

Cryospheric Data Assimilation

An Integrated Approach for Generating Consistent Cryosphere Data Set

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Academy of Sciences**



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[Snow Database](#)

Snow depth, snow disaster, and snowfall data

[Glacier Database](#)

Chinese Spatial Glacier Inventory Data and Yaluzangbu River Glacier Inventory

[Pumqu Basin, China](#)

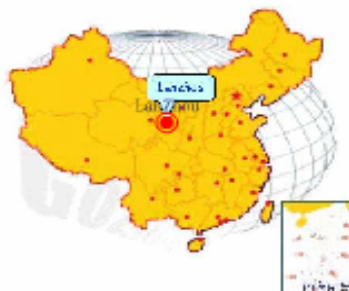
[Himalaya](#)

Inventory of Glaciers and Glacial lakes and the Identification of potential Glacial

Lake Outburst Floods (GLOFs) Affected by Global Warming in the Mountains of Himalayan Region
Pumqu Basin, China
Himalaya

[Frozen Soil Database](#)

Temperature Data of the



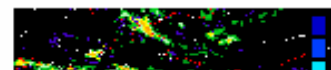
WDC For Glaciology and Geocryology, Lanzhou

WDC For Glaciology and Geocryology, Lanzhou, is the main part of the [World Data Centre](#). It is also one of the professional databases of Chinese scientific Database. The aims are the collection, saving, management and analysis on Chinese Cryosphere Database which includes the Polar Regions and high Asia Regions.

This data center also can promote the sharing of the cryosphere data in the earth science. It would contribute to the research of the global change, the protection of the cold and arid regions, the exploitation of the natural resource, the construction of the projects and the work to forefend and reduce the disease.

Operational Work

[From the last winter, we began to provide the snow depth data of the Qinghai-Tibet plateau for the Qinghai meteorological Bureau from November 19, 2001 to April 9, 2002. The snow](#)



Land data assimilation in WDCGG

- Establishing an integrated data and information service is one of the major objectives of the International Polar Year (IPY). The land data assimilation technology, which was booming in the last few years, provide an integrated approach to generate spatial and temporal consistent datasets of snow, frozen soil and other cryospheric (and related land surface) states. We have developed a land data assimilation system which can assimilate remote sensing observations into land surface models and then produce reanalyzed cryospheric datasets with high spatial and temporal resolutions.

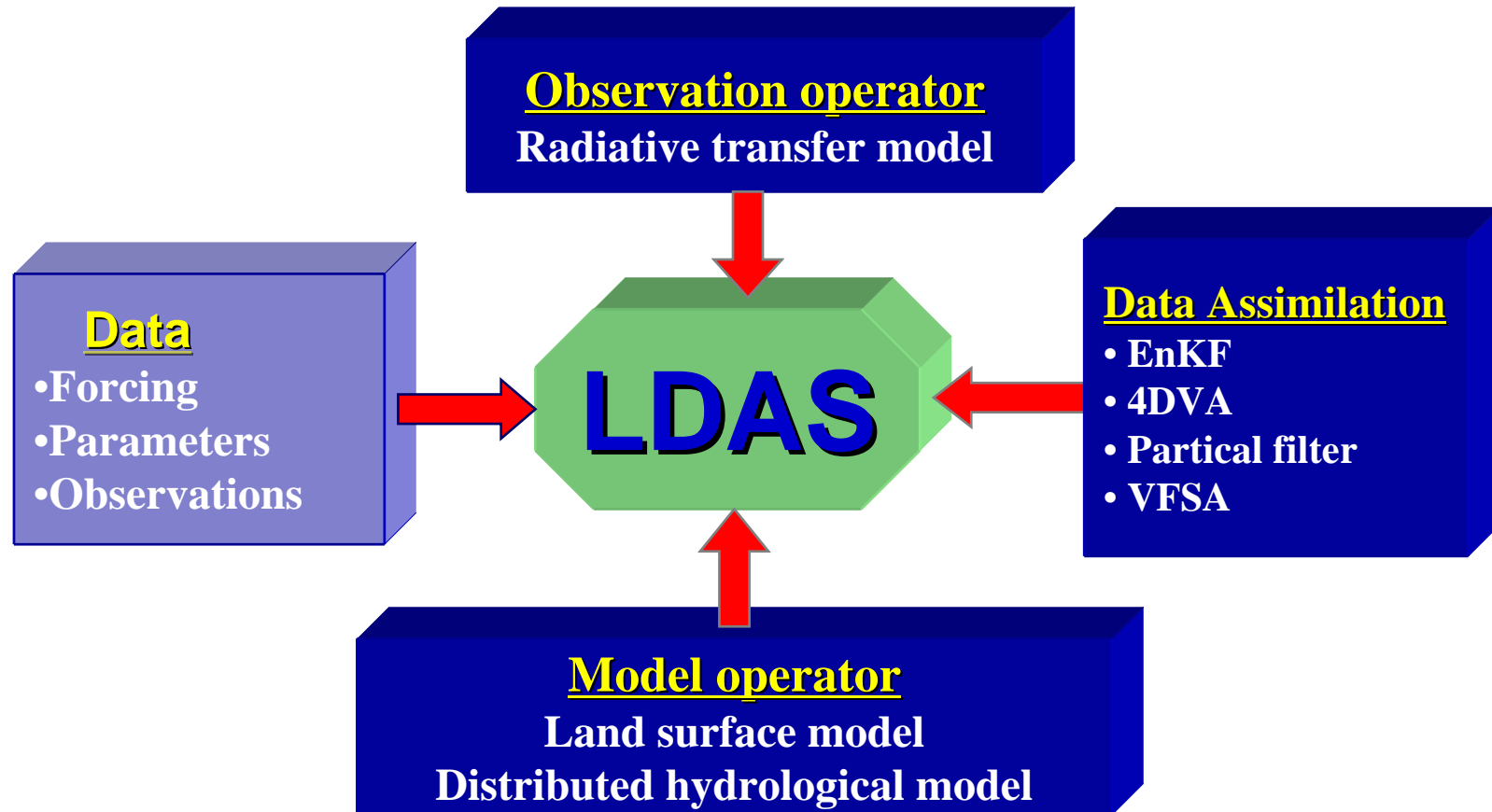


Chinese Land Data Assimilation System

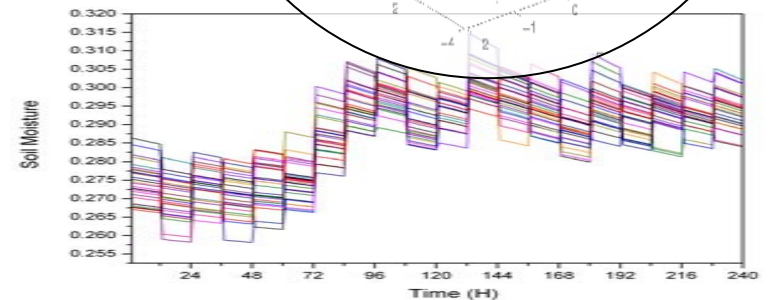
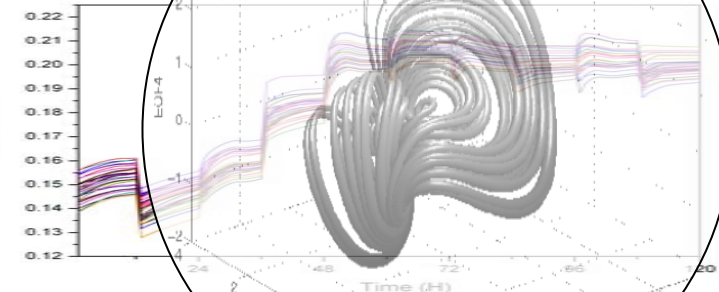
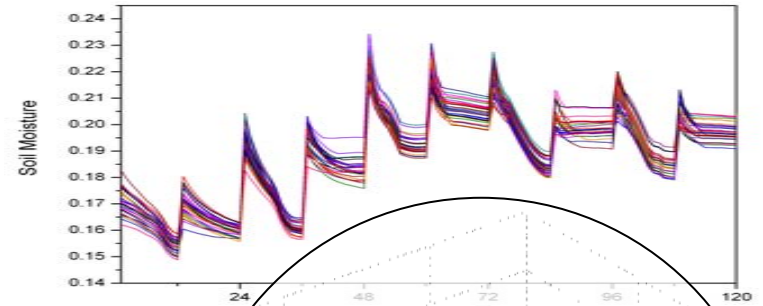
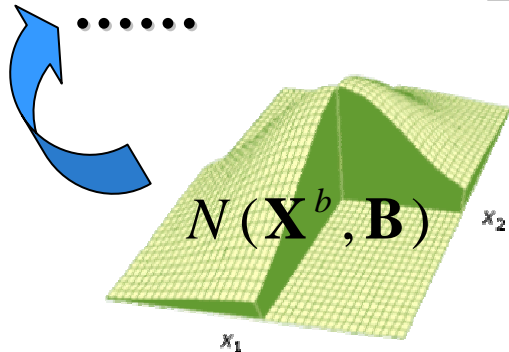
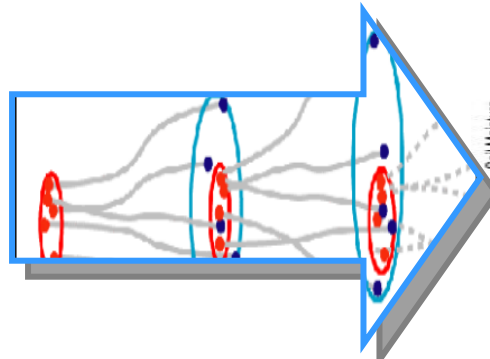
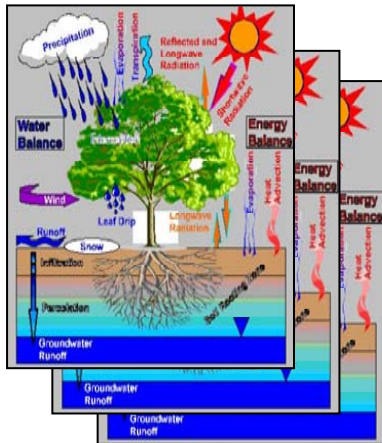
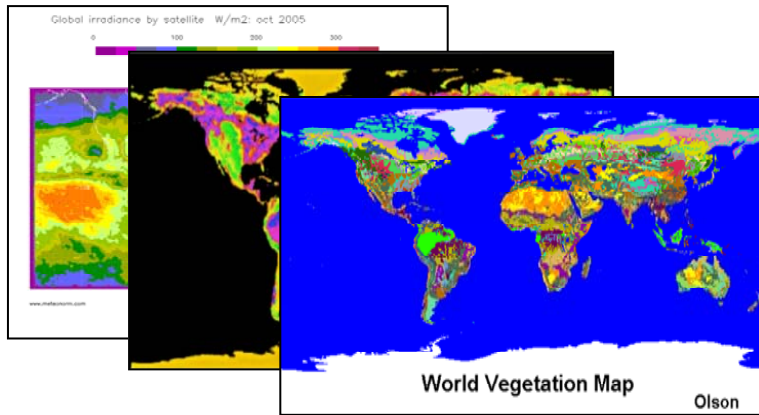
- The objective of CLDAS is to develop an operational Land Data Assimilation System for the whole China's land territory with a spatial resolution of 0.25° and temporal resolution of one hour, and in the mean time to improve the presentations of cold region process in both land surface models and radiative transfer models.



