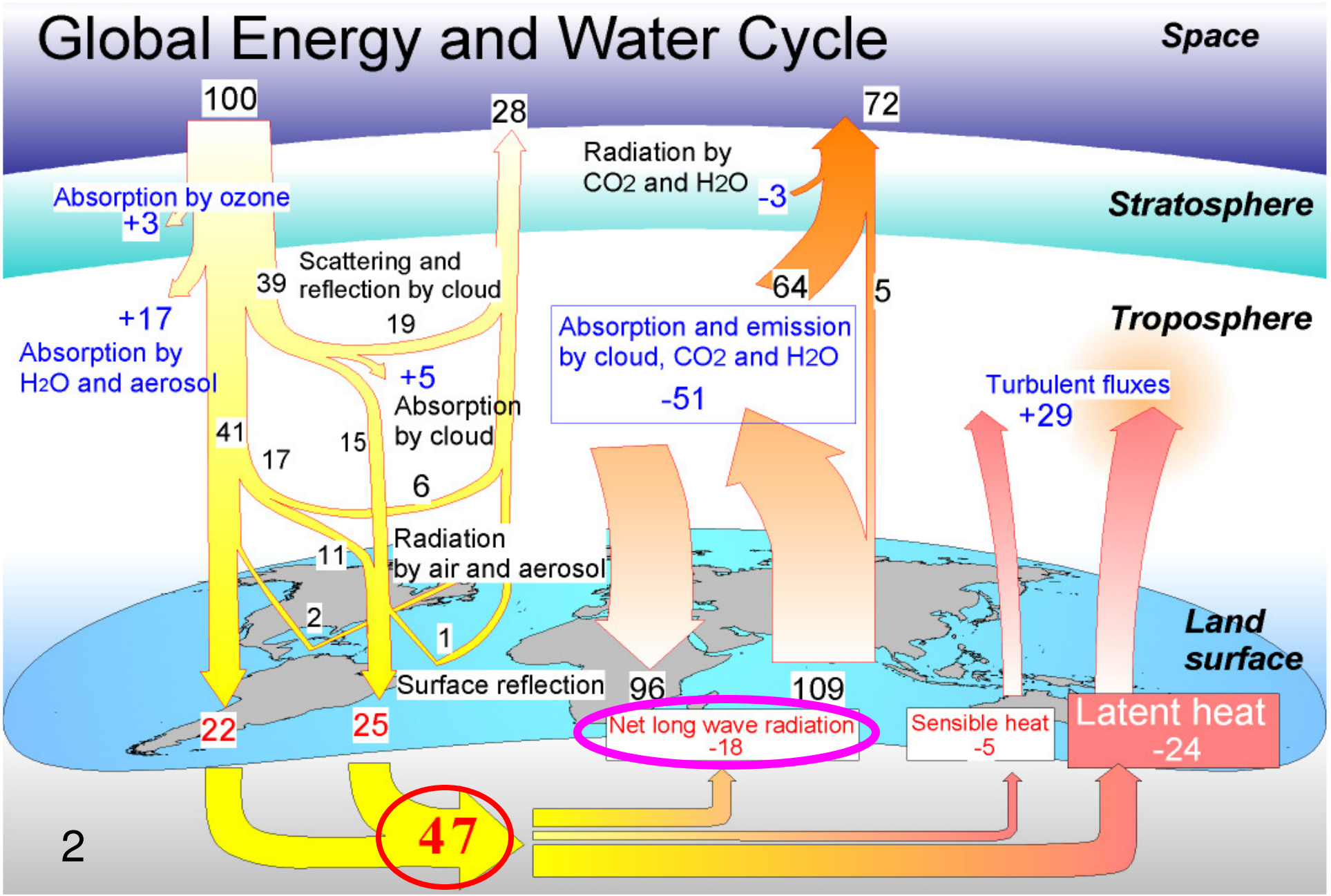
Water and Climate Change Adaptation

- Relationship between climate system and water cycle
- Climate projection uncertainty – why? and how to address?

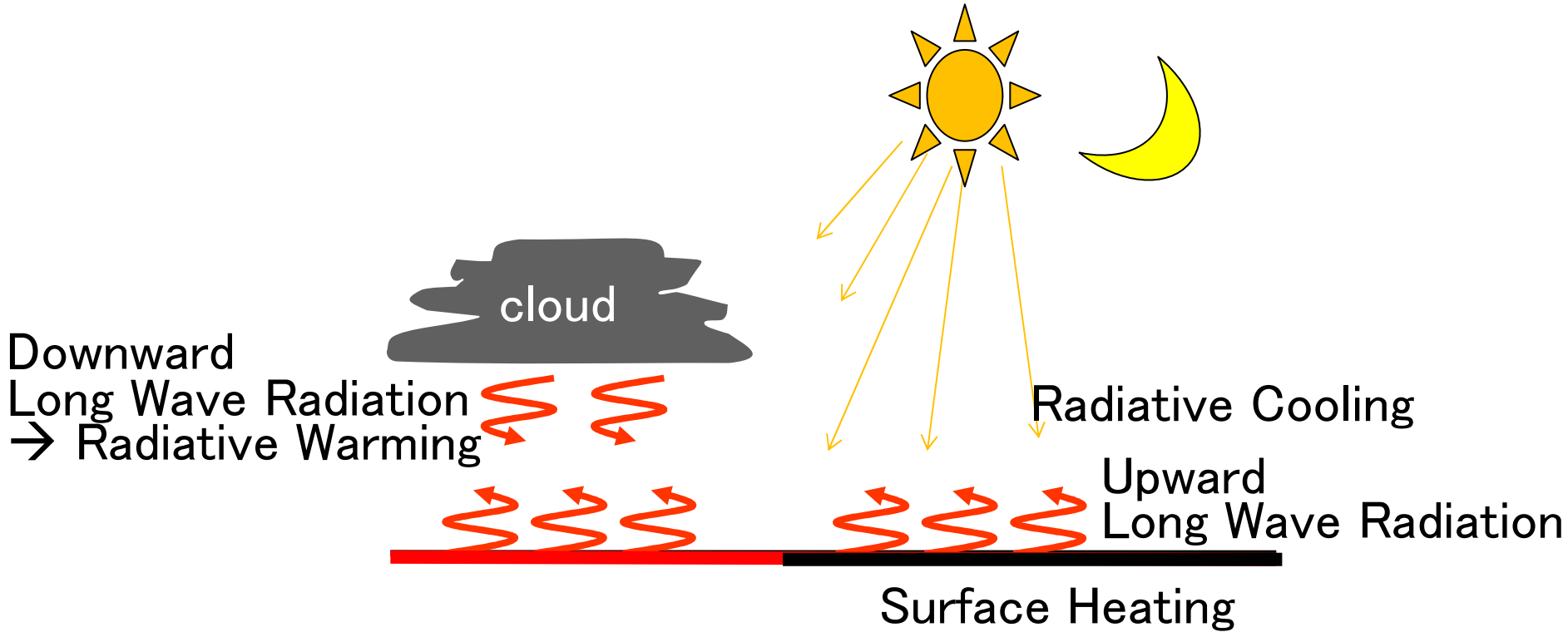
Toshio Koike
The University of Tokyo

Variability of Climate and Water Cycle: Unique Roles of Water



Radiative Cooling

Stefan-Boltzmann Law: *Material emits radiative energy with the forth power of the surface temperature.*



