Implementation of the Noah-MP land surface model in WRFV3.3 and preliminary results using coupled WRF/Noah-MP

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Outline:

- **Introduction**
- **Offline Results from Noah-MP**
- **Coupled WRF/Noah-MP Results**
- **Summary**

A new prototype: Noah Multi-Physics (Noah-MP)

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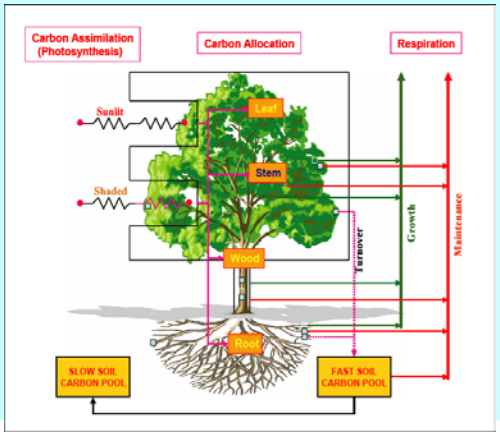
Noah-MP references: Niu et al., 2011, Yang et al., 2011. JGR

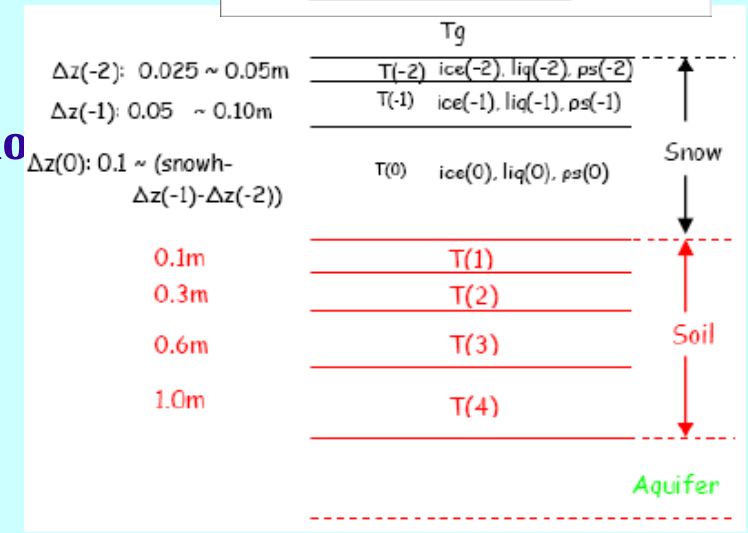
What is Noah-MP?

Noah-MP is an extended version of the Noah LSM with enhanced Multi-Physics option to address critical shortcomings in Noah for long-term soil state spin-up and snow modeling.

- **Groundwater model**
- **Multi-layer snowpack and new sno cover**
- **Dynamic vegetation, separate vegetation canopy**
- **Ball-Berry canopy resistance**
- **Snow albedo treatment**
- **Irrigation treatment**
- **2-D high-res explicit routing**
- **van Genuchten soil hydraulics, spatially varying soil layer thickness**
- **New frozen soil scheme**



Separate vegetation, Dynamic vegetation growth



3-layer snow model

Underground water

Improve the research version of Noah-MP at NCAR

- **Removed hardwired parameters (e.g., vegetation and soil) parameters to MPTABLE.TBL.**
- **Implemented Noah-MP options in namelist.input.**
- **Bug fixes and clean-up of the Noah-MP code.**
- **Added new features:**
  - Use of MODIS Land-use and land-cover data
  - Restart facility for Noah-MP is added which is useful when Noah-MP is run for long spin-up
  - Added an option for dynamic vegetation so it can use realtime MODIS data
  - Noah-MP is enhanced with the option to select multiple snow layers from the current fixed maximum 3 layers so that Noah-MP code can run with snow layers (0, 1, and 3).
- **The Noah-MP model is implemented in the HRLDAS framework and tested for summer and winter seasons.**

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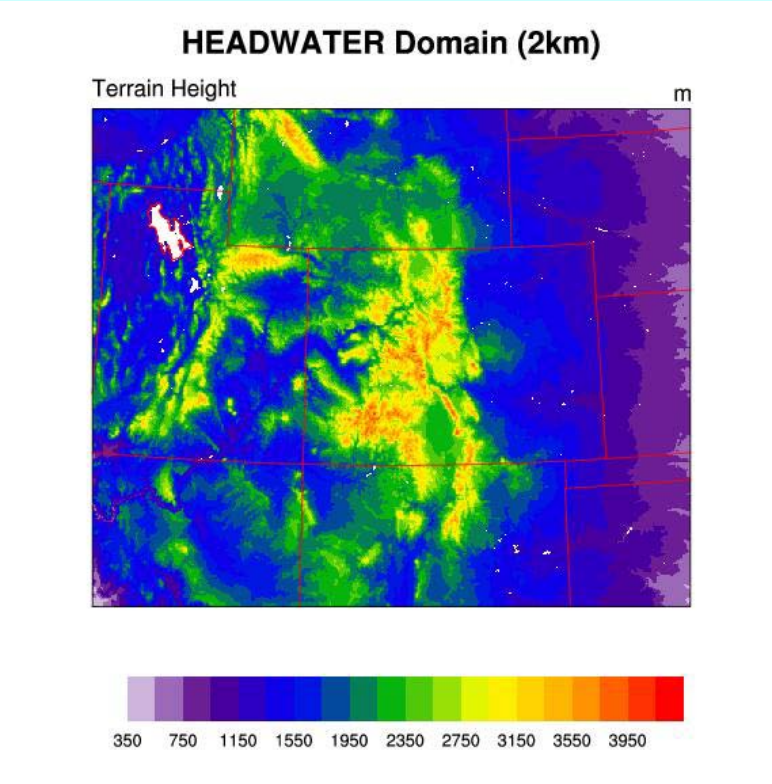
Noah/Noah-MP 1-D/2-D Runs

