Vermont EPSCoR

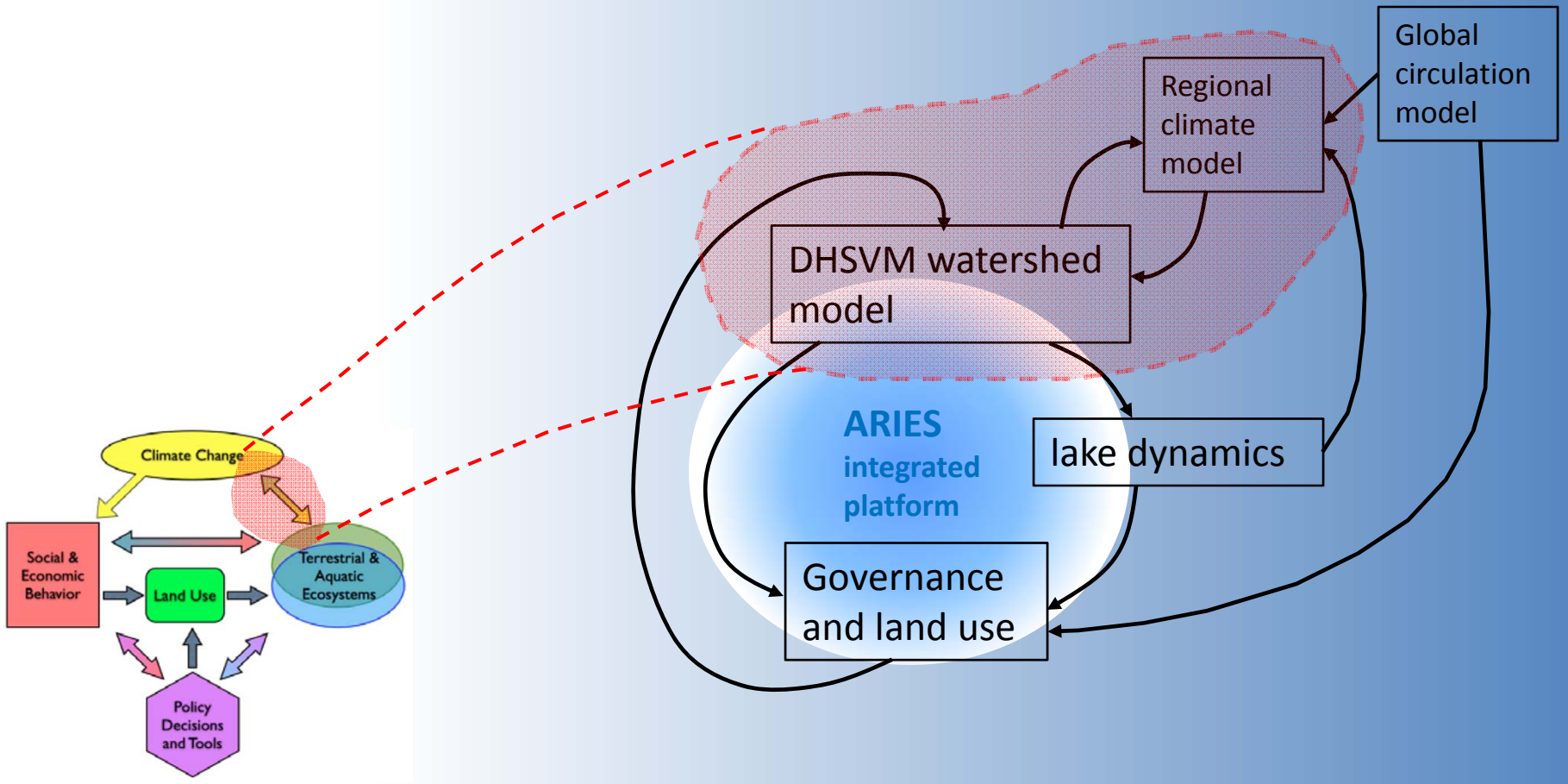
Experimental Program to Stimulate Competitive Research

Downscaling of climate change storylines

Brian Beckage

Broader question

"Which alternative stable states can emerge in the watershed and lake resulting from non-linear dynamics of climate drivers, lake basin processes, social behavior, and policy decisions?"



We are taking a SYSTEMS APPROACH to impacts and adaptation studies.

We seek to understand:

1. The expected impact of precipitation change on:
    1. Sediment and non-point phosphorus mobilization
    2. Flooding/scouring of channels and floodplains
    3. Natural vegetation and farming practices
    4. Built environment

    } Watershed model
2. The expected impact of temperature change on:
    1. Natural vegetation
    2. Frozen ground
    3. Snow/rain ratio

    } Regional Climate Model
3. System resilience to future changes under a variety of scenarios
    1. What variables dominate? (e.g. land use, governance, etc)
    2. What alternative stable states may the watershed take on? (agricultural/ urban, forest succession, healthy channels/impacted,etc)

We are using two approaches to regional climate downscaling:

1. Empirical downscaling:
    - Statistical mapping (static)
    - Information added through
        - increased topographic resolution
        - Climate analogues
2. Dynamical downscaling:
    - Regional climate models
    - GCM's provide boundary conditions
    - Allows feedbacks between local processes and regional climate

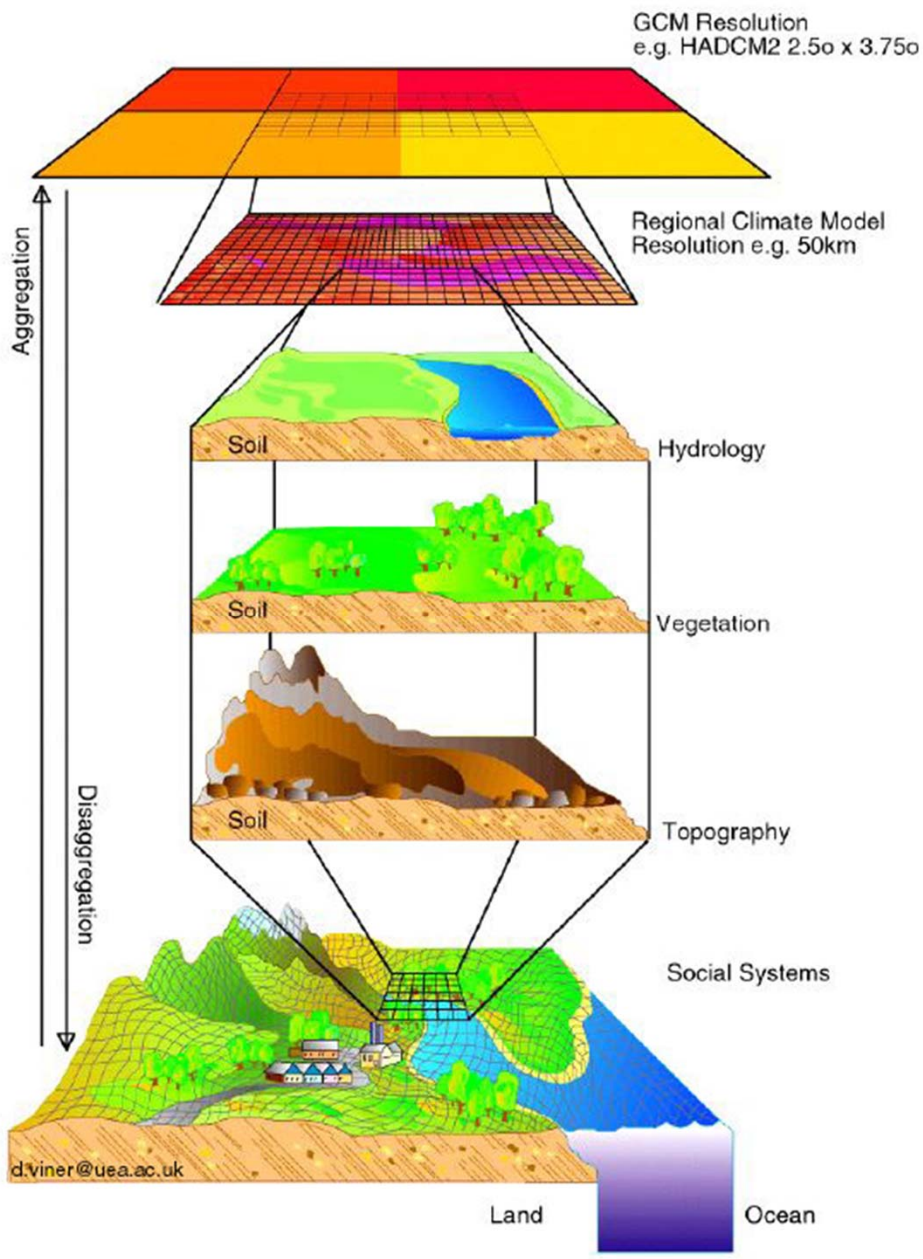
Climate downscaling

Dynamic (regional climate models)

