Extreme Value Theory to analyse, validate and improve extreme climate projections

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<u>Extremes</u>: events in the tail of the distribution

<u>Extreme Value Theory (EVT):</u> branch of statistics which studies the properties of extreme values and enable to fit them with theoretical distributions

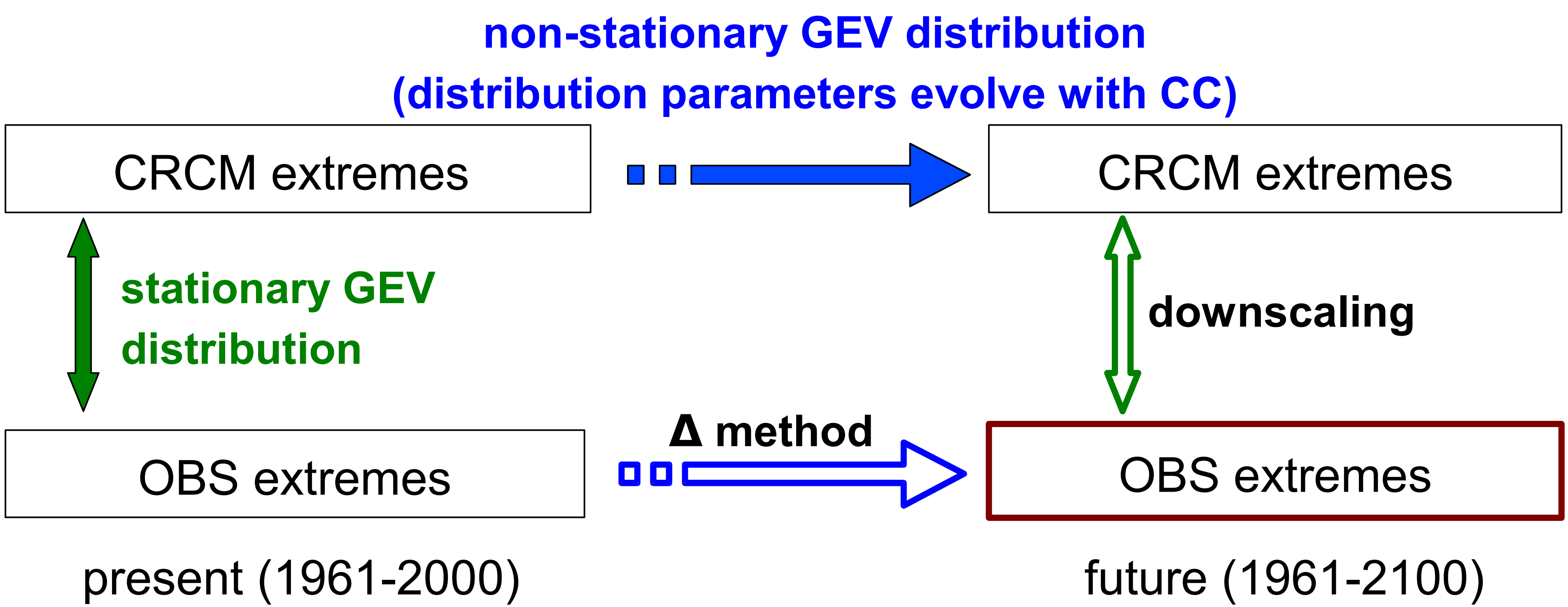
<u>Why EVT?</u> robustness (large values); inference (rare events); modelling (evolution of extremes with CC)

Objective: quantify future extremes in OBS space

1. bias + representativeness: diagnose relation between CRCM and OBS extreme distributions in the present (stationary GEV distributions)

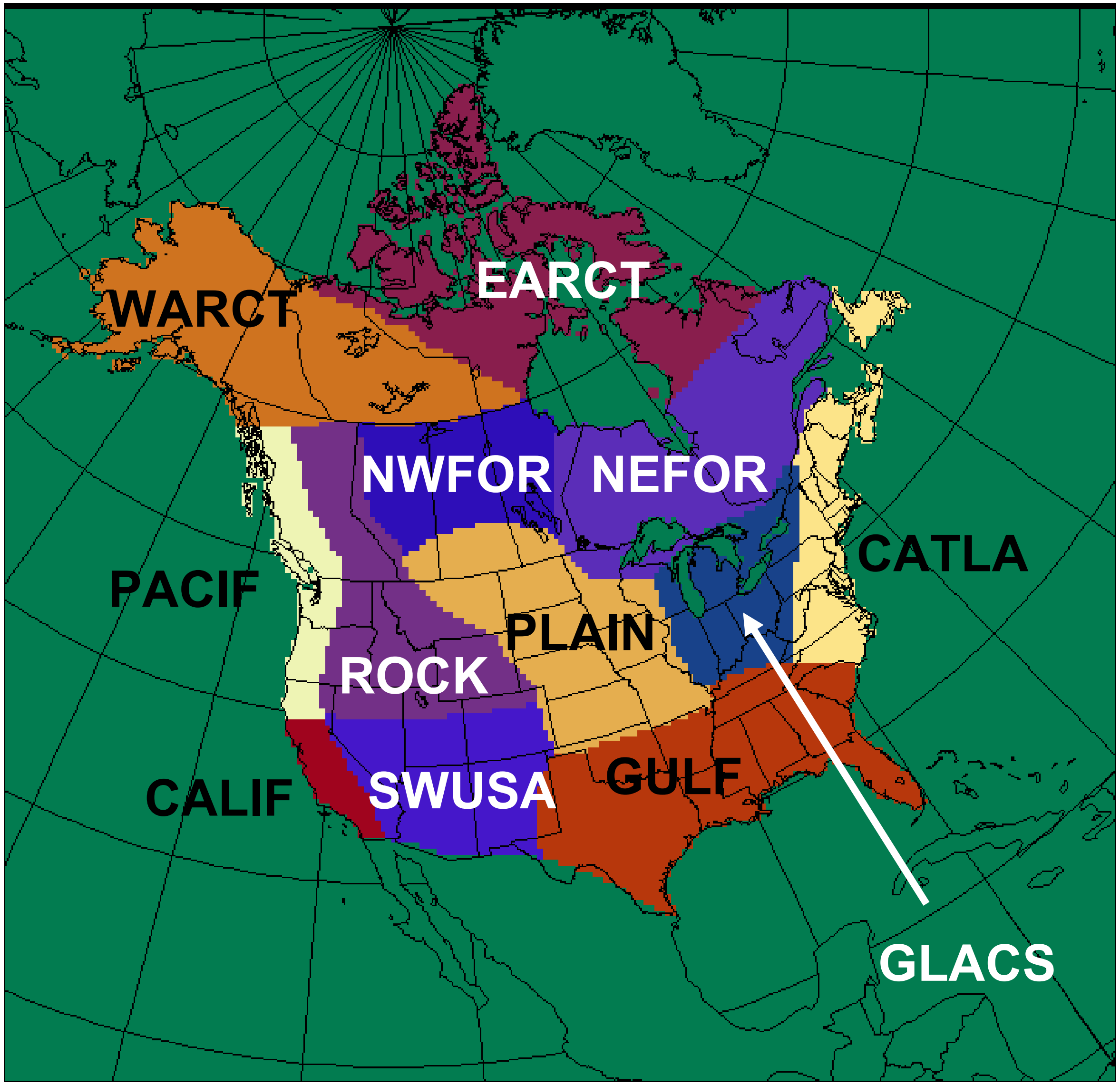
2. evolution: detect trends of the CRCM extreme distributions with climate change (non-stationary GEV distributions)

3. use these relations to estimate future (OBS) extremes



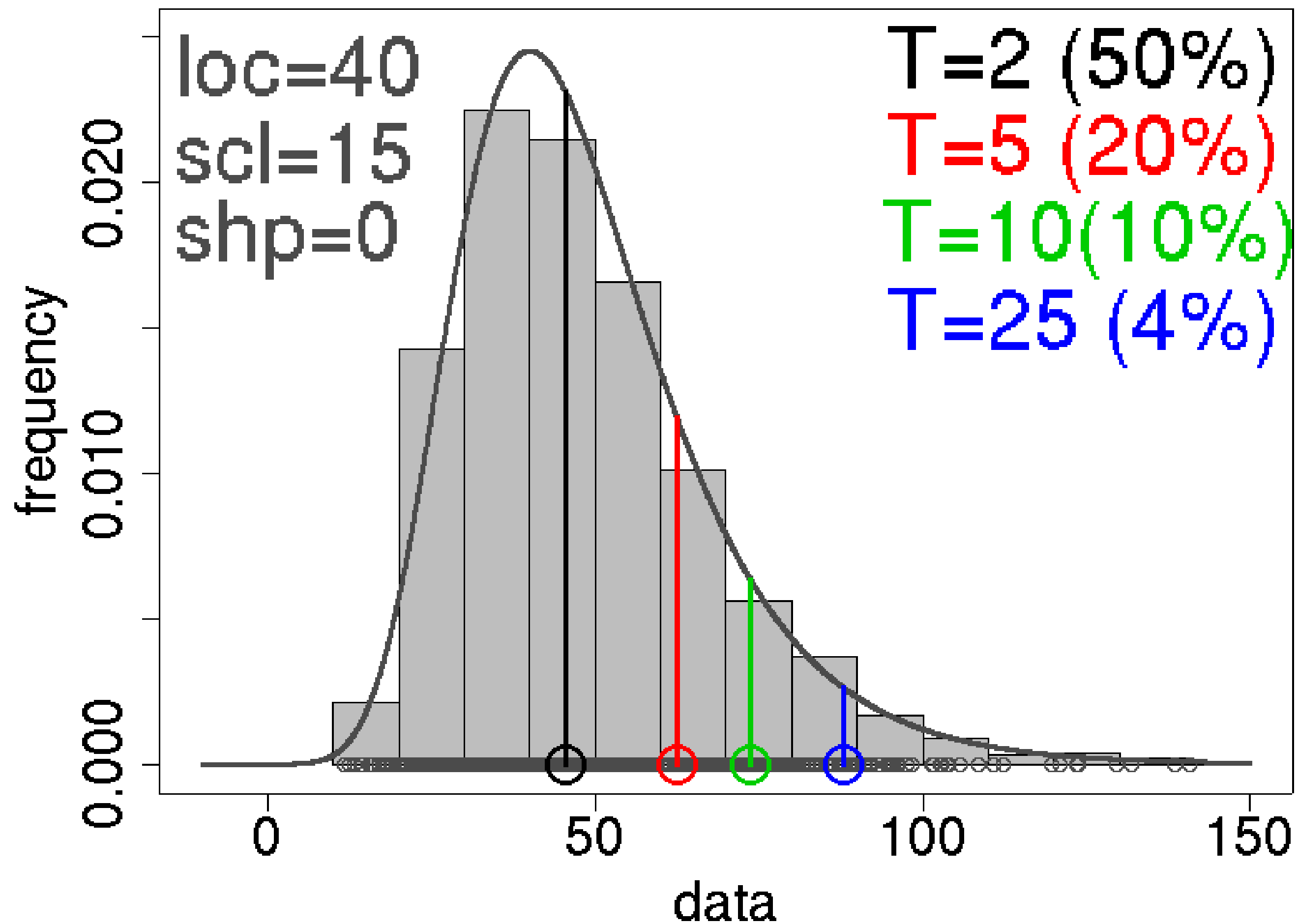
CRCM and OBS data

- 12 climatological regions over the AMNO domain, from Plummer et al (2006)
- Daily Tmax and Tmin, 24 hour precipitation accumulations
- GEV distributions of annual extremes
- Ensemble of Canadian Regional Climate Model (CRCM) simulations:
  1961-2000 = present
  1961-2100 = future
- Observations from Canadian (DAI), US (NCDC) and WMO (Res40) station networks



Block Maxima and GEV distributions

Block maxima (e.g. max annual temperature) are distributed as a Generalised Extreme Value (GEV) distribution (Coles 2001)

