WATER RESOURCES AND CLIMATE CHANGE

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Water: Source of Life, Food and Fiber

Water, At Times, Brings Miseries Too.

Hurricane Katrina (Sept. 2005)

Kenya Drought (Spring 2006)

China Drought (Spring 2010)

City of Multan (Aug. 2010)

CLIMATE CHANGE

Climate Change

"the greatest challenge facing the world at the beginning of the century."

World Economic Forum
Davos, Switzerland 2000
(www.weforum.org/)

"the most important long-term issue which we face as a global community".

Jack Straw,
British Foreign Secretary
(Daily NEWS 15 May 2004)

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Climate Change: Some Definitions

Weather: The state of the atmosphere at a given time and place, with respect to the variables, such as temperature, moisture, pressure, etc.

Climate: Average weather. Statistical description of mean weather conditions over a period of several years, typically 2-3 decades.

Climate Change: Climate Change in excess of natural variability, attributable to human activity.

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IMPACTS OF CLIMATE CHANGE

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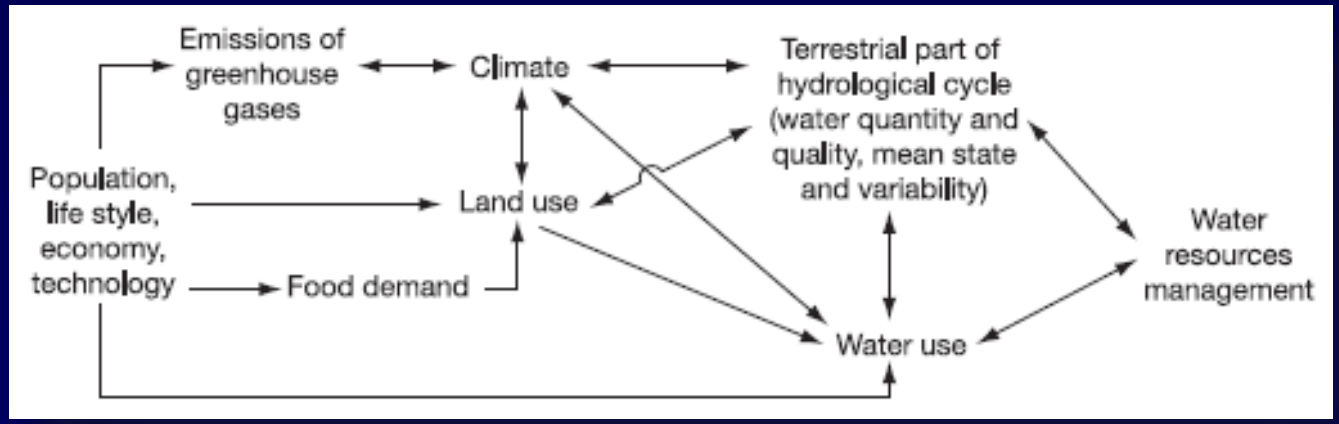
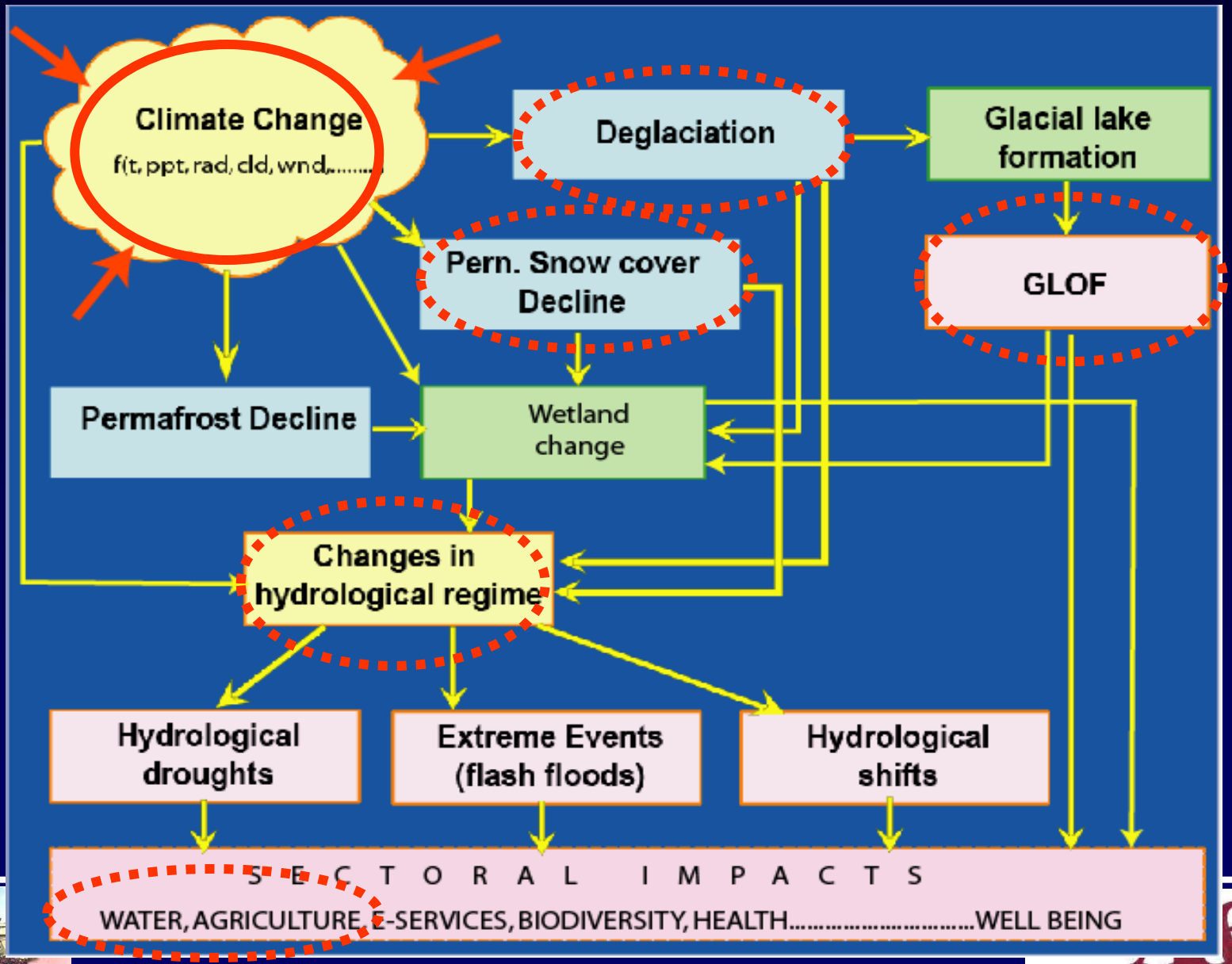
Climate Change Impacts on Hydrology

- Intensification of the hydrological cycle
  - More floods and droughts
  - More variability in rainfall
  - Shorter snowfall season
  - Early spring snowmelt earlier
  - Accelerated glacial melting
    - **May affect water availability, water quality, ecosystems, etc.**



