

Climate models – the new scenarios they present for building simulation approaches under a global warming trend

Presented at SimBuild2008
“Climate Change and Building”

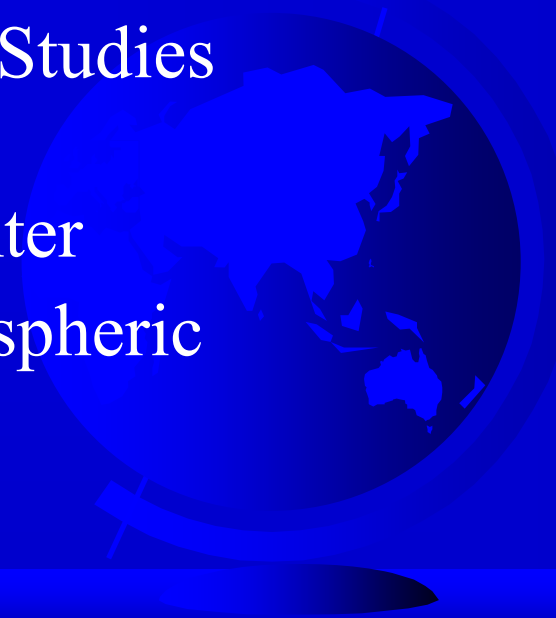
Wednesday, 10:30 a.m., 30 July 2008
Berkeley, CA

by
Larry O. Degelman, P.E.
Professor Emeritus of Architecture
Texas A&M University
ldegelman@suddenlink.net



Models and Organizations

- ☞ HadCM3 – Hadley Climate Model (European)
- ☞ IPCC – Intergovernmental Panel on Climate Change
- ☞ GFDL - Geophysical Fluid Dynamics Laboratory (NOAA)
- ☞ GISS – Goddard Institute for Space Studies (NASA)
- ☞ NCDC – National Climate Data Center
- ☞ NOAA – National Oceanic & Atmospheric Association.



Global warming information sources

NOAA (National Oceanic and Atmospheric Admin.):

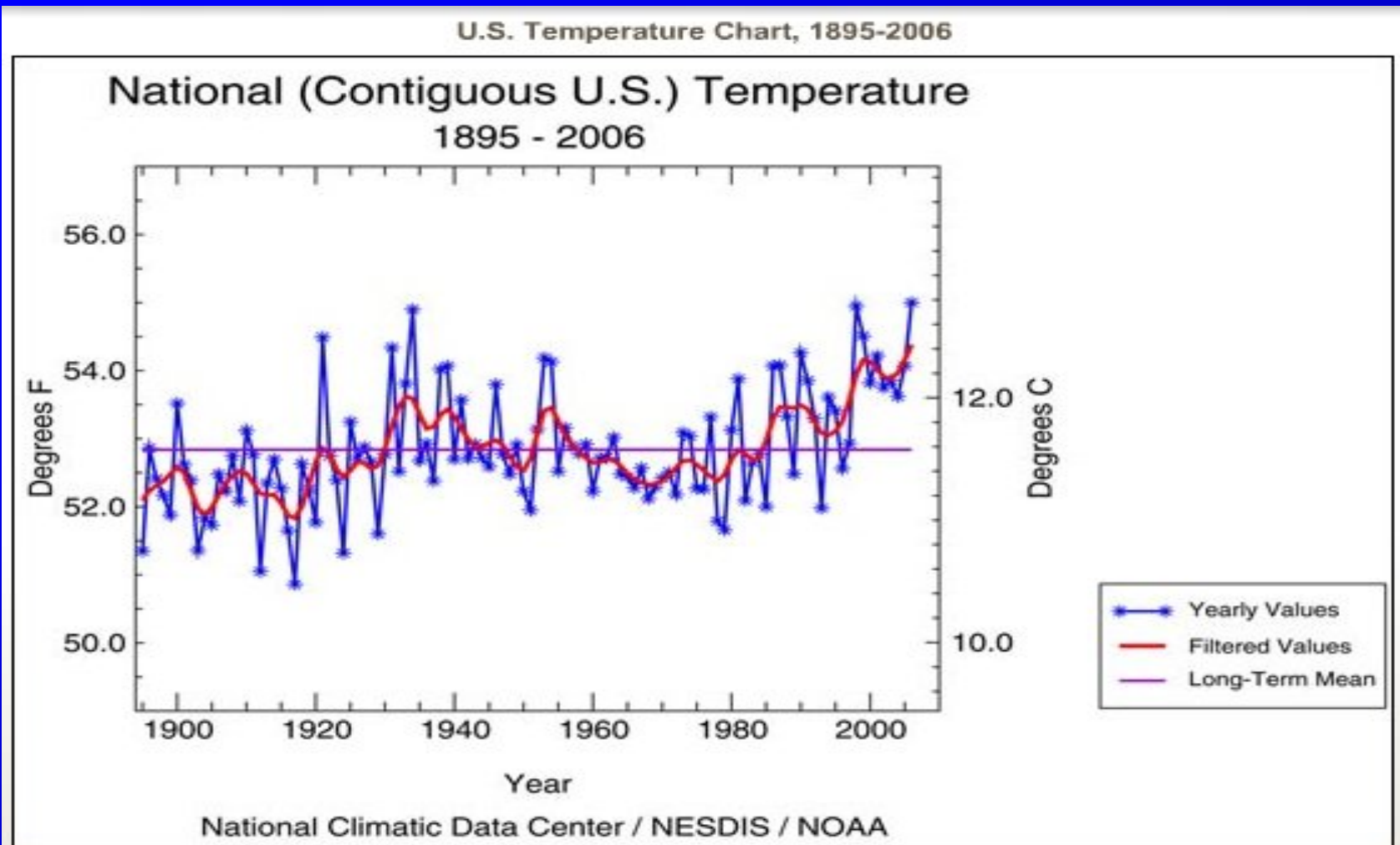
- ➔ NOAA maintains an informative web site on global warming.

NOAA's Geophysical Fluid Dynamics Laboratory:

- ➔ GFDL maintains an informative web site on modeling projections about global warming.



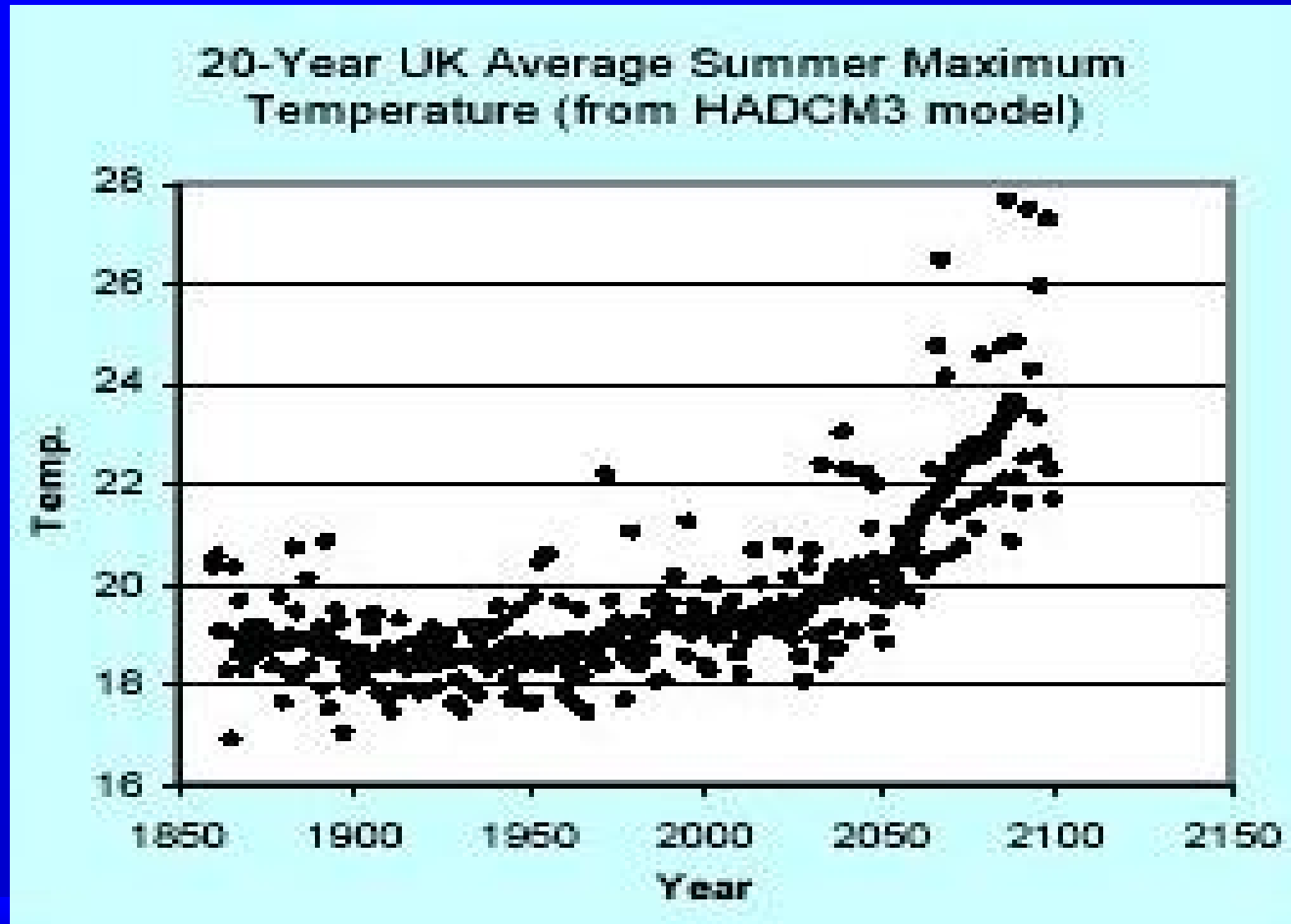
1895-2006 Historic trends (source: NOAA)