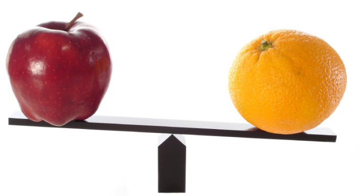


GEV distributions are characterised by **location** (typical value), **scale**(spread/variability) and **shape** (tail values) parameter

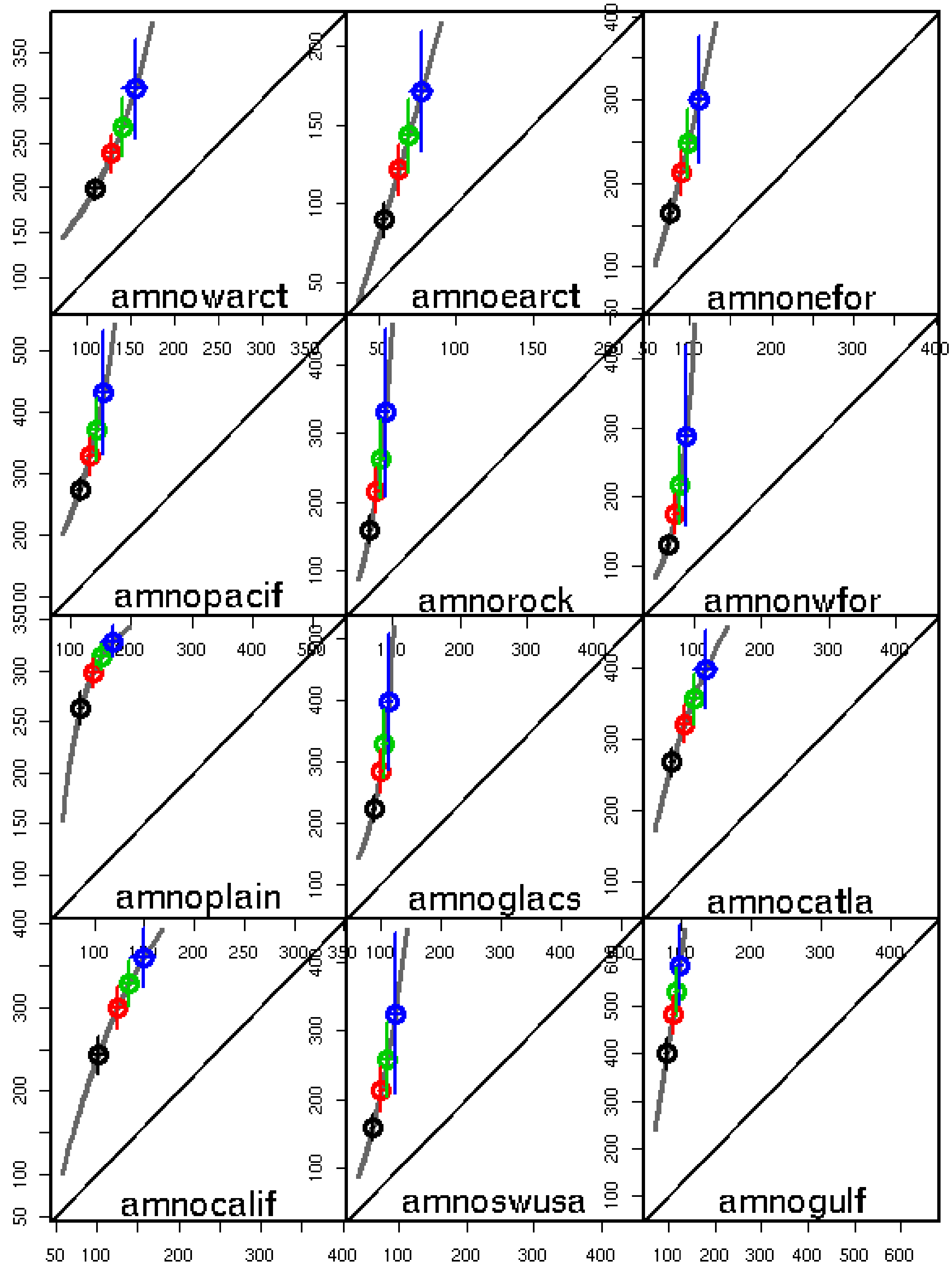
A **return value** with a return period of T years is the extreme event exceeded once every T years (its probability of exceedance is 1/T)

1. CRCM vs OBS - present climate (1961-2000)

PCPN extremes are systematically under-estimated (location, variability and tails)



Note: expected result, **representativeness** CRCM~45km resolution vs precipitation extremes = small-scale convection. Systematic behaviour ⇨ downscaling relation



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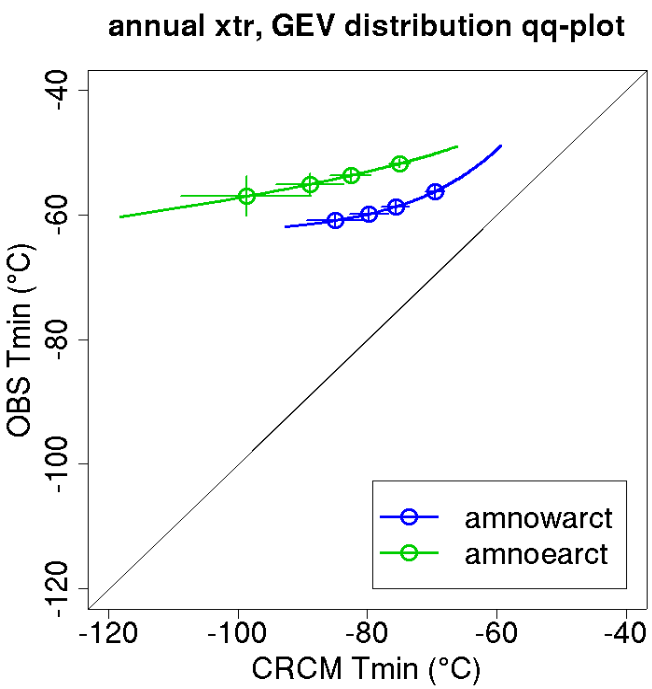

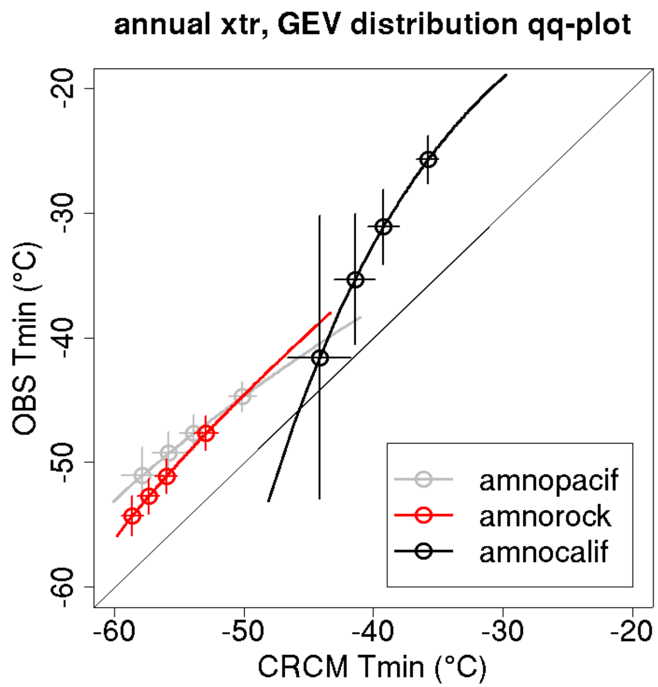

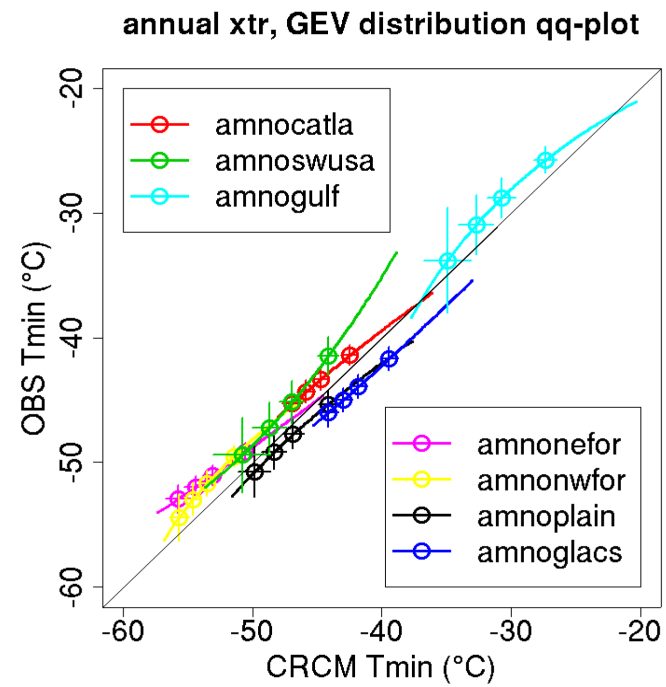

Tmin extremes are un-physically cold in the Arctic (CRCM glacier parametrization)

