



# **Observation and modeling of surface hydrological budget over Mongolian steppe**

Jun Asanuma

TERC, Univ. Tsukuba

Yuriko Koike

College of Geosci., Univ. Tsukuba



# Outlines: 3 parts

## ✿ Surface water balance

### ✿ What do we know?

- ✿ Current knowledge: observations and models

### ✿ How we can improve the knowledge?

- ✿ ADMIP: a model intercomparison project

## ✿ Why do we have drought?

- ✿ Backtrajectory analysis of rain water (preliminary)

## ✿ and some more ...



# Surface Water Balance: Motivation

- ✿ Surface water balance at arid land if river discharge is negligible.

$$P=E+dS \quad \text{or} \quad P-E=dS$$

P:Precipitation, E:Evap., R:Runoff, S: Soil Moist.

dS: soil moisture change

at larger timescale, this is maximum possible water resources, if it is positive.



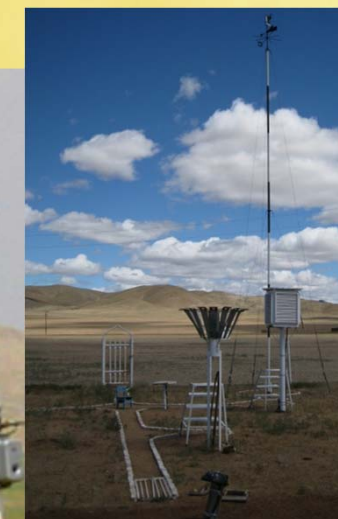
# Observation of surface water balance

nearby operational met. station

Eddy covariance system

measurements started from 2003-

Kherlen Bayan Ulaan

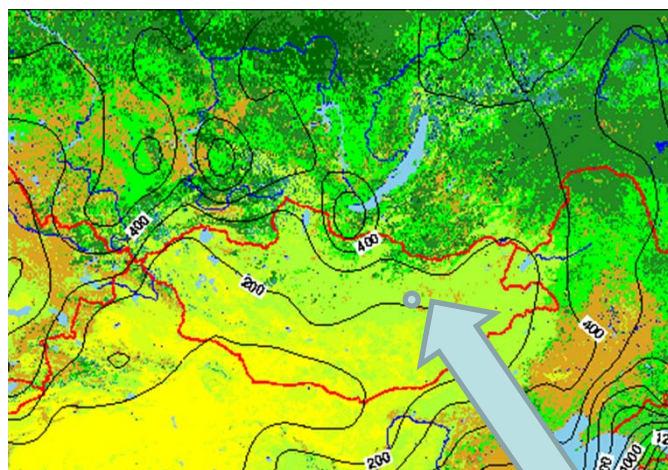


Soil moisture measurements



Tipping bucket rain gauge

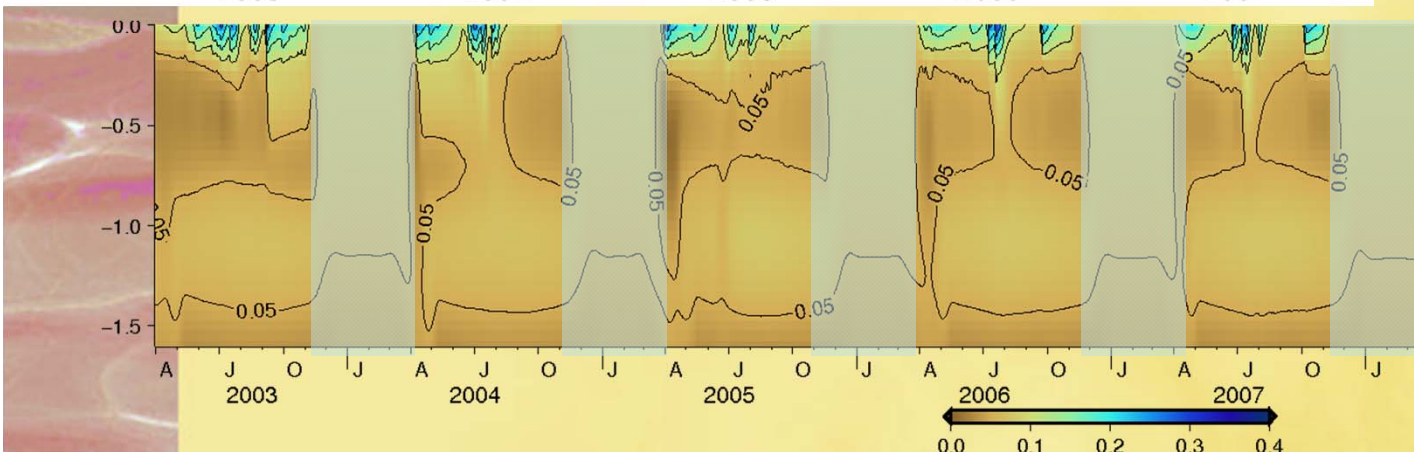
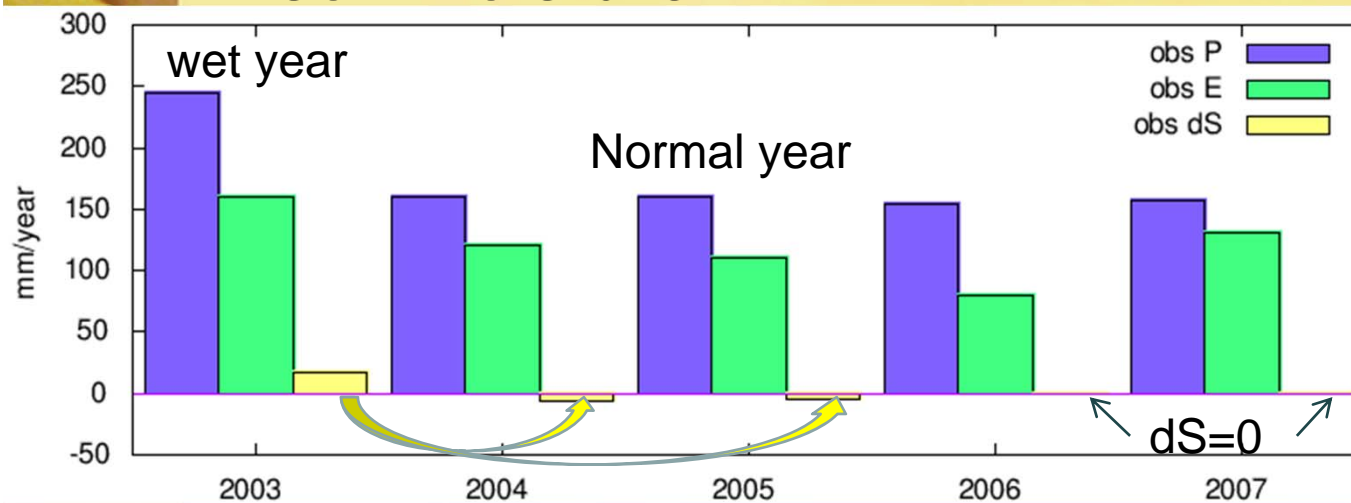
Asis Drought Workshop





