Numerical modelling and bias-correcting a precipitation climatology over coastal southern British Columbia

Bruce Ainslie

Peter Jackson

October 16, 2009

AIM of research

- Develop historical high-resolution gridded precipitation fields for use in GMB modelling and for statistical downscaling of GCM output

- Dynamical downscaling of a reanalysis

- Added value is not through increased skill at the large scale but rather by resolving smaller scale features which have a greater dependence on the surface boundary

- Output is bias-corrected and evaluated against different datasets

Numerical Modelling Setup

- Simulate regional climate over 30-year period (1979-2008) using RAMS to dynamically downscale NARR reanalysis to 8km over the south Coast mountains

- RAMS is set-up with:
  - 2 nests: 32 and 8 km
  - 54 by 62 grid points at 8 km resolution
  - Each year broken into 123-84 h runs with first 12 hours not used.

NARR domain (blue) RAMS outer (red) and inner (green)
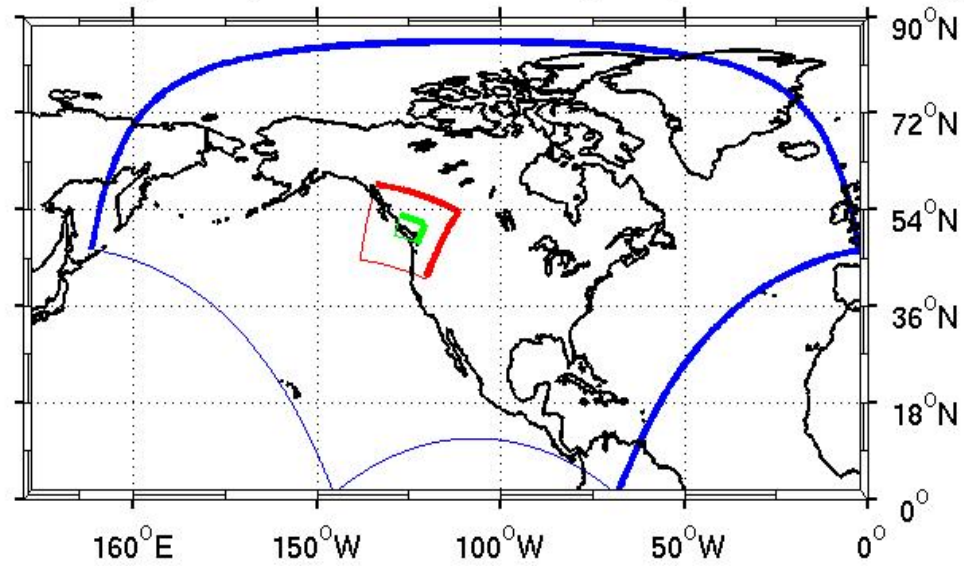
Topography on the inner 8km RAMS domain
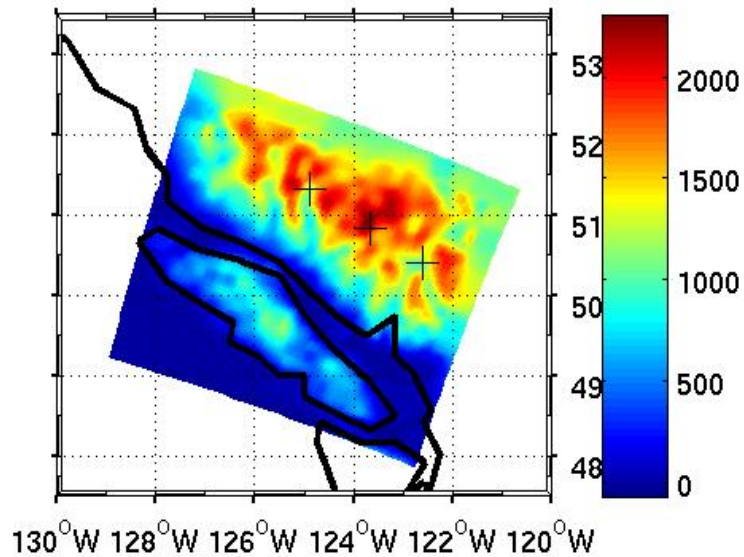
Raw Model Output

- Gridded hourly output for all 30 years
- Each year is about 90 Gb – 2.3 Tb in total
- Model variables saved on computational levels in hdf5 format
- Model output stored at:
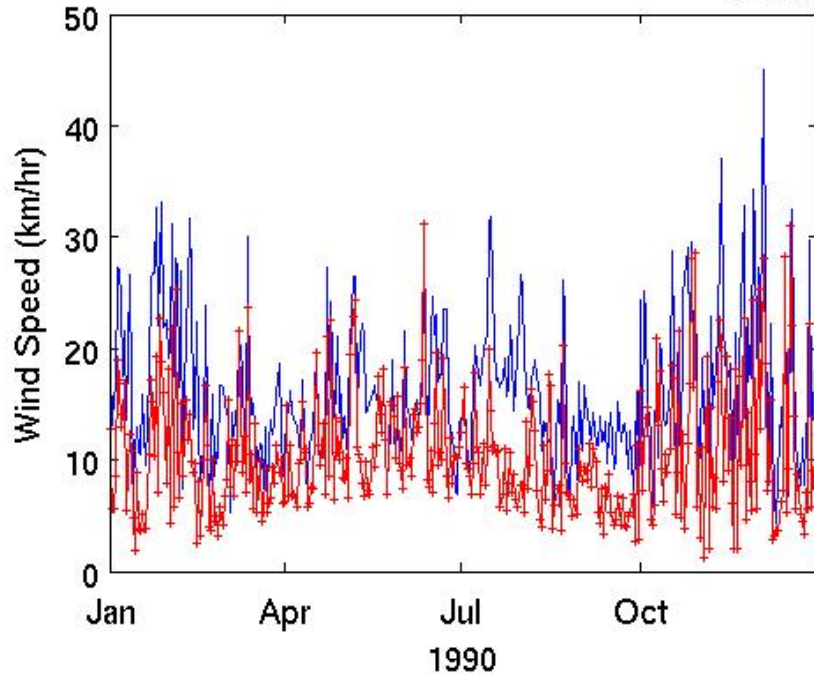
    gridstore.westgrid.ca

Extracted Key Fields

- Key fields extracted & saved as netcdf files
- Each file about 112 Mb (~ 360 Gb for the entire 30 years)

   Surface: Temperature, precipitation, slp, PBL height, latent & sensible heat fluxes, evapo-transpiration, incident SW & LW, upward LW, albedo, RH, horizontal wind components

