NOTES FOR IEEE

1. Slide. Spectra of solar & terrestrial radiation. The graph on the left is the emission spectrum for a blackbody at 6,000°K [the sun] while the graph on the right is the emission spectrum for a blackbody at 300°K [the earth].Note that because of absorption by ozone, there is a very sharp cut-off of UV radiation reaching the earth's surface at about 0.3 micron [3,000 Angstroms]. The visible region of the spectrum extends from 4,000 to about 7,000 Angstroms and the infra-red region from about 7,000 to 10^6 Angstroms. Note that the terrestrial radiation lies entirely in the infra-red.

2. Slide. Same Plus absorption of the atmosphere.

3. Slide. Keeling curve, named for Charles Keeling of the Scripps Institute of Oceanography at UC San Diego, is a graph that plots the concentration of CO_2 in the earth's atmosphere since 1958. It is based on measurements from the Mauna Loa Observatory on Hawaii.

4. Slide. World CO_2 emissions & compound average annual growth rates.
Note the growth rates for the periods 2001 - 2005 and 2005 - 2011. This table shows world CO_2 emissions from 1980 - 2011 and the average annual percent increases from 1980 - 1990, 1990 - 2001, 2001 - 2005, and 2005 - 2011. Note the rapid increases in emissions since 2001 compared with the earlier periods.

Discussion. There is general agreement that the average global surface temperature has risen about 0.8 degrees C. since the beginning of the twentieth century. Both the Keeling curve & especially the emissions data would suggest the global surface temperature should have continued to rise. It has not. The global temperature has remained essentially constant since 1997. Even the IPCC chairman Rajendra Pachauri has conceded the "pause" may already have lasted 17 years.

Even the IPCC has been forced to lower its estimates of future warming. In the Summary of the fifth assessment to be published later this month, the IPCC states the "Equilibrium Climate Sensitivity" [ECS]--eventual warming induced by a doubling of CO_2 in the atmosphere--which takes hundreds of years--is " likely" to be above 1.5 degrees C and "very likely" to be below 6 degrees C. In 2007, the IPCC said it was likely to be above 2 degrees C.

