Regional-scale modelization with the GEM forecast model

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The CMC/RPN operational GEM model is generally used to perform the short and medium timescale forecasts required by the Meteorological Service of Canada (MSC) clients. Recently, the model has also been used for seasonal forecasts, followings its Historical Forecast validation, and for even longer term AMIP-type integrations.

We will now focus on the longer-range results from a recent set of GEM simulations:

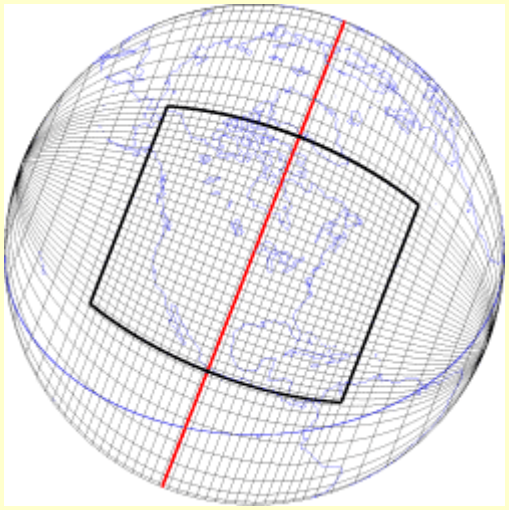
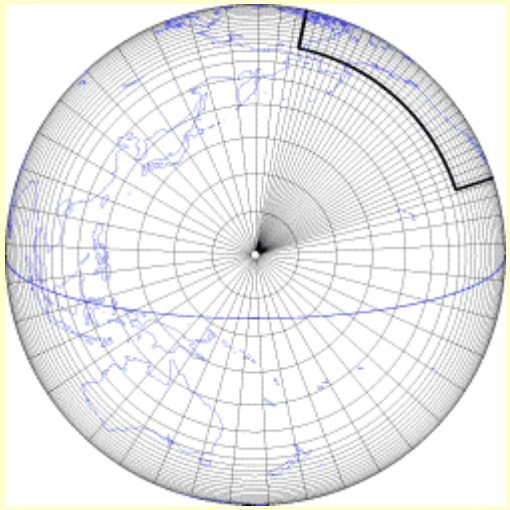
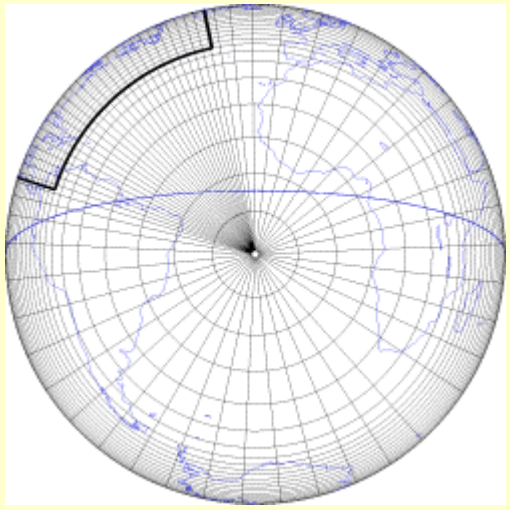
1) an AMIP2 standard simulation with a uniform 1,5° horizontal mesh;
2) a SGMIP (Stretched Grid Model Inter-comparison Project) simulation with a 0,45° horizontal mesh over North-America (NA), relaxing to 1,8° everywhere else;
and 3) preliminary results obtained with a LAM version of the model in regional climate mode. The LAM and SGMIP simulations results are compared over North-America. The three model versions share the same physics.

All results are compared to corresponding fields from the 2,5° ERA40 ECMWF re-analysis; these are shown as background difference fields in the figures, except for the zonal wind where the actual ERA40 fields are shown.

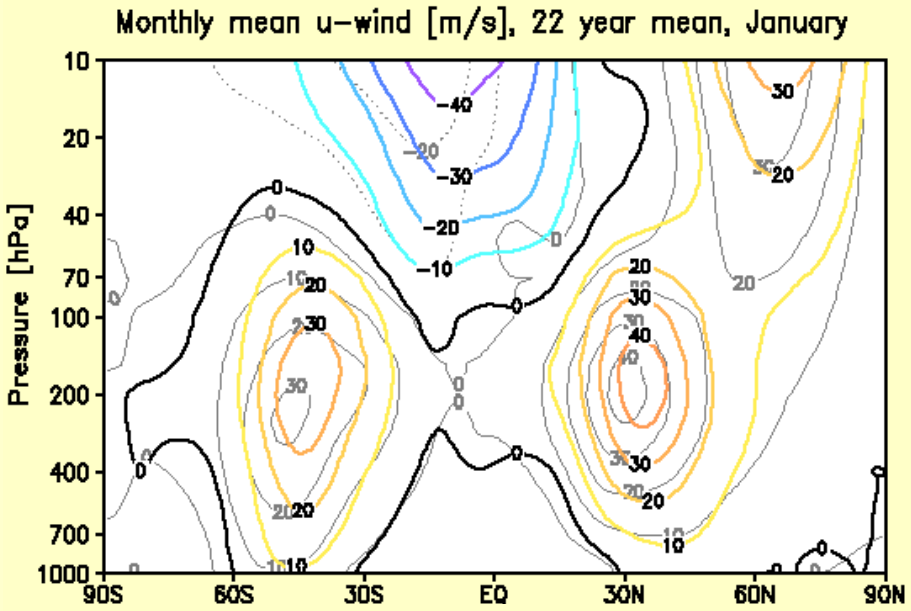
SGMIP/AMIP2

GEM model configurations:
- SGMIP simulation: 11-month spinup, starting in January 1986, ending in March 1999. AMIP2 starts in January 1978 with the same 11-month spinup.
- The SGMIP grid resolution varies from 0,45° over NA to 1,8° elsewhere: The grid's expansion coefficient is about 7% and occurs over 20 grid intervals. The AMIP2 grid resolution is a Globally Uniform 1,5°.
- 60 Hybrid vertical levels with a model top at 2 hPa.
- Timesteps: 1350 s (SGMIP) / 2700 s (AMIP2).

Physics:
- Gravity wave drag parameterization:
  McFarlane (1987)
- Radiation:
  Fouquart-Bonnel (1980) short-wave
  Garand and Mailhot (1990) long-wave radiation
  Full radiation is calculated at every two vertical levels and interpolated on the intermediary levels. The stratospheric long-wave radiation is provided by the Fomichev code upward of 30hPa.
- Convection and large scale condensation:
  Classical Kuo scheme.
  Condensation is handled by the Sundqvist scheme
- Land-surface scheme:
  Simple Force-Restore (Deardorff, 1978) everywhere but over NA, where the ISBA land-surface scheme is used

AMIP2


Monthly mean u-wind [m/s], 22 year mean, January
Pressure [hPa]
10
20
40
70
100
200
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700
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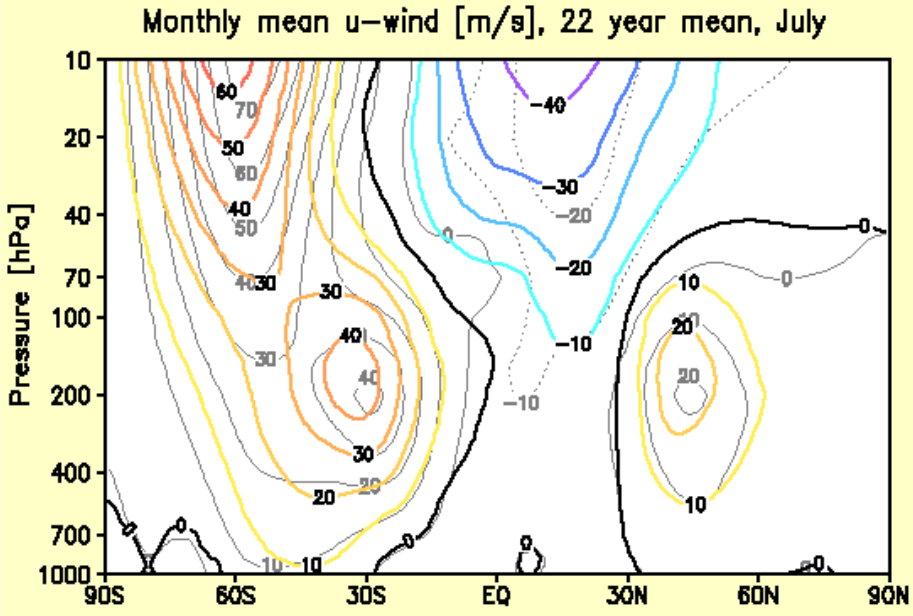
90S
60S
30S
EQ
30N
60N
90N


Monthly mean u-wind [m/s], 22 year mean, July
Pressure [hPa]
10
20
40
70
100
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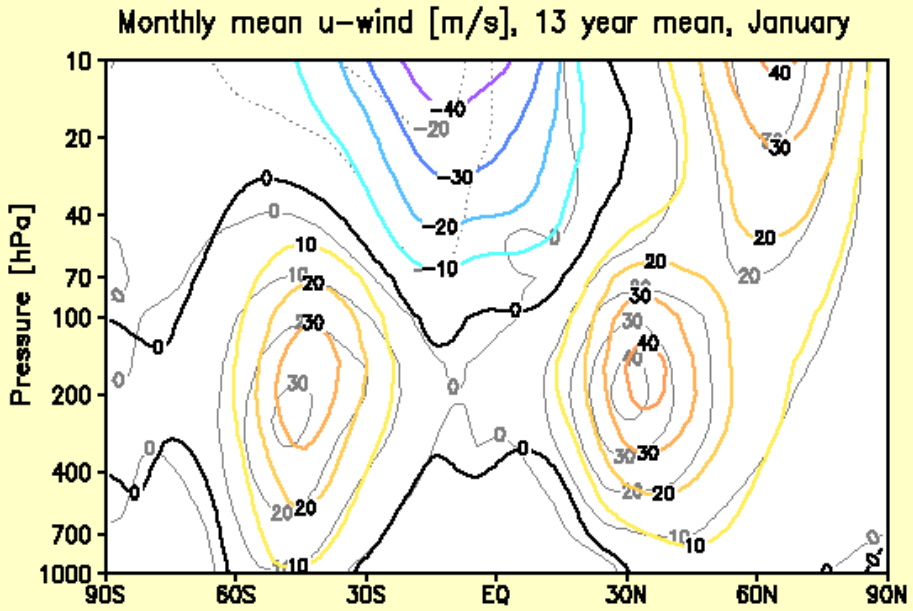
1000
90S
60S
30S
EQ
30N
60N
90N

