

WRF Model Simulation of June 2013 Alberta Flooding Event

Yanping Li¹, Kit Sezto², Ron Steward³, Julie Theriault⁴

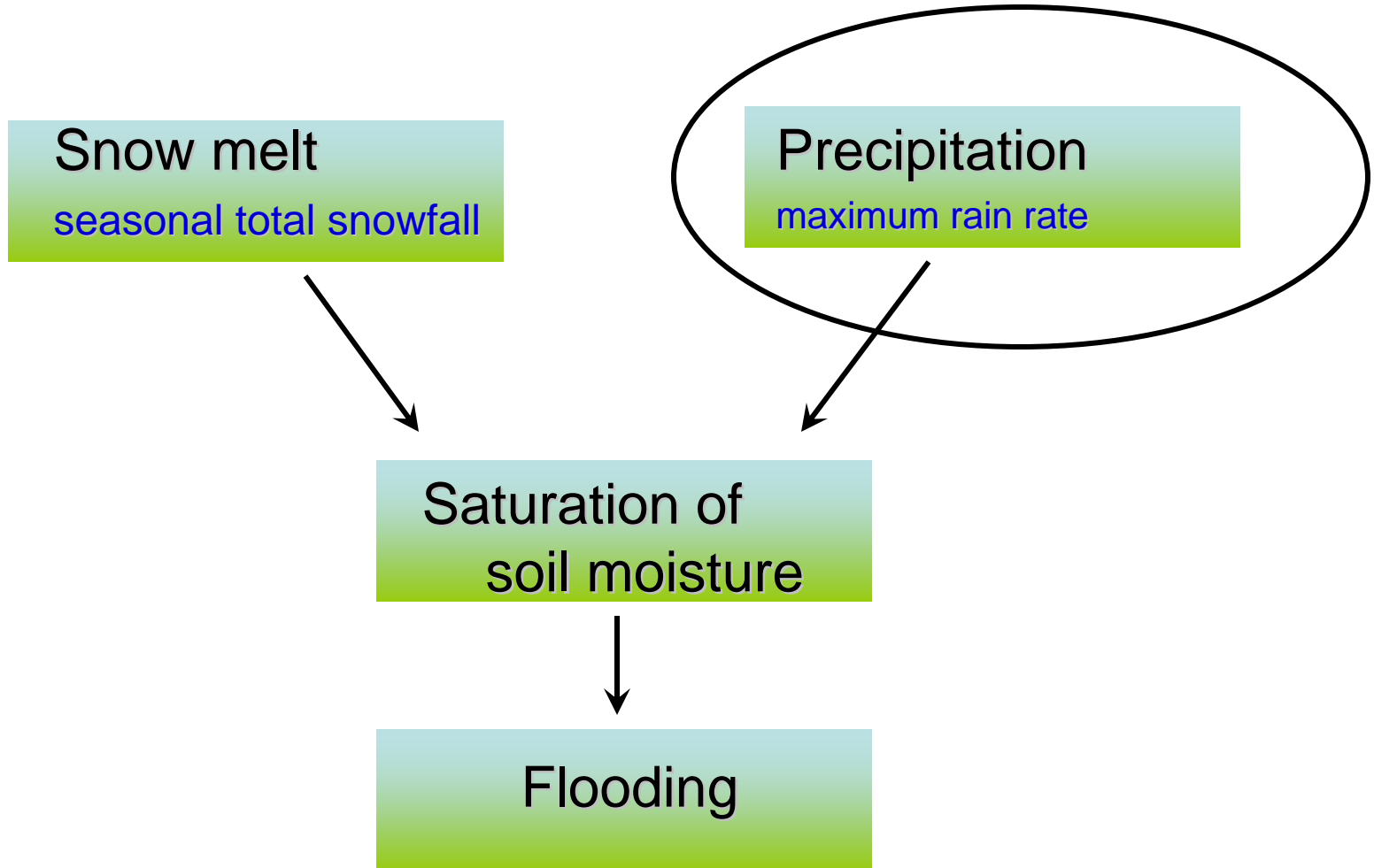
¹Global Institute for Water Security, University of Saskatchewan

²Climate Data and Analysis, Environment Canada, Toronto

³Department of Environment and Geography, University of Manitoba

⁴Department of Earth and Atmospheric Sciences, Université du Québec à Montréal

June 2013 Alberta Flooding



Outline

WRF (Weather Research and Forecast) numerical experiments to examine –

storm evolution and rainfall distribution during June 2013 Alberta Flooding

- > Synoptic precondition
- > Water vapor sources
- > the role of terrain



Weather Research & Forecasting model WRF the state-of-art model for regional climate modeling

The Weather Research and Forecasting (WRF) Model is a next-generation mesoscale numerical weather prediction system designed to serve both atmospheric research and operational forecasting needs. It features two dynamical cores, a data assimilation system, and a software architecture allowing for parallel computation and system extensibility. The model serves a wide range of meteorological applications across scales



WRF has many different model configuration options:

- Adjustable model grids both horizontally and vertically
- Two dynamical cores (NMM & ARW)
- A wide selection of model physics parameterizations:
 - 7 cumulus parameterizations
 - 14 explicit moisture schemes
 - 6 radiation schemes
 - 10 planetary boundary layer schemes
 - 5 land surface schemes

This site (wrf-model.org) provides general information on the WRF model and its organization and offers links to WRF users' pages, real-time applications, and WRF announcements. For full, updated information on use of the modeling system, users are encouraged to visit the WRF-ARW and WRF-NMM home pages (see above).

WRF setup

Data Uncertainties

- Initial and Boundary Condition

NCEP reanalysis with 1 degree resolution every 6 hours.

Model Uncertainties:

- Regional domain

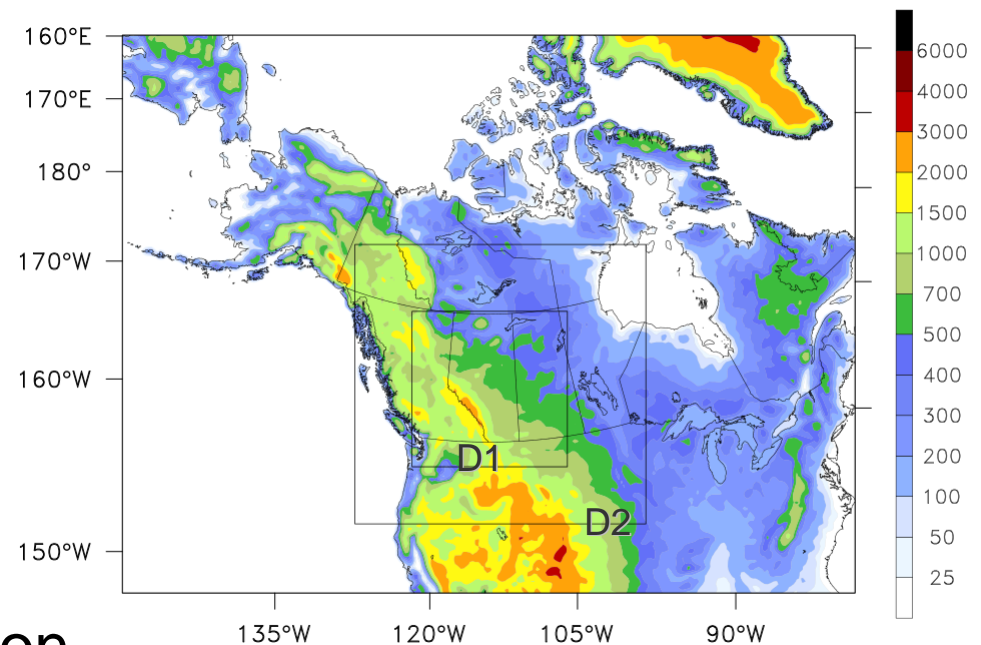
Domain-1, Domain-2

- Resolution

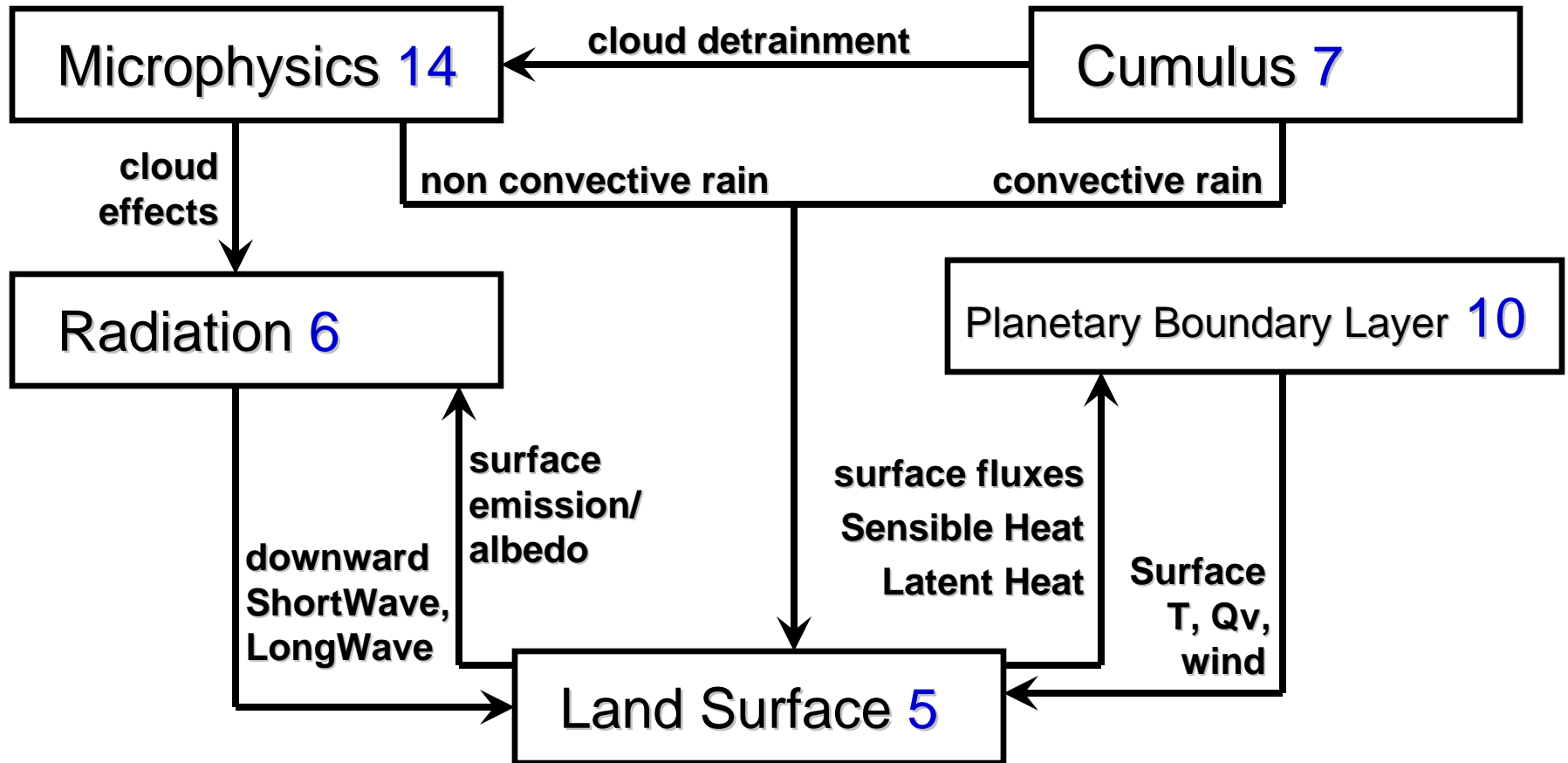
D1: 3km, D2: 27km

- Dynamics

- Physical parameterization



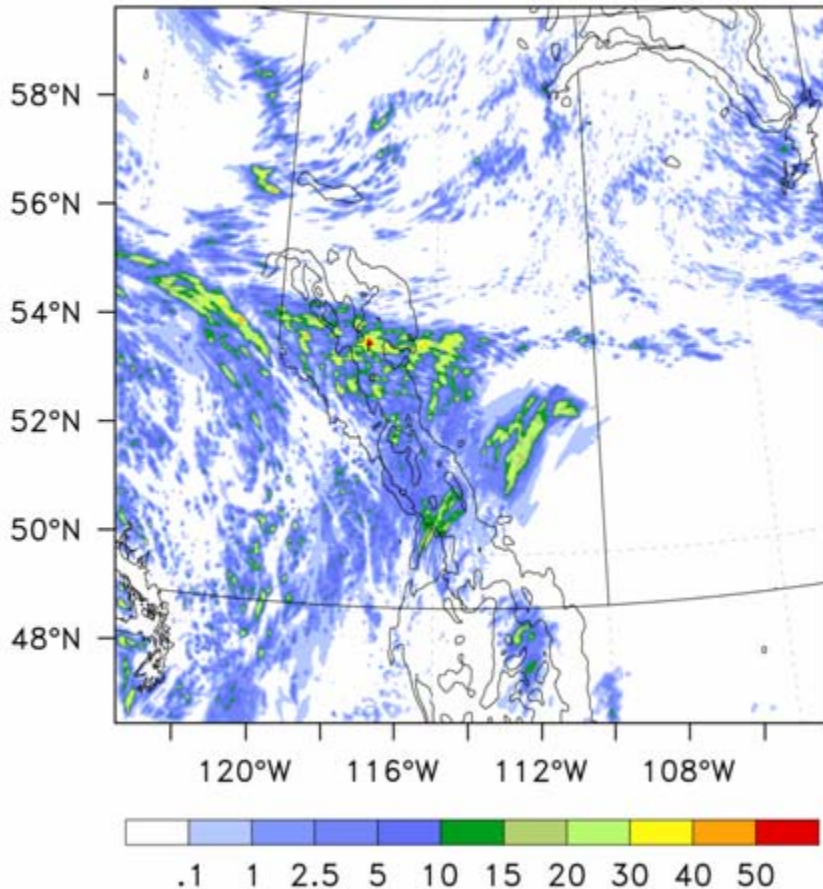
WRF Model Physics Parameterizations



WRF simulation vs CMORPH

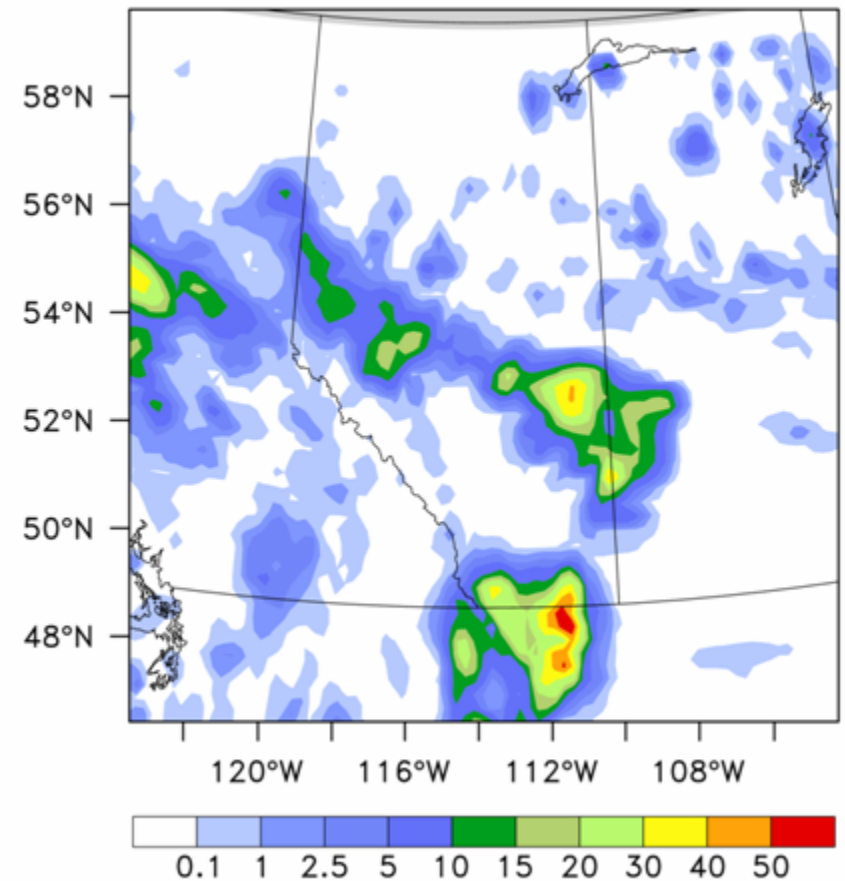
WRF

2013-06-19_00:00:00 UTC



CMORPH

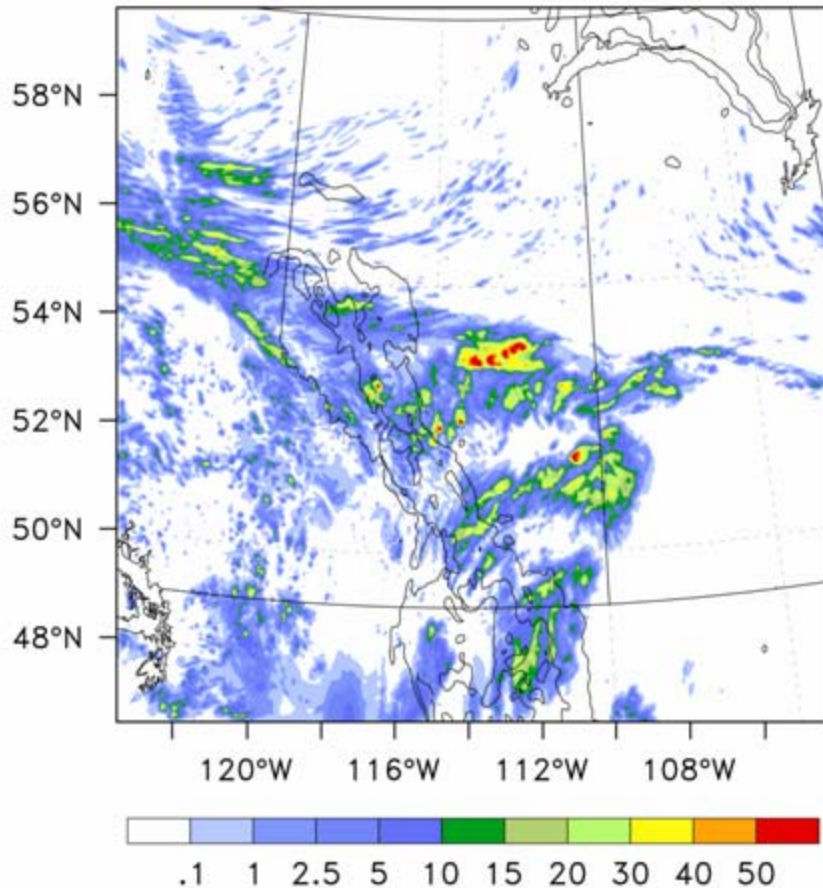
2013-06-19_00:00:00 UTC



WRF simulation vs CMORPH

