Land Surface Model Developments in WRFv3.6: Noah, Noah-MP and Input Datasets

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Code modifications and new input data

Noah LSM: no code changes from v3.5 to v3.6

Mosaic land cover capability: modification to Noah LSM driver

Noah-MP LSM: bug fixes

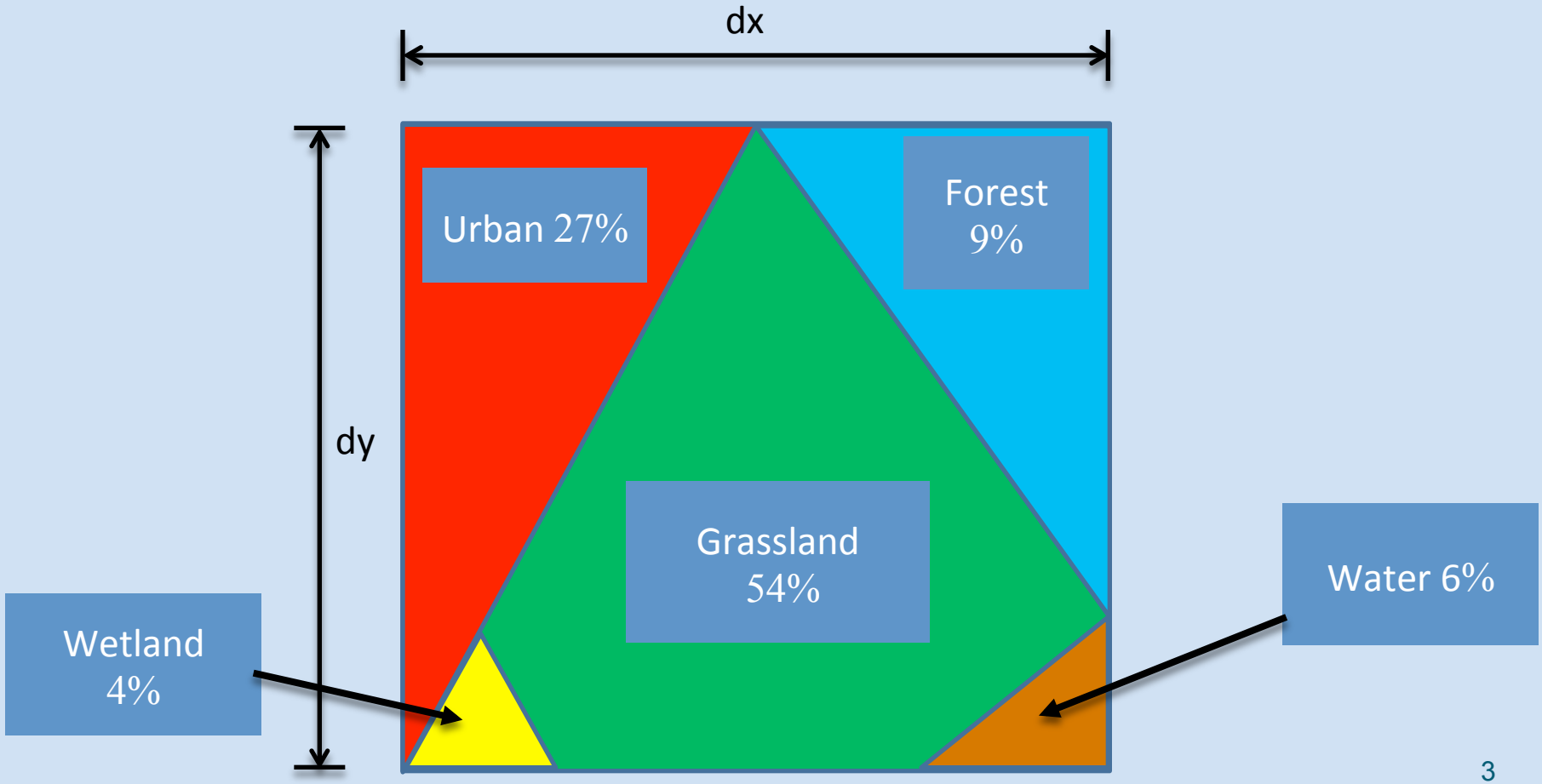
- use appropriate latent heat for frozen/unfrozen ground/veg
- revert to original snow cover parameter (global?)
- remove both SWE and snow height when snow very small
- modify minimum limits for LAI/SAI
- make MPTABLE for USGS and MODIS land cover consistent
- allow sublimation not only when canopy liquid present
- fix new snow density

Noah-MP LSM: new option for interactive groundwater

New input datasets for MODIS land cover (15”) and MODIS monthly LAI (30”)

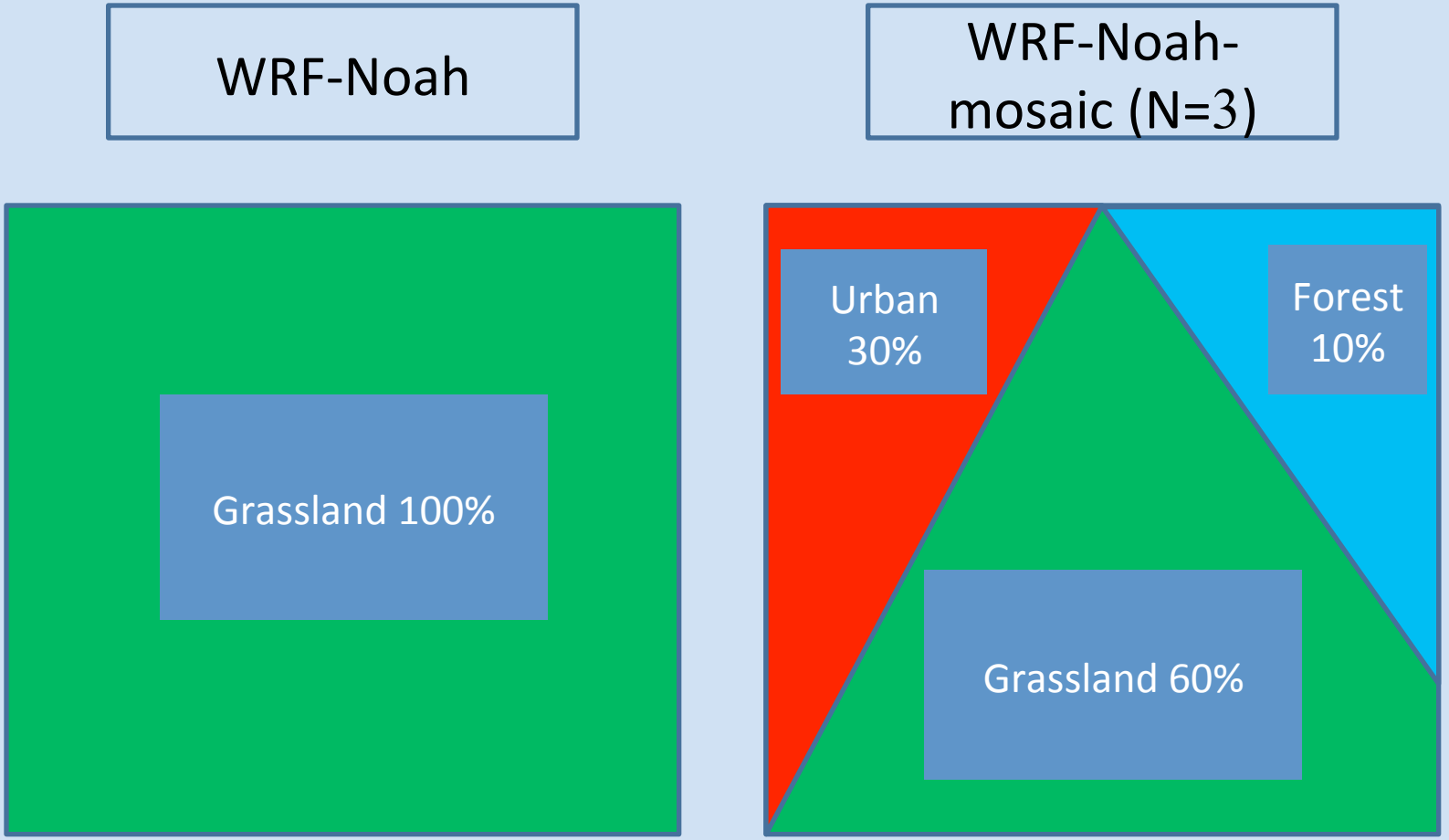
Land cover mosaic/tiling in the Noah LSM