   Pressure Levels (1000, 925, 850, 700, 500, 400, 300, 250 and 200 mb): horizontal wind components, vertical velocity, gph, Tdew, Potential Temperature, mixing ratio, vorticity and horizontal divergence.
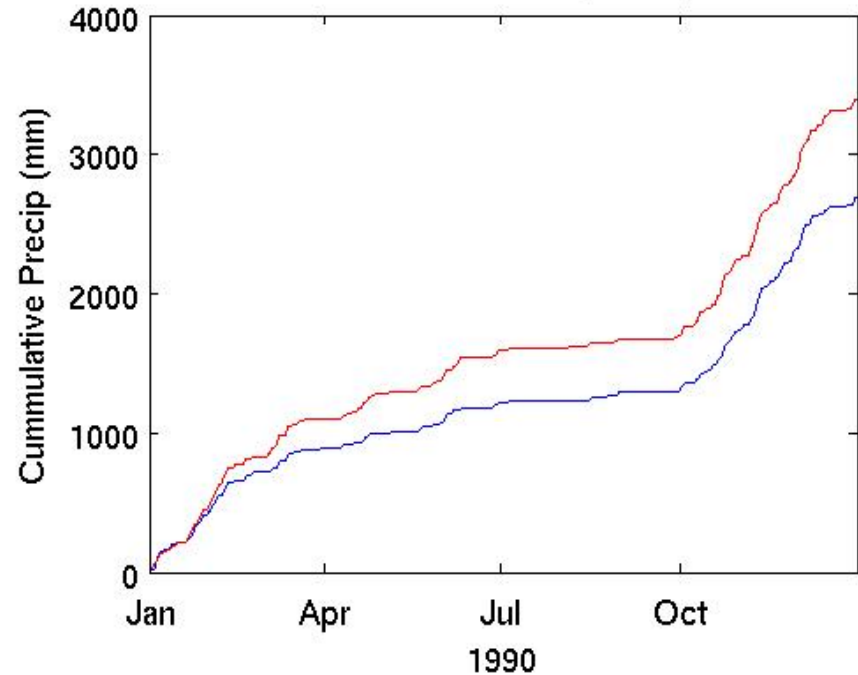
Daily average Wind Speed — 1990 Station:YAZ — Daily average Temperature
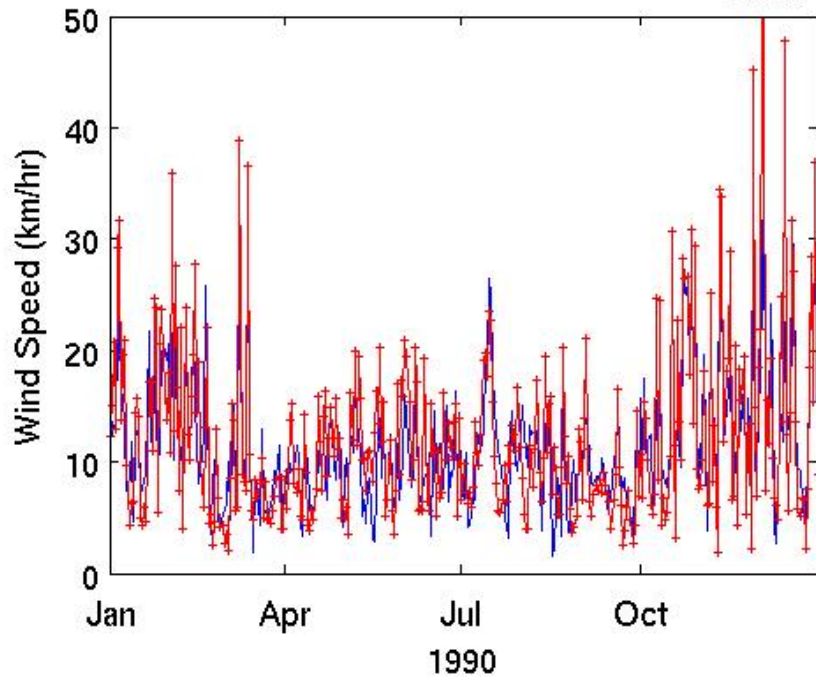
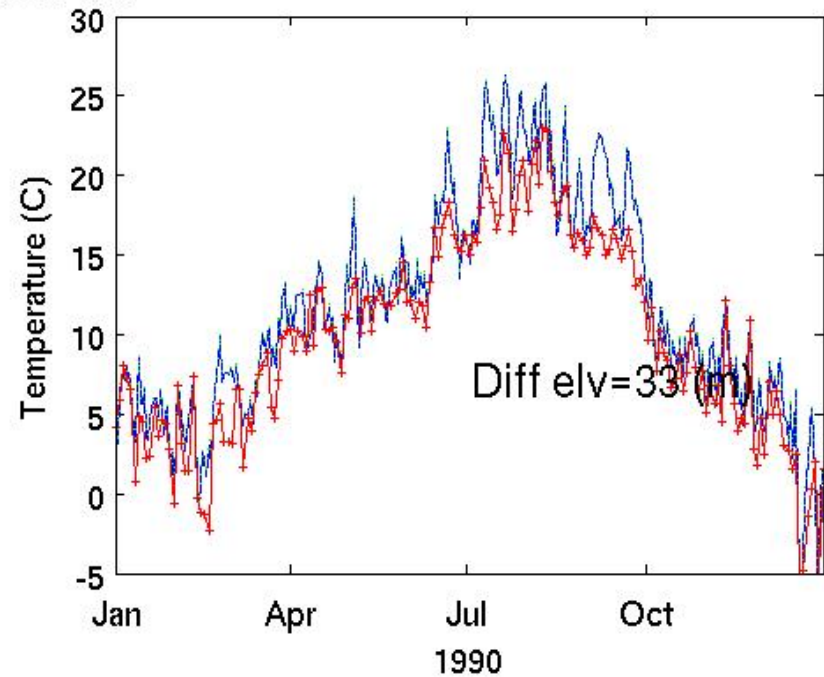Diff elv=-130 (m)
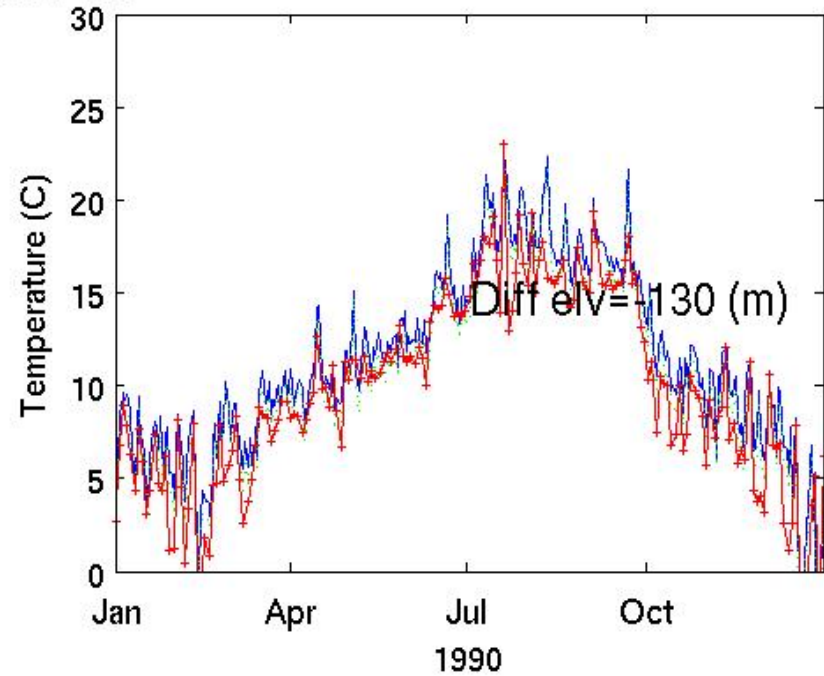
Cummulative Yearly Precip

