WRF-Hydro: A hydrological modeling extension package for the Weather Research and Forecasting System

Wei Yu, David Gochis, David Yates
Research Applications Laboratory
National Center for Atmospheric Research
Boulder, CO USA

Outline

- What is WRF-Hydro ?
  - Hydrological process of WRF-Hydro
  - WRF-Hydro system features
  - Software features
- Experiments
  - Flash flooding forecast capability

What is WRF-Hydro Extension Package?

WRF-Hydro is a community-based, supported coupling architecture designed to couple *multi-scale* process models of the atmosphere and terrestrial hydrology

It seeks to provide:

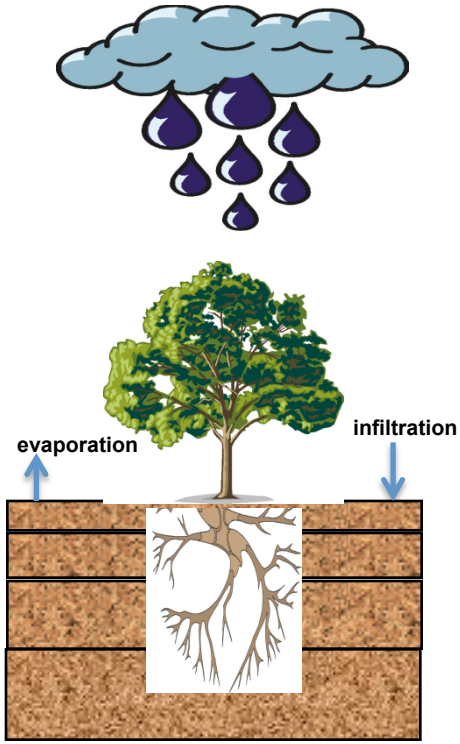
1. A capability to perform coupled and uncoupled *multi-physics* simulations and predictions
2. Fully utilize high-performance computing platforms
3. An extensible, portable and scalable environment for hypothesis testing, sensitivity analysis, data assimilation and observation impact research

Hydrologically-enhanced Land Surface Models

(Gochis and Chen, 2003, NCAR Tech Note)

Snow melting

Single Column

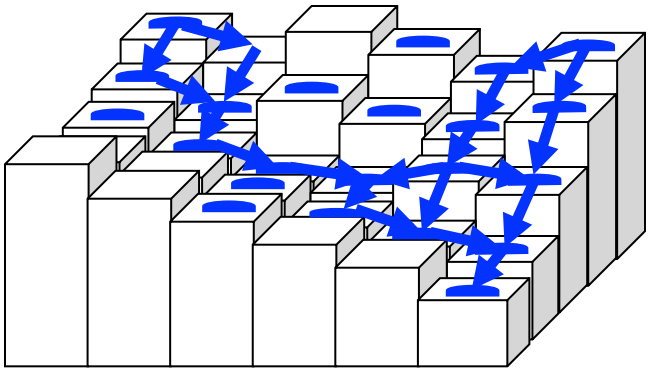


1-D Land Surface Models (e.g. 'Noah')