NOAA

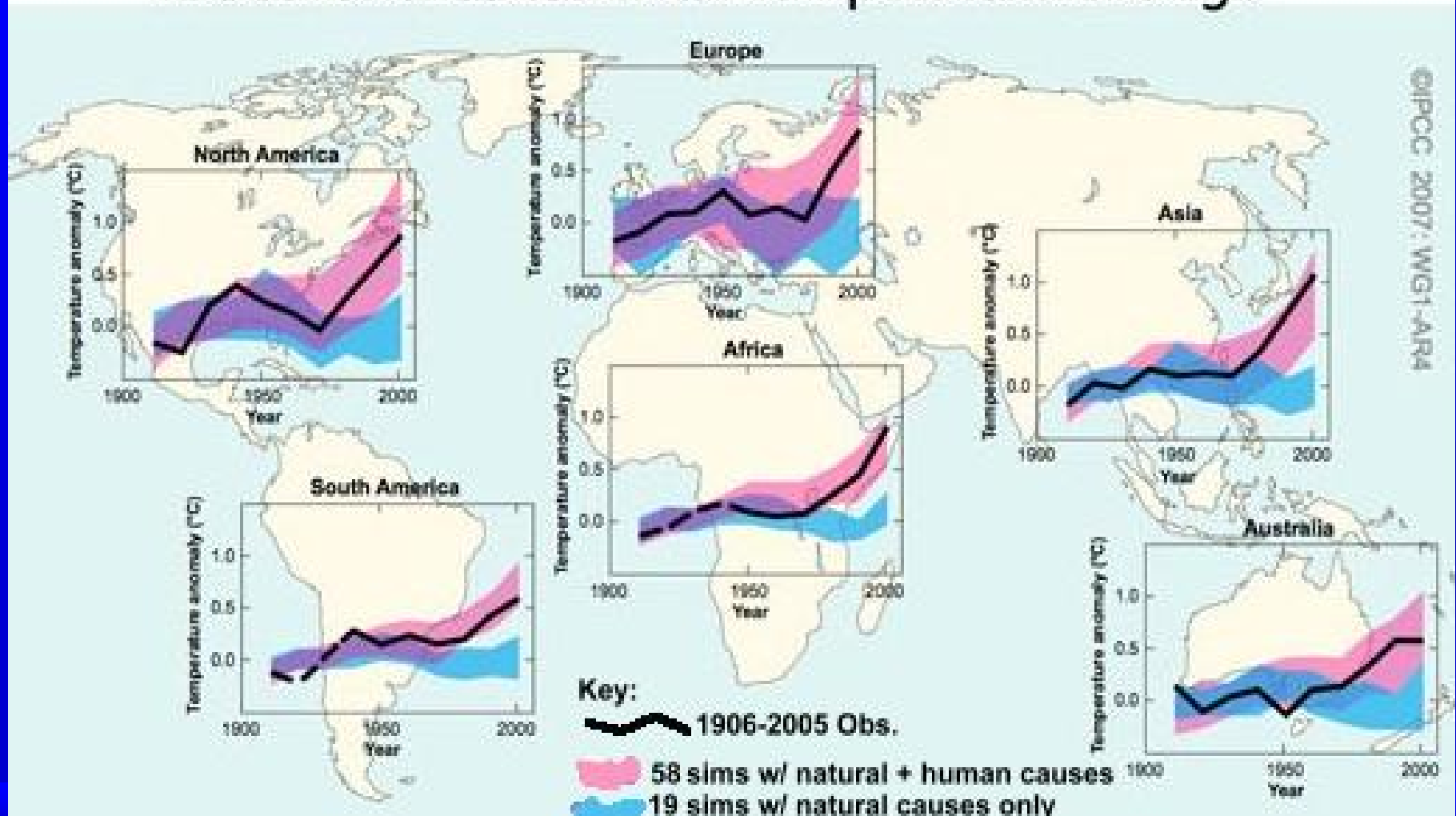
U.S. and global annual temperatures are now approximately 1.0 degrees Fahrenheit warmer than at the start of the 20th century, and the rate of warming has accelerated over the past 30 years, increasing since the mid-1970s at a rate about three times faster than the century-scale trend. The past nine years have all been among the 25 warmest years on record, a streak which is unprecedented in the historical record. [2006 Warmest on Record](#)

Projections for the UK by the HadCM3 model: “the hockey stick”

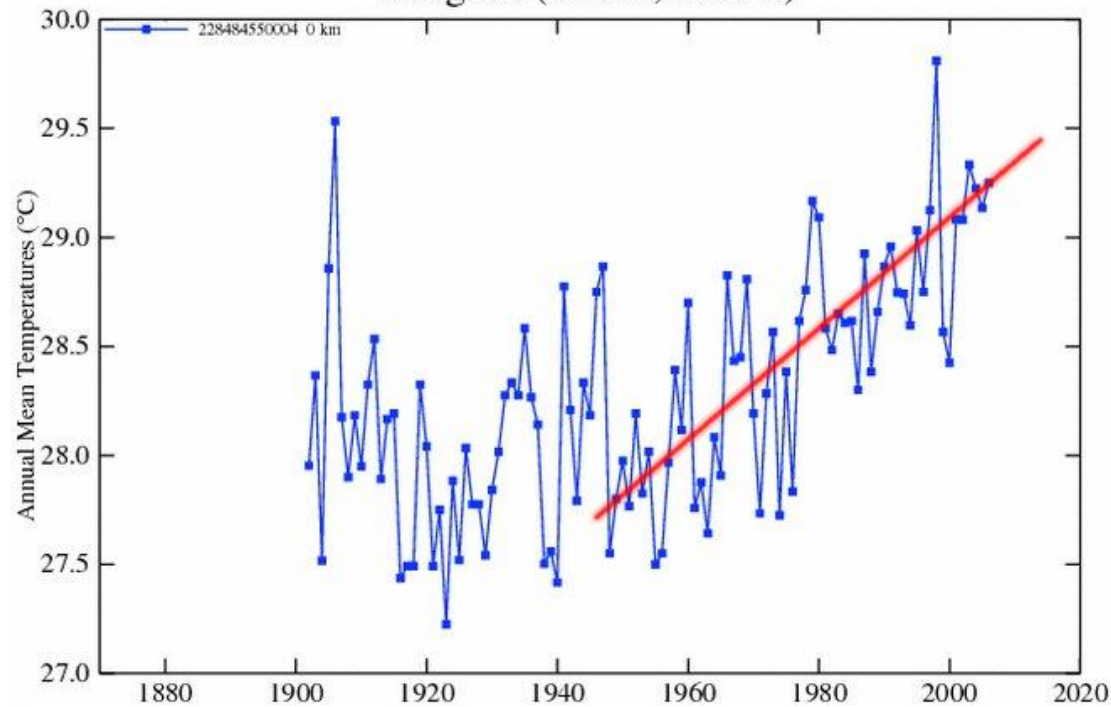


Historic records compared to predictions by 14 models (source: IPCC)