- •Computationally expensive
- •Captures local processes and feedbacks

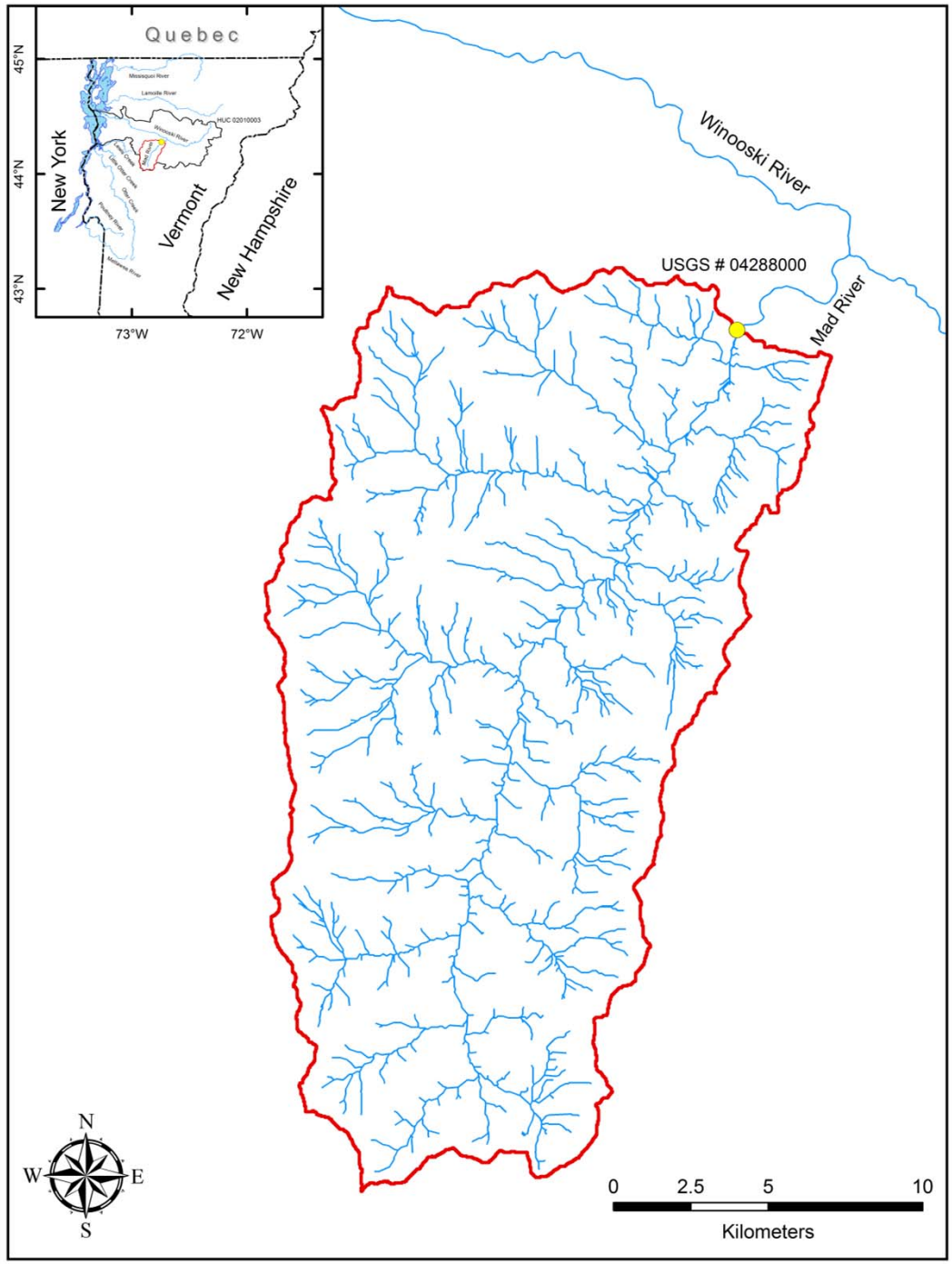
Statistical

- •Simpler
- •Assumes stationary transfer function

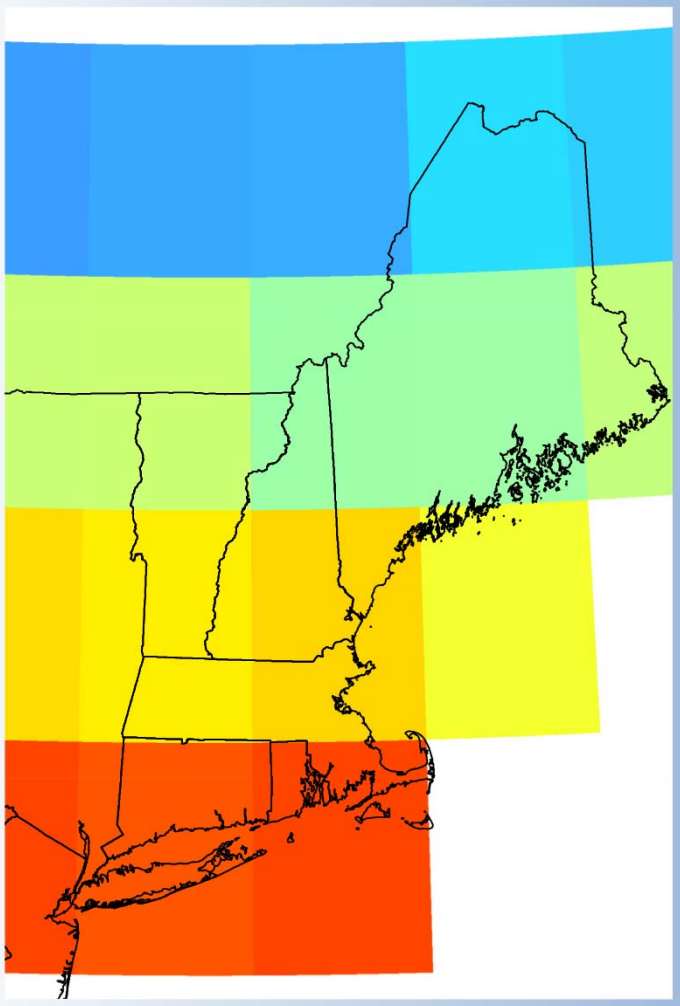


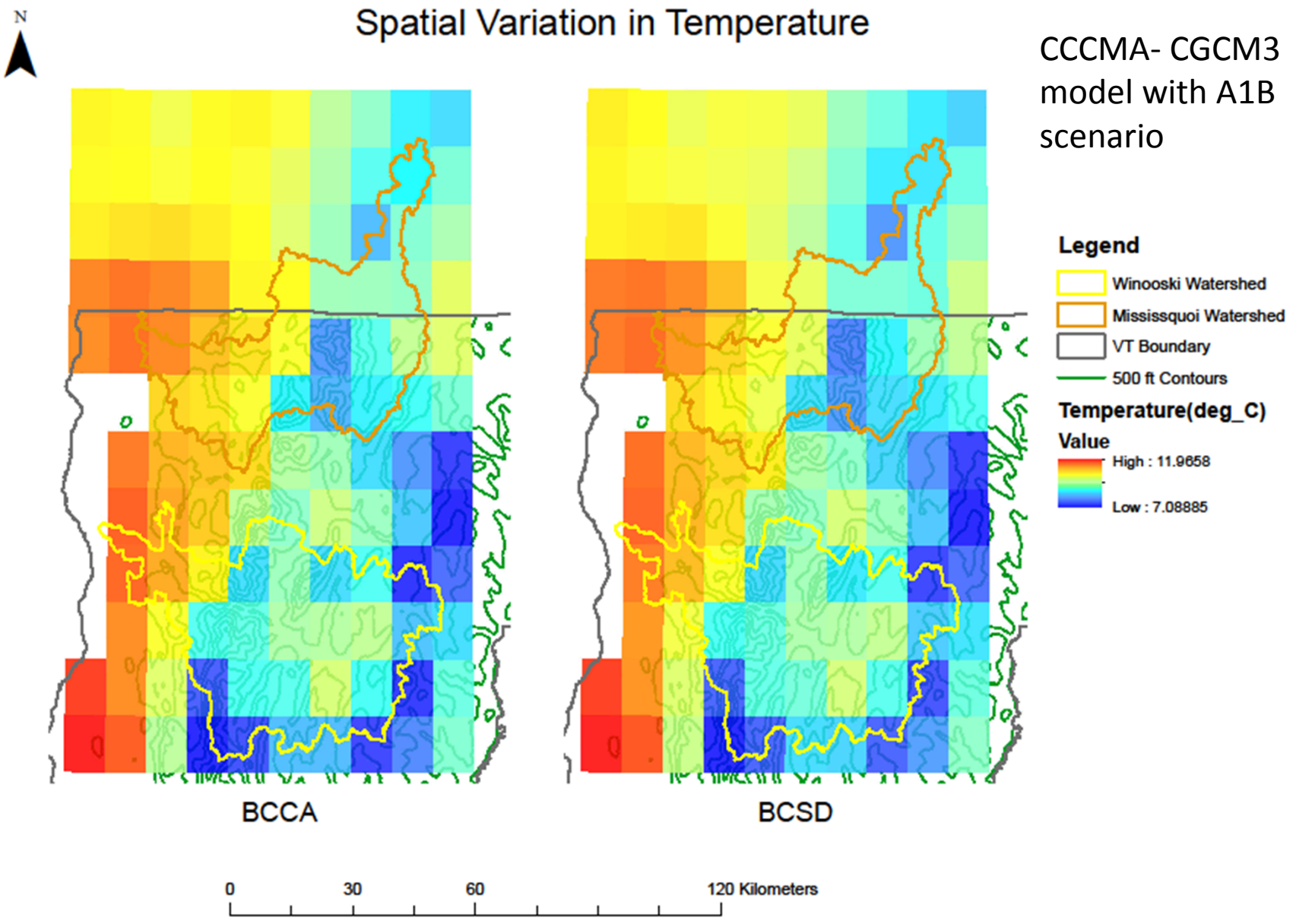
Hydrological modeling:

Begin with Mad River watershed

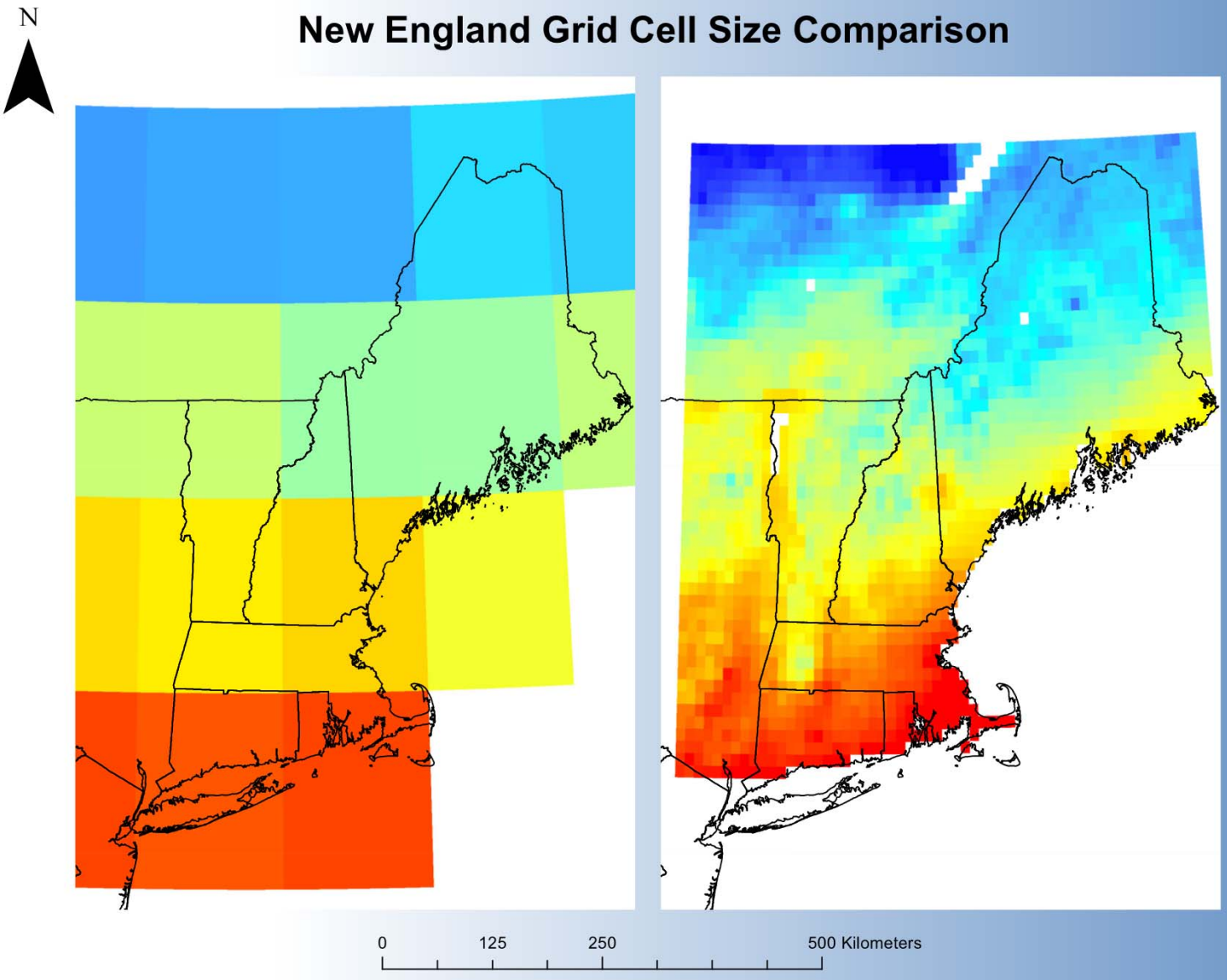


Scale of GCM data

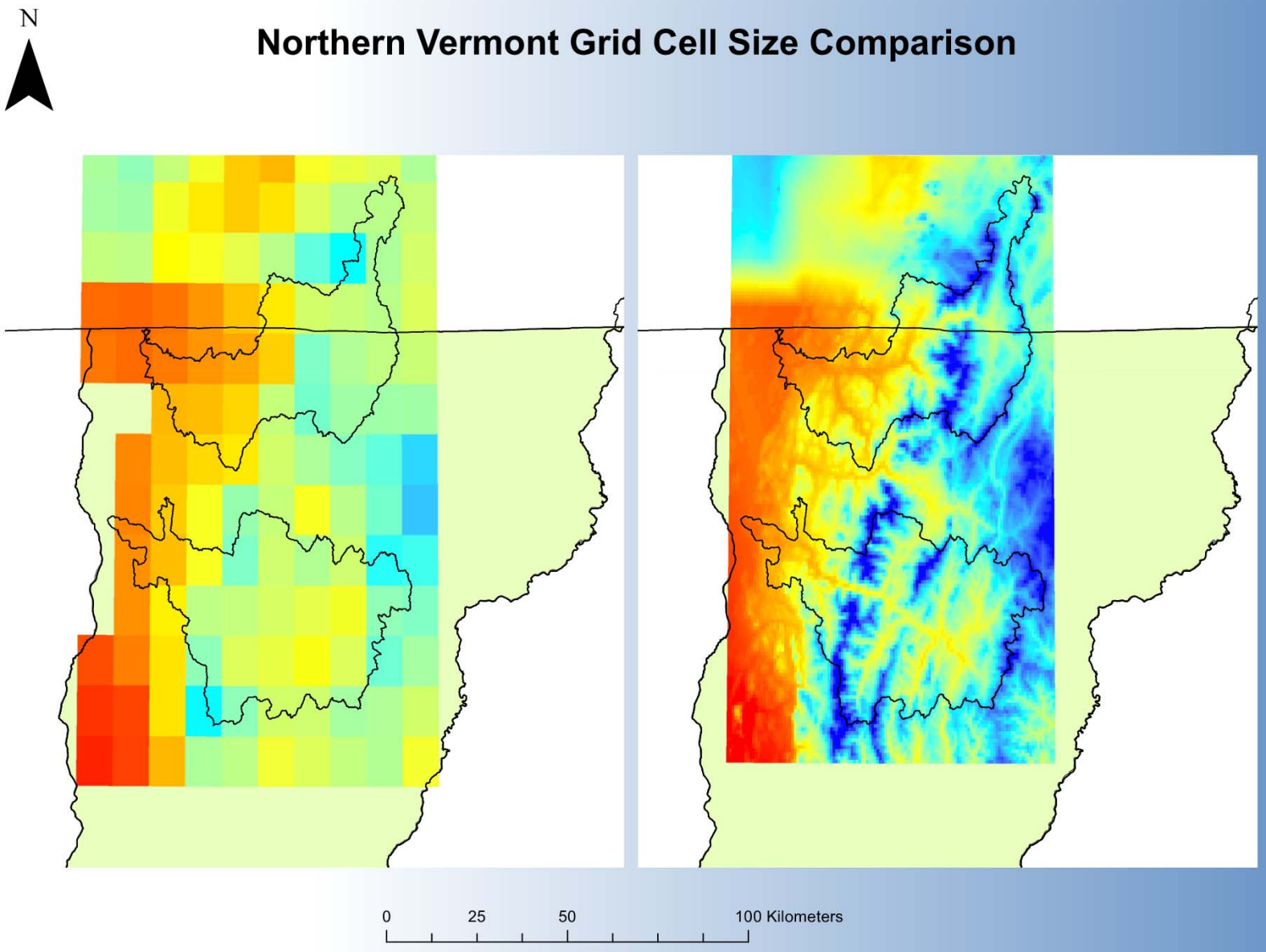


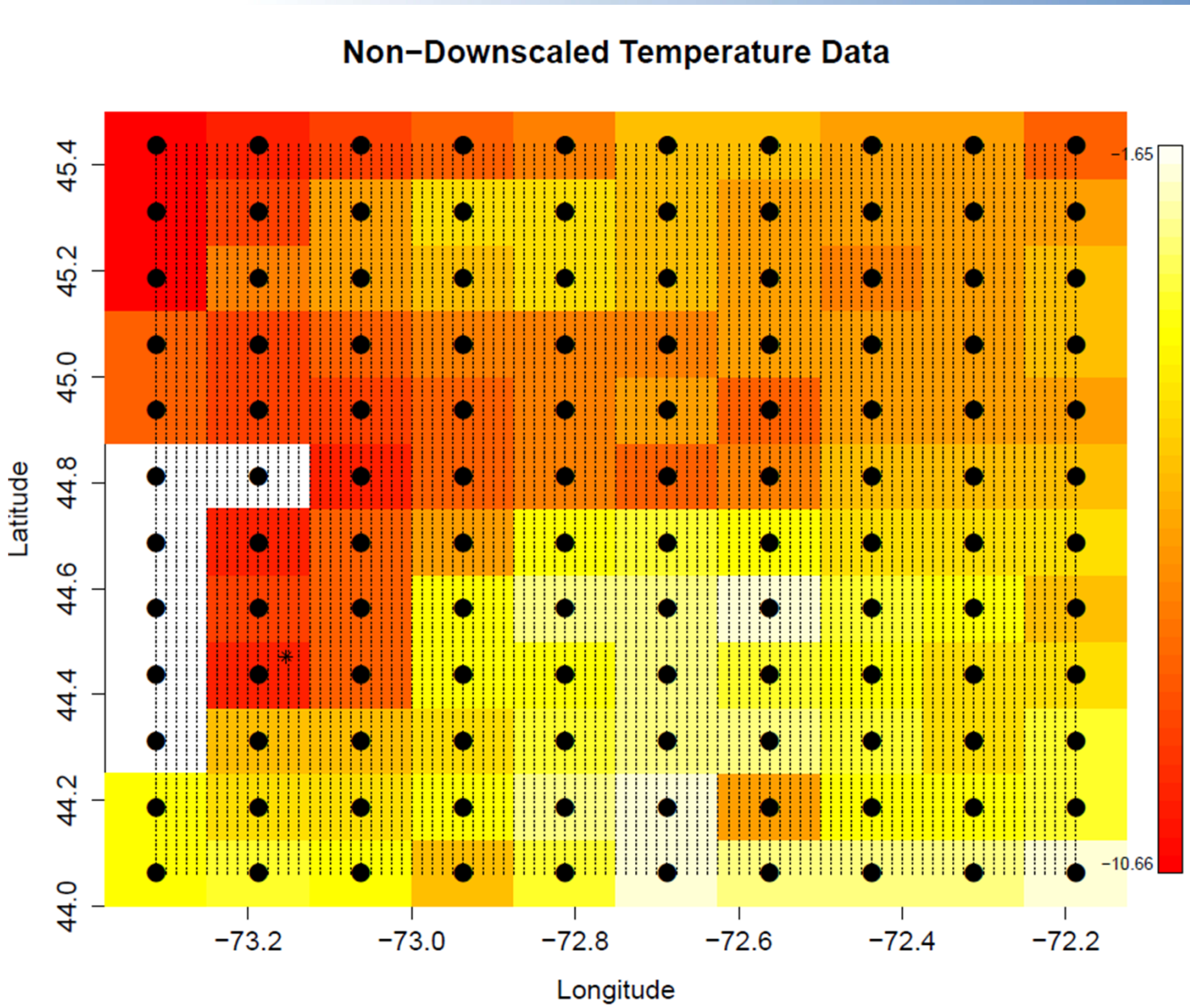

N
Spatial Variation in Temperature
CCCMA- CGCM3 model with A1B scenario
Legend
Winooski Watershed
Mississquoi Watershed
VT Boundary
500 ft Contours
Temperature(deg_C)
Value
High : 11.9658
Low : 7.08885
BCCA
BCSD
0
30
60
120 Kilometers

