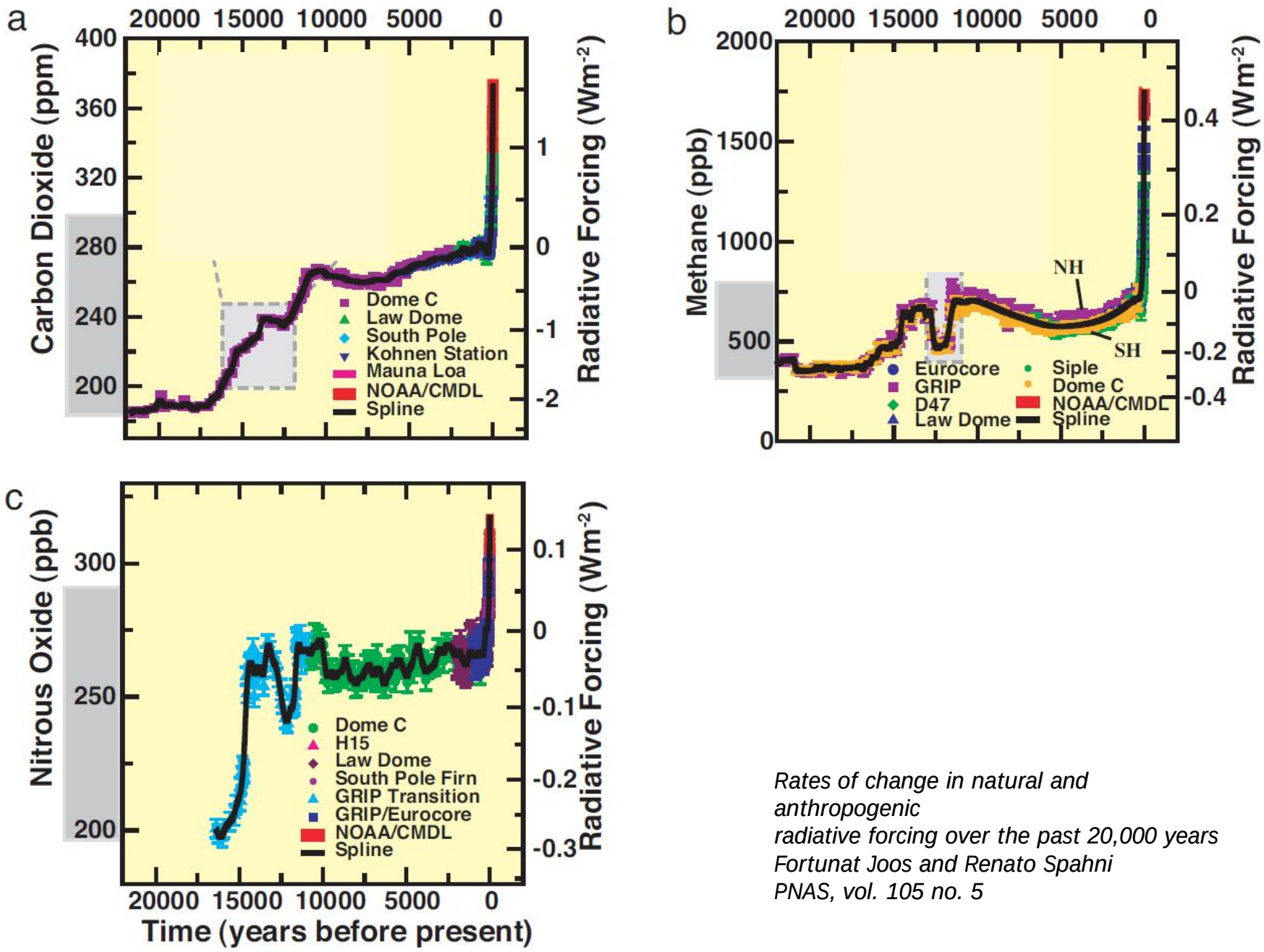
Climate Science, Climate Policy and Montana

Tom Fiddaman

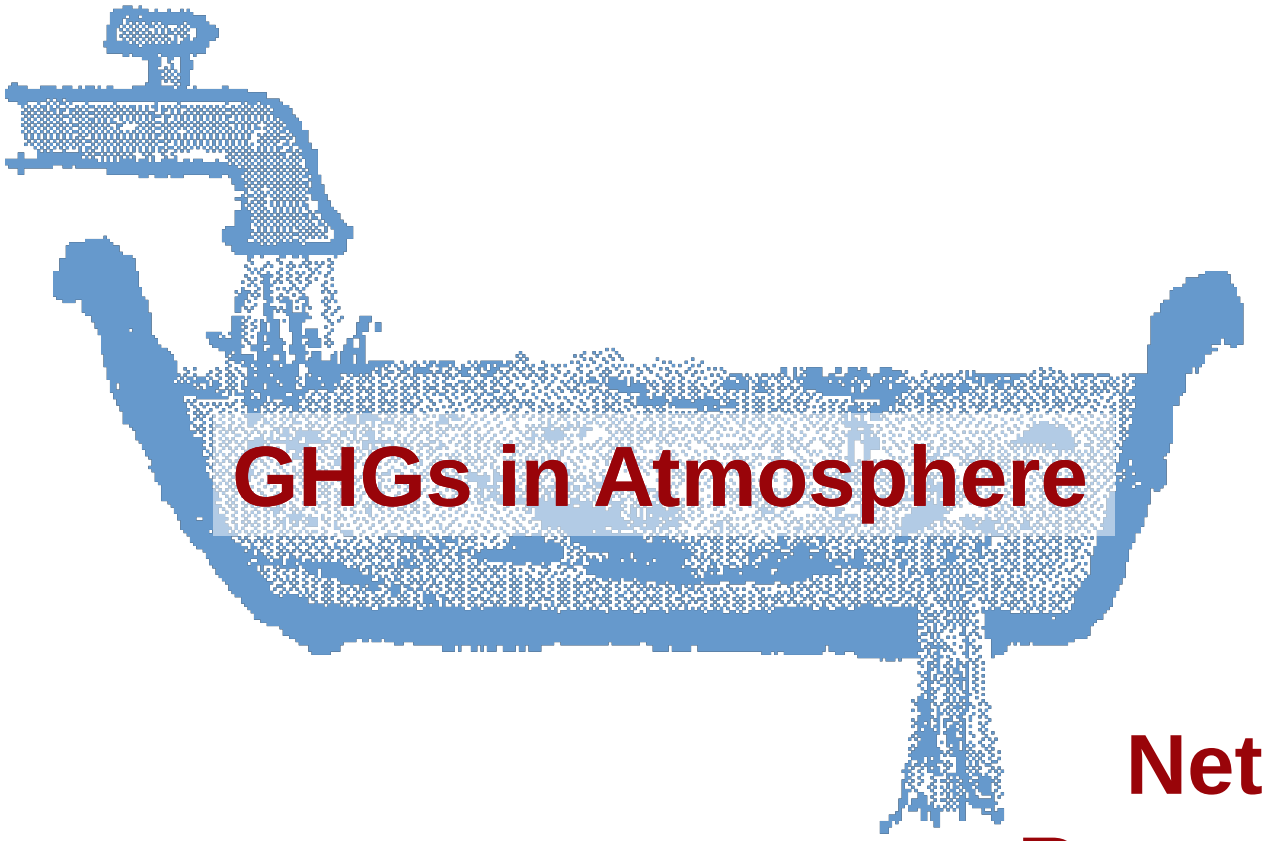
5/20/2010

Accumulation of Greenhouse Gases



Rates of change in natural and anthropogenic
radiative forcing over the past 20,000 years
Fortunat Joos and Renato Spahni
PNAS, vol. 105 no. 5

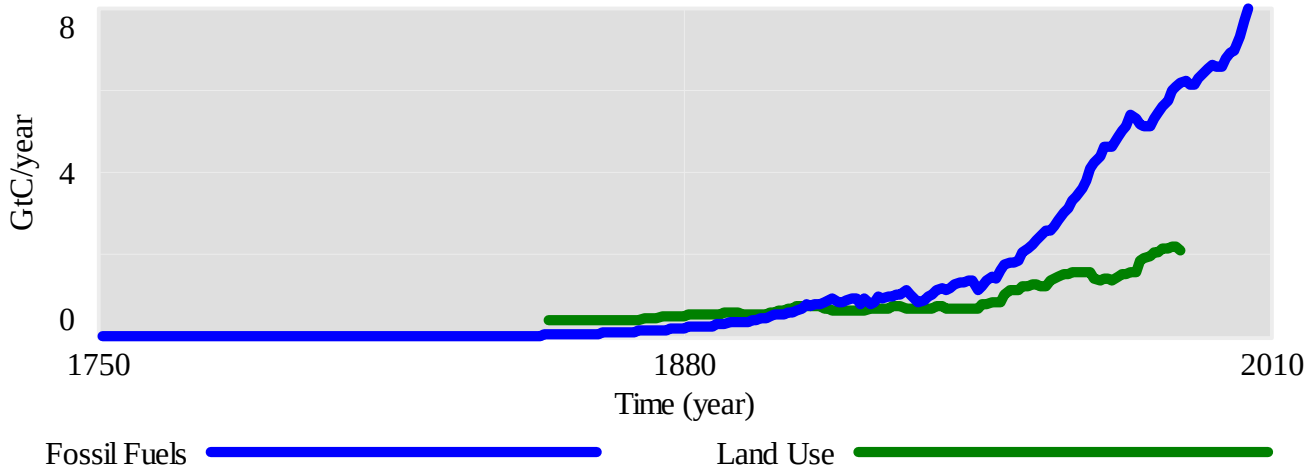
Atmospheric Greenhouse Gases (GHGs)



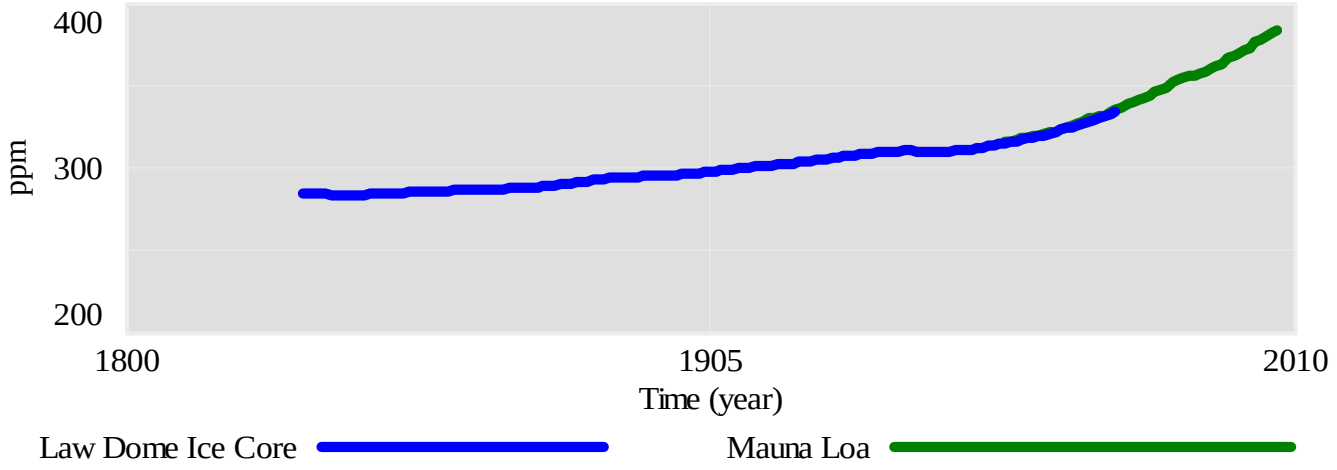
Courtesy of John Sterman, MIT

CO2 Emissions & Concentration

Emissions



Atmospheric Concentration



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Millennial Temperature Reconstructions

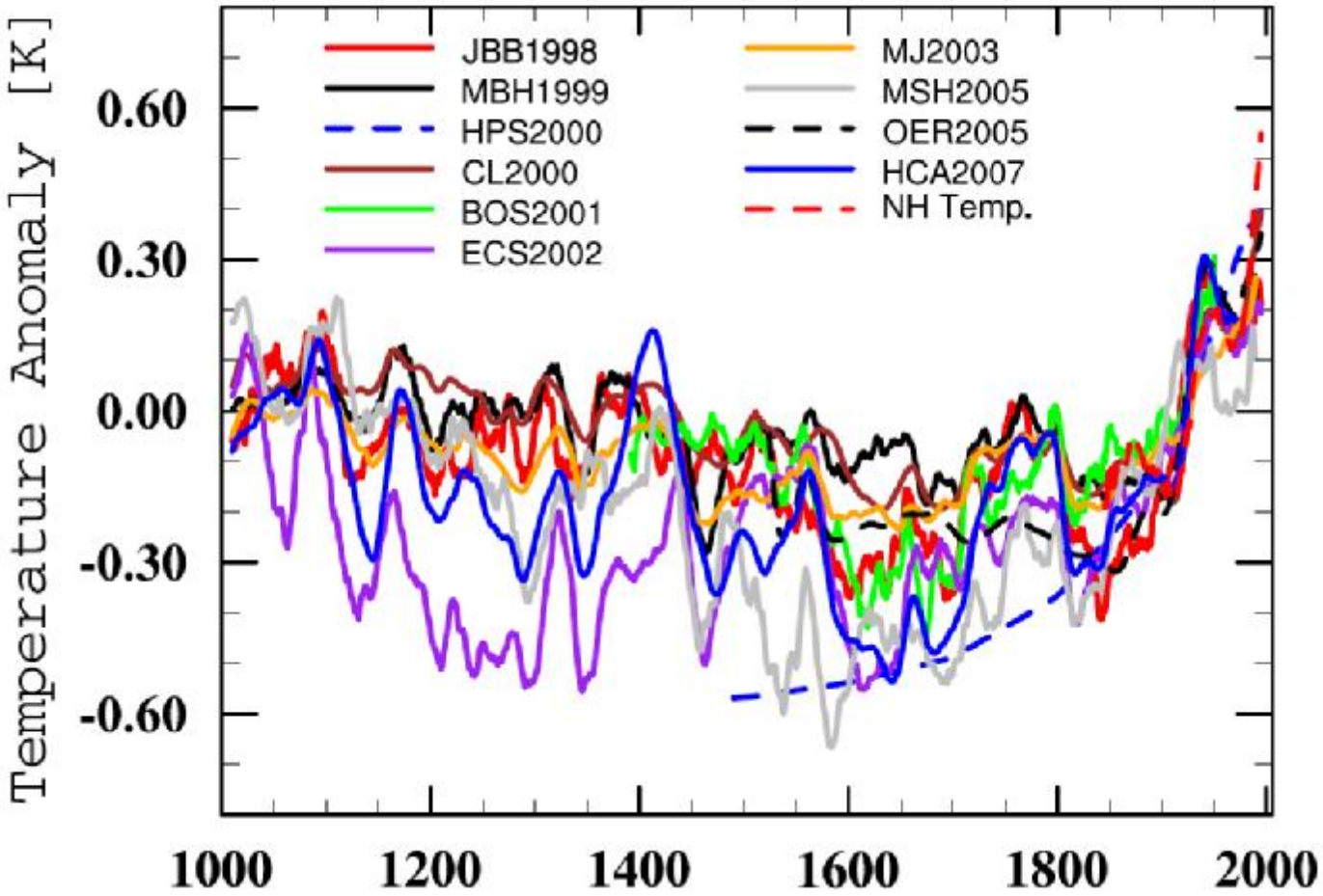
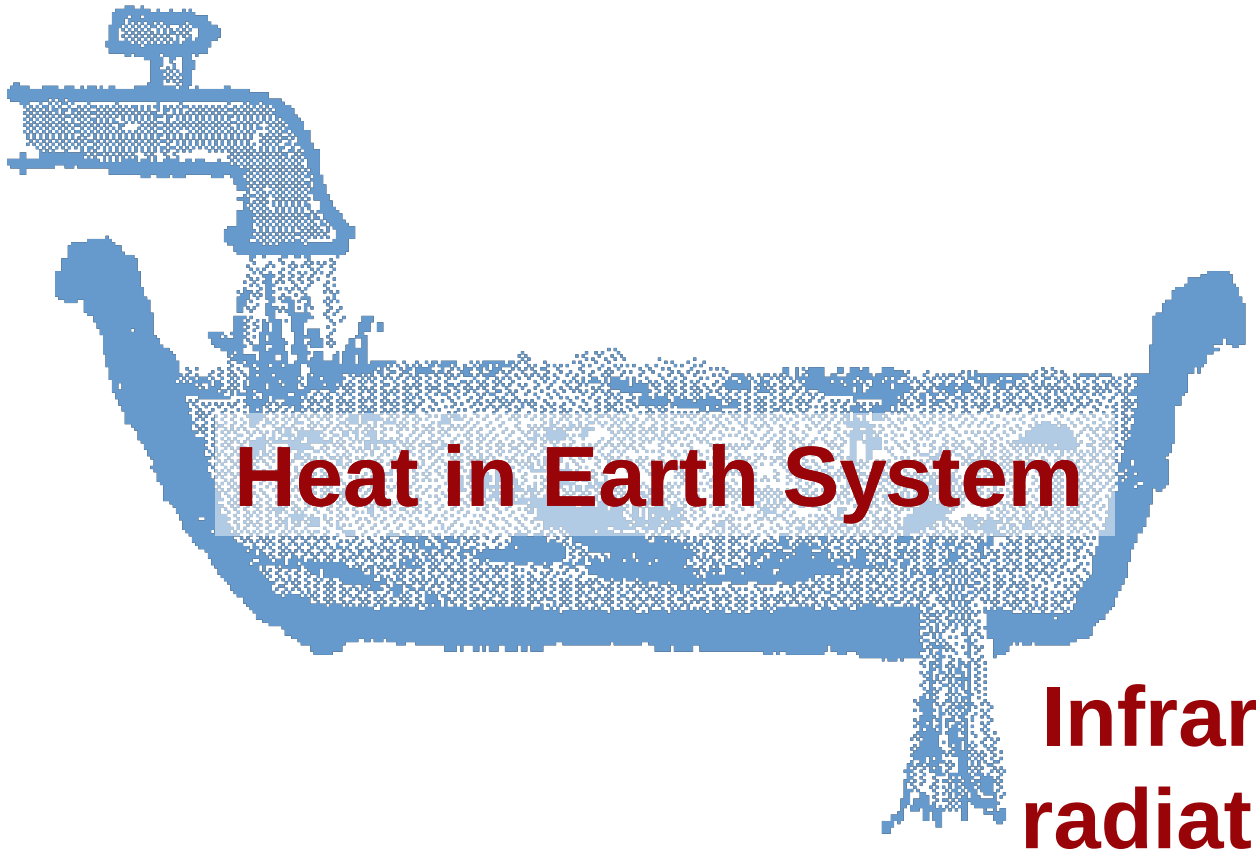


Fig. 1. Proxy based temperature reconstructions from AD1000 to present for various regions on hemispheric to global scales: see text for details. With mean of 1900 to 1960 removed, 21-year running means. NH mean instrumental temperatures are shown for the period AD1866 to 1995.

M. N. Juckes, M. R. Allen, K. R. Briffa, J. Esper, G. C. Hegerl, A. Moberg, T. J. Osborn, and S. L.Weber
Millennial temperature reconstruction intercomparison and evaluation
Clim. Past, 3, 591–609, 2007 www.clim-past.net/3/591/2007/

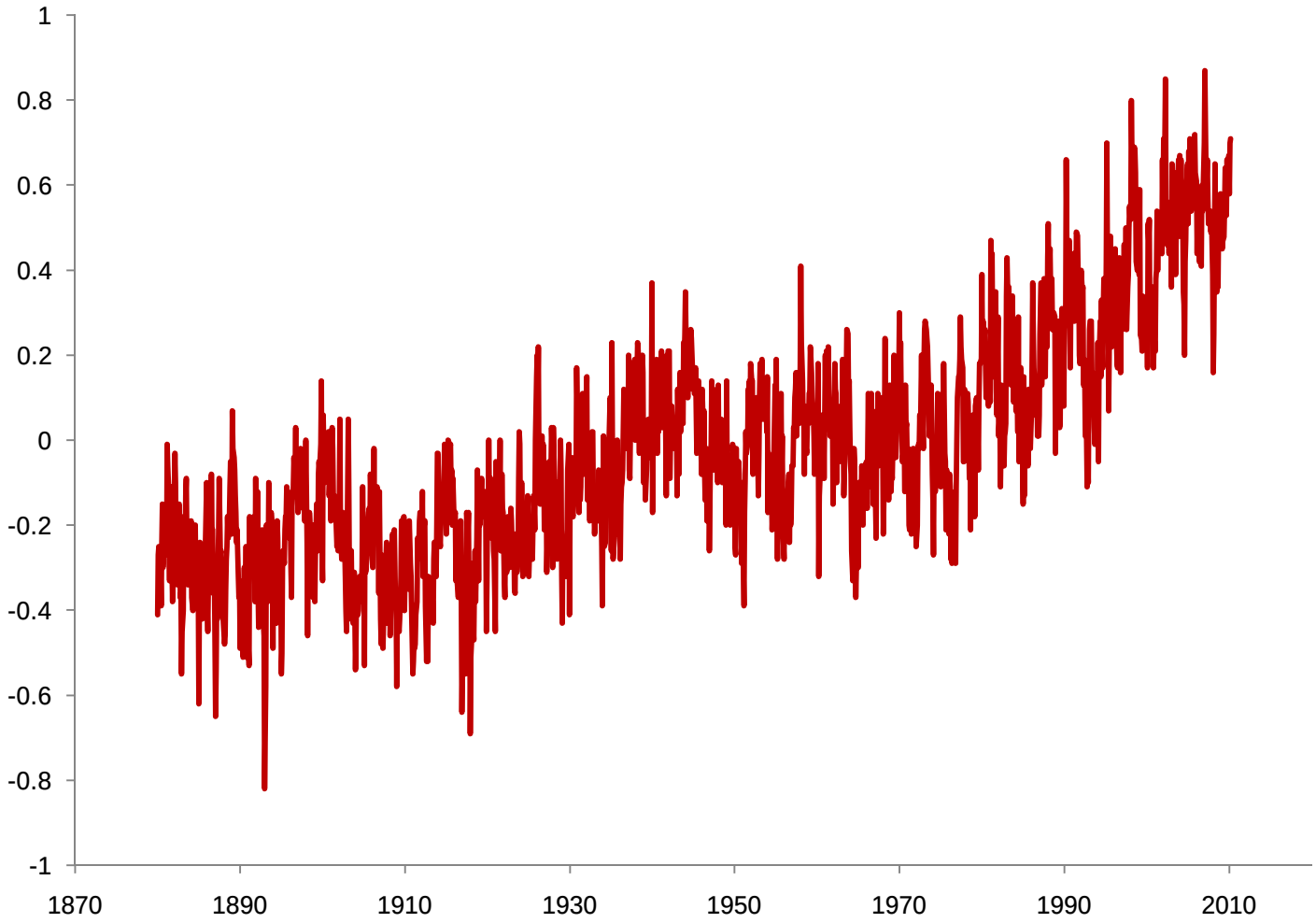
Atmospheric Temperature



Courtesy of John Sterman, MIT

F2

Global Surface Temperature



NASA/GISS – GISTEMP global land/ocean temperature, retrieved 4/5/2010.