Run off

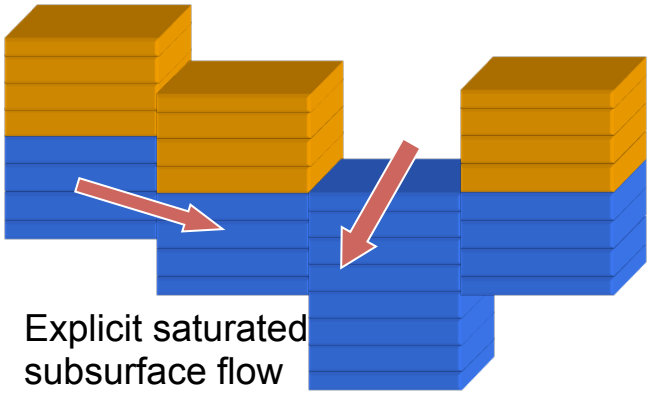
Land Surface Routing

Explicit diffusive wave overland flow



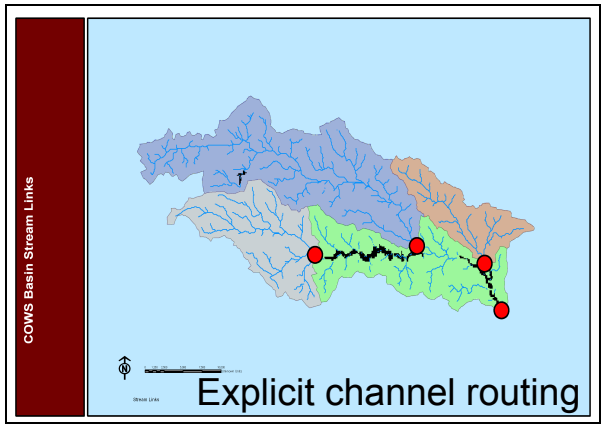
Base flow

Subsurface Routing



Explicit saturated subsurface flow

Channel Routing



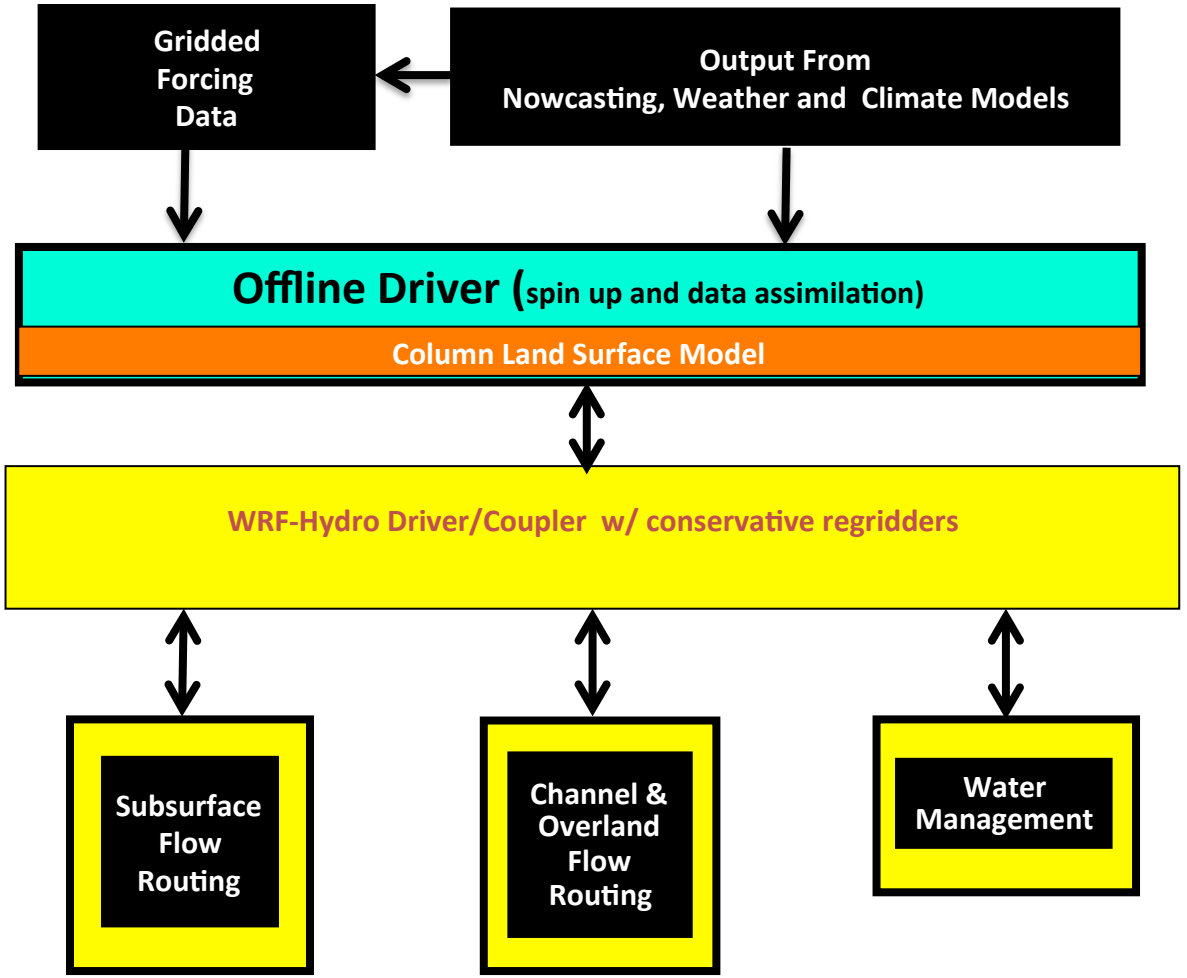
Three major components for river forecasting :
Snow melting, base flow and run off

System Function Overview

- WRF-Hydro offline
  - Noah and NoahMP
    - spin-up (data assimilation)
    - Forecasting
- WRF-Hydro fully coupled system
  - WRF model
    - with Land model option Noah and NoahMP
  - LIS system
  - CESM