- **Offline Noah/Noah-MP models are run over the SNOTEL sites (112*4 locations), AMERIFLUX sites (Niwot Ridge and GLEES), and HEADWATER domain**

- **Offline Noah/Noah-MP-2D uses the forcing data from 2-km WRF run for the Headwaters domain, starting 1 Nov 2007 for 2007-2008 winter season**

- **The radiation data from the WRF forcing files is replaced by GOES radiation**



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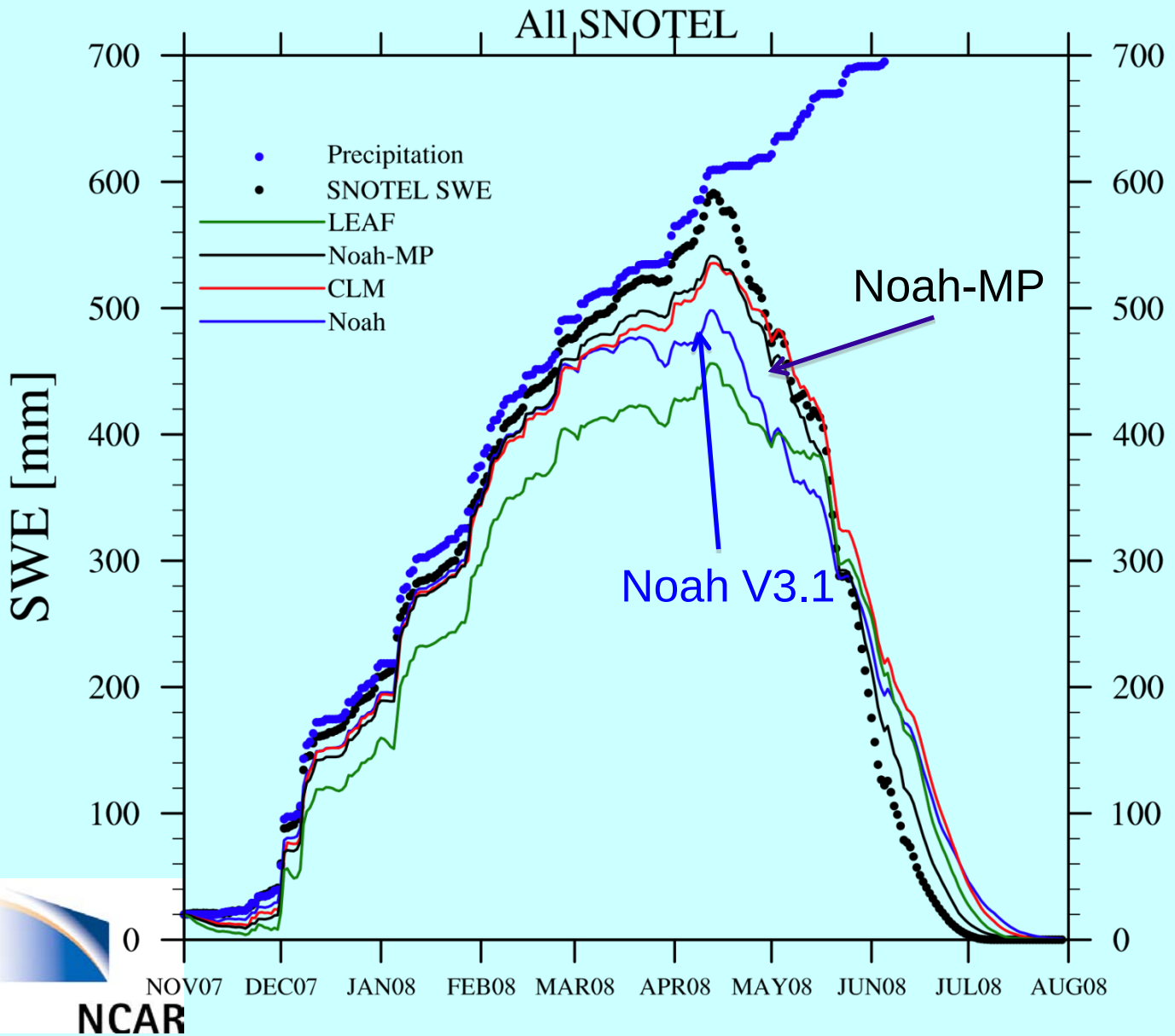
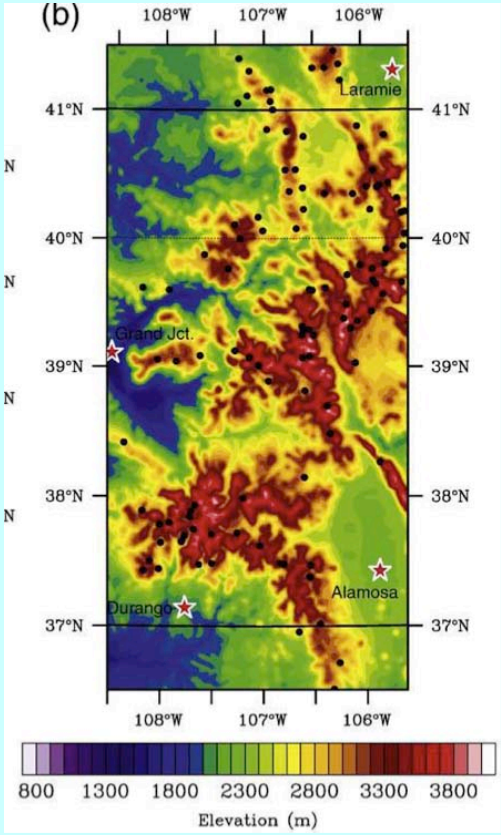
SWE simulated by four models
Averaged over 112 SNOTEL sites.