`geogrid` produces LANDUSEF, a "real world" fractional distribution of land cover within a grid cell



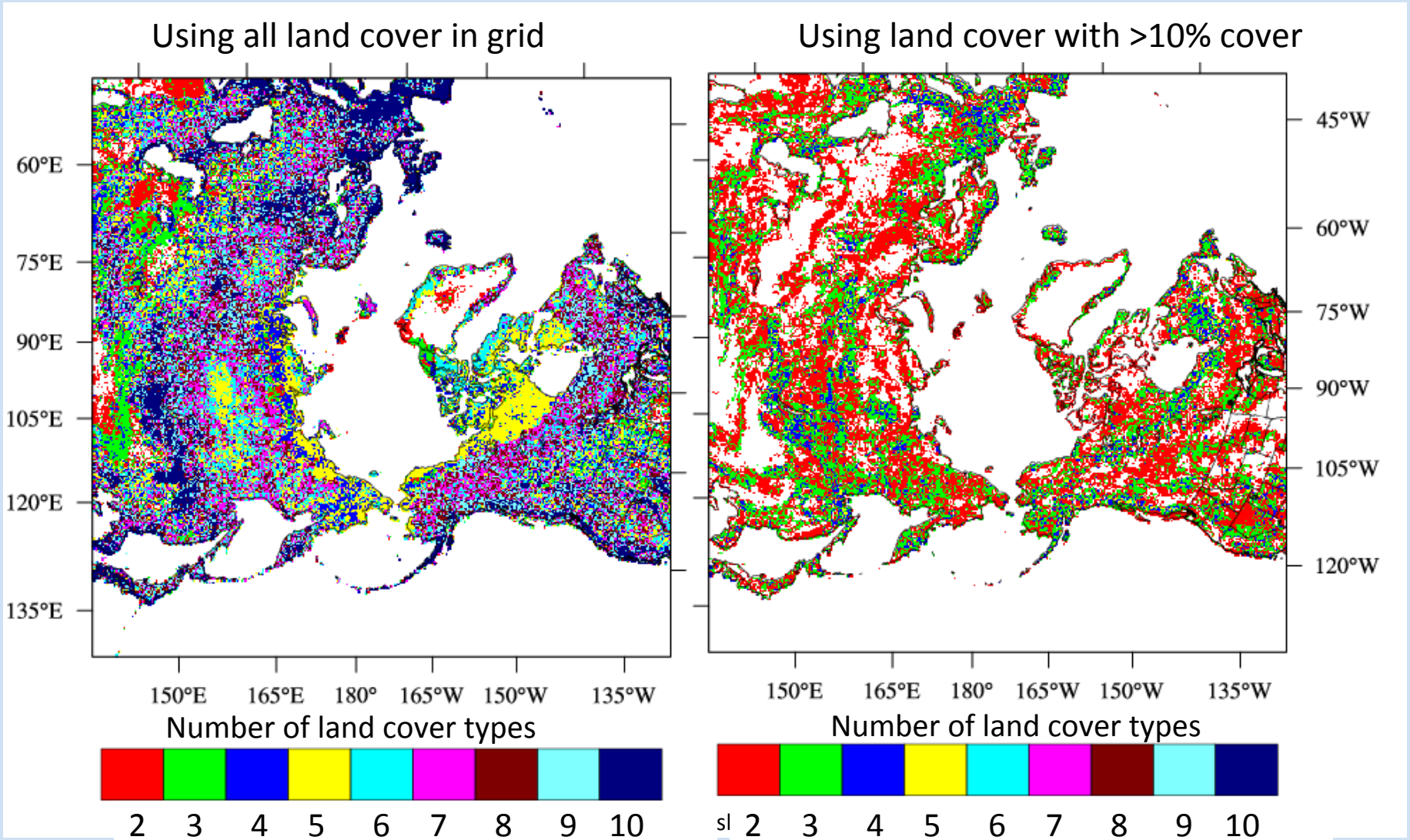
Land cover mosaic/tiling in the Noah LSM

In the model world, two possible choices: dominant vs. mosaic



Land cover mosaic/tiling in the Noah LSM

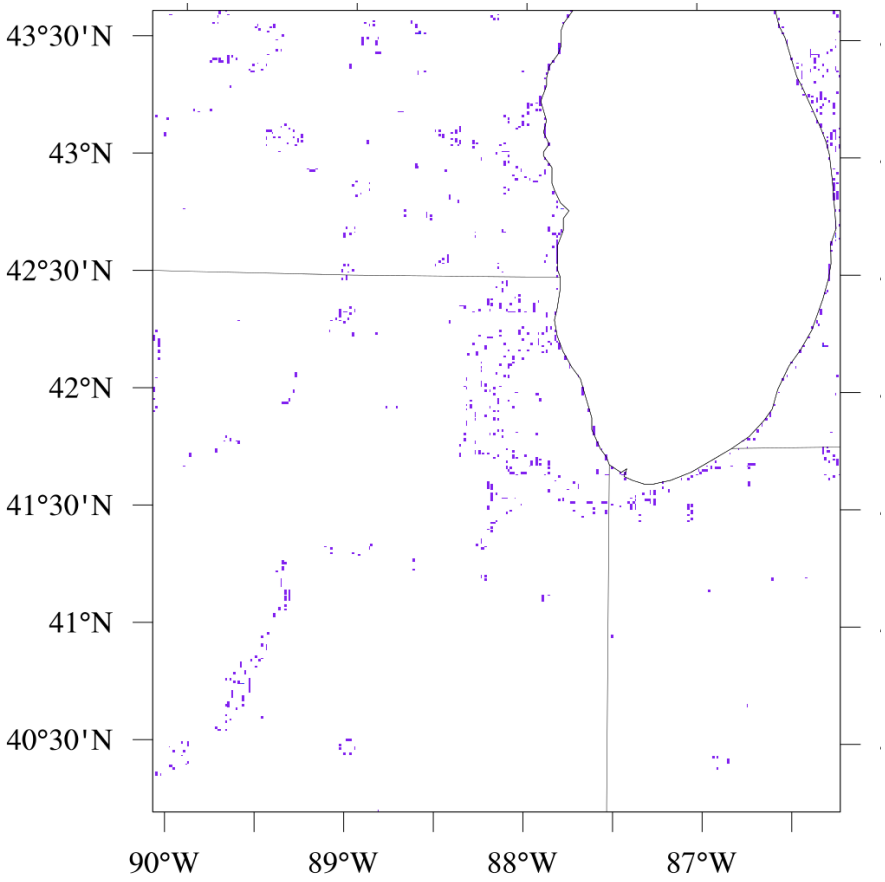
User note: should I use this mosaic approach?
Example: 30km grid spacing with 1km input land cover



