THE MEASURING METHOD OF GLOBAL TEMPERATURE

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Econ 428

THE BASICS

To get a complete picture of Earth's temperature, scientists combine measurements from the air above land and the ocean surface collected by ships, buoys and sometimes satellites, too.

The temperature at each land and ocean station is compared daily to what is 'normal' for that location and time, typically the long-term average over a 30-year period. The differences are called an 'anomalies' and they help scientists evaluate how temperature is changing over time.

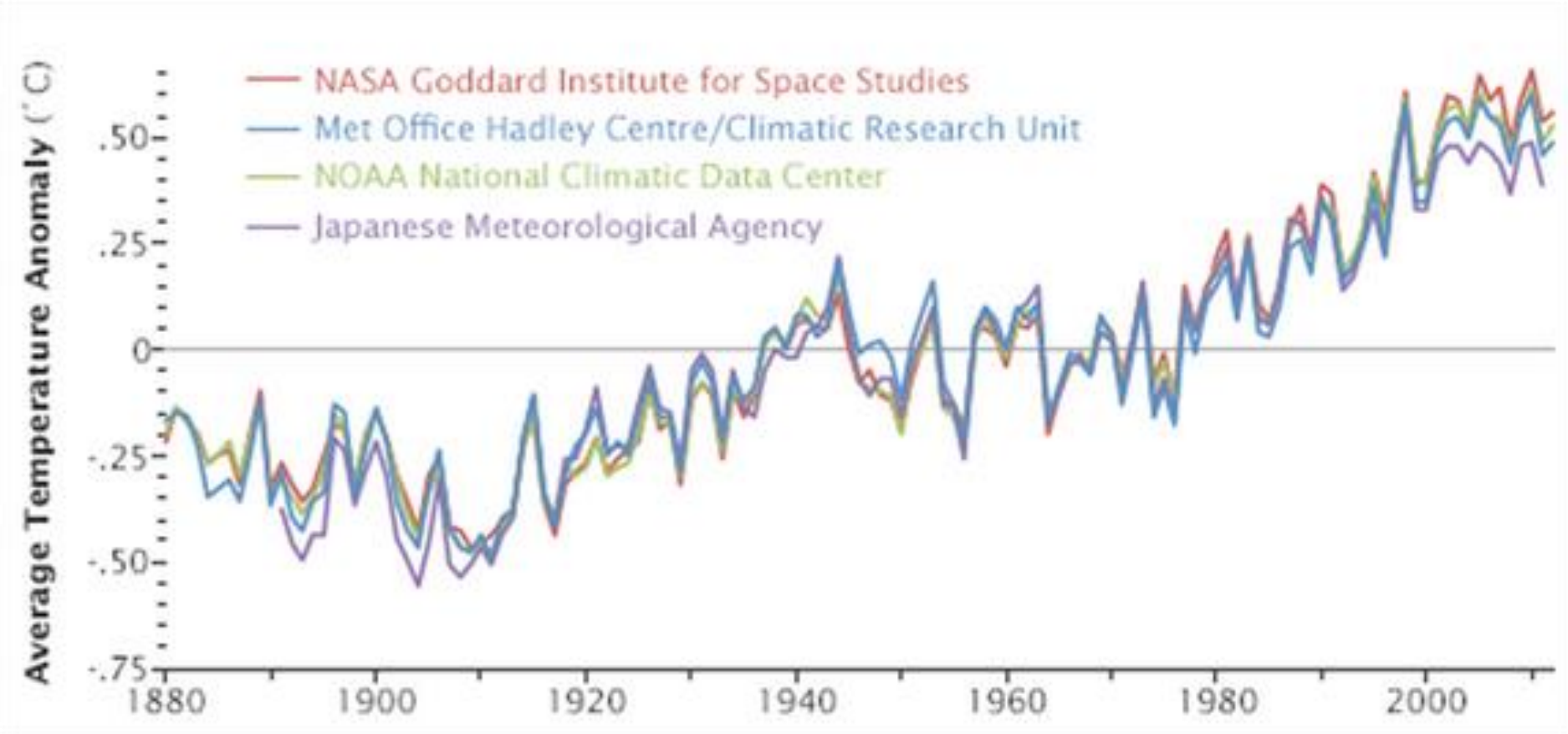
A 'positive' anomaly means the temperature is warmer than the long-term average, a 'negative' anomaly means it's cooler.