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Slide 7

F2

better color
show projections
get rid of short term
Fid, 5/20/2010

Montana Temperatures

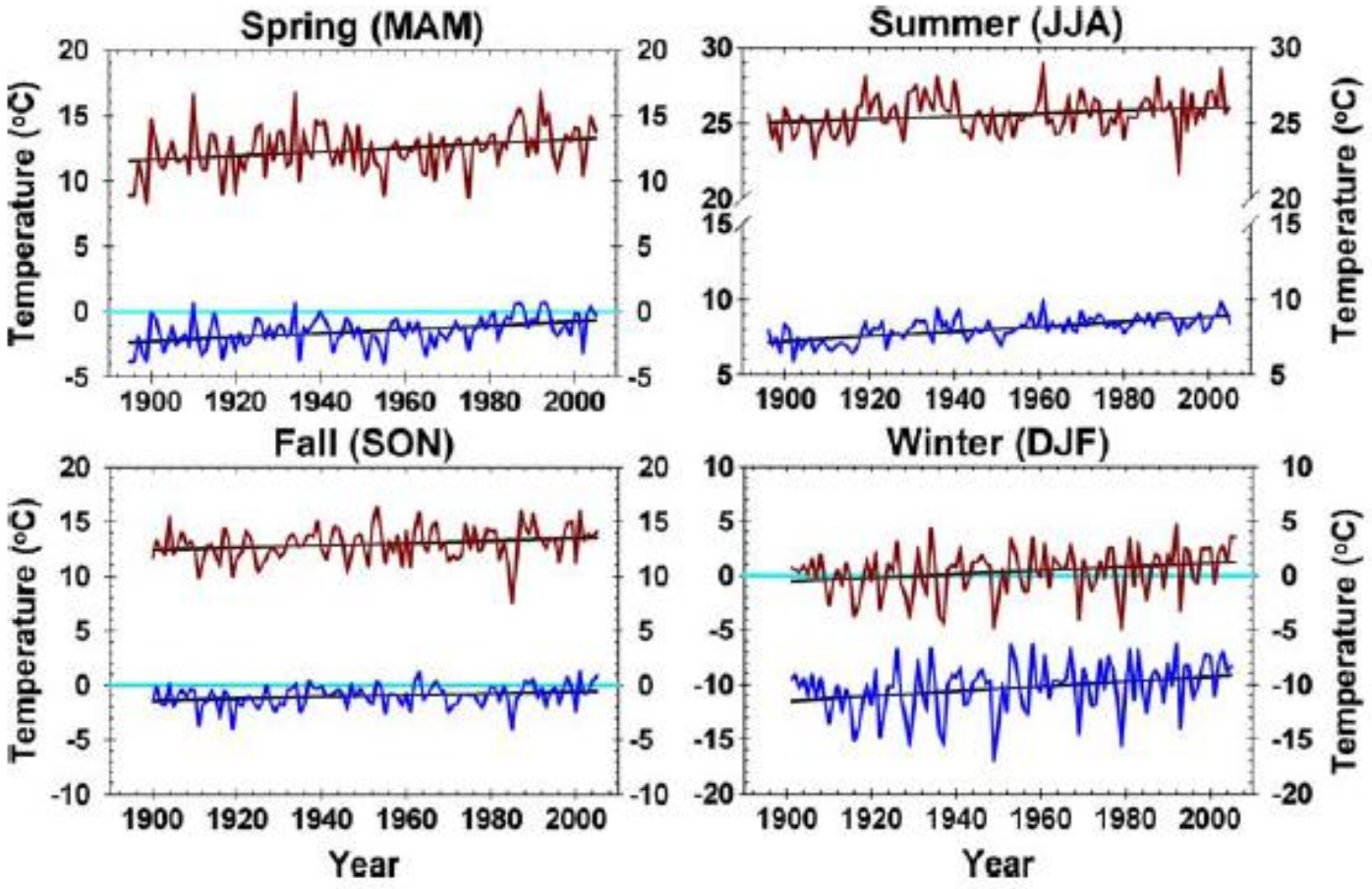

Fig. 3 Seasonal trends in maximum (*red line*) and minimum (*blue line*) temperatures for western Montana. Note change in scale of temperature axis for each season

Pederson et al. (2010) A century of climate and ecosystem change in Western Montana: what do temperature trends portend? Climatic Change 98:133-154

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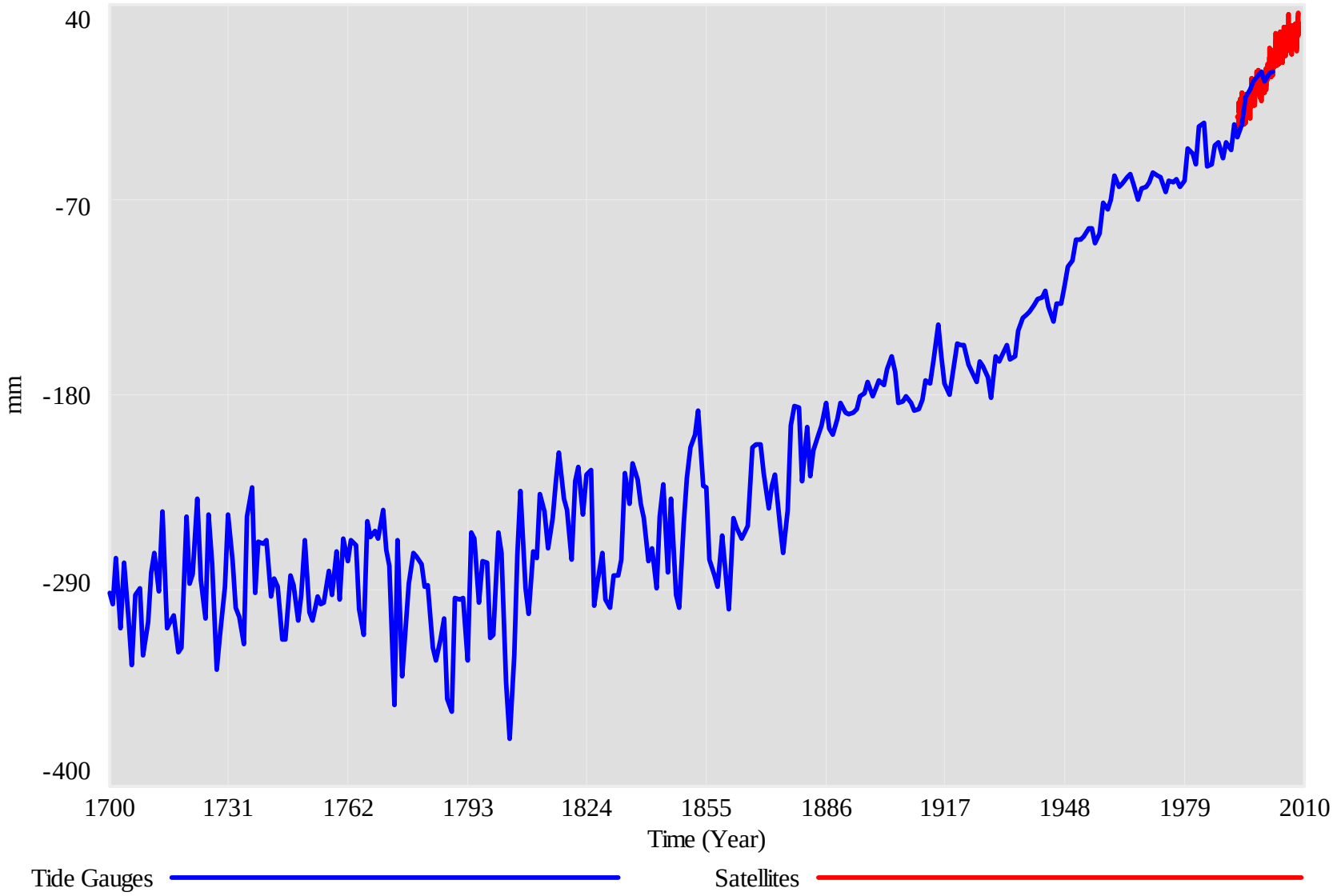
F1

Sea Level


40
-70
-180
-290
-400
mm
1700
1731
1762
1793
1824
1855
1886
1917
1948
1979
2010
Time (Year)
Tide Gauges
Satellites

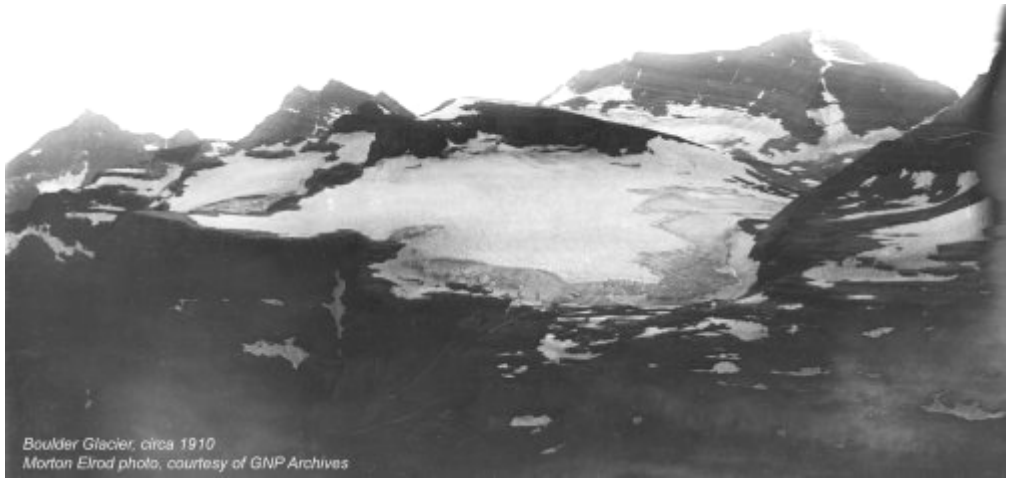
Slide 9

F1 source

Fid, 4/7/2010

Glaciers
Boulder Glacier, Glacier NP

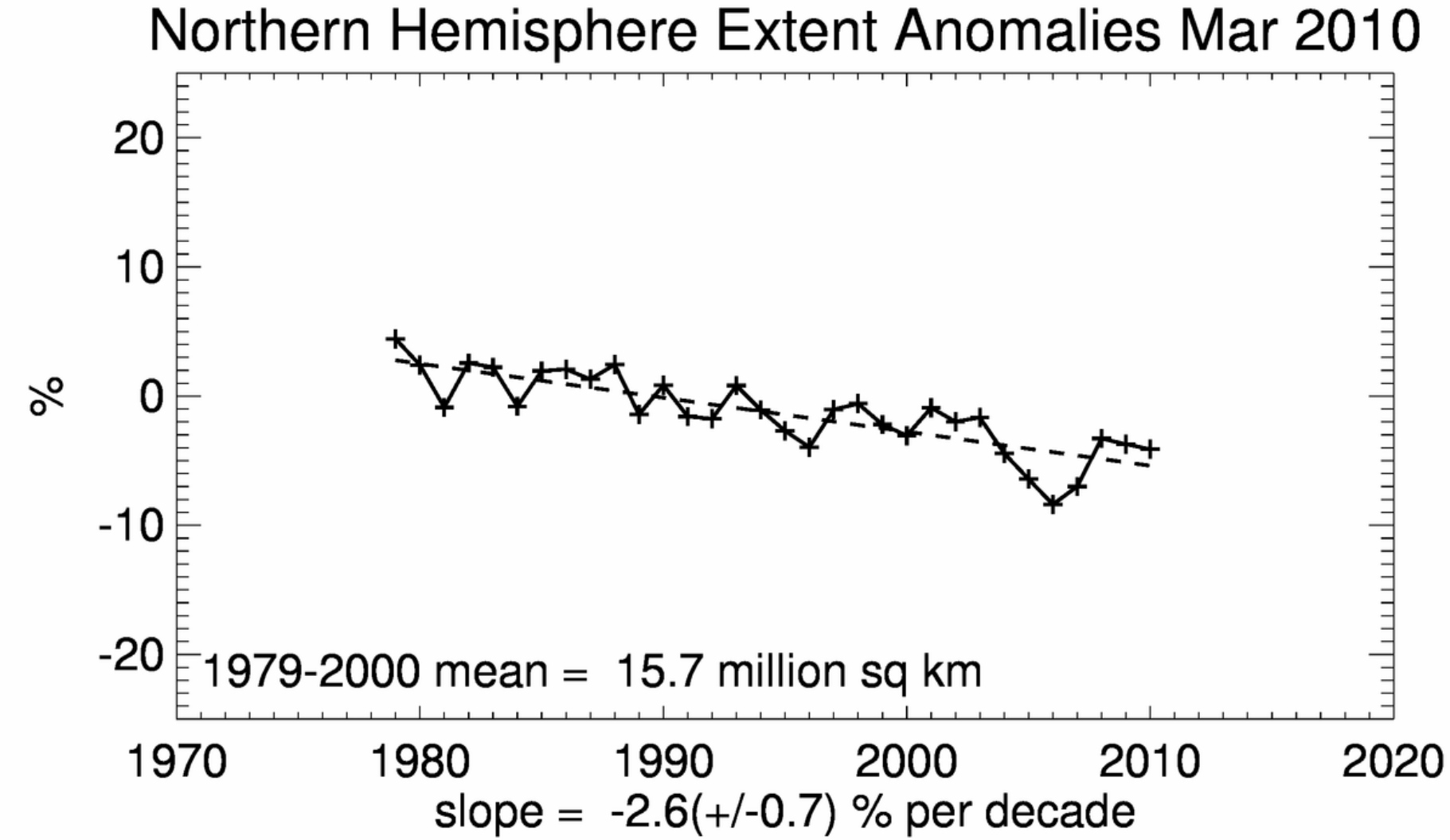
1910



2007

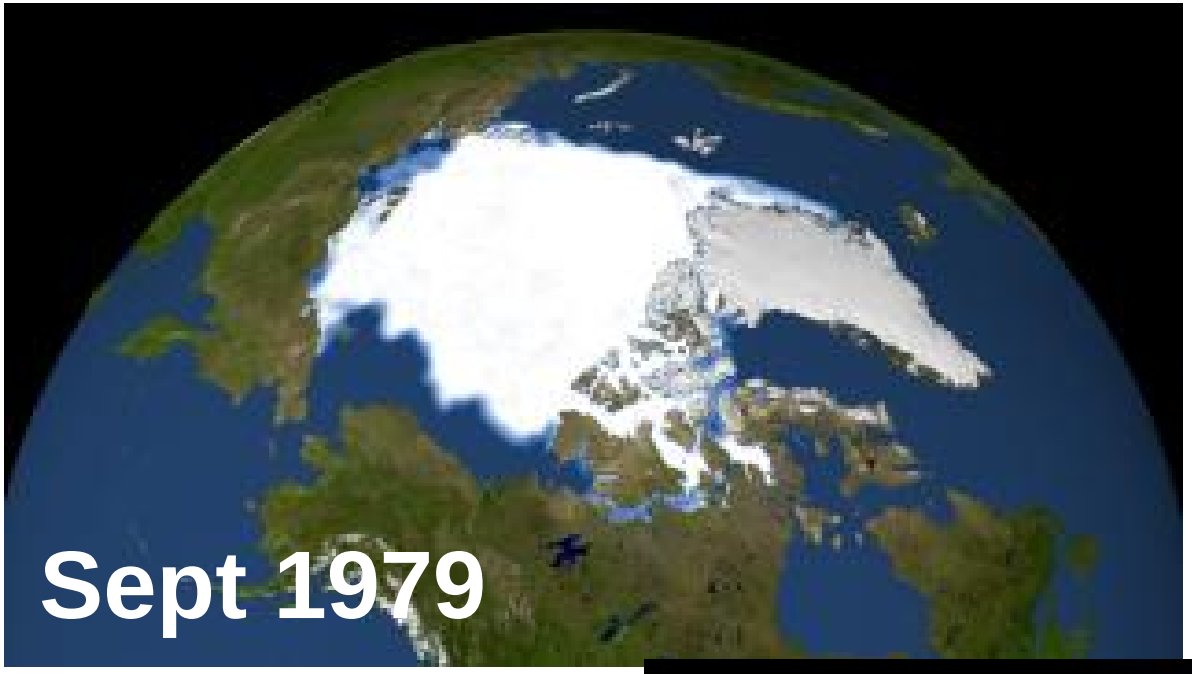
Source: USGS Repeat Photography Project, http://www.nrmsc.usgs.gov/repeatphoto/boulder-cp.htm

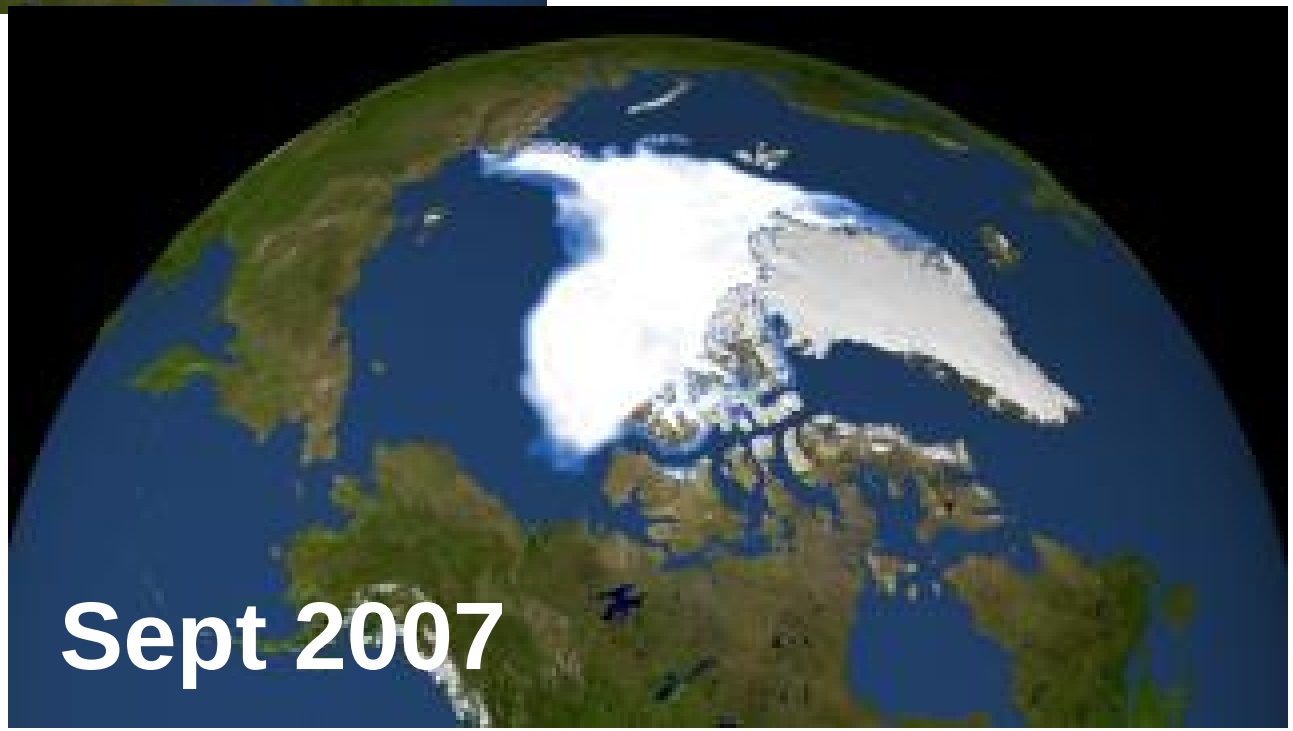
Arctic Sea Ice



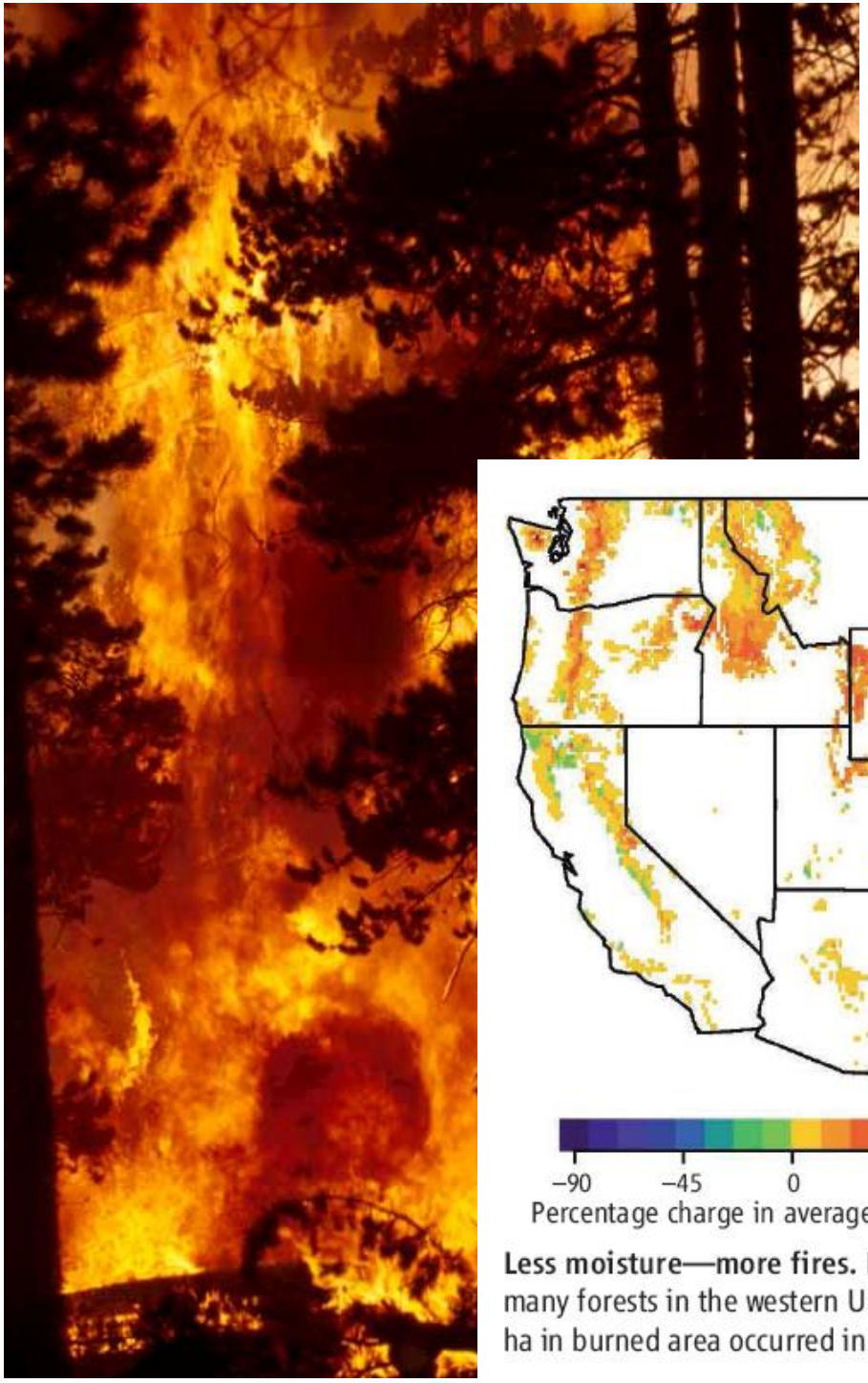
National Snow & Ice Data Center, retrieved 4/7/2010 from http://nsidc.org/data/seaice_index/

