



The Greening Earth

Prof. Ranga B. Myneni

**Department of Earth & Environment
Boston University
USA**

**ranga.myneni@bu.edu
<http://cliveg.bu.edu/>**

**Probing Vegetation Conference
From Past to Future
July 4-5, 2013
Antwerp, Belgium**

What Happens When Radiation from the Sun Strikes a Green Leaf?



**“La Belle Saison”
René Magritte**

Monitoring Vegetation From Space

Pigments in green leaves (notably chlorophyll) absorb strongly at red and blue wavelengths (approximately less than 0.7 microns).

Lack of such absorption at near-infrared wavelengths results in strong scatter from leaves (approximately greater than 0.8 to 1.2 microns).

The “greenness” of the ground is simply the difference between these two measurable quantities (appropriately normalized).

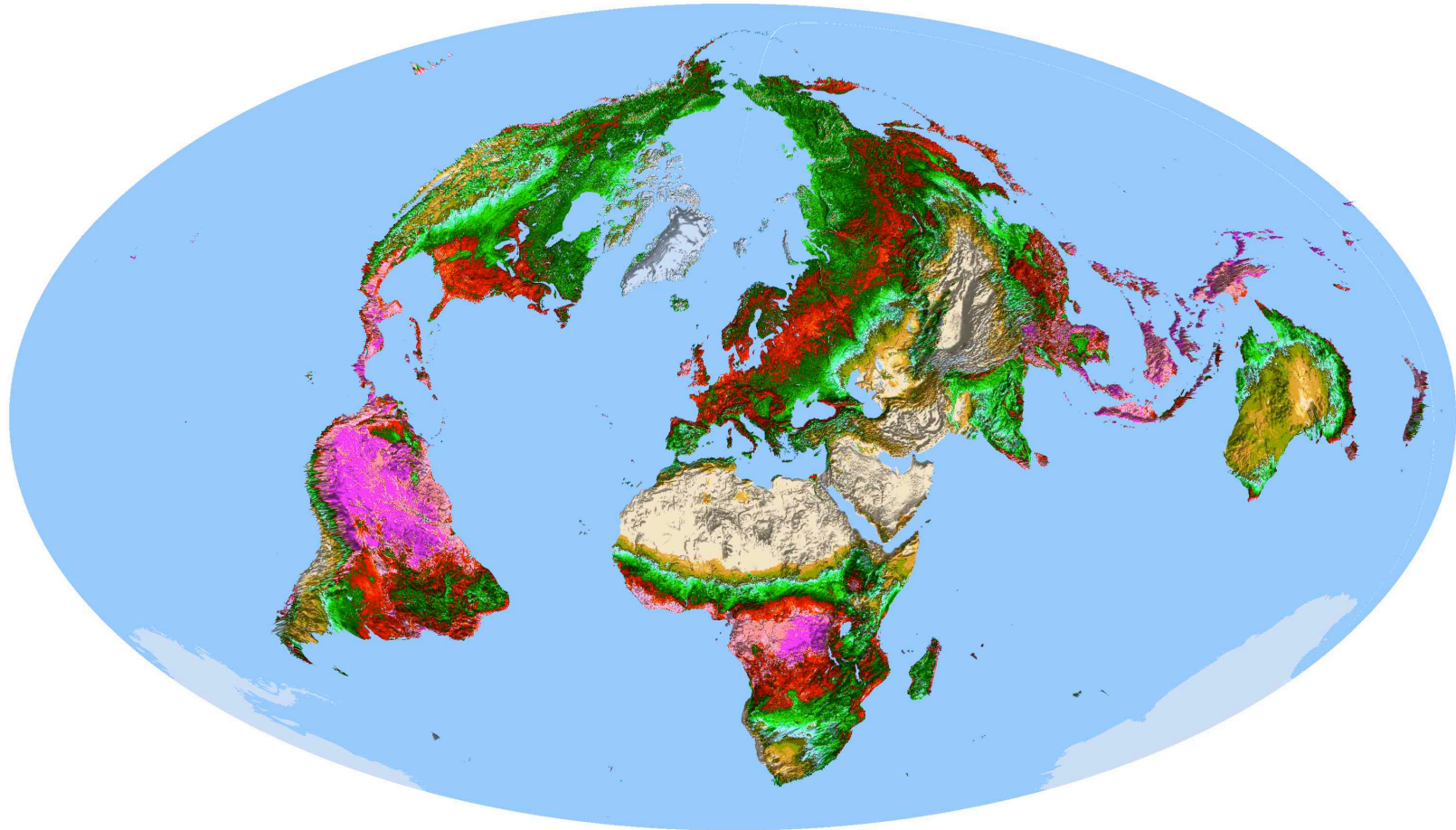
$$\text{NDVI} = (\text{NIR} - \text{RED}) / (\text{NIR} + \text{RED})$$