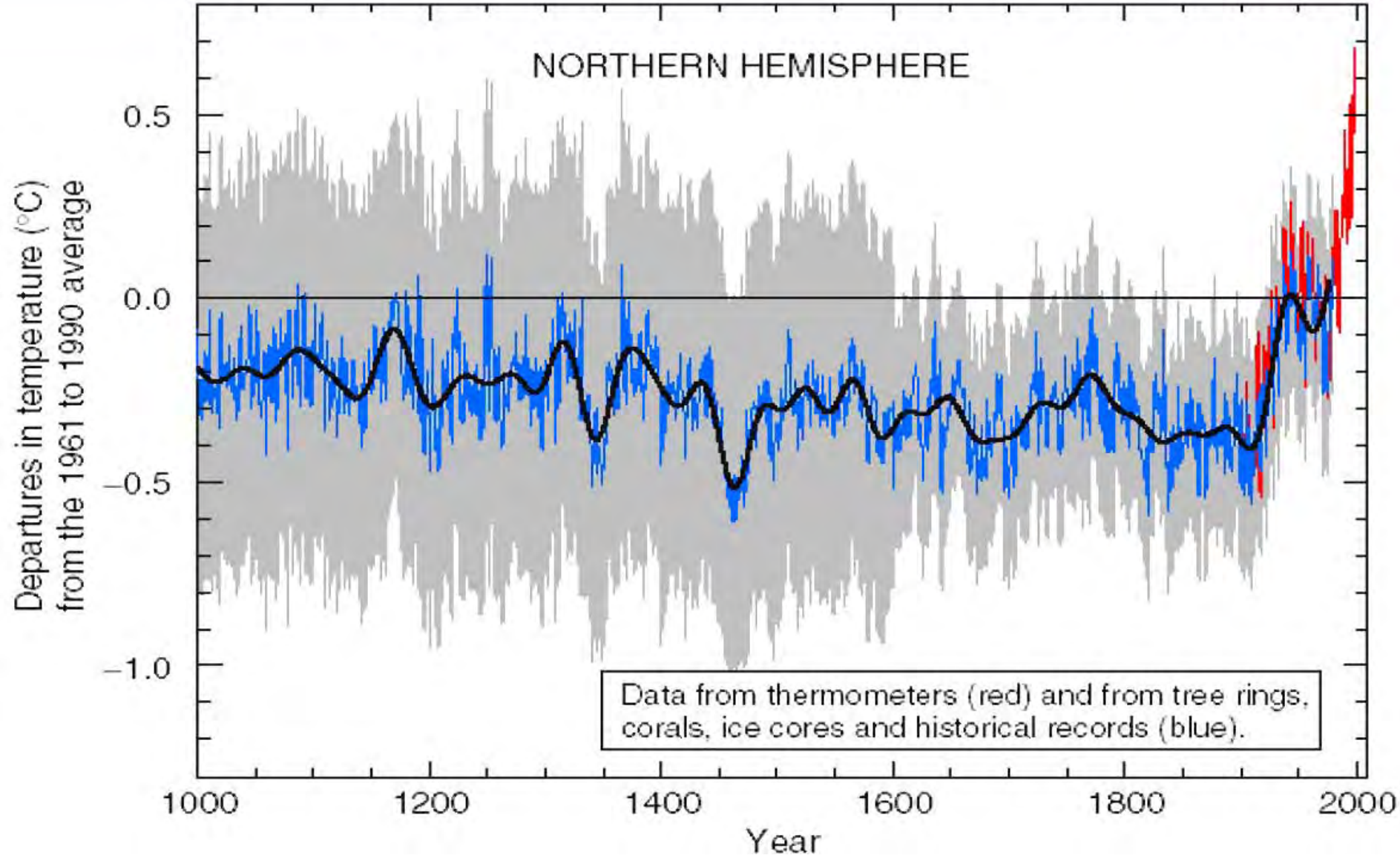
IPCC (2007) Freshwater Resources and their Management

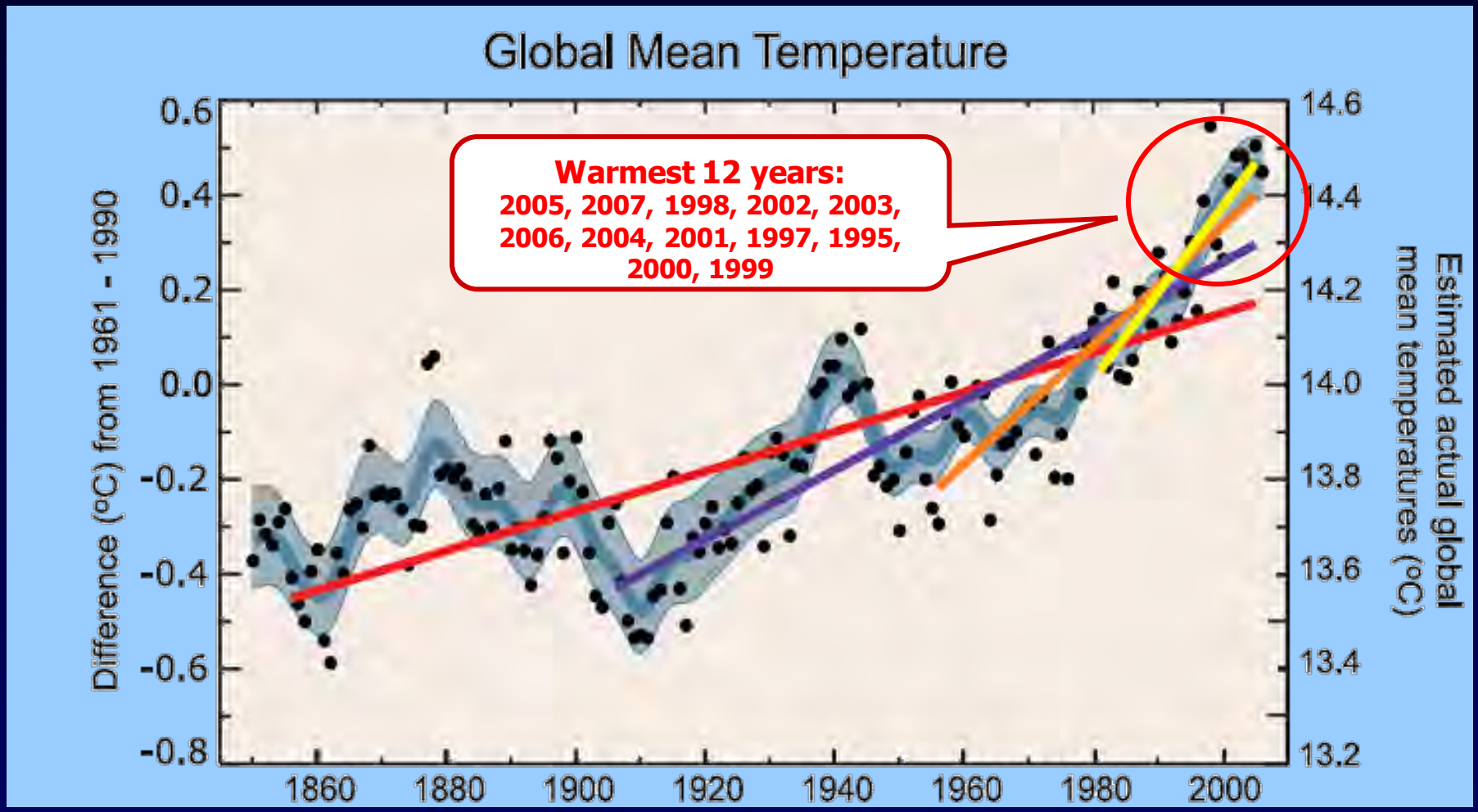
Climate Change and Water



Some Major Findings of IPCC Fourth Assessment Report (AR4), 2007

- 0.6 ^{0} C increase in average global temperature during the last century (11 of last 12 years being warmest since 1850, with 1998 being on top.)
- Increase by 1.1-6.4 ^{0} C projected over the 21st Century, with most likely range being 1.8-4.0 ^{0} C ;
- Associated to this will be large changes (both, increases and decreases) of temperature and precipitation in different world regions;
- Frequency and intensity of extreme climatic events (severe cyclonic storms, floods, droughts etc.) will increase considerably;
- Large scale melting of mountain glaciers and polar ice caps, particularly the Arctic;
- Substantial rise in sea level.


NORTHERN HEMISPHERE
0.5
0.0
−0.5
−1.0
Departures in temperature (°C)
from the 1961 to 1990 average
Data from thermometers (red) and from tree rings,
corals, ice cores and historical records (blue).
1000
1200
1400
1600
1800
2000
Year