SGMIP


Monthly mean u-wind [m/s], 13 year mean, January
Pressure [hPa]
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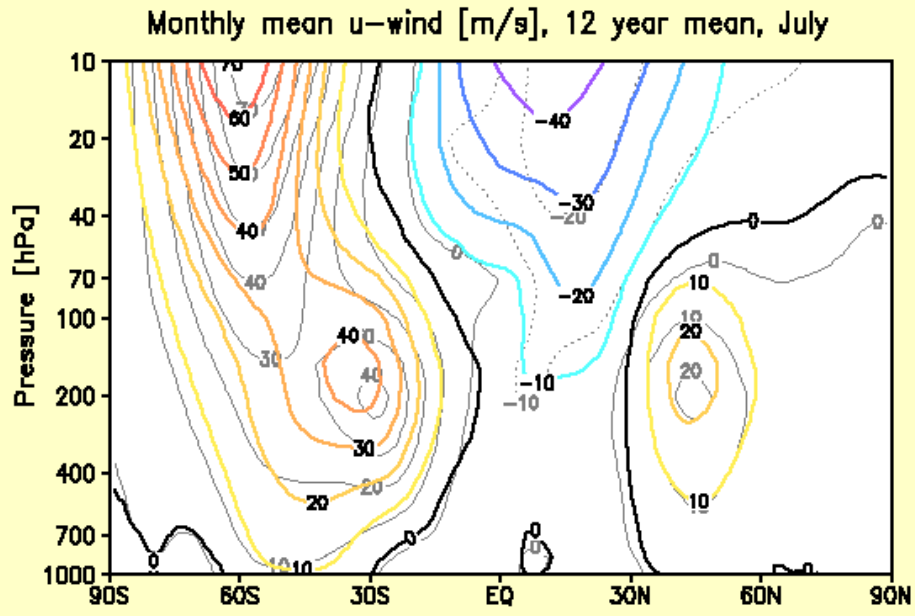
90S
60S
30S
EQ
30N
60N
90N


Monthly mean u-wind [m/s], 12 year mean, July
Pressure [hPa]
10
20
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100
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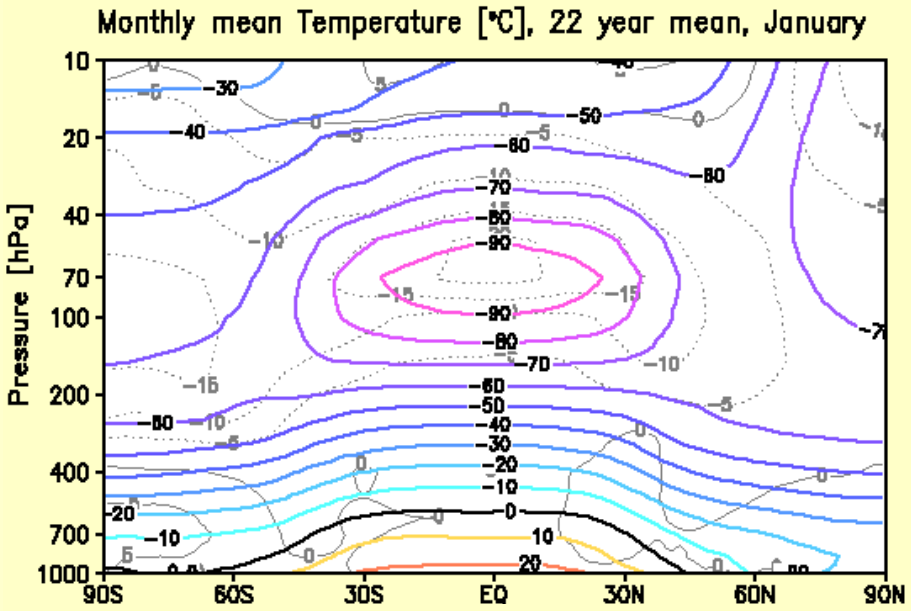
1000
90S
60S
30S
EQ
30N
60N
90N

AMIP2

SGMIP


Monthly mean Temperature [°C], 22 year mean, January
Pressure [hPa]
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20
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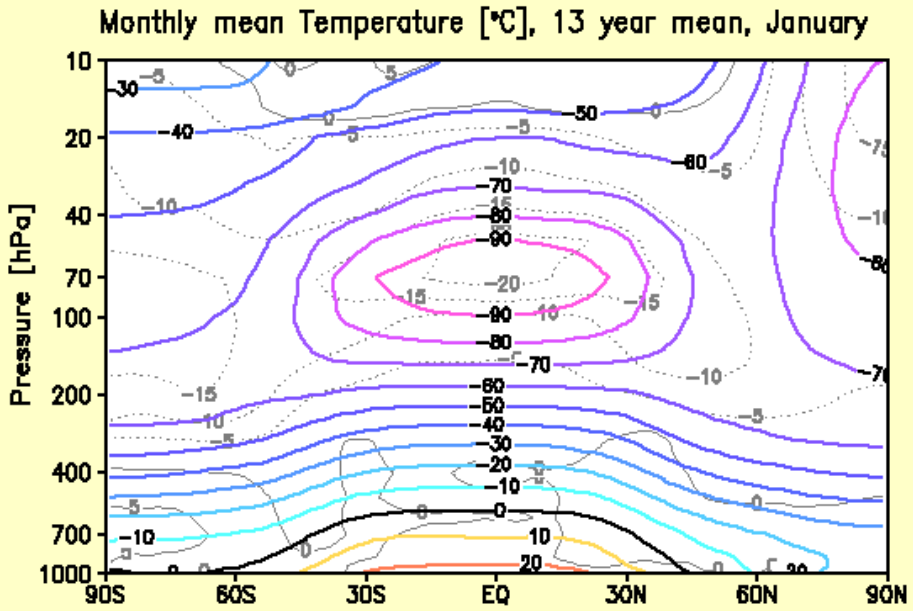
90S
60S
30S
EQ
30N
60N
90N


Monthly mean Temperature [°C], 13 year mean, January
Pressure [hPa]
10
20
40
70
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200
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700
1000
90S
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30S
EQ
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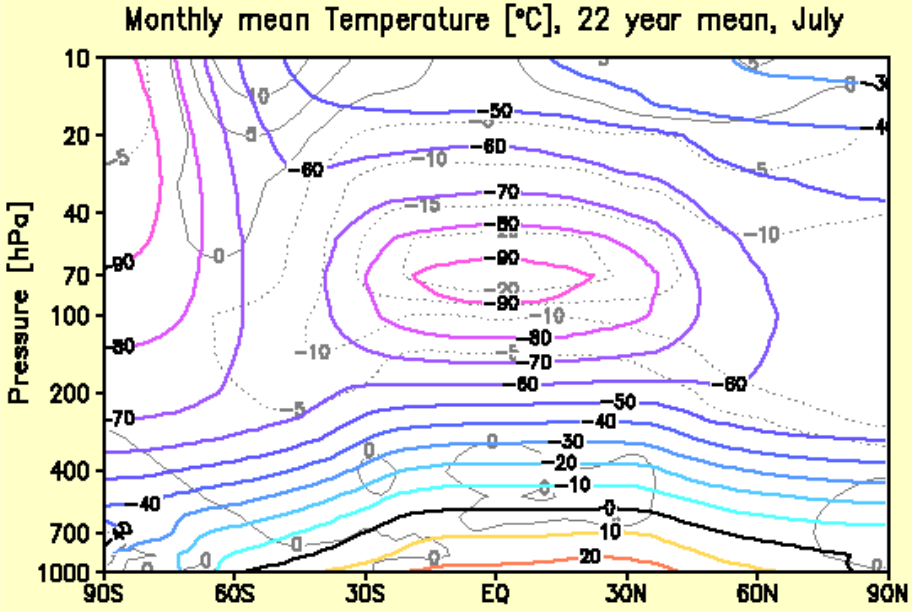
90N


Monthly mean Temperature [°C], 22 year mean, July
Pressure [hPa]
10
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90S
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EQ
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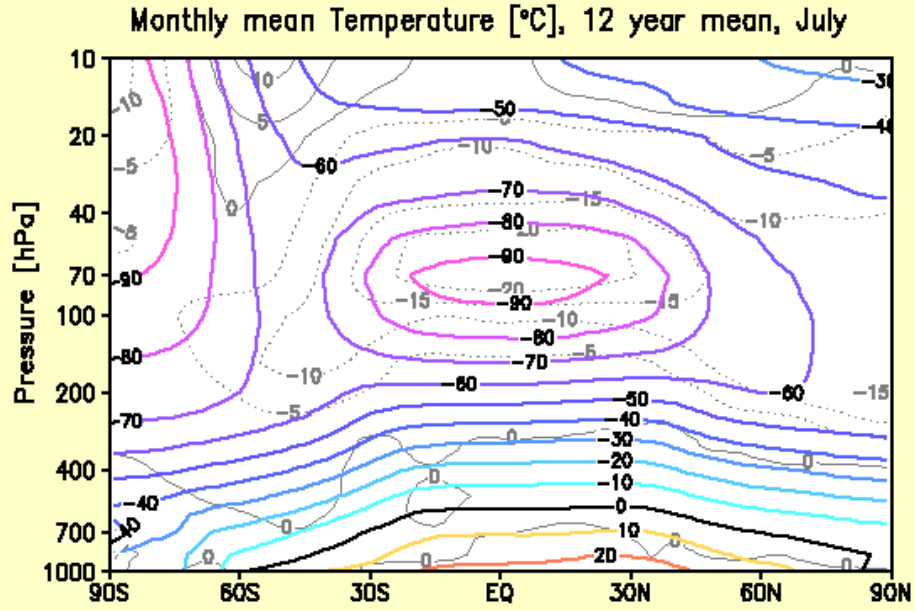
Monthly mean Temperature [°C], 12 year mean, July
Pressure [hPa]
10
20
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70
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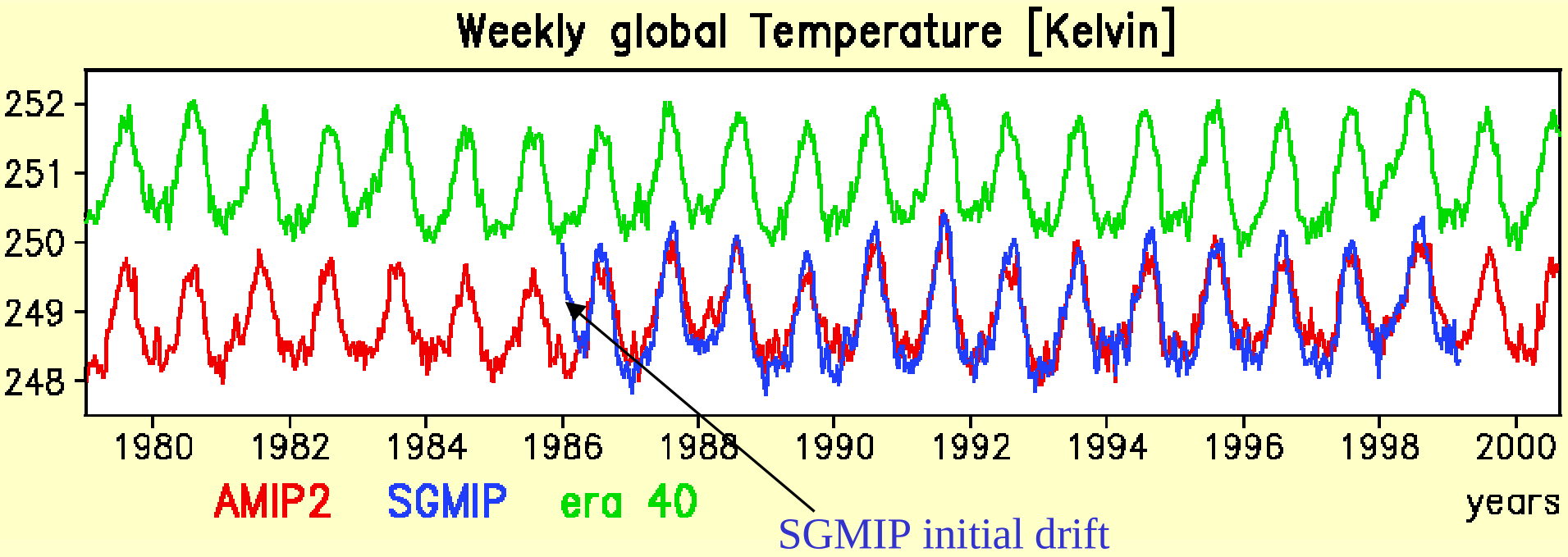
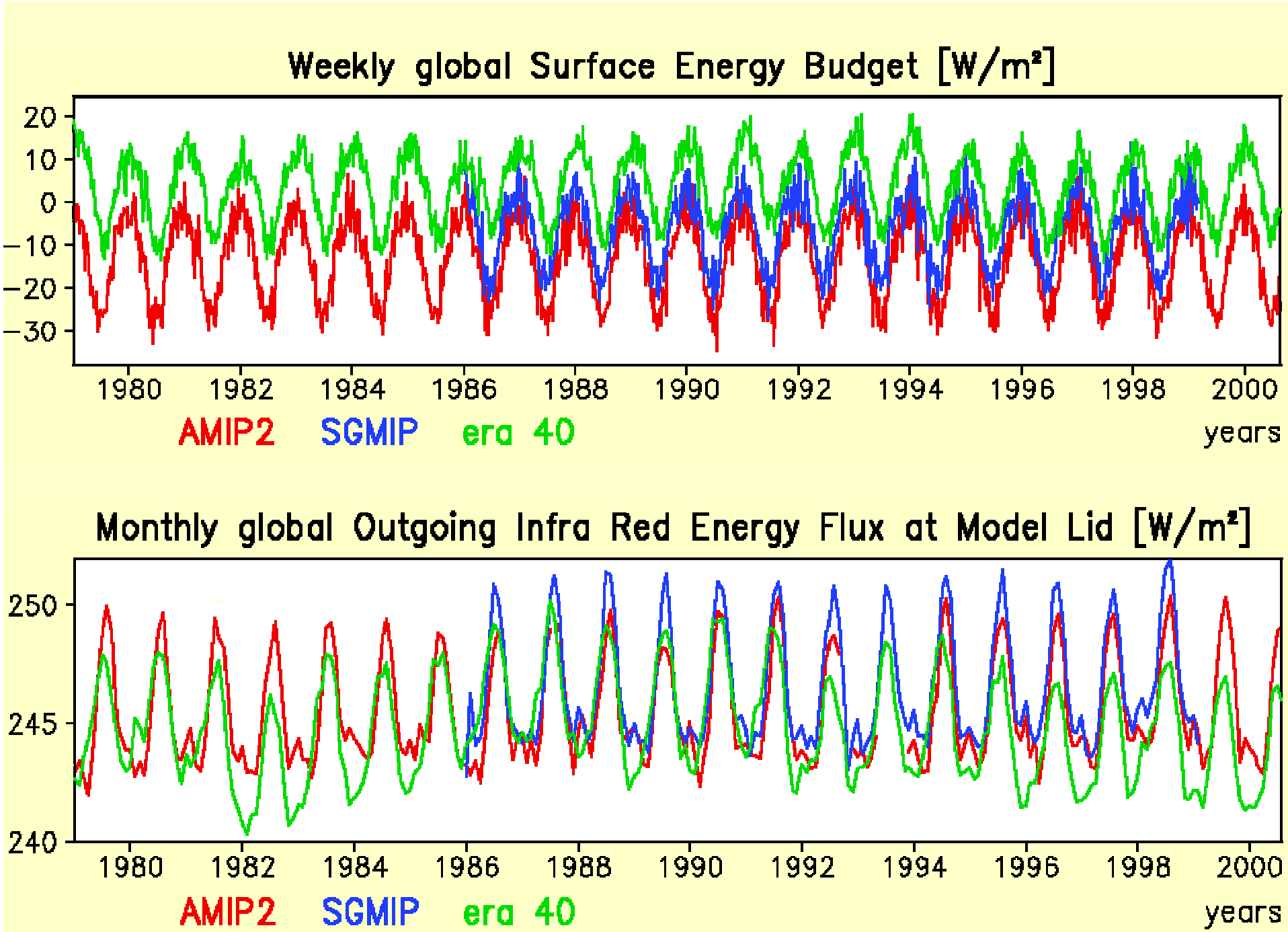
700
1000
90S
60S
30S
EQ
30N
60N
90N



