

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

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# Motivating Questions behind WRF-Hydro development:

1. What are the essential physical processes that need to be represented in modern, physics-based, hydrometeorological forecasting systems?
2. Are there ways to better facilitate and support coupling of hydrological models to WRF and other weather/climate architectures?



# What is WRF-Hydro Extension Package?

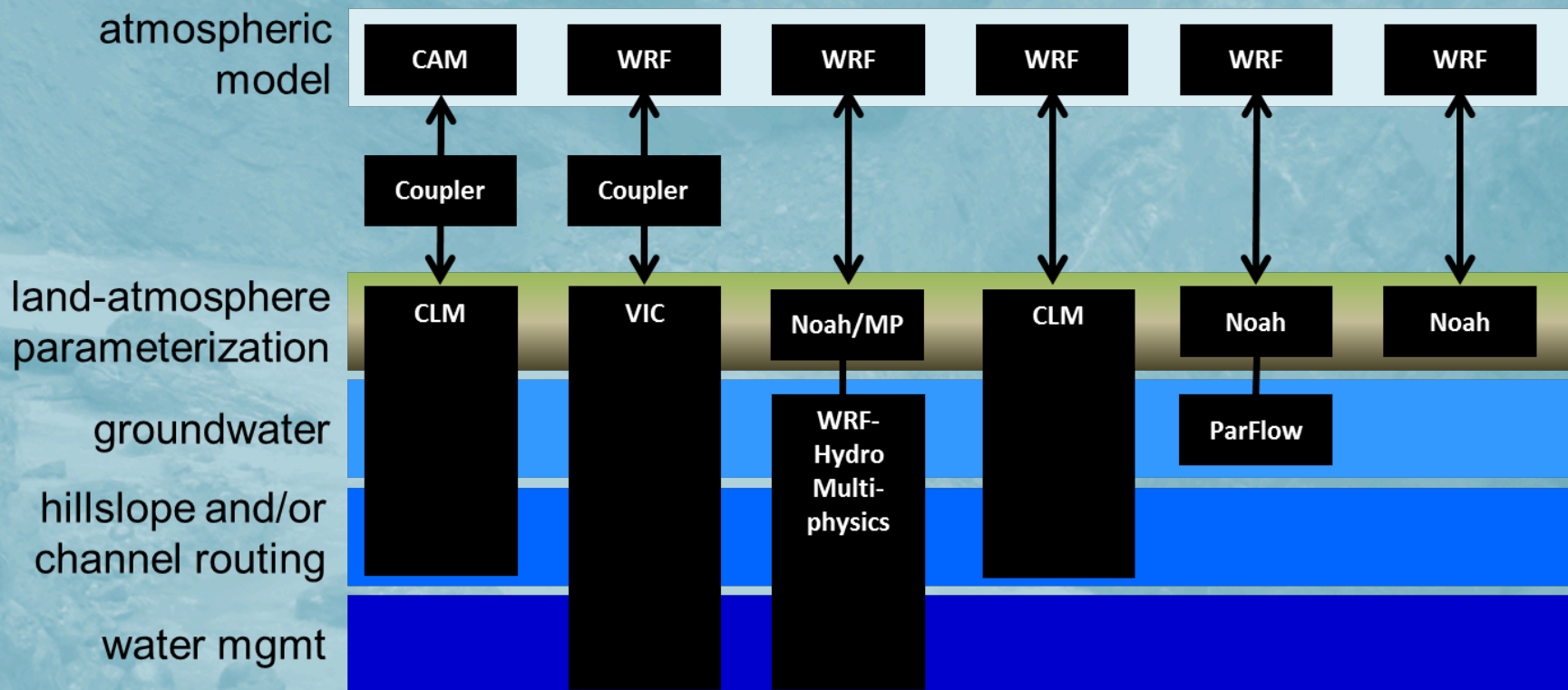
WRF-Hydro is a community-based, coupling architecture designed to couple *multi-scale* process models of the atmosphere and terrestrial hydrology

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. Leverage existing and emerging standards in data formats and pre-/post-processing workflows
4. An extensible, portable and scalable environment for hypothesis testing, sensitivity analysis, data assimilation and observation impact research

# Motivation for WRF-Hydro:

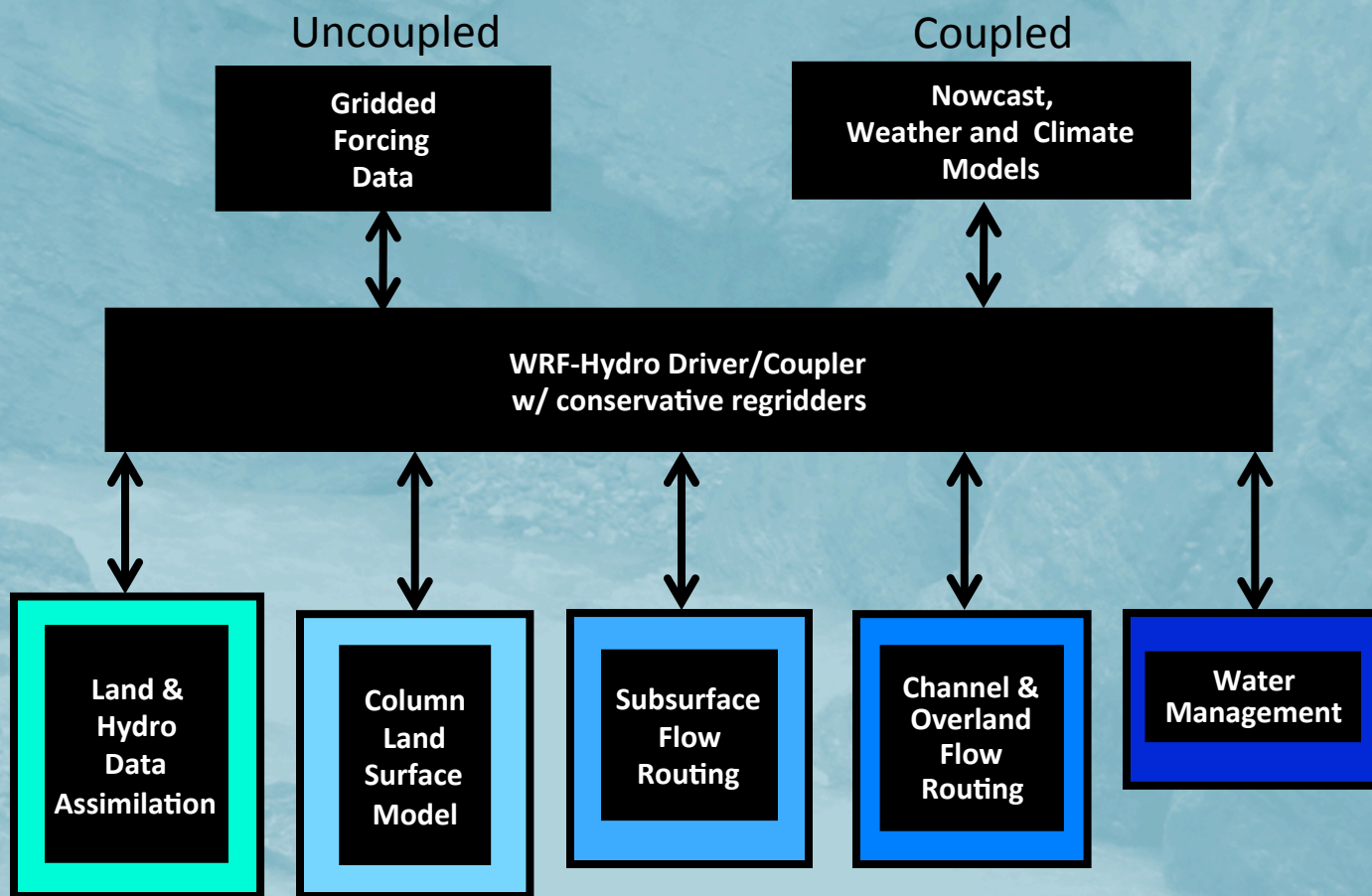
- Problem Statement: Components of Earth Systems Models are often stove-piped by geoscience domains which limits interoperability with other domains