Black dots are 112 SNOTEL sites in the Colorado Headwater region.

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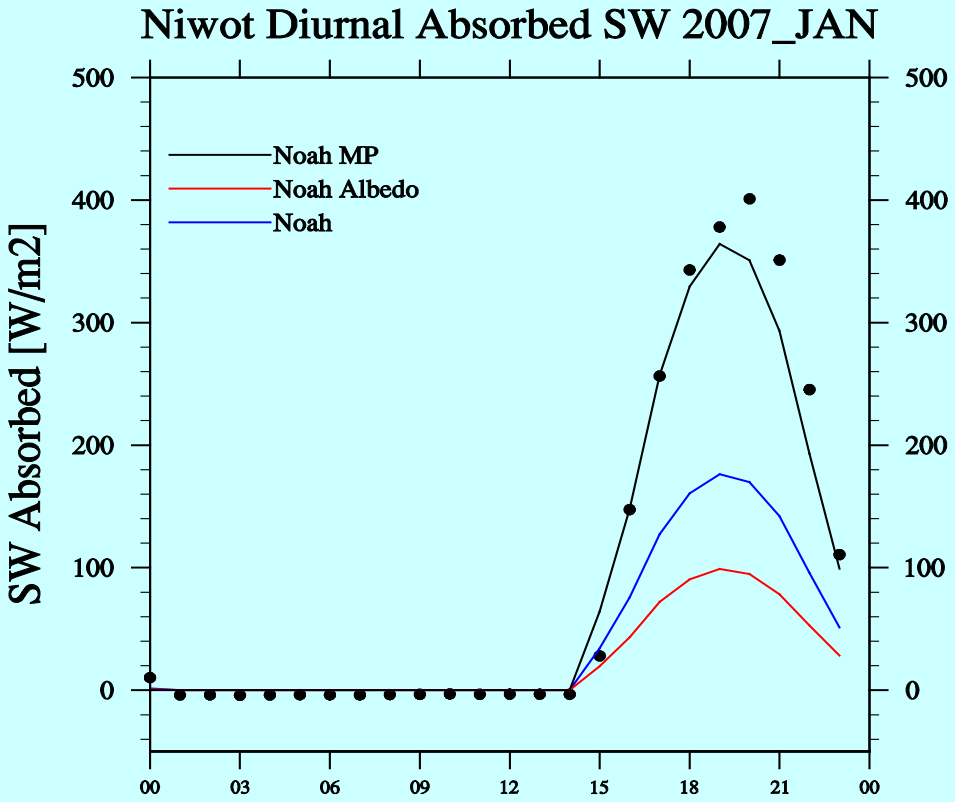
Impact of snow processes: absorbed solar radiation



Noah albedo is kept high in order to keep more snow on ground which affects fluxes at the surface

Noah-MP absorbed SW matches well with observation due to its canopy radiation treatment