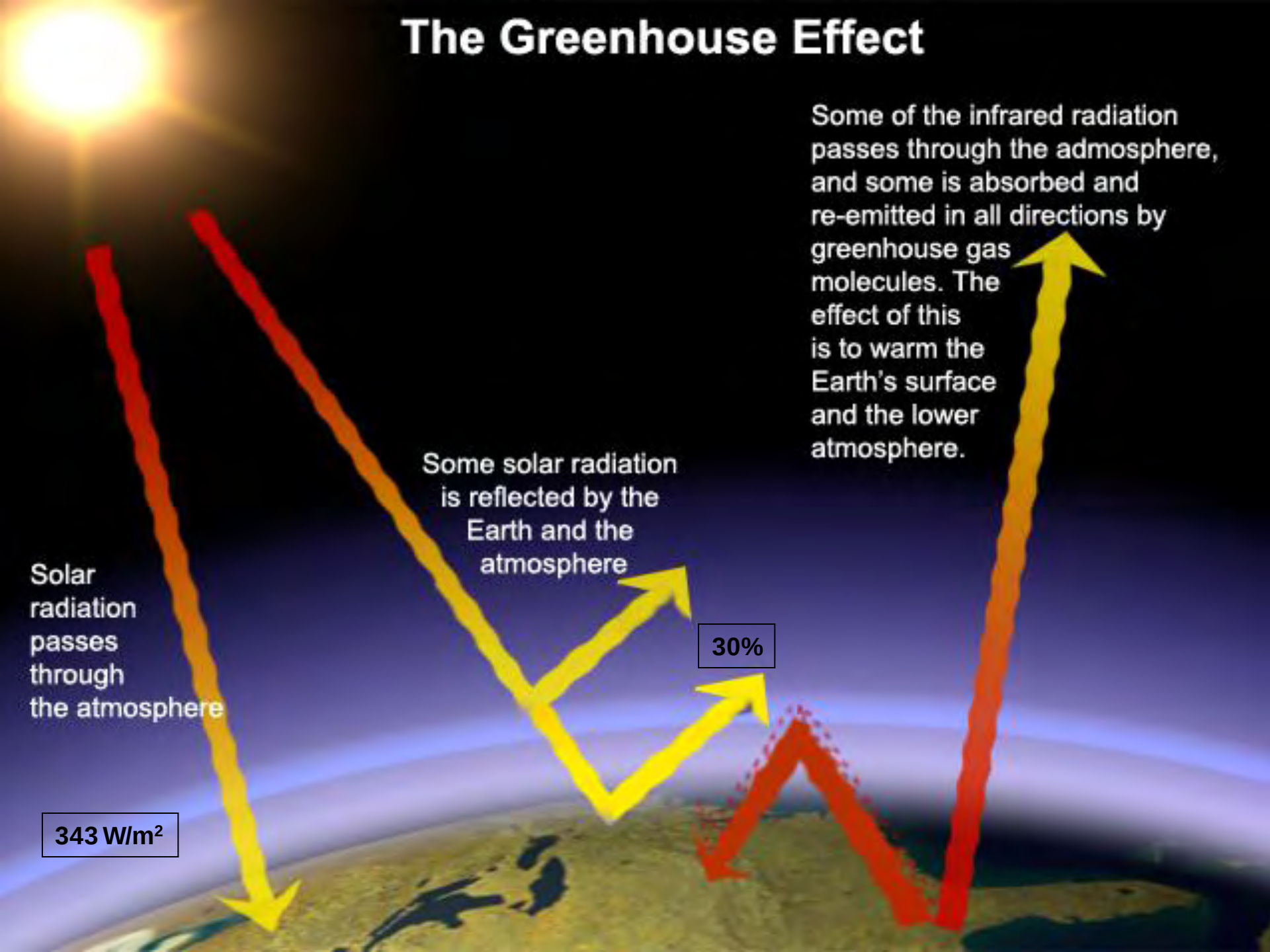


Rate of Change (°C per decade)

1850 – 2005	0.045
1905 – 2005	0.074
1955 – 2005	0.128

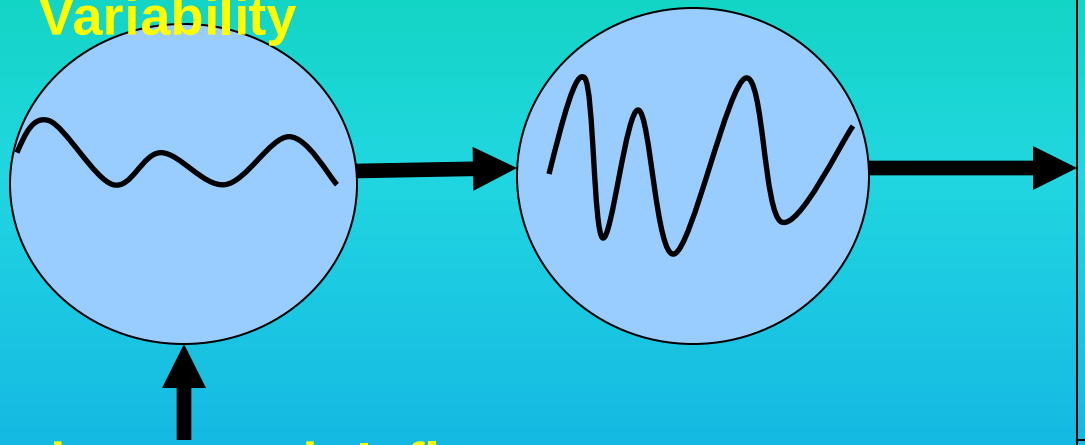
Average Global Temperature °C

1999	14.38
2000	14.40
1995	14.48
⋮	
1998	14.57
2007	14.60
2005	14.63

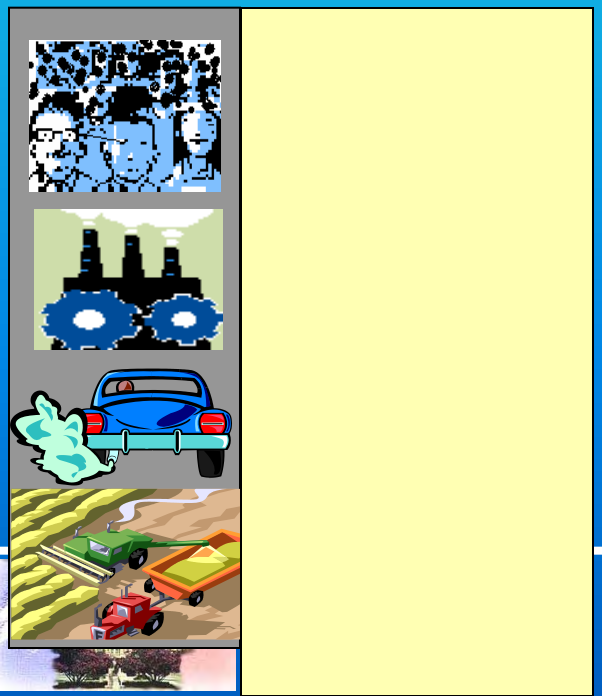

The Greenhouse Effect
Some of the infrared radiation passes through the admosphere, and some is absorbed and re-emitted in all directions by greenhouse gas molecules. The effect of this is to warm the Earth's surface and the lower atmosphere.
Some solar radiation is reflected by the Earth and the atmosphere
Solar radiation passes through the atmosphere
30%
343 W/m²

Natural Climate Variability

Climate Change
Natural + Anthropogenic



Anthropogenic Influences since the Industrial revolution



CLIMATE CHANGE

Global Warming

Increased Precipitation & its Uneven Distribution

Melting of Glaciers & Snow

Sea level Rise

Increase in Frequency & Intensity of Extreme Weather Events

IMPACTS

Uncertainty in Water Availability

Decrease in Crop Yields

Newer perspective for sources of energy

Loss of Biodiversity

Increased Health Risks

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Global Response

- Climate Change is being addressed by several national research programs in all developed countries:
- A number of developing countries are also actively pursuing climate change research, e.g.
  - **In South Asia region, India has some 20 establishments and Bangladesh, Nepal and Sri Lanka are also engaged in CC research;**
  - **China has a large number of establishments engaged in CC research.**

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Climate Change: Challenges

- Water Challenge
- Food Security challenge
- Climate Extreme Event Hazards
- Impacts on Ecosystems

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Climate Change Impacts

Freshwater availability

Freshwater Storage

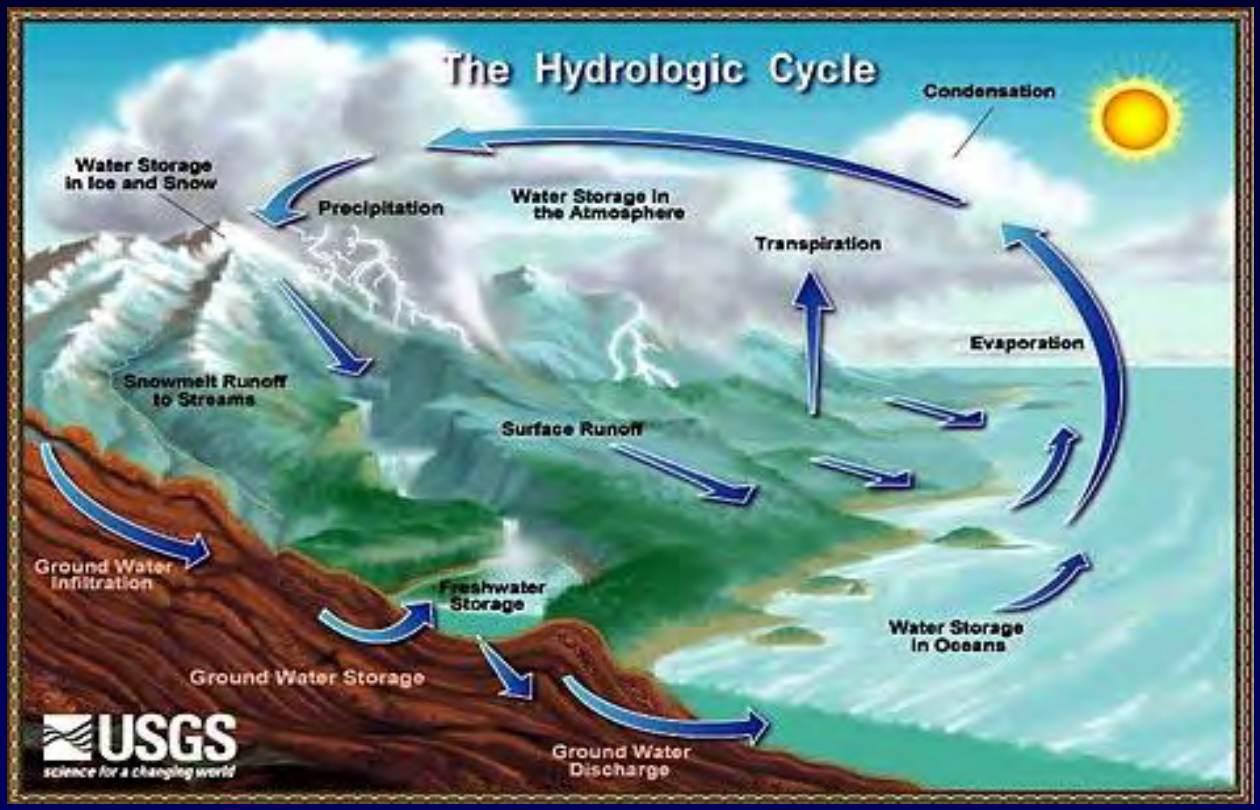
Rainfall Variability

Runoff Variability

Flow Variability

Extreme Events: Floods and Droughts

Limited Fresh-Water!