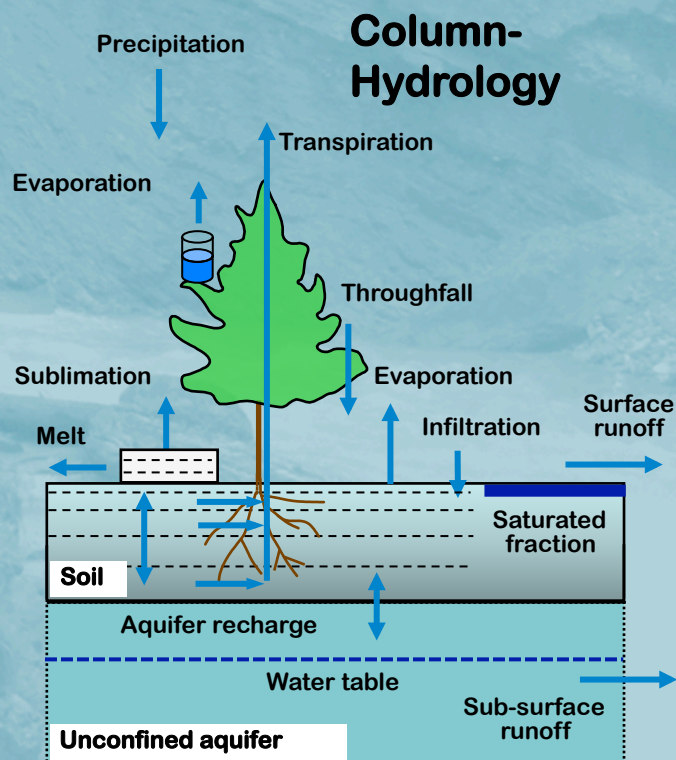
# Conceptualization of WRF-Hydro:

- Multi-scale/Multi-physics modeling...

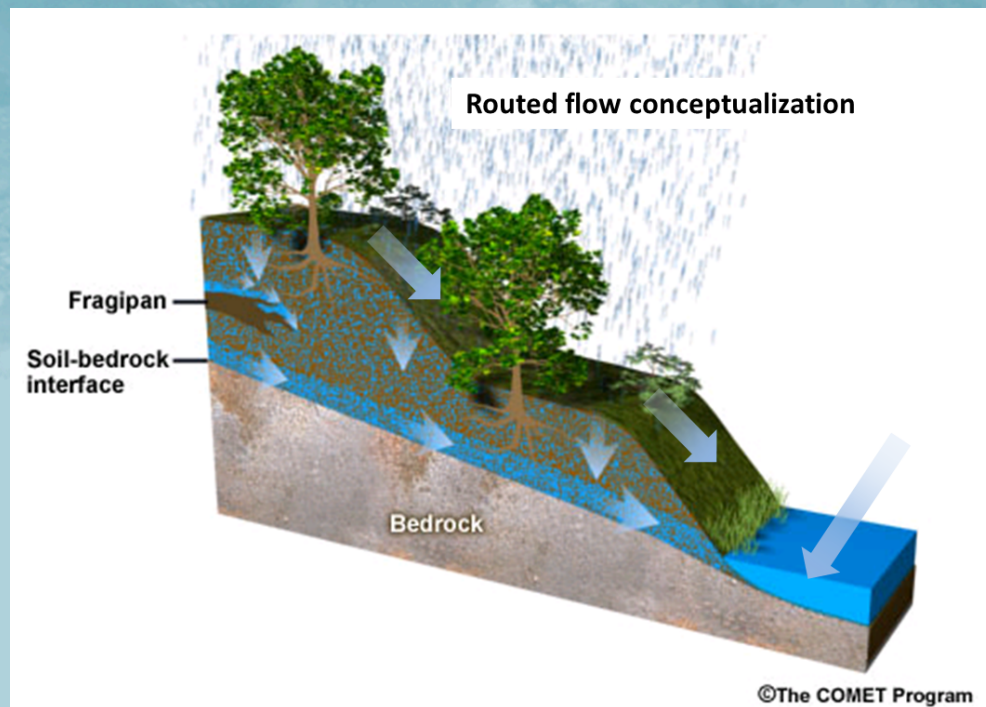


# Philosophy of WRF-Hydro:

- Where appropriate, maintain integrity of the 1-d column physics structure of individual LSMs while adding the capability to account for various lateral redistribution processes:



## Lateral Flows

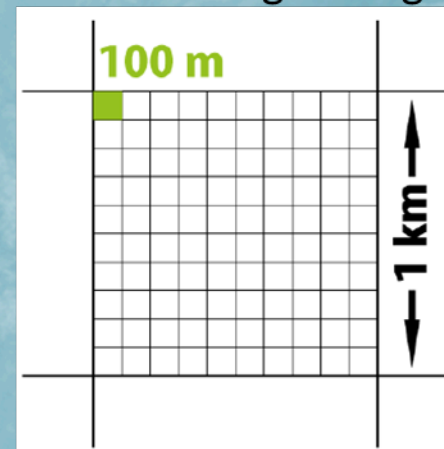




# Physics Options Currently Available:

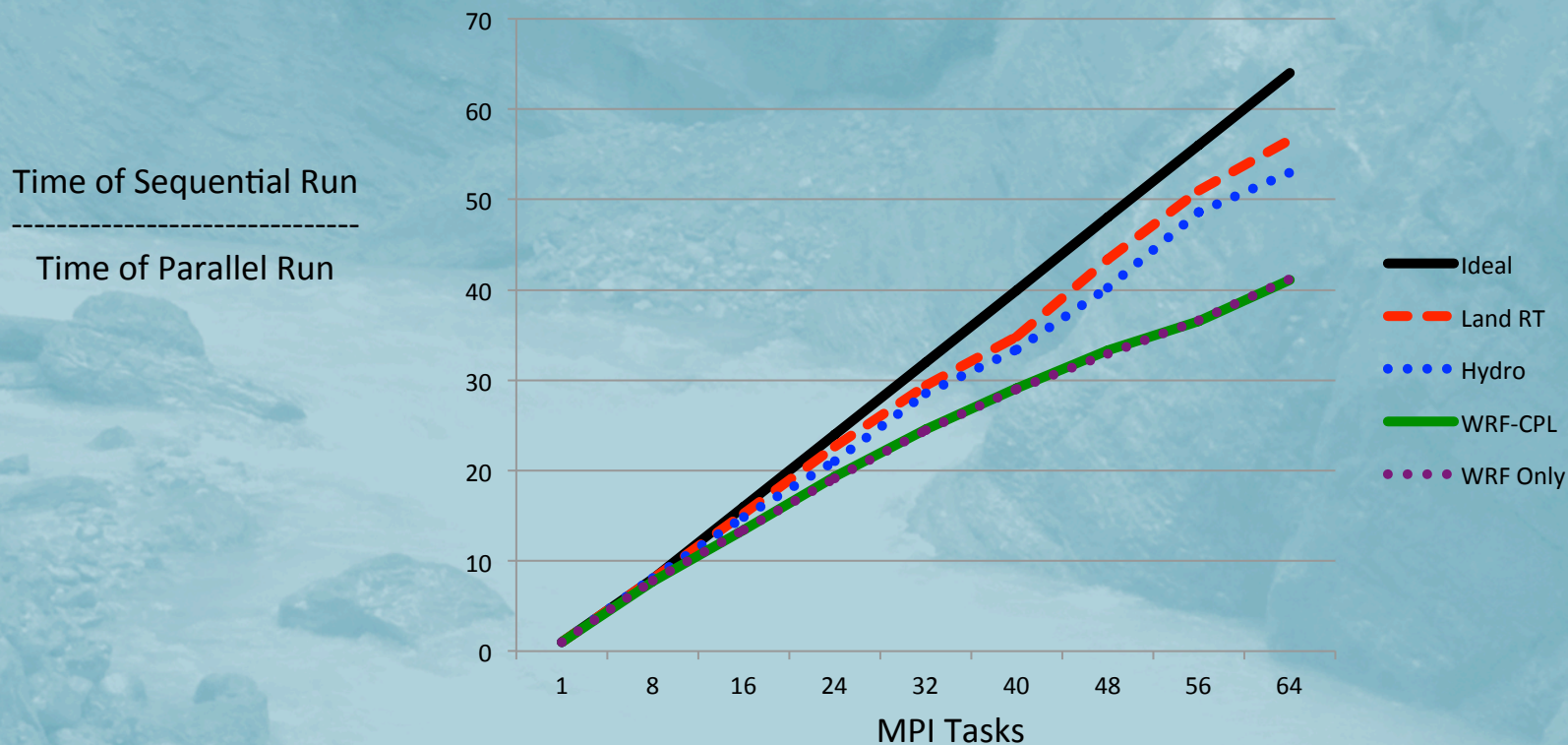
- Column land surface models supported:
  - Noah...Noah-MP,CLM,RUC in progress
- WRF-to-routing grid aggregation/disaggregation mapping
- Lateral flow components:
  - Diffusive wave overland flow (gridded)
  - Boussinesq/saturated subsurface flow (gridded)
  - Baseflow bucket model (lumped to gridded channel)
  - Diffusive wave channel flow (gridded)
  - Muskingam-type channel flow (reach based)
- Level pool reservoir flow (lumped object)

Current 'Regridding'



# WRF-Hydro features:

- Several pre- & post-processing tools available
- Can be run 'coupled' or 'uncoupled' to WRF
- Separate I/O from WRF (no WRF-registry mods.)
- Parallelized for HPC systems:







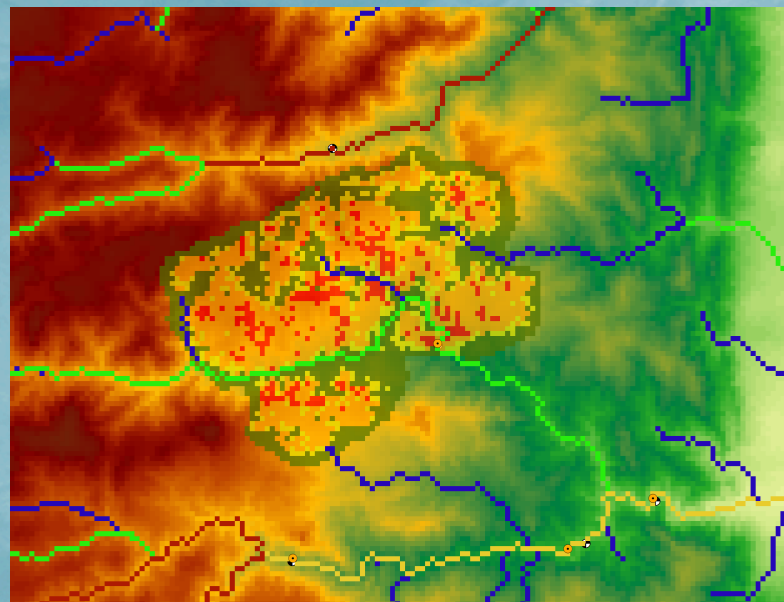
# **Recent Application: Hyrdometeorology in burned landscapes**