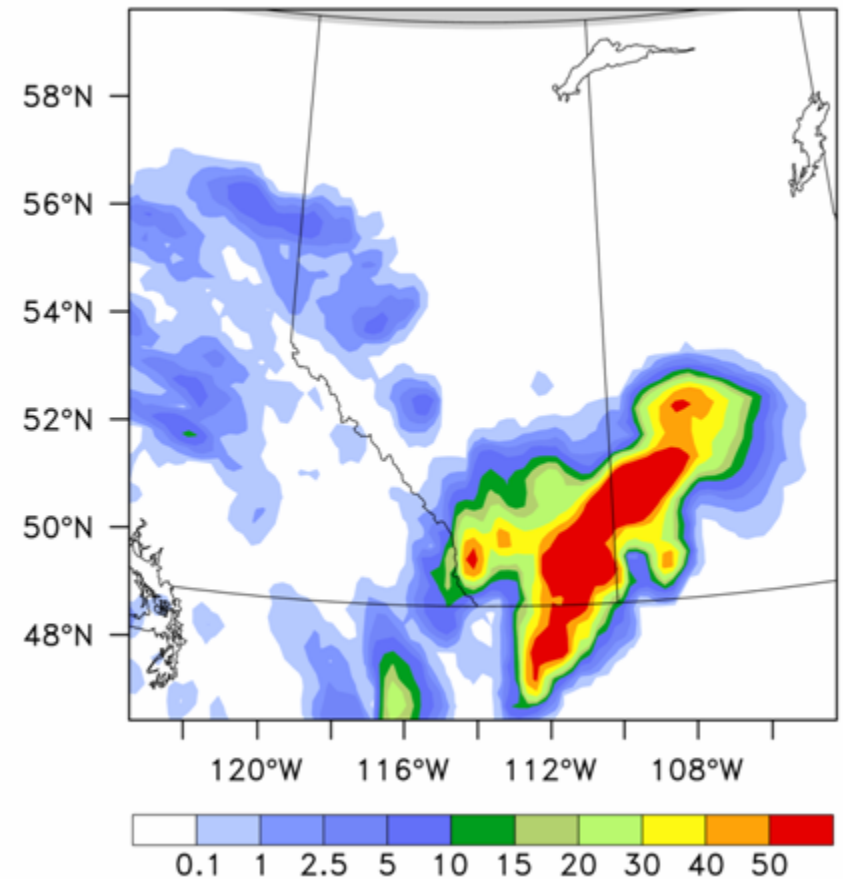
WRF

2013-06-19_06:00:00 UTC



CMORPH

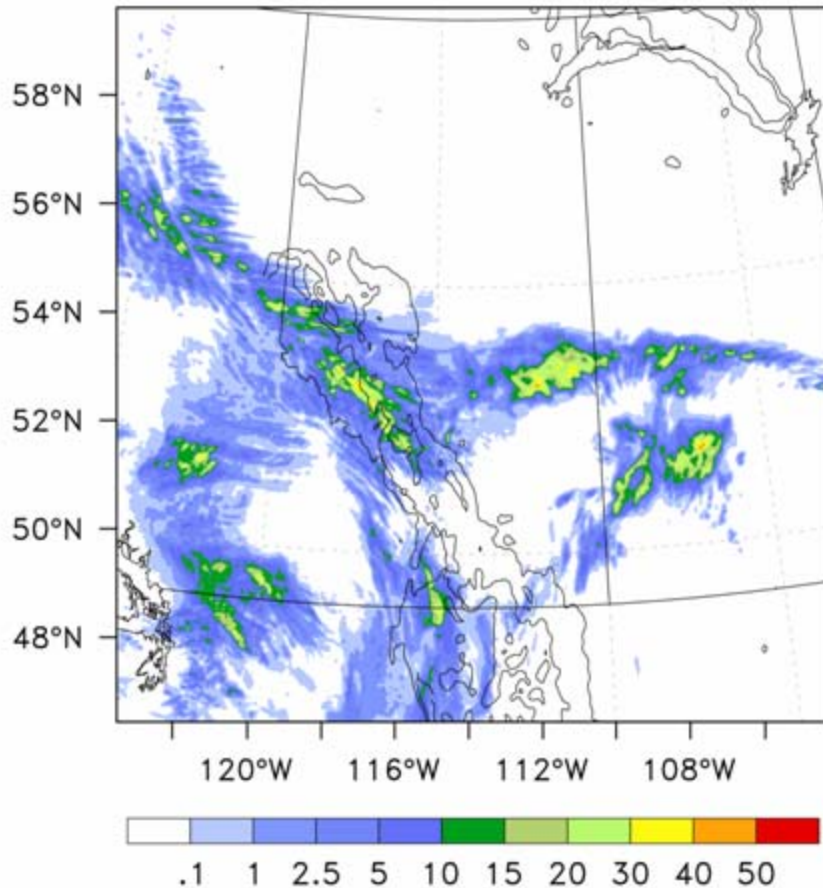
2013-06-19_06:00:00 UTC



WRF simulation vs CMORPH

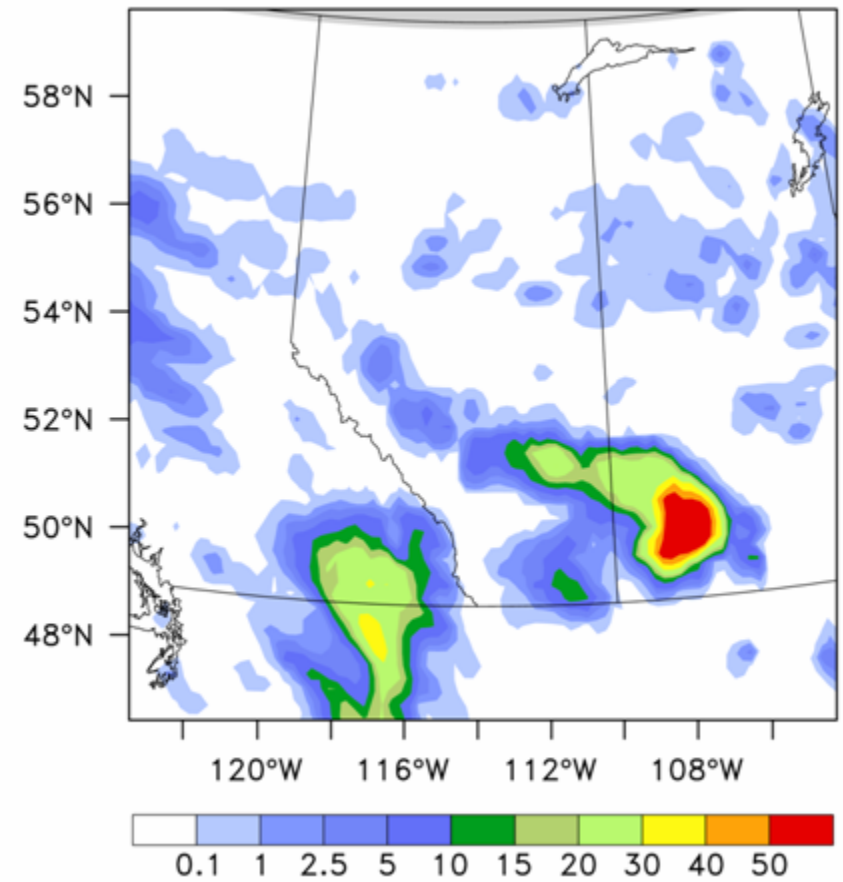
WRF

2013-06-19_12:00:00 UTC



CMORPH

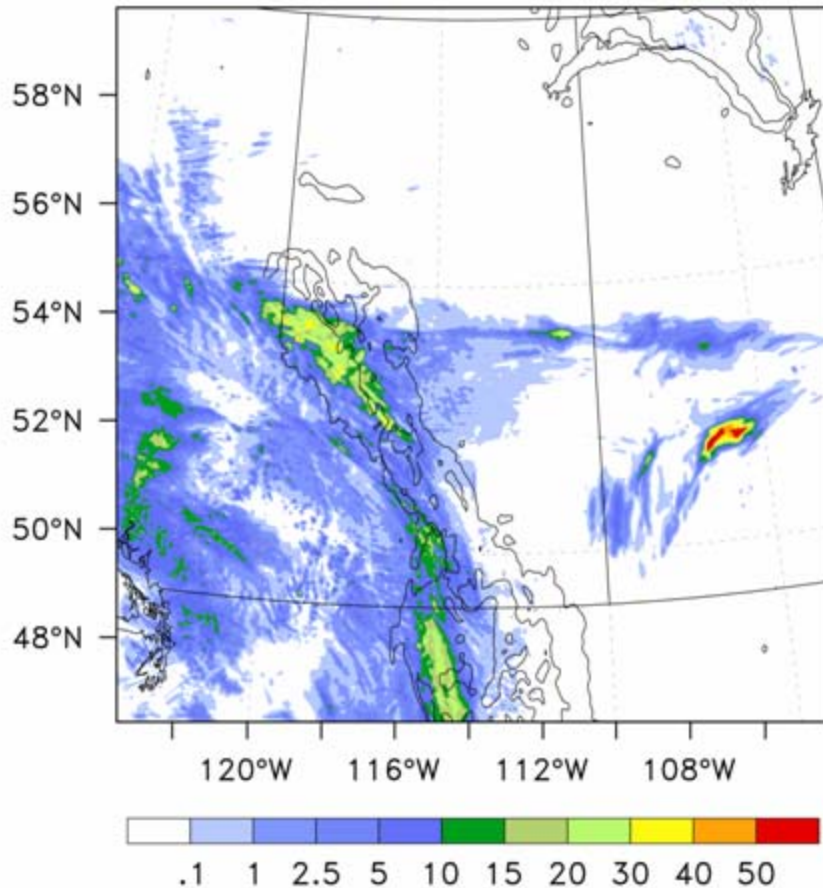
2013-06-19_12:00:00 UTC



WRF simulation vs CMORPH

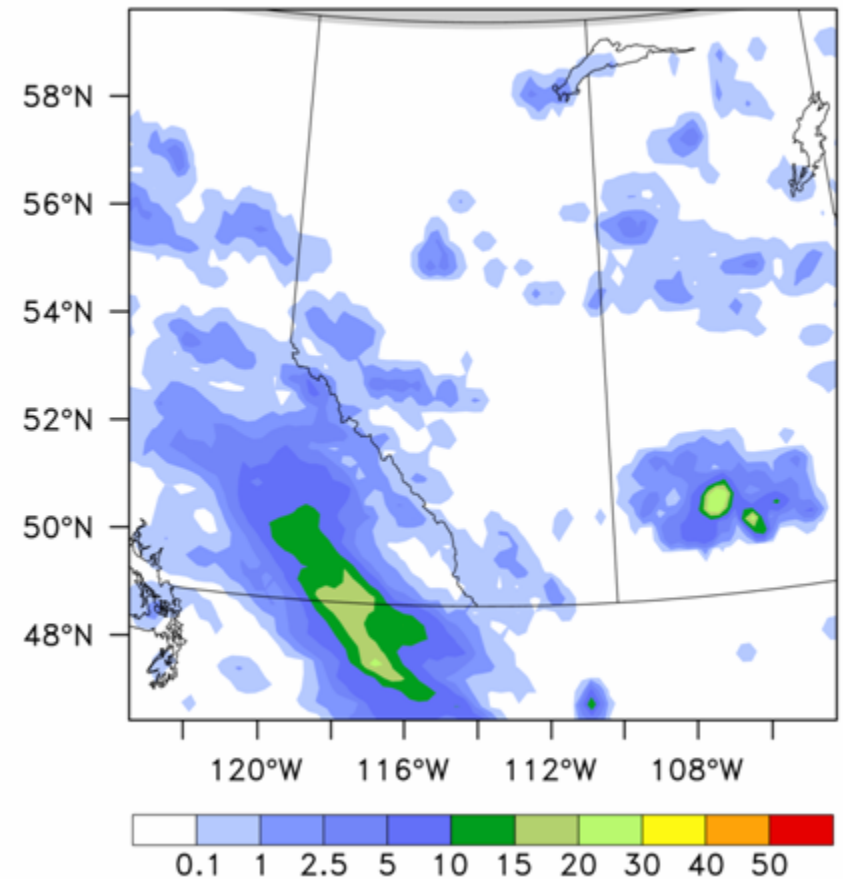
WRF

2013-06-19_18:00:00 UTC



CMORPH

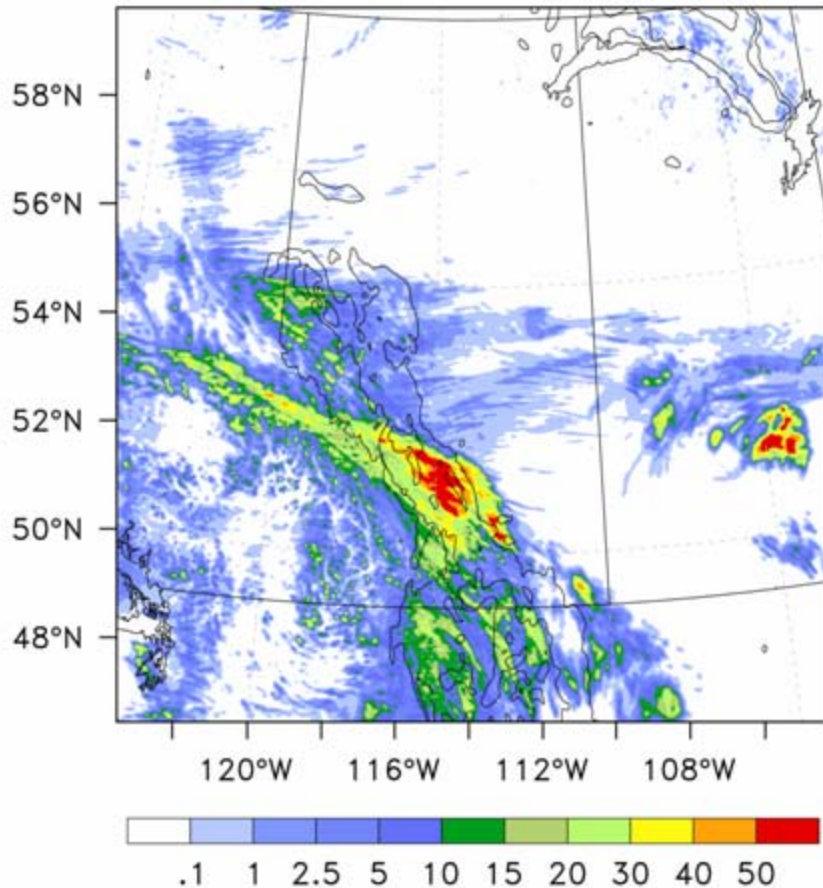