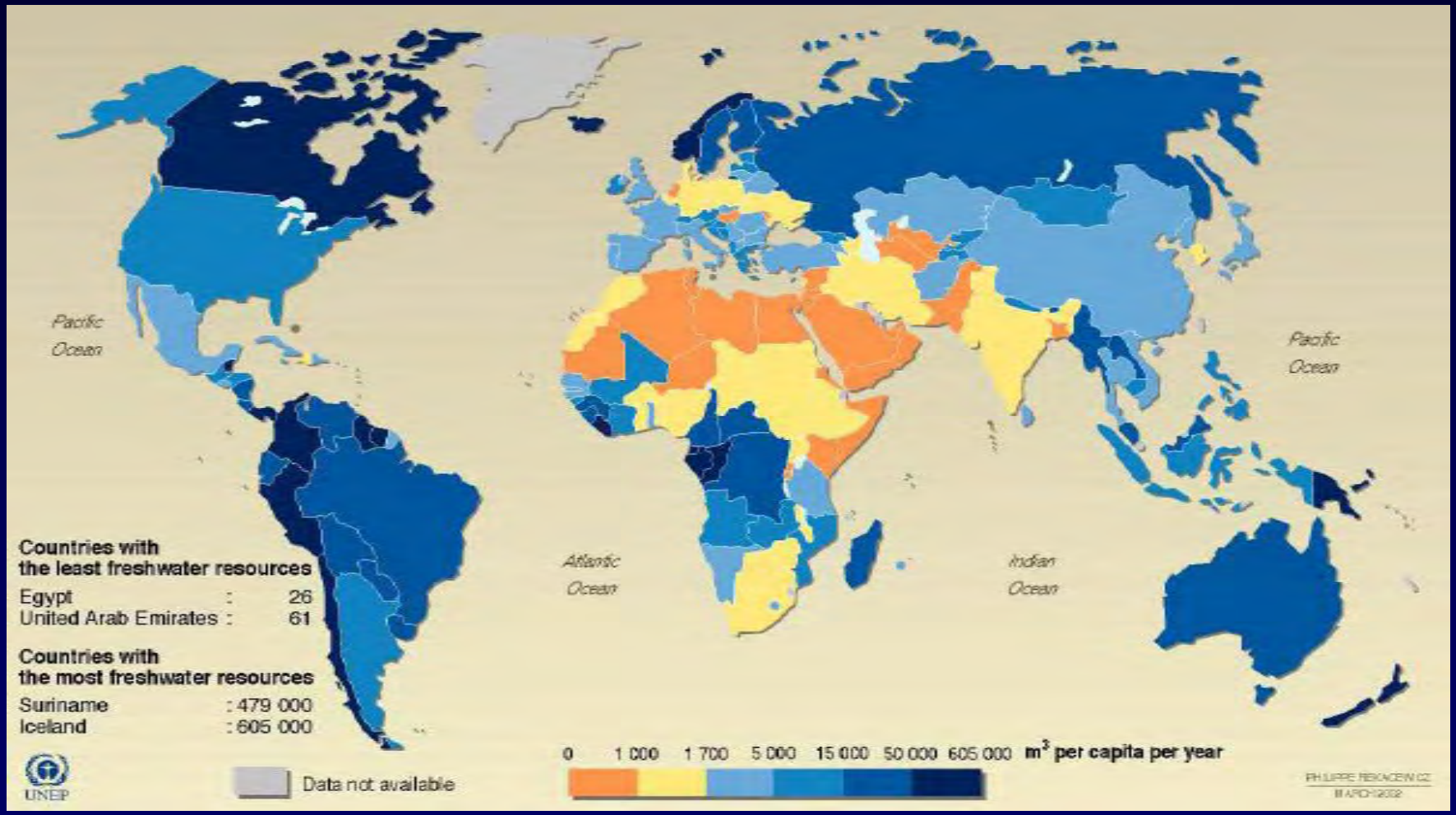
Total water: 1,400 mn cukm

- **97% saline**
- **2.5% fresh (35 million cubic kilometers)**
- **Only 0.8% usable (12 mn cukm)**
- **1/3 of this is too polluted (8 mn cukm)**

Freshwater: 42 mn cukm

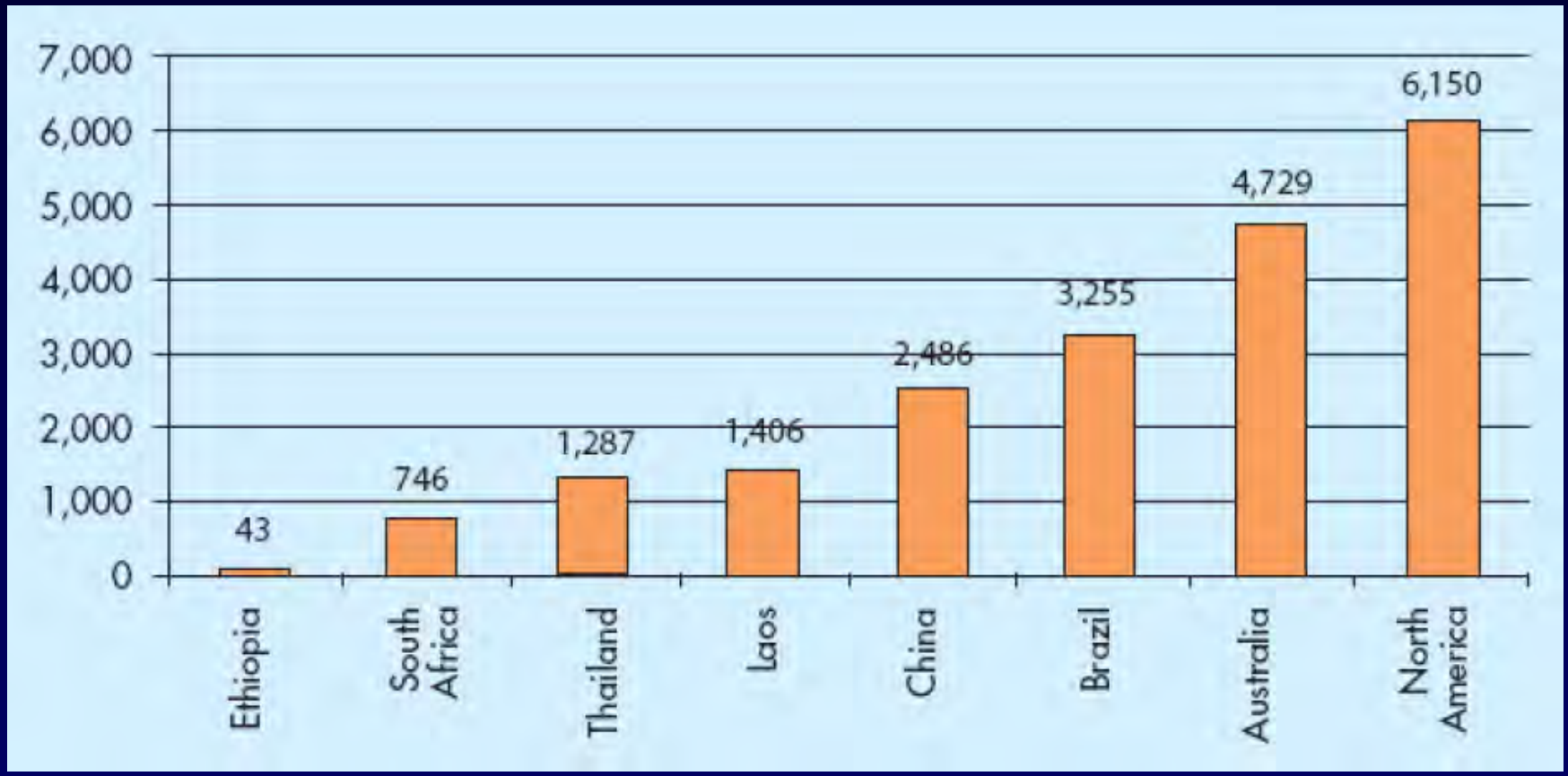
- **68.7% Ice, glaciers etc.**
- **30.1% fresh groundwater**
- **0.26% Lakes (105 K cukm)**
- **0.006% Rivers (2500 cukm)**

Per-Capita Freshwater Availability (2000)