NDVI = Normalized Difference Vegetation Index

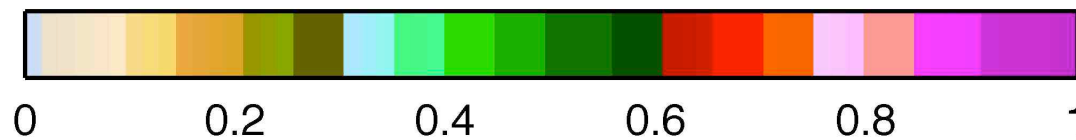


Image Credit: Satellite Imaging Corp.

Average Greenness Of Our Planet



Vegetation Greenness



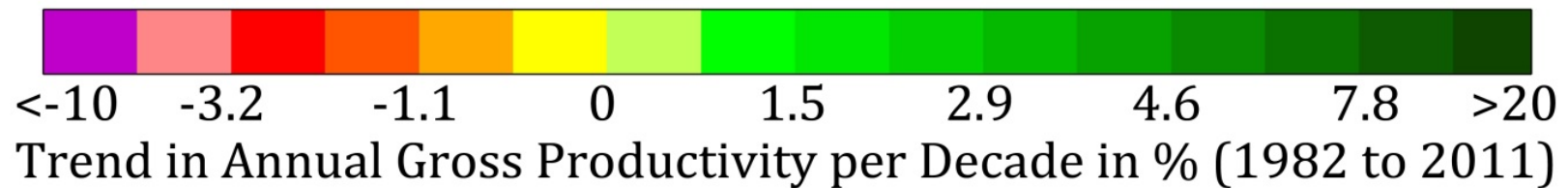
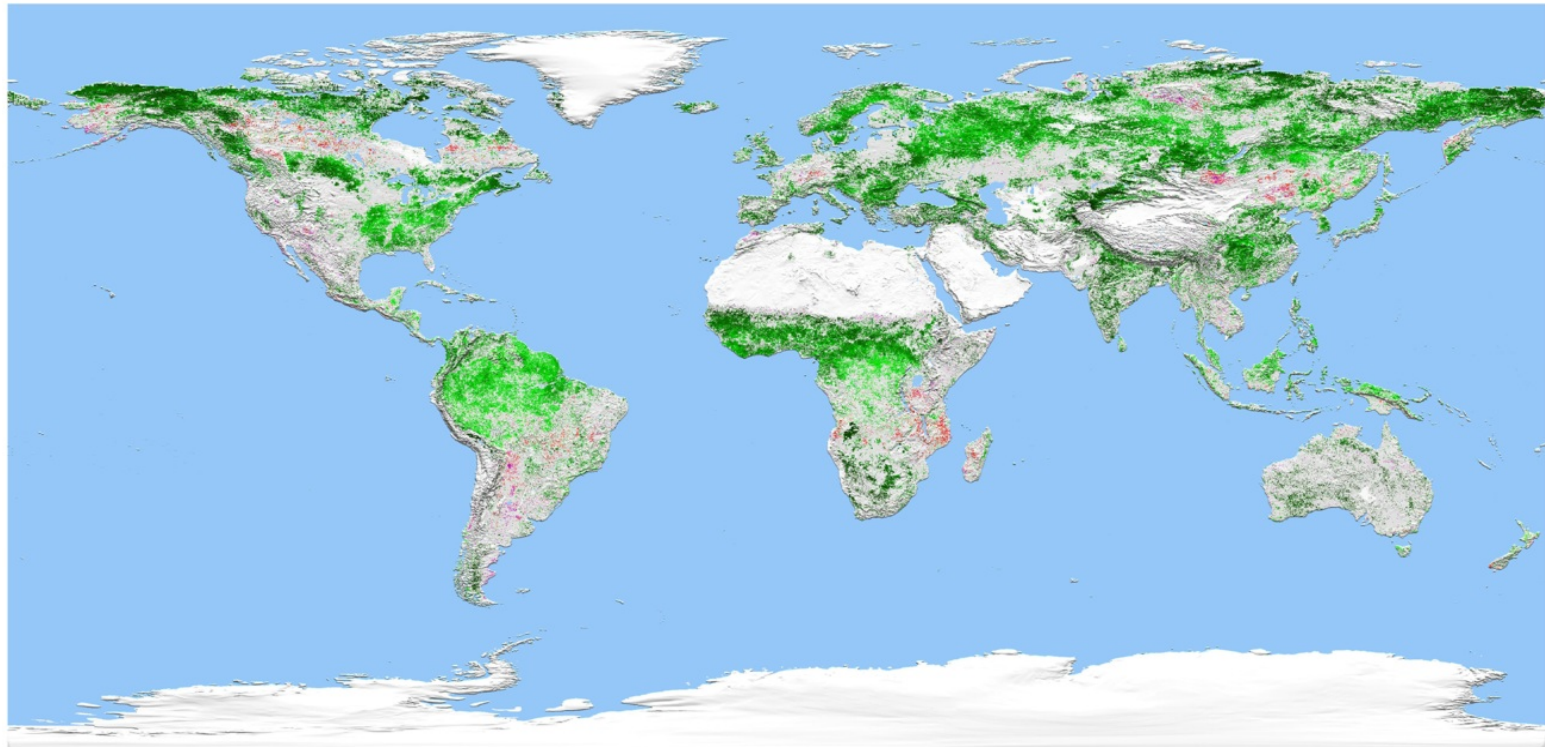
How Did The Greenness of Our Planet Change?

