Land Model Working Group

Matt Rodell[1], David Mocko[1], Hiroko Kato[1], and Toshio Koike[2]

[1]NASA Goddard Space Flight Center
[2]University of Tokyo

Previous Coordinated Land Modeling Activities

Project for Intercomparison of Land-surface Parameterization Schemes

- Local scale; several phases/locations; many groups/models involved
- Goal: Coordinate the evaluation of the next generation of land-surface schemes

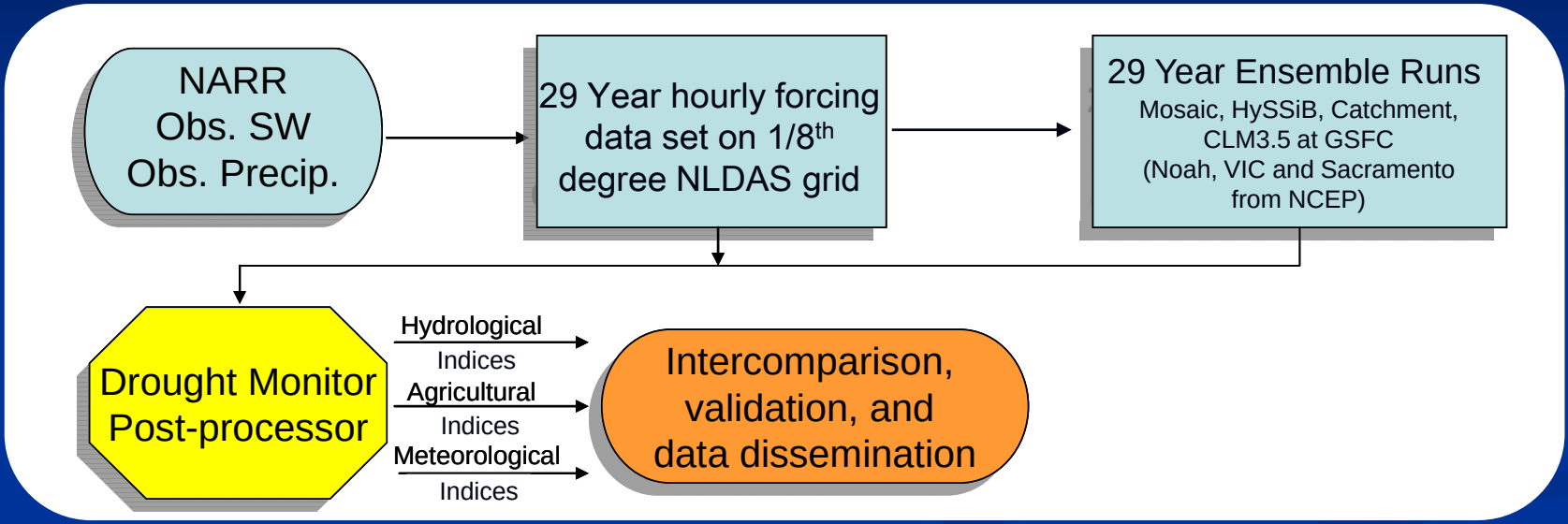
Global Soil Wetness Project 1 & 2

- Global scale; 1987-88 and 1986-95; many groups/models involved
- Objectives:
  - Produce state-of-the-art global data sets of land surface fluxes, state variables, and related hydrologic quantities;
  - Develop and test large-scale validation, calibration, and assimilation techniques over land;
  - Provide a large-scale validation and quality check of the ISLSCP data sets;
  - Compare Land Surface Schemes, and conduct sensitivity studies of specific parameterizations and forcings, which should aid future model and data set development.

North American Land Data Assimilation Systems

- North American domain; 8 groups; 4 LSMs; identical, high quality forcing
- Goal: Improve initialization and simulation of the land surface in coupled forecast simulations by forcing uncoupled LSMs with observation-based data

NASA GSFC Drought Project Overview



- Analyze drought monitor output to determine effect of model selection, forcing data, NARR climatology length , and ensemble construction on drought characterization
- Transition system to real-time operations, providing objective data to existing drought monitoring efforts such as the U.S. Drought Monitor

CEOP Land Model Working Group

Motivation:

- Land surface models (LSMs) encapsulate our understanding of physical processes at the land-atmosphere interface
- Observations are imperfect
- Data assimilation and related modeling techniques allow LSMs to integrate data from multiple sources in a physically coherent manner
- LSMs enable spatial and temporal downscaling, data gap filling, and quality control

Purpose: To coordinate global land modeling activities and share data, toward the common goal of generating physically coherent fields of land surface states and fluxes through the integration of disparate data products.

Objectives:

1) Identify and gather gridded global meteorological forcing data sets that are available for regional to global off-line LSM simulations
2) Analyze the consistency among the data sets to help assess uncertainty
3) Share model results and cooperate on intercomparison and cross-validation

CEOP Land Model Working Group

Relevance to CEOP: Direct relevance to GEWEX Phase II Objectives 1 and 2:

Objective 1: Produce consistent research quality data sets complete with error descriptions of the Earth's energy budget and water cycle and their variability and trends on interannual to decadal time scales, and for use in climate system analysis and model development and validation.

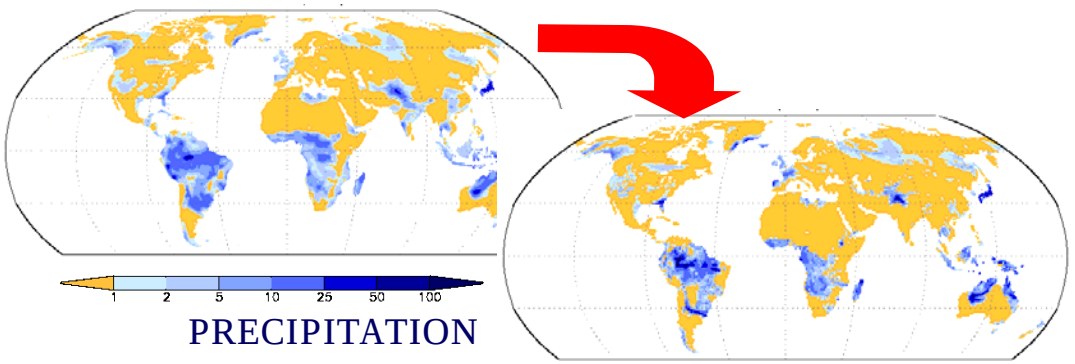
Objective 2: Enhance the understanding of how energy and water cycle processes function and quantify their contribution to climate feedbacks.

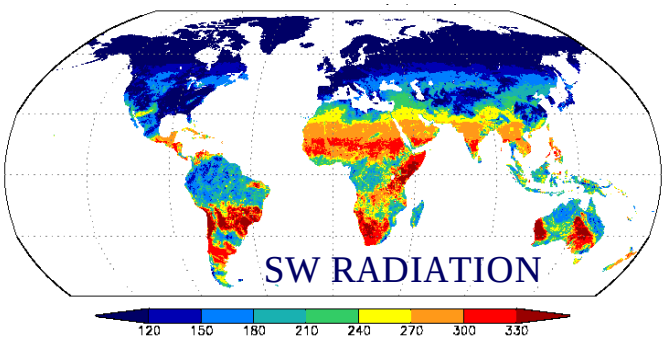
Current Involvement:

- University of Tokyo (T. Koike, T. Graf)
- NASA/GSFC (M. Rodell, D. Mocko, H. Kato, M. Bosilovich, C. Peters-Lidard)
- Princeton University (E. Wood)
- NOAA/NCEP (K. Mitchell)
- George Mason University (P. Houser)
- Indian Ministry of Earth Sciences (M. Ravindranath)
- Northern Illinois University (J. Song)
- Universidad de Concepcion, Chile (R. Abarca del Rio)
- *Others must be recruited…*