Disappearing Arctic Sea Ice



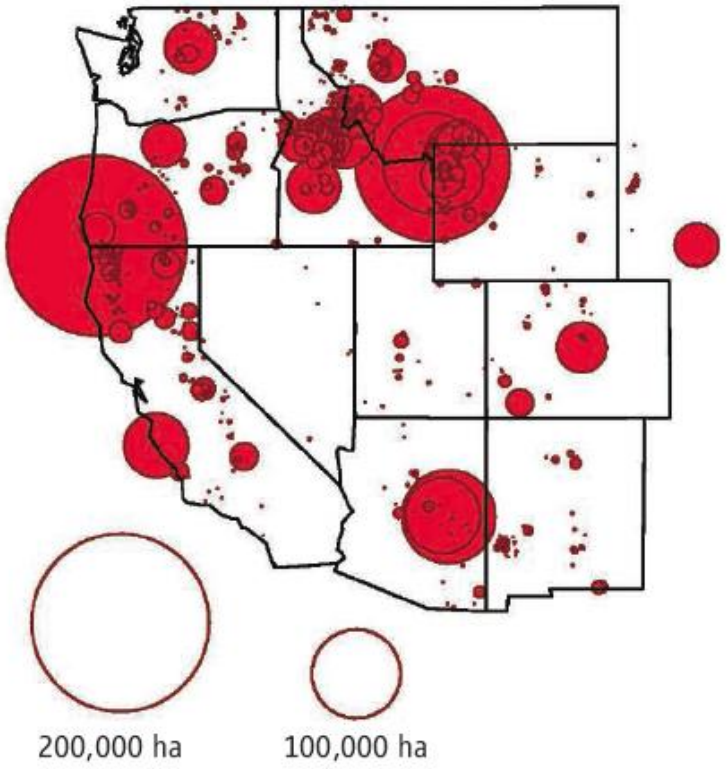


Source: NASA http://svs.gsfc.nasa.gov/vis/a000000/a003400/a003464/index.html, courtesy of John Sterman, MIT



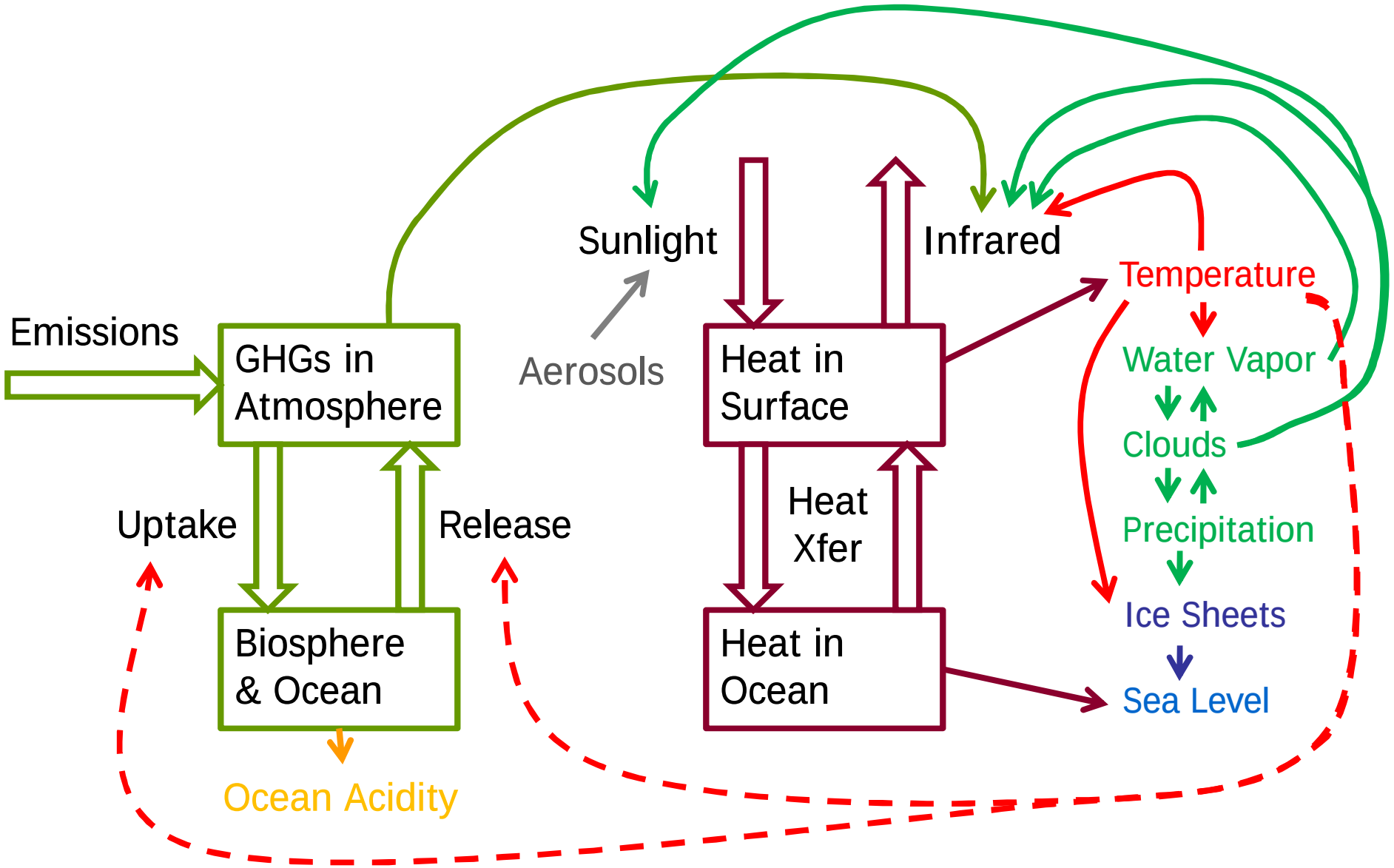
Wildfire Incidence Growing

Science 18 August 2006 313: 927-928



Less moisture—more fires. Between 1970 and 2003, spring and summer moisture availability declined in many forests in the western United States (**left**). During the same time span, most wildfires exceeding 1000 ha in burned area occurred in these regions of reduced moisture availability (**right**). [Data from (*4*)]

F4
F5



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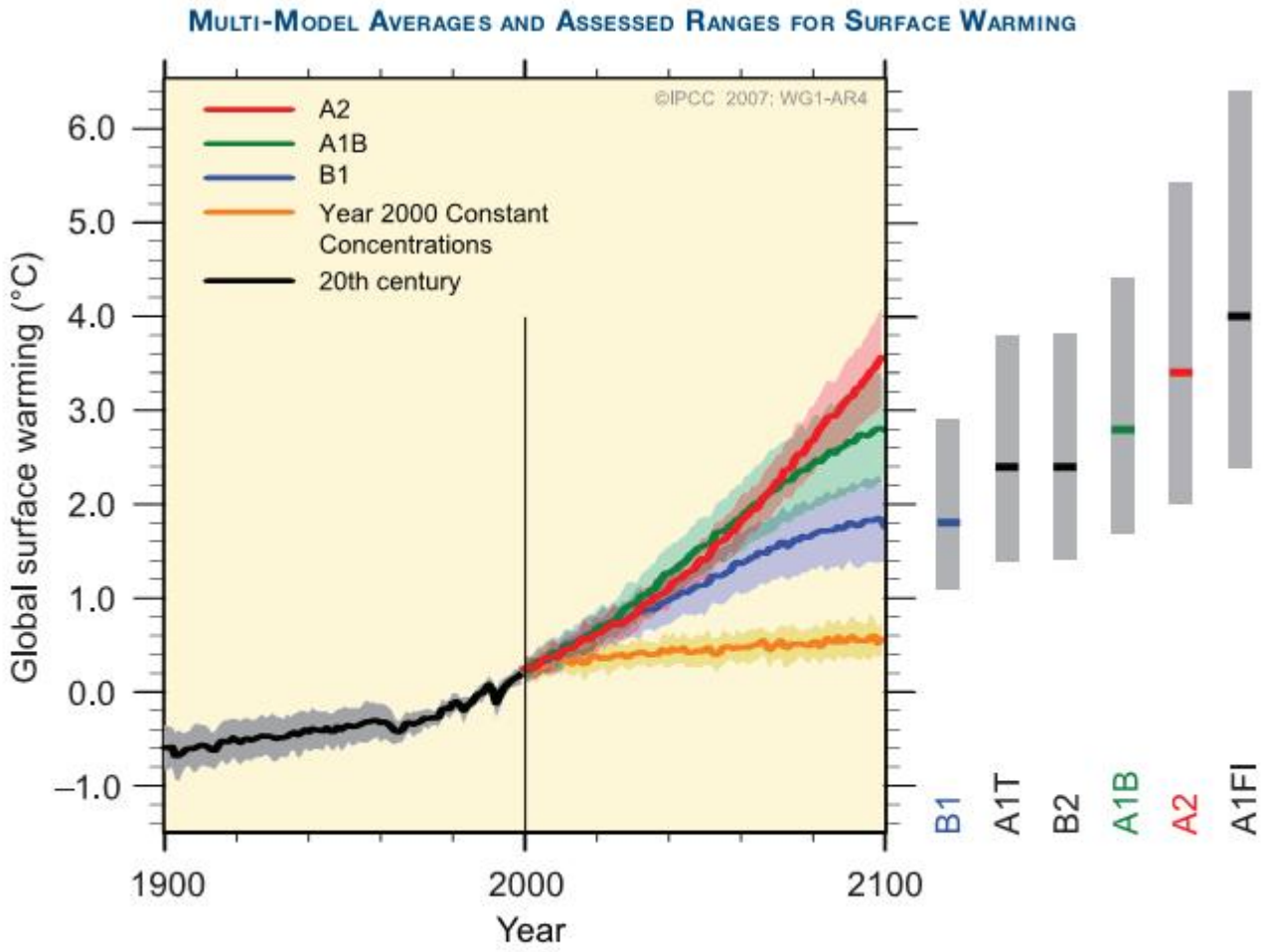
Slide 14

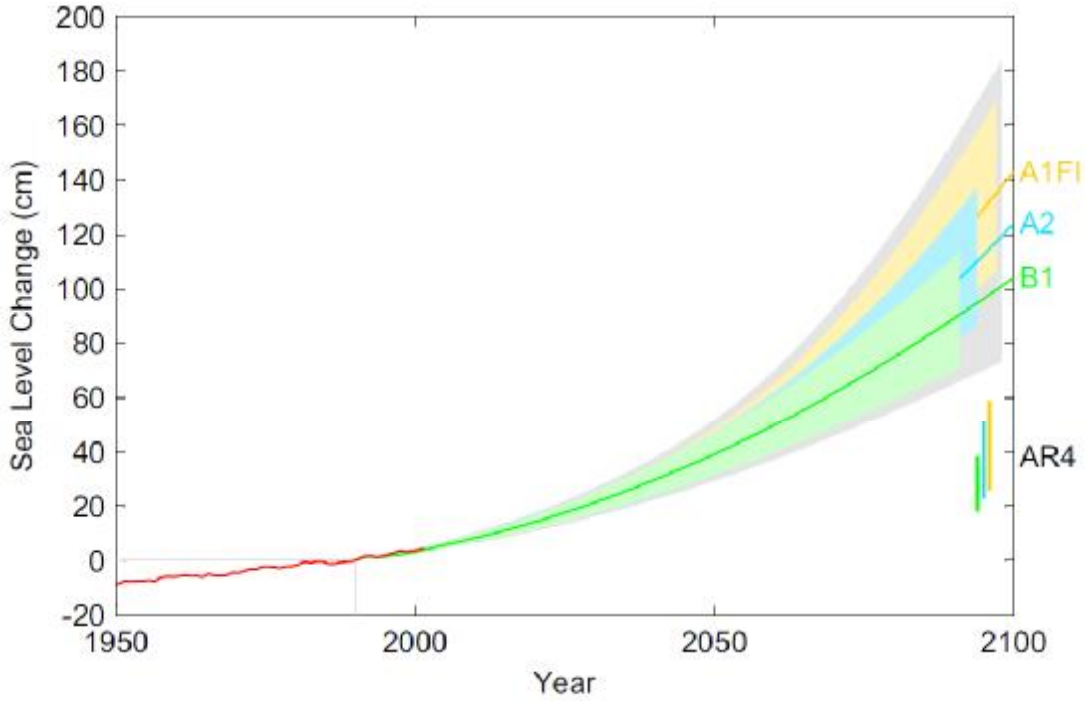
F4 Acidification
Fid, 5/20/2010

F5 precipitation
Fid, 5/20/2010

The Future
IPCC AR4 Temperature Projections



Sea Level Rise Projections



← +4 ½ feet

Fig. 6. Projection of sea-level rise from 1990 to 2100, based on IPCC temperature projections for three different emission scenarios (labeled on right, see Projections of Future Sea Level for explanation of uncertainty ranges). The sea-level range projected in the IPCC AR4 (2) for these scenarios is shown for comparison in the bars on the bottom right. Also shown is the observations-based annual global sea-level data (18) (red) including artificial reservoir correction (22).

Vermeer & Rahmstorf (2009) Global sea level linked to global temperature PNAS vol. 106 no. 51 Dec 22 2009

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Climate Weirding

Disappearing Climates with High Emissions (SRES A2)

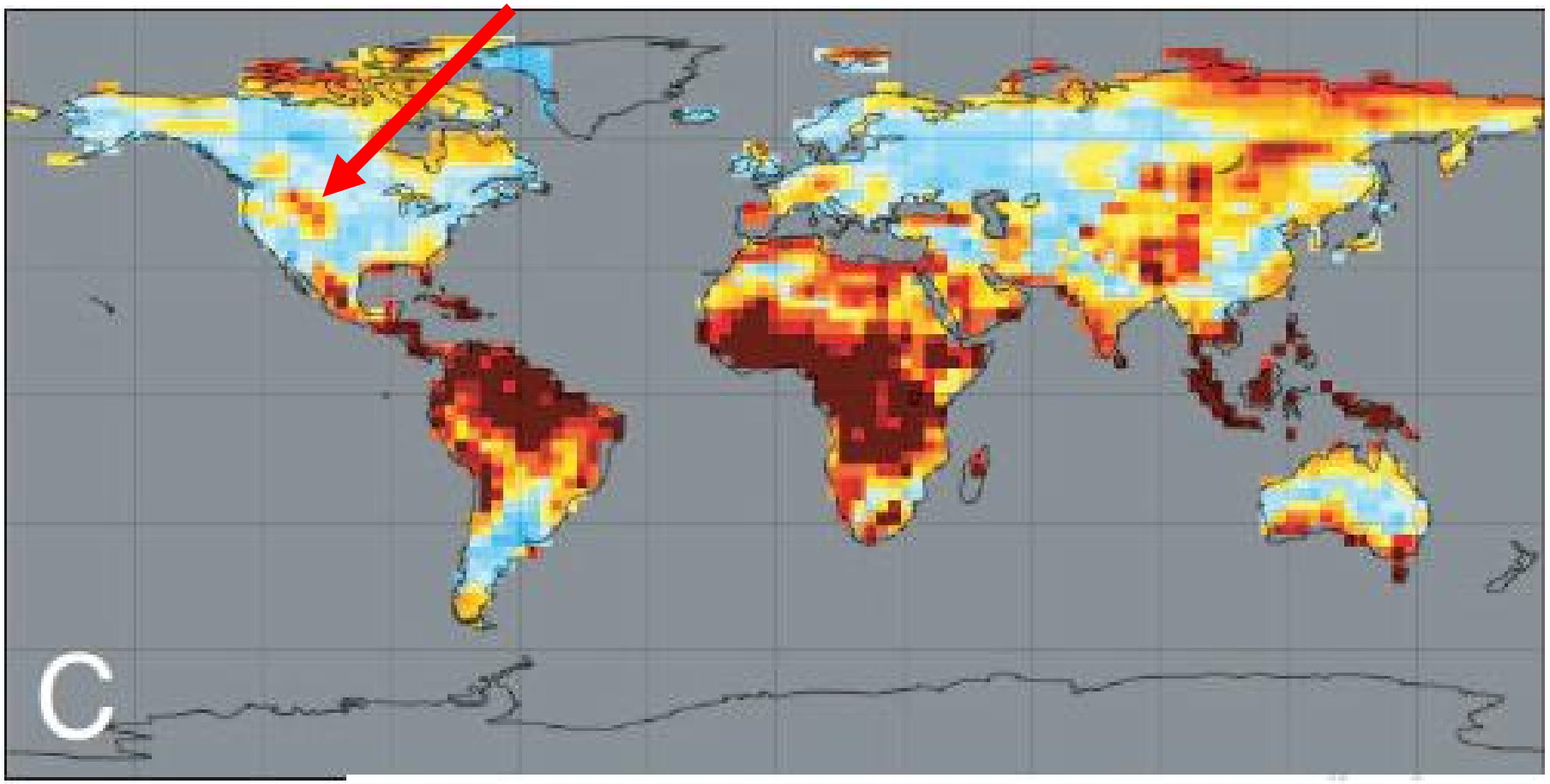
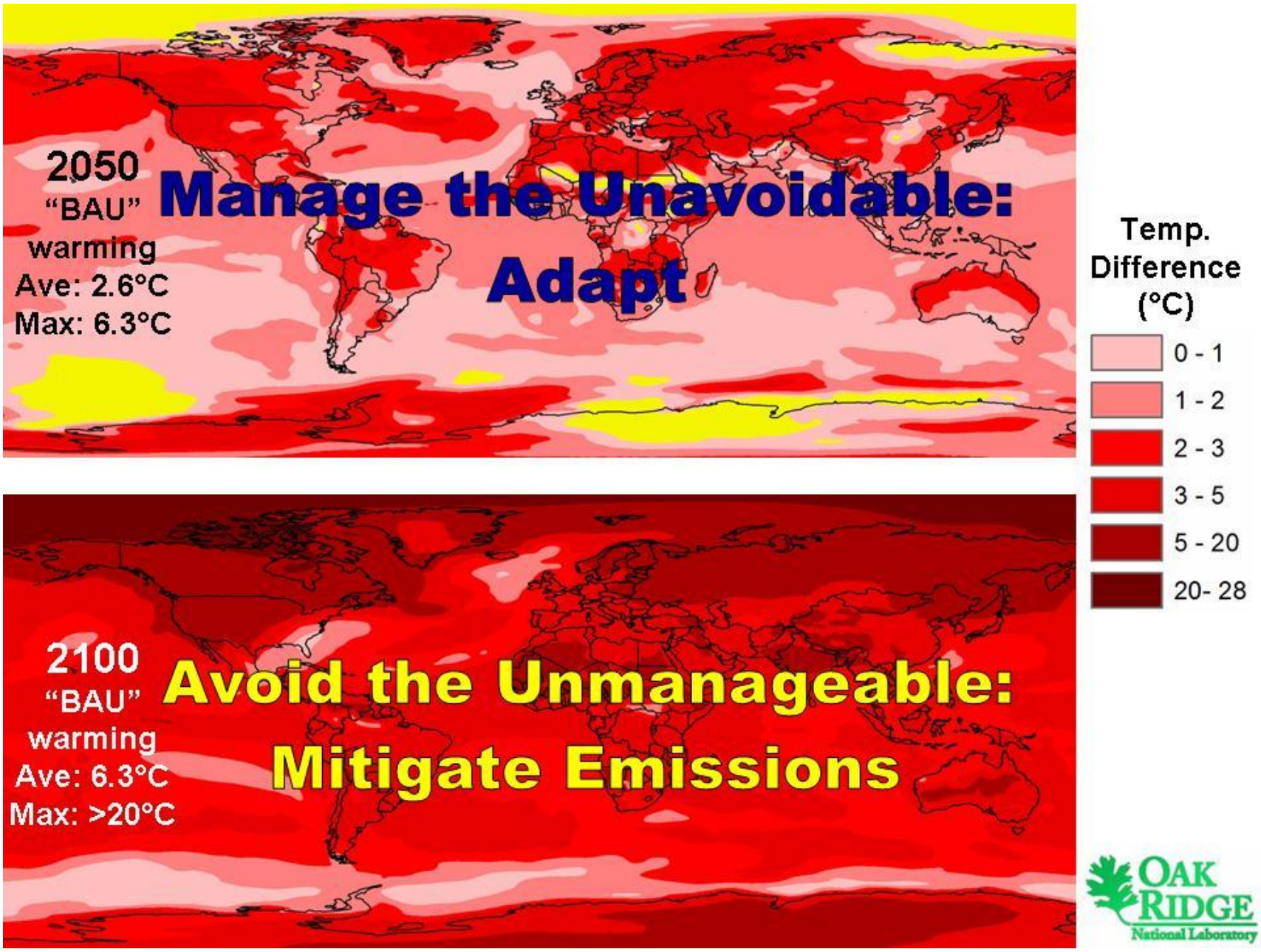


Fig. 3. … *pool of potential analogs is restricted to gridpoints within 500km of each target gridpoint*
John W. Williams, Stephen T. Jackson, and John E. Kutzbach. Projected distributions of novel and disappearing climates by 2100 AD. PNAS, vol. 104 no. 14


2050
"BAU"
warming
Ave: 2.6°C
Max: 6.3°C
Manage the Unavoidable:
Adapt
2100
"BAU"
warming
Ave: 6.3°C
Max: >20°C
Avoid the Unmanageable:
Mitigate Emissions
Temp.
Difference
(°C)
0 - 1
1 - 2
2 - 3
3 - 5
5 - 20
20- 28
OAK
RIDGE
National Laboratory

COP15
COPENHAGEN
UNITED NATIONS CLIMATE CHANGE CONFERENCE 2009

Difficulty assessing proposals

"…delegates [in Bonn] complained that their heads were spinning as they were trying to understand the science and assumptions underlying the increasing number of proposals tabled for Annex I countries' emission reduction ranges."

"They all seem to use different base years and assumptions…: how can we make any sense of them?"

http://www.iisd.ca/vol12/enb12403e.html

Current Confirmed Proposals

Country	2020	2050	Other
Australia	5% below 2000	60% below 2000	20% renewable energy by 2020
Brazil	36% below business-as-usual		Amazon deforestation 70% below 2009 by 2017
China	Carbon intensity 45% below 2005		Increase forest coverage 40M Ha by 2020
EU	20% below 1990	80% below 1990	
Russia	20% below 1990	50% below 1990	
US	17% below 2005		

and so on …

Compiled by Climate Interactive, Feb. 2 2010 release, http://climateinteractive.org/scoreboard/scoreboard-science-and-data

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Policymaker Mental Models

"Currently, in the UNFCCC negotiation process, the concrete environmental consequences of the various positions are not clear to all of us.

There is a dangerous void of understanding of the short and long term impacts of the espoused …unwillingness to act on behalf of the Parties."