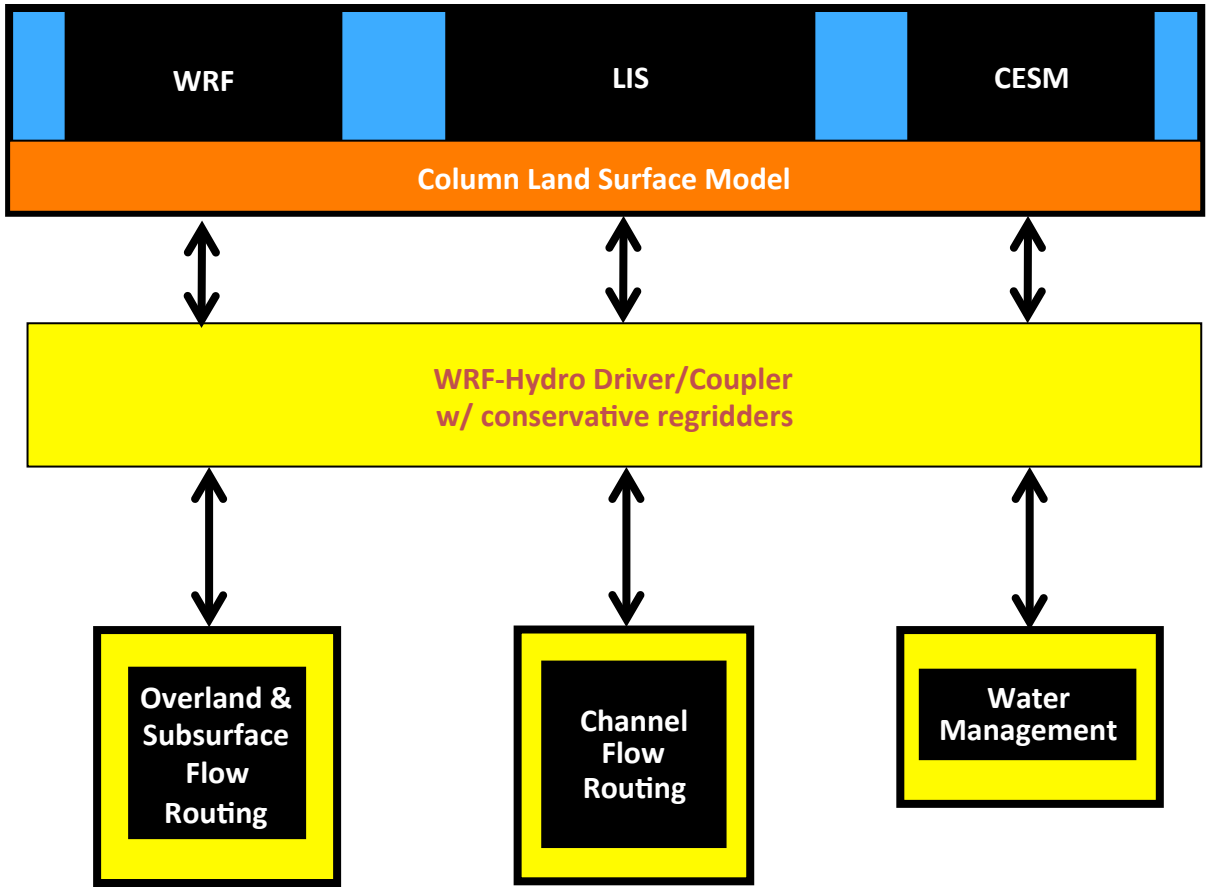
Conceptualization of WRF-Hydro Off-line

- Multi-scale/Multi-physics modeling…



Conceptualization of WRF-Hydro Coupling

- Multi-scale/Multi-physics modeling…



Data Grids

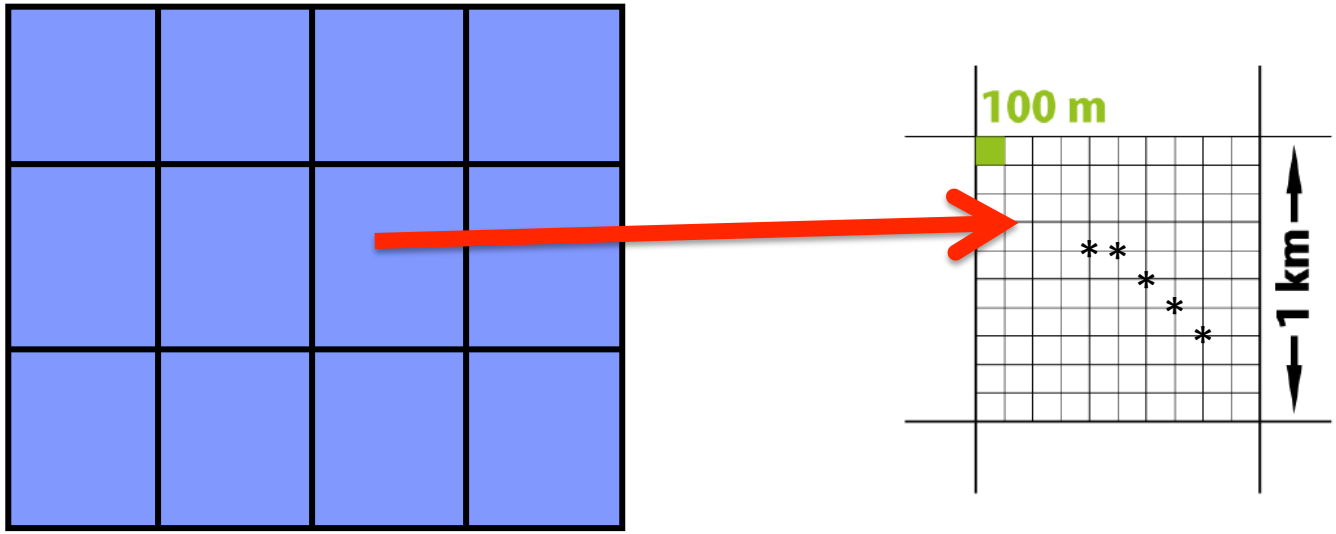
- Three Types of Data Grids

  Land Grids: (ix, jx), (ix, jx, n_soil_layer)

