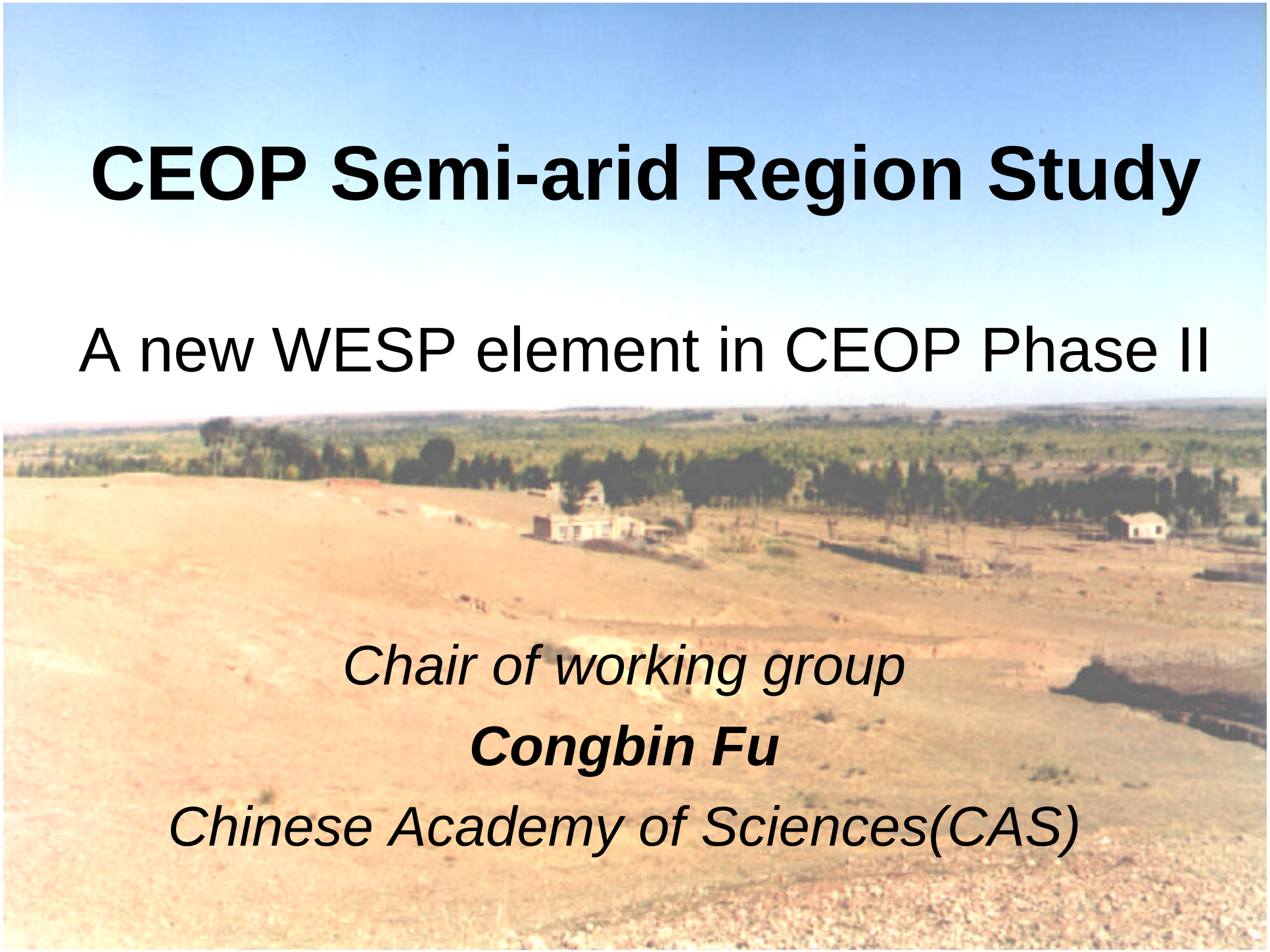
CEOP Semi-arid Region Study

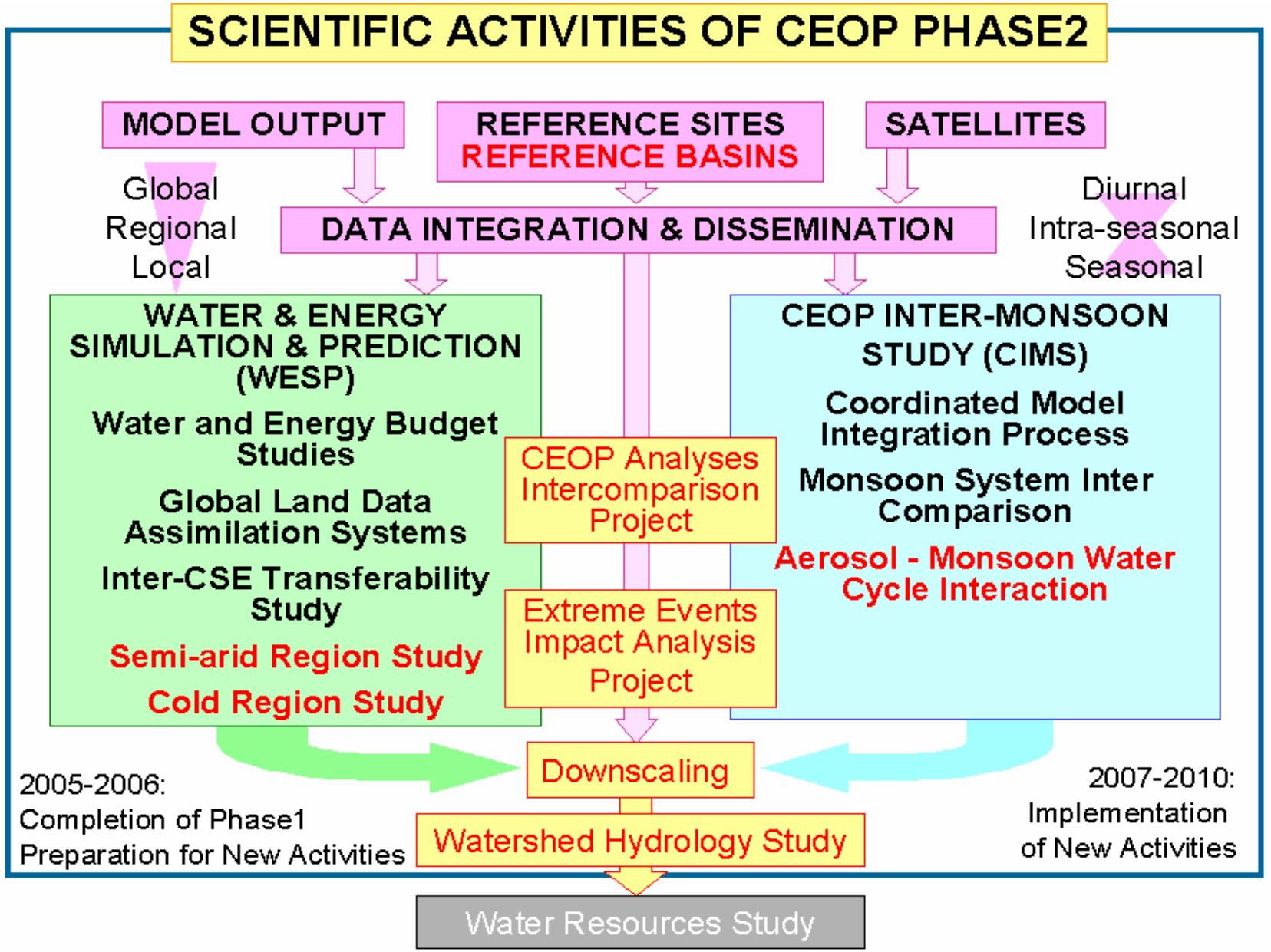
A new WESP element in CEOP Phase II



Chair of working group

Congbin Fu

Chinese Academy of Sciences(CAS)

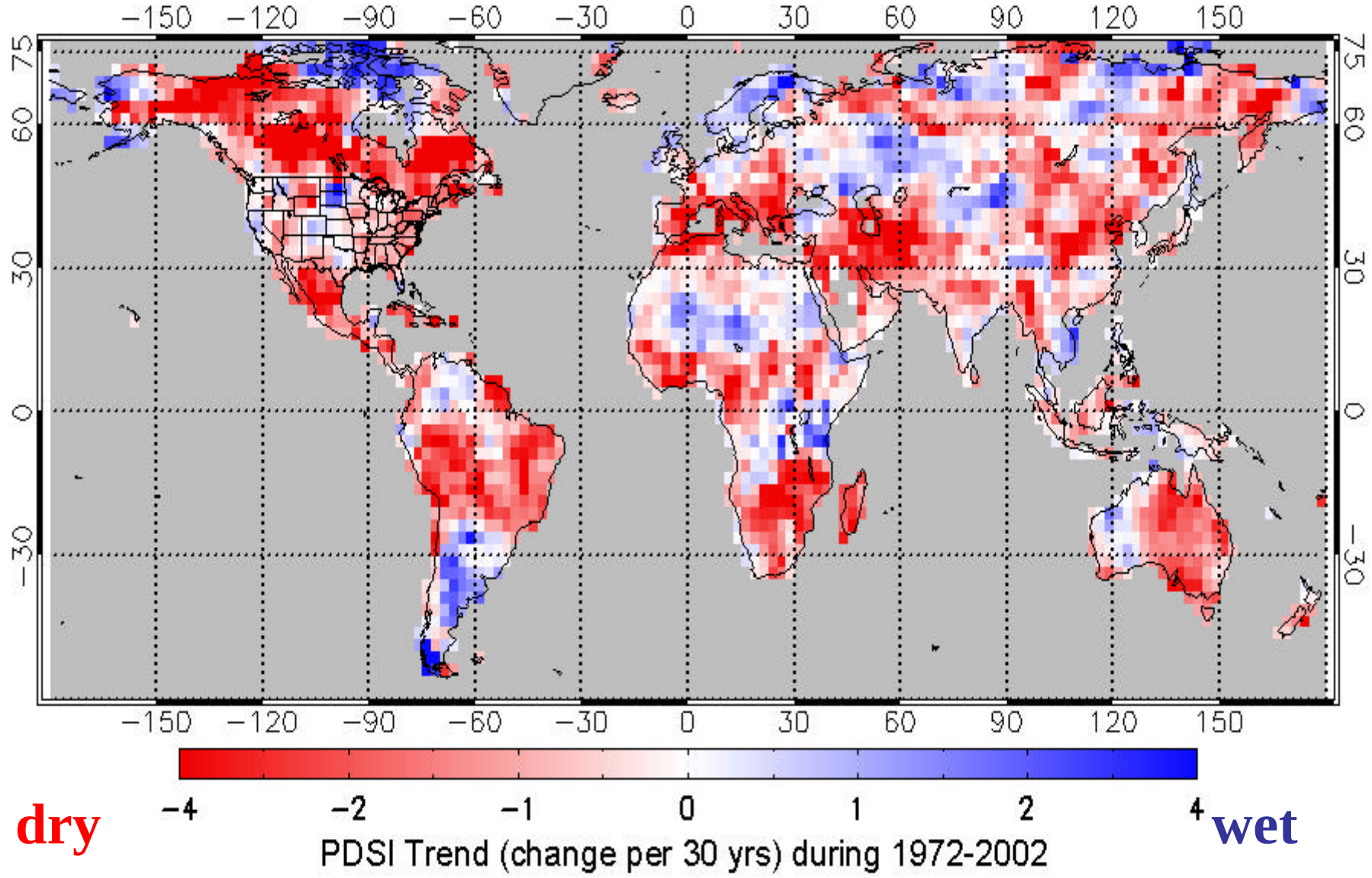

SCIENTIFIC ACTIVITIES OF CEOP PHASE2
MODEL OUTPUT
REFERENCE SITES
REFERENCE BASINS
SATELLITES
Global
Regional
Local
DATA INTEGRATION & DISSEMINATION
Diurnal
Intra-seasonal
Seasonal
WATER & ENERGY SIMULATION & PREDICTION (WESP)
Water and Energy Budget Studies
Global Land Data Assimilation Systems
Inter-CSE Transferability Study
Semi-arid Region Study
Cold Region Study
CEOP Analyses Intercomparison Project
Extreme Events Impact Analysis Project
CEOP INTER-MONSOON STUDY (CIMS)
Coordinated Model Integration Process
Monsoon System Inter Comparison
Aerosol - Monsoon Water Cycle Interaction
Downscaling
Watershed Hydrology Study
Water Resources Study
2005-2006:
Completion of Phase1
Preparation for New Activities
2007-2010:
Implementation
of New Activities

Why semi-arid region?