Global and Continental Temperature Change

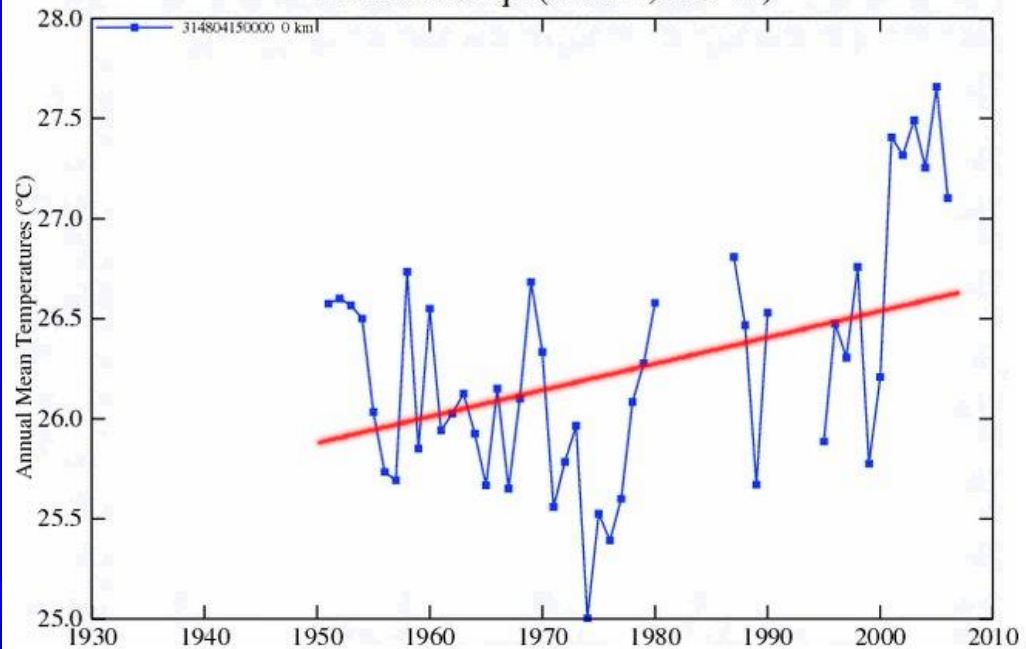


Bangkok (13.7 N,100.6 E)

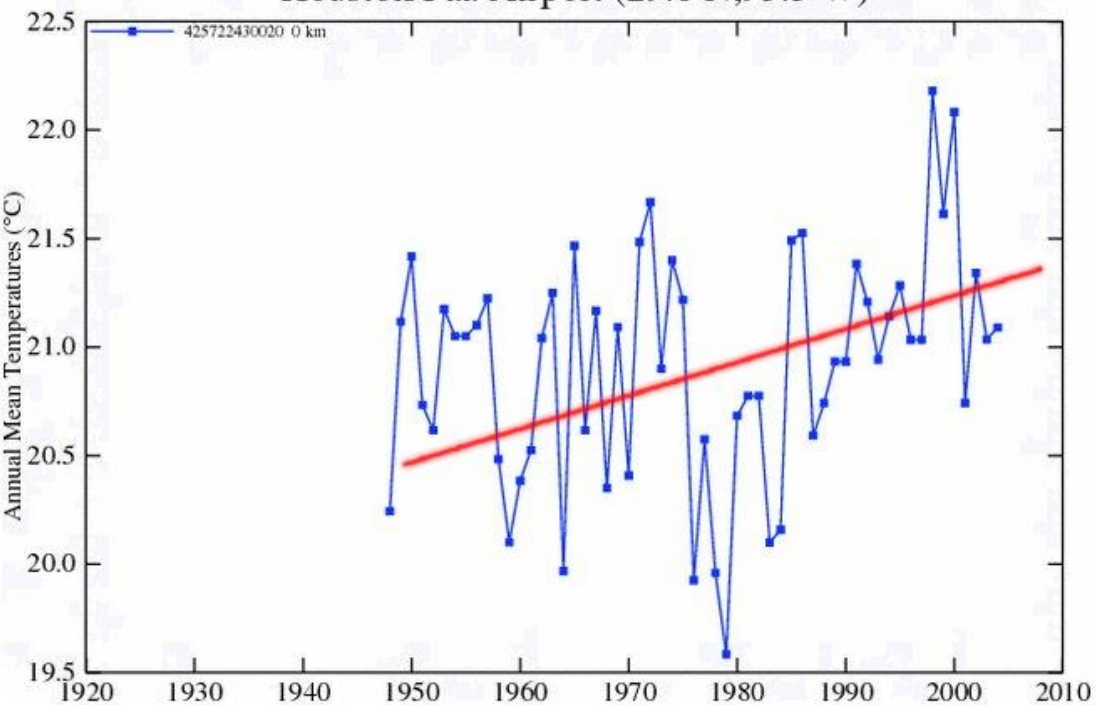


Trends
shown by
NCDC
records

Caracas/Maiqu (10.6 N,67.0 W)

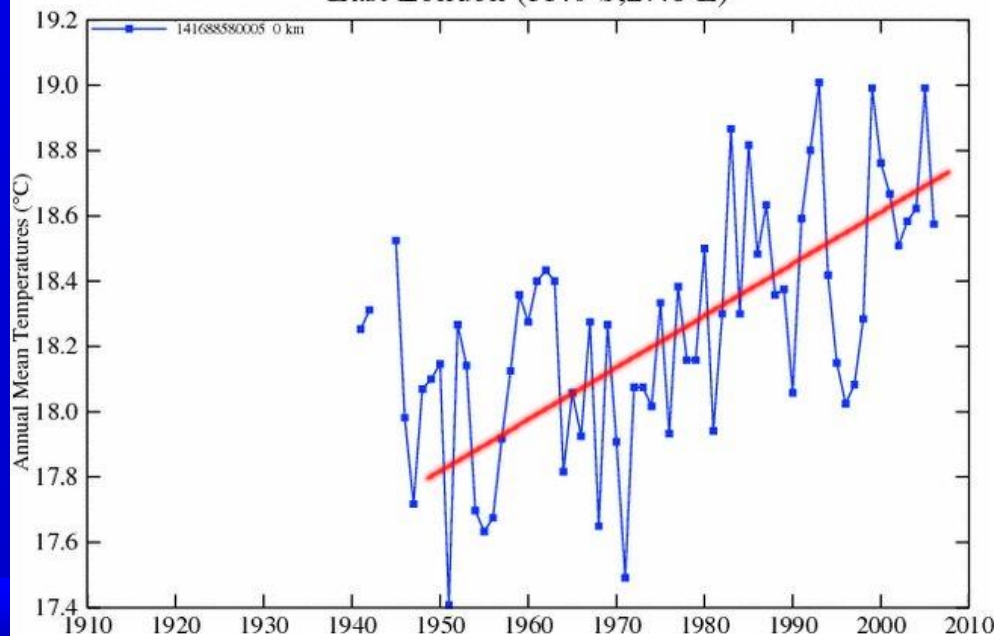


Houston/Faa Airport (29.6 N,95.3 W)

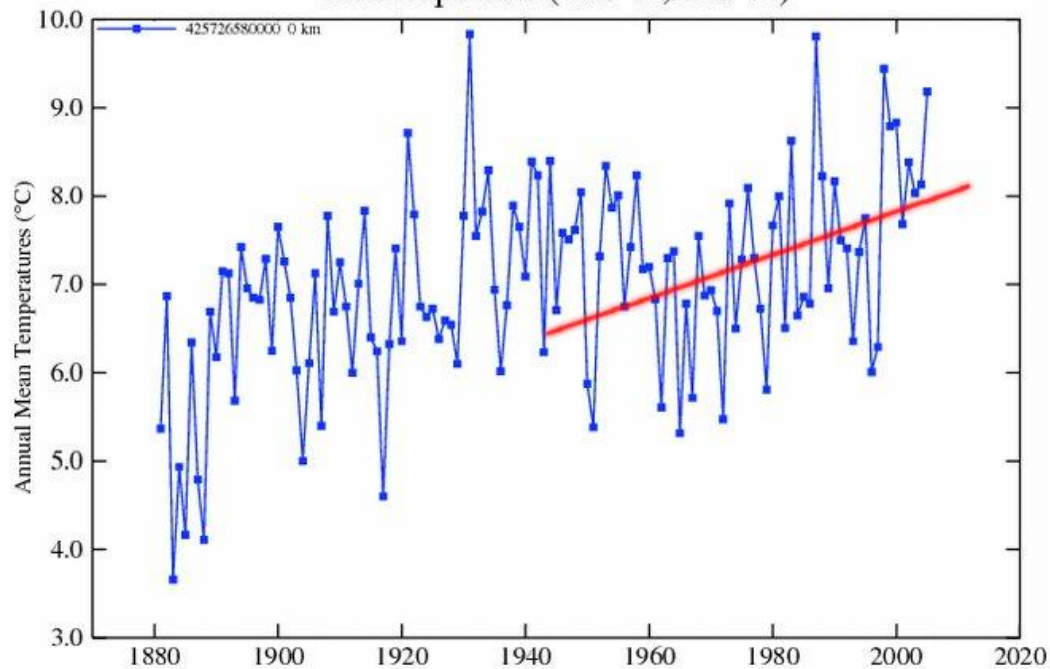


Trends
shown by
NCDC
records

East London (33.0 S,27.8 E)