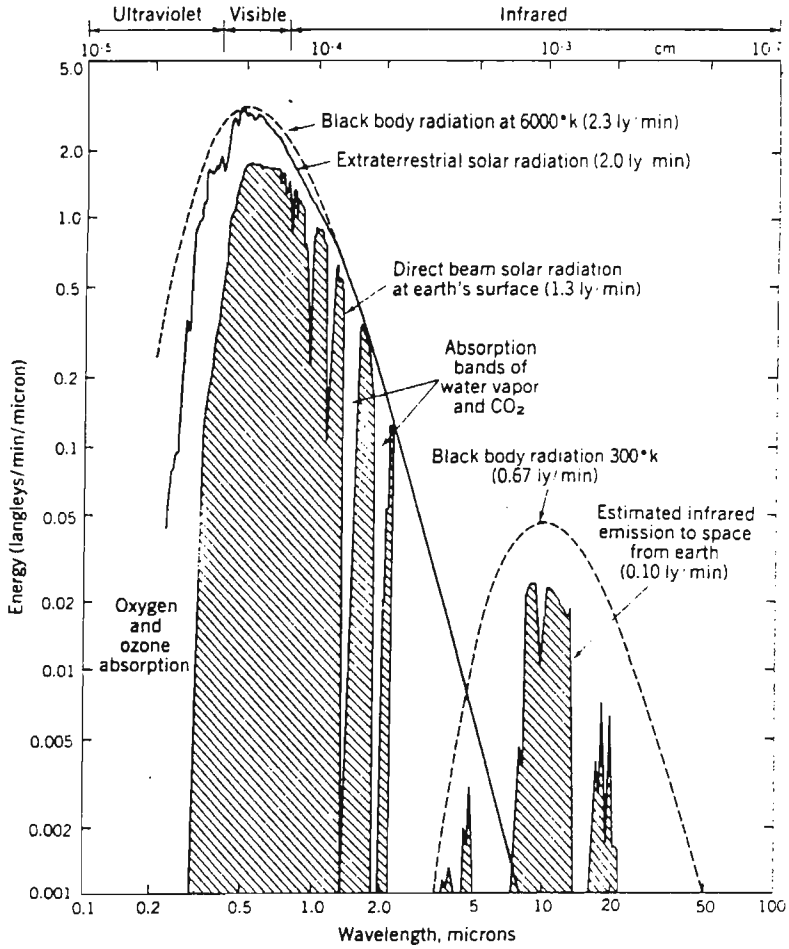


FIGURE 13.1. Spectrum of incoming and outgoing radiation from sun and earth. Logarithmic scales are used for both energy and wavelength. [From W. D. Sellers (1965), *Physical Climatology*, Chicago, Univ. of Chicago Press, p. 20, Figure 6.]

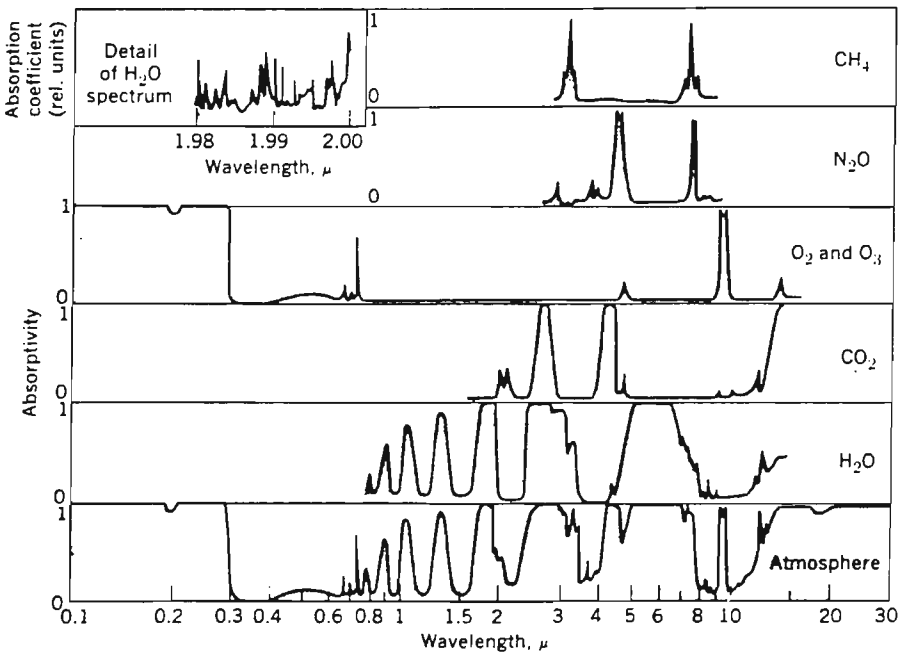
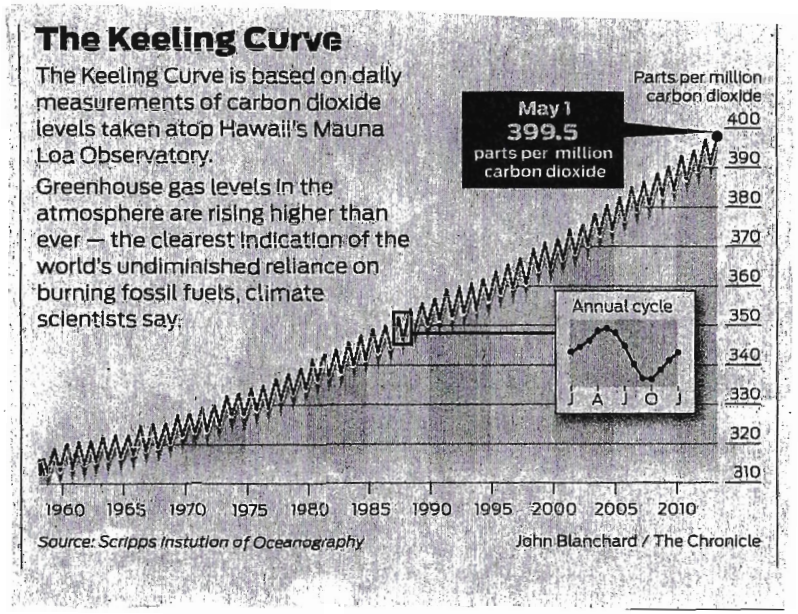


Fig. 5–7 Absorption characteristics of the important atmospheric gases. From R. G. Fleagle and J. S. Businger, *Introduction to Atmospheric Physics*, New York: Academic Press, 1963, p. 153, by permission.