- **The region, most vulnerable due to dry climate, low vegetation cover and nutrition content and low capacity of the water conservation;**
- **A transitional zone, most sensitive in response to both human perturbation and climate change.**

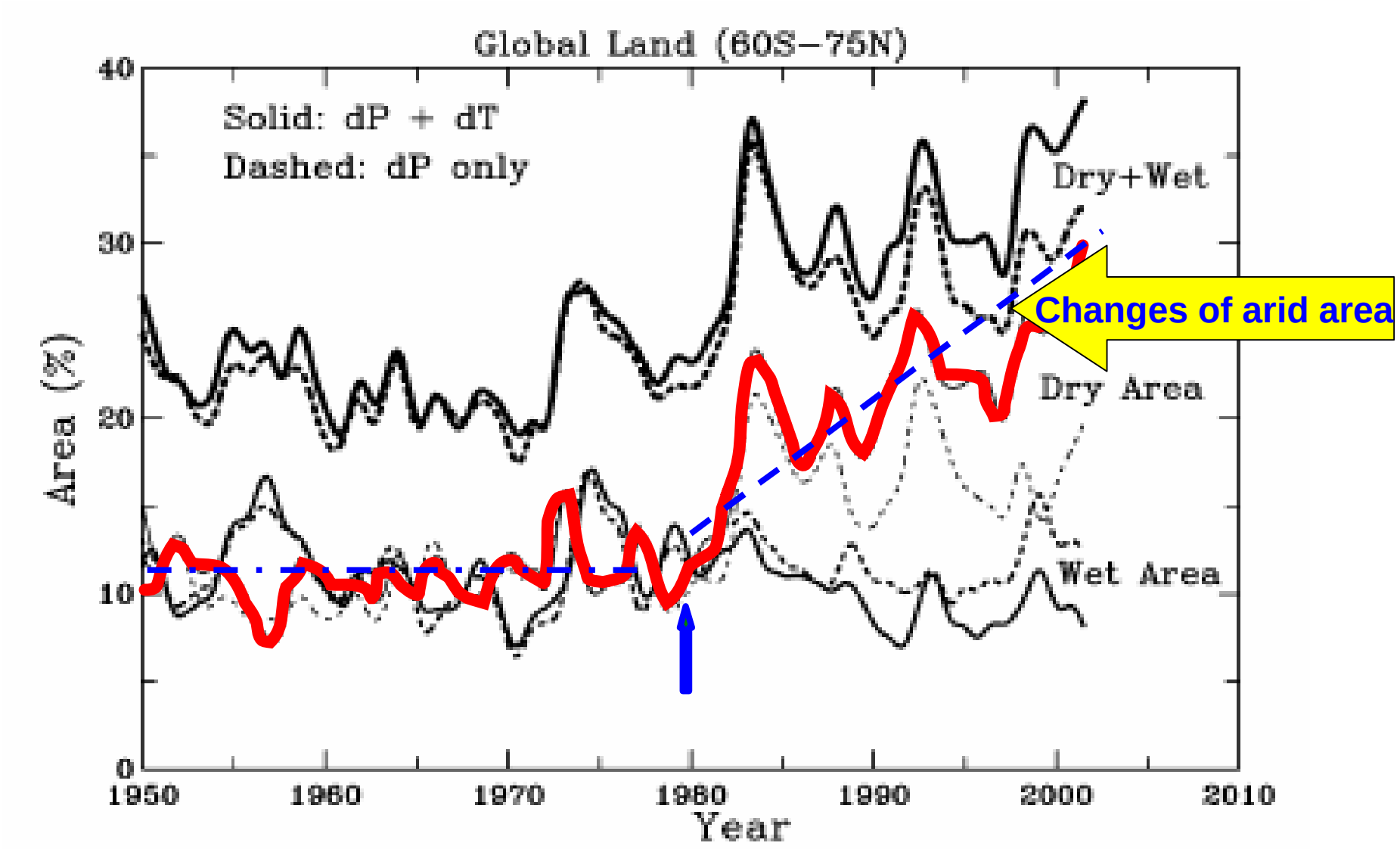
  e.g. significant trend of aridization and increasing dust storms due to both land use and climate variation, with potential impacts on the hydrological cycle, as well as climate.
- **A region having less knowledge in land surface process and their modeling**.

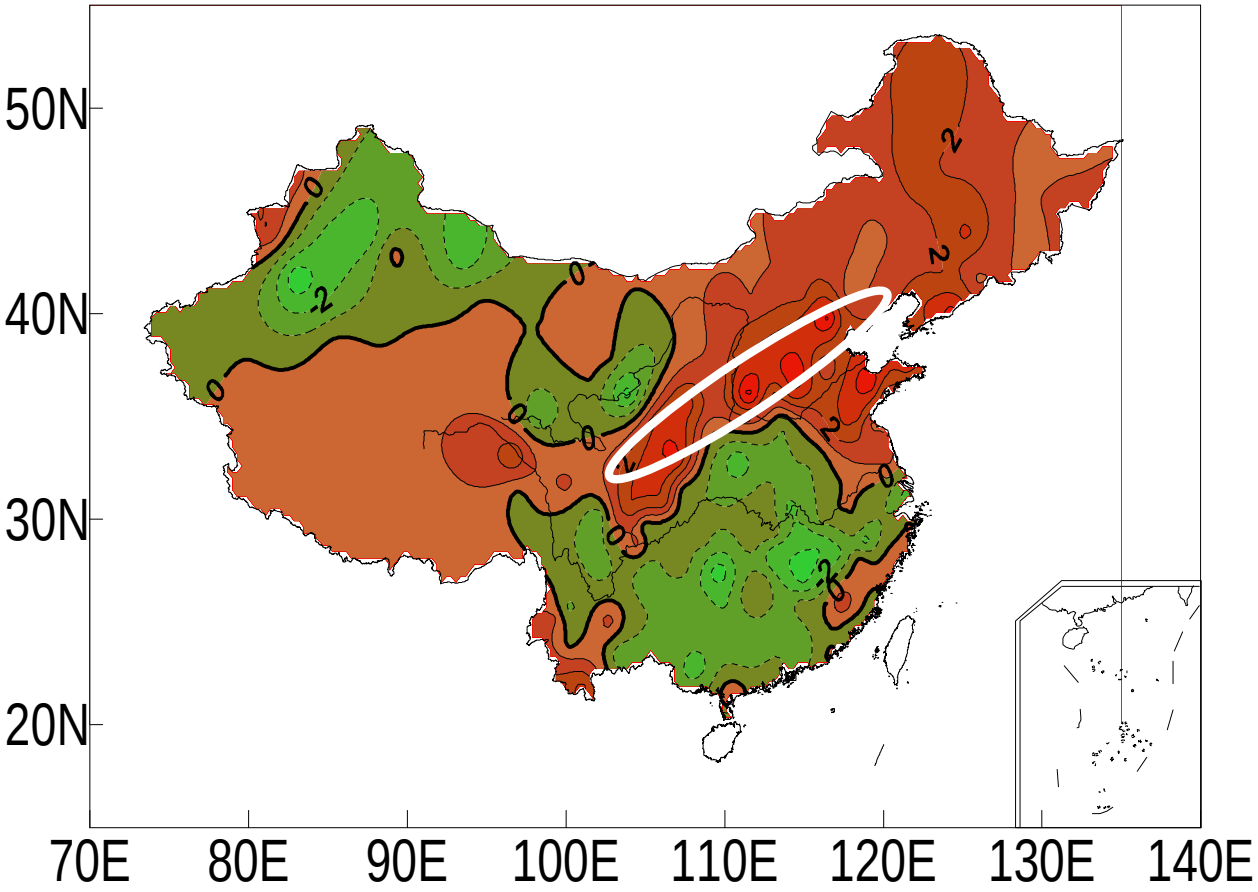
Global drying trend in last 30 years



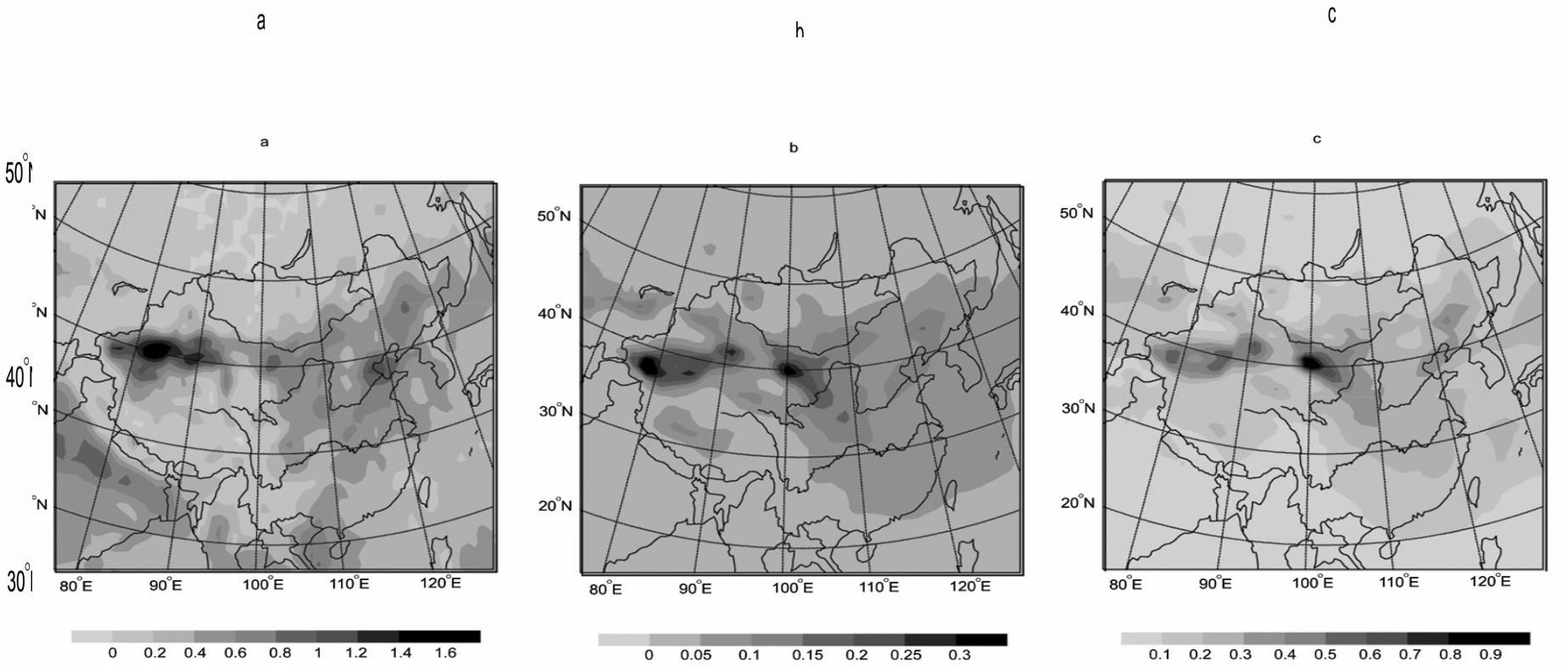
dry

wet


Global Land (60S−75N)
Solid: dP + dT
Dashed: dP only
Dry+Wet
Dry Area
Wet Area
Changes of arid area
Area (%)
Year
0
10
20
30
40
1950
1960
1970
1980
1990
2000
2010



