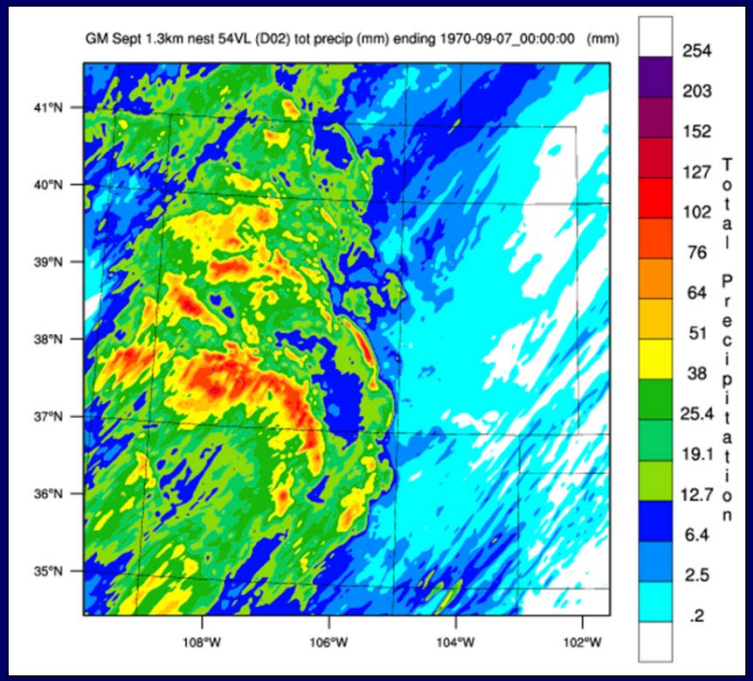
RECLAMATION
Managing Water in the West

Annual Progress Meeting on Reclamation Climate and Hydrology Research

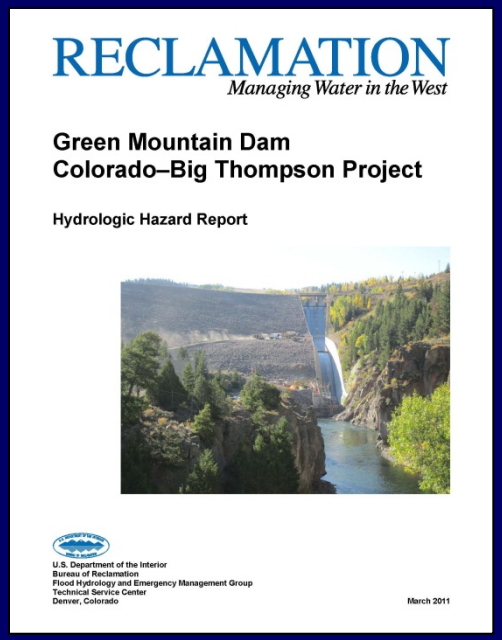
Green Mountain Dam Climate Change

Victoria Sankovich - Reclamation
Kelly Mahoney - CIRES



Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Research Background



RECLAMATION
Managing Water in the West

Green Mountain Dam
Colorado–Big Thompson Project

Hydrologic Hazard Report

U.S. Department of the Interior
Bureau of Reclamation
Flood Hydrology and Emergency Management Group
Technical Service Center
Denver, Colorado

March 2011

HMR 49 PMP Estimates for Green Mountain Dam	
18.58 inches	72 hours

Not seen in paleo record

HYDROMETEOROLOGICAL REPORT NO. 49

Probable Maximum Precipitation Estimates, Colorado River and Great Basin Drainages

REPRINTED 1984

PROPERTY OF:
NOAA,NATIONAL WEATHER SERVICE

U.S. DEPARTMENT OF COMMERCE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
U.S. DEPARTMENT OF ARMY
CORPS OF ENGINEERS

Silver Spring, Md.