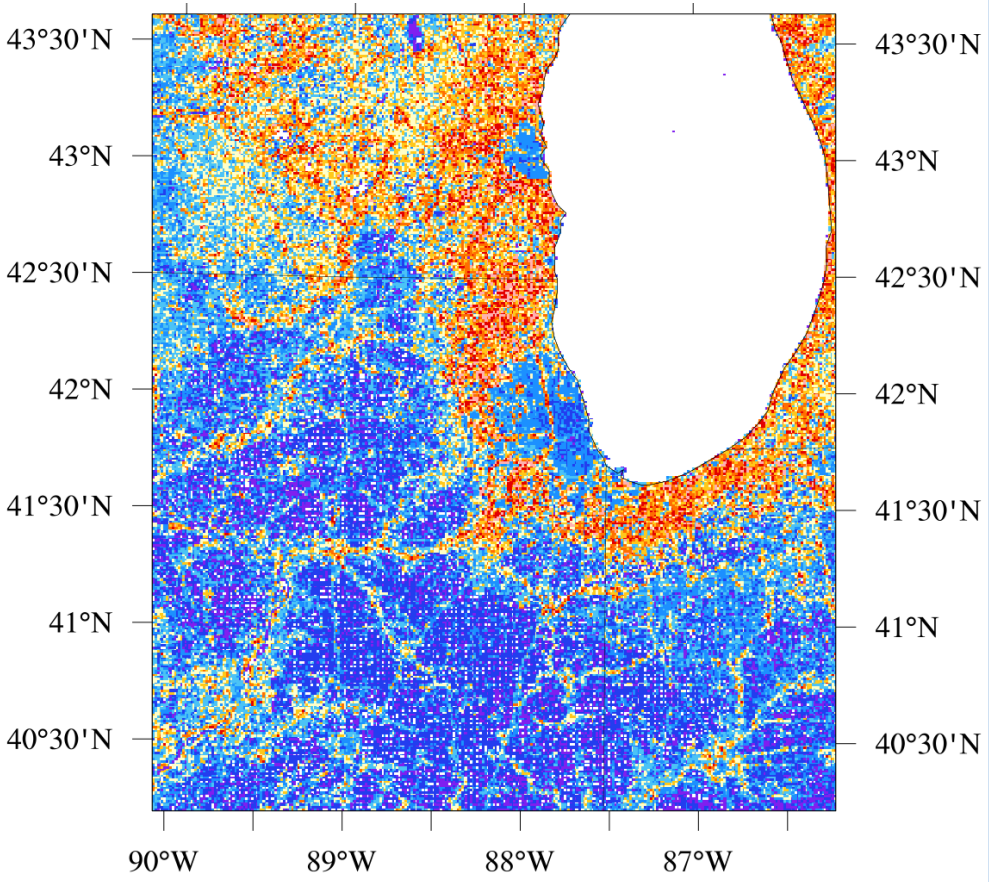
Land cover mosaic/tiling in the Noah LSM

Example: 1 km grid spacing with 1km(left) and 30m(right) input land cover

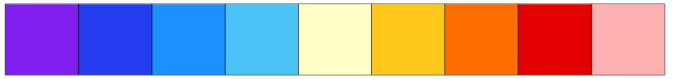
Using 1km MODIS land cover



Using 30m NLCD land cover



Data courtesy of Ashish Sharma

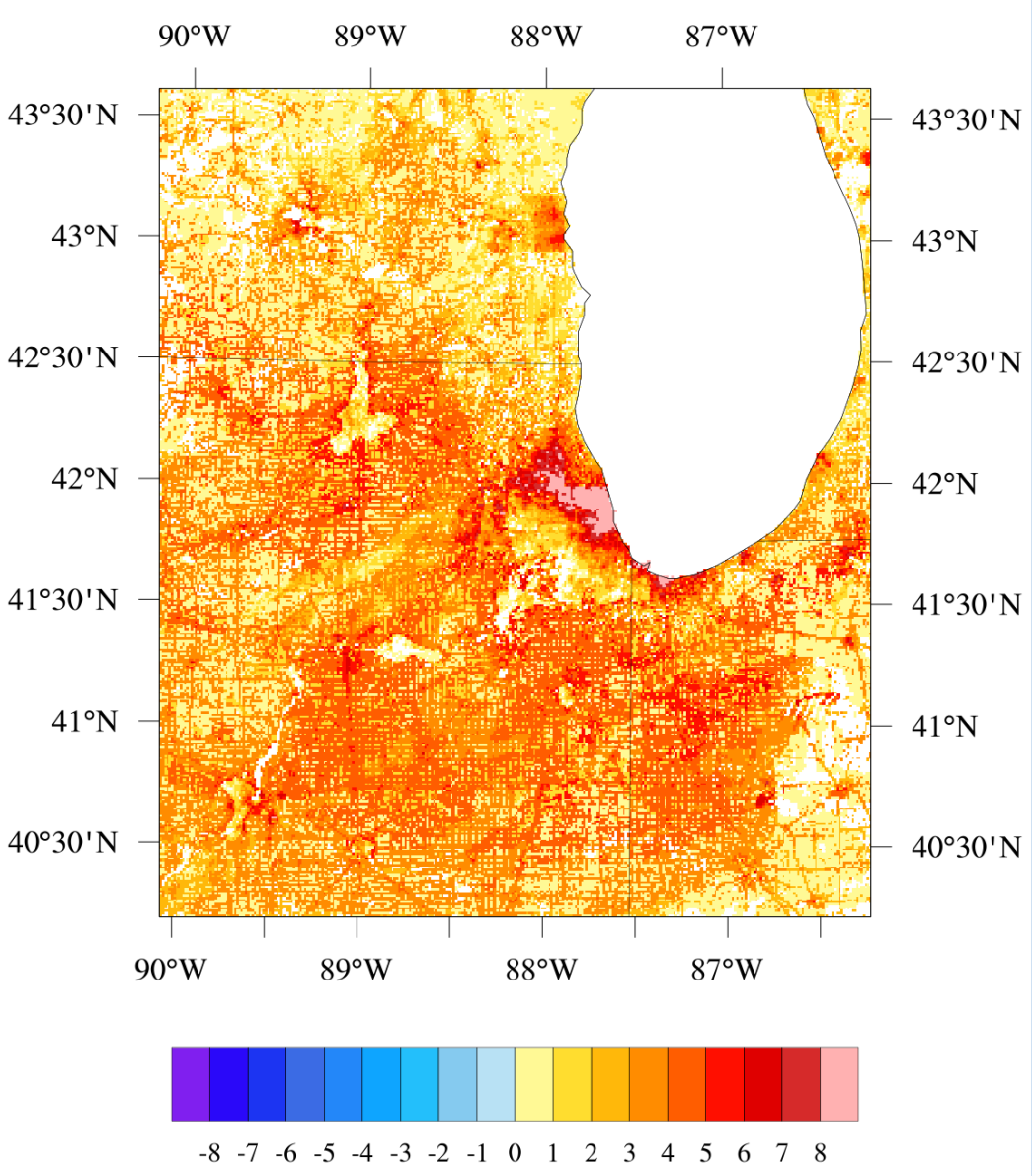


Land cover mosaic/tiling in the Noah LSM

Example: 1 km grid spacing with 1km and 30m input land cover

Significant differences between mosaic approach and dominant approach in heterogeneous urban areas

Potential importance for satellite data assimilation in surface-sensitive channels



