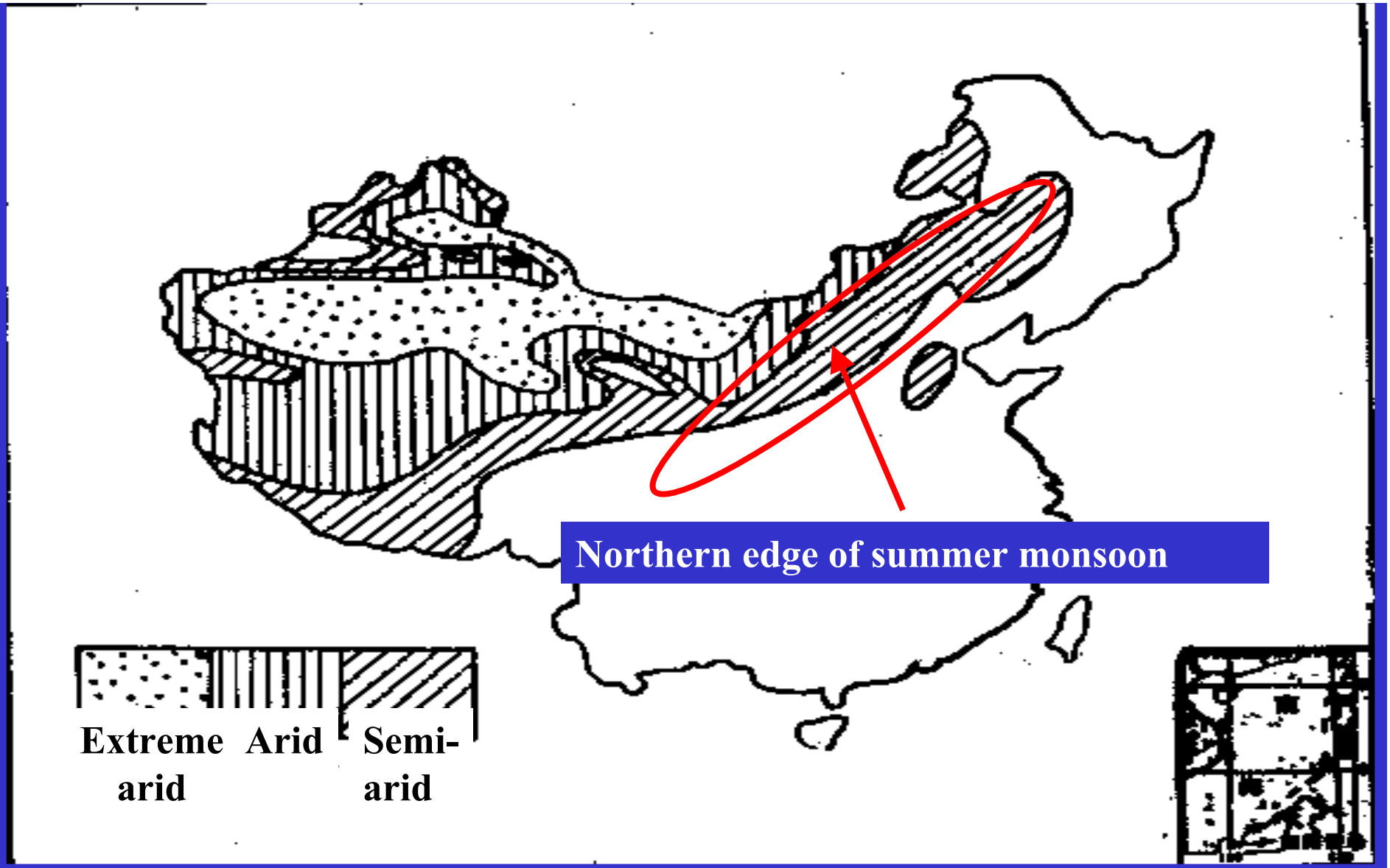
National Basic Science Research Program

Study on Aridization of Northern China

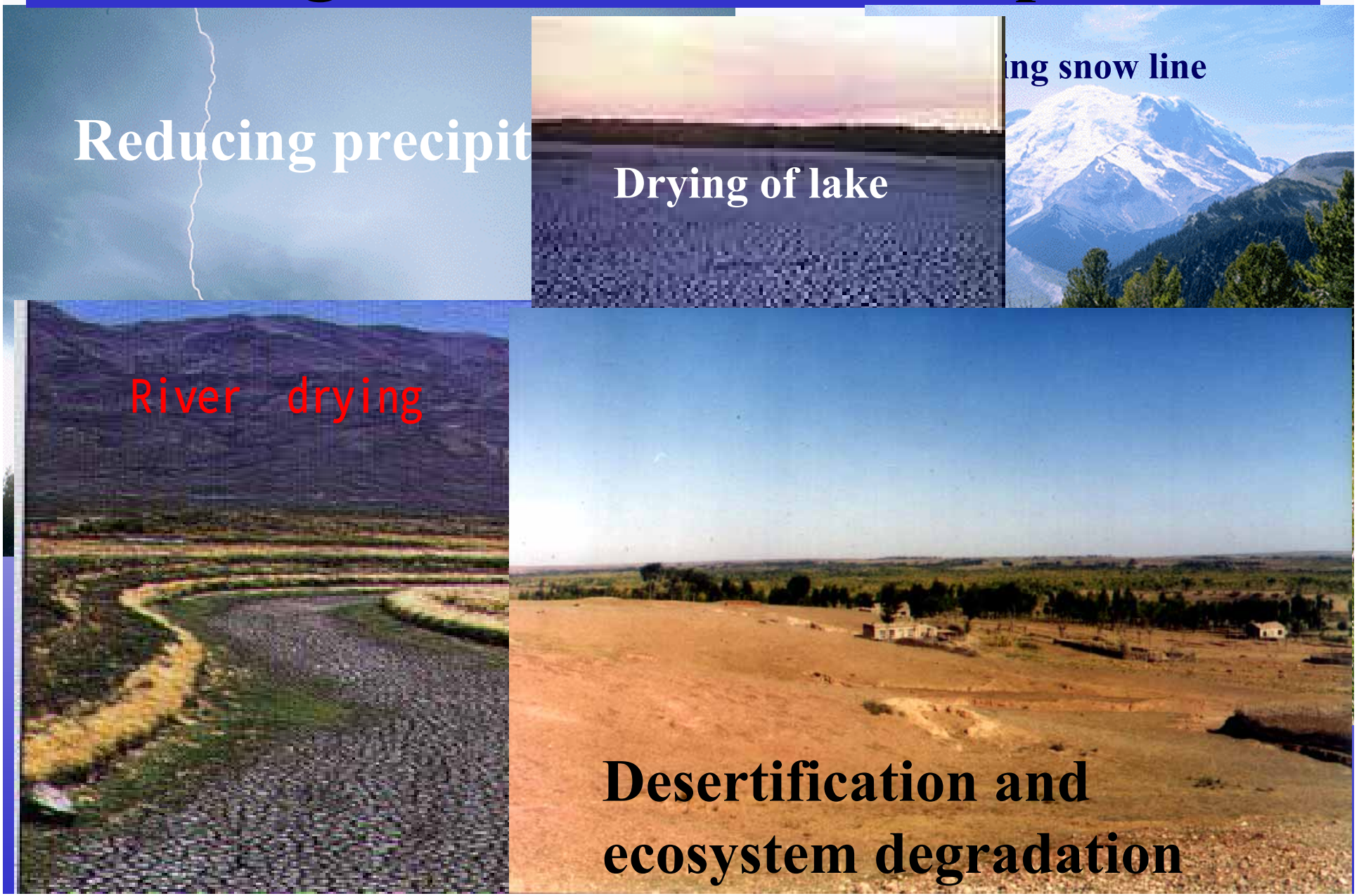
Congbin Fu
(Institute of Atmospheric Physics, Chinese Academy of Sciences)

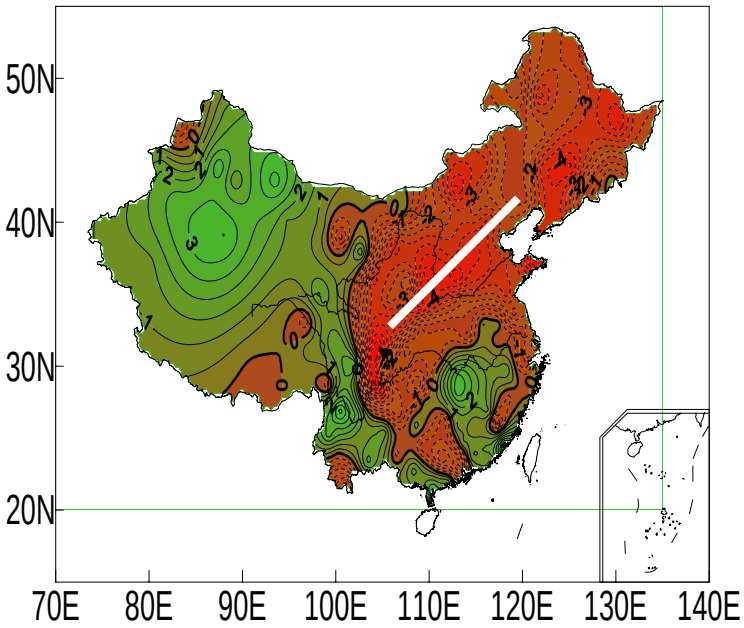
A Project under the support of Ministry of Science and Technology of China



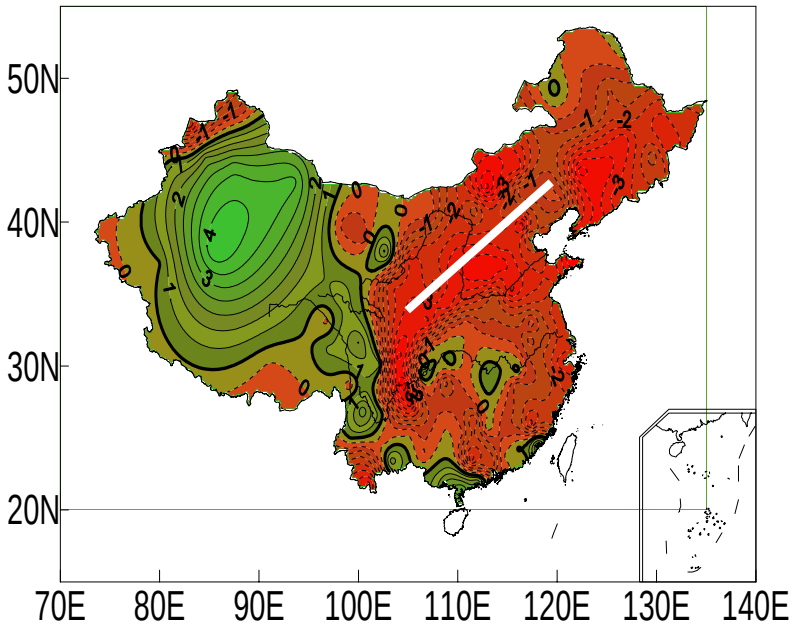
Arid and semi-arid areas cover 40% of land territory of China

