GLOBAL WARMING AND ITS IMPACTS WITH EMPHASIS ON THE CARIBBEAN

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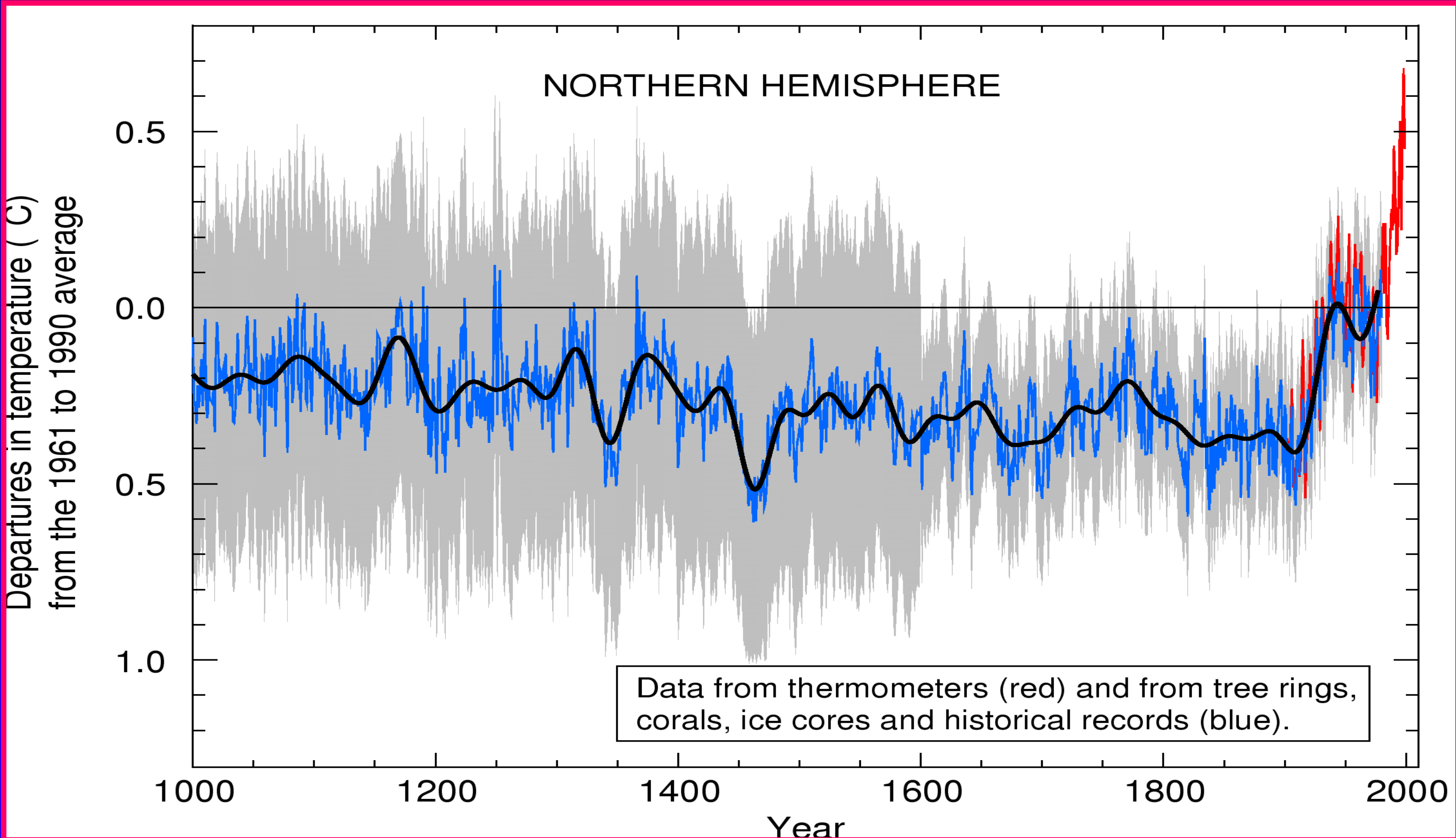
Earth's Surface Temperature Record

The Past 1,000 Years

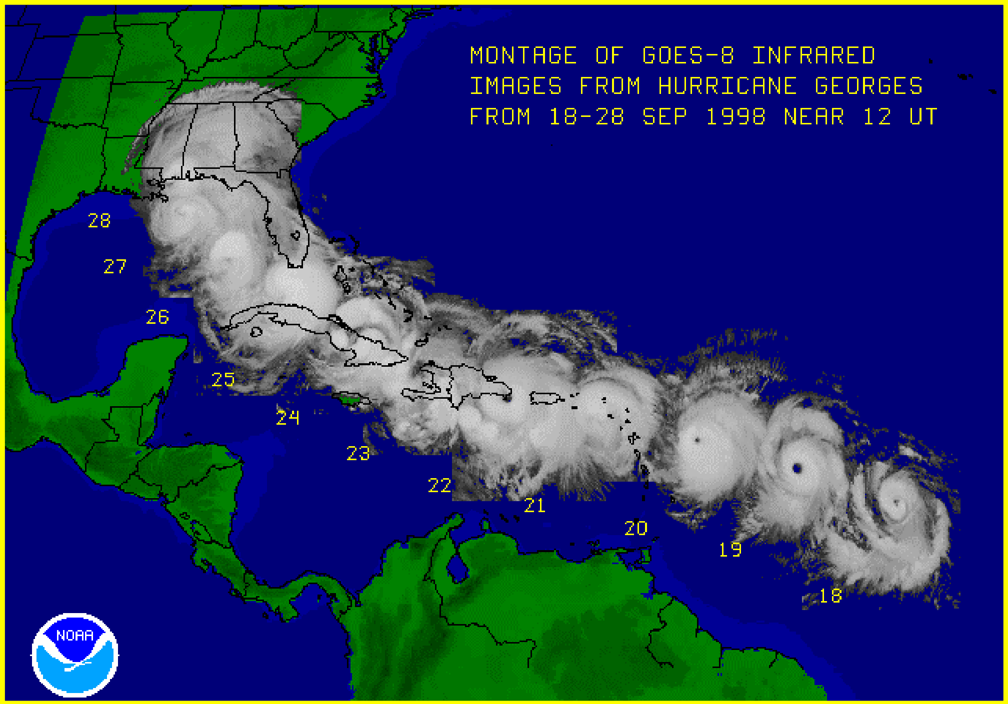


(Adapted from IPCC, 2001)

Are Climate Extremes Increasing?

UK Autumn 2000 Floods
(Loss ~ US $ 750 million)

River Ouse, Yorkshire, November 2000 (Courtesy Lawrence Kay)



Hurricane Georges Strikes Caribbean
(Loss ~ US $ 10 billion)

Presentation Structure

1. Causes of Long-Term Climate Change
2. Evidence for 20th Century Global Climate Change
3. Predicted Future Climate Change
4. Climate Extremes
   - *a) Atlantic and Caribbean Hurricanes*
   - *b) Rainfall Extremes*
   - *c) Temperature Extremes*

1. Causes of Long-Term Climate Change

What is Climate Change?

Any change in Earth's Climate on timescales longer than a year.

a) Interannual (yr-to-yr)
ENSO
Volcanic Eruptions

b) Multidecadal Trends
Global Warming
Solar Changes

Earth seen by Apollo 17 (Courtesy NASA)

MultidecadalTrends

a) Enhanced Greenhouse Effect

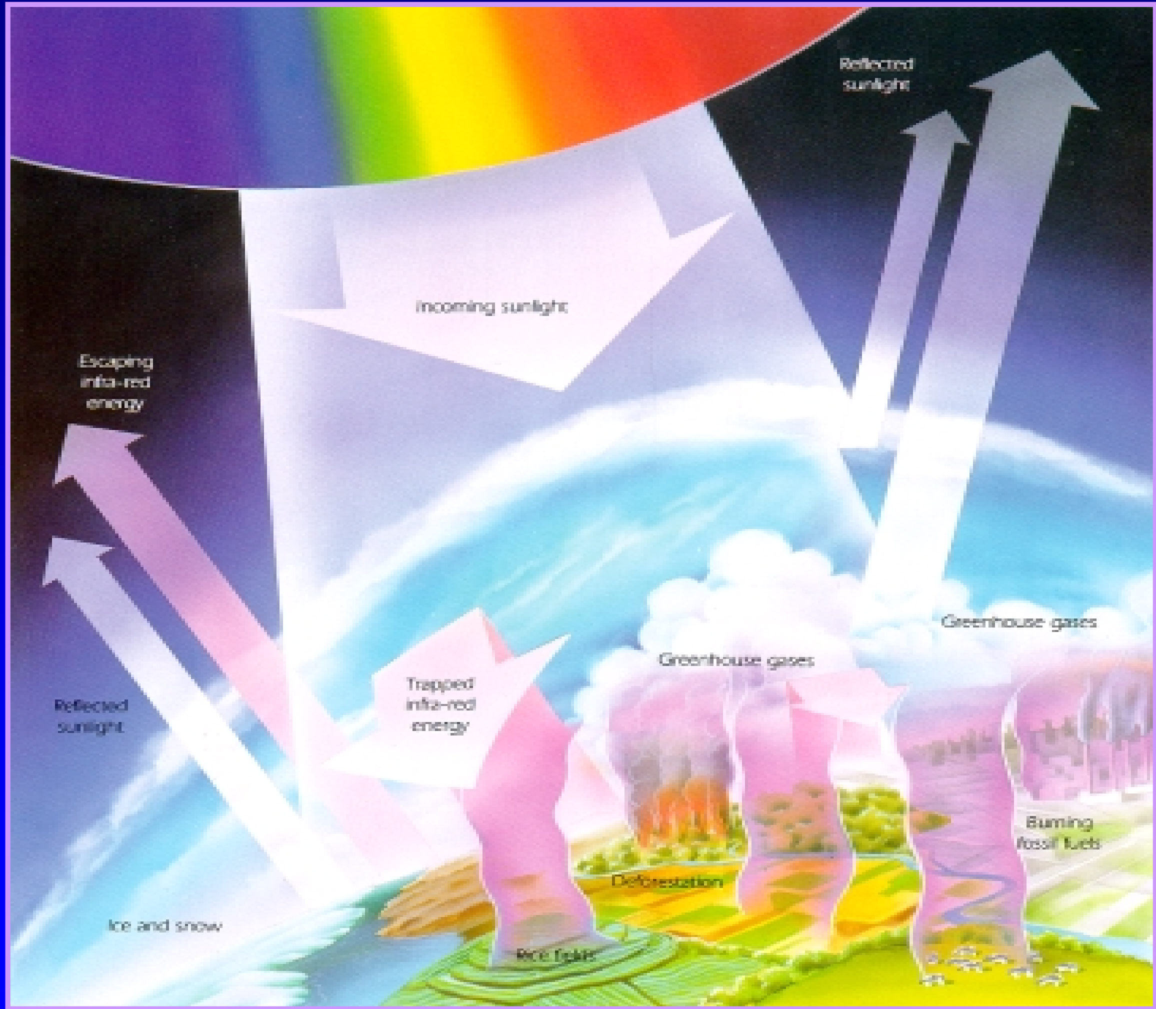
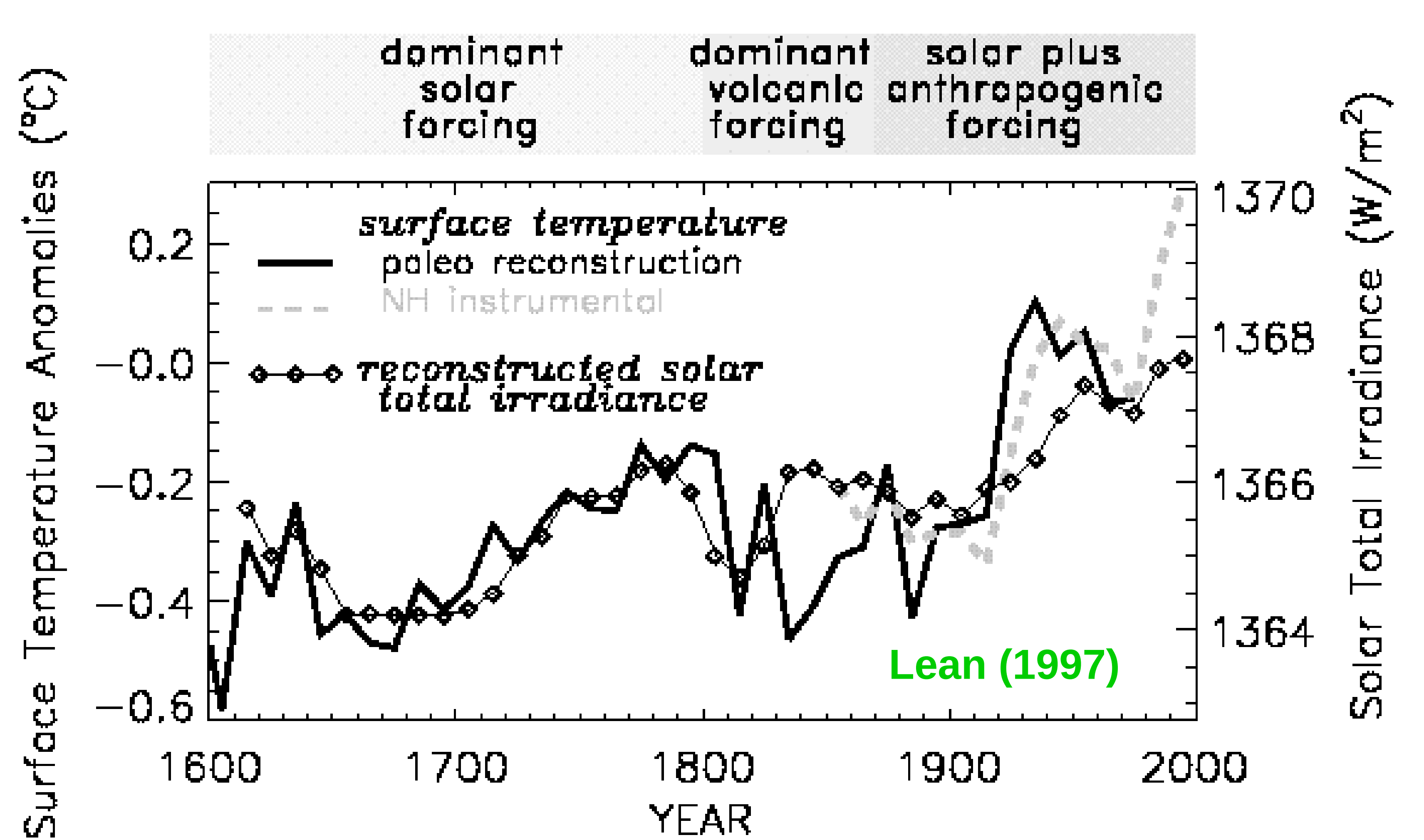
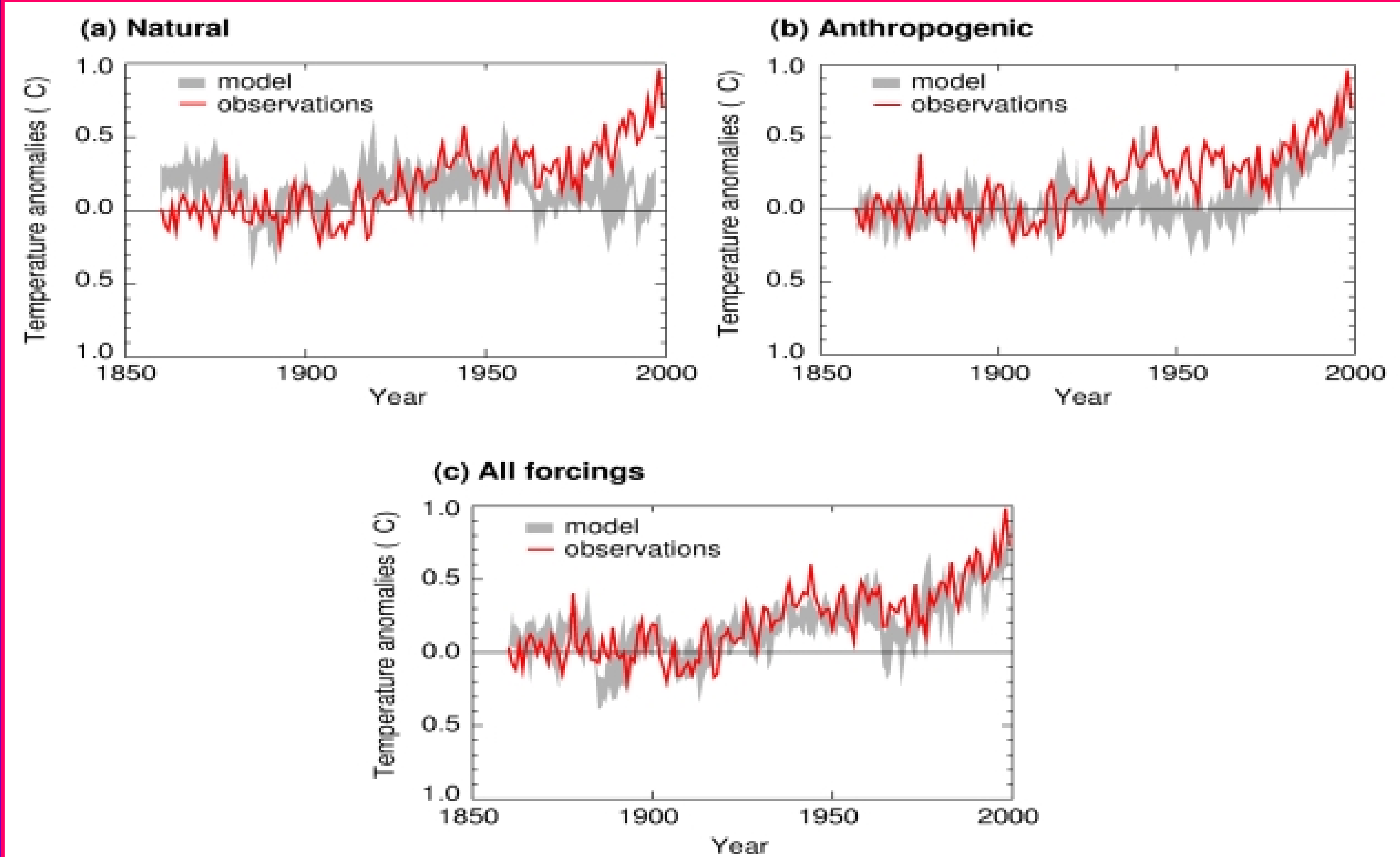