Correlation…

	Total	Annual	Monthly	Weekly	Daily	
Atmospheric Temperature	85.6	94.8	43.2	35.8	33.3	AMIP-ERA
	90.3	97.3	49.6	40.1	38.9	SGMIP-ERA
	90.6	98.5	58.1	47.3	44.1	AMIP-SGMIP
Global average OLR	69.9	90.3	4.5	2.8	2.3	AMIP-ERA
	74.6	92.3	12.0	3.7	3.1	SGMIP-ERA
	85.4	98.4	42.4	25.0	14.7	AMIP-SGMIP

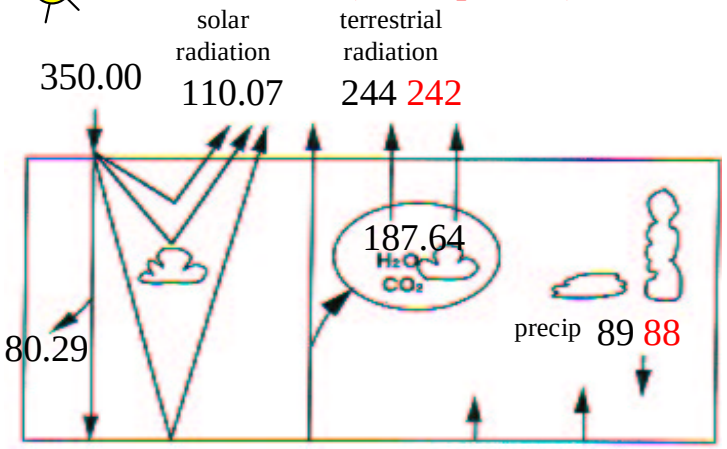
Red denotes significant values at the 95% level



Reference data for OLR: TOVS: 236 - 244 W/m², ERBE: 230 - 240 W/m², avhrr: 228 - 236 W/m²

Energy budgets [W/m²]

AMIP2 DJF, 22 year mean
ERA40 (same period)



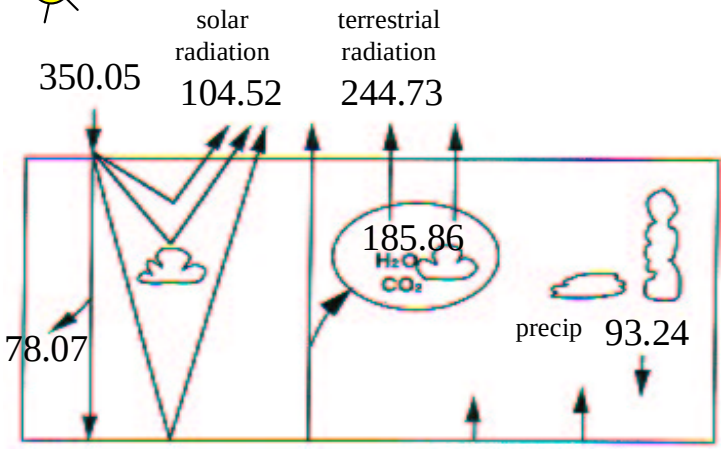
earth residuum -4.11

atmos Residuum 5.14

water residuum 6 -7

-3 -12 surface residuum

SGMIP DJF, 13 year mean



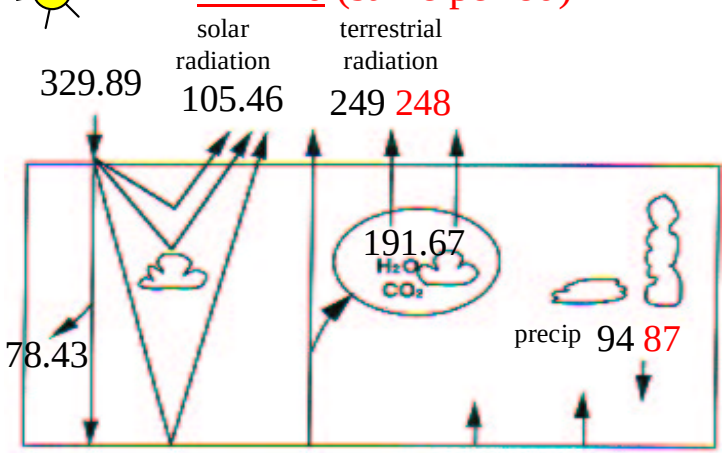
earth residuum 0.80

atmos Residuum 0.14

water Residuum 1.23

2.17 surface resisuum

AMIP2 JJA, 22 year mean
ERA40 (same period)