– Christiana Figueres, UNFCCC negotiator for Costa Rica

(model demo)

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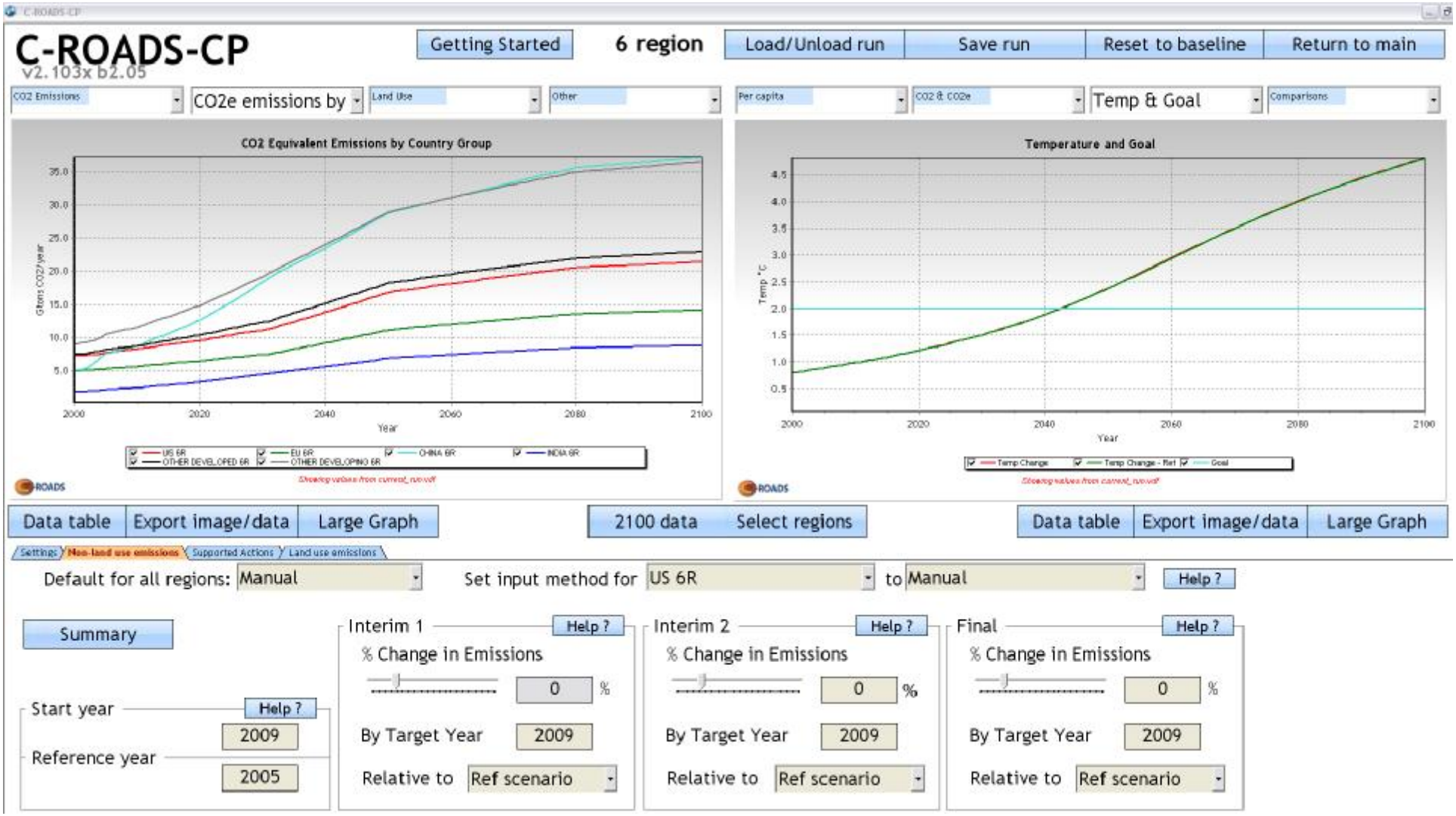
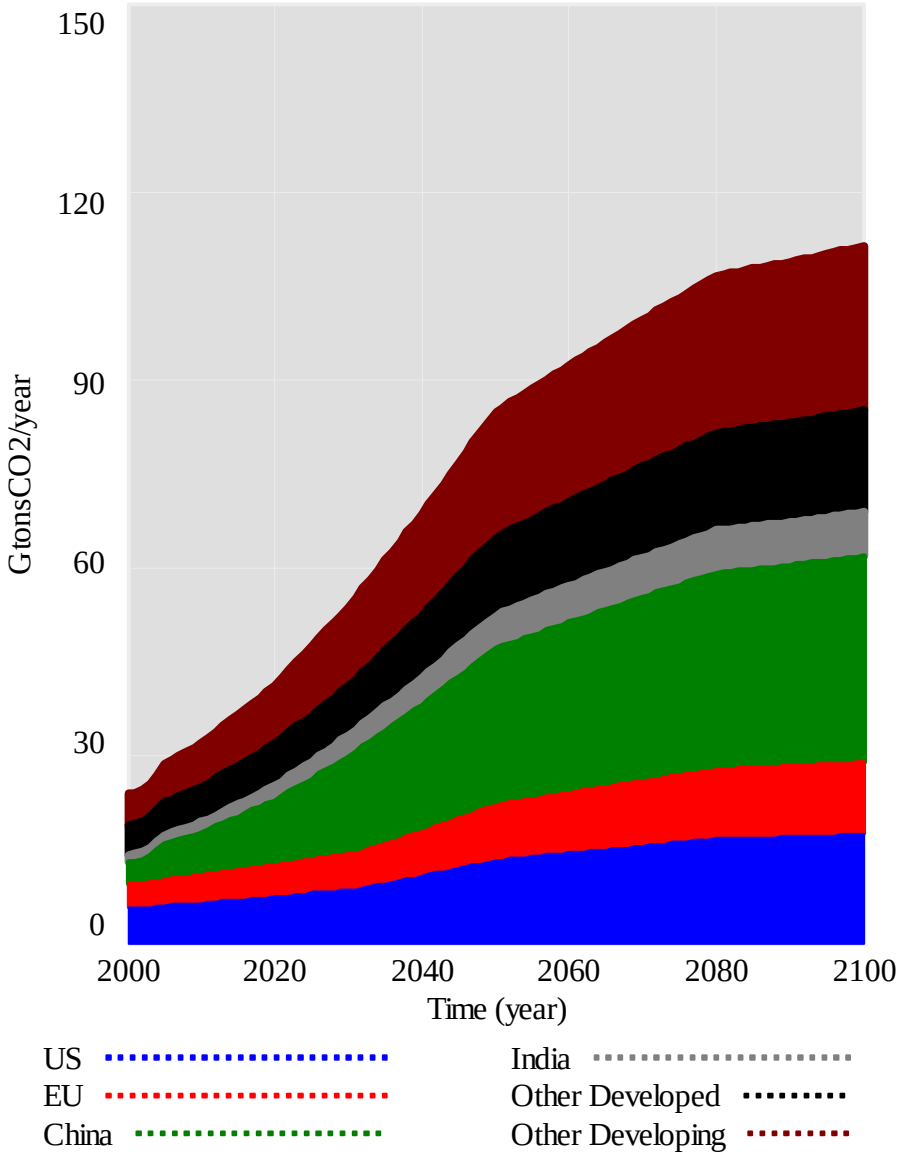
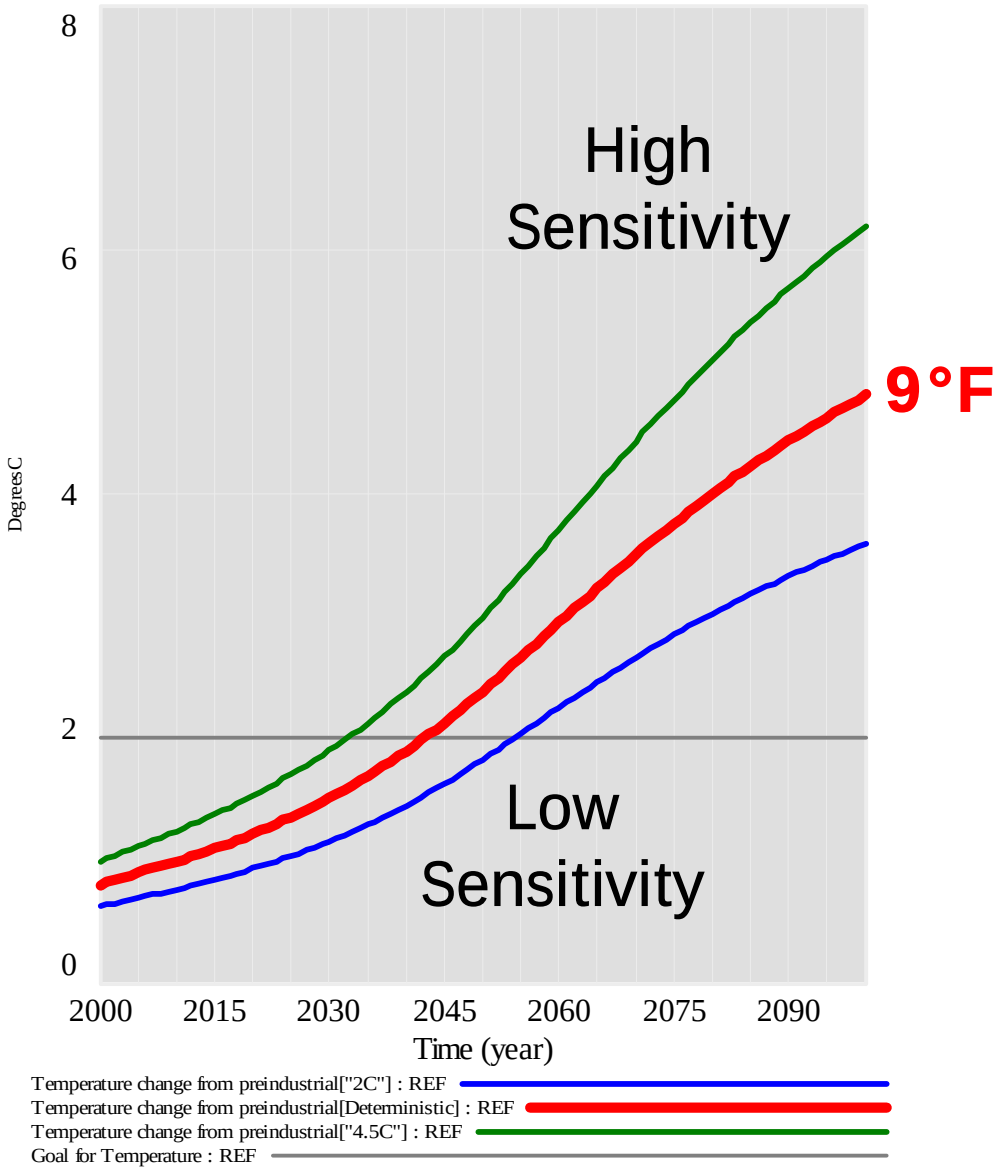

C-ROADS-CP
v2.103x b2.05
Getting Started
6 region
Load/Unload run
Save run
Reset to baseline
Return to main
CO2 Emissions
CO2e emissions by
Land Use
Other
Per capita
CO2 & CO2e
Temp & Goal
Comparisons
CO2 Equivalent Emissions by Country Group
Gtons CO2/year
Year
US 6R
EU 6R
CHINA 6R
INDIA 6R
OTHER DEVELOPED 6R
OTHER DEVELOPING 6R
Temperature and Goal
Temp °C
Year
Temp Change
Temp Change - Ref
Goal
Data table
Export image/data
Large Graph
2100 data
Select regions
Data table
Export image/data
Large Graph
Settings
Non-land use emissions
Supported Actions
Land use emissions
Default for all regions:
Manual
Set input method for
US 6R
to
Manual
Help ?
Summary
Start year
Help ?
2009
Reference year
2005
Interim 1
Help ?
% Change in Emissions
0
%
By Target Year
2009
Relative to
Ref scenario
Interim 2
Help ?
% Change in Emissions
0
%
By Target Year
2009
Relative to
Ref scenario
Final
Help ?
% Change in Emissions
0
%
By Target Year
2009
Relative to
Ref scenario