# Observational results: annual hydrological budget

✿ In wet year, rainfall is left over to the next as a soil moisture.

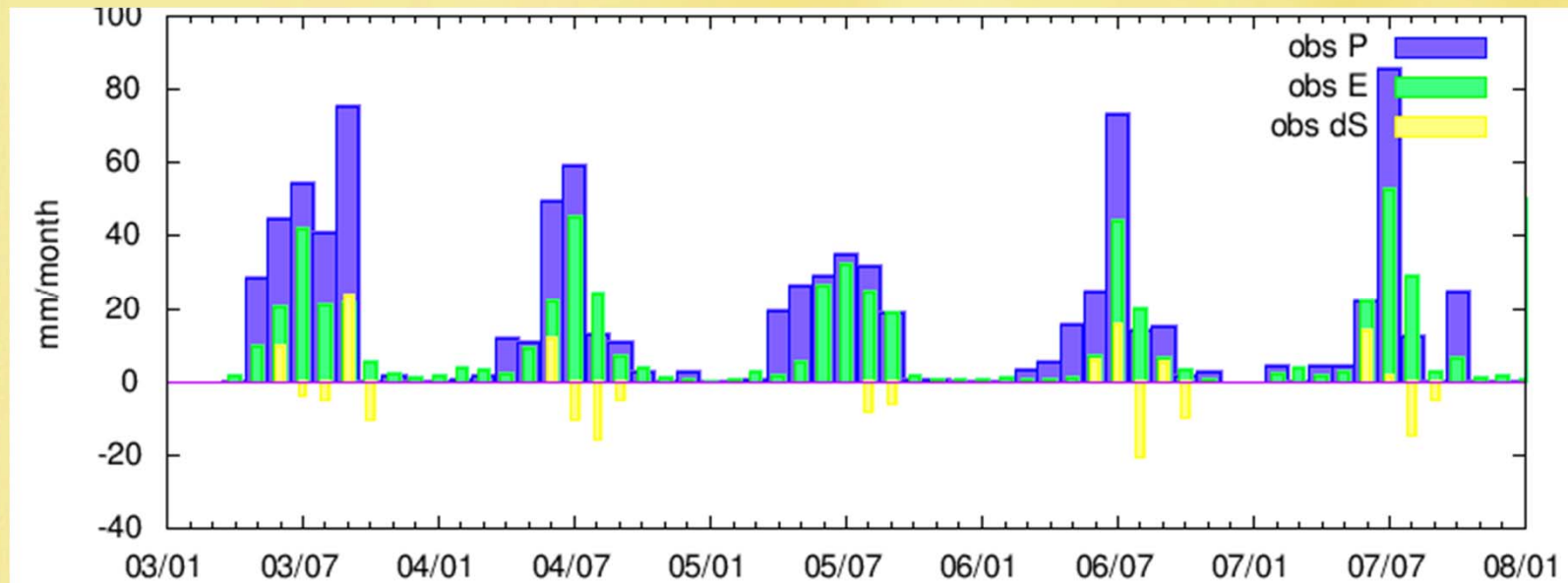






# Monthly hydrological budget

✿ With monthly averages,  $dS$  is never  $=0$