Tmin extremes exhibit a cold bias in the west

Tmin extremes are well simulated in the centre and east

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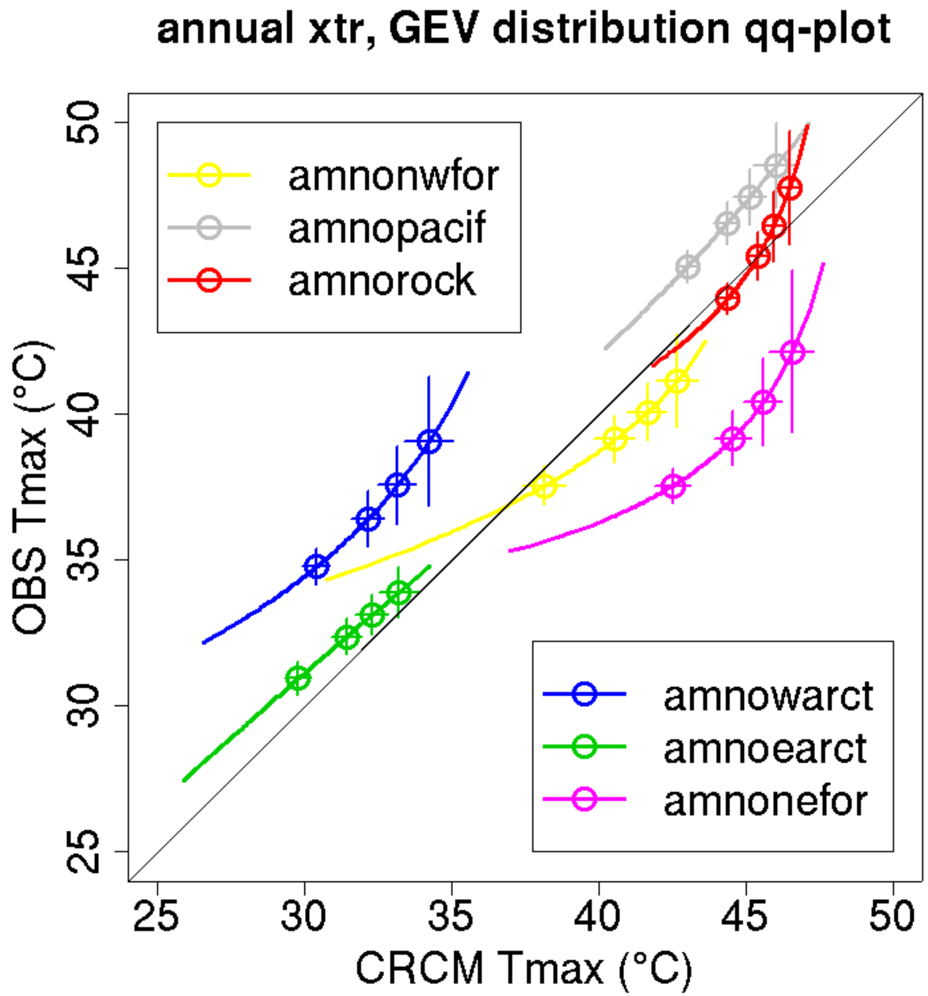
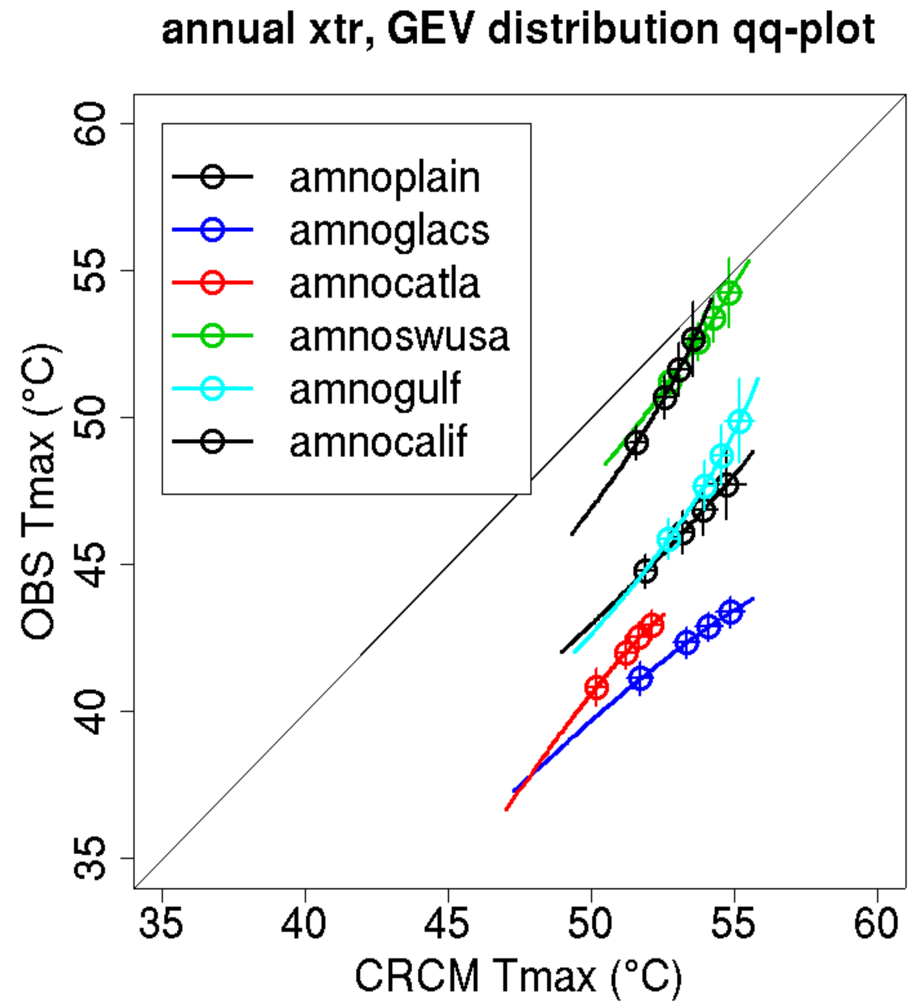
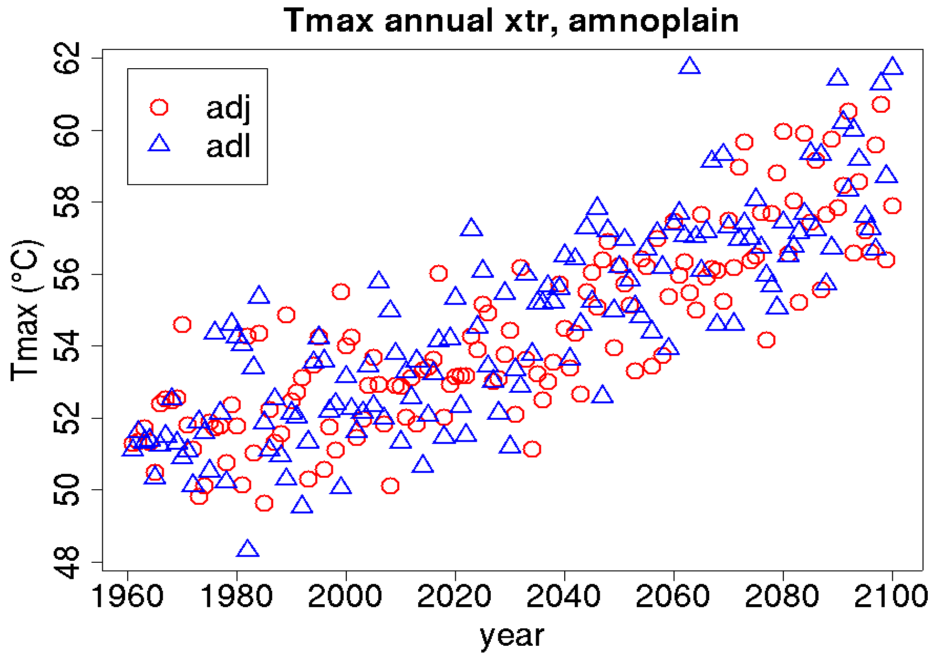
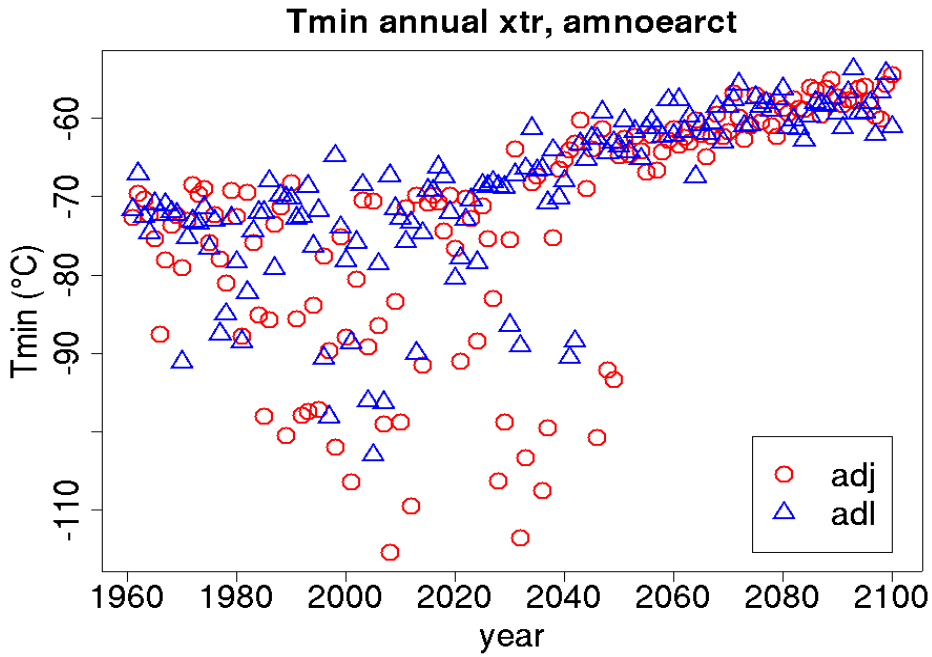


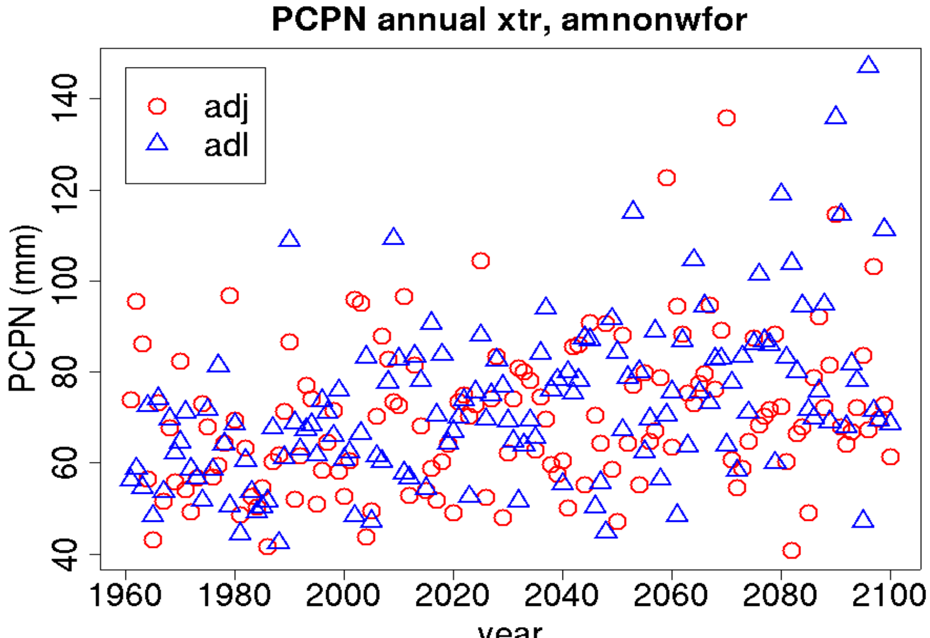


Tmax extremes are cold in the north-west, warm in the south-east

2. CRCM projections of annual extremes (1961-2100)







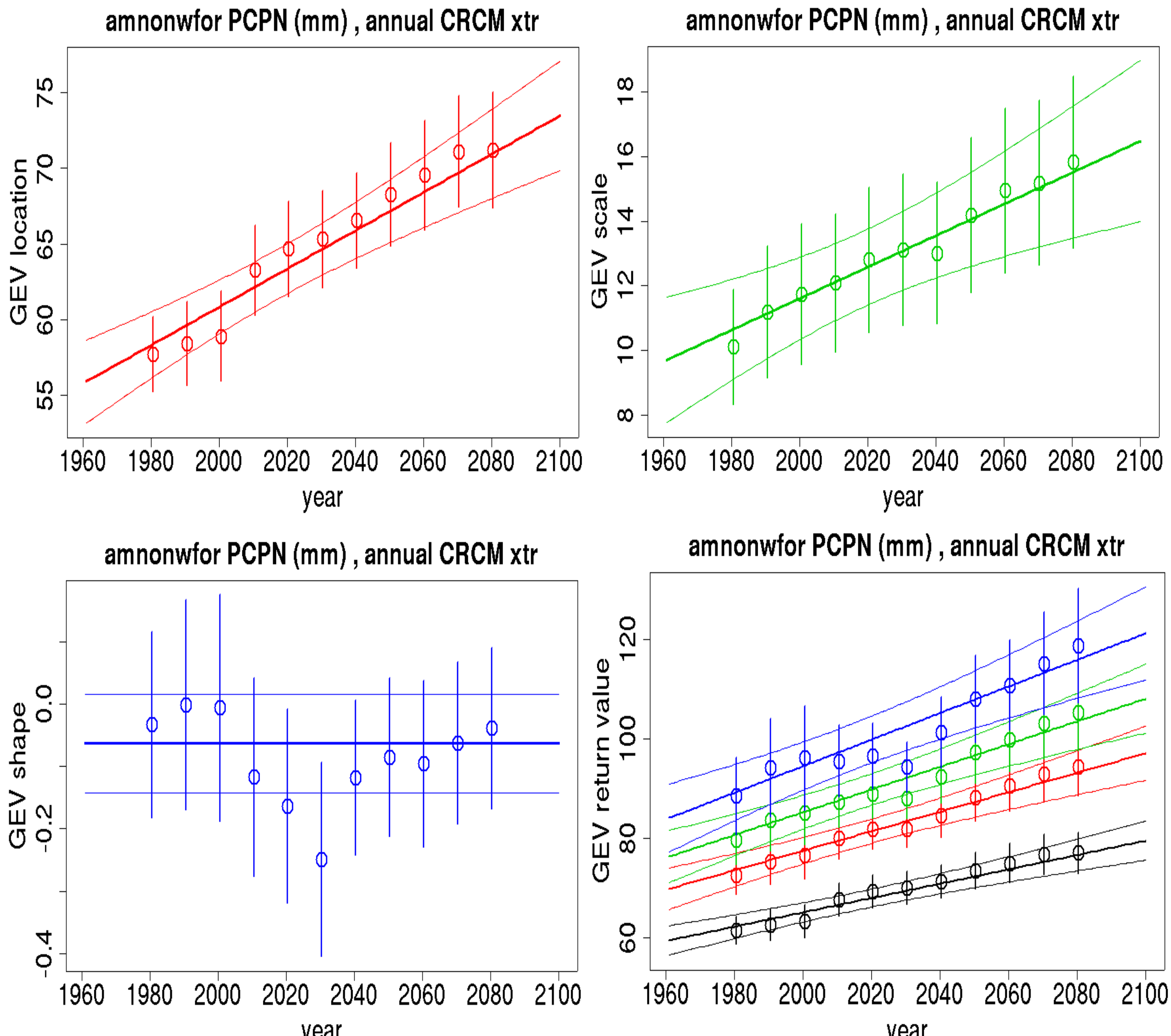
extreme values and their variability increases

parabolic? linear? logistic?