Figure Courtesy of Pringle (1988)

b) Solar Influences



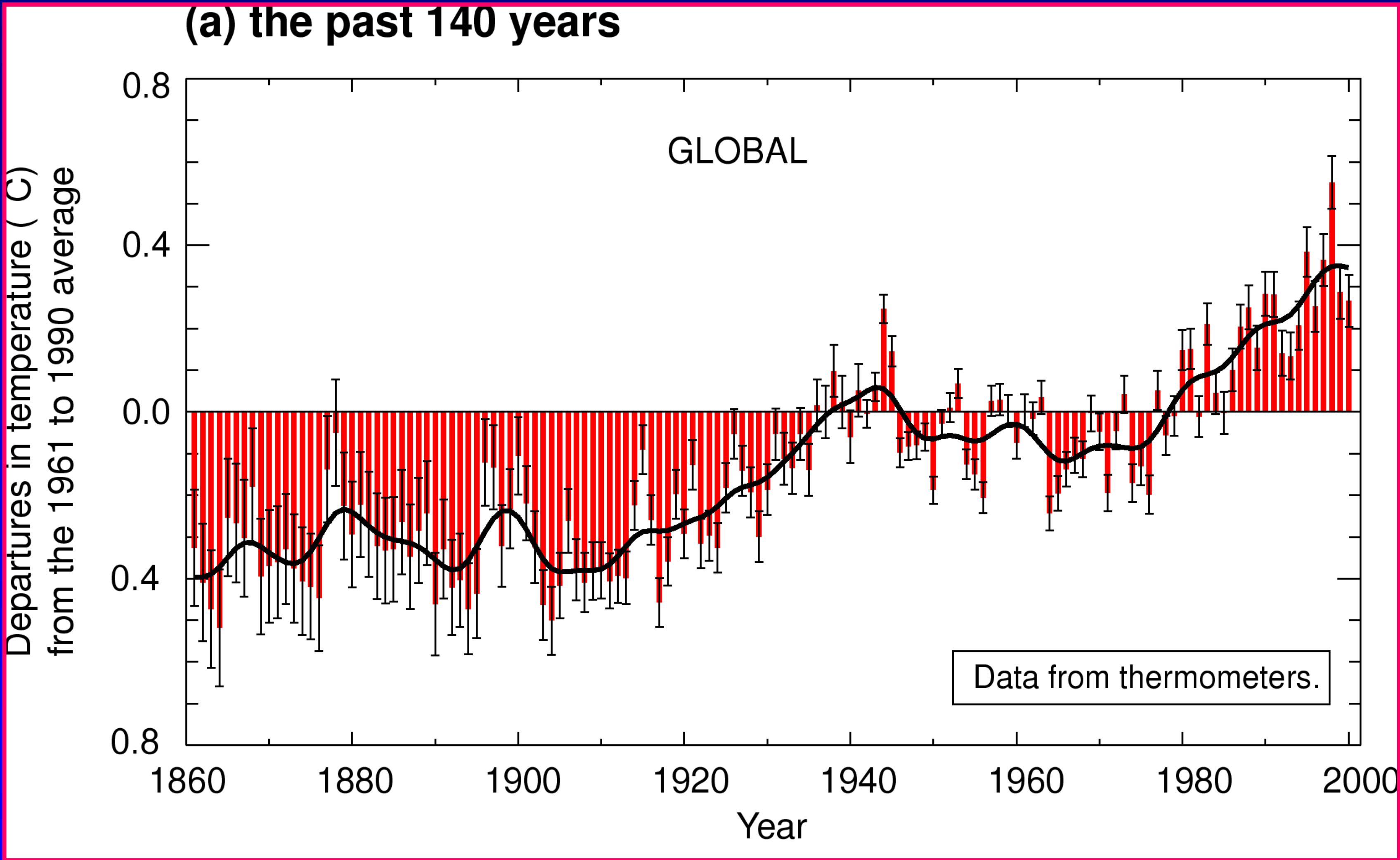
Simulated Annual Global Mean Surface Temperature



Adapted from Stott et al., Science, 2000

2. Evidence for 20th Century Climate Change

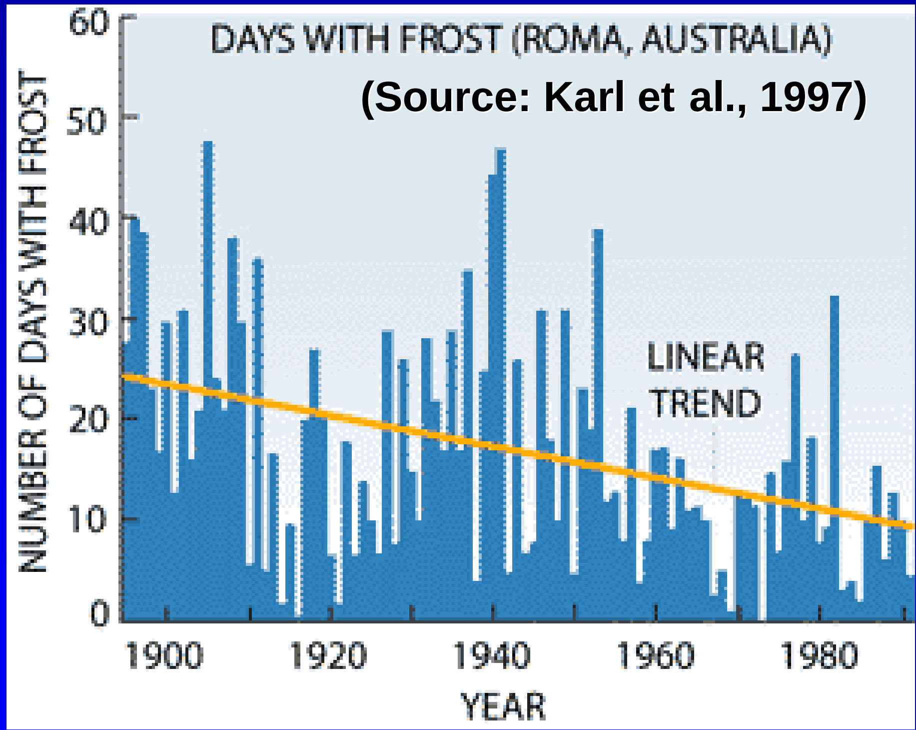
Earth's Surface Temperature Record



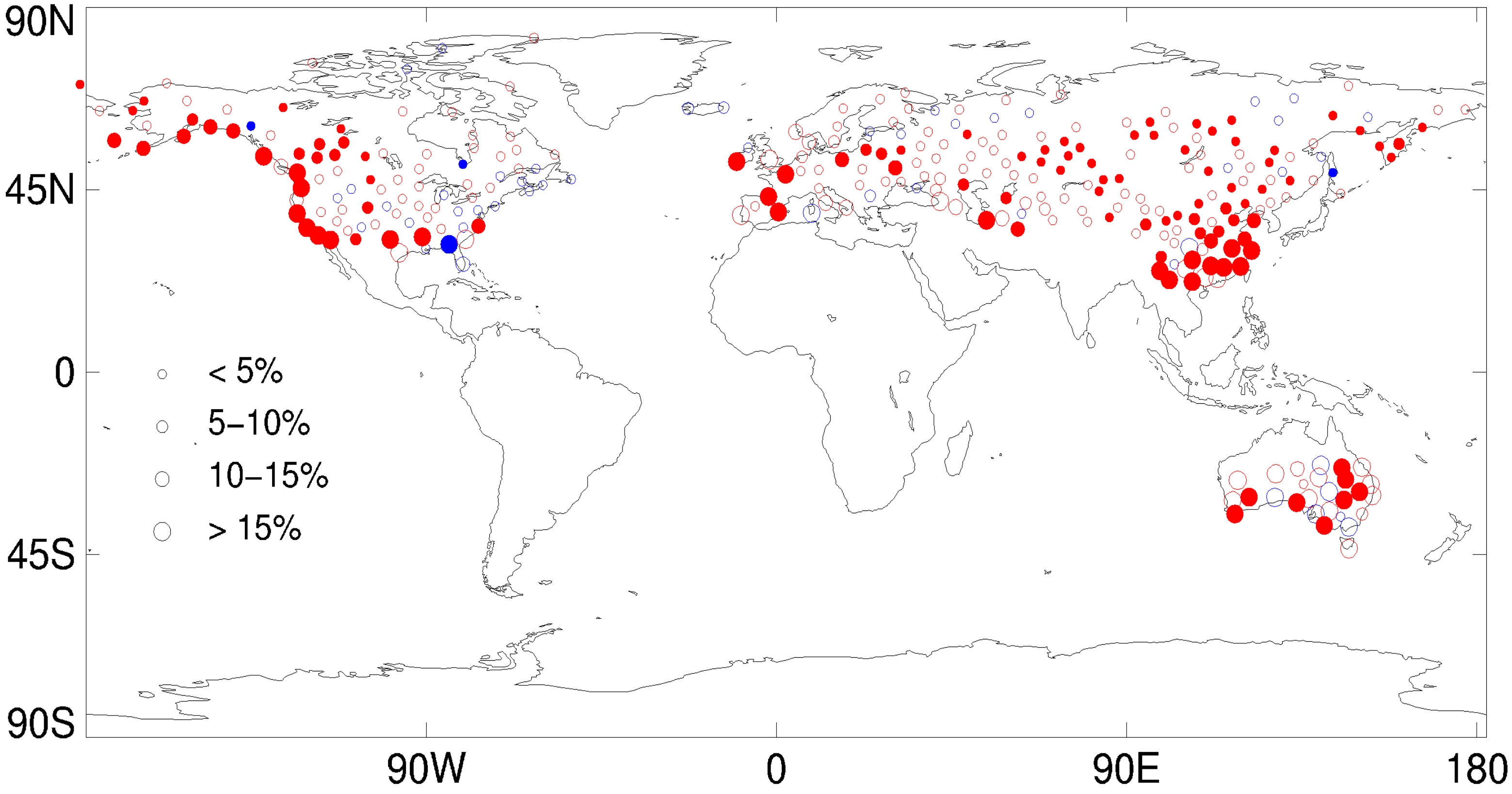
Adapted from IPCC 2001

Indirect Evidence

- Retreating Glaciers
- Fewer Frost Days



Trend in Frost Days 1950-1995



Blue is a positive change. Filled circles are significant at 95% level of confidence

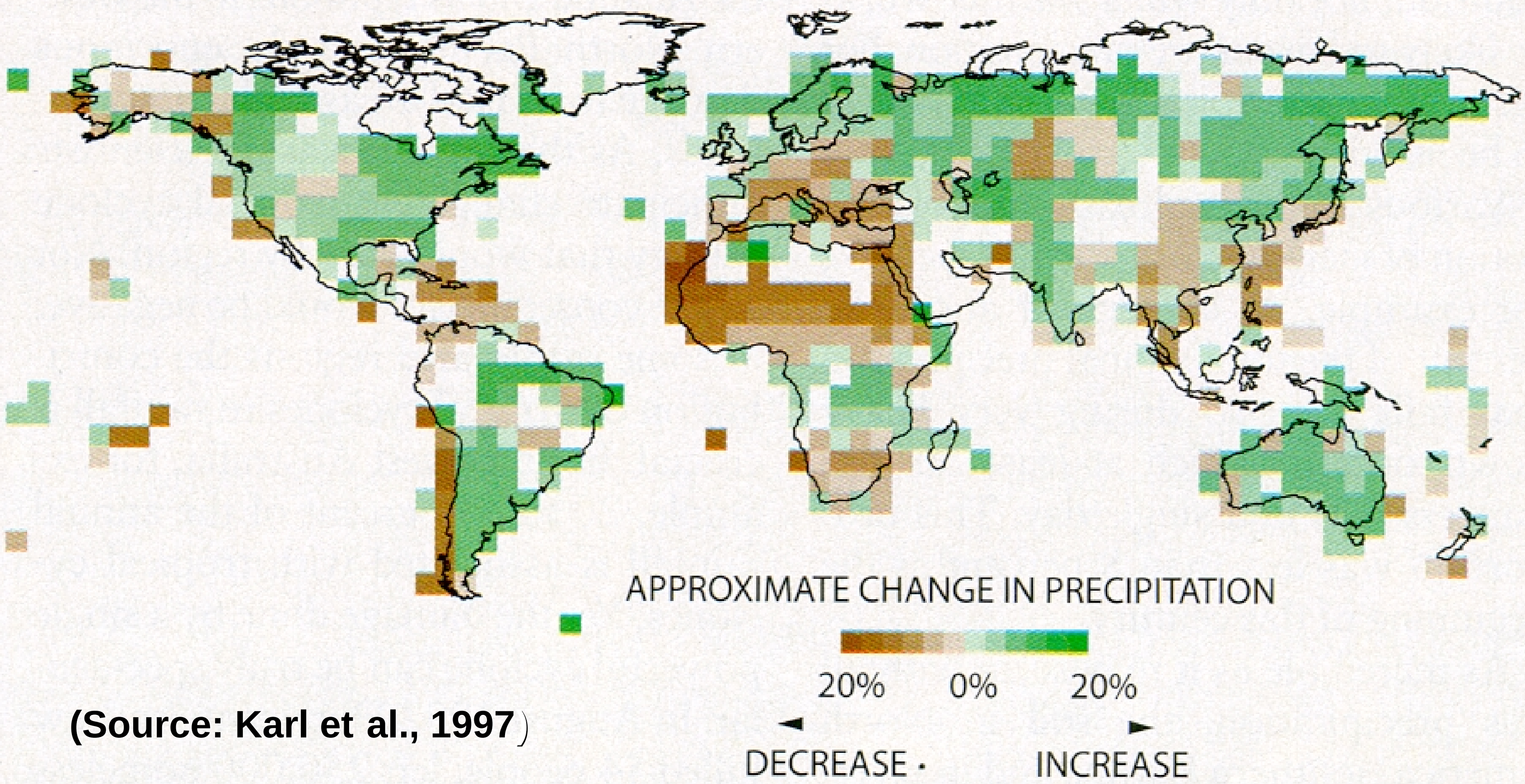
(Source: Frich et al., in press, 2001)

Historical Supporting Evidence

Dutch Winter Landscape painted in 1601 by Peter Brueghel the Younger. (Courtesy Kunsthistorisches Museum, Vienna)

More Precipitation

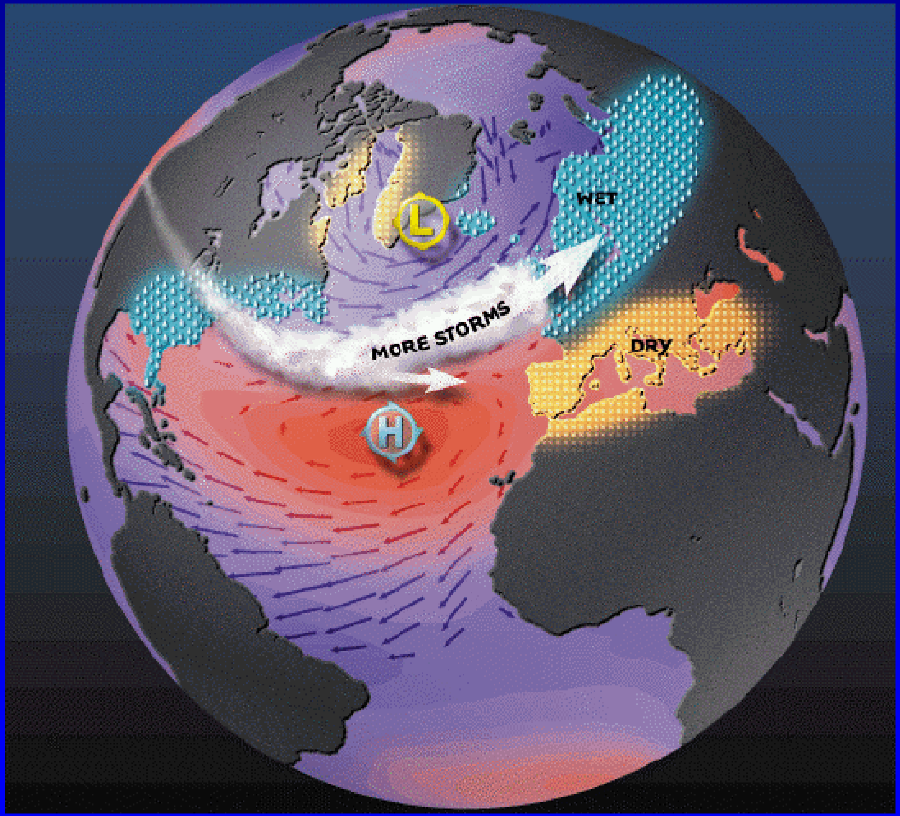
Precipitation Trend 1900-1994

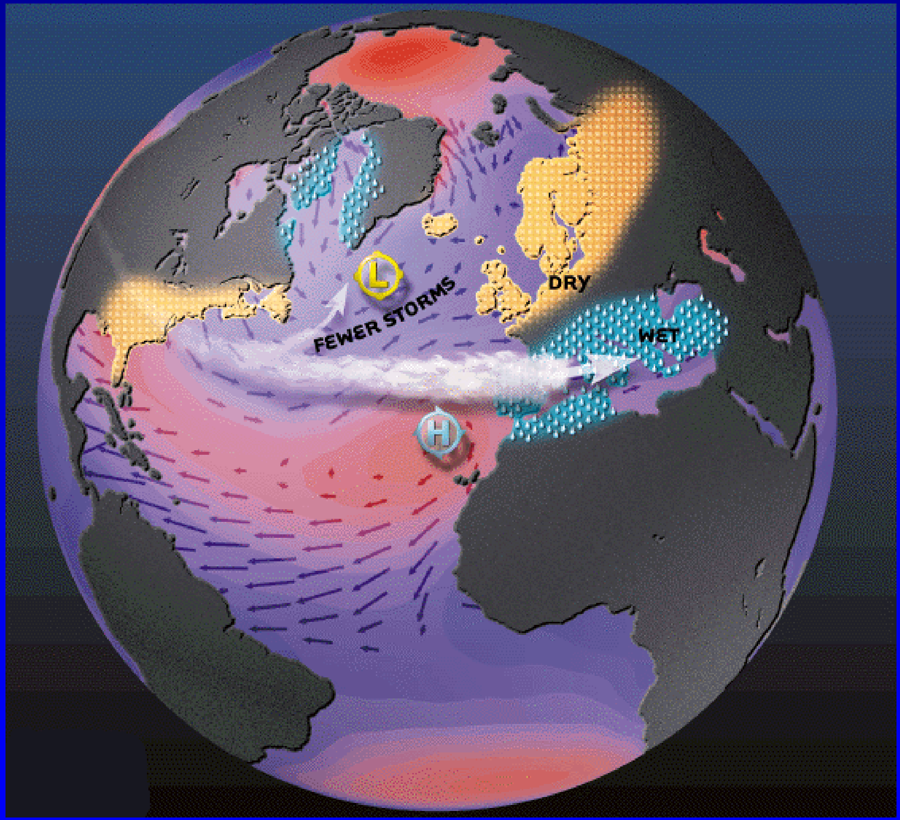


(Source: Karl et al., 1997)

