21 March 2012

On Arctic Sea ice melt and coal mine canaries

By Andrew Glikson

Frontispiece: the Arctic 2012

http://www.nasa.gov/topics/earth/features/thick-melt.html

Despite peak global temperatures in 2005 and 2010, unprecedented in the instrumental record, a recent sharp plunge in volume of the Arctic Sea ice and a spate of extreme weather events, coal mining, coal exports and carbon emissions continue to grow, overwhelming any mitigation attempted by schemes such as the Australian carbon price.

Following the peak El-Nino event of 1998, when mean global temperatures reached +0.45 degrees Celsius above pre-1975 levels, lower temperatures during 1999-2000 were heralded as '*global cooling'* [1], reversing the rise in mean temperature of about +0.8C since early in the 20th century (Figure 1). Unfortunately from 2001 temperatures continued to rise, including peak temperatures of +0.46C (2005) and +0.47C (2010) in the instrumental record (Figure 1). The 2011 La-Nina year saw the peak temperature of 0.4C higher than all previously recorded La-Nina years.

The rise in mean global temperature would be about double the above figures, had it not been for the masking the transient effects of short-lived sulphur aerosols emitted from fossil fuel combustion [2, 3]. However, with the onset of clean air policies in the 1980s SO2 emissions began to decline (Figure 2), which in part explains the sharp rise in temperatures from about 1975-1976 (Figure 1).

Factors underlying lower temperatures about 1999-2000 include the resurgence of sulphur emission from industry, in particular in growing economies (China, Middle East, Africa) (Figure 2). The role of the 11 years sun spot cycle is minor, contributing to temperature rise from the mid-1980s (1365.6 to 1366.5 Watt/m2) and to the relatively cool La-Nina dominated period during 2008 (Figure 3) [4, 5].

Typically the rise in global temperature is amplified in the polar regions by factors up to 4 and 5 [6]. Thus, of the parameters reflecting global warming, the state of the Arctic Sea ice is one of the most sensitive, often referred to as the '*canary in the coal mine'* [7].

The opening of a summer open-water ocean in the Arctic, absorbing infrared radiation where the electromagnetic spectrum was previously reflected back to space, is bound to has major implications for the global climate patterns. Since 2009 abrupt steepening of Arctic Sea ice melt rate [8, 9] (Figure 4), has led a group of UK scientists to call for urgent geo-engineering to cool the Arctic (*Climate 'tech fixes' urged for Arctic methane*) [10], (*The Case for Emergency Geo-Engineering to save the Arctic from Collapse*) [11].

Such measures would likely hinge on stratospheric injection of sulphur dioxide from jet planes flying high over the Arctic, increasing atmospheric albedo for relatively short periods on time scales of weeks to months [12]. Sulphur will need to be re-injected over the long term unless and until levels of atmospheric greenhouse gases decline.

So far as the carbon emissions are concerned, however, business as usual goes on and infrastructure of fossil fuel exploitation continues to be expanded in several parts of the world, including Australia's coal mining and coal export industry. According to ABRAE's report (*Australian coal exports outlook to 2025 and the role of infrastructure*) (Table 8) [13] Australia's coal exports are due to grow from a total of 306 Million ton coal (MtCoal) in 2012 to 394 MtCoal in 2025. For an average grade of ~80% carbon in high quality coal [14], this translates to between 245 MtCarbon in 2012 to 315 MtCarbon in 2025.

Annual emissions from Australian coal exports are near double the Australian annual carbon emissions during 1990-2008 (~420 to 550 MtCO2-equivalent per year = 114 to 150 MtCarbon per year) (Figure 2.1, Australian Greenhouse Emissions Information System, DCCEE [15]).

If local emissions for 2007 (540 MtCO2 = 147 MtCarbon) (excluding land use-related carbon loss) are combined with 2007 emissions from Australian coal exports (262*0.8 = 210 MtCarbon) (Table 8) [13], the total of ~357 MtCarbon constitutes ~4.5 percent of 2007 global emission of ~7900 MtCarbon [16]. Quadrupling of Australia's coal exports [17] would raise Australia's total direct and indirect emissions to over 1 billion tons (1 GtCarbon).