Tofino

EC (red) and RAMS (blue) daily average wind speed, temperature and precipitations
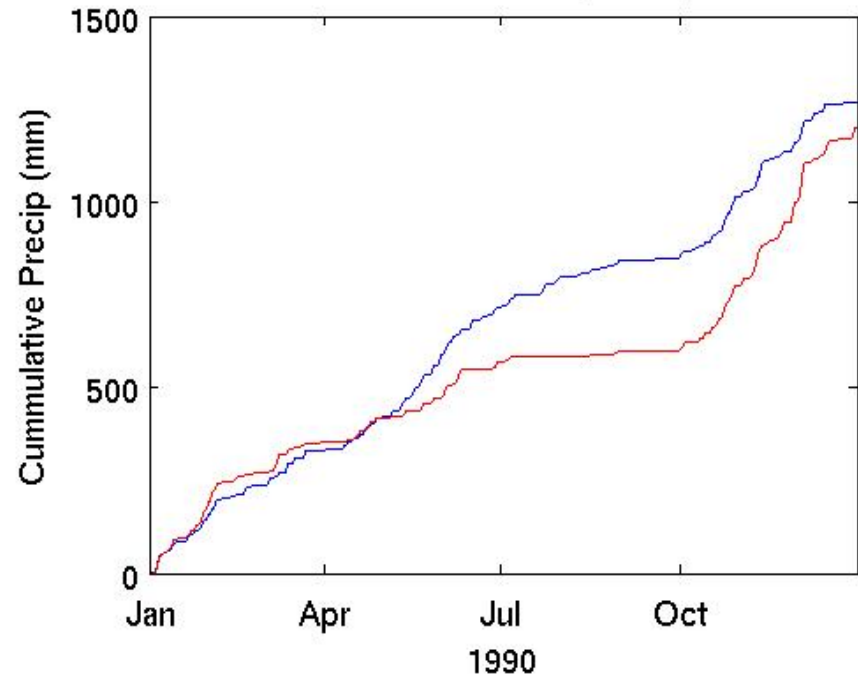
Daily average Wind Speed   1990 Station:YQQ   Daily average Temperature

Cummulative Yearly Precip

Comox
EC (red) and RAMS (blue) daily average wind speed, temperature and precipitations

Diff elv=33 (m)

Precipitation Bias Correction

- Correct any long-term model bias with spatially varying factor (b)
- 3 step process:
  – Estimate long-term bias at select locations
  – Interpolate bias to entire grid
  – Compare bias-corrected w/ additional datasets
- Due to under-catchment issues for solid precipitation estimate bias using:
  – flow based measurements (water balances)
  – accumulation based measurements (snow pillow)
 – rain gauge observations only on days Tavg>0

Bias Correction Estimation: Water balance

- 12 drainage basins located within model domain through GIS analysis
- Long term water balance budget:

$$R = (bP - E) - (Q + DS)$$

     – R: water balance residual

     – b: bias correction factor

     – P: modelled precipitation

     – E: modelled evapotranspiration

     – Q:1979-2002 HYDAT monthly streamflow

     – DS: Estimated glacier wastage

RAMS Inner domain with drainage basins shaded by area-averaged streamflow (mm/yr)
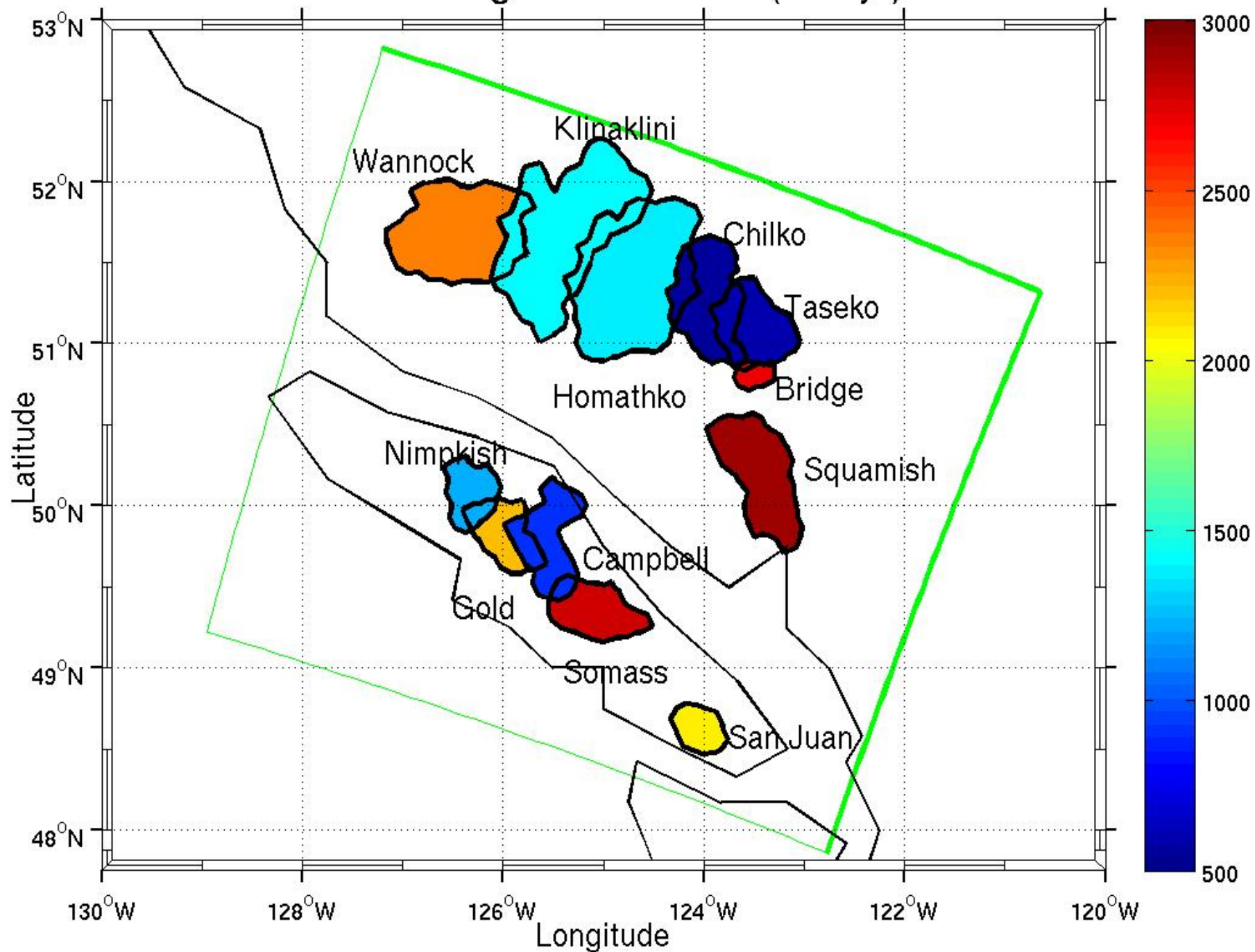
Bias Correction Estimation: Snow Pillow and climate stations