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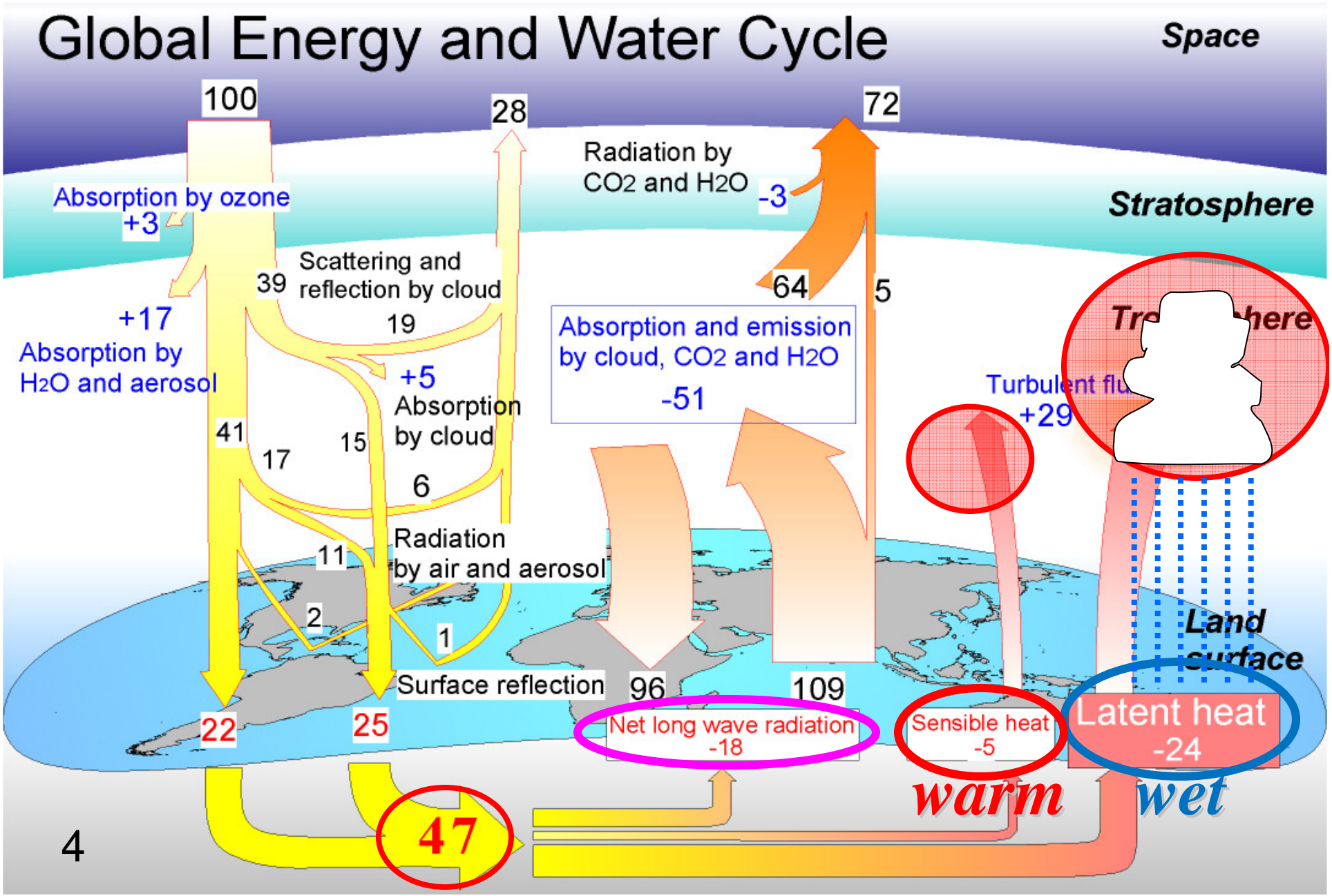