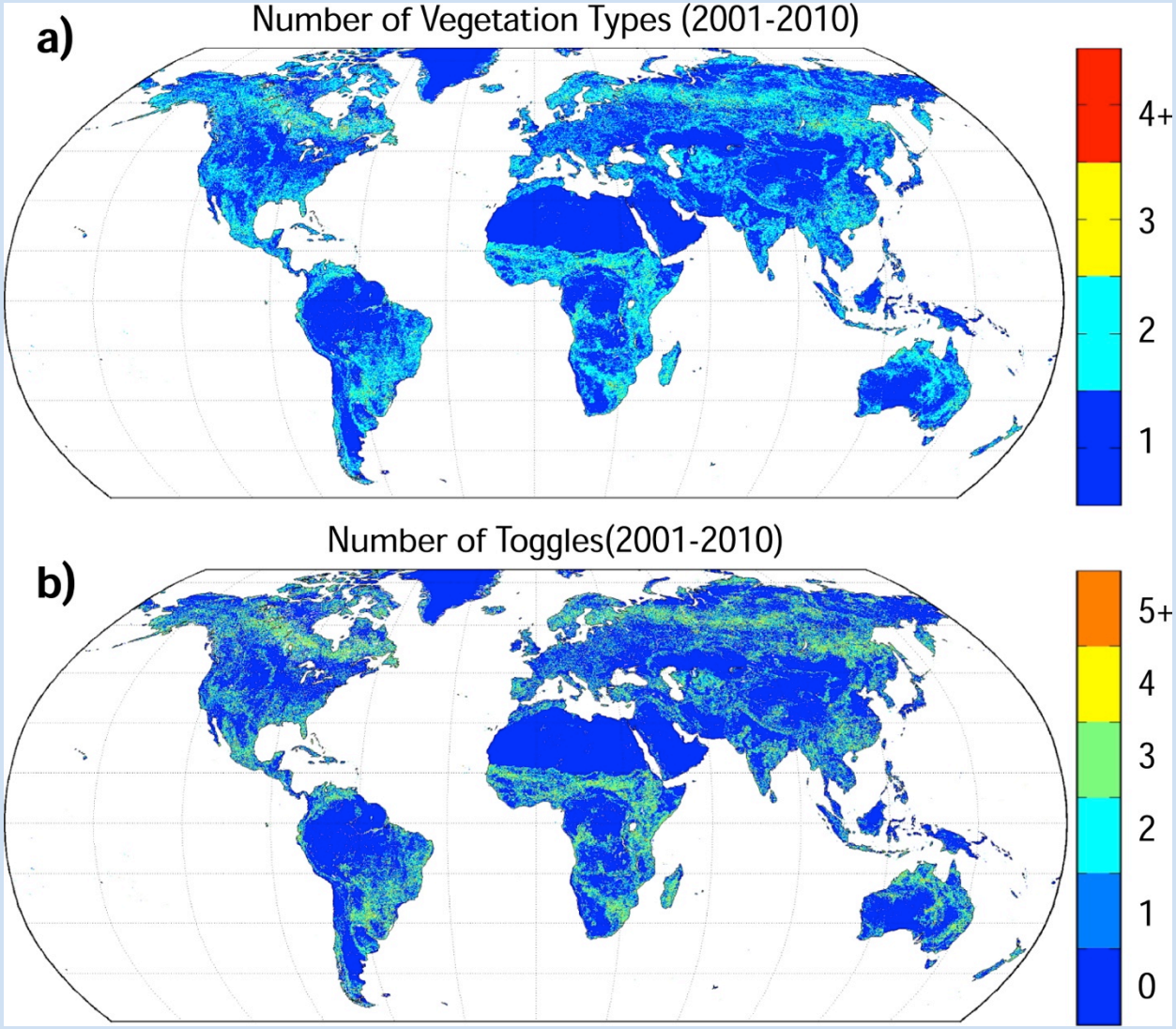
Data courtesy of Ashish Sharma

MODIS 500m land cover (Broxton et al. 2014)

Year-to-year variations exist in the MODIS land cover product (MCD12Q1)

~40% of non-water pixels have at least one change from 2001 - 2010

This dataset is an effort to create a “climatology” of land cover from MODIS



User note: MODIS 30” ≠ MODIS 30” + lakes (at non-lake points) ≠ MODIS 15”

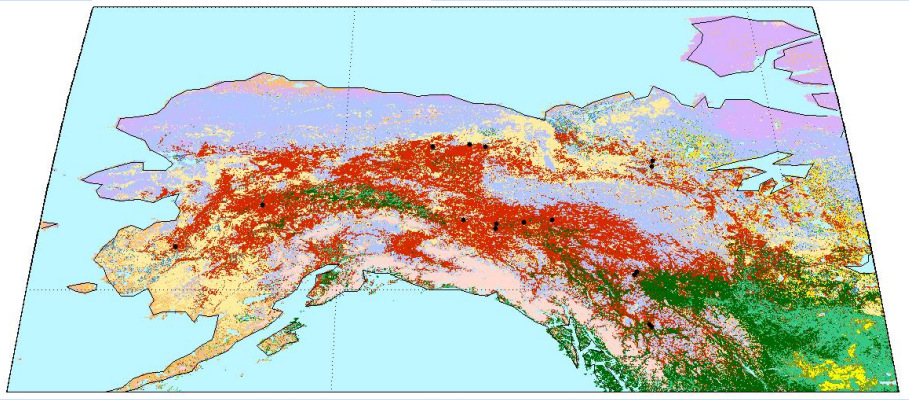
MODIS 500m land cover

A cautionary tale about using land cover directly in the WRF model: how does one define woody savanna?

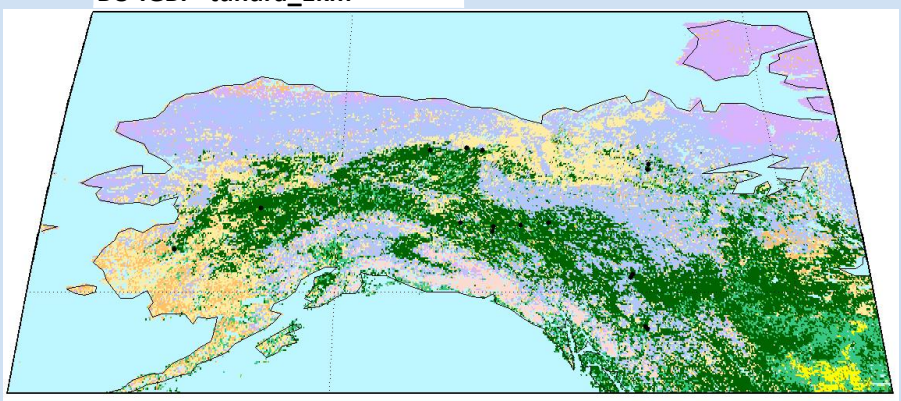
Fractional coverage of each land cover Type (%) - Alaska

Type	BU-IGBP+ tundra_1km	MODIS5.1 0.5km	MODIS5.1 Fill by surrounding 0.5 degree forest type
Evergreen Needleleaf	14.07	4.82	12.09
Evergreen Broadleaf	0.00	0.00	0.00
Deciduous Needleleaf	0.43	0.37	3.67
Deciduous Broadleaf	0.07	0.03	0.03
Mixed Forest	4.77	2.48	3.94
Woody Savanna	0.00	12.04	0.00