  Land Routing: (ixrt, jxrt), (ixrt, jxrt, n_soil_layer)

  Channel Routing: (n_nodes), (n_lakes)
- Parallel Scheme
  - Two dimensional domain decomposition
  - Distributed system (MPI) only

WRF-Hydro Multi-Grids Domain



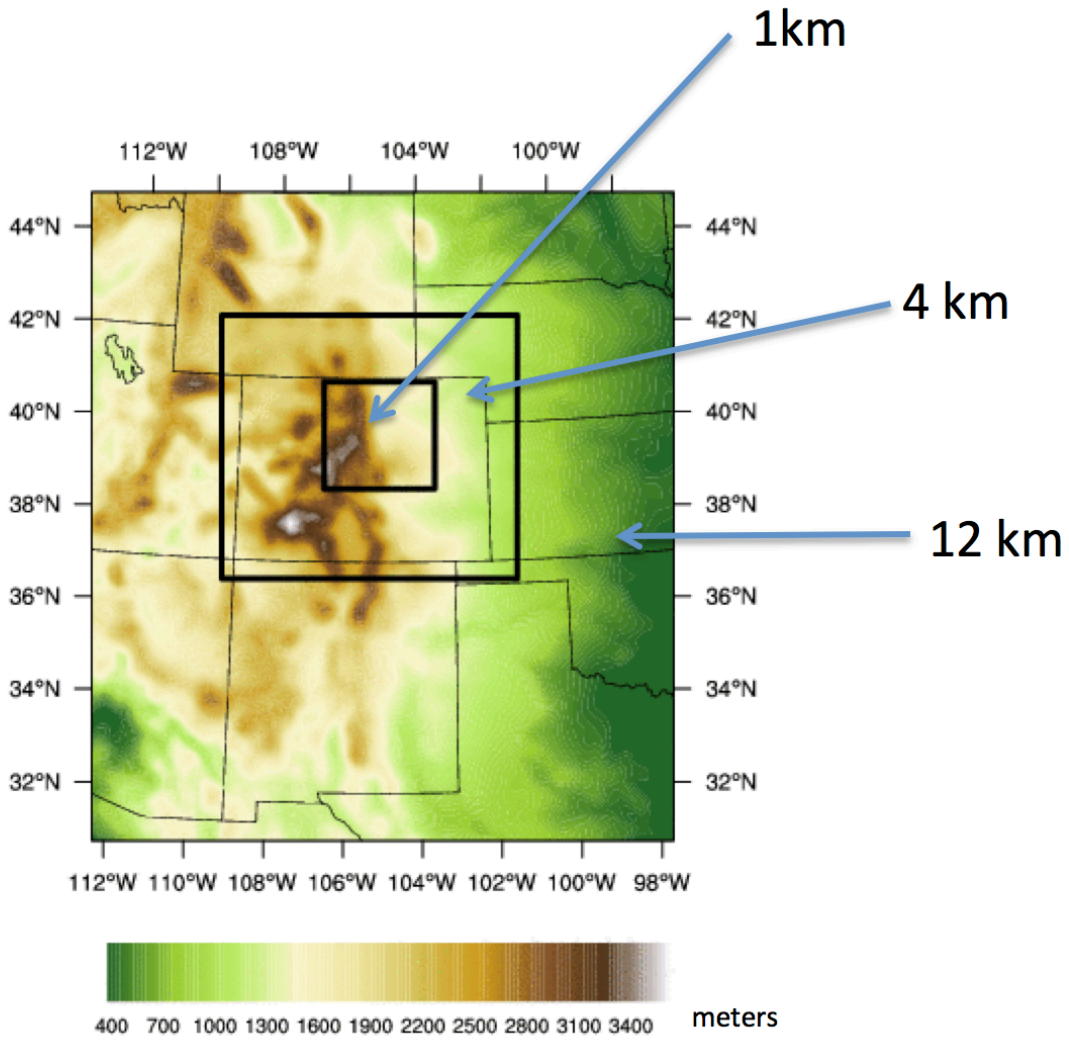
1 km Land grid

Land routing grid cell: regridding

Compiling

- Offline
  - Directory: WRFV3/hydro
  - Choose compiler options (./configure)
  - Building WRF-Hydro
    - with Noah (./compile_offline_Noah.csh)
    - With NoahMP (./compile_offline_NoahMP.csh)
- WRF fully coupled
  - setenv WRF_HYDRO 1