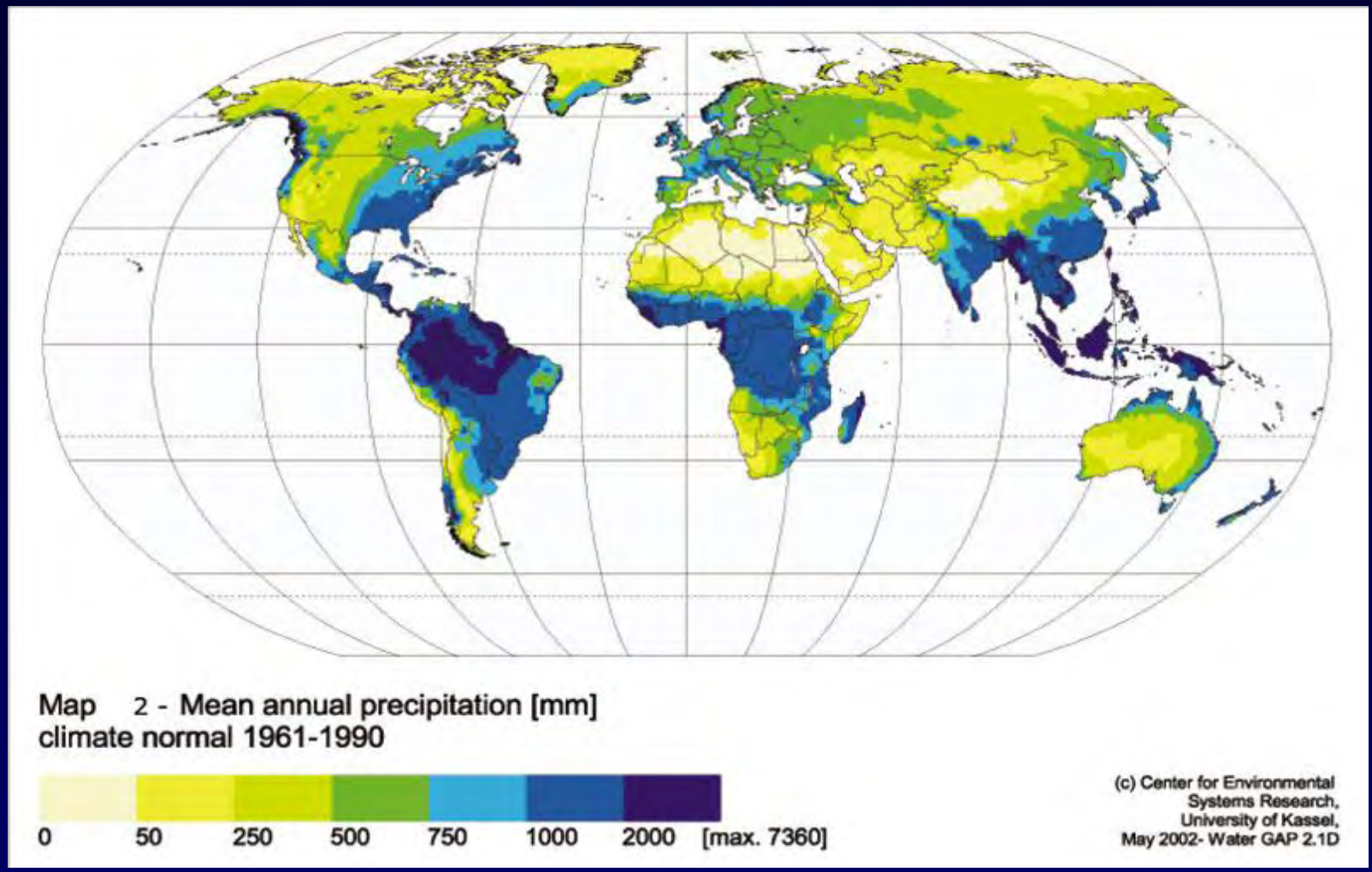
Per Capita Water Storage

(Dams and Other Storages in cum/capita)

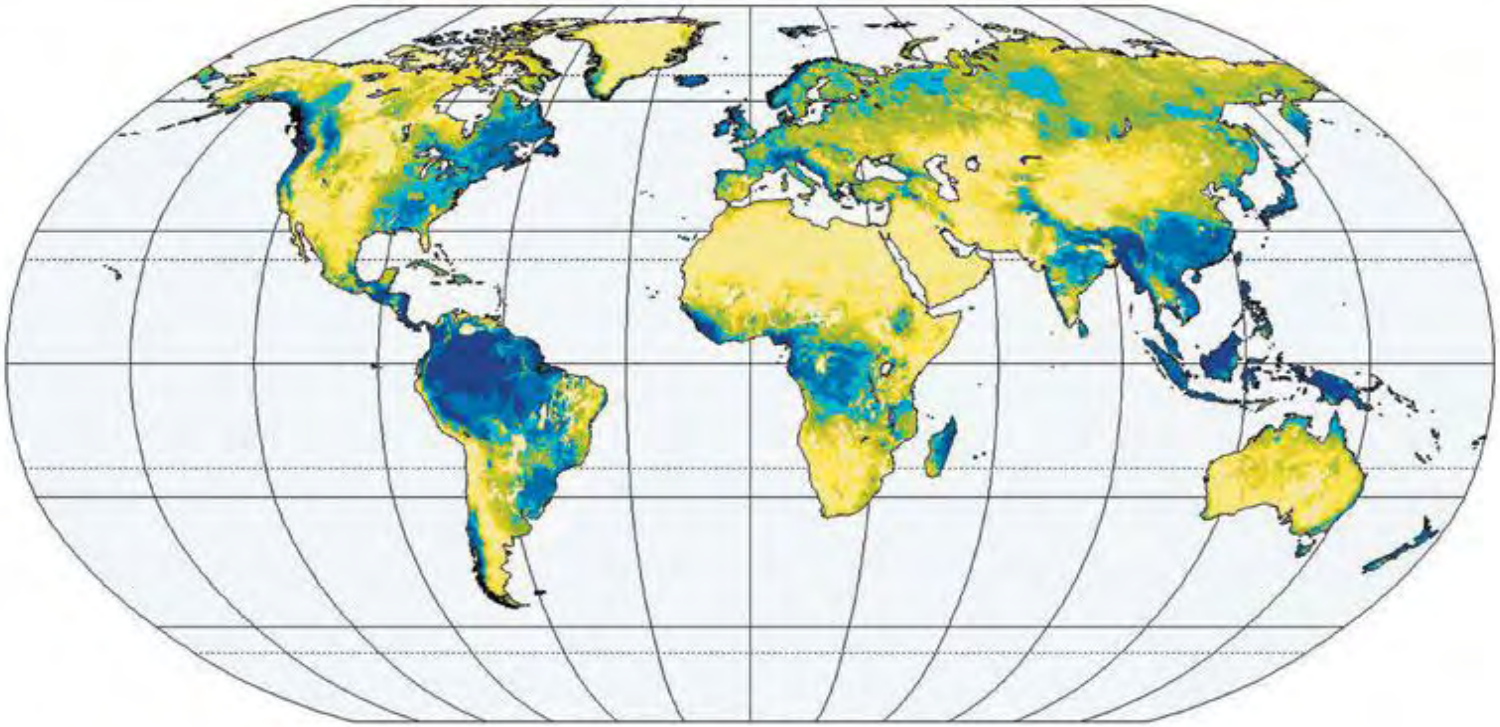


Asia = 400; India = 130; US = 5000 cum/capita

Precipitation Variability



Runoff Variability



Map 4. Long-term average runoff on a global grid [mm/annum]

less than 0 | 0 | 10 | 50 | 100 | 200 | 300 | 500 | 1000 | [max 6160]

(c) Center for Environmental Systems Research, University of Kassel, April 2002- Water GAP 2.1D

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Flow Variability at Kotri Barrage