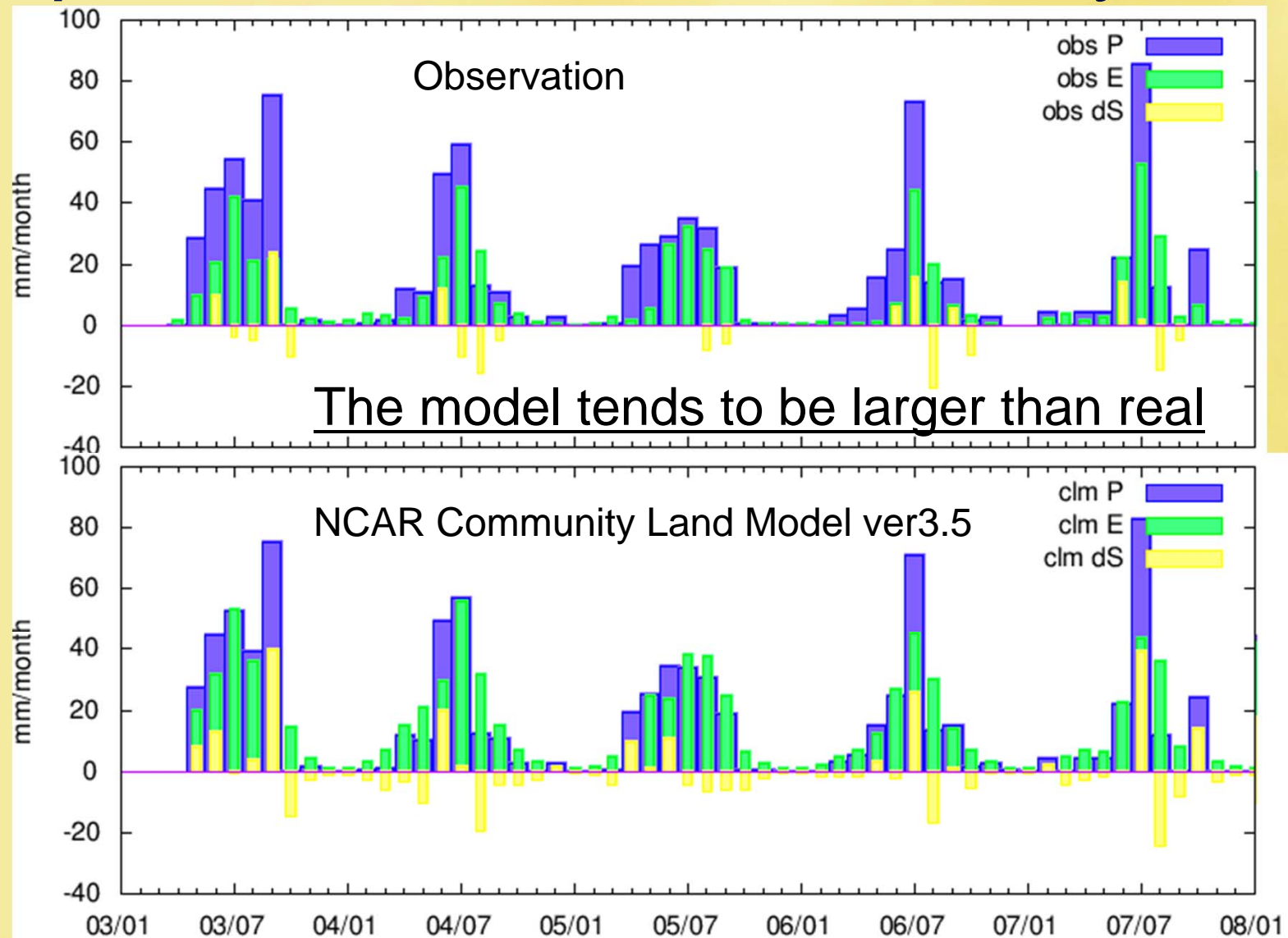


From the observations,  $P=E$  **never** hold at KBU.

This indicates a chance of recharge of groundwater, which suggests sustainability in groundwater use is possible