Data Integration Using Land Surface Models

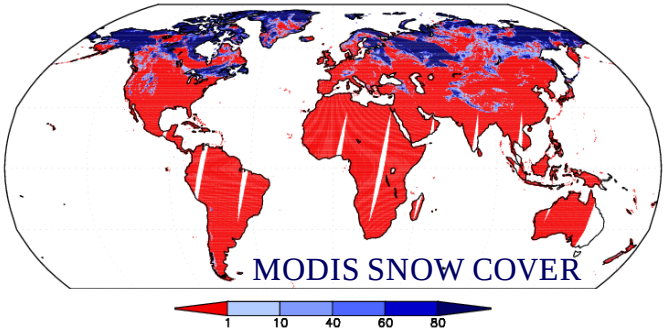
INTERCOMPARISON and OPTIMAL MERGING of global data fields

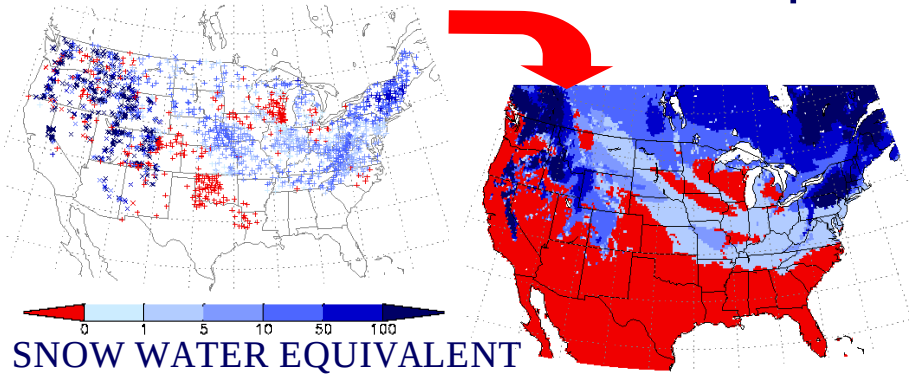




Satellite data products used to PARAMETERIZE and FORCE sophisticated land surface models

ASSIMILATION of satellite based land surface state fields (snow, soil moisture, surface temp, etc.)

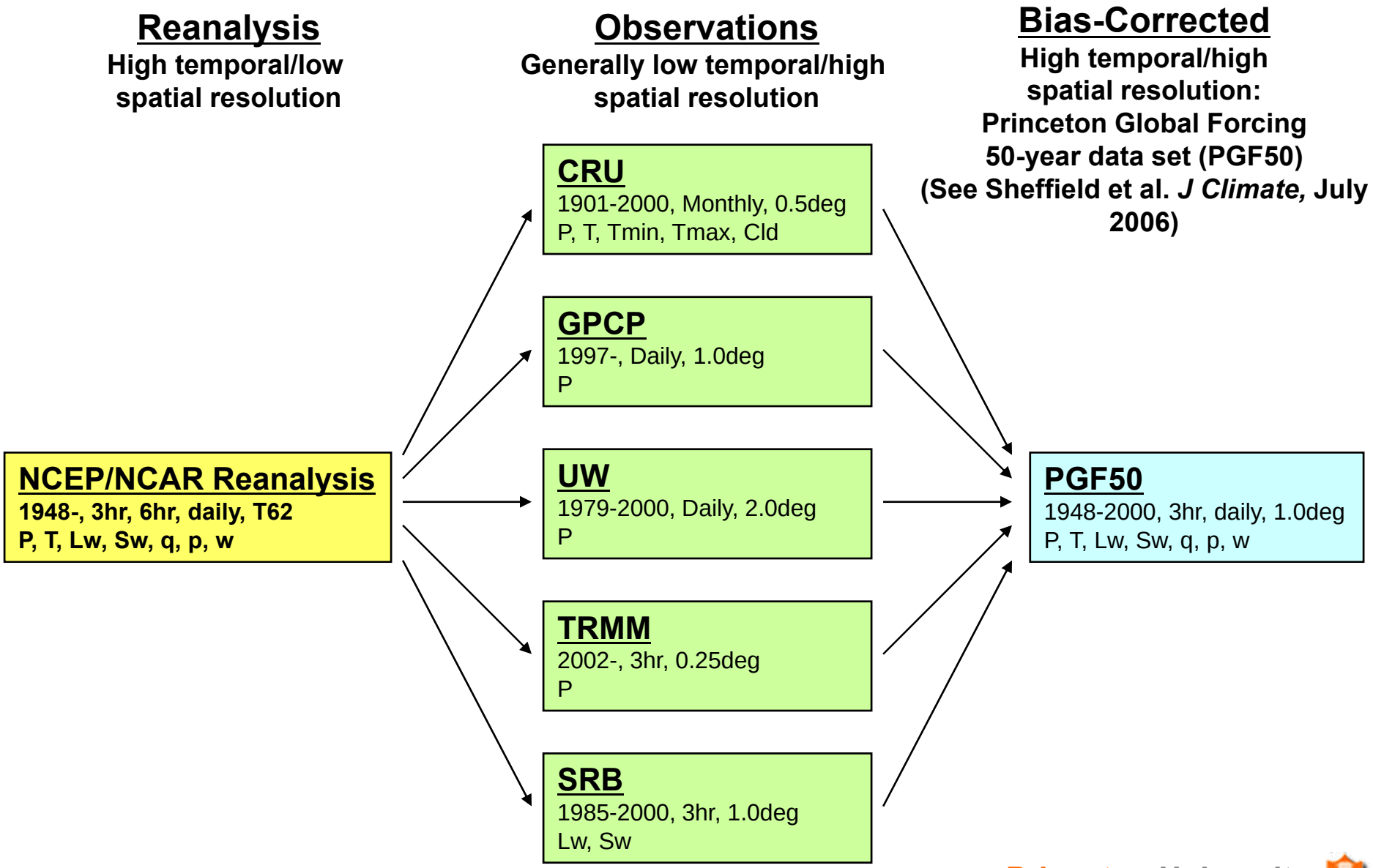




Ground-based observations used to EVALUATE model output

Land Model Activities: Princeton University

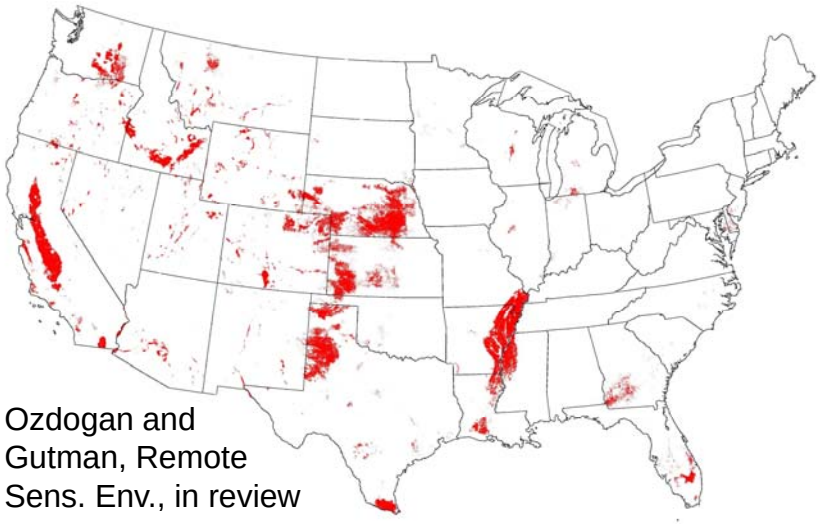
Princeton University's Global Forcing Dataset