2013-06-19_18:00:00 UTC



WRF simulation vs CMORPH

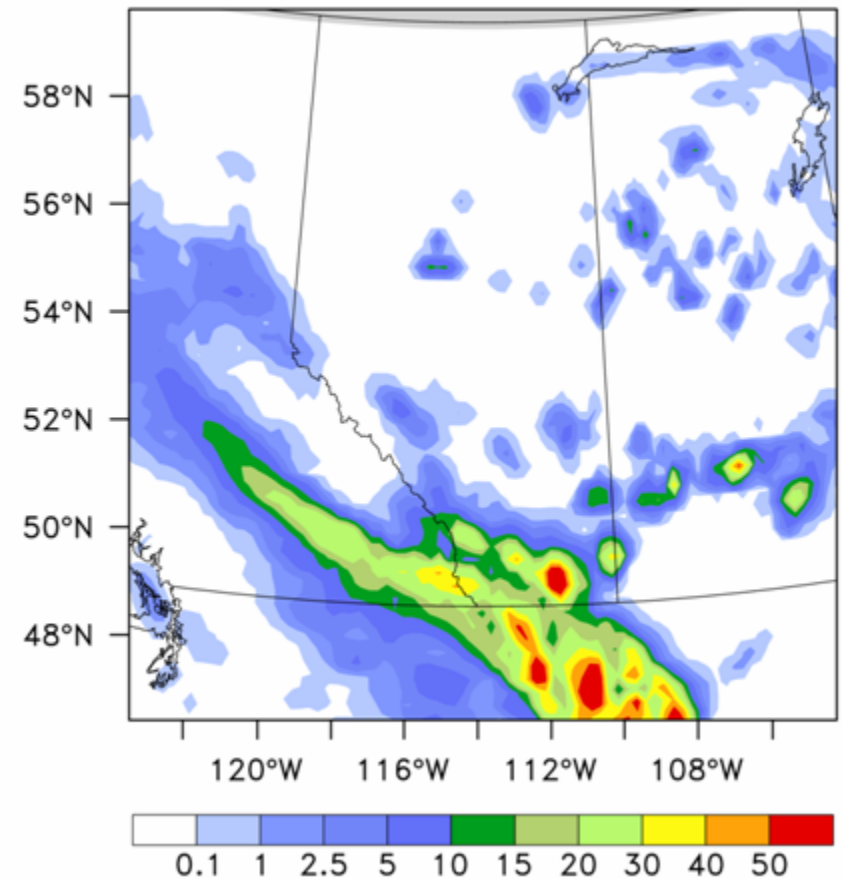
WRF

2013-06-20_00:00:00 UTC



CMORPH

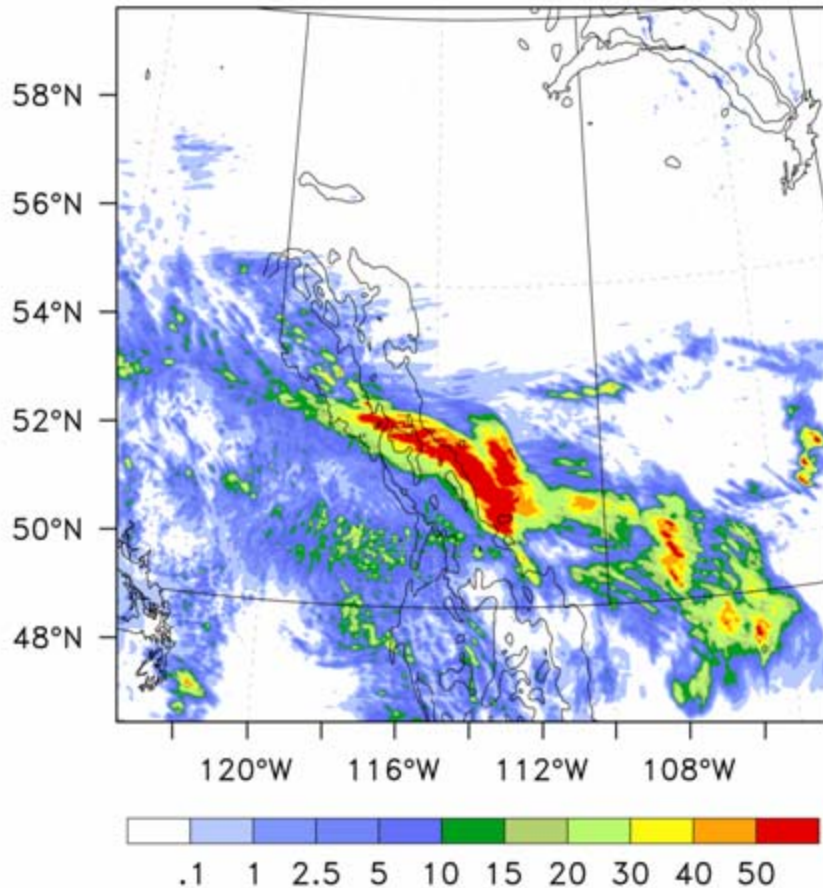
2013-06-20_00:00:00 UTC



WRF simulation vs CMORPH

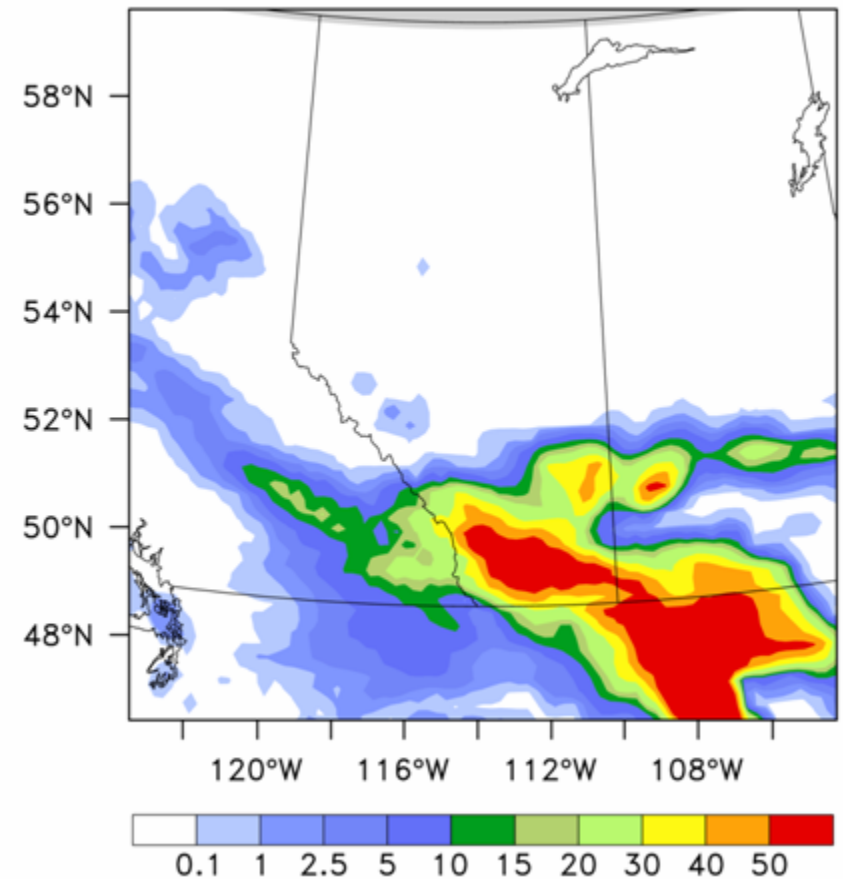
WRF

2013-06-20_06:00:00 UTC



CMORPH

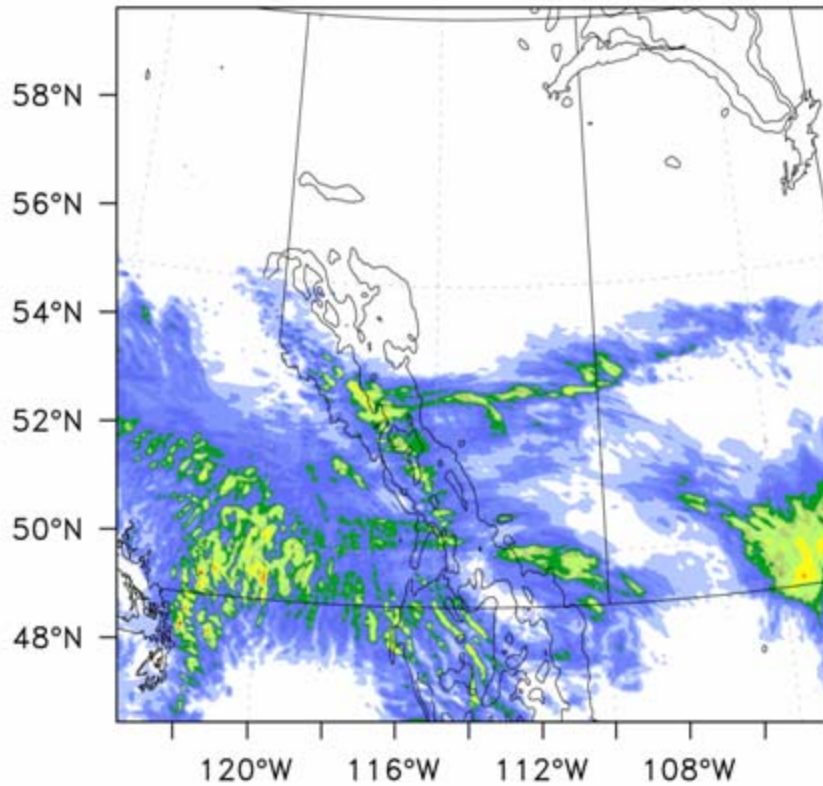
2013-06-20_06:00:00 UTC



WRF simulation vs CMORPH

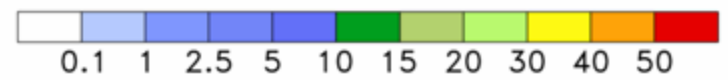
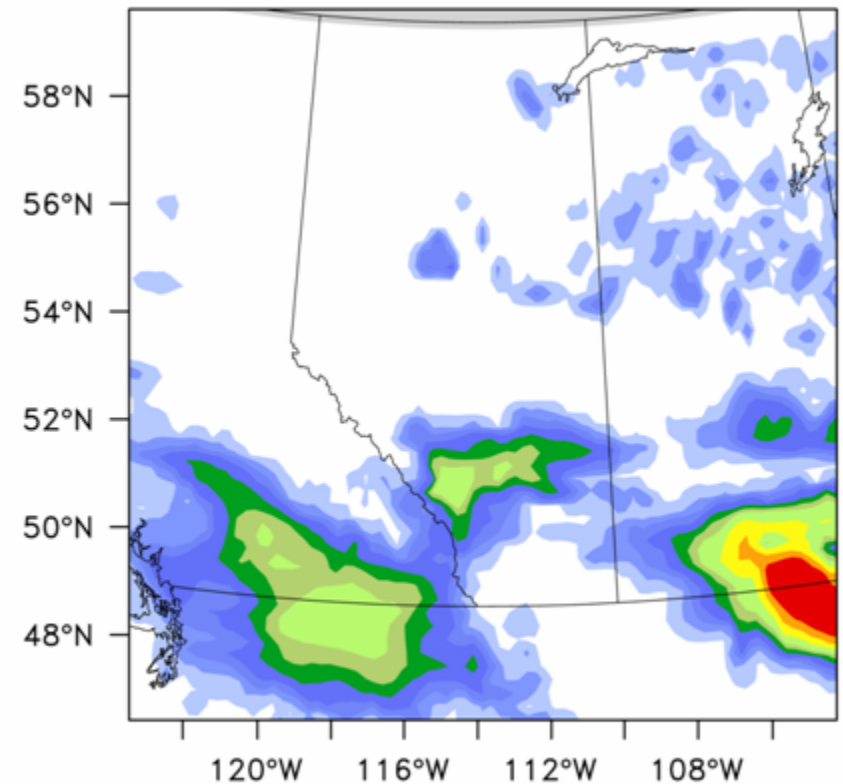
WRF