The Keeling Curve
The Keeling Curve is based on daily measurements of carbon dioxide levels taken atop Hawaii's Mauna Loa Observatory.
Greenhouse gas levels in the atmosphere are rising higher than ever — the clearest indication of the world's undiminished reliance on burning fossil fuels, climate scientists say.
Parts per million carbon dioxide
May 1
399.5
parts per million carbon dioxide
400
390
380
370
360
350
340
330
320
310
Annual cycle
J A J O J
1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010
Source: Scripps Instution of Oceanography
John Blanchard / The Chronicle

World Carbon Dioxide Emissions and Compound Annual Percent Increases,1980--2011

	1980	1990	2001	2005	2011
World Emissions	18,433	21,523	24,244	28,262	32,579
Annual percent increase		1.6%	1.1%	3.9%	2.4%

A more immediately relevant measure of likely warming--Transient Climate Response [TCR]--the actual temp change expected from a doubling of CO_2 about 70 years from now, without the delayed effects that come in the next century has also been lowered, The new report says this change is "likely' to be 1 - 2.5 degrees C and "extremely unlikely' to be greater than 3 degrees. In 2007 the IPCC said "very likely' warming of 1 - 3 degrees.

These latest IPCC estimates are still probably much too high. A whole bunch of recent papers suggest much less warming. Two recent papers [one in the Jour of Amer Meteorlogical Soc, the other in the journal Earth System Dynamics] estimate that TCR of about 1.65 degrees C. Back in 1938 Guy Callendar calculated the TCR to be 1,67 degrees. [Callendar was a British engineer. He assumed CO_2 acts alone. The current climate models all assume the effect of CO_2 is amplified by water vapor.

A recent study published in the journal, Nature Climate Change, compared 117 predictions made in the 1990s to the actual amount of warming. Of the 117 predictions, 3 were roughly accurate and 114 overestimated the amount of warming. On average, the predictions forecast 2 times more warming than occurred.

In 1972 the Christian Science Monitor reported, "Arctic specialist Bernt Balchen says a general warming trend over the North Pole is melting the arctic ice cap and may produce an ice-free Arctic ocean by the year 2000."

Last week, the National Snow and Ice Data Center released satellite images of the Arctic ocean taken on September 16, 2912 and in August 2013, This is the annual low point for arctic ice because the annual autumn freeze-up is about to begin. Arctic sea ice covered 2.35 million sq mi in August 2013 compared with 1.32 million sq mi on September 16, 2012--an increase of almost 1 million sq mi or 60% **in one year!**

So, what has happened? The IPCC blames the slowdown in worming on possibly greater ash from volcanoes, a decline in heat from the sun, more heat being absorbed by the deep oceans, etc. The fact is that the climate models are wrong. The fundamental thing a climate model is supposed to predict is temperature, and yet they get it wrong.

Most models assume that with CO_2 warming, the atmosphere can hold more water vapor. Hence clouds shrink, and that lets in more sun, and that is what heats up the

planet--not so much the direct effect of the CO_2 but the feedback effect of water vapor absorbing infra-red and the effect of having fewer clouds. In the real world, though, the clouds are not shrinking. Another major problem is created by the fact that temperature measuring stations are not the same places they were 150 years ago. Often, the original weather stations were located at railroad stations or post offices. Today, these are often in cities surrounded by acres of asphalt and tar-and-gravel roofs which makes them heat sinks. The IPCC claims they correct for this, but each station is unique. Consider the town of Willows in the Sacramento Valley. Today, it is surrounded by rice fields which are flooded from the first of May until to mid-September. The evapotranspiration from rice is about 3 ac-ft/ac/yr. This evapotranspiration removes a lot of heat energy.