NOAA Photo Library, NOAA Central Library

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Research Objective

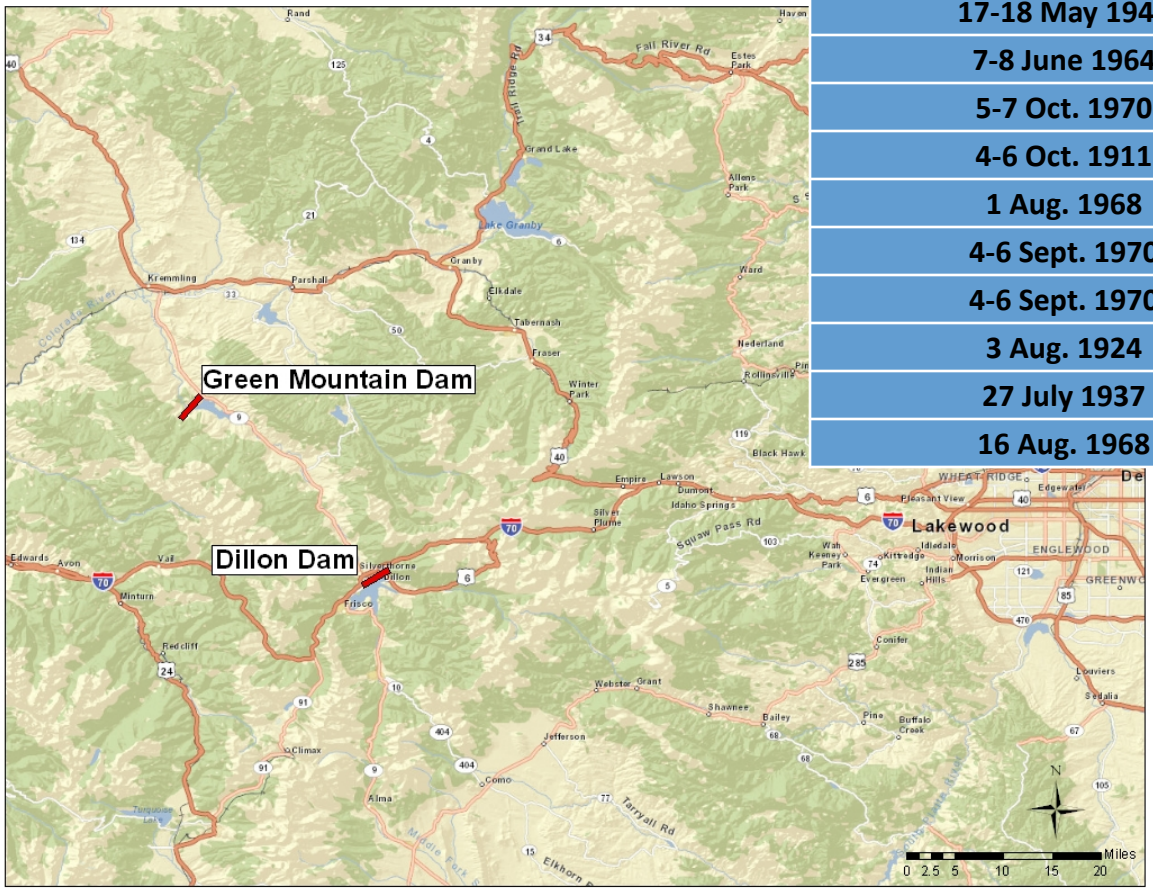
The capabilities of the WRF model will be investigated to:

- model historic, large precipitation events;
- allow users to maximize storm parameters;
- allow users to simulate storms under climate change ;
- aid users to understand the dynamics of an extreme event; and
- show how the meteorological aspect of Dam Safety projects could benefit and be improved by the latest technology.

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Previous Studies

Date	Center
1-3 June 1943	Glenwood Springs, CO
17-18 May 1944	East of Steamboat Springs, CO
7-8 June 1964	Spillover from Glacier Park, MT
5-7 Oct. 1970	Northeast of Steamboat Spring, CO
4-6 Oct. 1911	Gladstone, CO
1 Aug. 1968	Blanding-Monticello, UT
4-6 Sept. 1970	Bug Point, UT
4-6 Sept. 1970	South of Silverton, CO
3 Aug. 1924	Mesa Verde National Park, CO
27 July 1937	Leadville, CO
16 Aug. 1968	Morgan, UT



Estimates for Dillon Dam	
7.97 inches	48 hours

"None of the storms analyzed support the severity of the HMR 49 curve"

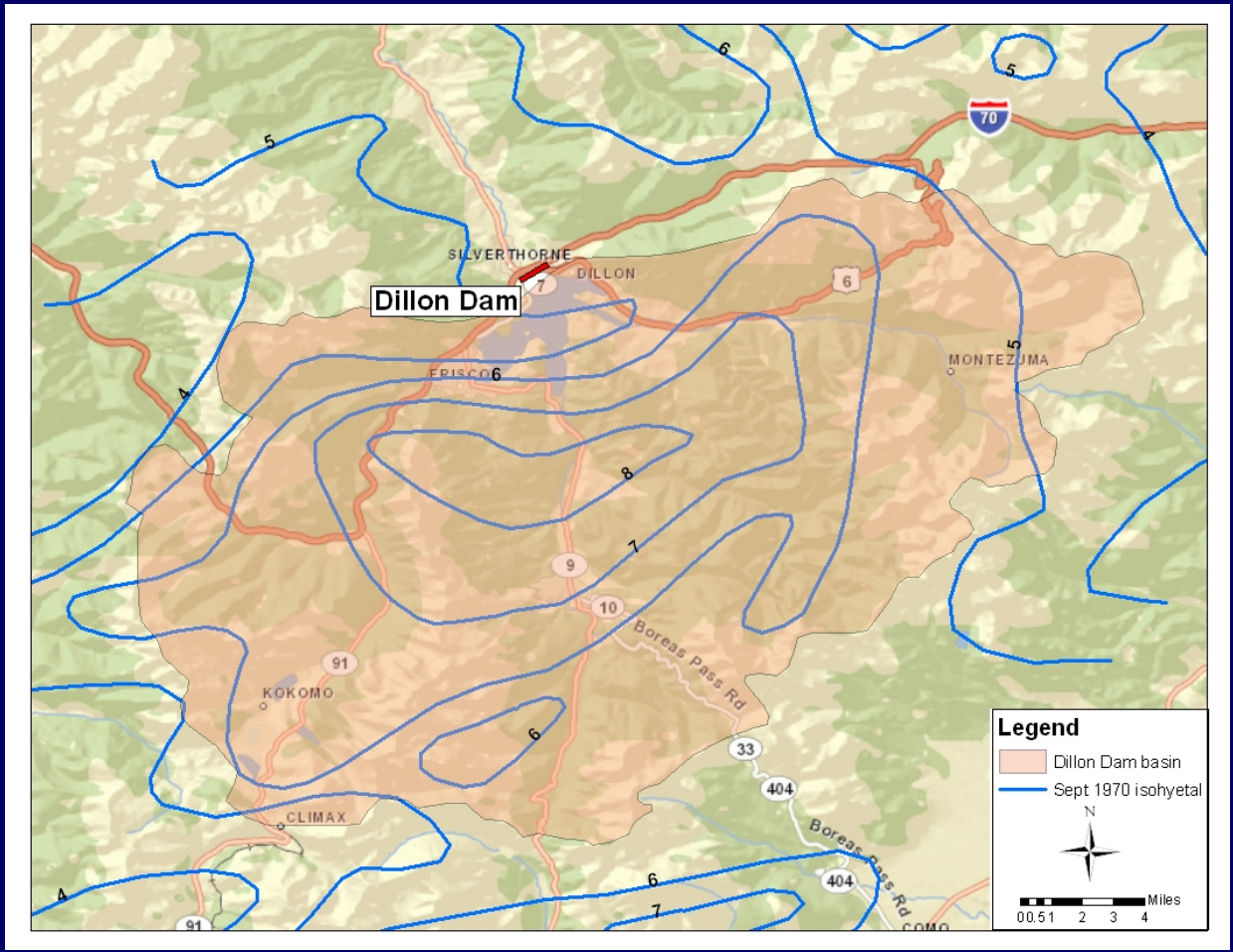
Design Storm Study for Dillon Dam (Bertle, 1982)