2013-06-20_12:00:00 UTC



CMORPH

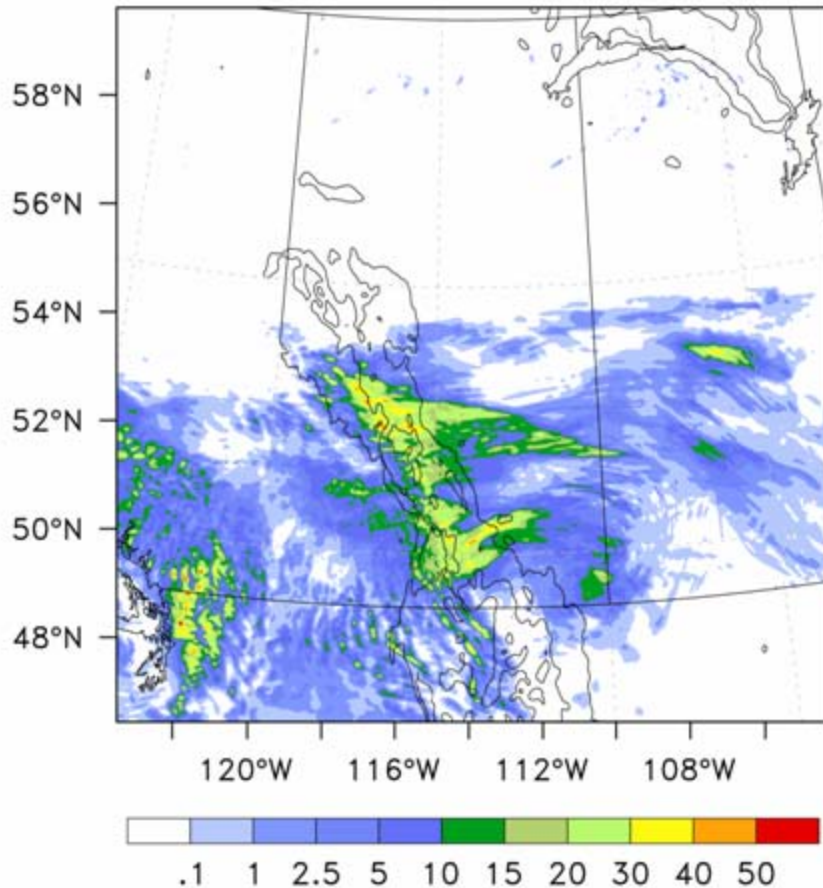
2013-06-20_12:00:00 UTC



WRF simulation vs CMORPH

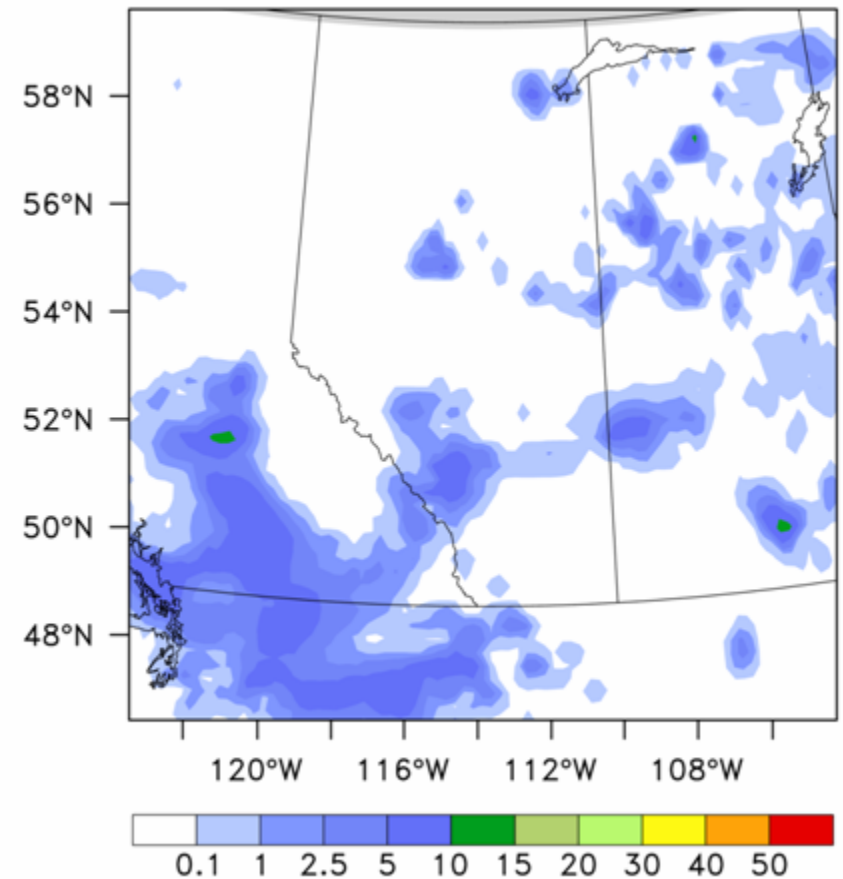
WRF

2013-06-20_18:00:00 UTC



CMORPH

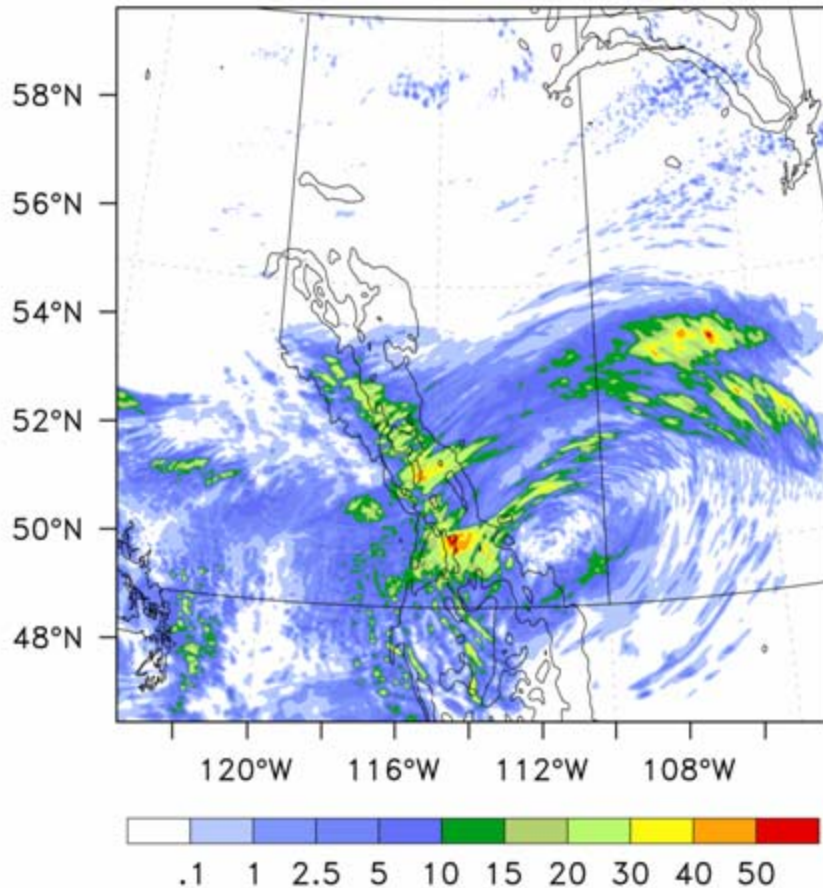
2013-06-20_18:00:00 UTC



WRF simulation vs CMORPH

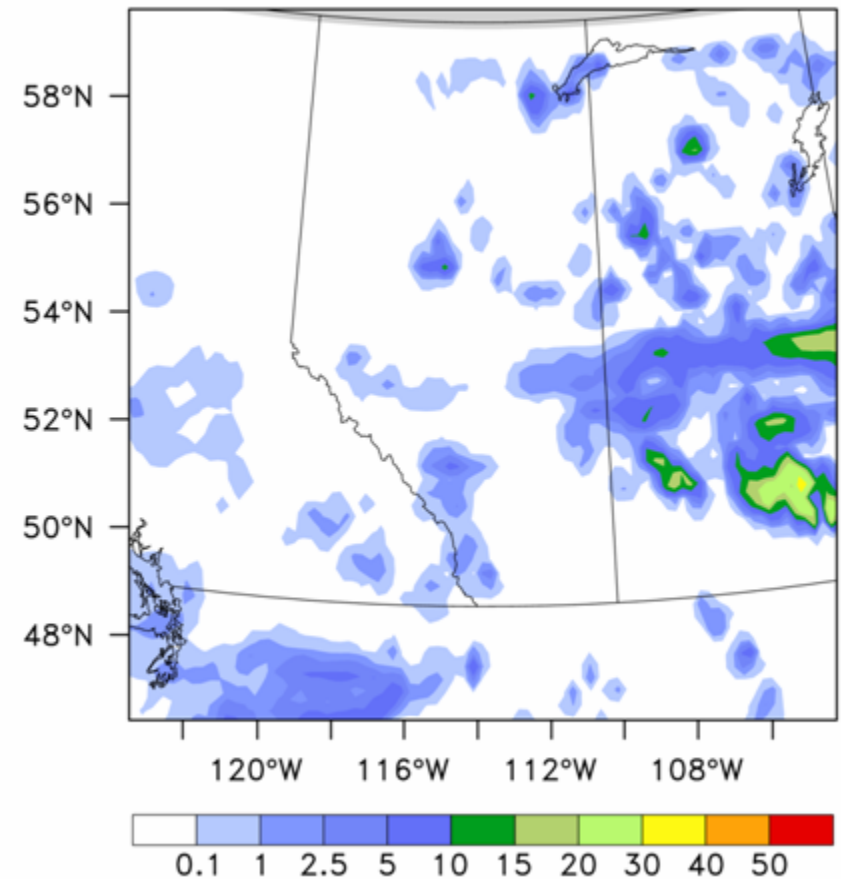
WRF

2013-06-21_00:00:00 UTC



CMORPH

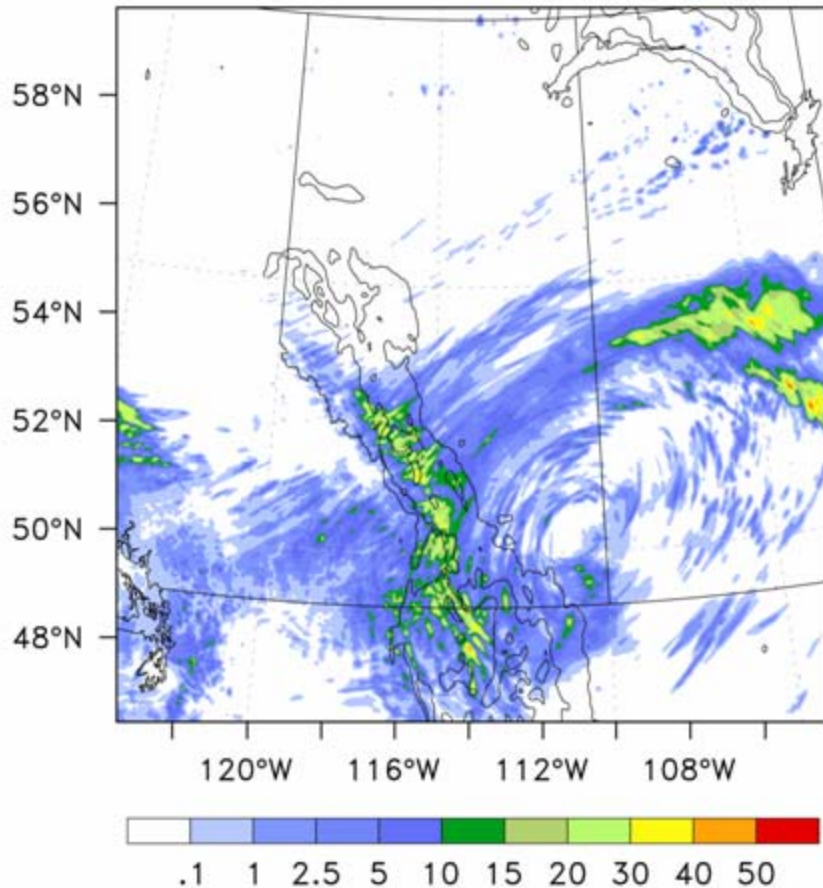
2013-06-21_00:00:00 UTC



WRF simulation vs CMORPH

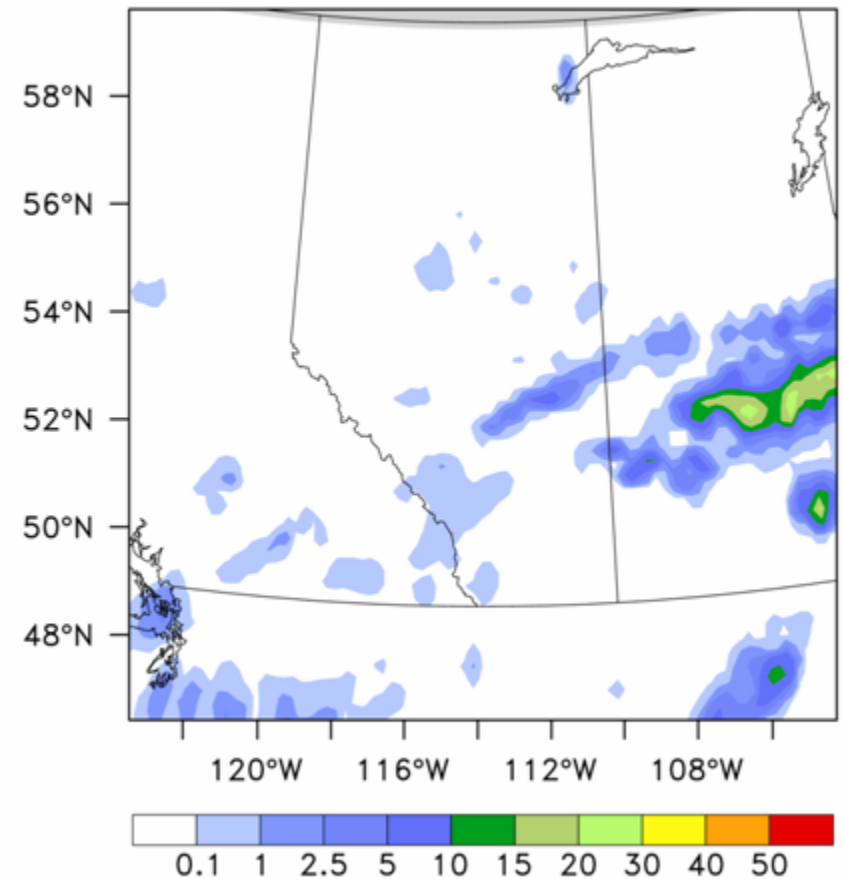
WRF

2013-06-21_06:00:00 UTC



CMORPH

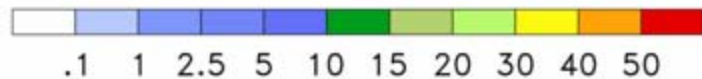
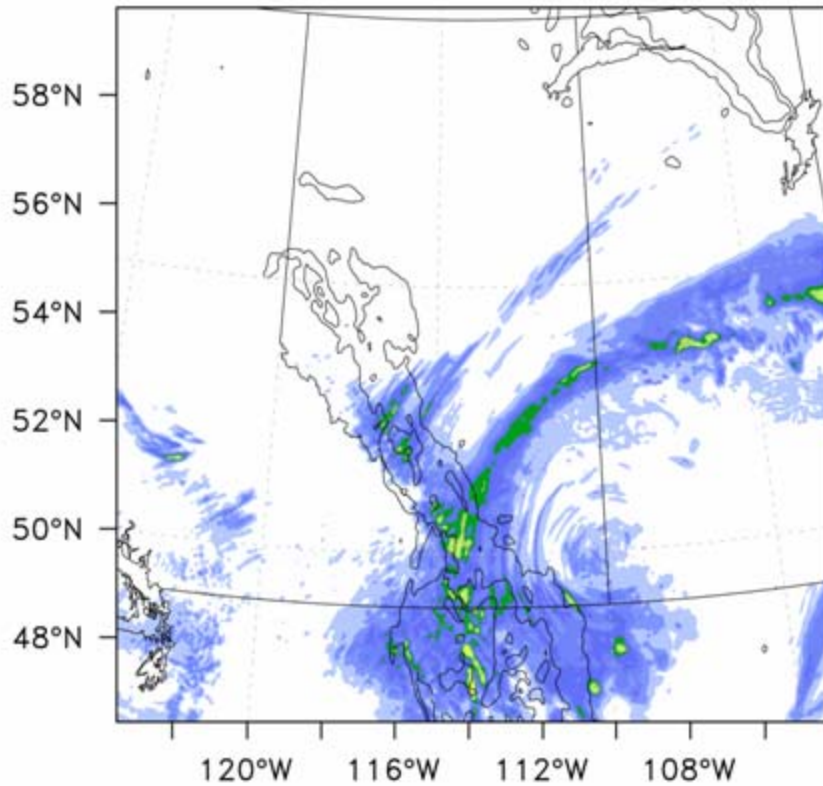
2013-06-21_06:00:00 UTC



WRF simulation vs CMORPH

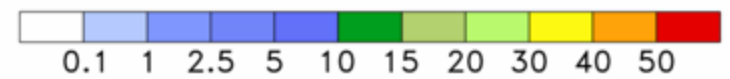
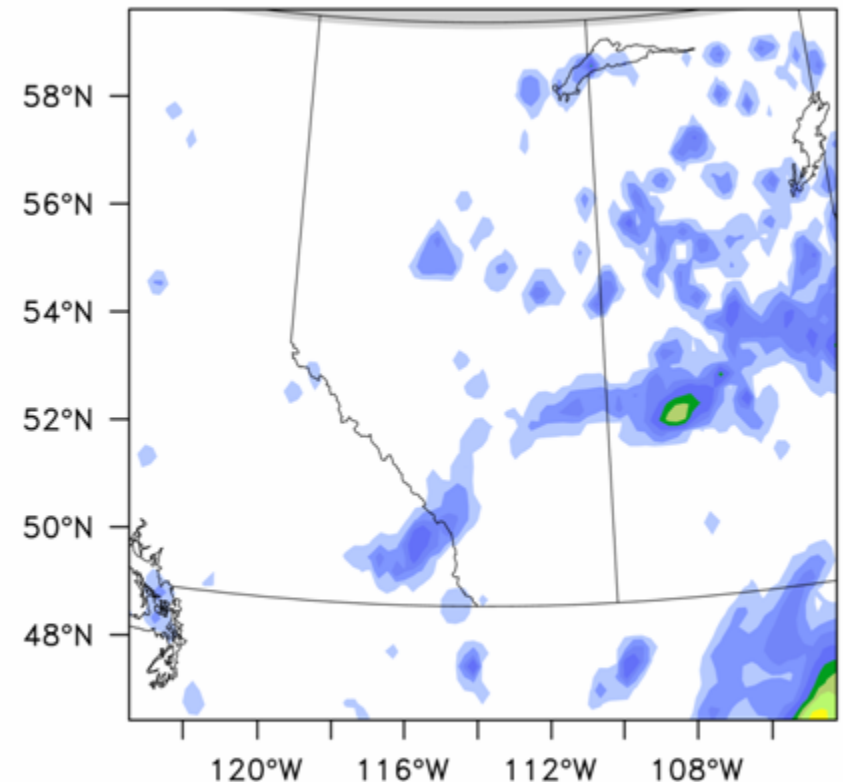
WRF