Daily anomalies are averaged together over a whole month. These are, in turn, used to work out temperature anomalies from season-to-season and year-to-year.

FOUR MAJOR DATASETS

Scientists use four major datasets to study global temperature. The UK Met Office Hadley Centre and the University of East Anglia's Climatic Research Unit jointly produce HadCRUT4 .

In the US, the GISTEMP series comes via the NASA Goddard Institute for Space Sciences (GISS), while the National Oceanic and Atmospheric Administration (NOAA) creates the MLOST record. The Japan Meteorological Agency (JMA) produces a fourth dataset.


NASA Goddard Institute for Space Studies
Met Office Hadley Centre/Climatic Research Unit
NOAA National Climatic Data Center
Japanese Meteorological Agency
Average Temperature Anomaly (°C)
.50
.25
0
-.25
-.50
-.75
1880
1900
1920
1940
1960
1980
2000

Of the four datasets, GISTEMP (red line) shows the fastest warming. JMA tends to track slightly lower than the others (purple). So why do we see differences between the datasets?

Data coverage has, perhaps, the biggest influence. NASA GISTEMP has the most comprehensive coverage, with measurements over 99 per cent of the globe. By contrast, JMA covers just 85 per cent of the globe, with particularly poor data in the poles, Africa and Asia.

HOW DO THE DATASETS DEAL WITH MISSING DATA?

Nasa's GISTEMP uses statistical methods to fill in gaps using surrounding measurements. How much each measurement influences the final value depends on how close it is geographically to the missing point. NOAA follows a similar process for the MLOST dataset.

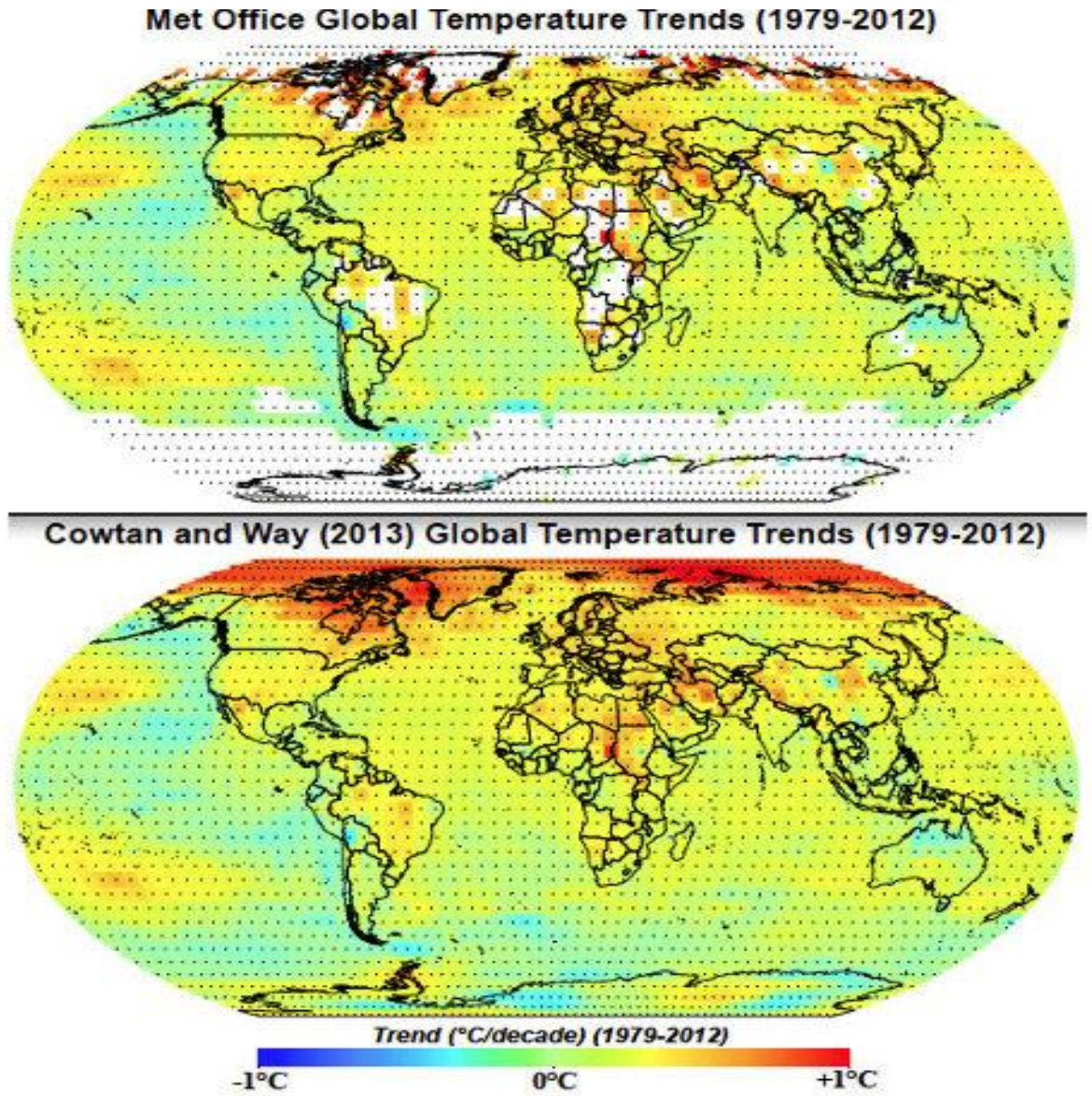
HadCRUT4 is the only dataset to leave regions with missing data blank, rather than try to fill them in. This effectively assumes temperatures there are in line with the global average.