Compared to total emissions from local combustion and exported coal, Australia's carbon price planned to reduce emissions by 5% to 25% by 2020 relative to 2000 emissions (2000 emissions – 500 MtCO2 = 136 MtCarbon [18]), would bring emissions down to 129 to 102 MtC per year. Such reduction cancelled out by the growth in coal exports.

Global emissions since 1750, totaling totaling 352,000 MtCarbon from combustion and 152,000 MtCarbon from land clearing, have driven atmospheric CO2 levels to 393 ppm (Figure 5) [19], the highest it has been since the Pliocene some 3 million years ago. Current CO2 rise rates near 2 ppm CO2/year are unprecedented in the last 65 million years of geological history.

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21 March, 2012

[1] http://www.youtube.com/watch?v=BIVY9Z4rhmU

[2] http://pubs.giss.nasa.gov/abs/ha06510a.html

[3] www.atmos-chem-phys.net/11/1101/2011/acp-11-1101-2011.pdf

[4] http://solarscience.msfc.nasa.gov/images/Zurich_Color_Small.jpg

[5] http://upload.wikimedia.org/wikipedia/commons/0/0d/Solar-cycle-data.png

[6] http://data.giss.nasa.gov/gistemp/

[7] http://ipsnews.net/news.asp?idnews=45091

[8] http://www.nasa.gov/topics/earth/features/thick-melt.html

[9] http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/#

[10] http://ameg.me/index.php/24-the-case-for-emergency-geo-engineering-to-save-the-arctic-from-collapse ;

[11] http://www.bbc.co.uk/news/science-environment-17400804

[12] http://en.wikipedia.org/wiki/Stratospheric_sulfate_aerosols_(geoengineering)#cite_note-18

[13] adl.brs.gov.au/data/warehouse/pe_abare99001318/pc13548.pdf

[14] http://en.wikipedia.org/wiki/Coal

[15] http://www.abs.gov.au/ausstats/abs@.nsf/Lookup/by%20Subject/1370.0~2010~Chapter~Atmosphere%20references%20(6.5.8)

[16] http://photos.mongabay.com/09/forecast_co2.jpg

[17] http://www.greenleft.org.au/node/50309

[18] http://www.google.com.au/publicdata/explore?ds=d5bncppjof8f9_&met_y=en_atm_co2e_pc&idim=country:AUS&dl=en&hl=en&q=australia+carbon+emissions; http://www.abs.gov.au/ausstats/abs@.nsf/0/95560b5d7449b135ca256e9e001fd879?OpenDocument