5. Slide. Factors other than CO_2.

6. Slide. Jet contrails. This photograph was taken on an autumn day near Rand, Colorado [north-central Colorado]. All of the clouds were induced by jet contrails. The following day, there were no contrails.

7. Slide. altered reflectivity caused by deforestation. This photo is an aerial of a large clear-cut on Lost Man Creek [Humboldt County] in what is now redwood National Park. Photo was taken in March, 1967.

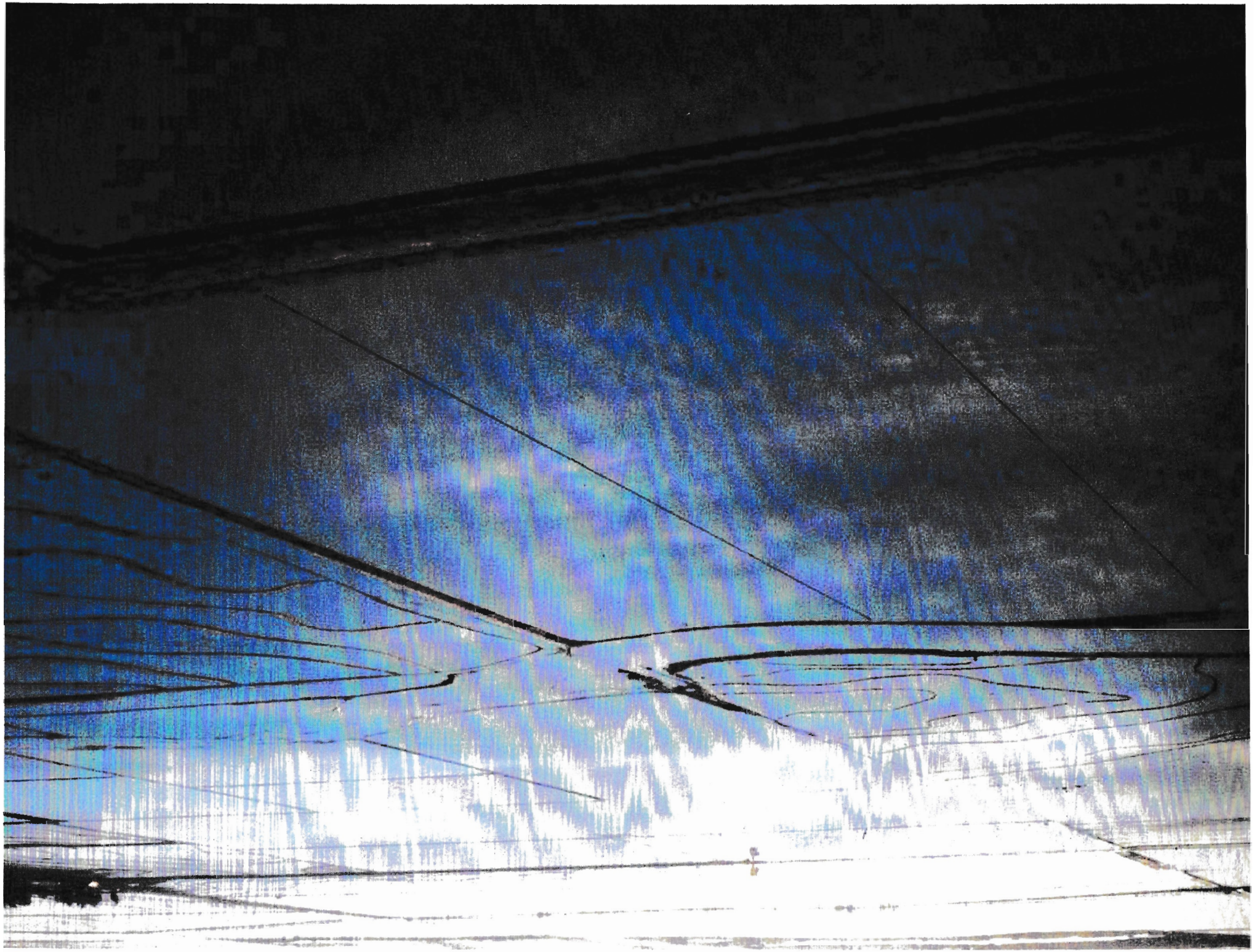
8. Slide. Altered reflectivity caused by irrigated agriculture. Aerial photo shows irrigated ag in the Great Plains. This irrigation is mostly done with groundwater from the Ogallala aquifer. Note that the irrigated crops have decreased reflectivity.