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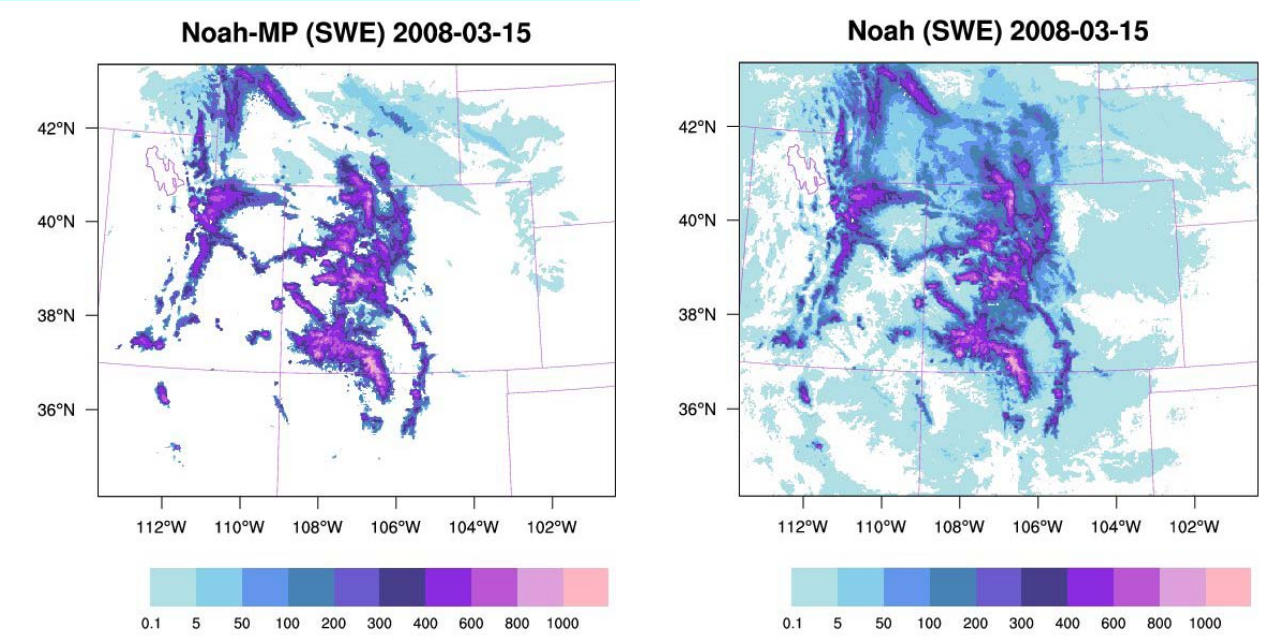
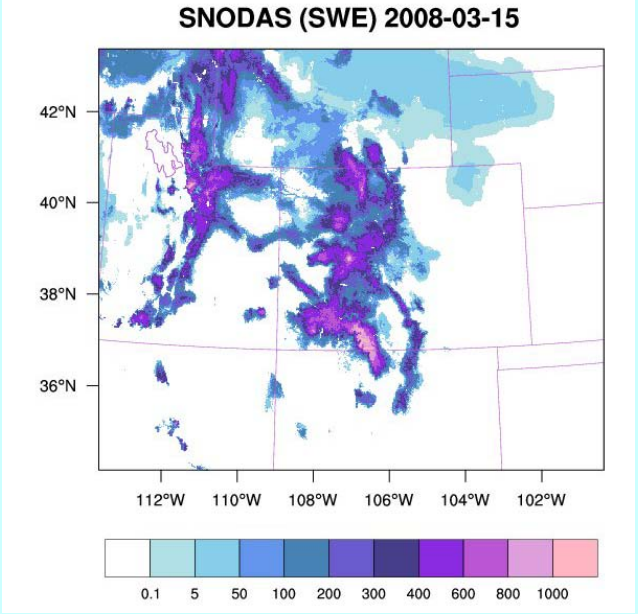
Snow Water Equivalent: Noah-MP, Noah and SNODAS: 15 Mar 2008





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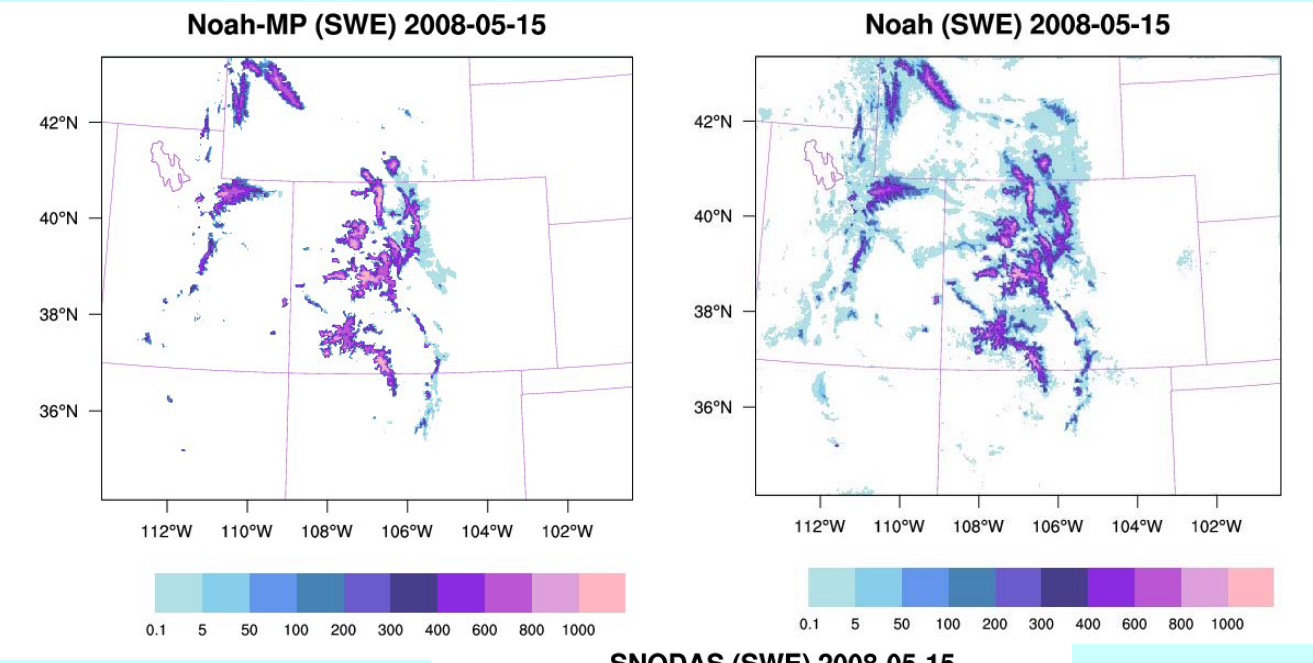
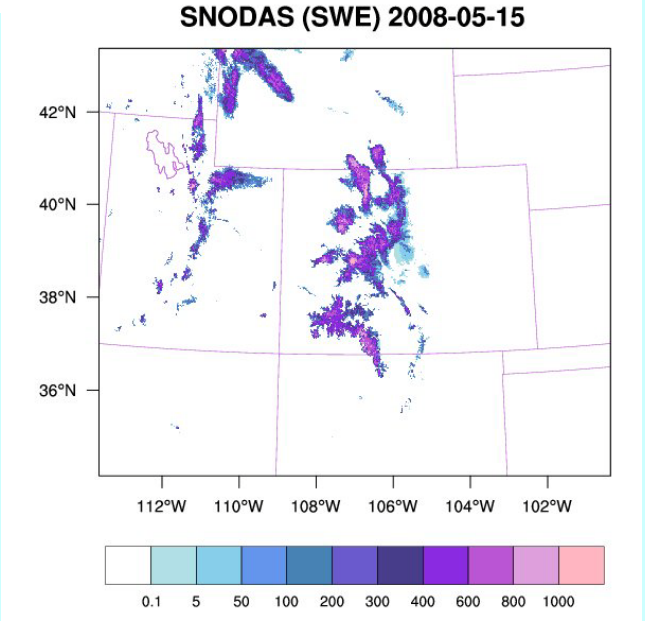
Snow Water Equivalent: Noah-MP, Noah and SNODAS, 15 May 2008