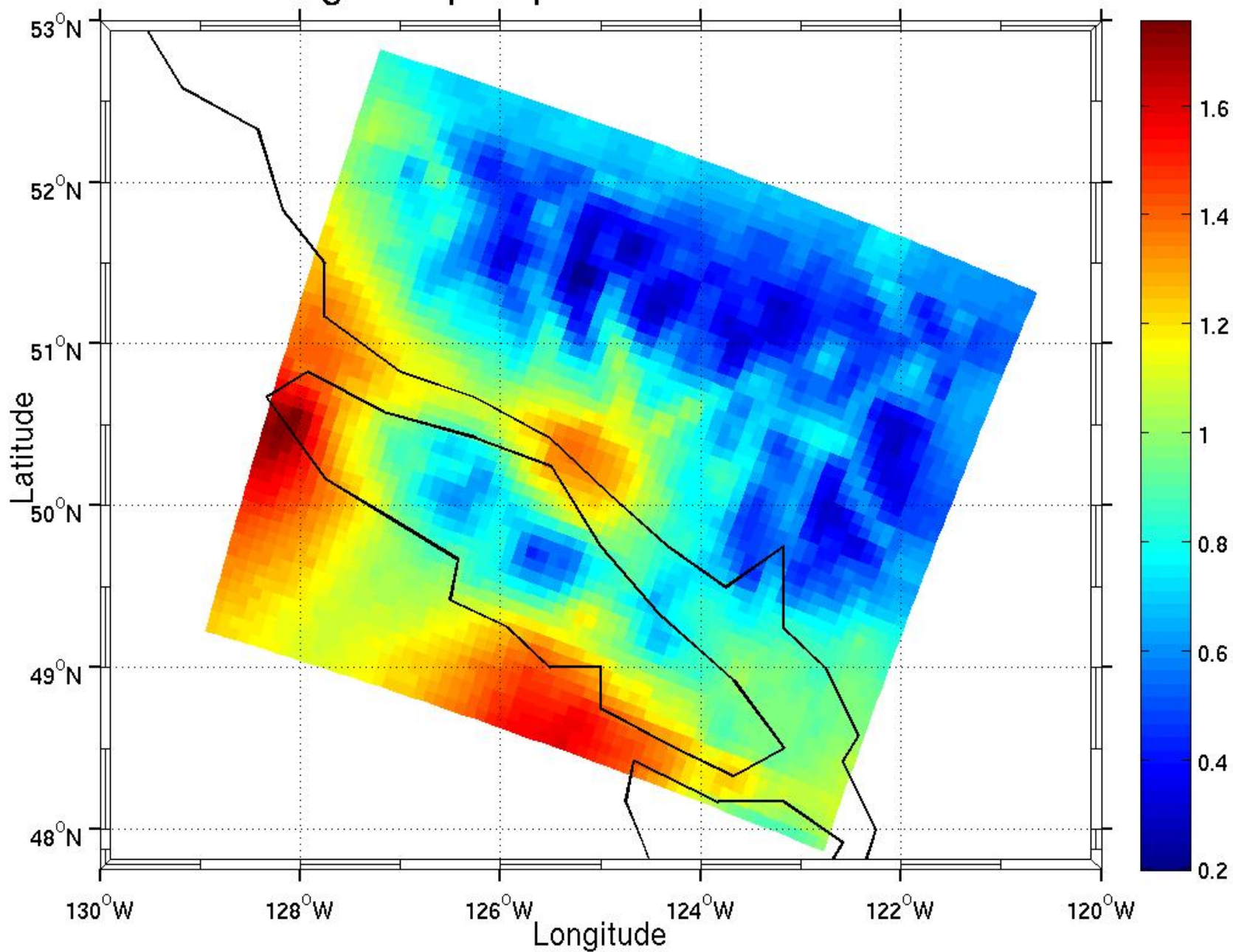- 6 BC MoE Snow Pillow stations
- 79 EC weather and climate stations

$$b = S\, O_d / S M_d$$

  - O_d: observed daily precipitation
  - M_d: modelled daily precipitation
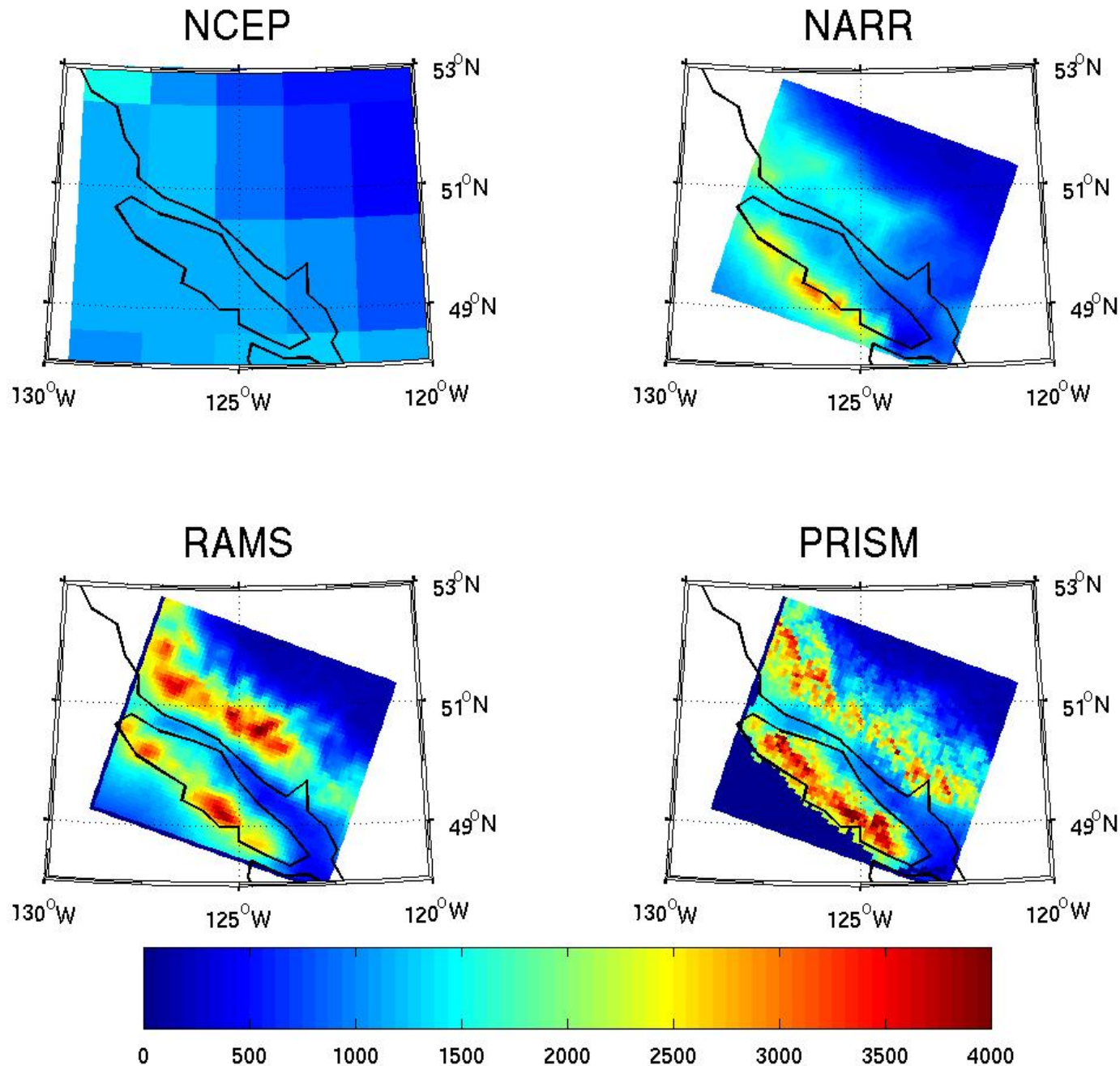
- Minimum 1500 obs/model pairs required