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Storm Used in Analysis

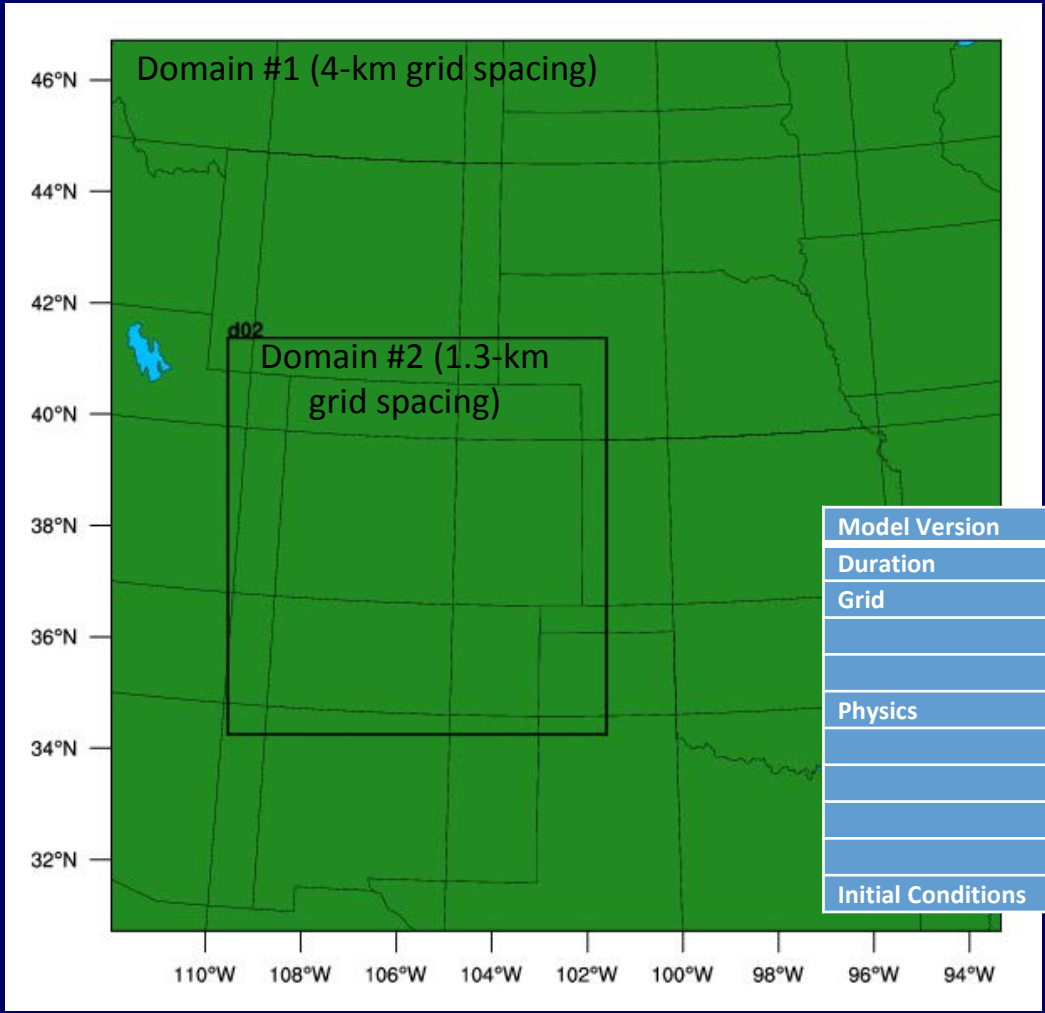
4-6 Sept. 1970

- Original center is south of Silverton, CO
- Transposed to Dillon Dam watershed
- Highest precip at center is 8”
- Basin-average is 6.15”



Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Methodology



- Control simulations
- Moisture maximization
- Climate change perturbation

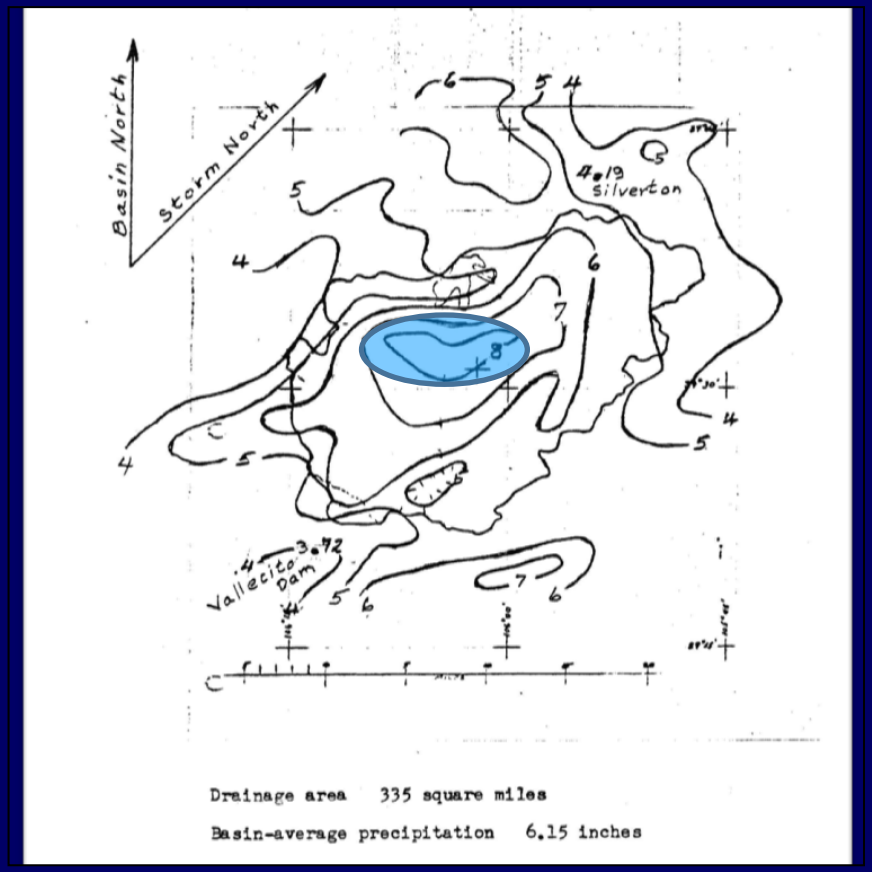
Model Version	**WRF (ARW) Version 3.3.1**
Duration	72 hours; output frequency: 1-hour
Grid	1.3-km grid spacing (within a 4-km outer nest)
	574 x 601 gridpoint domain (outer domain 450 x 450)
	54 vertical levels
Physics	Explicit convection (no cumulus parameterization)
	Thompson microphysics
	YSU planetary boundary layer (PBL) scheme
	NOAH land-surface model, Monin-Obukhov surface layer physics
	Dudhia, RRTM radiation physics
Initial Conditions	NCEP/NCAR Reanalysis Project (NNRP) dataset (Kalnay et al., 1996)