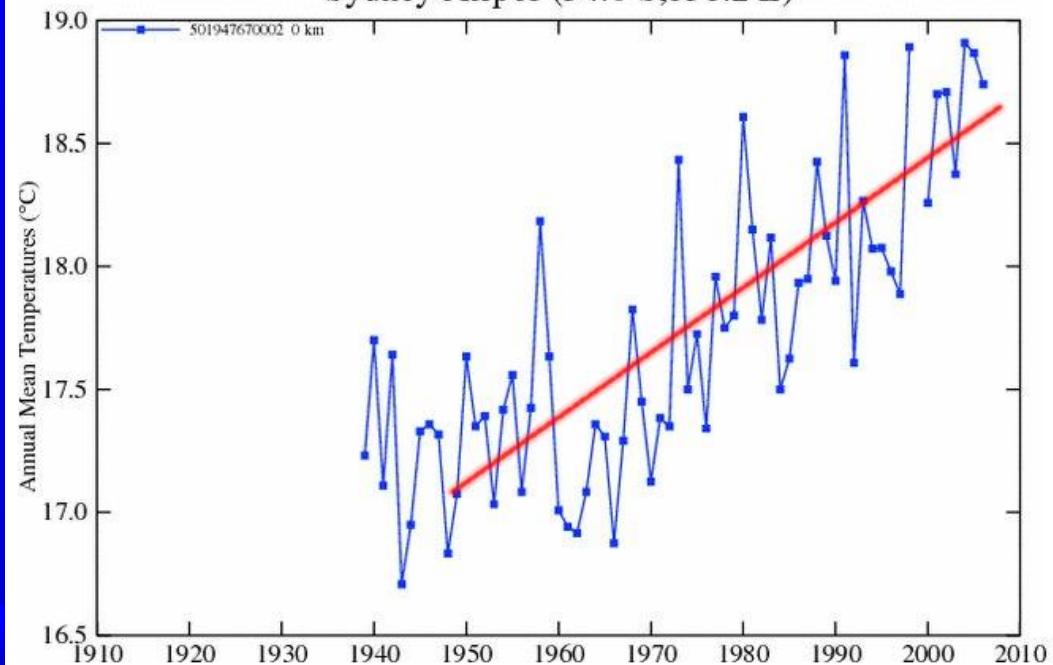


Minneapolis/S (44.9 N,93.2 W)



Trends
shown by
NCDC
records

Sydney Airpor (34.0 S,151.2 E)



Predicted changes likely

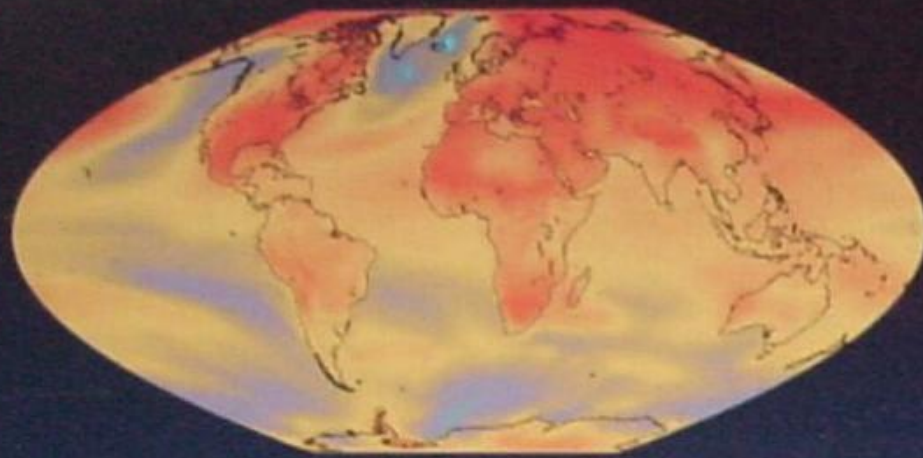
A report issued by an IPCC working group 1, “Climate Change 2001: The Scientific Basis”, lists “very likely” global climate changes for the 21st century. Among those are:

- Higher daily maximum temperatures and more hot days over nearly all of the Earth’s land,
- Warmer overnight low temperatures, (minimum daily temperatures)
- Fewer cold days and frost days over nearly all the land, and
- Reduced differences between daily highs and lows over nearly all land areas (smaller diurnal ranges.)

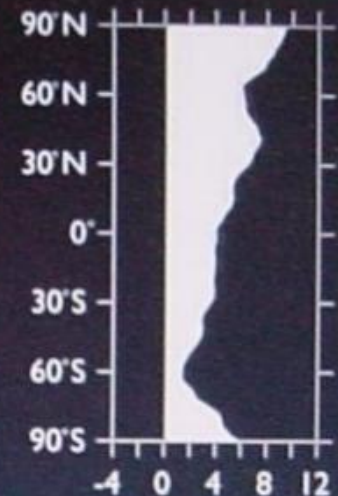


NOAA's GFDL model predictions

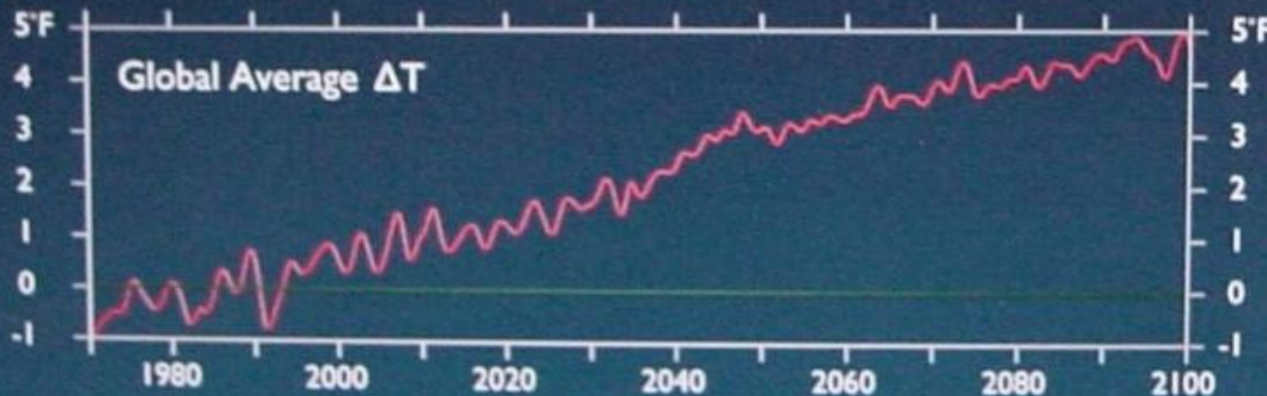
SURFACE AIR TEMPERATURE ANOMALIES



ΔT Anomalies Relative to 1971-2000 Mean



Zonal Average (°F)



2100
(Model Year)

GFDL CM 2.1
Climate Model

Latitude effects on average temperature increases predicted by the GFDL model

- ☞ Higher latitude cities (London, Minneapolis), +9F by year 2100.
- ☞ Mid-latitude cities (Houston, Sydney), +6F by year 2100.
- ☞ Lower latitude cities (Bangkok, Caracas), +2F by year 2100.