250 km to 12 km

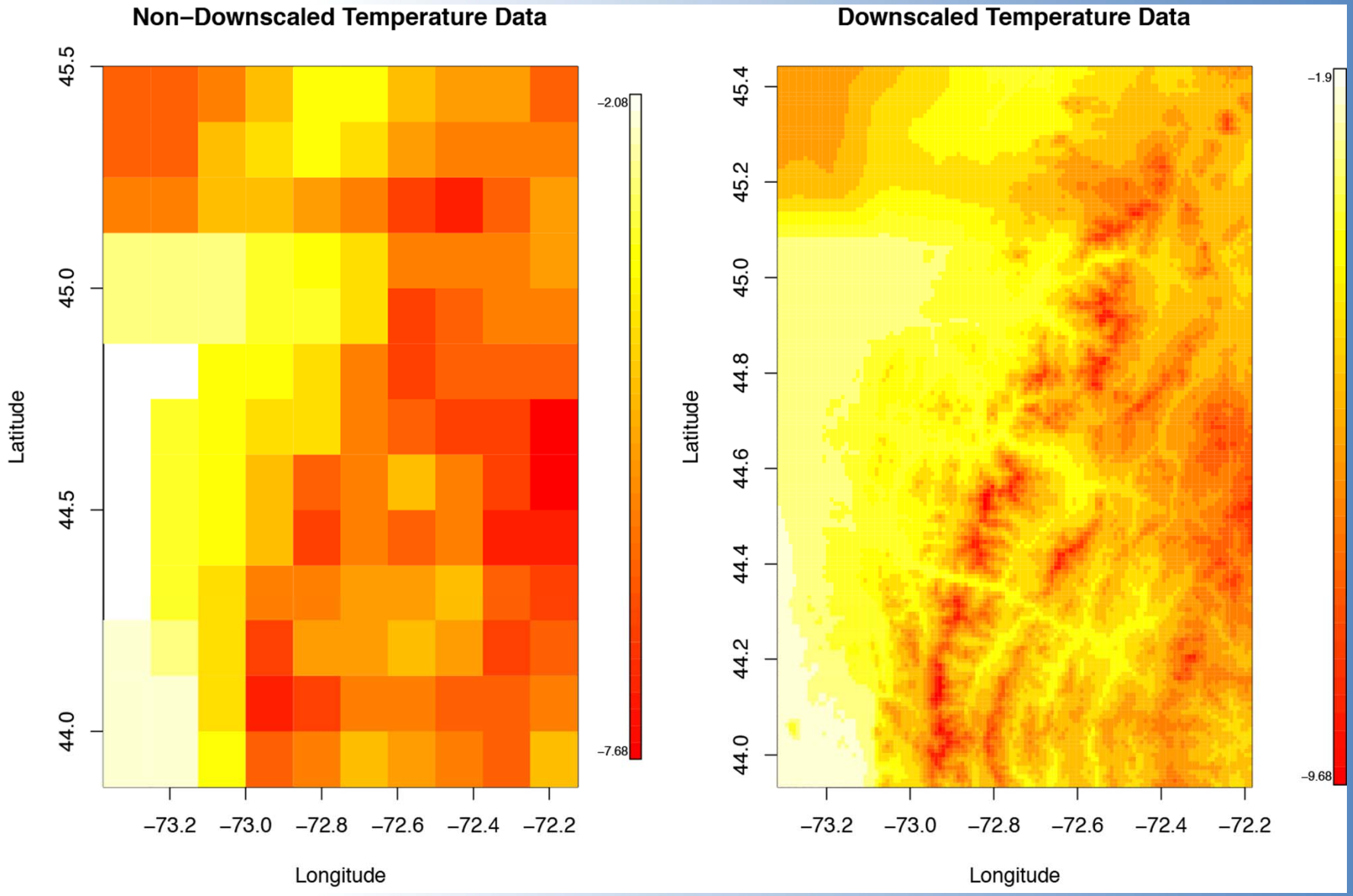


12 km to 1 km


N
Northern Vermont Grid Cell Size Comparison
0
25
50
100 Kilometers


Non−Downscaled Temperature Data
Latitude
45.4
45.2
45.0
44.8
44.6
44.4
44.2
44.0
−73.2
−73.0
−72.8
−72.6
−72.4
−72.2
Longitude
−1.65
−10.66

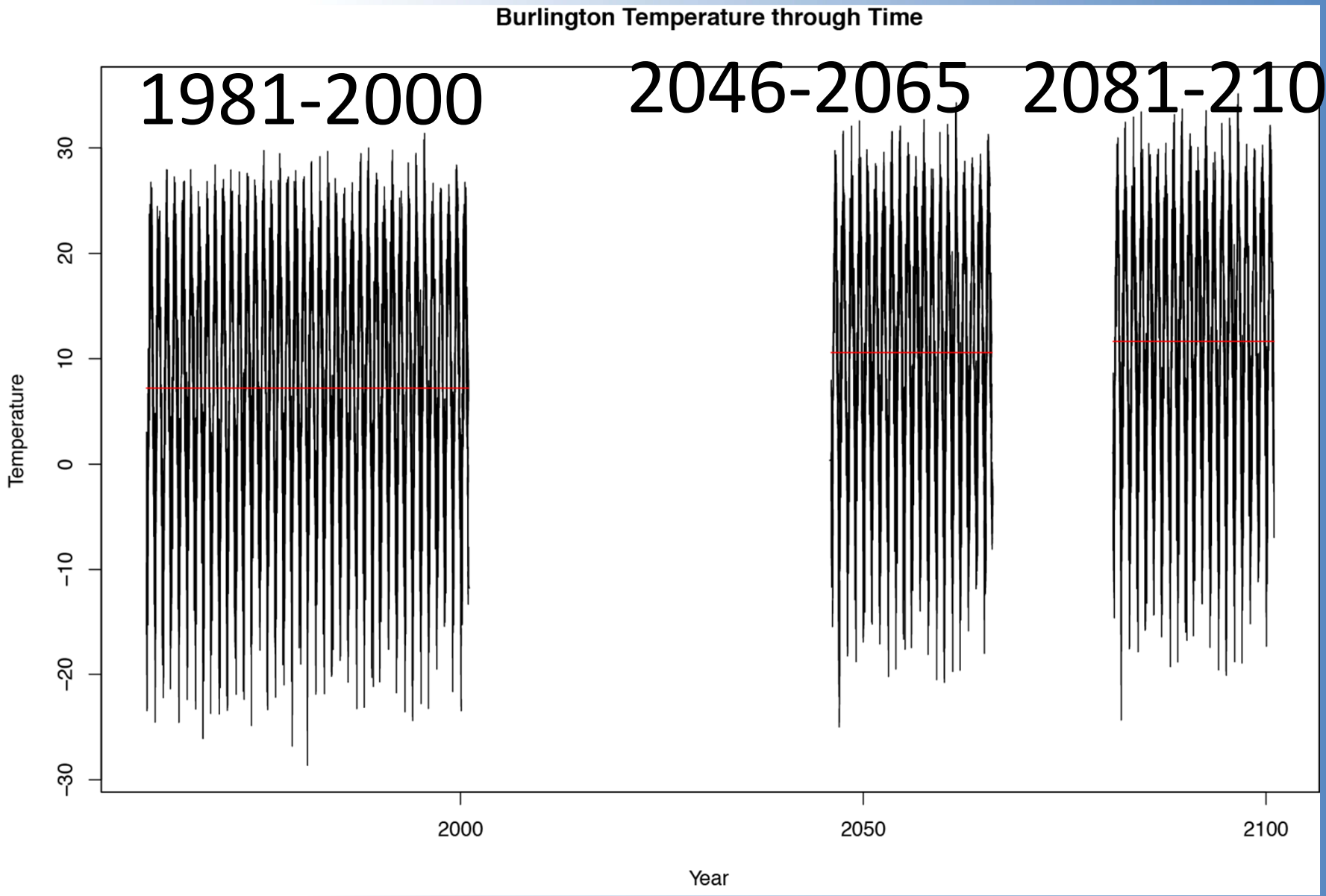
Spatially downscaled product



Temporal change:

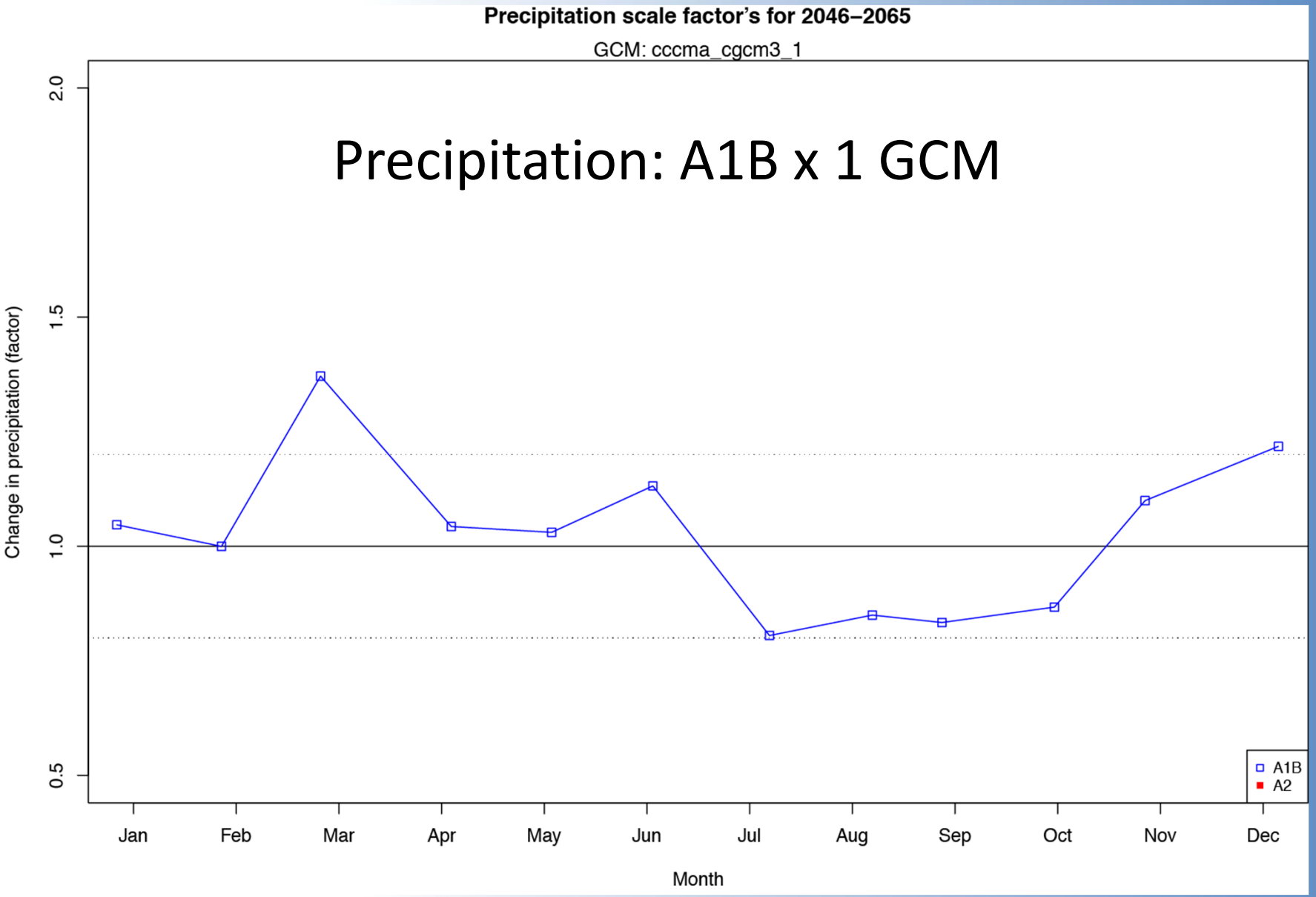
Delta method

1. Calculate difference in temperature between future and baseline period
   - Provides a projected change (delta) in temperature
2. Calculate ratio of precipitation between future and baseline period
   - Provides a projected change (scale factor) in precipitation