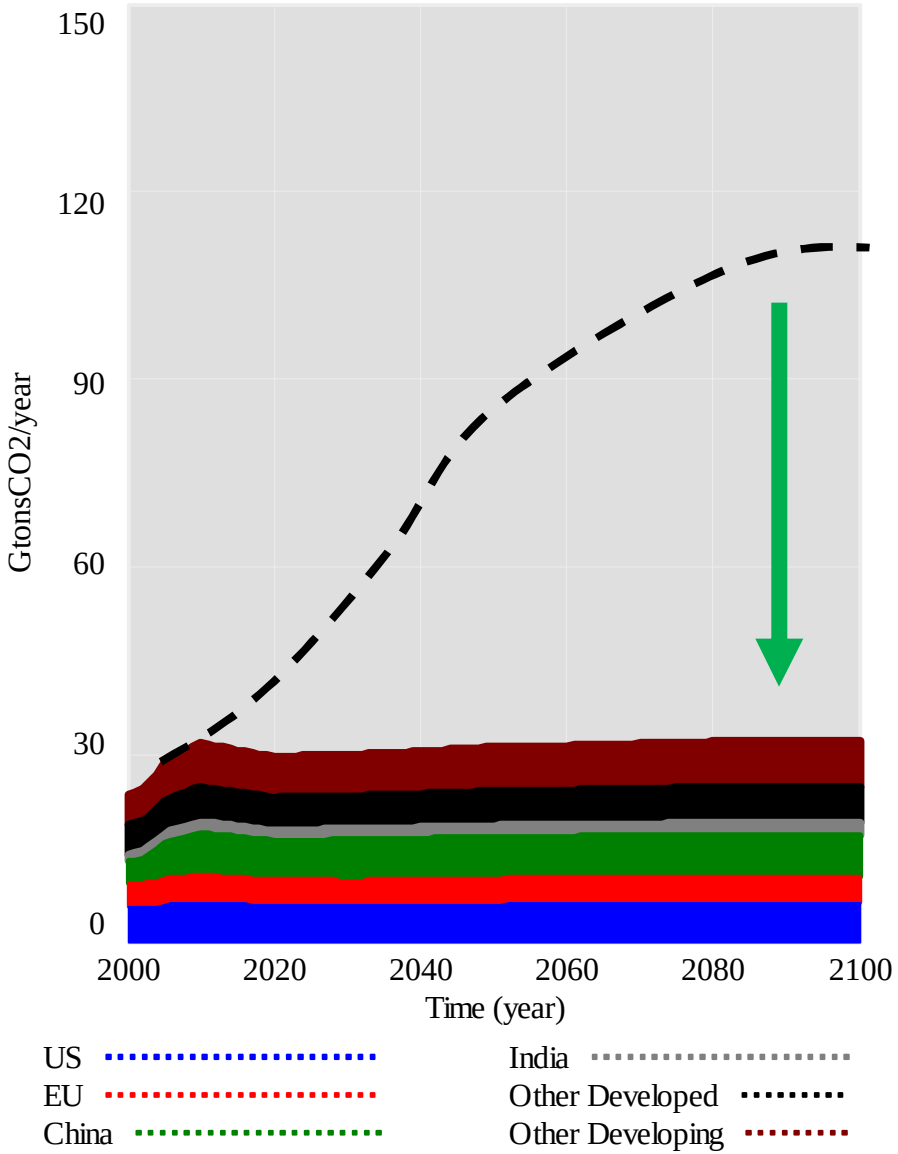
Emissions – Business as Usual



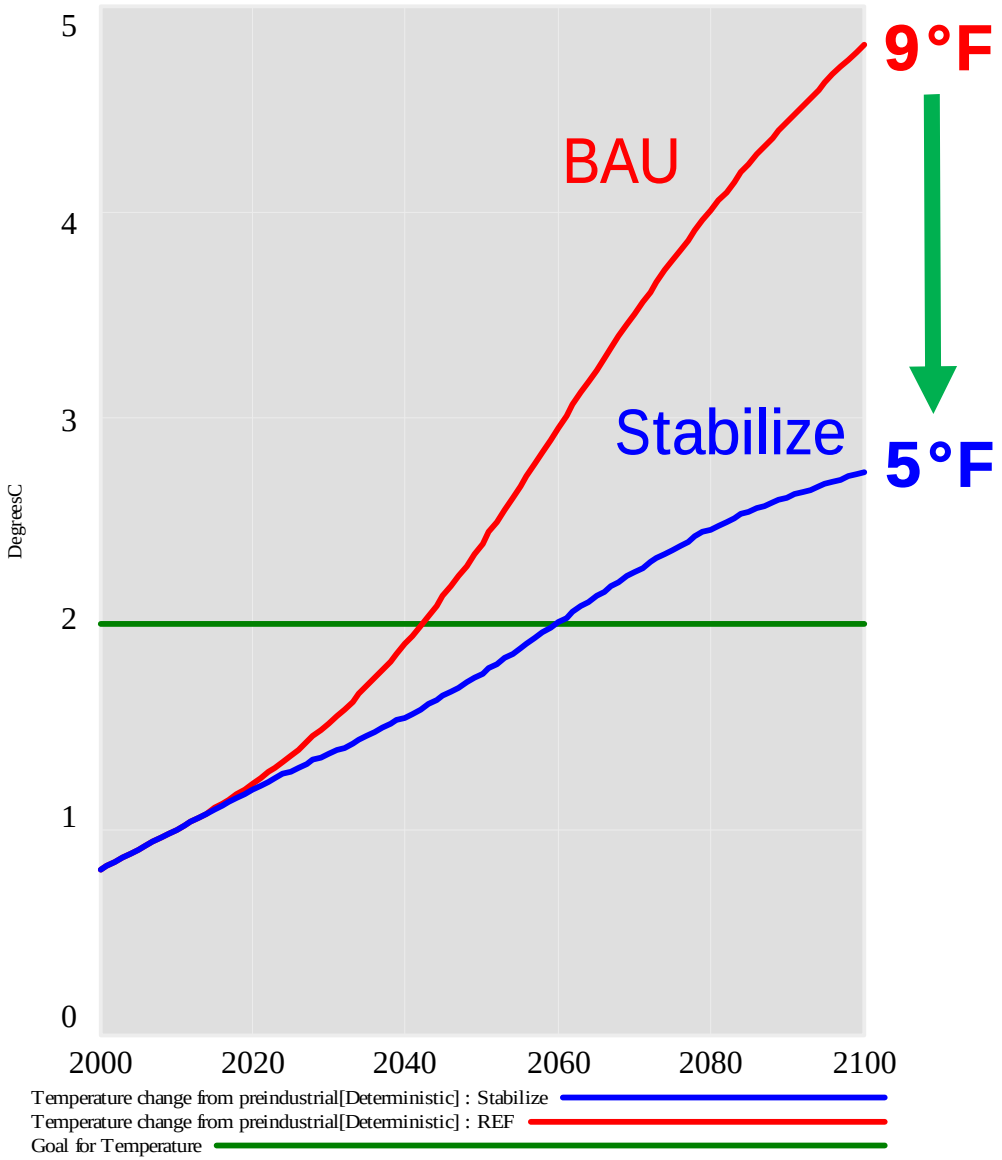
Temperature



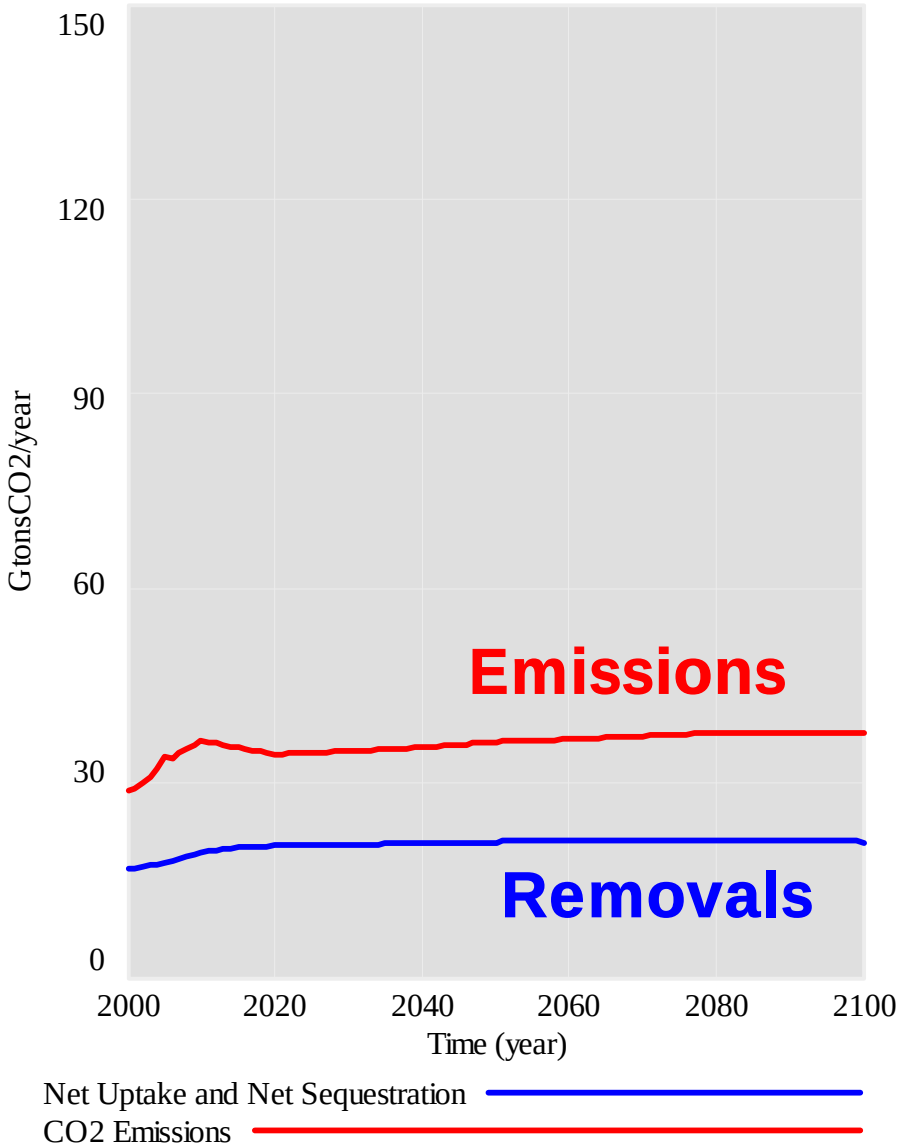
Emissions – Stabilized



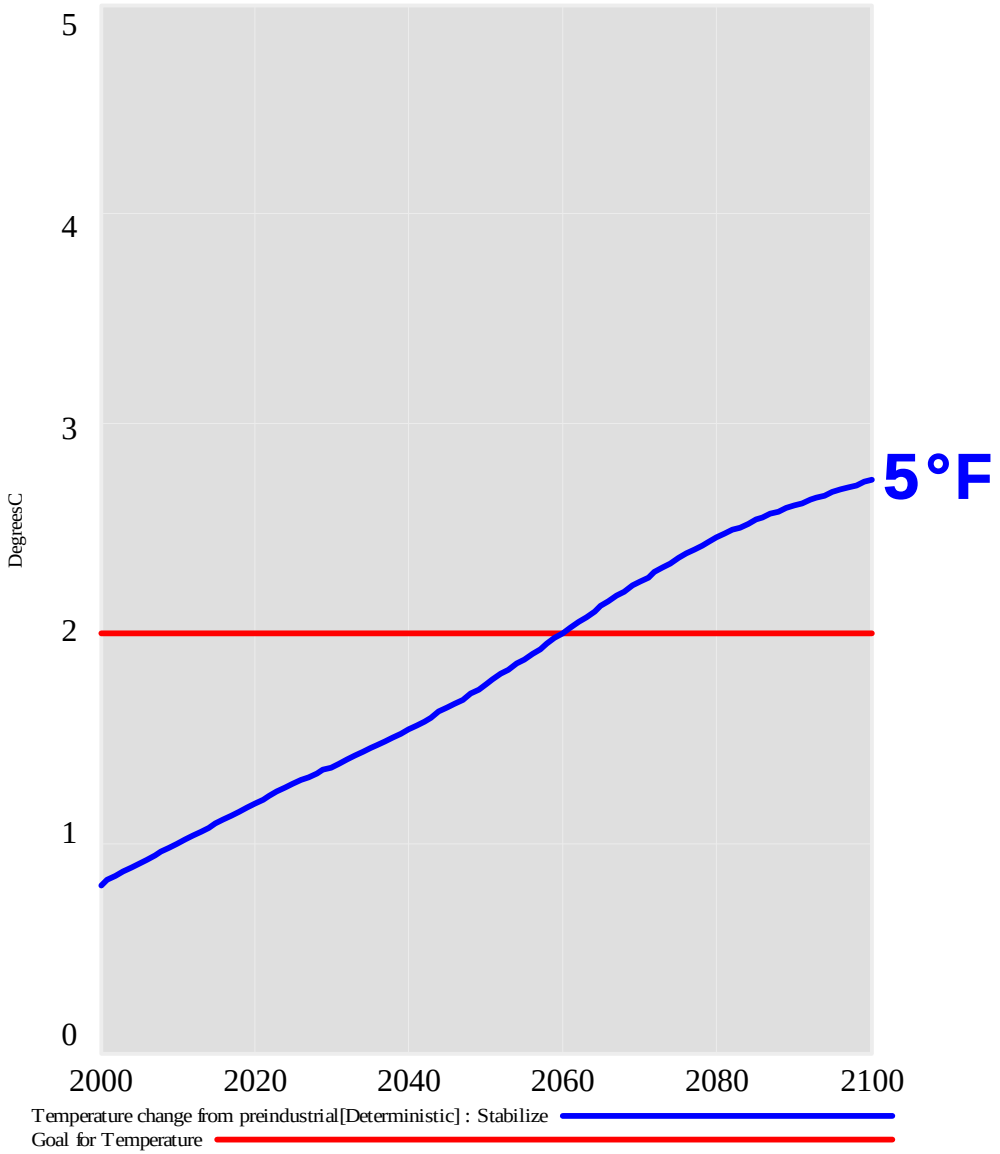
Temperature



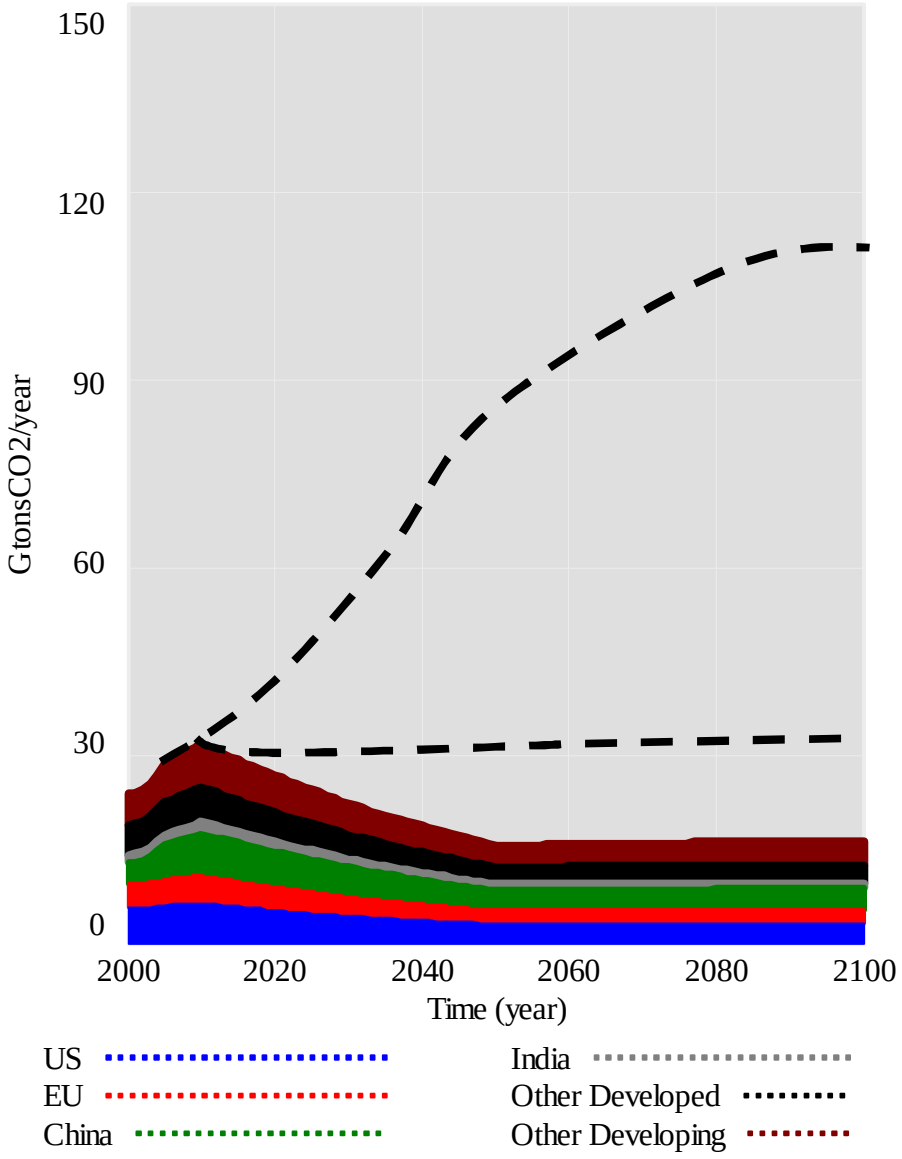
Emissions & Removals



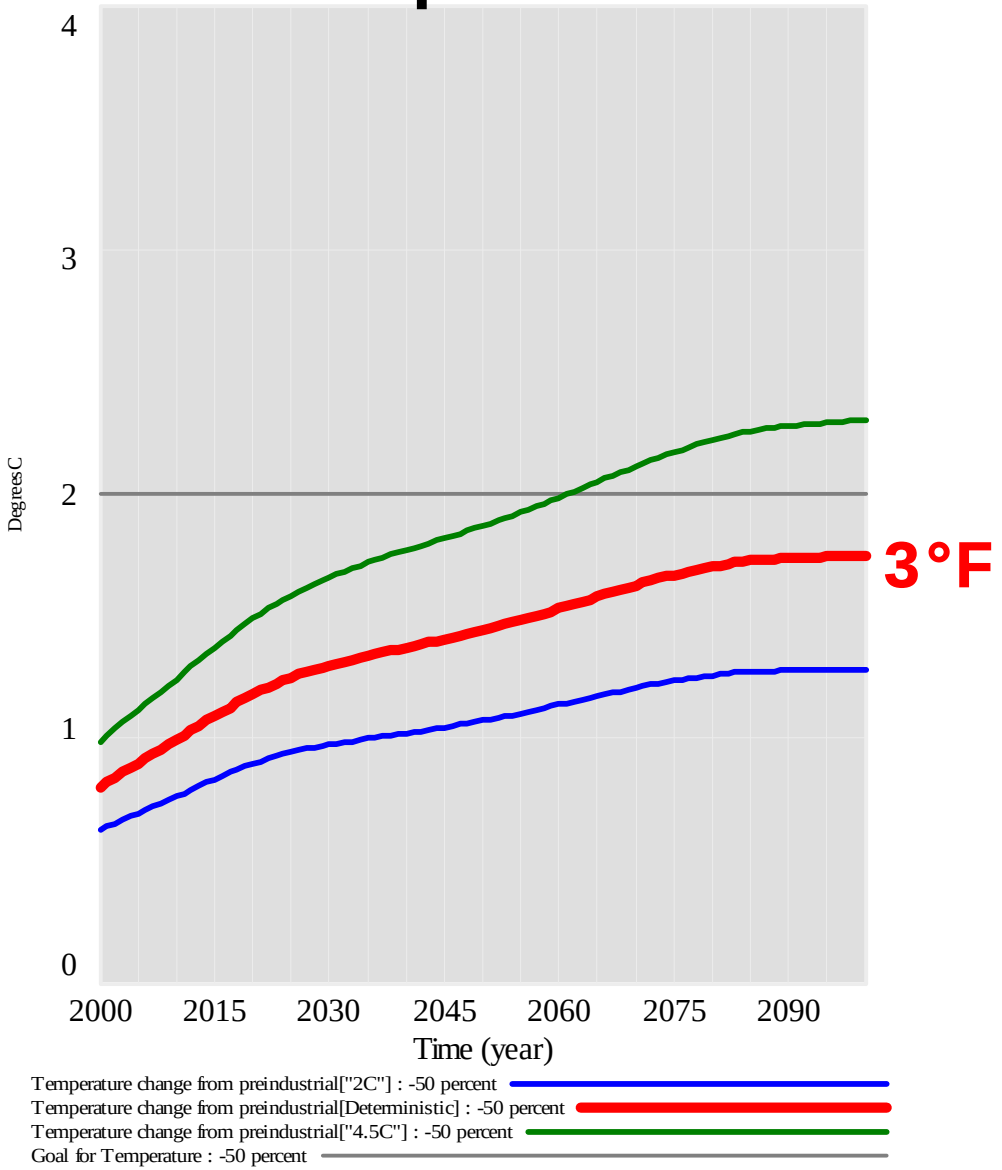
Temperature



Emissions – Cut 50 %



Temperature

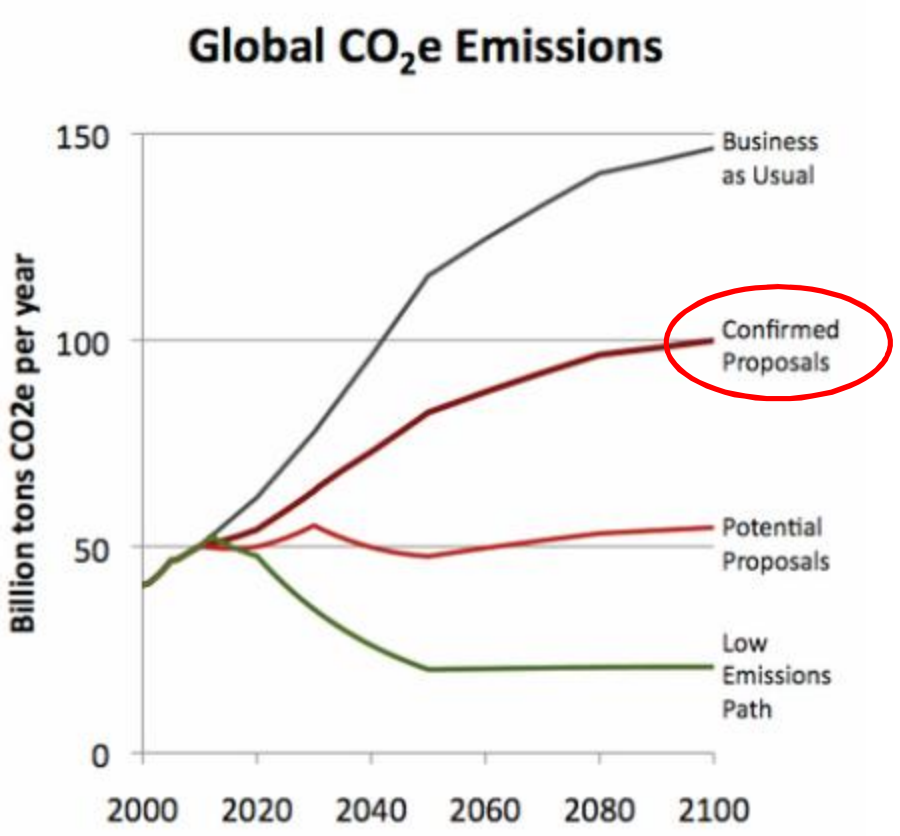


The world wasn't ready

- **Negotiators didn't have the mandate to achieve a meaningful agreement**

Result: as of recently,

+7 degrees F in 2100



VENTANA CLIMATE INTERACTIVE

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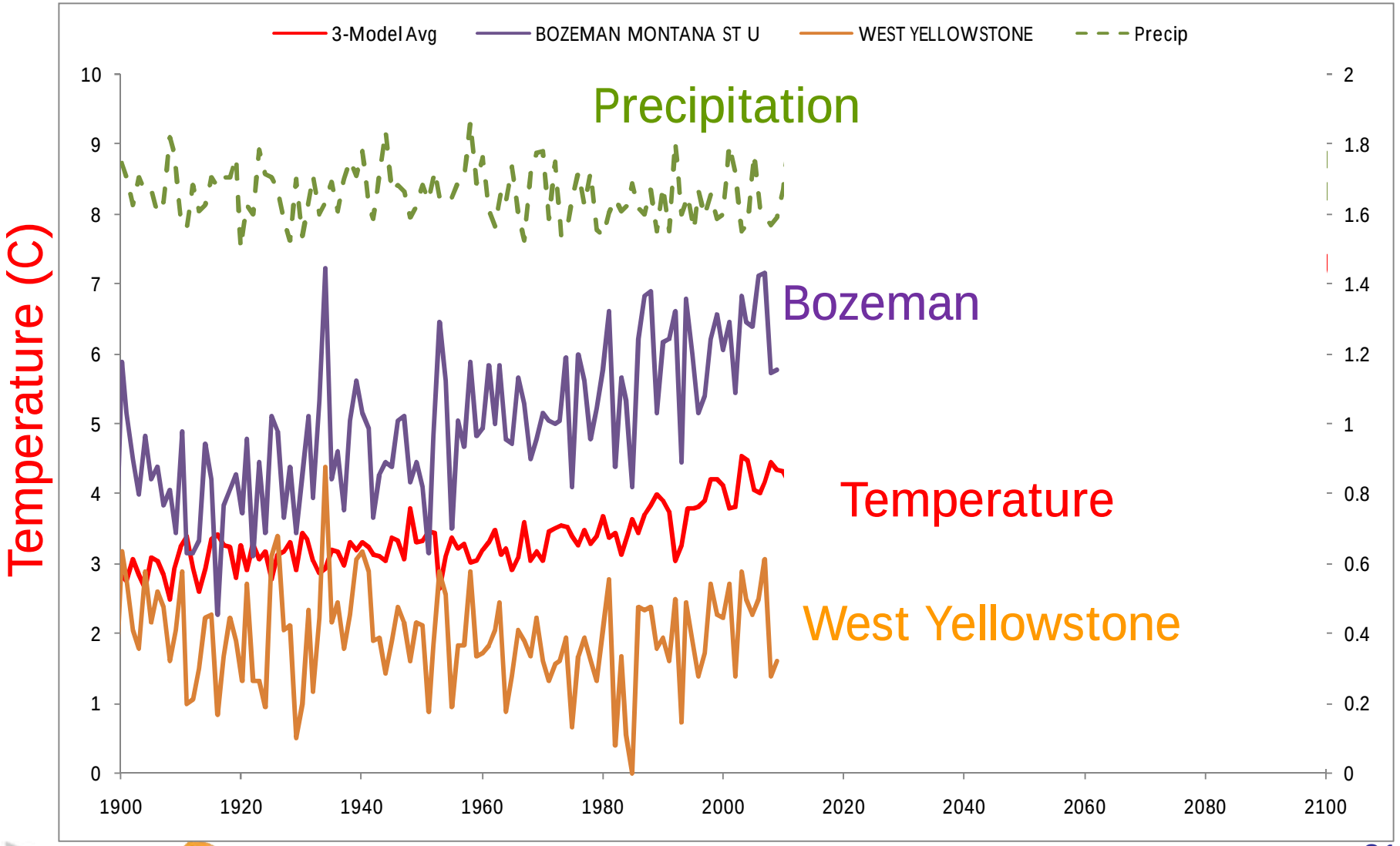
F6
F7

Model Futures for Montana

Average of GISS ER, CCSM, ECHAM5 ensembles from climexp.knmi.nl, lat 45.7 lon -110.9



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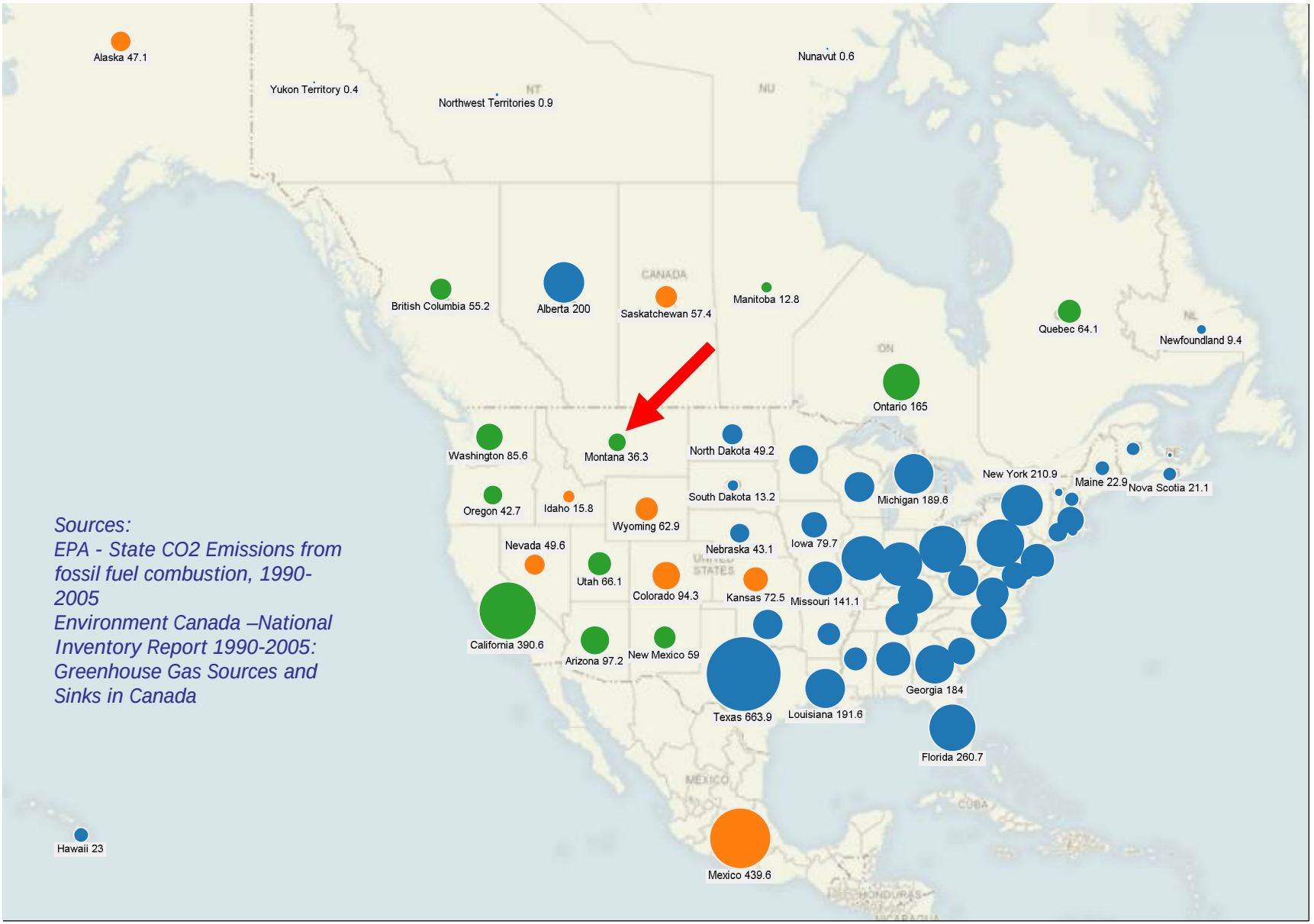
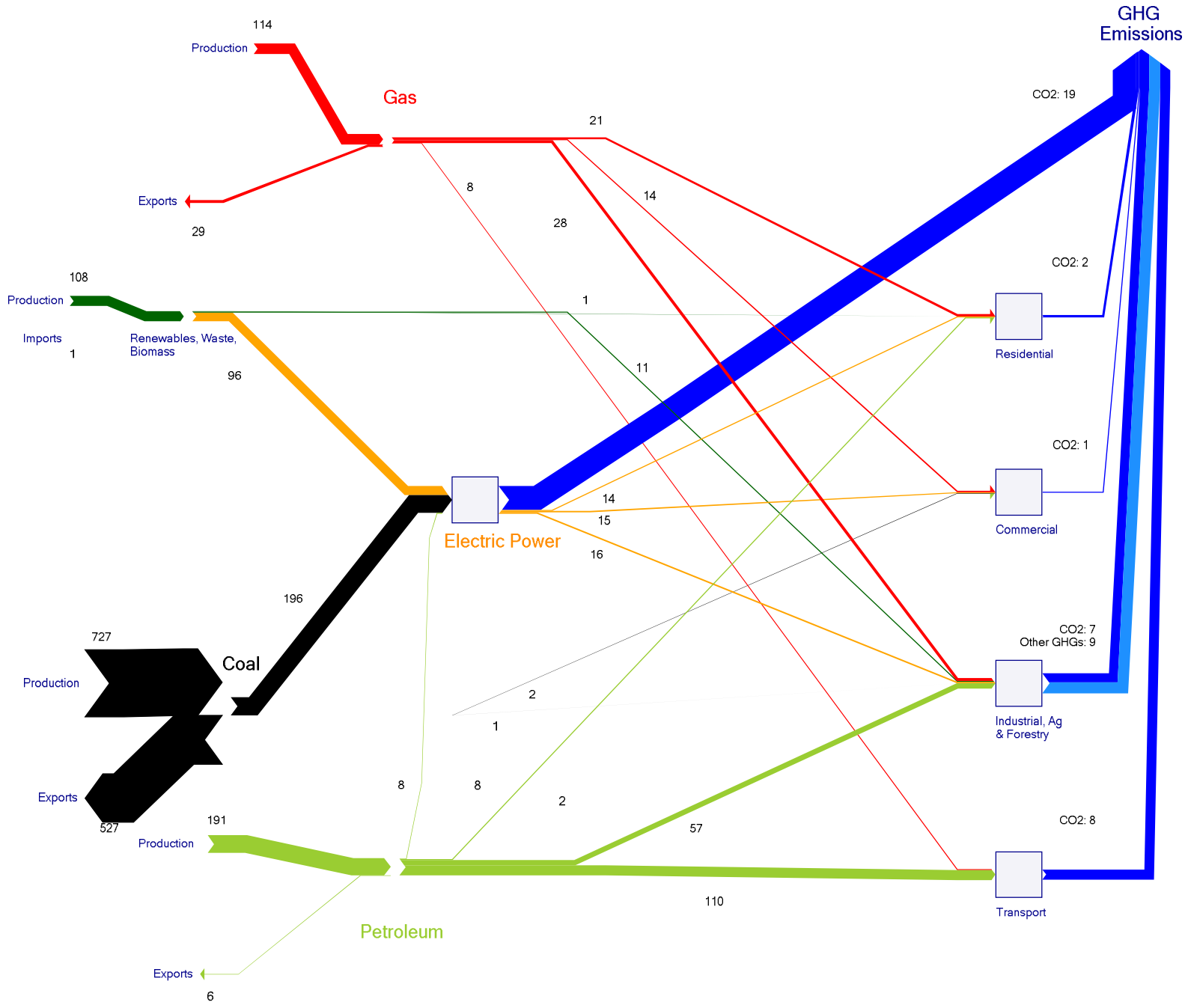
Slide 31

F6 how do we know it's not uhi
Fid, 5/20/2010

F7 fahrenheit
Fid, 5/20/2010

Energy Emissions – WCI Partners, Observers & Others





Montana Energy & GHG Flows ca. 2005

Legend

- Biomass/Renewables/Waste [Trillion BTU]
- Electricity [Trillion BTU]
- Coal [Trillion BTU]
- Gas [Trillion BTU]
- Petroleum [Trillion BTU]
- CO2 [Million Ton CO2eq]
- Other GHGs [Million Ton CO2eq]

Sources:

Energy Flows:
US - EIA State Energy Data System, 2005
Canada - Statistics Canada, Report on Energy Supply-demand in Canada, 2005

Energy CO2 emissions:
US - EIA SEDS + emissions factors
Canada - Environment Canada, National Inventory Report, 1990-2005, GHG Sources and Sinks in Canada

Non-Energy CO2 & Non-CO2 emissions:
US - Various state GHG inventories, ca. 1990-2005
Canada - Environment Canada, National Inventory Report, 1990-2005, GHG Sources and Sinks in Canada

Notes:

Emissions and energy flows may not match regional GHG inventories due to differences in aggregation and omitted factors, required to place regions on a common basis.

