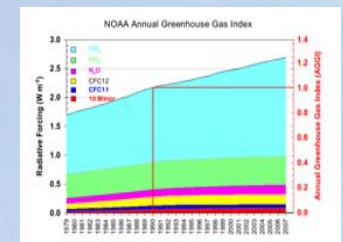




# The NOAA Annual Greenhouse Gas Index

## *Integrating NOAA's Climate Forcing Observations*





# Radiative Forcing

- ...an externally imposed perturbation in the radiative energy budget of the Earth climate system, for example, through changes in solar radiation, changes in the Earth albedo or changes in atmospheric gases and aerosol particles. – IPCC AR3, 2001; IPCC AR4, 2007
- ...a measure of the influence that a factor has in altering the balance of incoming and outgoing energy in the Earth-atmosphere system and ... an index of the importance of the factor as a potential climate change mechanism. Positive forcing tends to warm the surface while negative forcing tends to cool it. – IPCC AR4, 2007 (SPM)
- Radiative forcing values are calculated relative to pre-industrial conditions defined at 1750 and are expressed in watts per square metre ( $W m^{-2}$ ).



# The Problem

- People don't get it . . . .

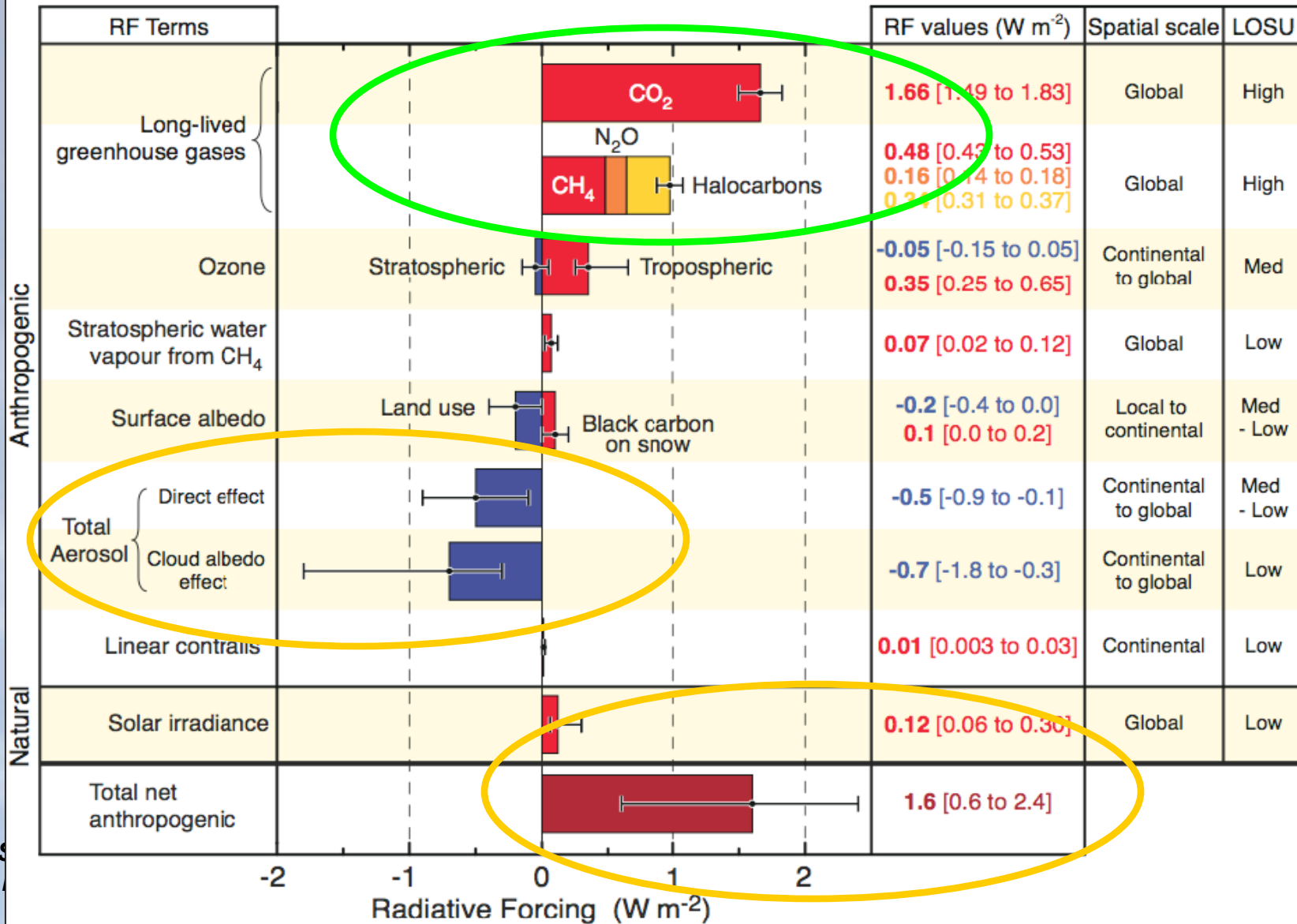


# Goal

- Enhance the connection between scientists and society by providing a normalized standard that can be easily understood and followed.
  - Reduce complexity
  - Reduce variability
  - Enhance exposure – reach a broader audience



# Radiative Forcing Components



©IPCC 2007: WG1-AR4



# Approach

- The largest and least-uncertain perturbation to Earth's radiation budget is that due to increases in the abundances of long-lived, well-mixed greenhouse gases
- NOAA measures all of these gases
- Measurements within NOAA/ESRL are well distributed, well calibrated, and internally consistent
- Therefore, calculate an index based on known measurements of long-lived gases