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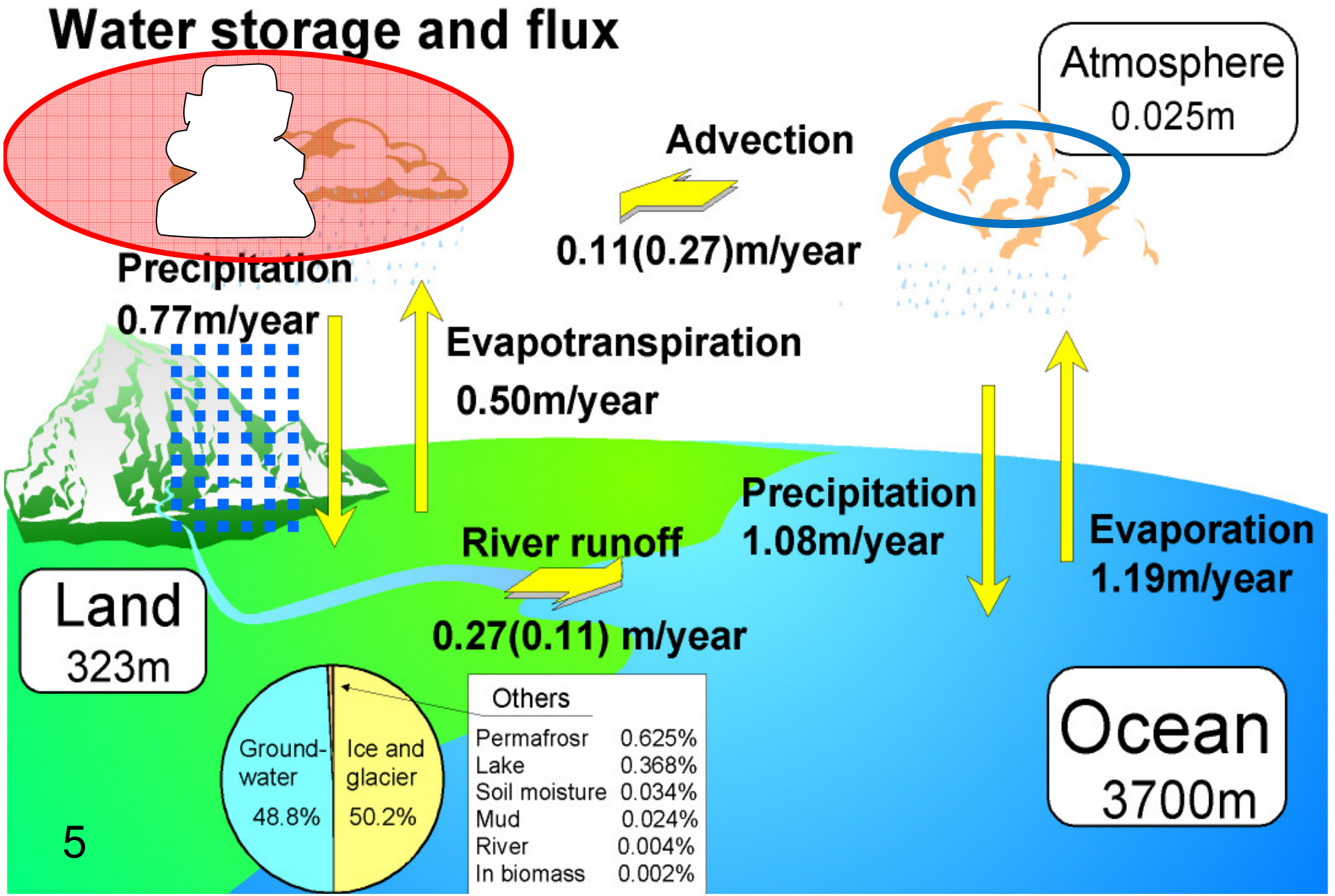
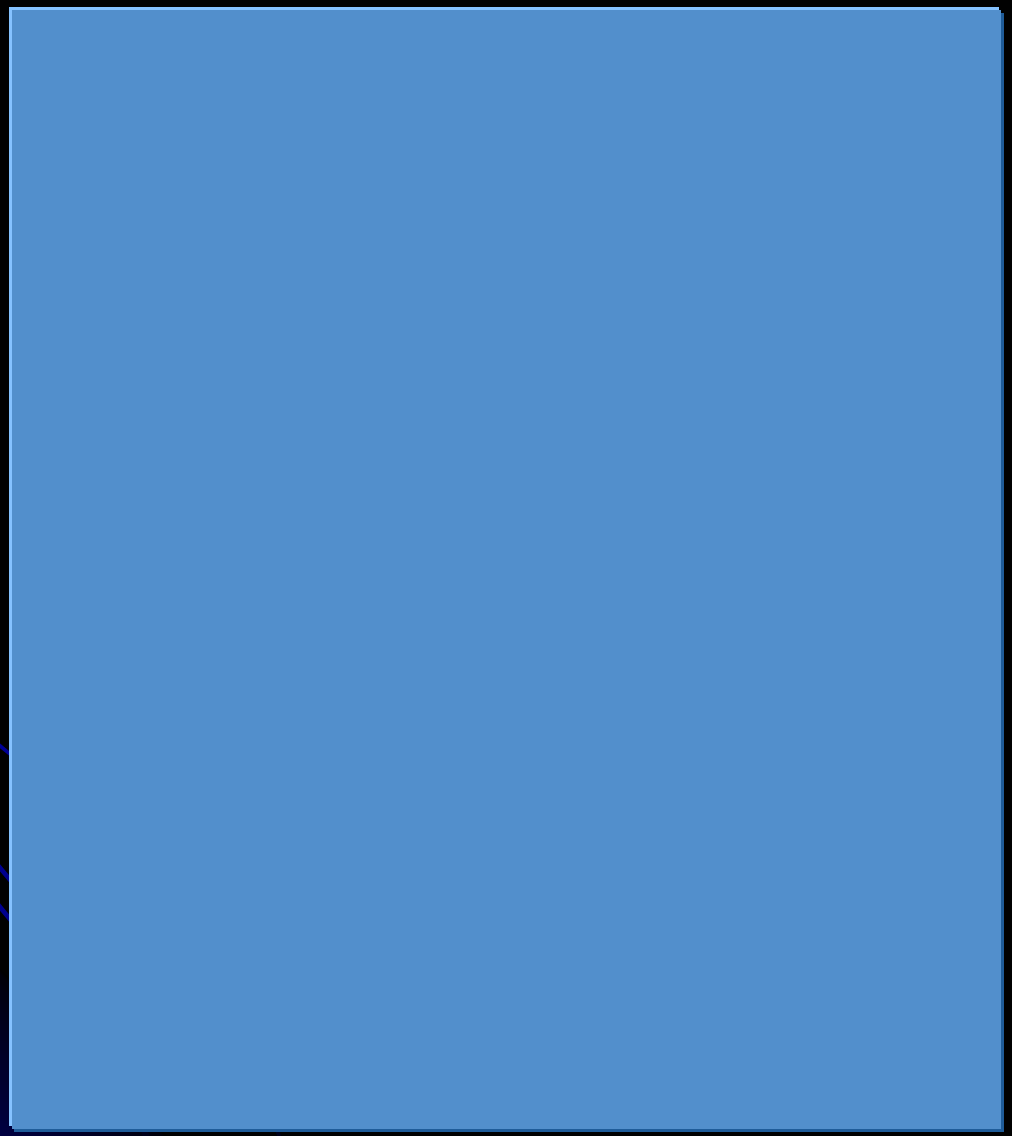
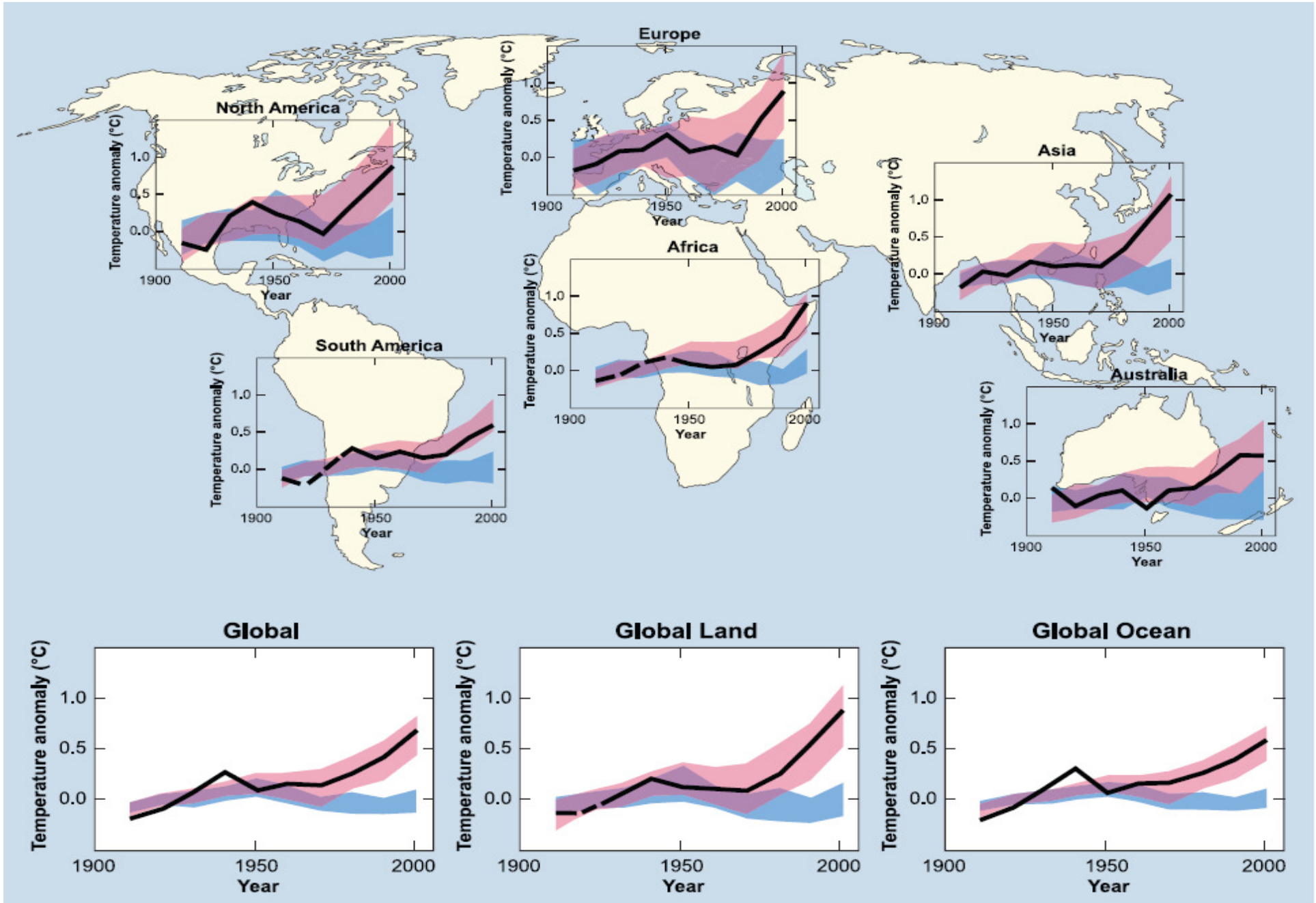