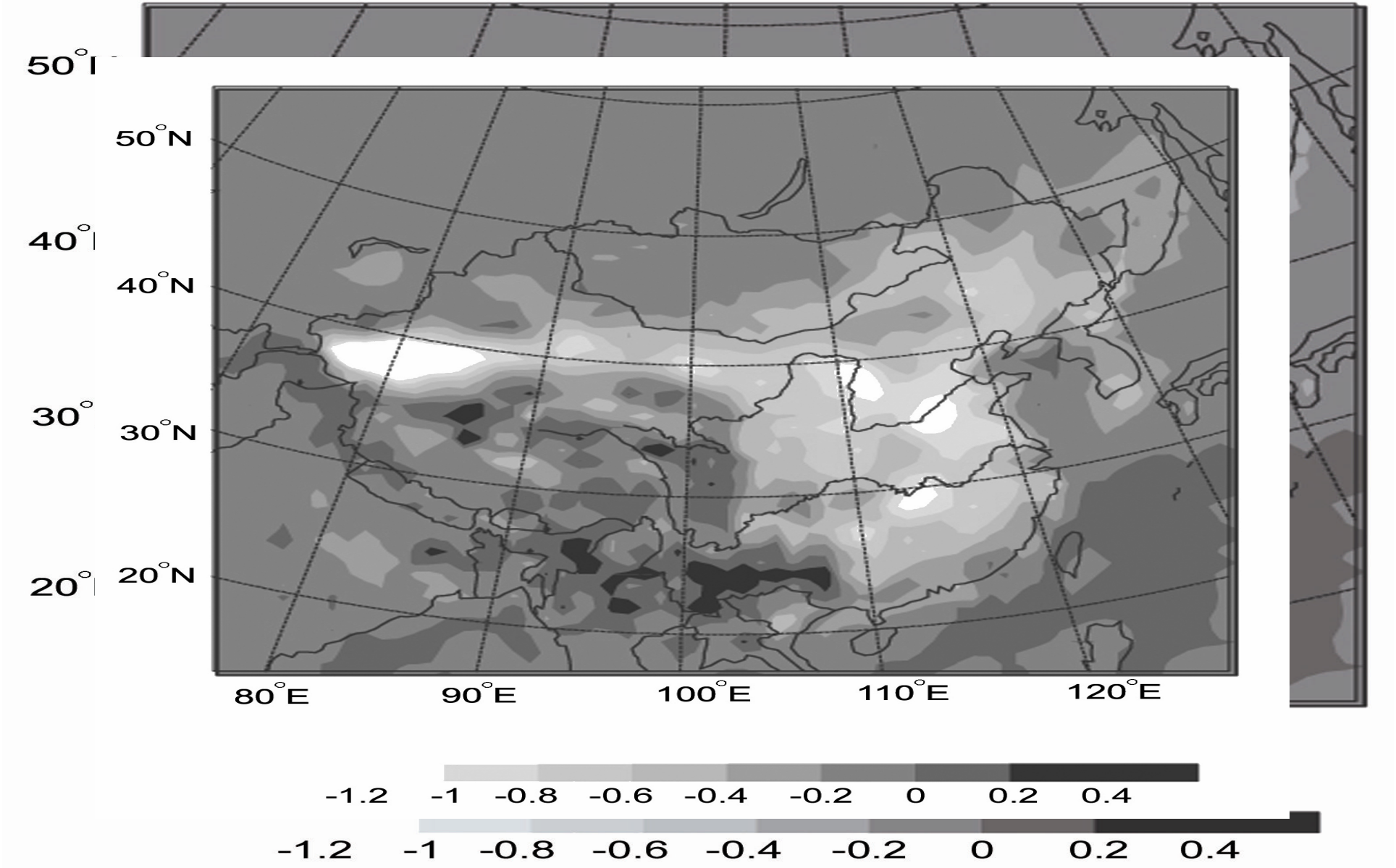
Changes of frequency of extreme drought events (1990’s –1950’-80’s)



Dust distribution of April 1998 from simulation and TOMS aerosol index (from Wu an, d Fu, 2004)

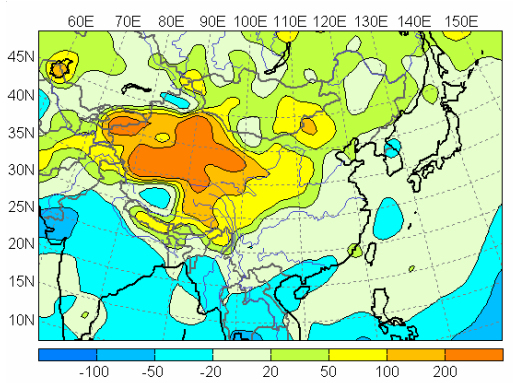
(a) Aerosol index of TOMS; (b) Simulated column burden of dust(g/m^2)

(c) Simulated optical depth of dust

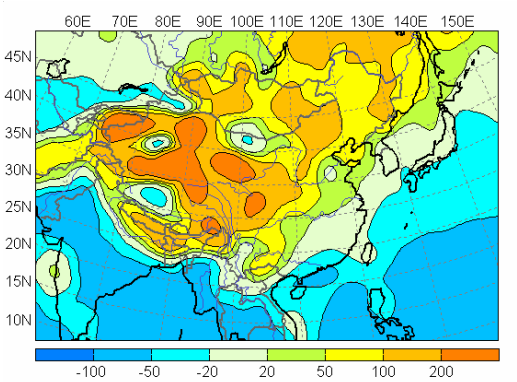


Changes of monthly averaged surface temperature (K) in response to dust aerosols (from Wu and Fu,2004)

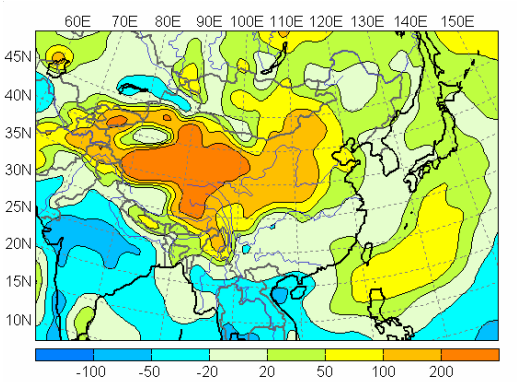
Bias of Simulated Annual Total Precipitation to Observation (%) (10 years average) (from RMIP for Asia)



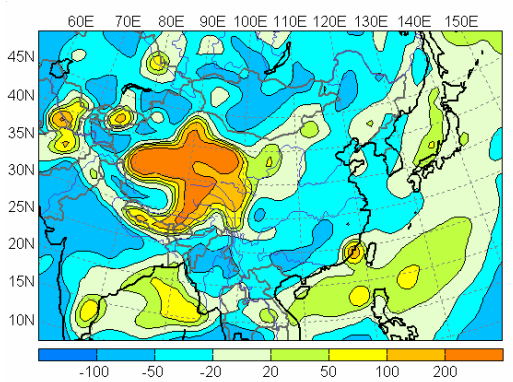
Ensemble



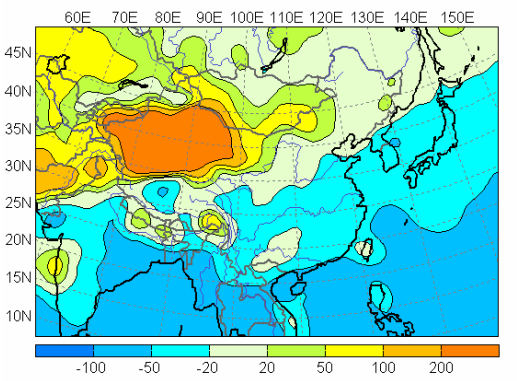
RIEMS



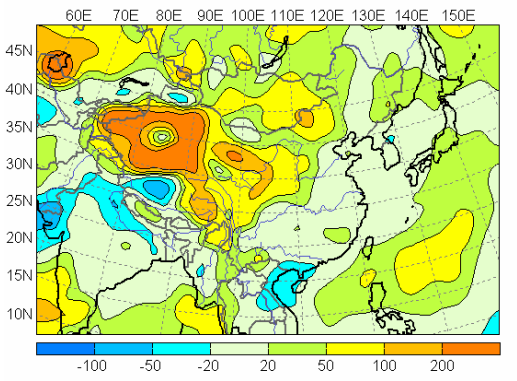
NJUM



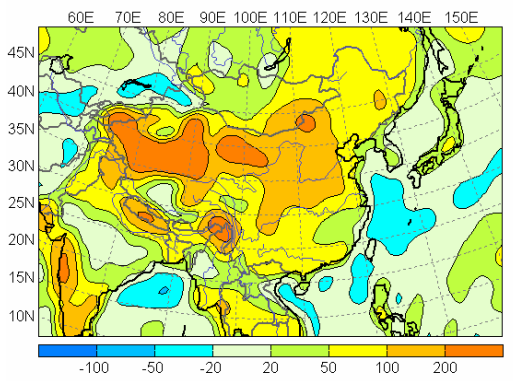
MRI



RegCM3



SNU RCM



CSIRO CCAM

Goal of CEOP Semi-arid Study

Contributions to understanding the water and energy cycles of semi-arid regions and their role in climate system

by globally integrated analysis of CEOP reference sites data, satellite observations and the model outputs

Assist in better prediction of water resources and their management in semi-arid regions where the shortage of water supply is crucial

Research Agenda

- Atmospheric boundary layer physics and dynamics of semi-arid regions;
- Water and energy cycle of air-soil-vegetation system in semi-arid regions;
- Development of land surface model of semi-arid region to be coupled in climate models;
- Impacts of dust aerosols on hydrological cycle as well as regional and global climate;

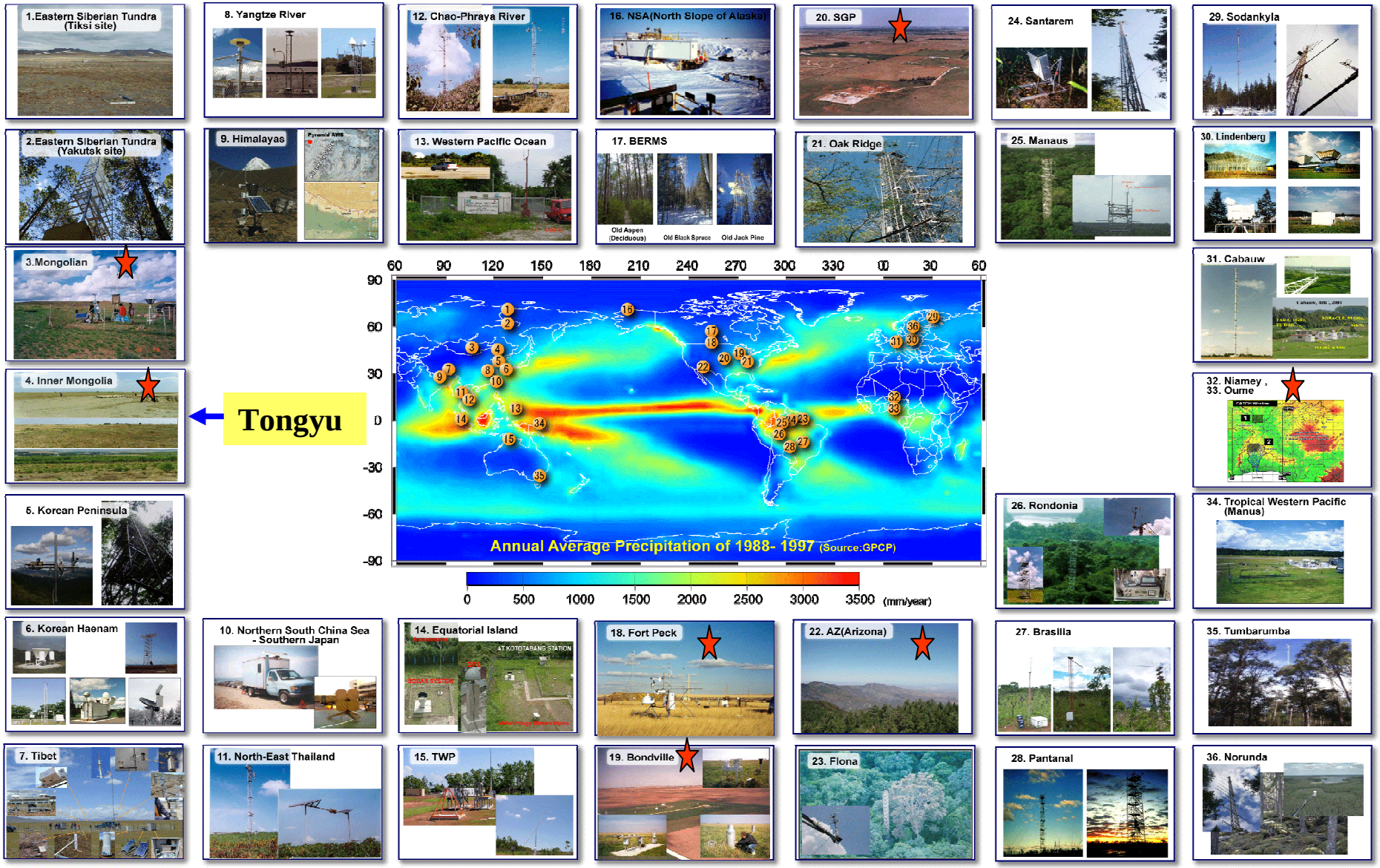
The reference sites may used in CEOP semi-arid study

for example:

- Tongyu, China (44.42N, 122.87E; Elevation: 184 m; annual precipitation: 404 mm);
- Langzhou, China (35.32N, 104.09E; Elevation: 1874.1m; annual precipitation: 381.8 mm over Loess plateau);
- Mongolia (46.28N, 107.30E);
- AZ(Arizona), USA
- Bondville (40.01N, 88.29W), USA;
- Oak Ridge (35.96N, 84.29W), USA;
- Niamey (13.5N, 2.5E); Niger;
- And other sites in North Africa, Australia, Iran and South America

Potential reference sites for Semi-arid CEOP study

International Cooperation for the Global Coverage



Required field observations

- **Surface Fluxes**
- **Biological component**
- **Atmospheric aerosols, particularly dust aerosols**
- **The spectrum of atmospheric radiation.**
- **land use /cover;**
- **water resources management, etc.**

Required field observations

- **Surface fluxes and profiles of near surface layer.**

  Sensors on towers, automatic stations and other instruments will support the observations of wind speed, temperature, humidity, radiation balance, etc. to obtain their profiles and fluxes of momentum, heat, water vapor,CO_2 over representative ecosystems.