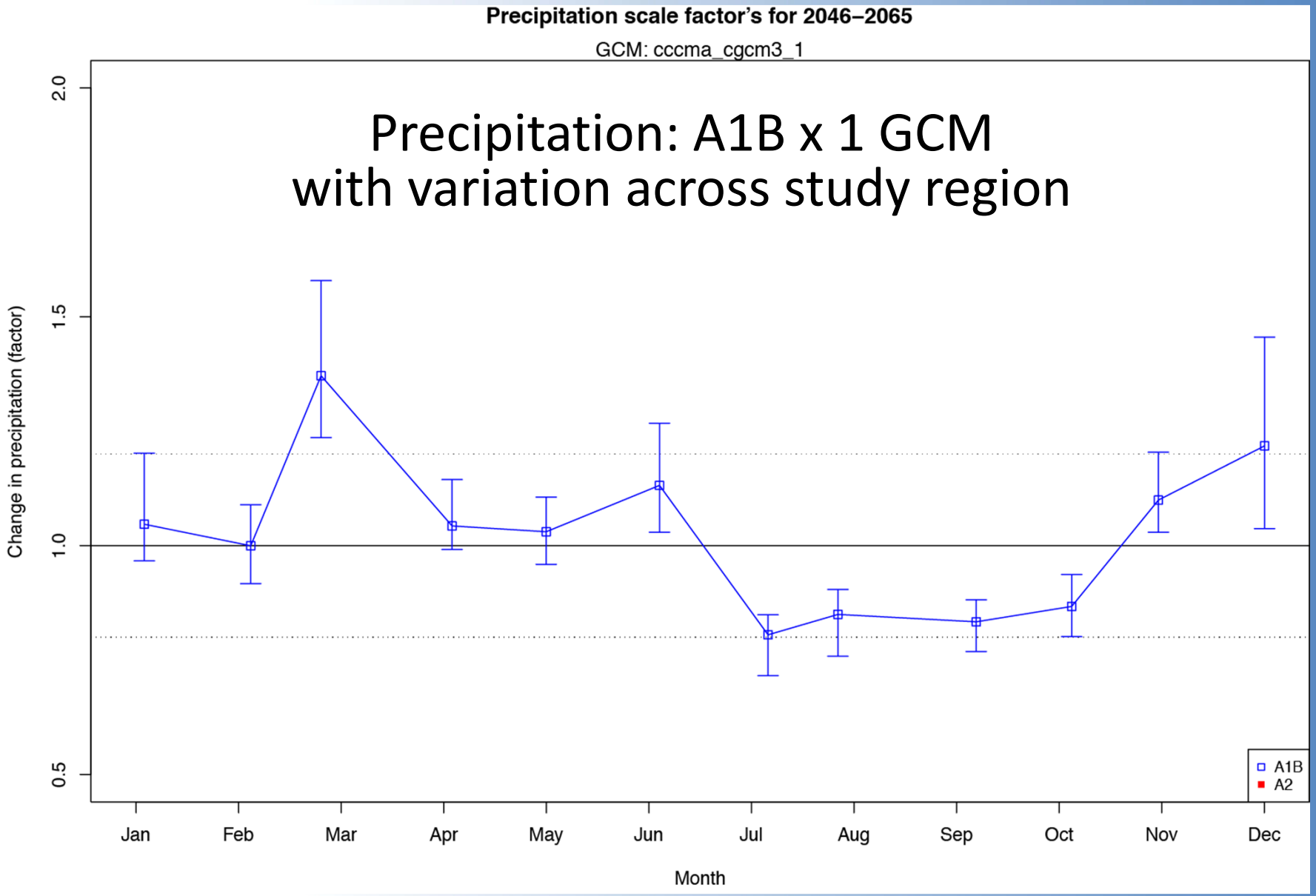

Burlington Temperature through Time
1981-2000
2046-2065
2081-2100
Temperature
30
20
10
0
−10
−20
−30
2000
2050
2100
Year

Some sources of uncertainty in downscaled projections

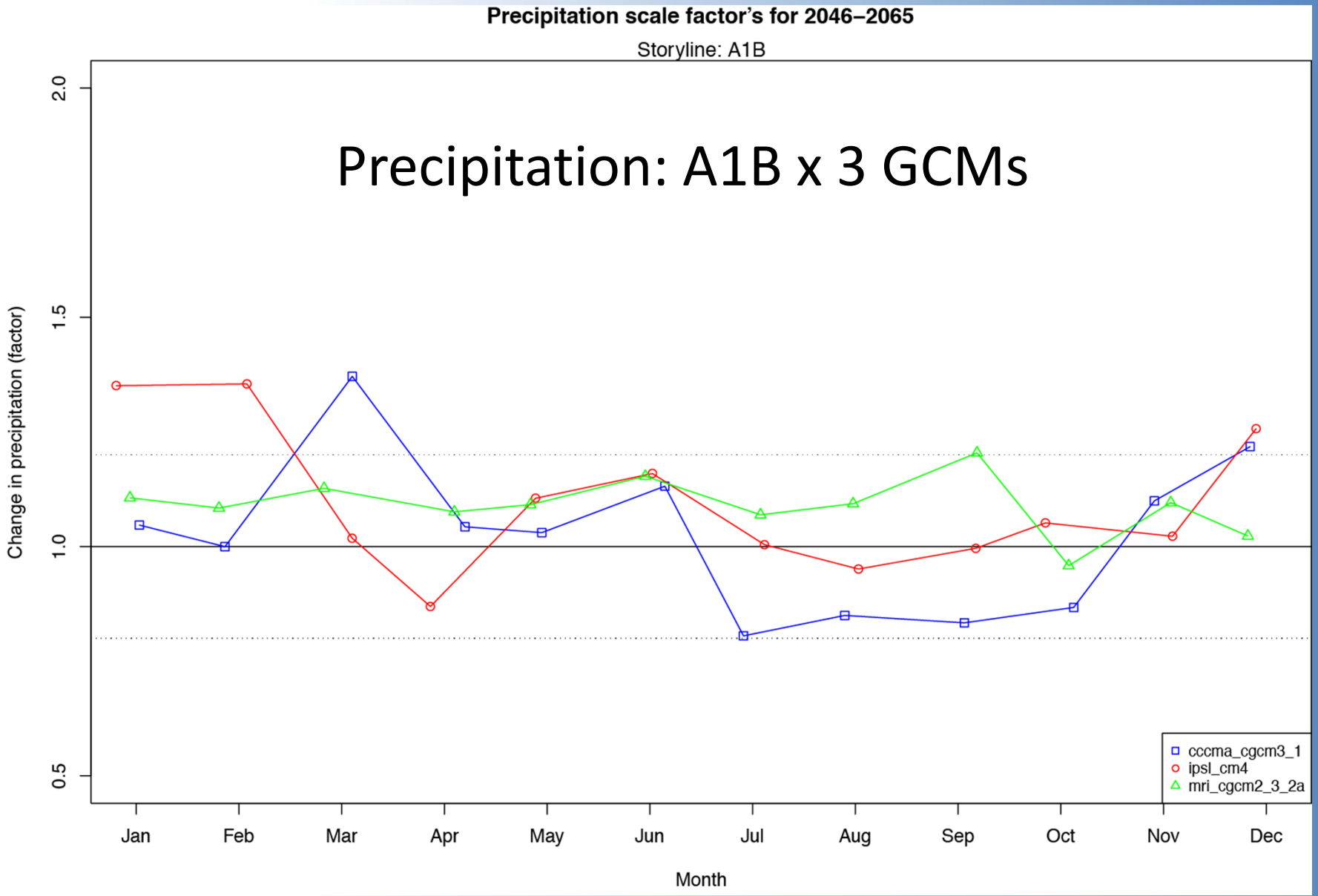
1. Storylines that describe future atm CO_2 concentrations
   - AIB and A2 storylines
2. GCM model structure and assumptions
   - cccma_cgcm3_1 ~ Canadian Centre for Climate Modelling and Analysis
   - ipsl_cm4 ~ Institut Pierre Simon Laplace, France.
   - mri_cgcm2_3_2a ~Meteorological Research Institute, Japan Meteorological Agency, Japan
3. Downscaling method
   - BCSD
   - BCCA


Precipitation scale factor's for 2046–2065
GCM: cccma_cgcm3_1
Precipitation: A1B x 1 GCM
Change in precipitation (factor)
2.0
1.5
1.0
0.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
A1B
A2

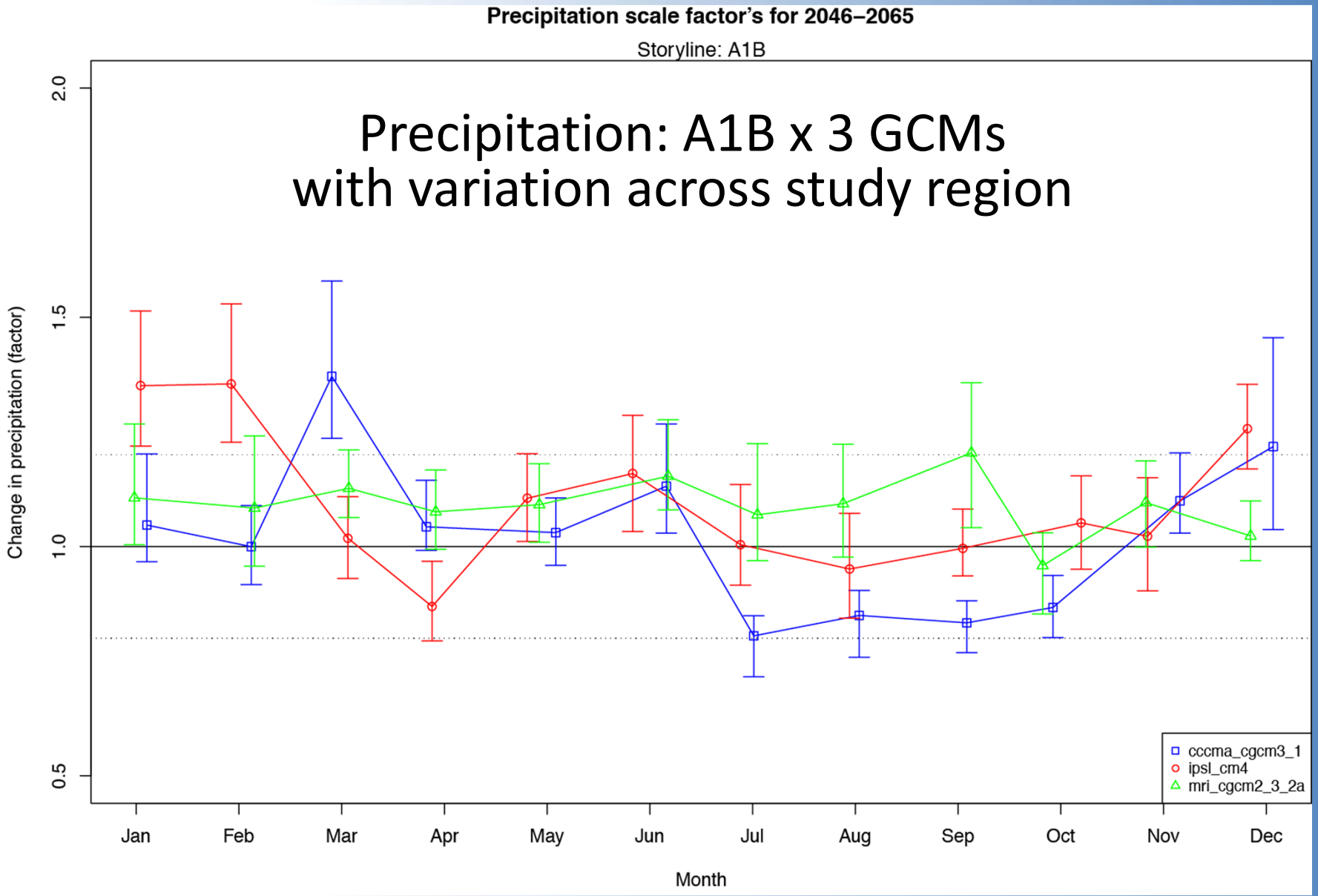
Precipitation: A1B x 1 GCM with variation across study region