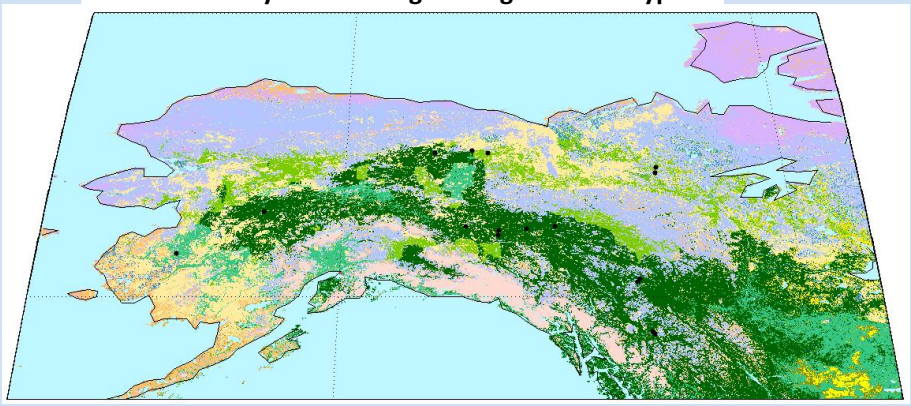
MODIS5.1 0.5km

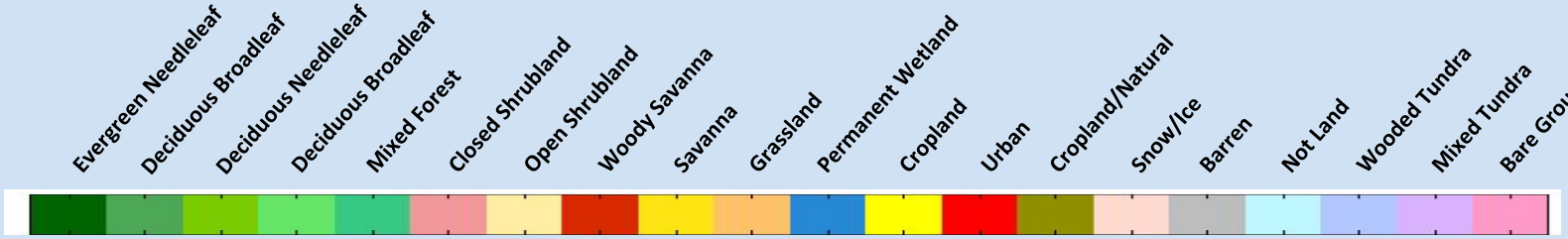


BU-IGBP+tundra_1km



MODIS5.1 Fill by surrounding 0.5 degree forest type





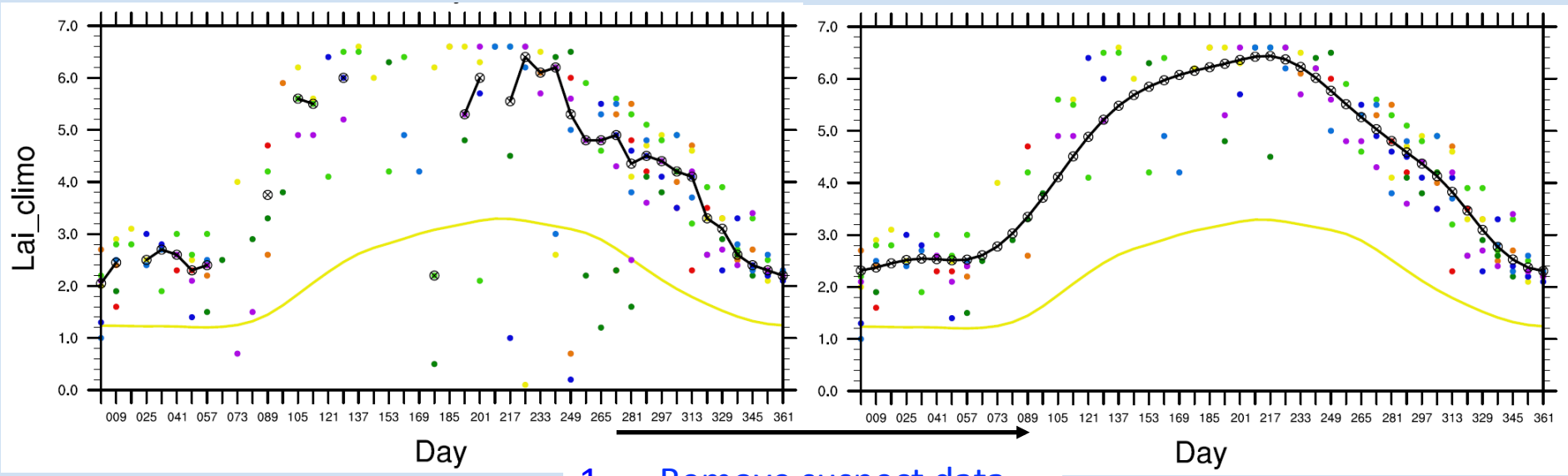
MODIS 1km Leaf Area Index Climatology

Developed through support from and collaboration with the Taiwan Central Weather Bureau

Important input dataset for Noah (transpiration and canopy resistance) and NoahMP (radiation/shading, photosynthesis/transpiration)