2013-06-21_12:00:00 UTC



CMORPH

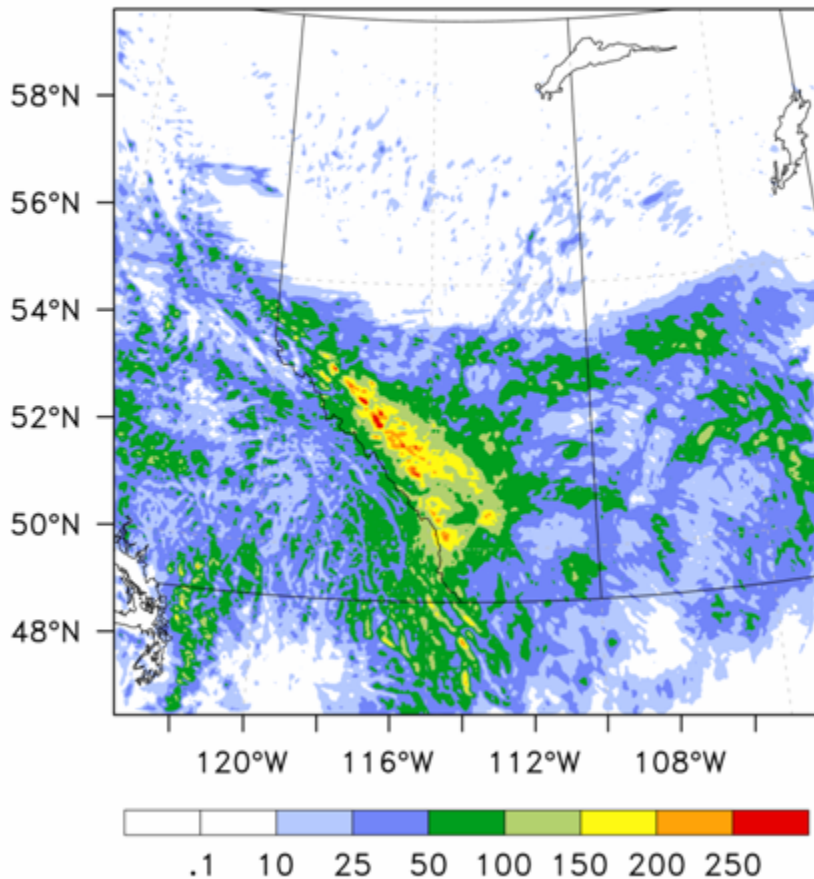
2013-06-21_12:00:00 UTC



WRF simulated total rain

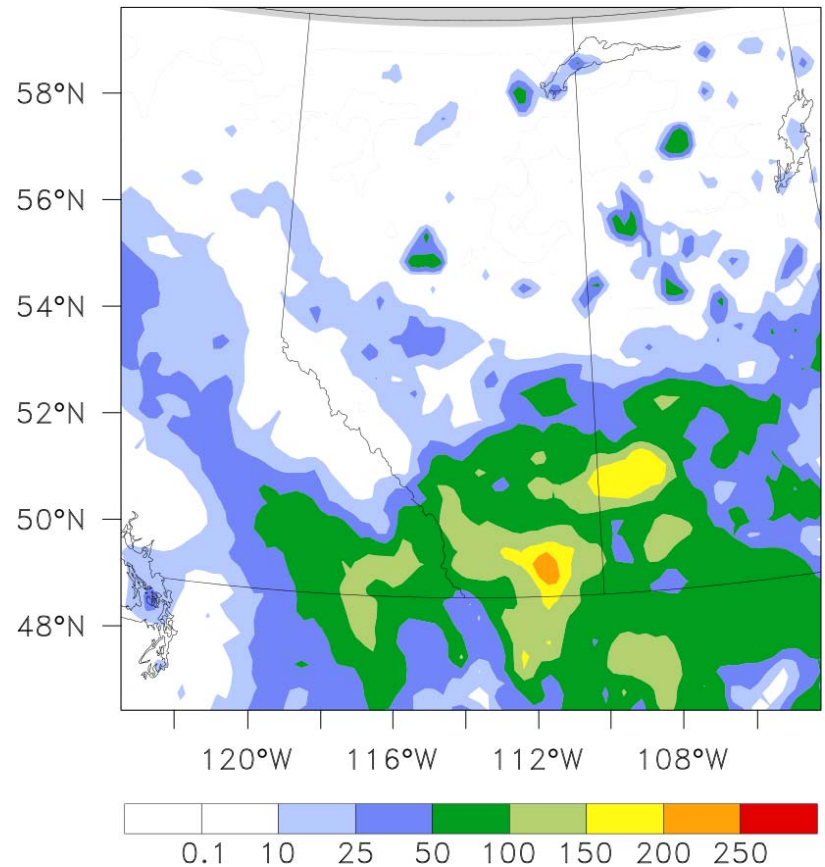
WRF

06/19 – 06/22



CMORPH

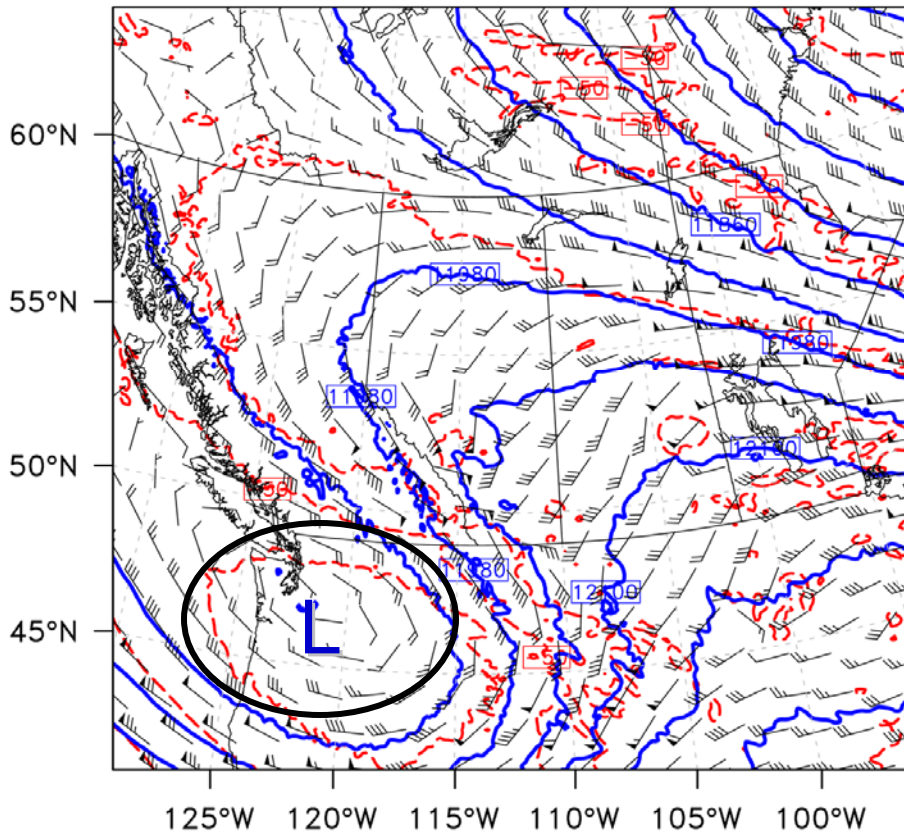
06/19 – 06/22



Synoptic Conditions for the Flooding

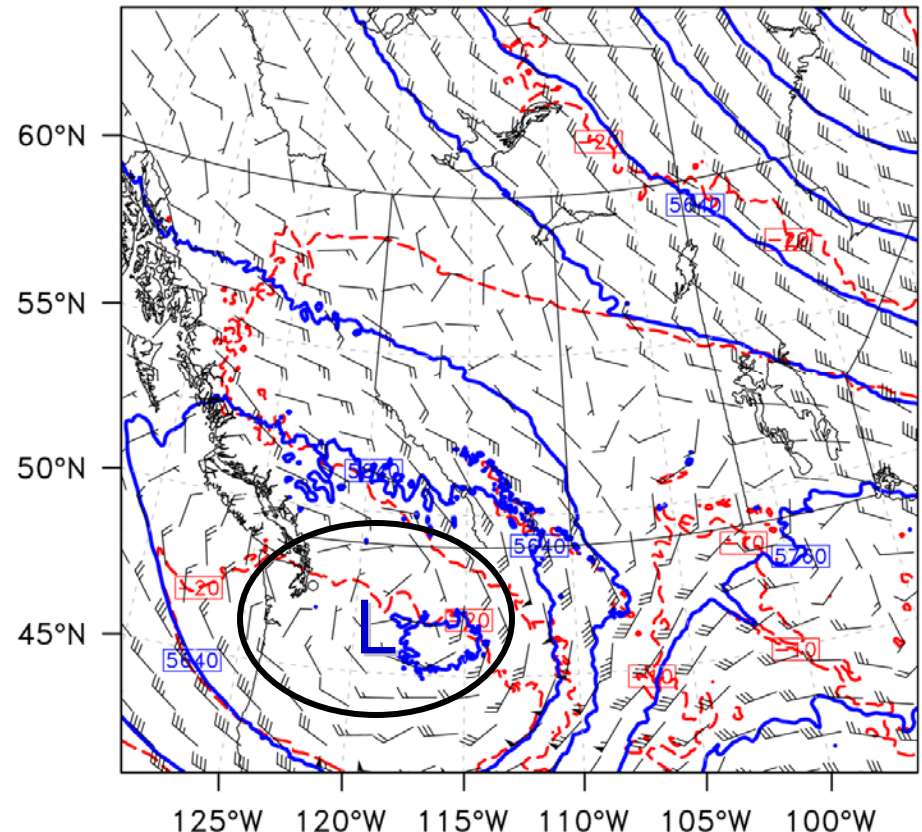
Temperature (C) at 200 hPa
Height (m) at 200 hPa
Wind (kts) at 200 hPa
2013-06-20_00:00:00

Temperature (C) at 500 hPa
Height (m) at 500 hPa
Wind (kts) at 500 hPa
2013-06-20_00:00:00



Height Contours: 11500 to 12380 by 60
Temperature Contours: -75 to -35 by 5

200hPa



Height Contours: 5340 to 5940 by 60
Temperature Contours: -35 to 5 by 5

500hPa

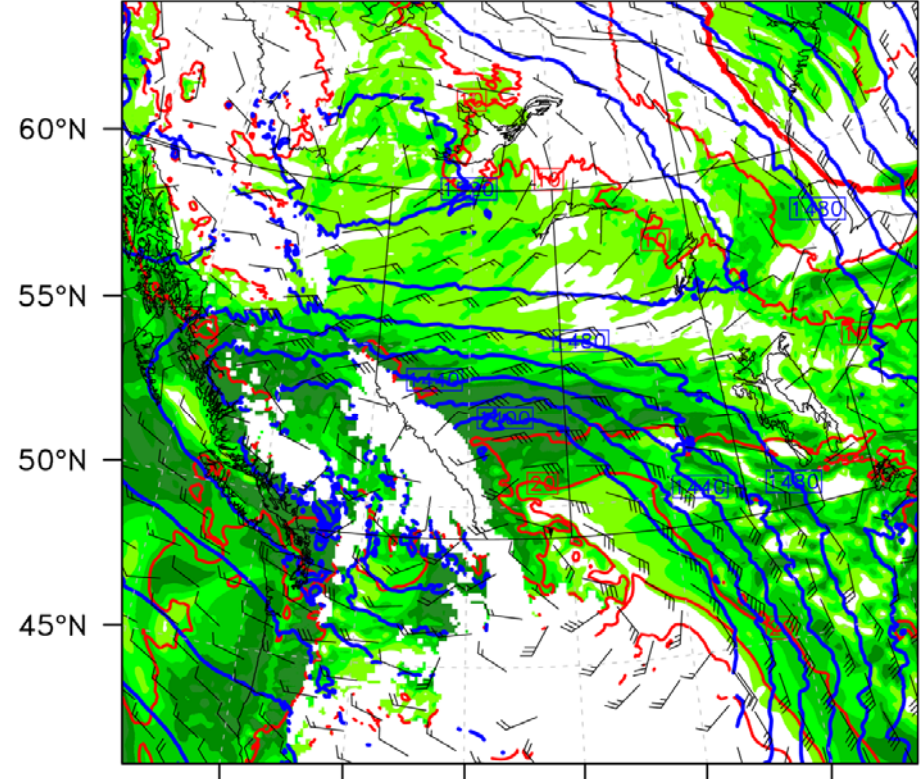
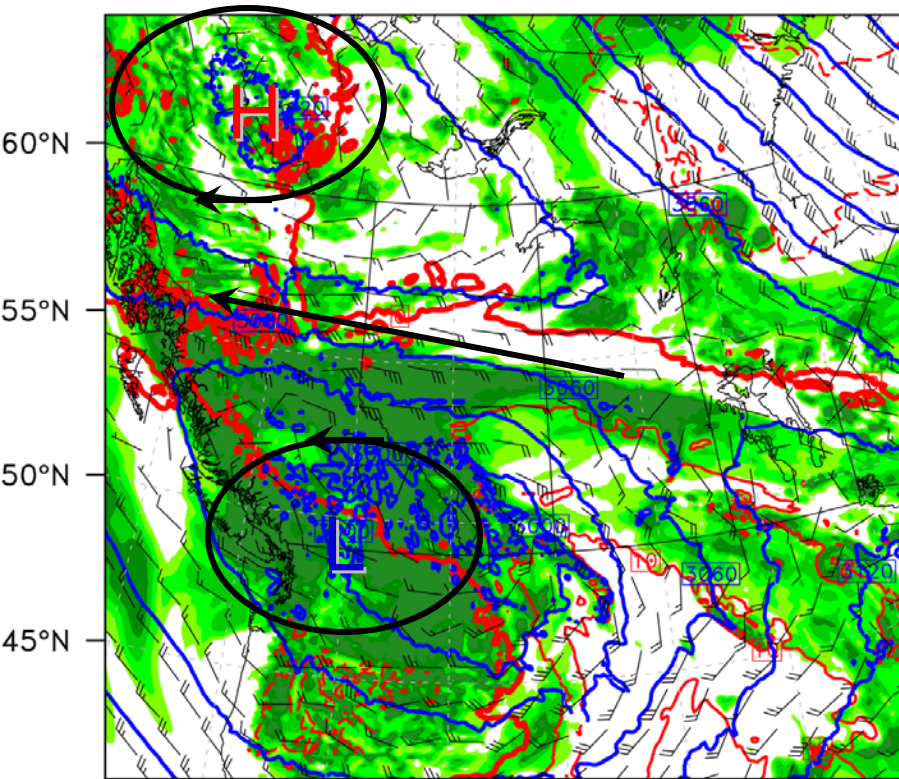
Synoptic Conditions for the Flooding

Relative Humidity (%) at 700 hPa
 Temperature (C) at 700 hPa
 Height (m) at 700 hPa
 Wind (kts) at 700 hPa

2013-06-20_00:00:00

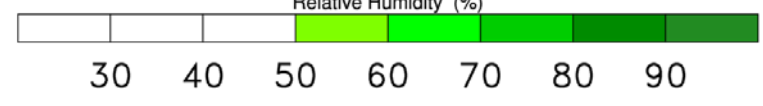
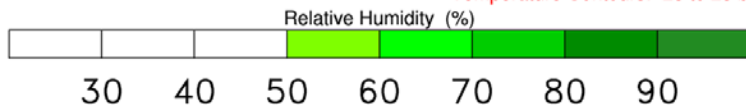
Relative Humidity (%) at 850 hPa
 Temperature (C) at 850 hPa
 Height (m) at 850 hPa
 Wind (kts) at 850 hPa

2013-06-20_00:00:00

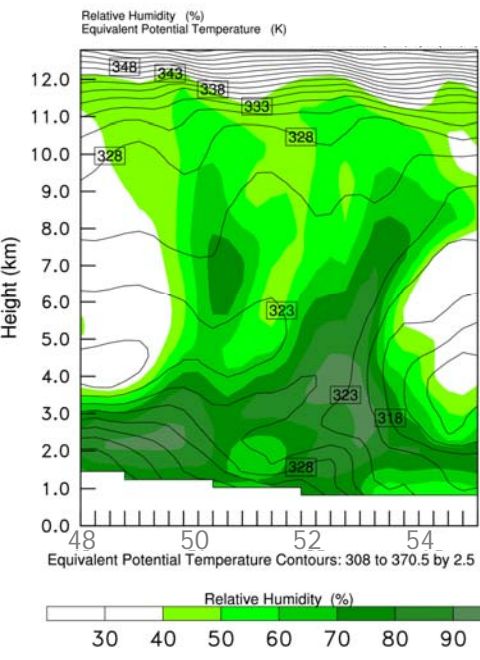
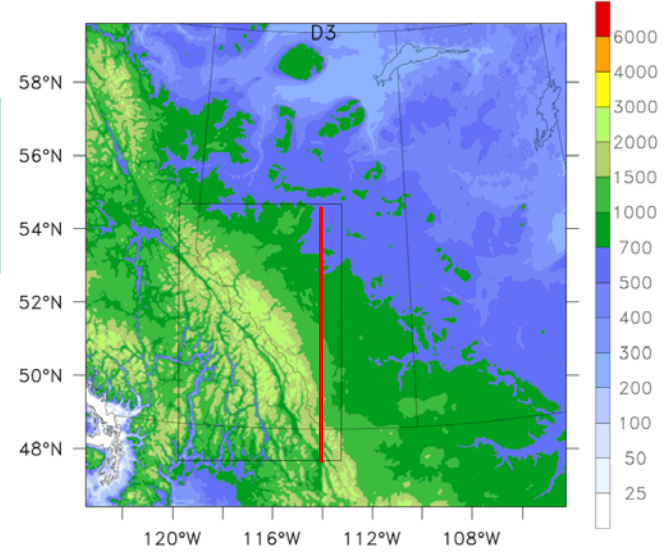