Required field observations

- **Biological component**

  include: above- and under-ground productivity, vegetation height, fraction of vegetation coverage, LAI, photosynthesis, water vapor potential, soil organic substance, litter decomposition, chemical elements cycling, etc.

Required field observations

- **Atmospheric aerosols**, particularly dust aerosols
- The spectrum of **atmospheric radiation** and atmospheric optical depth.
- **Human activities**. Land use and cover changes; water resources management, etc.

Satellite Data Requirements

- **Data from new generation sensors**, such as MODIS onboard NASA's Terra platform and VEGETATION onboard SPOT.

- **Other sources** of operational stationary and polar-orbit satellites would also be explored.

Model_Output_Requirements

The global model outputs will be used to drive the regional environmental system model to understand the physical, chemical and biological processes interactions in the semi-arid regions,

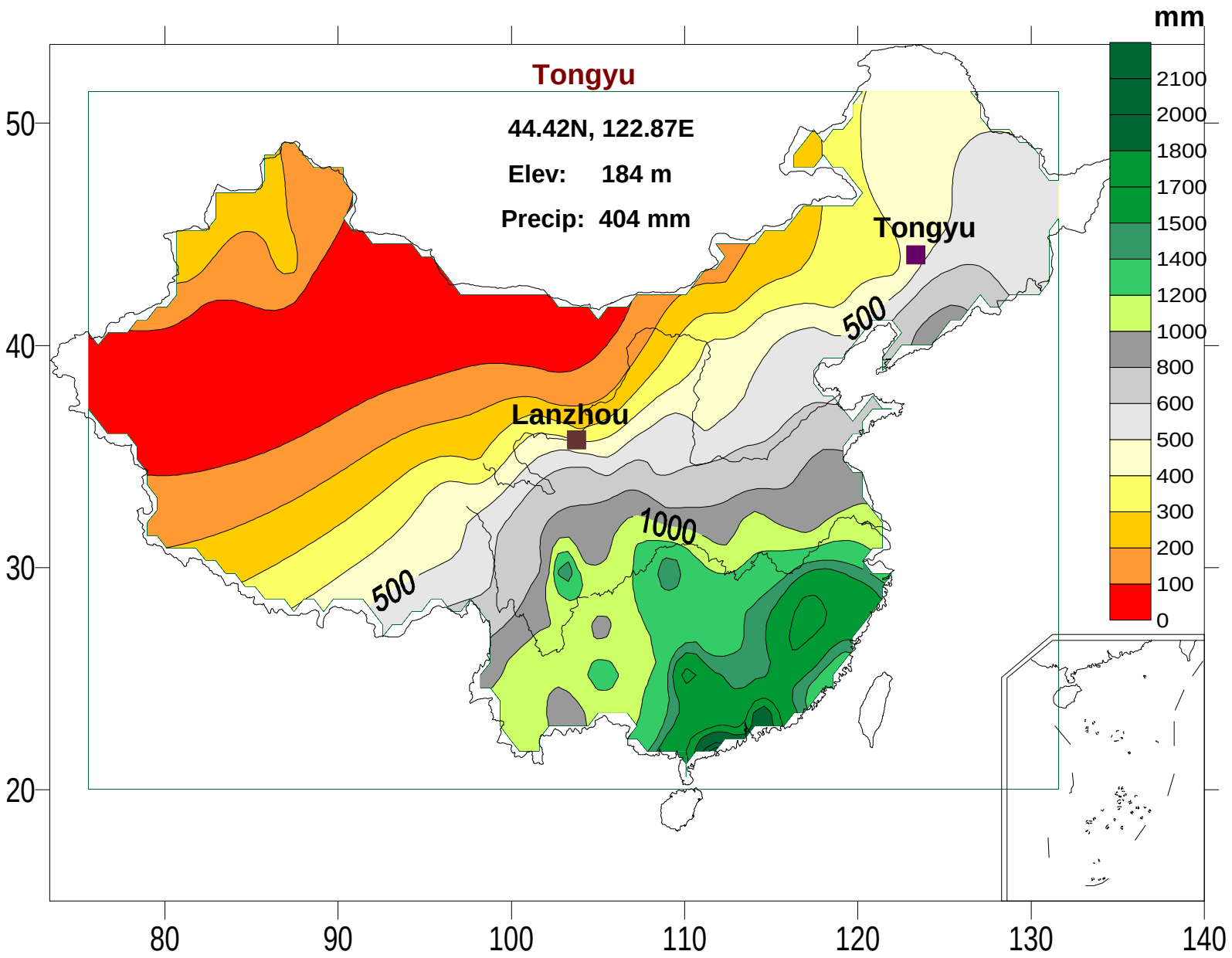
including: dust aerosol generation and transfer; the climate effects of dust aerosols and land use changes due to human activities, etc.

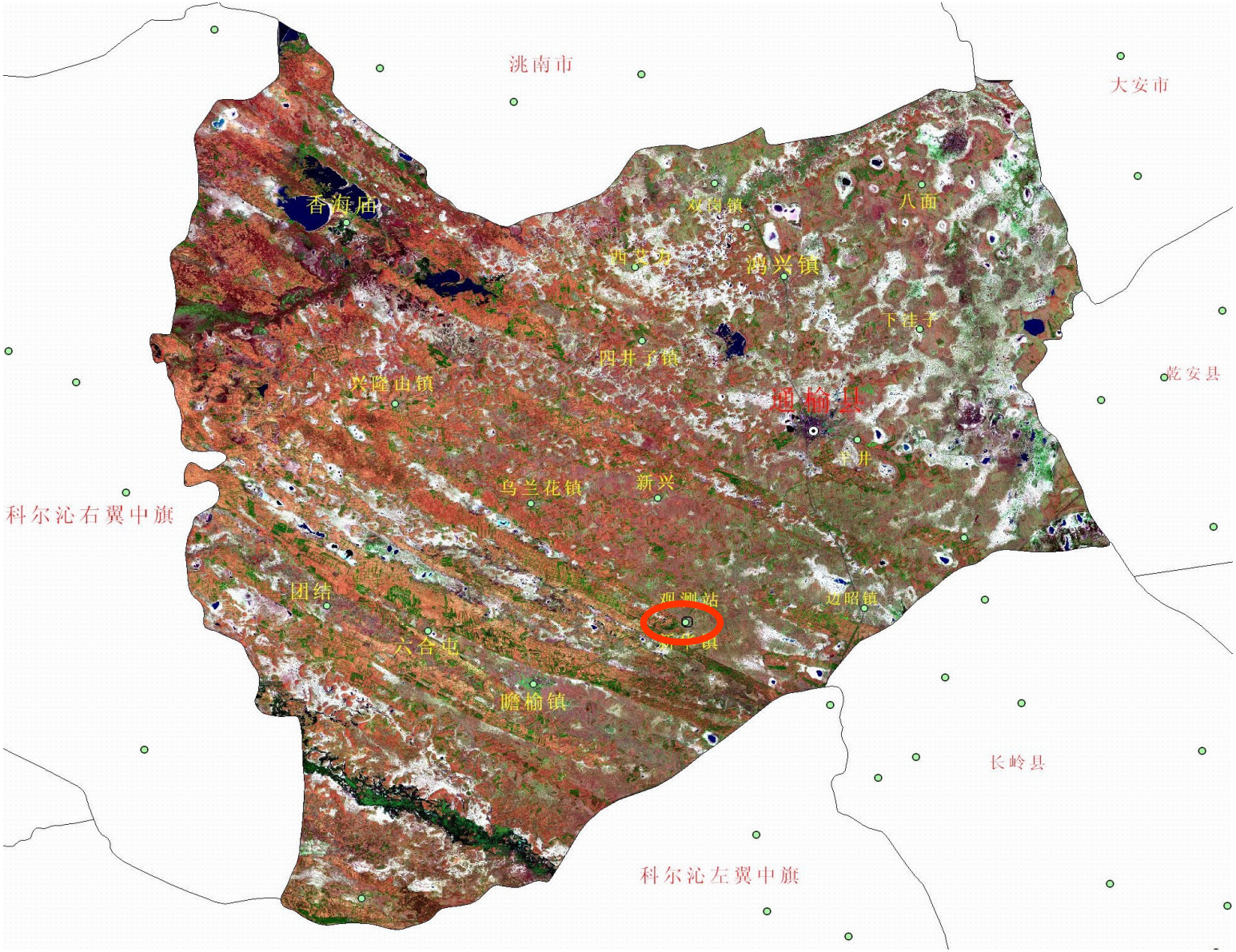
Some Preliminary Results

- **Analysis of data from Tongyu station, including:diurnal,seasonal variation of fluxes, near surface layer profiles,etc.**
- **Analysis of data from several reference sites of North America;**
- **Validation of land surface models by using data from Tongyu stations.**

MODEL- CEOP DATA INTERCOMPARISON

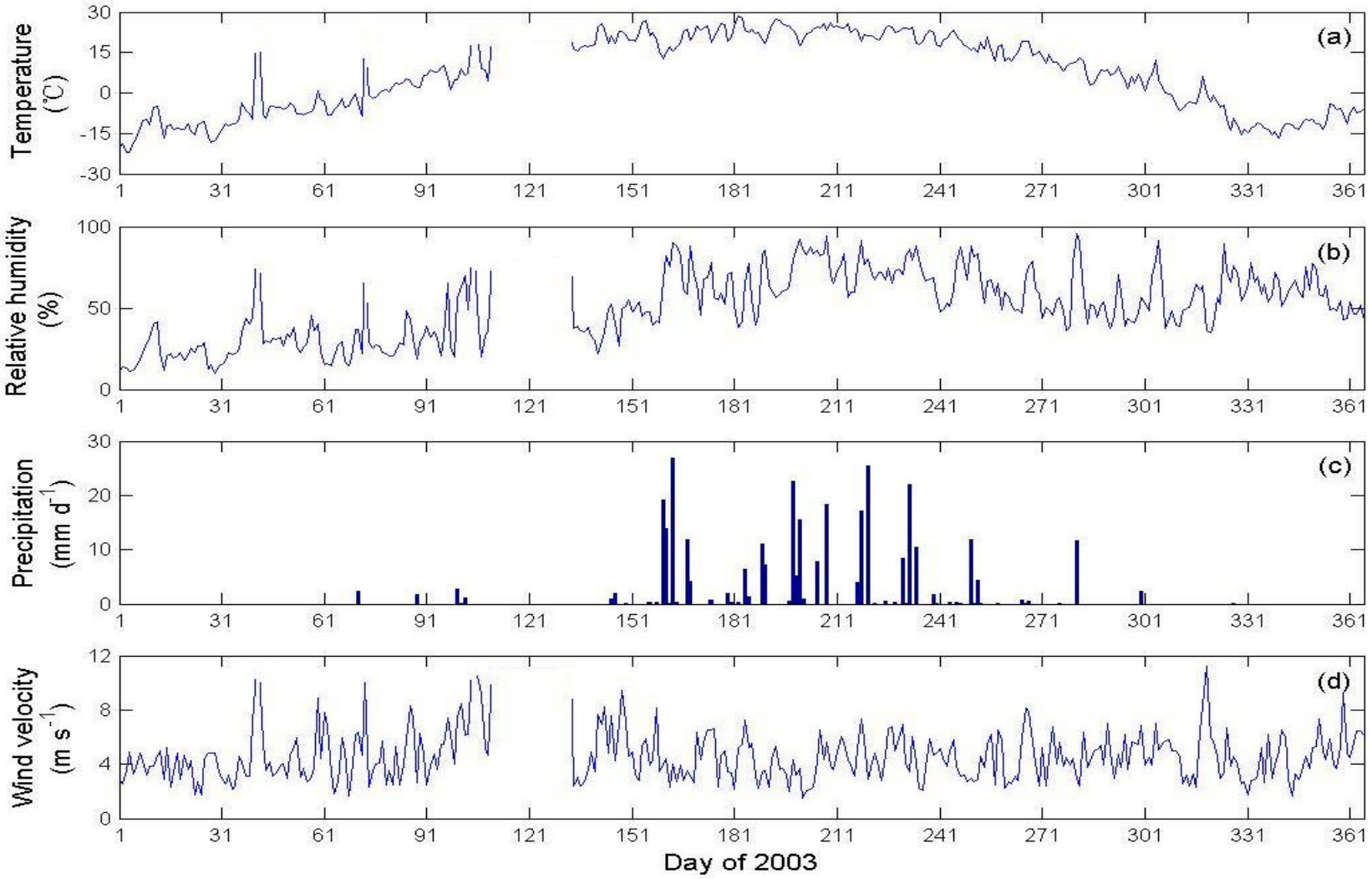
CEOP Reference site: Tongyu




洮南市
大安市
香海庙
双良镇
八面
西艾力
溜兴镇
下洼子
四井子镇
兴隆山镇
乾安县
通榆县
十井
乌兰花镇
新兴
科尔沁右翼中旗
团结
边昭镇
六合屯
瞻榆镇
长岭县
科尔沁左翼中旗