9. Slide. Irrigated cotton in southern San Joaquin Valley [west side]. Prior to irrigation, first with groundwater in the 1920s and 1930s, and then with canal water from the San Luis unit of the Central Valley Project, this land with the natural sparse vegetation had much higher reflectivity.

10. Slide. Flooded rice in the Sacramento Valley. Irrigated agriculture just in California accounts for about 24 million ac-ft of consumptive water use annually. This evapotranspiration is equal to about 1.5 times the average annual flow of the Sacramento River at Sacramento. The result is that we have put 24 million ac-ft of water vapor into the atmosphere that was not there 100 years ago. At the same time, the evapotranspiration of the water removes heat from the surface and probably affects cloud formation somewhere else. The climate models do not consider any of this.

Factors Other Than CO_2 That May Affect Climate

- Jet contrail-induced cloud formation.
- Altered reflectivity of the earth caused by deforestation.
- Altered reflectivity of the earth caused by irrigated agriculture.
- Increased water vapor in the atmosphere caused by irrigation of formerly arid lands.
- The plume of brown haze that envelops parts of Asia part of the year.



11. Slide. Emerging rice.

12. Slide. Shanghai. The pall of brown haze the envelopes parts of Asia part of the year is caused by burning fossil fuels, agriculture burning, and by forest clearing. It contains sulfur oxides, nitrogen oxides, and particulate matter.

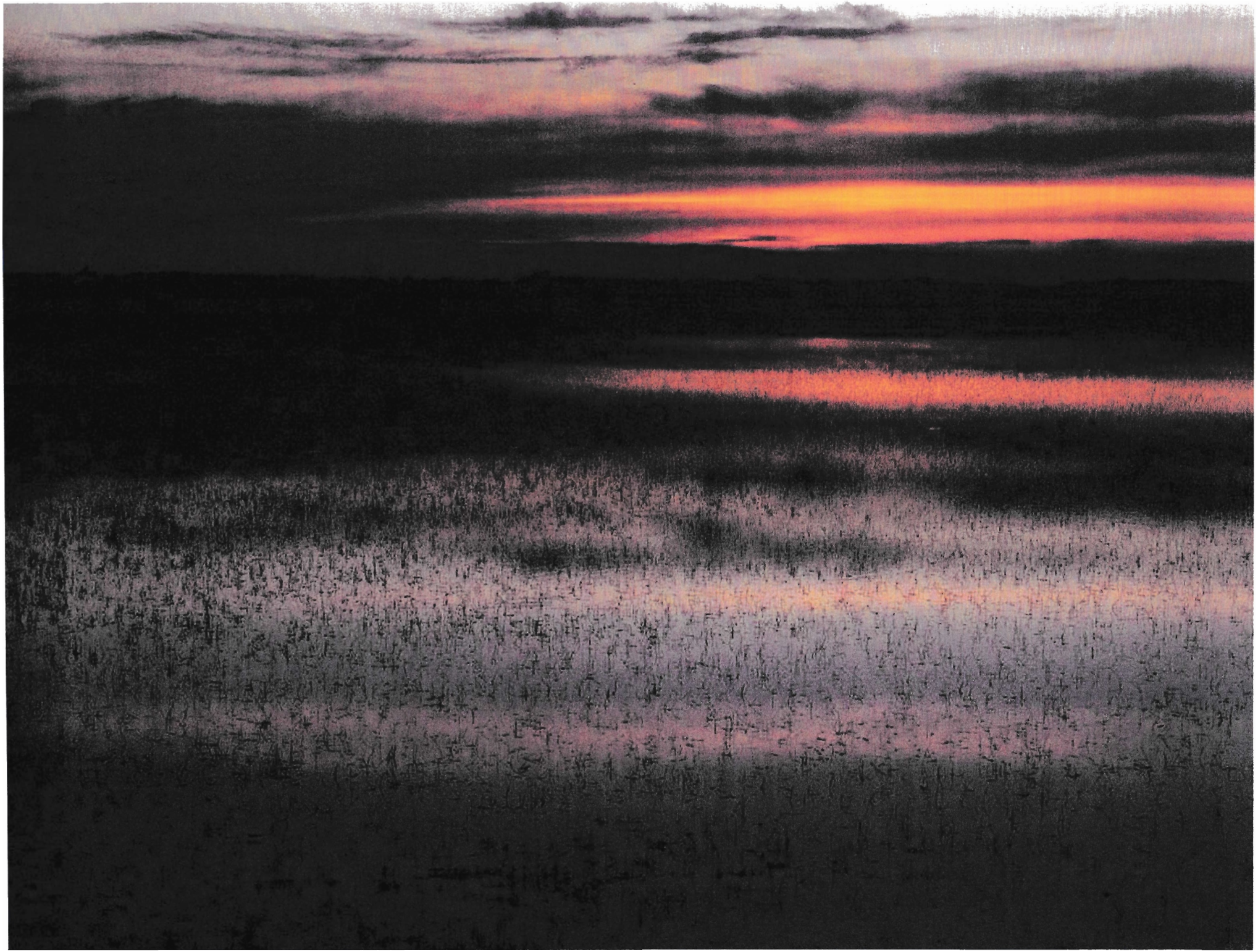
13. Slide. Ethanol. In its effort of reduce fossil fuel combustion, the Obama administration, with the backing of environmental organizations, has adopted some policies which are highly counter-productive, One of these is subsidizing fuel ethanol.