- Satellite Vegetation Greenness Data (AVHRR)
- July 1982 to December 2012 (30+ years)
- 8x8 kilometer pixels
- 2 Views a month



"Wooded Landscape"
Sir Anthony Van Dyck

The Greening Earth



Annual Gross Productivity = Growing Season Total Vegetation Greenness
Statistically significant ($p < 0.1$) based on Vogelsang's t-PS_T test

By How Much did the Earth Green over the Past 30 years?

IGBP Land Cover Classes	Area			Productivity	
	G (%)	B (%)	N (%)	I (%)	D (%)
Evergreen broadleaf forests	5.62	0.15	7.10	2.27	-0.04
Deciduous broadleaf forests	0.54	0.09	0.95	0.23	-0.05
Cropland/Natural vegetation mosaics	2.27	0.13	4.30	1.26	-0.09
Savannas	1.67	0.40	6.03	0.94	-0.16
Mixed forests	3.56	0.40	8.33	1.96	-0.19
Woody savannas	2.85	0.05	2.96	1.22	-0.03
Croplands	3.41	0.21	7.15	1.75	-0.12
Closed shrublands	1.80	0.19	3.36	0.68	-0.06
Evergreen needleleaf forests	0.92	0.01	1.15	0.25	0.00
Deciduous needleleaf forests	0.18	0.09	1.07	0.11	-0.07
Grasslands	2.86	0.48	10.53	1.08	-0.18
Open shrublands	5.18	0.57	13.39	1.80	-0.22
Total	30.87	2.76	66.32	13.54	-1.21