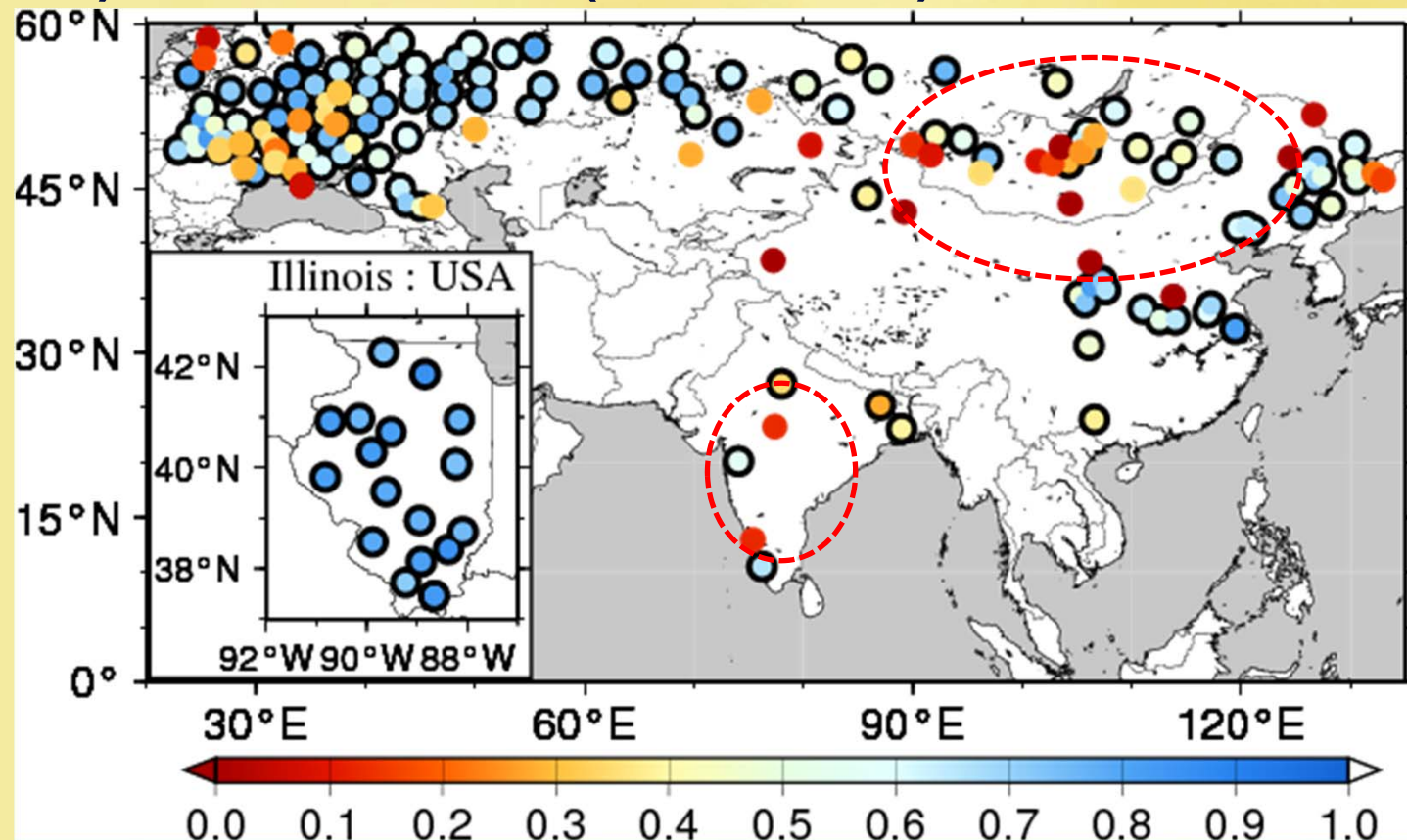


# How accurately do models can reproduce this well? - monthly





# Model performance at the region ex1) GSWP2 (annual)



correlation between GSWP2 (multi model analysis) and GSMDB(observation) (annual means)

figures made by Dr. Yorozu at Kyoto Univ.

in reference to Guo, and Dirmeyer (2002) JGR, Vol.111, D22S02





# How accurately do models can reproduce this well?

✿ Models that works good at America does not perform well at arid land in Asia?

✿ why?

☘ It used to be a blank area of observation.

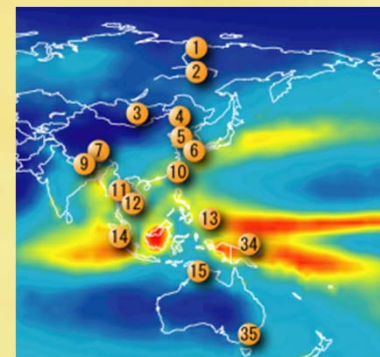
☘ No data to run/train models

✿ Now:

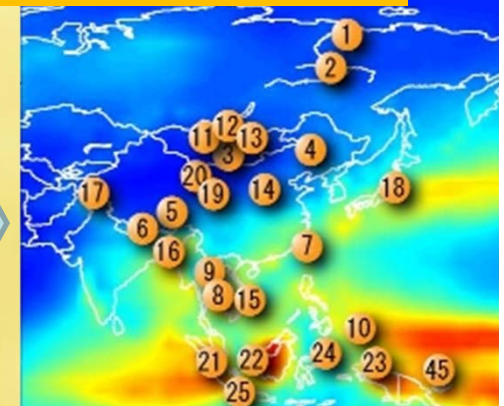
☘ there are a lot.

✿ Let's check!!

GEWEX-CEOP reference sites



phase1, 2003



phase1, 2007



# Asian Dryland Land Surface Process



## Model Intercomparison Project (ADMIP)

### ✿ Purpose

- ✿ Intercomparison of Land surface model (water & energy) & Terrestrial Ecosystem Model (carbon) at Asian Dryland

### ✿ PI:

- ✿ J. Asanuma, U. Tsukuba
- ✿ D. Ojima, Colorado State U.