# Major Contributors

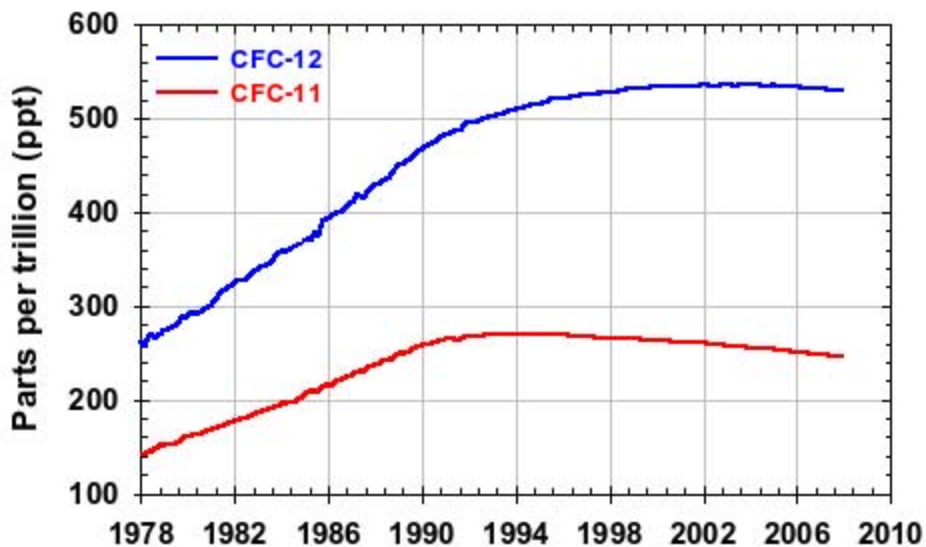
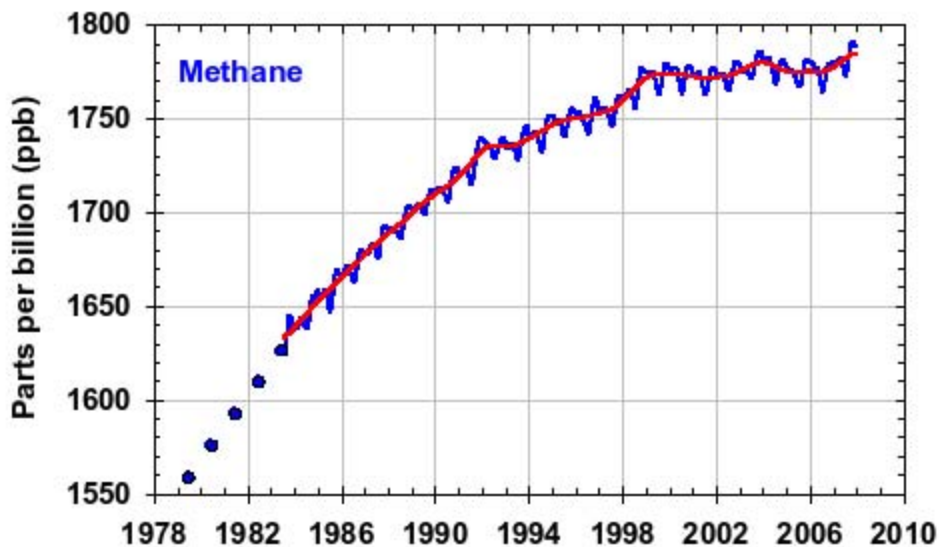