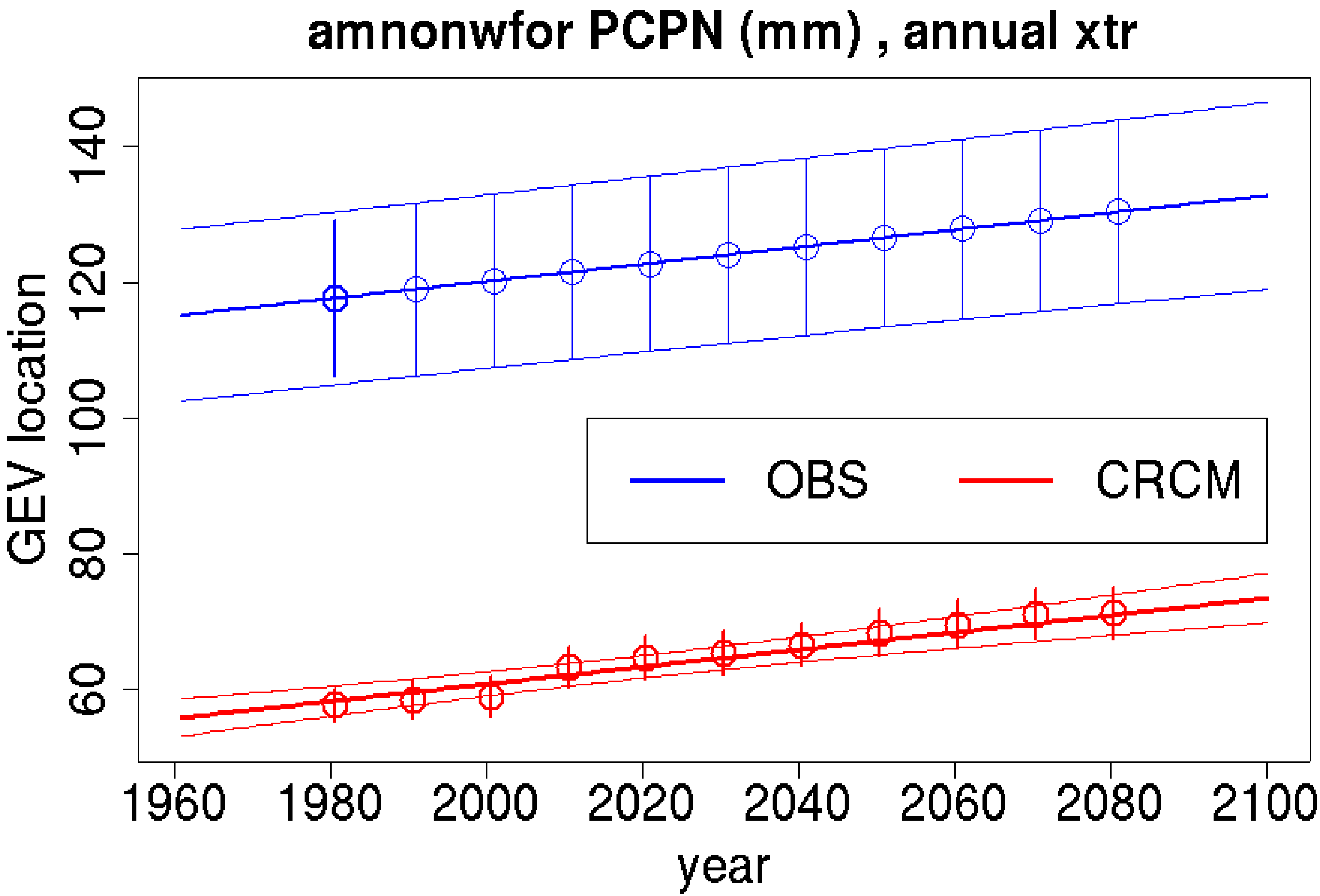
2. CRCM projections of the GEV distributions (1961-2100)

Fit annual xtr with a **non-stationary GEV distri-bution:** GEV parameters (loc,scl,shp) are allowed to have **linear, parabolic or logistic** trend

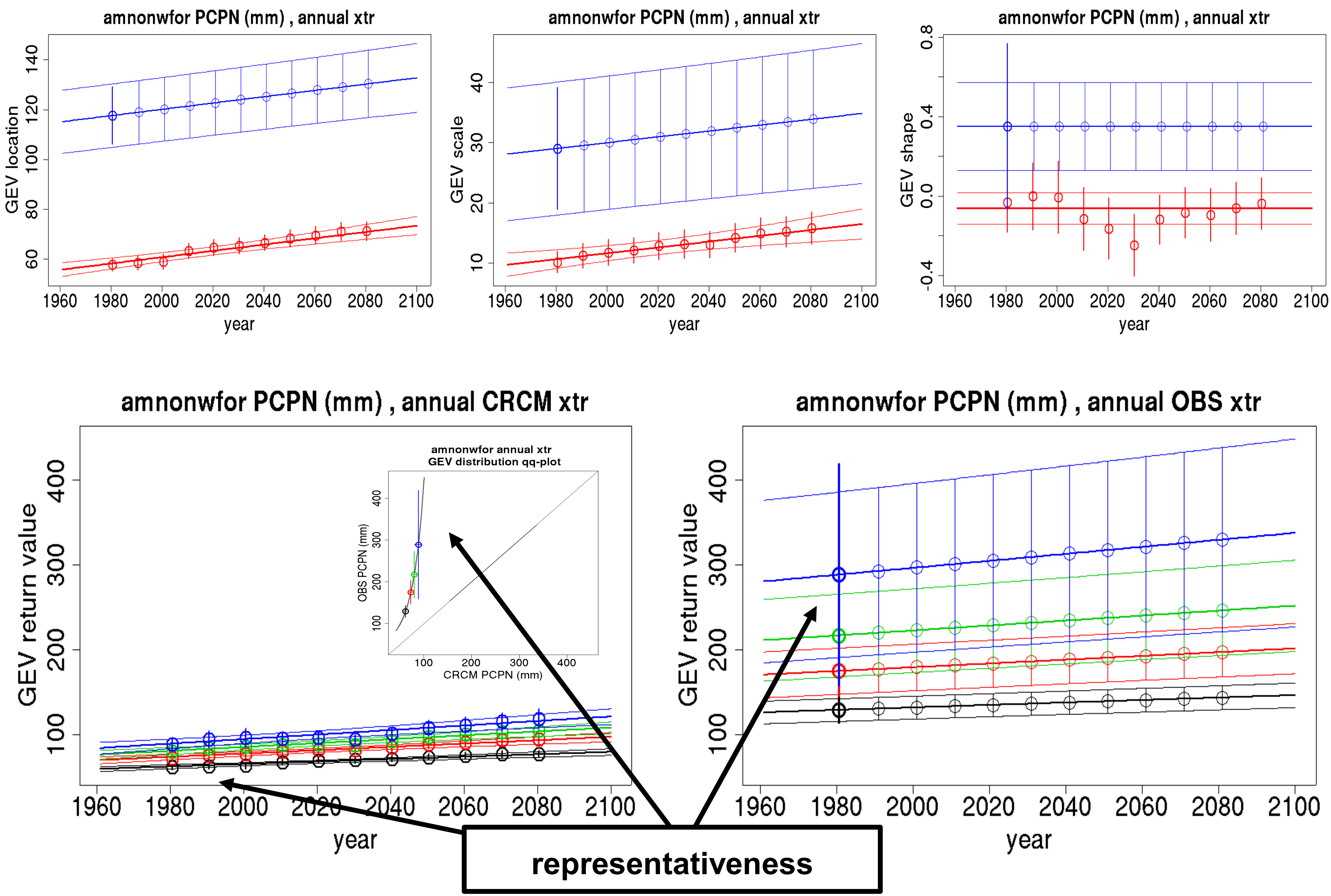
Technical Details: Maximum Likelihood Estimation; Swartz Bayesian Criterion



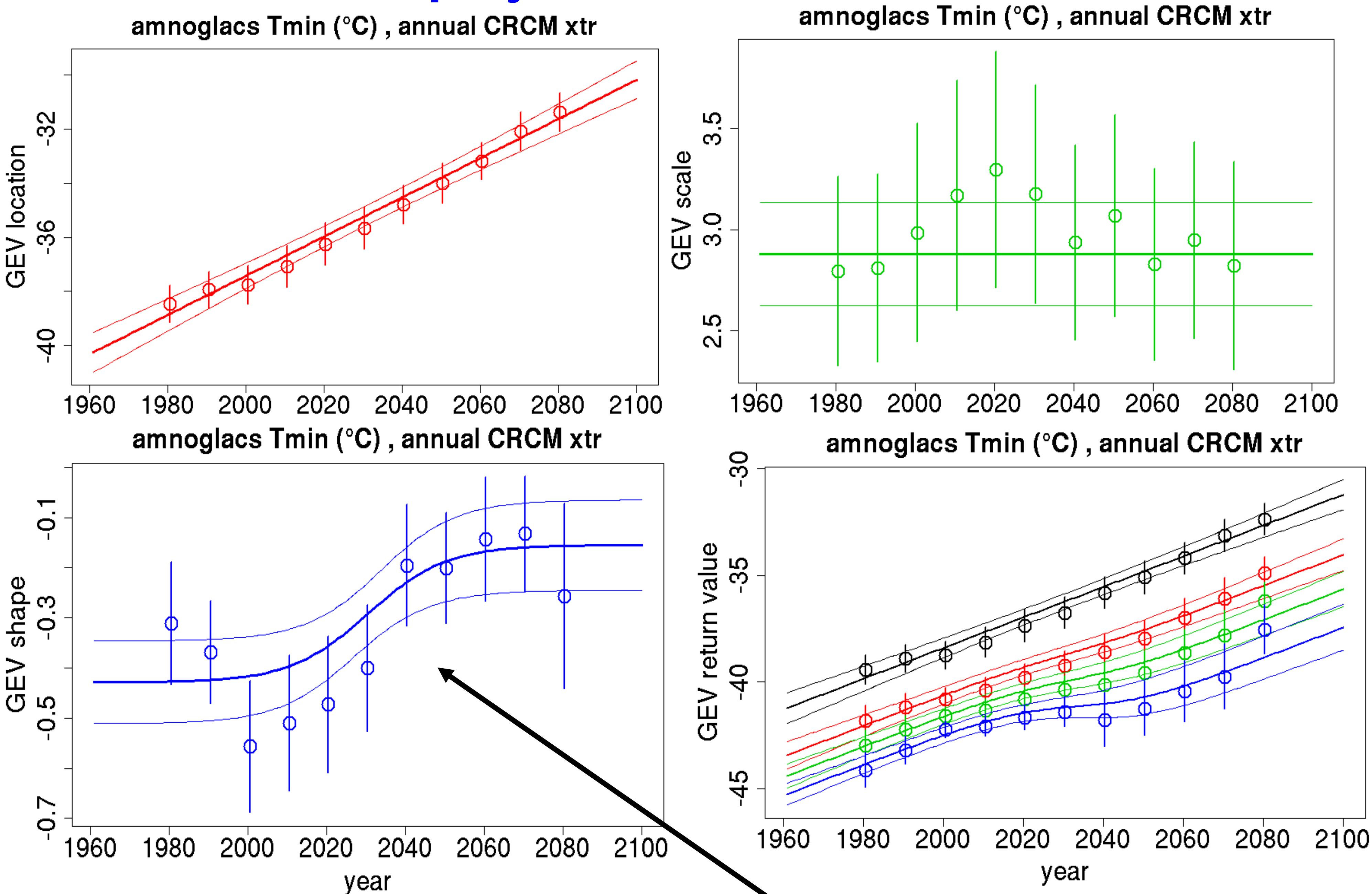
3. Δ method: apply the CRCM trends to the OBS GEV distribution parameters



3. Future extreme projections in OBS space



Tmin CRCM projec-tions for the Great-Lakes



Logistic behaviour: equilibrium-change-equilibrium?

