CO2, Earth "greening" and the shift in climate zones

Global warming involves an expansion of the tropics, greening of bordering savannah regions, a shift of arid zones into fertile temperate zones deleterious for agriculture, and migration of rain belts into the tundra regions. The increase in frequency and intensity of extreme weather events in every climate zone is deleterious to agriculture.

Recently the recurrent argument "CO2 is plant food" (http://blogs.telegraph.co.uk/news/jamesdelingpole/100002691/memo-to-prince-charles-co2-is-not-a-pollutant-co2-is-plant-food/) has received possible support. An article titled "Carbon emissions helping to make Earth greener" by Fred Pearce (http://www.newscientist.com/article/mg21829204.400-carbon-emissions-helping-to-make-earth-greener.html) states "Donohue cannot yet say to what extent CO2 fertilization will affect vegetation in the coming decades. But if it proves to be significant, the future may be much greener and more benevolent than many climate modelers predict.".

The article refers to an abstract of a paper titled "CO2 fertilization has increased maximum foliage cover across the globe's warm, arid environments" by Donohue et al. (in press) Http://onlinelibrary.wiley.com/doi/10.1002/grl.50563/abstract whose abstract states "*Satellite observations reveal a greening of the globe over recent decades. The role in this greening of the 'CO2 fertilization' effect – the enhancement of photosynthesis due to rising CO2 levels – is yet to be established. The direct CO2 effect on vegetation should be most clearly expressed in warm, arid environments where water is the dominant limit to vegetation growth. Using gas exchange theory, we predict that the 14% increase in atmospheric CO2 (1982–2010) led to a 5 to 10% increase in green foliage cover in warm, arid environments. Satellite observations, analyzed to remove the effect of variations in rainfall, show that cover across these environments has increased by 11%. Our results confirm that the anticipated CO2 fertilization effect is occurring alongside ongoing anthropogenic perturbations to the carbon cycle and that the fertilization effect is now a significant land surface process.*"

A number of factors is involved in the analysis of global vegetation changes associated with CO2 rise, including:

1. The level of CO2 rise from ~280 to ~400 ppm through the 19th-21 centuries.

2. An increase in atmospheric moisture with temperature following the Clausius-Clapeyron relationship of (a rise in relative humidity of 7% per 1ºC) http://airs.jpl.nasa.gov/documents/science_team_meeting_archive/2010_11/slides/Ye.pdf accounts for a rise in total atmospheric moisture content over the oceans by **0.41 kg/m2** per decade since 1988, as measured by Special Sensor Microwave Imager (SSM/I) (Santer et al. 2007 http://www.pnas.org/content/104/39/15248.full) These findings point to an emerging anthropogenic signal in the cycling of moisture between the atmosphere, land, and oceans (http://www.pnas.org/content/104/39/15169.full). The rise in moisture is in principle beneficial to arid zone vegetation which derives some of its water from the air, such as in the Atacama and Namib deserts.
3. Aerosols and sunlight effect (see Figure 1). The rise in concentrations of atmospheric aerosols, which decreases direct sunlight, is likely to have a negative effect on vegetation.
4. Atmospheric circulation and the shift in climate zones.

The distinction between the effects of CO2 versus the effects of higher moisture and rainfall in marginal desert regions remains unclear.

Here I comment on the effect of the shift in climate zones on the greening, drying and rainfall of major physiographic regions (Figures 2, 3, 5).

According to Seidel et al 2008 (http://www.nature.com/ngeo/journal/v1/n1/fig_tab/ngeo.2007.38_F2.html) recent studies indicate that over the past few decades the tropical belt has expanded, involving pole-ward movement of large-scale atmospheric circulation systems such as jet streams and storm tracks. These could result in shifts in precipitation patterns affecting natural ecosystems, agriculture, and water resources. The observed recent rate of expansion is greater than climate model projections of expansion over the twenty-first century.

A greening of arid zones CF Sahara, Gobi, Mexico deserts) is consistent with a shift in climate to Pliocene-like conditions, when global temperatures were 2 – 3 degrees C warmer that pre-industrial and sea levels higher by 25 +/- 12 meters higher than at present. Present desert regions (Sahara, Gobi) were largely occupied by savannah (Figure 4).