Photo Credit: Aaron Ontiveroz, The Denver Post

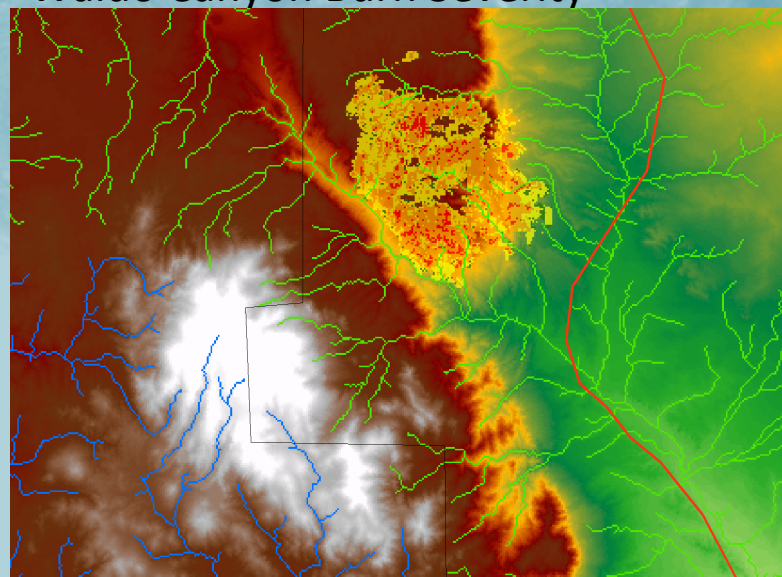
# Fire Impacts on Hydrometeorology:

- Inserting 'fire-burned' landscapes into Noah/ Noah-MP and WRF-Hydro
- 14 active fires now
  - 2011 Fourmile Canyon
  - 2012 Waldo Canyon
  - 2012 High Park
  - 2012 Upp. N. Fork
- Use 'burn-severity' index as a 'VEGTYP' category and calibration filter

Fourmile Canyon Burn Severity

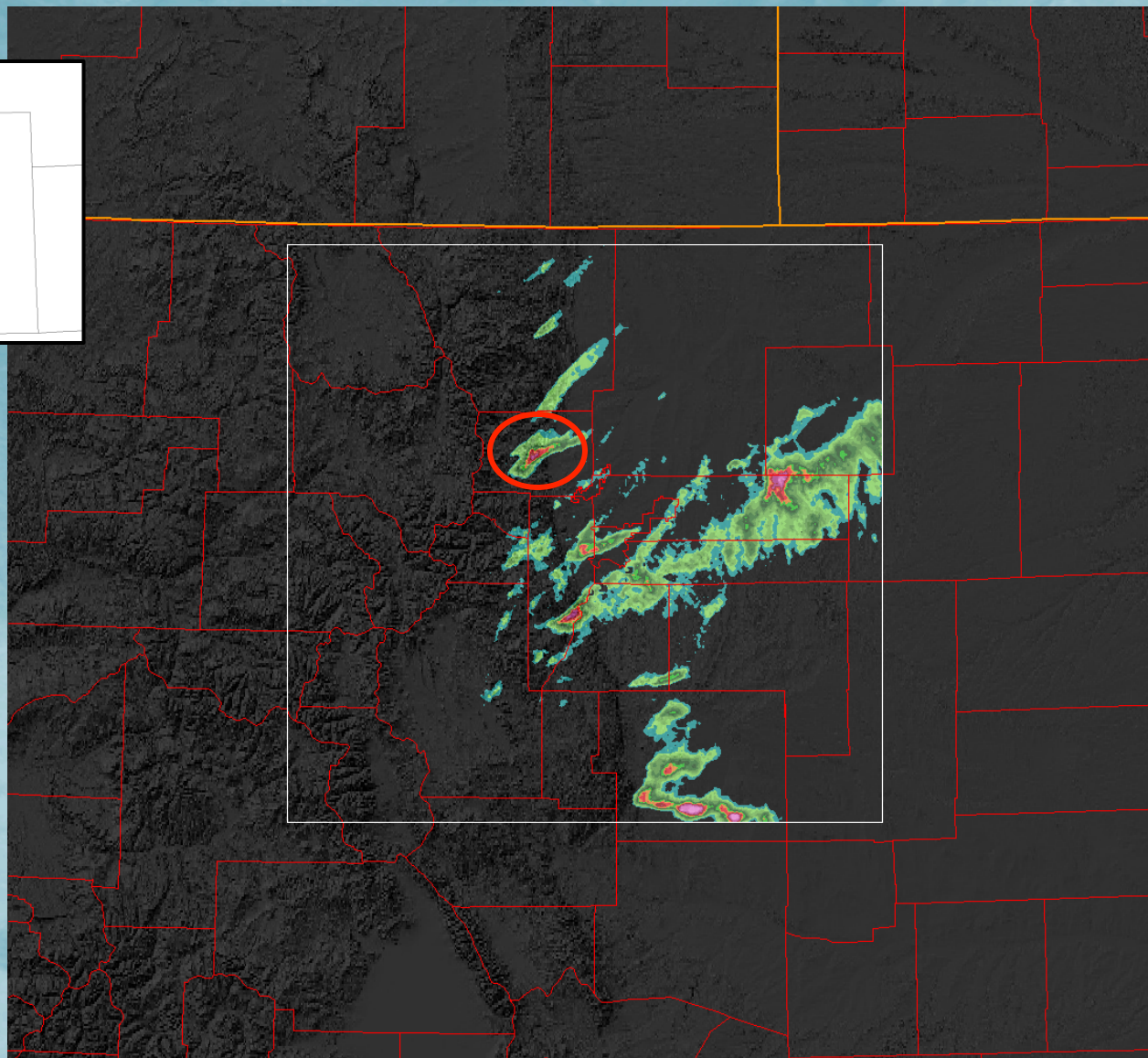
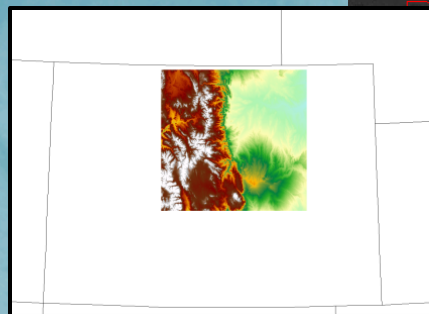