RAMS inner domain with EC synoptic (red) climate (blue)
and MoE snow pillow (purple) used stations for bias calculations
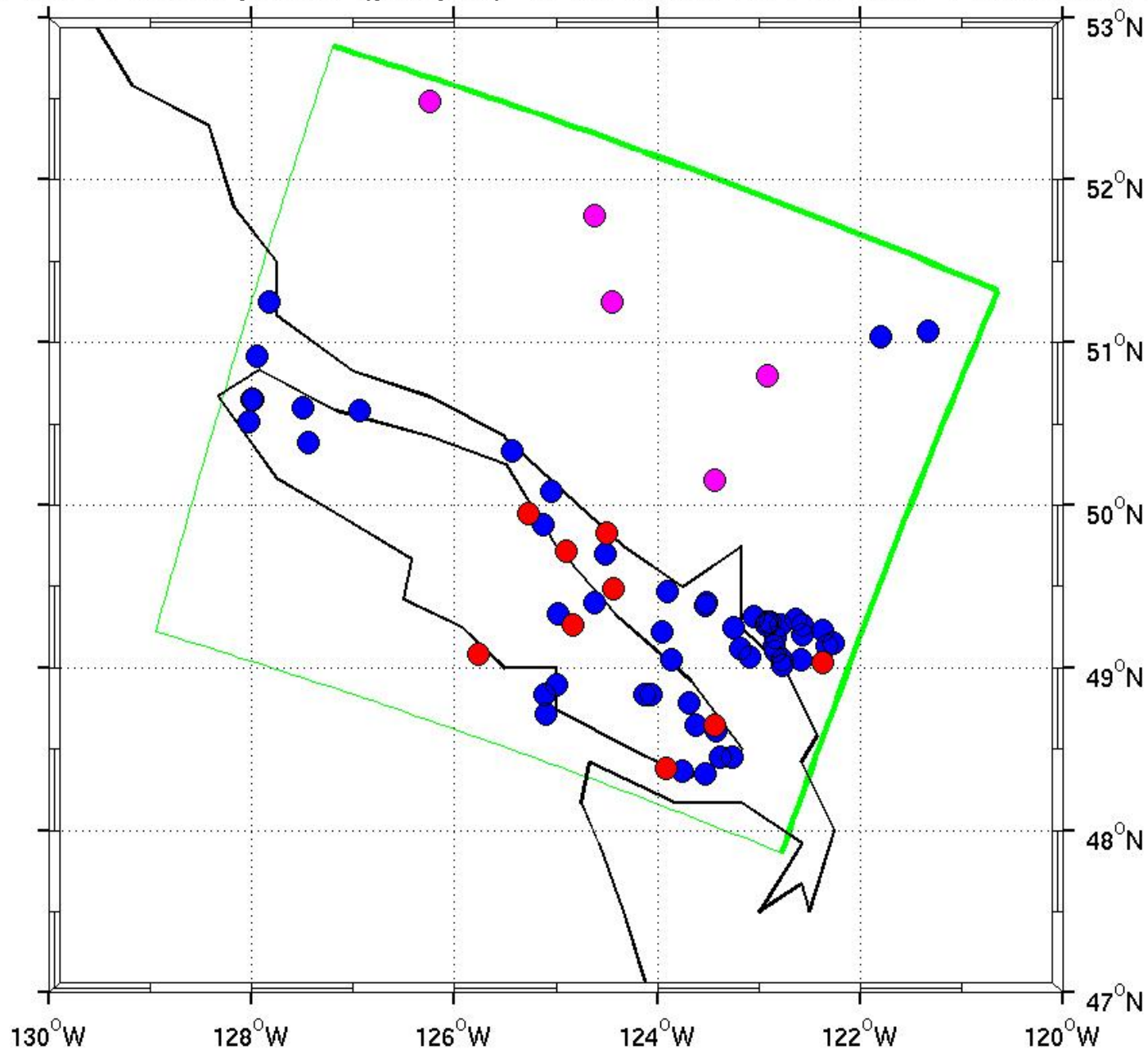
RAMS long-term precipitation bias-correction factors

# Cold season (Nov-Apr) Precipitation (mm) climatologies

Precipitation Model Evaluation – Direct Methods

- Monthly observed and bias-corrected precipitation compared at the following stations:
  - 7 EC reference climate stations
  - 10 BC MoTH stations
  - 30 BC MoF stations
  - 35 BC Hydro stations

Rams Inner domain with RCS (red) MoTH (blue) MoF (purple) BCH (green) validation stations
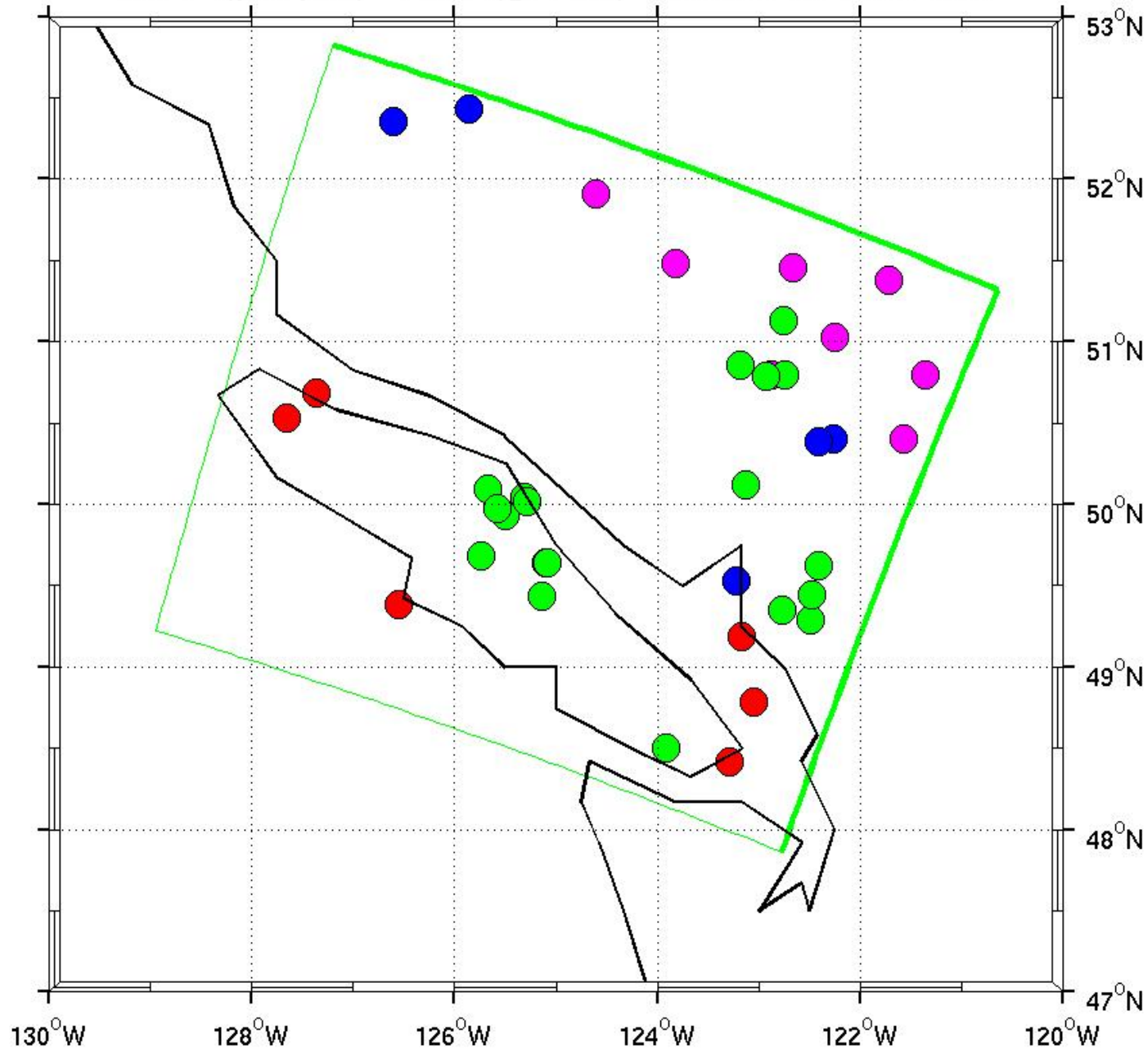
Raw Observed (red) Modeled (Blue) and Bias corrected (Green) Precipitation as a function of Daily Temperature
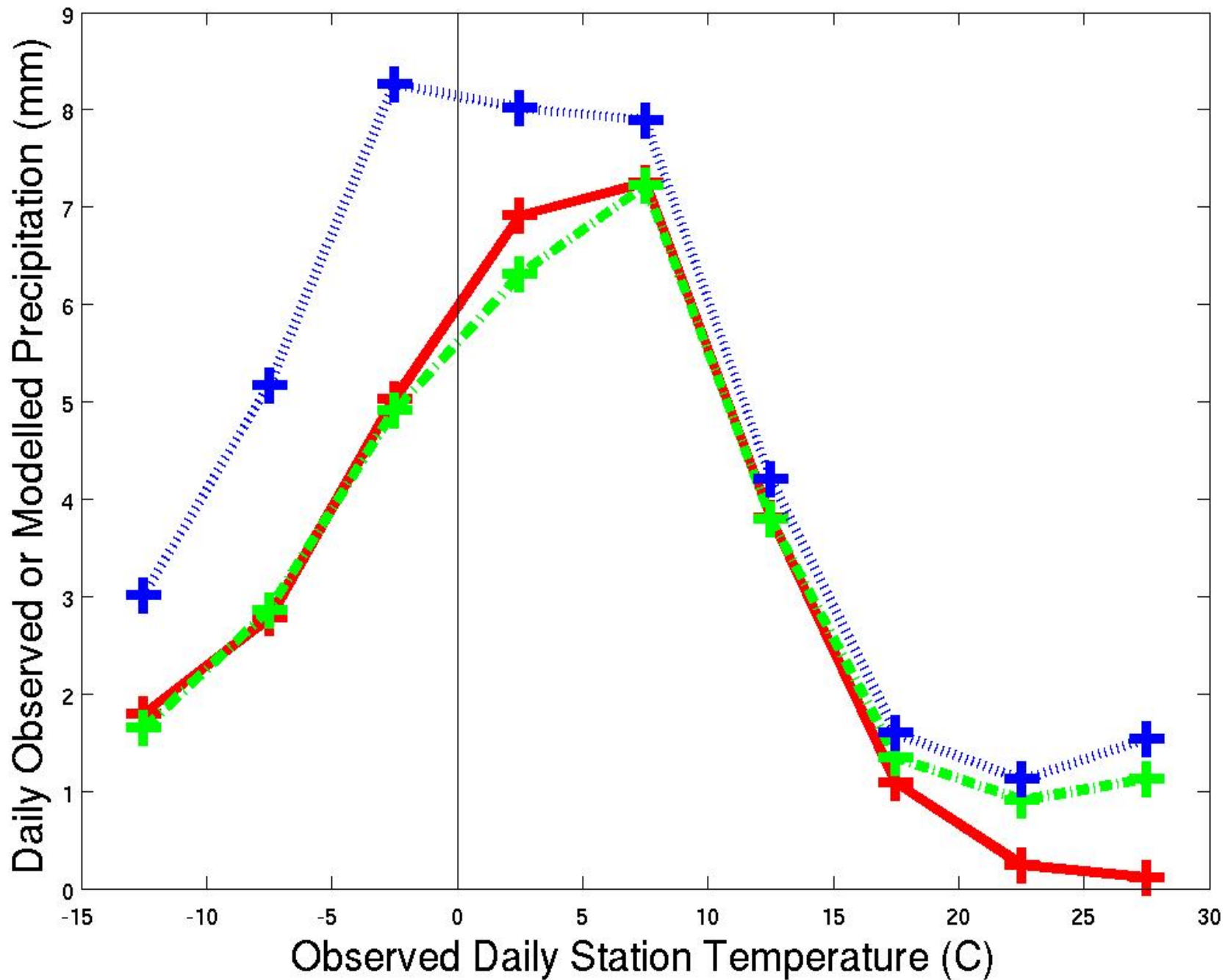
Precipitation Model Validation – Indirect Methods