Sector inflows and outflows may not sum to zero due to statistical differences and changes in stocks.

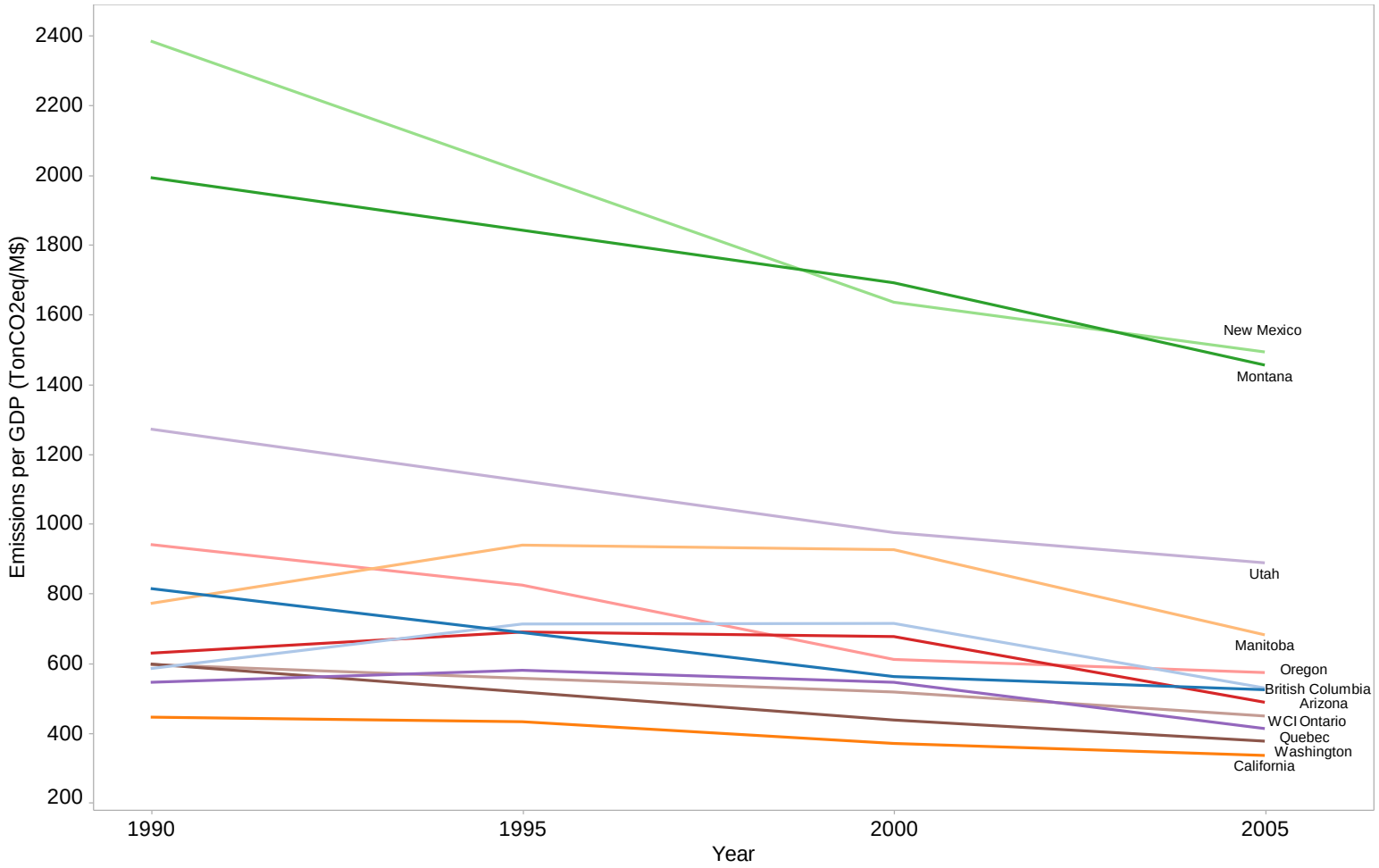
Completeness of data varies by region; generally non-CO2 and non-energy emissions, energy imports and exports, non-energy use, and flows of small magnitude will be understated.

Not shown: statistical differences, changes in stocks, producer consumption, and non-market fuels, land use change and sink uptake, international transport and marine bunker fuels.

Process emissions from oil and gas production and refining, coal mining, etc. appear in the industrial category.

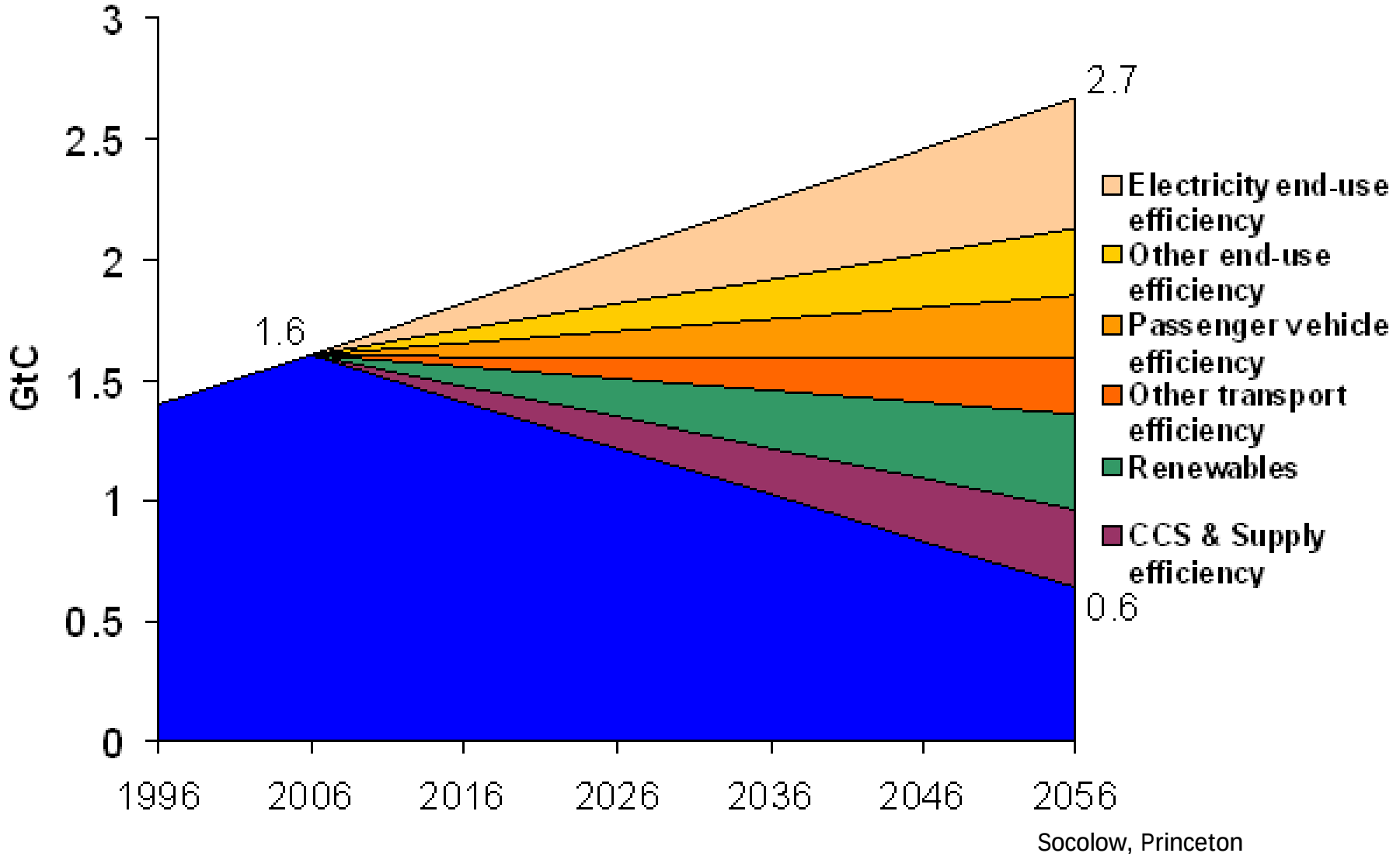
Compiled by Tom Fiddaman, Ventana Systems, for the WSPA-sponsored WCI Collaborative, March 2009

Emissions per GDP



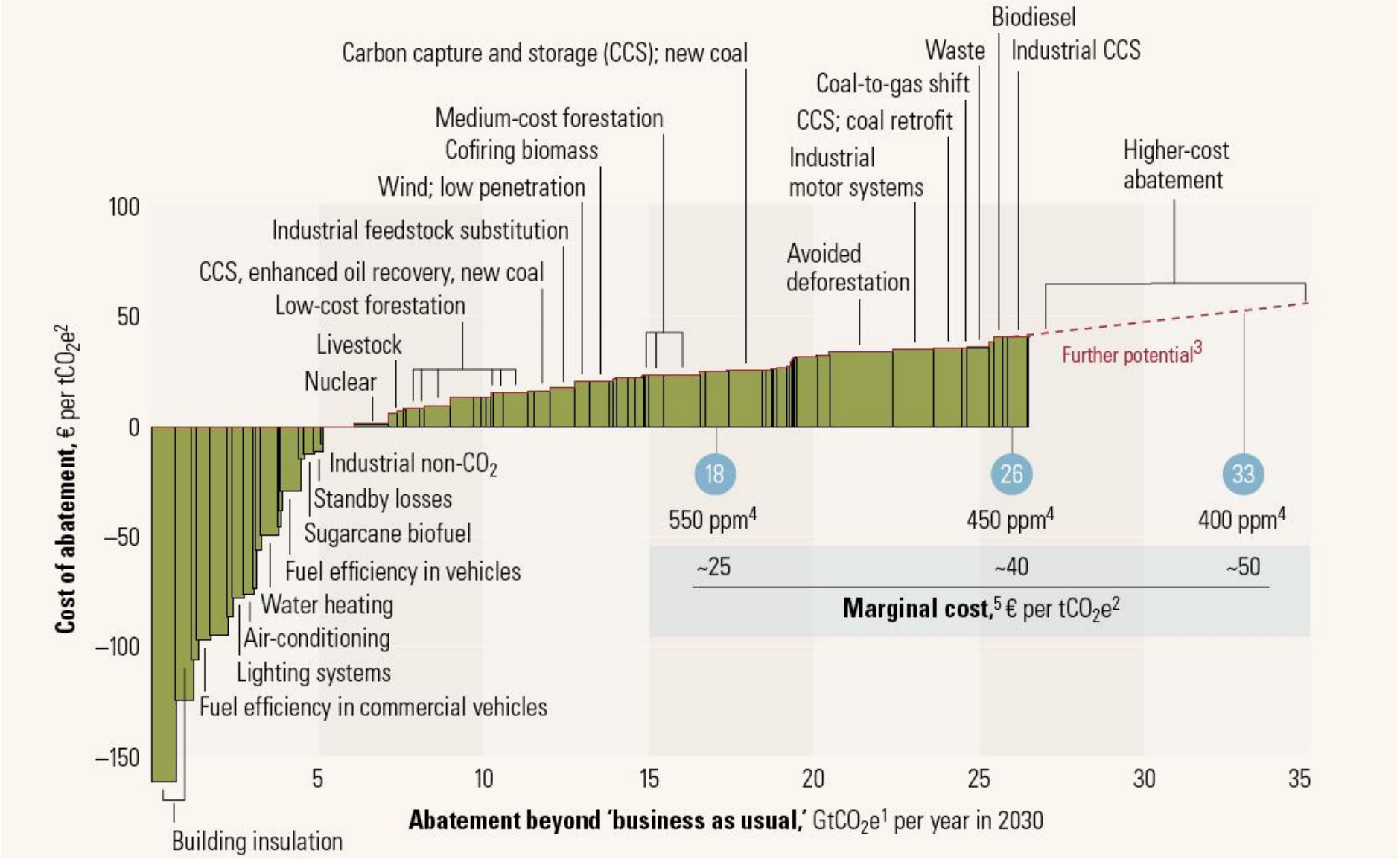
Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada –National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada
US GDP – EIA SEDS; Canada GDP – Statistics Canada, converted to $US at market exchange rates

Current Technologies Can Reduce Emissions



Socolow, Princeton

McKinsey: Initial Emissions Reductions Save Money



http://www.mckinsey.com/clientservice/ccsi/pdf/Cost_Curve_for_Greenhouse_Gas_Reduction.pdf

Triggering the Good Tipping Points

- **Regional Government**
  - Imitation of successful policies
  - Complementary infrastructure
- **Corporate**
  - economies of scale, learning curves
  - networks, thought leadership
- **Personal**
  - Habits
  - Word of mouth, knowledge diffusion
  - Vision – what seems possible

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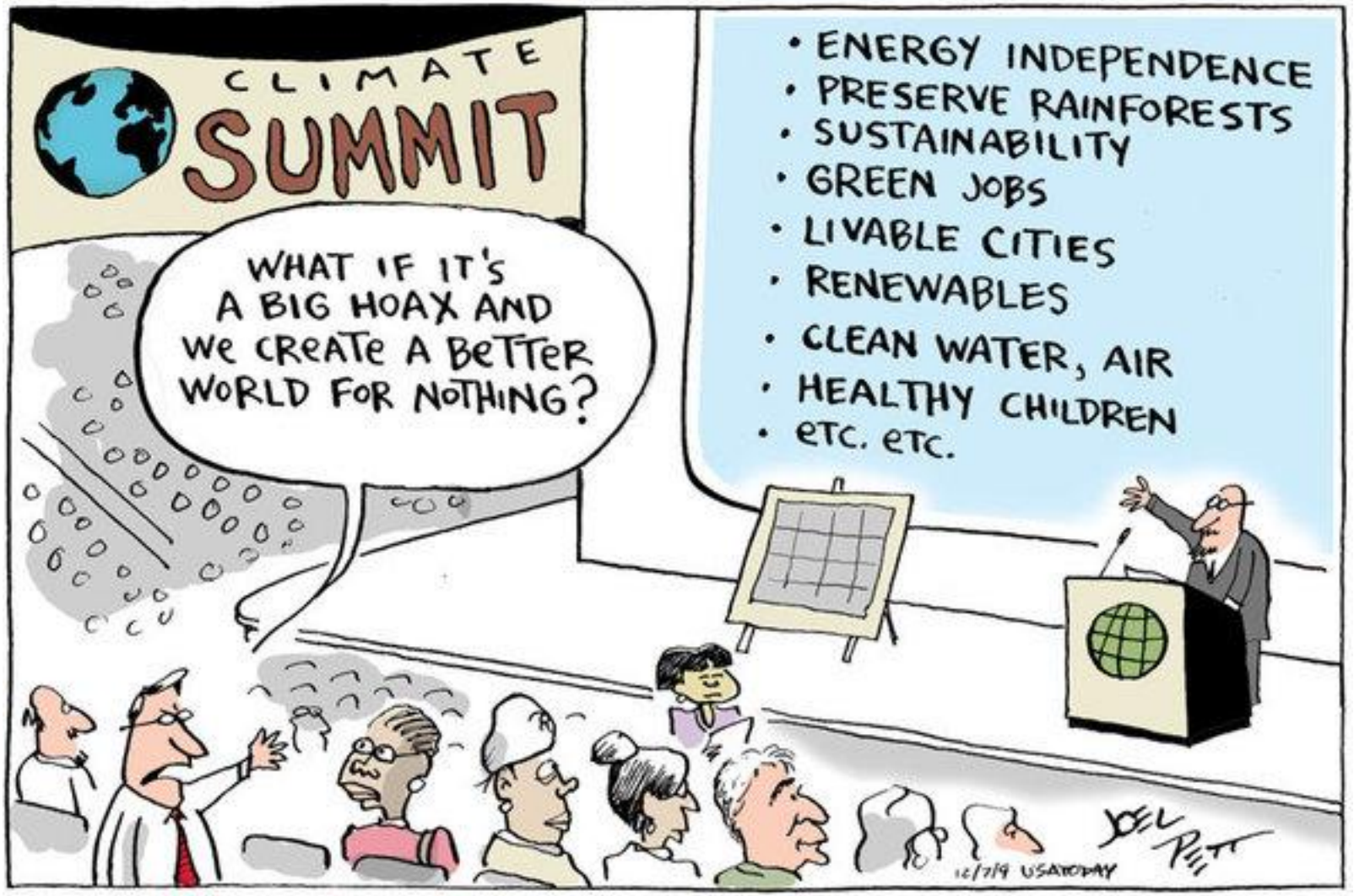
Many policies are “no regrets”



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http://blog.metasd.com

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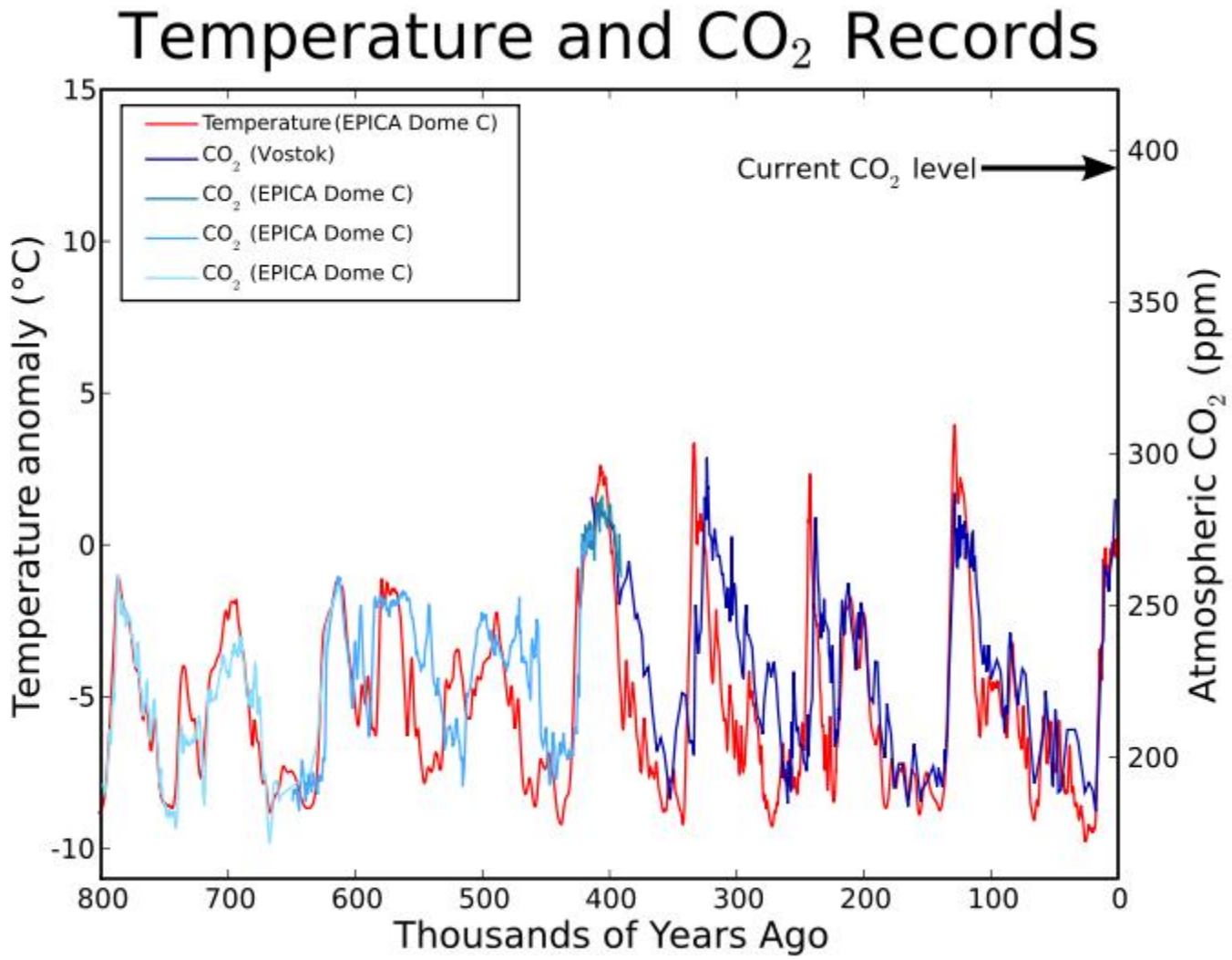
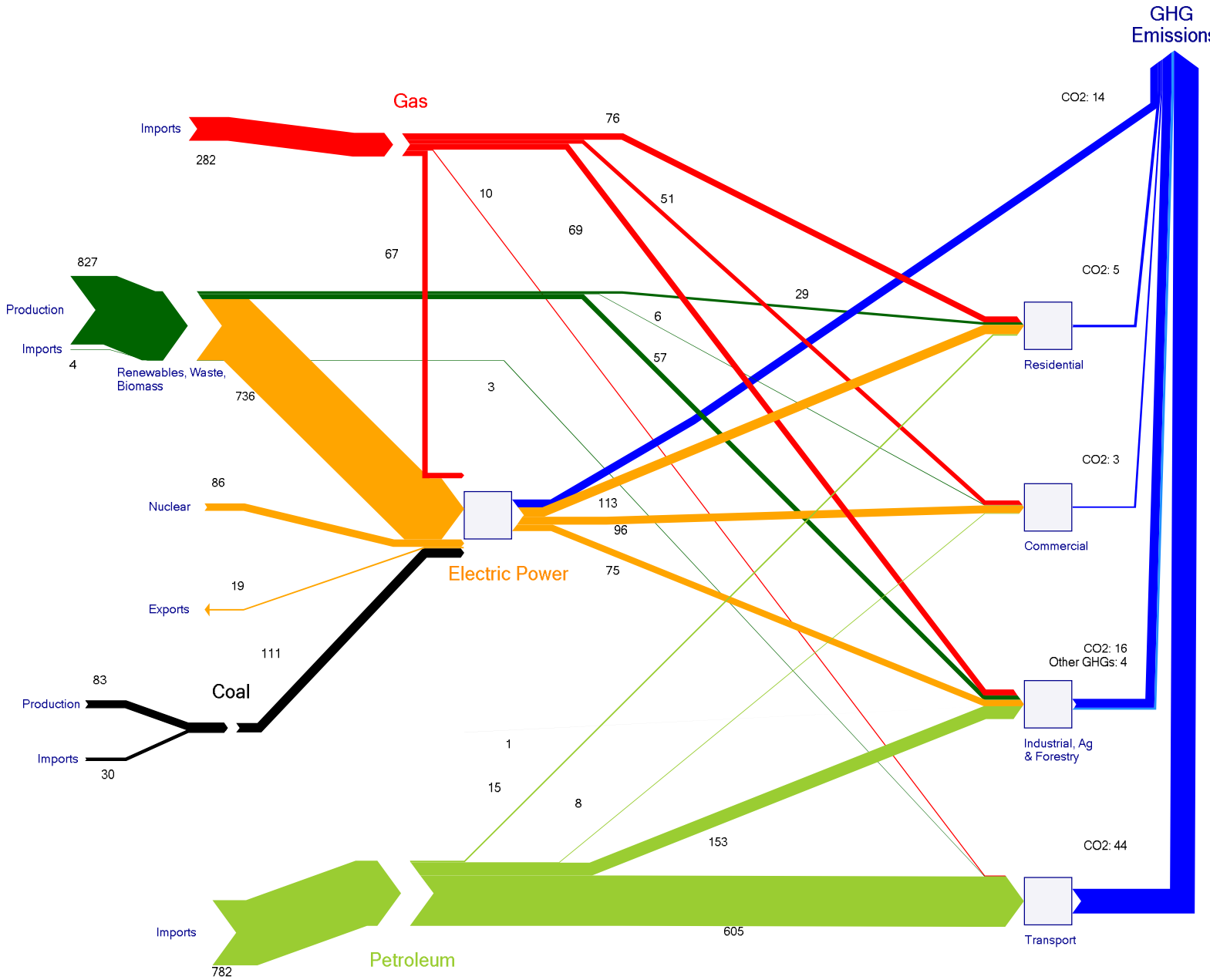


Data Sources
(red) EPICA Dome C temperature data: http://doi.pangaea.de/10.1594/PANGAEA.683655
(dark blue) Vostok CO2 data: http://doi.pangaea.de/10.1594/PANGAEA.55501
(steel blue) EPICA DomeC temperature data, 423-391 kybp: http://doi.pangaea.de/10.1594/PANGAEA.472482
(pale blue) EPICA DomeC CO2 data, 650-413 kybp: http://doi.pangaea.de/10.1594/PANGAEA.472481
(cyan) EPICA DomeC CO2 data, 800-650 kybp: http://doi.pangaea.de/10.1594/PANGAEA.710901
This figure was produced by Leland McInnes using python and matplotlib and is licensed under the GFDL. All data is from publicly available sources.