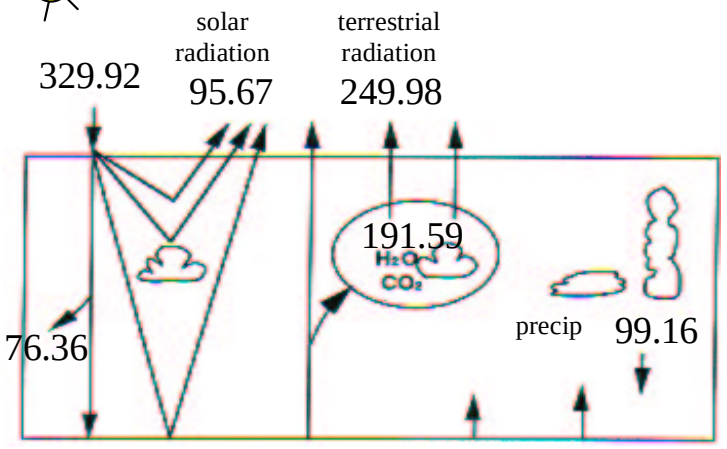
earth residuum -24.08

atmos Residuum 6.14

water residuum 6 -2

-23 -6 surface residuum

SGMIP JJA, 12 year mean



earth resisuum -15.73

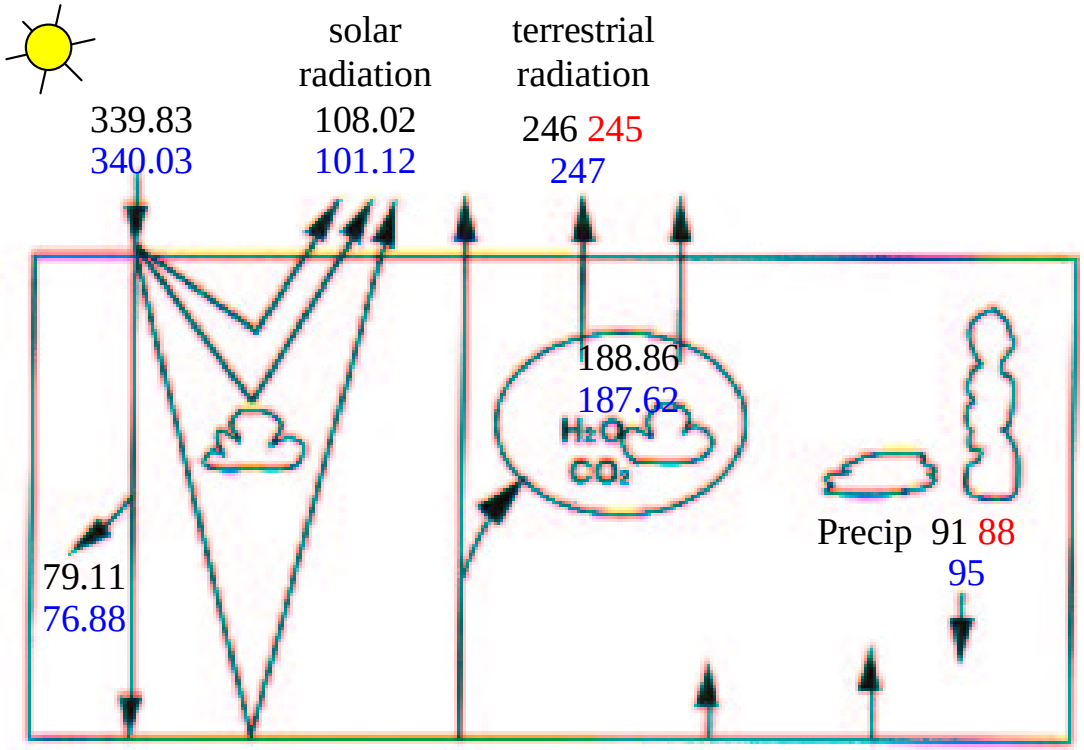
atmos Residuum 0.15

water residuum 1.05

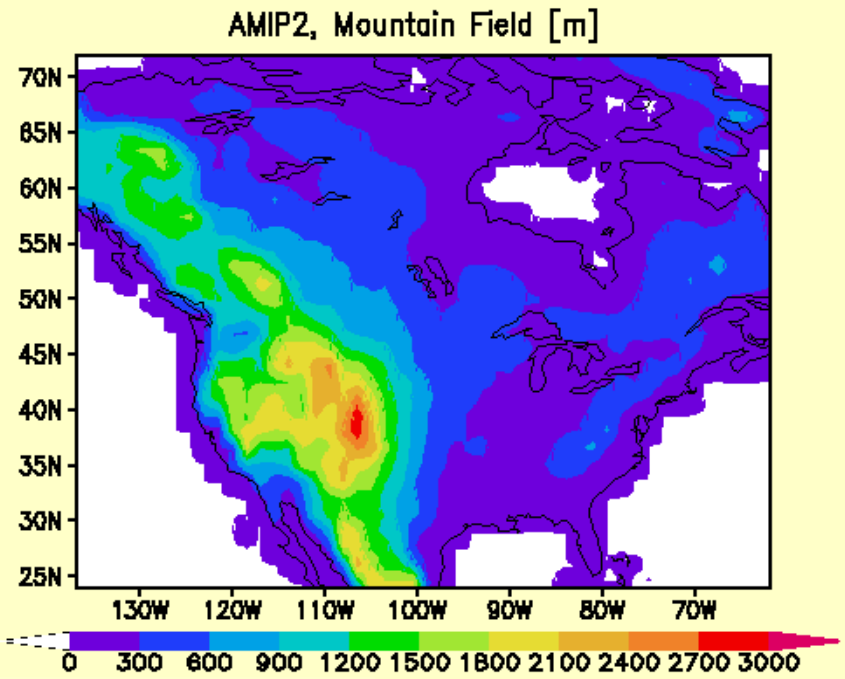
-14.83 surface residuum

Energy budgets [W/m²]

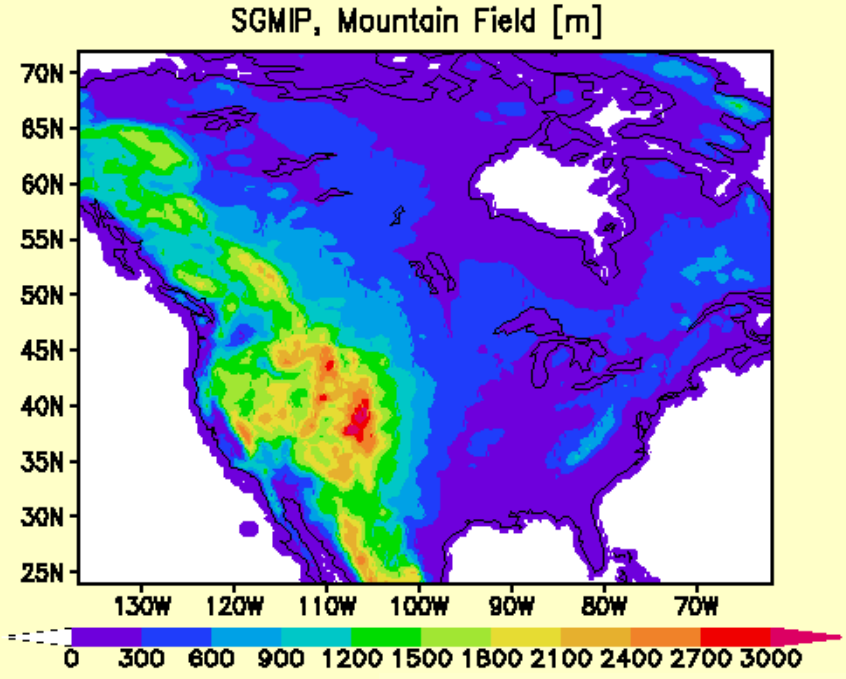
AMIP2 (and ERA40), 22 year mean
SGMIP, 12 year mean

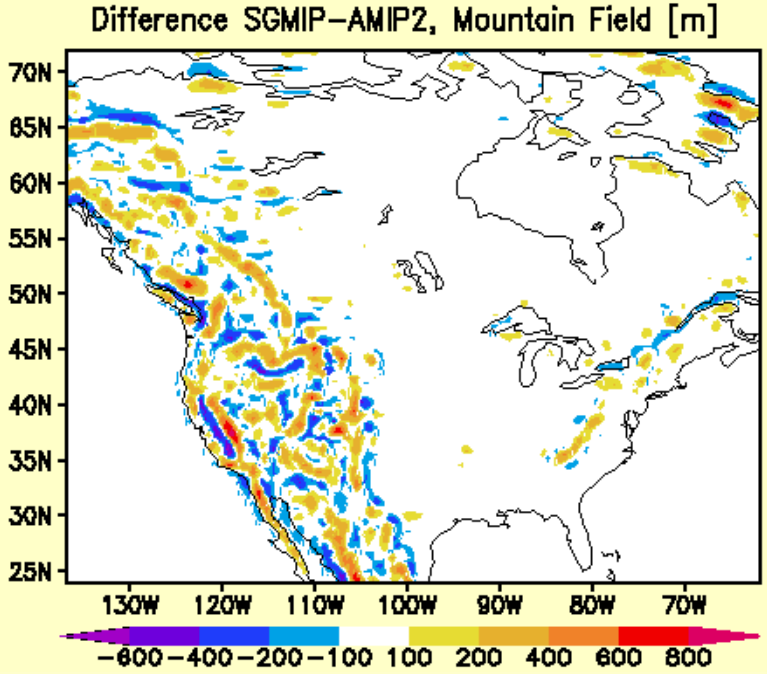


AMIP2

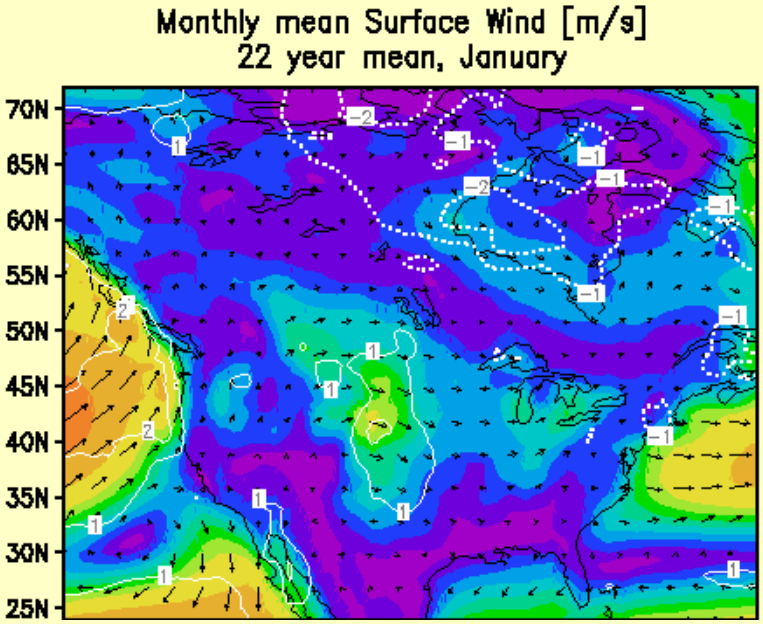

AMIP2, Mountain Field [m]
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W 120W 110W 100W 90W 80W 70W
0 300 600 900 1200 1500 1800 2100 2400 2700 3000

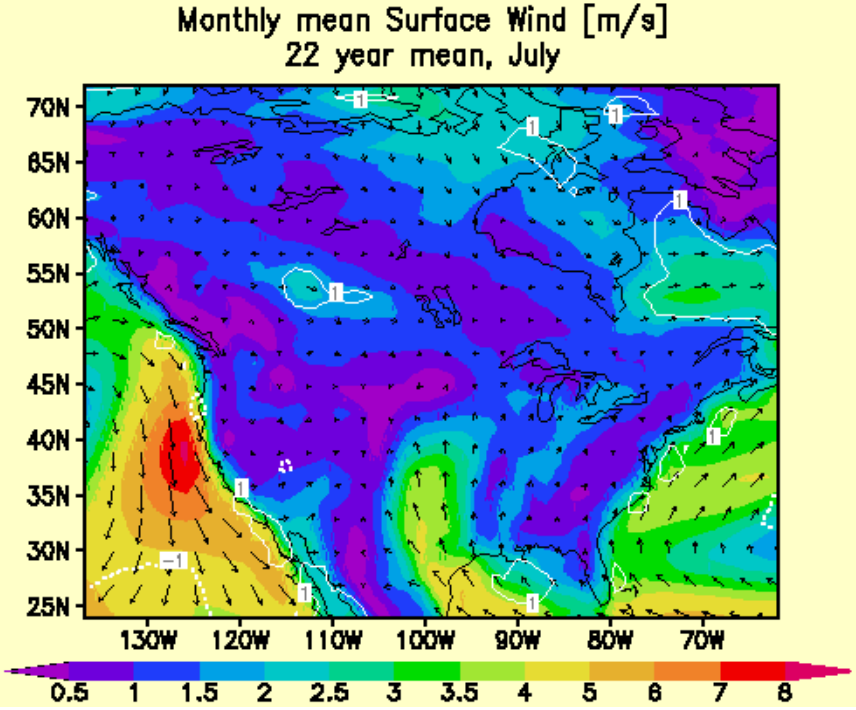
SGMIP


SGMIP, Mountain Field [m]
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W 120W 110W 100W 90W 80W 70W
0 300 600 900 1200 1500 1800 2100 2400 2700 3000