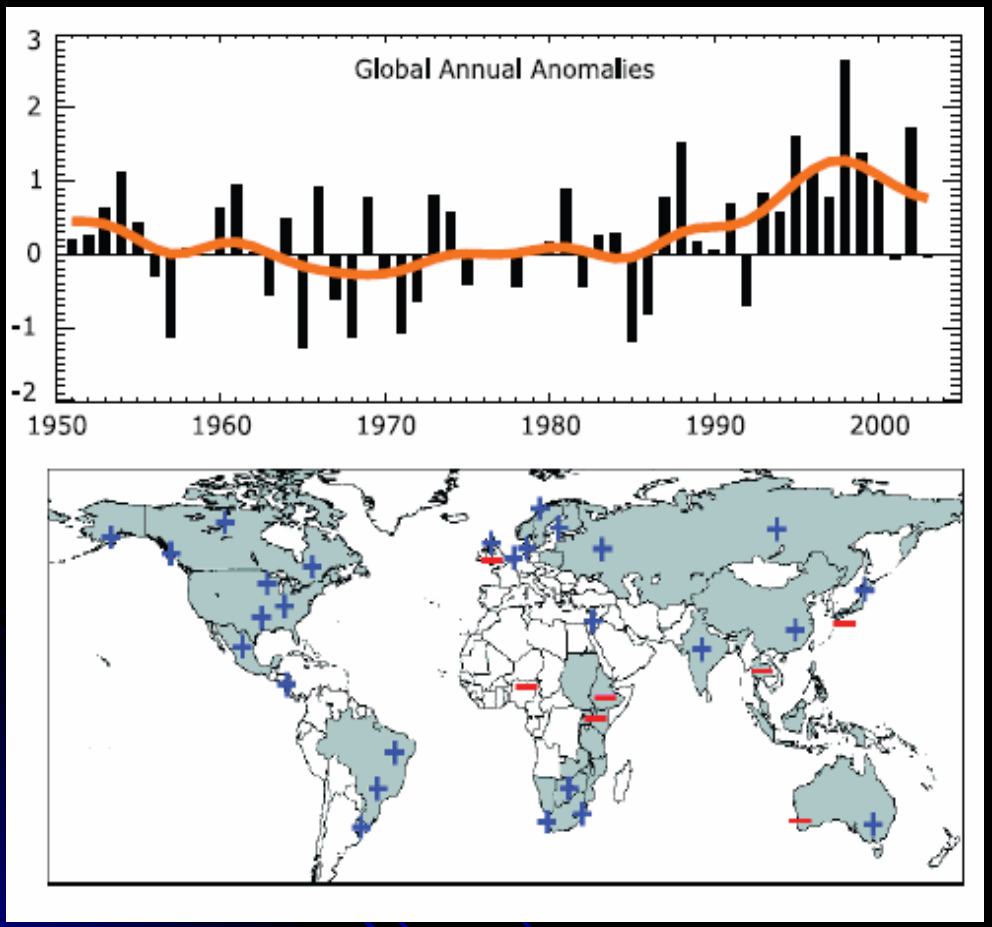
Warming of the climate system is unequivocal.

(IPCC AR4, 2007)





Heavy Precipitation Events: Frequency increases over most areas



Anomalies (%) of the global annual time series defined as the percentage change of contributions of very wet days from the base period average .