[19] http://www.esrl.noaa.gov/gmd/ccgg/trends/

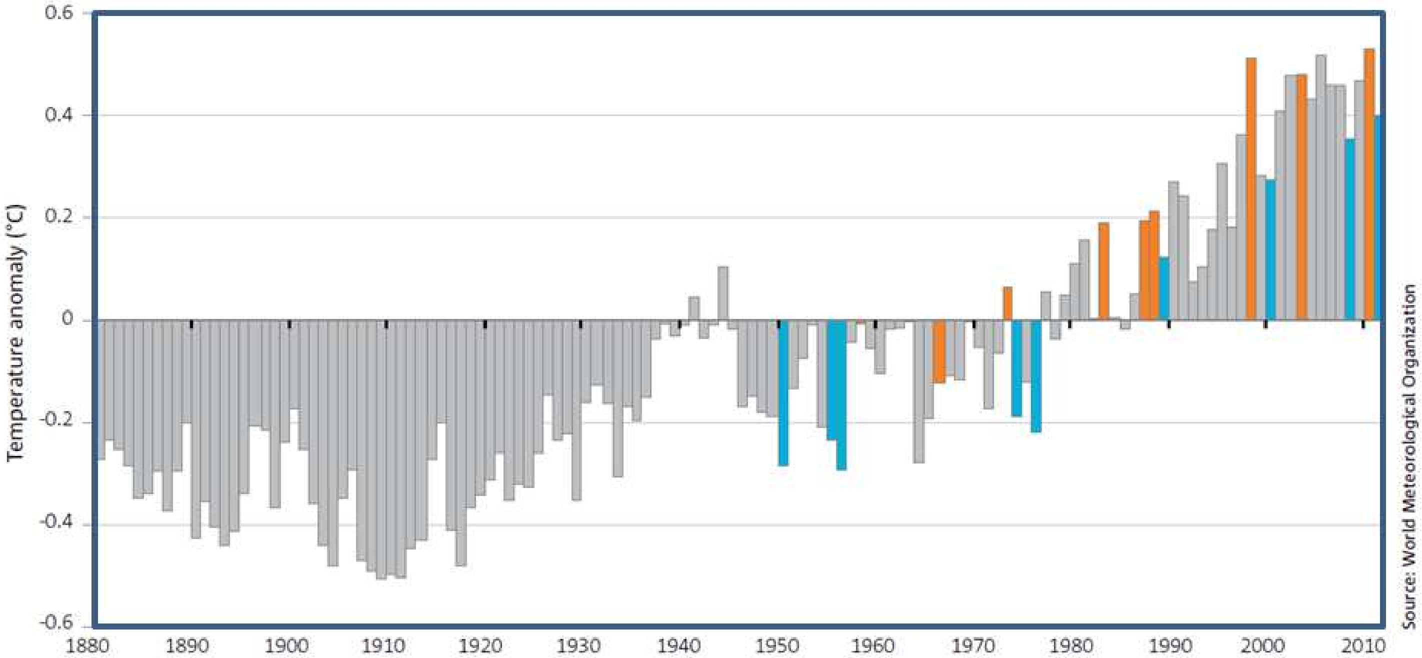

Figure 1

NASA, the US National Climatic Data Centre, and the UK Hadley Centre have each produced global temperature datasets. The graph shows the annual means calculated from the three datasets. Years beginning with an El Niño (orange) and La Niña (blue) are shown. http://www.csiro.au/Outcomes/Climate/Understanding/State-of-the-Climate-2012.aspx