An integrated environmental problem

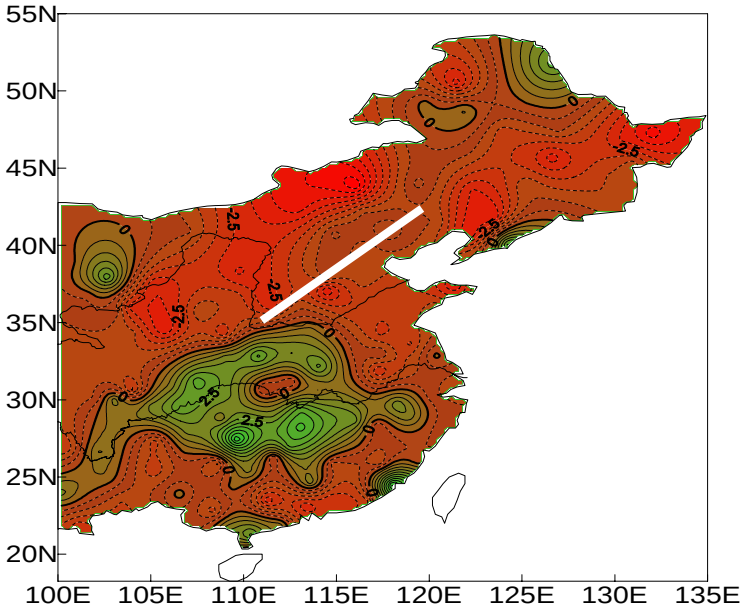




Palmer index

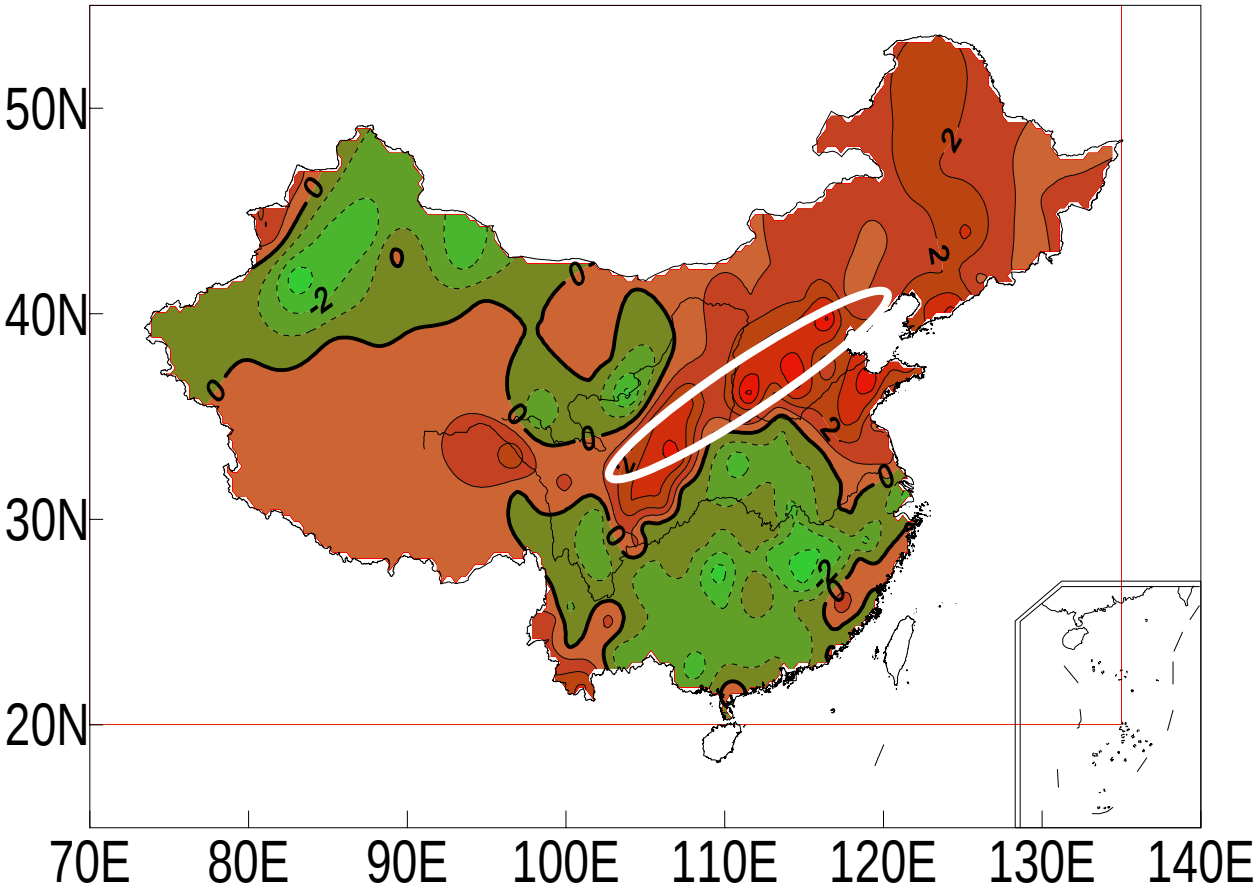


Wetness index

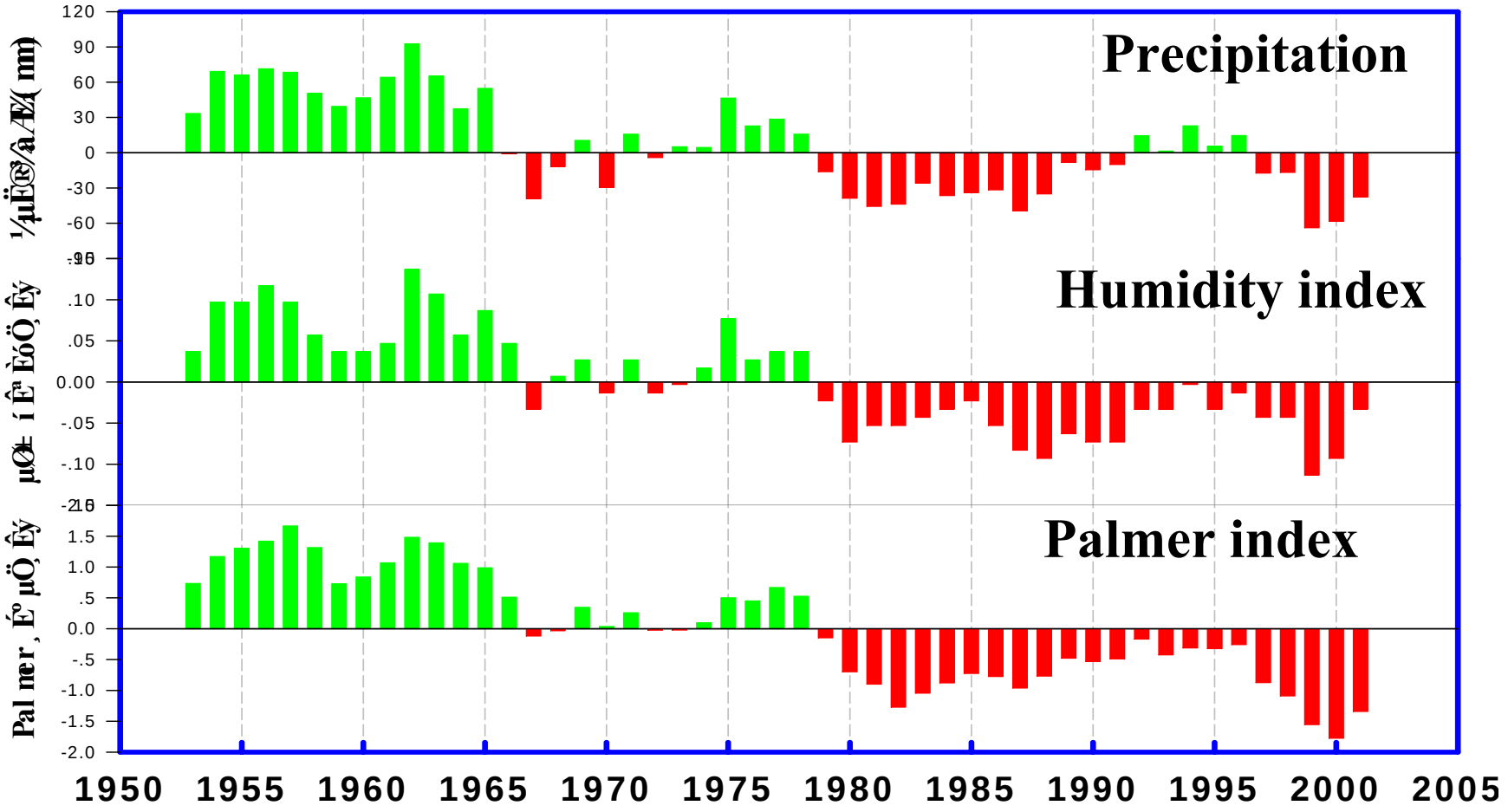


Soil moisture （50～60cm）

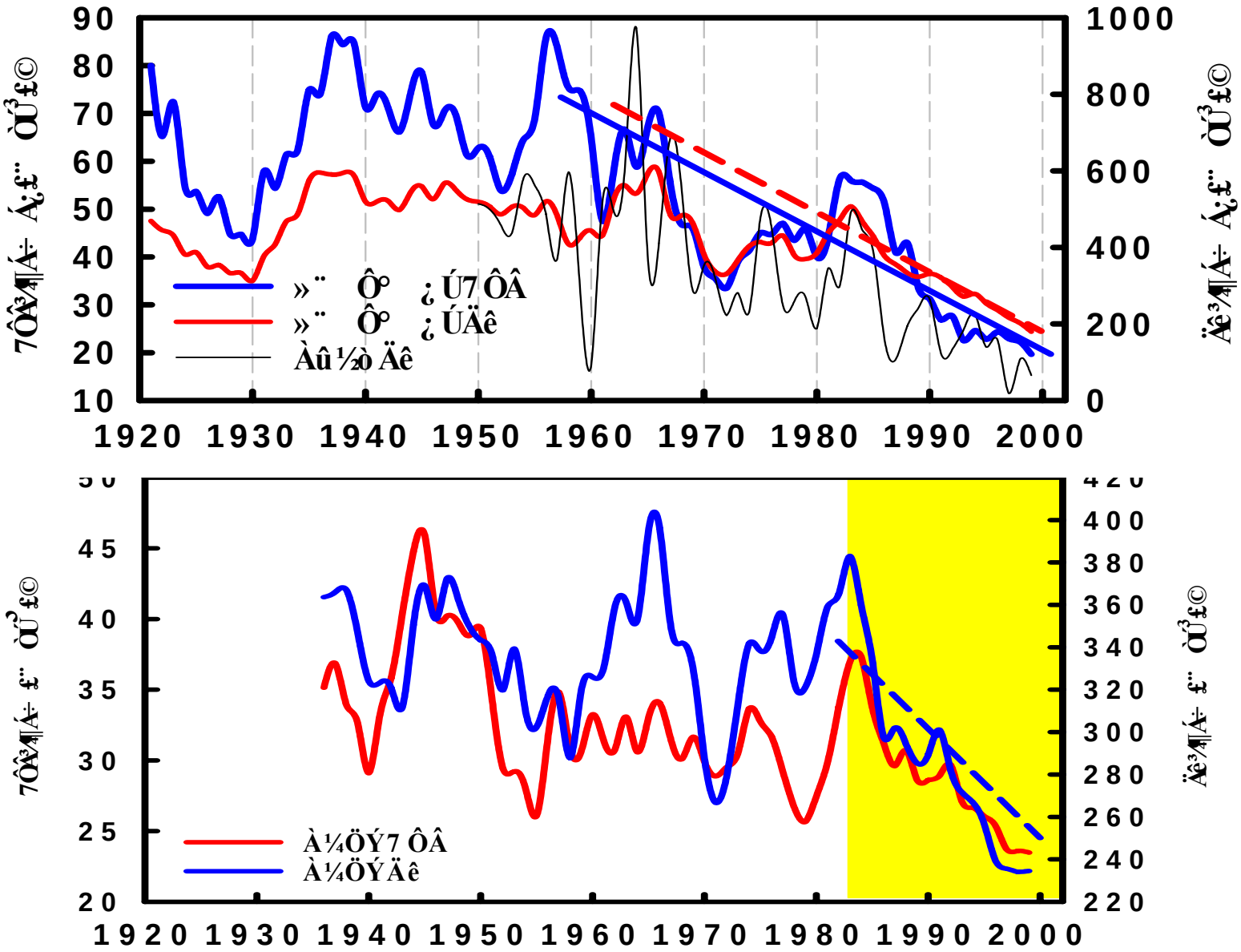
Trend of three aridity indices during last 50 years (1951-2004)



Changes of frequency of extreme drought events (1990’s –1950’-80’s)