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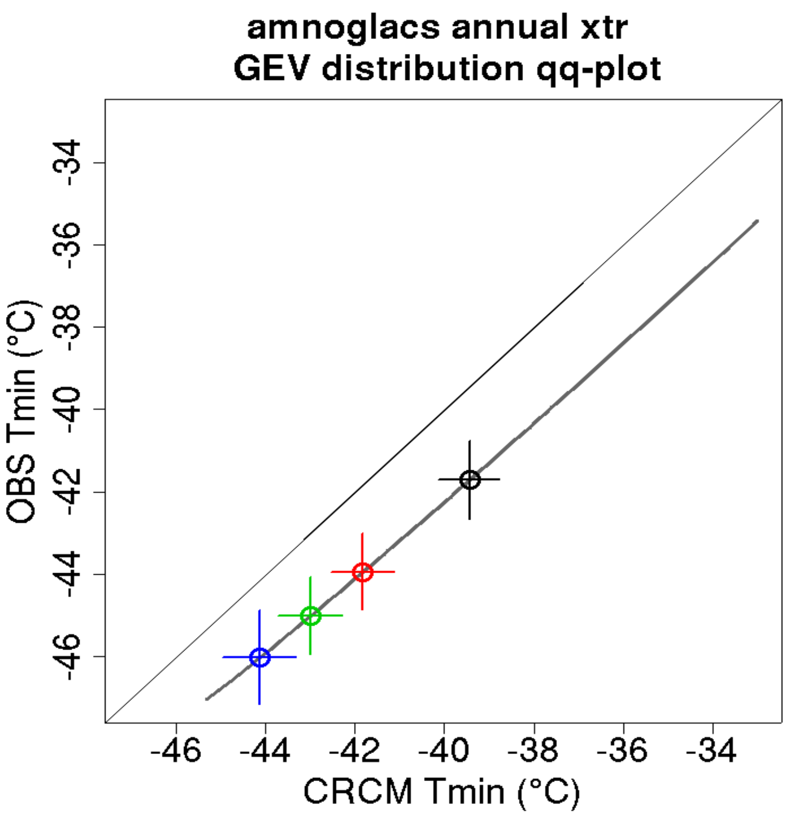
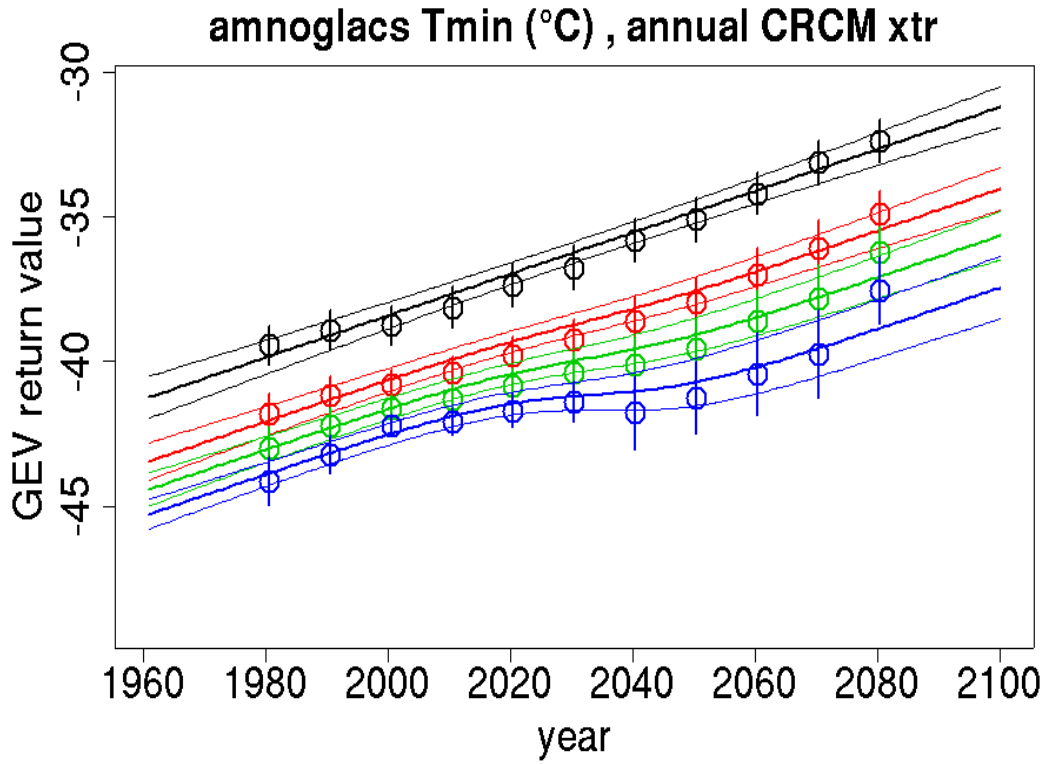
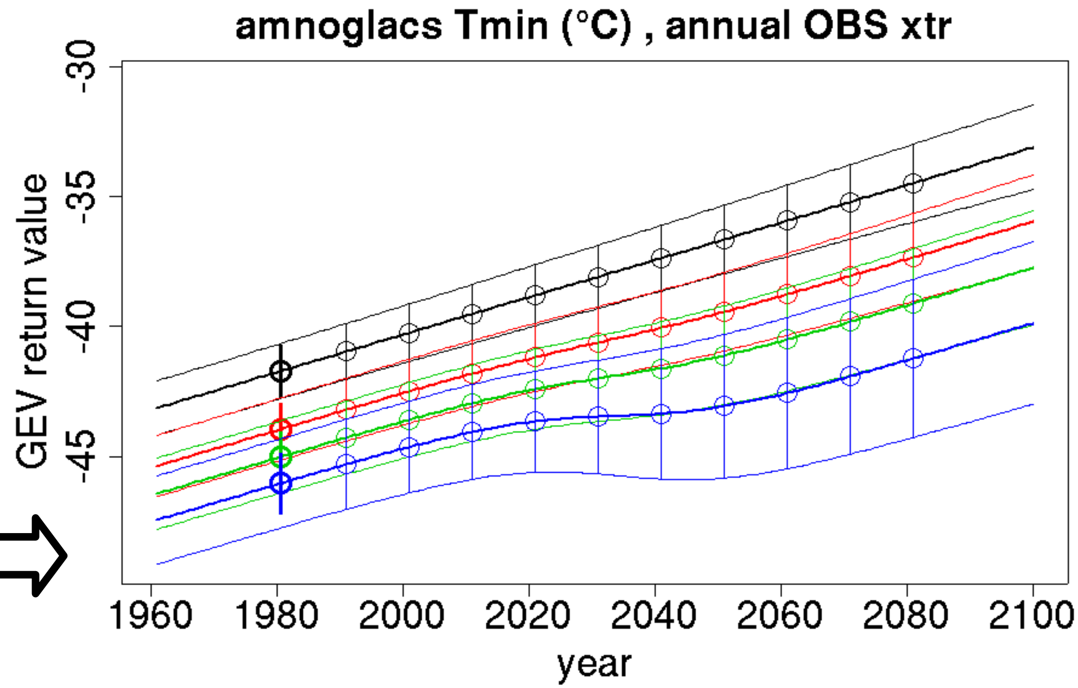
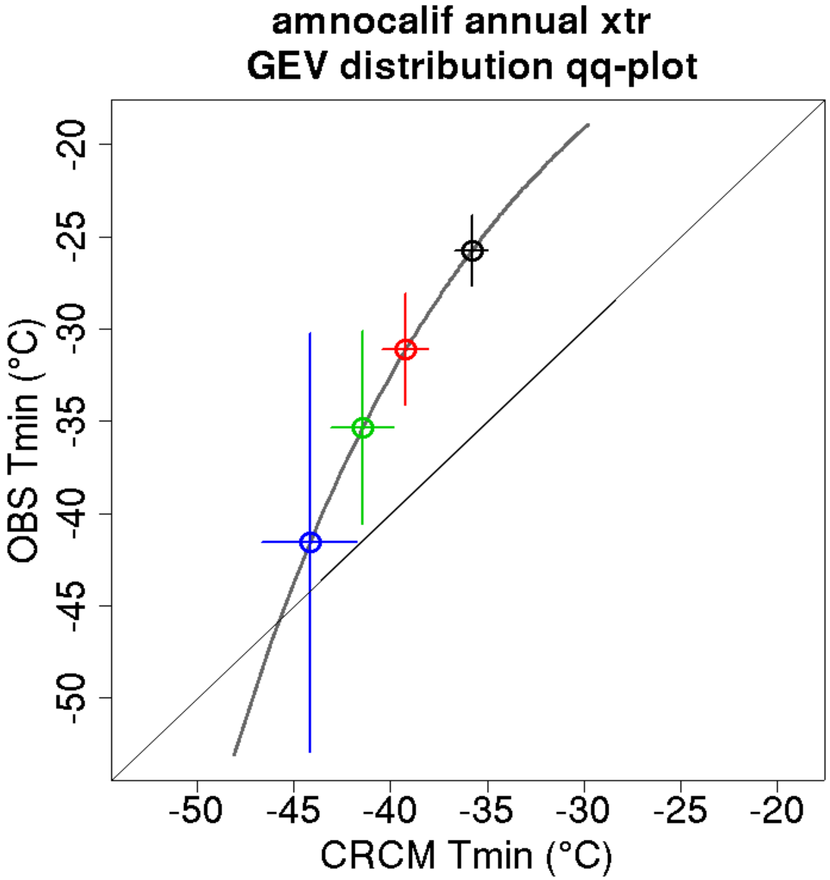