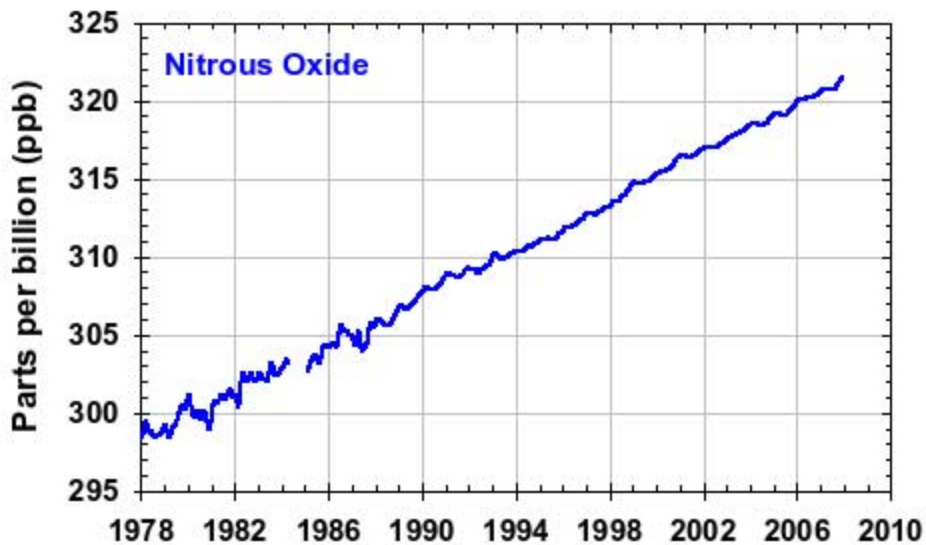
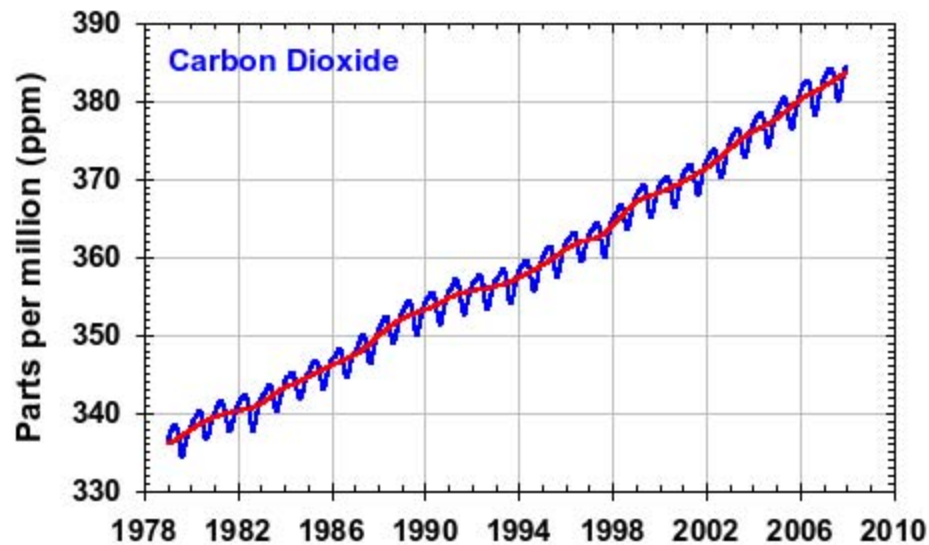