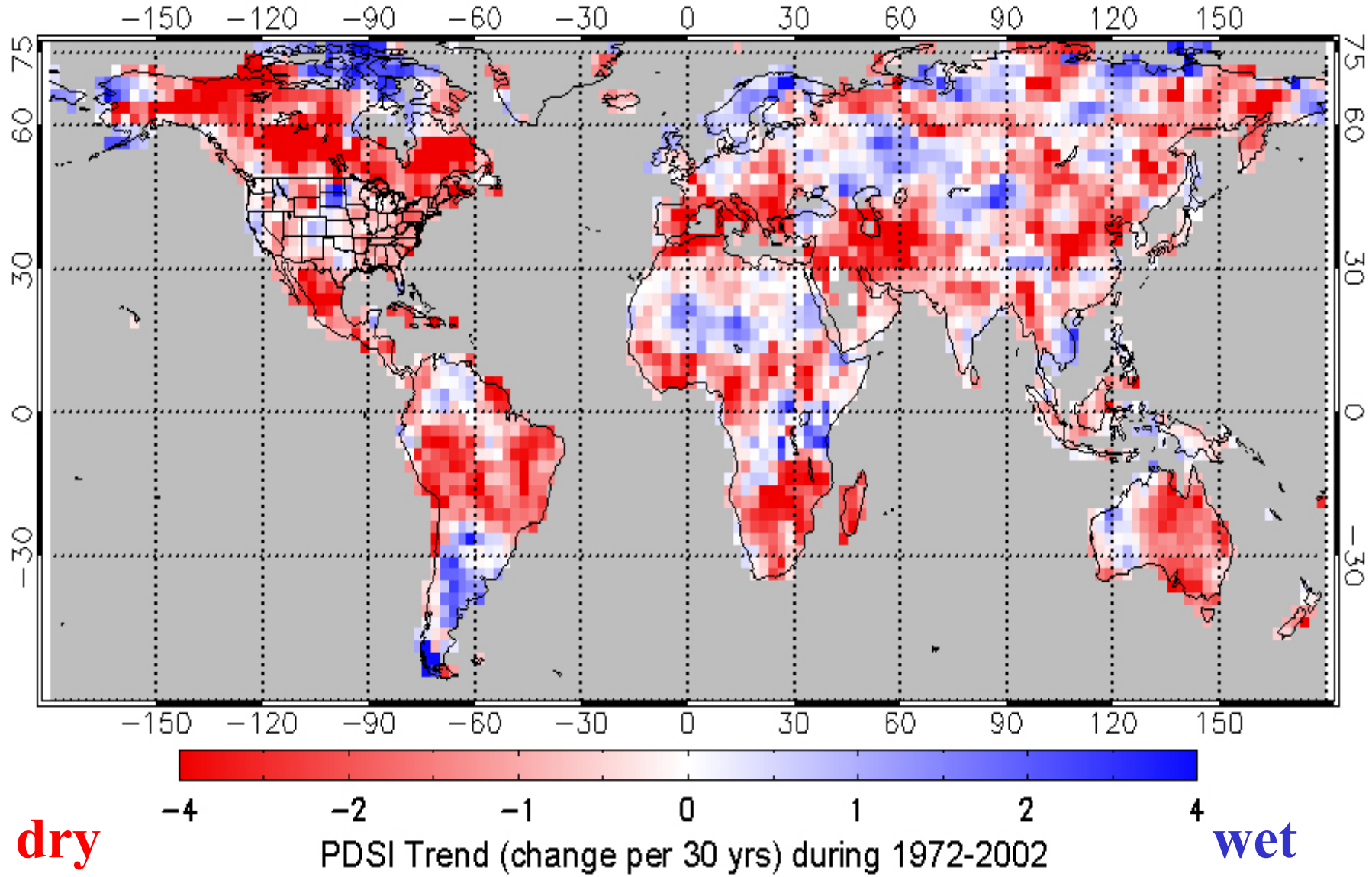


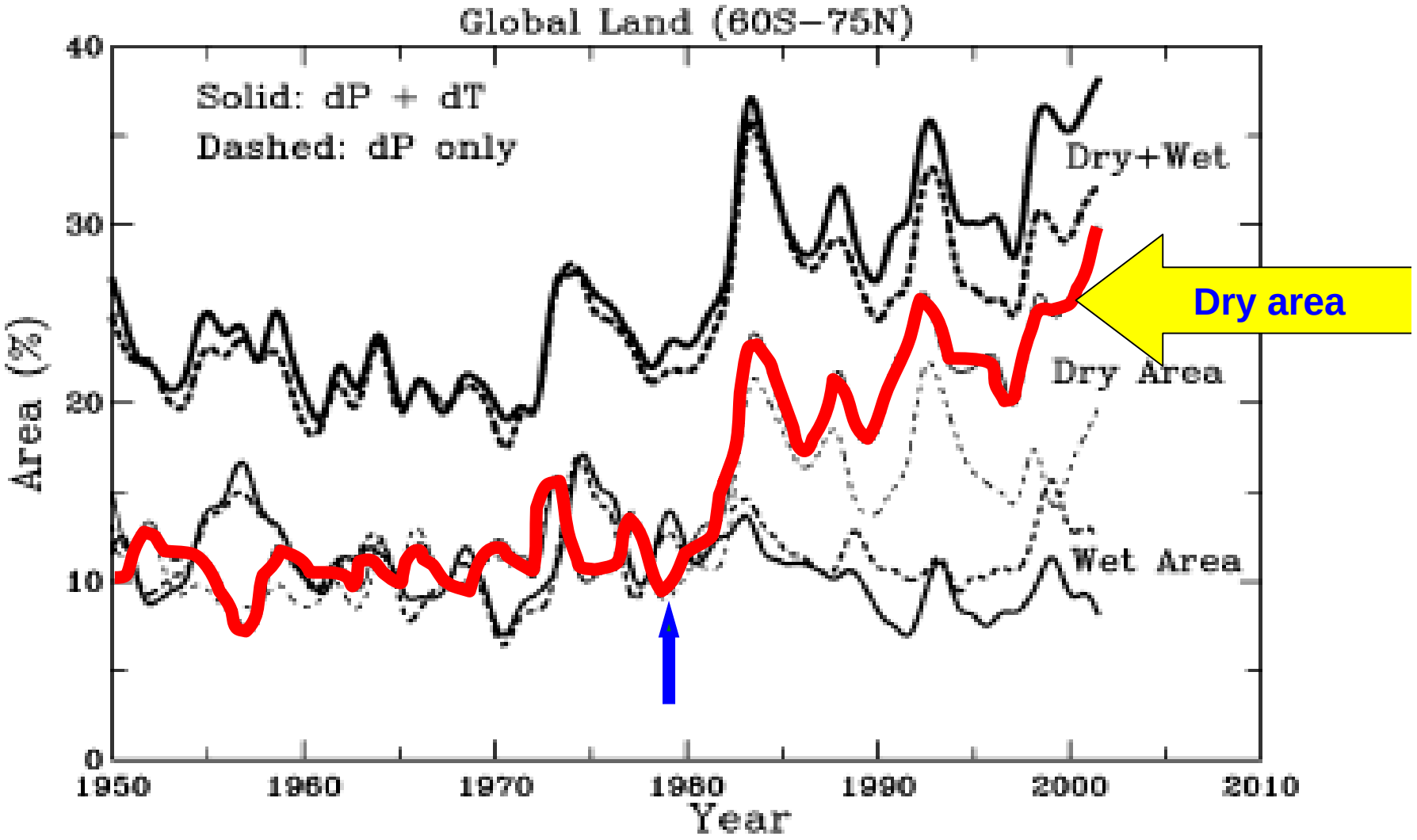
Indices of Northern China Plain



Yellow river runoff (10^3 Mm^3)

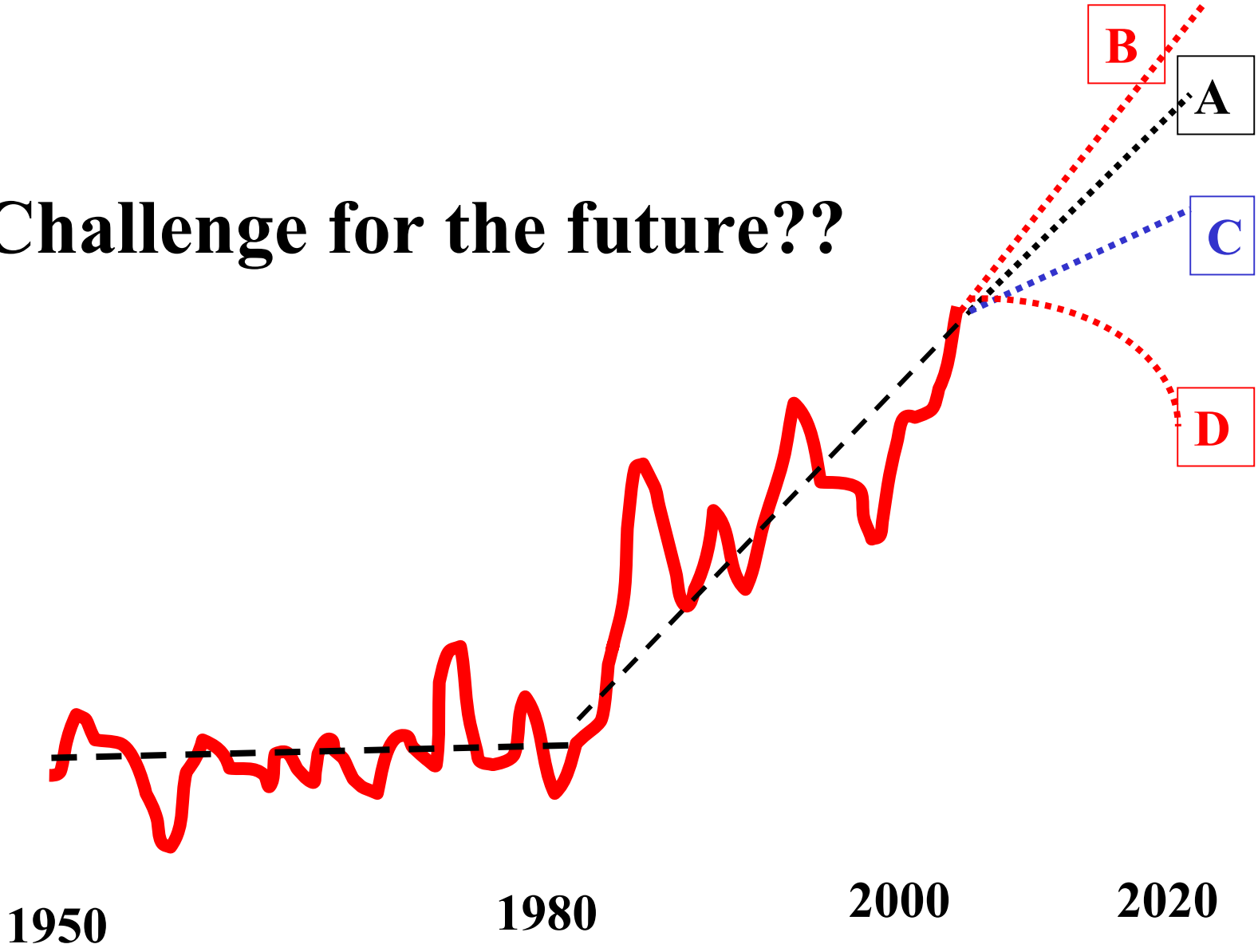
Global drying trend(Dai)

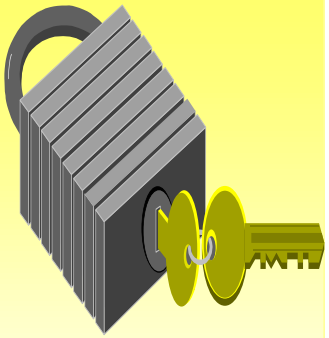




Global arid area increasing 2 times since 1980's

Challenge for the future??





Central Scientific Theme

Relative role of natural variation, global warming and human perturbation in the aridization process

1

Is the aridization the part of the long-term dry-wet alternative processes of Asian monsoon system evolution?

2

Does global warming matter for the aridization?

3

To what extent the human activities would influence the aridization process?

Study on Aridization of Northern China

- **Phase I: 2000-2005;**
- **Phase II: 2006-2010.**

Major Achievement of Phase I

- **New and more concrete evidence of aridization;**
- **Semi-quantitative evidence of human impact on aridization;**
- **Preliminary projection of future trend;**
- **Preliminary assessment of impacts on water resources, agriculture and ecosystems;**
- **Establishment of a CEOP reference site in semi-arid region.**

Goal of the Project in Phase II

- **Providing scientific bases for decision makers in the formation of policy to adapt the aridization and their future development;**

- **Providing knowledge bases to understand the function of arid/semiarid regions in climate and hydrological cycles of Earth System**

Main Research Tasks of Phase II

✓ Understanding the **interactions** among atmospheric dynamics, land surface hydrological/ecological processes and human perturbation;

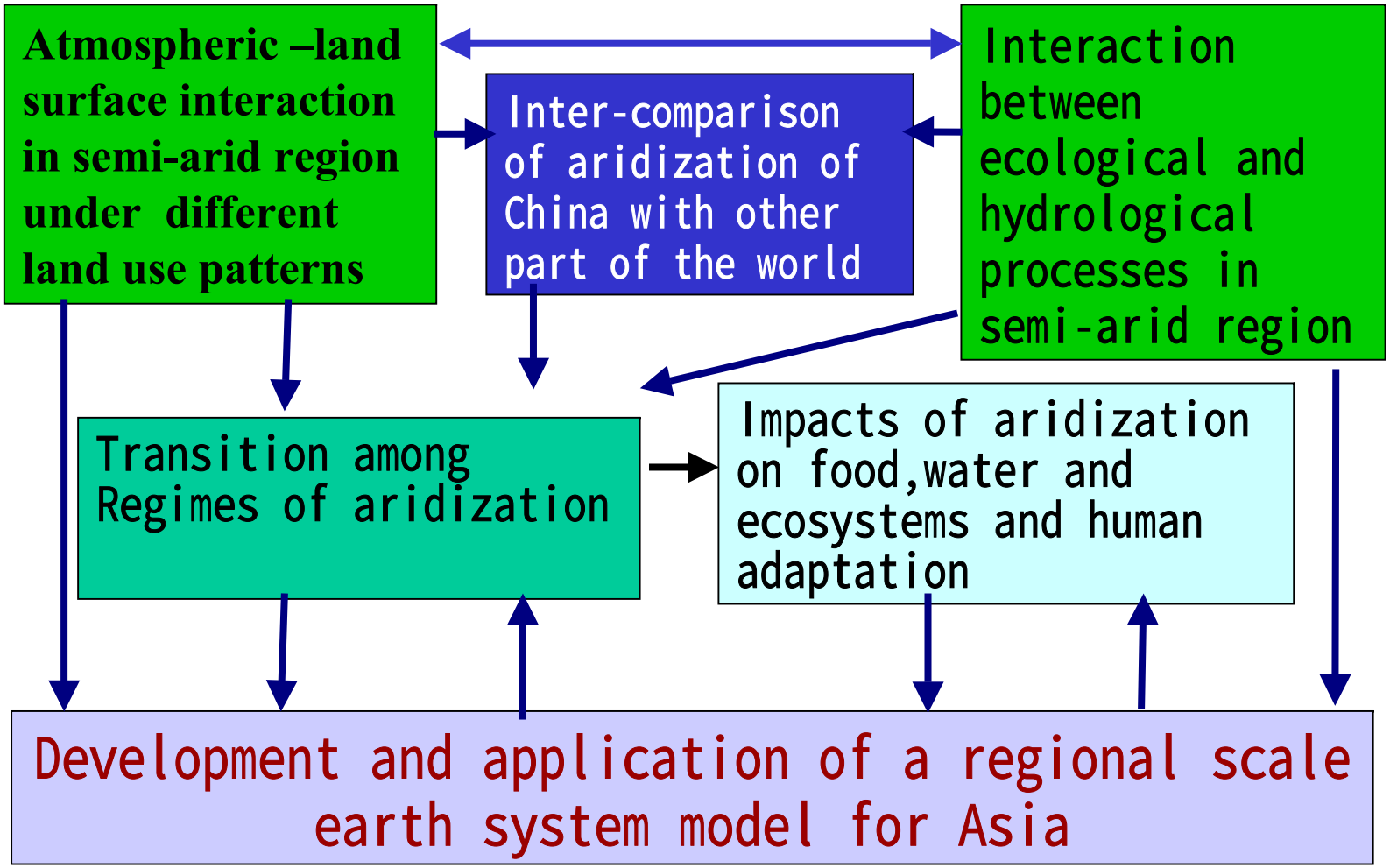
✓ Exploring further the regulation of aridization, particularly the **transition** among the different regimes ;