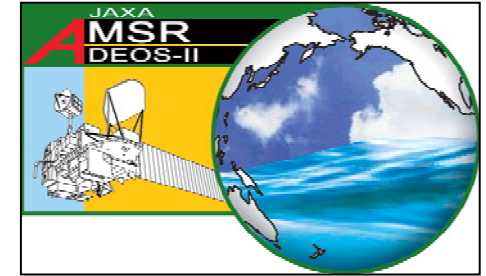
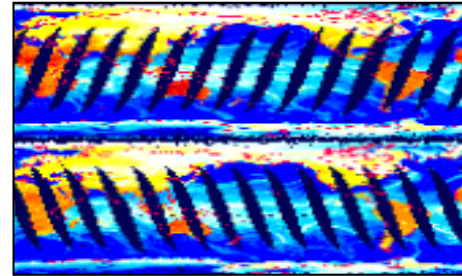
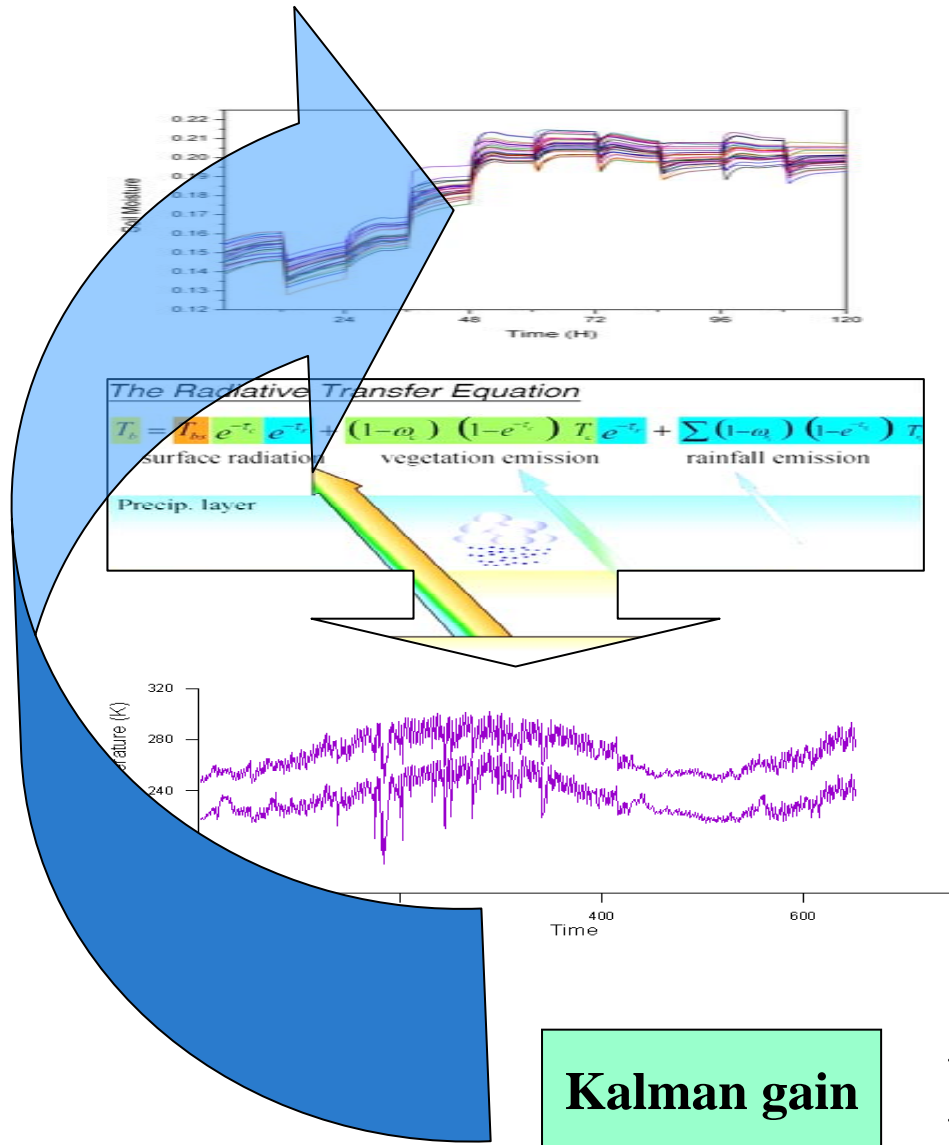
1. Overview of CLDAS



LDAS -- (1) Ensemble Prediction



LDAS -- (2) Ensemble Kalman filter



SSM/I

AMSR-E

+



Kalman gain

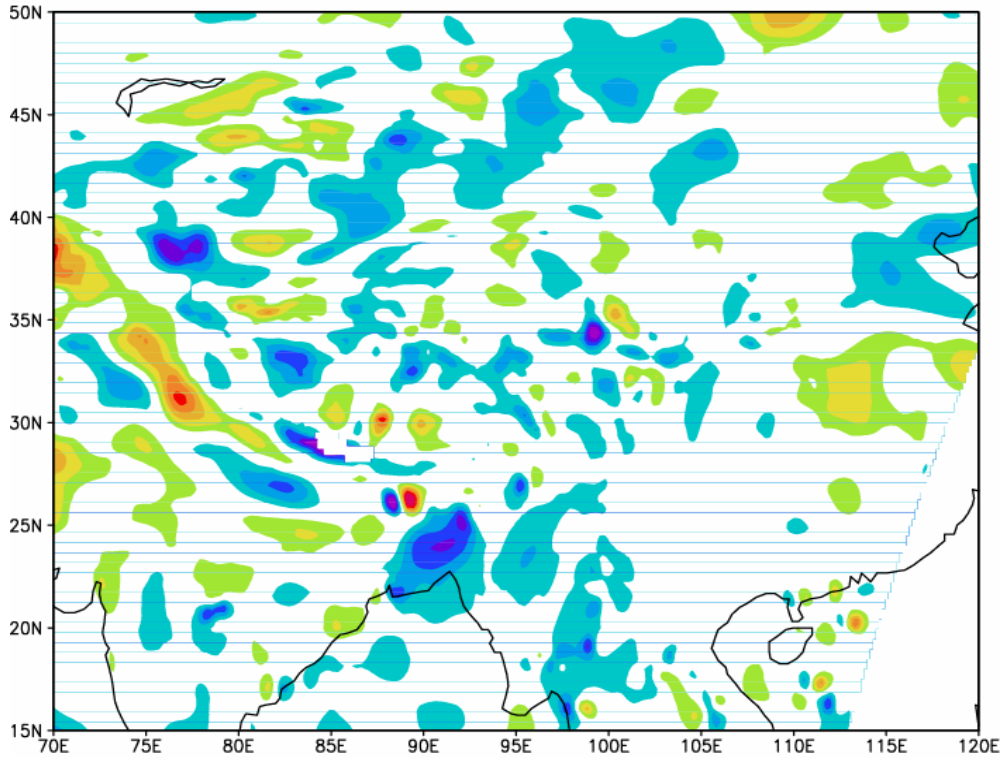
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Innovation vector