North Atlantic Oscillation

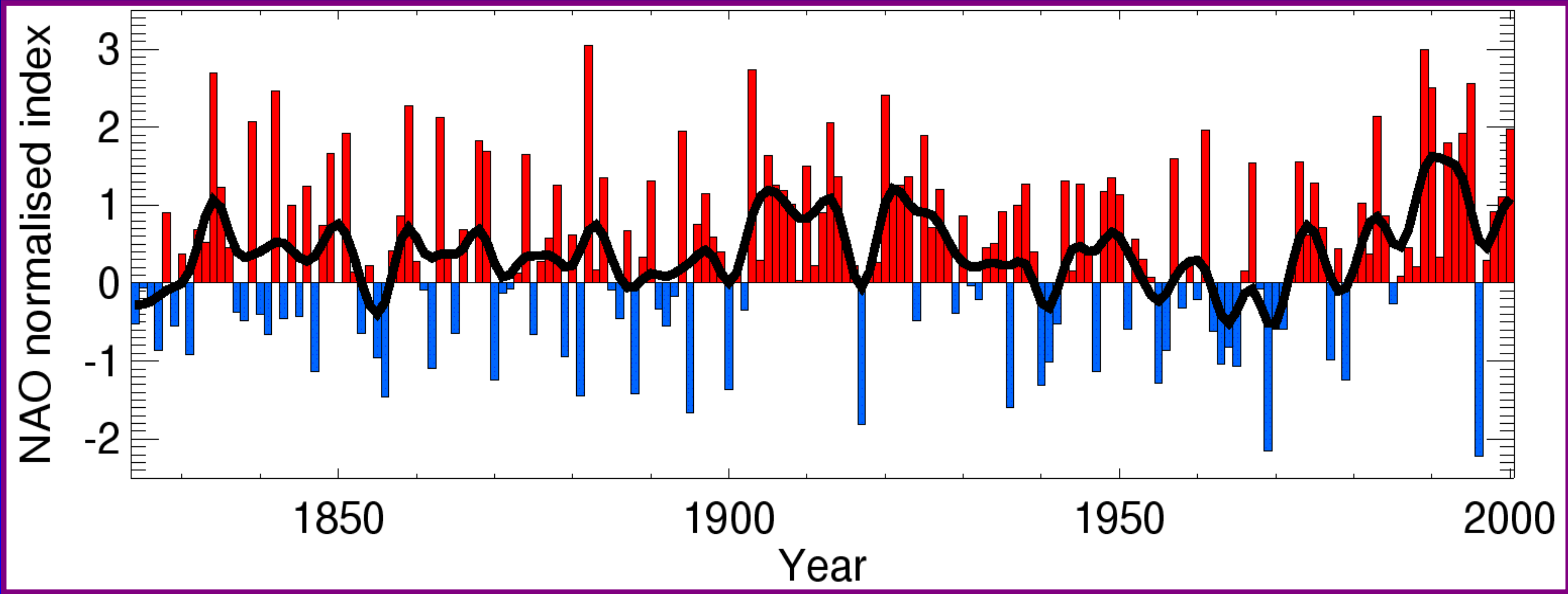
+ve NAO **-ve NAO**





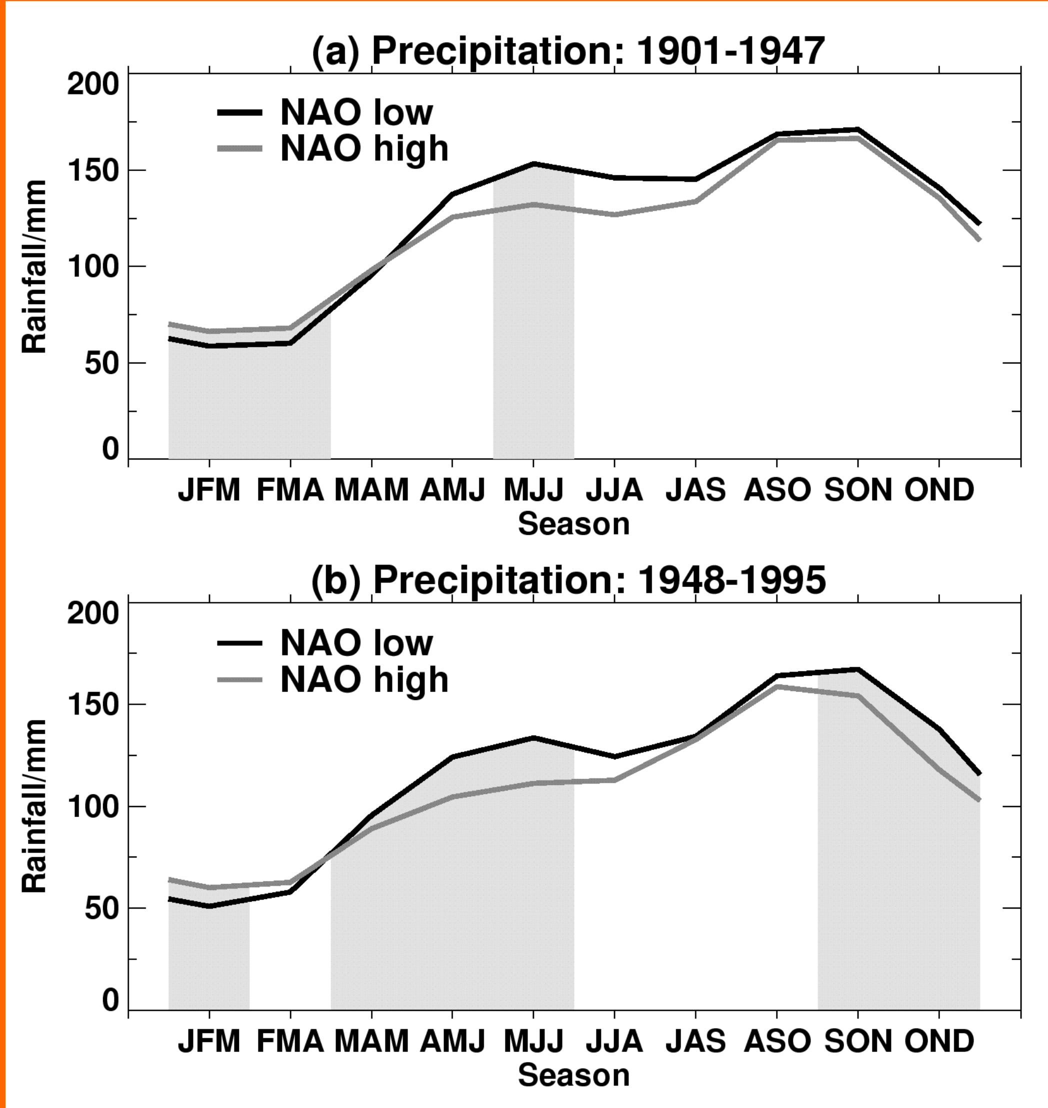
(Figures Courtesy of Martin Visbeck, Columbia University)

NAO Winter Index 1825-2000



(Figure Courtesy of Tim Osborn, University of East Anglia)

Caribbean Precipitation

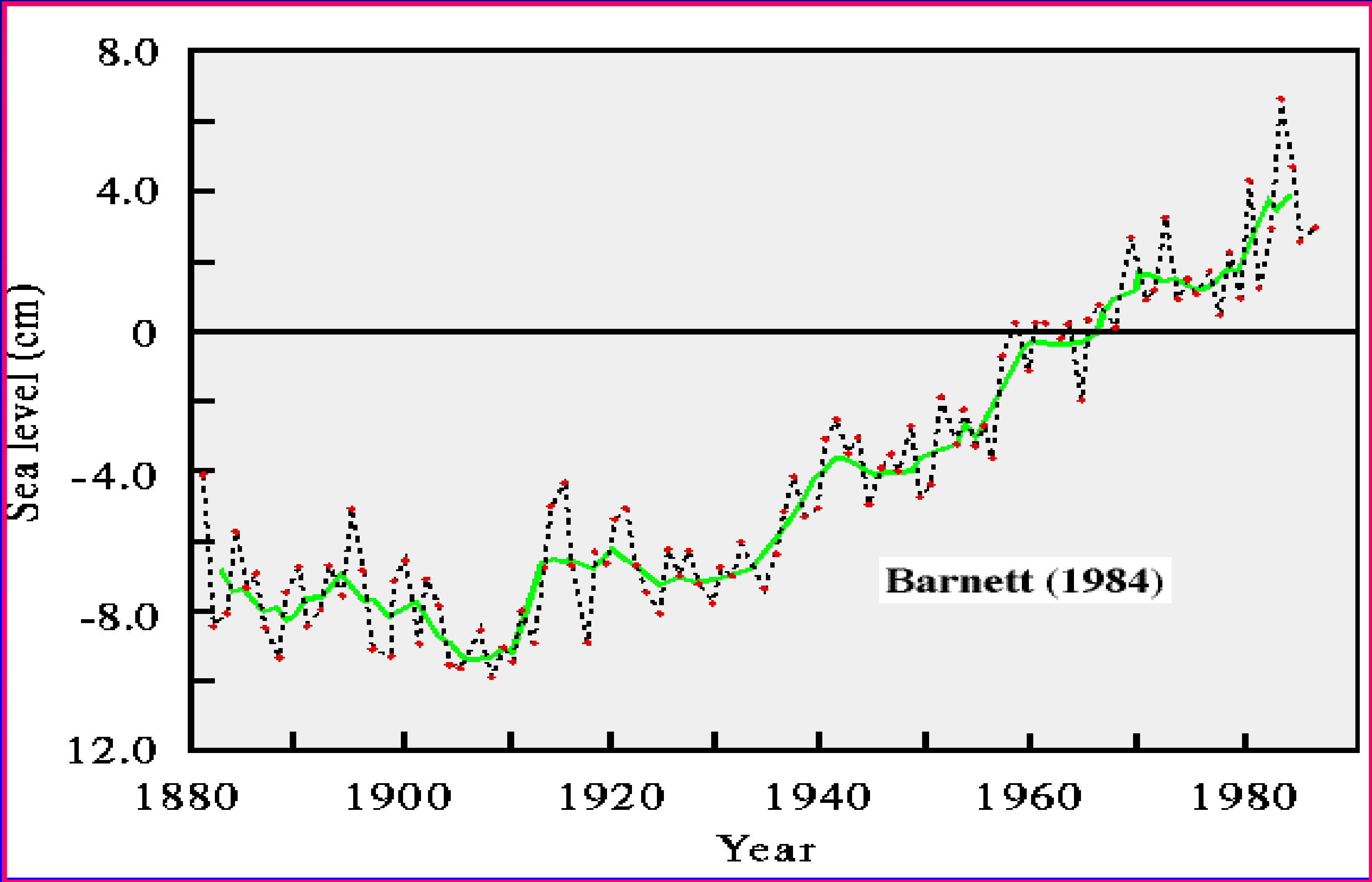


Seasonal Composites by NAO sign

Shading Indicates the Seasons where the Difference in Rainfall Between Low and High NAO Composites is Significant at the 90% Level.

(George and Saunders, 2001)

Sea Level Rise



3. Future Climate Predictions

Global Climate Models (GCMs)

- Most complex of climate models.
- Used to perform climate change experiments.
- Fully coupled ocean and atmosphere.
- Runs may take months to complete on the fastest Cray.

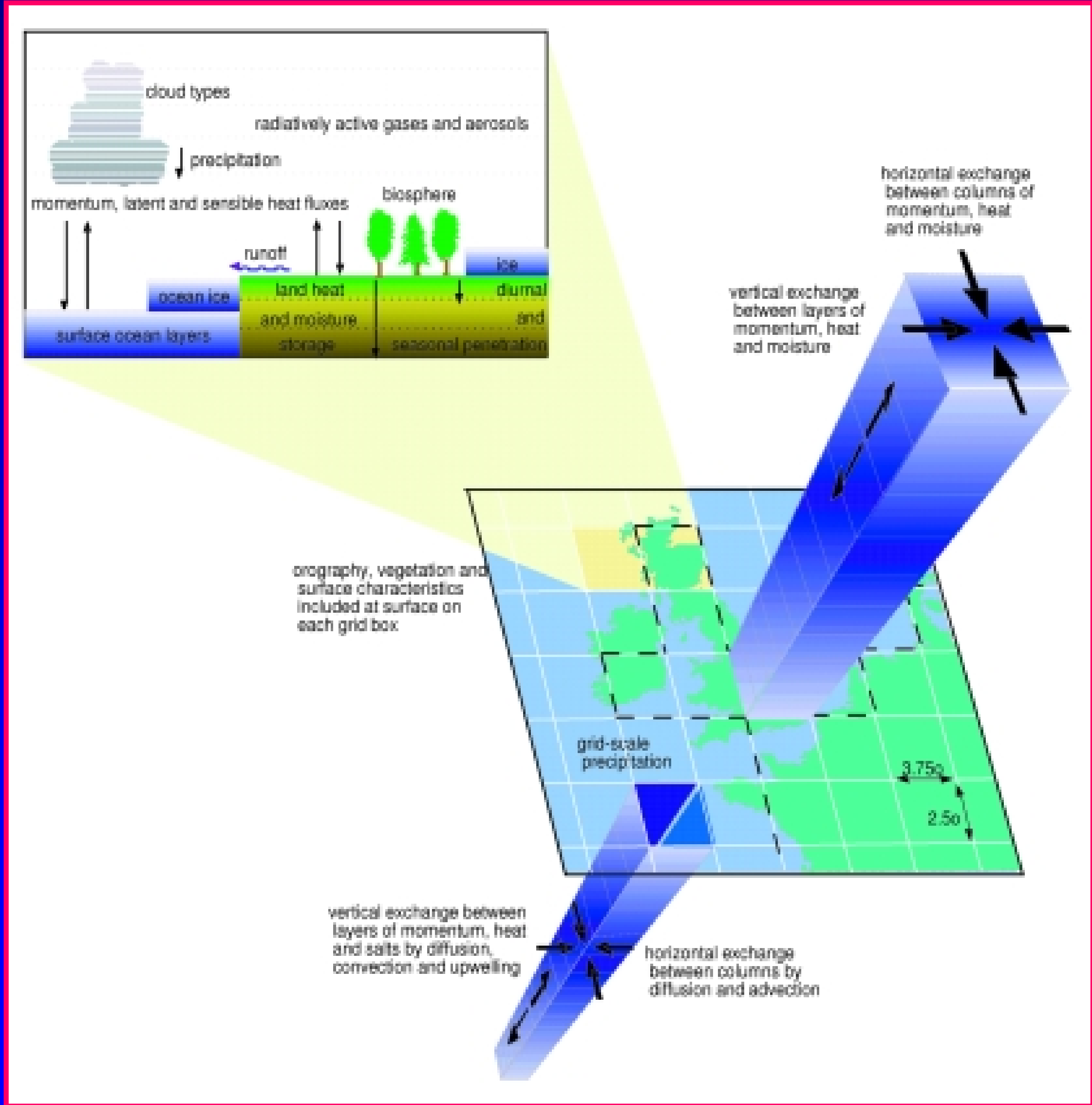
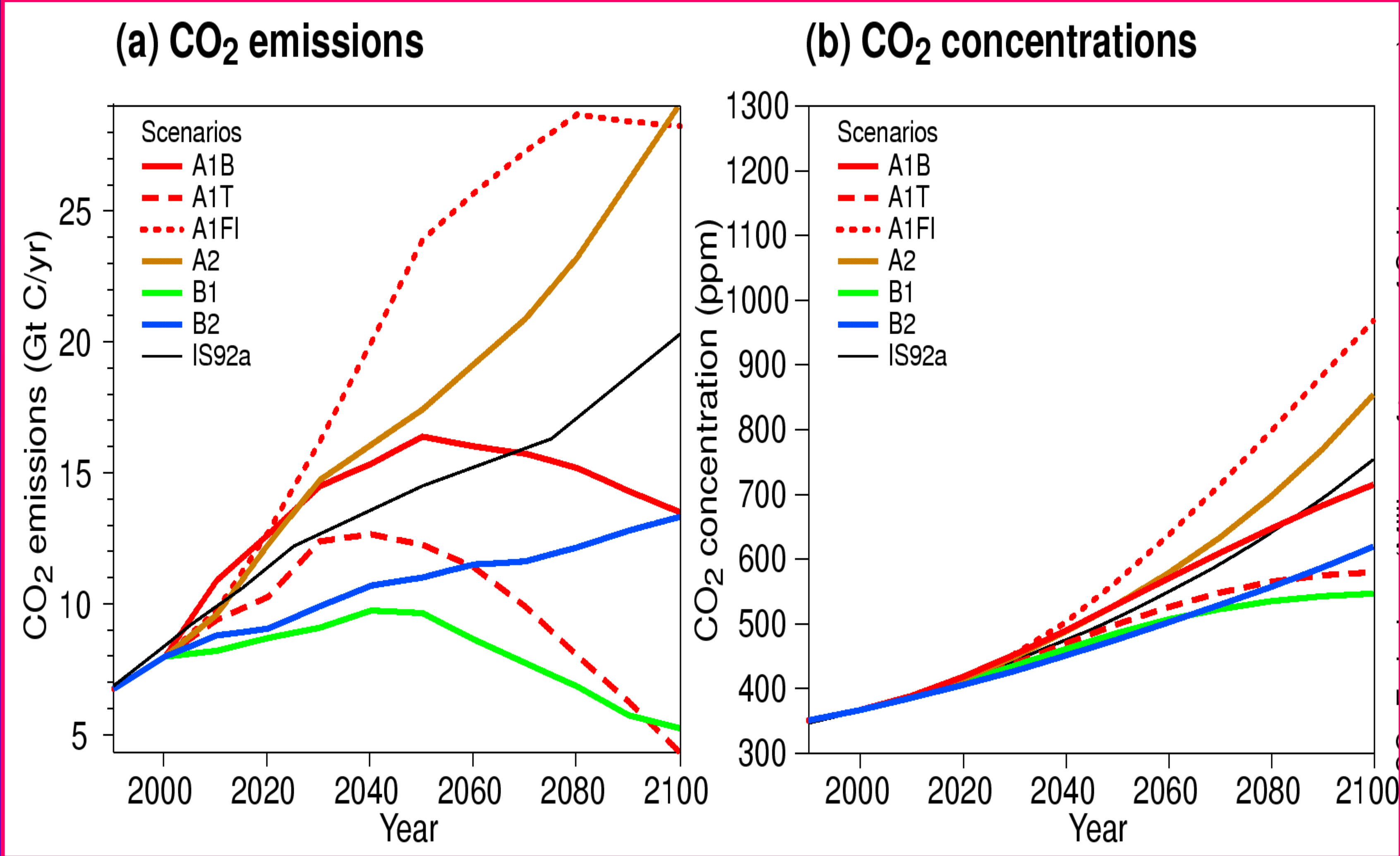


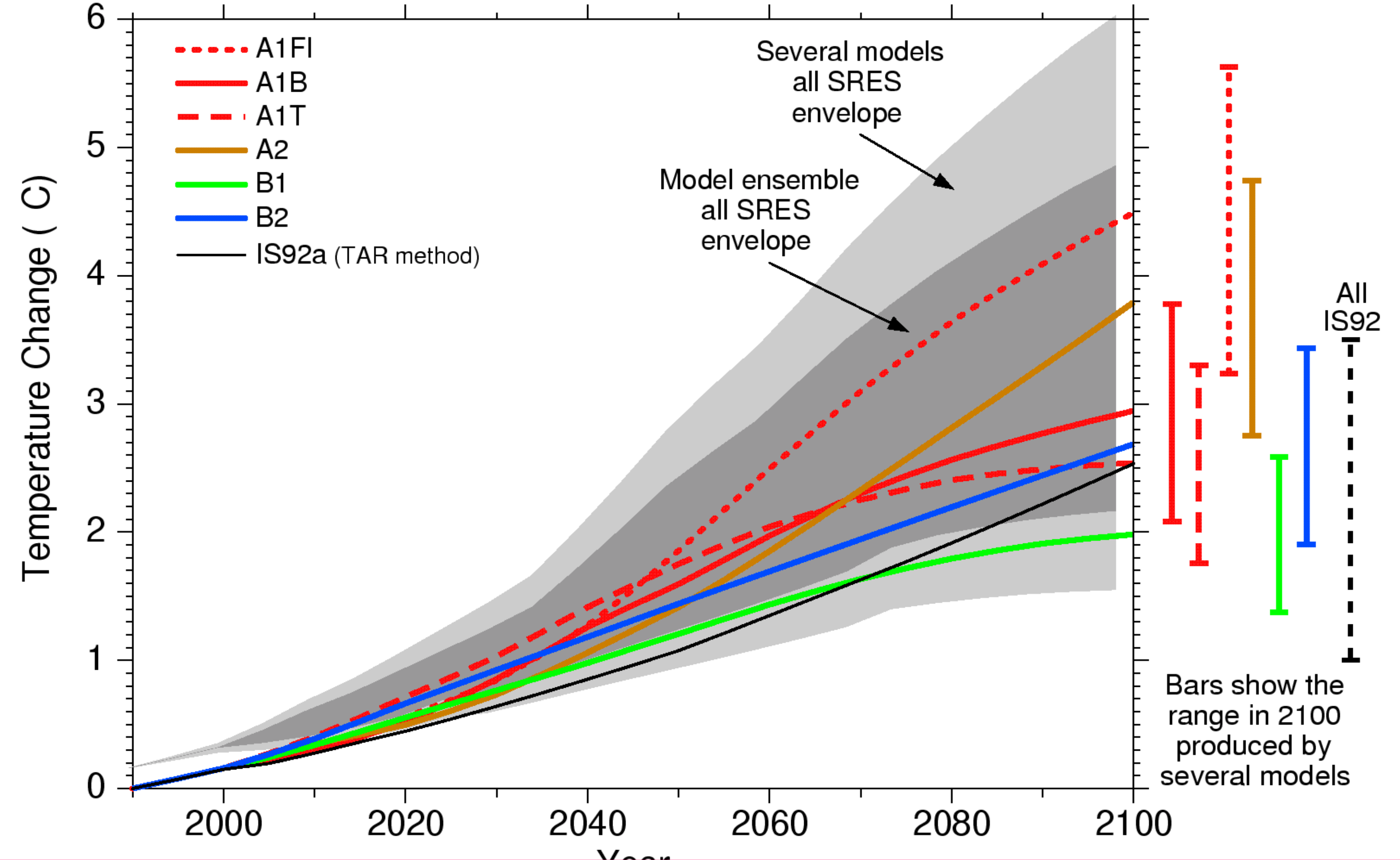
Figure Courtesy of David Viner, Climatic Research Unit, UK