Original Pixel Data

Final Smooth Climatology



1. Remove suspect data
2. Fill missing data
3. Smooth

Marks

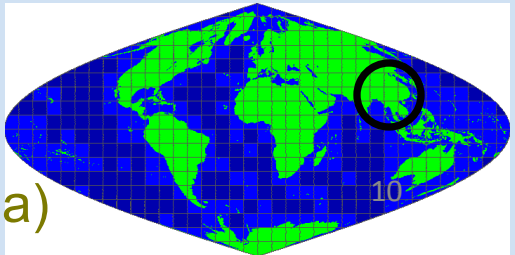
— Individual value of year

2001 2002 2003 2004 2005 2006 2007 2008

Lines

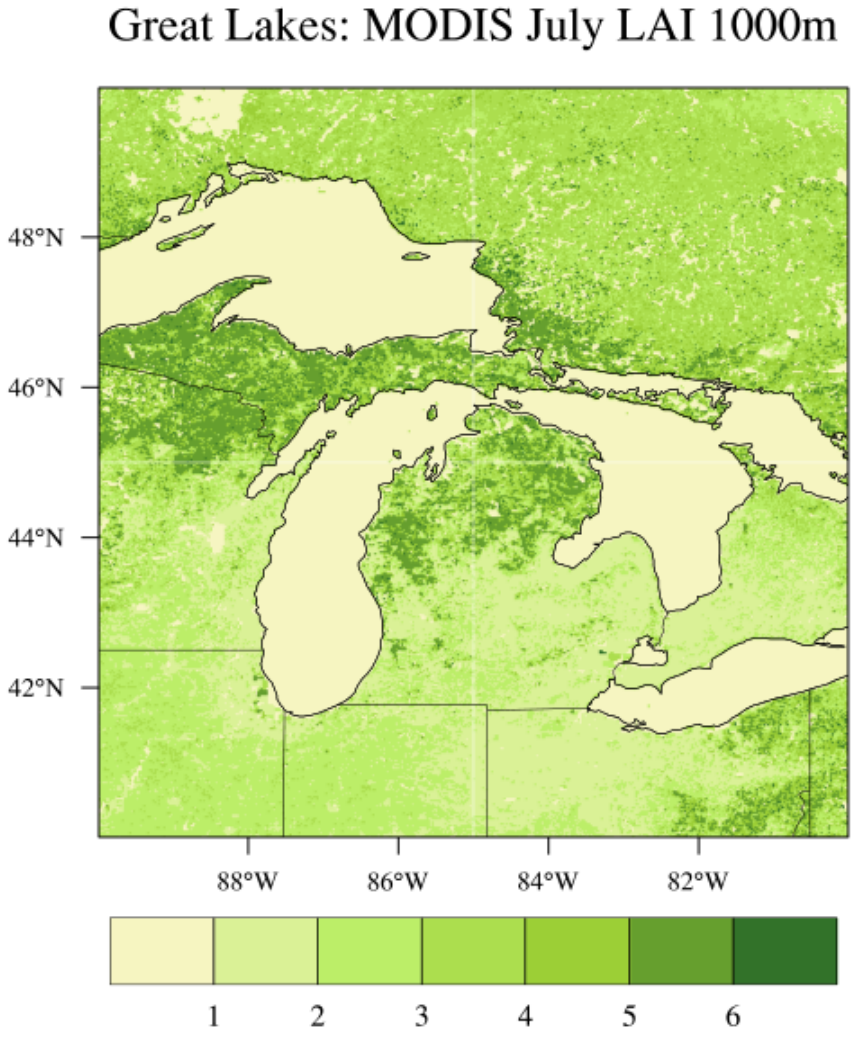
— black: median

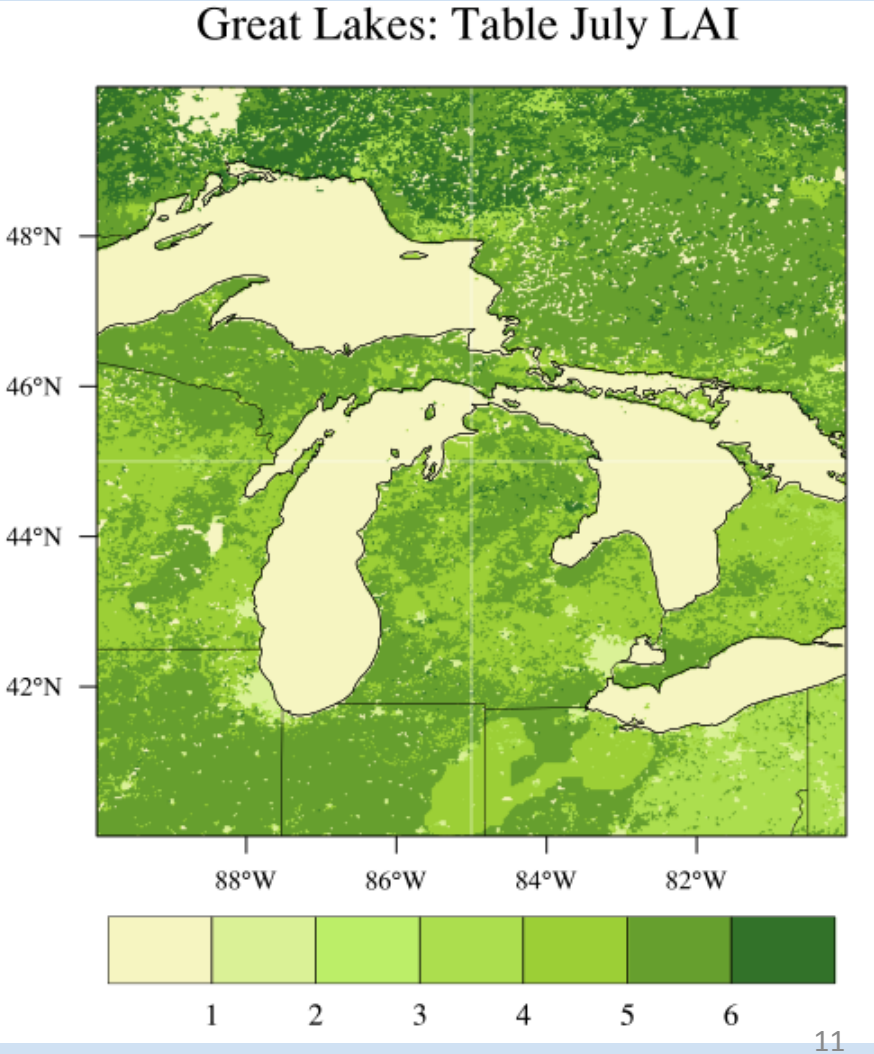
— yellow: tile climo (Savanna)



MODIS 1km Leaf Area Index Climatology

Comparison of MODIS LAI to default table-based LAI
User note: activate using rd2dlai namelist flag





Miguez-Macho & Fan water table dynamics in Noah-MP

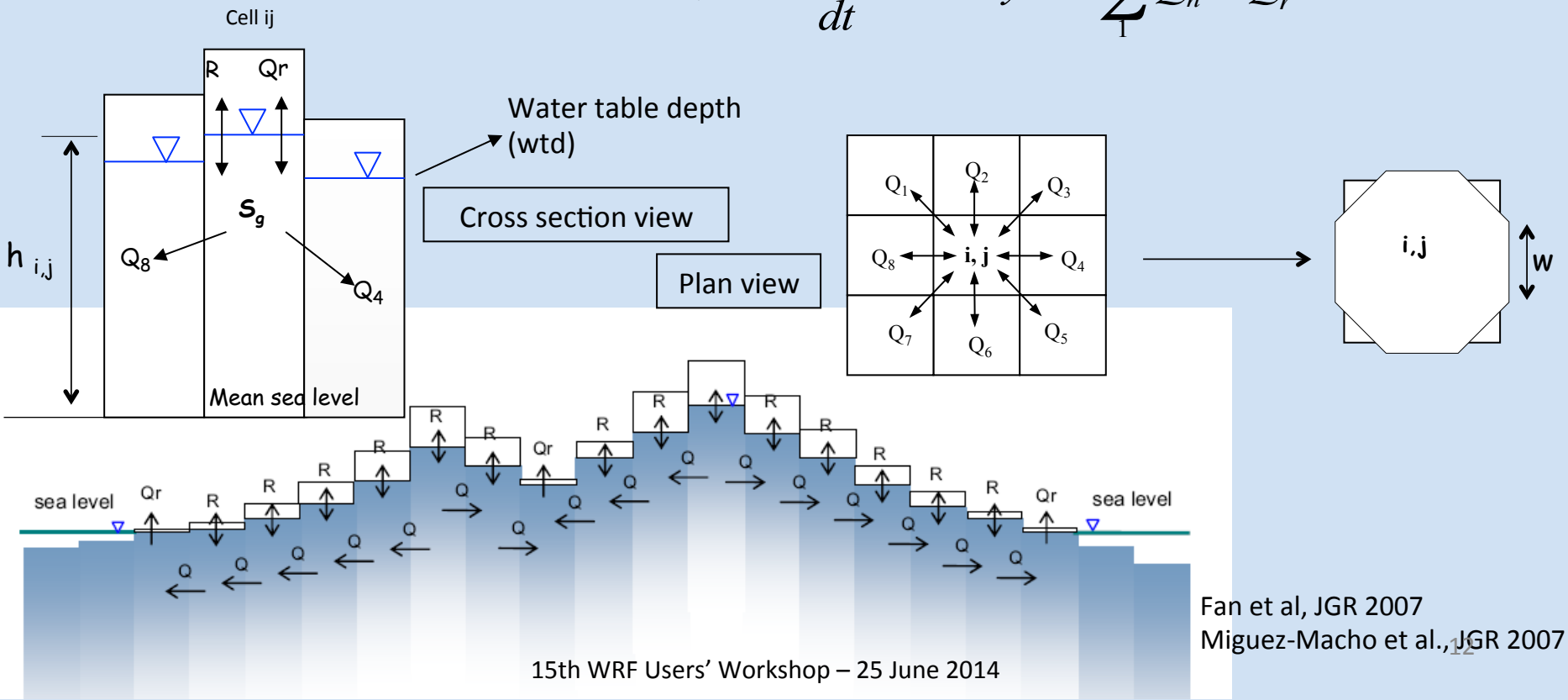
Noah-MP options exist for

- free drainage soil lower boundary condition
- 1D aquifer interaction
- new option added for 1D interaction with horizontal aquifer transport

User note: not a river routing, overland flow scheme (see WRF-hydro)

Mass balance in groundwater storage:

$$\frac{dS_g}{dt} = \Delta x \Delta y R + \sum_1^8 Q_n - Q_r$$

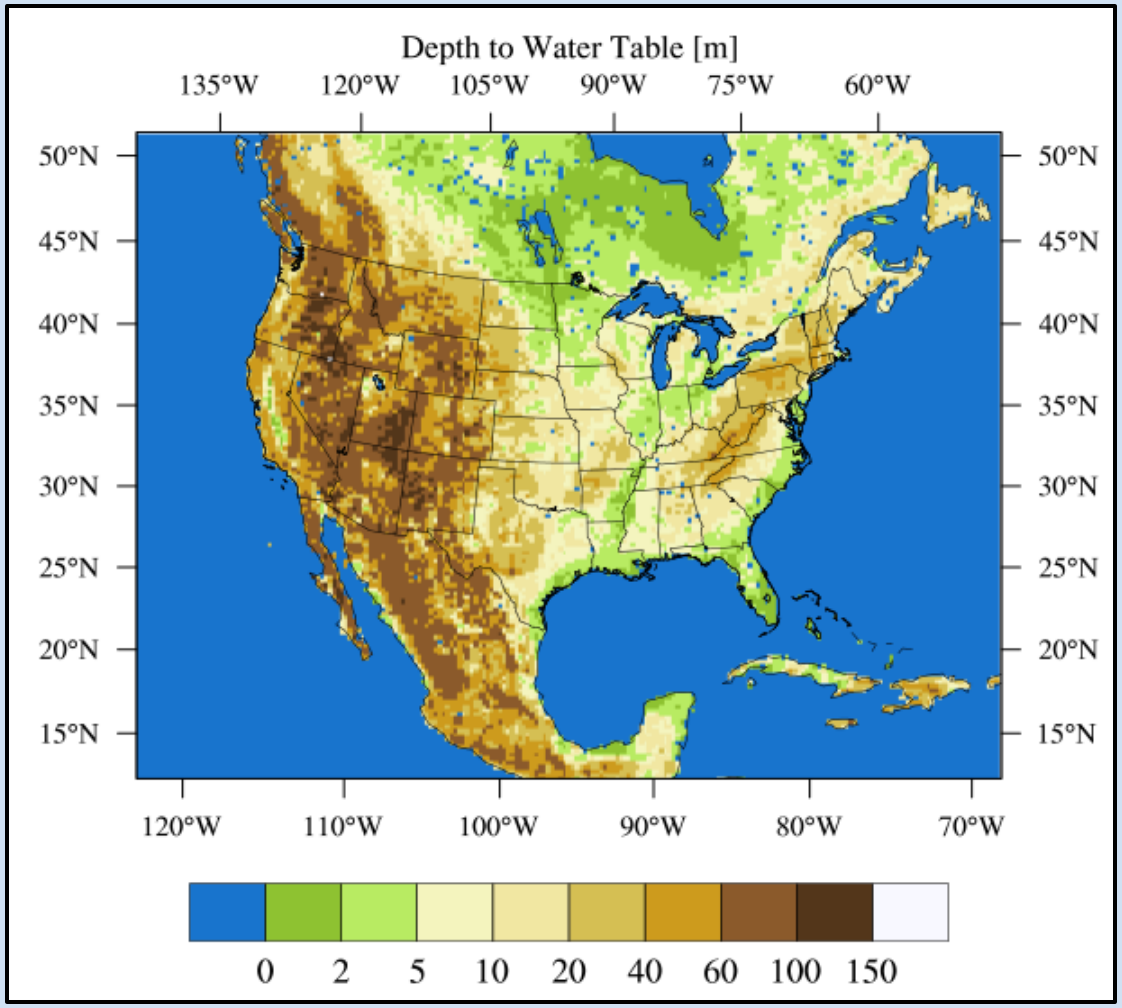


Fan et al, JGR 2007

Miguez-Macho et al., JGR 2007

Miguez-Macho & Fan water table dynamics in Noah-MP

Depth to Water Table – MMF input



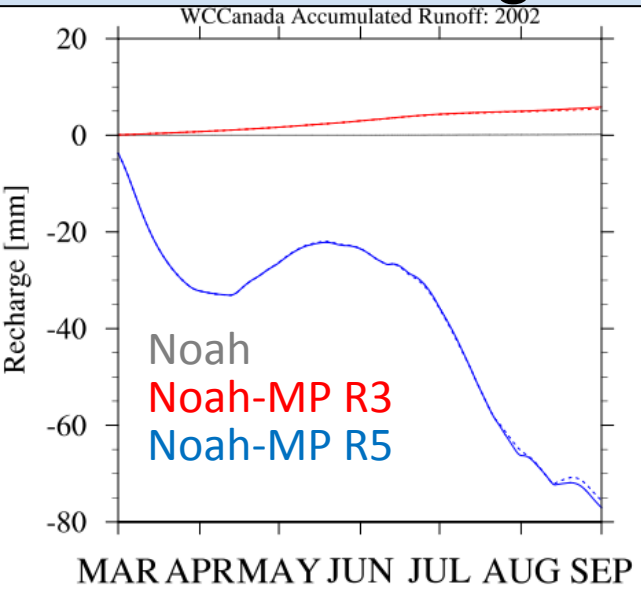
Code is present in WRFv3.6

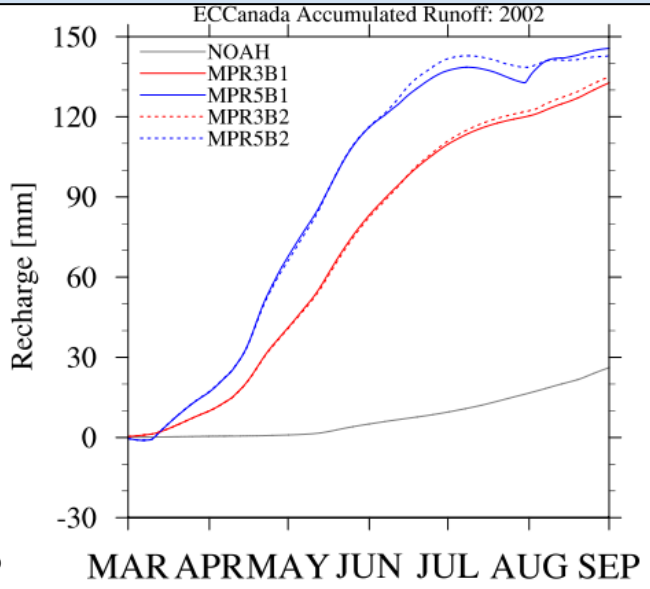
Extra input datasets are required

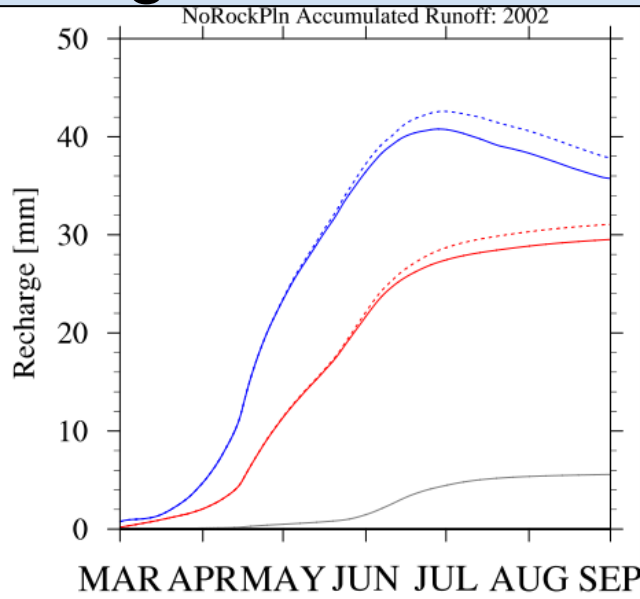
Work continues to make these datasets available (possibly 3.6.1 or next full release)

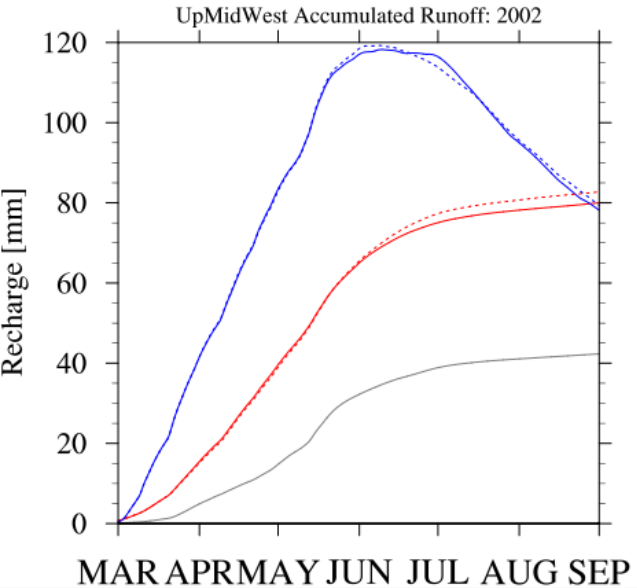
Miguez-Macho & Fan water table dynamics in Noah-MP