Land Model Activities: NASA/GSFC GLDAS

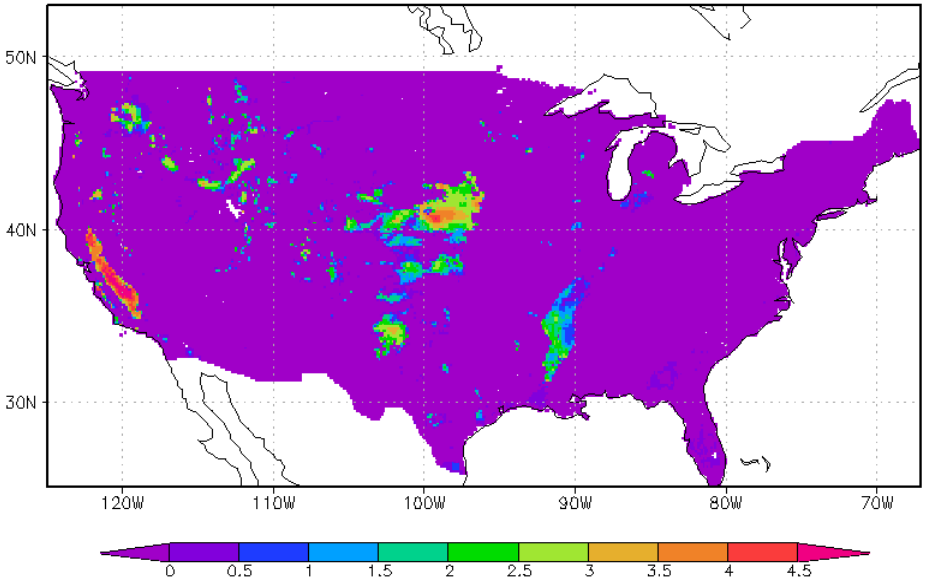
Integrating MODIS Irrigation Data

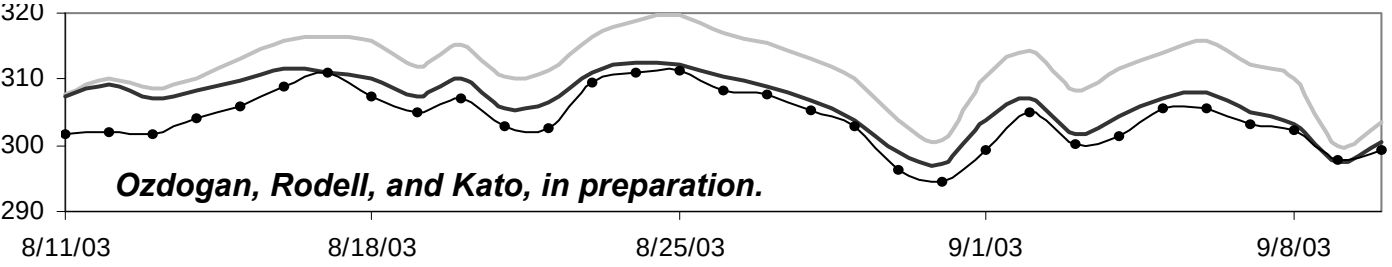
MODIS derived intensity of irrigation



Ozdogan and Gutman, Remote Sens. Env., in review

Difference (%) in evapotranspiration between irrigation and control runs, Aug-Sep 2003





Max surface temperature (K) at an irrigated site, from control run (gray line), irrigation run (black line), and observations (dots)

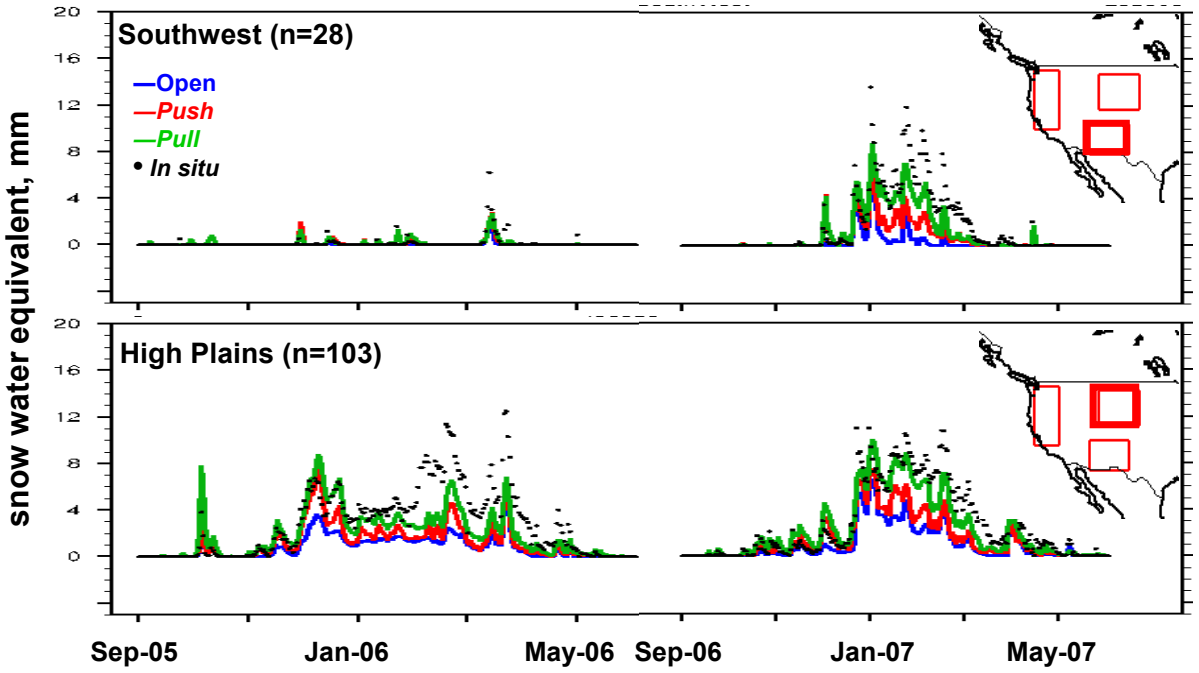
GLDAS/Noah integrates irrigation data with other observations to improve state and flux estimates

Matt Rodell
NASA GSFC

Advanced Rule-Based MODIS Snow Cover Assimilation

Foreward-looking "pull" algorithm

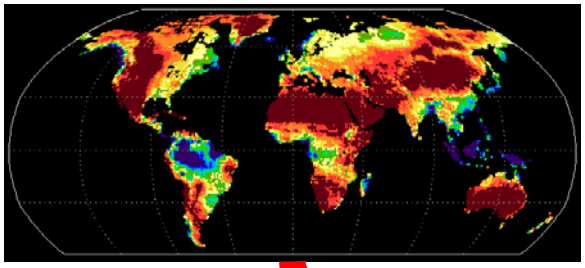
- Assesses MODIS snow cover observation 24-72 hours ahead
- Adjusts temperature to steer the simulation towards the observation
- Generates additional snowfall if necessary



Zaitchik and Rodell, J. Hydromet., in press, 2008.

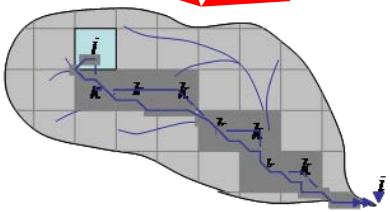
Source-to-Sink Runoff Routing

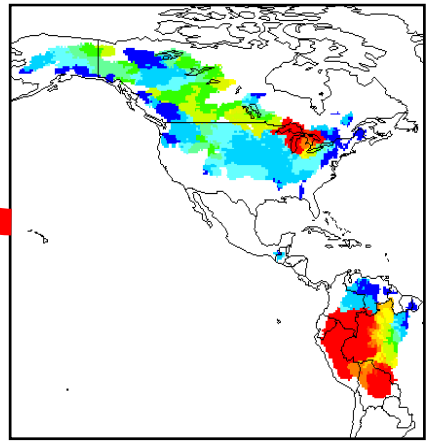
Gridded 3-hourly runoff output



- Computationally efficient post-processor for GLDAS
- Can utilize high resolution landscape data for global applications

STS routing scheme
Olivera et al., 2000
Coe et al., 2000

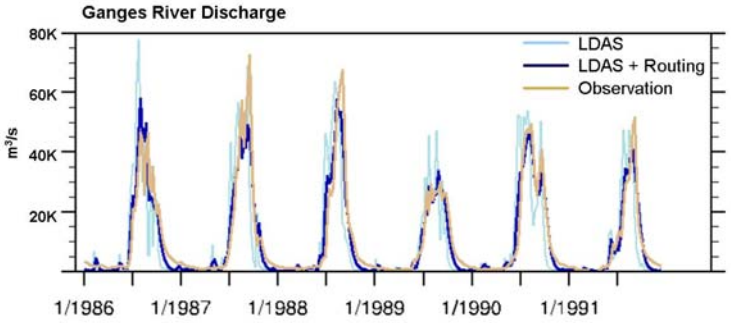




Flow times to GRDC gauge locations

- Allows for spatially variable parameterization of velocity, dispersion, and loss
- Can accept any resolution of gridded input
- Facilitates evaluation of modeled runoff