Relationships between high, low, and average temperature and diurnal range

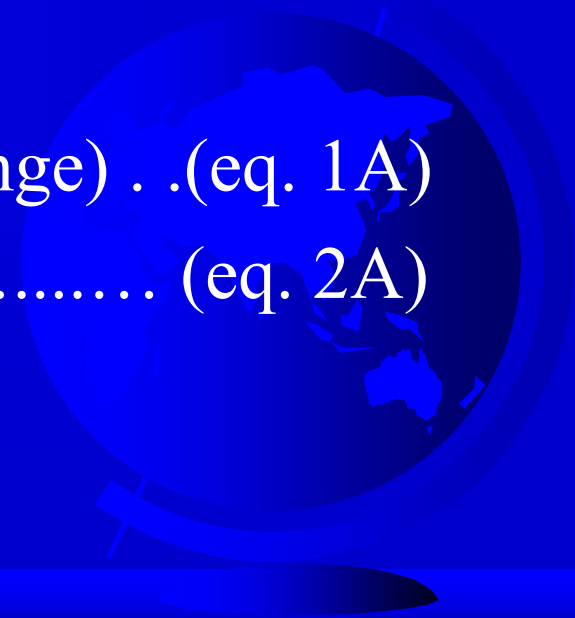
☞ $H - L = \text{MDR (mean diurnal range)} \dots\dots\dots (\text{eq. 1})$

☞ $H + L = 2 * T_{\text{ave}} \dots\dots\dots (\text{eq. 2})$

☞ Or

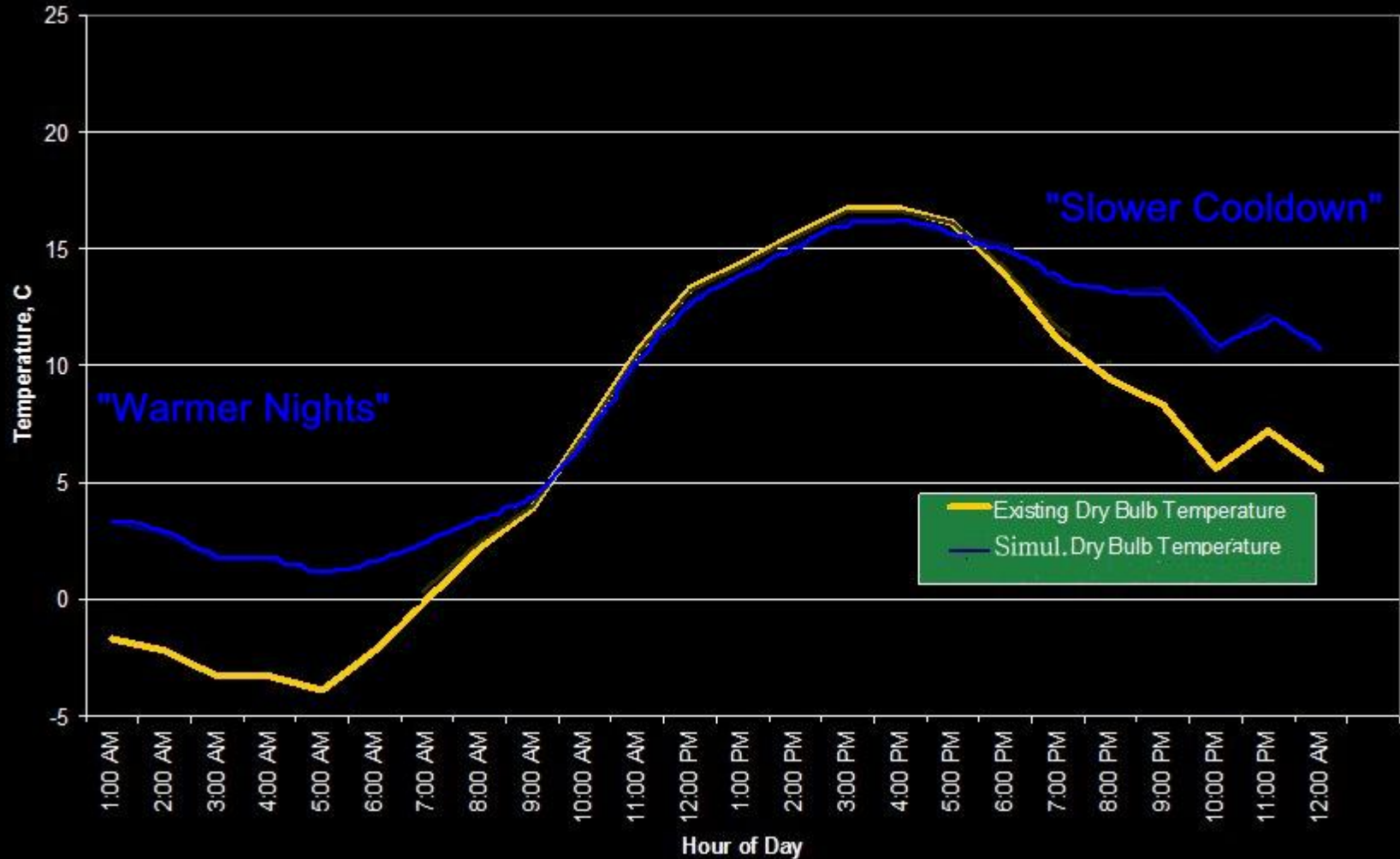
☞ $\Delta H - \Delta L = \Delta \text{MDR (mean diurnal range)} \dots\dots (\text{eq. 1A})$

☞ $\Delta H + \Delta L = 2 * \Delta T_{\text{ave}} \dots\dots\dots (\text{eq. 2A})$



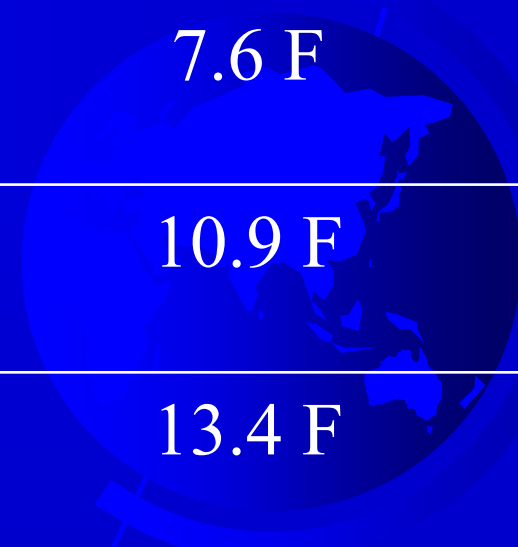
Diurnal change

Sample City, April 10 w/ TMY2 Data



Min-Max temperatures as a function of reduced diurnal swing (for $\Delta T_{ave} = 6.7F$)

Change in diurnal swing (ΔMDR)	Increase in daily max. temp. (ΔH)	Increase in daily min. temp. (ΔL)
-1.8 F	5.8 F	7.6 F
-8.4 F	2.5 F	10.9 F
-13.4 F	0.0 F	13.4 F



Existing and future design temperatures for 6 case study cities

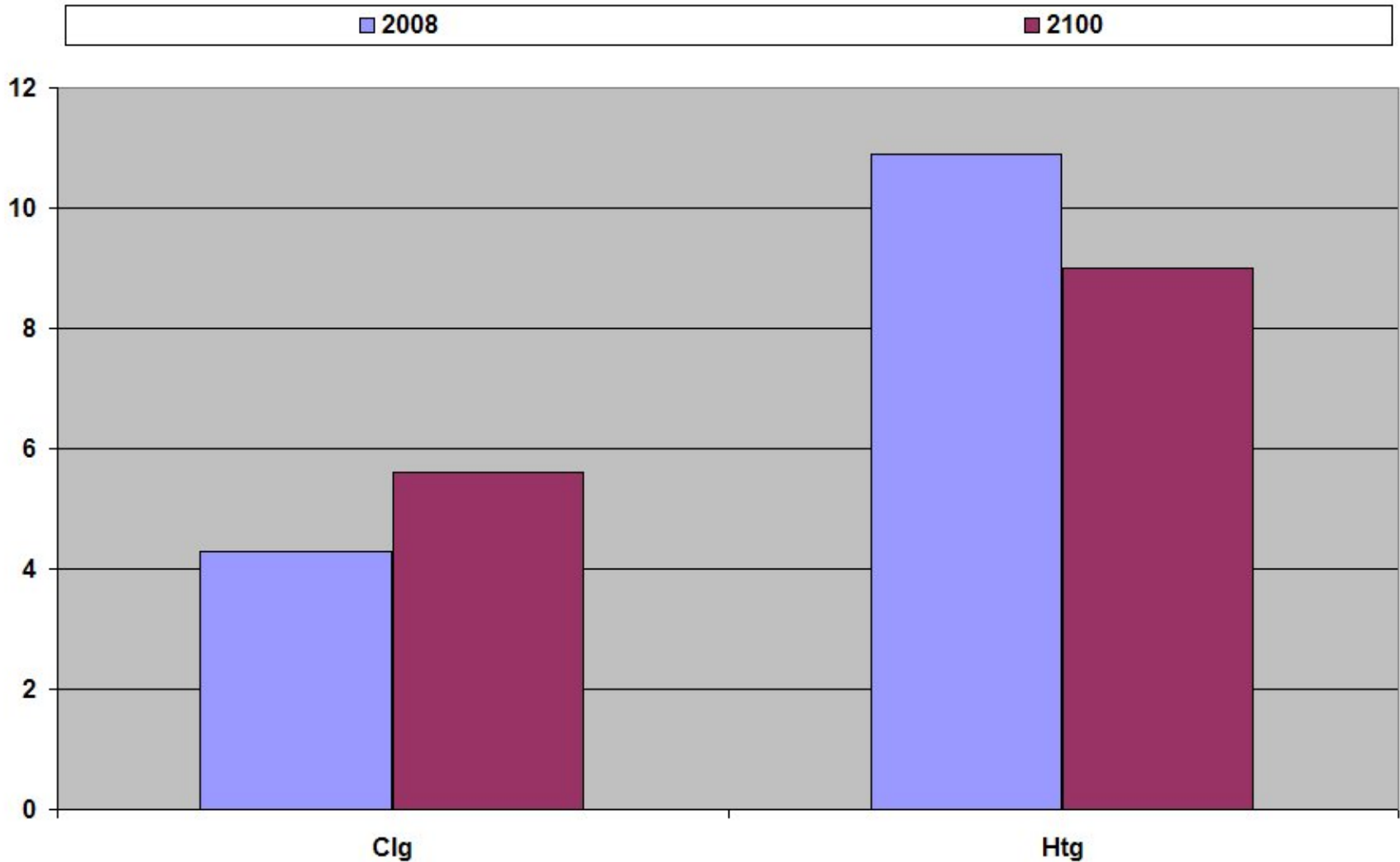
City Name	Lat. class	Lat. (deg.)	ASHRAE Design Temp. (F)		MDR (F) *	GFDL temp chg (F)	MDR chg (F) *	Year 2100 design temp. (°F)			
			sum. #	wint #				summer		winter	
								chg	val.	chg	val.
London	High	51.2N	77.2	26.4	17.6	9	-3.6	7	84.2	11	37.4
Minn.	High	44.9N	87.8	-9.4	19.1	9	-3.6	7	94.8	11	1.6
Houston	Mid	30N	94.9	31.5	18.2	6	-2.7	4.7	99.4	7.3	38.8
Sydney	Mid	33.9S	83.4	46.3	12.1	6	-2.7	4.7	88.1	7.3	53.6
Bangkok	Low	13.7N	95	68.5	16.7	2	-1.8	1.1	96.1	2.9	71.4
Caracas	Low	10.6N	90.9	69.9	12.6	2	-1.8	1.1	92	2.9	72.8