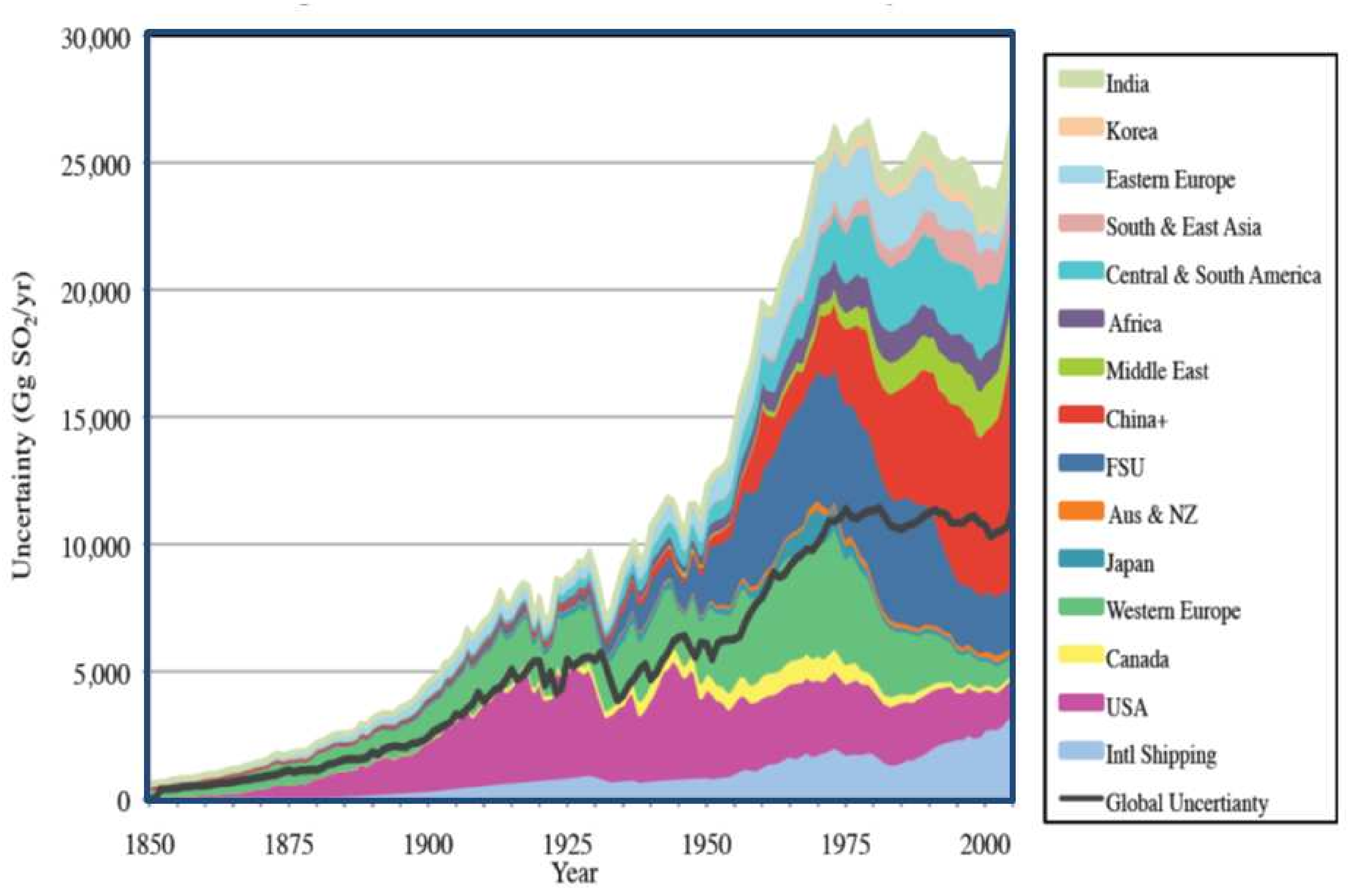

Figure 2

Global industrial sulphur emissions during 1850 – 2010.