Main Research Tasks

✓ Developing a regional scale earth system model for Asia to be used for projection of future trend and impacts assessment;

√ **Development of strategies to adapt the impacts of aridization on water resources , agriculture and ecosystems.**

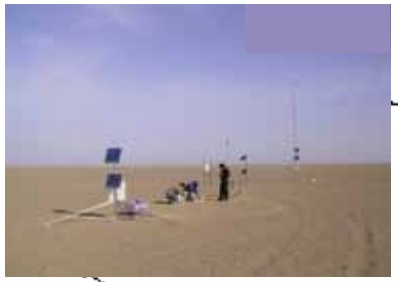
Main Components of Research



(1) Observation and field experiment study on atmosphere-land surface interaction in semi-arid region under different land use pattern

- Structure and dynamics of atmospheric boundary layer in the semi-arid region ;
- Land surface process of semi-arid region and its parameterization ;
- Radiation effects of dust aerosols and their potential influence on cloud microphysics and hydrological cycle of the atmosphere

CEOP Reference sites and related stations



阜康

海伦

三江

内蒙

奈曼

长白山

Tongyu

策勒

鄂尔多斯

北京

沈阳

临泽

沙坡头

海北

安塞

Langzhou

禹城

CEOP sites

Ecological stations

农田

森林

草地

荒漠

海湾

湖泊

湿地

overgraizing-protection-recovery

In-situ observation

- Subsurface (-1.6m): soil temperature, moisture, heat flow
- Surface(0+2m): radiation, surface temperature, moisture, precipitation, vegetation, snow
- Near surface(20m): temperature, specific humidity, wind speed, momentum, latent and sensible heat fluxes
- Atmospheric aerosols, particularly the dust aerosols and spectrum of atmospheric radiation. Ground based measurements of atmospheric optical depth.

Ecological process observation

Sample fields with fence

at sandy land, grassland and crop land

each with 100m x 100m

Observation items on

biodiversity, above- and under-ground

productivity, vegetation height, fraction, biomass,

LAI, photosynthesis, water vapor potential

soil organic substance, litter decomposition,

chemical elements

Satellite remote sensing

Additional information, i.e.

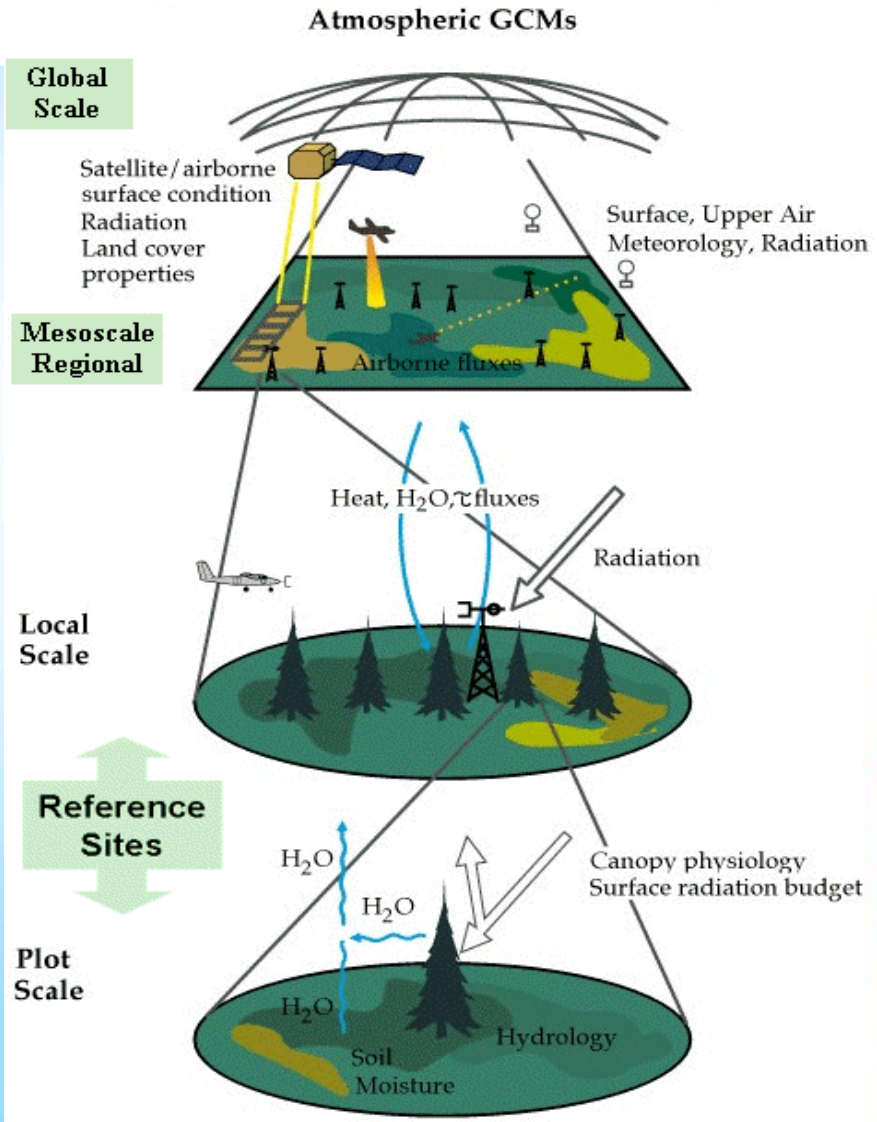
- **Land cover and land use changes;**
- **Dust transferring track and dust aerosol distribution;**

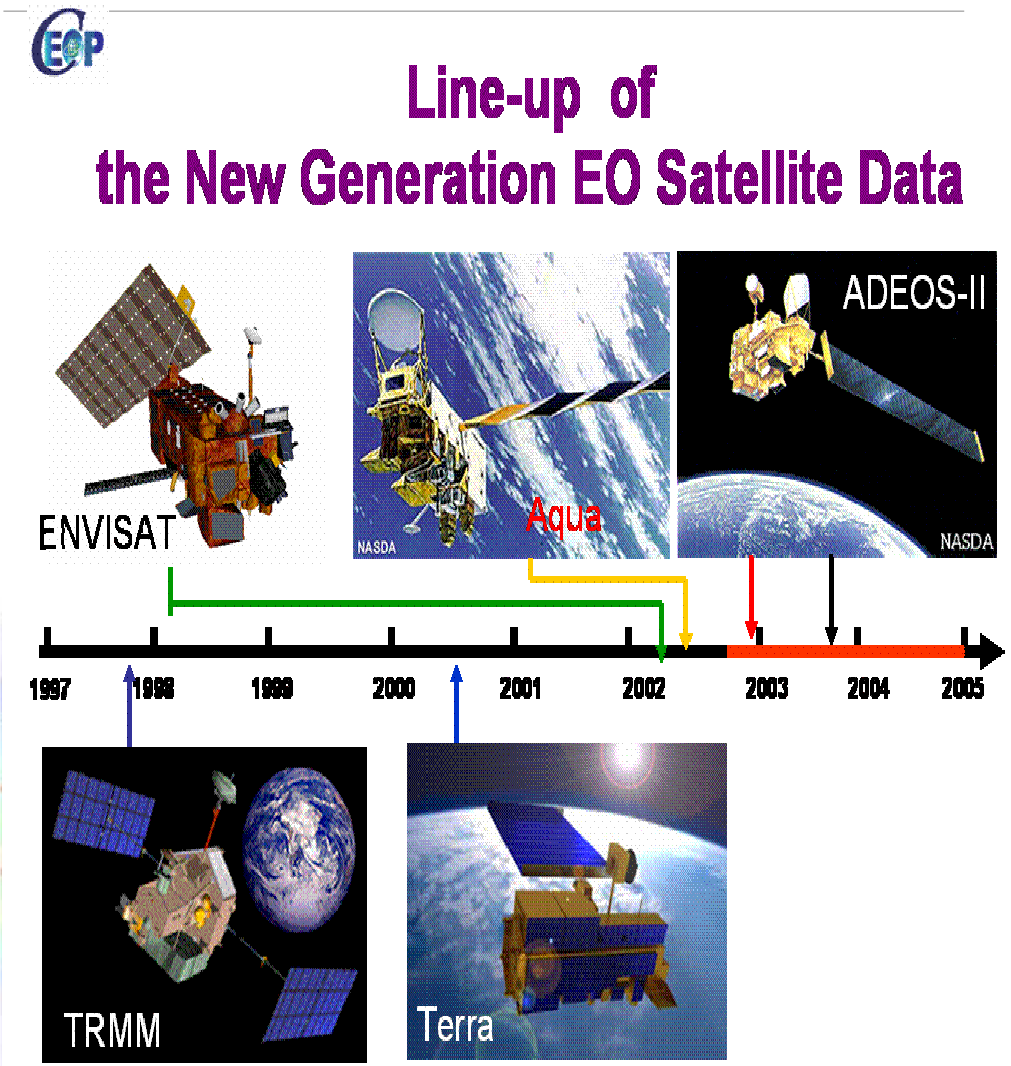
Modeling:

Regional climate model with additional modules:

- **Chemical/aerosols module;**
- **Land use module.**

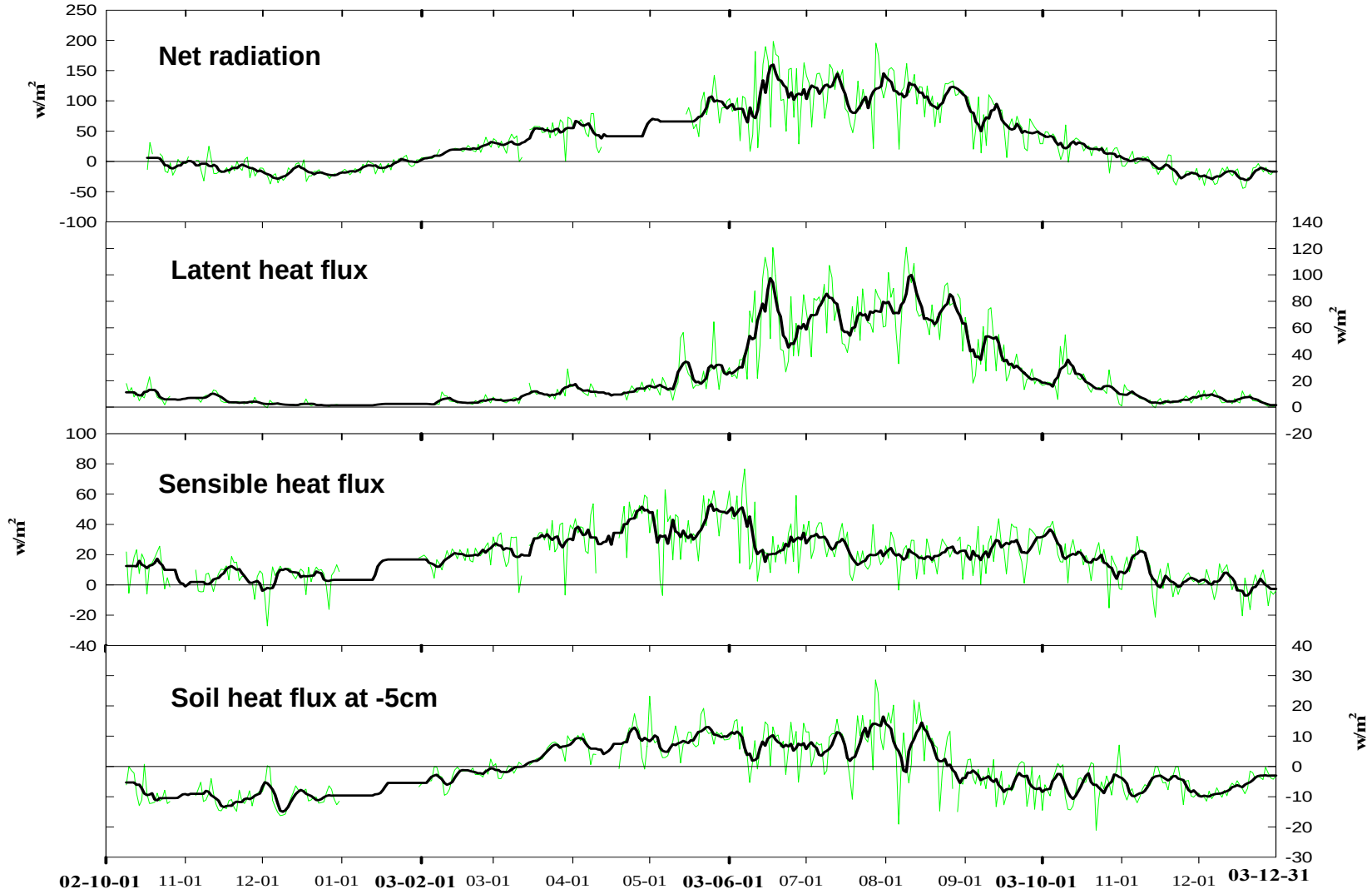
Scaling up by using satellite information



