the most important long-lived "forcing" of climate change.

Methane: A hydrocarbon gas produced both through natural sources and human activities, including the decomposition of wastes in landfills, agriculture, and especially rice cultivation, as well as ruminant digestion and manure management associated with domestic livestock. On a molecule-for-molecule basis, methane is a far more active greenhouse gas than carbon dioxide, but also one which is much less abundant in the atmosphere.

Nitrous oxide: A powerful greenhouse gas produced by soil cultivation practices, especially the use of commercial and organic fertilizers, fossil fuel combustion, nitric acid production, & biomass burning.

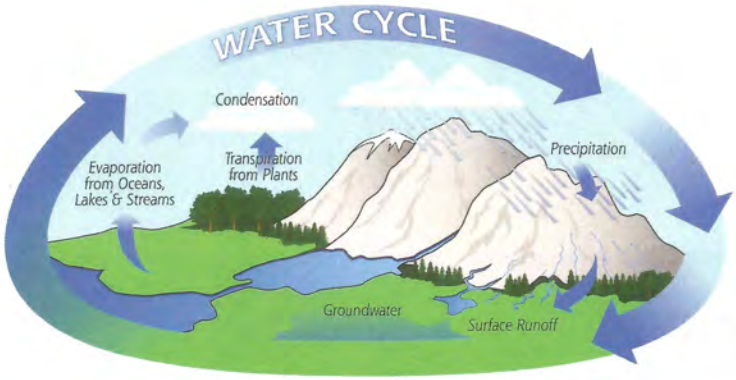
Chlorofluorocarbons (CFCs): Synthetic compounds entirely of industrial origin used in a number of applications, but now largely regulated in production and release to the atmosphere by international agreement for their ability to contribute to destruction of the ozone layer. They are also greenhouse gases.

Land Hydrology

The Earth cycles water annually between land and ocean, in regional patterns of precipitation and evaporation, and this cycle also may be accelerating in response to climate change—with more variability, more flooding and more frequent drought.

Human manipulation of this water cycle, including increasingly high levels of groundwater withdrawal, contributes to sea level rise; the water withdrawn is ultimately reclaimed by the sea. And while the contribution is smaller than that of thermal expansion and melting ice, it is not insignificant.

Sharpening the accuracy of global sea-level rise estimates will require a clearer picture of other land-based influences on water storage and transfer. These include human engineering, such as the construction of reservoirs for water storage or dams to hold water back, which can tip the balance toward water storage on land.



As with so many other attempts to capture sea level data, firmly establishing input from the land will depend upon satellite measurements, including gravitational monitoring by the twin GRACE satellites.

LOCAL EFFECTS

Tides

Sea level changes near coastlines include tides, a kind of wave caused by the gravitational effects of the sun and moon, along with the Earth's rotation.

Tidal changes across various time scales, though cyclic, can be superimposed upon the background rise in global sea level; add regional rise driven by ocean circulation, and the highest tides can begin to cause flooding in coastal zones that were previously unaffected, or that experienced such flooding at lower frequencies.

Storm Surge

Storm surge is a higher-than-normal rise of coastal waters, above the astronomical high tide. Its main causes are strong winds within a tropical storm or hurricane, both literally pushing seawater and creating huge waves that travel to the coast and break there. Low atmospheric pressure also induces a dome of water near the storm center. Precipitation and the Coriolis effect may also play a role.

While making direct causal connections between globally averaged climate change and individual storms remains very difficult, improved modeling techniques offer a rare chance to forecast the potential imprint of the global climate signal on short-term, localized meteorological events as the next few decades unfold.

UNITED STATES
REGIONAL EFFECTS

Below are some of the impacts that are currently visible throughout the U.S. and will continue to affect these regions, according to the Third National Climate Assessment Report2, released by the U.S. Global Change Research Program:

Northeast. Heat waves, heavy downpours and sea level rise pose growing challenges to many aspects of life in the Northeast. Infrastructure, agriculture, fisheries and ecosystems will be increasingly compromised. Many states and cities are beginning to incorporate climate change into their planning.

Northwest. Changes in the timing of streamflow reduce water supplies for competing demands. Sea level rise, erosion, inundation, risks to infrastructure and increasing ocean acidity pose major threats. Increasing wildfire, insect outbreaks and tree diseases are causing widespread tree die-off.

Southeast. Sea level rise poses widespread and continuing threats to the region's economy and environment. Extreme heat will affect health, energy, agriculture and more. Decreased water availability will have economic and environmental impacts.

Midwest. Extreme heat, heavy downpours and flooding will affect infrastructure, health, agriculture, forestry, transportation, air and water quality, and more. Climate change will also exacerbate a range of risks to the Great Lakes.

Southwest. Increased heat, drought and insect outbreaks, all linked to climate change, have increased wildfires. Declining water supplies, reduced agricultural yields, health impacts in cities due to heat, and flooding and erosion in coastal areas are additional concerns.