Washington Energy & GHG Flows ca. 2005

Legend

- Biomass/Renewables/Waste [Trillion BTU]
- Electricity [Trillion BTU]
- Coal [Trillion BTU]
- Gas [Trillion BTU]
- Petroleum [Trillion BTU]
- CO2 [Million Ton CO2eq]
- Other GHGs [Million Ton CO2eq]

Sources:

Energy Flows:
US - EIA State Energy Data System, 2005
Canada - Statistics Canada, Report on Energy Supply-demand in Canada, 2005

Energy CO2 emissions:
US - EIA SEDS + emissions factors
Canada - Environment Canada, National Inventory Report, 1990-2005, GHG Sources and Sinks in Canada

Non-Energy CO2 & Non-CO2 emissions:
US - Various state GHG inventories, ca. 1990-2005
Canada - Environment Canada, National Inventory Report, 1990-2005, GHG Sources and Sinks in Canada

Notes:

Emissions and energy flows may not match regional GHG inventories due to differences in aggregation and omitted factors, required to place regions on a common basis.

Sector inflows and outflows may not sum to zero due to statistical differences and changes in stocks.

Completeness of data varies by region; generally non-CO2 and non-energy emissions, energy imports and exports, non-energy use, and flows of small magnitude will be understated.

Not shown: statistical differences, changes in stocks, producer consumption, and non-market fuels, land use change and sink uptake, international transport and marine bunker fuels.

Process emissions from oil and gas production and refining, coal mining, etc. appear in the industrial category.

Compiled by Tom Fiddaman, Ventana Systems, for the WSPA-sponsored WCI Collaborative, March 2009

VENTANA CLIMATE INTERACTIVE

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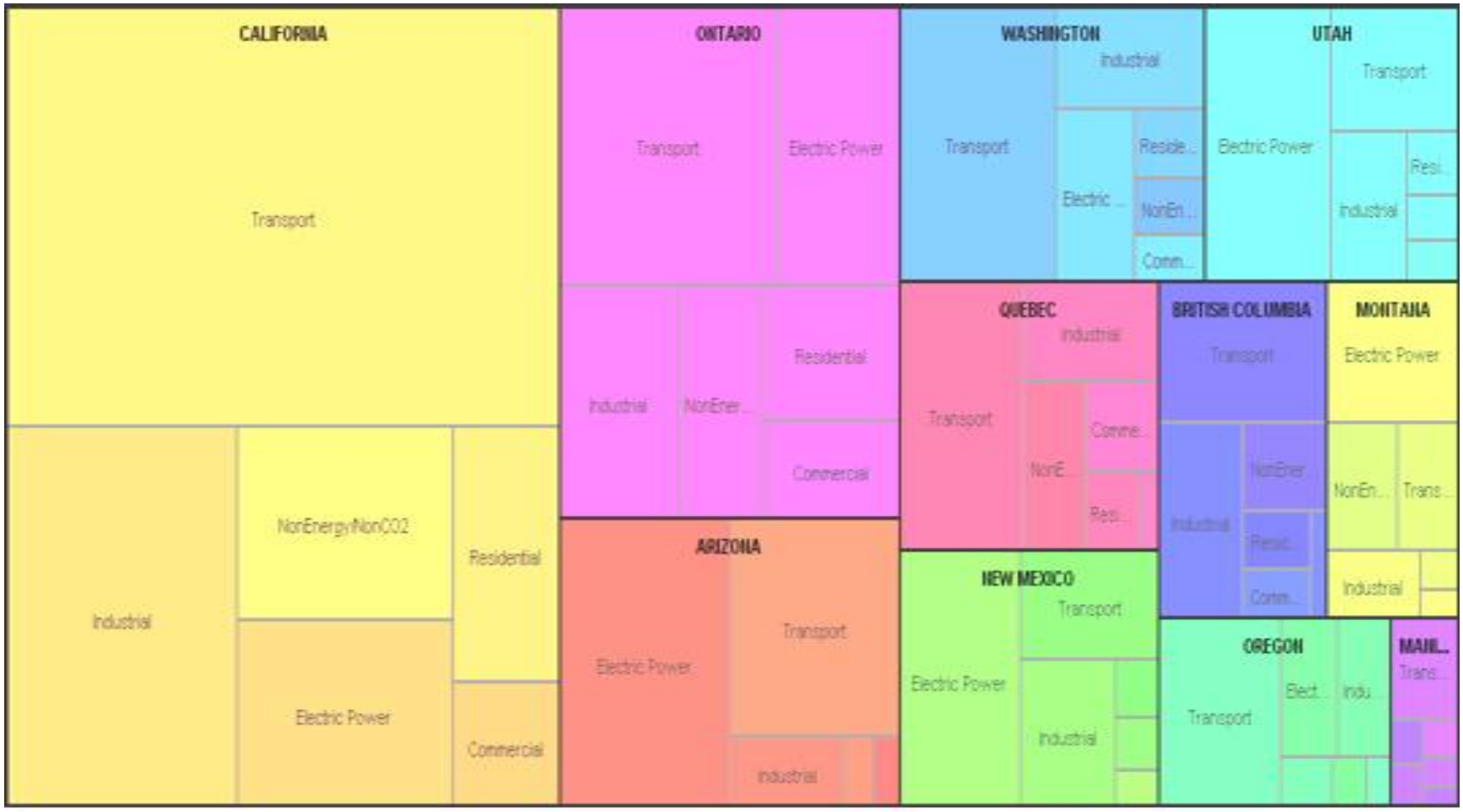
WCI Partner Emissions, 2005



Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada –National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada

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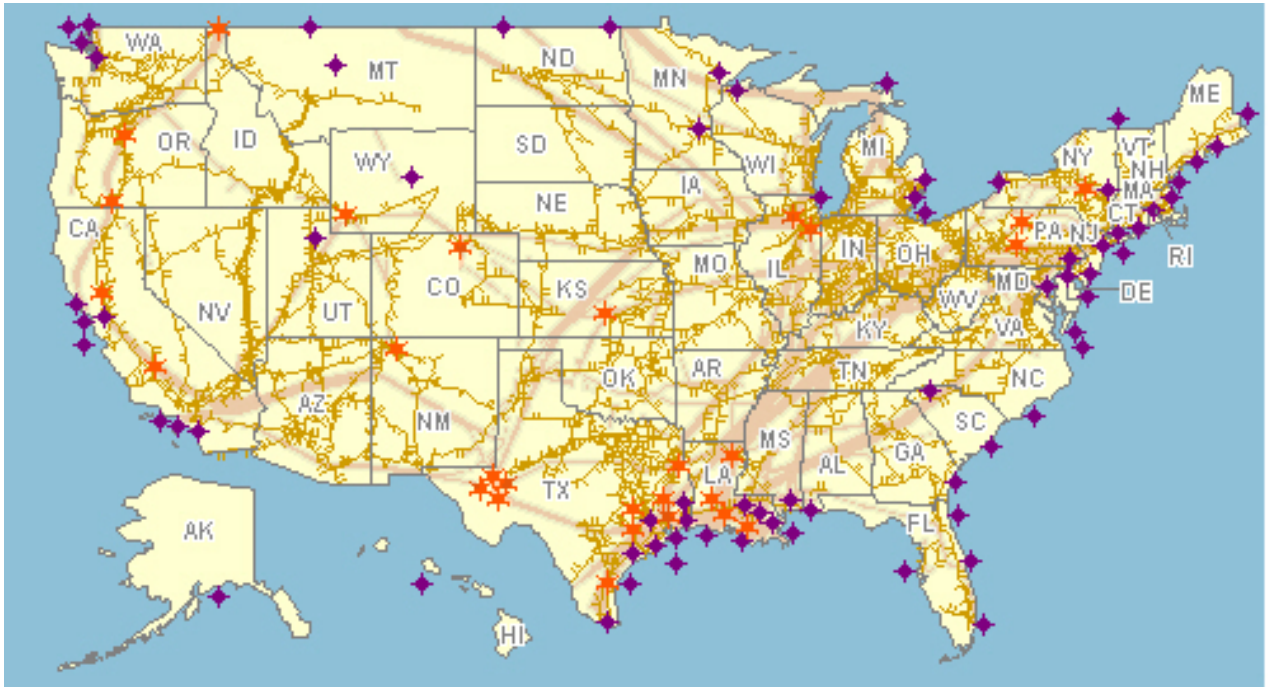
US Energy Infrastructure



Energy Distribution

- Electricity Transmission Line (min. 345 kV)
- Oil Seaport & Import Sites (min. 10,000 barrels/day) U.S. Total = 72
- Natural Gas Flow (above 100 million cu ft/day; 1 mile band width = 100 million cu ft/day)
- Natural Gas Hub U.S. Total = 28

Source:
EIA State Energy Profiles, 2009; http://tonto.eia.doe.gov/state/

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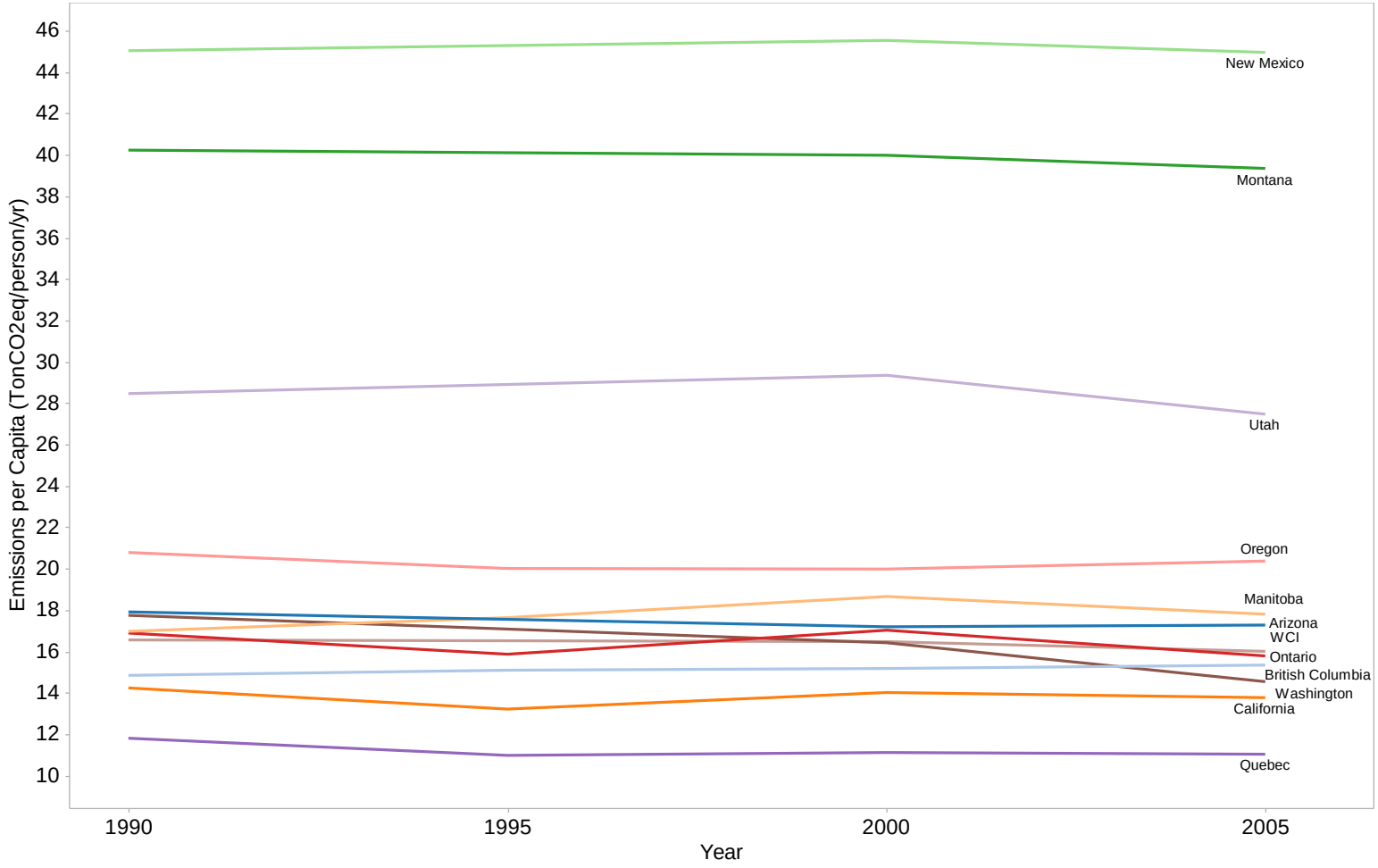
Emissions per Capita



Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada –National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada
US population – EIA SEDS; Canada population – Statistics Canada

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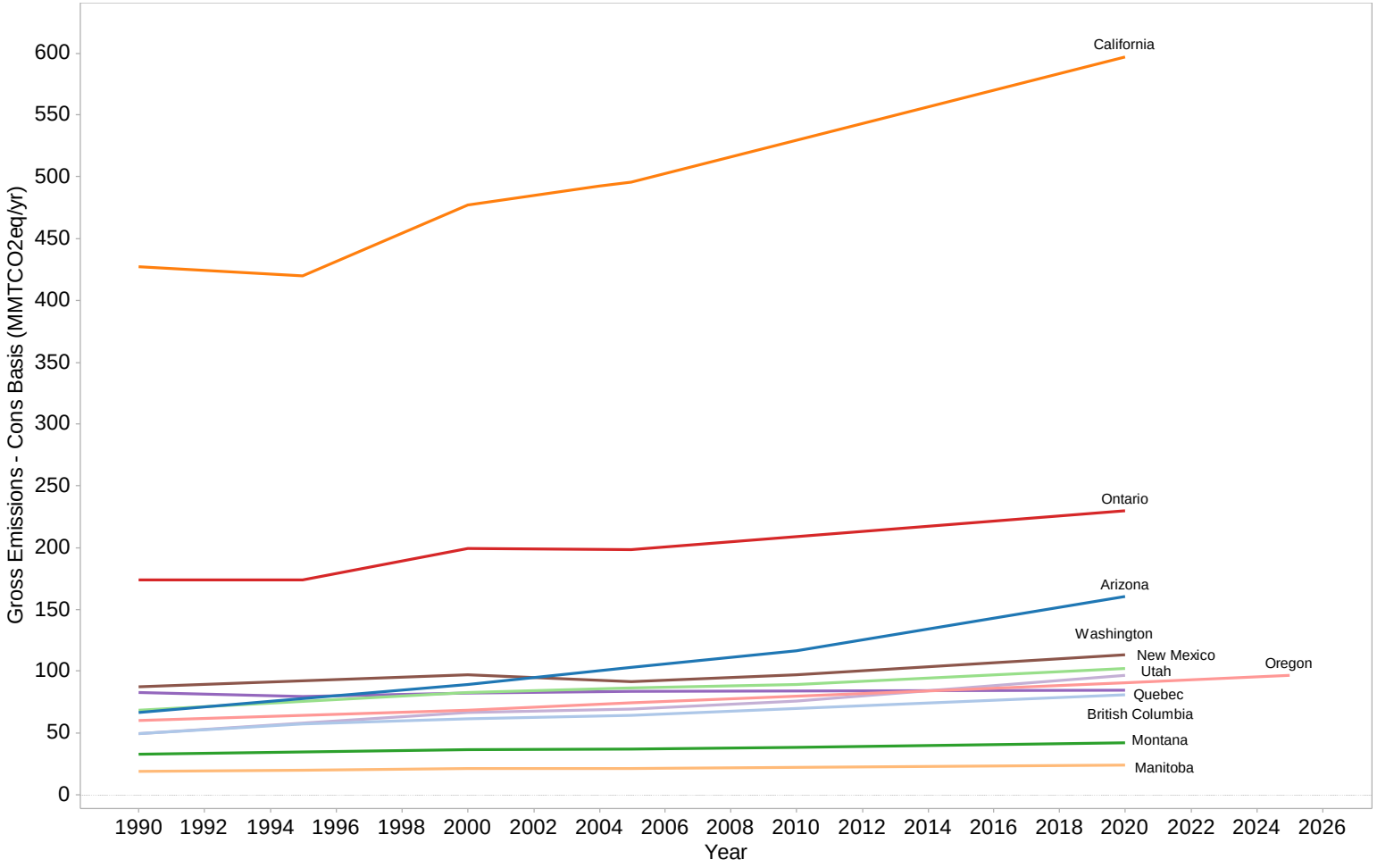
Gross Emissions – Consumption Basis



Sources:
EPA - State CO2 Emissions from fossil fuel combustion, 1990-2005
Environment Canada –National Inventory Report 1990-2005: Greenhouse Gas Sources and Sinks in Canada

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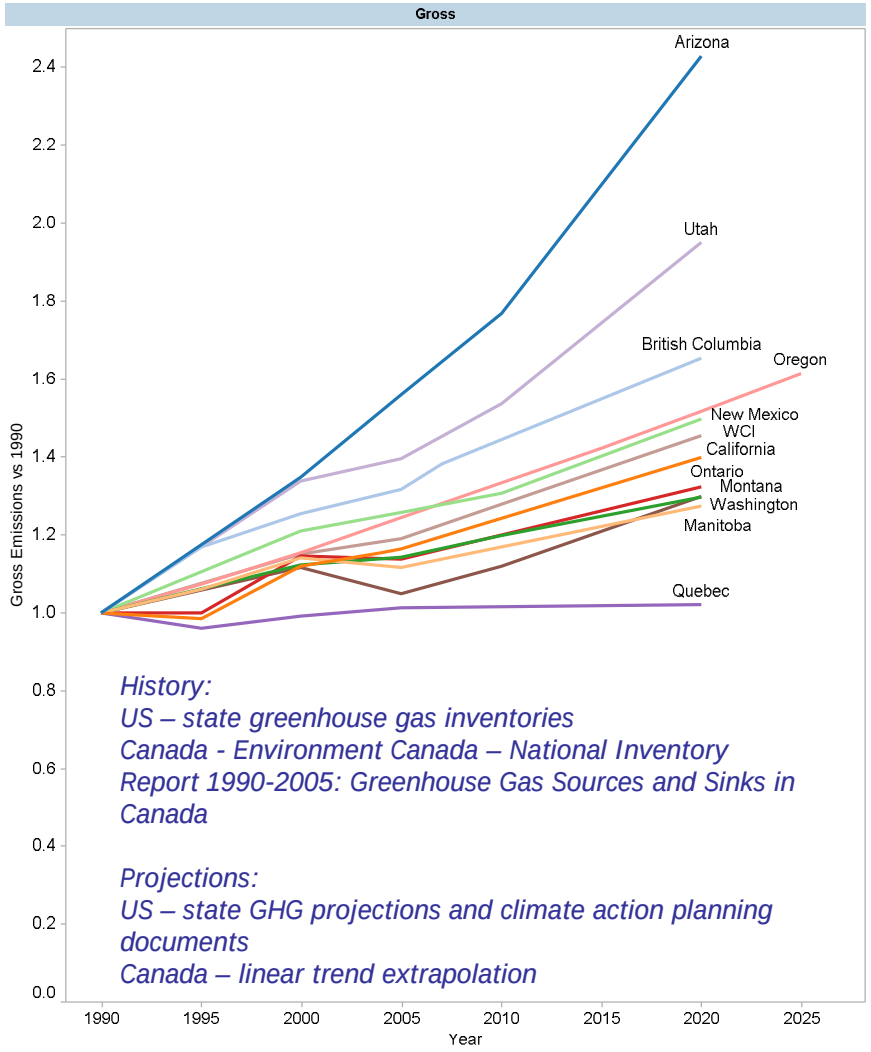
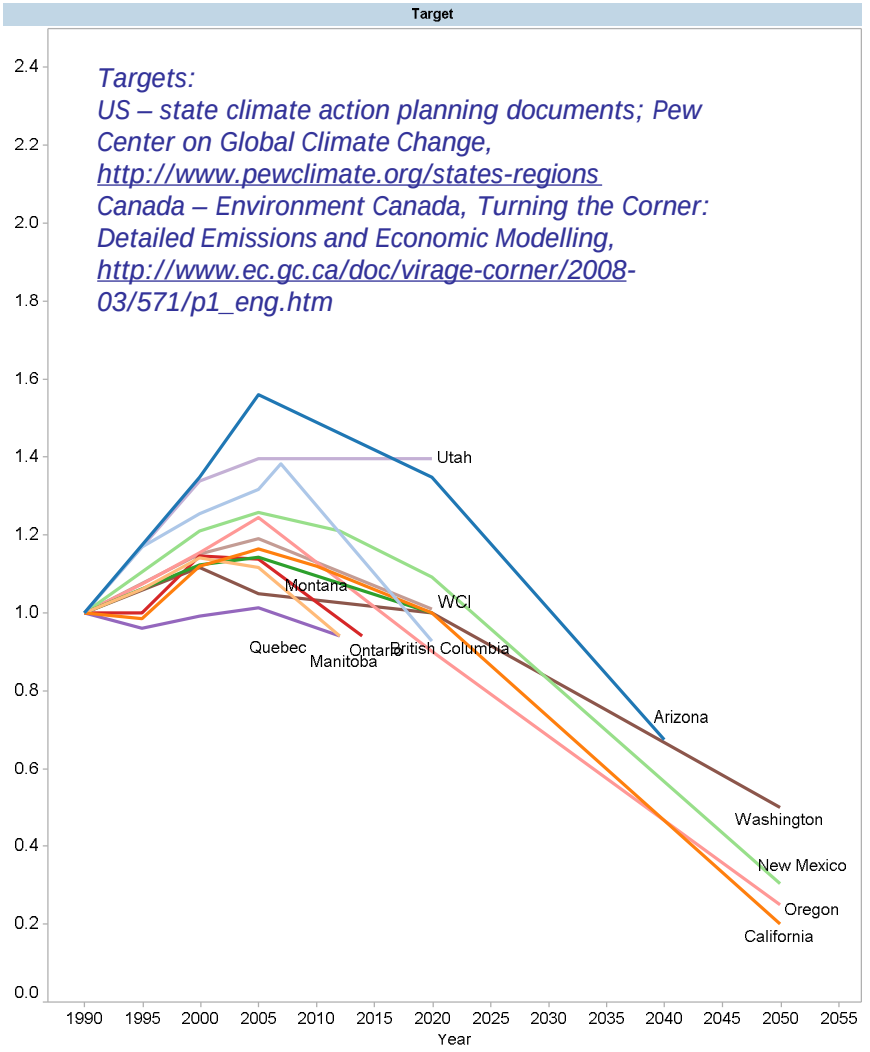
Partner Emissions & Targets vs. 1990





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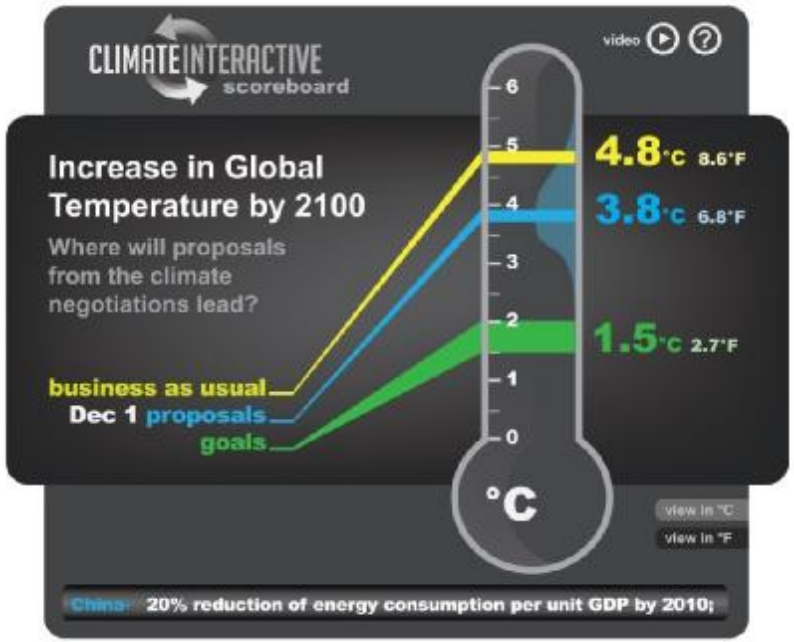
C-ROADS at COP-15

- **President briefed by Science Advisor**
- **Scoreboard went viral**
- **Real-time analysis picked up by media, negotiators**
- **US State Dept used as common platform, picked up by other delegations**



"This capability, had it been available to me when we negotiated Kyoto, would have yielded a different outcome."