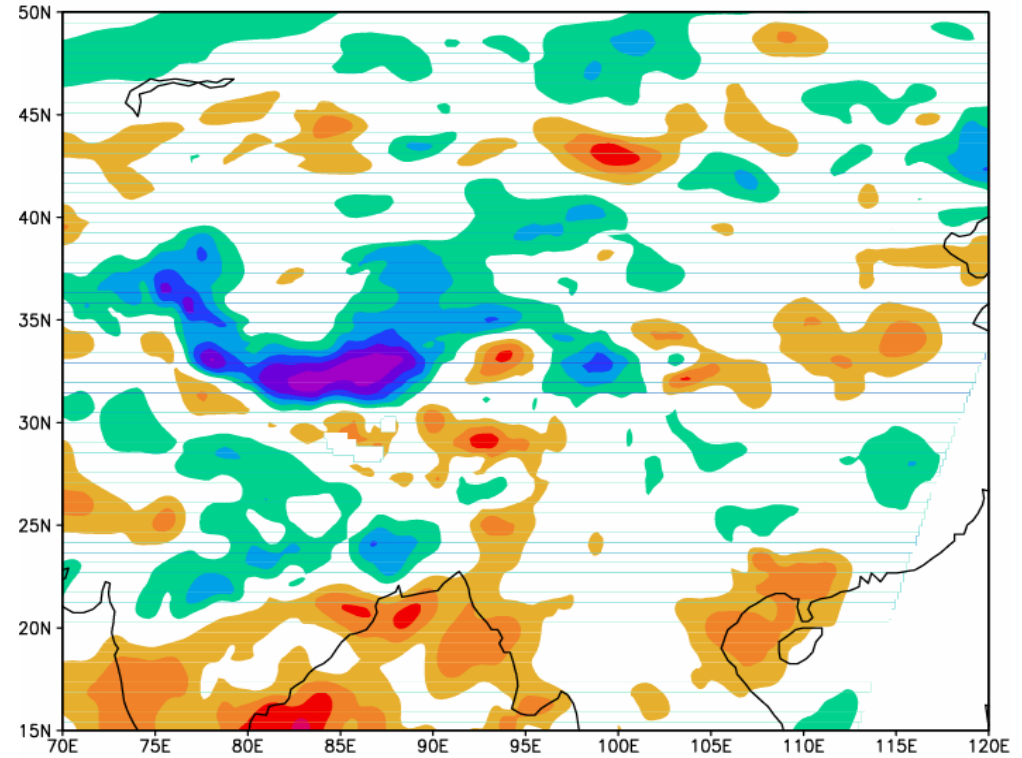
2. Forcing data preparation by using an atmospheric data assimilation system

- In CLDAS, the forcing data are prepared by an atmospheric data assimilation system based on Newtonian nudging. The NCEP reanalysis data are dynamically downscaled using the regional climatic model MM5 with reanalysis data as the background and observations. Comparisons with the objective analysis of meteorological measurements and the uncontrolled modeling showed that the atmospheric data assimilation system can produce more reliable downscaling of forcing fields.

060400Z 500hPa FDDA-Obj U



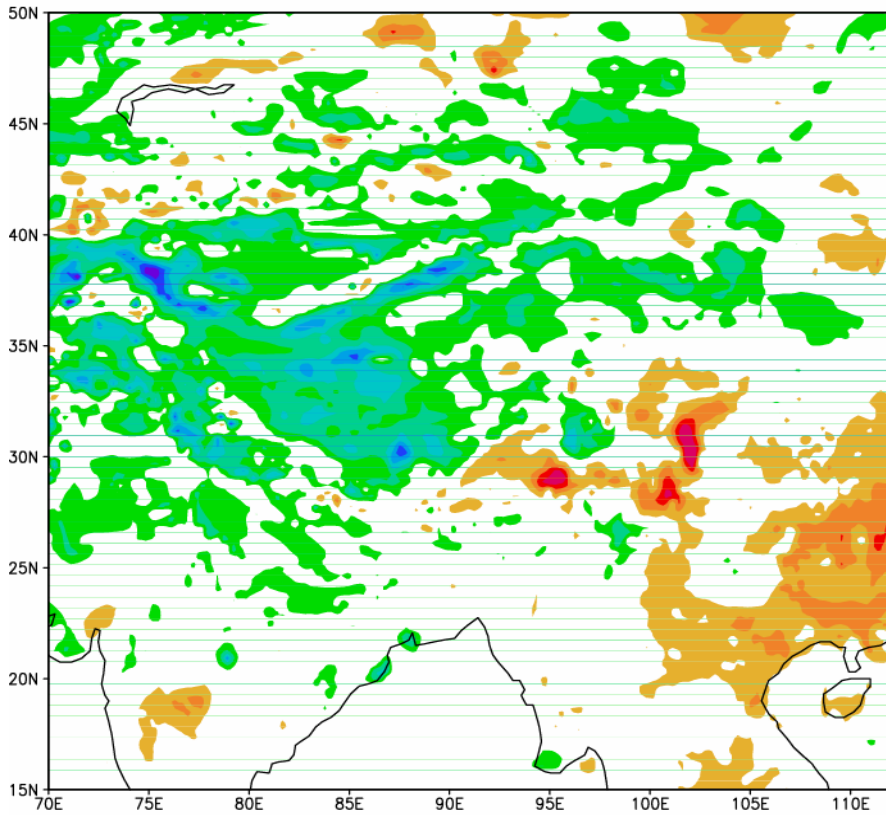
060400Z 500hPa NOFDDA-Obj U



FDDA - objective analysis
500 hPa wind speed (U)

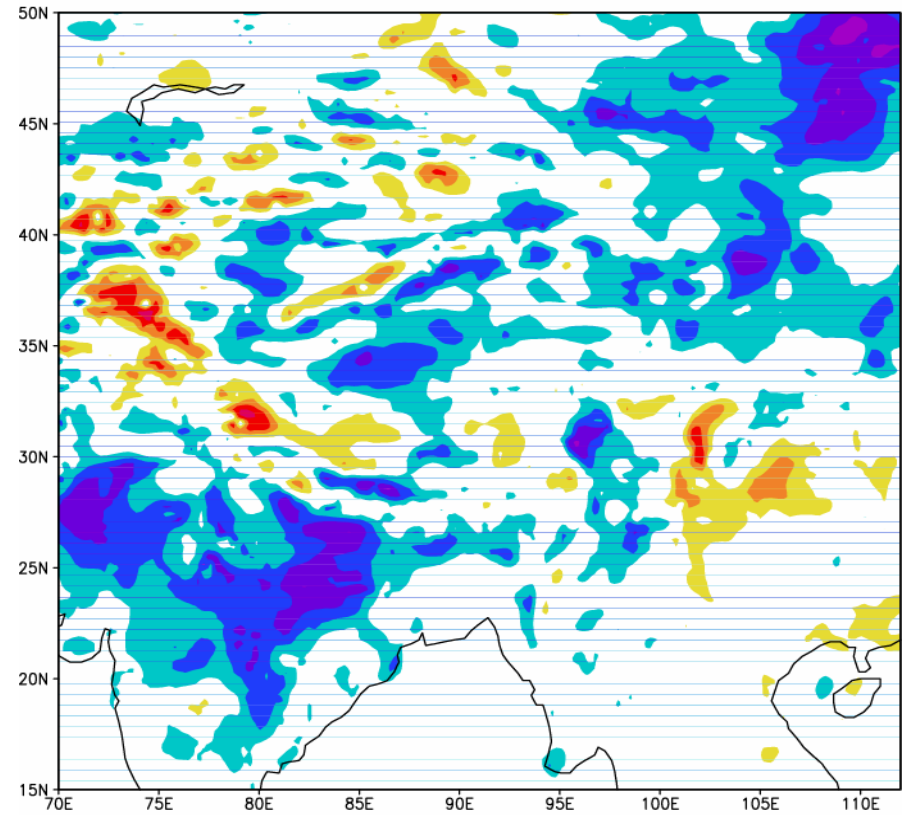
MM5 - objective analysis
500 hPa wind speed (U)