March 14, 2009

June 29, 2009

August 24, 2010

August 25, 2010

DROUGHTS:
SOME RECENT OCCURRENCES

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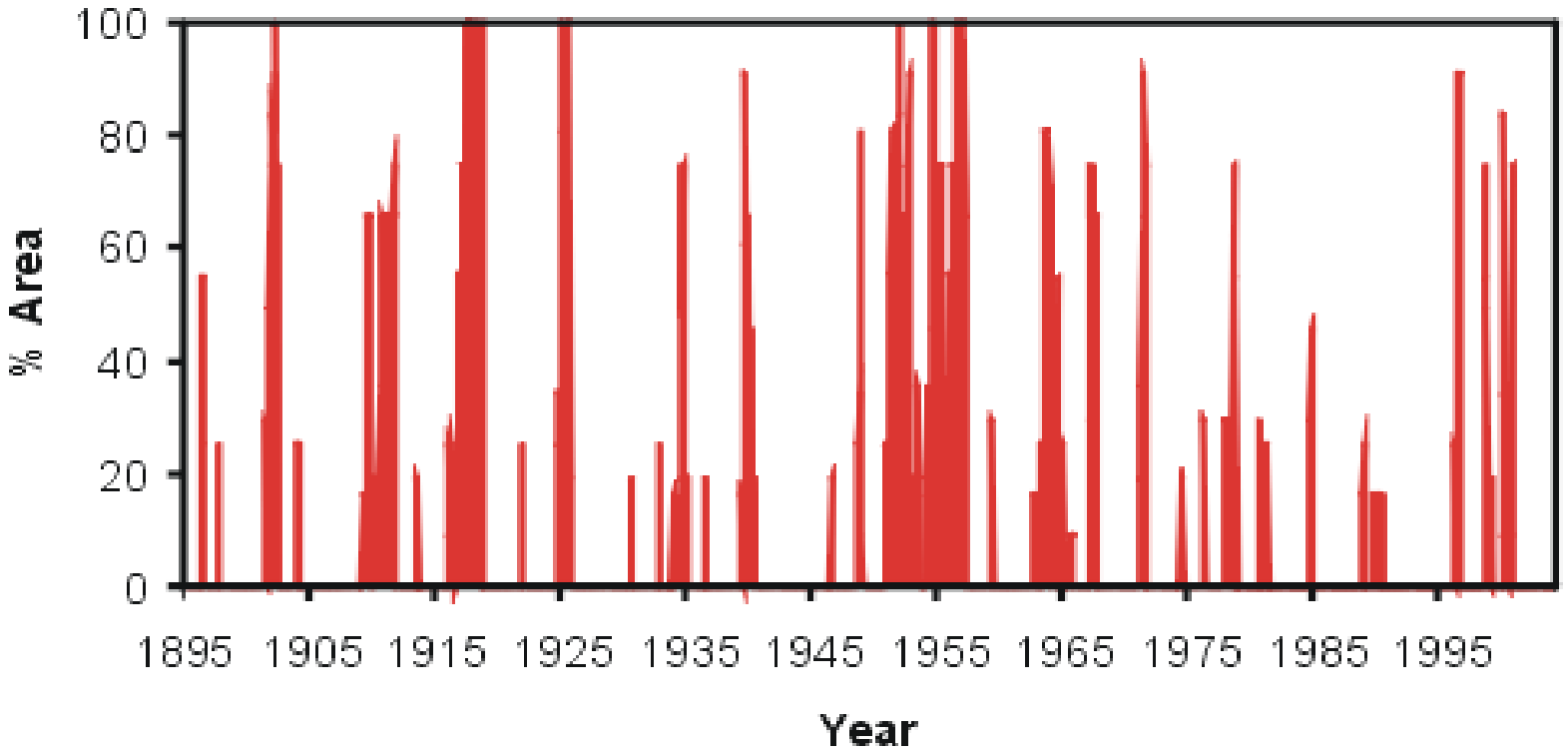
Example: Drought in Texas 1895-2004



Based on data provided by the National Climatic Data Center, NOAA

Drought in Texas (Recent)

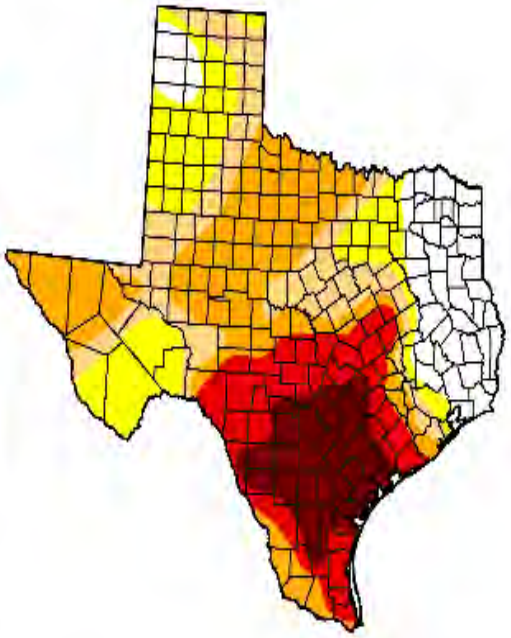
U.S. Drought Monitor

Texas

April 14, 2009
Valid 7 a.m. EST

Drought Conditions (Percent Area)

	None	D0-D4	D1-D4	D2-D4	D3-D4	D4
Current	14.9	85.1	68.2	50.6	25.1	11.5
Last Week (04/07/2009 map)	6.7	93.3	79.1	53.5	24.6	7.1
3 Months Ago (01/20/2009 map)	26.9	73.1	45.8	22.2	16.0	4.2
Start of Calendar Year (01/06/2009 map)	41.7	58.3	24.5	15.0	9.1	4.2
Start of Water Year (10/07/2008 map)	67.2	32.8	20.5	11.0	3.6	0.0
One Year Ago (04/15/2008 map)	36.2	63.8	45.0	18.4	10.5	3.3



Intensity:

- D0 Abnormally Dry
- D1 Drought - Moderate
- D2 Drought - Severe
- D3 Drought - Extreme
- D4 Drought - Exceptional

The Drought Monitor focuses on broad-scale conditions. Local conditions may vary. See accompanying text summary for forecast statements

http://drought.unl.edu/dm

USDA

Released Thursday, April 16, 2009
Author: Richard Heim, NOAA/NESDIS/NCDC

In 2006, drought-related crop and livestock losses were the state's worst for a single year, totaling $4.1 billion.

3/13/2009 (www.usatoday.com/weather) Ranchers in the nation's largest cattle-producing state have already lost nearly $1 billion because of Texas ongoing drought.

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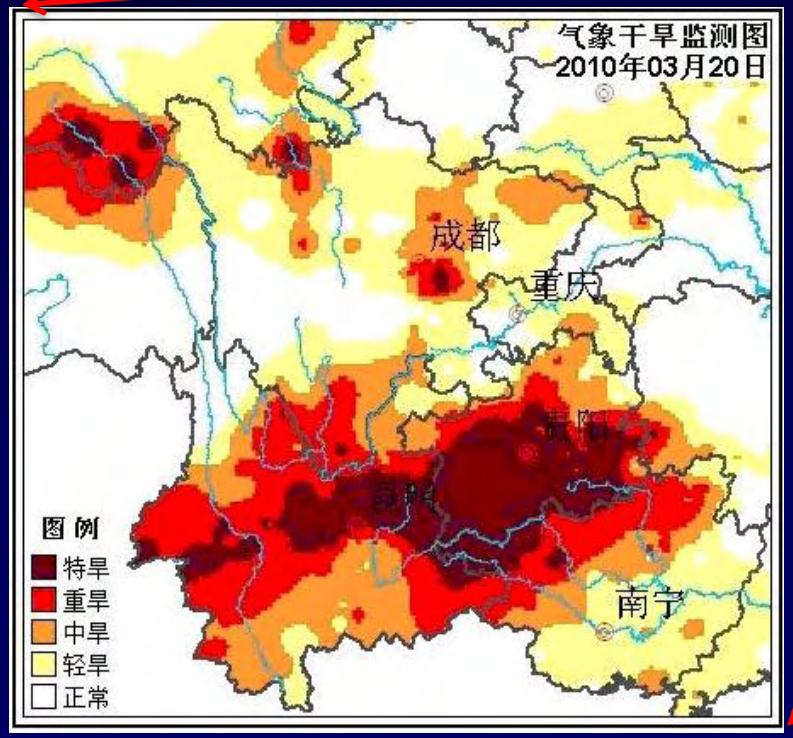
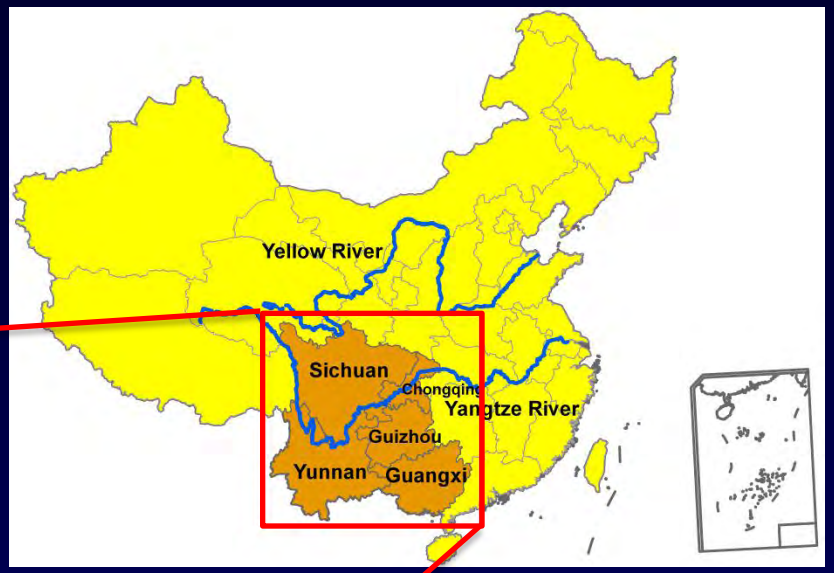
Drought in, Water Surplus, Southwestern China (Spring 2010)

Satellite Observations (20 March, 2010)





Dark red shows severest drought. Most parts of Yunnan and Guizhou provinces suffered from the severest droughts. The drought was classified into five grades: severest, severer, moderate, mild, and normal.