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Implementation of Noah-MP in WRFV3.3

- **Noah-MP LSM is added as another sf_surface_physics option in WRFV3.3 through namelist.input.**
- **The multi-physics options of Noah-MP are also part of the current WRF namelist.input file and added in a separate NoahMP section.**
- **The initial testing of coupled WRF/Noah-MP has started over a single/multiple domains over continental US .**
- **Noah-MP v1.0 is planned for the spring 2012 release along with WRF next release.**

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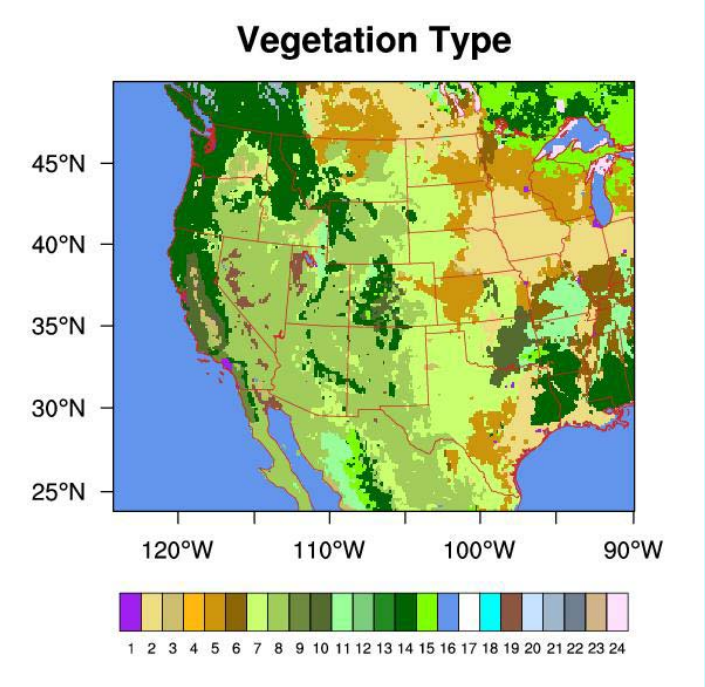
Model Configuration for WRF Runs

- **Landuse (USGS)**
- **12 Km horizontal resolution with**
  - e_we = 300
  - e_sn = 250
  - 28 Vertical levels



- **NARR data is used as initial condition**
- **WRF Runs starts 1 March 2008, 12Z**
  - Using WRFV3.3/Noah
  - Using WRFV3.3/Noah-MP

- **Models are integrated for 15 days.**
- **Results are compared**
  - Noah Vs Noah-MP
  - With Niwot Ridge observations