Scenarios for Greenhouse Gas Emissions in the 21st Century



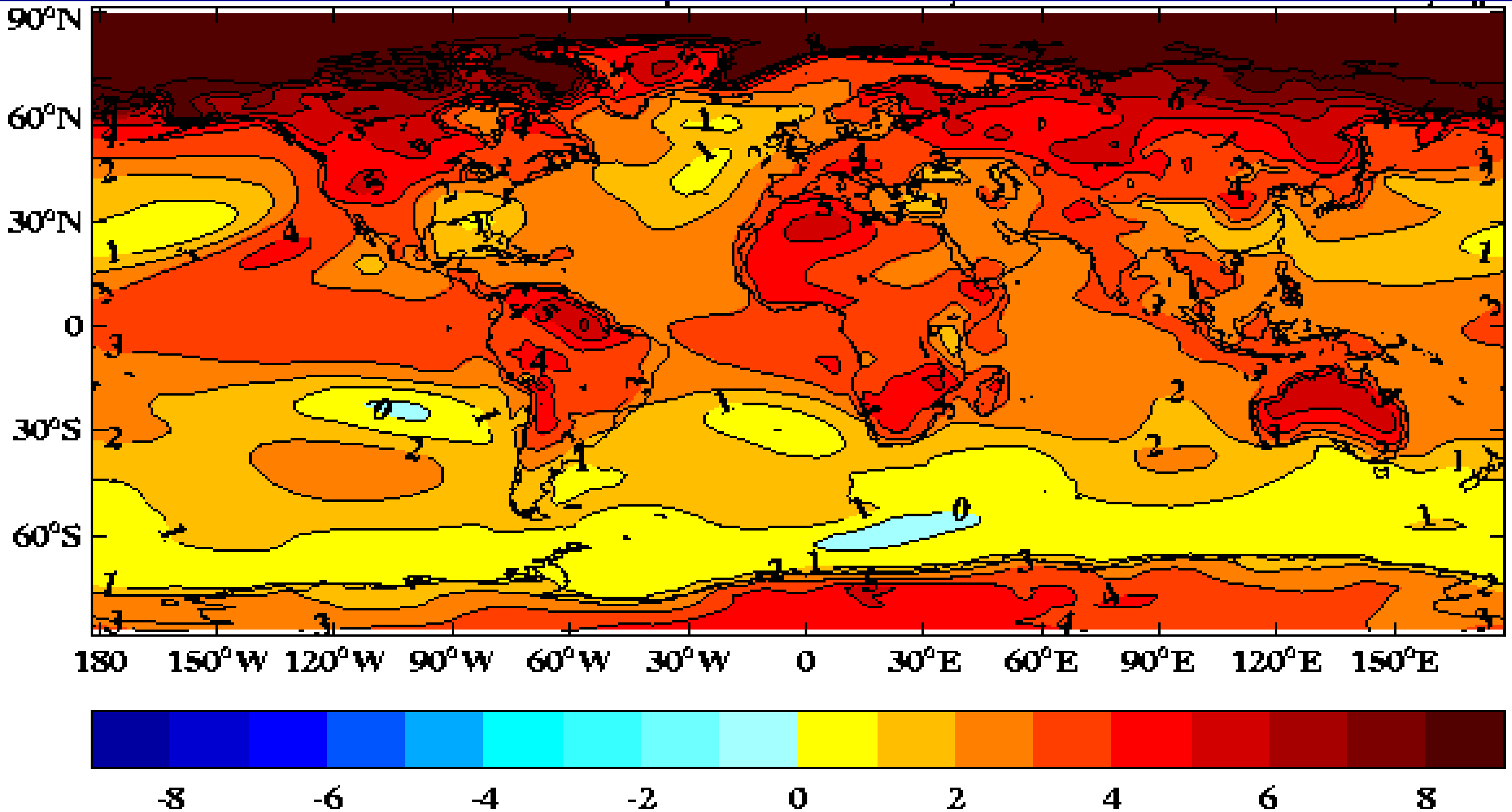
Adapted from IPCC, 2001

Global Temperature Change in the 21st Century



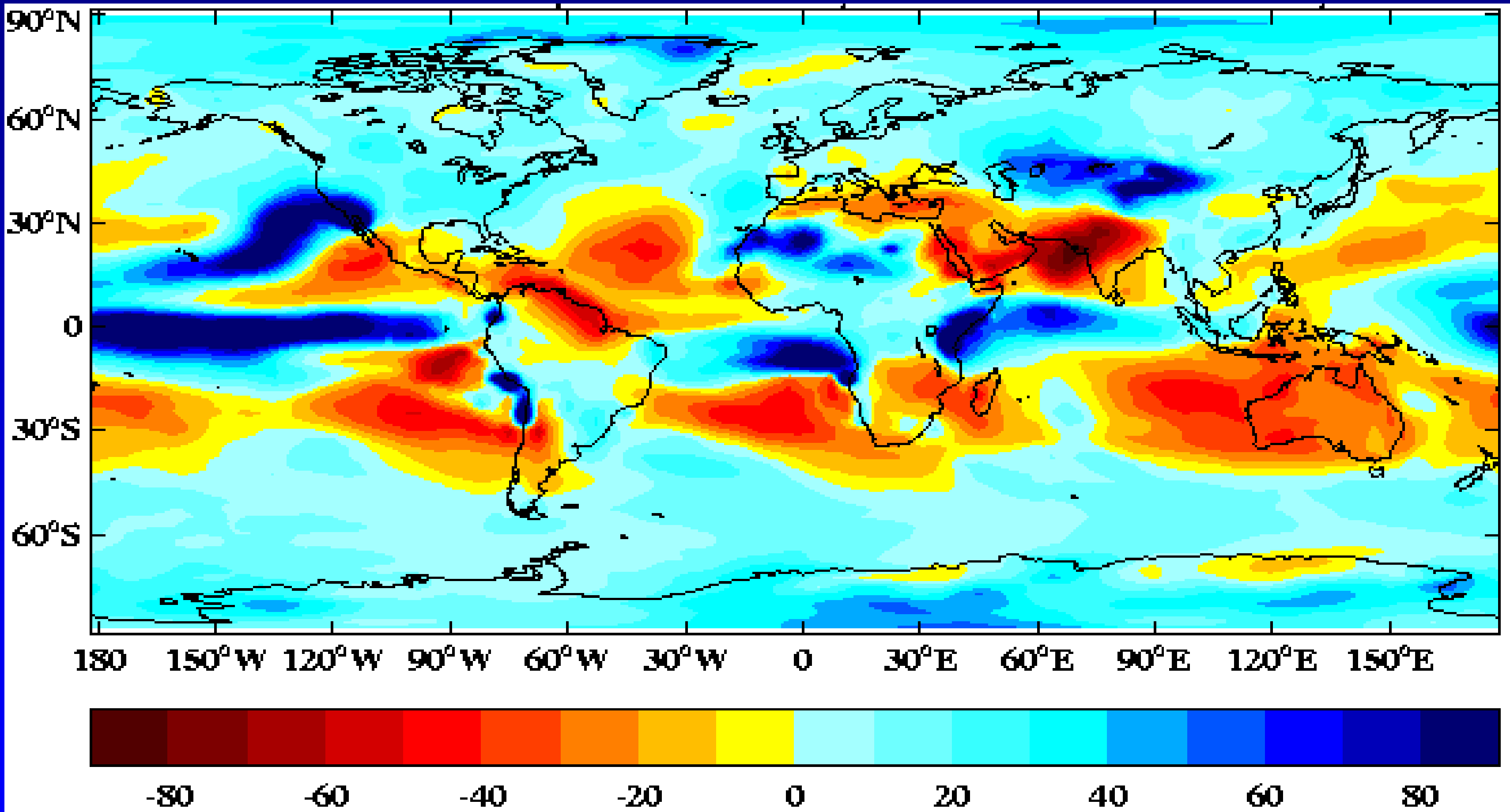
Adapted from IPCC, 2001

Global Warming Temperature Changes 1990-2100



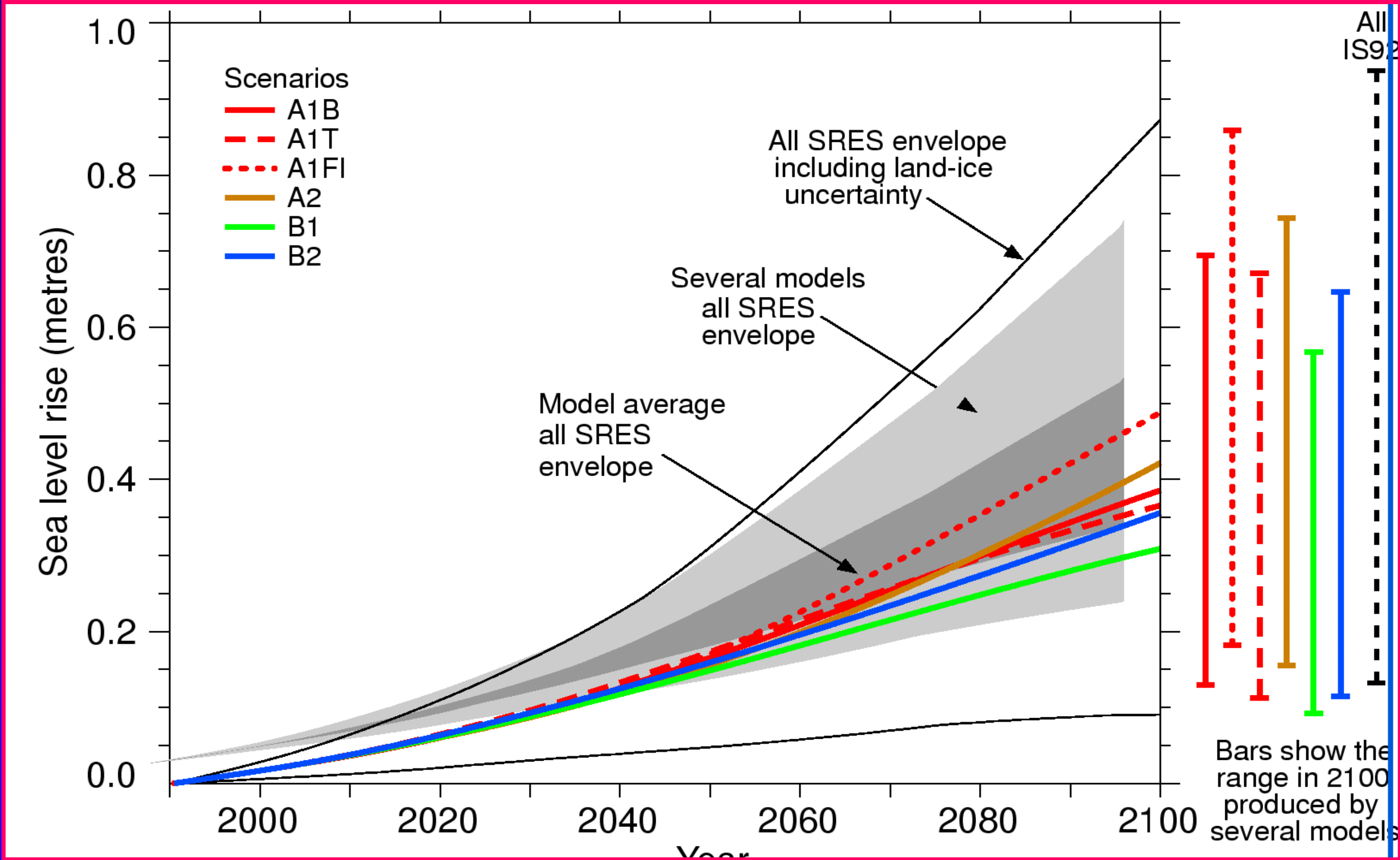
(Image Courtesy Hadley Centre for Climate Prediction)

Global Warming Precipitation Changes 1990-2100



(Image Courtesy Hadley Centre for Climate Prediction)

Global Sea Level Rise in the 21st Century

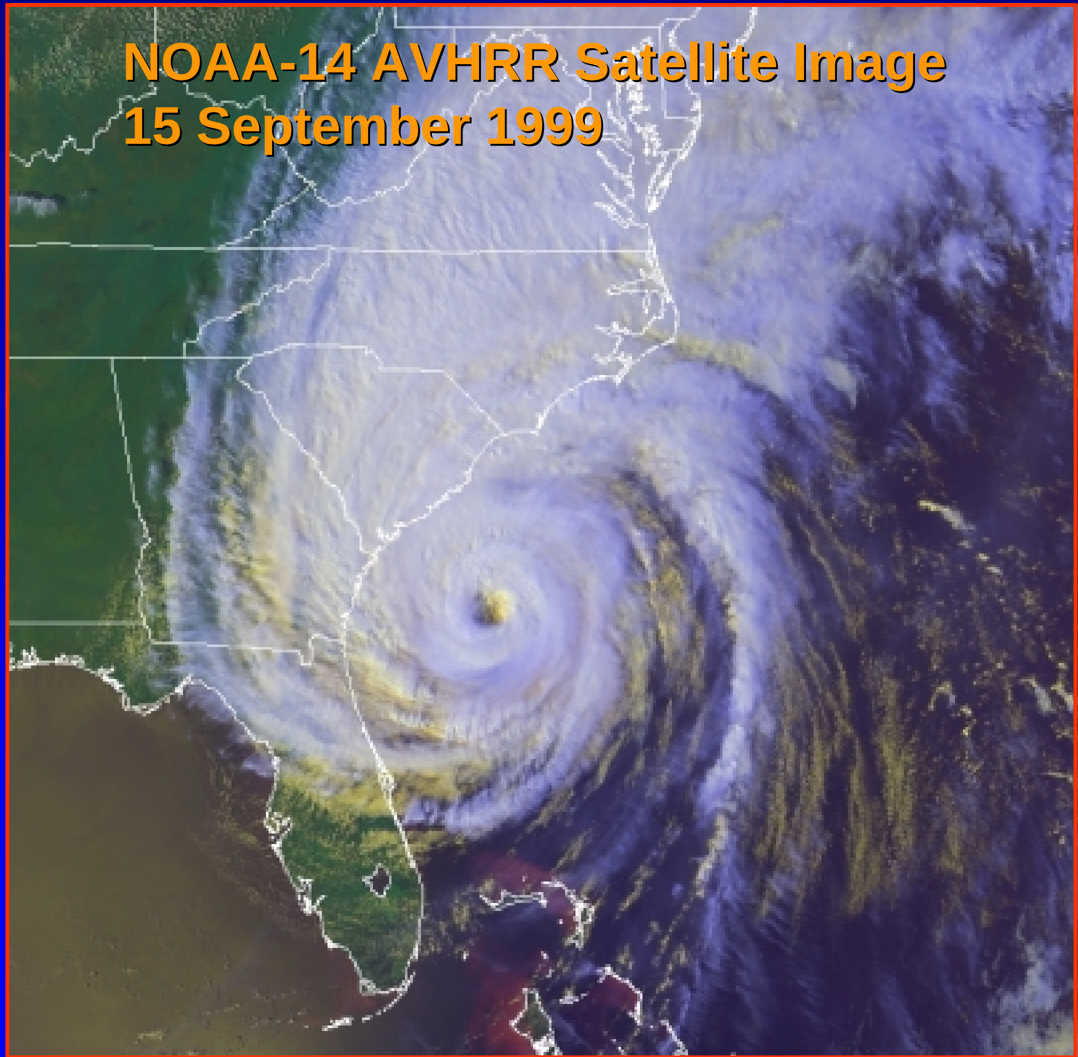


Adapted from IPCC, 2001

4. Climate Extremes

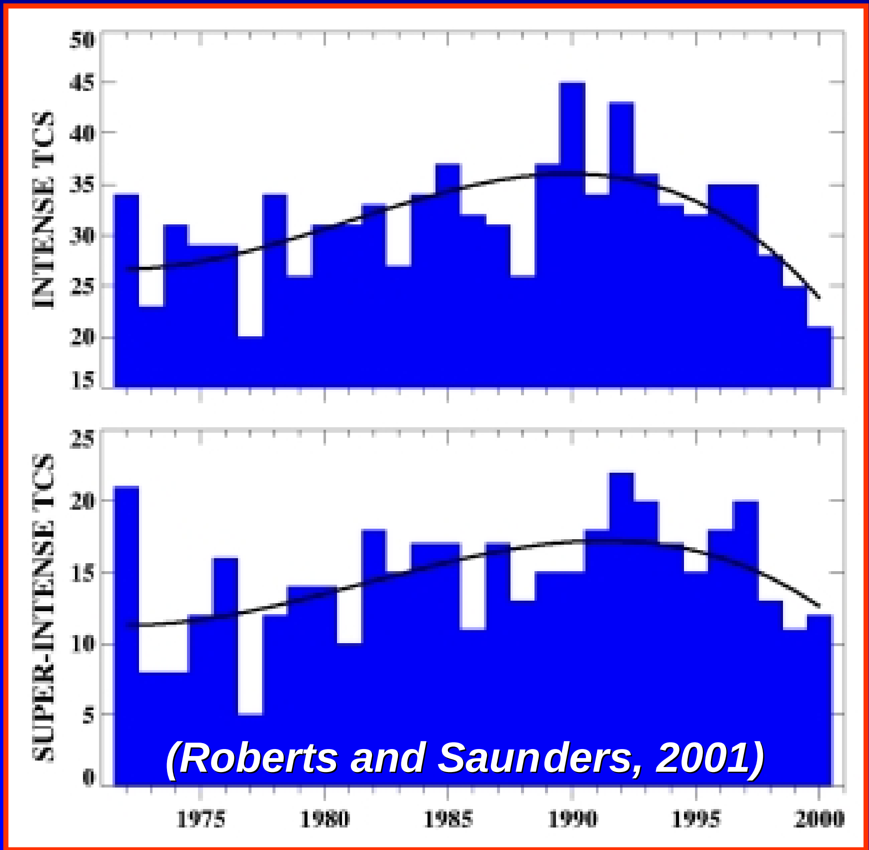
A. Atlantic Hurricanes

- Rank as the largest cause of US catastrophe loss (US $ 5.3 bn per year 1925-2000)
- Floyd (pictured) had a damage bill of US $ 5.0 billion.