The Arctic

Data suggests the Arctic, for example, is warming more than twice as fast as the global average.

It's reasonable then that a missing Arctic could lead to a global temperature that's lower than in the real world.

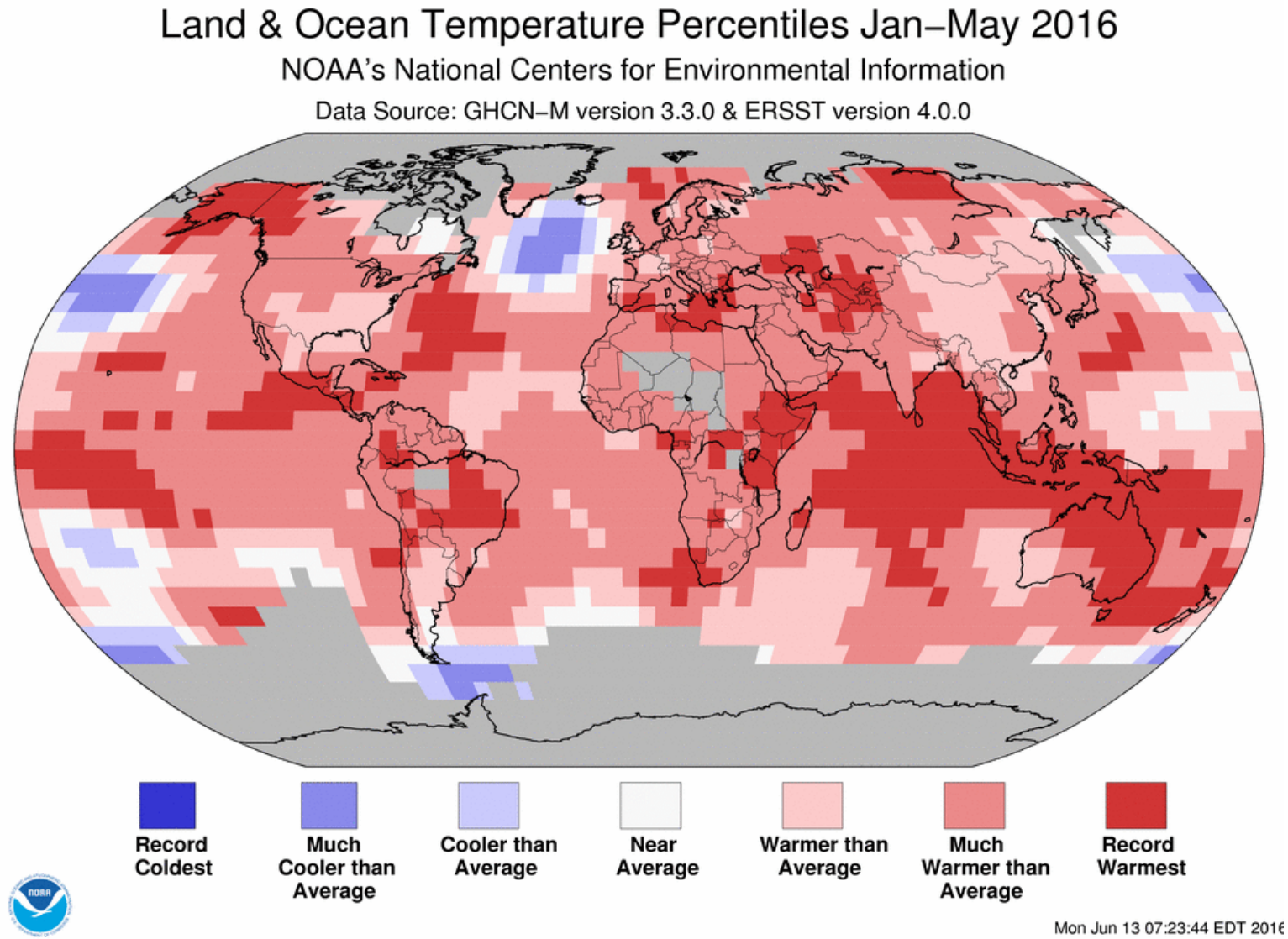
Data gaps still exist, as the white areas in the top map in the figure below show.