www.atmos-chem-phys.net/11/1101/2011/acp-11-1101-2011.pdf

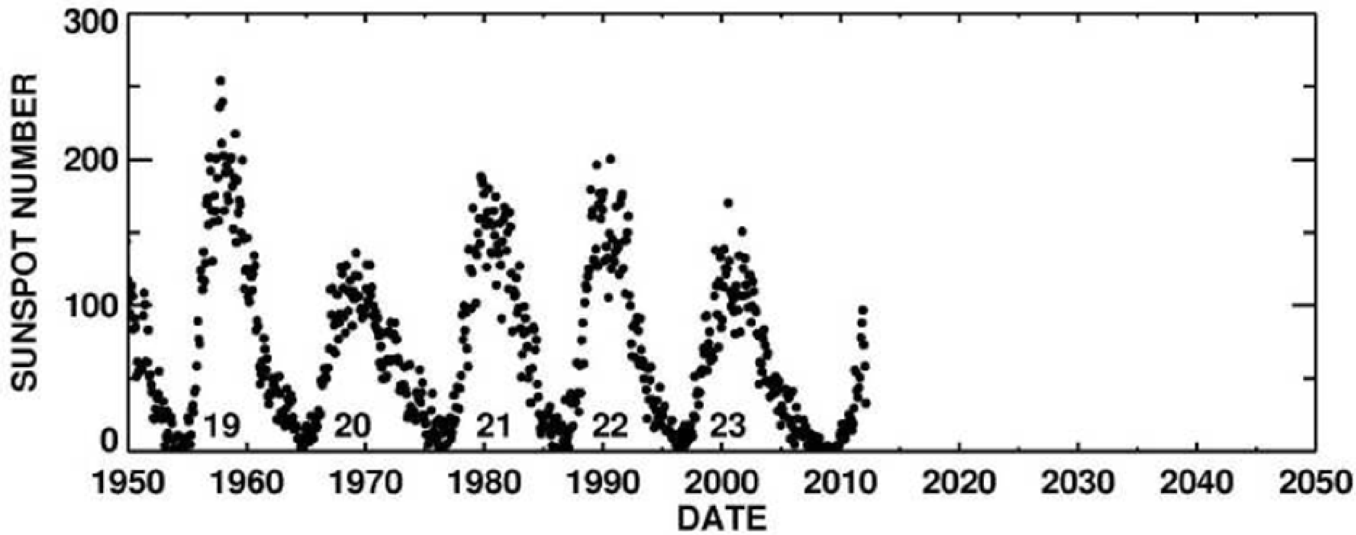

Figure 3

Sun spot numbers between 1950 -2011

http://solarscience.msfc.nasa.gov/images/Zurich_Color_Small.jpg

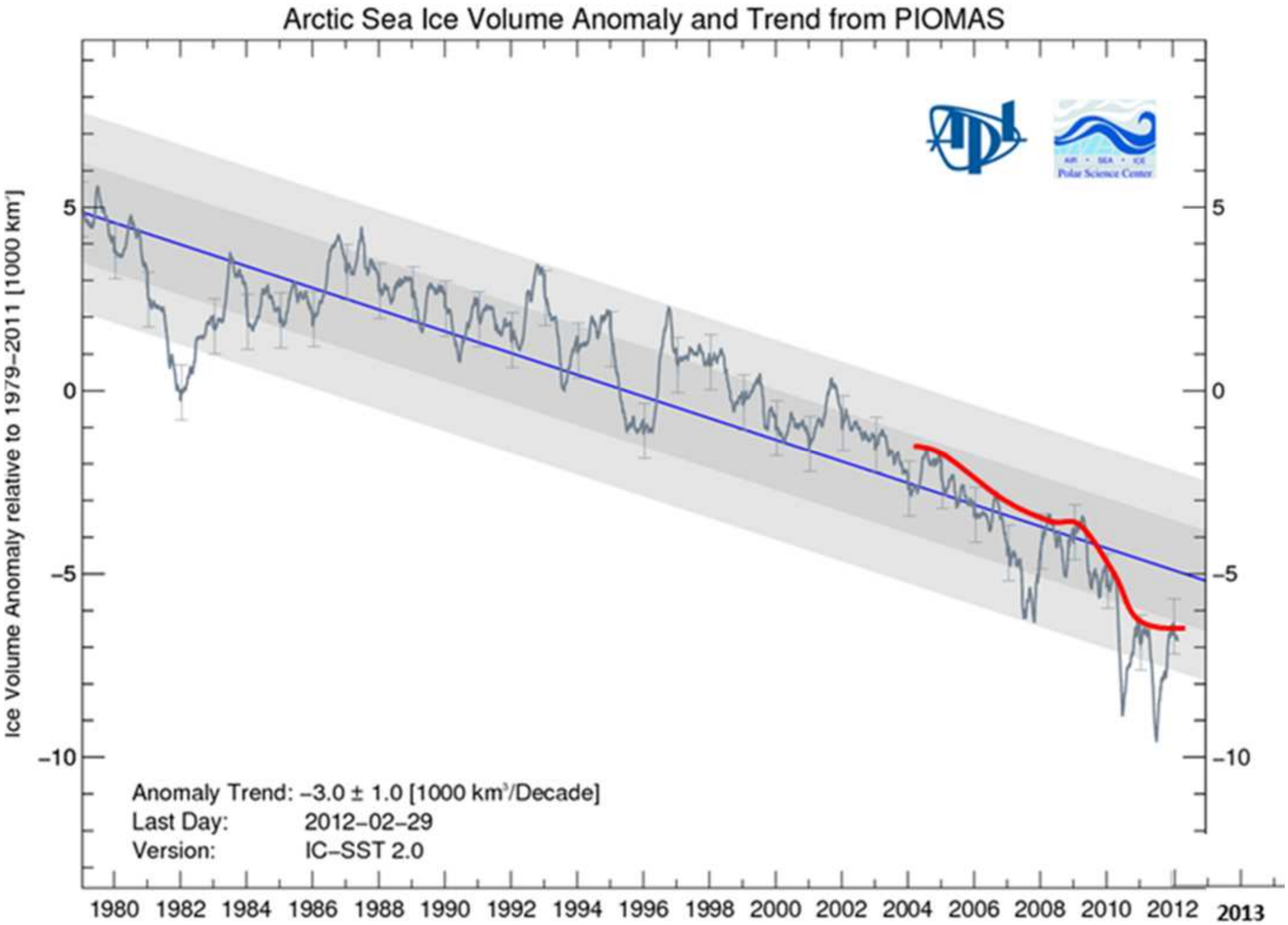

Figure 4

Arctic sea ice volume anomaly from PIOMAS updated once a month. Daily Sea Ice volume anomalies for each day are computed relative to the 1979 to 2011 average for that day of the year. Tick marks on time axis refer to 1st day of year. The trend for the period 1979-present is shown in blue. Shaded areas show one and two standard deviations from the trend. Error bars indicate the uncertainty of the monthly anomaly.