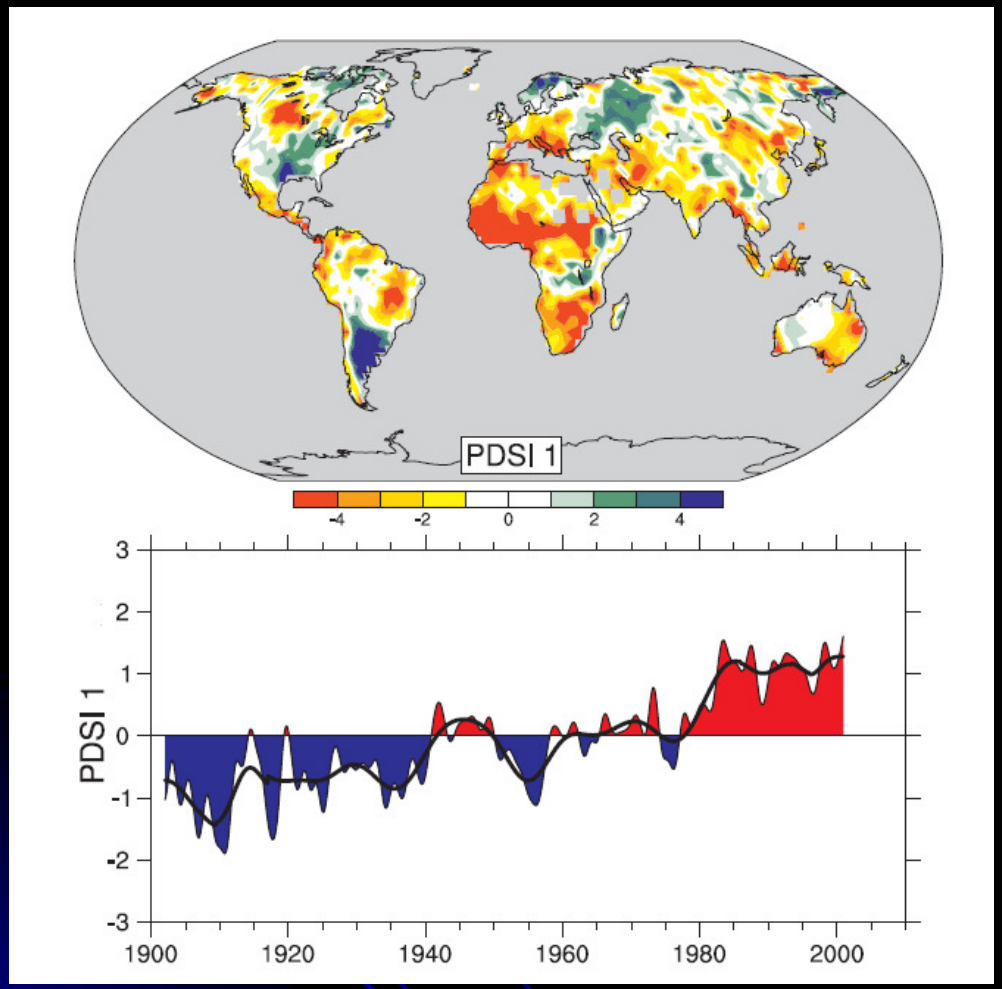
IPCC AR4

944mm/24h
Mumbai
India
2005

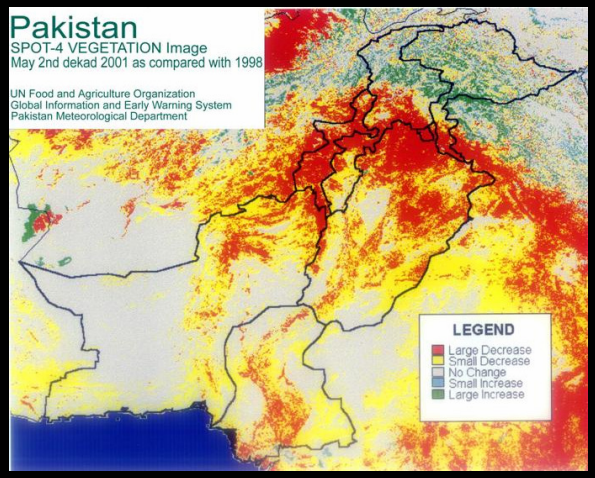
Singapore
Jun. 2010
Jun. & Dec. 2011

Thailand
2011

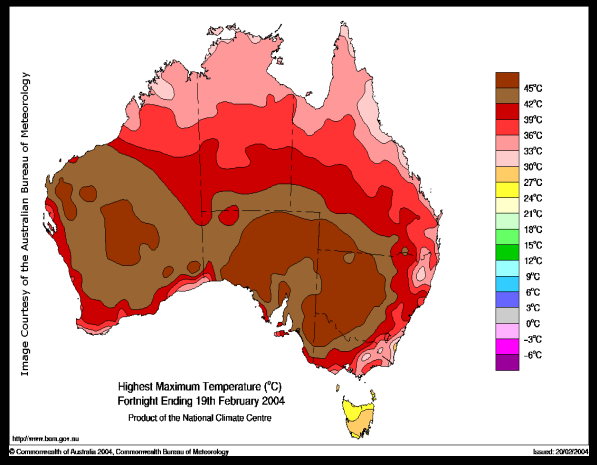
Area affected by droughts increases



Monthly Palmer Drought Severity Index (PDSI)



Pakistan
1999-2002



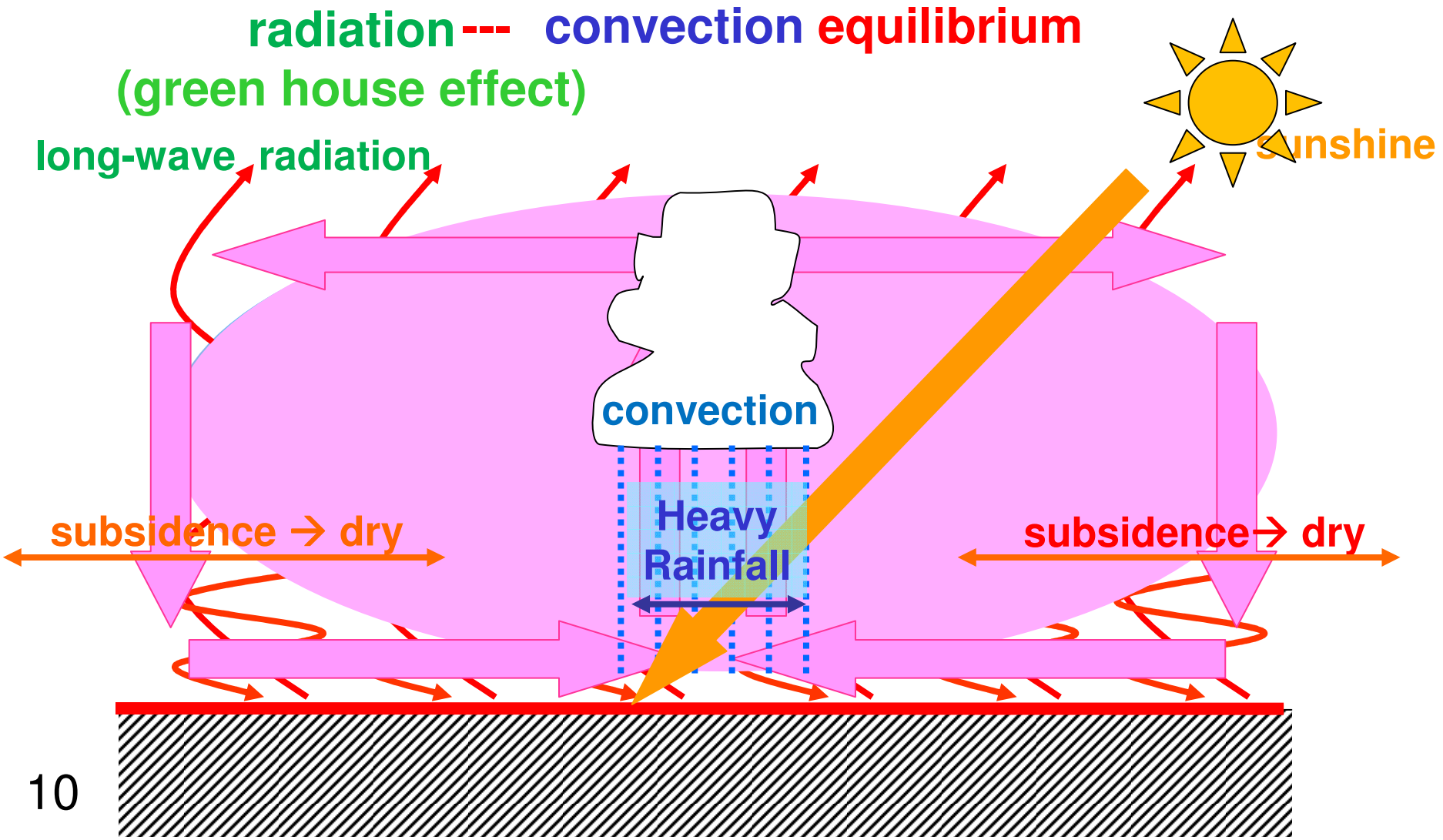
Australia
2002-2003
2006-2007

Mekong
2010

IPCC AR4

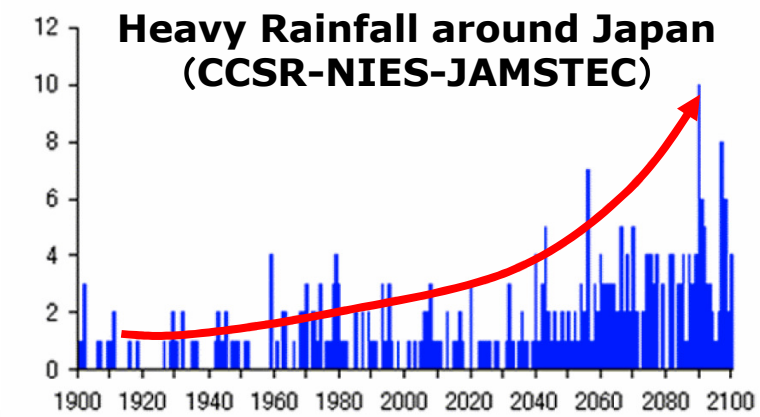
Variability of Climate and Water Cycle: Unique Roles of Water