As climate zones shift toward the poles, the extension of tropics and greening of arid zones improves the possibilities of pasture. The extension of the northern rain-belt into tundra regions increases the prospects of farming in these Siberia and Canada. By contrast, the advance of the desert zones toward the poles results in droughts and desertification of fertile temperate zones which constitutes some of the best agricultural regions, such as southern Europe, southern Africa and Western Australia (Figure 5). The rise in the frequency and intensity of extreme weather events in every climate zone is deleterious to agriculture and therefore to civilization.

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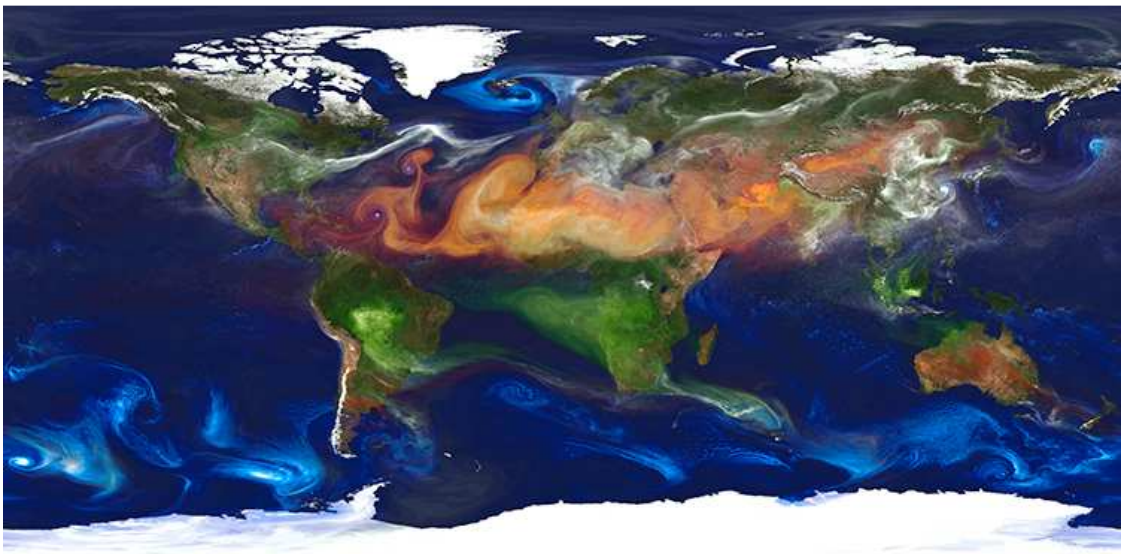

Figure 1.

Portrait of global aerosols by NASA GISS at 10 km resolution. Red – dust; blue – sea salt; green – smoke from fires; white – sulphate particles.
http://www.nasa.gov/externalflash/earthmonth2013/