060400Z Sfc FDDA-Obj T



**FDDA - objective analysis
surface temperature**

060400Z SFC NOFDDA-Obj T



**MM5 - objective analysis
surface temperature**

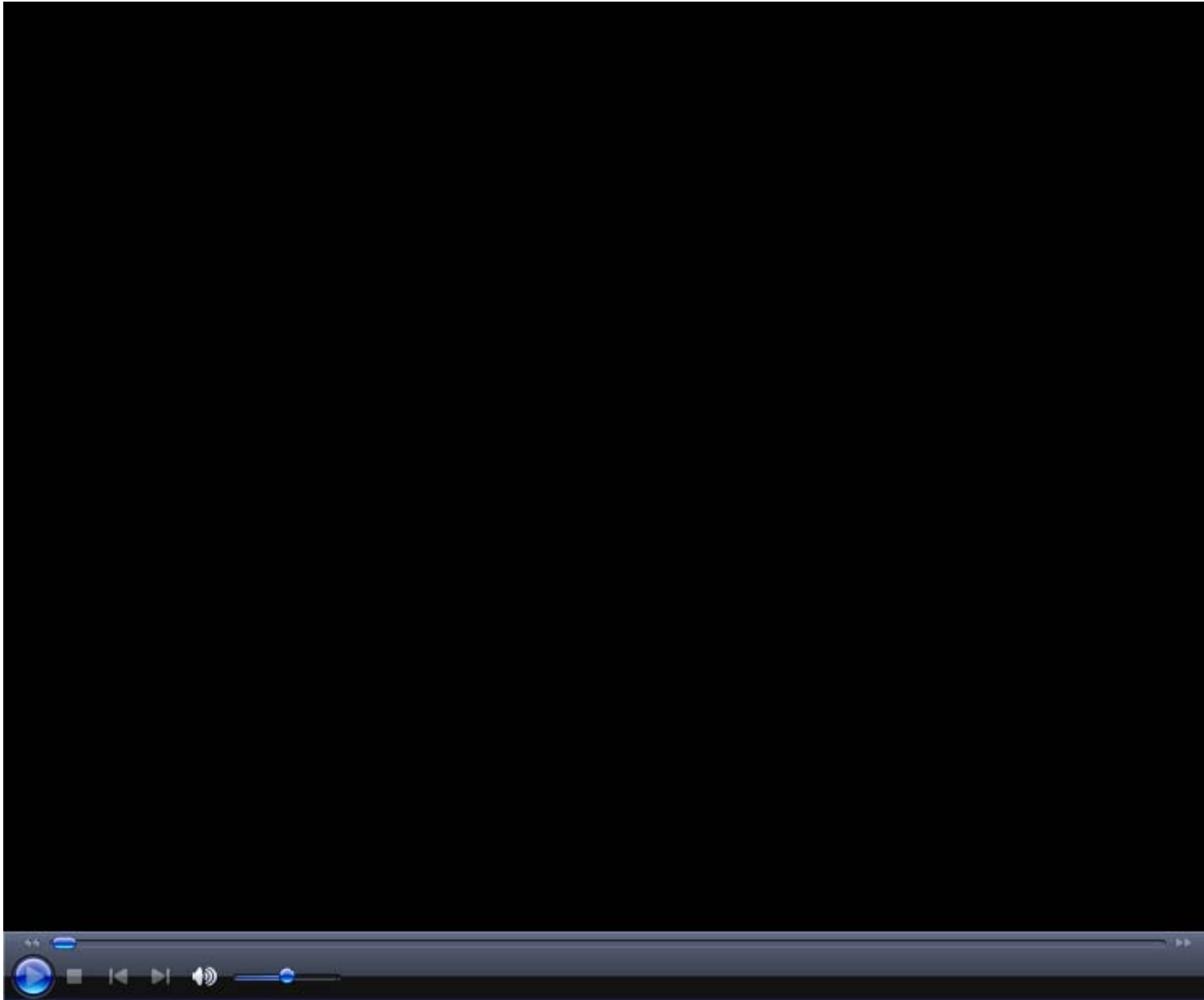
Dynamically downscaled forcing data of July, 2002

Precipitation

**Air
temperature**

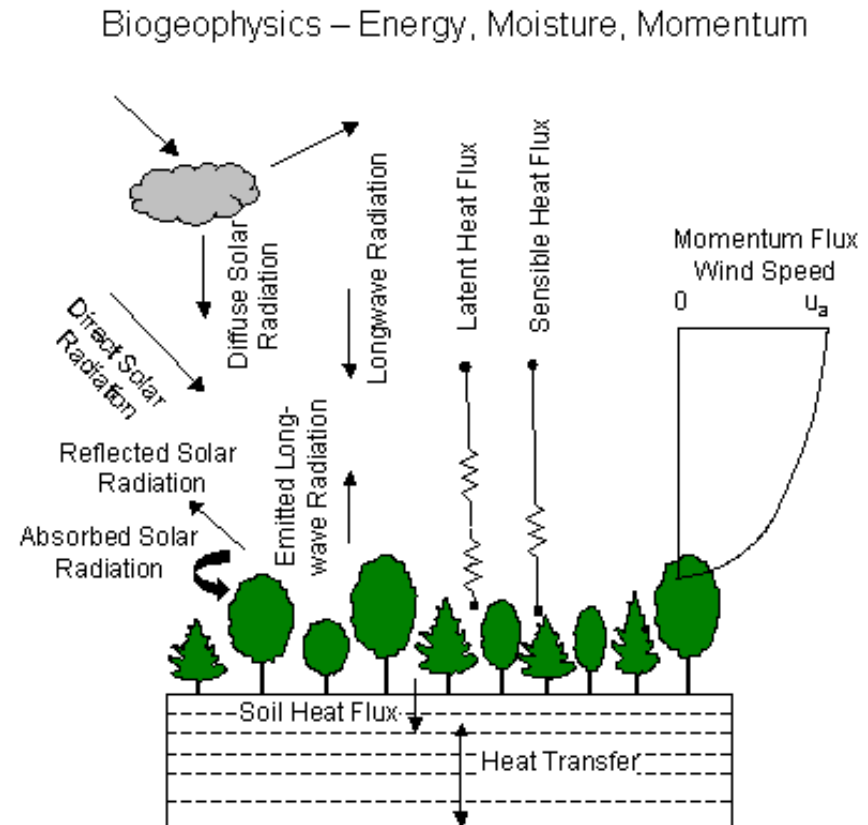
Humidity

**Downward
shortwave
radiation**



3 Land models in CLDAS

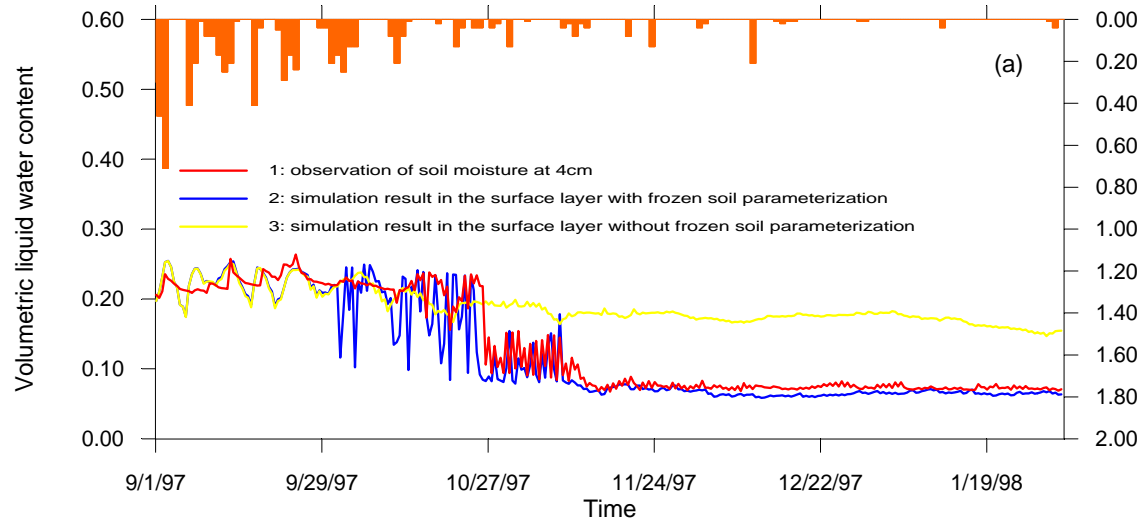
- **Common land model**
- **SiB2 with frozen soil parameterization**
- **JMA new SiB**