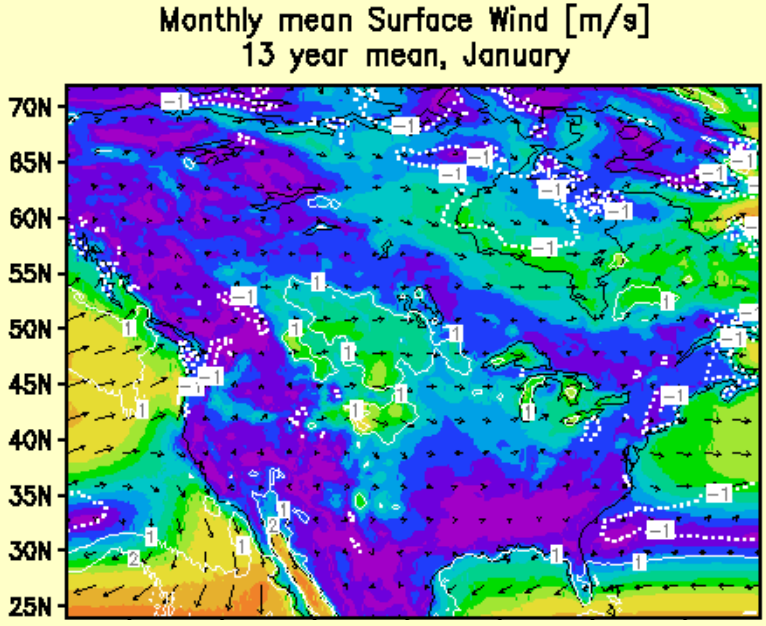

Difference SGMIP−AMIP2, Mountain Field [m]
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W 120W 110W 100W 90W 80W 70W
−600 −400 −200 −100 100 200 400 600 800

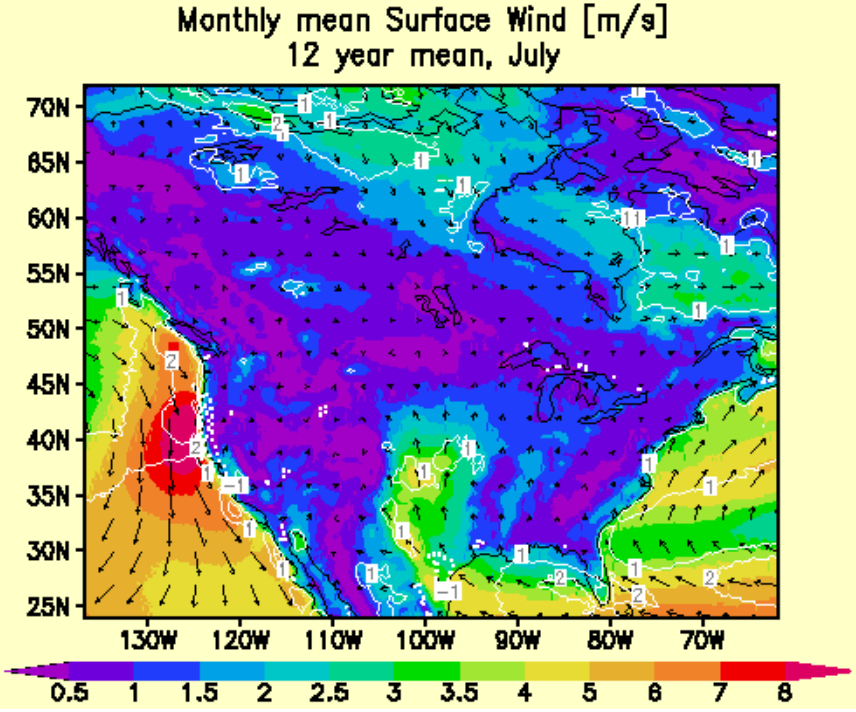
AMIP2


Monthly mean Surface Wind [m/s]
22 year mean, January
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N

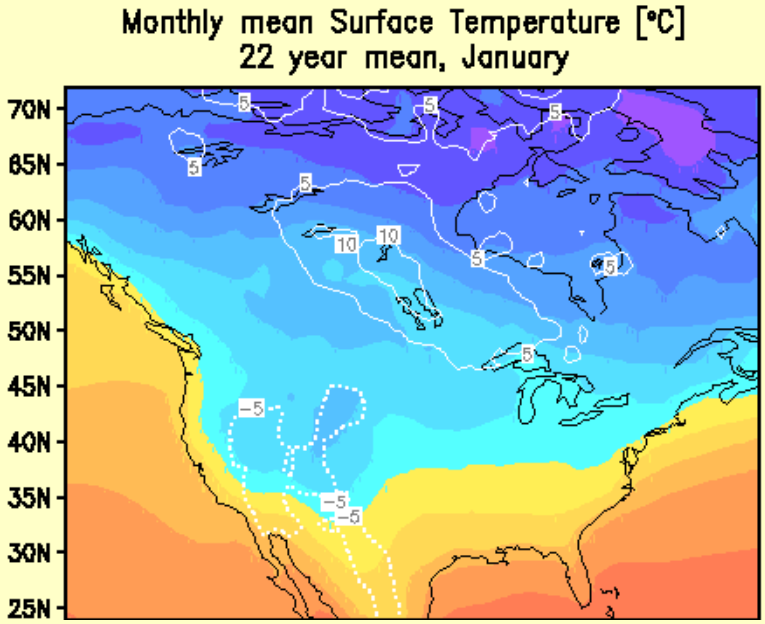

Monthly mean Surface Wind [m/s]
22 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
0.5
1
1.5
2
2.5
3
3.5
4
5
6
7
8

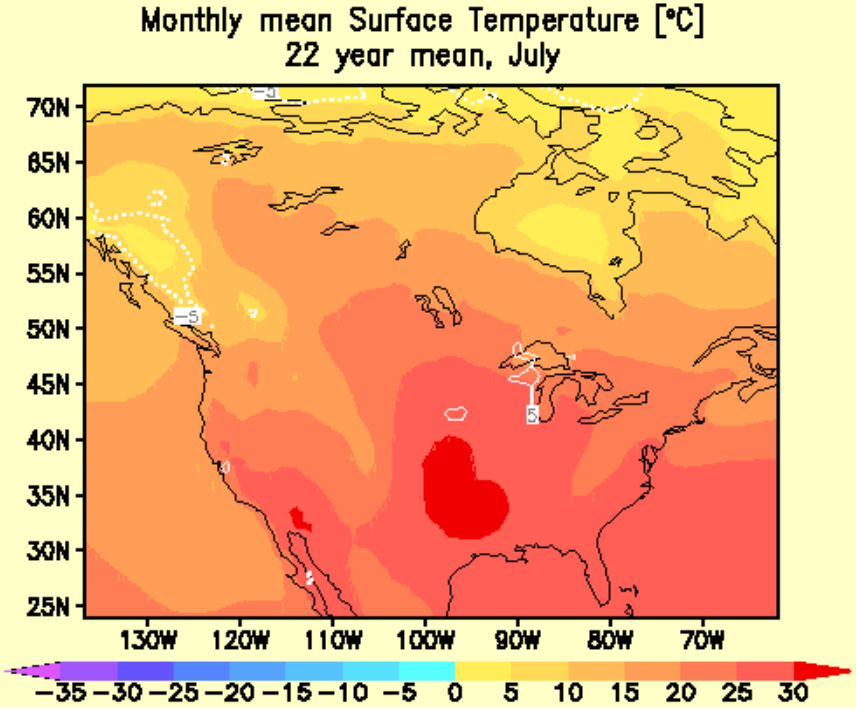
SGMIP


Monthly mean Surface Wind [m/s]
13 year mean, January
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N

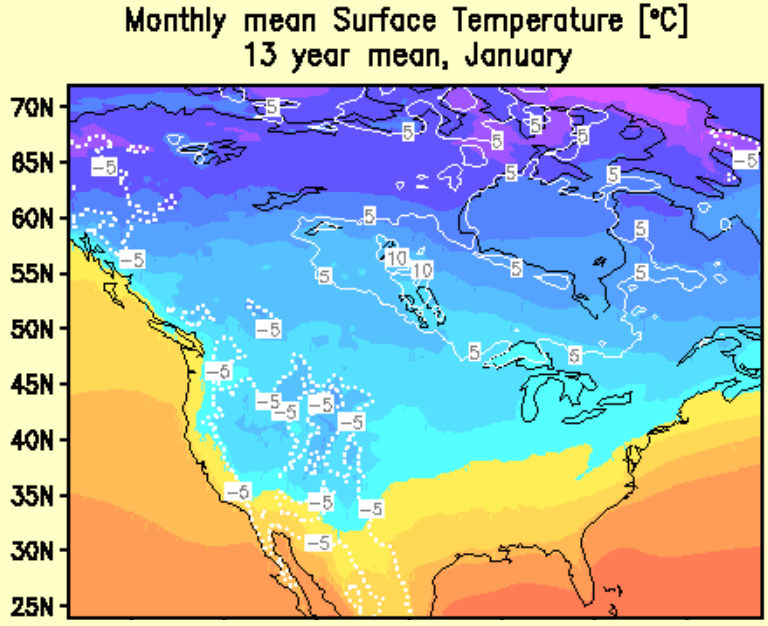

Monthly mean Surface Wind [m/s]
12 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
0.5
1
1.5
2
2.5
3
3.5
4
5
6
7
8

AMIP2


Monthly mean Surface Temperature [°C]
22 year mean, January
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N


Monthly mean Surface Temperature [°C]
22 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
−35 −30 −25 −20 −15 −10 −5 0 5 10 15 20 25 30

SGMIP


Monthly mean Surface Temperature [°C]
13 year mean, January
70N
65N
60N
55N
50N
45N
40N
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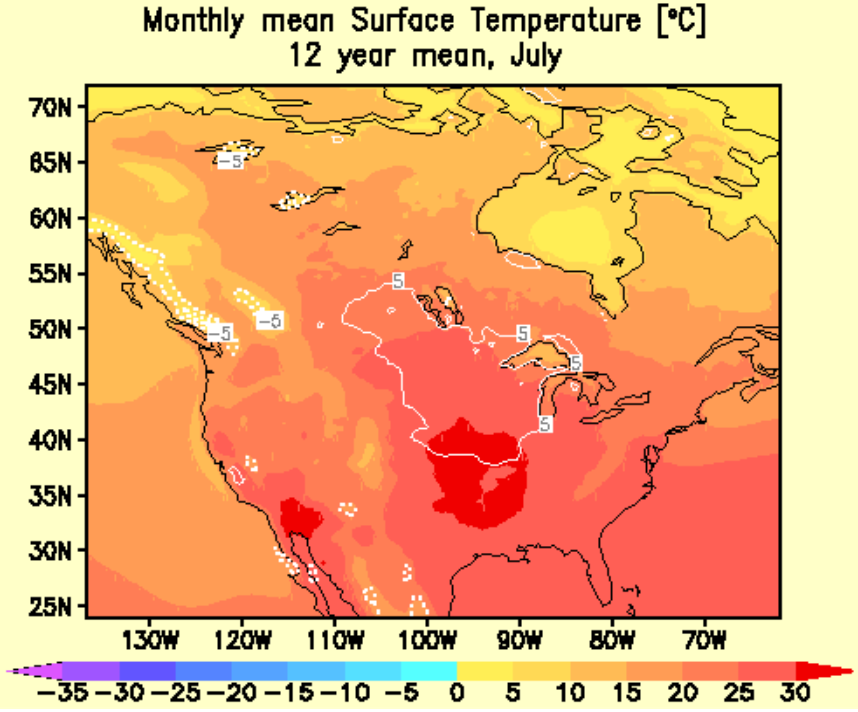
30N
25N