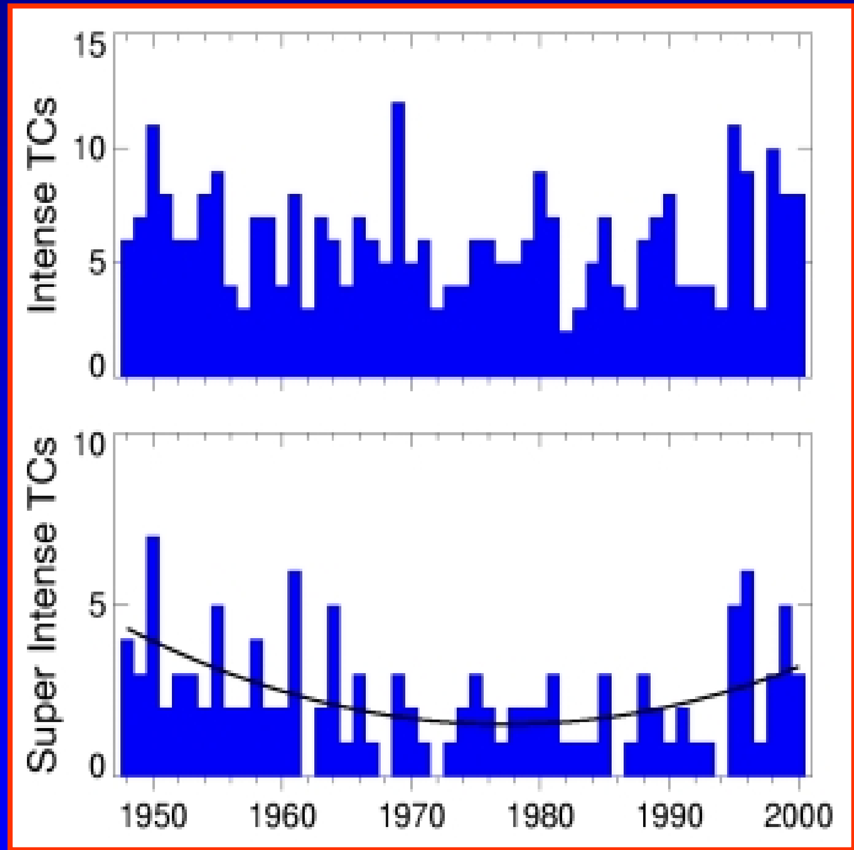


Trends in Intense Tropical Cyclone Numbers

Northern Hemisphere 1971-2000



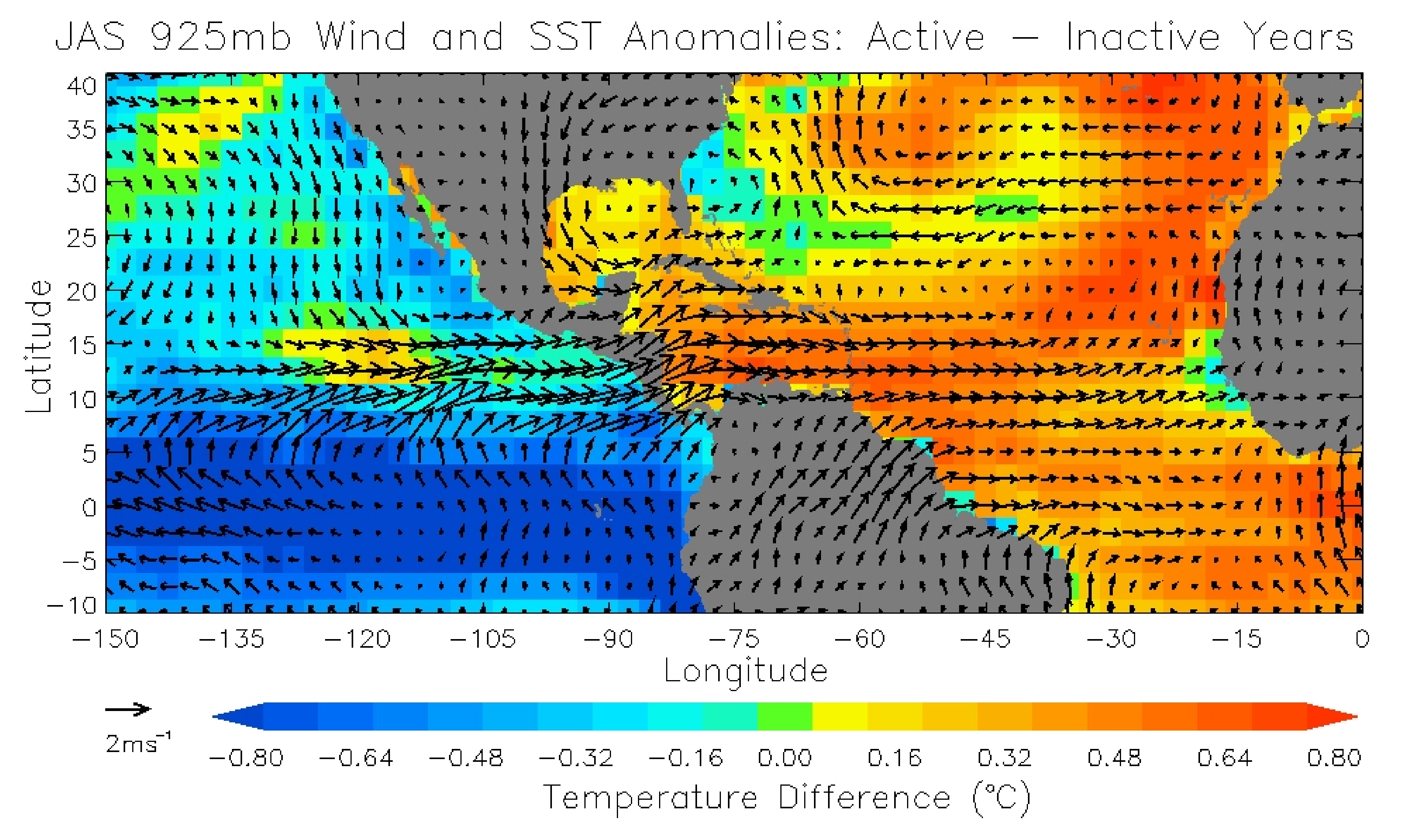
Atlantic Basin 1948-2000



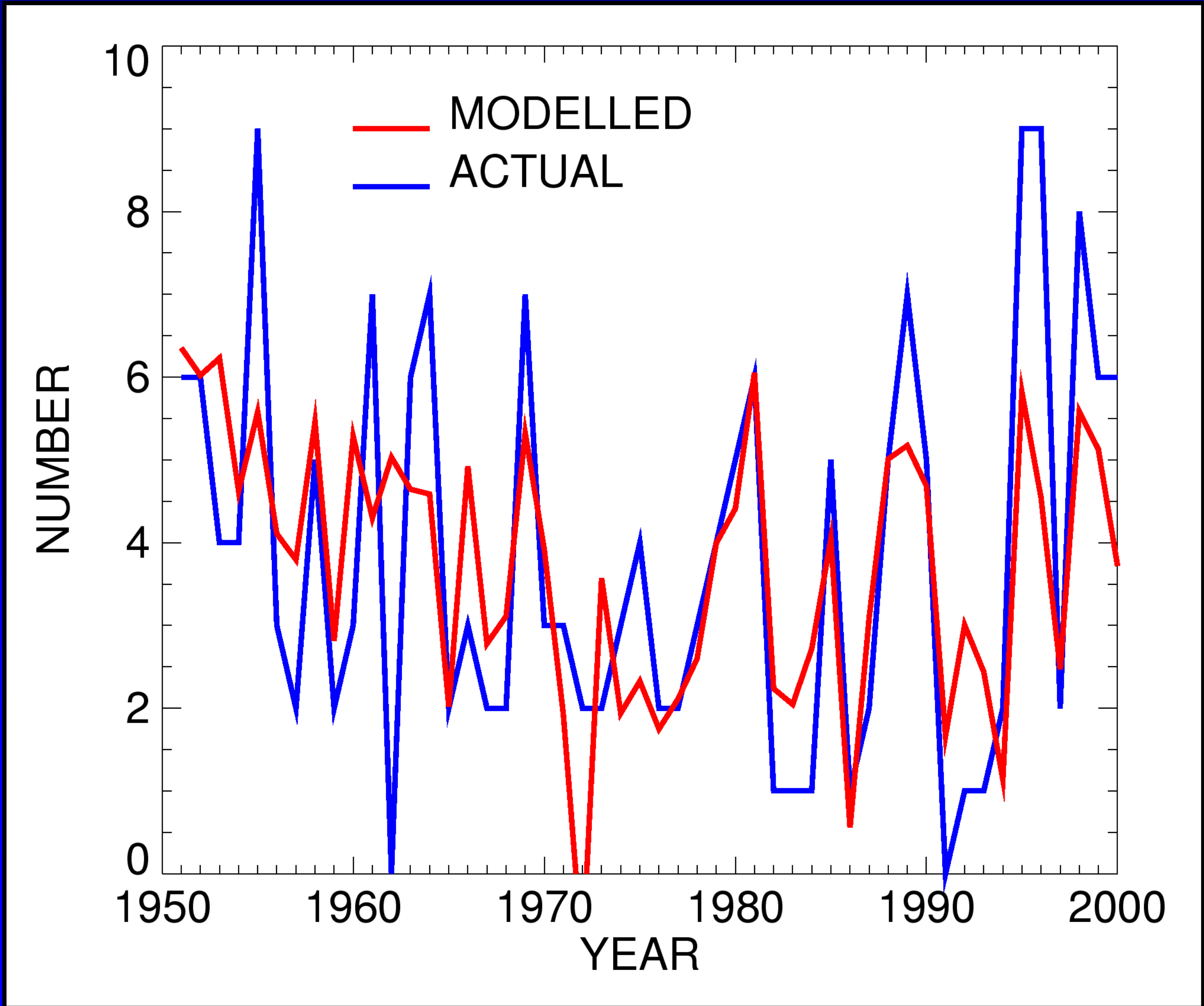
Intense TCs = 1-min Sustained Winds > 73 mph

Super Intense TCs = 1-min Sustained Winds > 110 mph

Key Factors Behind Atlantic Hurricane Activity



Tropical Atlantic, Caribbean and Gulf Hurricane Numbers

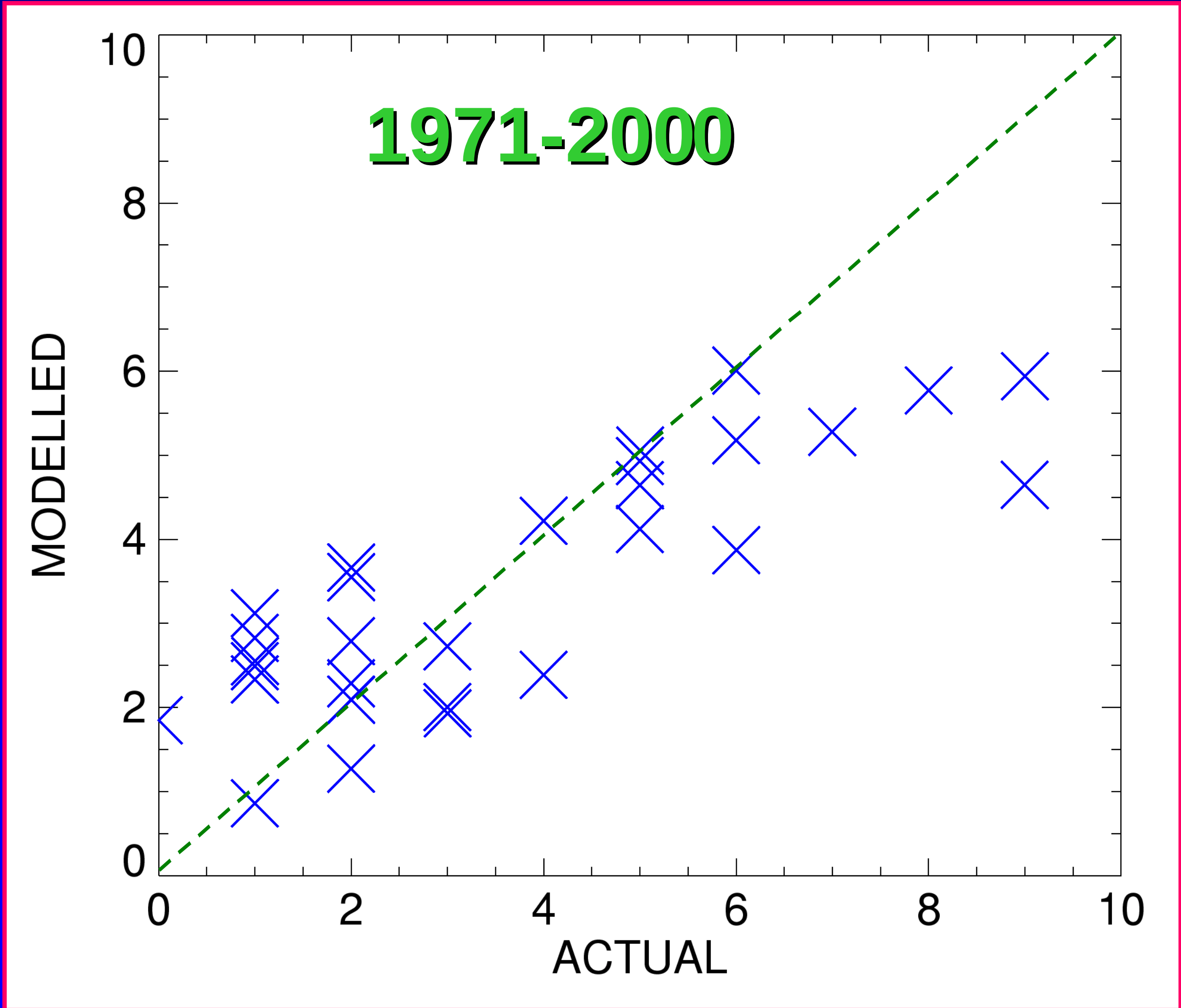


r = 0.69

Model Employs August-September Tropical Atlantic Sea Surface Temperature and Caribbean Trade Wind Speed

(Roberts and Saunders, 2001)

Tropical Atlantic, Caribbean and Gulf Hurricane Numbers

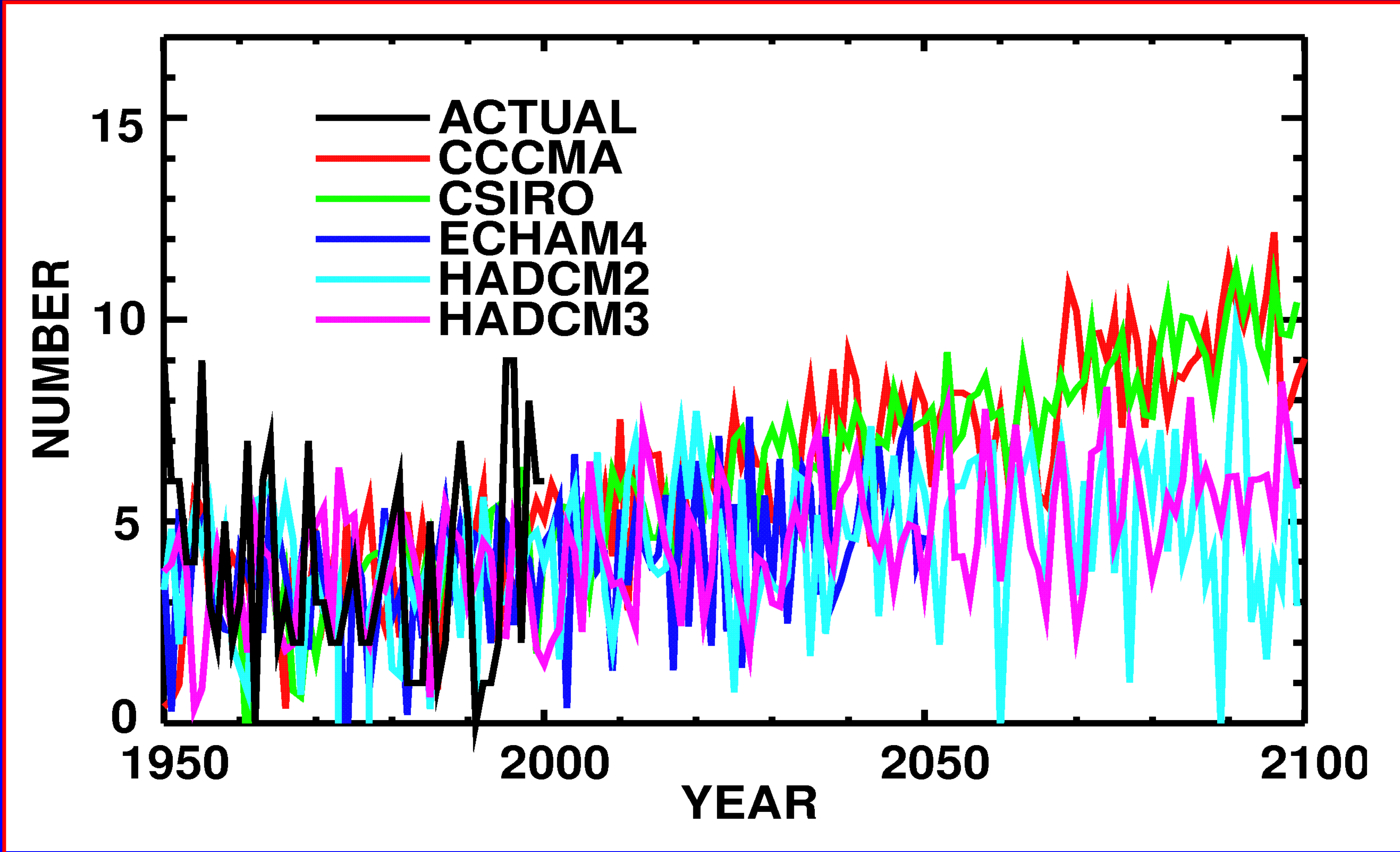


r = 0.79

Model Employs August-September Tropical Atlantic Sea Surface Temperature and Caribbean Trade Wind Speed

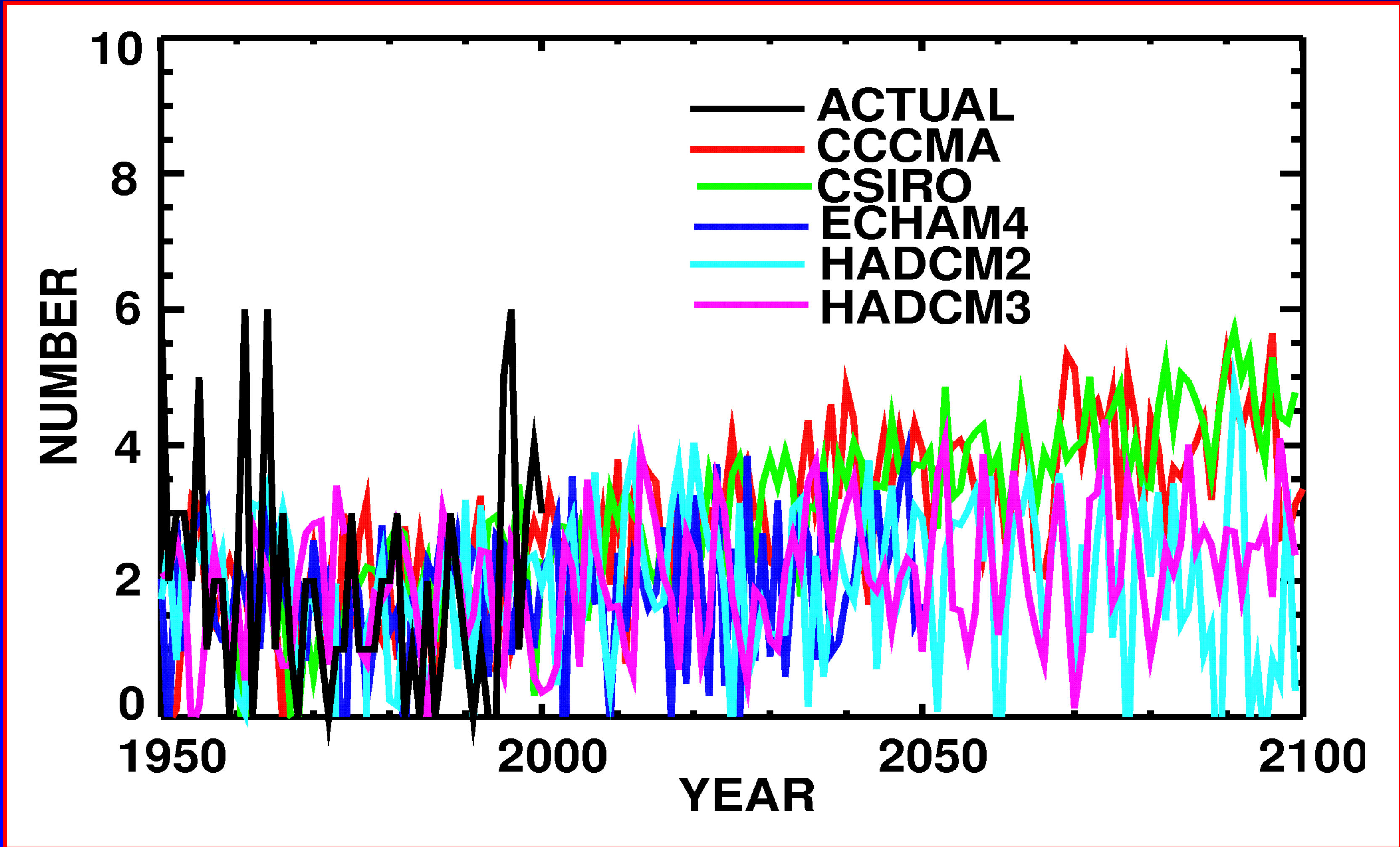
(Roberts and Saunders, 2001)