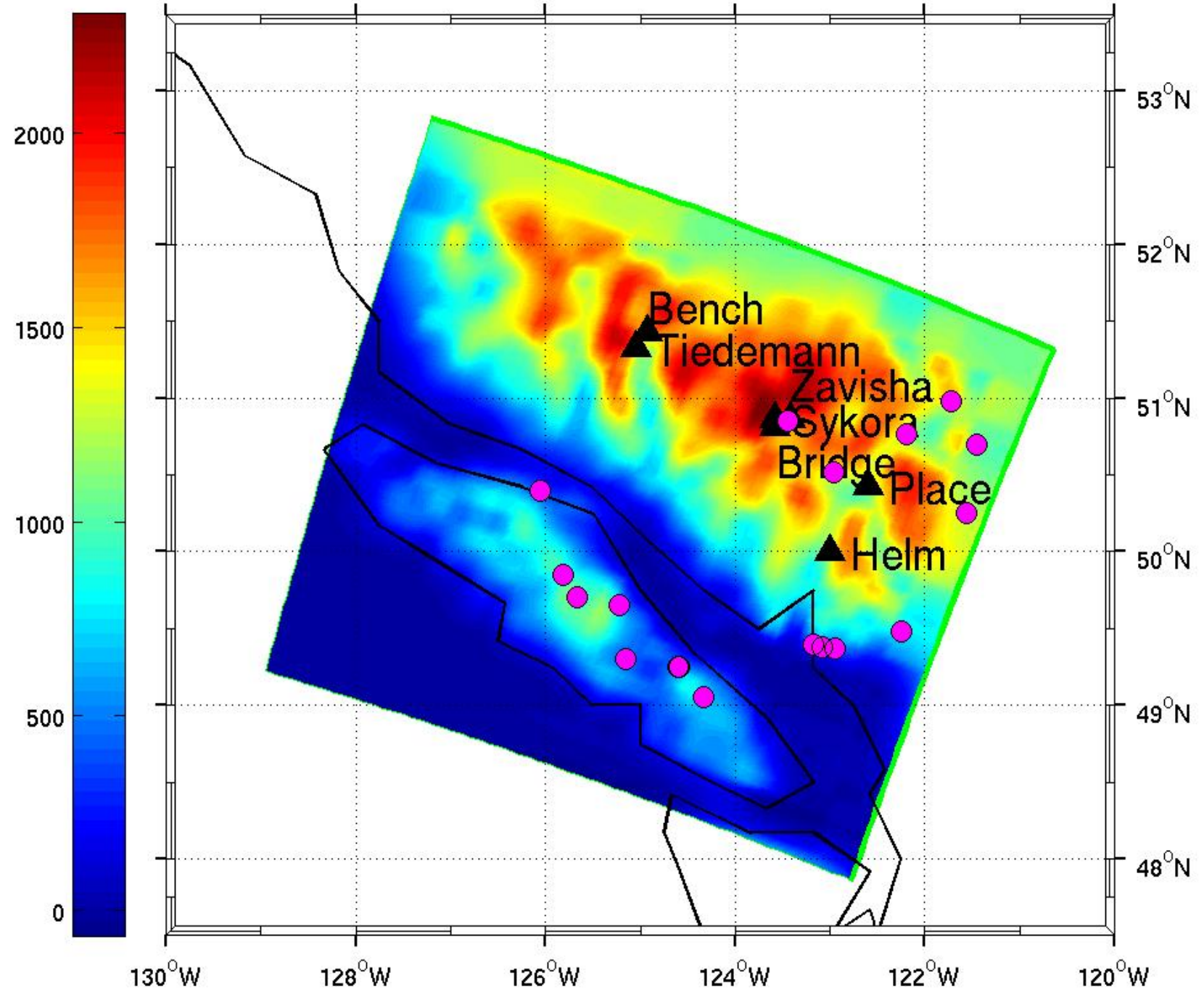## Hydrological Validation

- 12 drainage basins

Snow Course Validation

- 20 snow course stations
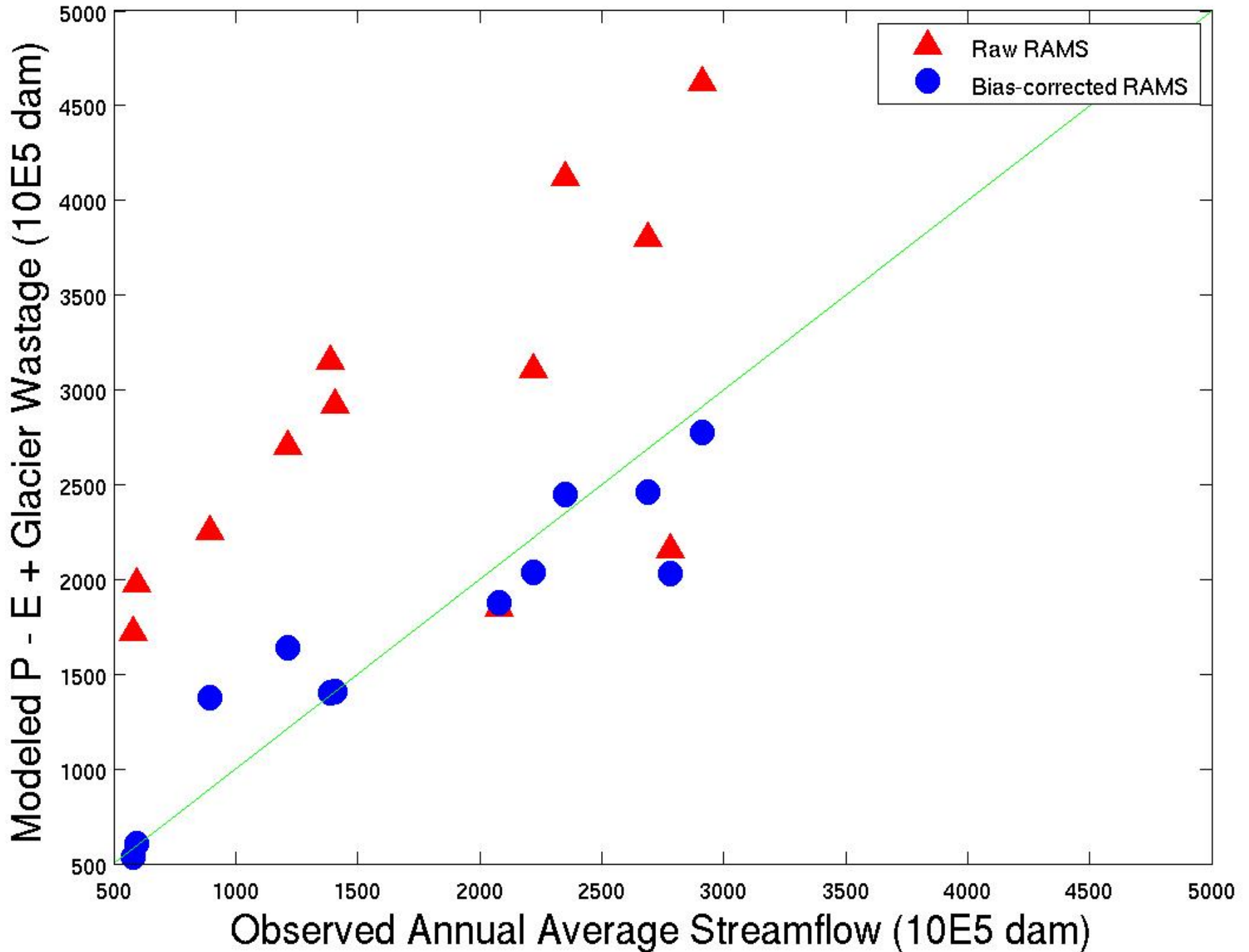- April 30 – Jan 1 SWE data used

GMB Validation

- Winter (Nov-Apr) mass balance from 7 glaciers
- Elevational data converted to glacier-wide WMB
- 46 glacier-wide values spanning 1979-1995

Glacier (triangles) and Snow Course (circles) Locations
RAMS topography (m)

Observed Annual Streamflow vs Modeled P - E + Glacier Wastage
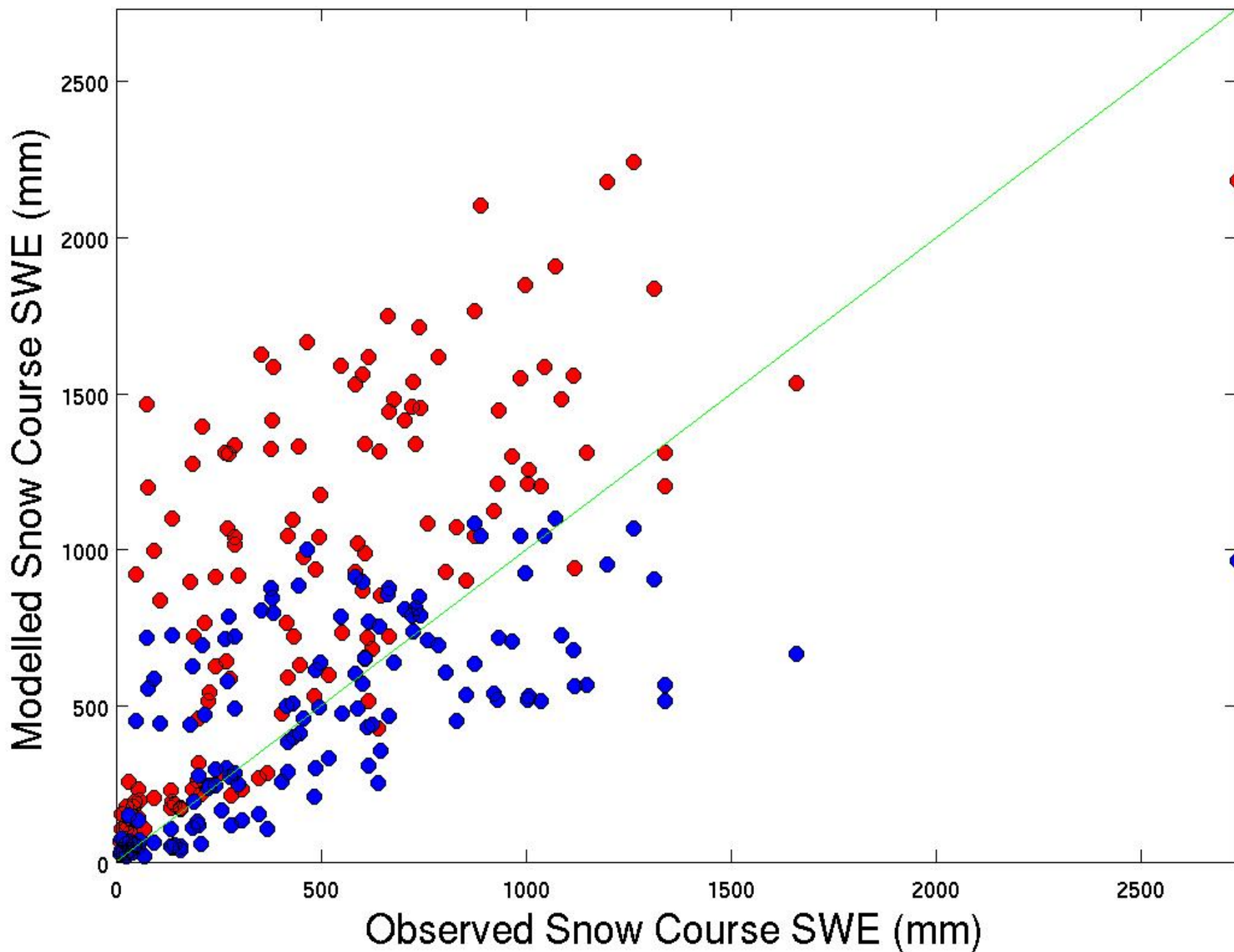At the 12 drainage basins within the modeling domain