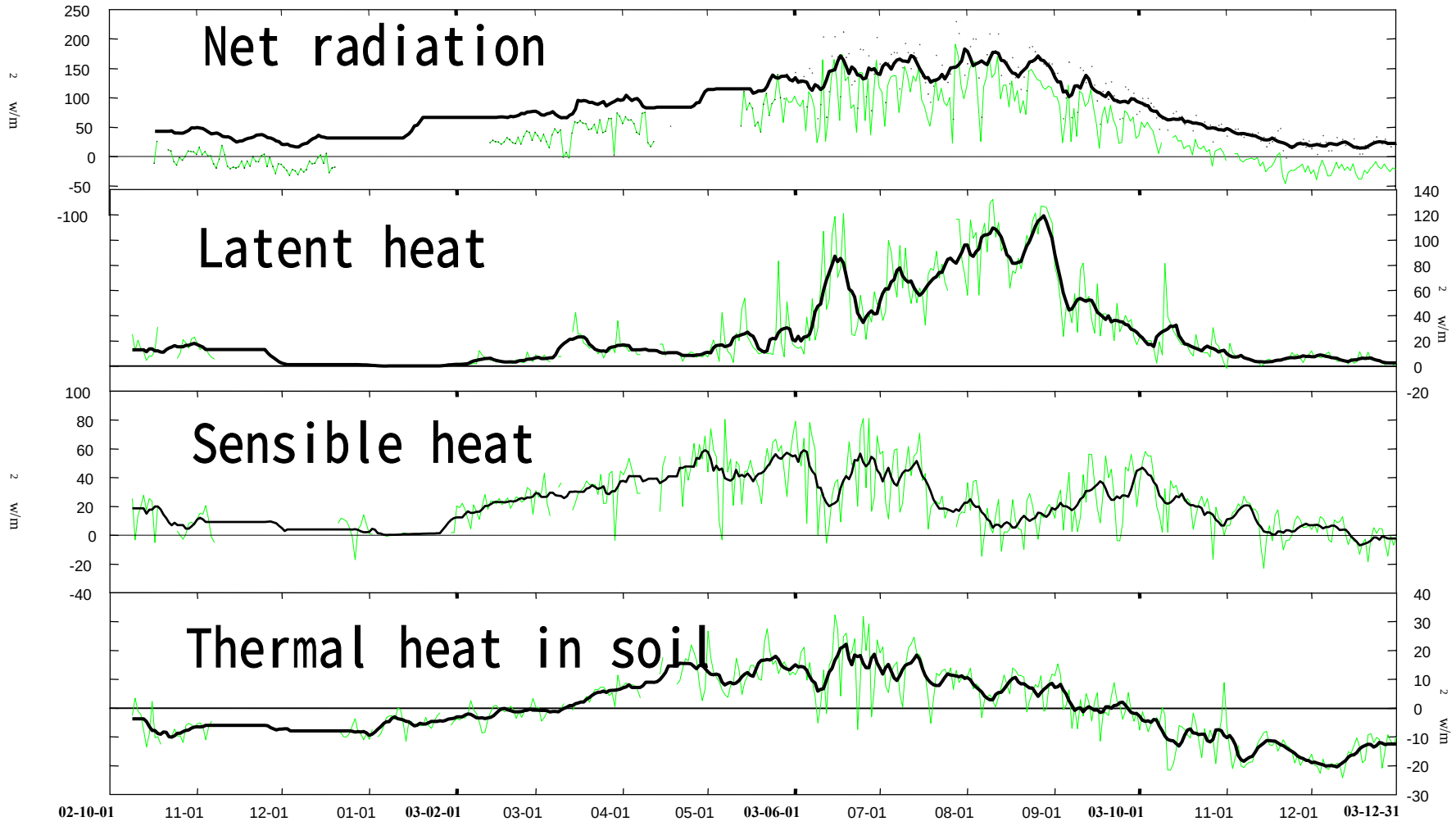


Daily average energy fluxes over degraded grassland

(black line: 10-days moving average; green line: daily average).