Table 1. Expressions for calculating radiative climate forcing<sup>a</sup>

Trace gas	Simplified expression for radiative forcing, $F$ ( $\text{W m}^{-2}$ )	Constant
CO <sub>2</sub>	$F = a [\ln(C/C_o)]$	$a = 5.35$
CH <sub>4</sub>	$F = b (M^{1/2} - M_o^{1/2}) - [f(M, N_o) - f(M_o, N_o)]$	$b = 0.036$
N <sub>2</sub> O	$F = c (N^{1/2} - N_o^{1/2}) - [f(M_o, N) - f(M_o, N_o)]$	$c = 0.12$
CFC-11	$F = d (X - X_o)$	$d = 0.25$
CFC-12	$F = e (X - X_o)$	$e = 0.32$

<sup>a</sup>IPCC, 2001.

$C$  is CO<sub>2</sub> in ppm,  $M$  is CH<sub>4</sub> in ppb,  $N$  is N<sub>2</sub>O in ppb,  $X$  is CFC in ppb.

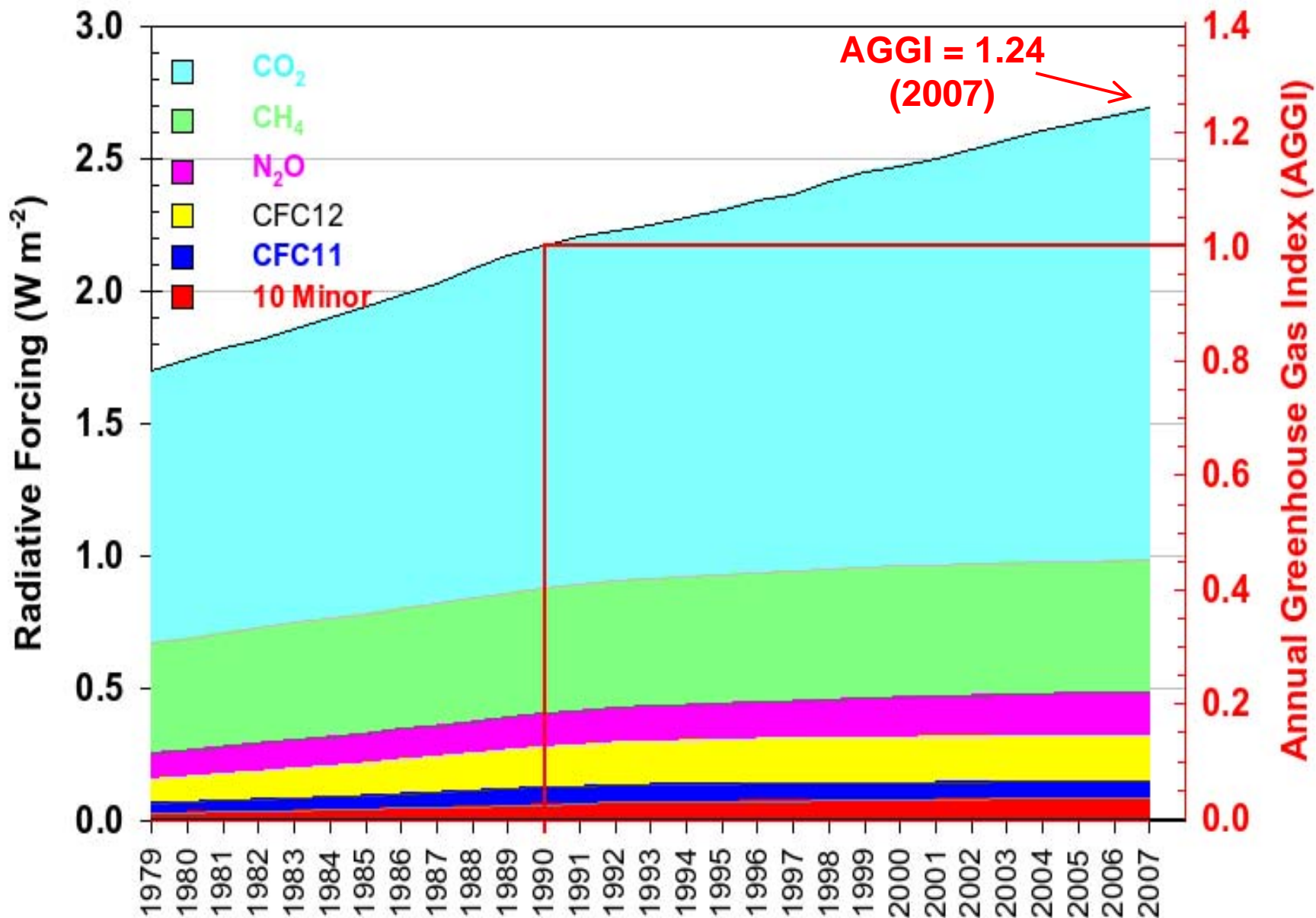
The subscript o denotes unperturbed (1750) values:

$C_o = 278$  ppm,  $M_o = 700$  ppb,  $N_o = 270$  ppb,  $X_o = 0$

$f(M, N) = 0.47 \ln[1 + 2.01 \times 10^{-5} (MN)^{0.75} + 5.31 \times 10^{-15} M (MN)^{1.52}]$ .

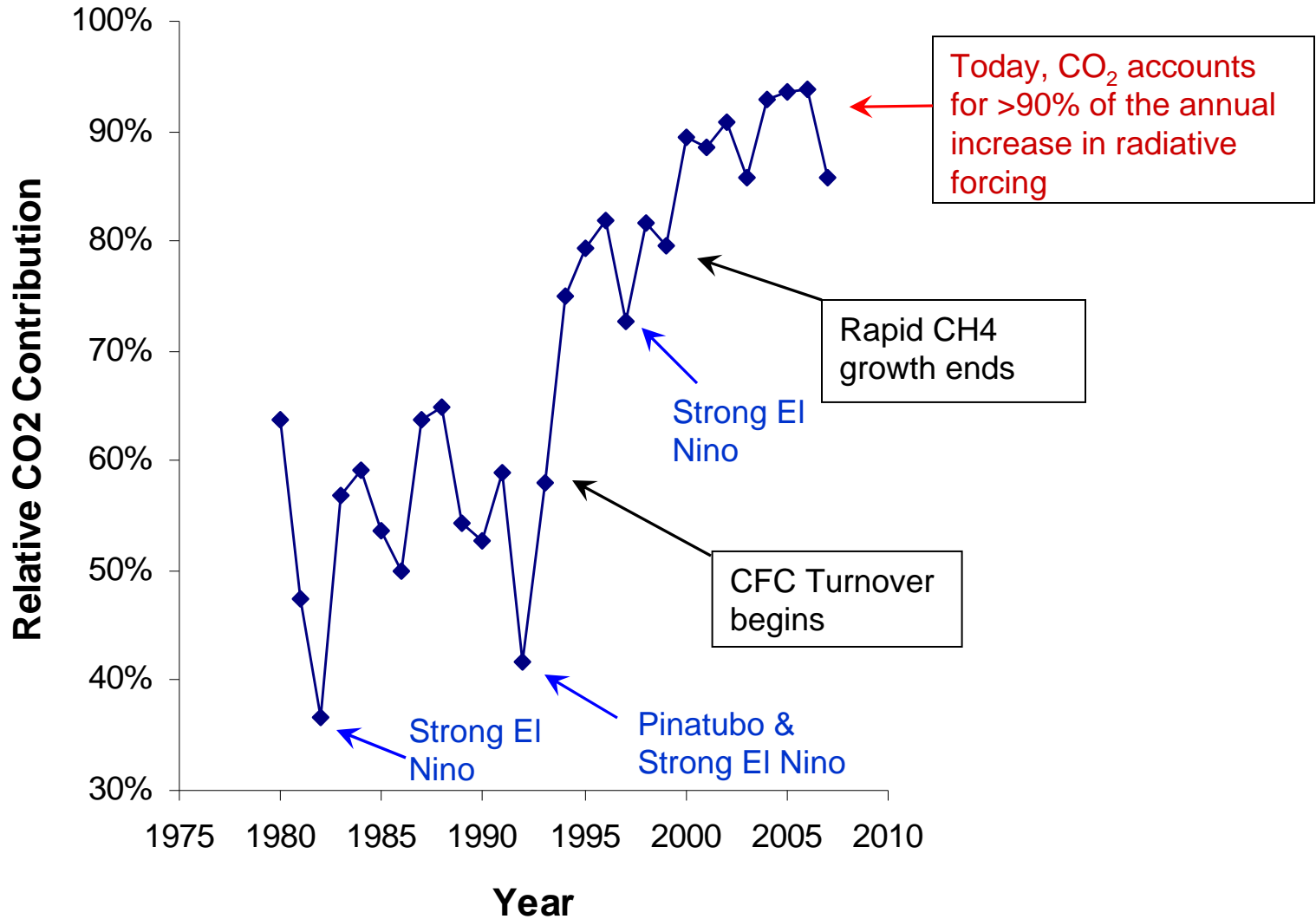


# NOAA Annual Greenhouse Gas Index





# CO<sub>2</sub> Role in increasing Radiative Forcing -- (Annual running mean)





# El Nino Consensus

(<http://ggweather.com/enso/years.htm>)