River basin discharge time series

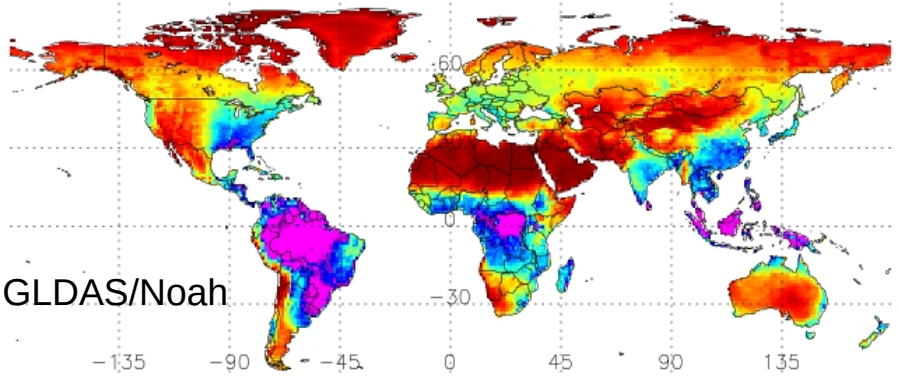


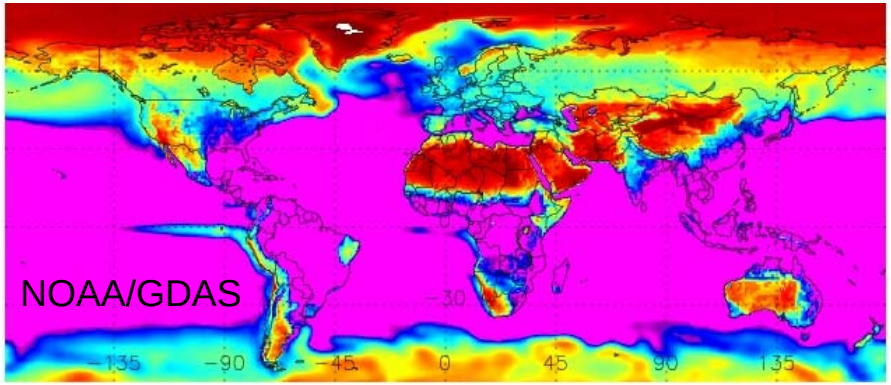
Zaitchik, Rodell, and Olivera, in preparation.

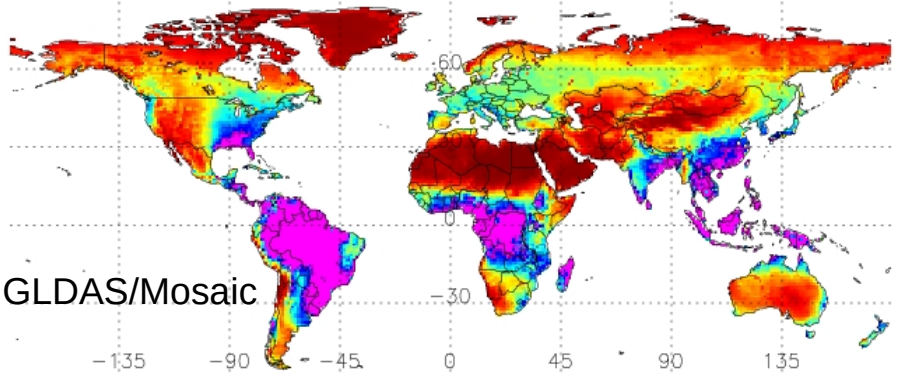
Model Intercomparison

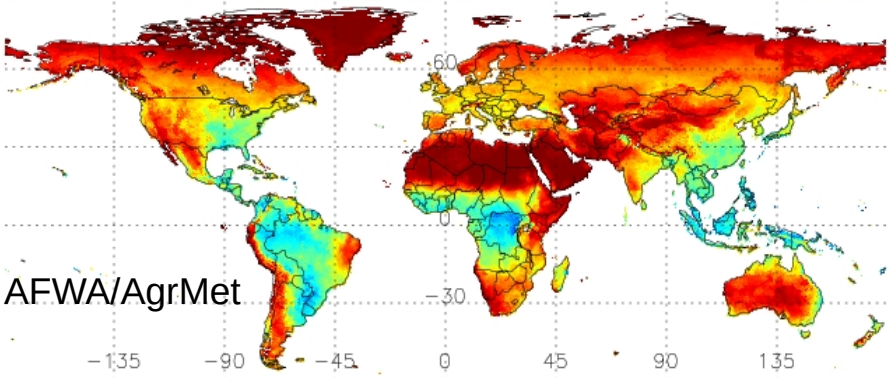
Modeled Evapotranspiration

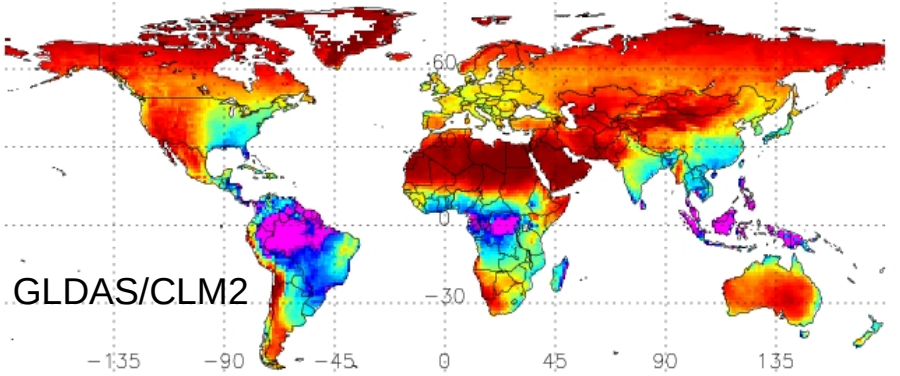
Annual Mean (mm/yr)