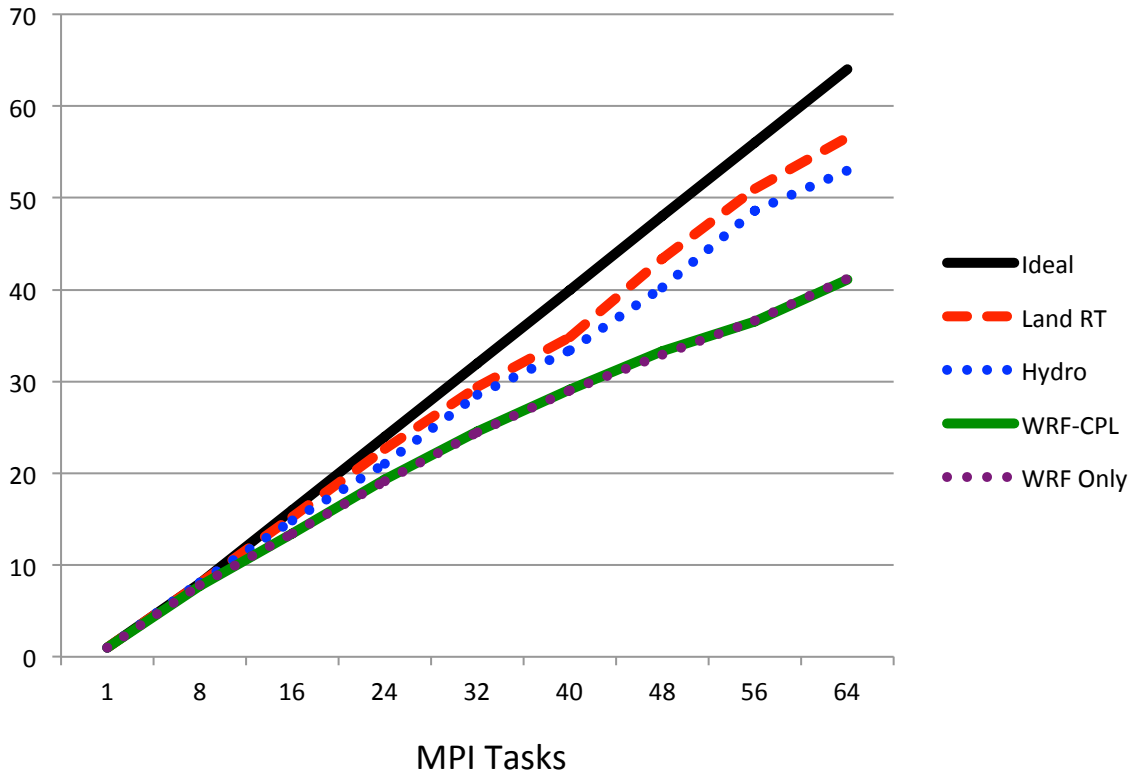
Front Range Model Domain



WRF-Hydro Performance Speedup

Time of Sequential Run

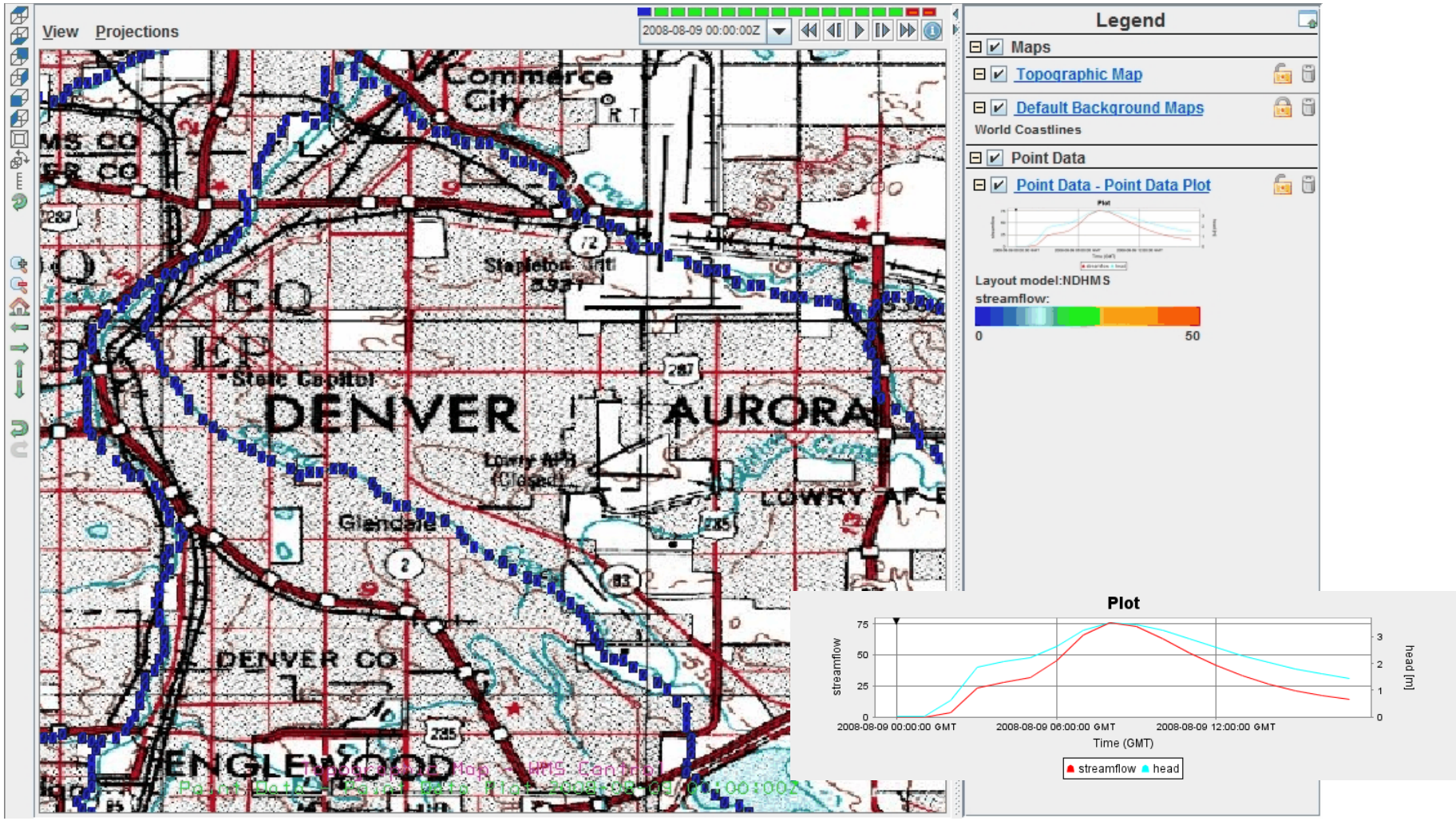
Time of Parallel Run



Hydro running time: 10%-20% of WRF run