Overherding-protection-recovery

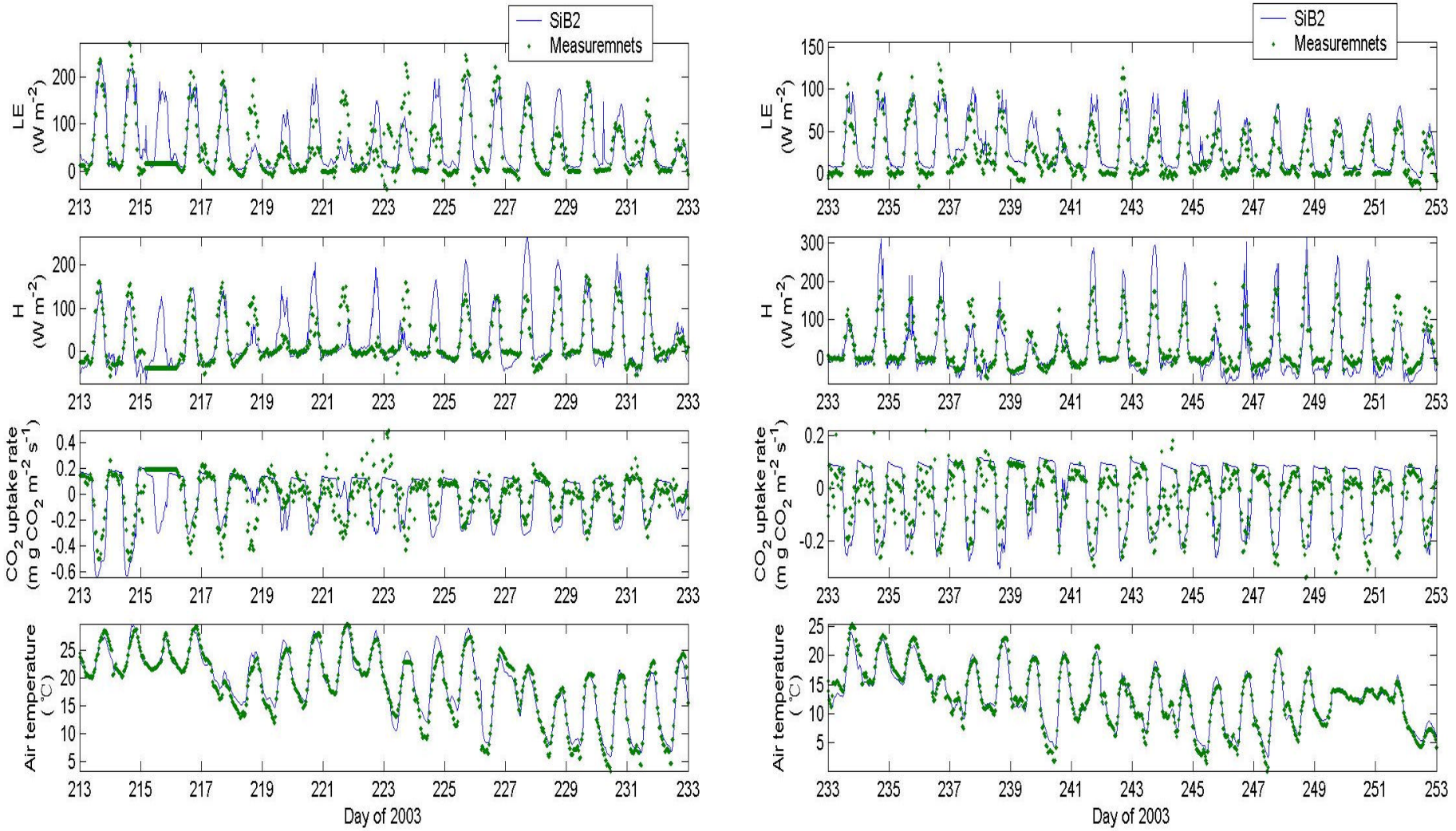
Meteorological data



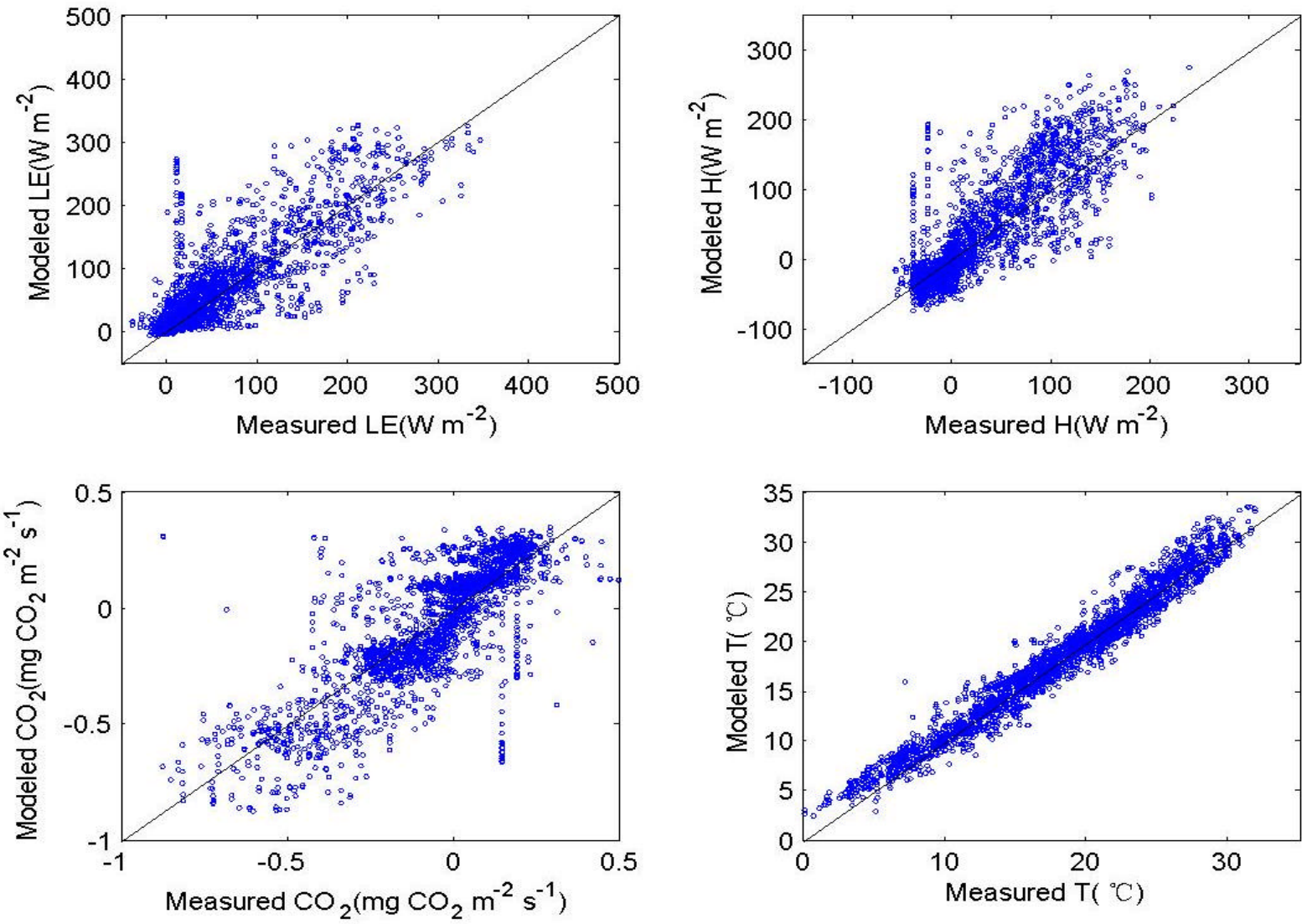
Meteorological conditions of degraded grassland in Tongyu reference site in 2003: (a) air temperature, (b) relative humidity, (c) precipitation and (d) wind velocity, * data from 21 April to 11 May are missing.

Variation of fluxes in growing season degraded grassland

Model SiB2~OB

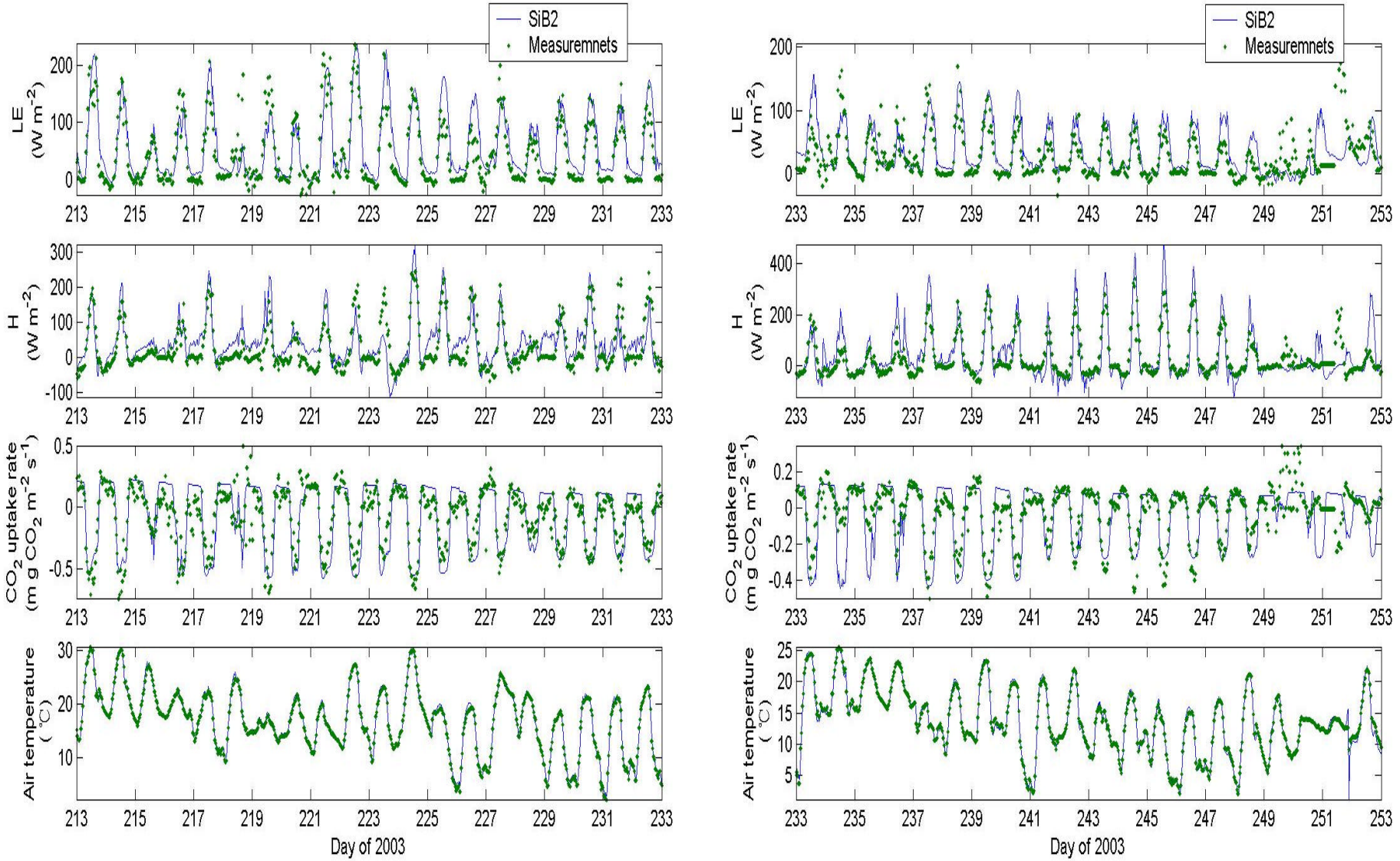


Hourly change of latent heat flux (LE), sensible heat flux (H) and CO_2 flux modeled using SiB2 against direct measurements degraded grassland.