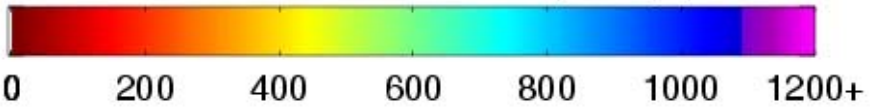




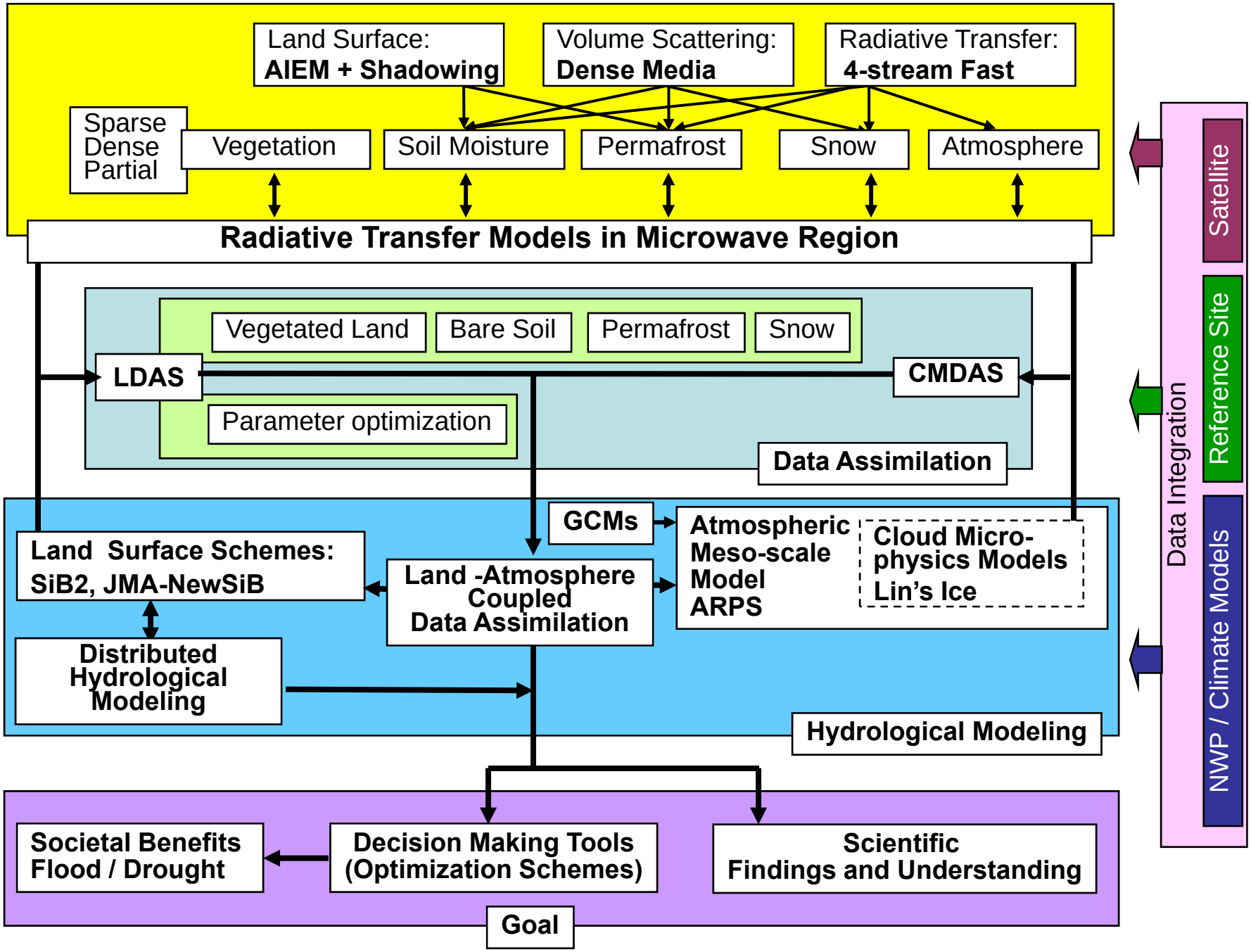


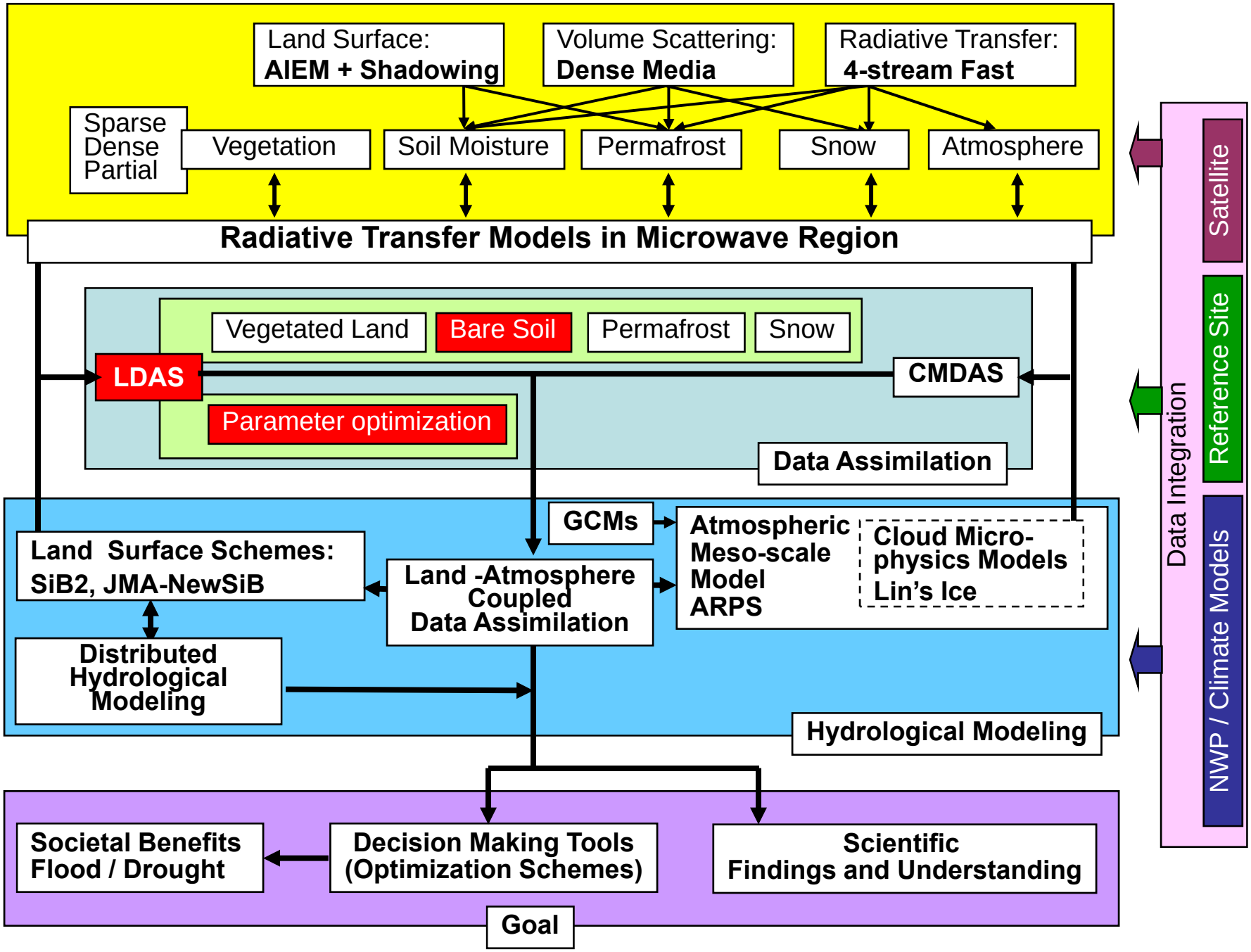


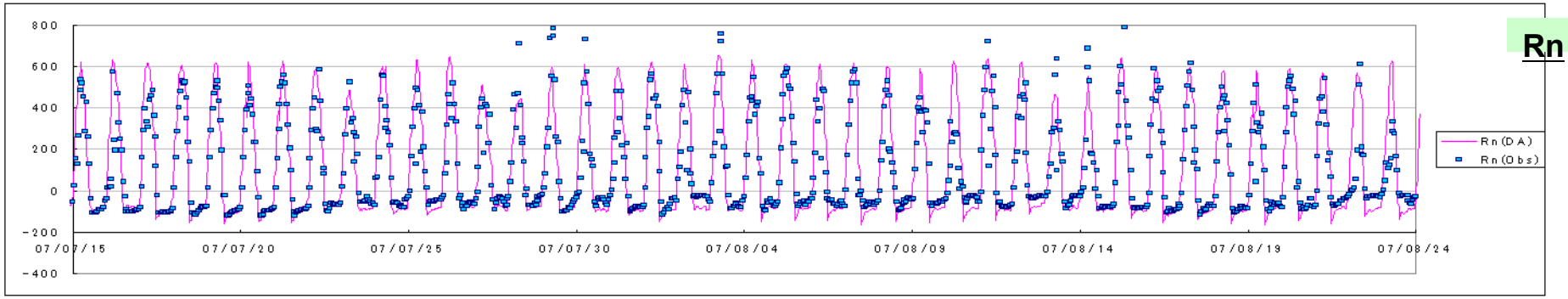


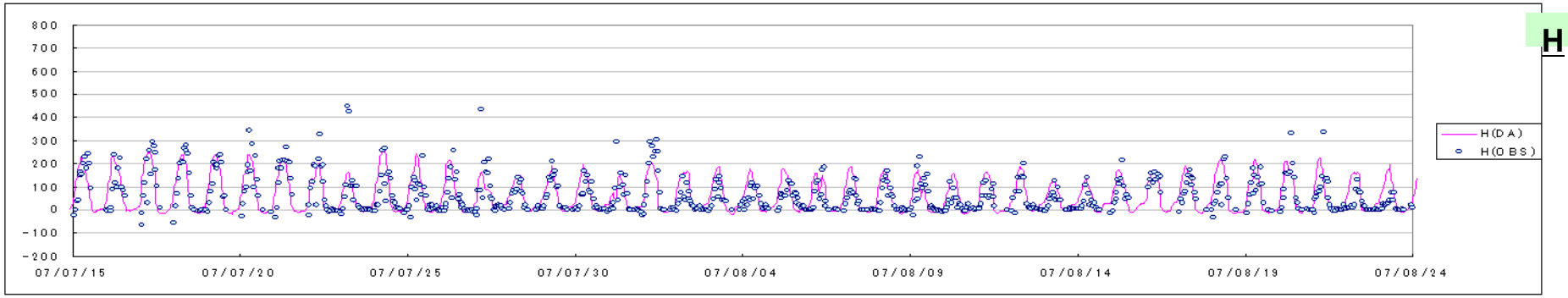


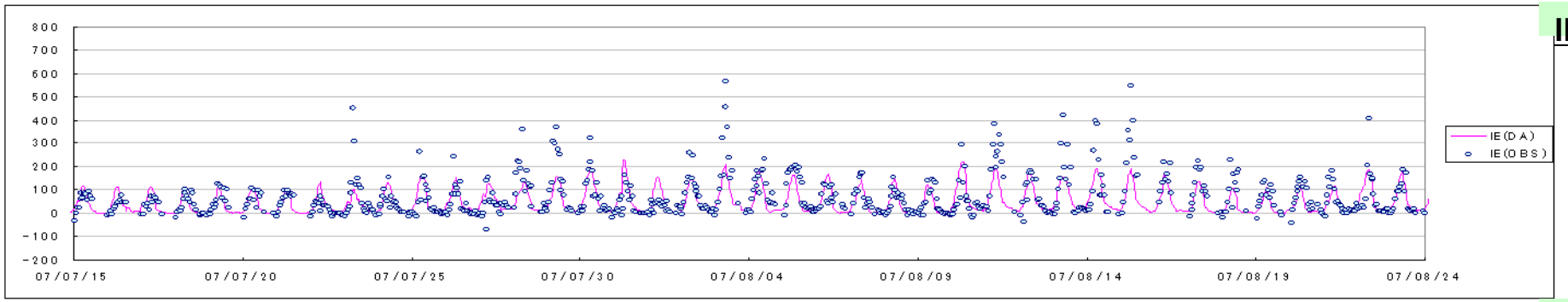
Land Model Activities: University of Tokyo

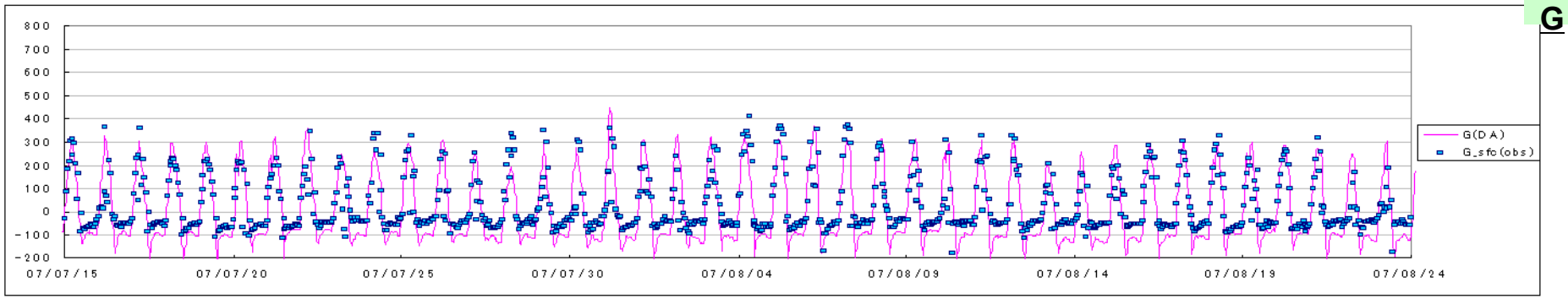

Land Surface:
AIEM + Shadowing
Volume Scattering:
Dense Media
Radiative Transfer:
4-stream Fast
Sparse
Dense
Partial
Vegetation
Soil Moisture
Permafrost
Snow
Atmosphere
Radiative Transfer Models in Microwave Region
Vegetated Land
Bare Soil
Permafrost
Snow
LDAS
CMDAS
Parameter optimization
Data Assimilation
GCMs
Land Surface Schemes:
SiB2, JMA-NewSiB
Land -Atmosphere
Coupled
Data Assimilation
Atmospheric
Meso-scale
Model
ARPS
Cloud Micro-
physics Models
Lin's Ice
Distributed
Hydrological
Modeling
Hydrological Modeling
Societal Benefits
Flood / Drought