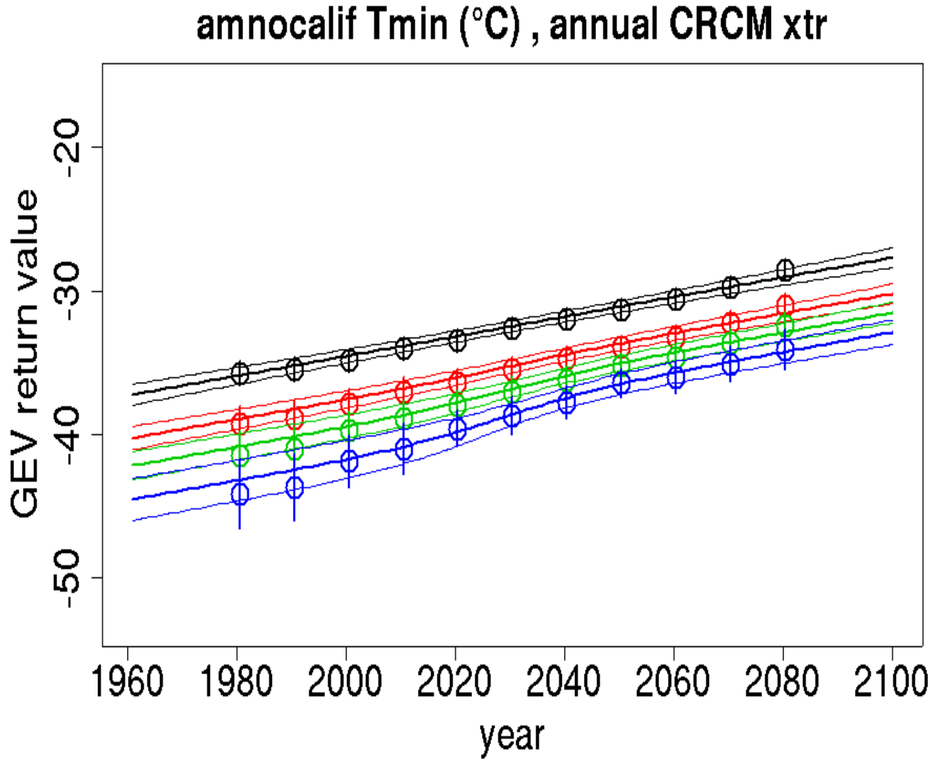




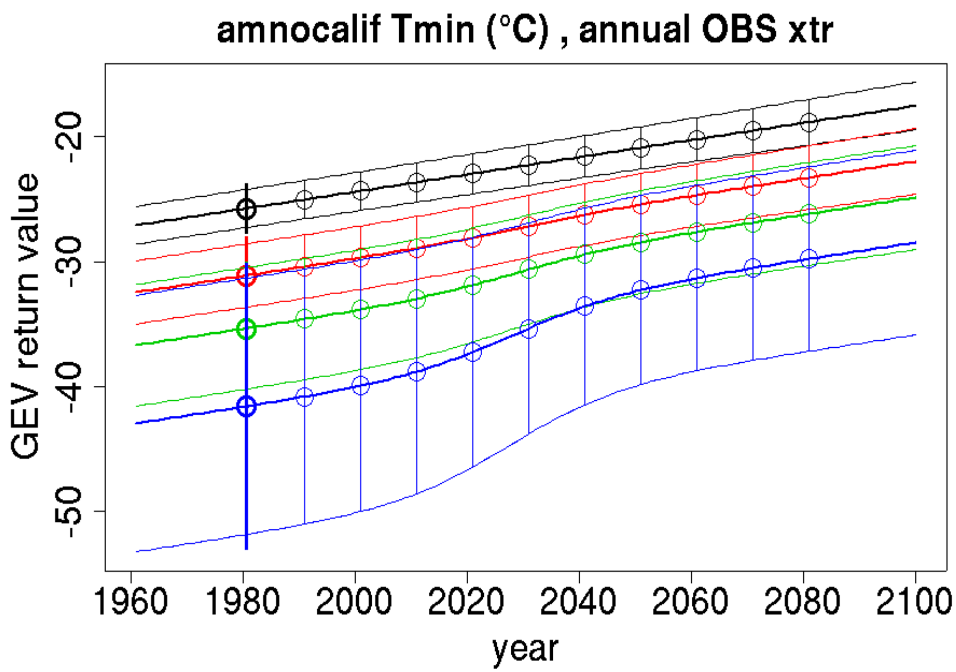
Temperature increases, variability in Tmin increases (more ice-free lakes?)

Tmin OBS projections for California

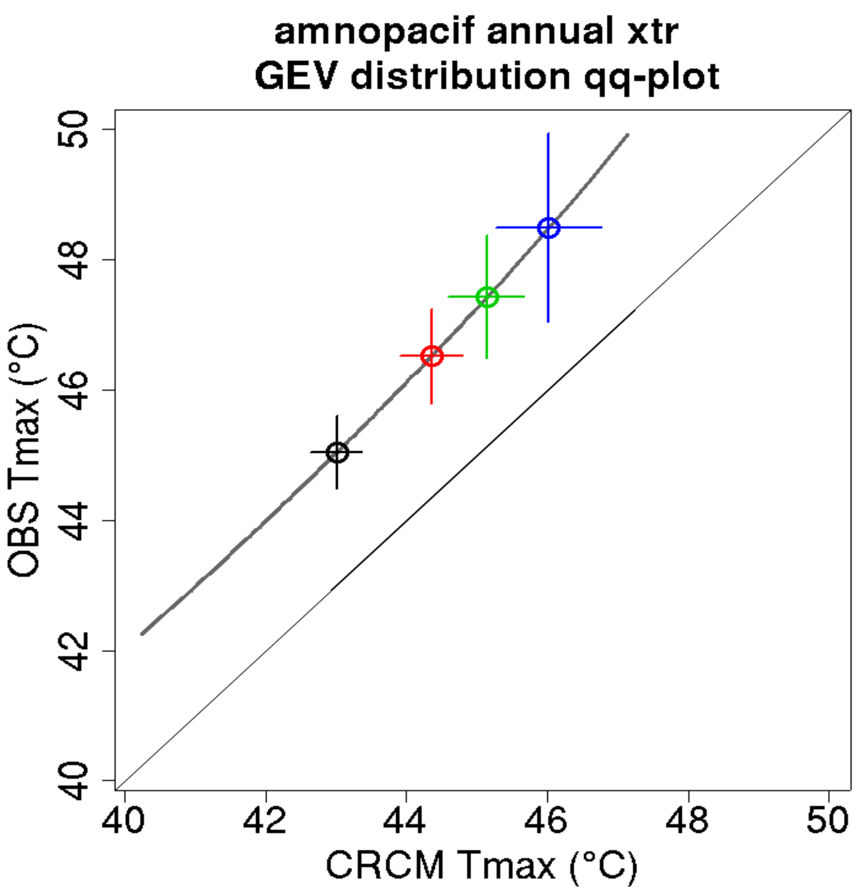


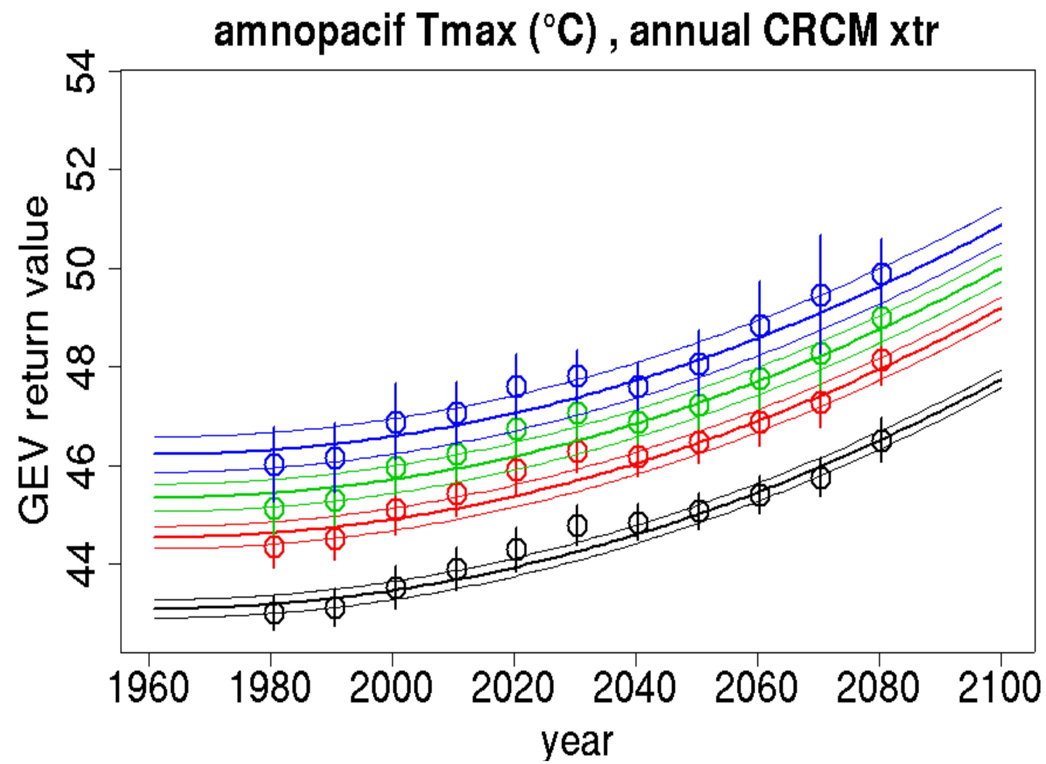


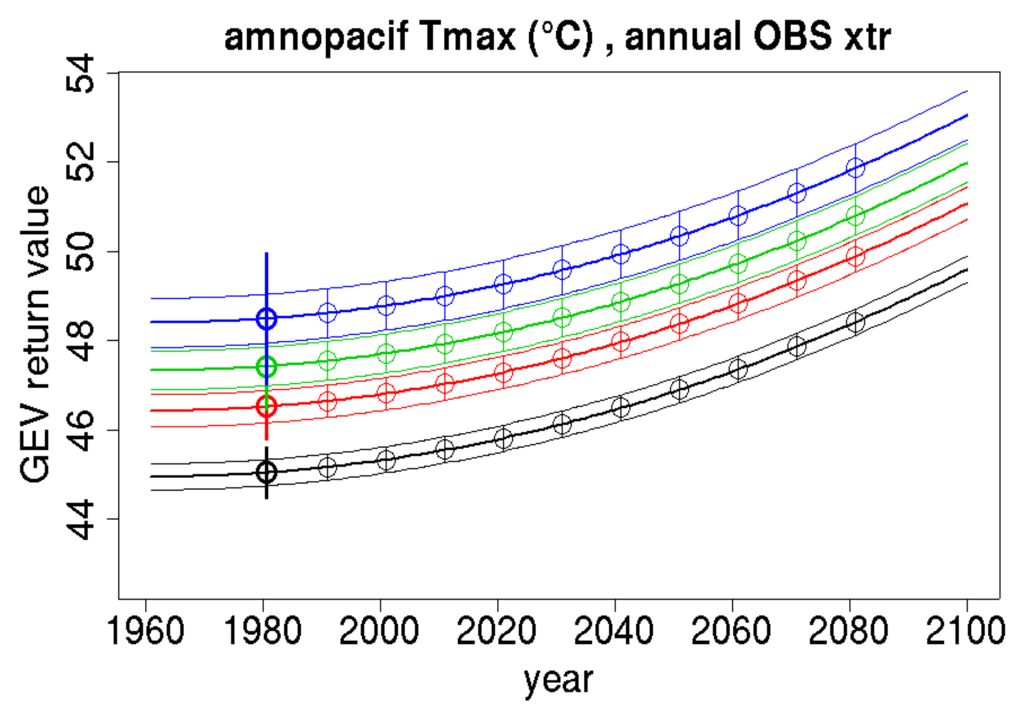
Temperature increases, variability in Tmin diminishes (mountain glaciers disappear?)