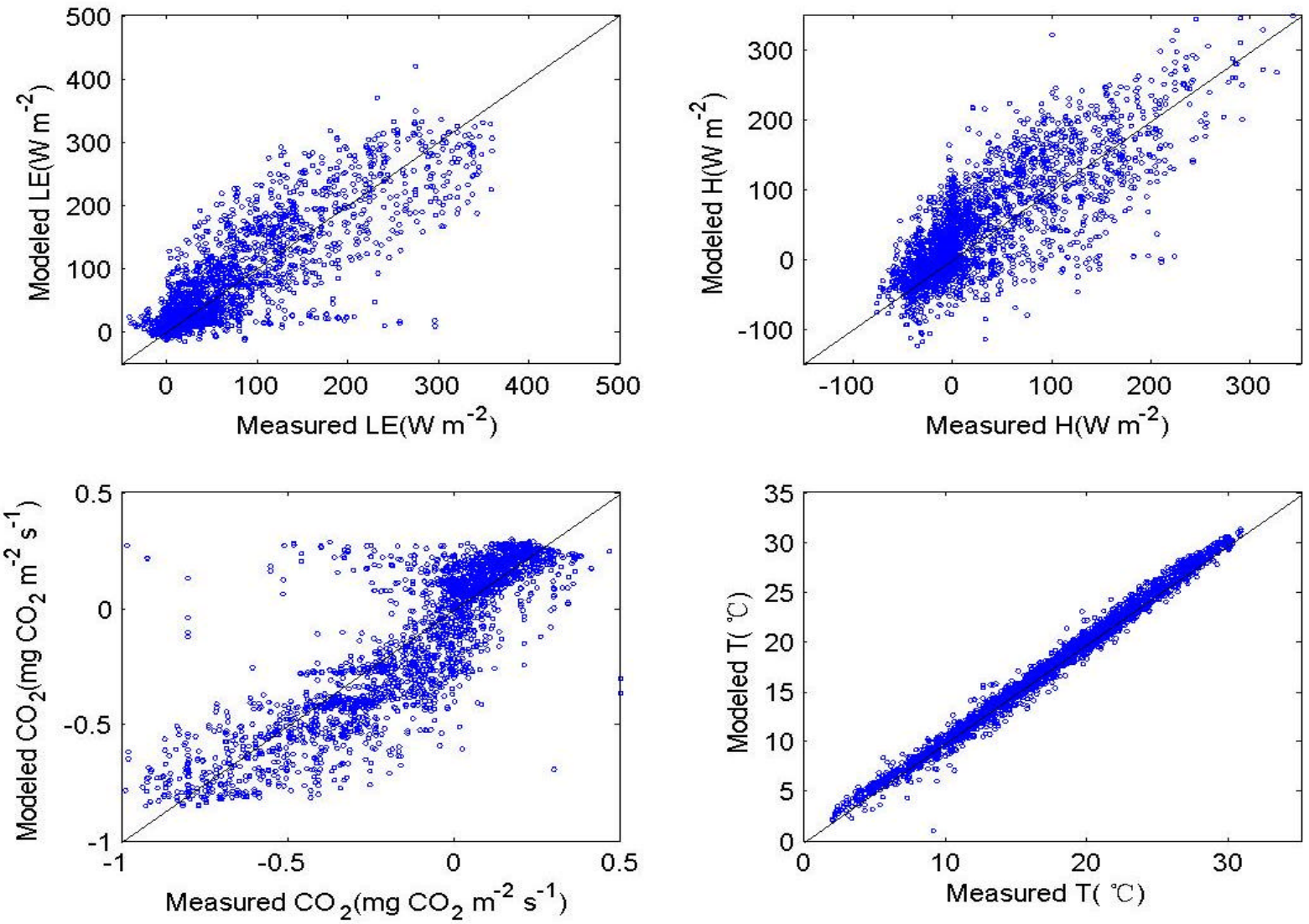


Scatter plots of latent heat flux (LE), sensible heat flux (H), and CO_2 flux modeled using SiB2 against direct measurements in degraded grassland.

Hourly modeling during the growing period: cropland

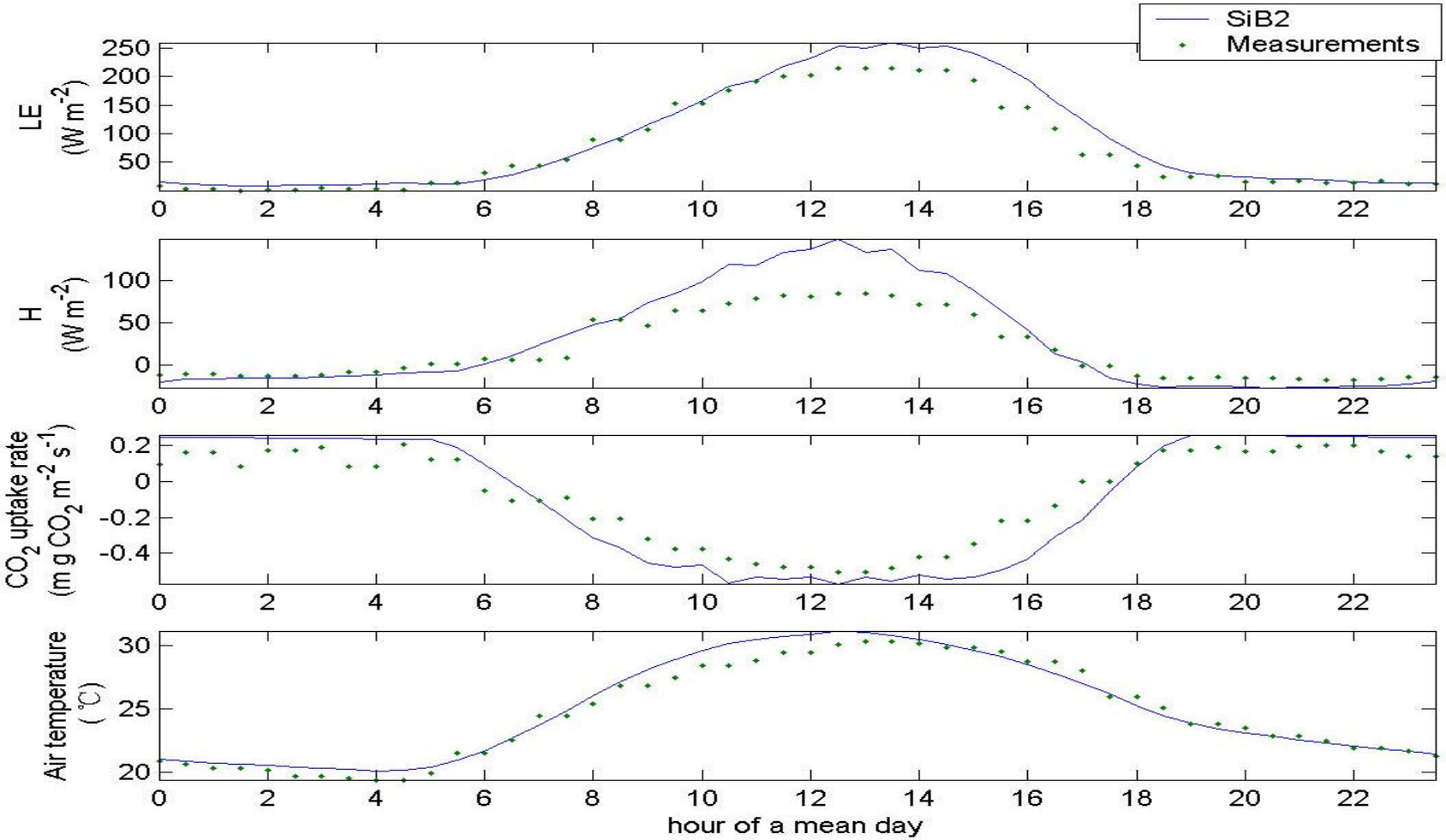


Hourly change of latent heat flux (LE), Sensible heat flux (H) and CO_2 flux modeled using SiB2 against direct measurements at cropland.



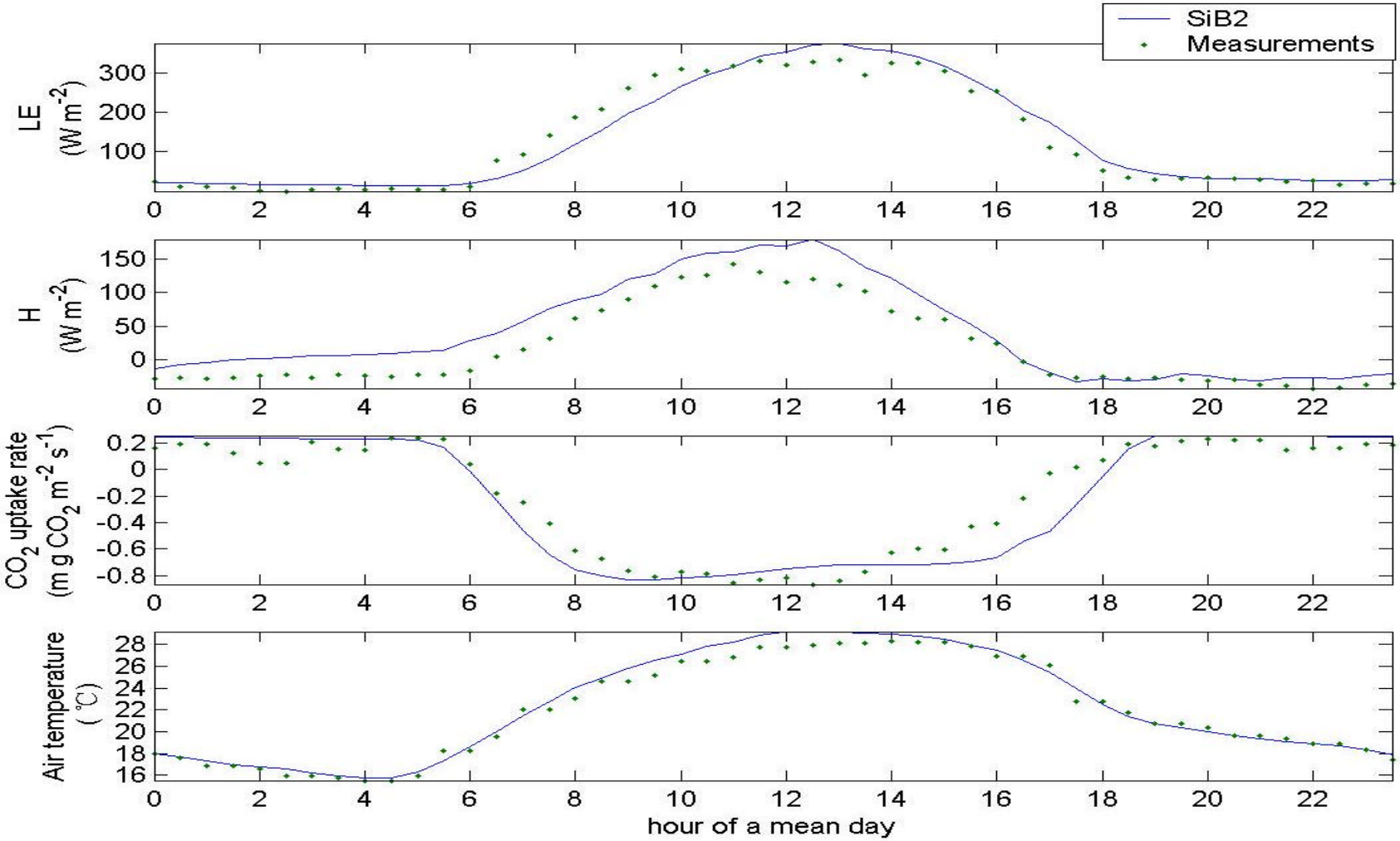
Scatter plots of latent heat flux (LE), sensible heat flux (H), and CO_2 flux modeled using SiB2 against direct measurements in cropland.