Monthly mean Surface Temperature [°C]
12 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
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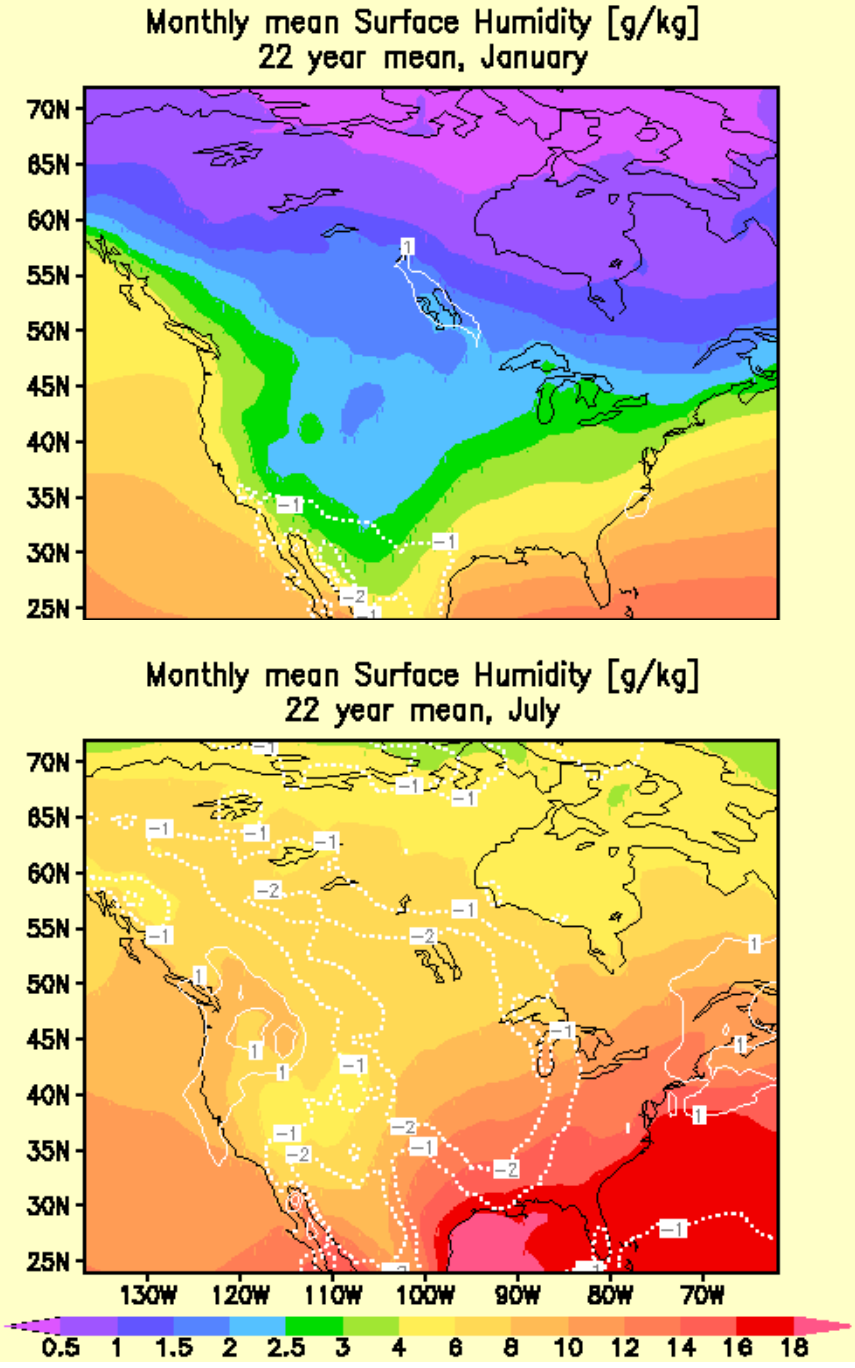
110W
100W
90W
80W
70W
−35 −30 −25 −20 −15 −10 −5 0 5 10 15 20 25 30

AMIP2


Monthly mean Surface Humidity [g/kg]
22 year mean, January
Monthly mean Surface Humidity [g/kg]
22 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
0.5
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2.5
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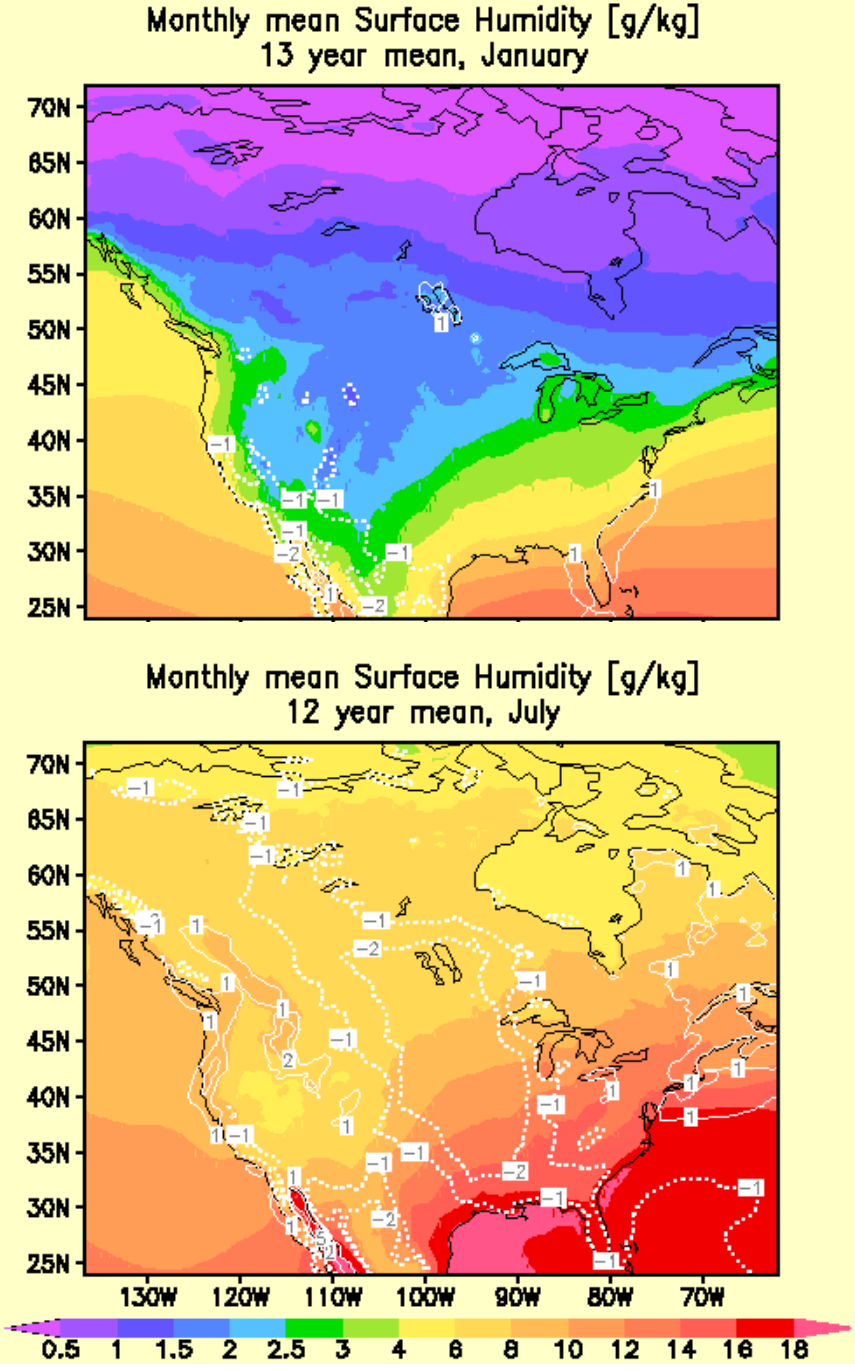
16
18

SGMIP


Monthly mean Surface Humidity [g/kg]
13 year mean, January
Monthly mean Surface Humidity [g/kg]
12 year mean, July
70N
65N
60N
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40N
35N
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25N
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18

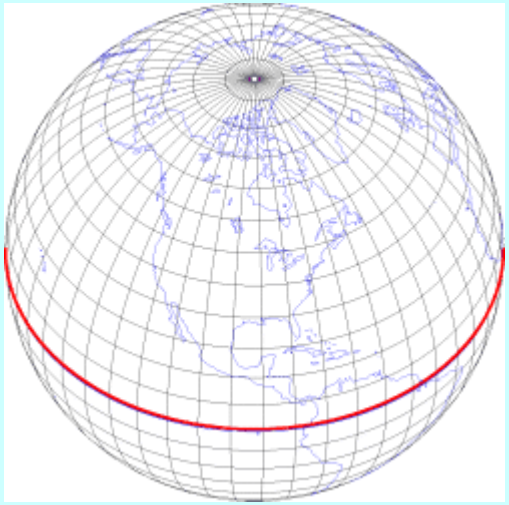
GEM/LAM experiment

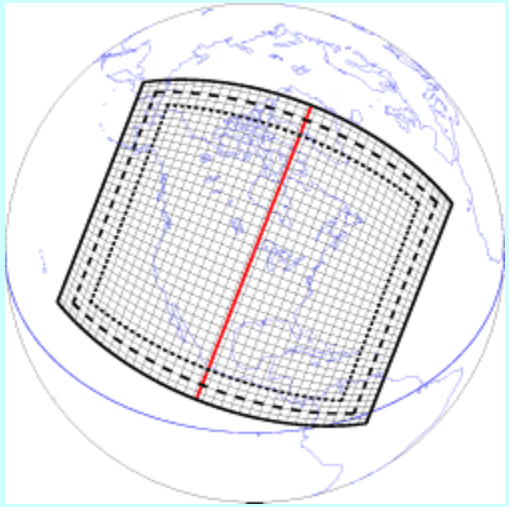
Model grid:

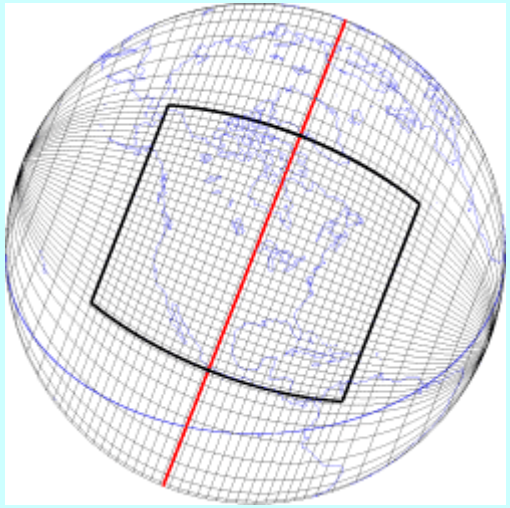
- Uniform 0,45° horizontal resolution over NA, as in the SGMIP simulation.
- The inner area of the LAM grid covers the same general area as that used by the high-resolution SGMIP experiment. However, a 10-point sponge is included all around this, as well as another 10-point area where the actual low-resolution driving boundary condition are applied. This pilot information is supplied every 3 hours by a 1,5° uniform AMIP2 run of the global model.
- 53 hybrid vertical levels, top level at 10 Hpa. Same levels as for the SGMIP simulation below that.
- 1350 second timestep.

Physics as in the SGMIP and Uniform AMIP2 runs described previously.

We now compare July and January average results from a preliminary two-year simulation of the GEM/LAM and from the SGMIP experiment discussed previously.