Decision Making Tools
(Optimization Schemes)
Scientific
Findings and Understanding
Goal
Data Integration
Satellite
Reference Site
NWP / Climate Models

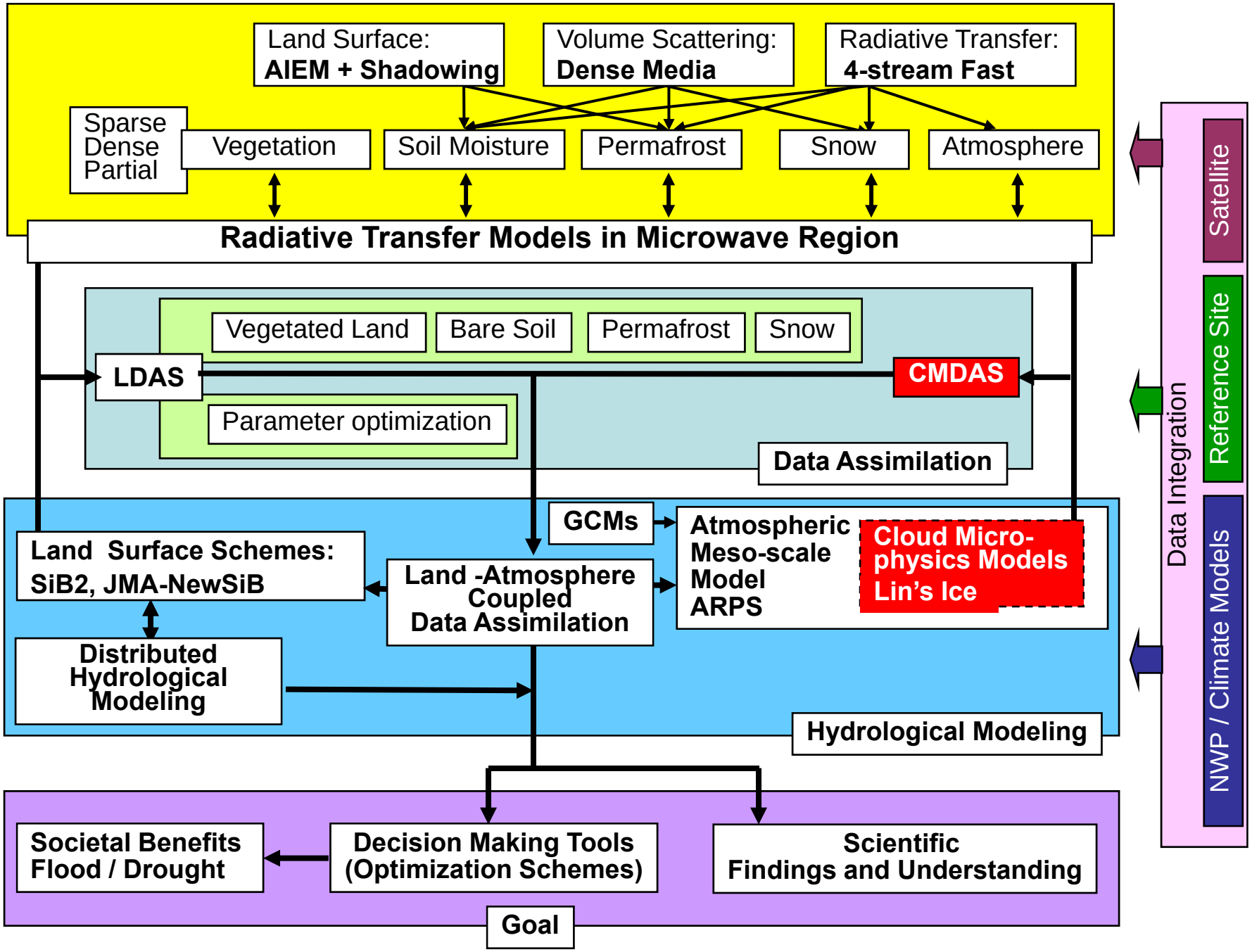

Land Surface:
AIEM + Shadowing
Volume Scattering:
Dense Media
Radiative Transfer:
4-stream Fast
Sparse
Dense
Partial
Vegetation
Soil Moisture
Permafrost
Snow
Atmosphere
Radiative Transfer Models in Microwave Region
Vegetated Land
Bare Soil
Permafrost
Snow
LDAS
CMDAS
Parameter optimization
Data Assimilation
GCMs
Land Surface Schemes:
SiB2, JMA-NewSiB
Land -Atmosphere
Coupled
Data Assimilation
Atmospheric
Meso-scale
Model
ARPS
Cloud Micro-
physics Models
Lin's Ice
Distributed
Hydrological
Modeling
Hydrological Modeling
Societal Benefits
Flood / Drought
Decision Making Tools
(Optimization Schemes)
Scientific
Findings and Understanding
Goal
Data Integration
Satellite
Reference Site
NWP / Climate Models