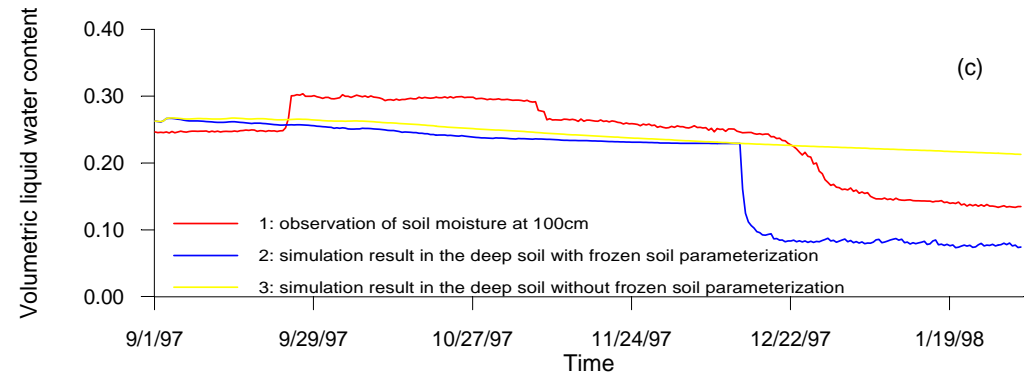
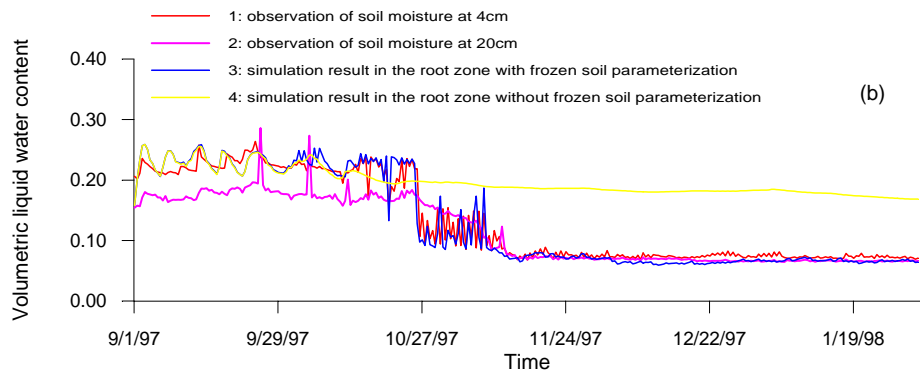
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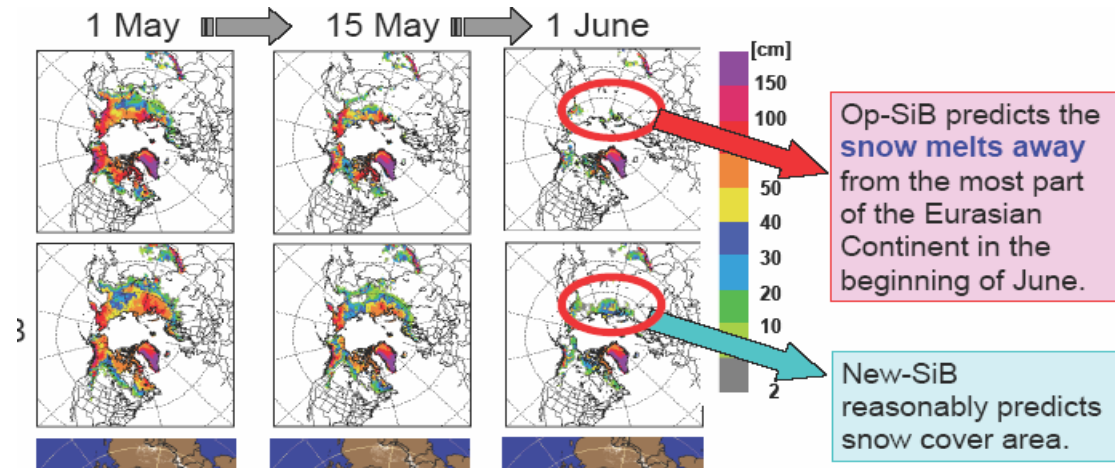
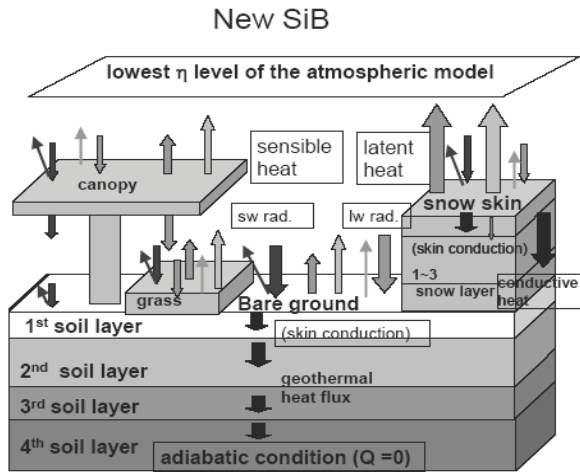
Frozen soil parameterization in SiB2



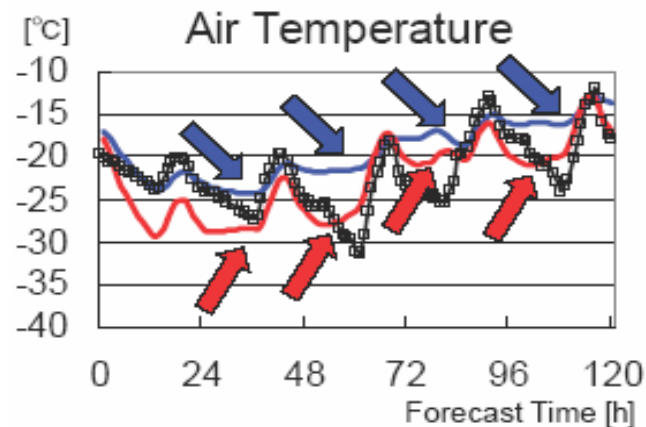
- Comparisons of the observations and model simulation results of soil moisture in (a) the surface layer, (b) the root zone, and (c) the deep soil at MS3608 site, Tibetan Plateau from Sep 01, 1997 to Jan 31, 1998



JMA new SiB



- JMA-GSM currently adopts a Simple Biosphere (SiB) model, which is developed by Sellers in 1986.
- In new SiB, snow and soil processes are improved substantially.

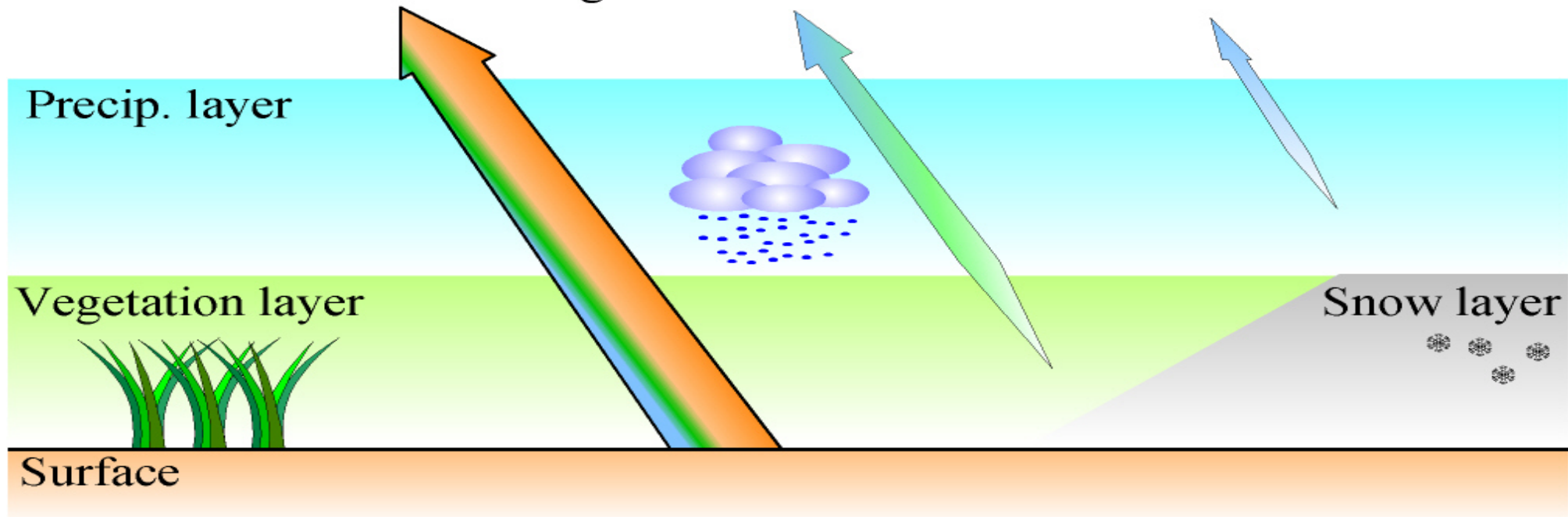


4. Passive microwave remote sensing of snow and soil freeze/thaw

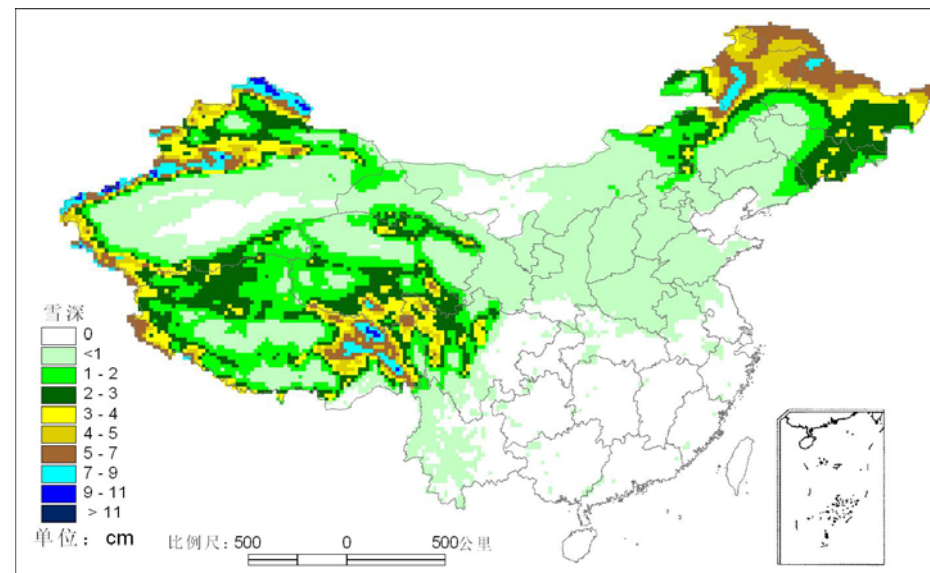
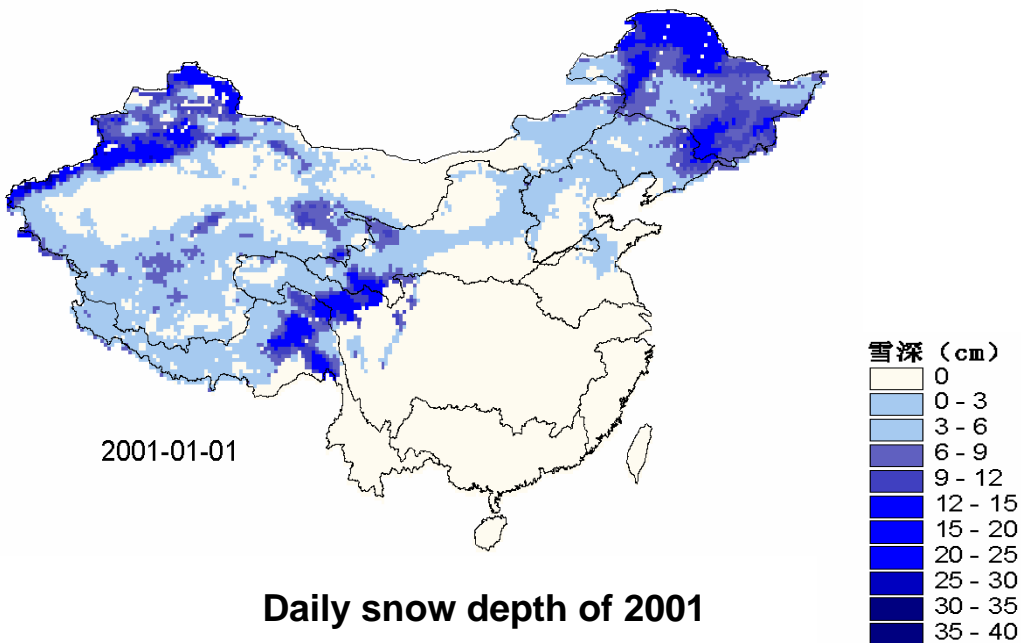
The Radiative Transfer Equation