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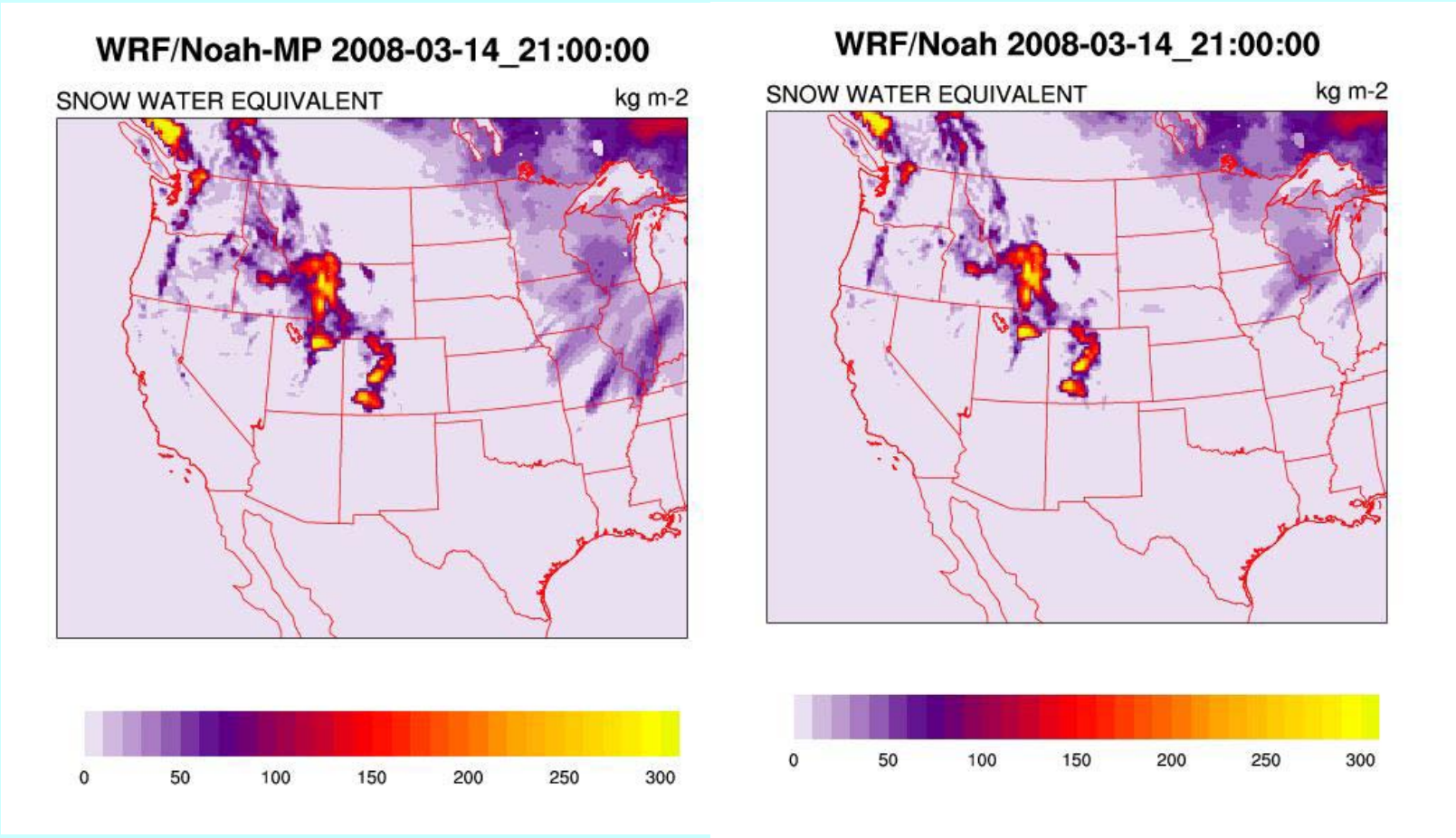
Snow Water Equivalent:
345 hrs FCST valid at 14 March 2008, 21Z



Noah-MP run keep higher snow over the ground as compared to Noah.

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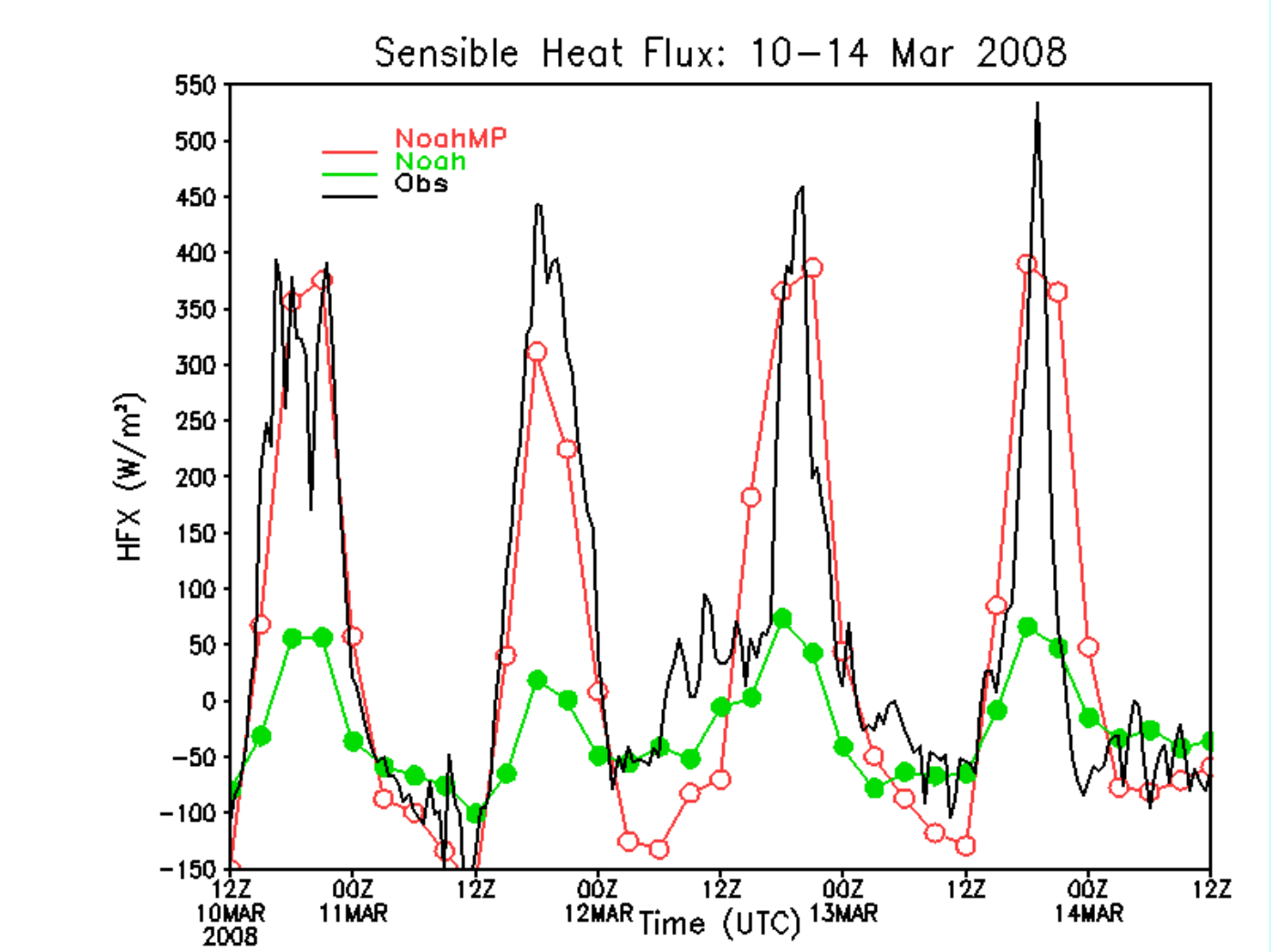
Sensible Heat Flux at Niwot Ridge, CO: 10-14 Mar 2008