Waldo Canyon Burn Severity





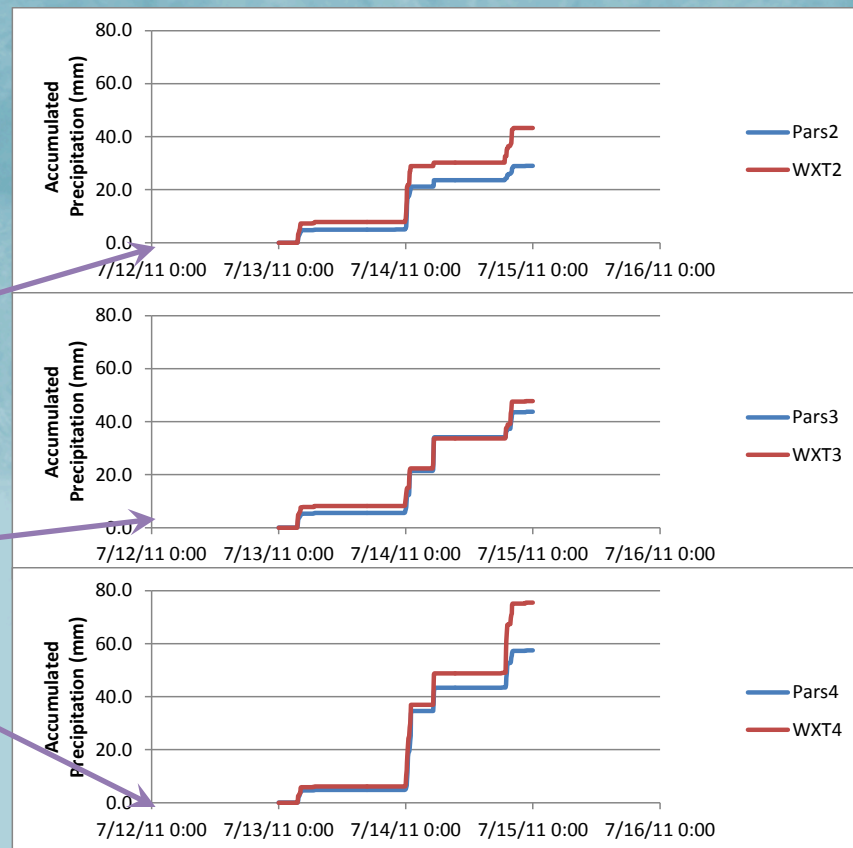
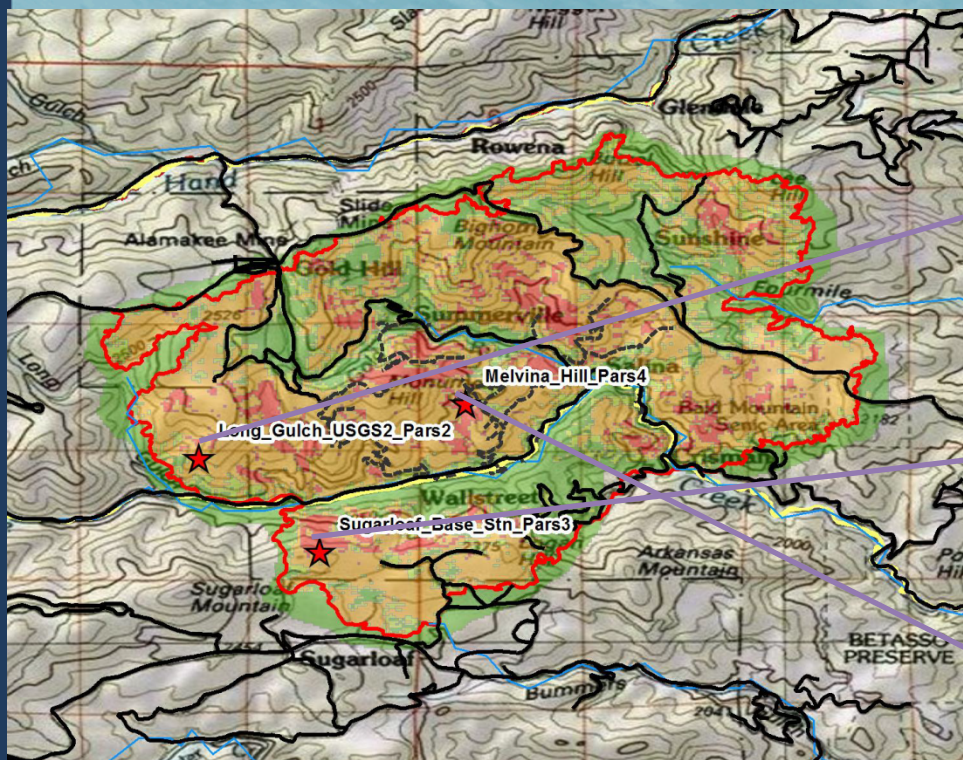
# July 13, 2011 Fourmile Canyon Flood Event: Coupled WRF-Hydro/RTFDDA model prediction...12 hour lead time