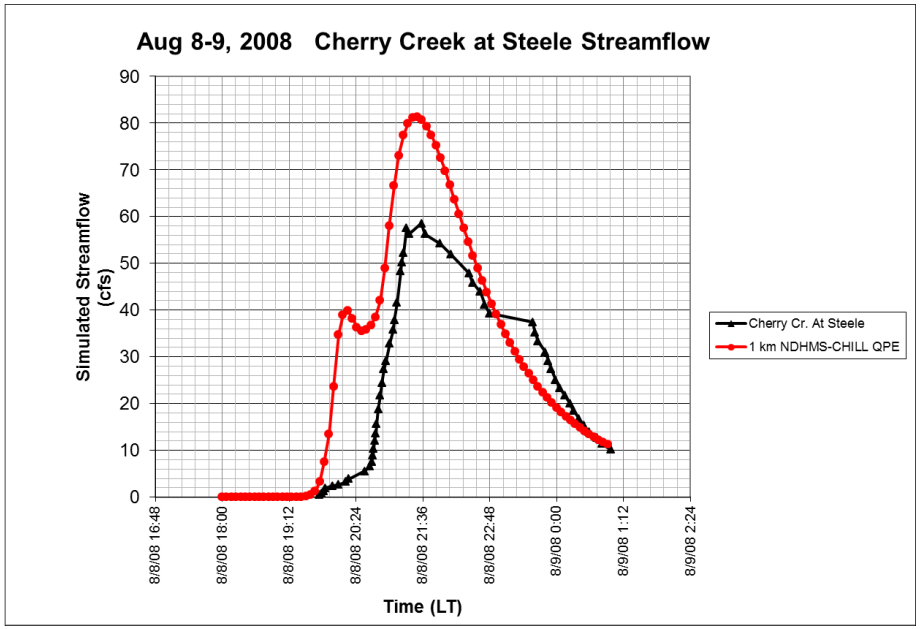
Initial Results: WRF-Hydro Simulations

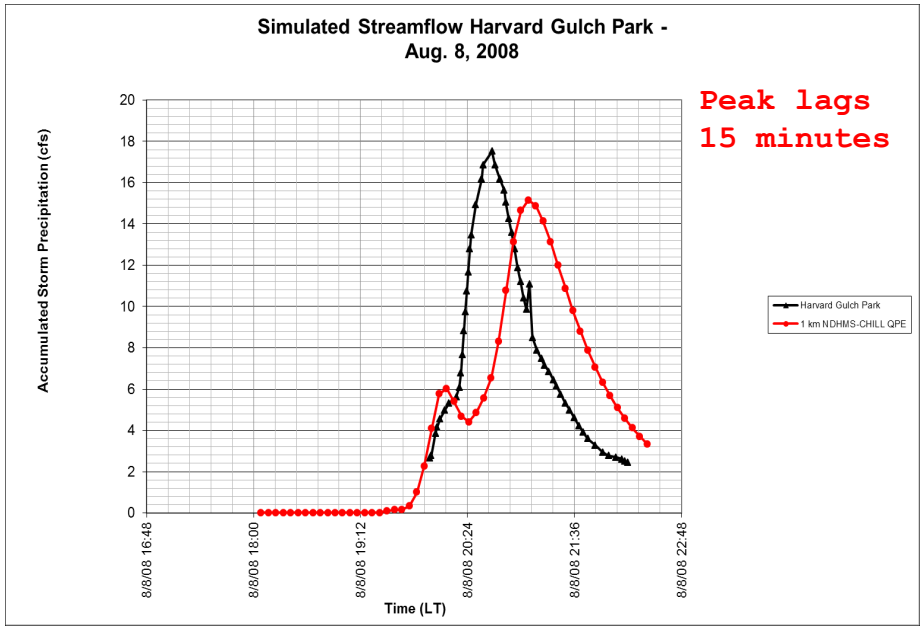
- Evaluation of simulated streamflow using multiple precipitation products: Aug. 8, 2008