$$T_b = T_{bs} e^{-\tau_c} e^{-\tau_r} + (1-\omega_c) (1-e^{-\tau_c}) T_c e^{-\tau_r} + \sum (1-\omega_{r_i}) (1-e^{-\tau_{r_i}}) T_{r_i}$$

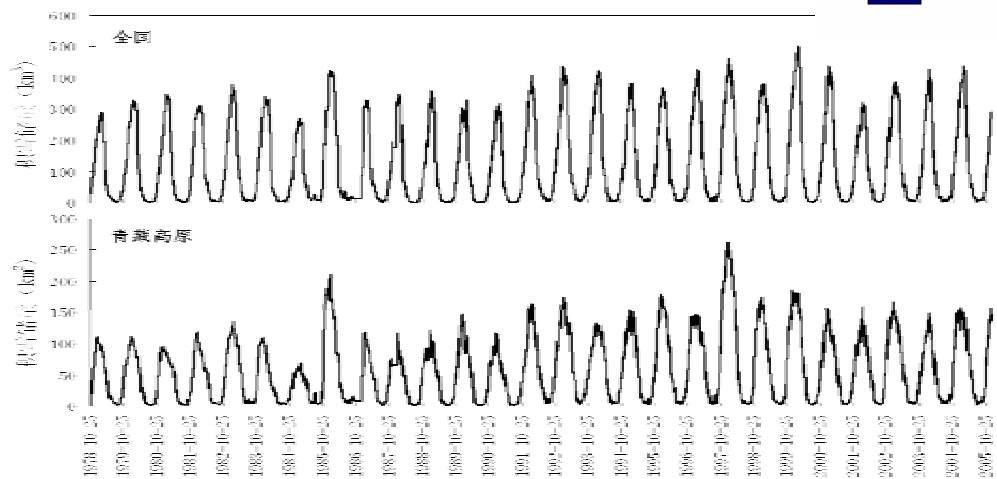
surface radiation vegetation emission rainfall emission



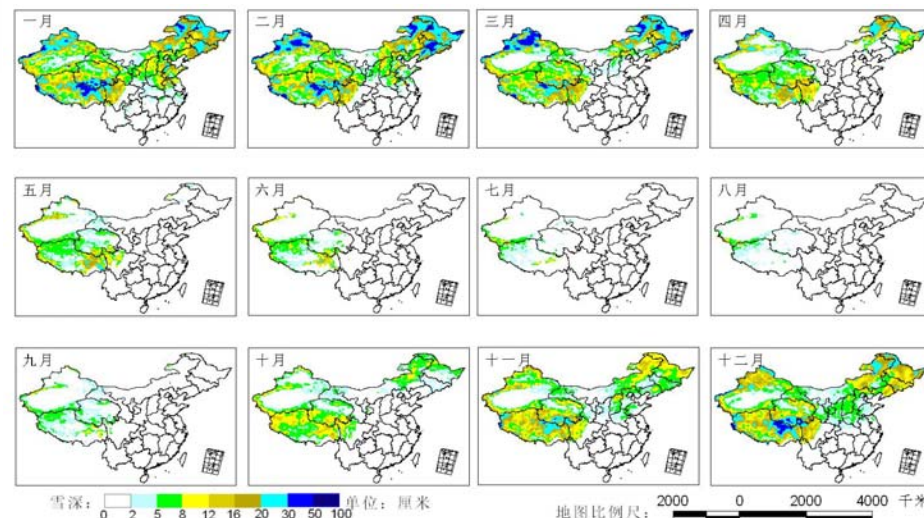
Snow depth data set (1978–2005) derived from PM remote sensing



Mean snow depth (1978-2005)