Future Projections for Tropical Atlantic, Caribbean and Gulf Hurricane Numbers



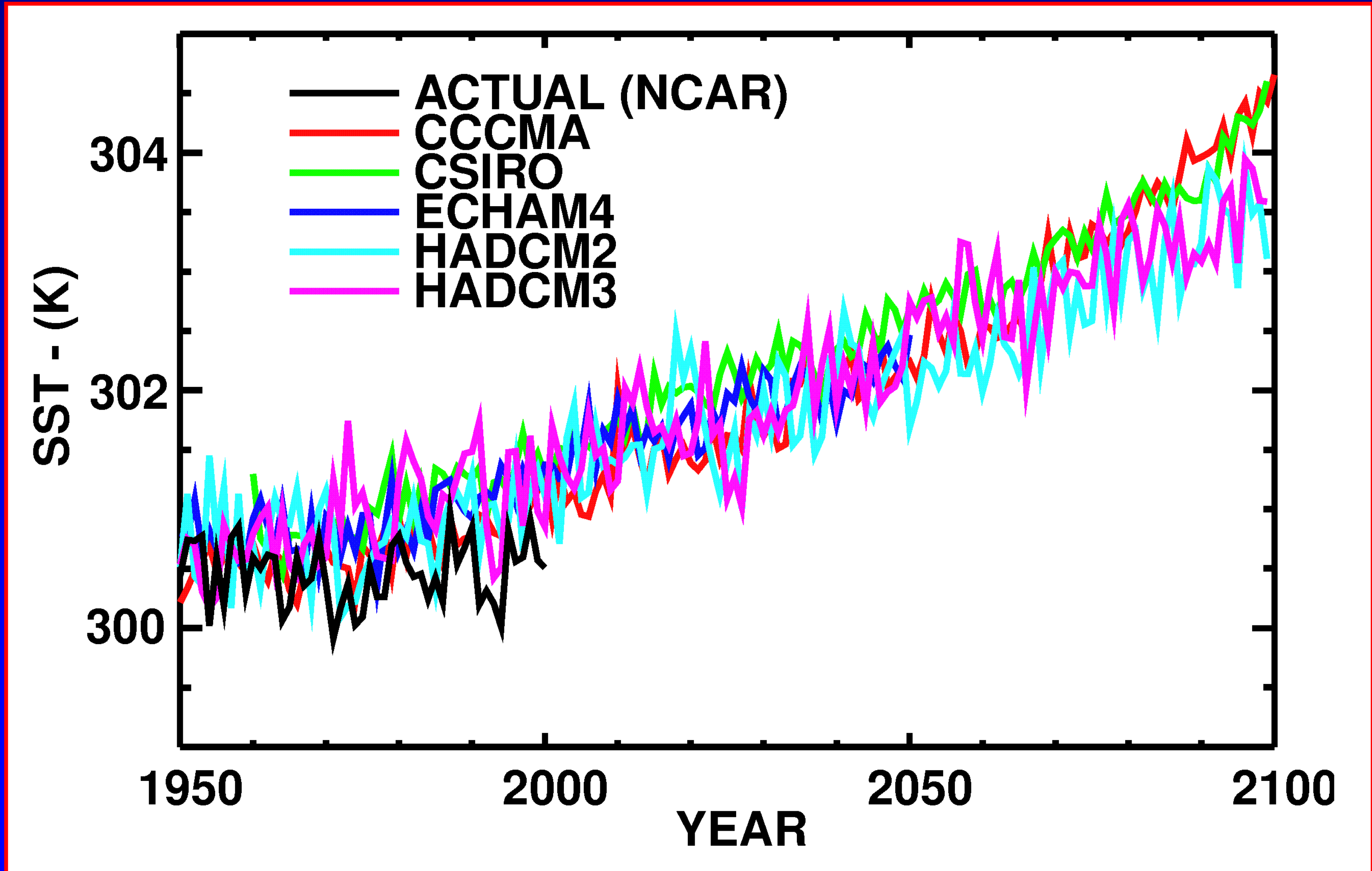
(Roberts and Saunders, 2001)

Future Projections for Tropical Atlantic, Caribbean and Gulf Intense Hurricane Nos



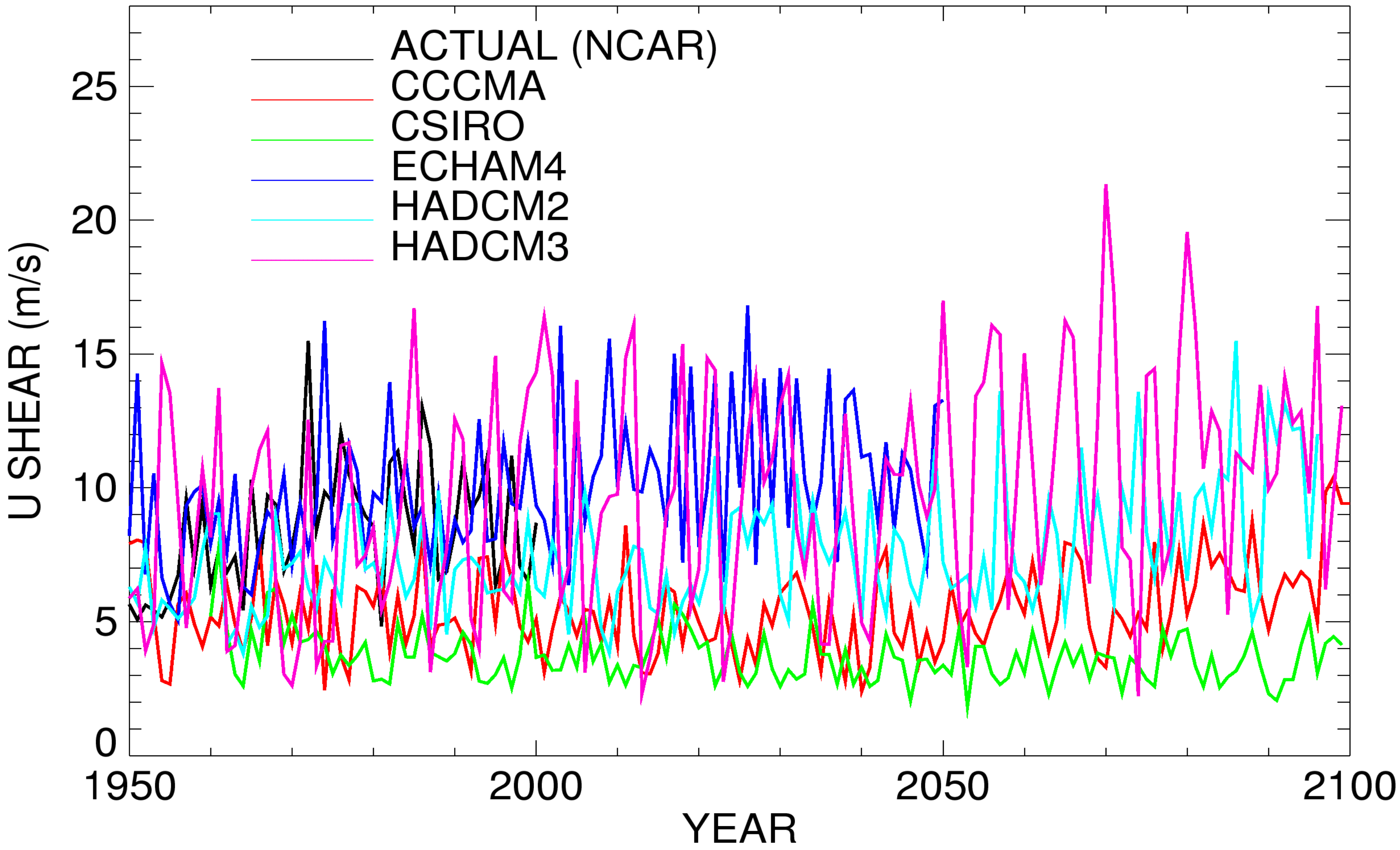
(Roberts and Saunders, 2001)

Future Projections for Tropical Atlantic SST



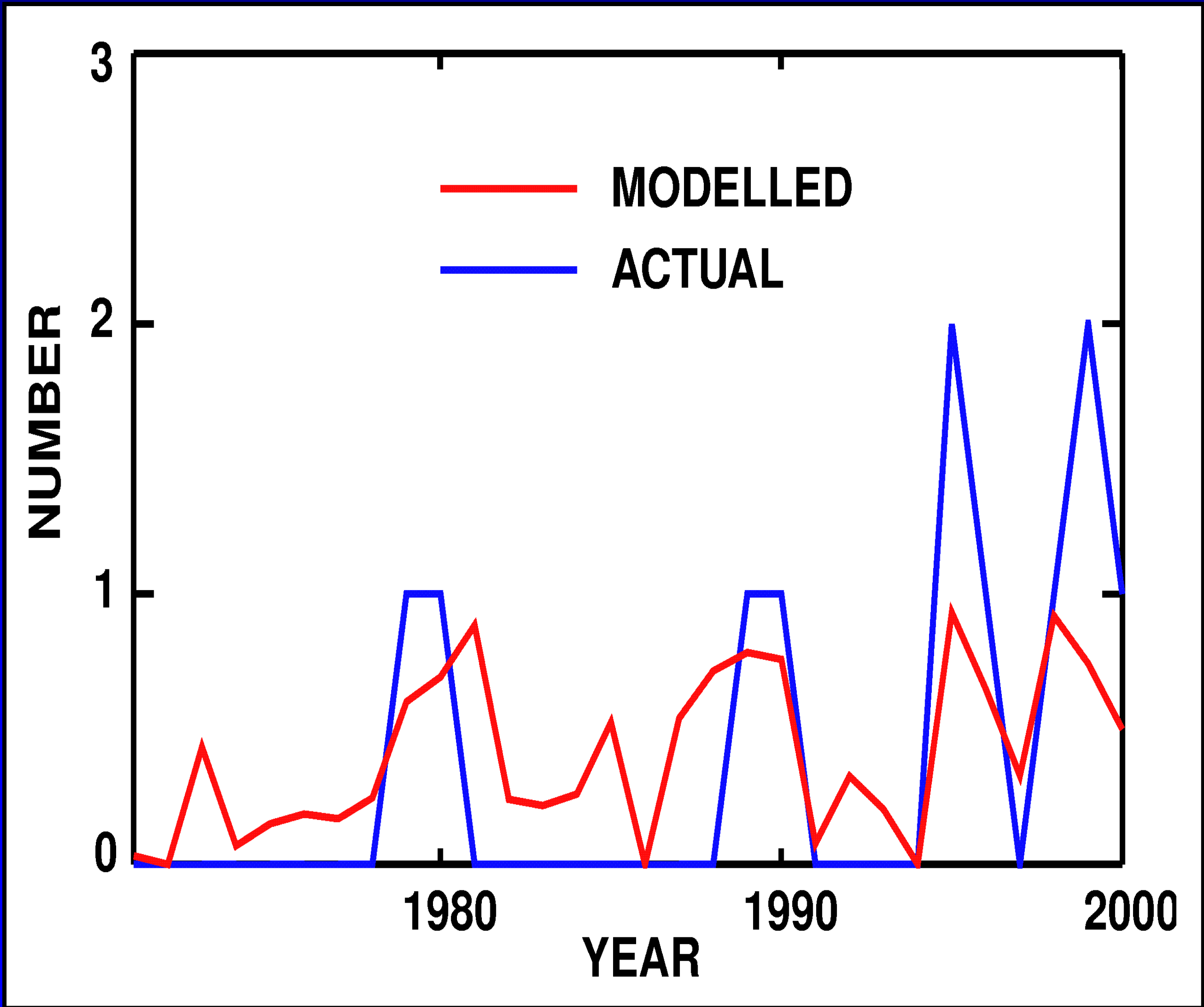
(Roberts and Saunders, 2001)

Future Projections for Tropical Atlantic Vertical Wind Shear



(Roberts and Saunders, 2001)

Lesser Antilles Landfalling Hurricane Numbers

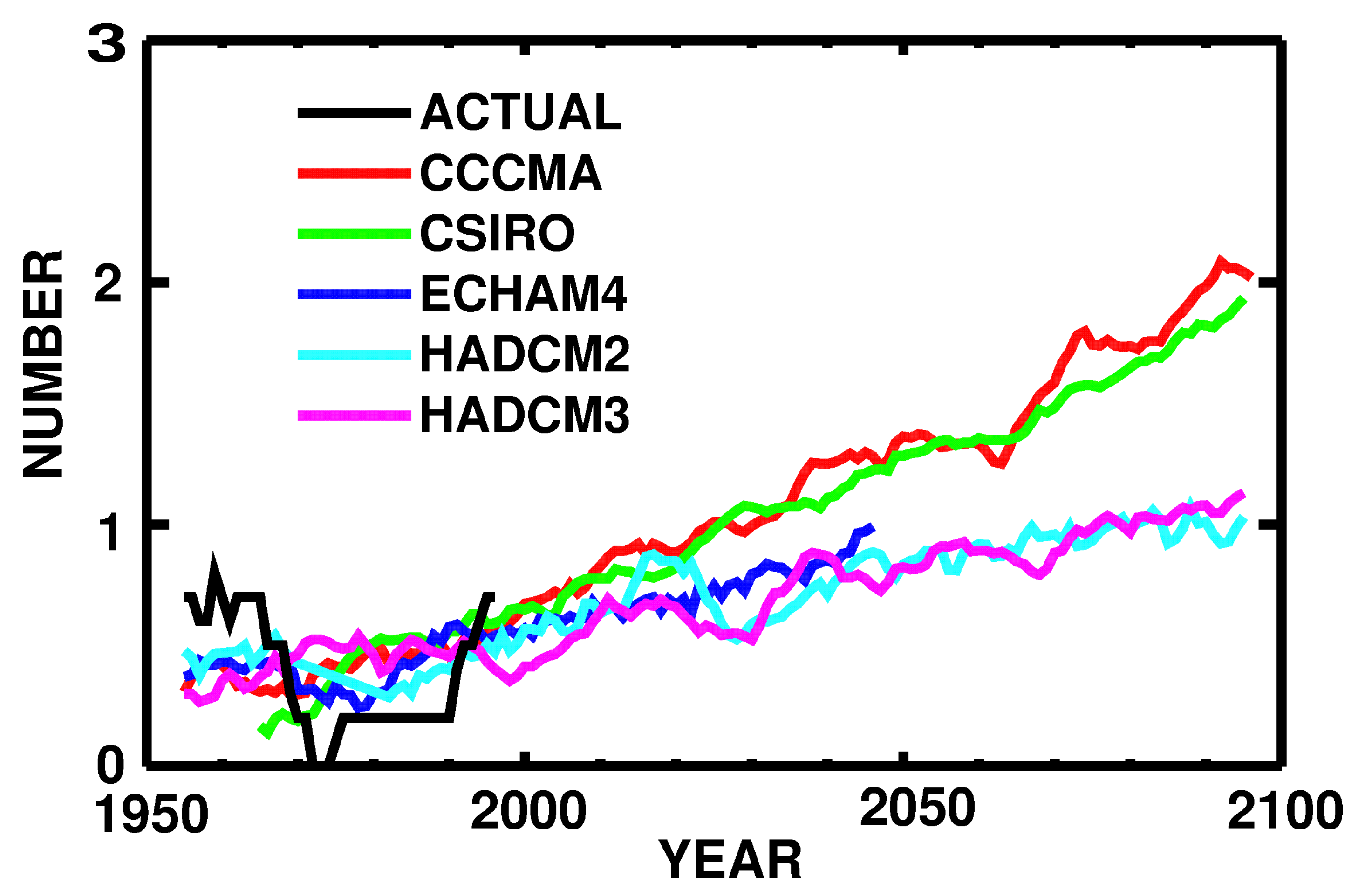


r = 0.72

Model Employs Thinning (24% Factor) From Tropical Atlantic Hurricane Numbers.

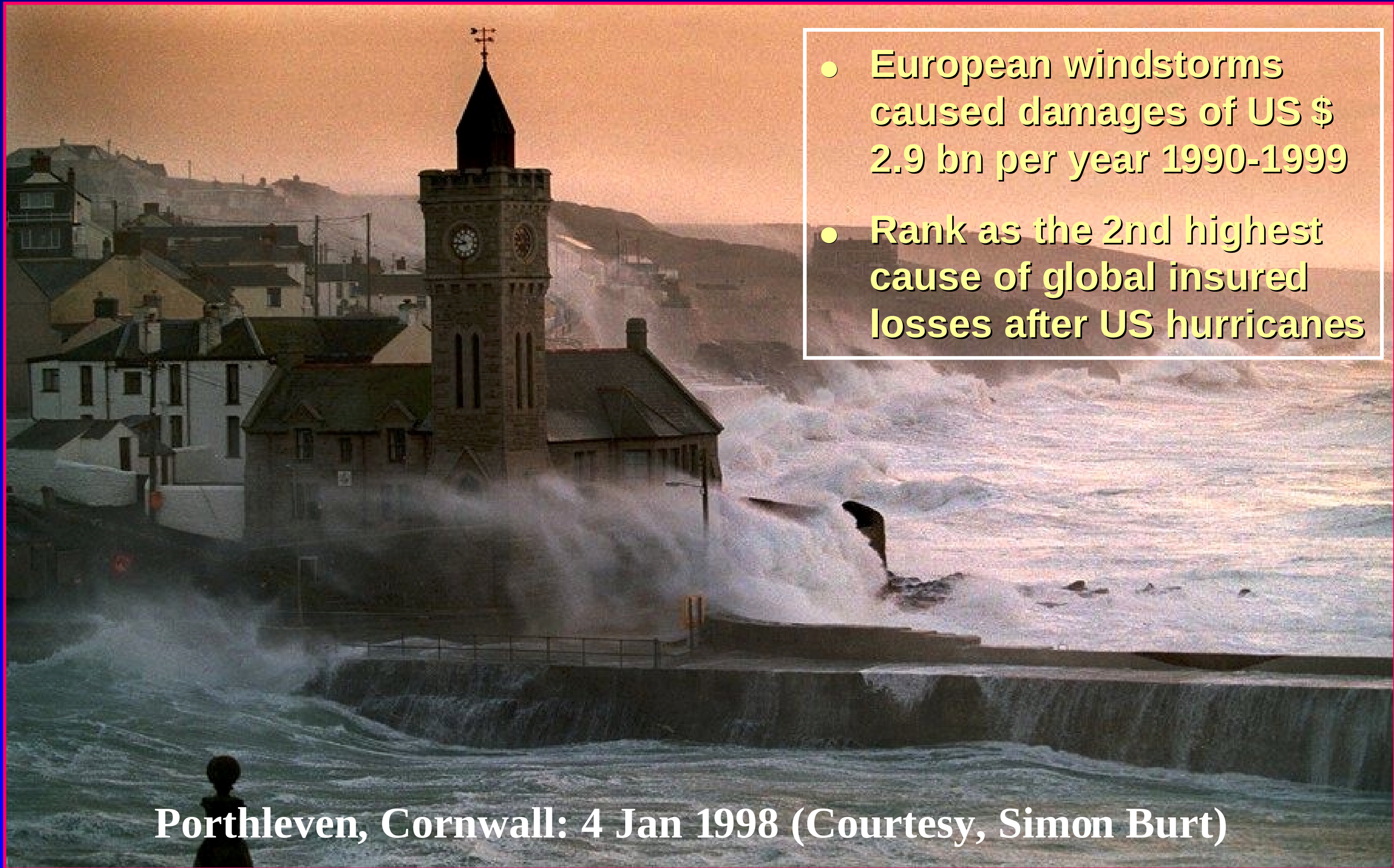
(Roberts and Saunders, 2001)

Future Projections for Lesser Antilles Hurricane Strikes



(Roberts and Saunders, 2001)