Initial Results: WRF-Hydro Simulations

- Evaluation of simulated streamflow using multiple precipitation products: Aug. 8, 2008

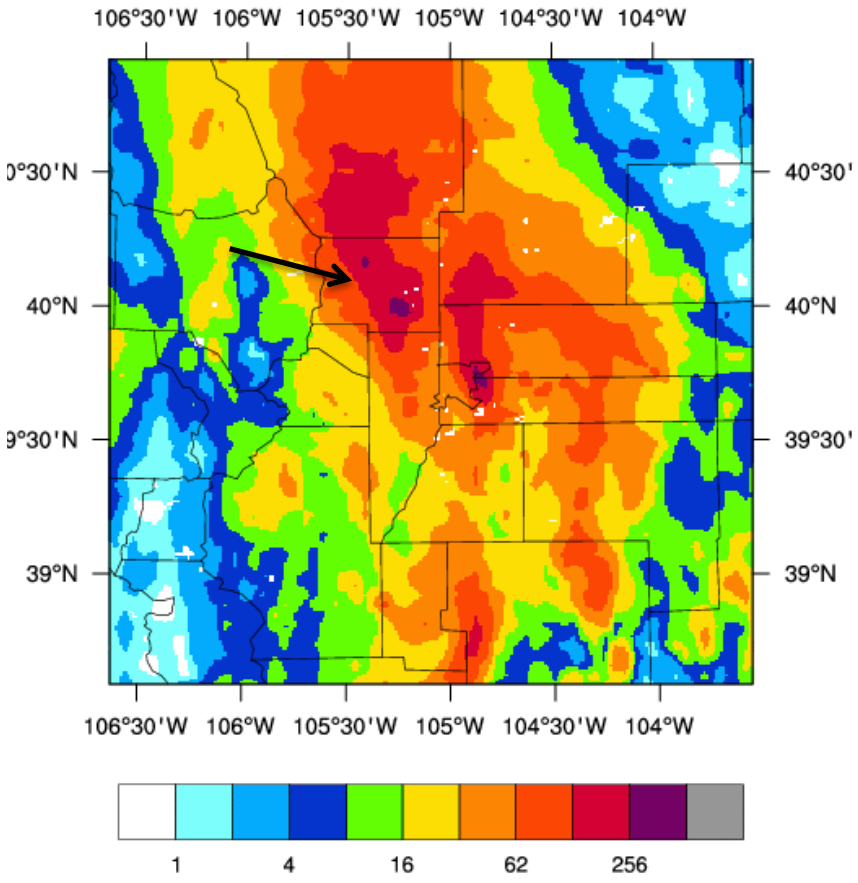




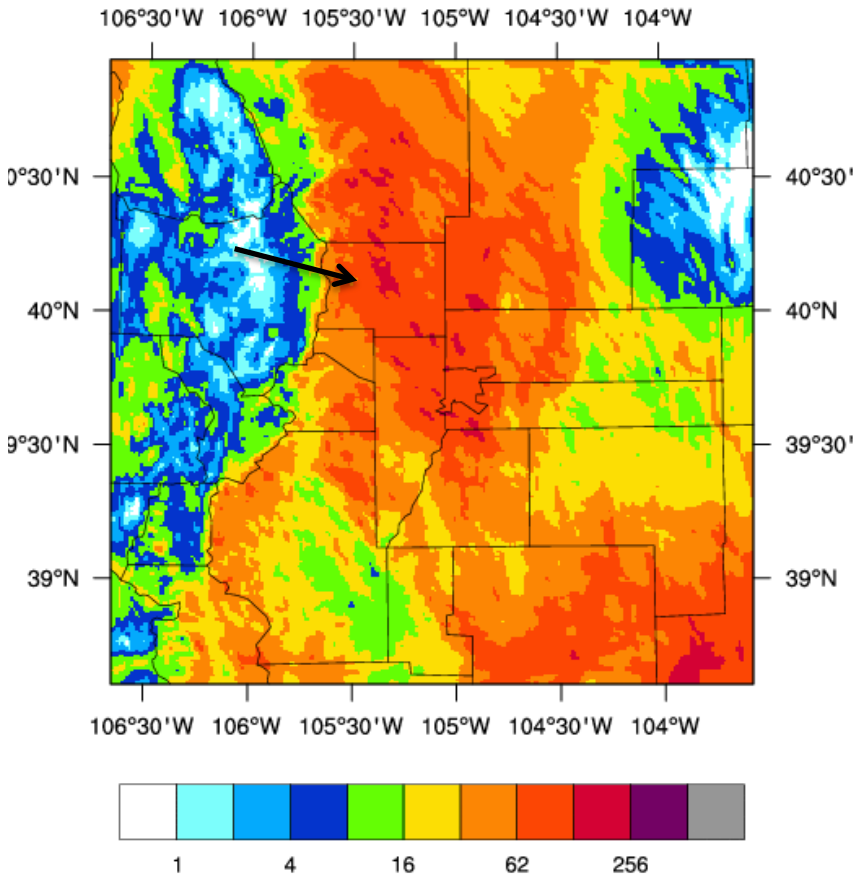
- Here the QPE is provided by the CSU-CHILL dual-polarimetric radar.
- Noah and CHILL QPE precipitation on a 1km grid, NDHMS routing executed on a 100m
- NDHMS-Noah is un-calibrated
- LIS-NDHMS coupling near complete…