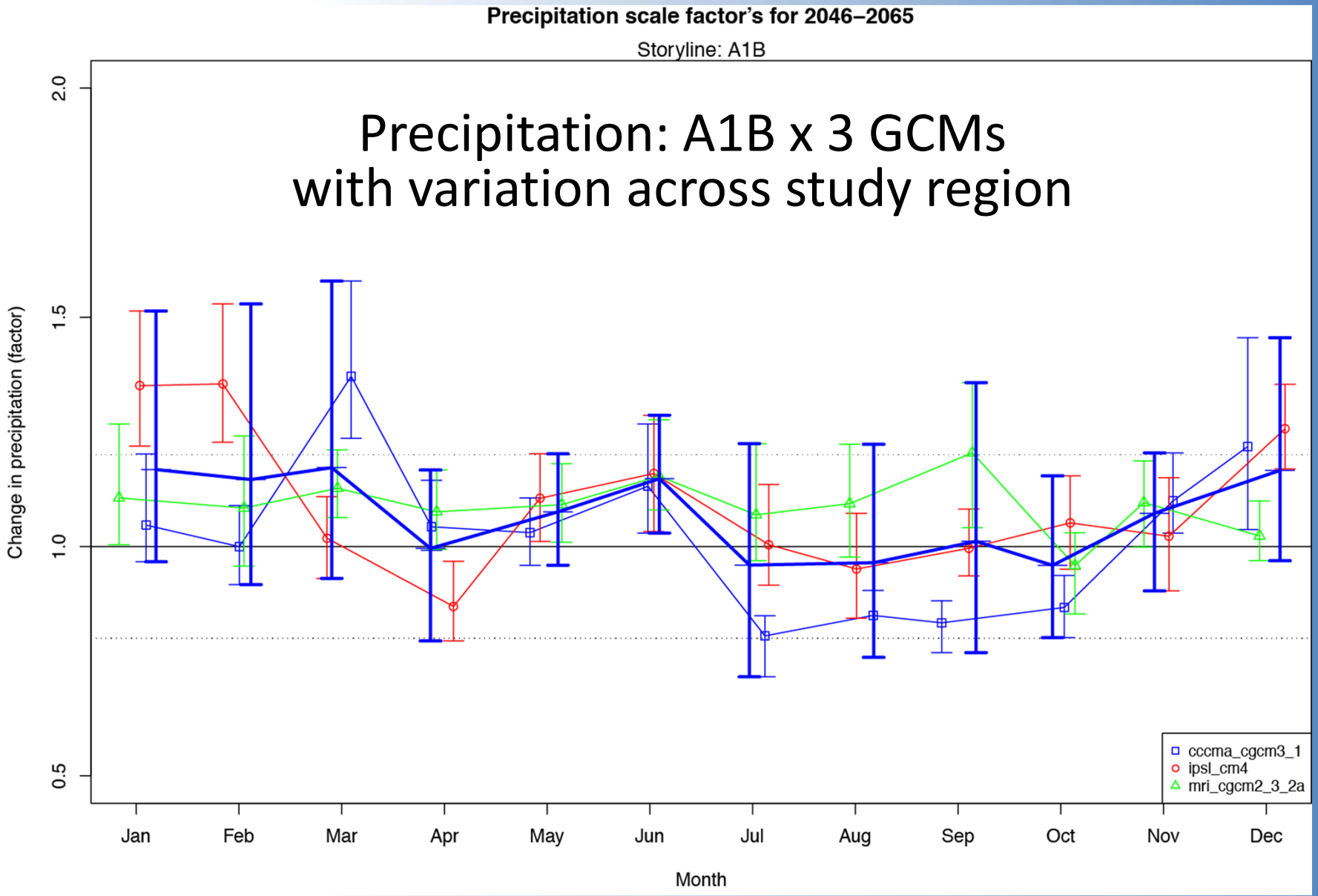


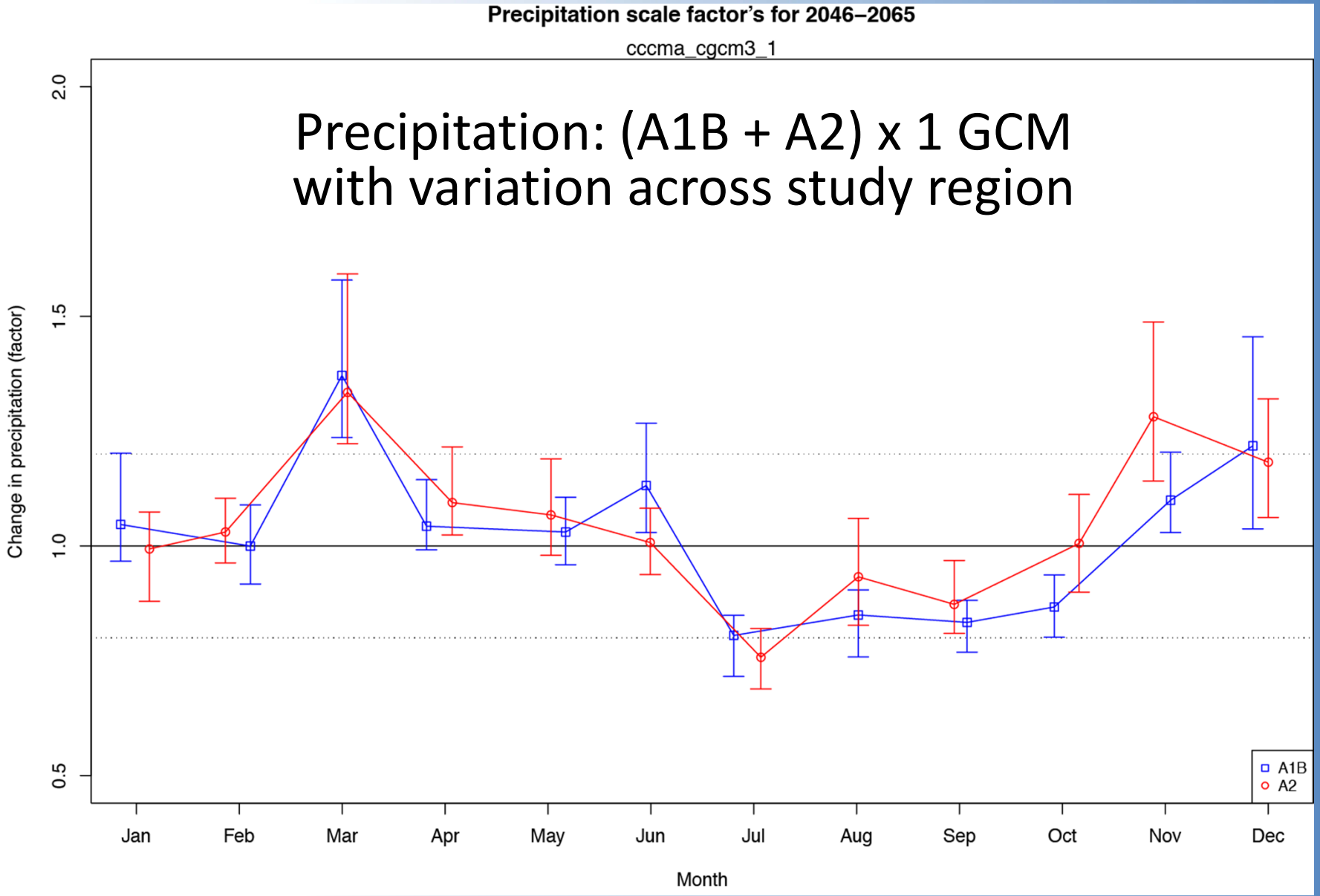
Precipitation: A1B x 3 GCMs

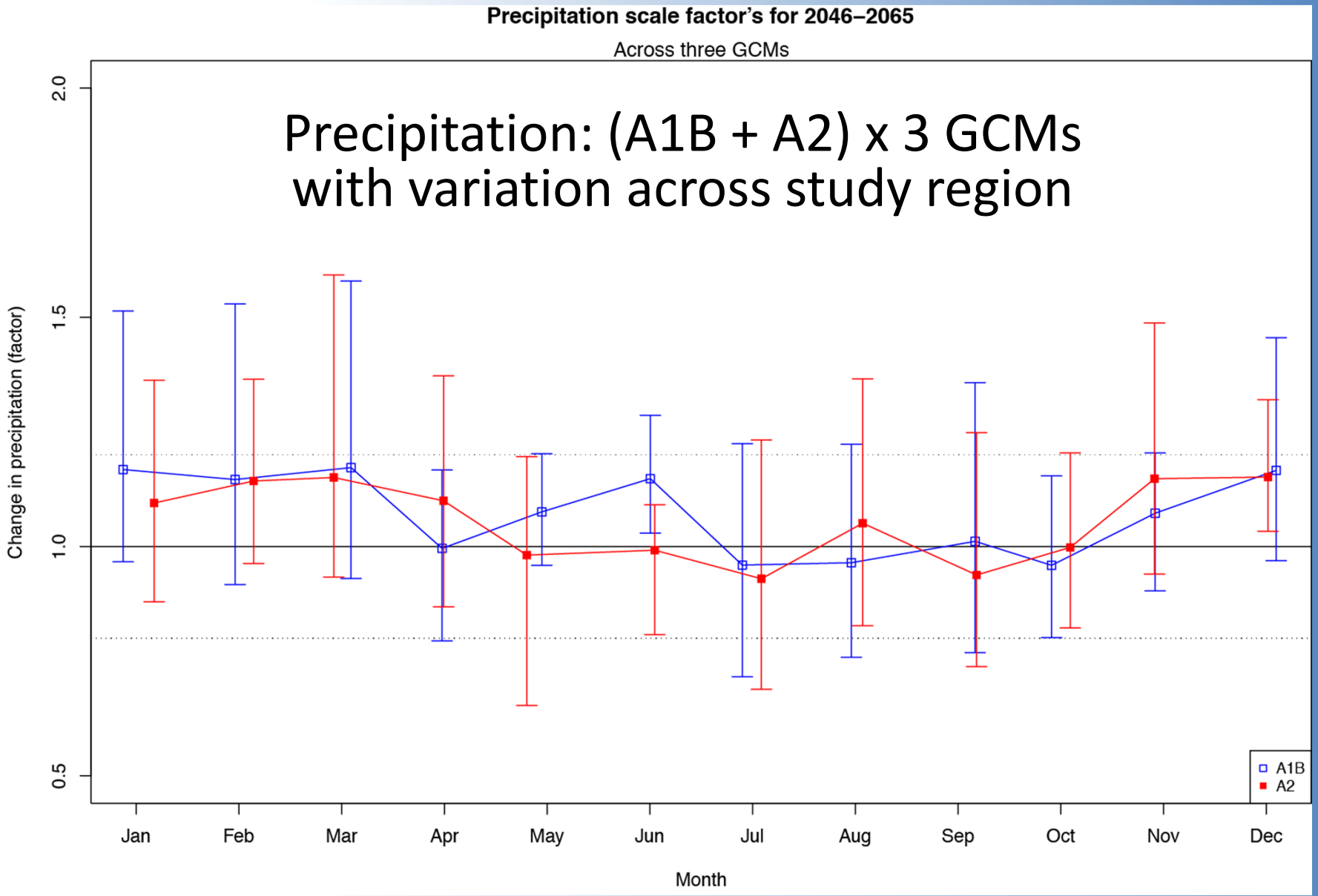


Precipitation: A1B x 3 GCMs with variation across study region

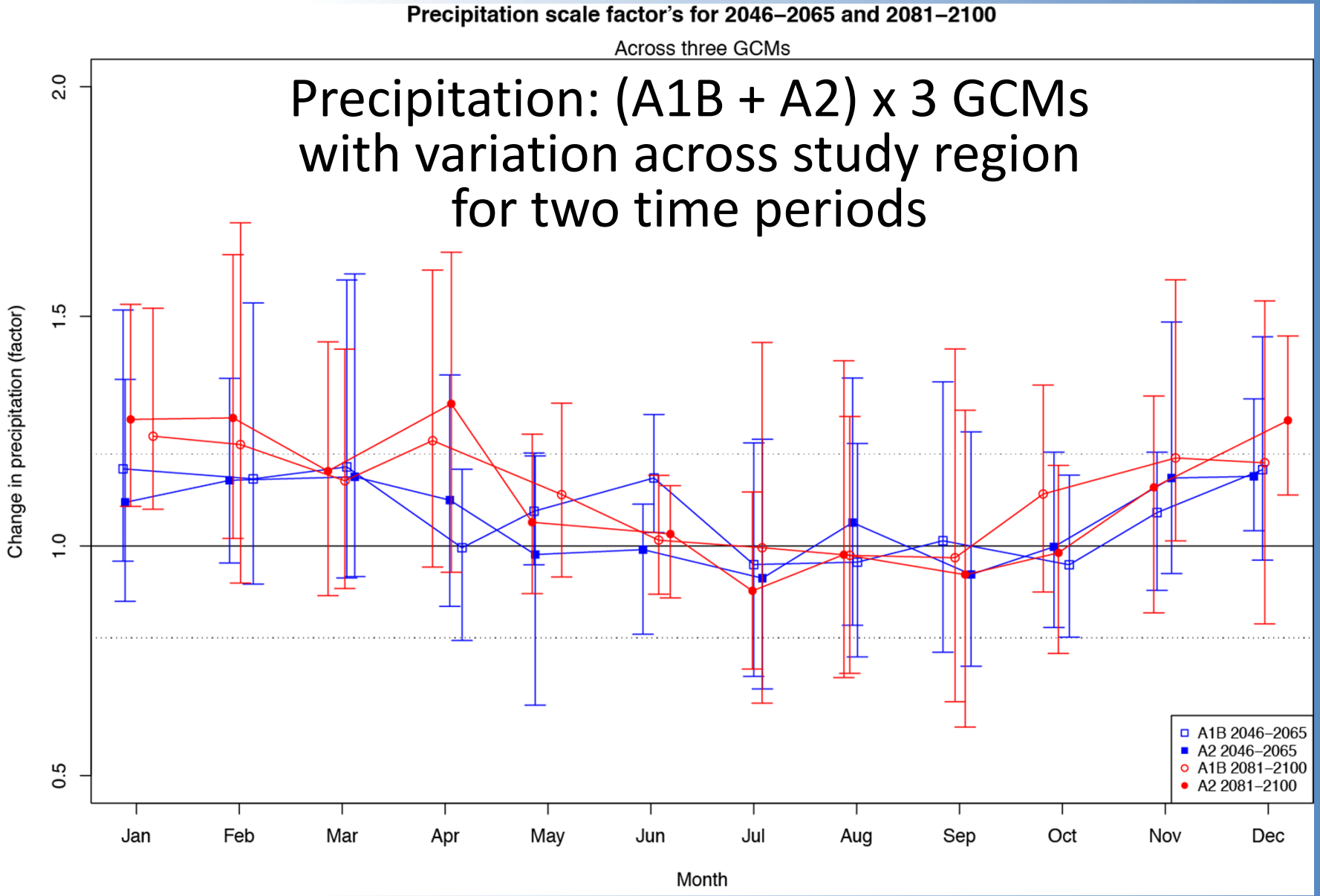


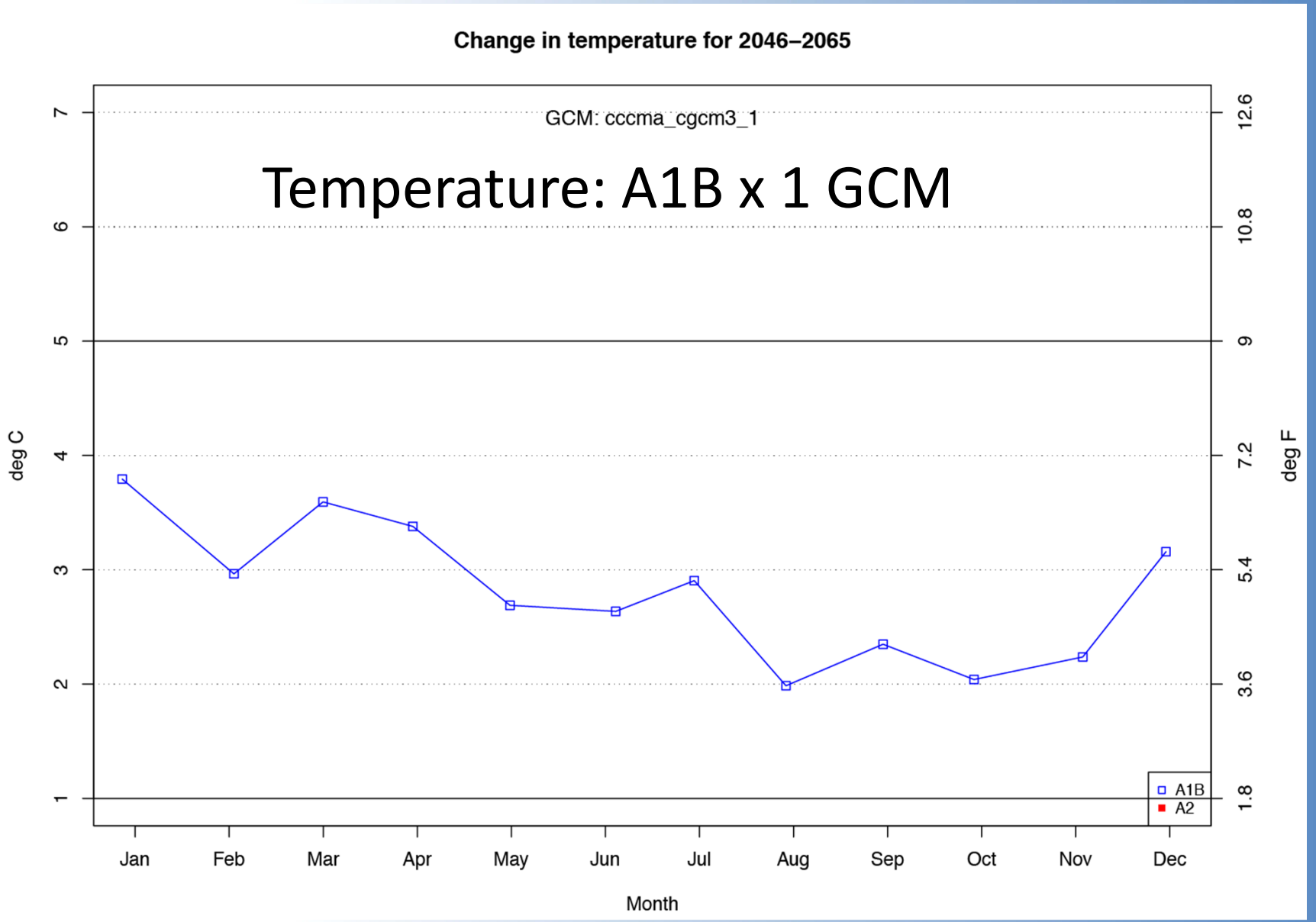

Precipitation scale factor's for 2046–2065
Storyline: A1B
Precipitation: A1B x 3 GCMs
with variation across study region
Change in precipitation (factor)
2.0
1.5
1.0
0.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
cccma_cgcm3_1
ipsl_cm4
mri_cgcm2_3_2a