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Land, Rivers and Water Transportation During China 2010 Drought

Affected:

60 mn people

12 mn livestock

5 mn hect. crops

Cost = $3.5 billion

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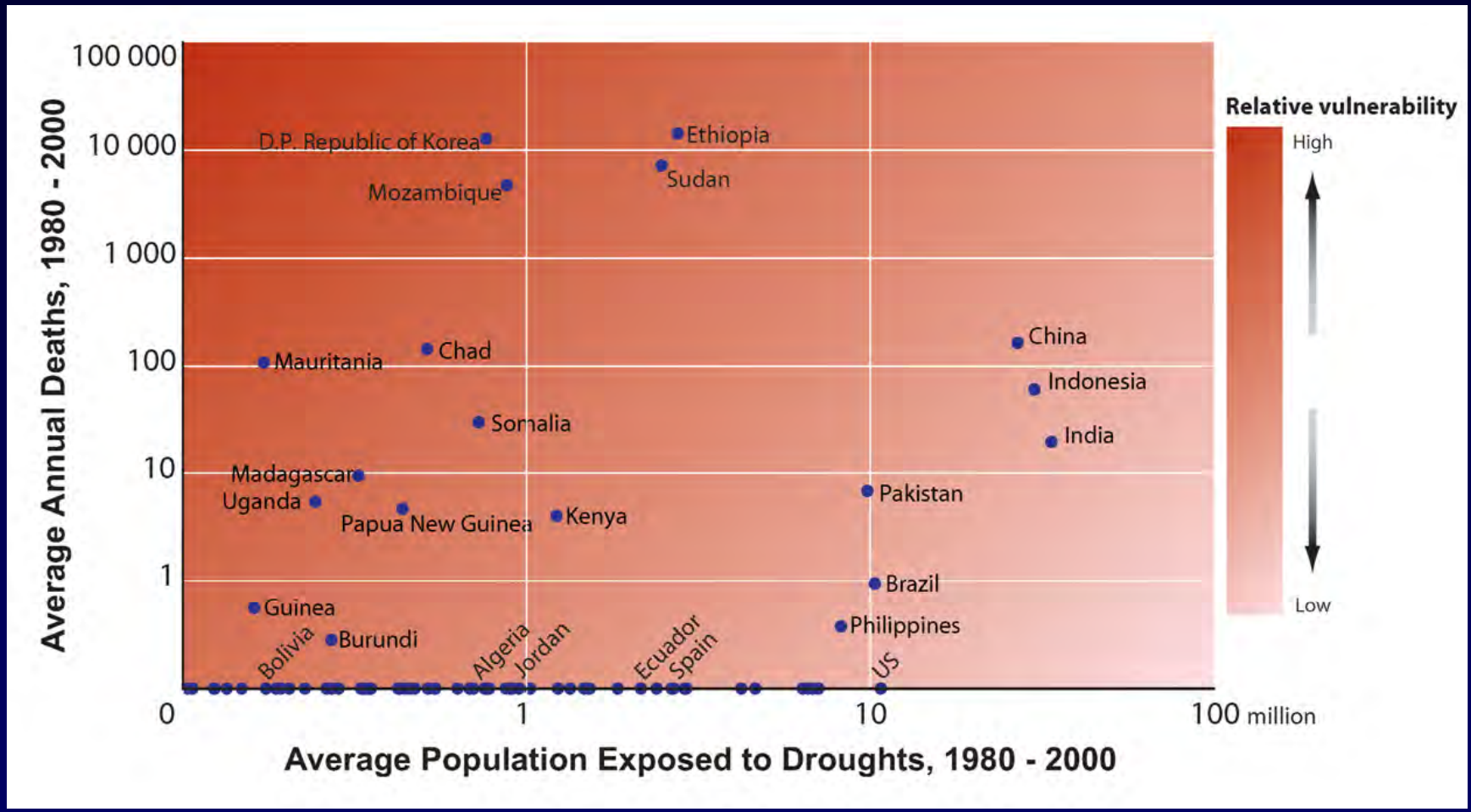
Severe Drought Fires in Russia

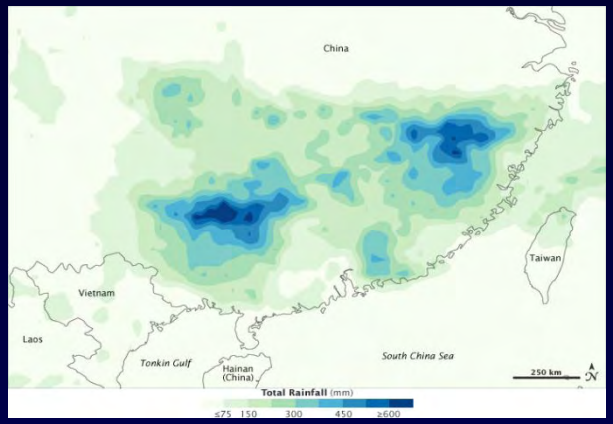
(2010)

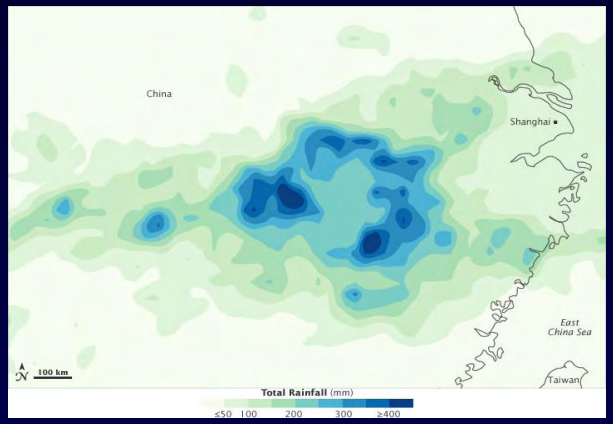
Deaths Due to Droughts



FLOODS:
SOME RECENT OCCURRENCES

2010 Flood in China





15-21 June **6-12 July**

Severity:

3000 Deaths; 1100 Missing **13 Aug. 2010**

305 mn people; 1.36 mn Houses

28 Provinces

100,000 sqkm. Land

$ 41 bn in Damages

China Flooding (August 2010)
(Zhouqu Mudslide: 10 August 2010)

Pakistan 2010 Floods

(Worst Natural Disaster Ever: U.N.)

Severity:

2000+ Deaths

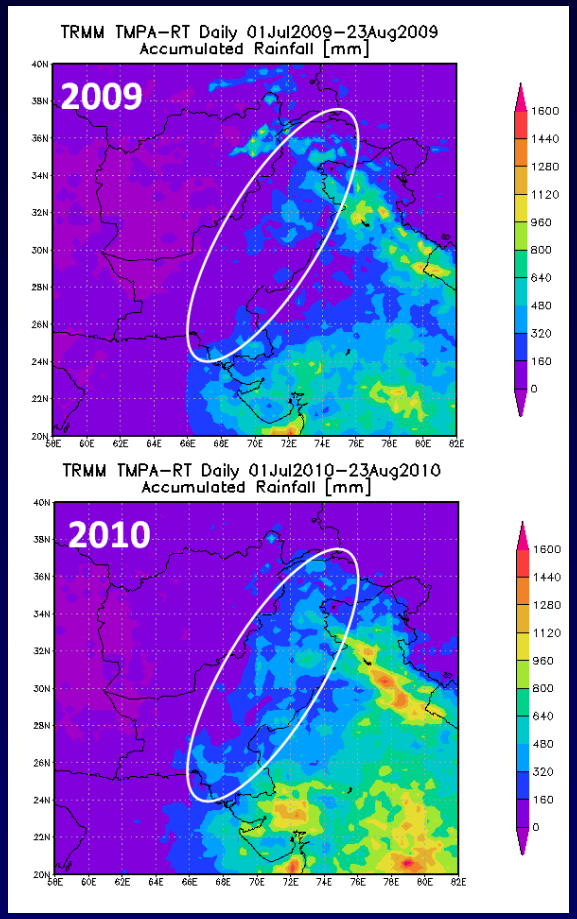
20 mn People Affected

1 mn Houses Damaged

160,000 sqkm. Land

$ 6 bn in Damages

$45 bn Total Economic Impact



Total Rainfall During 1 July to 23 Aug.