* MDR = Mean Daily Range (F)

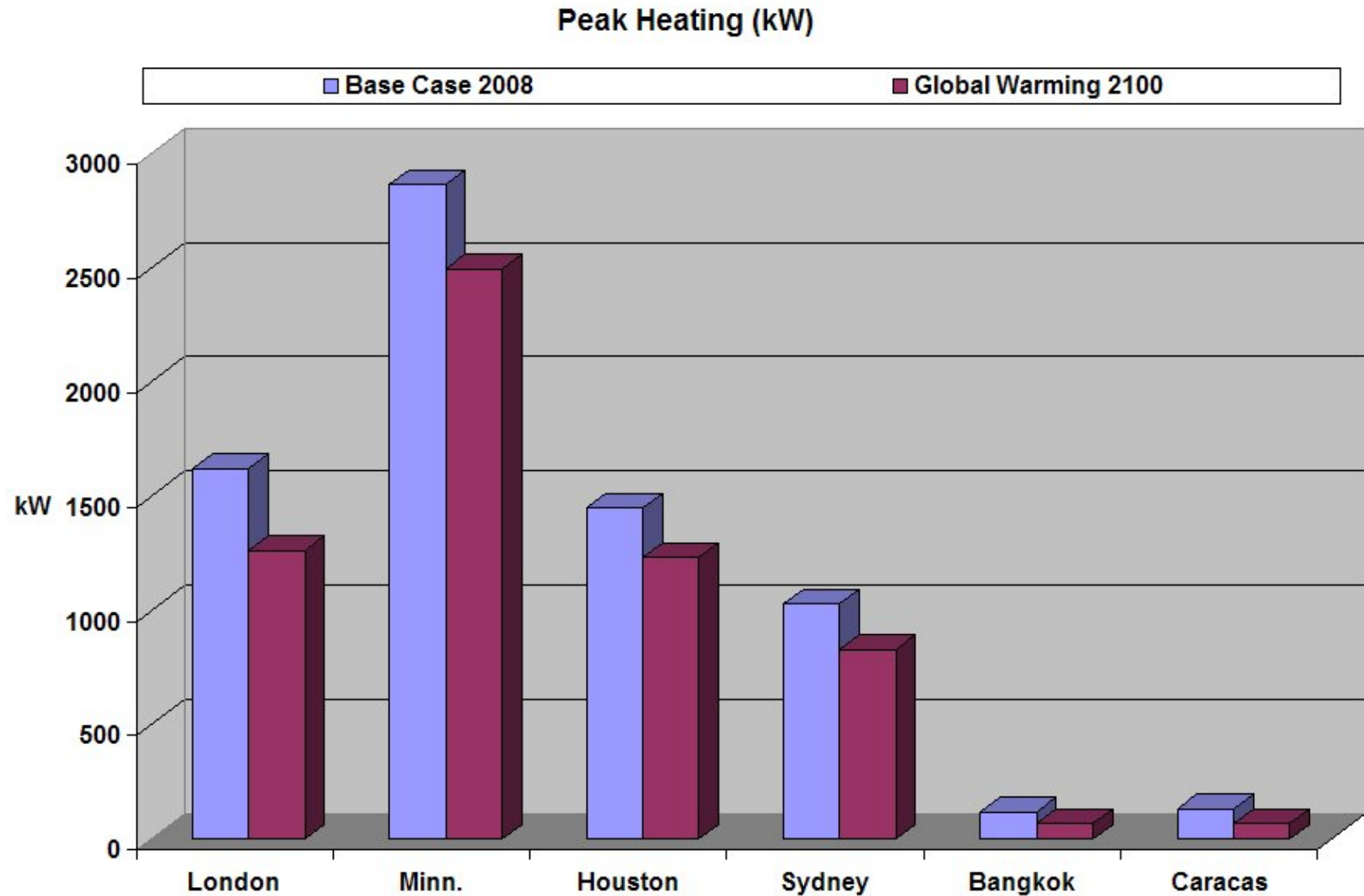
sum.=summer 1% design val.; wint.=winter 99% val (2005 ASHRAE HOF)

Peak Cooling & Heating Loads

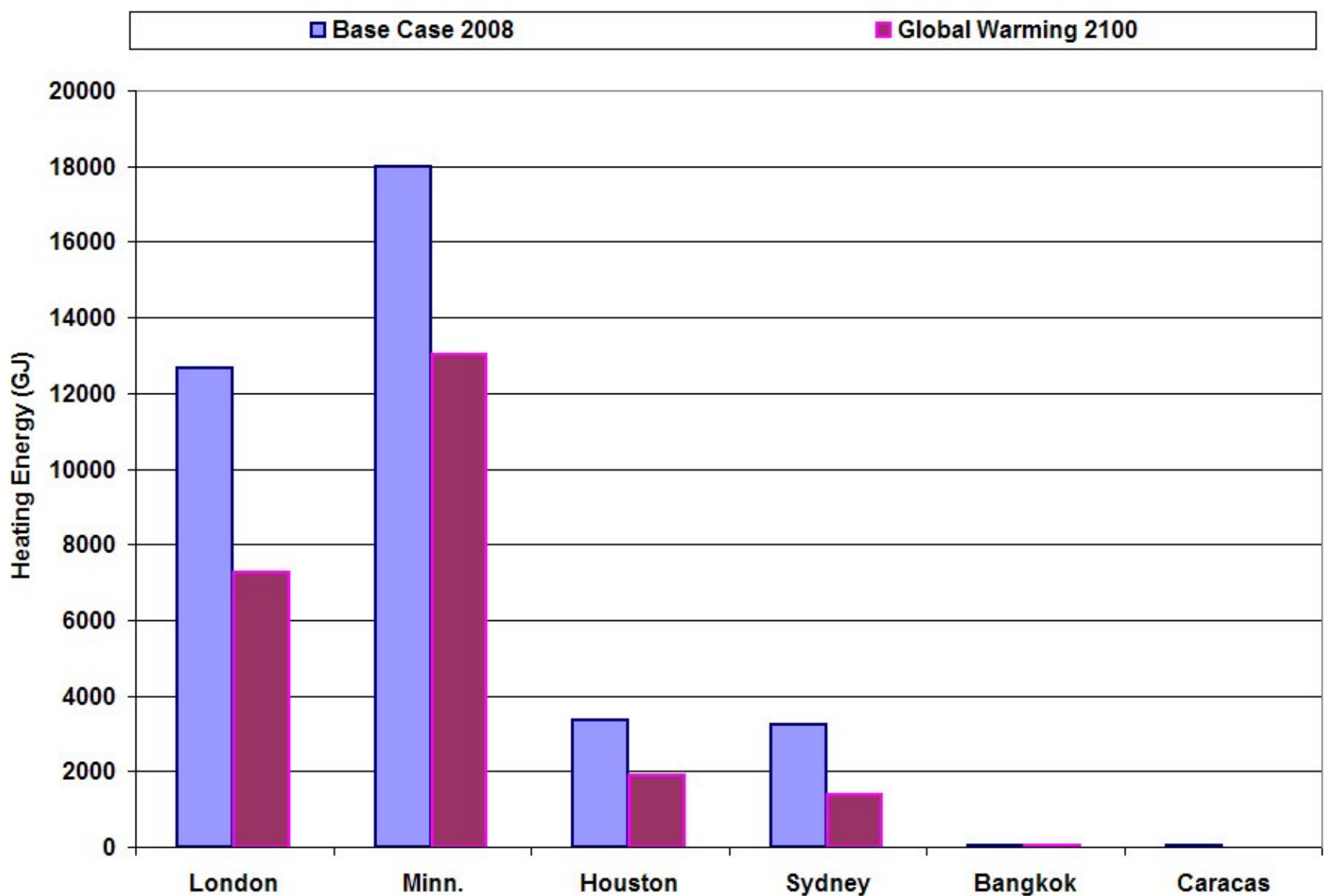
Minneapolis -- Cooling & Heating Design Loads (MBtu/h)