Crop land

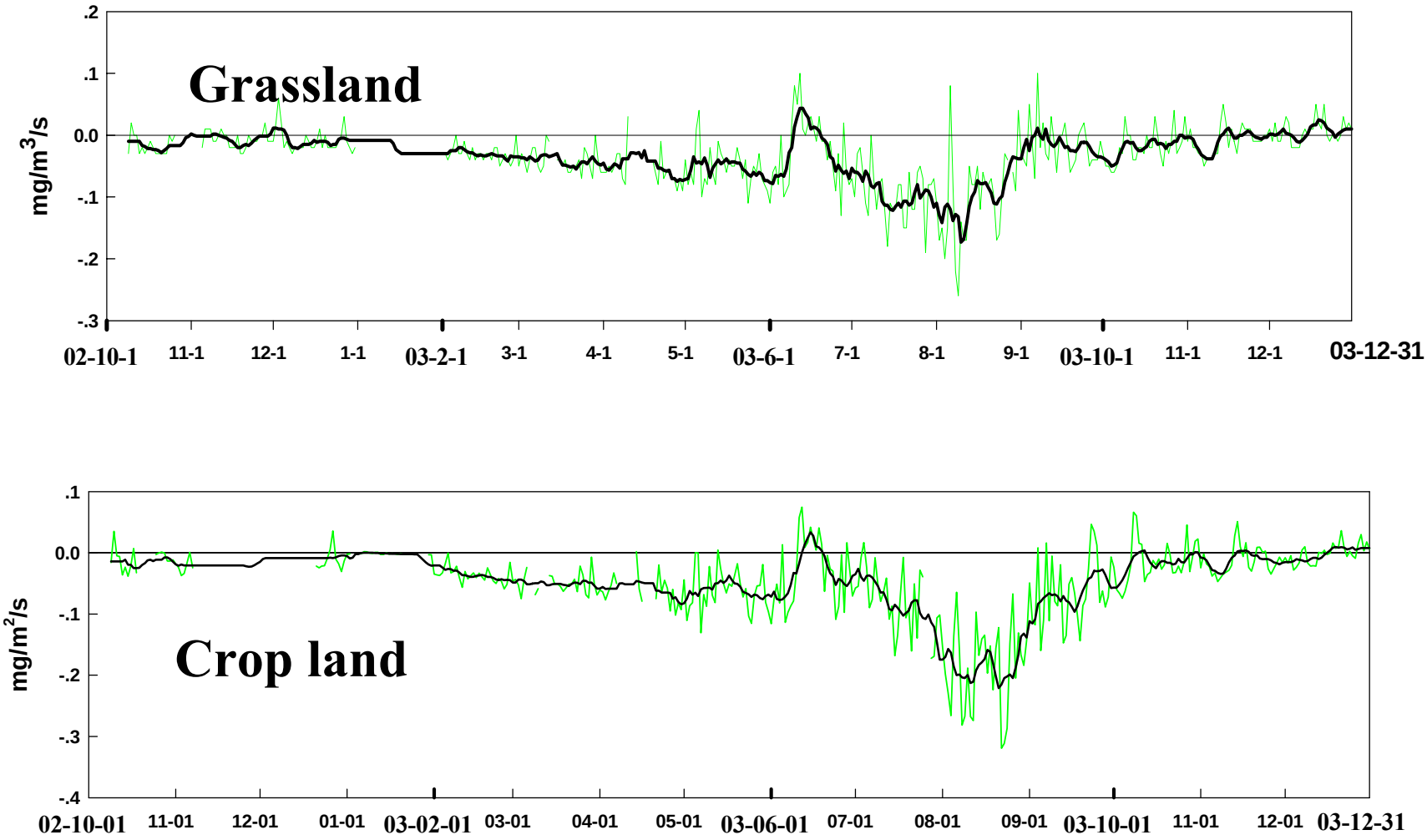


日均值

10日滑动平均

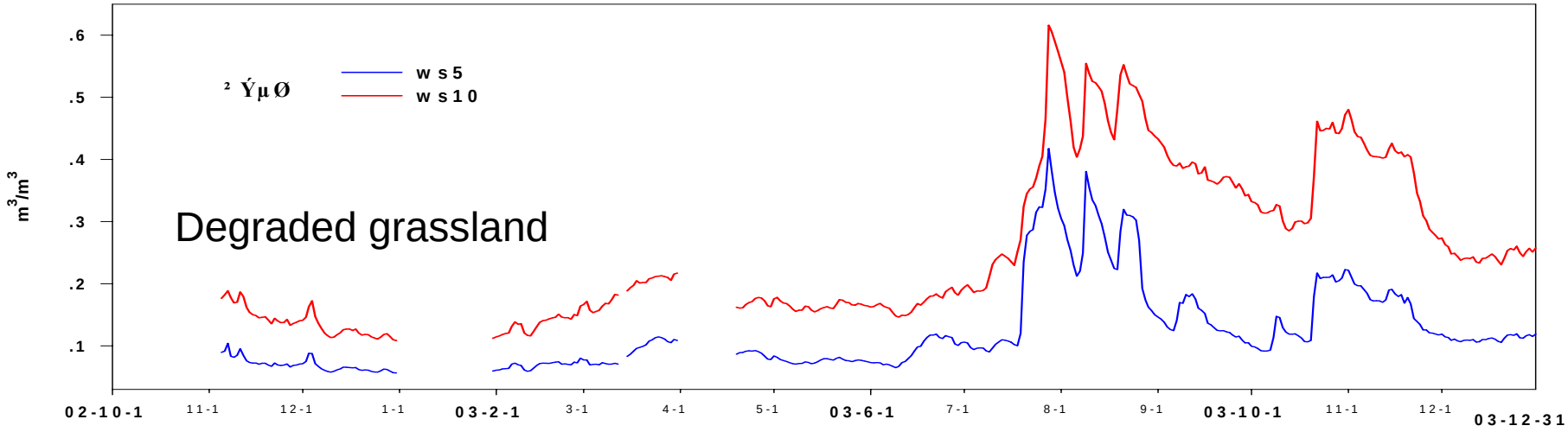
农田能量平衡各分量日均值的年变化

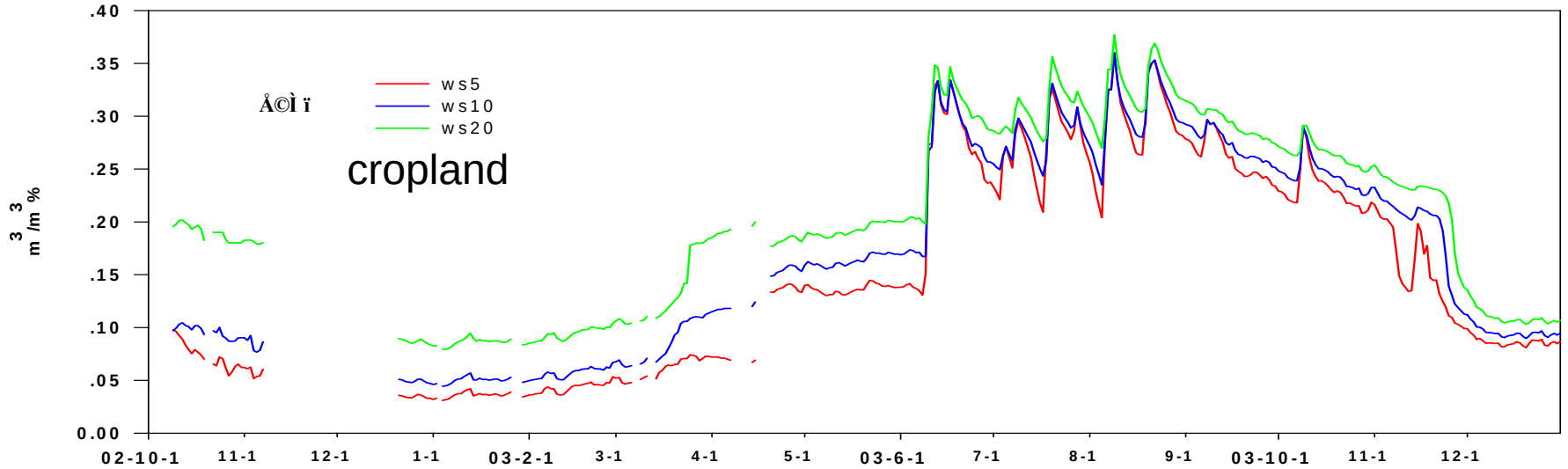
CO2 flux



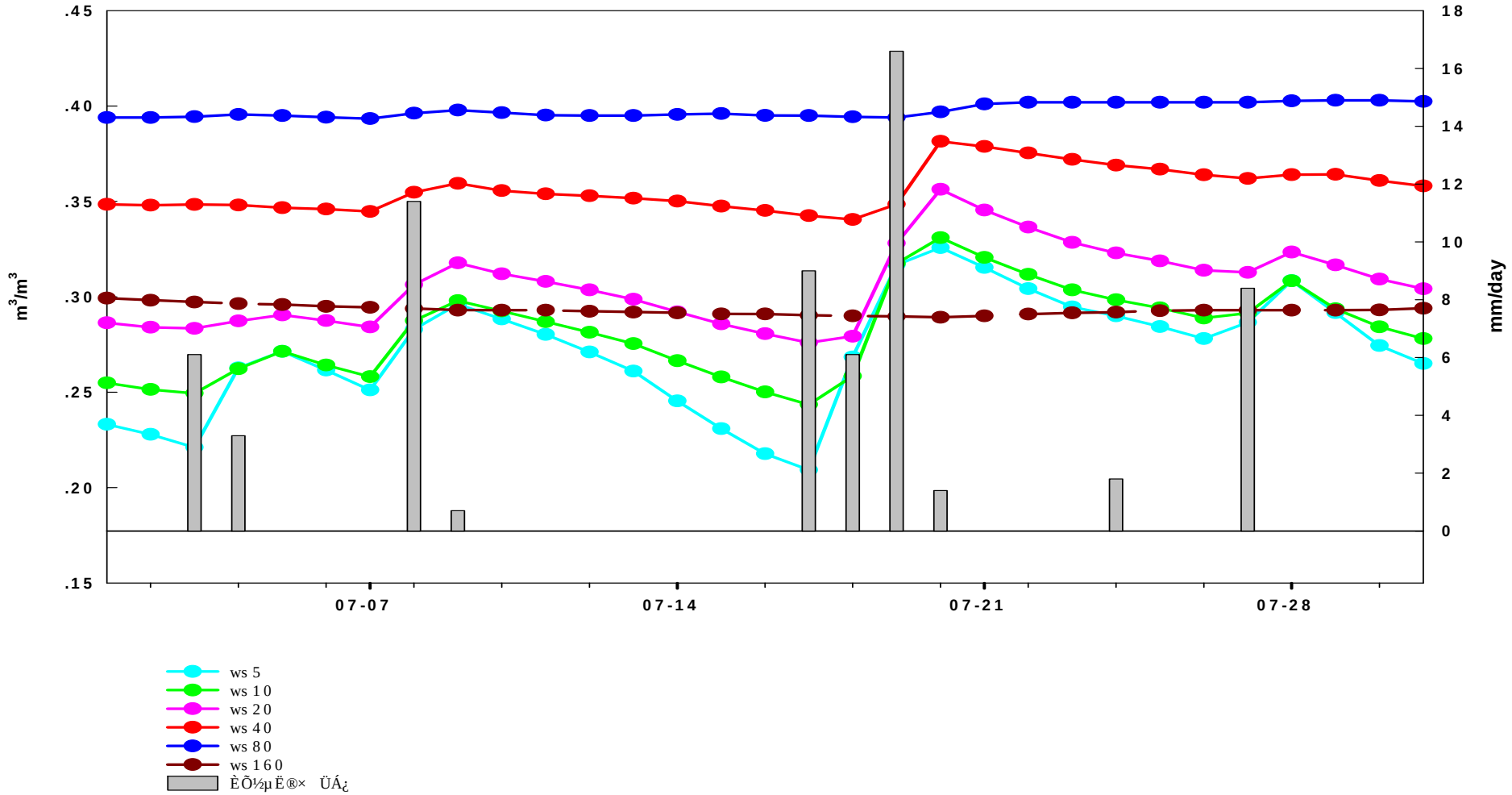
二氧化碳通量日均值的年变化

The volumetric soil water content



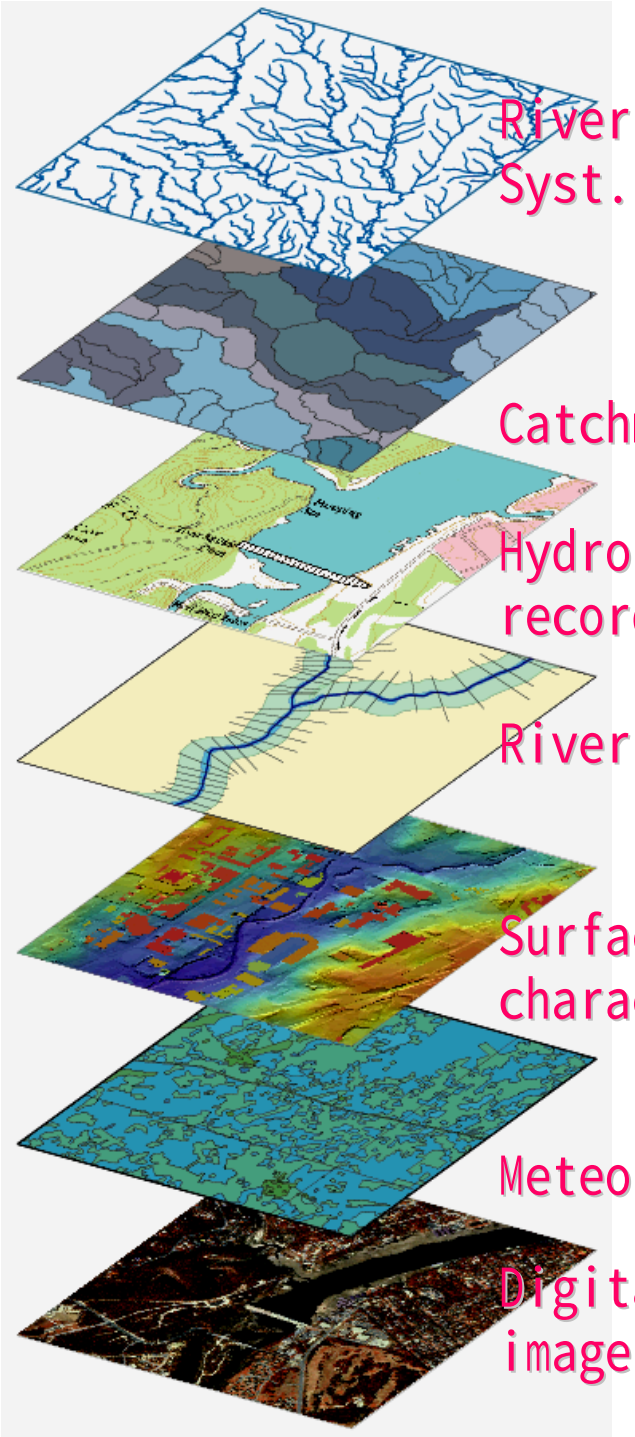


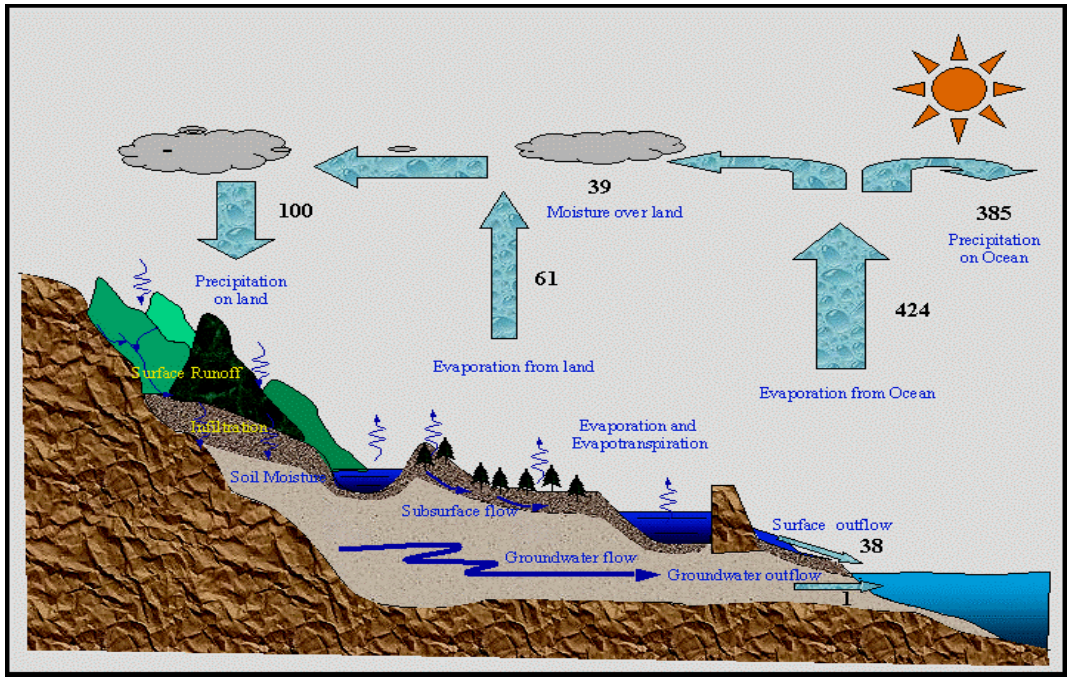
The volumetric soil water content over cropland with the daily rainfall (2003/07)

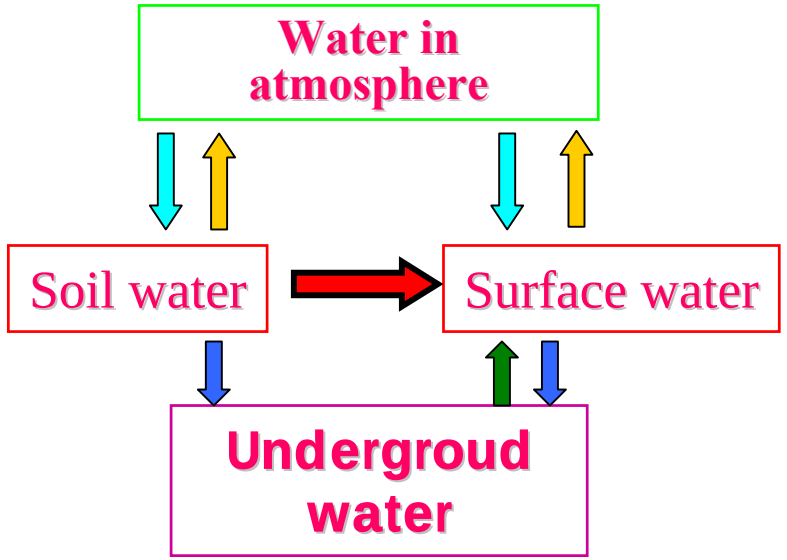


(2)Interaction between hydrological and ecological processes of the land surface in semi-arid region

- Ecological regulation of water cycle
- Ecological consequence of changing water resources in semi-arid region
- Development of an eco-hydrological coupled model for semi-arid region







A schematic diagram of the model system

(3)Inter-comparison of aridization of northern China with other semi-arid regions of the world

Contributions to CEOP II

semi-arid region Study

Water & Energy Simulation & Prediction (WESP)
Semi-arid Region Study

Background

The semi-arid regions are transitional zone of climate and ecosystems, the most vulnerable areas in response to both human perturbation and climate change and also major sources of dust storms, which have significant influence on the human health, the regional and global climate. So far there is no any model that can better apply to these regions.