Pakistan 2010 Flood
(July 28 -31 Rainfall > 12 in)

– Between July 28 and 29, as much as 400 mm (16 inches) of rain fell, triggering flooding along the Indus and Kabul rivers (NASA)

01 Aug 2010 - Floods caused by heavy rains affected Azad Kashmir, Baluchistan, Khyber-Pakhtunkhwa and Punjab districts.[1] More than 1 million people affected[2], 870 dead and 30,000 houses damaged.[1]

Map Sources: FFRC, UNCS.
Reference: [1]Government of Pakistan, Pakistan: FLOODS – 2010 (01 August Evening), 01 Aug 2010.
[2]OCHA, Situation Report No. 3: Monsoon Floods in Pakistan – 1 August 2010, 01 Aug 2010.
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by the United Nations. Dotted line represents approximately the Line of Control in Jammu and Kashmir agreed upon by India and Pakistan. The final status of Jammu and Kashmir has not yet been agreed upon by the parties. Map created 02 Aug 2010 – www.reliefweb.int

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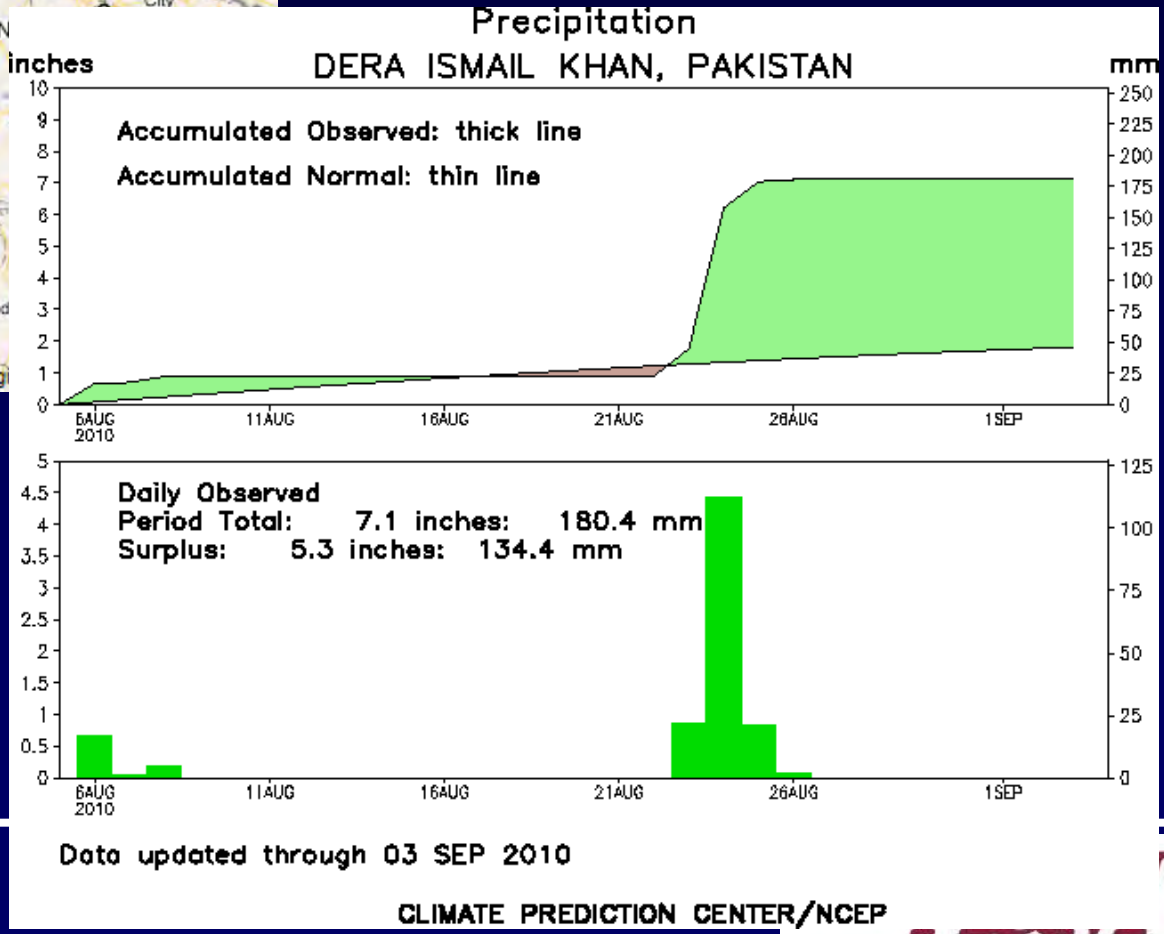
Andkhvoy
Kholm
Kulob
Qonduz
Balkh
Meymaneh
Baghlan
Herat
Chaghcharan
Mehtar Lam
Kabul
Ghurian
Afghanistan
Gardeyz
Peshawar
Jammu and Kashmir
Khowst
Farah
Dadyal
Jammu City
Himachal Pradesh
Qandahar
Lashkar Gah
Lahore
Amritsar
Quetta
Multan
Punjab
Zahedan
Pakistan
Bathinda
Uttarakhand
Sibbi
Haryana
Rudrapur
Bahawalpur
Khuzdar
Panjgur
Khairpur
Bahawalpur
Rajasthan
Hoshab
Nawabshah
Pali
Karachi
Hyderabad
Gujarat
Ahmedabad
Jamnagar
Rajkot
©2010 Google - Map data ©2010 AND, Europa Technologi


Precipitation
DERA ISMAIL KHAN, PAKISTAN
inches
mm
Accumulated Observed: thick line
Accumulated Normal: thin line
6AUG 2010
11AUG
16AUG
21AUG
26AUG
1SEP
Daily Observed
Period Total: 7.1 inches: 180.4 mm
Surplus: 5.3 inches: 134.4 mm
Data updated through 03 SEP 2010
CLIMATE PREDICTION CENTER/NCEP

2010 Flood

- 180% of normal rainfall in July
- Deluge in China and Pakistan may have some connection with unusually severe drought fires in Russia
- La-Nina events in Pacific may also be reasons for this flooding but has not been studied/linked

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EXTRME RAINFALL OCCURRENCES IN THE PAST

3 Feet Rain in 1 day (Dharampur, Surat; 2nd July 1941)

Table 2 Stations which received rainfall of more than 250 mm in a single day during the rainstorm of 1–5 July 1941

Name of the station	Lat.	Long.	Rainfall during 1–5 July, 1941 (mm) 1/7	2/7	3/7	4/7	5/7	Total for 5 days (mm)	Mean annual rainfall (mm)	5-day rainfall as per cent of mean annual rainfall (%)	1-day 100-year rainfall (mm)	1-day PMP (mm)
Bajana	23° 07′	71° 46′	29	31	20	262	22	364	486	75	309	863
Vagra	21° 51′	72° 51′	133	257	137	77	24	628	811	77	331	738
Ankaleshwar	21° 38′	73° 00′	80	297	51	35	28	491	937	52	363	787
Valia	21° 33′	73° 09′	95	382	23	10	35	545	1271	43	302	780
Palitana	21° 31′	71° 50′	269	51	79	65	70	534	616	87	370	920
Matar	22° 42′	72° 38′	97	2	43	81	319	542	728	74	323	755
Kaira	22° 45′	72° 42′	76	5	37	72	309	499	769	65	346	818
Dholka	22° 43′	72° 27′	83	22	91	26	278	500	707	71	313	836
Mandvi	21° 15′	73° 18′	207	389	30	23	86	735	1344	55	403	813
Surat	21° 12′	72° 50′	58	459	278	12	63	870	1071	81	440	921
Bardoli	21° 07′	73° 07′	144	340	138	15	141	778	1341	58	396	781
Valod	21° 03′	73° 16′	334	270	357	10	141	1112	1433	78	357	665
Navsari	20° 57′	72° 56′	460	783	17	141	71	1472	1455	101	405	950
Jalalpur	20° 57′	72° 54′	69	359	637	9	126	1200	1345	89	472	994
Bansada	20° 46′	73° 22′	164	511	404	34	72	1185	1881	63	483	823
Chikhli	20° 45′	73° 04′	98	537	404	23	44	1106	1693	65	461	850
[illegible]	20° 37′	72° 56′	49	[illegible]	171	25	20	[illegible]	1806	36	458	793
Dharampur	20° 33′	73° 11′	192	987	273	42	35	1529	2410	63	635	1100
[illegible]	21° 28′	73° 08′	370	[illegible]	25	74	24	[illegible]	1218	46	345	785
Ahwa	20° 45′	73° 41′	132	358	181	71	74	816	1780	46	286	590
Waghai	20° 46′	73° 30′	394	424	357	36	70	1281	2218	58	286	690
Jamner	20° 49′	75° 47′	298	32	11	2	10	353	802	44	217	462
Trimbak	19° 57′	73° 32′	182	411	204	105	92	994	2457	40	376	657

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WATER RESOURCES: SUMMATION

- Taking stock of current situation
- Acknowledgment of social and cultural constraints
- Taking account of looming global changes
- Re-examination and re-evaluation of our social values and value systems
- Development paradigm: Distributed and controlled urban growth
- Future can be bright or dark-all in our hands


Thanks