B. European Winter Storms



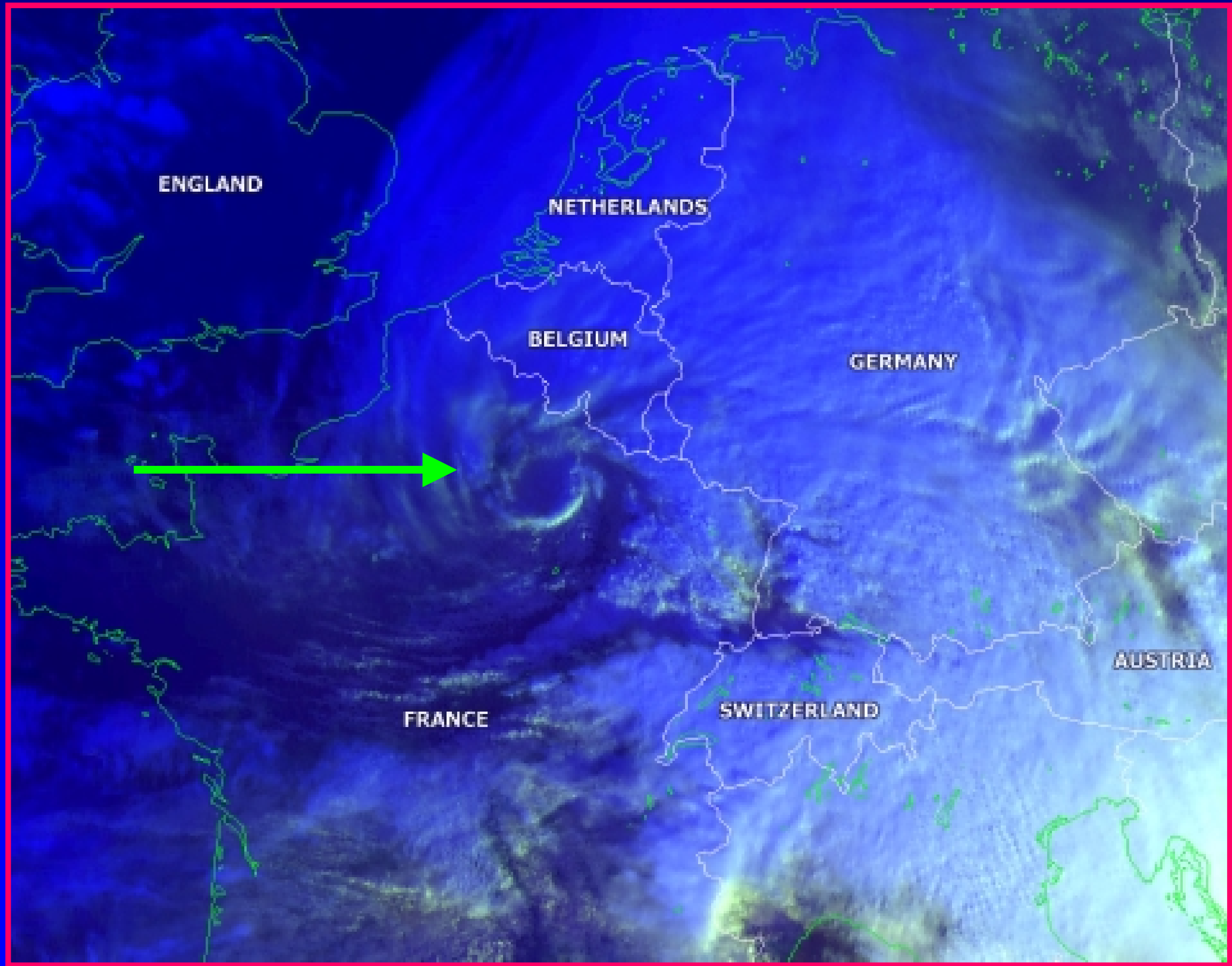
- European windstorms caused damages of US $ 2.9 bn per year 1990-1999
- Rank as the 2nd highest cause of global insured losses after US hurricanes

Porthleven, Cornwall: 4 Jan 1998 (Courtesy, Simon Burt)

Severe Storm Lothar

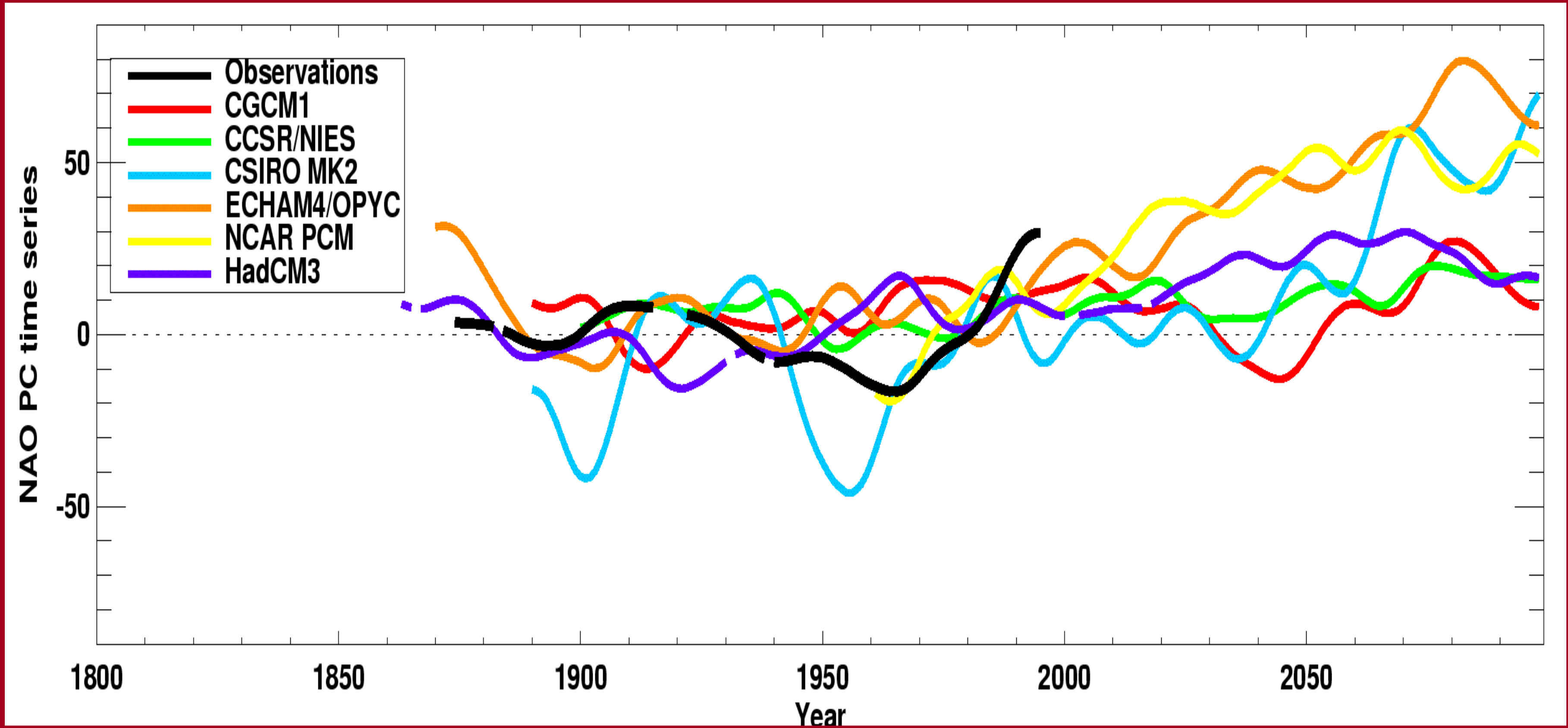
- Damage bill of US $ 9.0 billion
- Very deep depression (960 hPa) crossing north France at ~100 km/hr
- Wind gusts of over 170 km/hr
- Zone of very strong winds 150 km wide

26th Dec 1999, 07:32 UT NOAA-15



(Courtesy NOAA/NESDIS)

NAO Future Projections



(Figure Courtesy of Tim Osborn and Phil Jones, University of East Anglia)

- **Suggests slightly increased risk of stormy and wetter winters for UK and northern Europe during 21st Century**

Storm and ENSO Extremes

	Observed (20th Century)	Modeling (End of 21st Century)
Storm and El Niño Extremes		
More tropical storms	Unlikely	Possible
More intense tropical storms	Unlikely	Possible
More intense mid-latitude storms	Possible	Possible
More intense El Niño Events	Possible	Possible
More common El Niño-like conditions	Likely	Likely*

*No direct model analyses but expected based on other simulated model changes

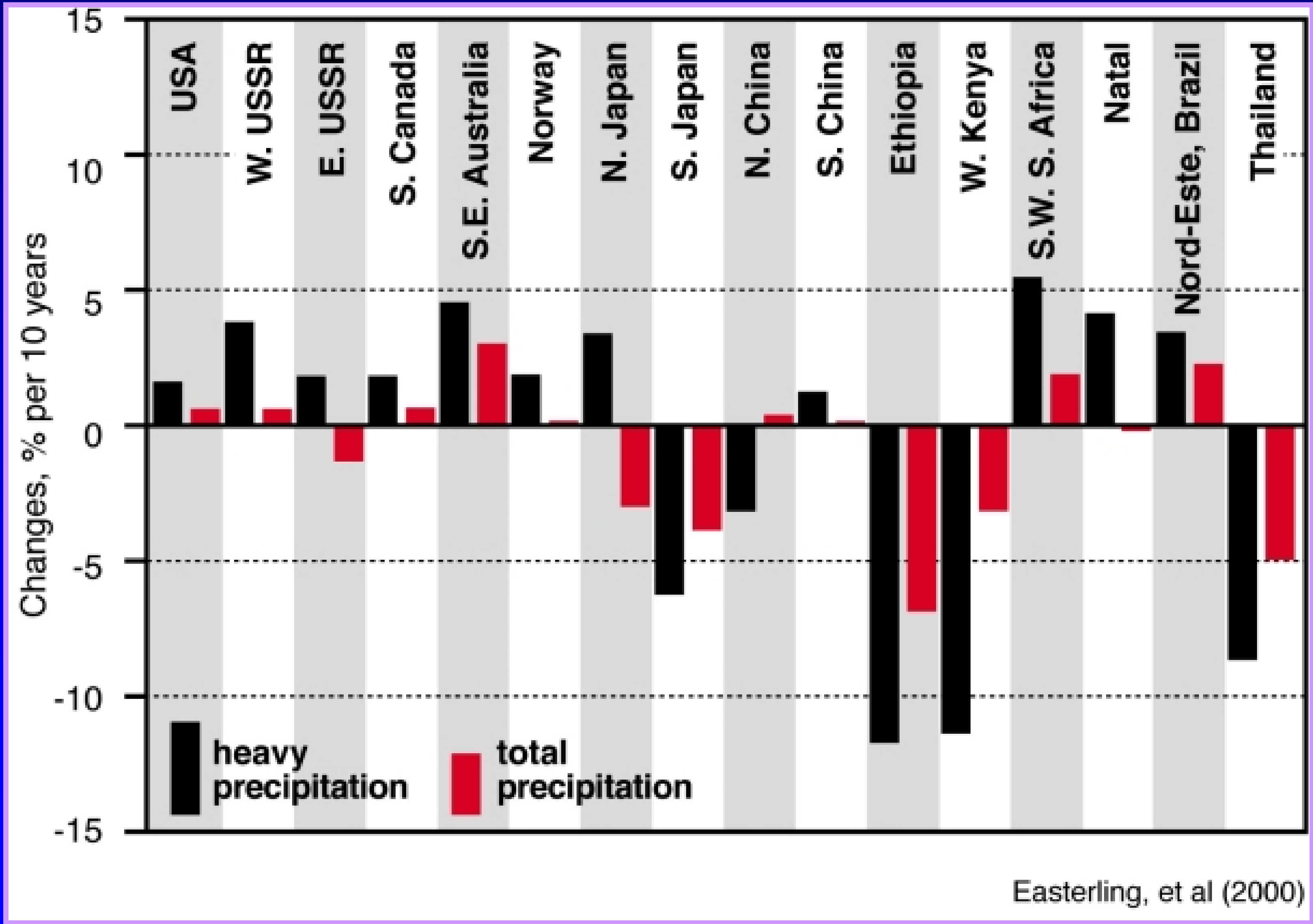
Probability Levels			
Virtually Certain	> 99%	Unlikely	10 to 33%
Very Likely	90 to 99%	Very Unlikely	1 to 10%
Likely	67 to 90%	Improbable	< 1%
Possible	33 to 66%		

C. Rainfall Extremes

Royal Leamington Spa
10th April 1998
(Courtesy News Team International)

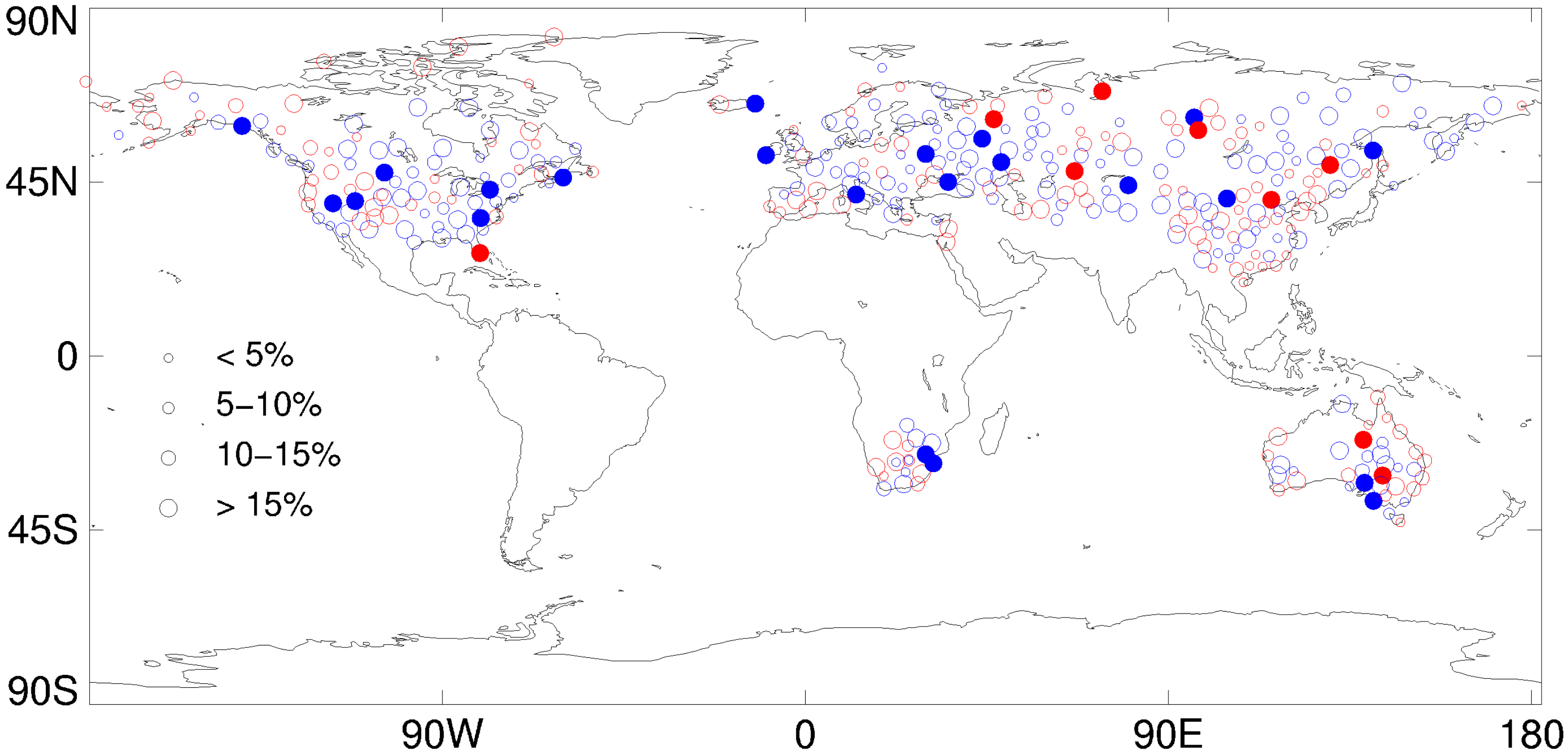
Cologne, January 1995
(Courtesy Munich Re.)

Trends in 20th Century Total and Heavy Rainfall for Various Countries



Trend in Heavy Precipitation

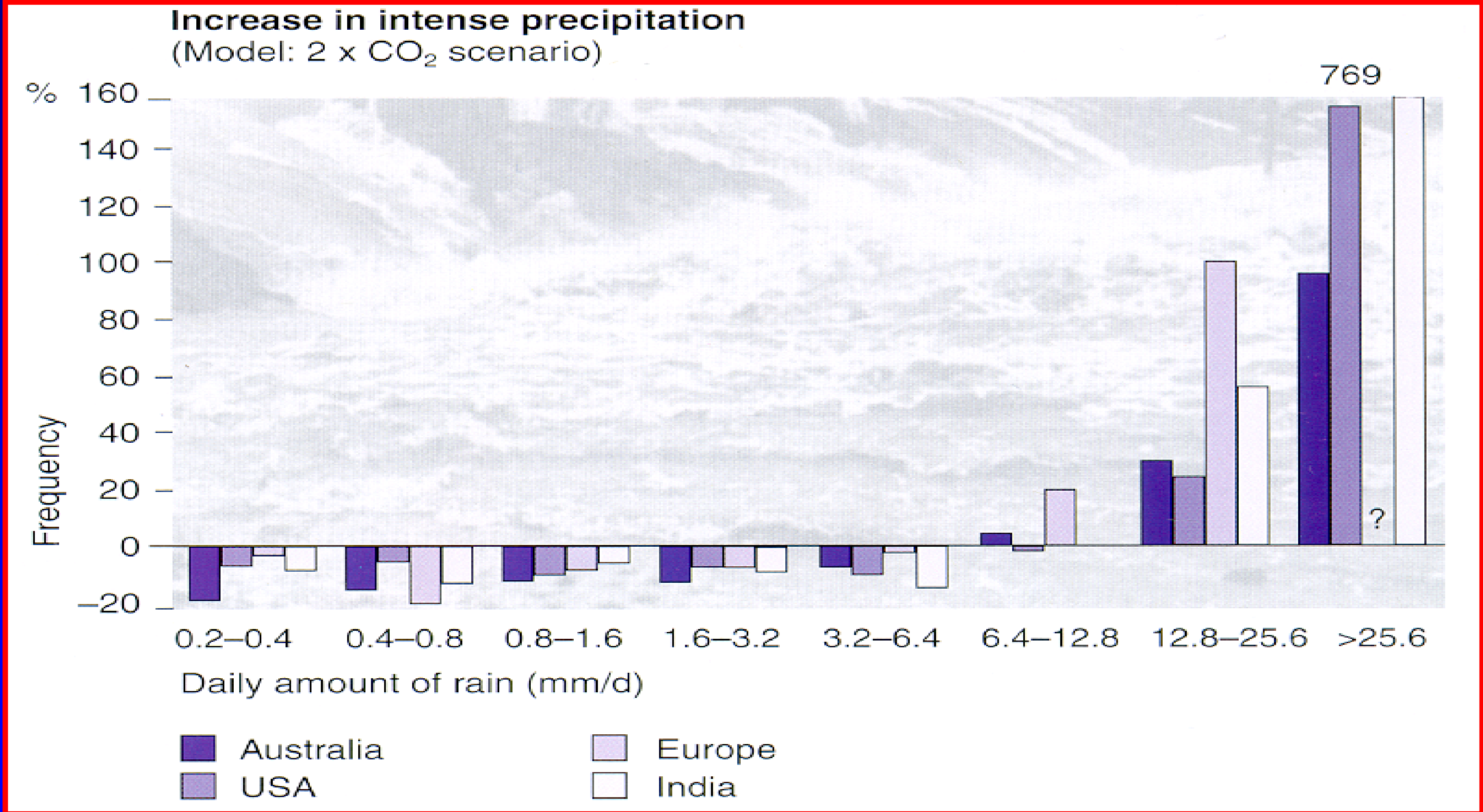
Slight upward trend 1950-1995 but generally not significant.