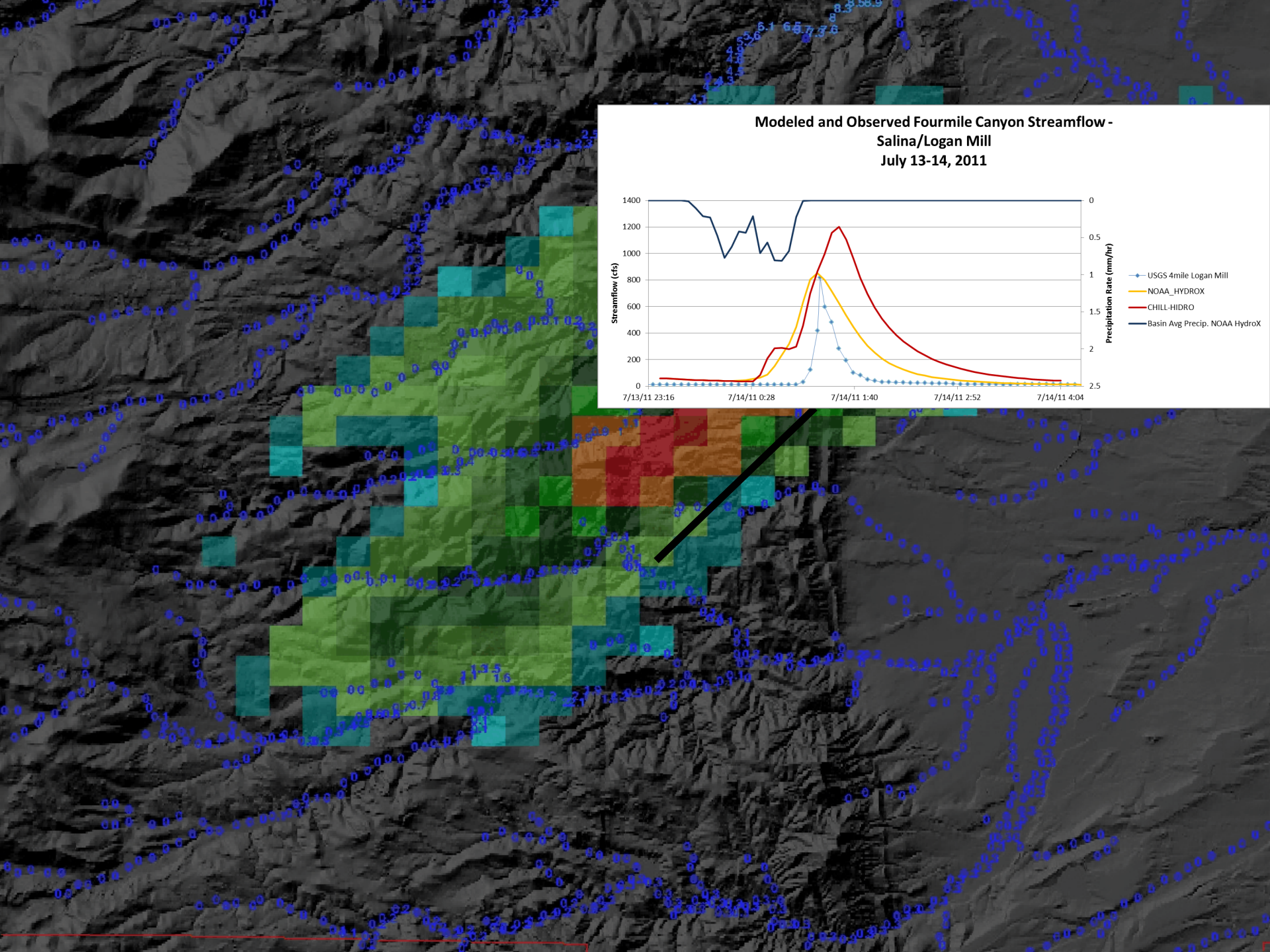


# July 13, 2011 Fourmile Canyon Flood Event:

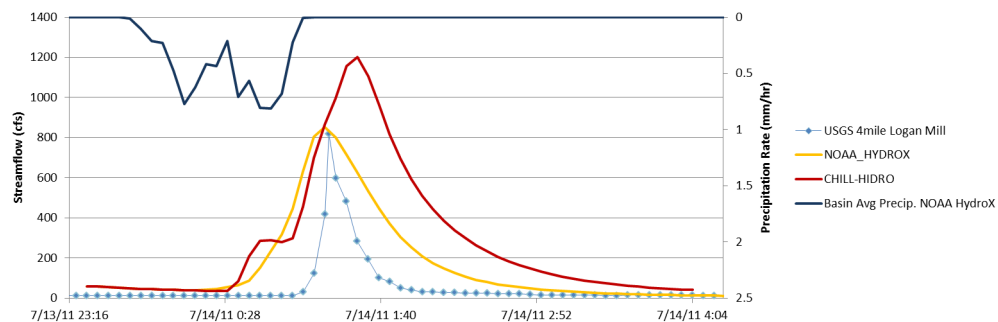
- Severe fire in Sept. 2010 in the ex-urban interface & complex terrain
- Between 25-40mm in 1.5 hours over severely burned area
- Flooding and debris flow ensued



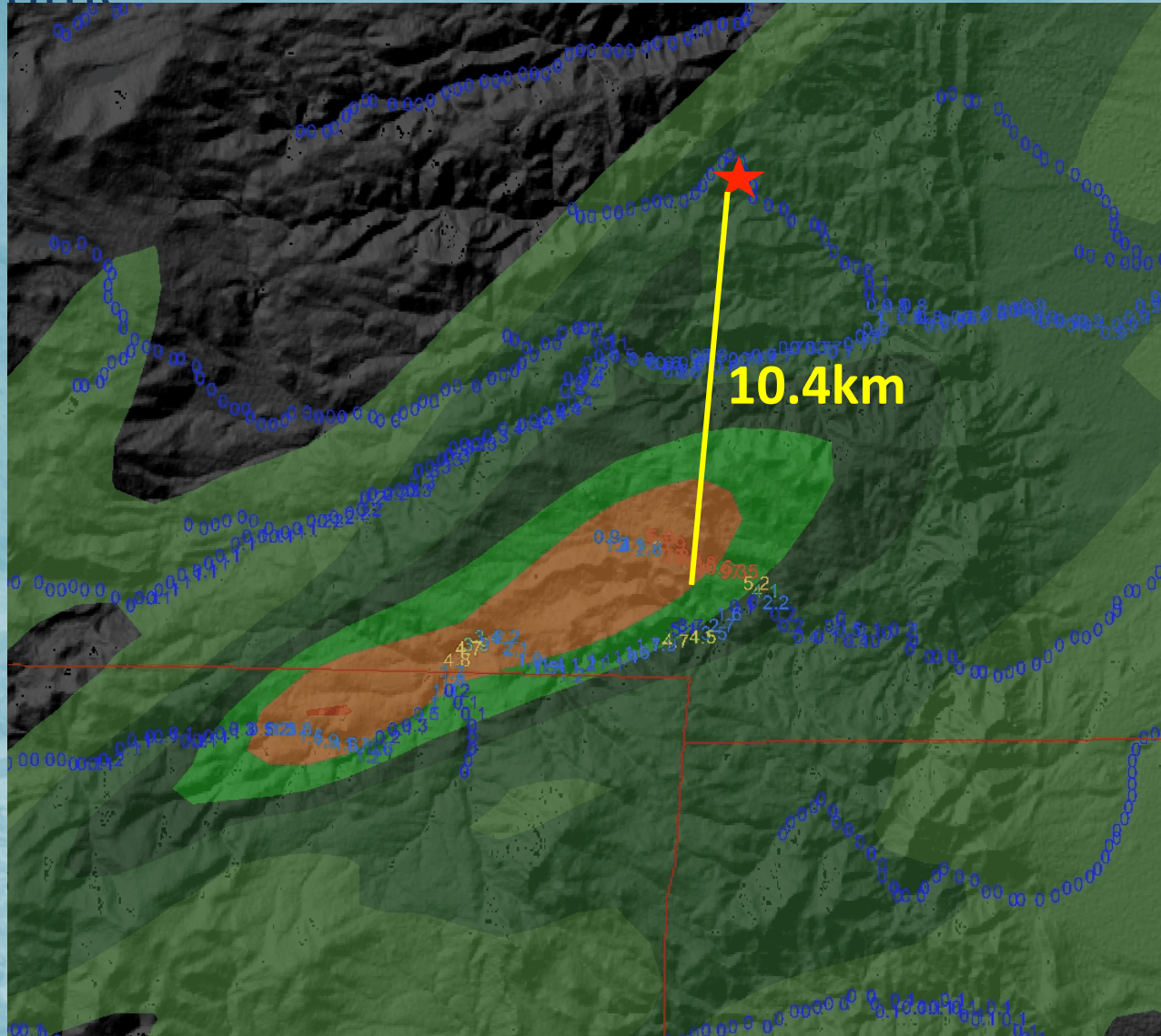




Modeled and Observed Fourmile Canyon Streamflow -  
Salina/Logan Mill  
July 13-14, 2011