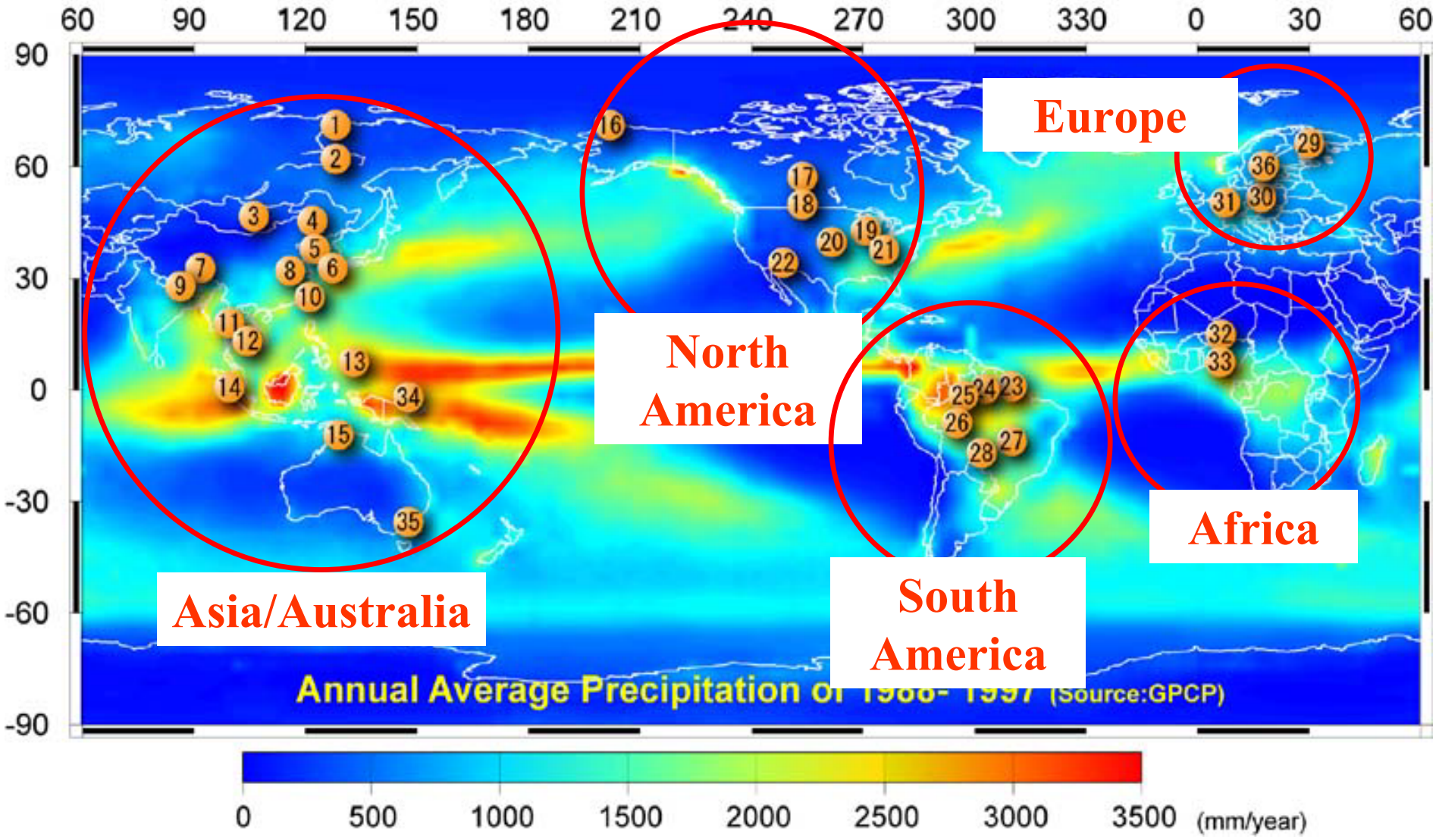
CEOP Unique Contribution

globally integrated data systems of CEOP in-situ reference sites over semi-arid regions, with coordinated satellite observations and the model outputs

CEOP Implementation Approach

- Atmospheric boundary layer physics and dynamics;
- Land surface process;
- Water balance and energy balance of air-soil-vegetation system;
- Interaction of dust aerosols and hydrological cycles;
- Impacts of dust aerosols on regional and global climate;
- Long distance transport and deposition of dust aerosols on oceans;
- Integrated study on water issues.

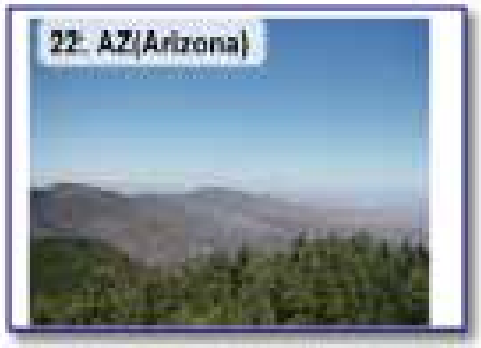
CEOP 36 Reference Sites

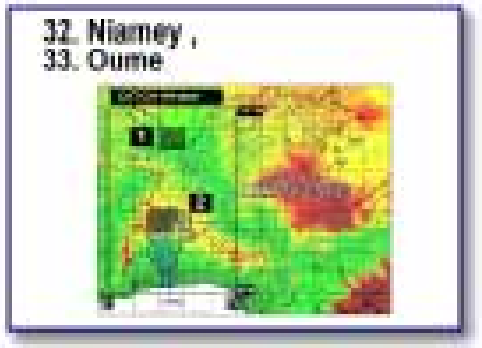


Suggested Stations to be involved in CEOP arid/semi-arid Inter-comparison study

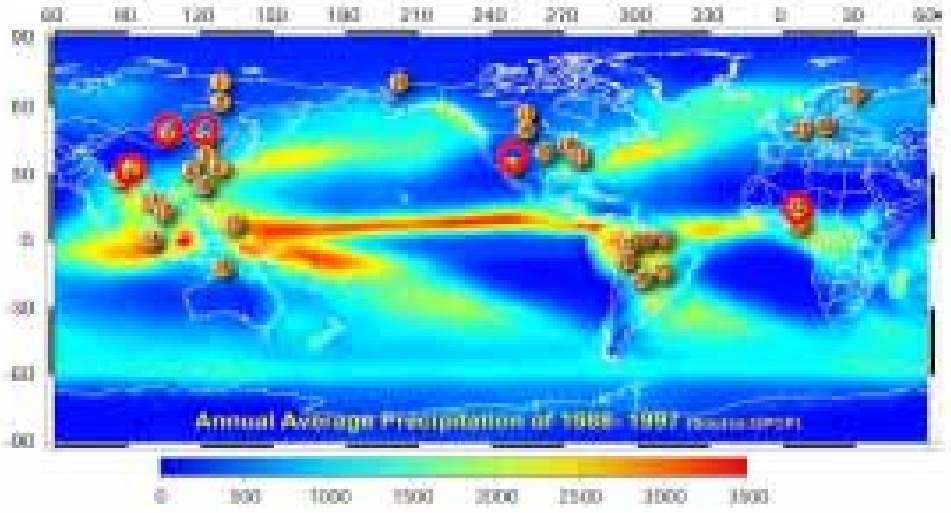
- **Tongyu, China**
- **Lanzhou, China**
- **Ulanbator, Mongolia;**
- **Arizona, USA;**
- **North Africa;**
- **Australia;**
- **Iran;**
- **South America**