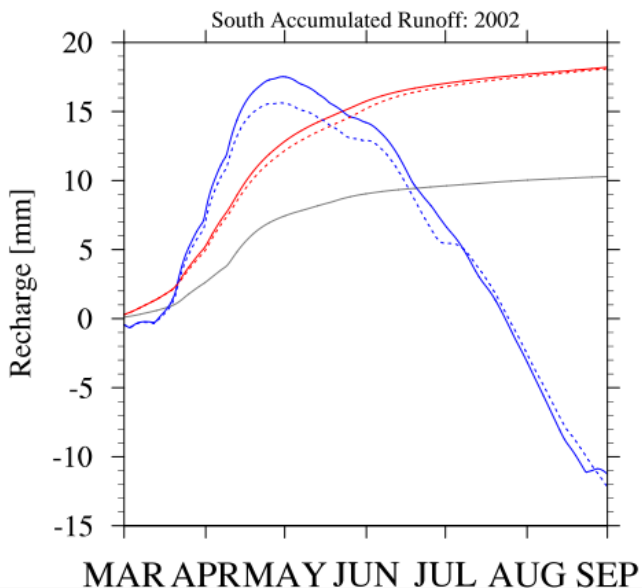
Regional Groundwater Recharge

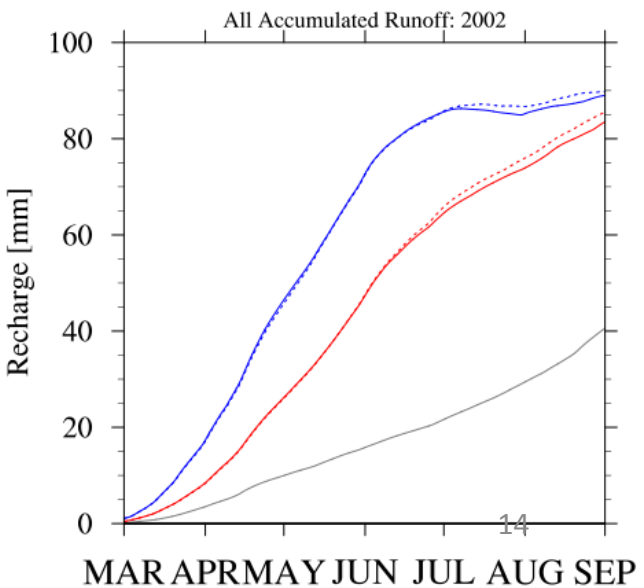








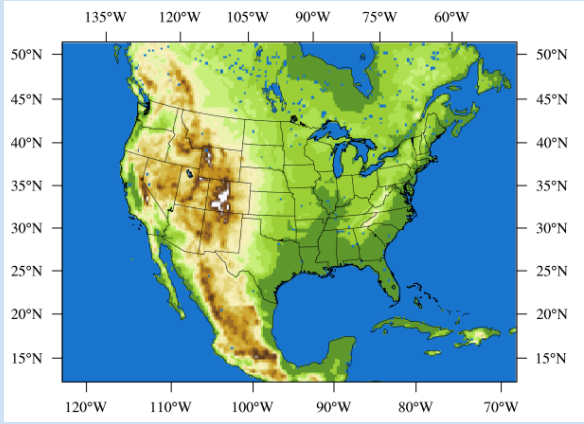




Miguez-Macho & Fan water table dynamics in Noah-MP

Noah vs. NoahMP
Surface Verification

- Six-month 30km WRF simulations - 2010
- Spin-up soil for one year using offline HRLDAS
- IC/BC from NARR
- Verification against ~2600 surface stations



Model	Season	Output field	Day bias	Day RMSE	Night bias	Night RMSE
Noah	MAM	T_{2m}	-2.79	3.18	-1.95	2.17
Noah-MP	MAM	T_{2m}	**0.17**	**0.92**	**-0.01**	**0.77**
Noah	JJA	T_{2m}	**-0.04**	**0.75**	-1.04	1.37
Noah-MP	JJA	T_{2m}	1.09	1.53	**0.13**	**0.94**
Noah	MAM	Td_{2m}	-0.48	1.16	-1.29	1.64
Noah-MP	MAM	Td_{2m}	**0.19**	**1.04**	**0.48**	**1.01**
Noah	JJA	Td_{2m}	**-0.98**	**1.53**	-1.73	2.08
Noah-MP	JJA	Td_{2m}	-1.18	1.84	**-1.00**	**1.57**

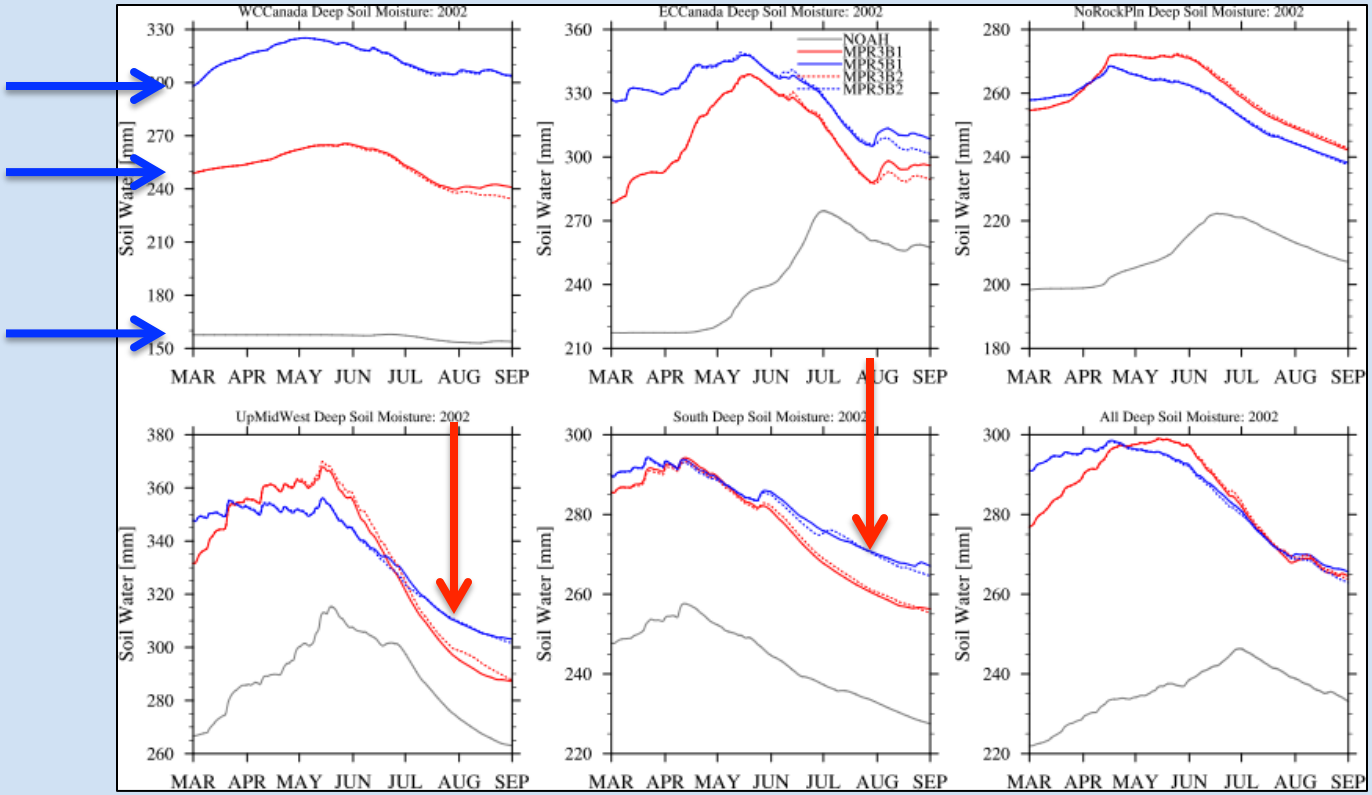
Green: Noah-MP improves Red: Noah-MP degrades

Miguez-Macho & Fan water table dynamics in Noah-MP

Time series of 1-2m soil moisture shows the effect of upward transport of water from the aquifer to soil (red arrows).

User note: the importance of one-year model spin-up (blue arrows).

Regional Deep Soil Moisture: 2002



Noah Noah-MP R3 Noah-MP R5

High-Resolution Land Data Assimilation System

We have recently released an updated version of the offline system which can be used to spin-up LSM soil states or perform land model testing

- The current system contains Noah-MP (consistent with v3.6)
- Noah to be added within the same HRLDAS soon
- instructions are included to use lowest model lever NARR output as land model forcing
- other forcing options, including global NASA GLDAS to be added soon

Download the code at:
http://www.ral.ucar.edu/research/land/technology/noahmp_lsm.php

Summary

Land-related datasets based on global satellite products continue to be improved. Future work in this area needs to focus on *how* these datasets are used in the land models.

Though no code changes have occurred for the Noah LSM, development still continues, including adding a sub-grid tile capability.

The Noah-MP LSM continues to implement bug fixes and parameter modifications. Additional process options, such as groundwater interaction, continue to be added and users are encouraged to test and propose others.