# WRF-Hydro Extension Package Status:

- Code & Documentation now available on WRF-Hydro website: [http://www.ral.ucar.edu/projects/wrf\\_hydro/](http://www.ral.ucar.edu/projects/wrf_hydro/)
- Tested on multiple platforms and compilers (Yellowstone-enabled, XSEDE, Linux-clusters, MAC)
- Test cases available online
- GIS pre-processing tools now available
  - Web service for pre-processing coming soon
- User support just now getting going...
- Working group to be convened over the next 6 months

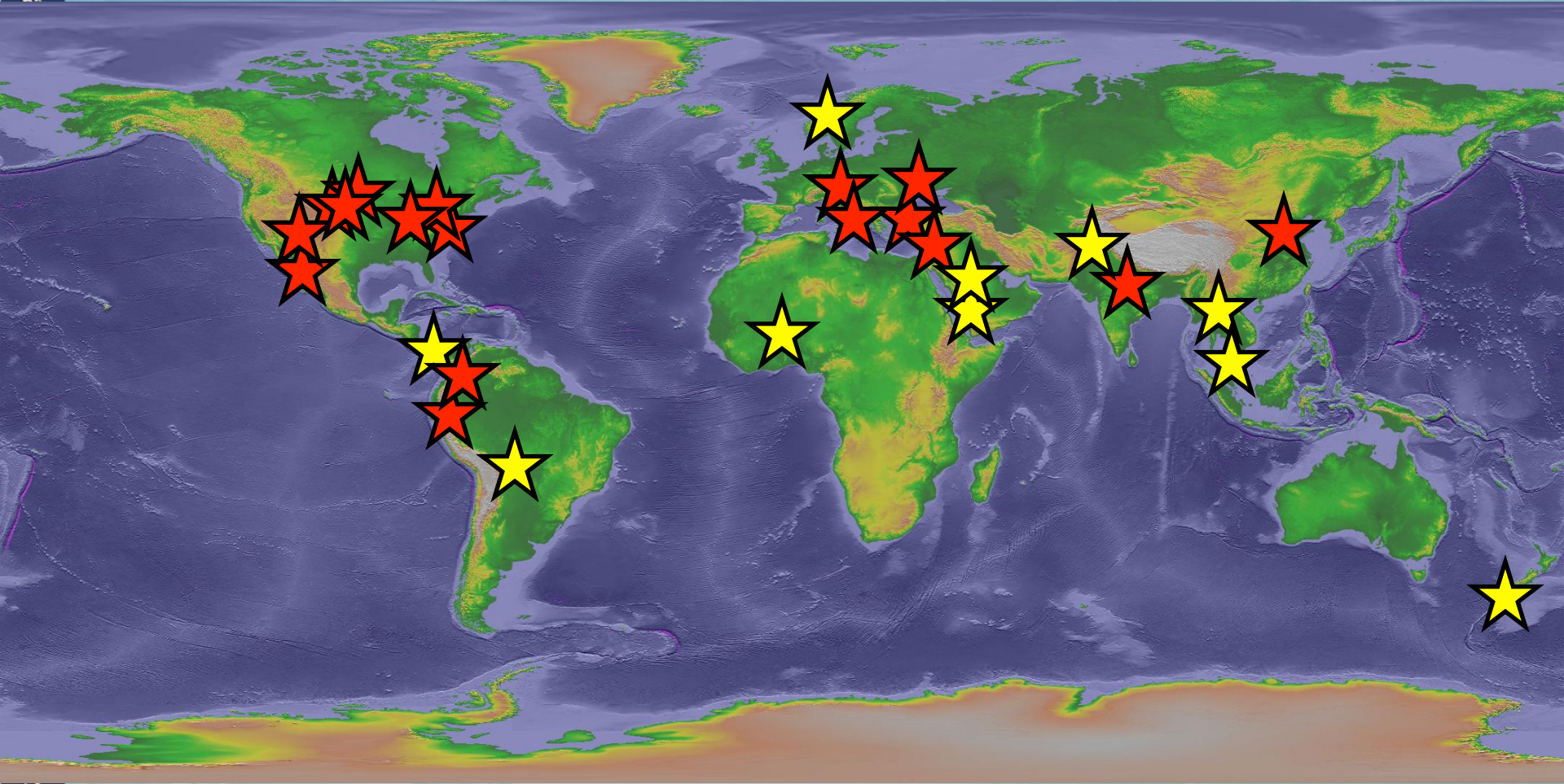
# The End...

*See you Friday morning!*

[http://www.ral.ucar.edu/projects/wrf\\_hydro/](http://www.ral.ucar.edu/projects/wrf_hydro/)