Noah-MP Noah Obs



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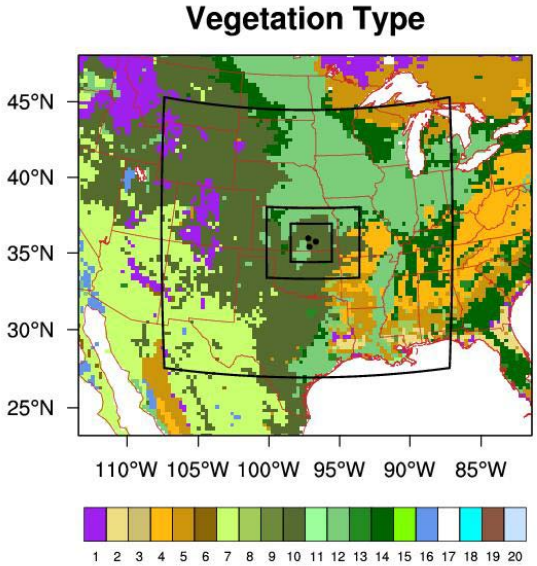
Spring simulations with WRF/Noah/Noah-MP: 29-30 Apr, 1997, 12Z. Comparison with CASES-97 data

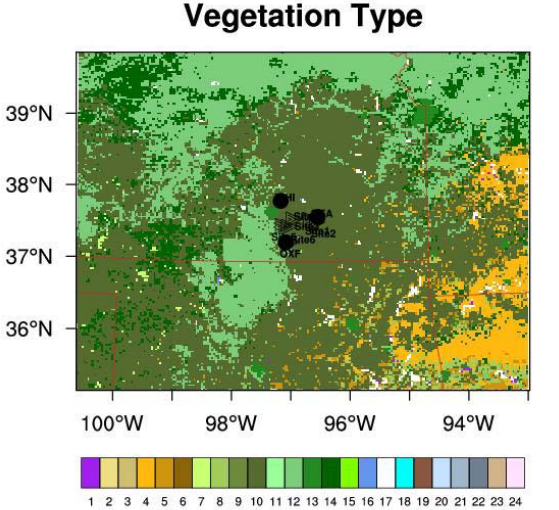
- **Domains (27, 9, 3km)**
  - e_we = 127, 235, 229
  - e_sn = 107, 223, 175
  - 44 vertical levels

- **Landuse (Modis, 20 Cats)**

- **NARR data is used to initialize the model**

- **24 hrs WRF Runs (Using MYJ PBL) starting 29 Apr 1997,12Z**
  - Using default WRF/Noah
  - Using WRF/Noah-MP