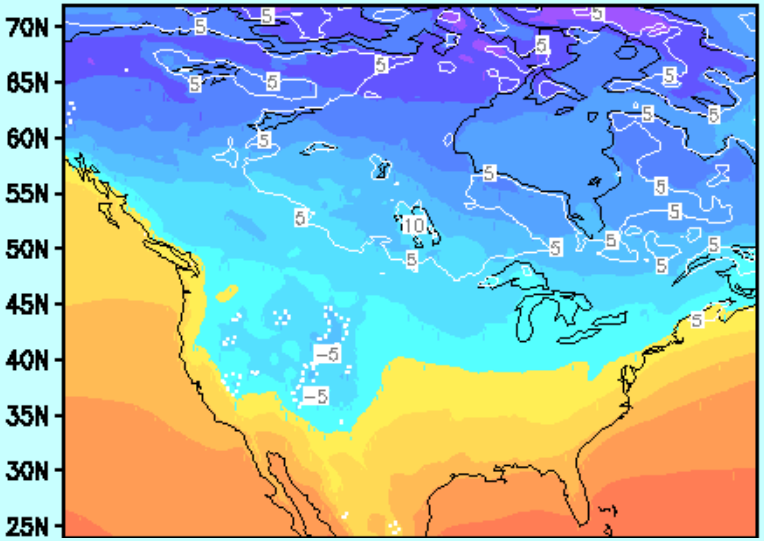




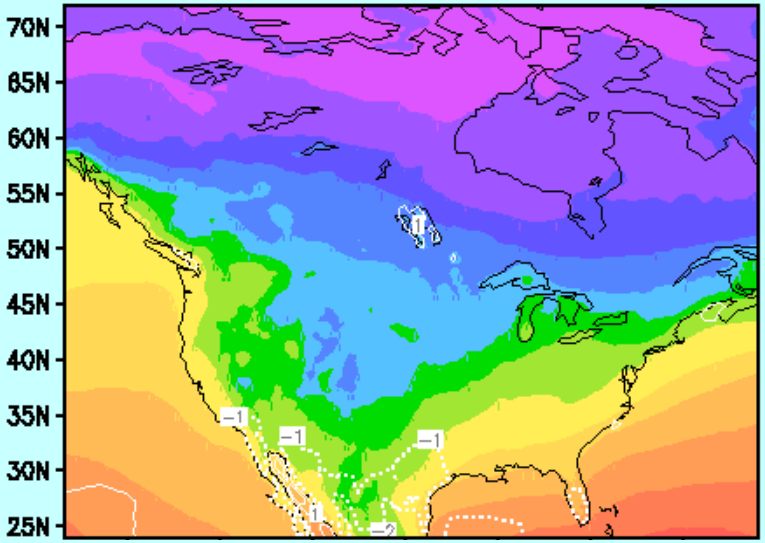


LAM

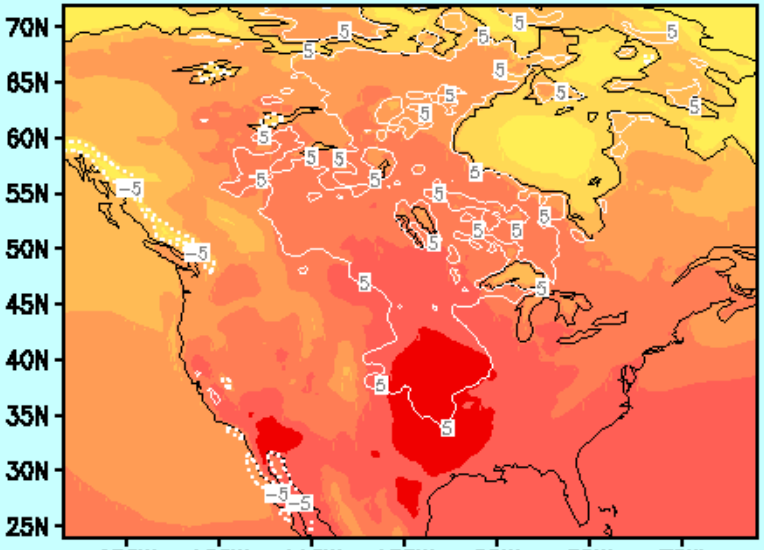
Monthly mean Surface Temperature [°C]
2 year mean, January

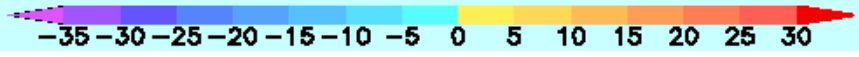


Monthly mean Surface Humidity [g/kg]
2 year mean, January

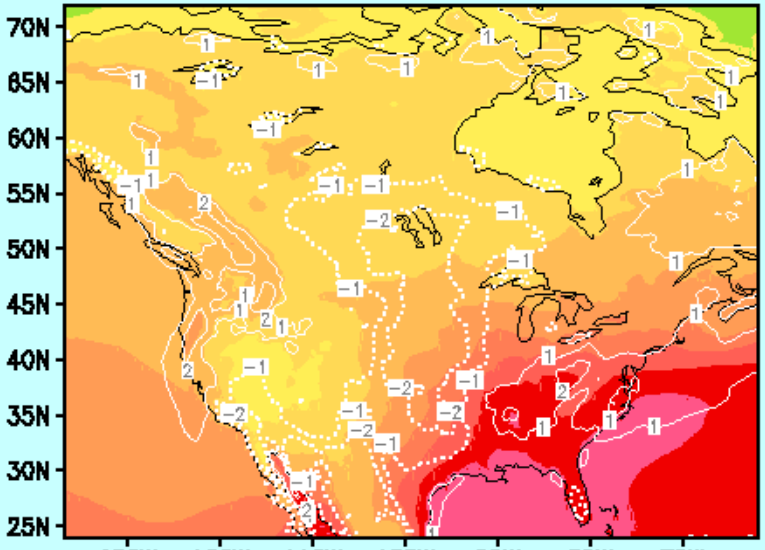


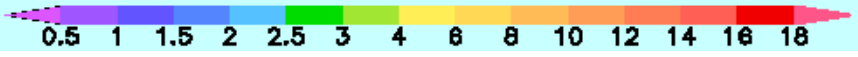
Monthly mean Surface Temperature [°C]
2 year mean, July