### ✿ Under

- ✿ MAHASRI, MAIRS-dryland & CEOP-dryland

### ✿ Supporting funds:

- ✿ APN (Asia Pacific Network for Global Change Research)
- ✿ ESSP-MAIRS
- ✿ MEXT-JSPS

### ✿ Participating models: 1617 models in total

- ✿ LSM: CLM, CoLM, NOAH, JULES, Sib2, BAIM, SiBUC, MATSIRO,
- ✿ TEM: VISIT, Biome-BGC, DayCent

### ✿ Participating countries

- ✿ Japan, USA, China, Korea, Mongolia, Pakistan, Australia, etc







# ADMIP Phase 1: details

## ✿ Objective:

- ✿ point-based intercomparison with observation-based drivers.

## ✿ Models

- ✿ LSM: CLM, CoLM, NOAH, JULES2, SiB2, BAIM, SiBUC, MATSIRO, SiB-UC
- ✿ TEM: VISIT, Biome-BGC, DayCent, SEIB

## ✿ Target Points

- ✿ Tongyu: Inner Mongolia (CAS)
- ✿ Kherlenbayan Ulaan(KBU): Mongolia, IMH&U. Tsukuba
- ✿ Pinglian: Lanzhou (CAREERI)

## ✿ Logistics

- ✿ home page and data WG (Kyoto U.) (京大 萬氏)
- ✿ PALS (Protocol for the Analysis of Land Surface models) at Univ. New South Wales for data platform



# ADMIP Phase 1: Timeline

- ✿ 2010/7/11-12: Kick-off meeting
- ✿ 2011/7: International Workshop (Tsukuba)

	2010						2011											
	07	08	09	10	11	12	01	02	03	04	05	06	07	08	09	10	11	12
Kickoff meeting	▲																	
Agenda																		
drafting protocol	■	■																
distribution for review		■	■															
finalizing protocol			▲															
Model registration	■	■	■	■														
deadline for submission				▲														
Forcing data & Ancillary data																		
preparation	■	■	■	■														
deadline for submission			▲															
available to the community				▲														
Stage 1 basic model runs																		
model runs	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
deadline for model output									▲									
Analysis of stage 1 model outputs									■	■	■	■	■	■	■	■	■	■
Meetings																		
AMS meeting at Texas							▲											
WS at Tsukuba, Japan										▲								
WPGM or AOGS (?)														▲				

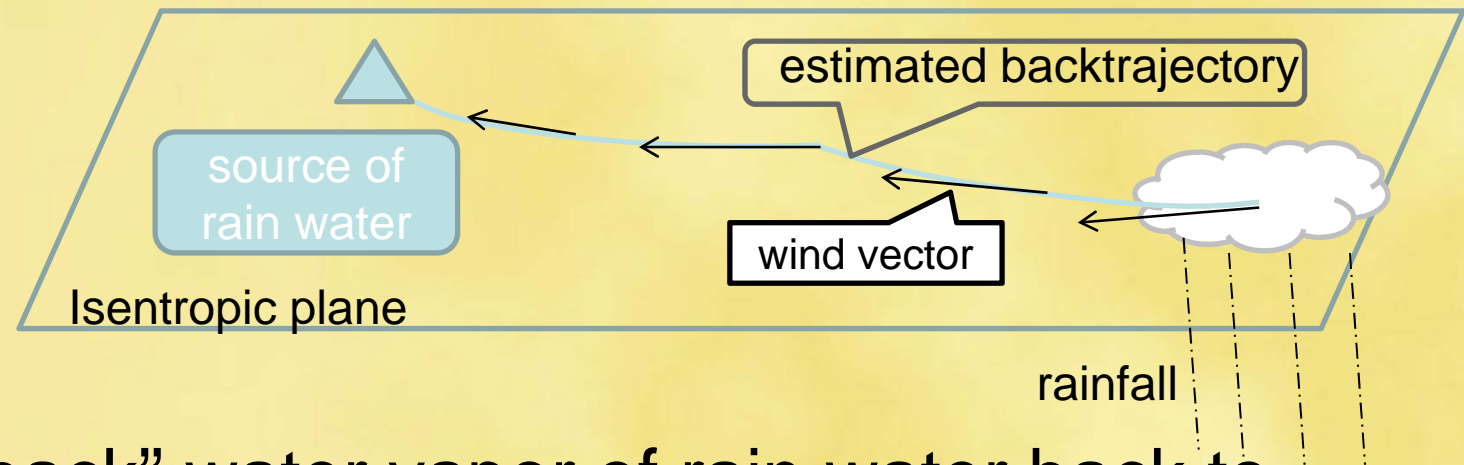




# **BACKTRAJECTORY ANALYSIS OF RAINWATER**



# Backtrajectory analysis



“tracking back” water vapor of rain water back to the past toward its source on the ground



trajectory line: trace of material



Data needed

- 3D field of wind speed (e.g. reanalysis)
- rainfall measurements with high temporal resolution (e.g. rainfall products)