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

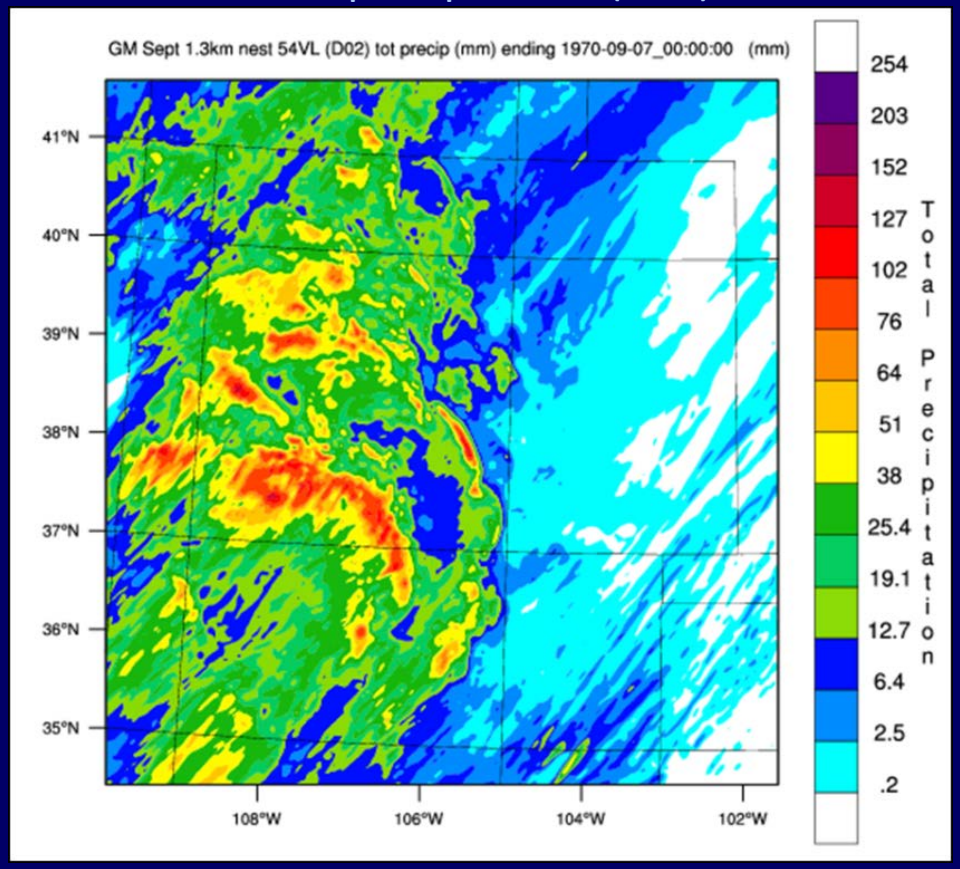
Preliminary Results: Control Simulation

Manual precipitation analysis 4 – 6 Sept 1970

Extrapolated from bucket survey data, rotated(?)



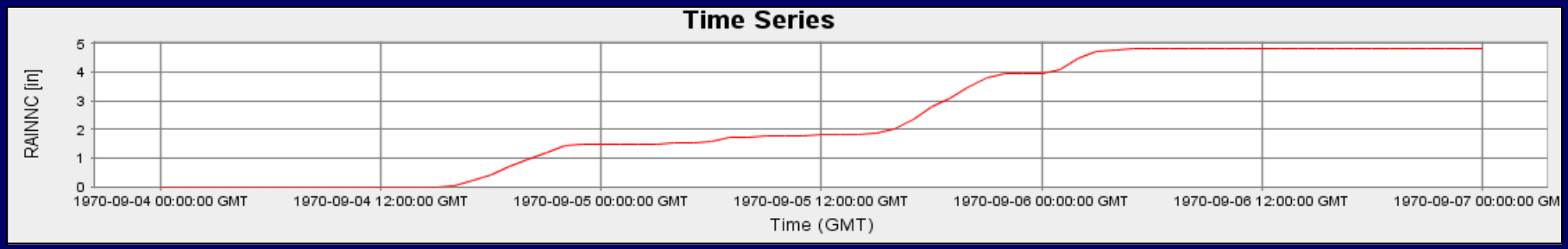
WRF Control (CTRL) 4 – 6 Sept 1970 72-h total precipitation (mm)