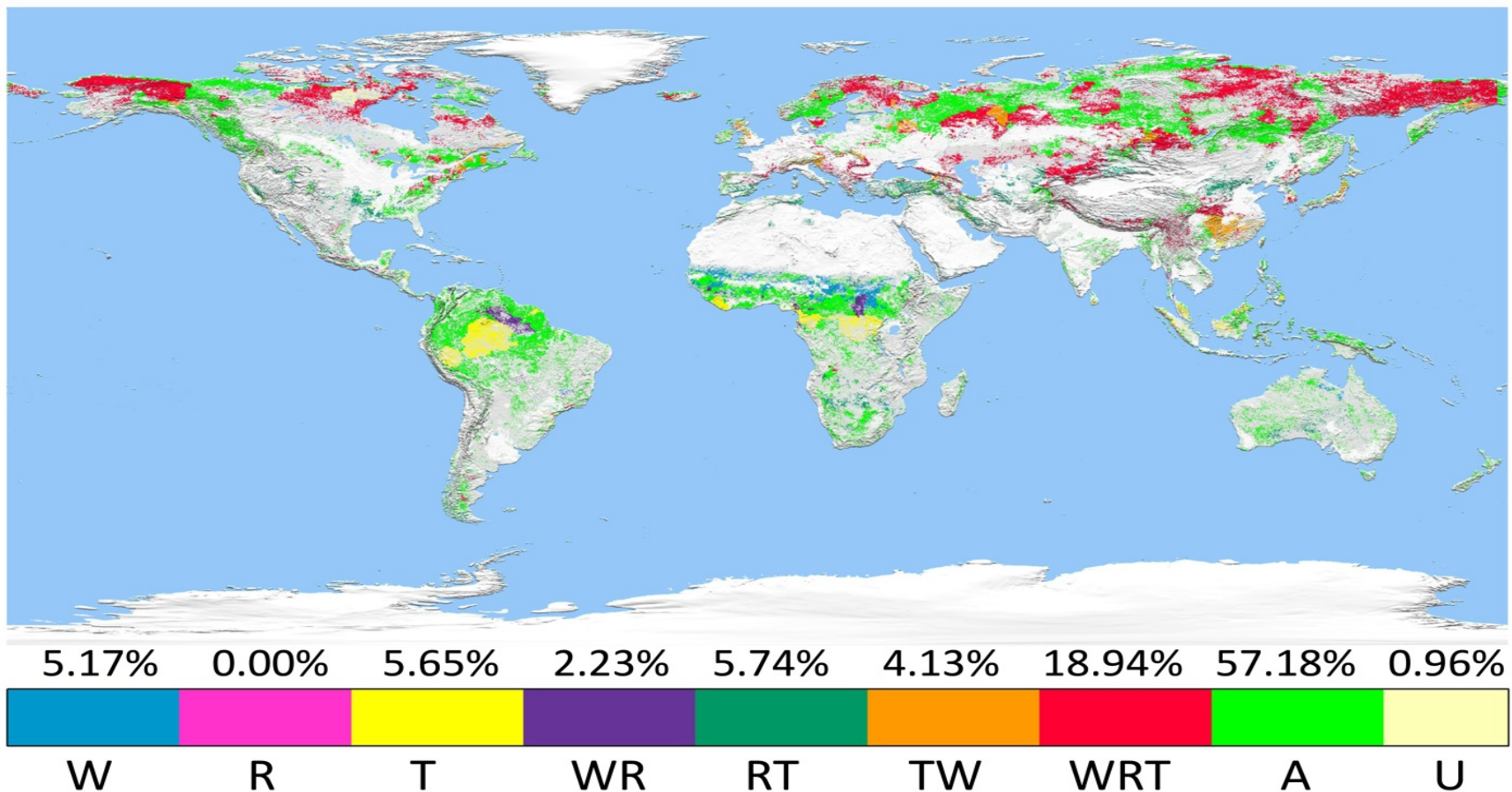
- 31% of the global vegetated area greened
- This greening translates to a 14% increase in gross productivity
- The greening is seen in all vegetation types

Why did Our Planet Green?