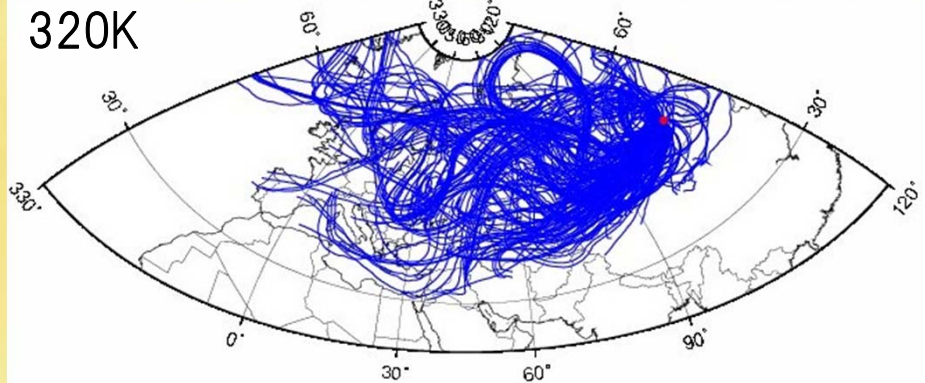




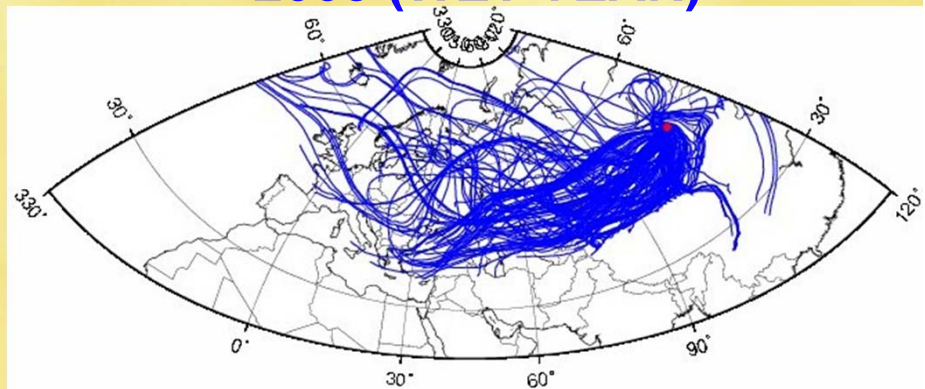
# Case study in Mongolia



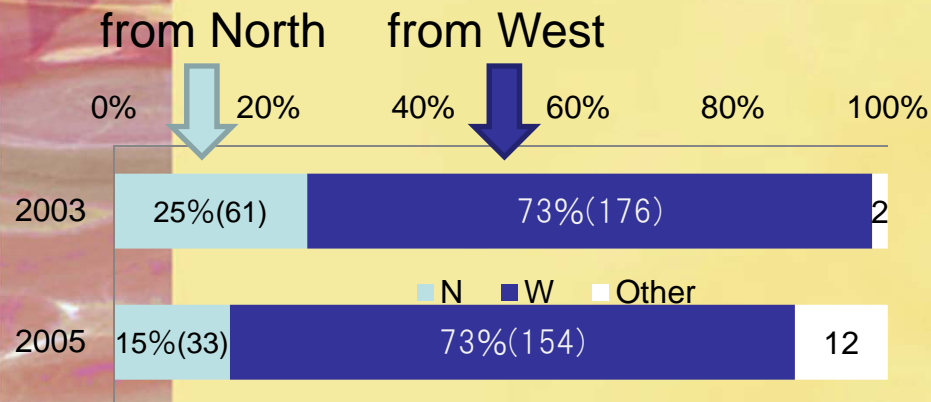
Target point	Kherlenbayan Ulaan(KBU)
Height	300K, 310K, 320K
Target period	Warm season (JJAS) of 2003 ( <b>Wet</b> ) & 2005 ( <b>Dry</b> )
Tracking lengths	5 days (moisture source is somewhere on the line)
Data set	JRA25/JCDAS(reanalysis) RAISE observed rainfall