Precipitation scale factor's for 2046–2065
cccma_cgcm3_1
Precipitation: (A1B + A2) x 1 GCM
with variation across study region
Change in precipitation (factor)
2.0
1.5
1.0
0.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
A1B
A2

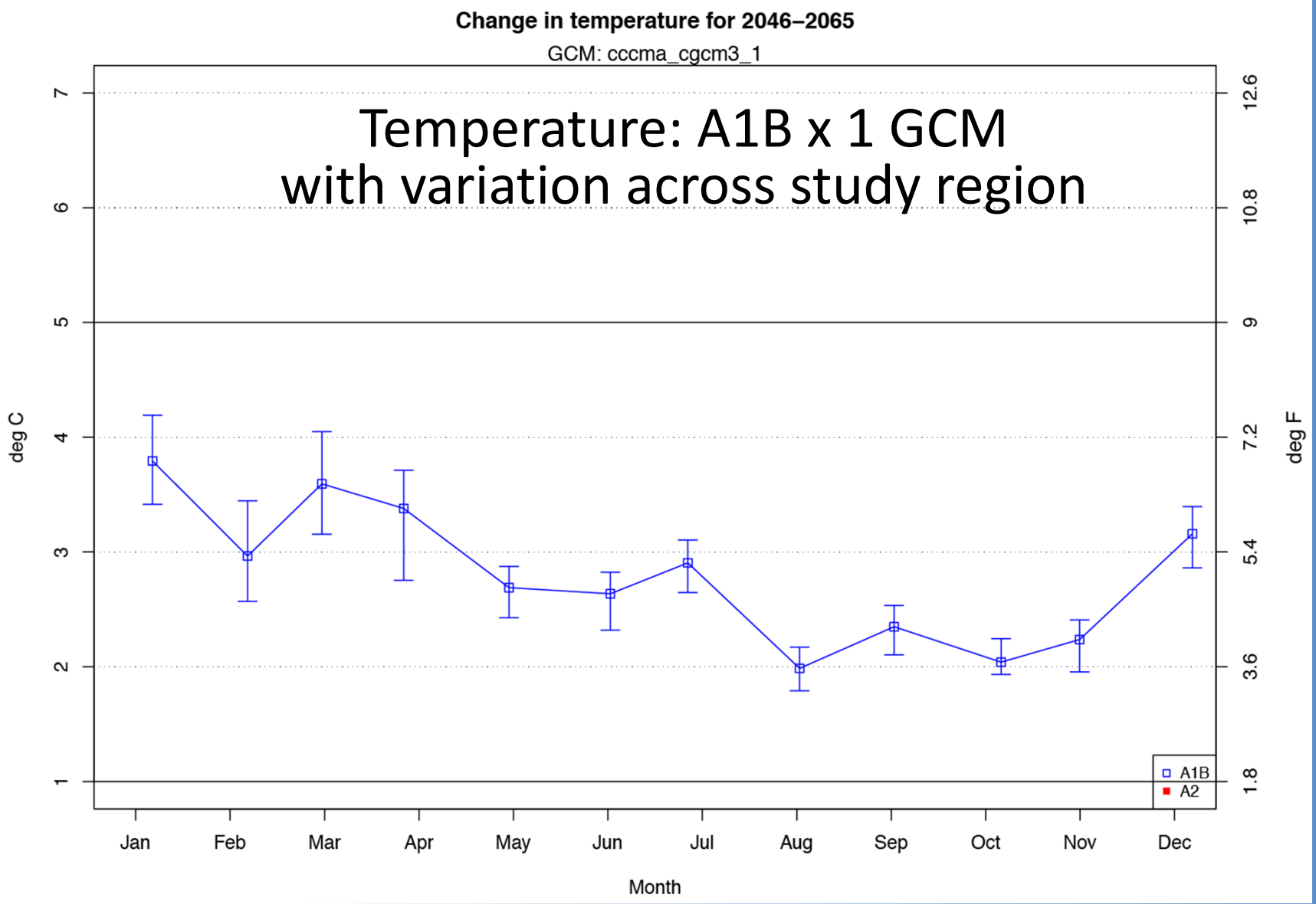

Precipitation scale factor's for 2046–2065
Across three GCMs
Precipitation: (A1B + A2) x 3 GCMs
with variation across study region
Change in precipitation (factor)
2.0
1.5
1.0
0.5
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
A1B
A2

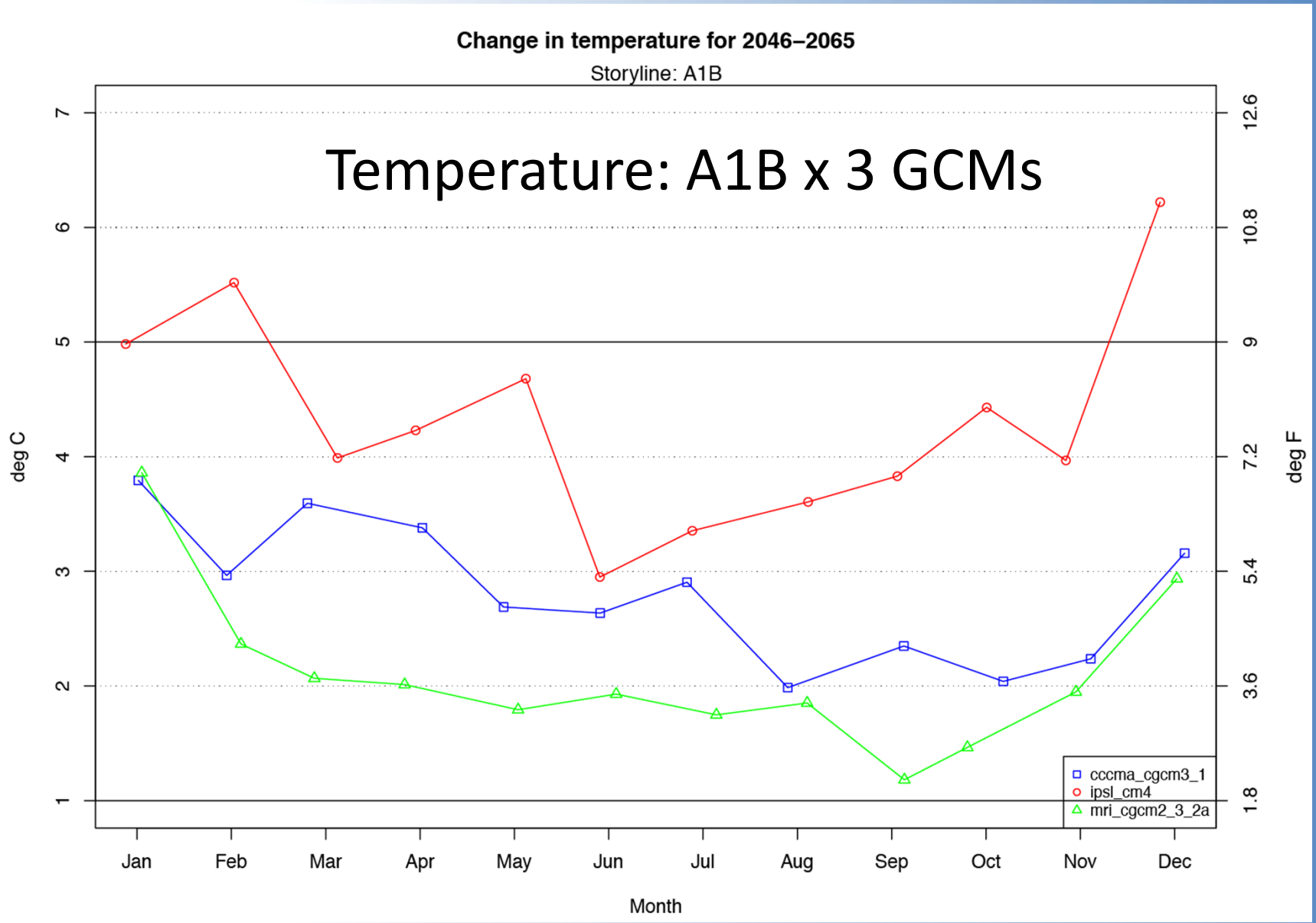
Precipitation: (A1B + A2) x 3 GCMs with variation across study region for two time periods