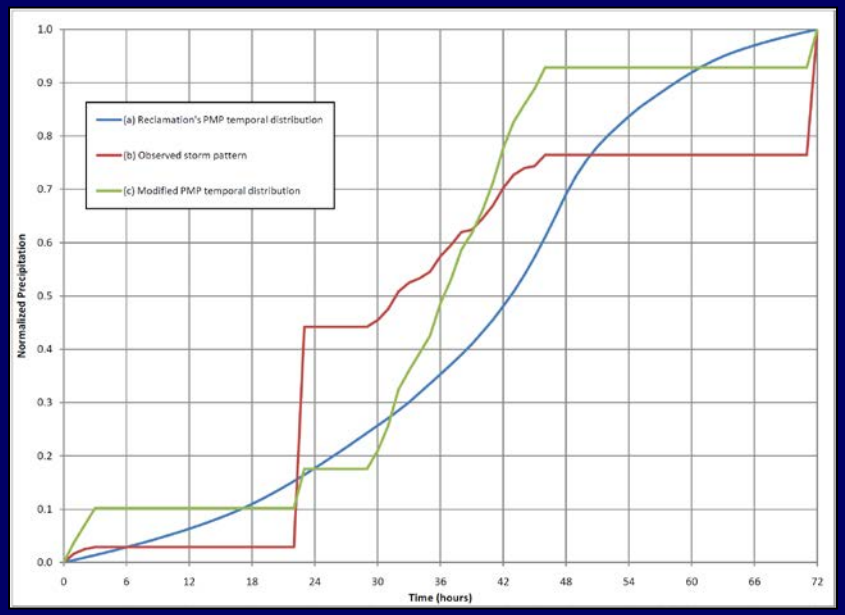


Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

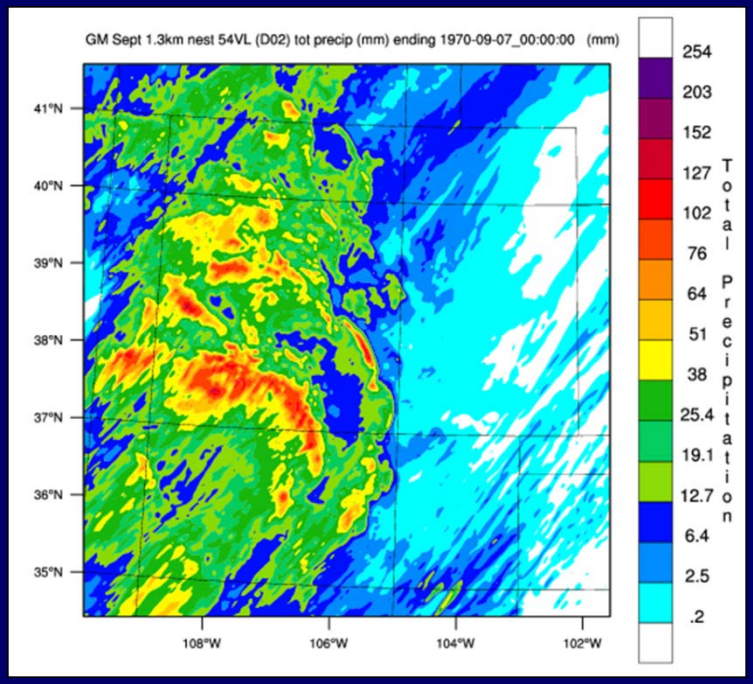
Preliminary Results: Control Simulation

Time series from CTRL





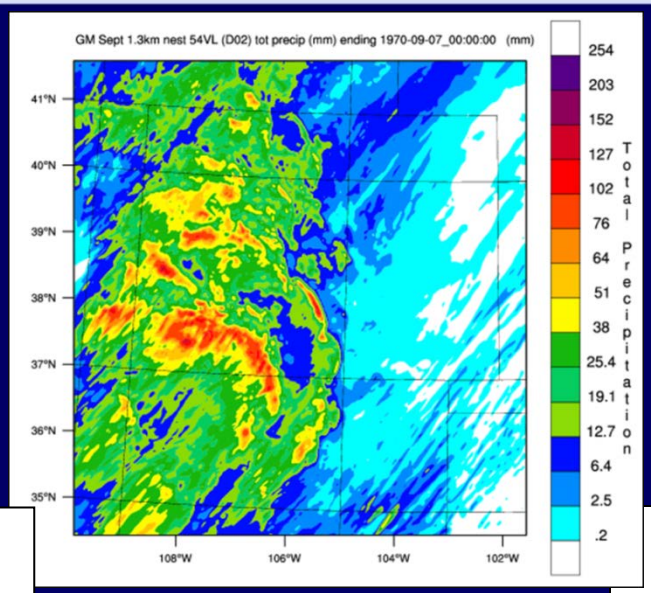
Time series from USBR Hydrologic Hazard



Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

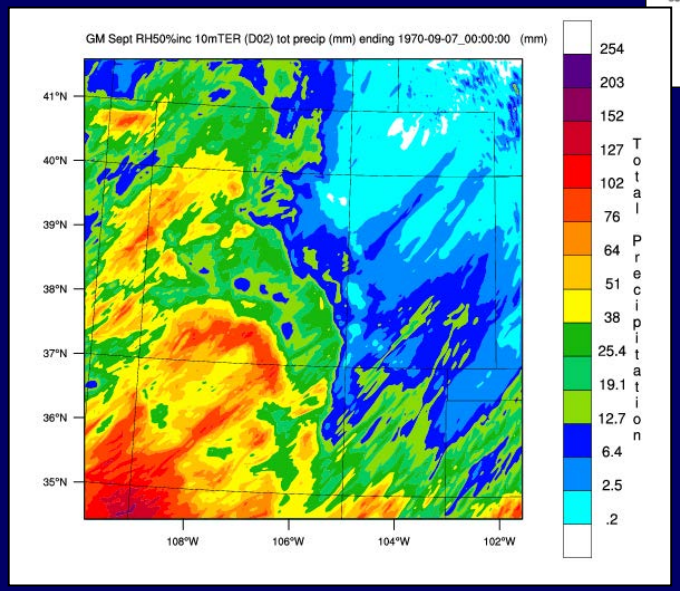
Preliminary Results: Moisture Maximization

72-h total precipitation (mm)