Rn
800
600
400
200
0
-200
-400
07/07/15
07/07/20
07/07/25
07/07/30
07/08/04
07/08/09
07/08/14
07/08/19
07/08/24
Rn(DA)
Rn(Obs)


H
800
700
600
500
400
300
200
100
0
-100
-200
07/07/15
07/07/20
07/07/25
07/07/30
07/08/04
07/08/09
07/08/14
07/08/19
07/08/24
H(DA)
H(OBS)

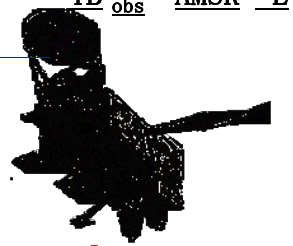

IE
800
700
600
500
400
300
200
100
0
-100
-200
07/07/15
07/07/20
07/07/25
07/07/30
07/08/04
07/08/09
07/08/14
07/08/19
07/08/24
IE(DA)
IE(OBS)


G
800
700
600
500
400
300
200
100
0
-100
-200
07/07/15
07/07/20
07/07/25
07/07/30
07/08/04
07/08/09
07/08/14
07/08/19
07/08/24
G(DA)
G_sfc(obs)


Land Surface:
AIEM + Shadowing
Volume Scattering:
Dense Media
Radiative Transfer:
4-stream Fast
Sparse
Dense
Partial
Vegetation
Soil Moisture
Permafrost
Snow
Atmosphere
Radiative Transfer Models in Microwave Region
Vegetated Land
Bare Soil
Permafrost
Snow
LDAS
CMDAS
Parameter optimization
Data Assimilation
GCMs
Land Surface Schemes:
SiB2, JMA-NewSiB
Land -Atmosphere
Coupled
Data Assimilation
Atmospheric
Meso-scale
Model
ARPS
Cloud Micro-
physics Models
Lin's Ice
Distributed
Hydrological
Modeling
Hydrological Modeling
Societal Benefits
Flood / Drought
Decision Making Tools
(Optimization Schemes)
Scientific
Findings and Understanding
Goal
Data Integration
Satellite
Reference Site
NWP / Climate Models