"L'Eveil de la Foret"
Paul Delvaux

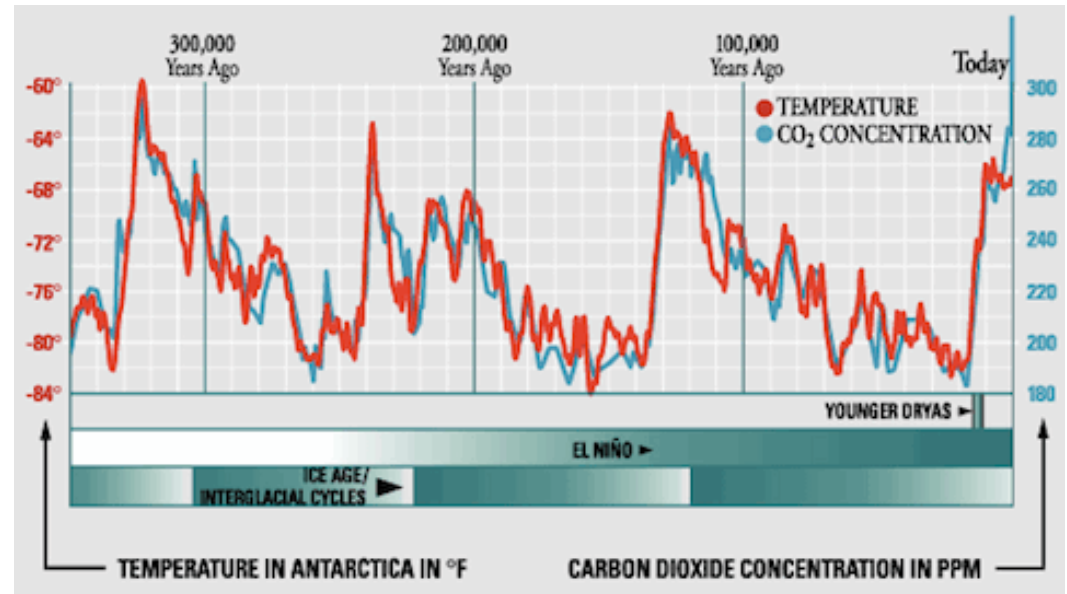
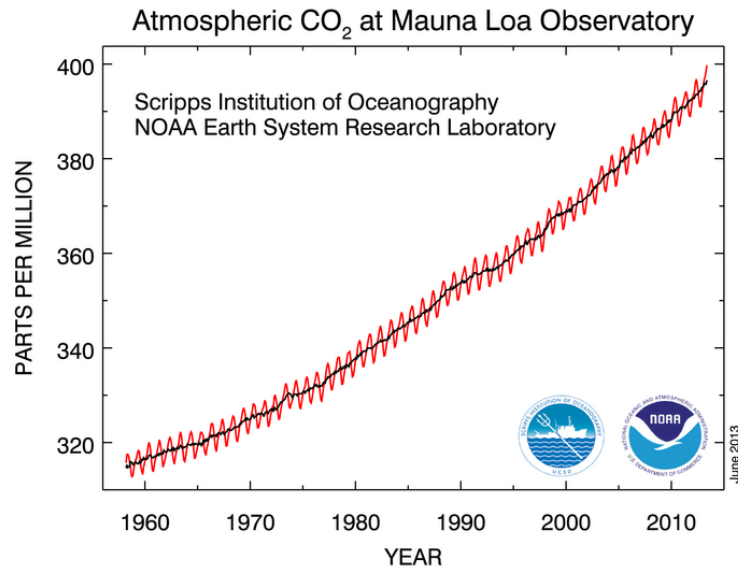
Why did Our Planet Green?



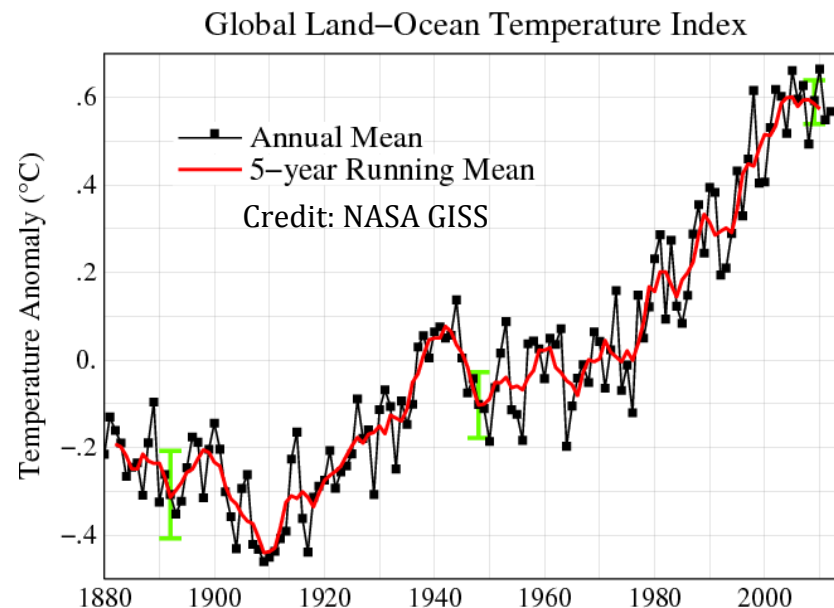
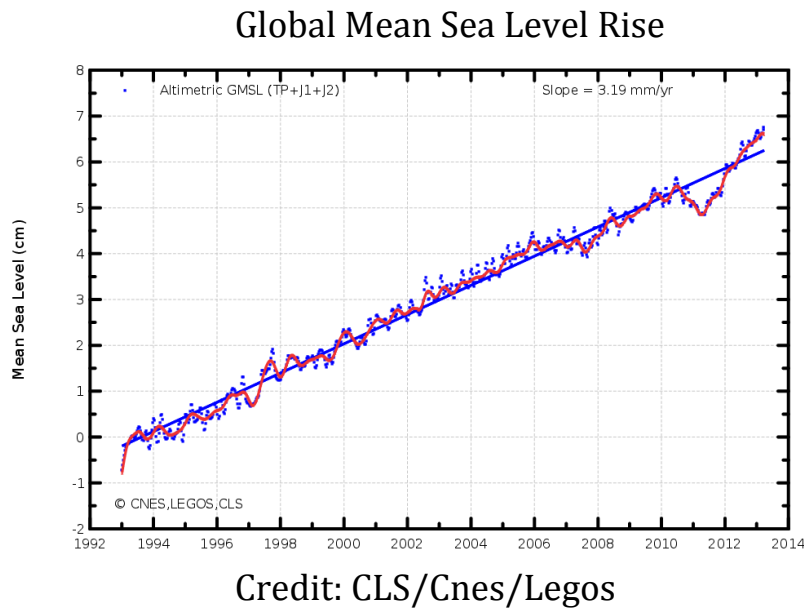
Attribution of Increase in Annual Gross Productivity