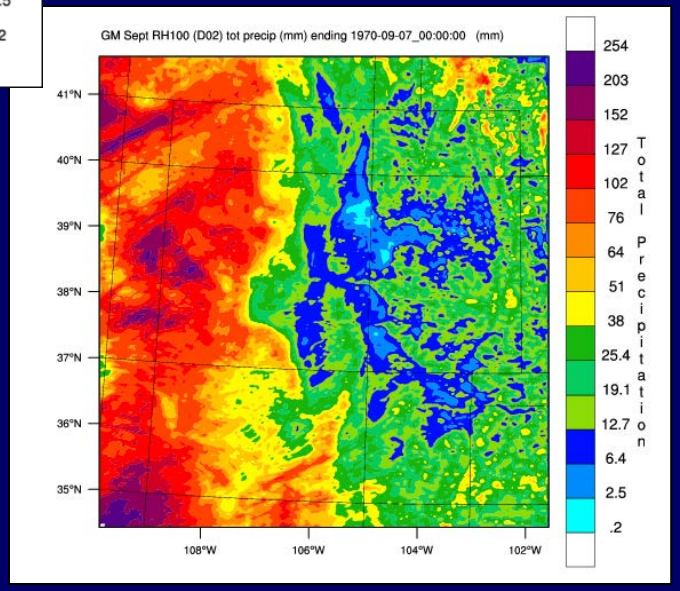


Control

RH 1.5x



RH 100%



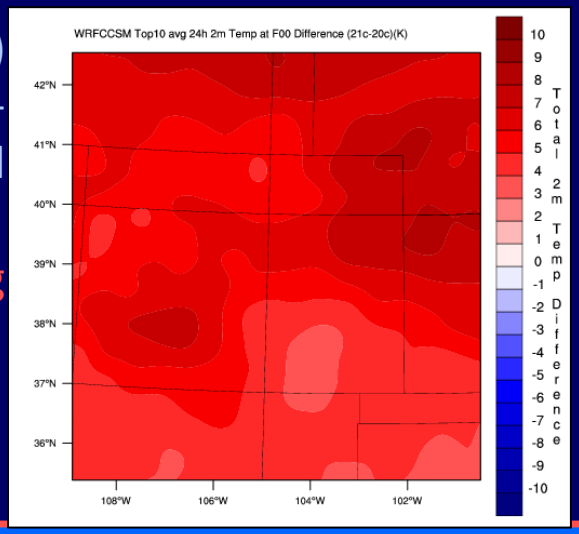
Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

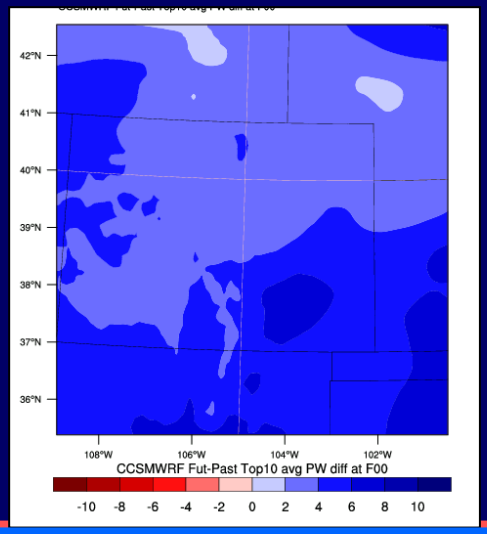
Preliminary Results: Climate Change Perturbation