125°W 120°W 115°W 110°W 105°W 100°W
700hPa Height Contours: 2850 to 3290 by 30
 Temperature Contours: -25 to 25 by 5

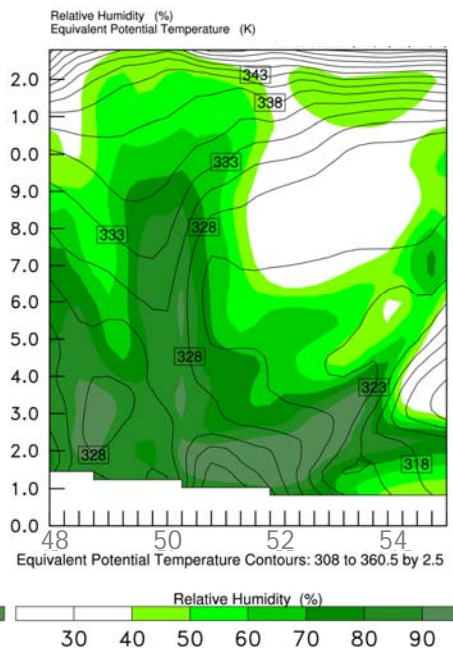
125°W 120°W 115°W 110°W 105°W 100°W
850hPa Height Contours: 1400 to 1660 by 20
 Temperature Contours: -15 to 45 by 5



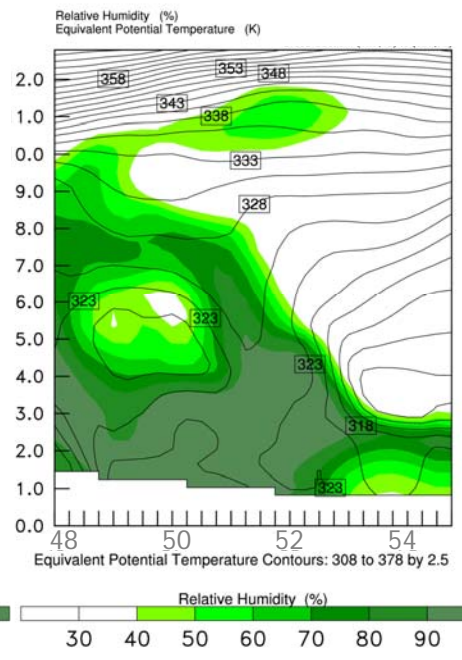
Water Vapor Sources



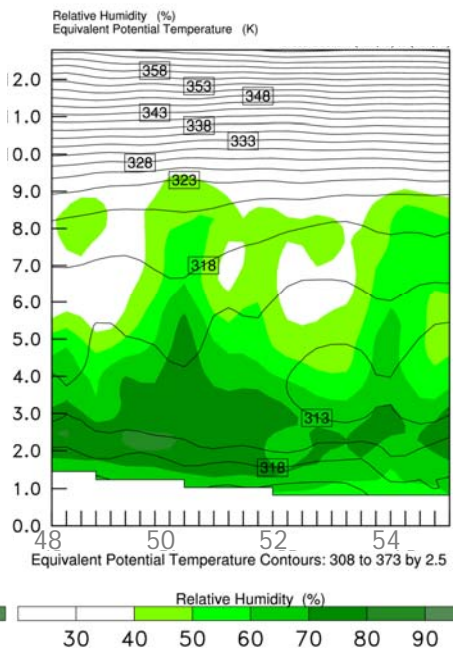
2013-06-19



2013-06-20

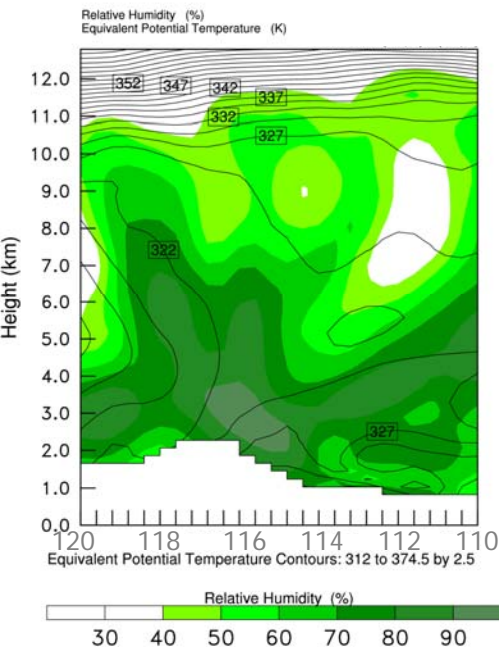
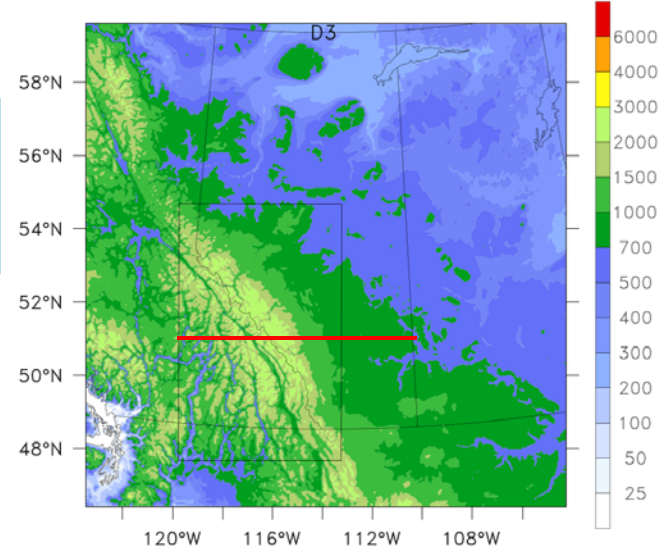


2013-06-21

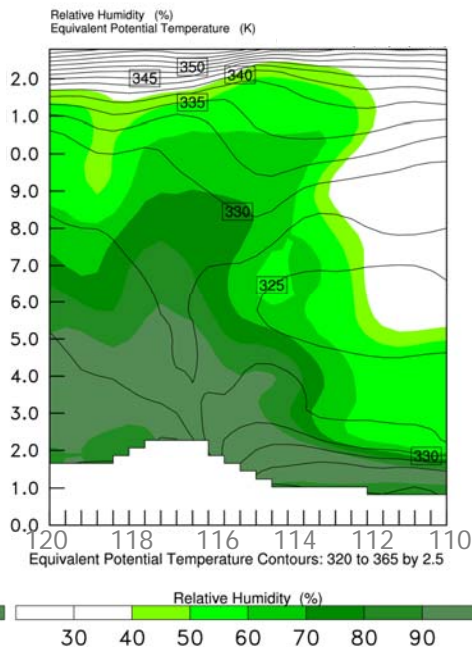


2013-06-22

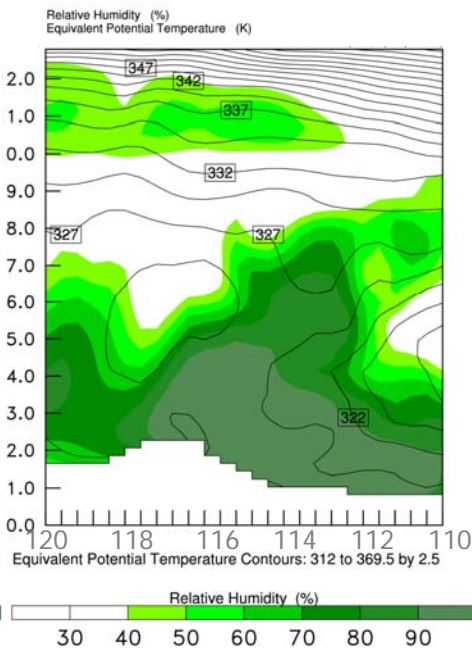
Water Vapor Sources



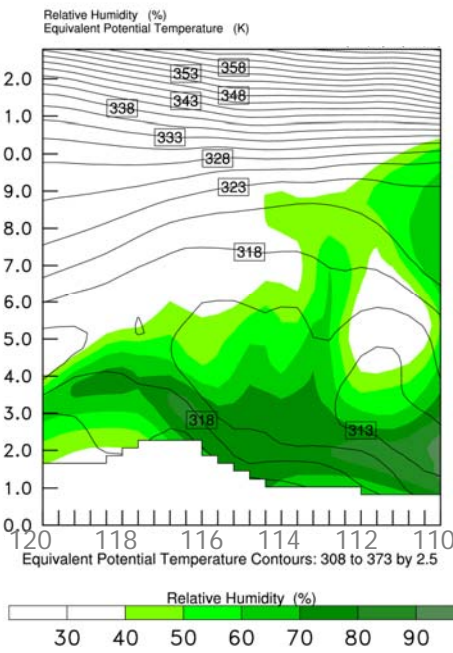
2013-06-19



2013-06-20



2013-06-21



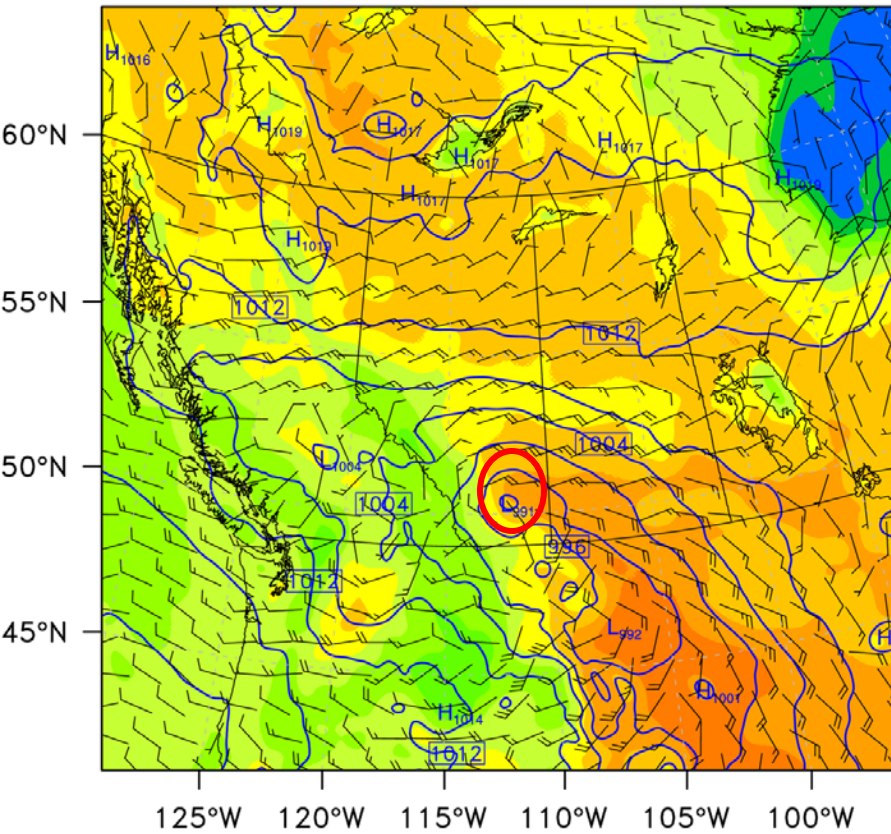
2013-06-22

Water Vapor Sources

Surface Temperature

Surface Temperature (C)
Sea Level Pressure (hPa)
Wind (kts)

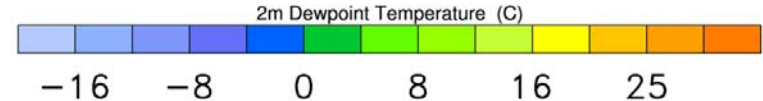
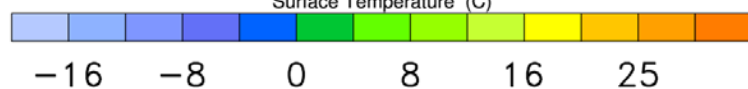
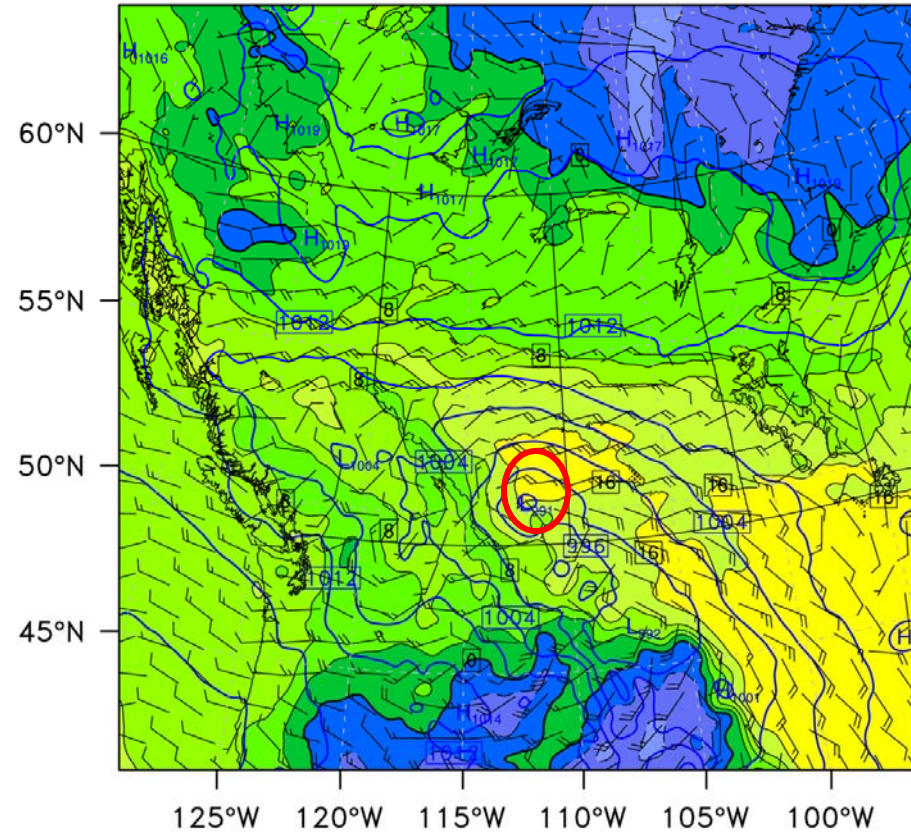
2013-06-20_00:00:00