Met Office Global Temperature Trends (1979-2012)
Cowtan and Way (2013) Global Temperature Trends (1979-2012)
Trend (°C/decade) (1979-2012)
-1°C
0°C
+1°C

After working out the annual temperature anomalies for each land or ocean station, the next job for scientists is to divide the earth up into grid boxes.

They work out the average temperature for each box by combining data from all the available stations.

The smaller the grid boxes, the better the average temperature of the box will reflect the actual temperature at any given point


Land & Ocean Temperature Percentiles Jan–May 2016
NOAA's National Centers for Environmental Information
Data Source: GHCN–M version 3.3.0 & ERSST version 4.0.0
Record Coldest
Much Cooler than Average
Cooler than Average
Near Average
Warmer than Average
Much Warmer than Average
Record Warmest
Mon Jun 13 07:23:44 EDT 2016

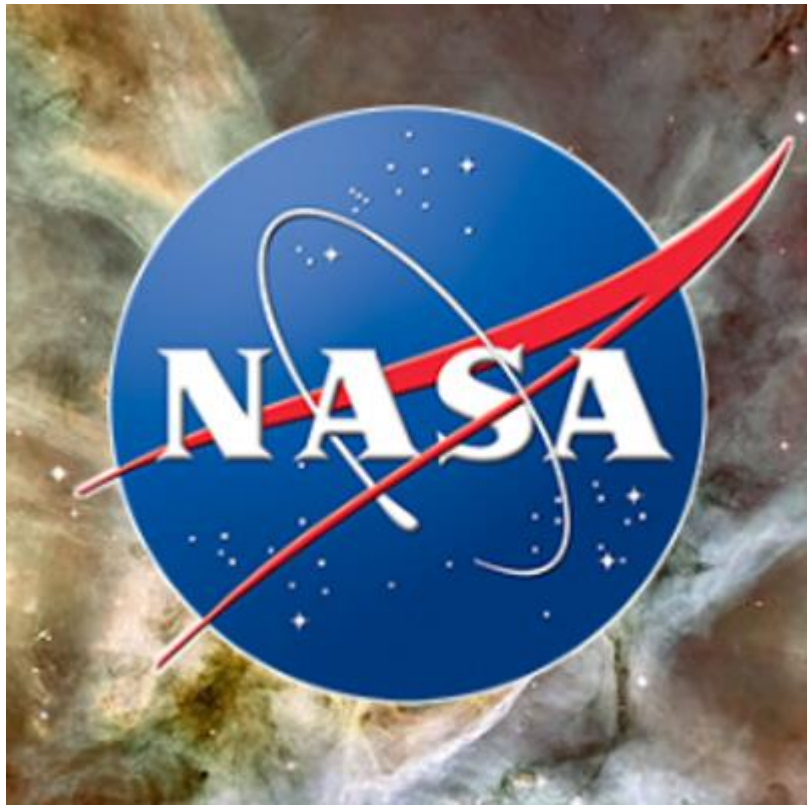

TEN HOTTEST YEARS
All Since 1998
1.5°
1.0°
2006
2007
2012
1998
2009
2005
2013
2010
2014
2015
2003 (not shown) tied with 2006, 2007. Columns represent difference from 20th century average.
Data as of January 20, 2016. Subject to change based on NCEI revisions.
Source: NOAA/NCEI
CLIMATE CENTRAL

NASA GISTEMP IS MOST DETAILED

The NASA GISTEMP record is the most detailed of the four datasets, with grid boxes two degrees longitude by two degrees latitude.

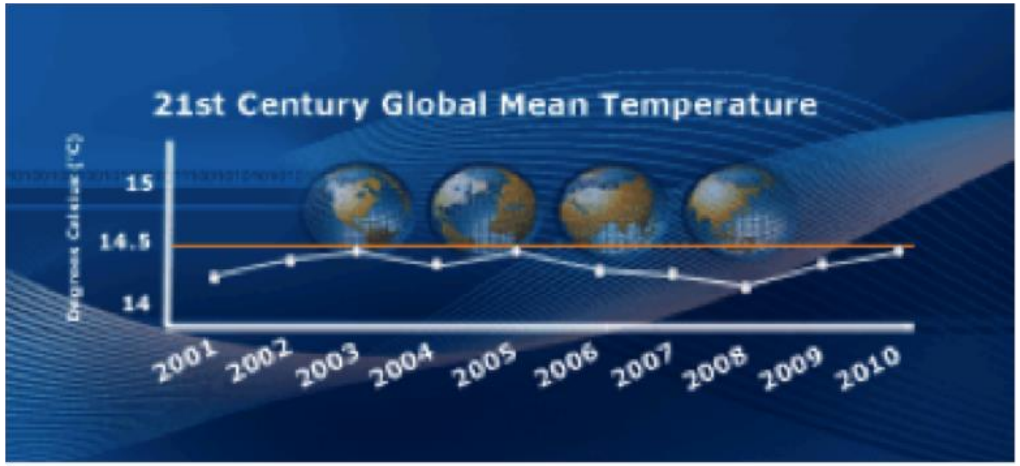
The other three have grid boxes measuring five by five degrees. They also differ in how many land stations they have around the world, too. HadCRUT4 has about 5,500, GISTEMP takes middle place with about 6,300, but MLOST has the most of all, with about 7,000 land stations.