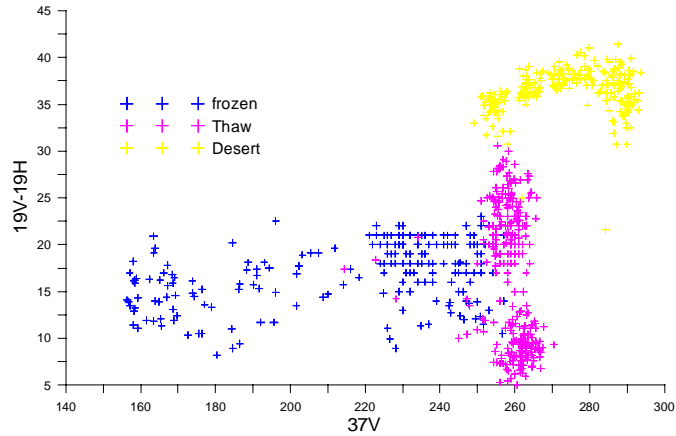


Snow depth variation from 1978 to 2005

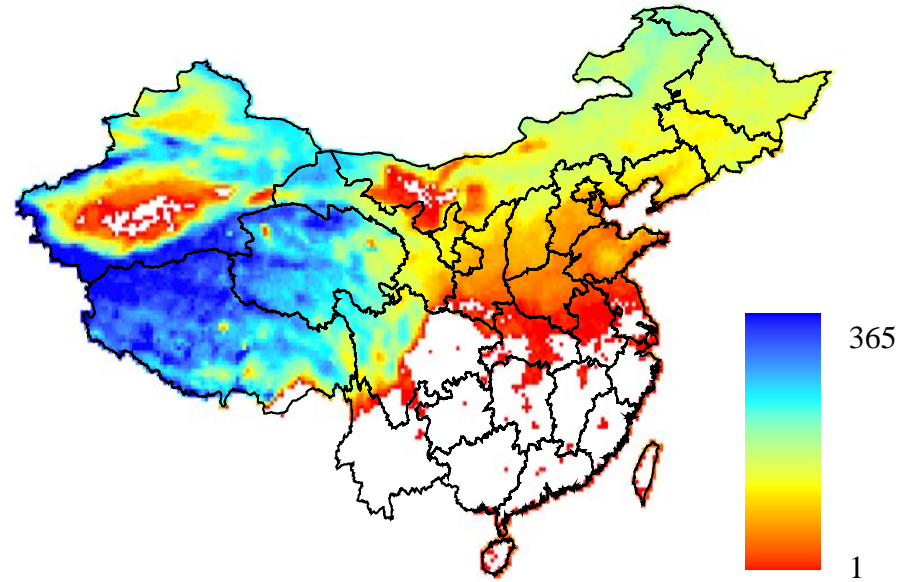


Monthly maximum snow depth

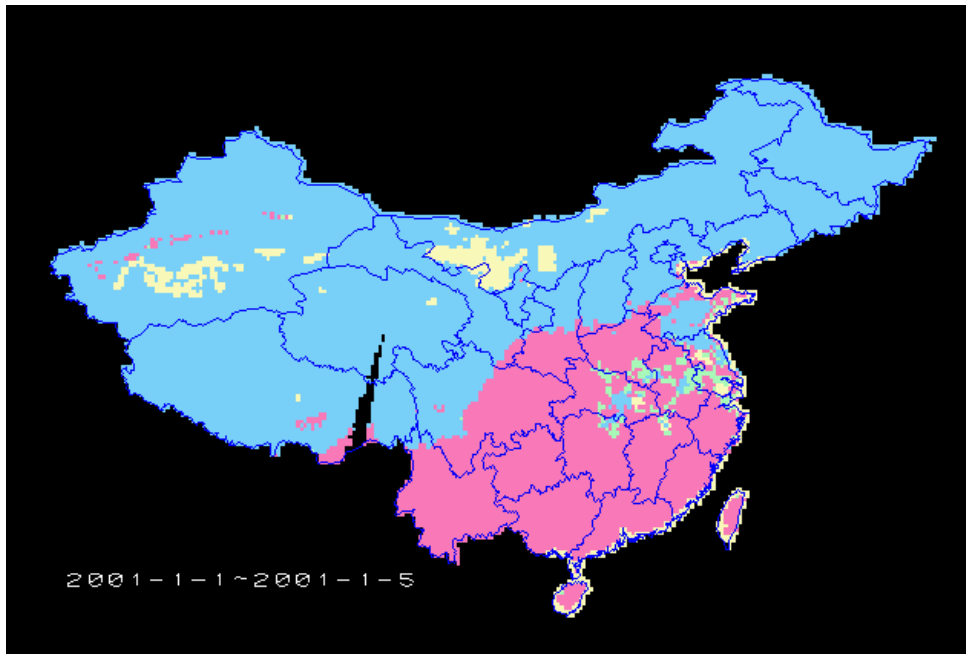
Monitoring of surface freeze/thaw



Classification of frozen or thawed soil



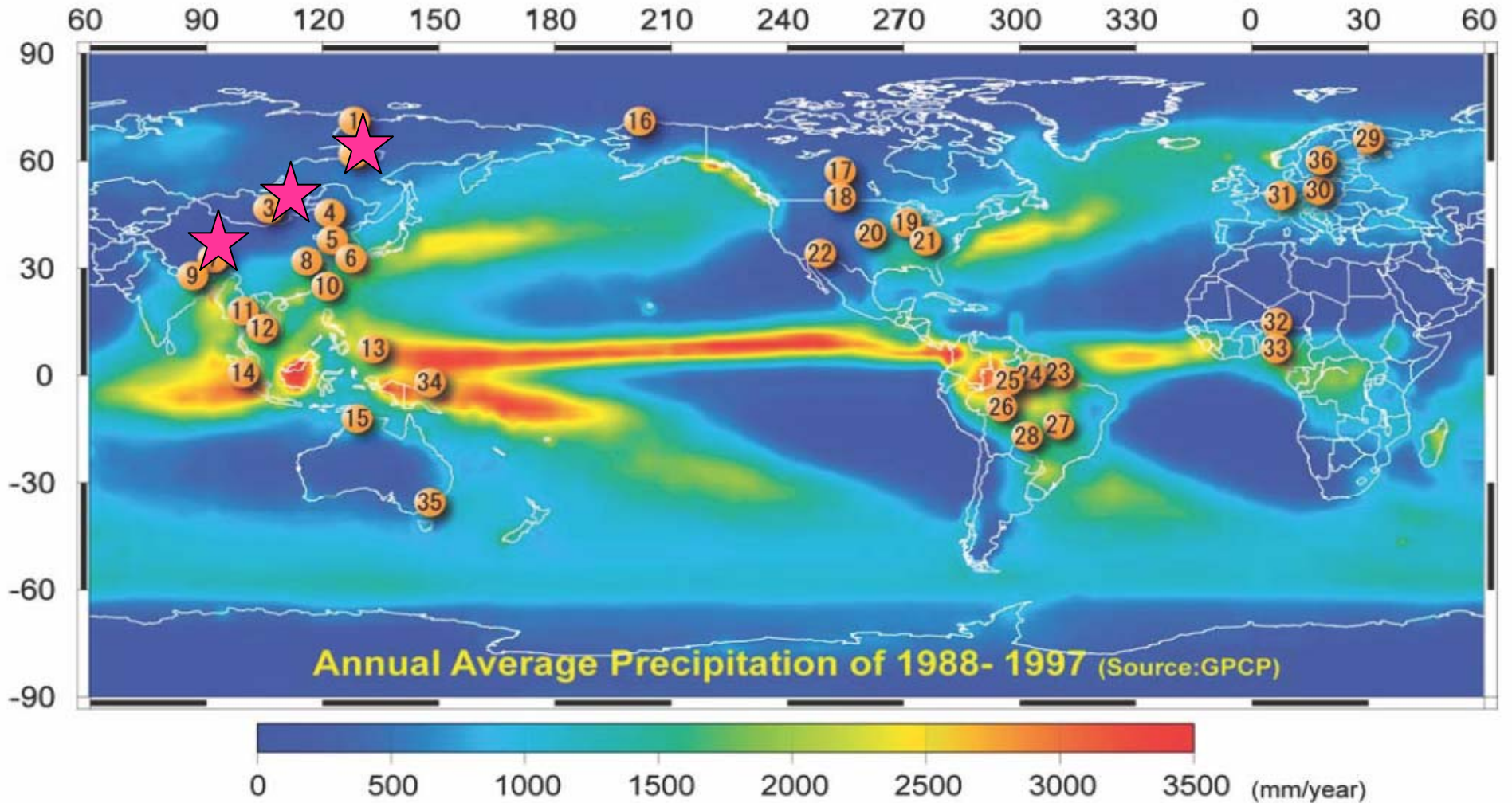
Maximum frozen days in 2001



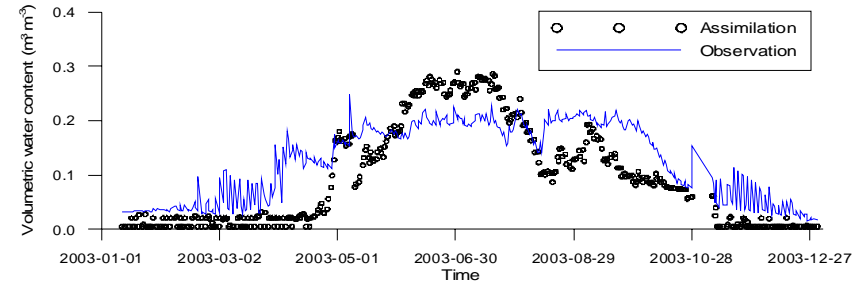
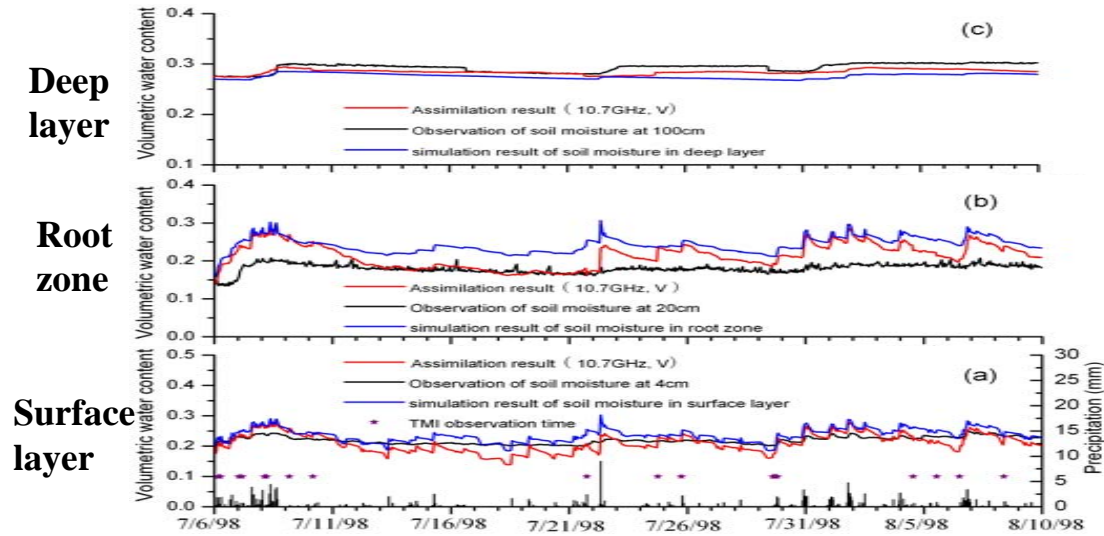
Daily surface freeze/thaw in 2001



5. CLDAS Validation and output

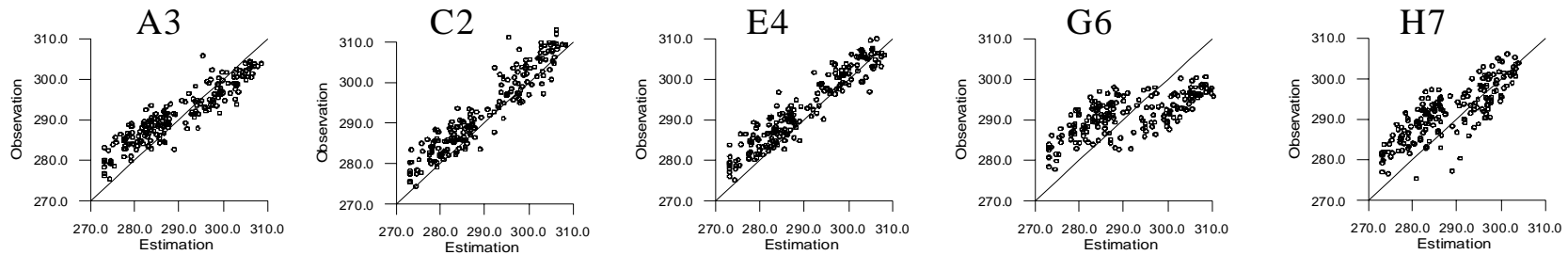


Point experiment of assimilating TMI and AMSR-E data



**Model operator: JMASiB; Observation operator: Q/h model;
Assimilation time: 2003/1/1-12/31; Data: CEOP Tibet
reference**