14. Slide. Map of the Ogallala Aquifer.

15. Slide. Biofuels potential. Biofuels will **never** make any significant contribution to the US energy supply. Solar radiation is a very diffuse energy source and green plants are very inefficient at converting this energy into starch or cellulose. The environmentalists argue that biofuels can be produced on marginal land. Marginal land is called "marginal land" for a reason. It is infertile, arid, saline, highly erodable, lacks a water supply, lacks drainage, or all of the above. Diverting scarce fresh water supplies to grow biofuels in the desert does not solve anything.

16. Slide. CO_2 emissions for world & selected countries 1990-2011. The Kyoto Protocol was adopted in December 1997 and entered into force in February 2005. The first commitment period started in 2008 and ended in 2012. Signers committed to reducing CO_2 emissions 5% below 1990 levels by 2012. The second commitment period is from 2013 - 2020. Signers committed to reducing CO_2 emissions 18% below 1990 levels by 2020. The developing countries are exempt from any constraints of Kyoto. The US never signed it. This table and the next clearly show that the developing countries are the problem in terms of rising CO_2 emissions. It should be noted that the selection of the year 1990 as the base was no accident. Between 1990 and 1997, emissions in Russia and eastern Europe fell sharply due to the collapse of the soviet Union. Emissions in western Europe were largely flat due to fuel switching made possible by North Sea gas and pipeline gas from Russia . Therefore, both of these blocks believed it would be easy to comply with the terms of Kyoto.

17. Slide. CO_2 emissions in EU countries. This table shows the reality. Data for 20122 are not yet available, so I have tabulated data for 2011. All of the