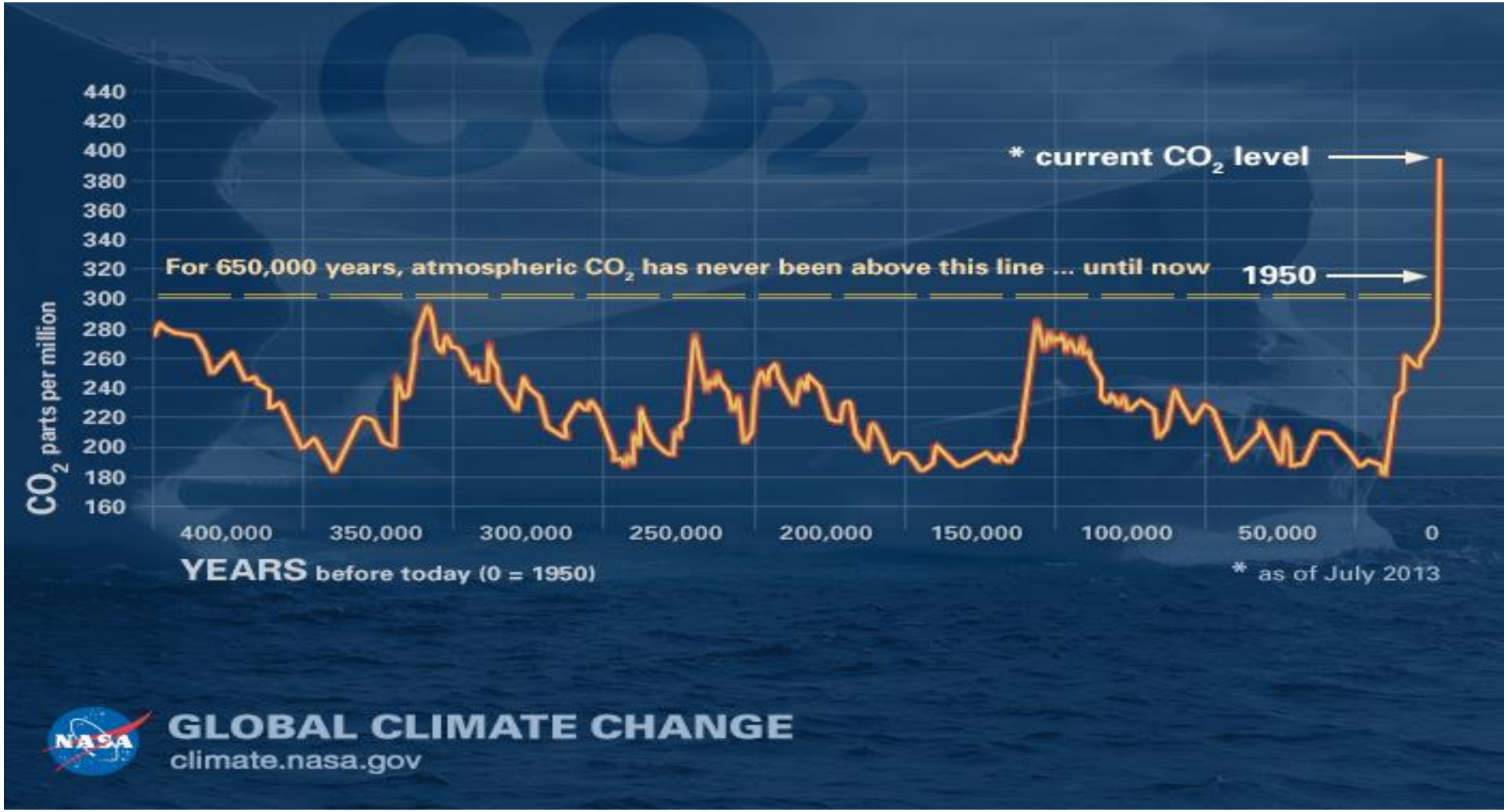
THE FOUR DATASETS DIFFER IN OTHER IMPORTANT WAYS, TOO, INCLUDING THE TIME PERIOD THEY COVER. HADCRUT4 STRETCHES BACK THE FURTHEST TO 1850. GISTEMP AND MLOST BOTH BEGIN IN 1880, WHEREAS JMA STARTS A BIT LATER IN 1891.



THREE WAYS TO MEASURE GLOBAL TEMPERATURES

The primary ways to monitor global average air temperatures are surface based thermometers (since the late 1800s), radiosondes (weather balloons, since about the 1950s), and satellites measuring microwave emissions (since 1979). Other technologies, such as GPS satellite based methods have limited record length and have not yet gained wide acceptance for accuracy.




* current CO_2 level
For 650,000 years, atmospheric CO_2 has never been above this line ... until now
1950
CO_2 parts per million
440
420
400
380
360
340
320
300
280
260
240
220
200
180
160
400,000
350,000
300,000
250,000
200,000
150,000
100,000
50,000
0
YEARS before today (0 = 1950)
* as of July 2013
GLOBAL CLIMATE CHANGE
climate.nasa.gov