Blue is a positive change. Filled circles are significant at 95% level of confidence

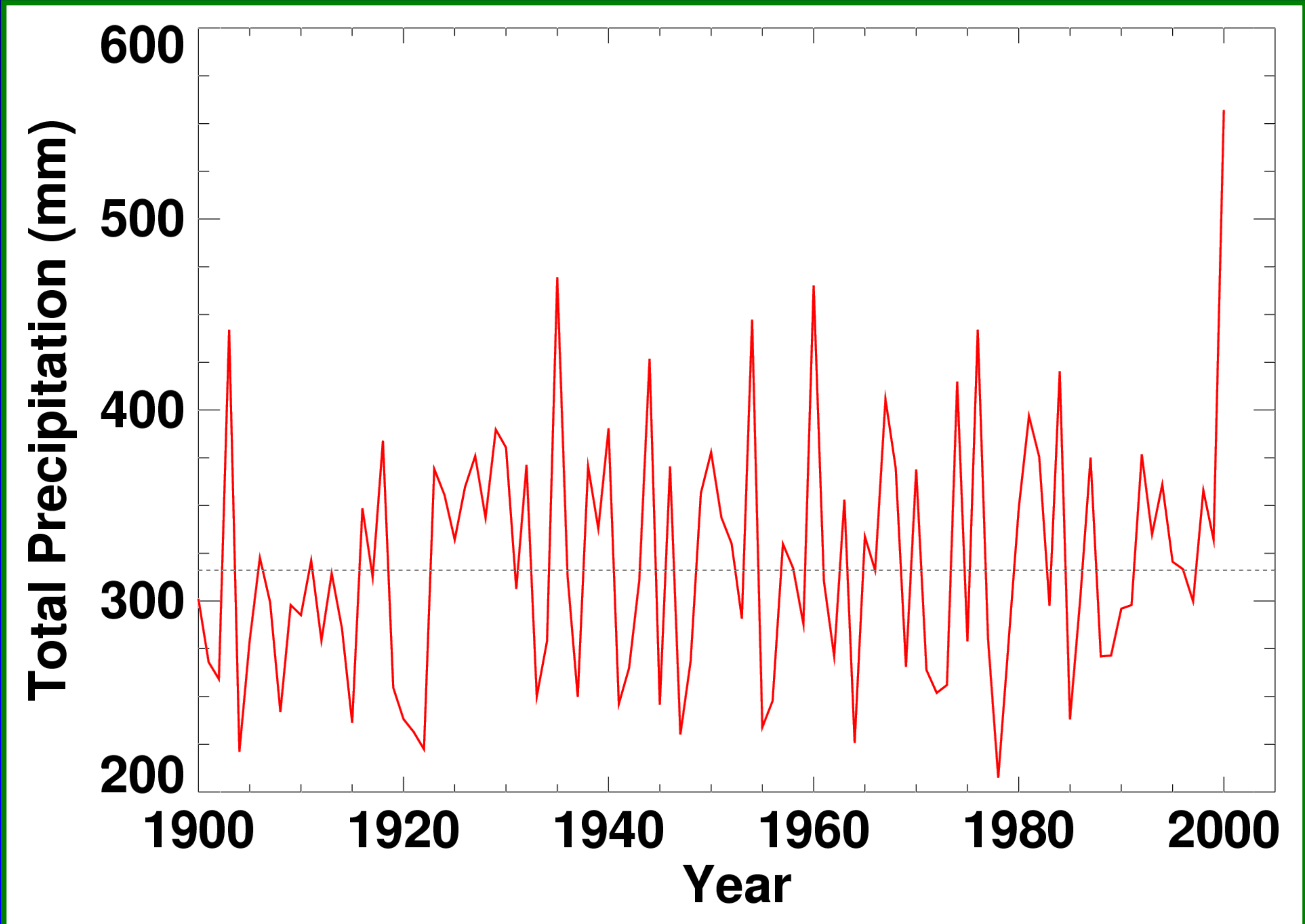
(Source: Frich et al., in press, 2001)

Prediction for Rainfall Extremes

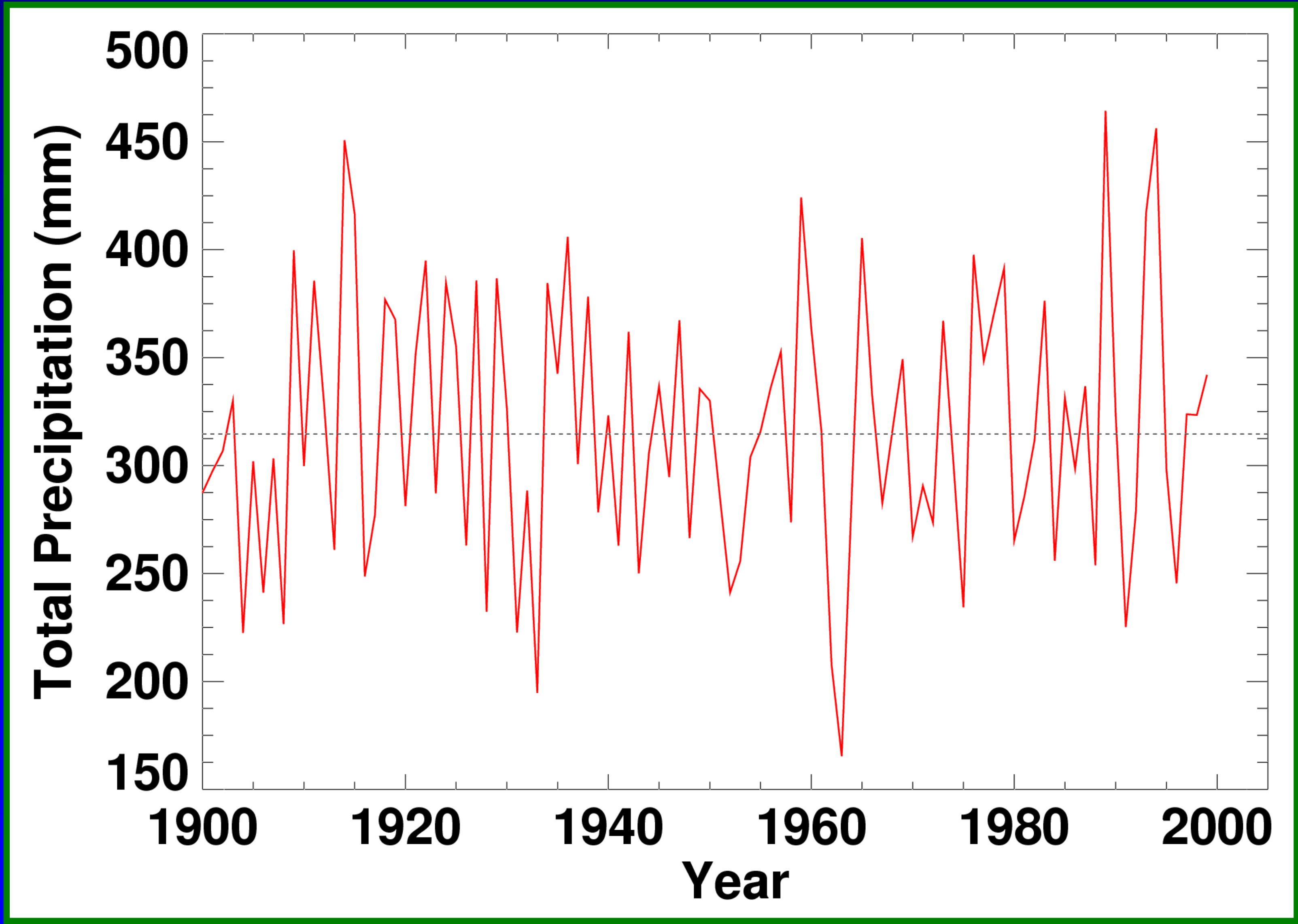


(Courtesy Gordon et al., 1992)

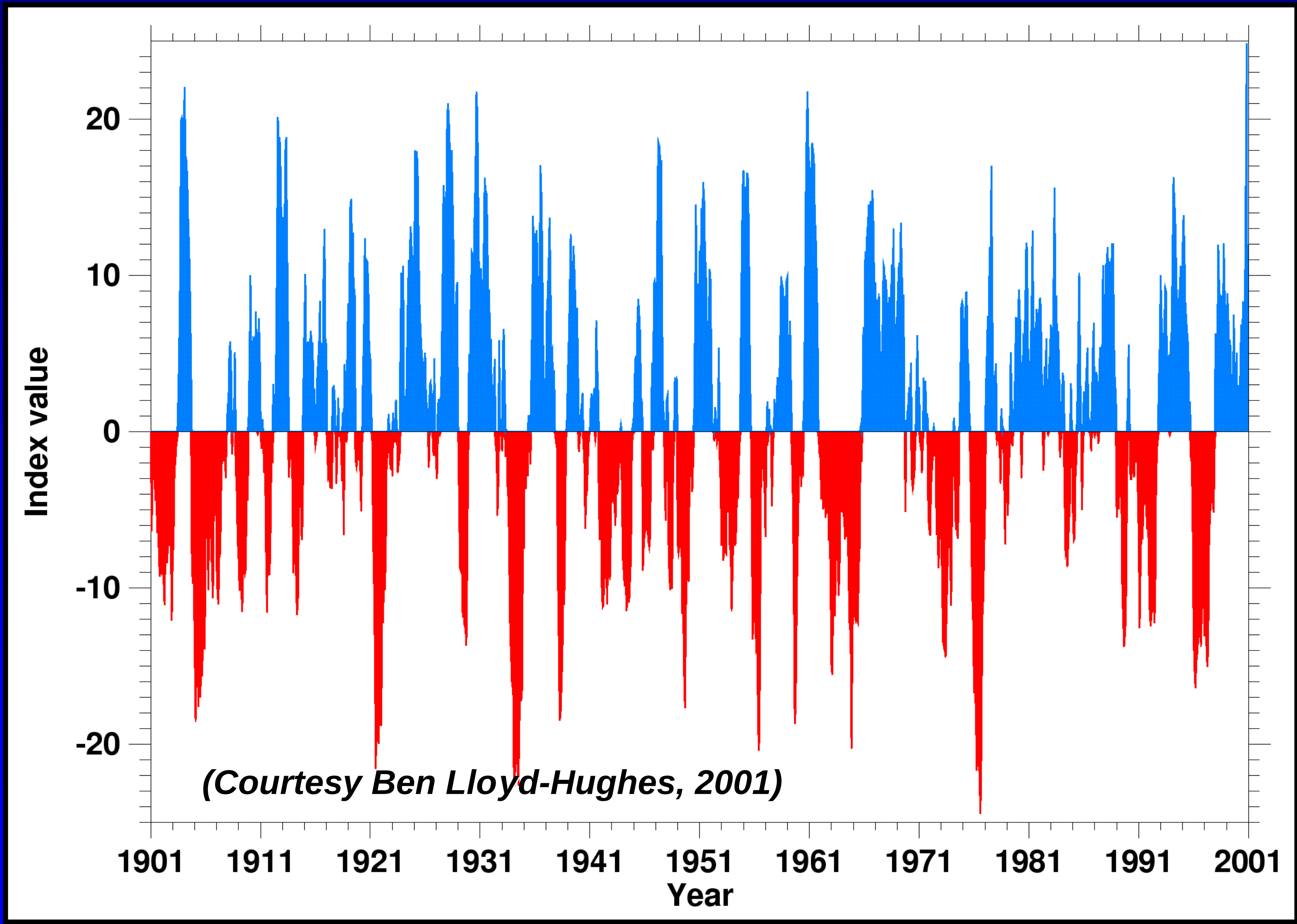
England and Wales Autumn Precipitation 1901-2000



England and Wales Winter Precipitation 1900/01-1999/00



England and Wales Drought Index 1901-2000



Precipitation Extremes

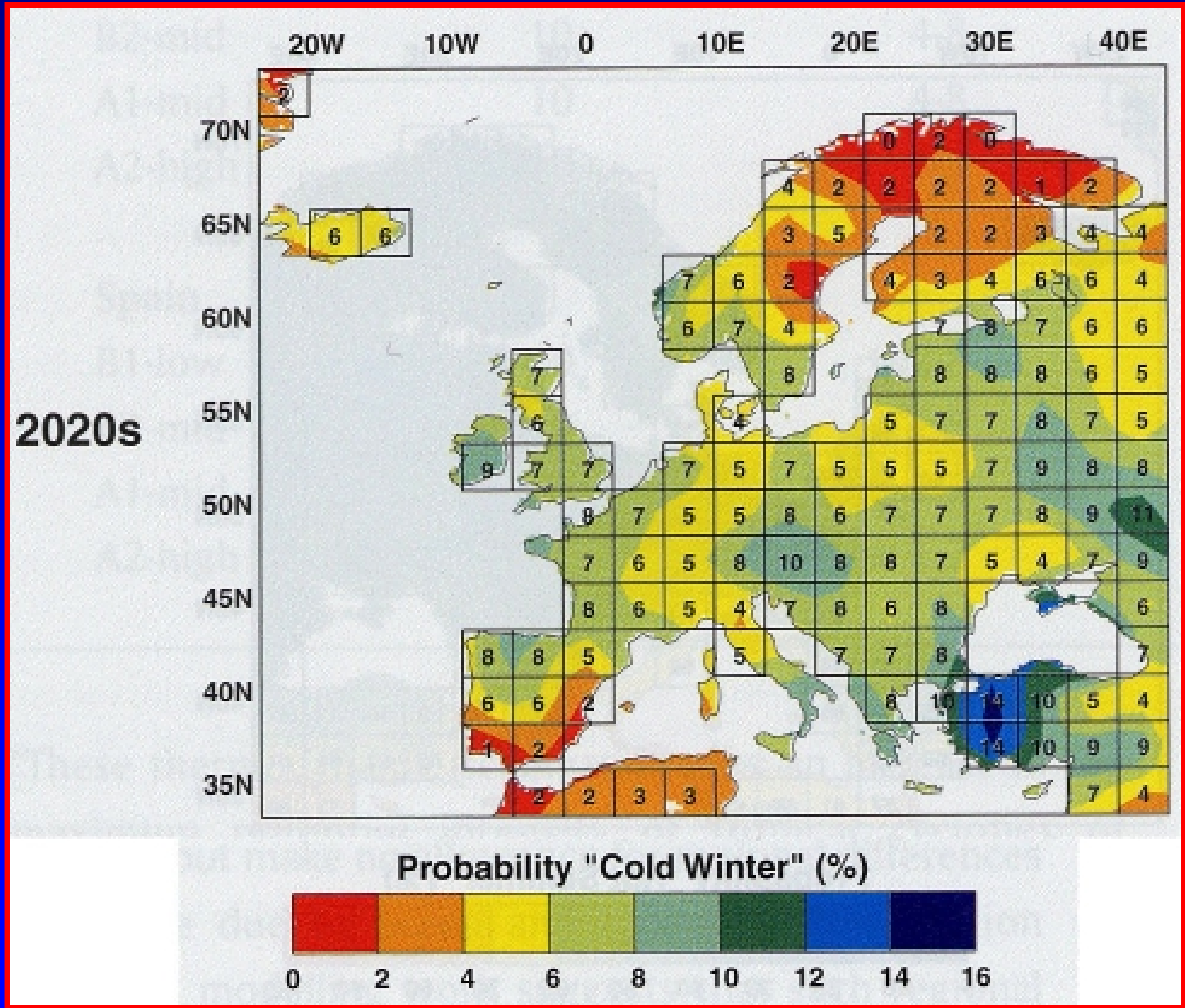
	Observed (20th Century)	Modeling (End of 21st Century)
Precipitation Extremes		
More heavy 1-day precipitation events	Likely	Very Likely
More floods	Likely	Very Likely
More droughts	Unlikely	Likely

Probability Levels			
Virtually Certain	> 99%	Unlikely	10 to 33%
Very Likely	90 to 99%	Very Unlikely	1 to 10%
Likely	67 to 90%	Improbable	< 1%
Possible	33 to 66%		

Probability of a 'Cold' Winter in the 2020s

Europe ACACIA Project (2000)

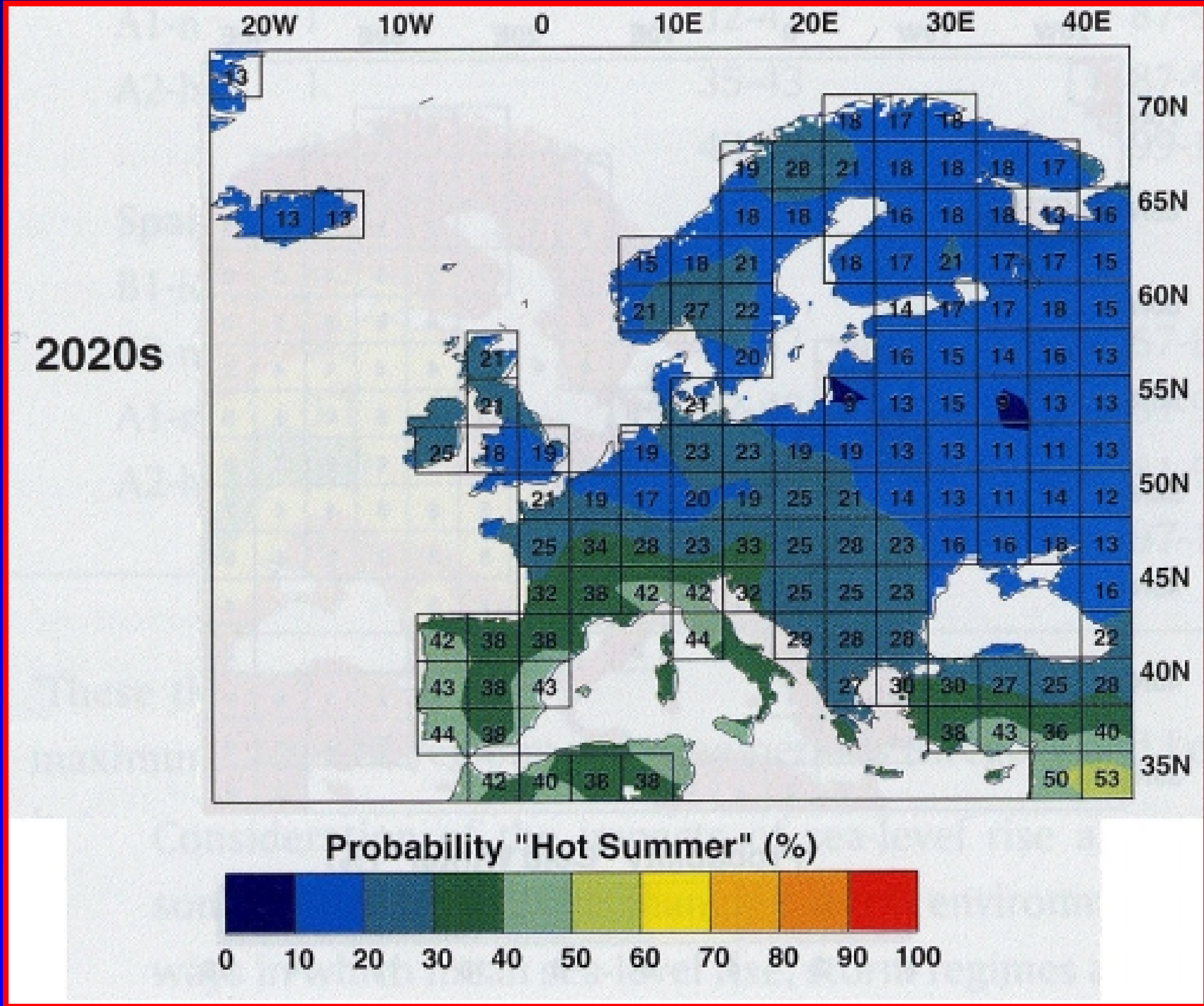
B1-Low Scenario



Probability of a 'Hot' Summer in the 2020s

Europe ACACIA Project (2000)

B1-Low Scenario



Temperature Extremes

	Observed (20th Century)	Modeling (End of 21st Century)
Temperature Extremes		
Higher maximum temperatures	Very Likely	Very Likely
More hot summer days	Likely	Very Likely
Higher minimum temperatures	Virtually Certain	Very Likely
Fewer frost days	Virtually Certain	Likely*
More heat waves	Possible	Very Likely*
Fewer cold waves	Very Likely	Very Likely*
*No direct model analyses but expected based on other simulated model changes		

Probability Levels			
Virtually Certain	> 99%	Unlikely	10 to 33%
Very Likely	90 to 99%	Very Unlikely	1 to 10%
Likely	67 to 90%	Improbable	< 1%
Possible	33 to 66%		

5. Conclusions - Global

- The concern that climate change will slowly increase the number of extreme events is justified for floods, droughts and heatwaves.
- For other extremes (including Atlantic hurricanes and European windstorms) the situation is unclear and trends could be small.
- The majority of future changes in climate extremes affecting the (Re)Insurance Industry will continue to result from natural interannual and decadal variability.

5. Conclusions - Caribbean

- Lesser Antilles Hurricane Strikes - upward trend appears likely.
- Caribbean Rainfall - winter increase but overall annual decrease.
- Increased risk of Heatwaves.
- Sea level to rise by 0.4±0.2 m.
- The majority of future changes in climate extremes affecting the (Re)Insurance Industry will continue to result from natural interannual and decadal variability.