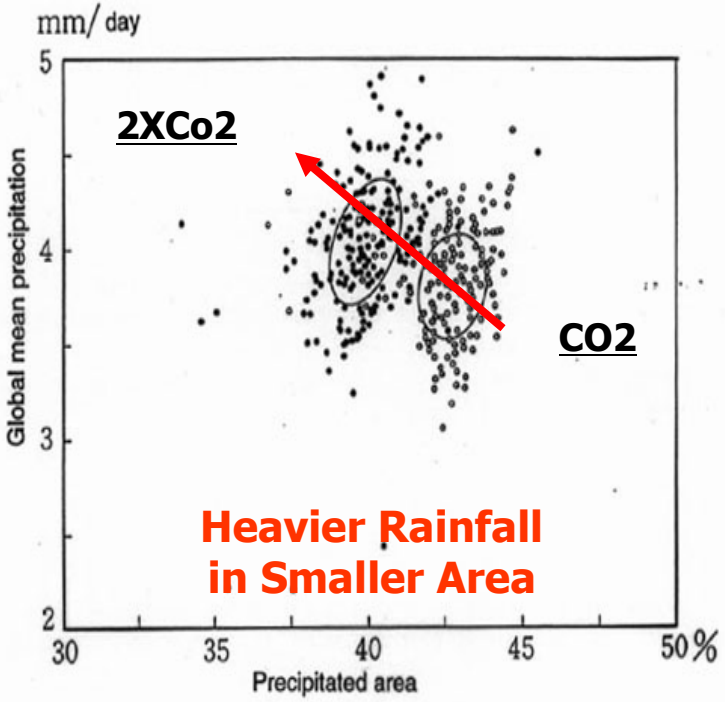
Temperature ⇧ → Saturated Water Vapor Pressure ⇧ → Cloud Formation ⇩

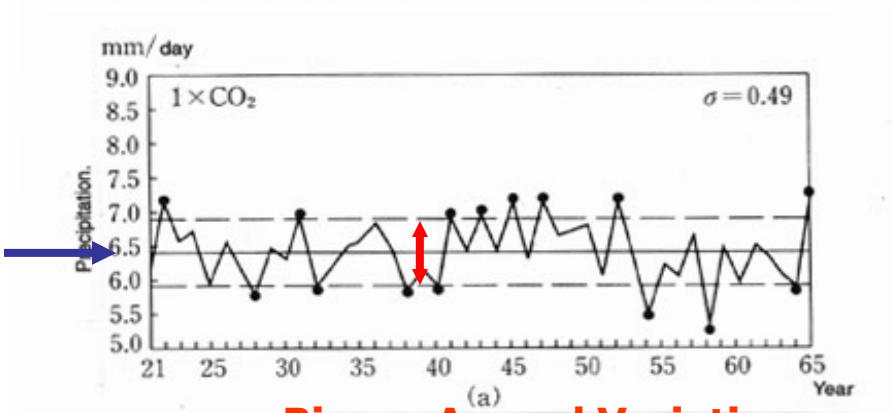


Variability of Climate and Water Cycle: Unique Roles of Water

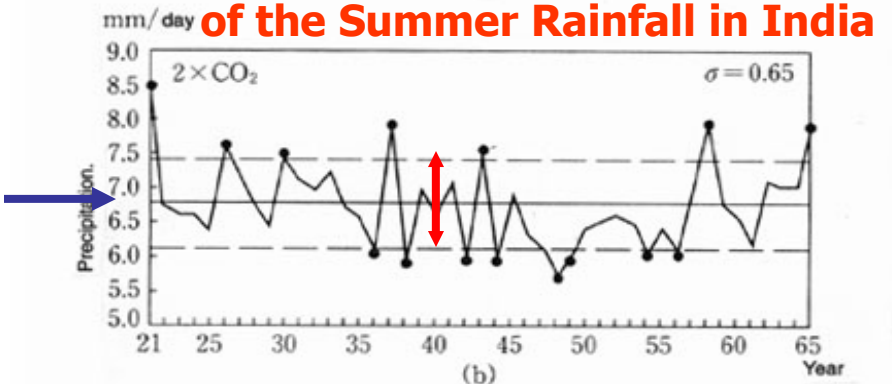
Impacts of CO2 Increase on the Water Cycle Predicted by Models



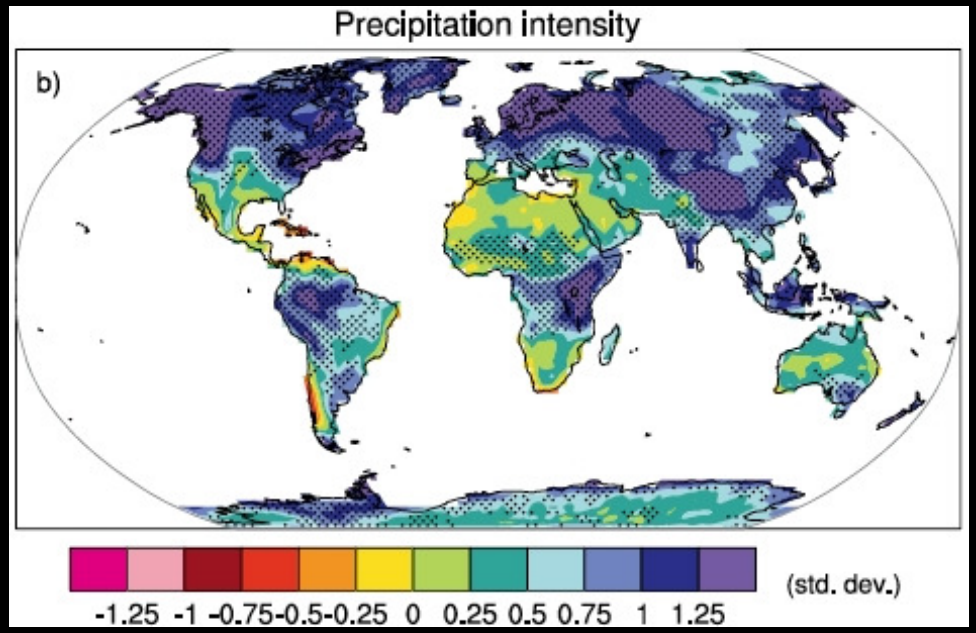




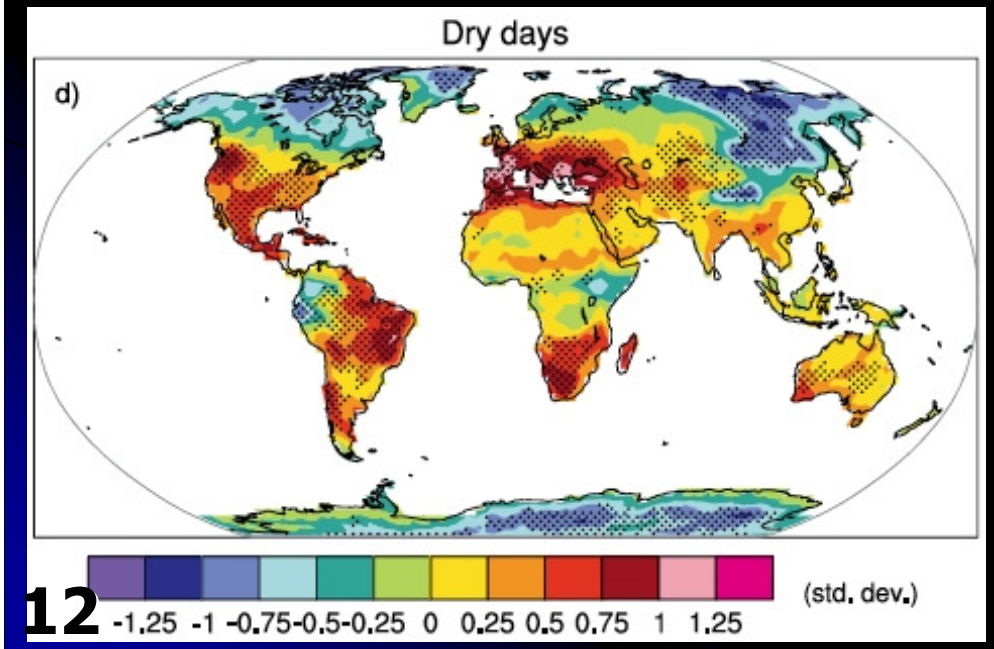
Bigger Annual Variation of the Summer Rainfall in India



Projected changes in extremes



It is *very likely* that heavy precipitation events will continue to become more frequent.