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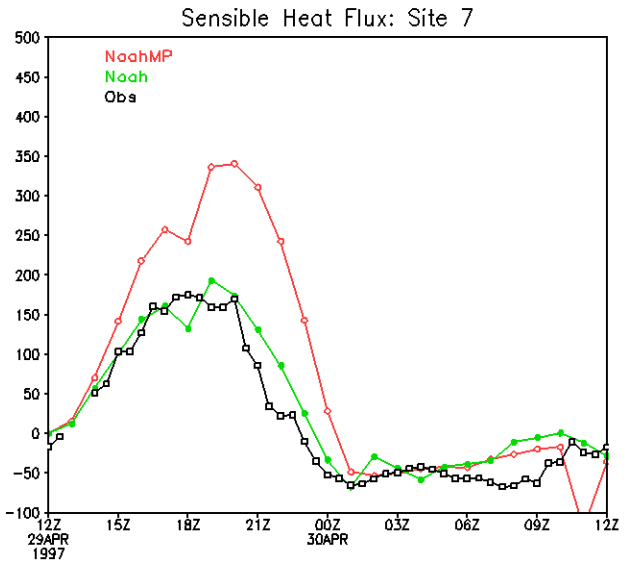
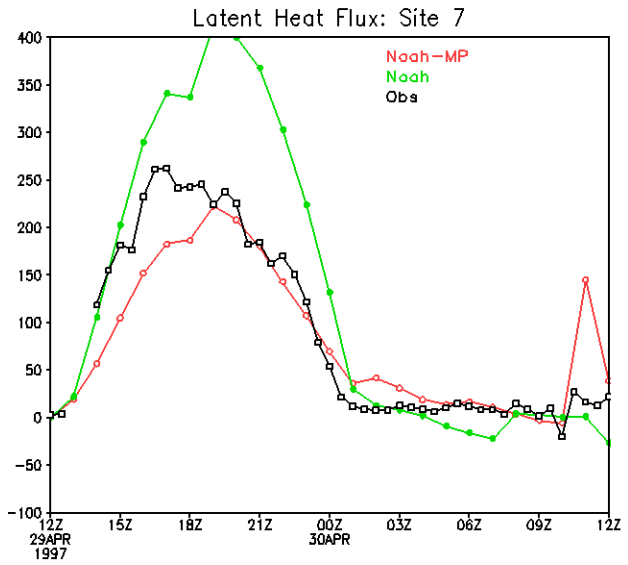
Sensible and Latent Heat Flux: 29-30 Apr 1997

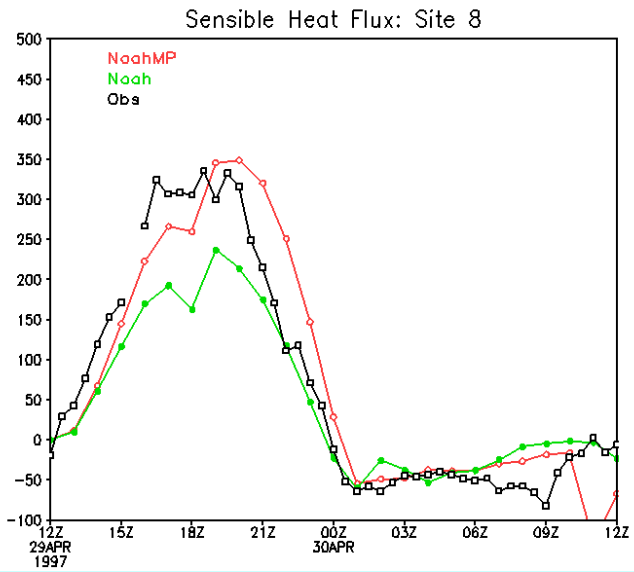
Noah-MP Noah

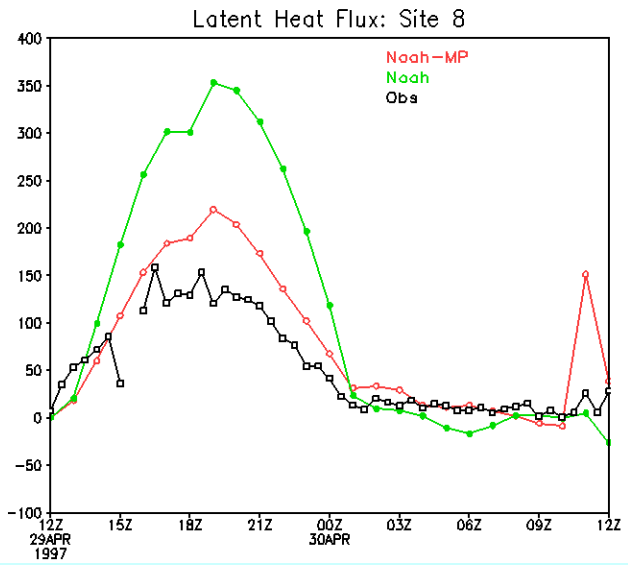
Winter wheat





Grassland





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New Modules for sea-ice/glacial-ice

- **New Sea-ice module (currently a part of Noah) will be implemented as a separate module for use with Noah-MP.**

- **Goal is to generalize this sea-ice code and implement it at the surface driver level**
  - as a possible option for use with other LSMs (land surface model) , not tied with a particular LSM.
  - It would be linked to Noah-MP LSM as well.
  - This would serve as a possible starting point for more complex sea-ice treatment in the future.

- **Similarly glacial-ice code (currently a part of Noah) will be implemented as a separate module.**

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Summary and Future Plans

- **Uncoupled 1-D/2-D simulations of Noah-MP are promising.**
- **Noah-MP is tested offline over different domains (CASES-97, IHOP-2002, Colorado Headwaters), different horizontal resolutions (1km, 2km, 12km) and different physics options available within Noah-MP.**
- **Noah-MP is implemented in WRFV3.3.**
- **Coupled WRFV3.3/Noah-MP is tested for 15 days simulation over the CONUS.**
- **Preliminary coupled WRF/Noah-MP results for spring and winter show improved surface heat fluxes.**
- **The code will be committed to the WRF repository for the 2012 release after successful testing.**

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