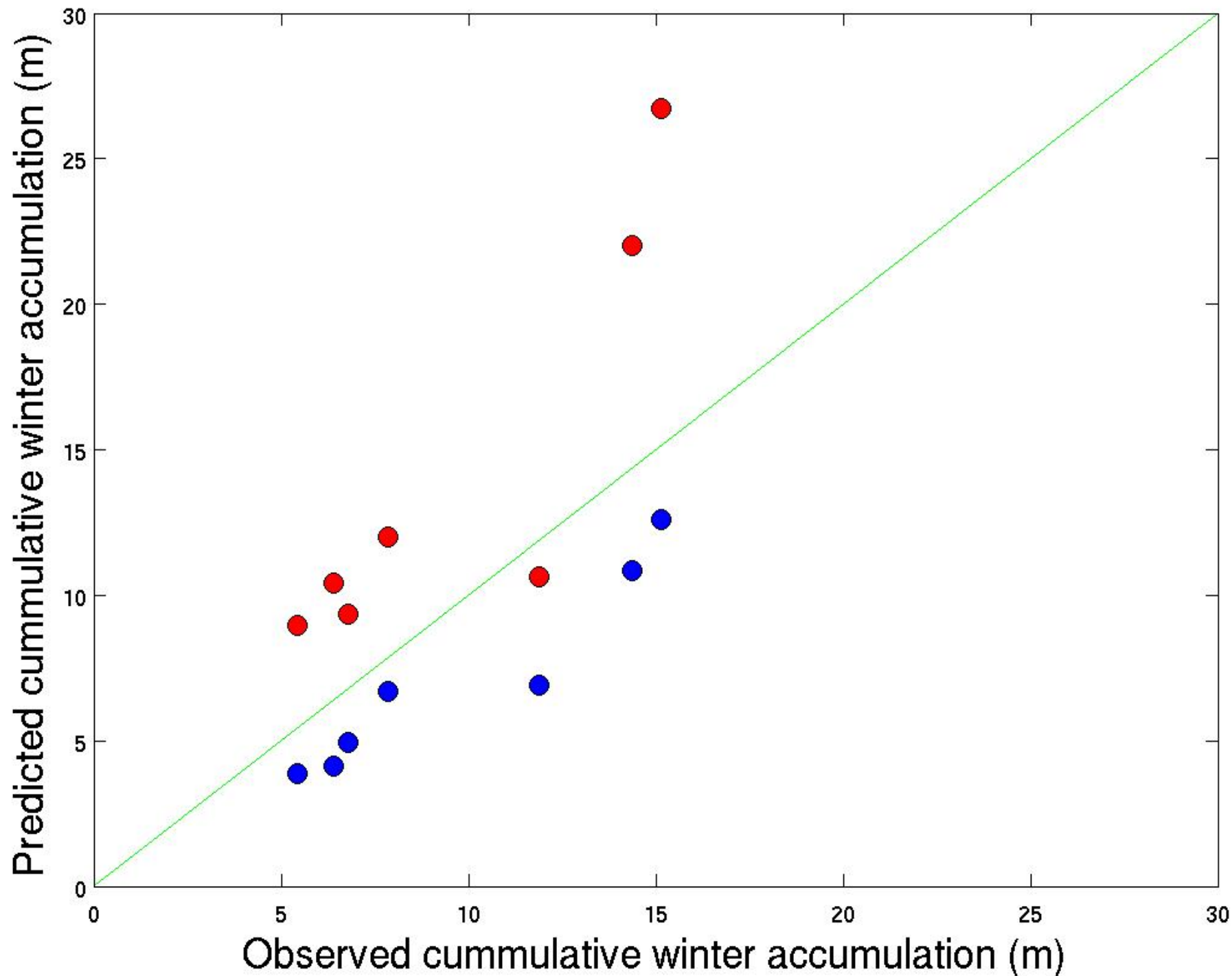Observed vs RAMS Predicted April 1 - Jan 1 Snow Course SWE
Raw (red) Bias-corrected (blue)
Results from stations where 50 % (or more) of precip occurs w/ Tday <= 0.0C

Observed vs RAMS Predicted Cummulative winter accumulation (m)
Raw (red) Bias-corrected (blue)

Conclusions

- RAMS fields show influences of higher resolution topography over driving reanalysis

- Bias correction improves model output as verified using streamflow, snow course, glacier WMB and monthly station observations

- RAMS output includes all radiation and surface energy fields suitable for more complex mass balance studies

Comments and Suggestions

Outline

- Modelling
- Bias-correction
- Results
- Conclusions

Average precipitation (mm/yr) RAMS bias-corrected (A) PRISM (B)
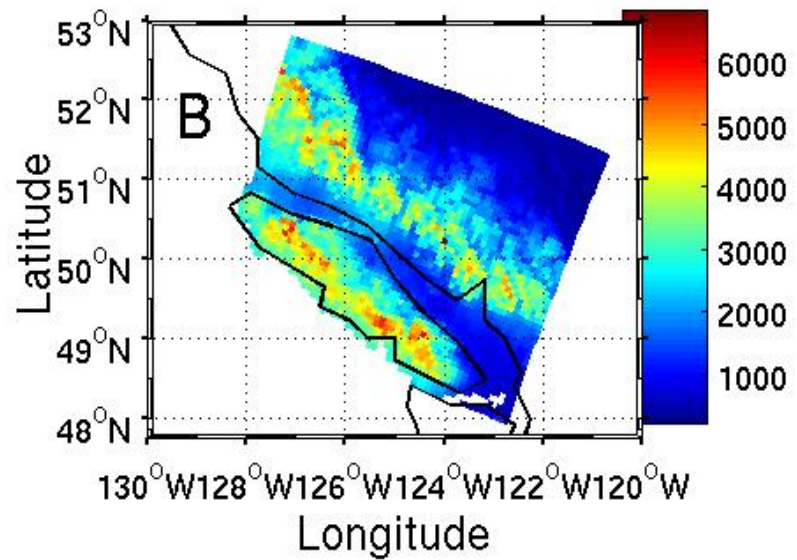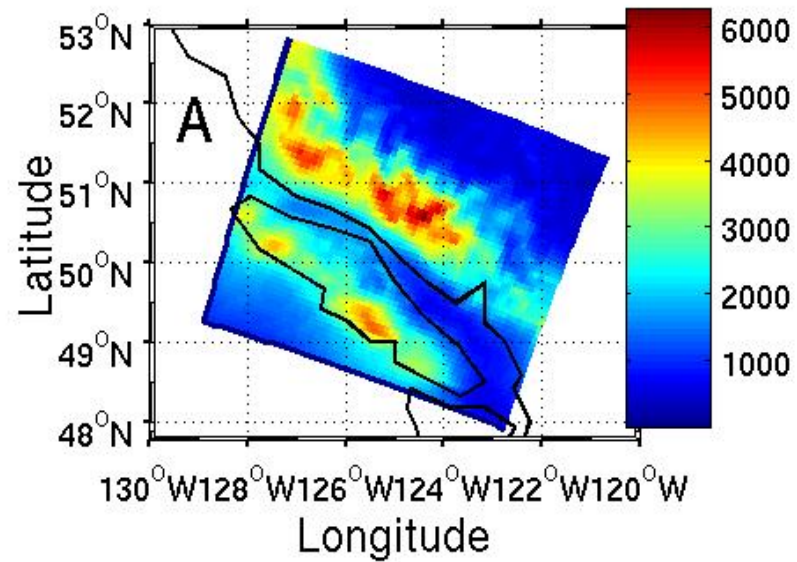
Climatologies

- Compare RAMS with NCEP, NARR and PRISM
- 17 year period from 1987-2002