2m Dewpoint temperature

2m Dewpoint Temperature (C)
Sea Level Pressure (hPa)
Wind (kts)

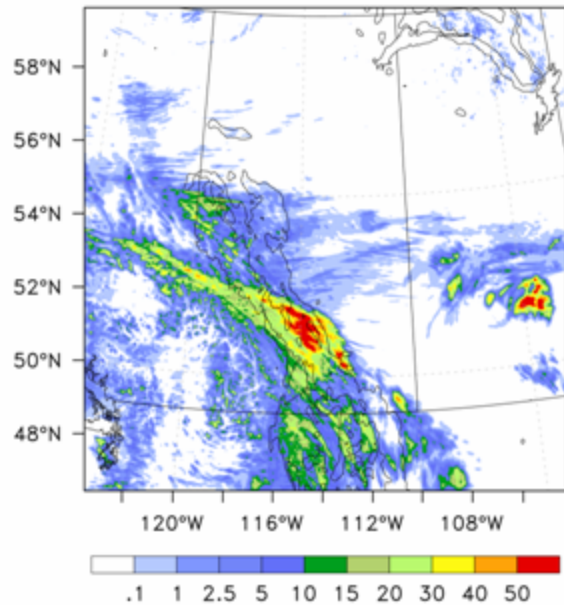
2013-06-20_00:00:00



Effects of Orography

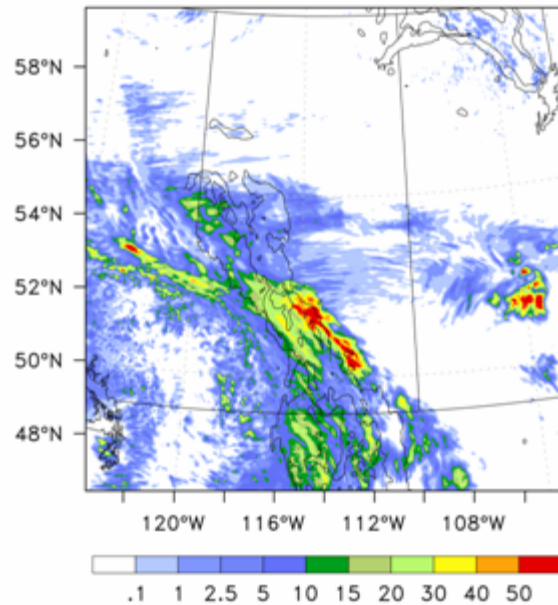
Original terrain

2013-06-20_00:00:00



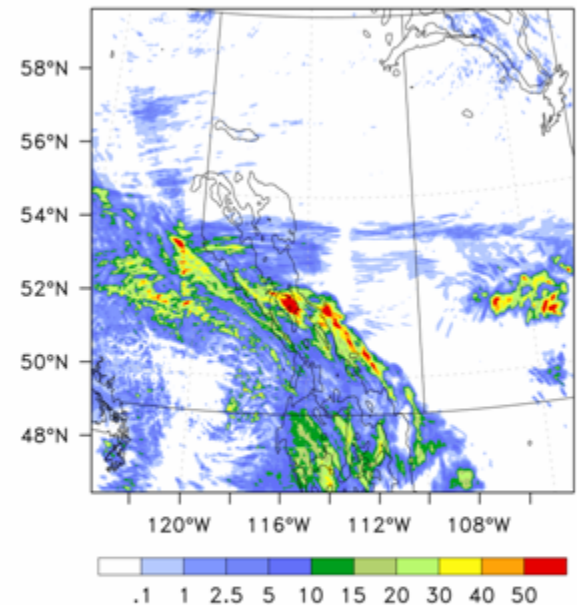
Smooth terrain

2013-06-20_00:00:00



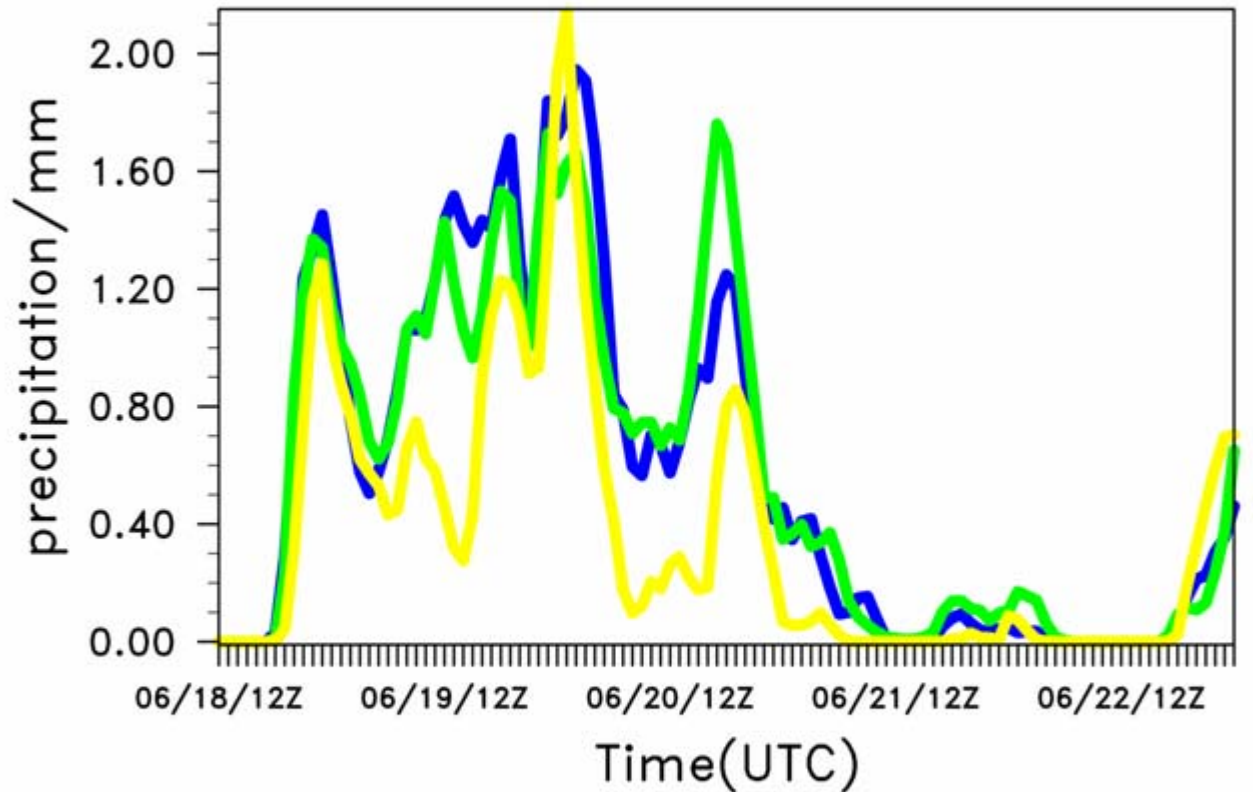
0.5 terrain

2013-06-20_00:00:00



Effects of Orography

WRF simulated total rain (06/19-06/21)

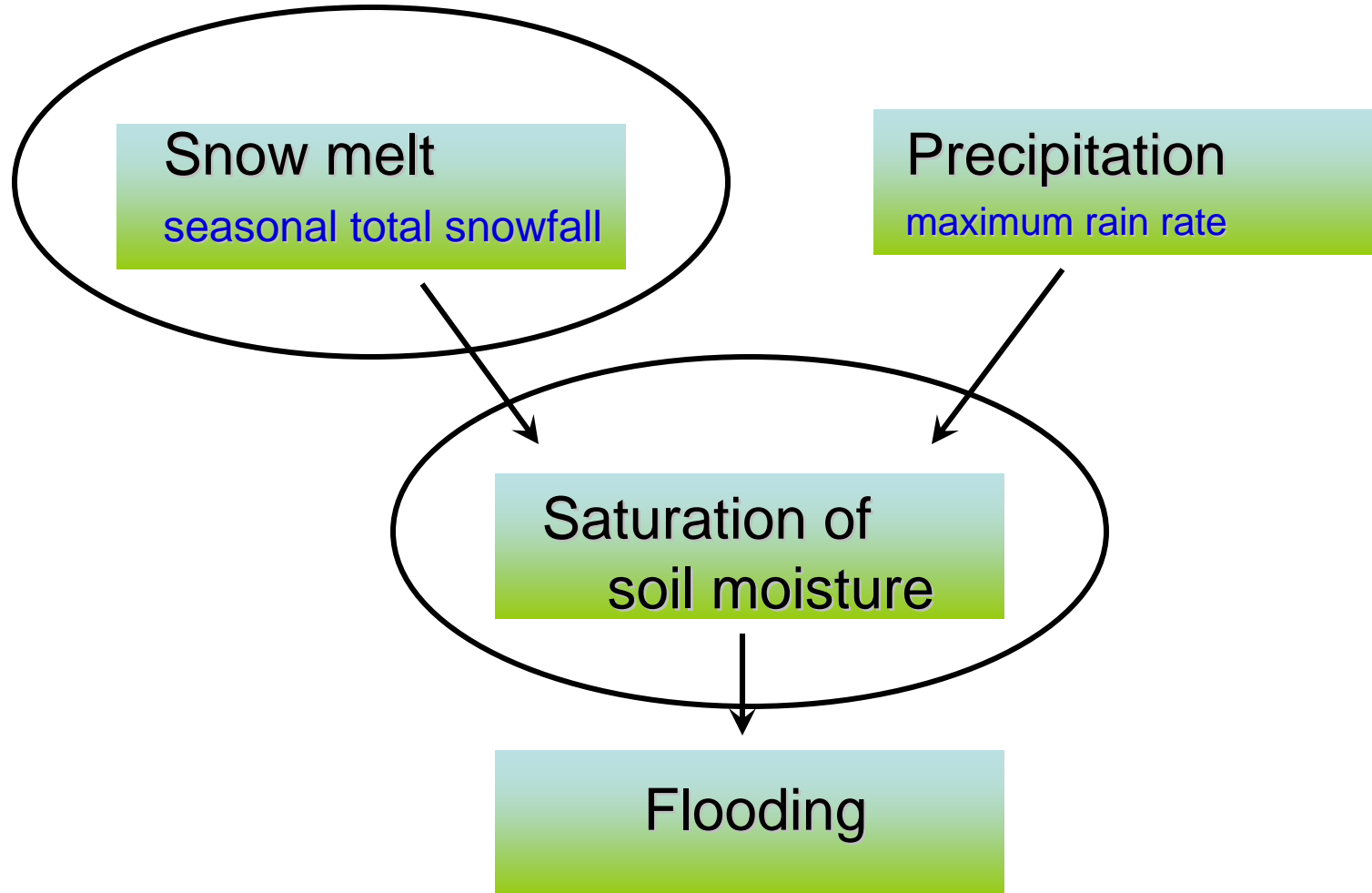


— control test — smooth terrain — 0.5 terrain

Summary

- Rainfall structure and evolution play a critical role: large-scale dynamics, especially in settings with strong moisture convergence, can result in land surface processes playing a secondary role in determining flood properties.
- Local terrain can alter “details” of the heavy rainfall distribution, but not the occurrence of heavy rainfall and flooding over the region.
- A reduction in mountain elevation decreases maximum precipitation significantly over the mountains and foothills, indicating that heavy precipitation was mainly contributed by the orographic lifting of the mountains.

June 2013 Alberta Flooding



Next step

- Whether a combination of heavy rain and melting snow caused this serious flood event.
- Examine the antecedent soil moisture conditions: how much previous rainstorms had moistened the soil during the entire season and especially over the few days leading up to the June 2013 Alberta flood so that the normally arid mountainsides were likely not able to rapidly absorb the additional rainfall of the sudden.
- Whether land surface processes playing a secondary role in flooding. What is the major role of surface evaporation, changing the buoyancy or providing additional moisture to the already plentiful moisture influx from the Prairies. Local evaporation may have enhanced the precipitation and helped perpetuate and prolong the conditions.

Future work: Regional Climate Change Studies Using WRF

Modeling studies of regional climate of Canadian Prairies using WRF model, paired with long-term trend analyses of variables linked to the hydrologic cycle to study:

- 1) human impacts (due to land-use and land-cover change) on regional climate;
- 2) the climatology of extreme rainfall and flooding: to use regional climate analyses based on WRF simulations as a vehicle for enhancing global model capabilities for regional climate analyses, with a special focus on the climatology of heavy rainfall and flooding.