Heavy rainfall prediction coupling CMDAS with ARPS using NCEP-GFS and AMSR-E

TB obs AMSR -E

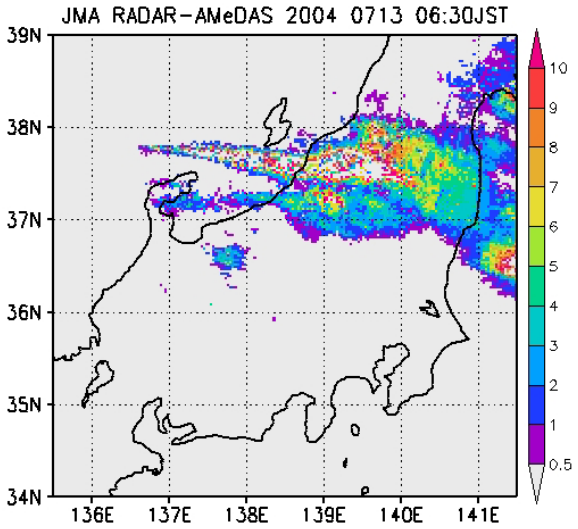


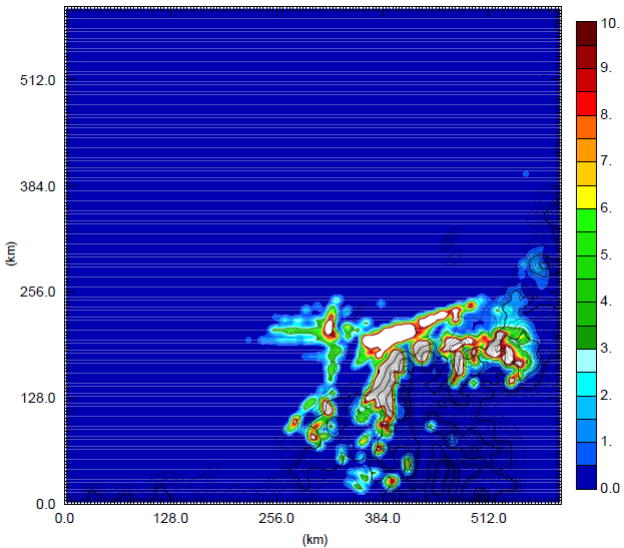
Initial Guess

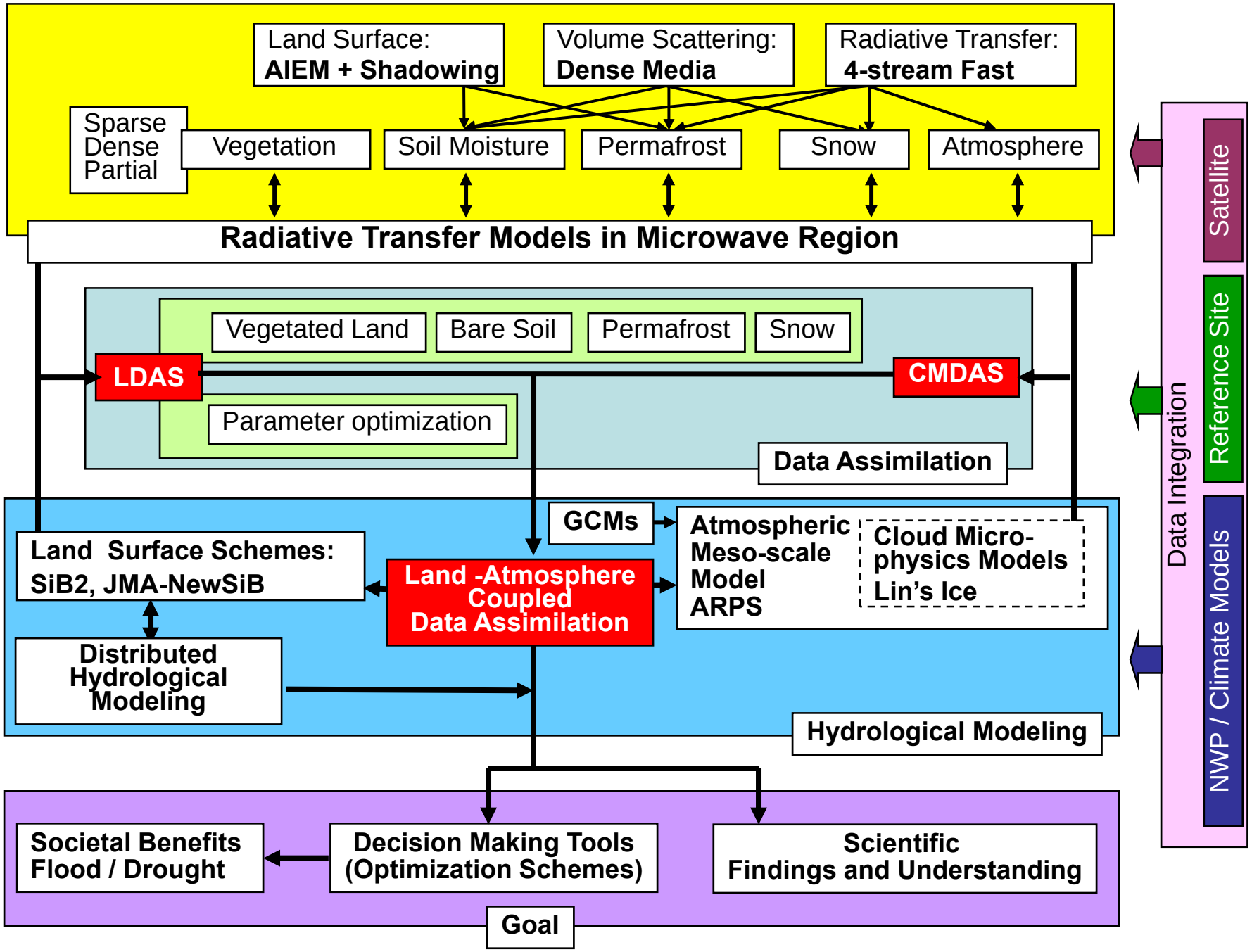
18:30z 18:49z

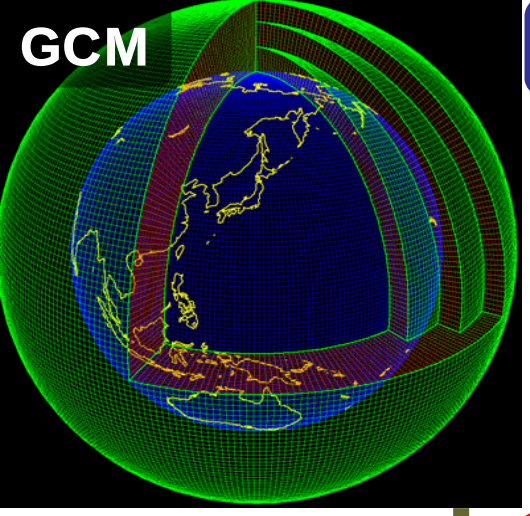
Assimilation Window: 19 mins

CMDAS



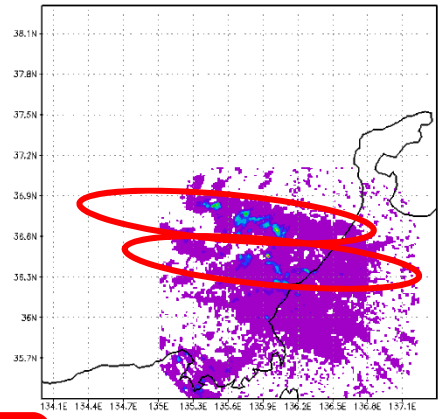


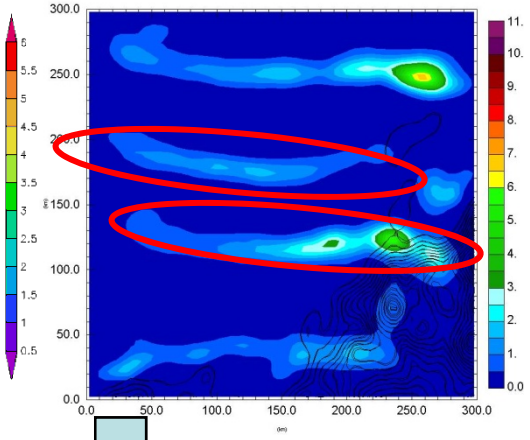

Land Surface:
AIEM + Shadowing
Volume Scattering:
Dense Media
Radiative Transfer:
4-stream Fast
Sparse
Dense
Partial
Vegetation
Soil Moisture
Permafrost
Snow
Atmosphere
Radiative Transfer Models in Microwave Region
Vegetated Land
Bare Soil
Permafrost
Snow
LDAS
CMDAS
Parameter optimization
Data Assimilation
GCMs
Land Surface Schemes:
SiB2, JMA-NewSiB
Land -Atmosphere
Coupled
Data Assimilation
Atmospheric
Meso-scale
Model
ARPS
Cloud Micro-
physics Models
Lin's Ice
Distributed
Hydrological
Modeling
Hydrological Modeling
Societal Benefits
Flood / Drought
Decision Making Tools
(Optimization Schemes)
Scientific
Findings and Understanding
Goal
Data Integration
Satellite
Reference Site
NWP / Climate Models



Satellite-CMDAS

3 hourly precipitation prediction over ocean

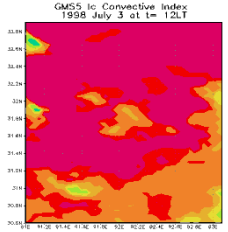




Satellite-LDAS

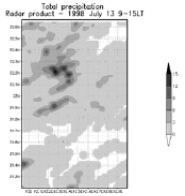
NHM

Convection

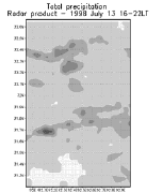


Diurnal Cycle of Rainfall

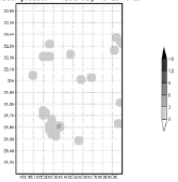
9-15



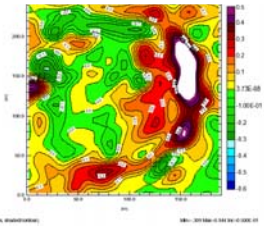
16-22



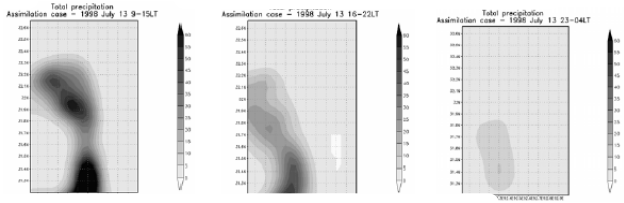
23-04



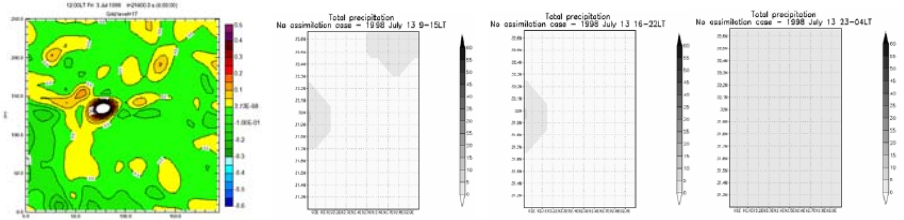
Satellite IR



Ground-based Radar



Assimilation Yes↑ No↓

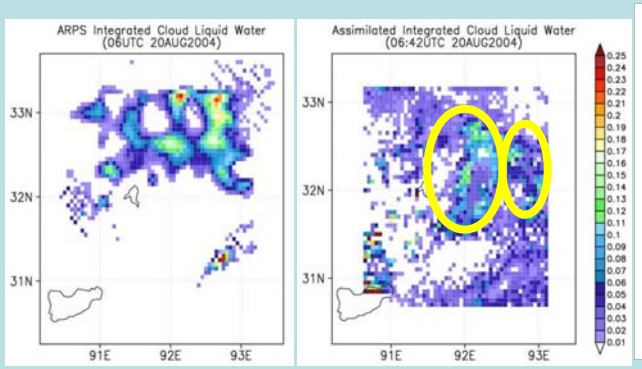


Satellite-CMDAS

NHM

Satellite-LDAS

Satellite-CMDAS Coupled with Satellite-LDAS



Only LDAS

Coupled

IR

CEOP Land Model Working Group: Summary

Purpose: To coordinate global land modeling activities and share data, toward the common goal of generating physically coherent fields of land surface states and fluxes through the integration of disparate data products.

Relevance to CEOP: Direct relevance to Objectives 1 and 2

Current Involvement: Eight institutions

Recent Results:
- Princeton 50-year land model forcing dataset
- GLDAS forward looking approach for MODIS snow cover data assimilation
- GLDAS irrigation simulation using MODIS observations
- GLDAS Source to sink runoff routing for major river basins
- Improved flux estimation in LDAS-UT models over Tibet using AMSR-E
- CMDAS improved heavy rainfall prediction using NCEP-GFS and AMSR-E

Data Availability:
- NASA/GSFC: http://disc.gsfc.nasa.gov/hydrology/
- Princeton: http://hydrology.princeton.edu/data.pgf.php

Key Issue: Increasing membership and collaboration among groups in the absence of a central funding mechanism