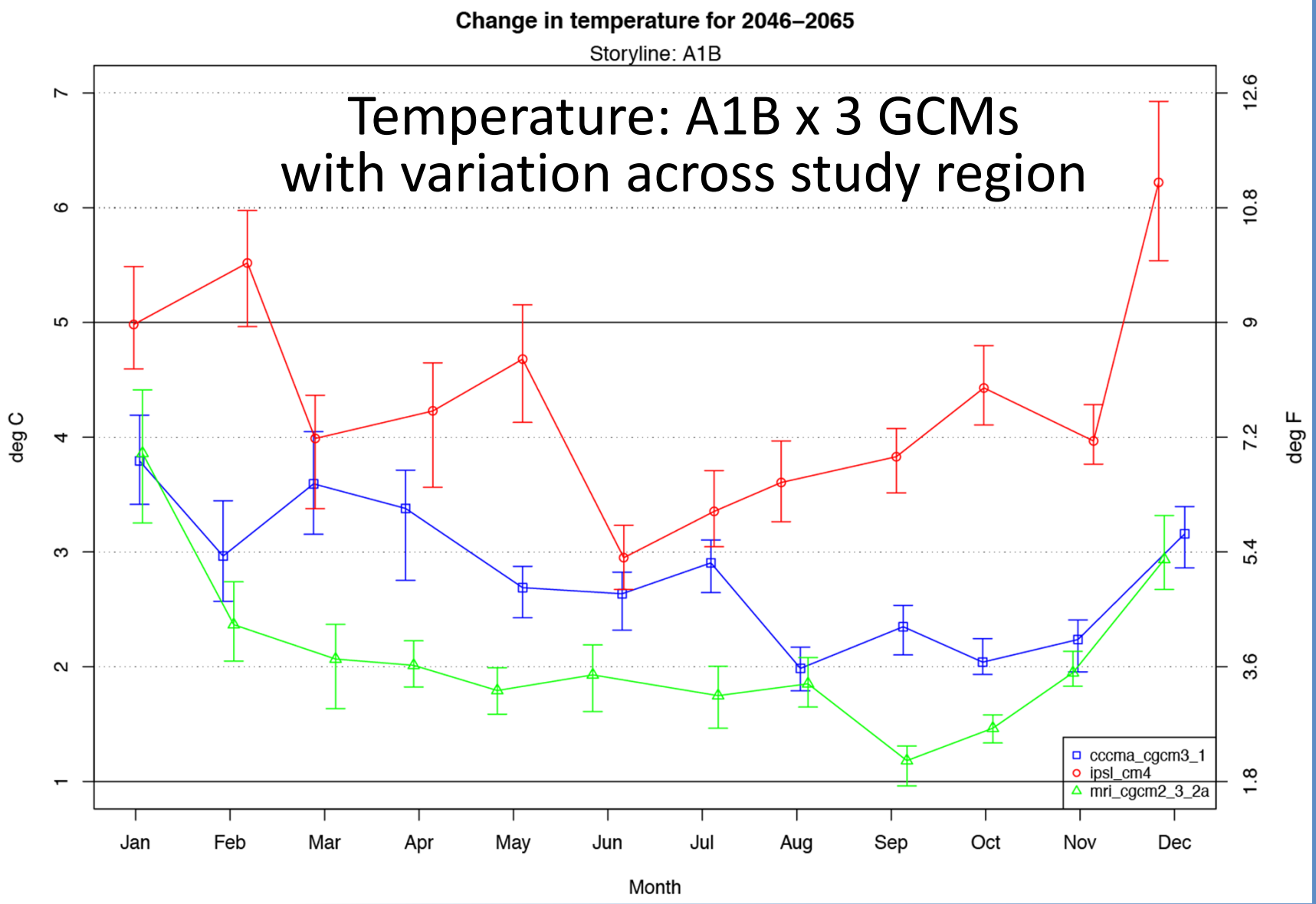


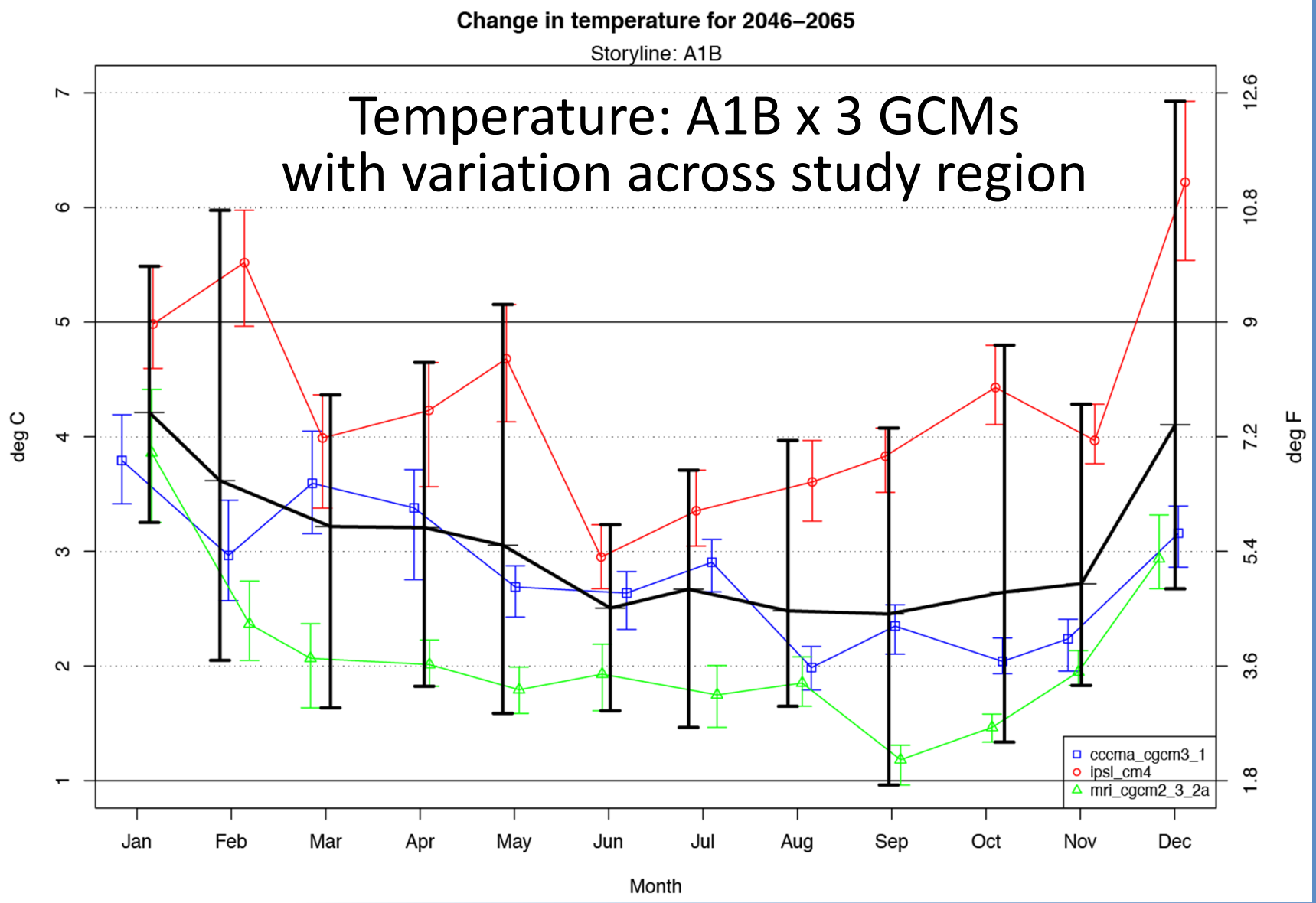

Change in temperature for 2046–2065
GCM: cccma_cgcm3_1
Temperature: A1B x 1 GCM
deg C
deg F
1
2
3
4
5
6
7
1.8
3.6
5.4
7.2
9
10.8
12.6
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
A1B
A2

Temperature: A1B x 1 GCM with variation across study region

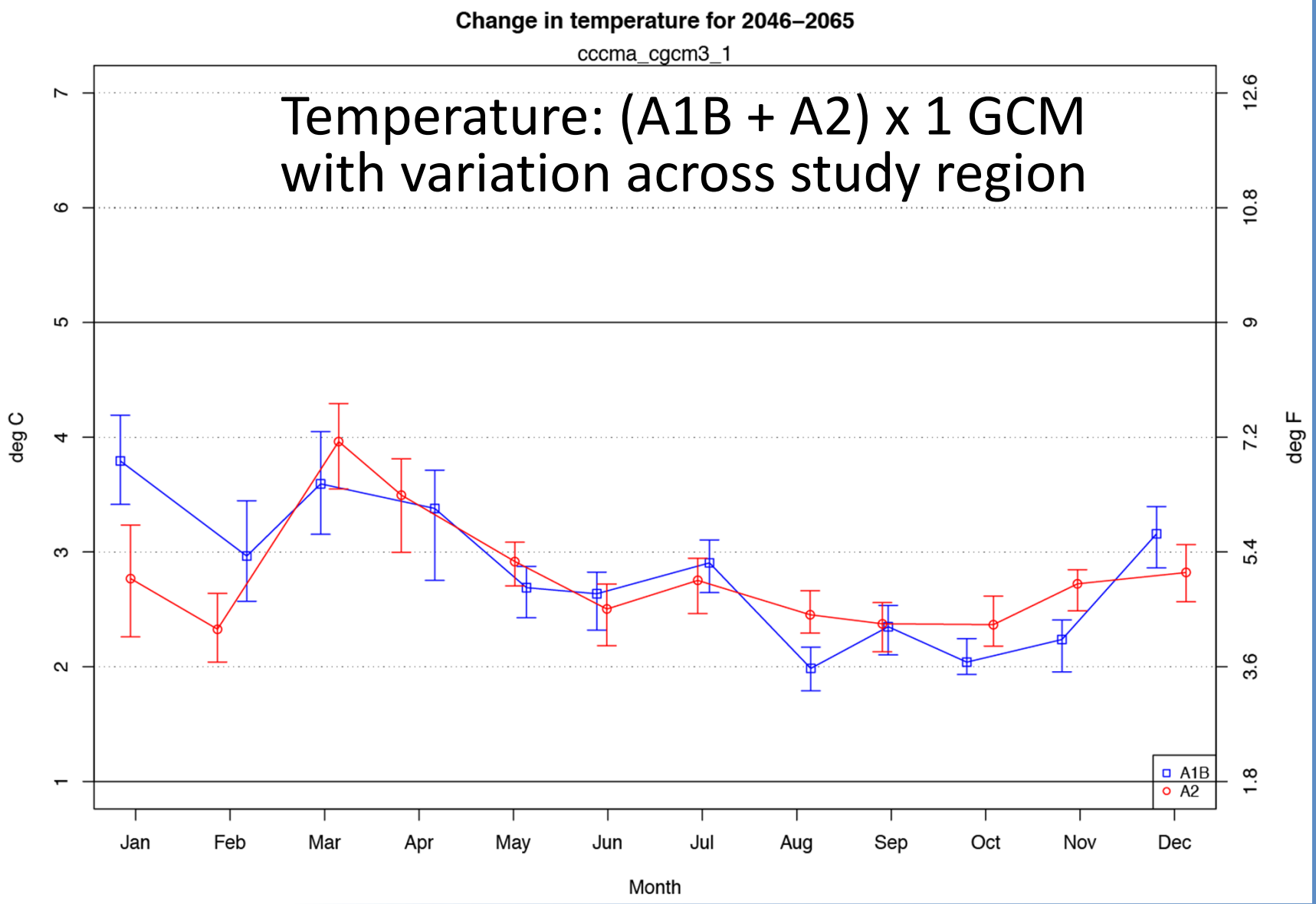


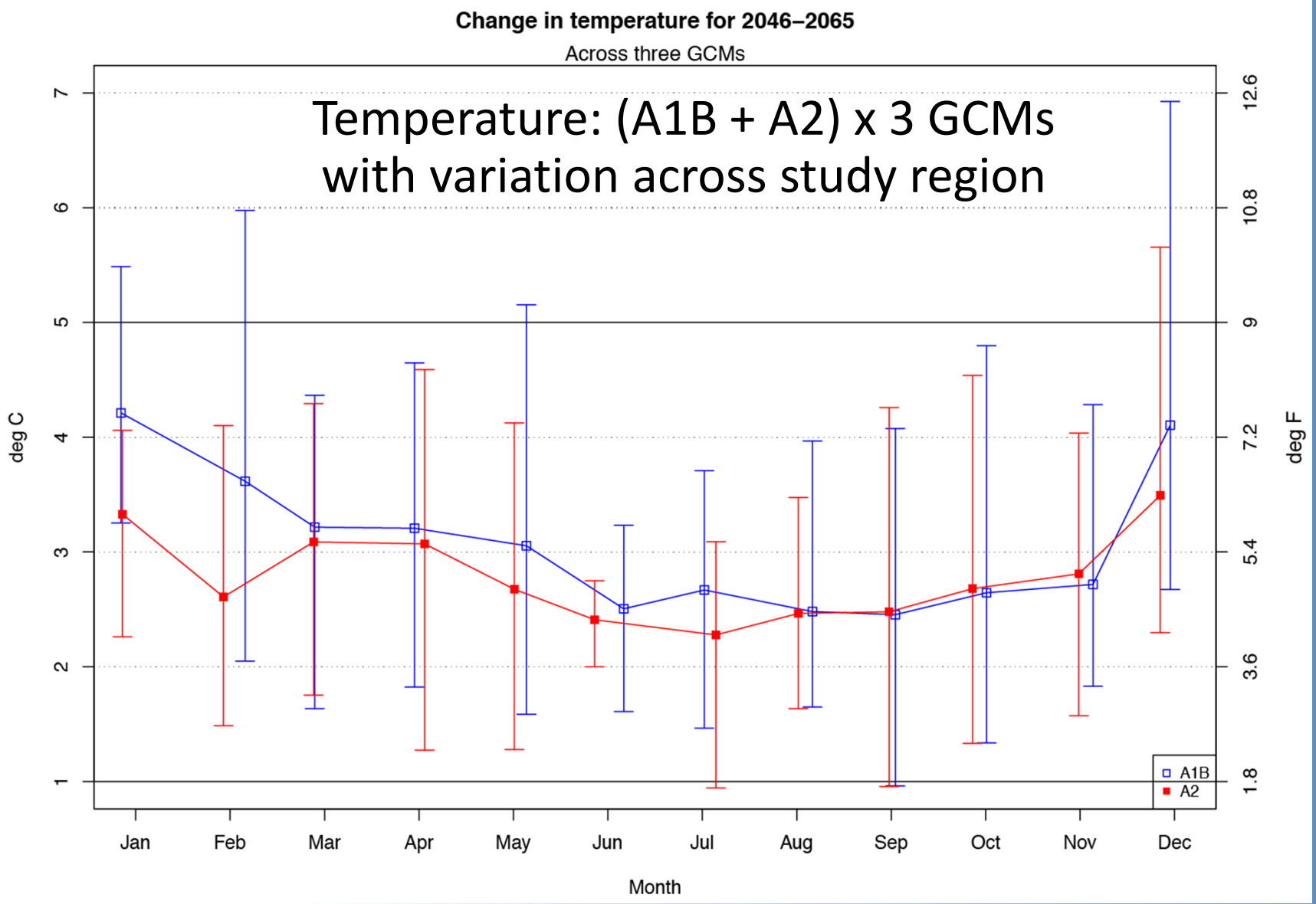

Change in temperature for 2046–2065
Storyline: A1B
Temperature: A1B x 3 GCMs
deg C
deg F
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1
2
3
4
5
6
7
1.8
3.6
5.4
7.2
9
10.8
12.6
cccma_cgcm3_1
ipsl_cm4
mri_cgcm2_3_2a


Change in temperature for 2046–2065
Storyline: A1B
Temperature: A1B x 3 GCMs
with variation across study region
deg C
deg F
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1
2
3
4
5
6
7
1.8
3.6
5.4
7.2
9
10.8
12.6
cccma_cgcm3_1
ipsl_cm4
mri_cgcm2_3_2a

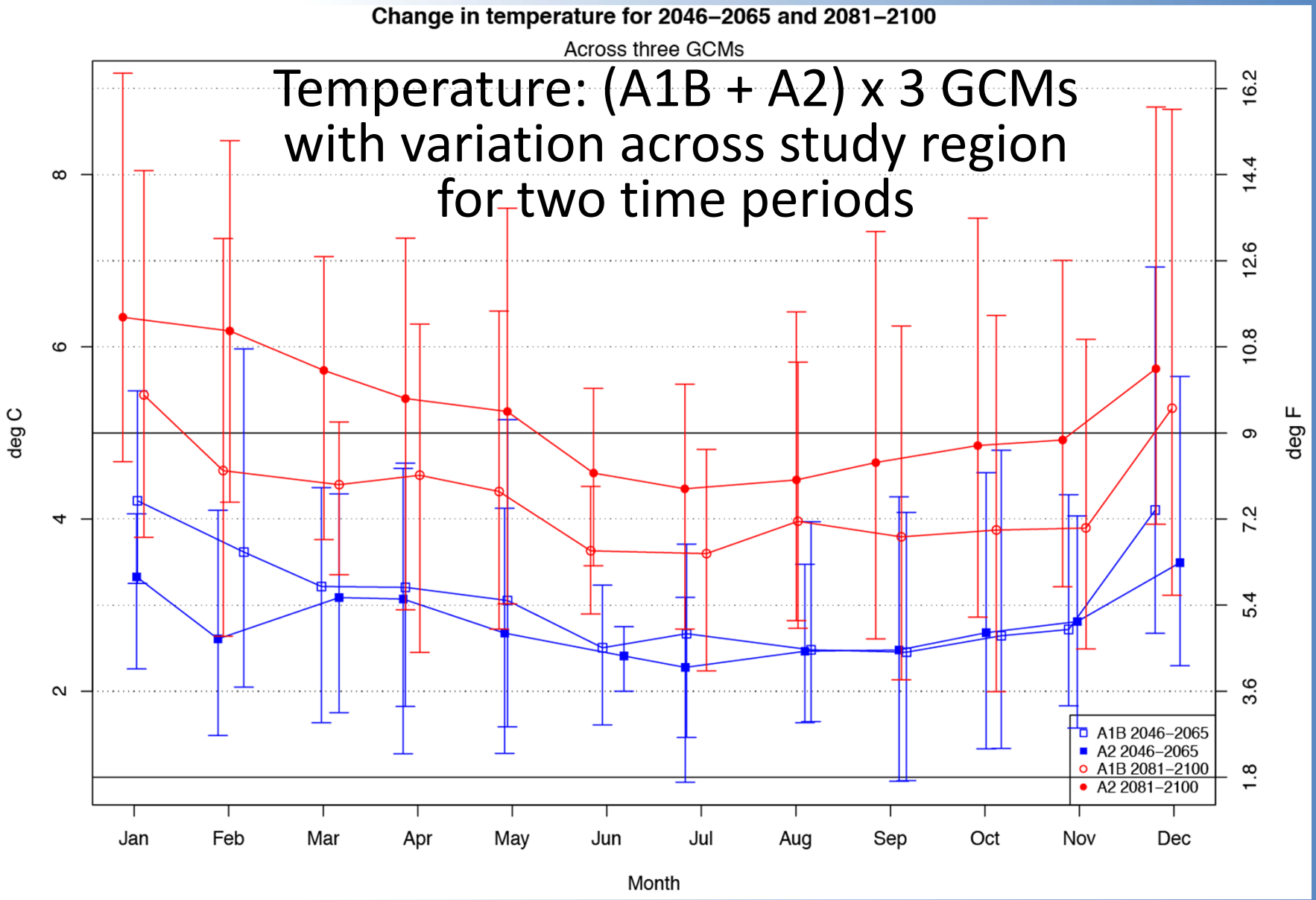

Change in temperature for 2046–2065
Storyline: A1B
Temperature: A1B x 3 GCMs
with variation across study region
deg C
deg F
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1
2
3
4
5
6
7
1.8
3.6
5.4
7.2
9
10.8
12.6
cccma_cgcm3_1
ipsl_cm4
mri_cgcm2_3_2a