http://psc.apl.washington.edu/wordpress/research/projects/arctic-sea-ice-volume-anomaly/#

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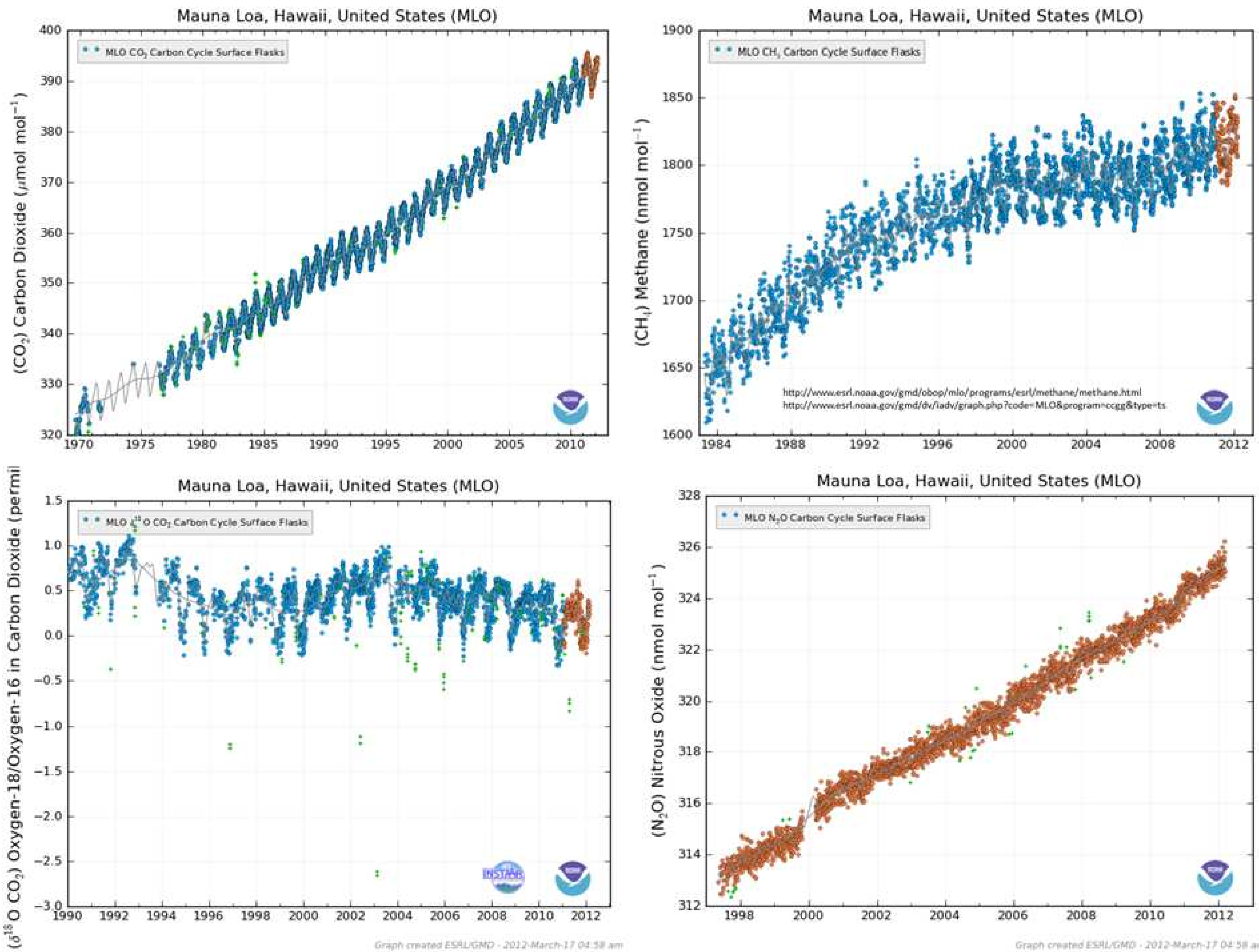

Figure 5

Mouna Loa 1970 – 2012 trends in (A) CO2; (B) Methane; (C) 18O/16O (decreasing – representing relative increase in 16O and thereby rising temperatures), and (D) N2O. http://www.esrl.noaa.gov/gmd/ccgg/trends/

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Coal mine canary