Modeling of Mean Diurnal variation: grassland



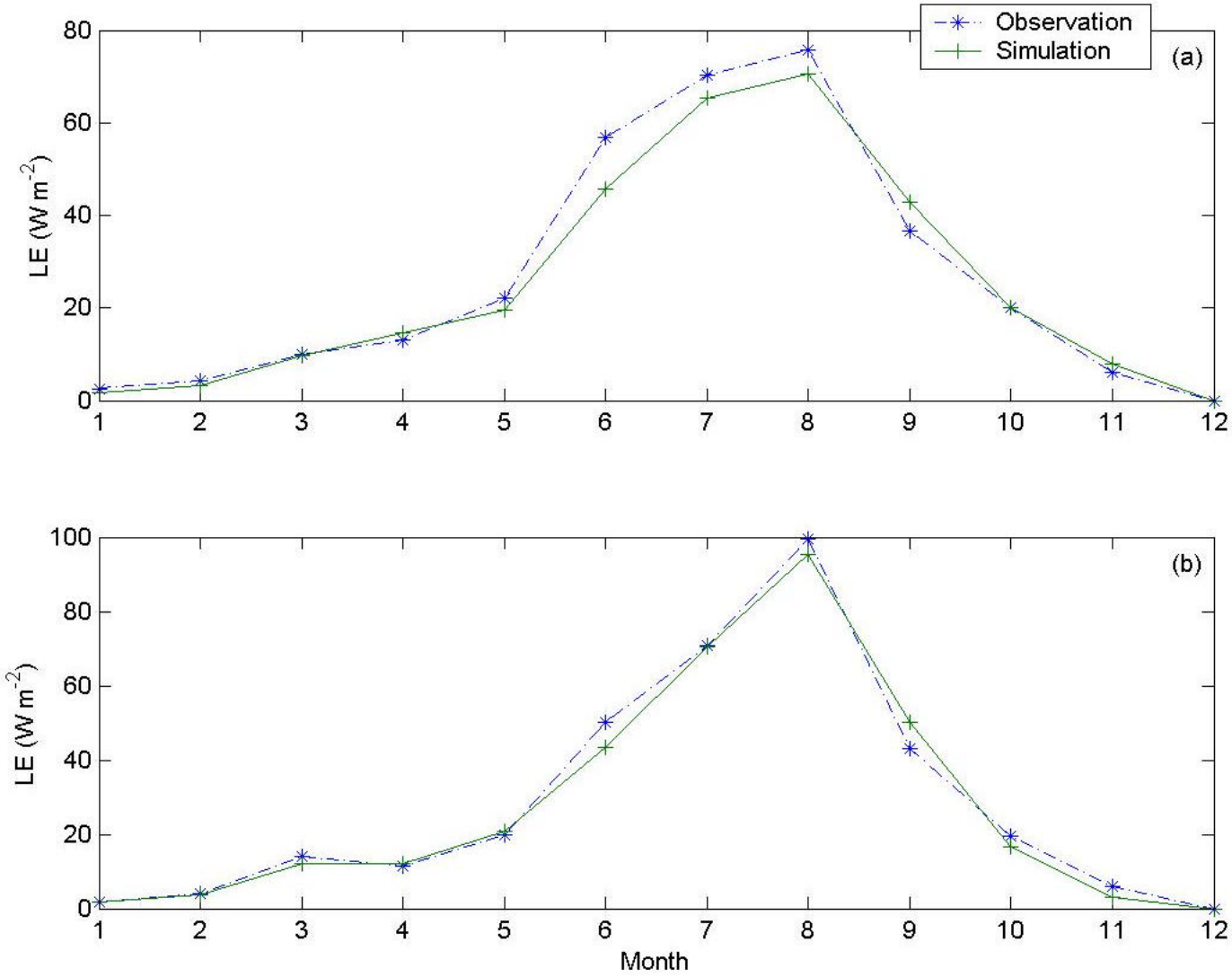
Mean diurnal variation: grassland

Modeling of Mean Diurnal variation : cropland

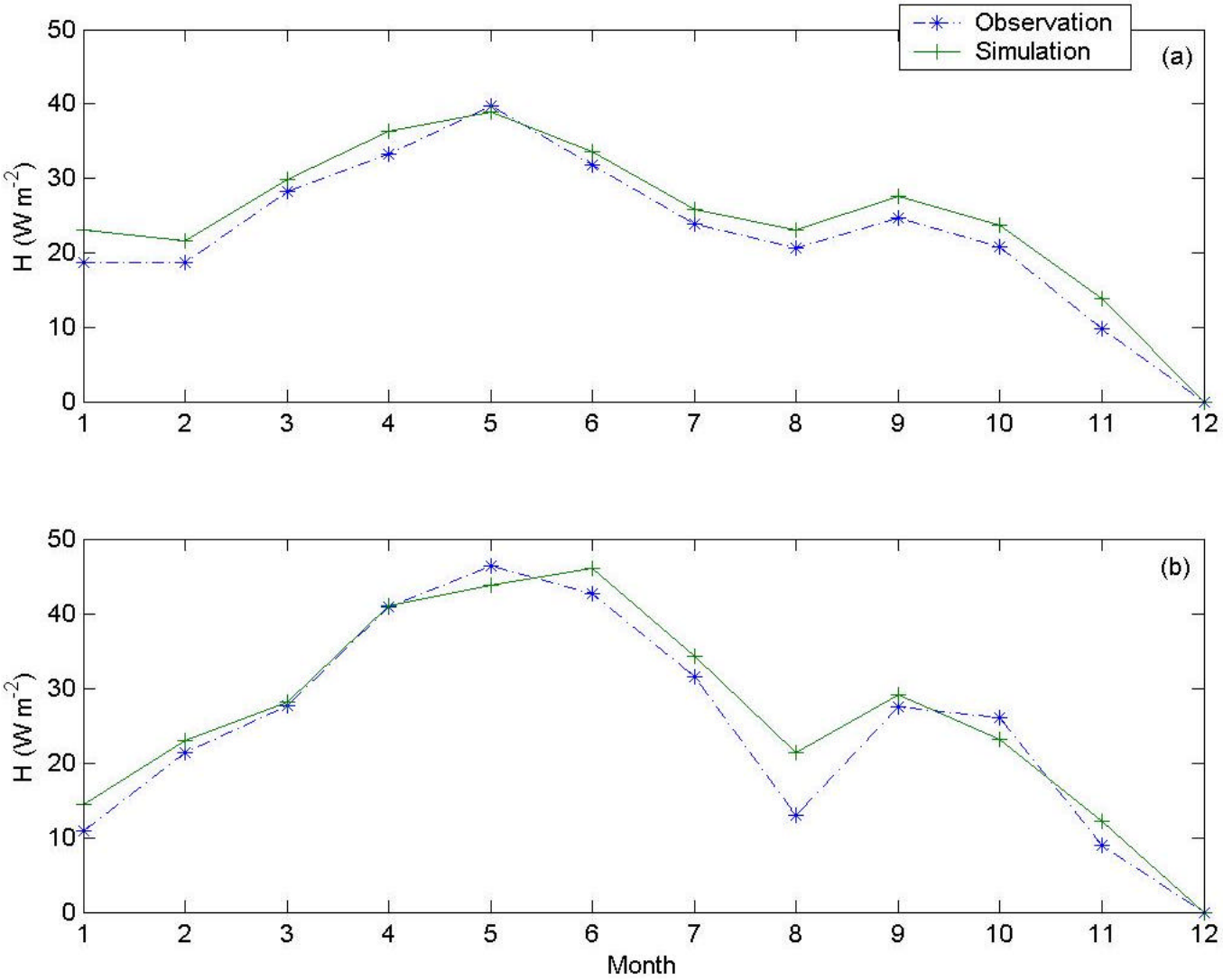


Modeling of Mean Diurnal variation : cropland (averaged from DOY 200 to DOY 210)

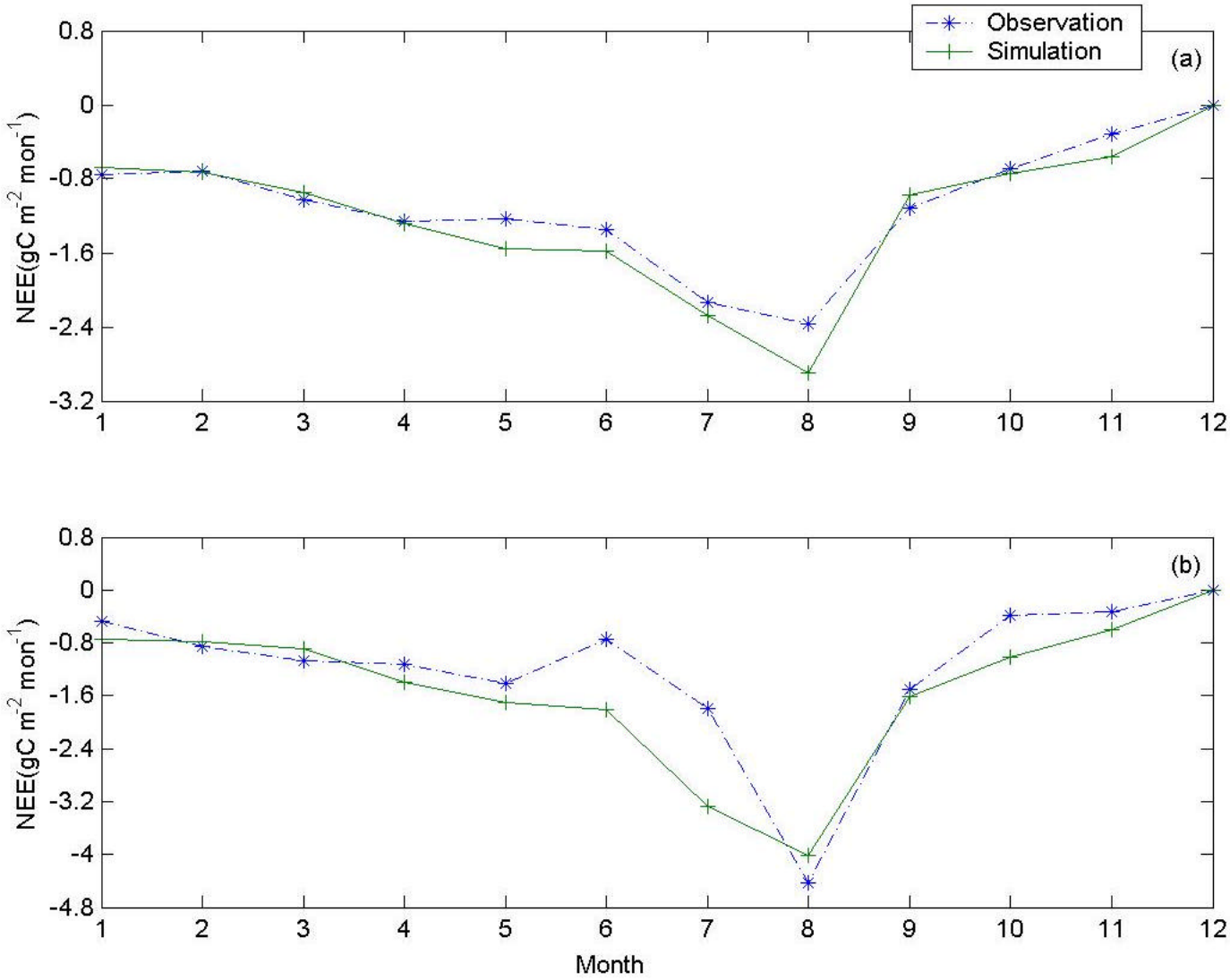
Annual variations (IBIS~Observation)



Annual variation of simulated(IBIS)and observed latent heat flux at Tongyu Reference Site in 2003: (a) degraded grassland and (b) cropland.