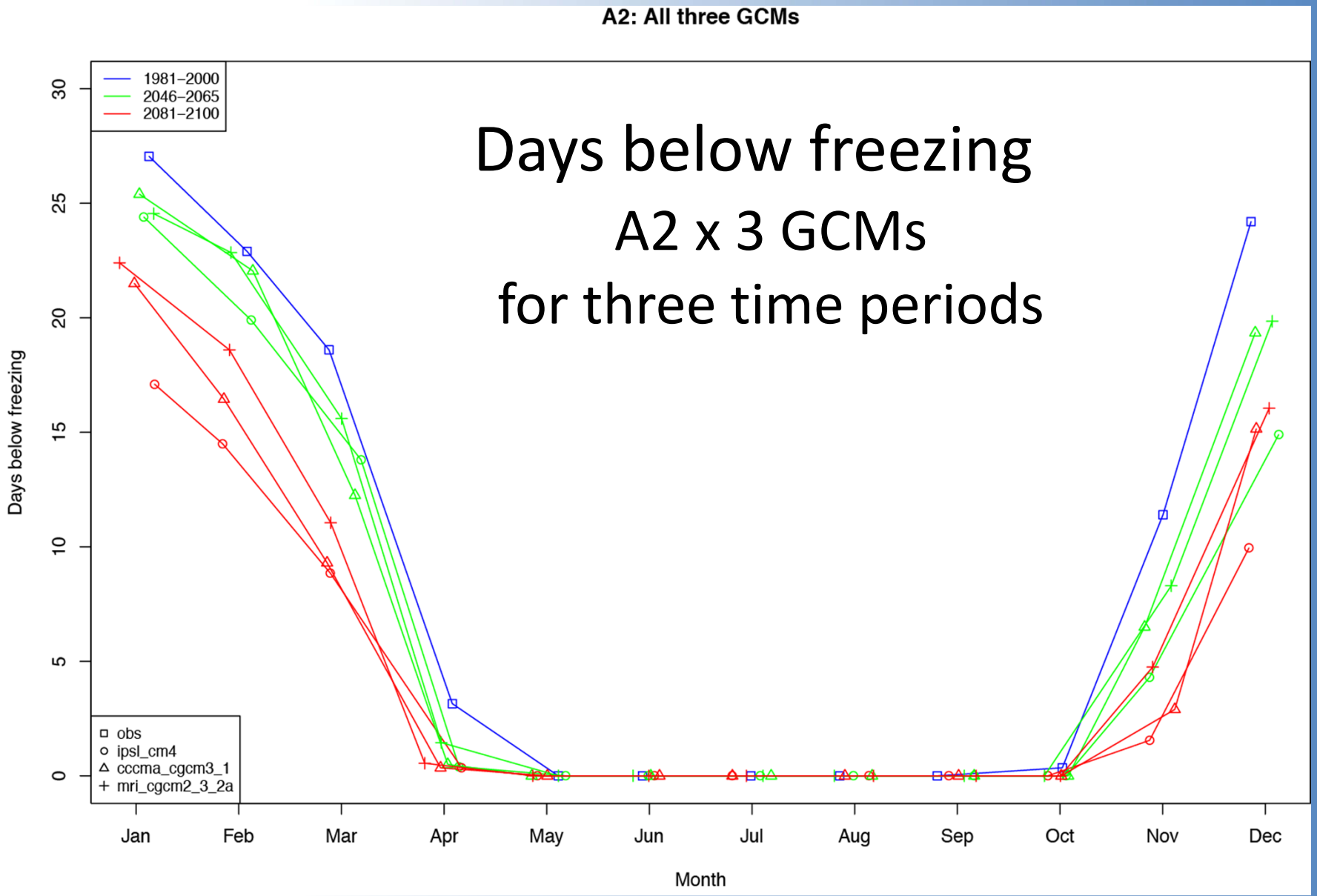
Temperature: (A1B + A2) x 1 GCM with variation across study region




Change in temperature for 2046–2065
Across three GCMs
Temperature: (A1B + A2) x 3 GCMs
with variation across study region
deg C
deg F
Month
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
1
2
3
4
5
6
7
1.8
3.6
5.4
7.2
9
10.8
12.6
A1B
A2

Temperature: (A1B + A2) x 3 GCMs with variation across study region for two time periods




A2: All three GCMs
1981–2000
2046–2065
2081–2100
Days below freezing
A2 x 3 GCMs
for three time periods
obs
ipsl_cm4
cccma_cgcm3_1
mri_cgcm2_3_2a
Days below freezing
0
5
10
15
20
25
30
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month

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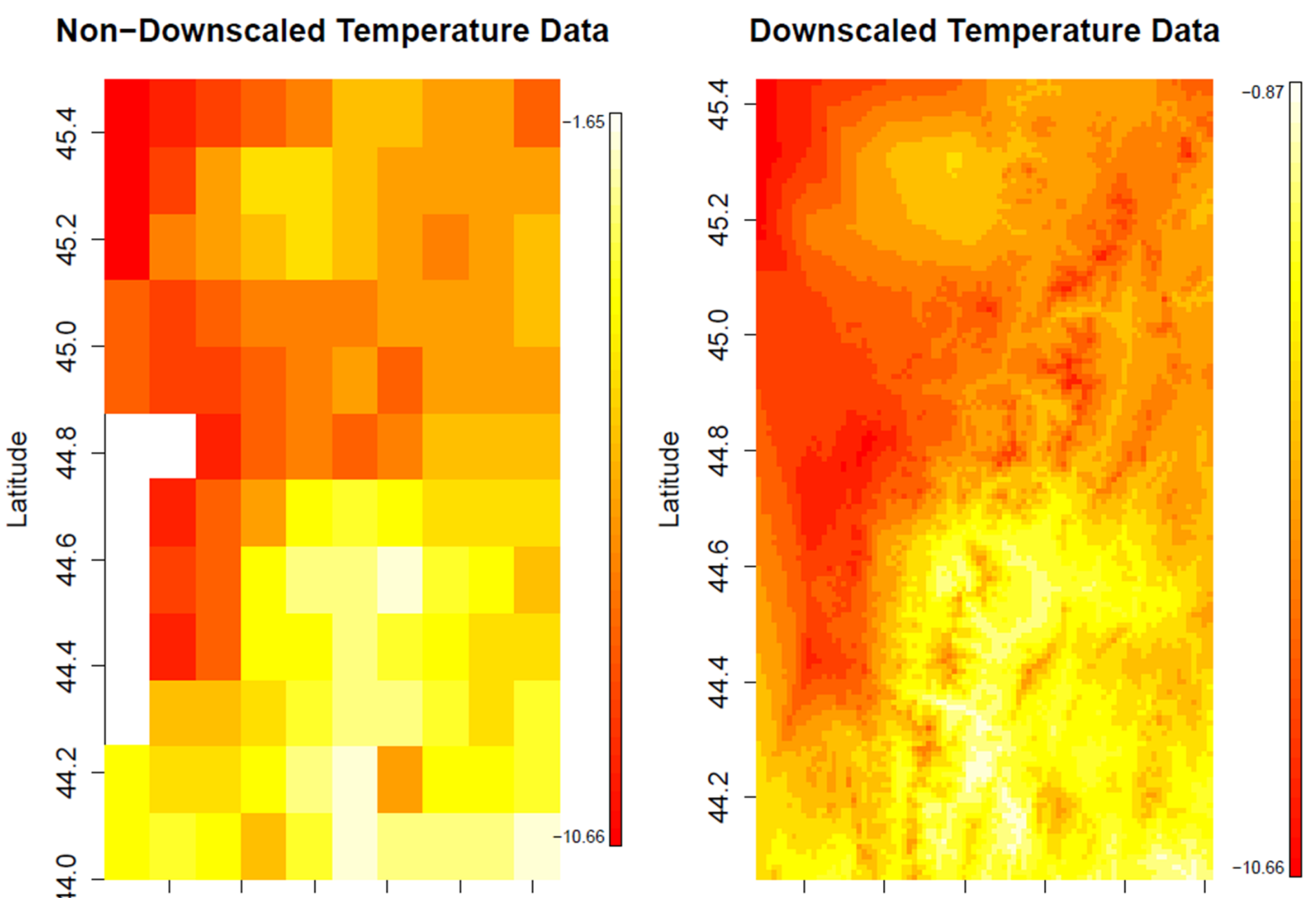
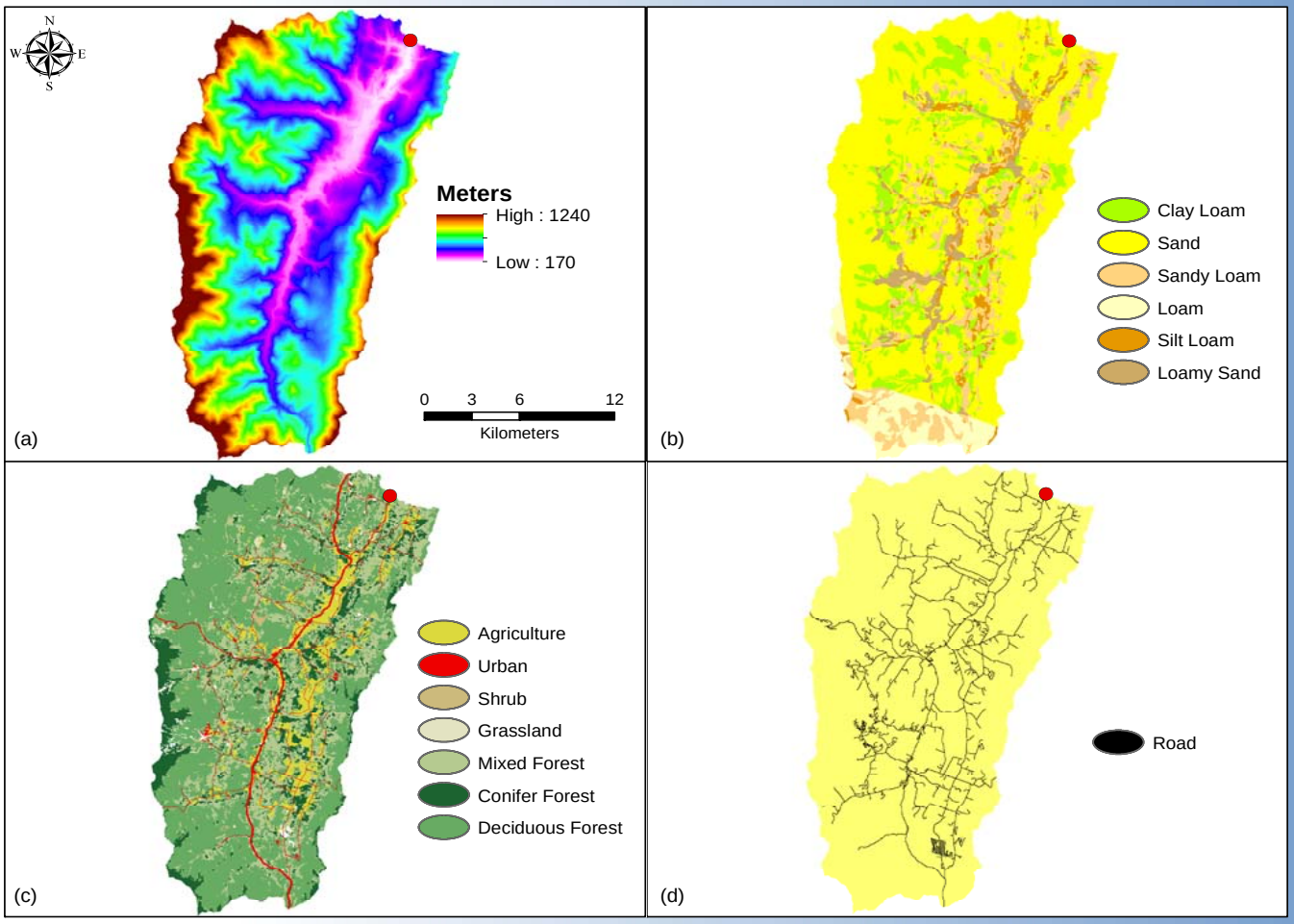
Questions?


Non−Downscaled Temperature Data
Latitude
45.4
45.2
45.0
44.8
44.6
44.4
44.2
44.0
−1.65
−10.66
Downscaled Temperature Data
Latitude
45.4
45.2
45.0
44.8
44.6
44.4
44.2
−0.87
−10.66



Spatial input data. a) Digital Elevation Model (DEM) (30 meter grid size), b) Soil Texture, c) Land Cover, and d) Roads. Soil Texture data are from SSURGO 2.2 dataset, Land Cover data are from the NLCD 2006 dataset, and Roads data are from the Vermont E9-1-1 GIS dataset.