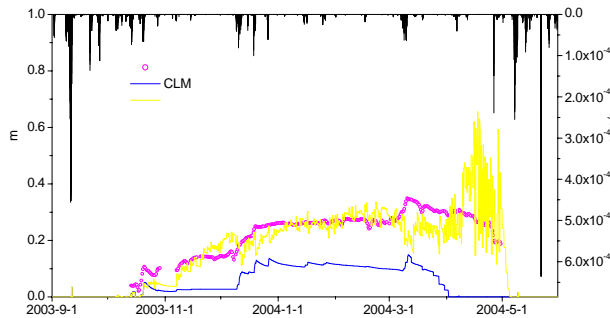
**Model operator: SiB2; Observation operator: AIEM;
Assimilation time: 1998/7/6-1998/8/9; Data: GAME-Tibet
MS3608**



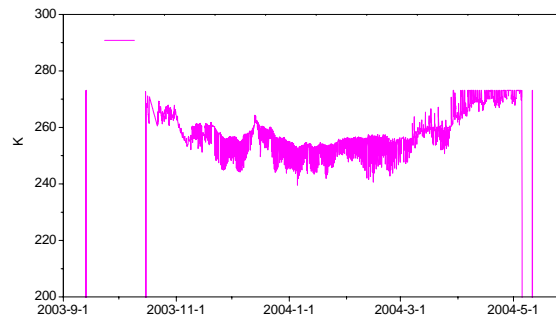
**Model operator: JMASiB; Observation operator: Q/h model; Assimilation time:
2003/5/1-9/30; Data: CEOP Mongolia reference**

Point experiment of assimilating AMSR-E data for snow state estimation

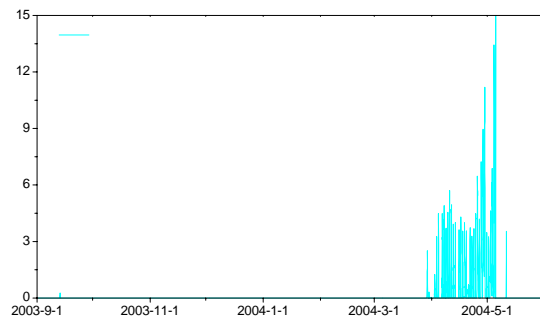
- Data: CEOP Siberia reference; Land model: CoLM; Radiative transfer model of snow: MEMLS



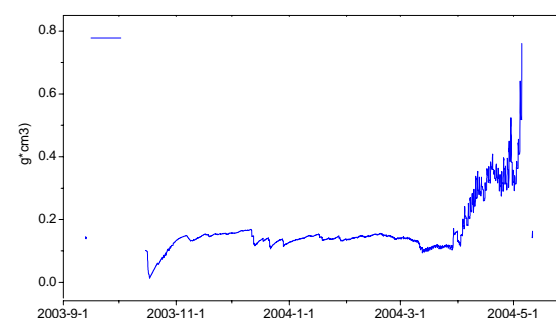
(a)



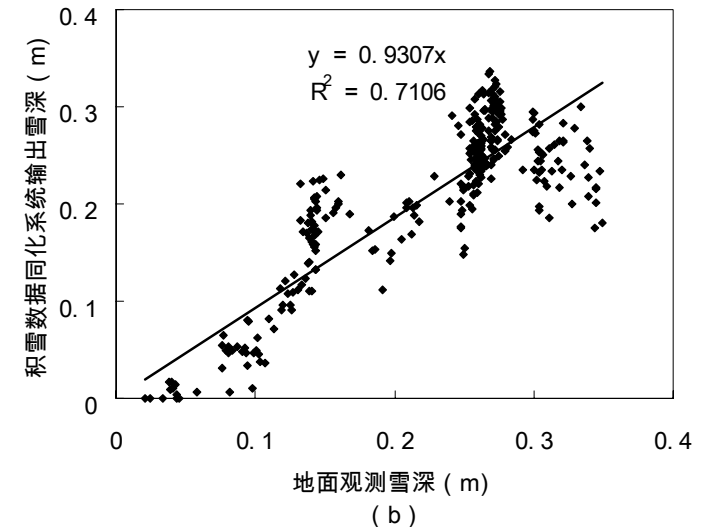
(b)



(c)



(d)



Assimilated dataset for west China (July, 2002)

**Volumetric
LWC in
surface layer**

**Volumetric
ice content
in surface
layer**

**Soil
temperature
in surface
layer**

Snow depth



Assimilated dataset for west China (July, 2002)

**Volumetric
LWC at
second layer**

**Volumetric
LWC at
third layer**

**Soil
temperature at
second layer**

**Soil
temperature at
third layer**



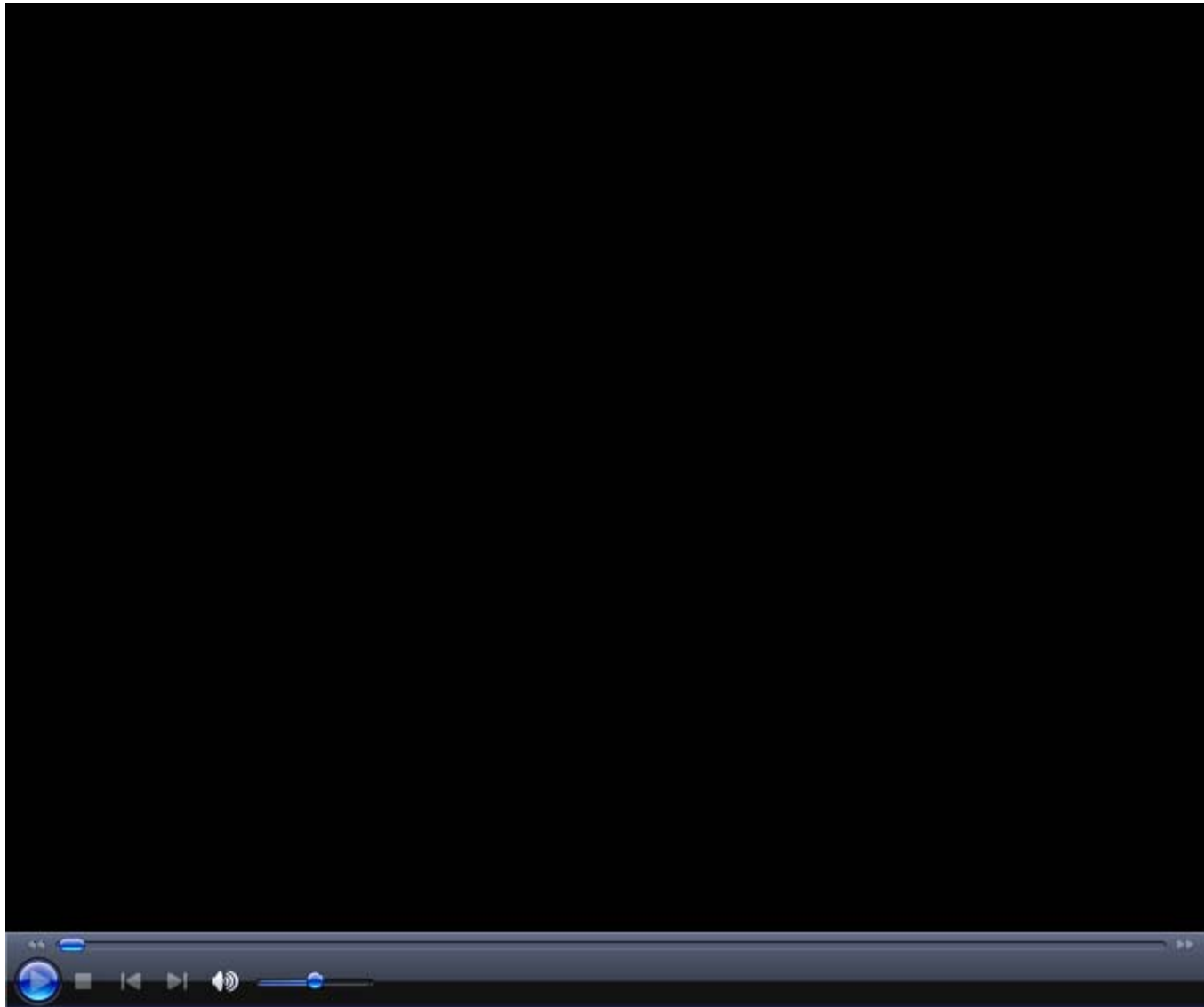
Assimilated dataset for west China (July, 2002)

**Sensitive
heat flux**

**Latent
heat flux**

**Ground
heat flux**

**Evapotran-
spiration**



6. Summary

- We have developed a LDAS for China's land territory. By merging the remote sensing observations into the dynamics of land surface model, CLDAS is capable of producing the evolution of land surface states, such as soil moisture, soil temperature and snow water equivalent, in good physical and spatiotemporal consistence and improved accuracy.
- CLDAS is capable of using passive microwave remotely sensed data such as SSM/I, TMI, and AMSR-E. We expect that the CLDAS output will be used in various large-scale and catchmental-scale land surface and hydrological studies and **can have a potential contribution to IPY.**

ldas.westgis.ac.cn
wdcdgg.westgis.ac.cn



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