ΔT_{sfc}(fut-past) from CW-model

Red = warming

Climate change from model #1





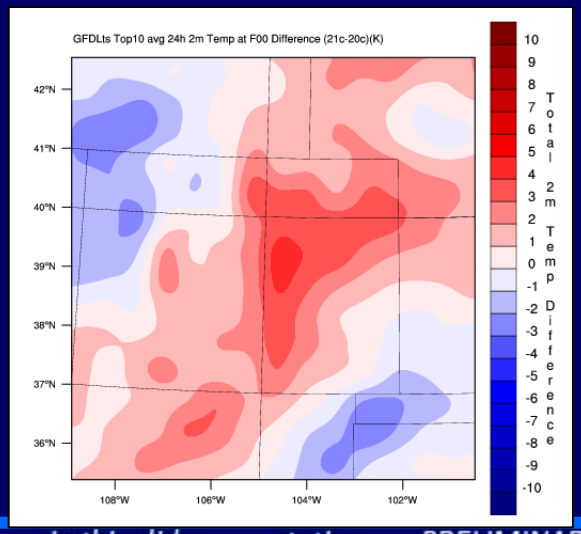
ΔPW(fut-past) from CW-model

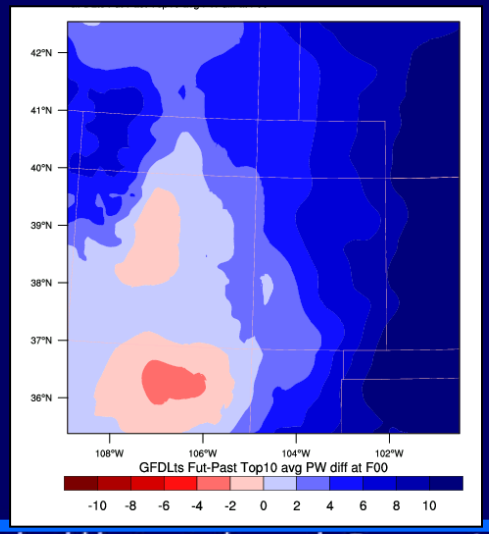
PW: precipitable water

Blue = moistening

ΔT_{sfc}(fut-past) from GT-model

Climate change from model #2



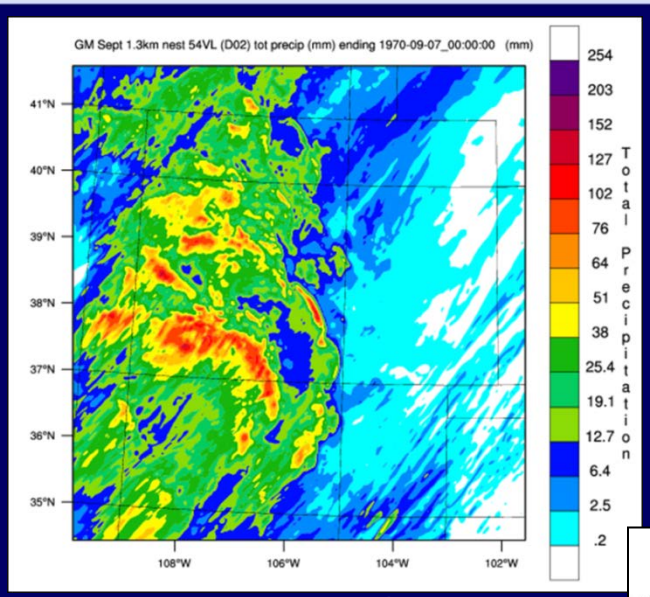


ΔPW(fut-past) from GT-model

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

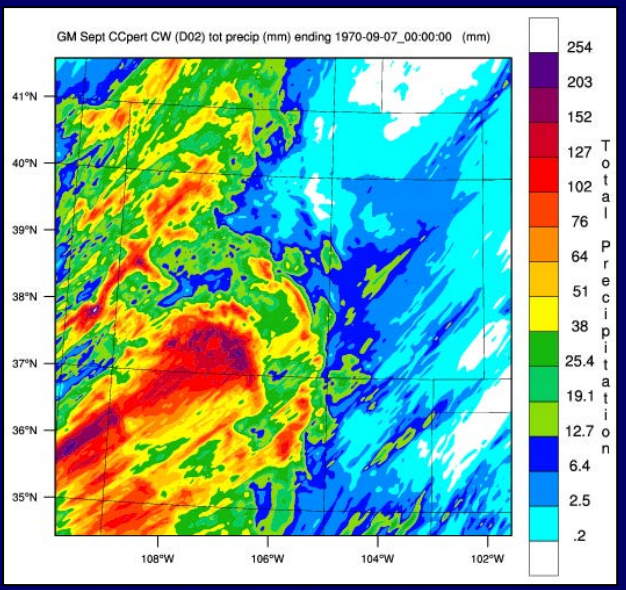
Preliminary Results: Climate Change Perturbation

72-h total precipitation (mm)

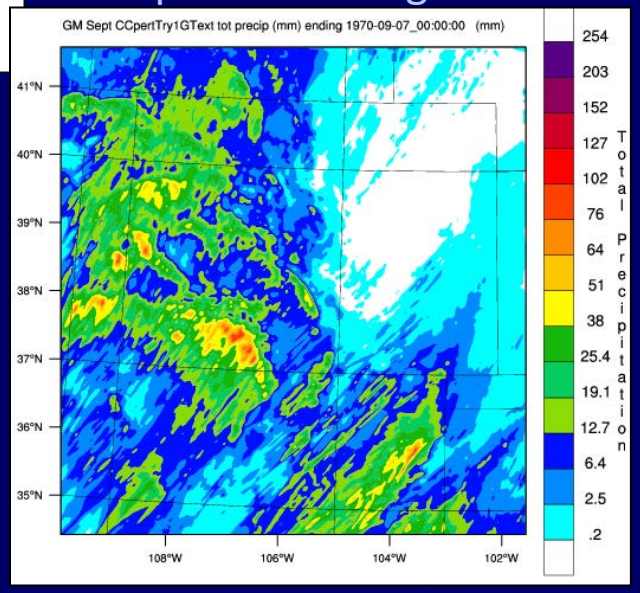


Control

CC pert run using CW-model



CC pert run using GT-model



Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Potential Improvements

More recent storm event when higher resolution reanalysis data are available

Moisture Maximization

- Hold relative humidity constant while increasing the atmospheric mixing ratio/specific humidity
- Adjust moisture at low levels to replicate maximum persisting dewpoints

Climate Change

- Extreme event-centered definitions of climate change
- Seasonal mean-based perturbations
- Ensemble modeling

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Future Work

1. Test additional moisture maximization techniques

2. Calculate more relevant climate change signatures using both seasonal average deltas and extreme deltas that are chosen using the Green Mountain Dam region

3. Investigate the utility of using more recent cases from NARR and GDCN; take advantage of better observations to validate the model results

4. Connect these results to specific metrics used in previous reports such as basin-average precipitation totals, temporal distribution over 24-, 48-, and 72-h intervals, and compare specific fields (e.g., surface dewpoint) with data used to calculate the original PMP

5. Expand simulation perturbations to be dynamical too; identify methods to incorporate potential storm track shifts in future climates, explore the feasibility of an larger ensemble-based approach

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Conclusion

Successful WRF proof-of-concept analysis. Proven ability to:

- ✓ model historic, large precipitation events;
- ✓ maximize storm parameters;
- ✓ perturb storms in climate change scenarios; and
- ✓ demonstrated the benefit of a high-resolution numerical model for extreme storm analysis needed for Dam Safety Hydrologic Hazard Analyses.

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.

Questions

This research, after continued improvement, will be presented at the

American Meteorological Society Annual Meeting in January 2013 in Austin, TX

Disclaimer: All results shown in this slide presentation are PRELIMINARY and should be treated as such. For more info, please contact the author.