48 hr accumulated Pcp validated at 2013091300Z

Multiple sensor precipitation Estimation (MPE)

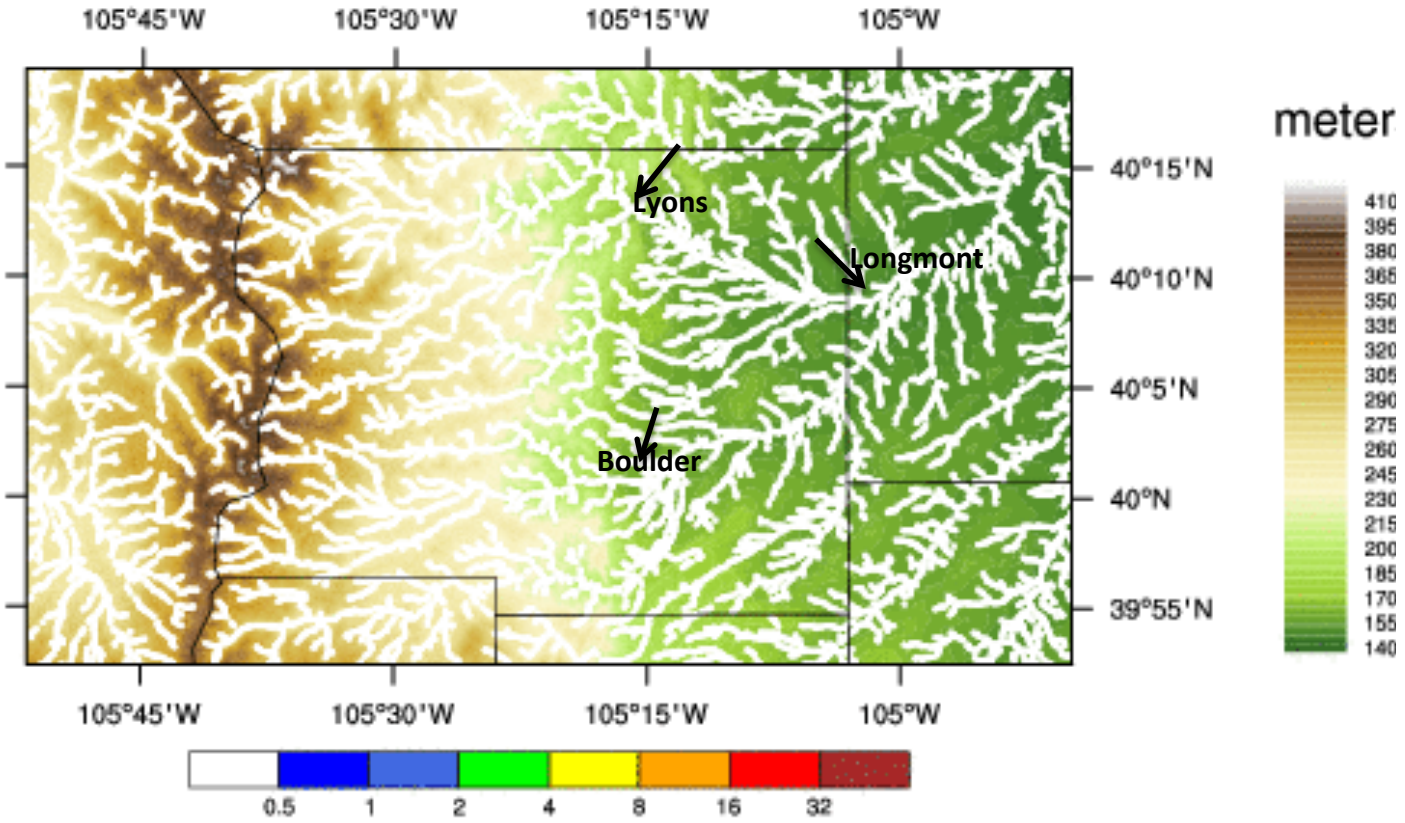


WRF



Stream Flow Forecast

2013091100Z – 2013091300Z



Future Work

- IO for large domain application
- Stream flow data assimilation
- Coupling with CLM

Thank you!