Ethanol

Harvested acreage of corn in the US in 2012: 87 million acres

Percent of harvested acreage used for fuel ethanol production: 49.4%

Percent of US gasoline supply supplanted by ethanol in 2012: 6.7%

Ave. price or corn [received by farmers] in 2006: $2.28/bu

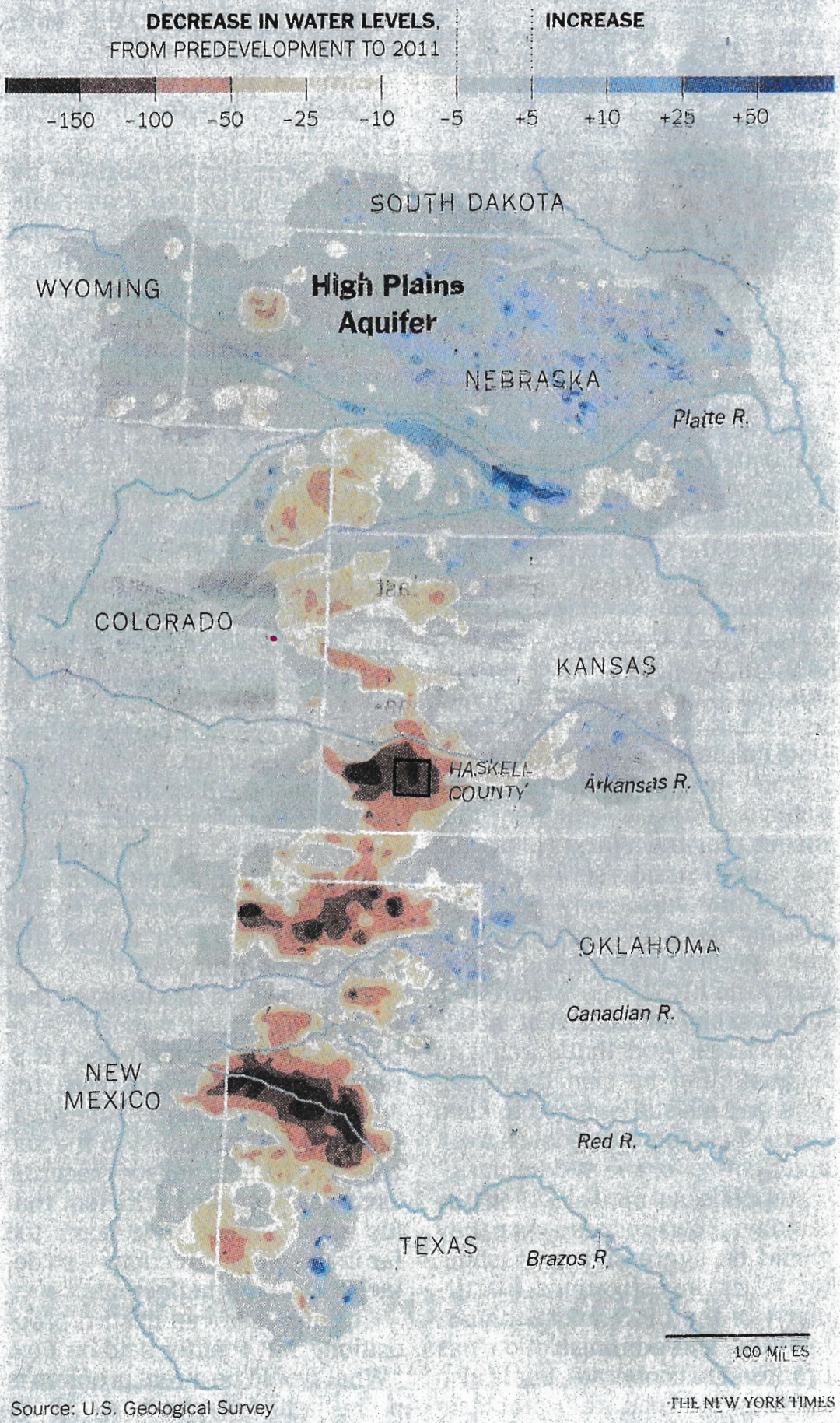
Ave. price of corn [received by farmers] in 2012: $6.67/bu

Corn acreage irrigated with groundwater from the Ogallala aquifer in 2012: 8.9 million.

Volume of groundwater consumed: 15 million acre-ft.

Annual flow of the Colorado River at Lee's Ferry: 14 million acre-ft.

242 feet in some areas, from predevelopment — before substantial groundwater irrigation began — to 2011.