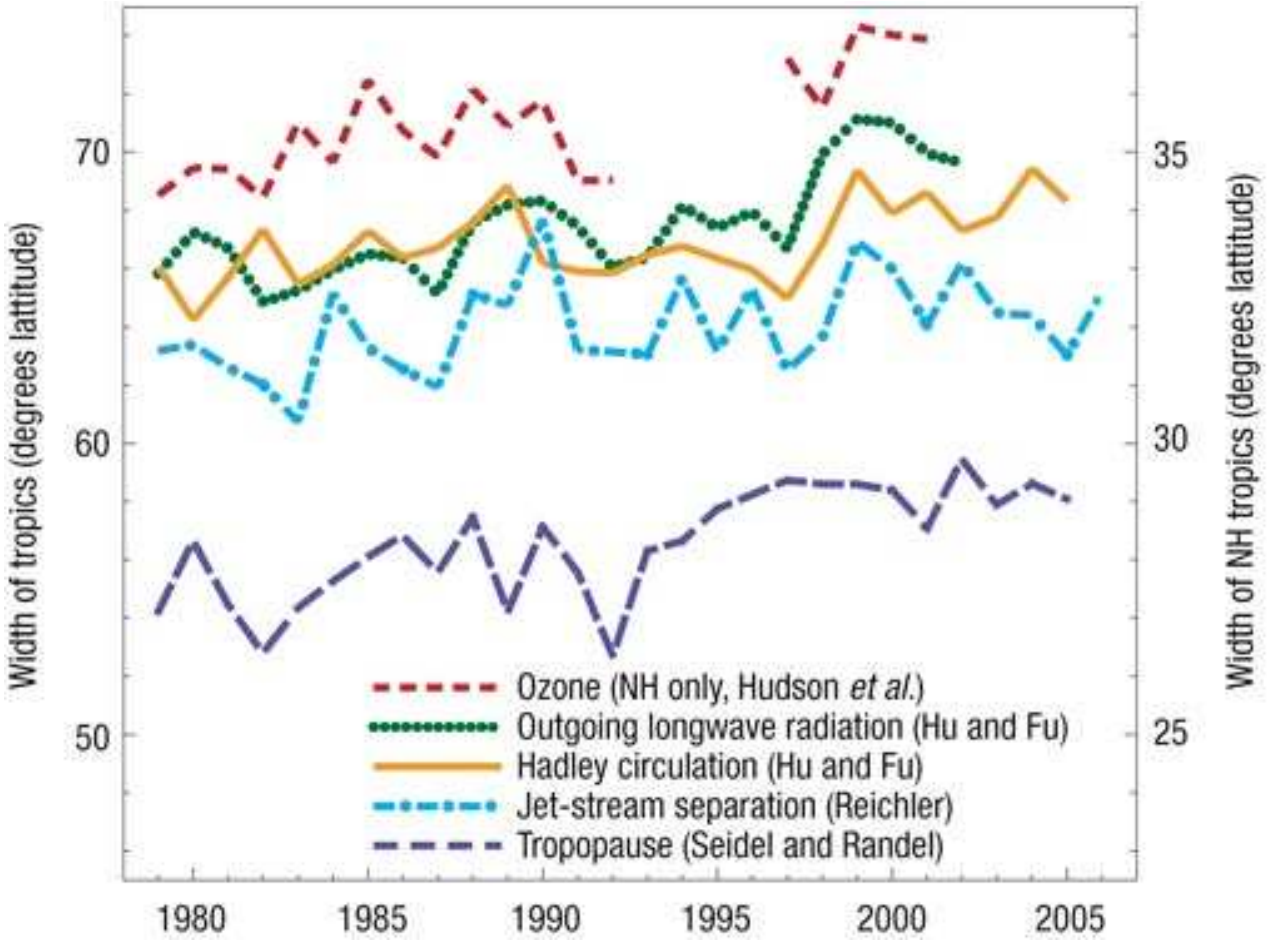

Figure 2

Changes in several estimates of the width of the tropical belt since 1979. The width of the Hadley circulation, based on both outgoing long-wave radiation and horizontal winds stream function; the separation of the Northern and Southern Hemisphere subtropical jet-stream cores; the width of the region of frequent high tropopause levels; and the width of the region with tropical column ozone levels (Northern Hemisphere only, right axis). Although each shows an increase since 1979, the rates vary from 2.0 to 4.8 degrees latitude per 25 years, with an even larger range when considering the entire spread of trend estimates in each individual study.
http://www.nature.com/ngeo/journal/v1/n1/fig_tab/ngeo.2007.38_F2.html