Tmax OBS projections for the Pacific Coast

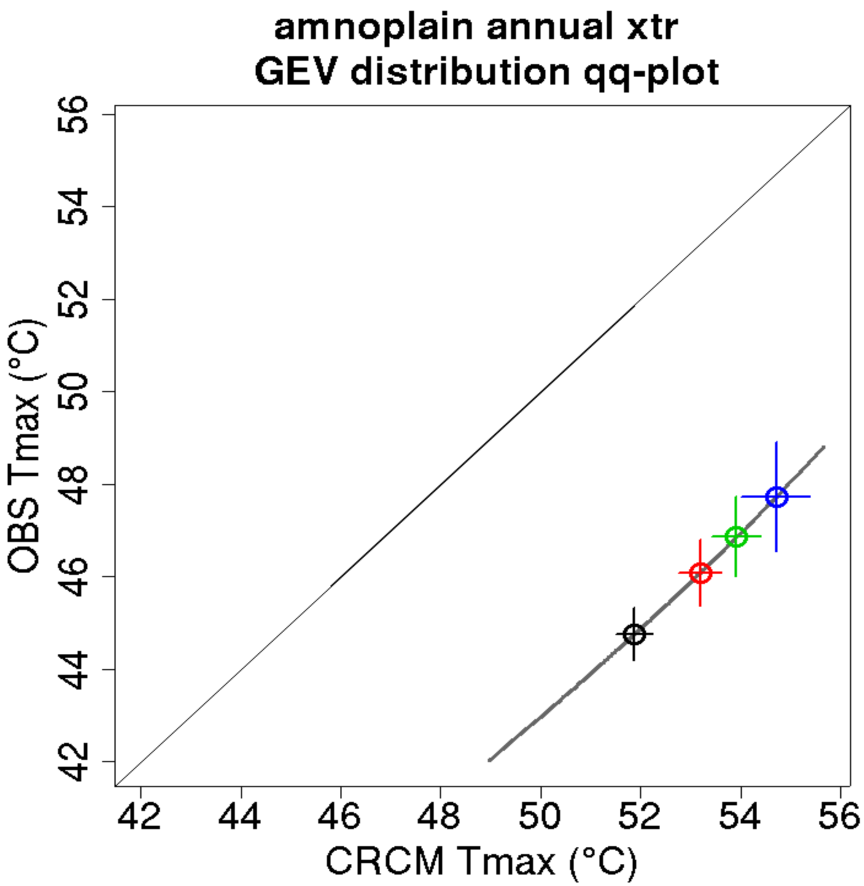


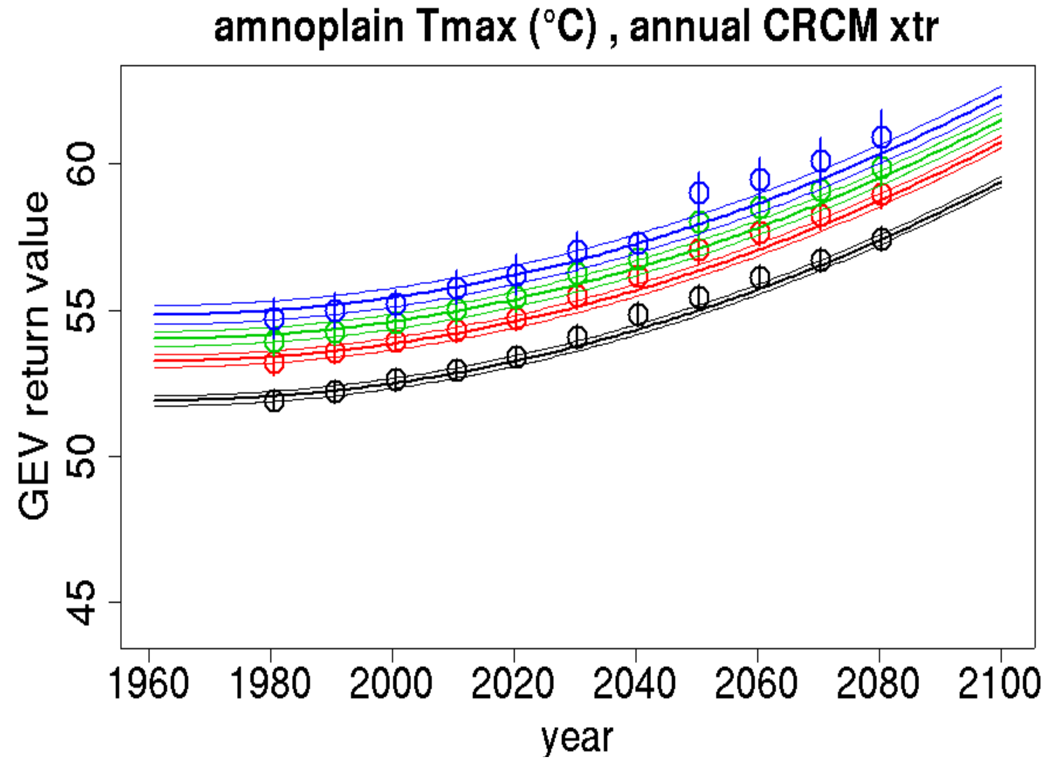


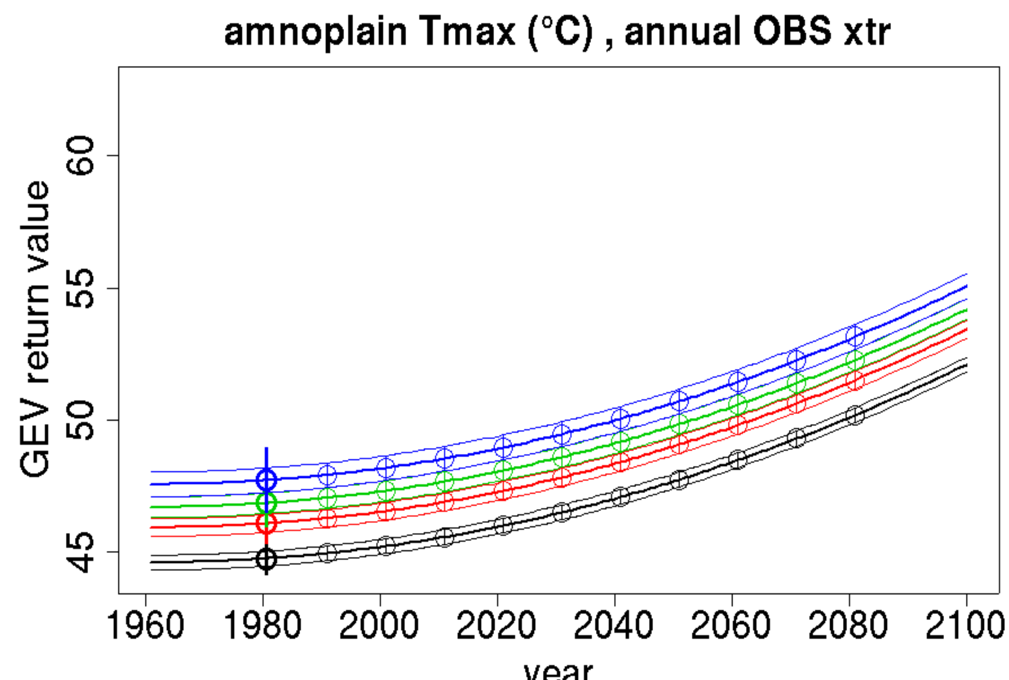


CRCM cold bias in the north-west

Tmax OBS projections for the Plains

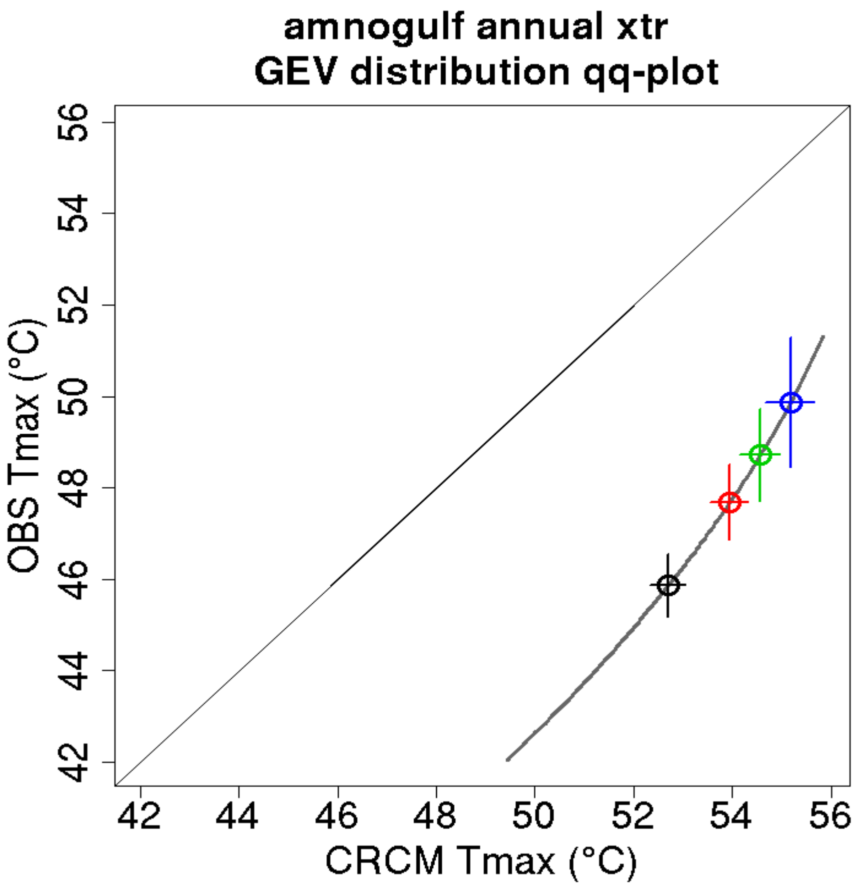


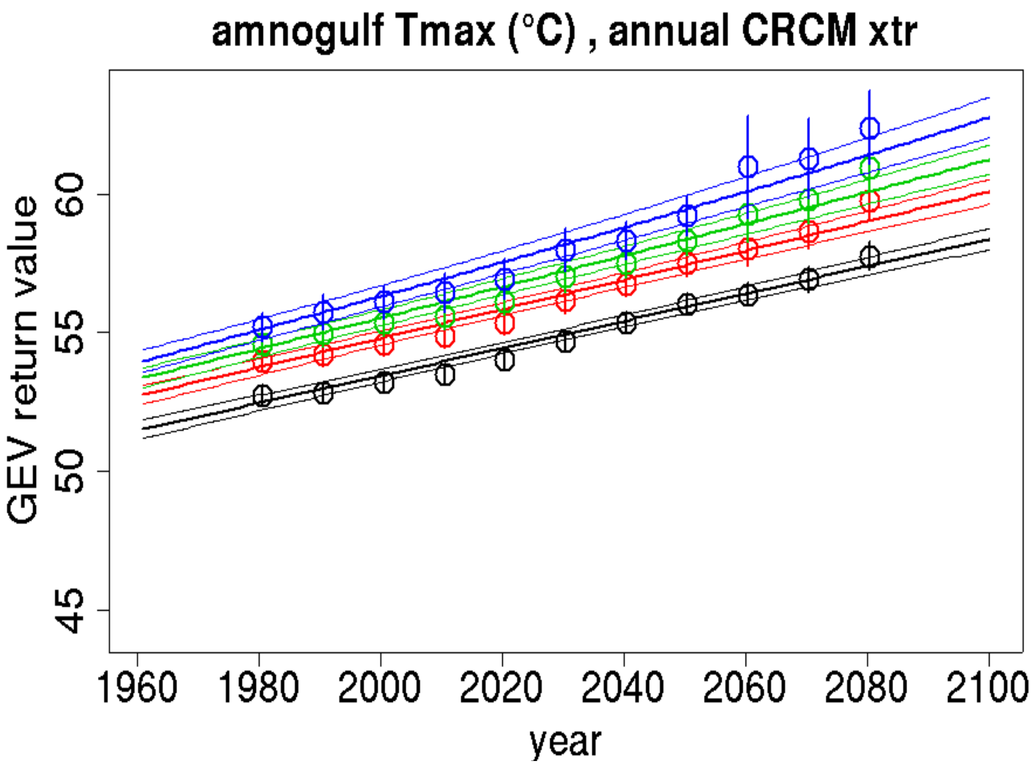


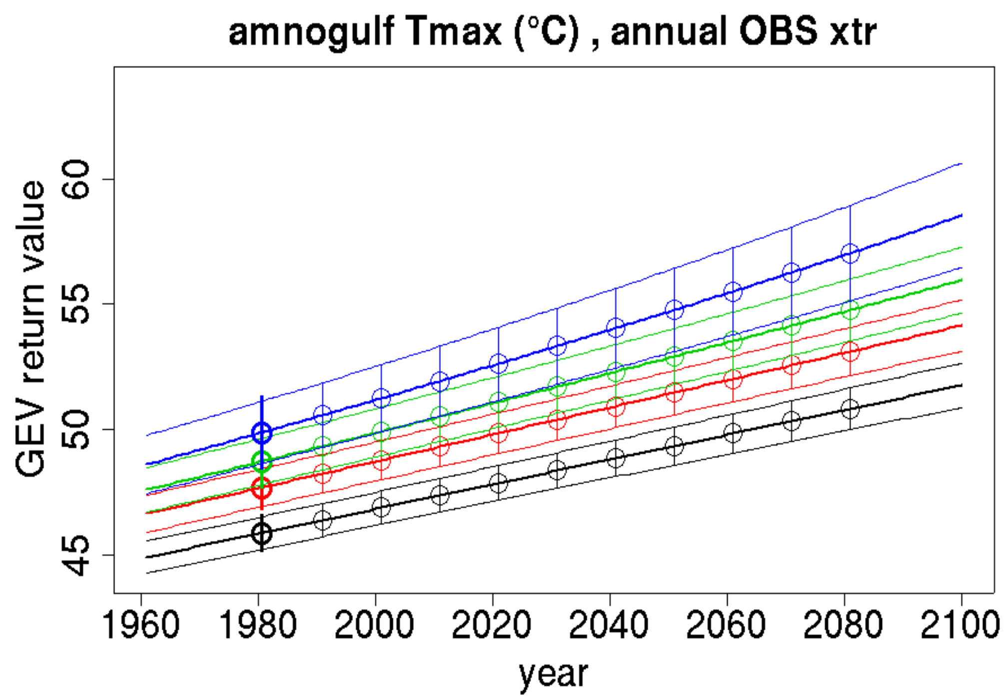


CRCM warm bias in the south-east

Tmax OBS projections for the Gulf







CRCM warm bias in the south-east

Preliminary Results

PCPC: Precipitation extremes increases either linearly or parabolically ~ 10 to 20 mm/century (in most regions). Representativeness issue: CRCM underestimate precipitation extremes, their variability and tail values (in all regions).