possible candidates
Iran, Tunisia, Mexico, China



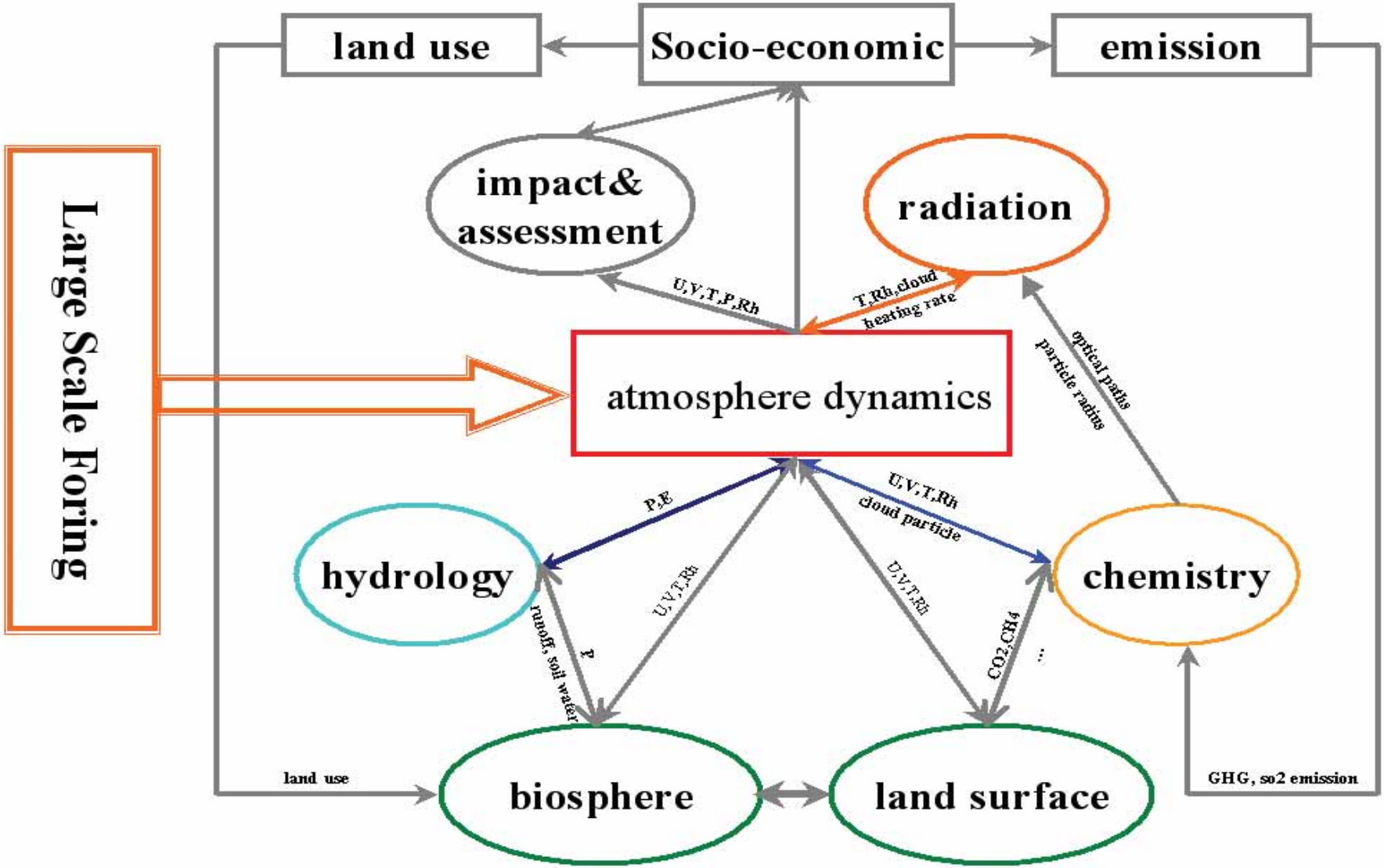


CEOP Reference Site
in the Semi-arid Regions

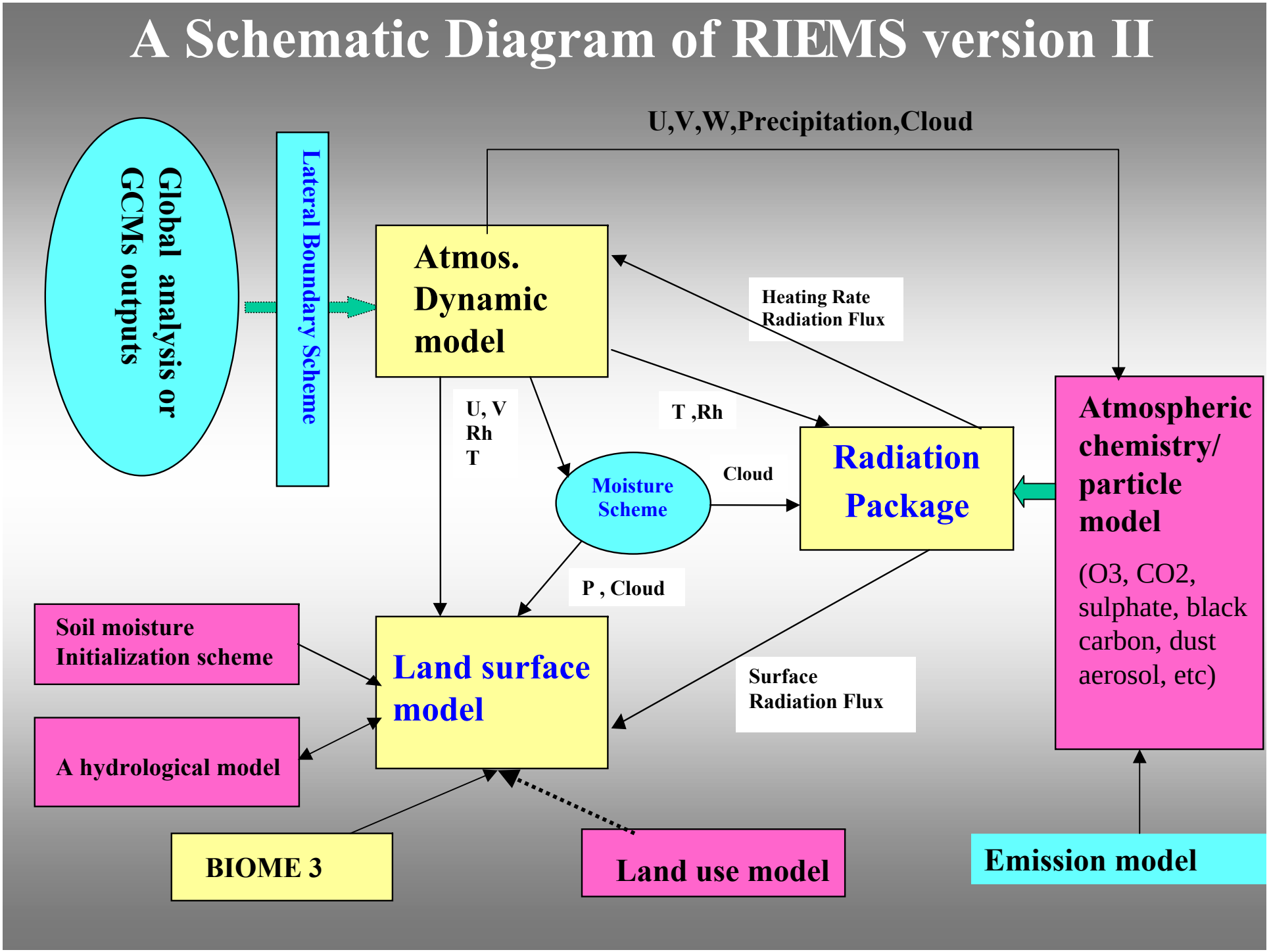


(4)Development of a Regional Model of Earth System for Asia

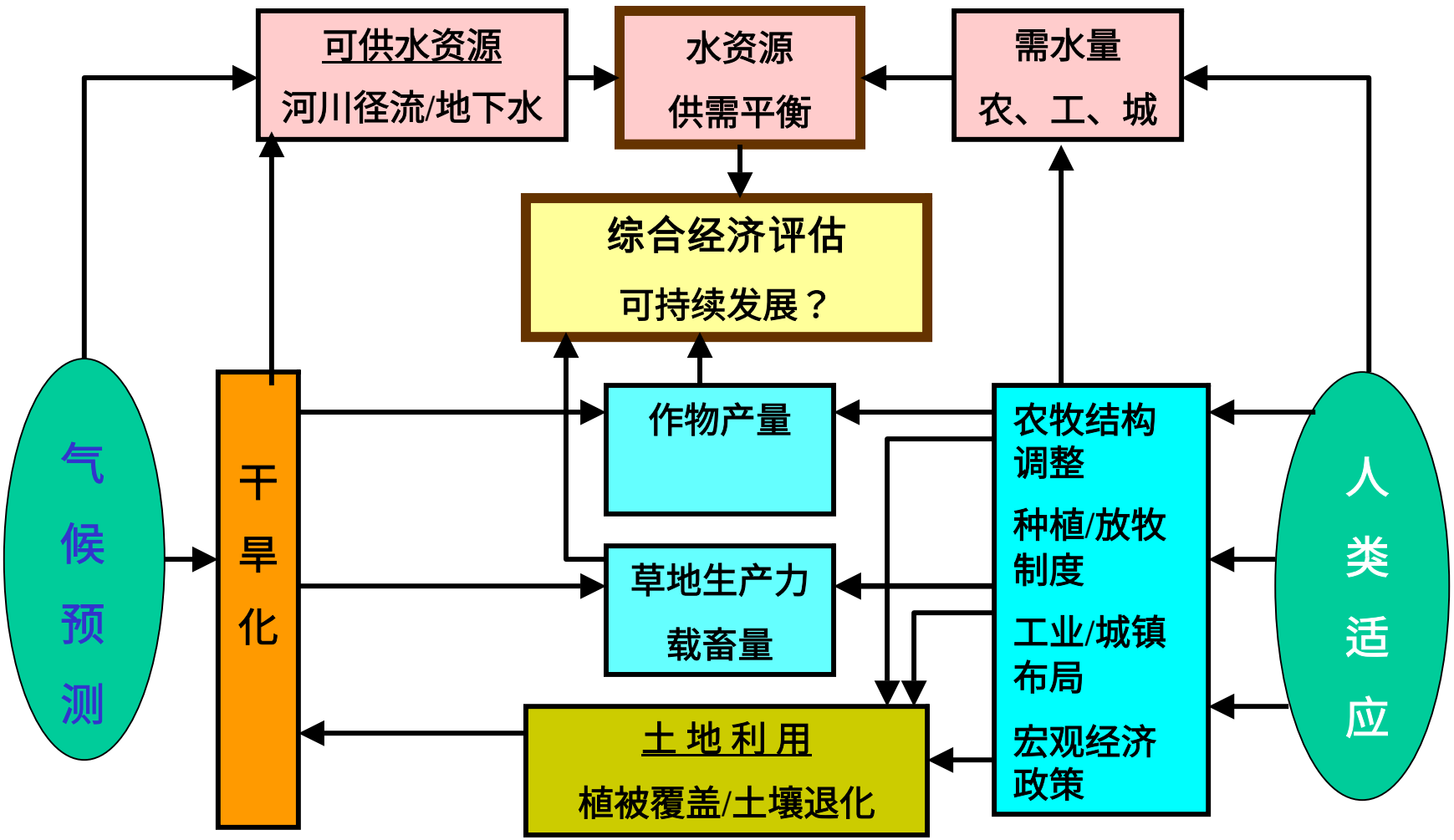
A Regional Earth System Model



A Schematic Diagram of RIEMS version II



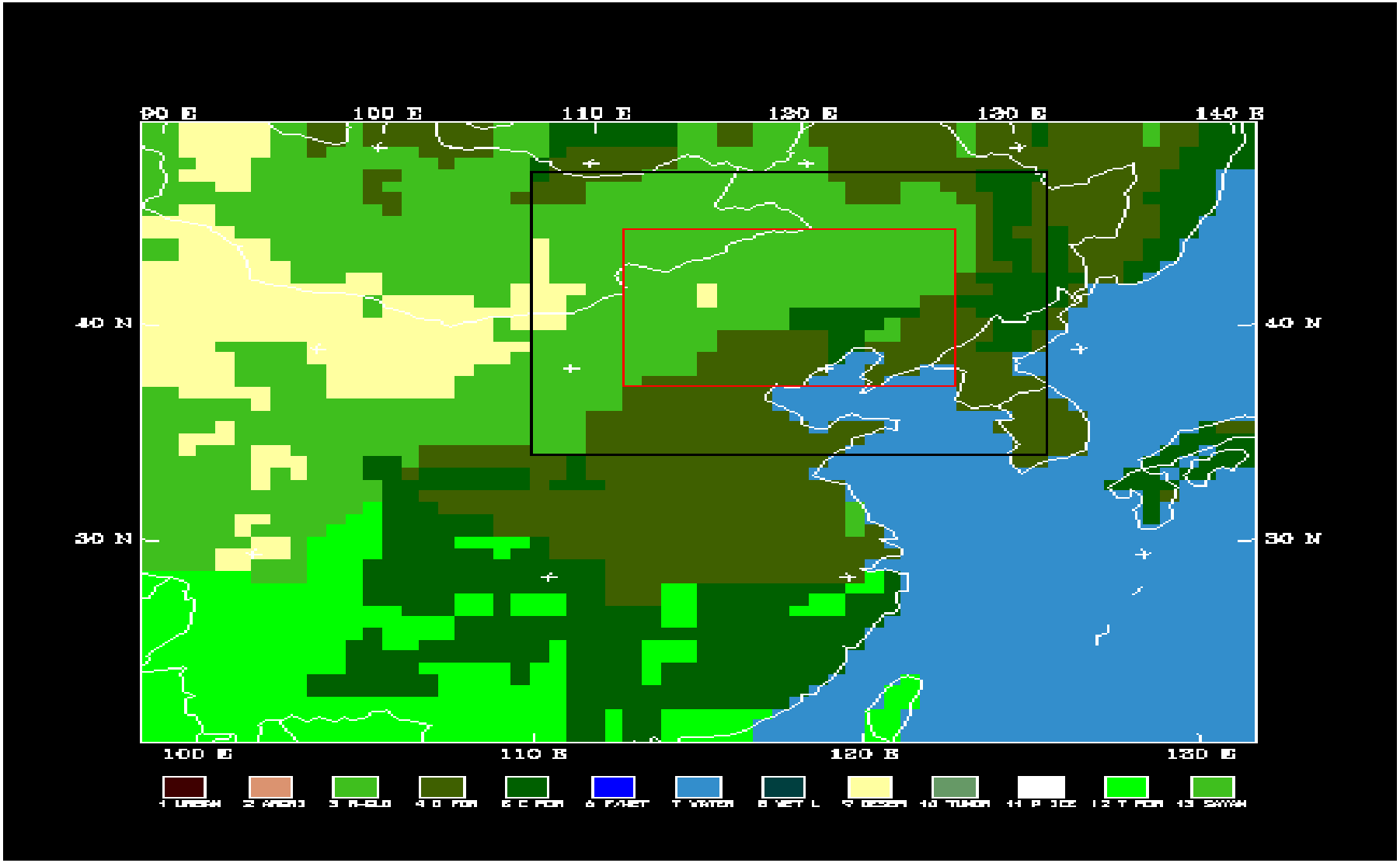
An Integrated Assessment Model Centered on Water



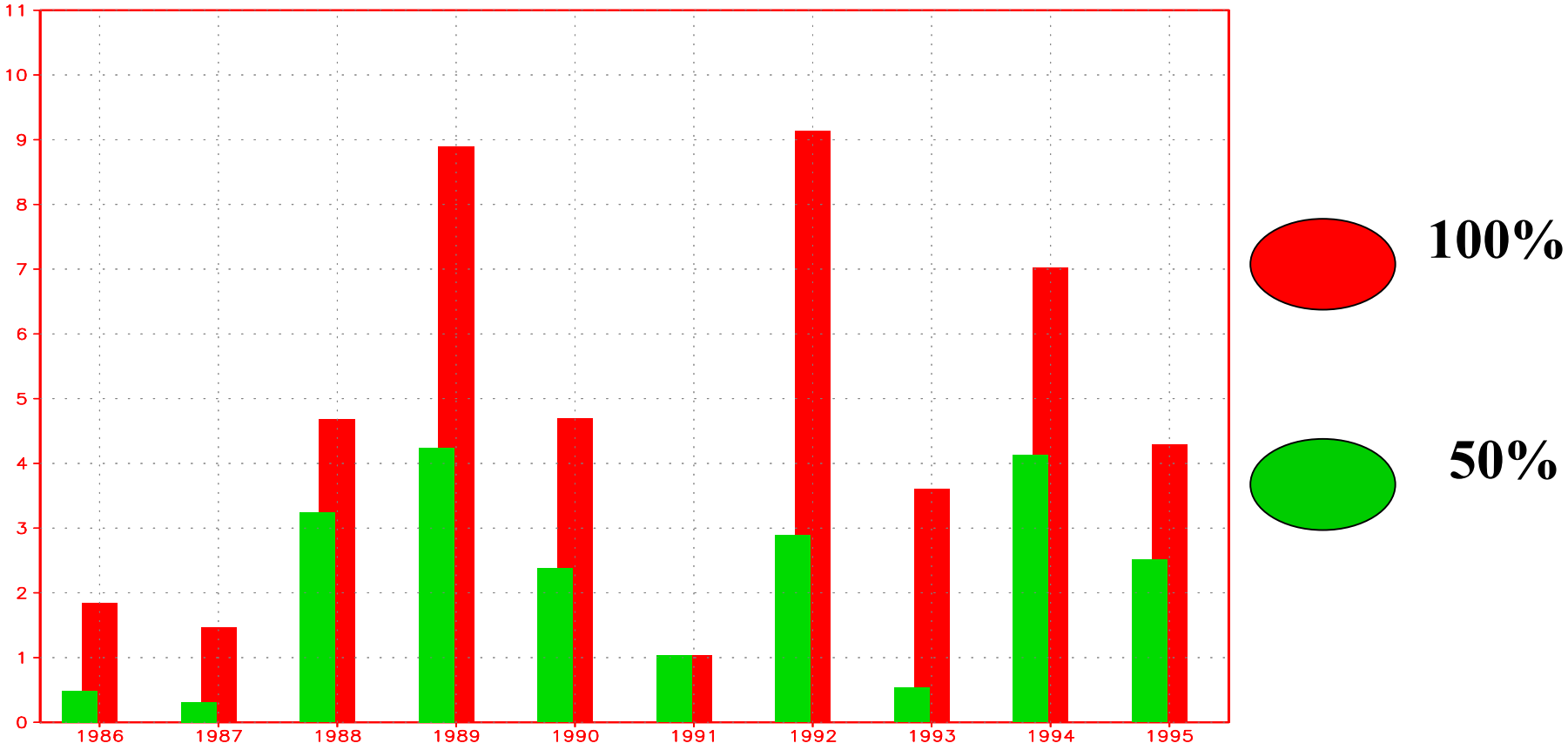
Can human adapt to the aridization?

A case of numerical simulation by *RIEMS*

Areas`of simulation, experiment and analysis for recovering natural vegetation in semi-arid region



Changes of soil moisture by recovering the natural vegetation in the experiment area(%)(10 years simulation by RCM)



Regional Model Inter-comparison Project for Asia(RMIP)

- **USA:** CU, A. Lynch; ASU, W.Gutowski
- **Japan:** NIES, S. Emori; CRIEPI, H.Kato
  MRI, Sato
- **Australia:** CSIRO, J.McGreger
- **R.Korea:** SNU, D.Lee; YU, J.Kim
- **China:** TEA-RC, C.Fu; NU, B.Su

A Joint effort of 10 research groups of 5 countries

(Bulletin of AMS, Feb.2005)

Monsoon Asia Integrated Regional Study for Global Change （MAIRS）

Earth System
Science Partnership

WCRP Climate

diversitas

GLOBAL CHANGE IGBP

Thank you