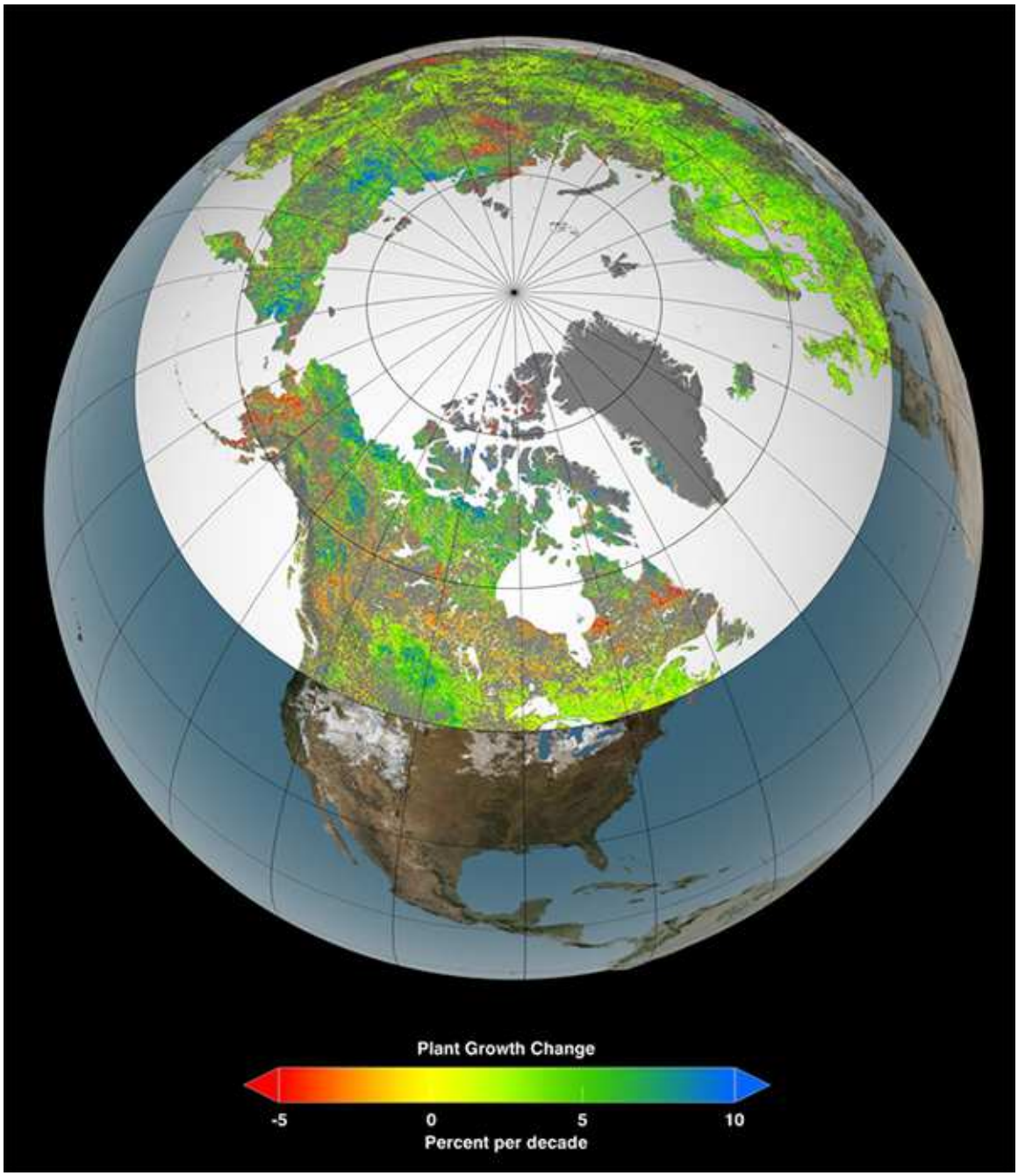

Figure 3

Vegetation growth at Earth's northern latitudes increasingly resembles lusher latitudes to the south. Of the 26 million square km of northern vegetation lands, 34 to 41 percent showed increases in plant growth (green and blue), 3 to 5 percent showed decreases in plant growth (orange and red) and 51 to 62 showed no changes (yellow) over the past 30 years. http://www.nasa.gov/externalflash/earthmonth2013