Tmin: minimum temperatures increase linearly ~ 7°C/century. Logistic behaviour in Tmin variability and tails: equilibrium-change-equilibrium? CRCM exhibit a cold bias in the west, well represent Tmin extremes in the centre and east. Tmin extremes in the Arctic are un-physically cold (glacier parametrization).

Tmax: maximum temperatures increases either linearly or parabolically ~ 5°C/century. CRCM exhibits a cold bias in the north-west and a warm bias in the south-east

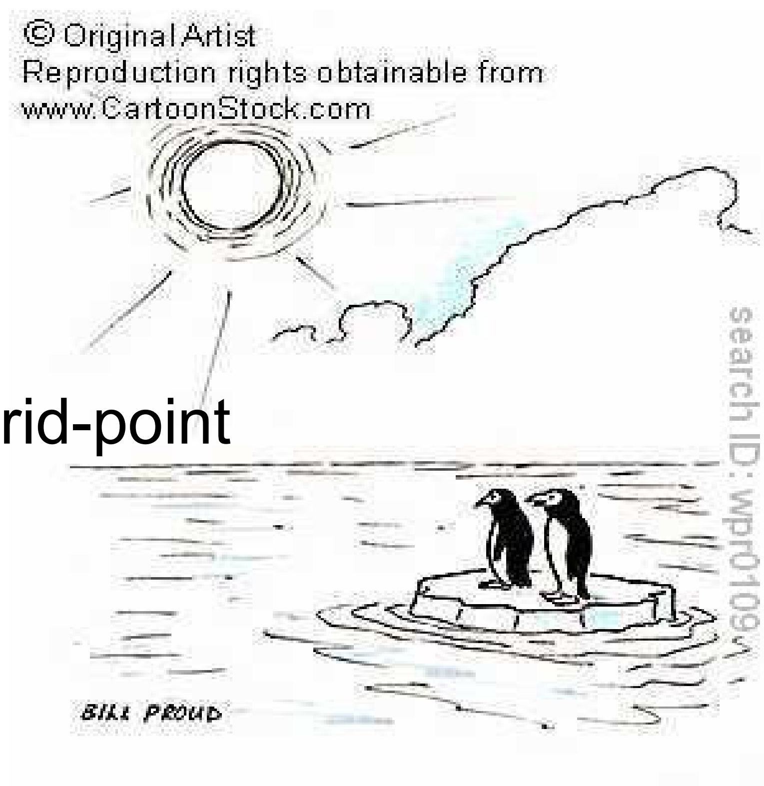
Conclusions & Future Work

Conclusions

1. EVT: powerful tool to investigate extremes future projections

2. Estimates of future precipitation and temperature extremes in OBS space are obtained by applying the Δ method to the GEV distribution parameters

3. Model biases and representativeness errors are “corrected” by the Δ method



"I remember when this was all ice fields."

Future Work:

- Include other CRCM simulations
- Apply the extreme analysis grid-point by grid-point
- Define downscaling relation
- Separate bias and representativeness

Feedback: casati.barbara@ouranos.ca

THANK YOU!

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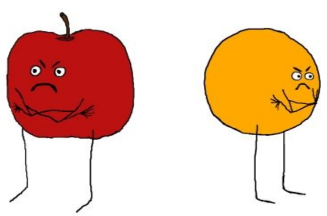

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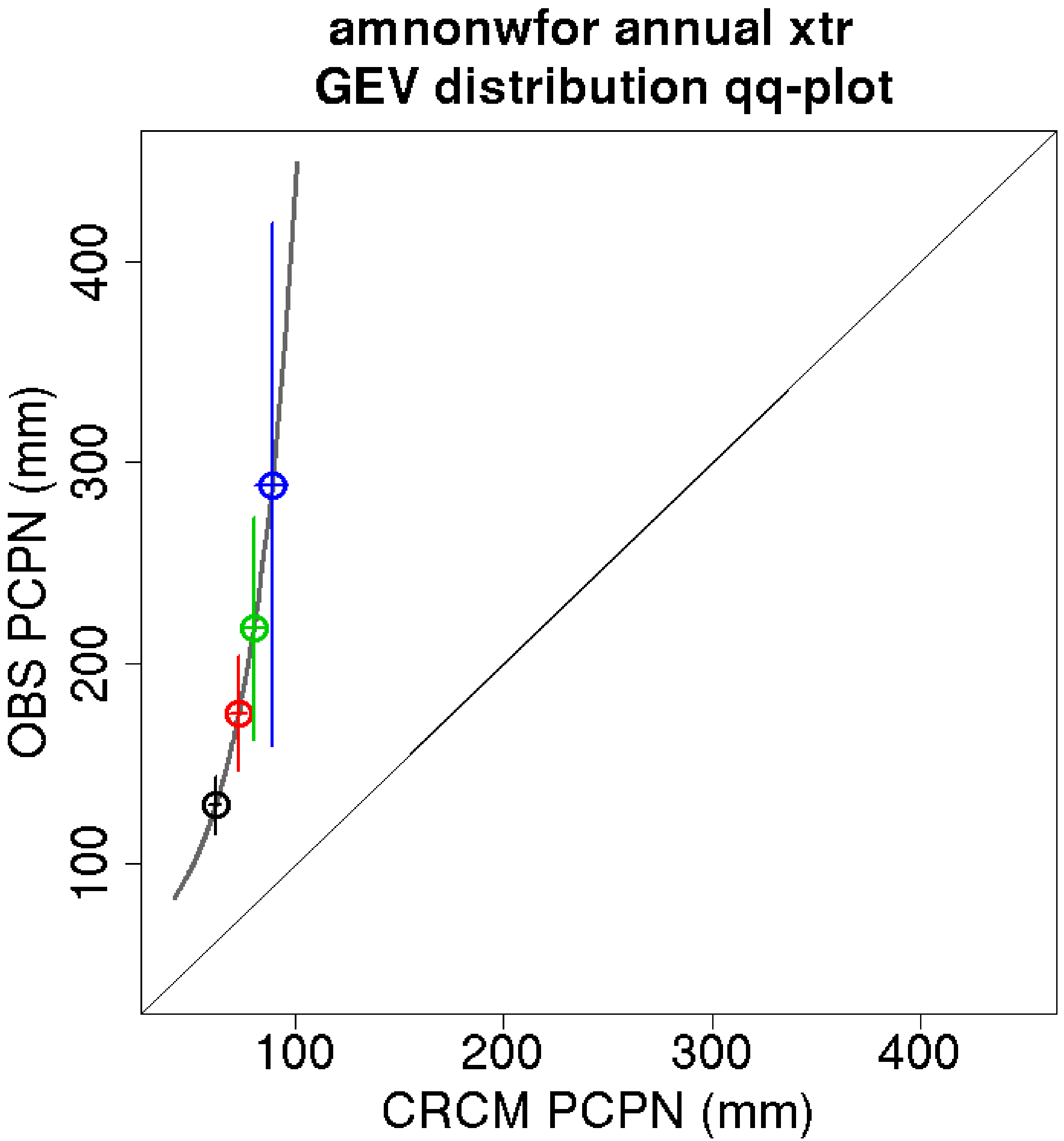
Systematic behaviour = downscaling relation



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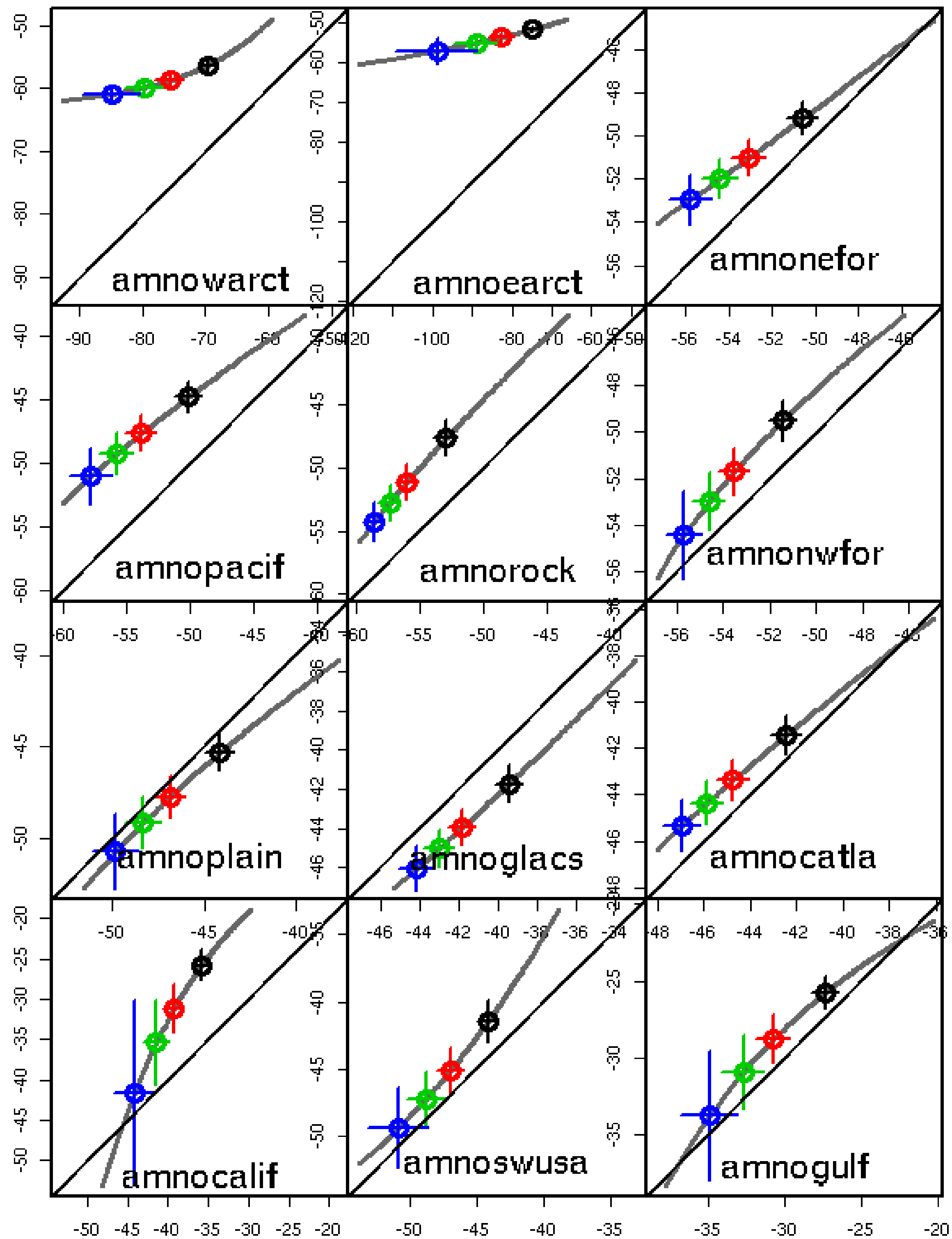

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