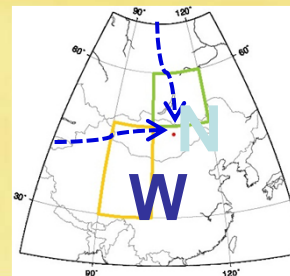
**2003 (WET YEAR)**



**2005 (DRY YEAR)**

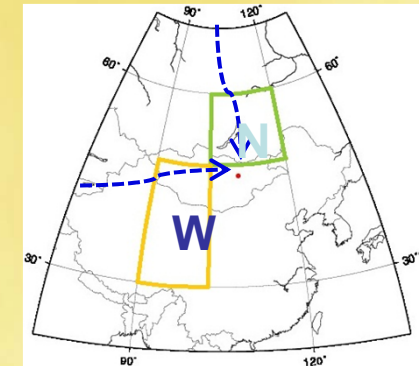
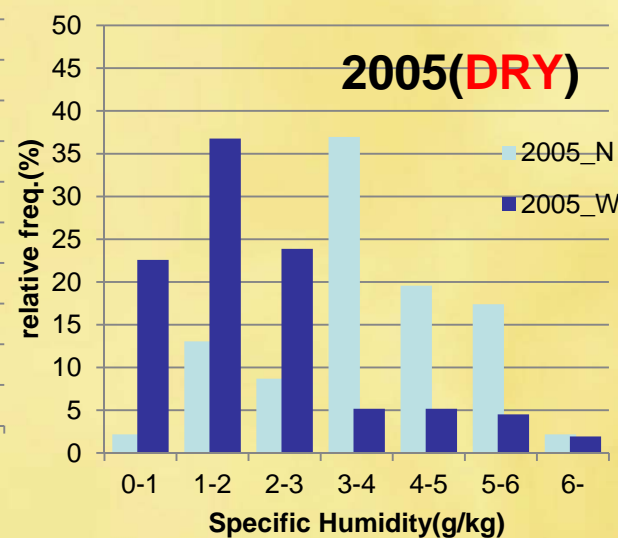
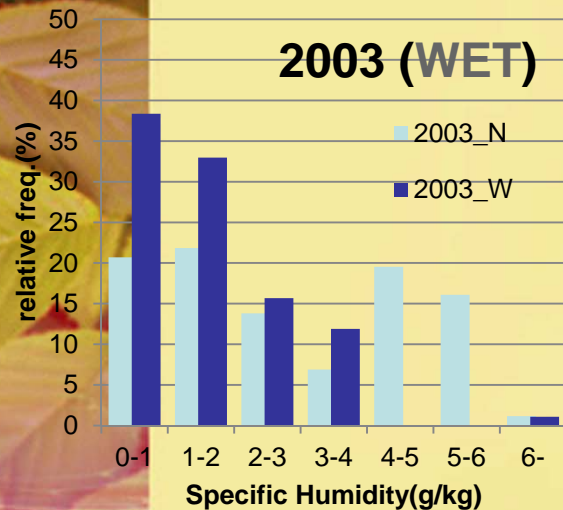


More trajectories from north in 2003(**wet**) than 2005 (**dry**).

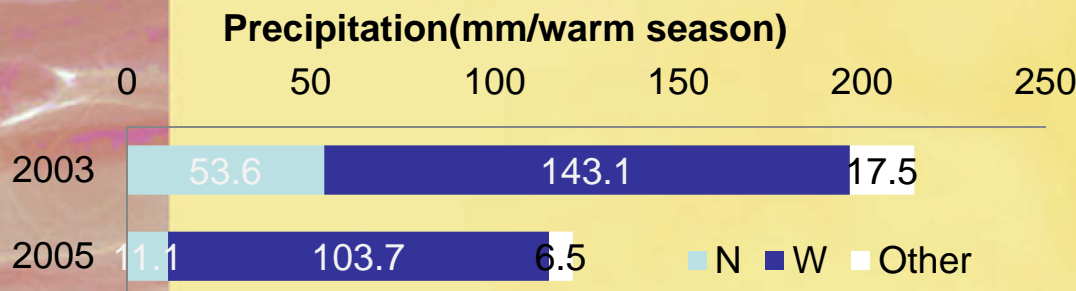




# Difference between the two years and the trajectory lines



Specific humidity of upper air at rain time: Drier air from the west than from the north both in 2003 & 2005.



Year 2003 has more rainfall with more Northern trajectory line





# Summary of back trajectory analysis - preliminary -

- ✿ Moisture source at KBU is north or west of Mongolia
- ✿ More trajectories from north in 2003 (**wet**) 2003 than 2005(**dry**).
- ✿ Trajectories from north is associated with wetter air and causes more rainfall
- ✿ Hypothesis:
  - ✿ More moisture coming from north causes more rainfall in warm season at the center of Mongolia.



# Recommendation

- ✿ Need spatial rainfall data set with higher temporal and spatial resolution
  - ✿ In order to know where, when and why draught happens
- ✿ For this,
  - ✿ we need high resolution observation, and automatic and online (wired or wireless) data collection system

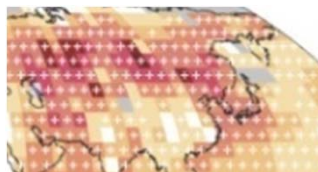
# Acquiring Sustainability in Water Sector Under Increasing Natural and Social Stresses

## Social Aspects :

1. Increasing population, concentrating to urban area
2. Increasing life standard and water demand
3. need for updating infrastructure



2009/7 Flood (UB city and the south, 20 or more deaths)



Strong warming signal in 20th century (IPCC-AR4)

## Background

## Natural Aspects :

1. more droughts and floods
2. threat of climate change
  - more frequent drought and floods are projected

## JICA's aid policy to Mongolia(2009)

- "Climate change impact such as decrease in water resources"
- technologies for appropriate management of natural resources
  - early warning and mitigation to natural disaster
  - human security at Geru area in UB city

## National Development Policy, 2007-

Adaptation to climate change is a first priority

## National Disaster Risk Management Plan

- Climate change impact on disaster
- Early warning system

## Domestic policies

## National Water Program

- intensified monitoring
- climate change adaptation
- introducing water management

## Project goal :

Developing new technologies for efficient water usage and reducing flood risks

## Outputs and Activities

### b) Improving Efficiency in Municipal Water Use

Future projection of Water demand

Evaluation of water resources sustainability in UB

### a) Improving Future Projection of Climate Change

Climate Change Impact Projection

d) Disseminate the achieved scientific and technical results to the public and the policymakers

### c) Building Strategies for Urban Storm Drainage

Disaster risk projection

New method for Disaster risk management

**Overall Goal: Acquiring Sustainability in Water Sector Under Increasing Natural and Social Stresses**







# Outline

## ✿ Observed Surface Hydro. Balance at Mon. Grassland

- ✿ Annual & Monthly

- ✿ Are we able to reproduce with model?