Source: U.S. Geological Survey

THE NEW YORK TIMES

gallons in 1991, the Yosts capped

them produced 195 gallons a minute — a warning, he said, that

The Limited Potential of Biofuels

The RFS, issued by EPA in 2009, caps the amount of corn ethanol blended into gasoline at 15 billion gal/yr, but mandates the production of 21 billion gal/yr of cellulosic biofuels.

The KiOR plant, which went online earlier this year, will produce 11 million gal/yr of gasoline blendstocks from 9.4 million cu.ft. of southern yellow pine.

These 11 million gal constitute 0.052% of the 21 billion gal/yr of cellulosic biofuels mandated by the RFS.

Commercial timberland is defined as forest land capable of producing 20 cu. ft/ac/yr and not withdrawn for other purposes.

Commercial timberland covers 514 million acres--approximately one-fourth of the land area of the US.

Average annual timber growth on this commercial timberland is 52 cu. ft./ac.

Percent of the US gasoline supply furnished if the entire 514 million acres of commercial timberland were devoted to biofuel production: 23%.

Carbon Dioxide Emissions for Selected Countries and the World, 1990 - 2011
[million metric tons CO_2]

Country	1990	2001	2005	2011	Percent Change 1990 - 2011
United States	5040	5754	5999	5491	8.9
Mexico	302	380	398	462	53
Brazil	237	349	371	475	100
India	579	1016	1181	1726	198
Indonesia	156	275	331	427	174
South Korea	242	450	494	611	152
China	2178	3354	5464	8715	300
World	**21523**	**24244**	**28262**	**32579**	**51**

Carbon Dioxide Emissions for EU Countries, 1990 - 2011
[Million metric tons of CO_2]

Country	1990	1999	2011	Percent Change 1990 - 2011
Belgium	125	143	131	4.6
Denmark	57	58	47	-18
France	368	403	374	1.8
Greece	82	96	91	12
Ireland	26	36	43	42
Italy	415	441	401	-3.5
Luxembourg	11	9	12	11
Netherlands	211	236	253	20
Portugal	44	63	61	23
Spain	224	299	319	42
UK	602	557	497	-17
EU [excluding Germany]	**2164**	**2339**	**2215**	**+2.4**
Russia	**2020**	**1459**	**1788**	**-11.5**
World	**21523**	**23459**	**32578**	**+51.3**

numbers in the far right-hand column should be down at least -5.0%. In fact, the EU as a whole is +2.4%. I have not included Germany in this table because the data for Germany are badly skewed by the reunification of East and West Germany in the early 1990s. This table shows that even with the base year [1990] carefully chosen for their own advantage, achieving a 5% reduction in CO_2 emissions has proved to be extremely difficult.

18. Slide. Projected world CO_2 emissions in 2020. This table, taken from data in the Energy Information Administration's *International Energy Outlook*, illustrates the folly of the US unilaterally reducing its CO_2 emissions with no constraints on emissions from the developing countries. In its reference case, EIA projects world emissions to increase to 36,400 million metric tons in 2020. Suppose the US were to shut down **all** of its coal-fired electrical generating plants and replace them with nuclear plants. US CO_2 emissions would be reduced by 1500 million metric tons annually, or 28%. However, world CO_2 emissions would still rise from 32,600 million metric tons to 34,900 million metric tons in 2020. Replacing the coal-fired generation would require 200,000 MW of **new** nuclear generating capacity--the equivalent of 100 new Diablo Canyon plants.

Projected World Carbon Dioxide Emissions in 2020[1]
[Million metric tons of CO_2]

Country	2011 [Actual]	2020	Percent Change 2011 - 2020
United States	5491	5454	-0.7
Brazil	475	547	15
China	8715	11532	32
India	1726	2109	22
World	**32579**	**36446**	**12**

(1) Estimated emissions in 2020 taken from International Energy Outlook, DOE/EIA, 2013.

World Electrical Energy Generation
[Billion kw-hrs]

Country	2000	2011	Percent Change 2000 - 2011
United States	3802	4099	7.8
Brazil	343	531	55
Mexico	194	258	33
South Korea	272	485	78
China	1281	4204	228
India	530	985	86
Russia	831	996	20
World	**14617**	**20400**	**40**