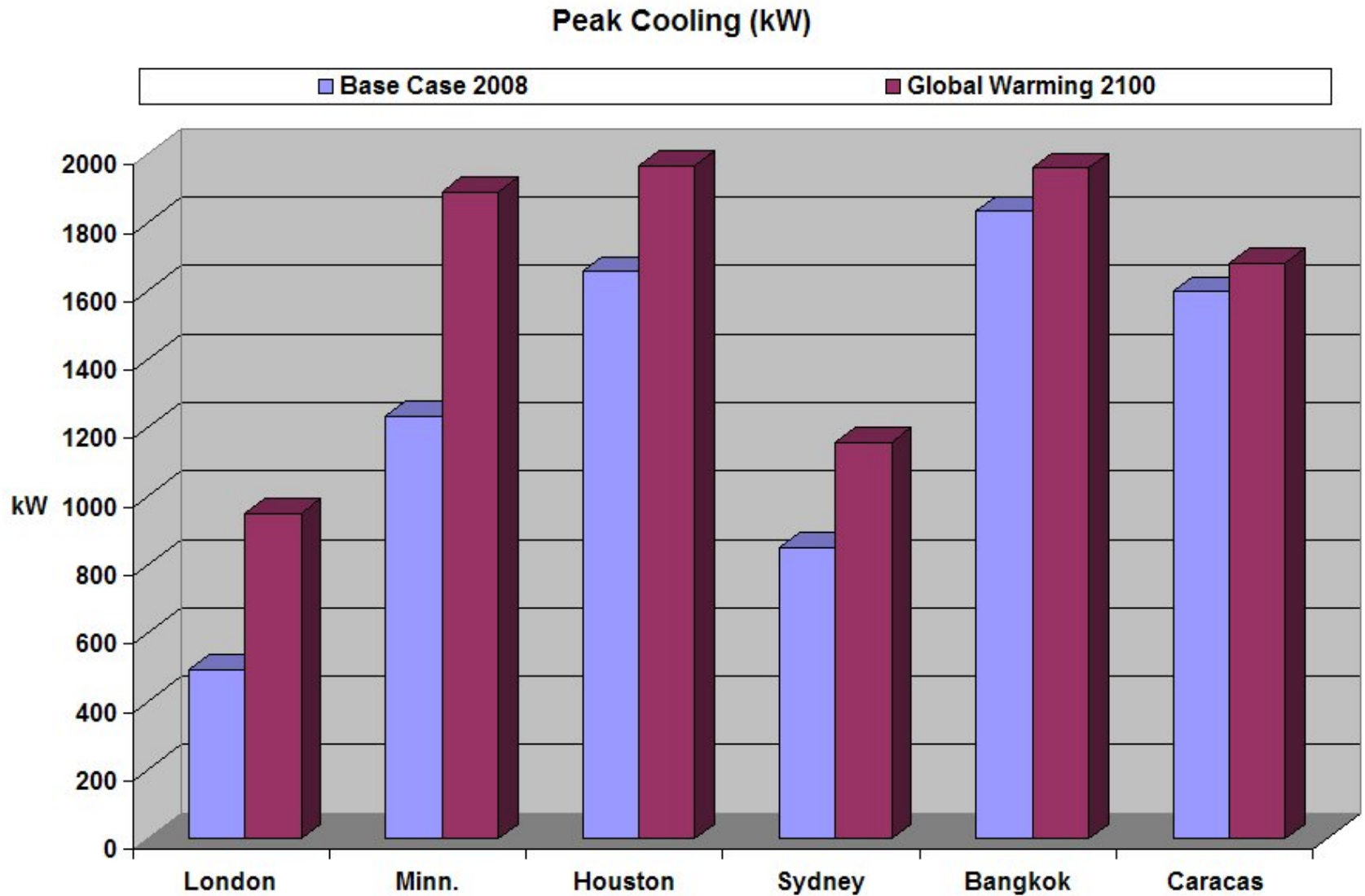
Peak Heating Load



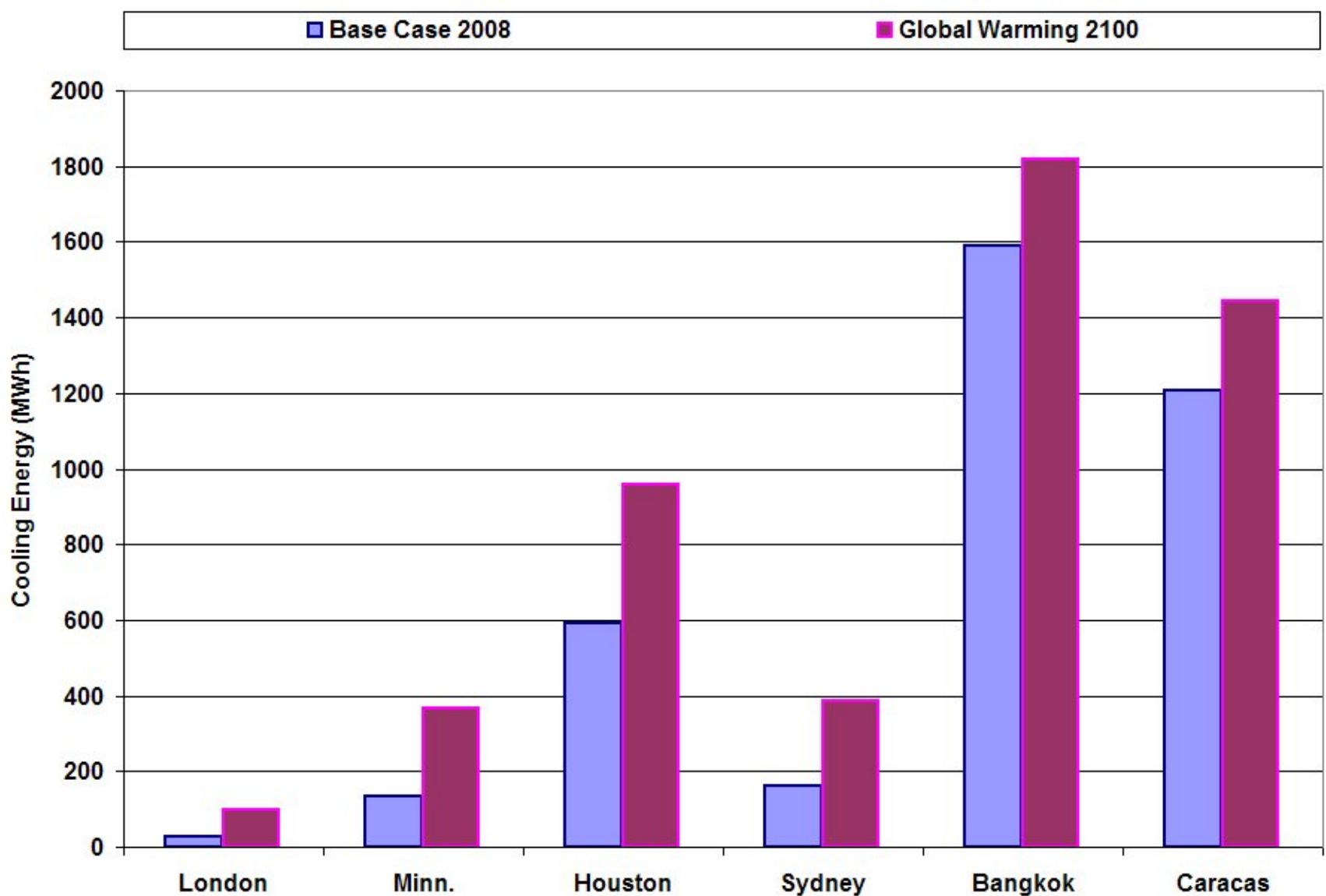
Annual Heating Energy



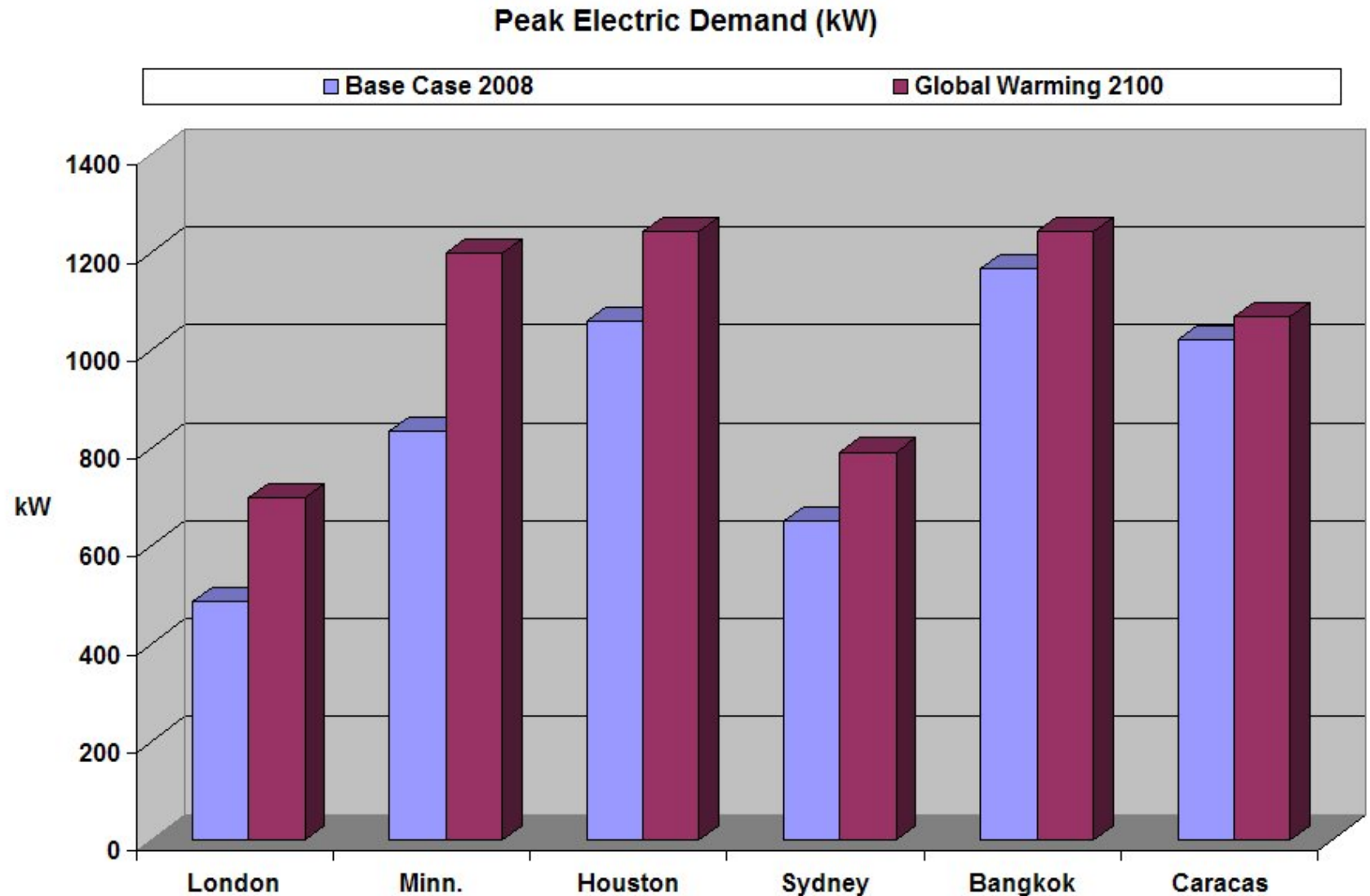
Peak Cooling Load



Annual Cooling Energy

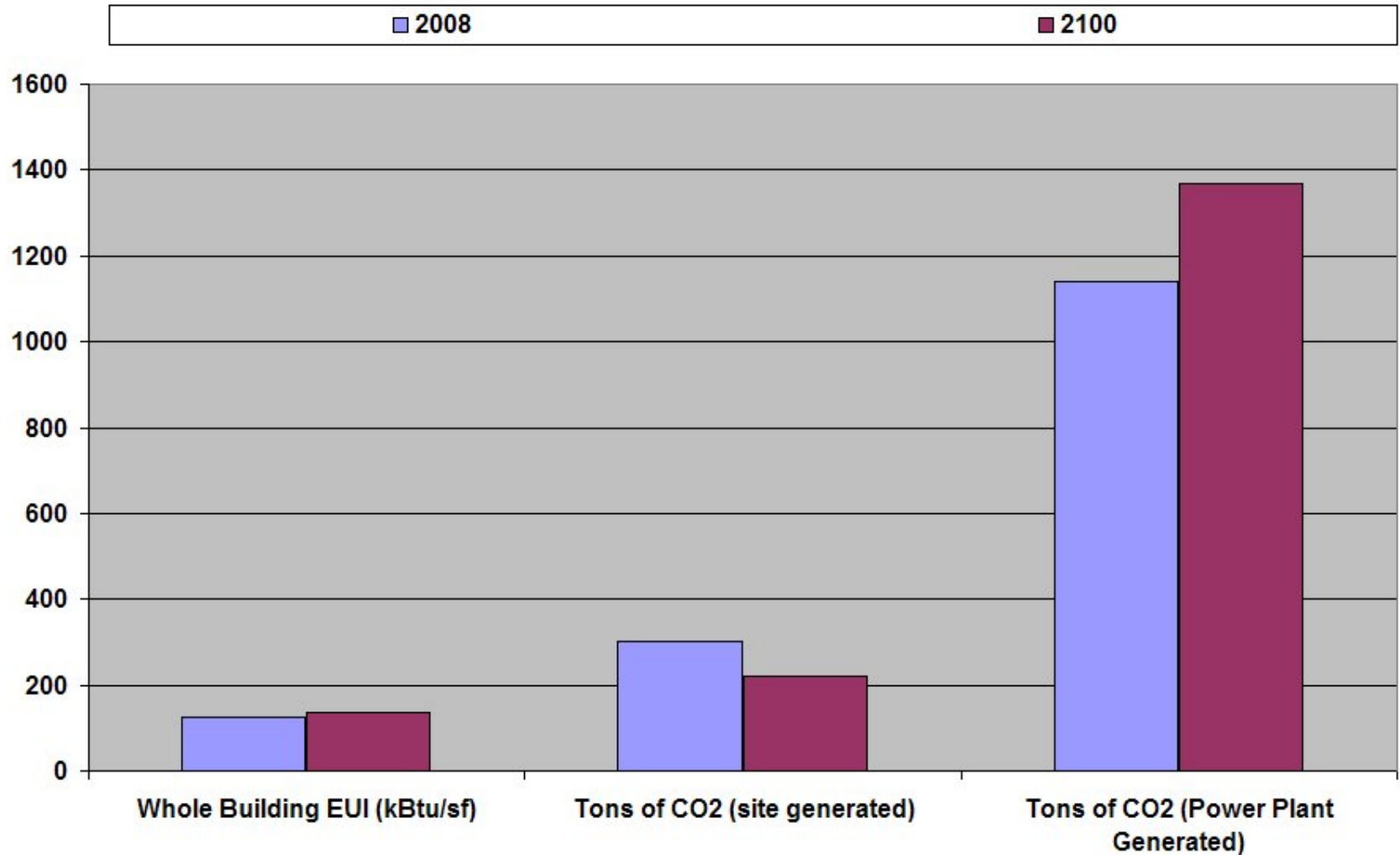


Whole Building Peak Demand



Greenhouse Gas Emissions

Minneapolis, Energy Utilization Index and Emissions



The new Scenarios that Impact Simulations

- ☞ Warmer nights, fewer frost days
- ☞ Possibly cloudier skies and higher RH
- ☞ Higher or equal daily high temperatures
- ☞ Higher cooling loads, lower heating loads
- ☞ Lower diurnal ranges
- ☞ Models need to be in tune with time of day temperature shifts from the currently assumed diurnal temperature patterns.



Thank you!