It is *likely* that area affected by drought increases.

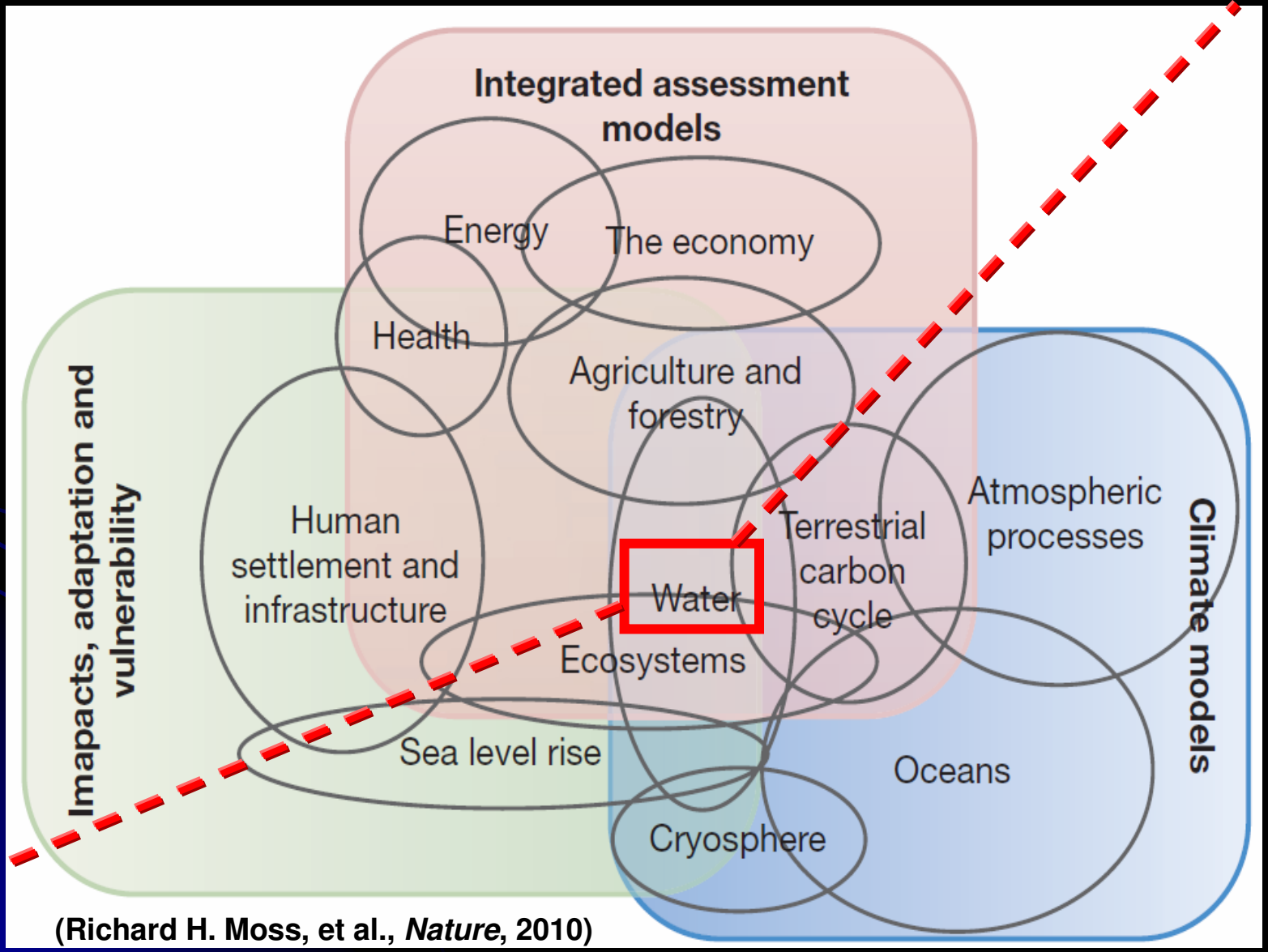
Table 4. Likelihood Scale.

Terminology	Likelihood of the occurrence/ outcome
Virtually certain	> 99% probability of occurrence
Very likely	> 90% probability
Likely	> 66% probability
About as likely as not	33 to 66% probability
Unlikely	< 33% probability
Very unlikely	< 10% probability
Exceptionally unlikely	< 1% probability

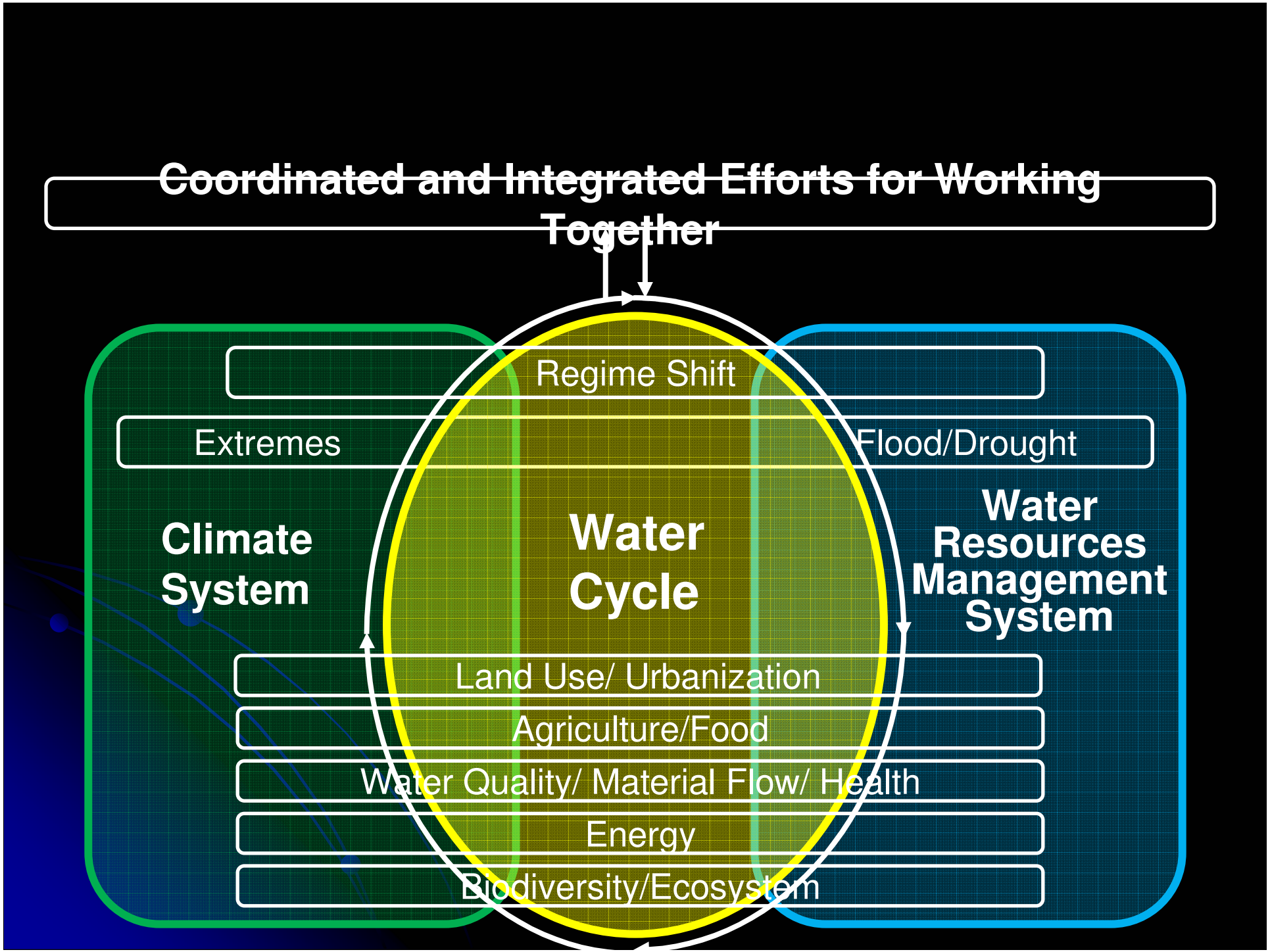
Recent trends, assessment of human influence on the trend and projections for extreme weather events for which there is an observed late-20th century trend.