- 42% can be attributed to relaxation of climatic constraints to plant growth
- 57% to “other” anthropogenic factors
- 1% unknown

Is this a Good or Bad Development?



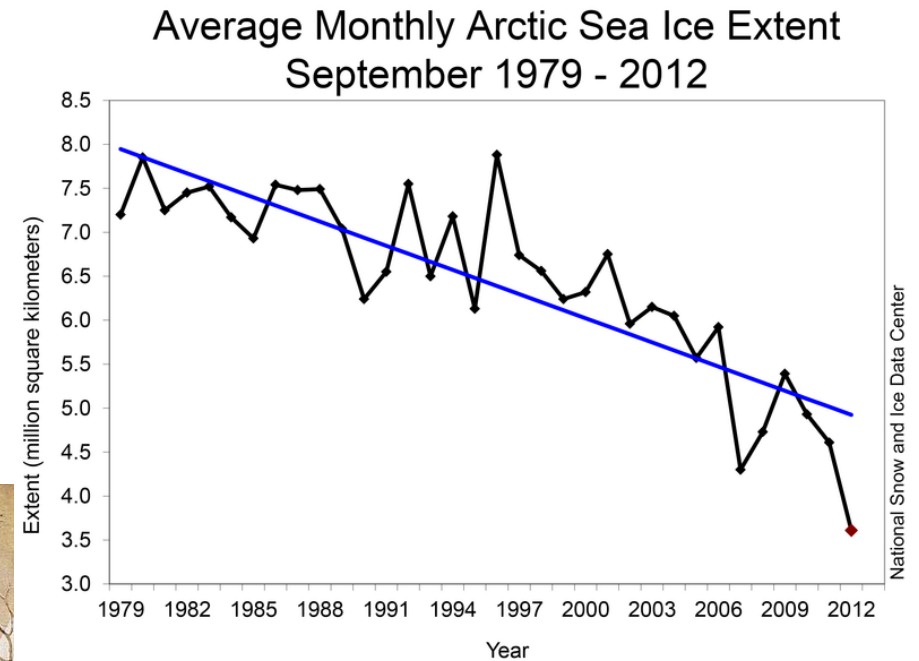
Ice core record from Vostok, Antarctica: Antarctic temperature and CO₂ levels Credit: Siegenthaler et al. (2005)



Elfstedentocht? We Can Forget it!



“Winterlandschap met Schaatsers en een Vogelval”
Pieter Bruegel de Oude



**The Arctic could be ice-free
in about 30-50 years!**

What Can We Do?

- Monitor Changes: Cost-effectively and accurately with Satellite Sensors
- Action: Inform the Public & Policy Makers
- Hope: We can be as happy as these David Teniers II's "Peasants"



"Peasants Merry-Making"
David Teniers de Jonge