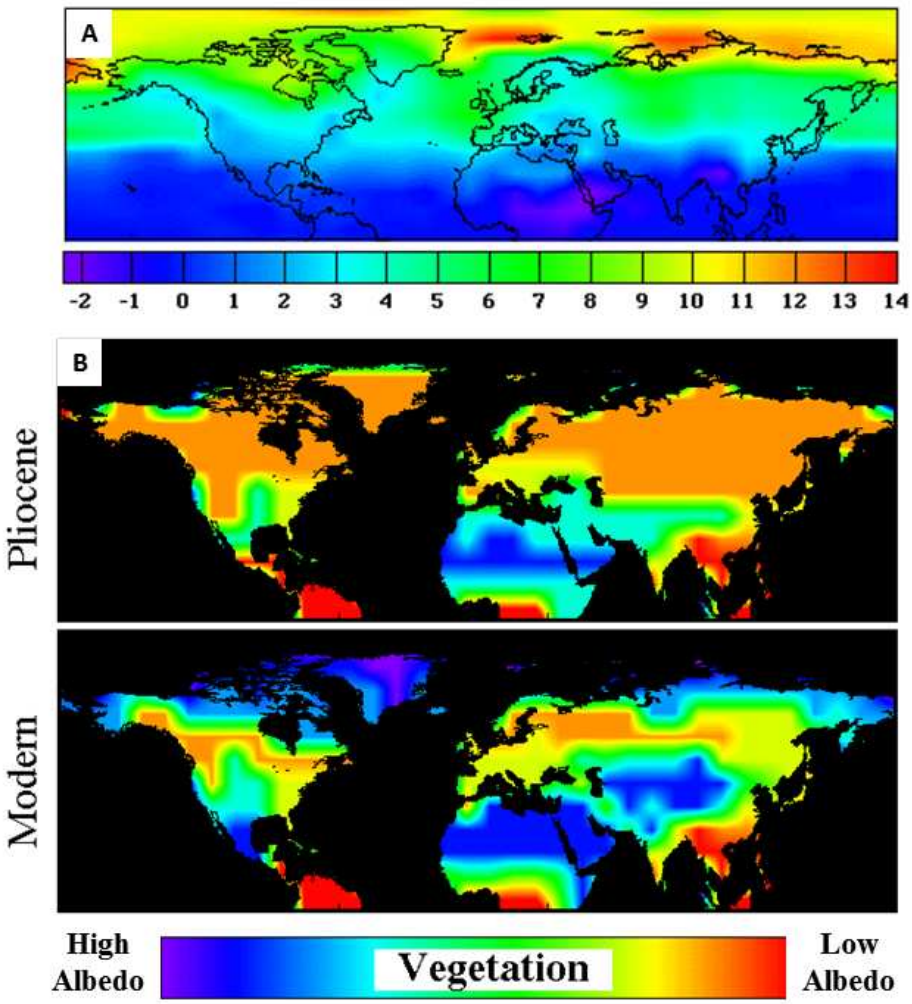

Figure 4

Model and paleo-data based comparisons between Pliocene and late Holocene climates. (A) Pliocene Northern Hemisphere surface air temperatures relative to Holocene pre-industrial temperatures. Model and data indicate significantly warmer temperatures at high latitudes and diminished relative warming nearer to the equator; (B) Pliocene and modern vegetation albedo distribution (NASA - National Aeronautics and Space Administration / Goddard Institute for Space Studies; http://www.giss.nasa.gov/research/features/199704_pliocene/page2.html

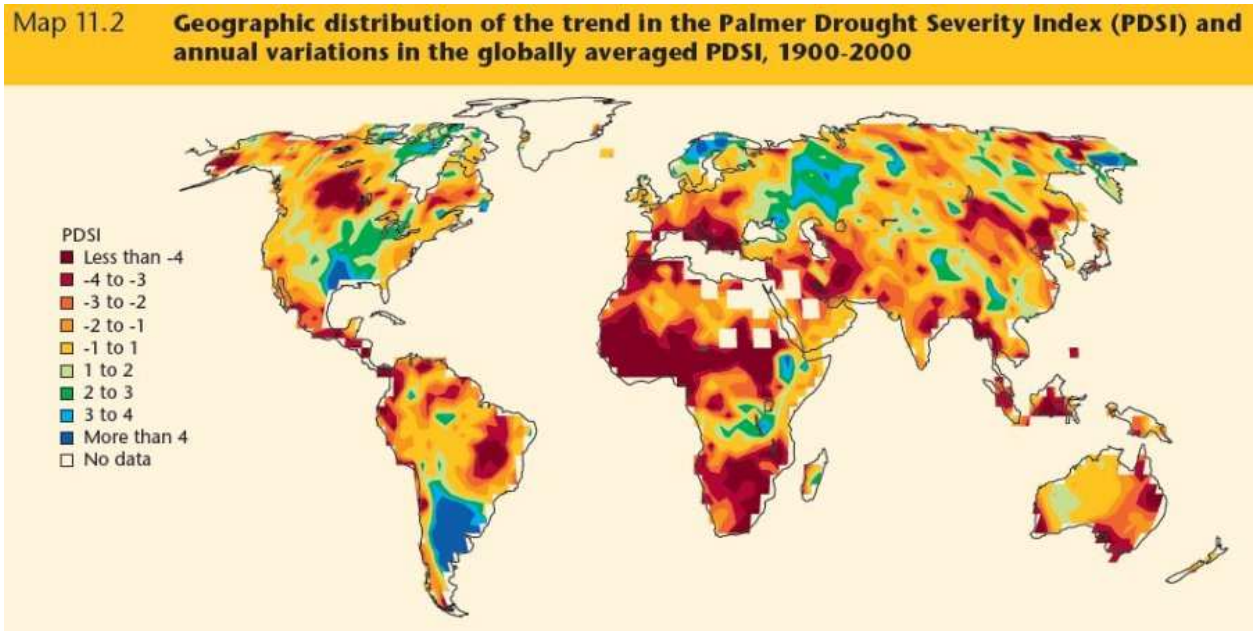

Figure 5.

Variations in the Palmer index 1900-2000. The Palmer Index uses temperature and rainfall information in a formula to determine dryness. http://au.businessinsider.com/water-crisis-2011-3?op=1#drought-severity-has-drastically-increased-over-the-past-100-years-10