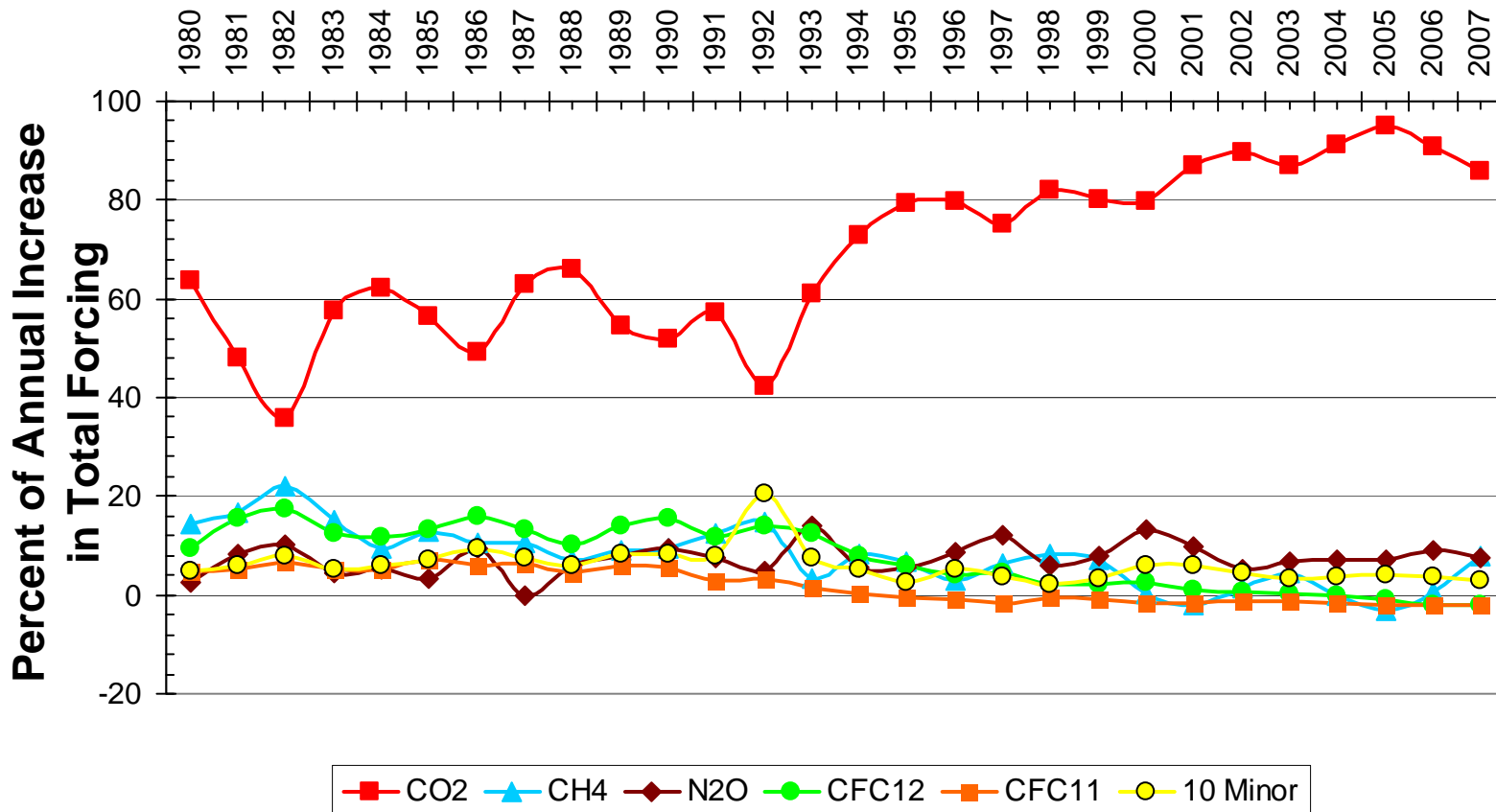


**Table 1. Consensus List of El Niño and La Niña Years**

Winter	<a href="#">WRCC</a>	<a href="#">CDC</a>	<a href="#">CPC</a>	<a href="#">MEI</a>	Consensus
1981-82					
1982-83	W+	W	W+	W+	Strong El Niño
1983-84			C-		
1989-90					
1990-91			W+		
1991-92	W	W	W+	W+	Strong El Niño
1992-93	W		W+	W-	El Niño
1993-94	W+		W		
1994-95	W+		W	W-	El Niño
1995-96			C-	C-	
1996-97					
1997-98	W+	W	W+	W+	Strong El Niño
1998-99	C+		C	C-	La Niña
1999-00			C	C	
2000-01	C	C	C-	C-	La Niña



# Relative Contributions of All Long-Lived Gases





# Summary

- The Annual Greenhouse Gas Index (AGGI) was **1.24** for the year 2007, (an increase in total radiative forcing of 24% since 1990).
- Since 1990, the radiative forcing due to CO<sub>2</sub> alone has increased about **34%**.
- Of the four major groups of long-lived greenhouse gases that contribute to radiative climate forcing, CO<sub>2</sub> and N<sub>2</sub>O are the only ones that continue to increase at a regular rate.
- The contribution to radiative forcing by methane and CFCs has been nearly constant or declining in recent years. As a consequence, the contribution to the annual increase in the total radiative forcing of long-lived greenhouse gases due to CO<sub>2</sub> is now **over 90%**, up from about 55% before 1990.
- Had the ozone-depleting gases not been regulated by the Montreal Protocol (1987) and its amendments, climate forcing is estimated to have been as much as 0.2 watt m<sup>-2</sup> higher, or about one-half of the increase in radiative forcing due to CO<sub>2</sub> alone since 1990.