  - ▾ Answer: No



# Science of Water Resources

## ✿ Resource Exploration

✿ where is water? (rainfall, groundwater,

## ✿ Resource Management





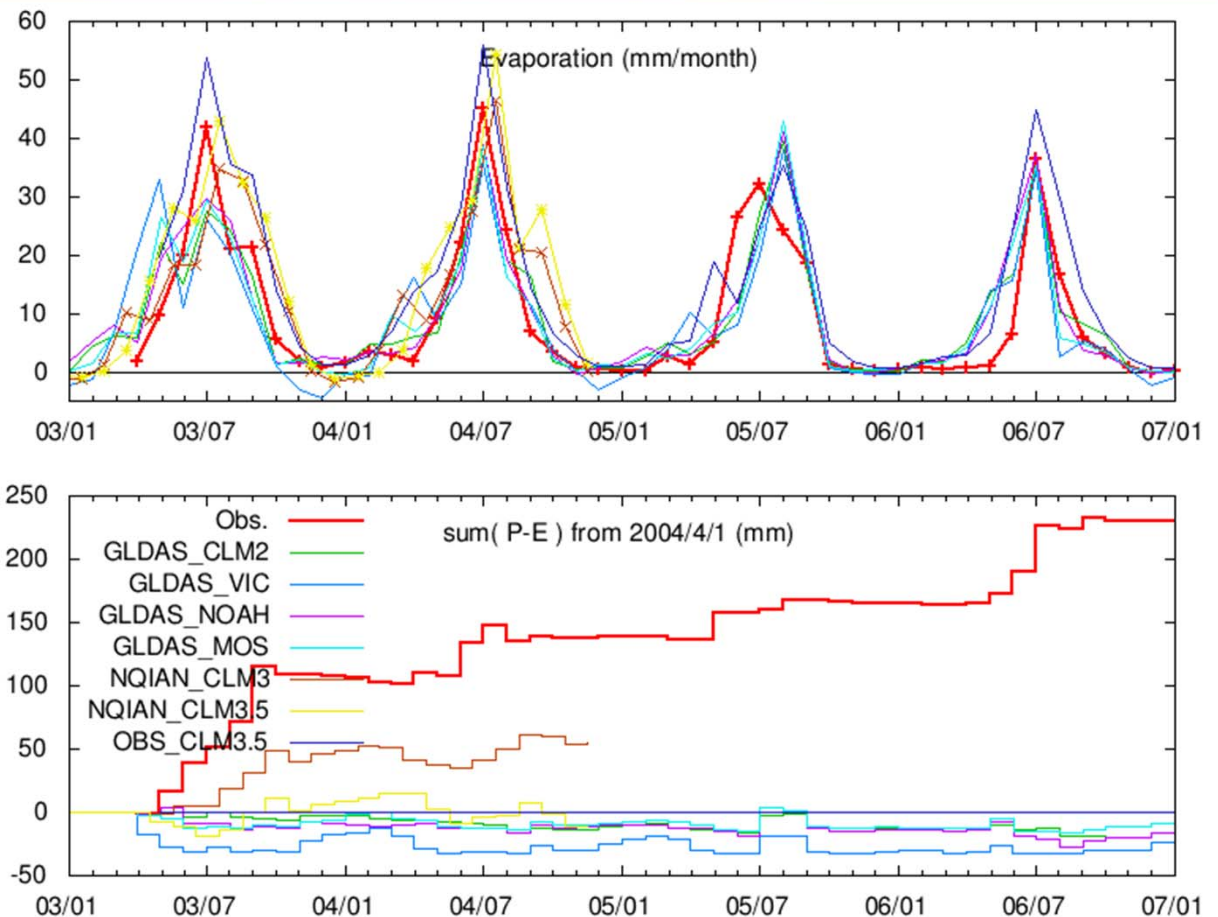
# Model performance at the region ex2) recent models & data sets

- ✿ GLDAS (Global Land Data Assimilation System), NASA
  - ✿ Synthesized atmospheric forcing data:
    - merge of surface & satellite observation and reanalysis
  - ✿ land use/cover & vegetation: satellite-based
  - ✿ models: NOAH, CLM2, MOSAIC, VIC
- ✿ reanalysis-driven NCAR-CLM3.0 & 3.5
  - ✿ Atmospheric forcing data:
    - Qian et al.(2006): reanalysis corrected with ground obs.
  - ✿ land use/cover & vegetation: satellite-based
- ✿ compared with observation at Mongolian grassland (monthly)



# Another model result

- ✿ GLDAS (Global Land Data Assimilation Sys.)
- ✿ Surface hydrological budget is not well reproduced.



2010/7/11