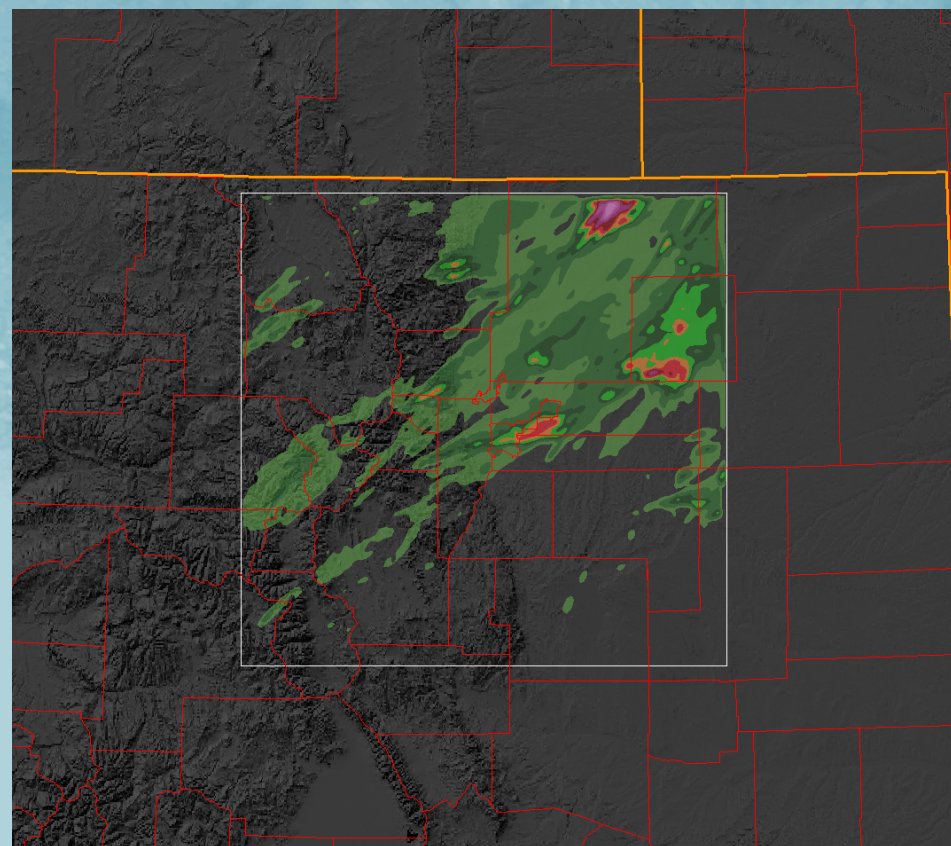
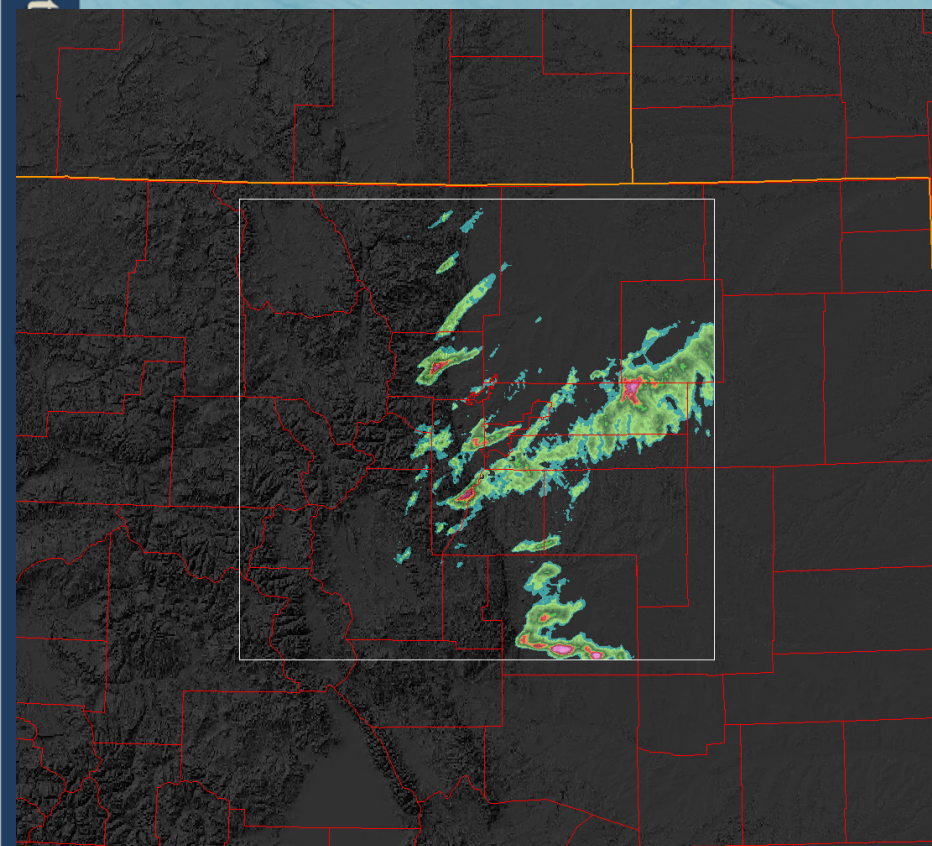
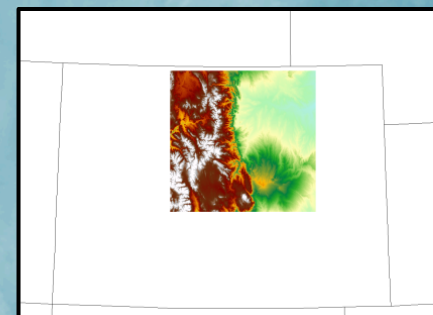
# WRF-Hydro Community of Developers & Users:



- ★ Past or current implementations
- ★ Recently proposed implementations



# July 13, 2011 Fourmile Canyon Flood Event: Coupled WRF-Hydro/RTFDDA model prediction...12 hour lead time





# WRF-Hydro 'Hydro-Grid' Web Service: Tool Output

The screenshot shows a Mozilla Firefox browser window displaying the WRF-Hydro Modeling System web page. The browser's address bar shows the URL [http://www.ral.ucar.edu/projects/wrf\\_hydro/](http://www.ral.ucar.edu/projects/wrf_hydro/). The page features a navigation menu with links to RAL home, research, technology, people/org, publications, events, pressroom, and for staff. The main content area is titled "WRF-Hydro Modeling System" and includes a "Welcome" message, a "Description" section, and a list of "Projects". The "Description" section states that the WRF-Hydro system was originally designed as a model coupling framework to facilitate easier coupling between the Weather Research and Forecasting model and components of terrestrial hydrological models. The "Projects" section lists several ongoing and past projects, including the Colorado Headwaters Water System Program, Flash Flood System, North American Monsoon Experiment, and the CASES-97 (Cooperative Atmosphere Surface Exchange Study).

WRF-Hydro Modeling System

You are here: NCAR • RAL • WRF-Hydro Modeling System

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**WRF-Hydro Modeling System**

**Welcome**

Welcome to the users page for the WRF-Hydro modeling system. The WRF-Hydro modeling system has been developed by the National Center for Atmospheric Research and its research partners through the generous support of the U.S. National Science Foundation and through research projects supported by the U.S. National Aeronautics and Space Administration (NASA) and the U.S. National Oceanic and Atmospheric Administration (NOAA).

**Description**

The WRF-Hydro system was originally designed as a model coupling framework designed to facilitate easier coupling between the Weather Research and Forecasting model and components of terrestrial hydrological models. WRF-Hydro is both a stand-alone hydrological modeling architecture as well as a coupling architecture for coupling of hydrological models with atmospheric models. WRF-Hydro is fully-parallelized to enable its usage on clusters and high performance computing systems alike. Like the WRF model it does not attempt to prescribe a particular or singular suite of physics but, instead, is designed to be extensible to new hydrological parameterizations. Although it was originally designed to be used within the WRF model, it has evolved over time to possess many additional attributes as follows:

- Multi-scale functionality to permit modeling of atmospheric, land surface and hydrological processes on different spatial grids

**Projects**

**HYDROMETEOROLOGICAL PROCESSES AT THE LAND SURFACE**

**Current Projects**

Colorado Headwaters Water System Program

Flash Flood System ([view article](#))

North American Monsoon Experiment ([view article](#))

Climate Impacts on local water resource management tool: WEAP ([view article](#))

**Past Projects**

CASES-97 (Cooperative Atmosphere Surface Exchange Study)

IHOP (Soil Moisture, Soil Temperature, and Vegetation Observation Network)

**Recent Accomplishments and Plans**

Annual Report

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