Phenomenon[a] and direction of trend	Likelihood that trend occurred in late 20th century (typically post 1960)	Likelihood of a human contribution to observed trend[b]	Likelihood of future trends based on projections for 21st century using SRES scenarios
Warmer and fewer cold days and nights over most land areas	*Very likely*[c]	*Likely*[d]	*Virtually certain*[d]
Warmer and more frequent hot days and nights over most land areas	*Very likely*[e]	*Likely (nights)*[d]	*Virtually certain*[d]
Warm spells/heat waves. Frequency increases over most land areas	*Likely*	*More likely than not*[f]	*Very likely*
Heavy precipitation events. Frequency (or proportion of total rainfall from heavy falls) increases over most areas	*Likely*	*More likely than not*[f]	*Very likely*
Area affected by droughts increases	*Likely* in many regions since 1970s	*More likely than not*	*Likely*
Intense tropical cyclone activity increases	*Likely* in some regions since 1970	*More likely than not*[f]	*Likely*
Increased incidence of extreme high sea level (excludes tsunamis)[g]	*Likely*	*More likely than not*[f,h]	*Likely*[i]

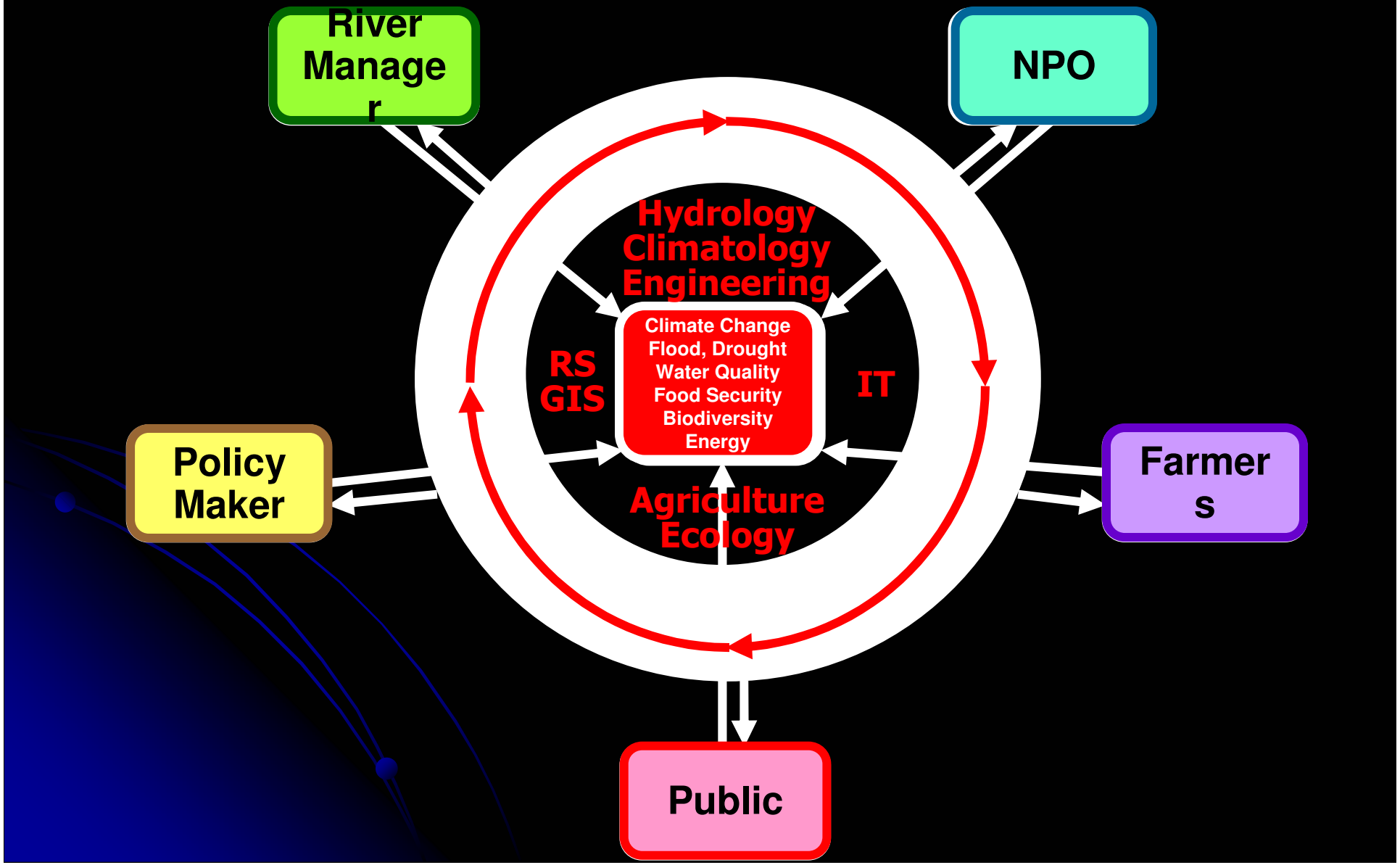
Water is a Key
bridging between climate processes and societal benefits.



(Richard H. Moss, et al., *Nature*, 2010)


Coordinated and Integrated Efforts for Working Together
Regime Shift
Extremes
Flood/Drought
Climate System
Water Cycle
Water Resources Management System
Land Use/ Urbanization
Agriculture/Food
Water Quality/ Material Flow/ Health
Energy
Biodiversity/Ecosystem

Sharing Data and Information
Exchanging Knowledge, Experiences and Ideas
Working Together



Large Uncertainty in Climate Projection
– how to address? –

Computational Loads >> Computer Power

- **Time Integration**
  - weather prediction: one week
  - climate projection: one hundred years
- **Ocean Dynamics as well as Atmospheric Dynamics**
  - weather prediction: initial condition of atmosphere
  - climate projection: ocean & land boundary conditions

→ Coarse Spatial Resolution: several 10s km

- can not express clouds physically
- can not express orographic effects