Tim Wirth, President, UN Foundation, former Senator

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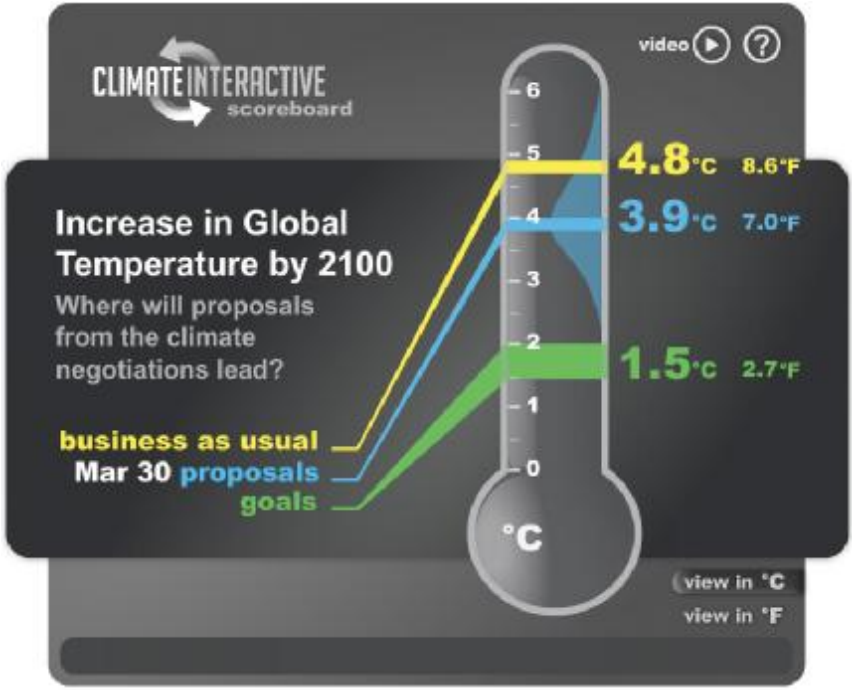


The Climate Scoreboard

Dr. Elizabeth Sawin

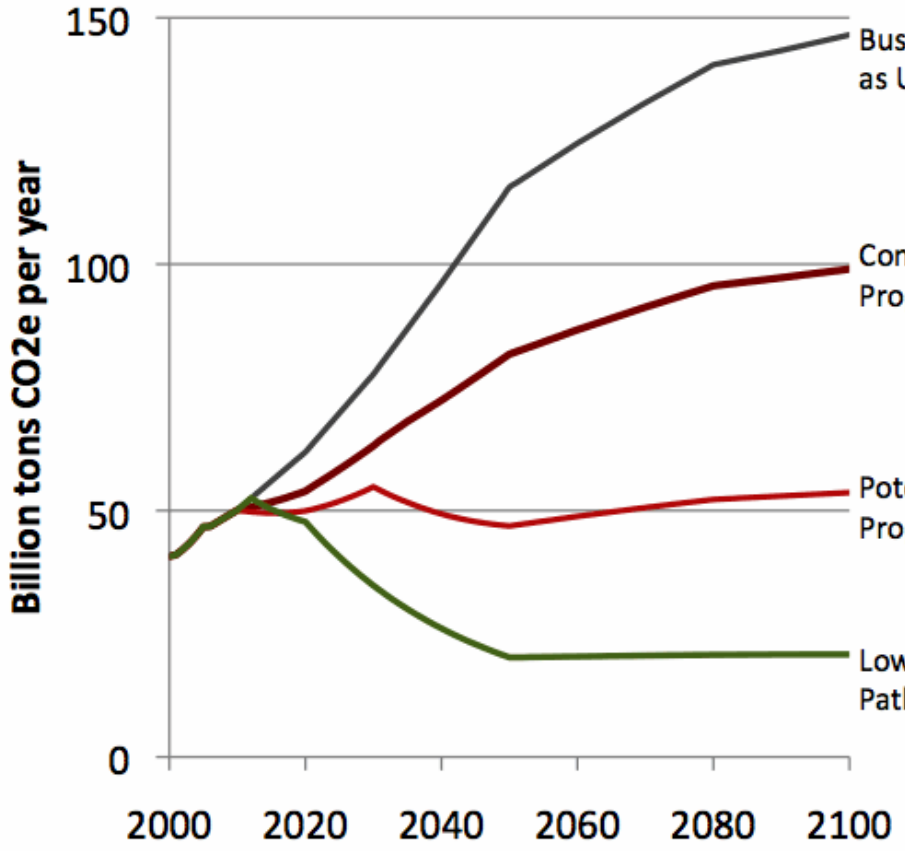
Andrew Jones

Stephanie McCauley

1 April 2010

www.climatescoreboard.org

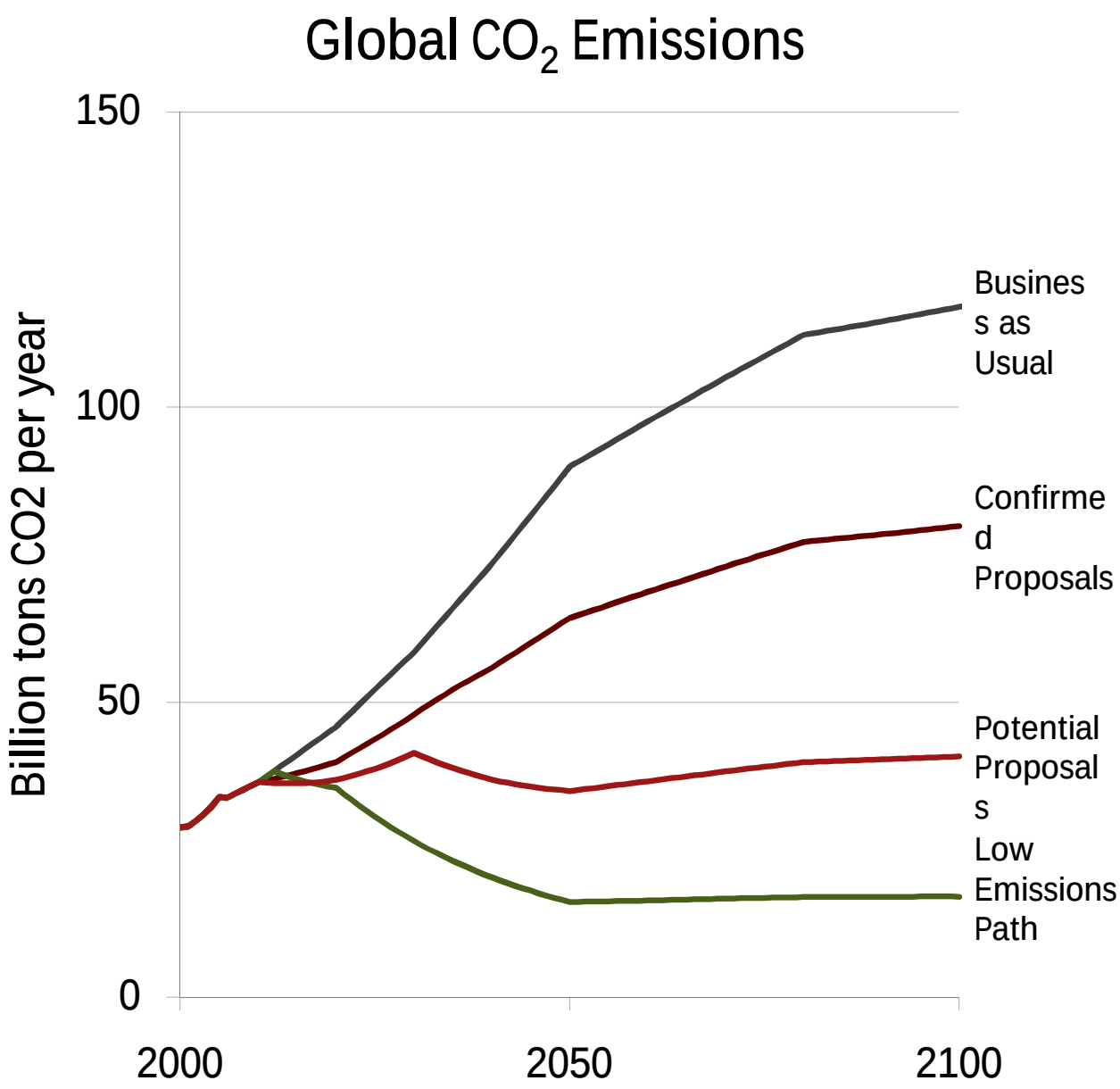
Recent Results



2100 Values

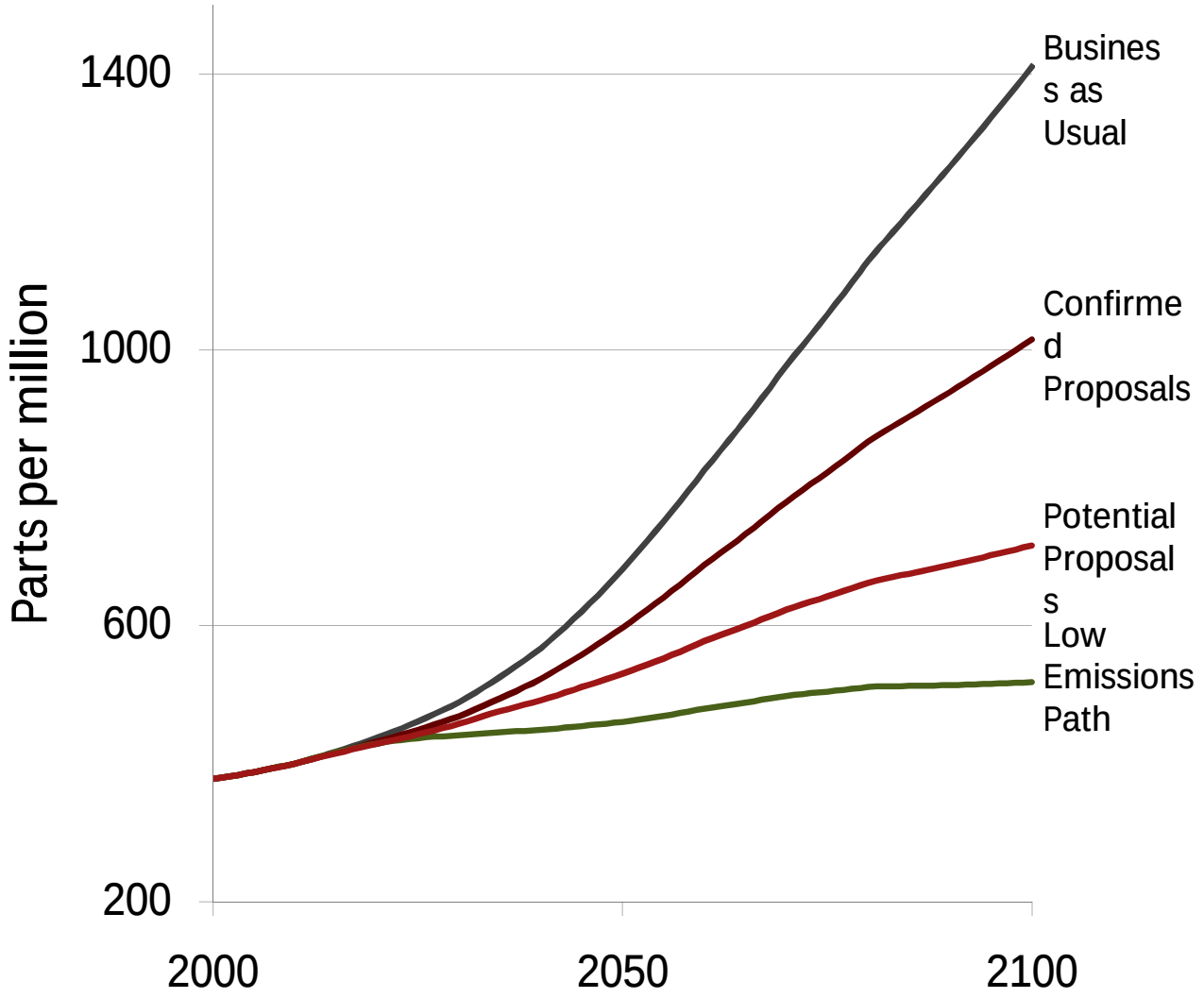
	Atmospheric CO_2	Atmospheric CO_2e	Temp. Increase Over Preindustrial (90% C.I.)
Business as Usual	965 ppm	1410 ppm	4.8°C (2.9°-7.7°) 8.7°F (5.2°-13.9°)
Confirmed Proposals	770 ppm	1015 ppm	3.9°C (2.3°-6.2°) 7°F (4.2°-11.1°)
Potential Proposals	585 ppm	715 ppm	2.9°C (1.7°-4.6°) 5.2°F (3.1°-8.3°)
Low Emissions Path	470 ppm	520 ppm	2°C (1.2°-3.1°) 3.5°F (2.1°-5.7°)

Climate Scoreboard ©Sustainability Institute April 1, 2010 www.ClimateScoreboard.org



01-Apr-10 Climate Scoreboard ©Sustainability Institute www.ClimateScoreboard.org

CO_2e in the Atmosphere



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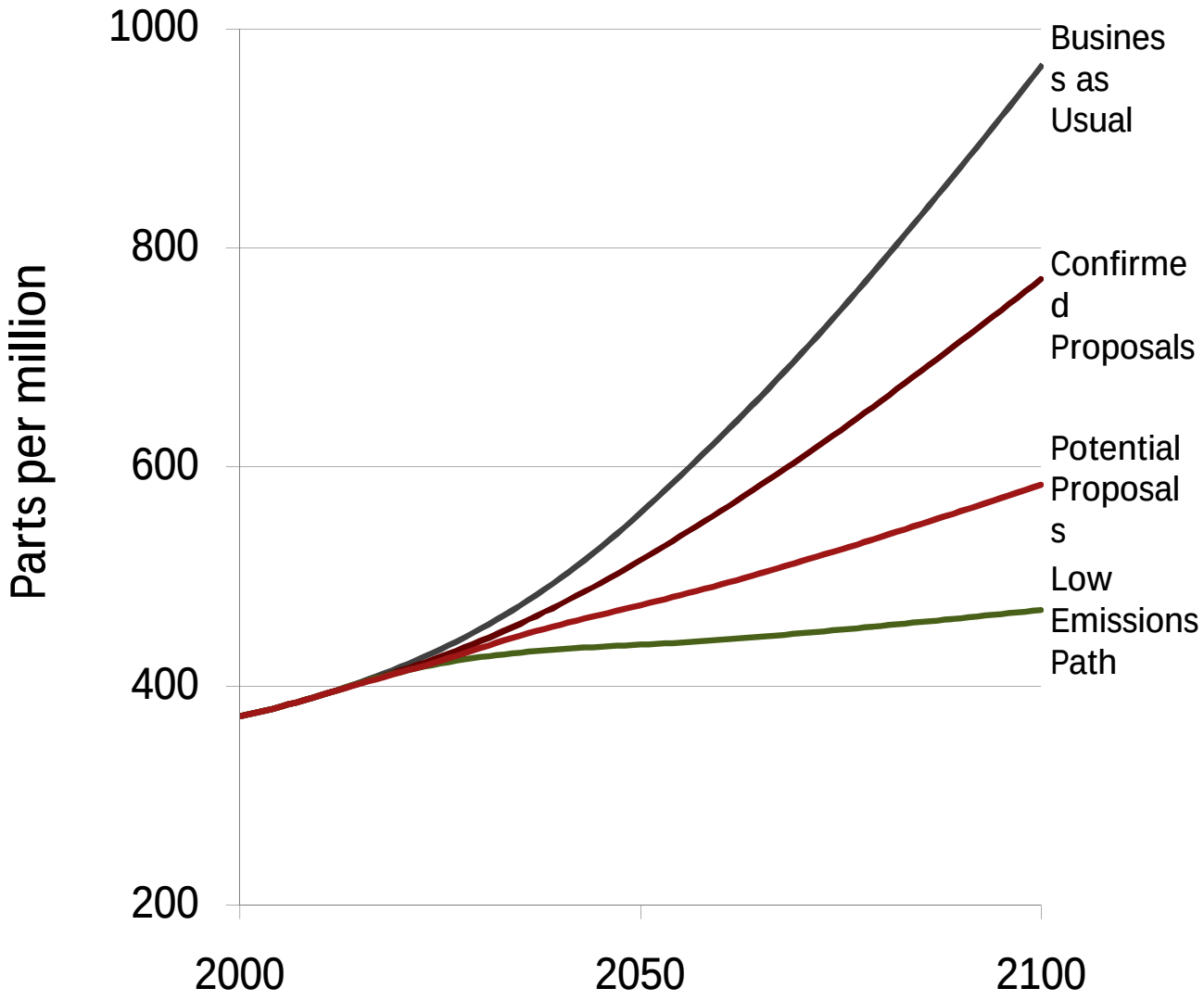
CO_2 in the Atmosphere



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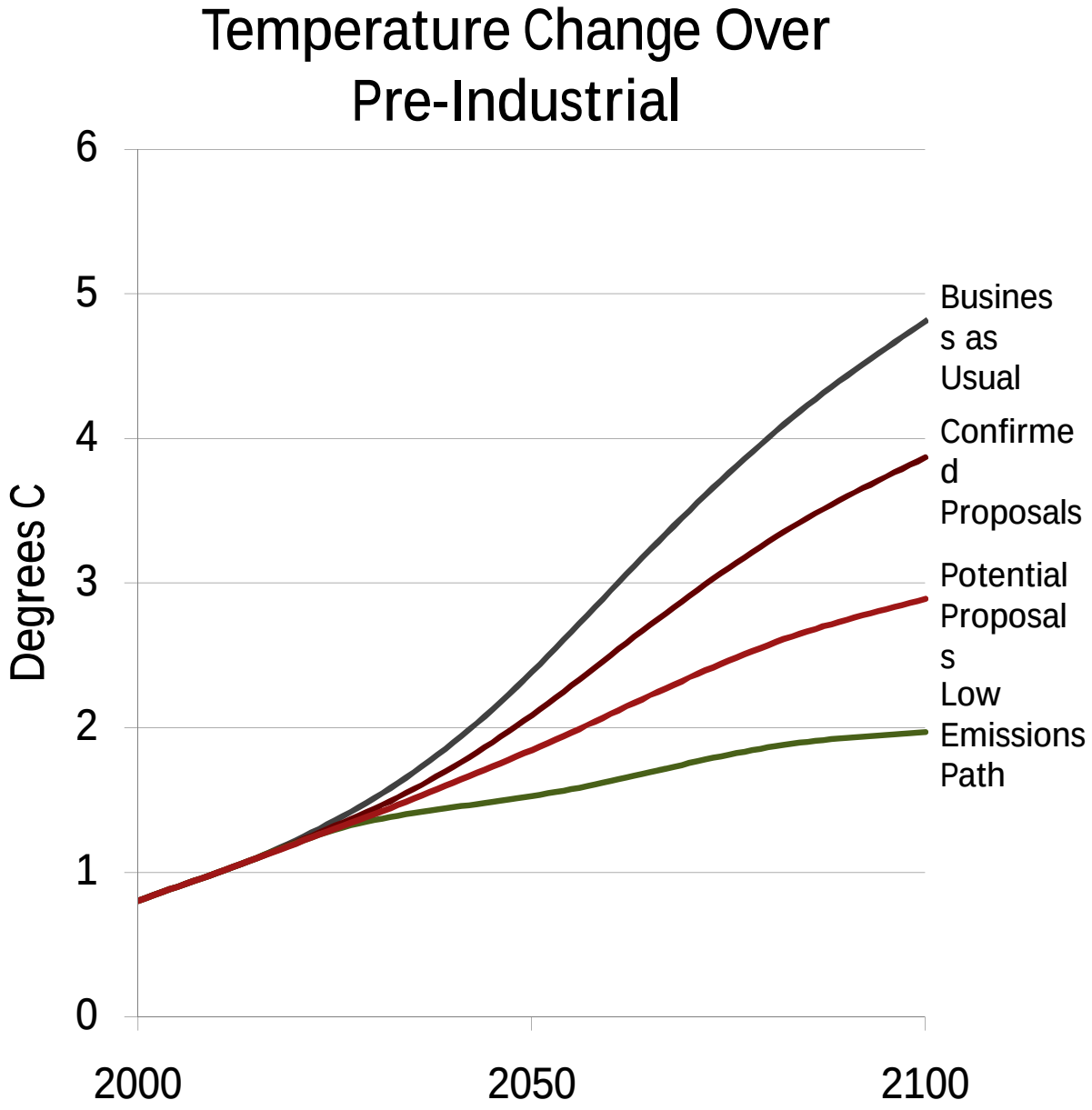

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For latest results or questions

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