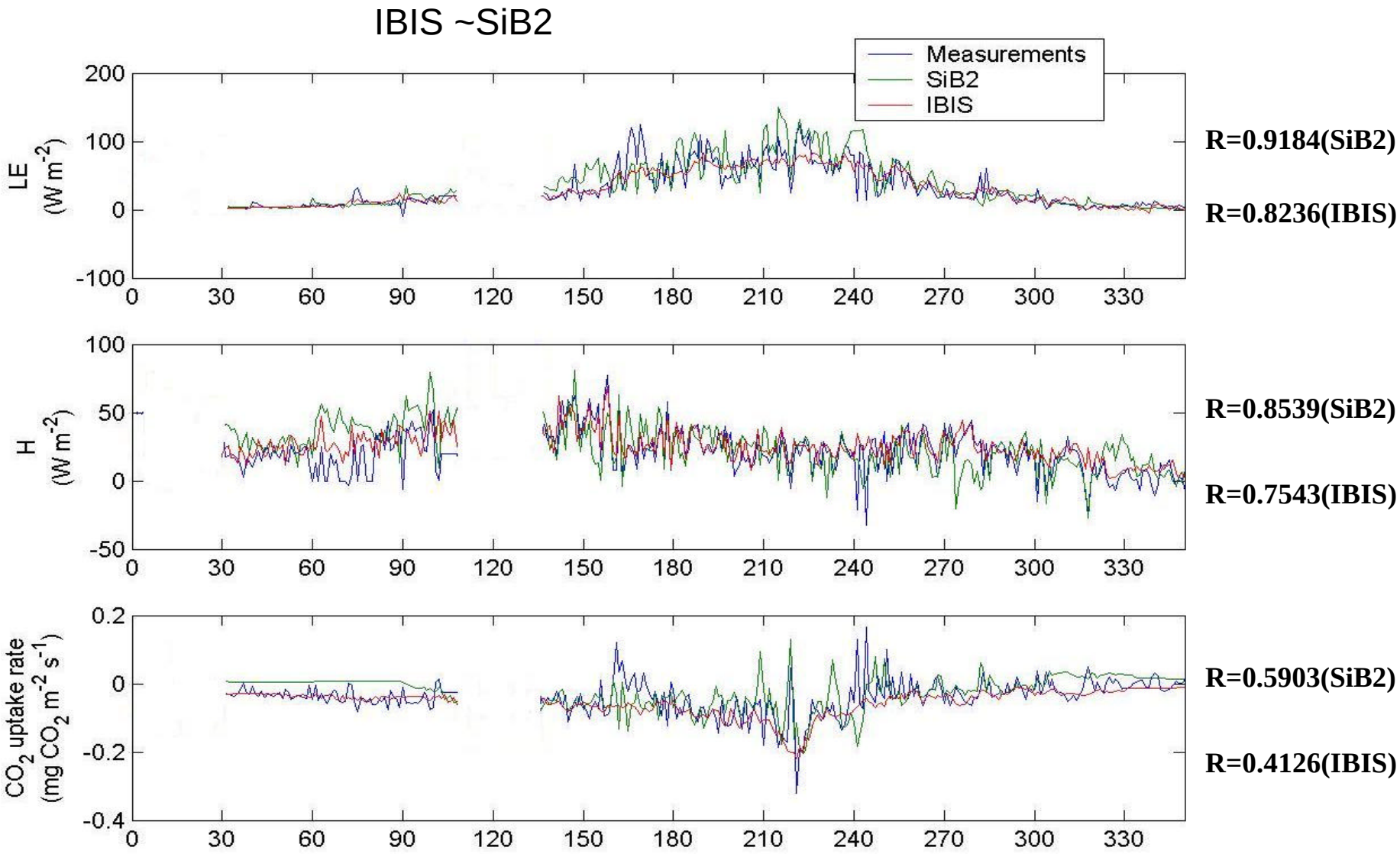


Annual variation of simulated (IBIS) and observed sensible heat flux at Tongyu Reference Site in 2003: (a) degraded grassland and (b) cropland.



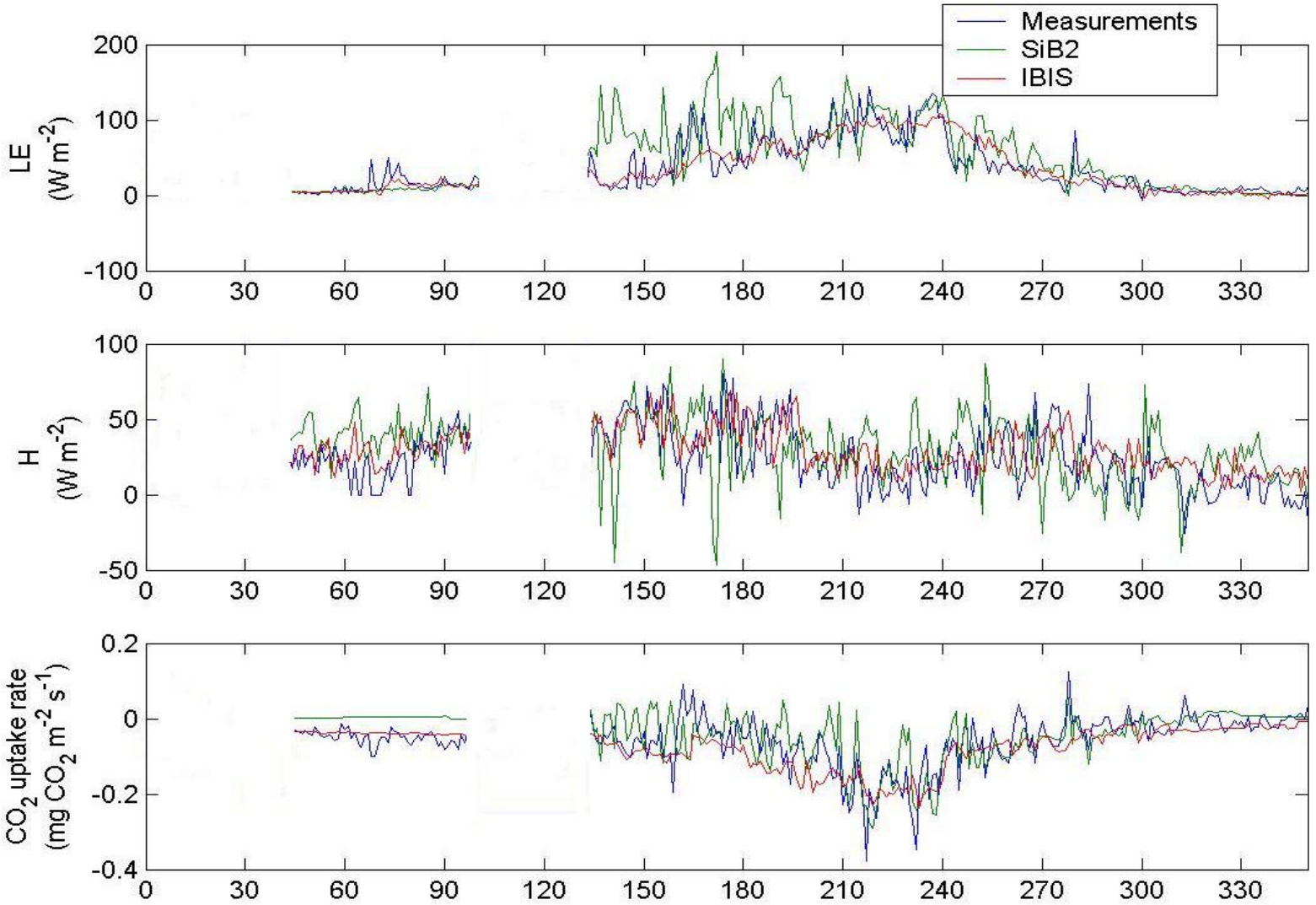
Annual variation of simulated (IBIS) and observed CO_2 flux at Tongyu Reference Site in 2003: (a) degraded grassland and (b) cropland.

Modeling of daily mean surface fluxes: grassland



Comparison of mean daily mean latent heat flux (LE), and Sensible heat flux (H) and CO_2 flux modeled using SiB2 and IBIS against direct measurements at degraded grassland.

Modeling of daily mean surface fluxes: cropland



R=0.8535(SiB2)

R=0.8435(IBIS)

R=0.7353(SiB2)

R=0.7248(IBIS)

R=0.7542(SiB2)

R=0.4924(IBIS)

Comparison of mean daily mean latent heat flux (LE), sensible heat flux (H) and CO_2 flux modeled using SiB2 and IBIS against direct measurements at cropland.

On-going works

•To set up a new CEOP reference site over Loess Plateau of Northwest China

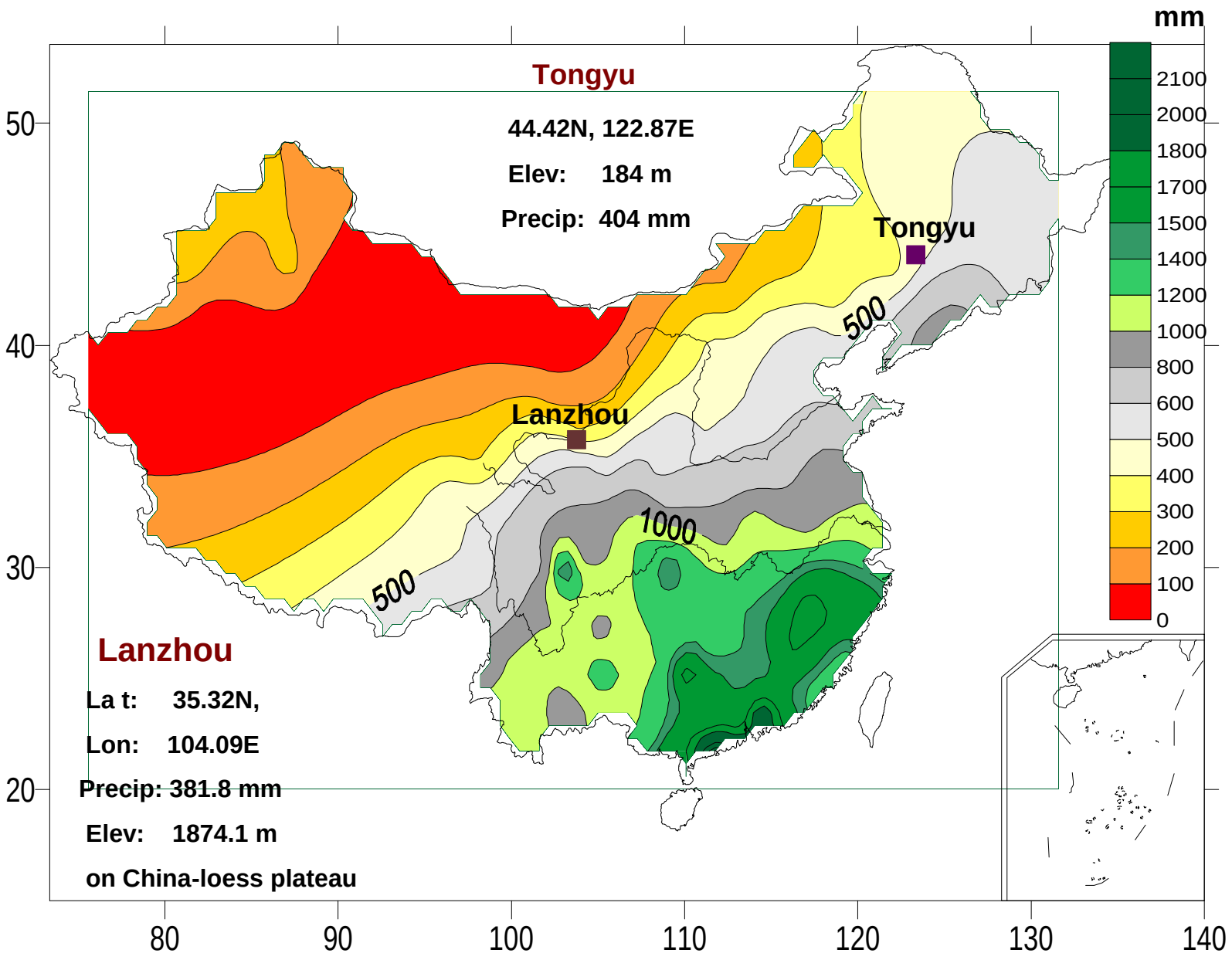
*** To subtract information from satellite:**

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

*** To develop additional components to be coupled with climate model:**

- **a new Eco-hydrological module;**
- **Chemical/aerosols module;**
- **Land use module.**

A new CEOP Reference site over Loess Plateau




Thank you

Science Plan for phase II

2006-2007:

1. **Analysis of phase I data from reference sites and comparisons among different sites of semi-arid regions and different ecosystems;**
2. **Validation of land surface models by using CEOP reference sites data of phase I;**
3. **Analysis of satellite data of phase I in related to activities 1 and 2;**
4. **Apply existed RCMs for semi-arid region simulation and find out the problems.**

Science Plan for phase II

2008-2010

- **Analysis of phase II data of reference sites in semi-arid regions with coordinated satellite observations;**
- **Validation of land surface models and RCMs against the data of phase II;**
- **Development of land surface model for semi-arid region, with particularly a new scheme of hydrological process;**
- **Researches of impacts of dust aerosols on radiation,cloud micro-physics and hydrological process as well as the regional climate.**

Planning activities for 2006-2007

- **Formation of CEOP-semi-arid study working group;**
- **Initiate an Asia-North America semi-arid Inter-comparison study project;**
- **A workshop of Land Surface-Atmosphere Interaction in semi-arid regions.**

Proposed members of working group of CEOP semi-arid study

- Congbin **FU,** Institute of Atmospheric Physics, CAS/China (Chair)
- Dave **Billesbach,** University of Nebraska,USA
- David R.**Cook,** Argonne National Laboratory,USA
- Davaa **Gombo ,** Institute of Meteorology and Hydrology, Mongolia
- Jianping **Huang,** Lanzhou University, China
- Pavel **Kabat,** Wageningeu University, Netherlands
- Joon **Kim,**Yonsei University, Korea,
- Toshio **Koike ,** University of Tokyo, Japan
- Huizhi **Liu,** LAPC, CAS/China
- Tilden **Meyers,** NOAA/ARL,USA
- Russell **Scott,** USDA-ARS Southwest Watershed Research Center
- Jie **Song,** Northern Illinois University, USA
- Additional members from Africa, South America, Australia etc. TBD