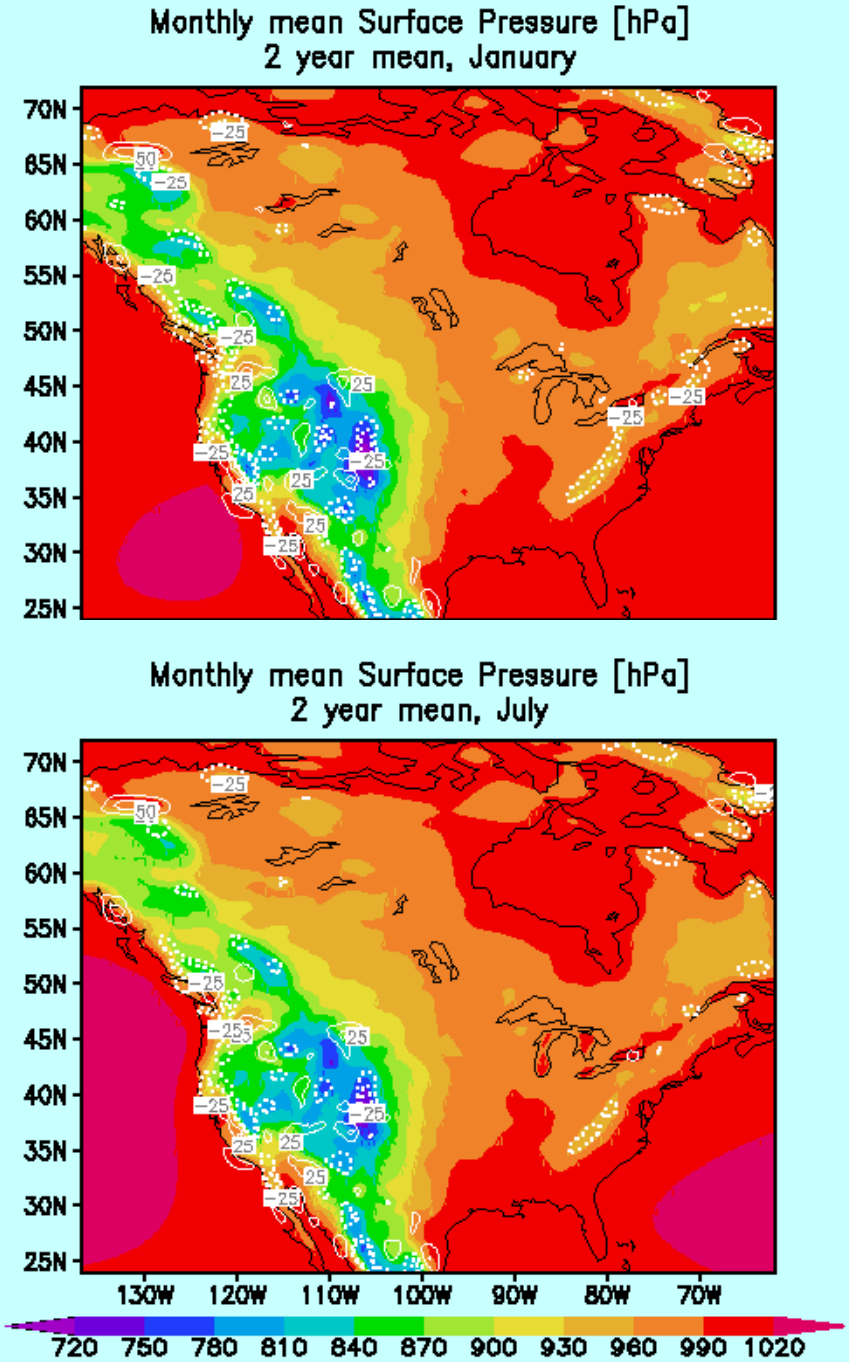


Monthly mean Surface Humidity [g/kg]
2 year mean, July

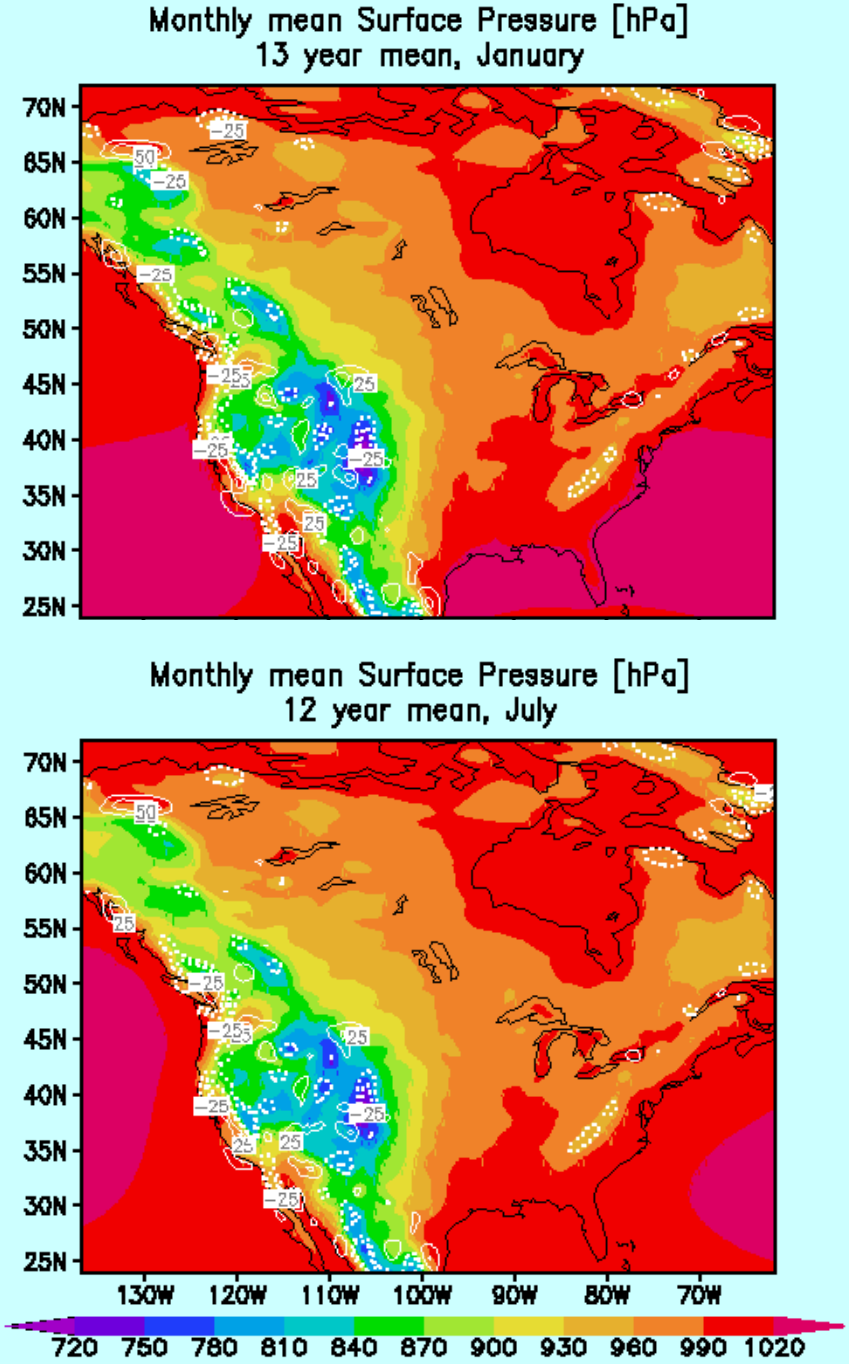




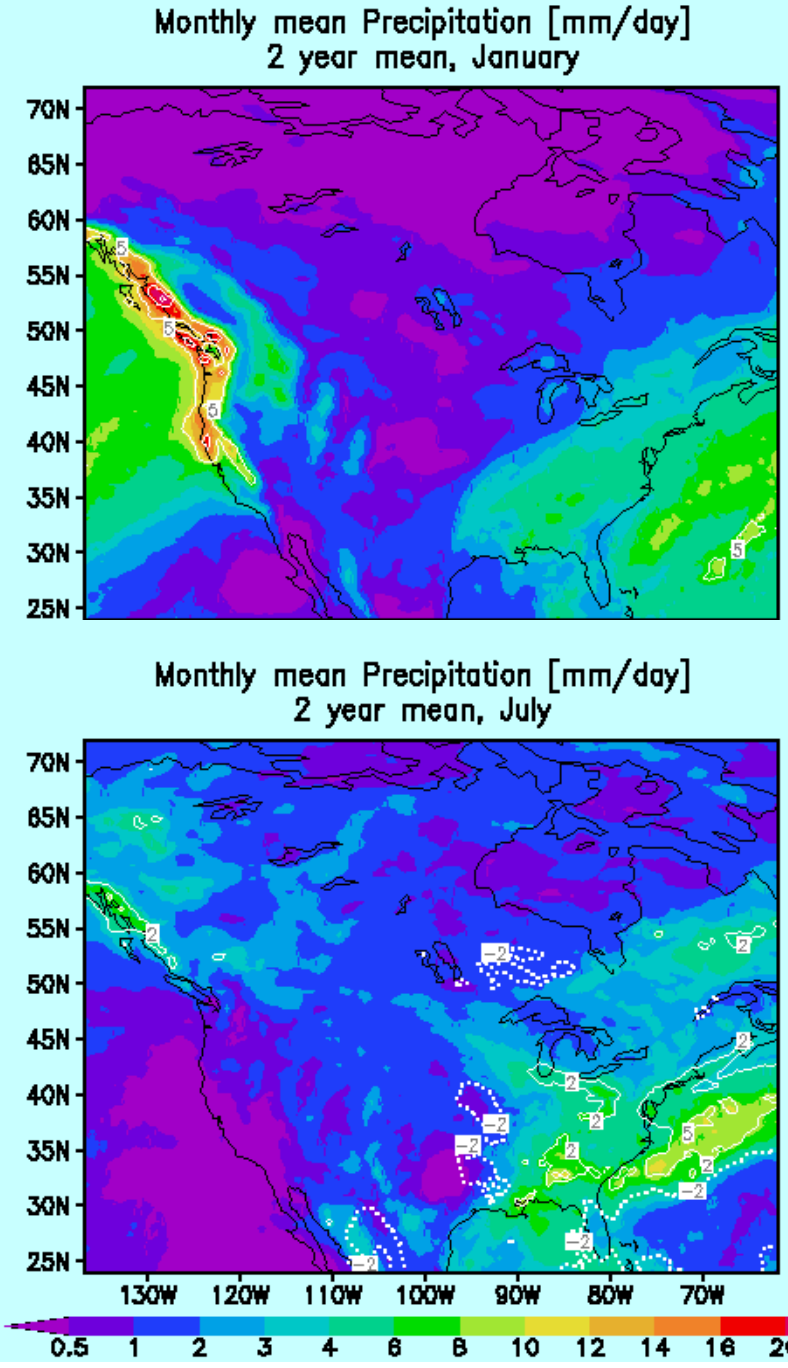
LAM


Monthly mean Surface Pressure [hPa]
2 year mean, January
Monthly mean Surface Pressure [hPa]
2 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
720 750 780 810 840 870 900 930 960 990 1020

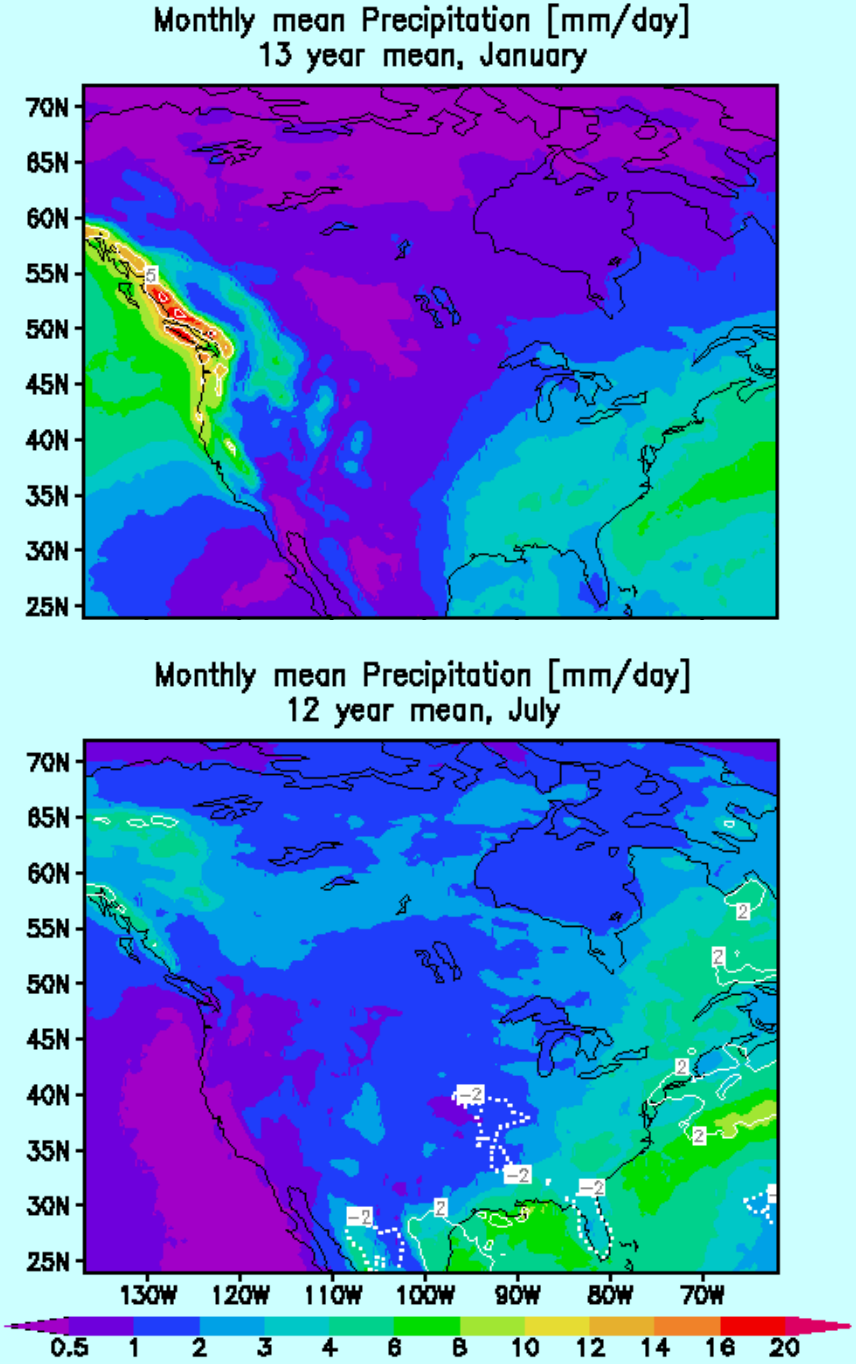
SGMIP


Monthly mean Surface Pressure [hPa]
13 year mean, January
Monthly mean Surface Pressure [hPa]
12 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
720 750 780 810 840 870 900 930 960 990 1020

LAM


Monthly mean Precipitation [mm/day]
2 year mean, January
Monthly mean Precipitation [mm/day]
2 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
0.5
1
2
3
4
6
8
10
12
14
16
20

SGMIP


Monthly mean Precipitation [mm/day]
13 year mean, January
Monthly mean Precipitation [mm/day]
12 year mean, July
70N
65N
60N
55N
50N
45N
40N
35N
30N
25N
130W
120W
110W
100W
90W
80W
70W
0.5
1
2
3
4
6
8
10
12
14
16
20

Conclusion

The results from the AMIP2 and SGMIP simulations are very similar with respect to the large scales. The two generally share the same strengths and weaknesses. For example, both suffer from a too cold and too high equatorial tropopause, a problem related to the convection scheme used here. The SGMIP simulation's global budgets turn out to be closer to equilibrium than their AMIP2 counterparts. As expected, significant differences between the two can be seen over the SGMIP North-American high resolution domain.

The SGMIP and LAM results over North-America are also rather similar. Some of the differences can be attributed to the small number of samples in this preliminary LAM simulation.

References

• Côté, J., S. Gravel, A. Méthot, A. Patoine, M. Roch and A. Staniforth (1998). The operational CMC-MRB Global Environmental Multiscale (GEM) model. Part I: Design considerations and formulation. *Monthly Weather Rev*., **126**, pp. 1373-1395.

• Côté, J., J.-G. Desmarais, S. Gravel, A. Méthot, A. Patoine, M. Roch and A. Staniforth (1998). The operational CMC-MRB Global Environmental Multiscale (GEM) model. Part II: Results. *Monthly Weather Rev*., **126**, pp. 1397-1418.