

A GEM/Climat version with meso-global physics

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Abstract:

We present the results obtained with the climate version of GEM when the meso-global physics options are activated. As some of these are resolution dependant, the code can not be used as is and the modifications are discussed. Finally, preliminary results obtained when adding the CCCMa's "Correlated-K" radiation code to the new model version are presented.

Dorval, March 23 2005

Part 1: Where are we coming from ?

A short review of previous results from long simulations of GEM/Climat in the AMIP2 and SGMIP experimental frameworks.

AMIP2 Model configuration:

- 11-month spinup, starting in **January 1978**, ending in **September 2000**
- GEM/DM (Distributed Memory mode, v3.01+)
- 60 hybrid vertical levels, model top at 2 hPa
- **1.5° uniform horizontal resolution**
- **2700 second timestep**

SGMIP Model configuration:

- 11-month spinup, starting in **January 1986**, ending in **March 1999**.
- The grid resolution varies from **0.45° over NA** (North-America) to **1.8° elsewhere**. The grid expansion parameter is about 7% and occurs over 20 grid points. See the grid figures below.
- 60 Hybrid vertical levels with a model top at 2 hPa.
- **1350 second timestep**.

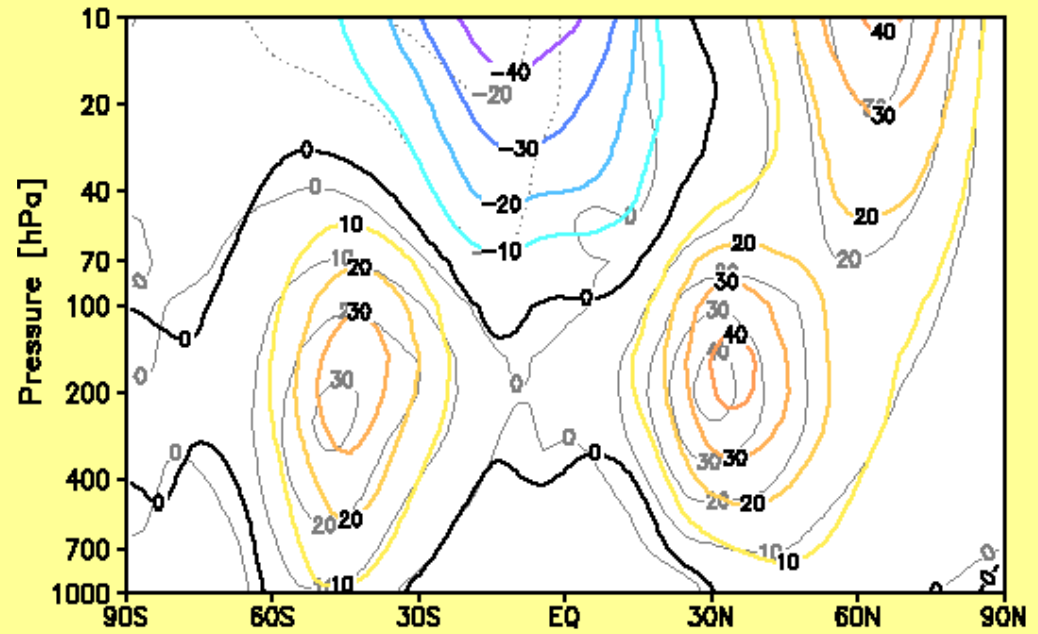
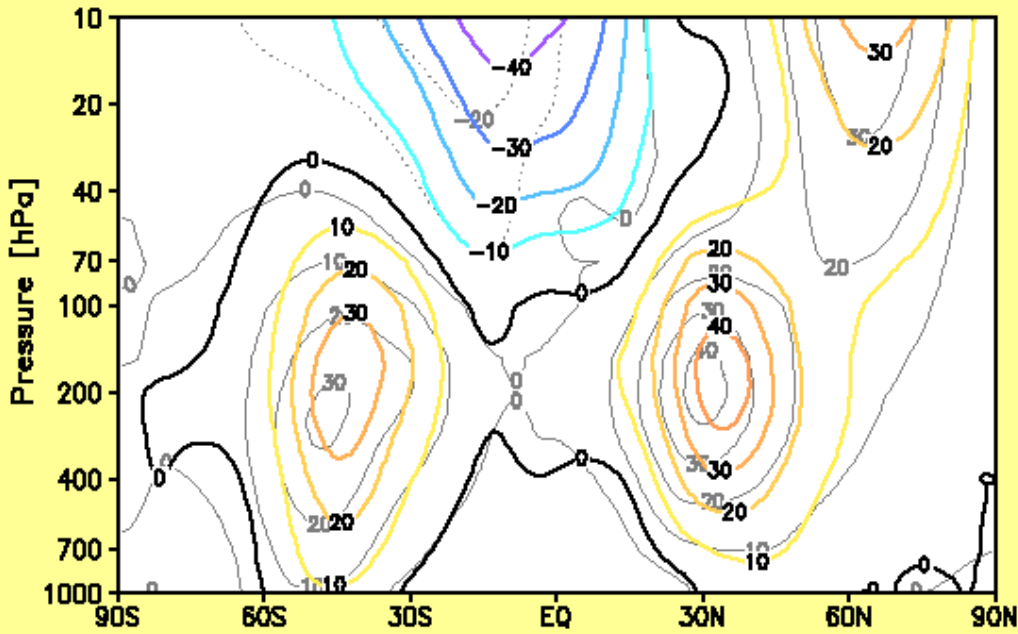
Both of these use a physics configuration that is very close to that of our current long-range global forecast model, except for ISBA which was used over North-America

AMIP2

SGMIP

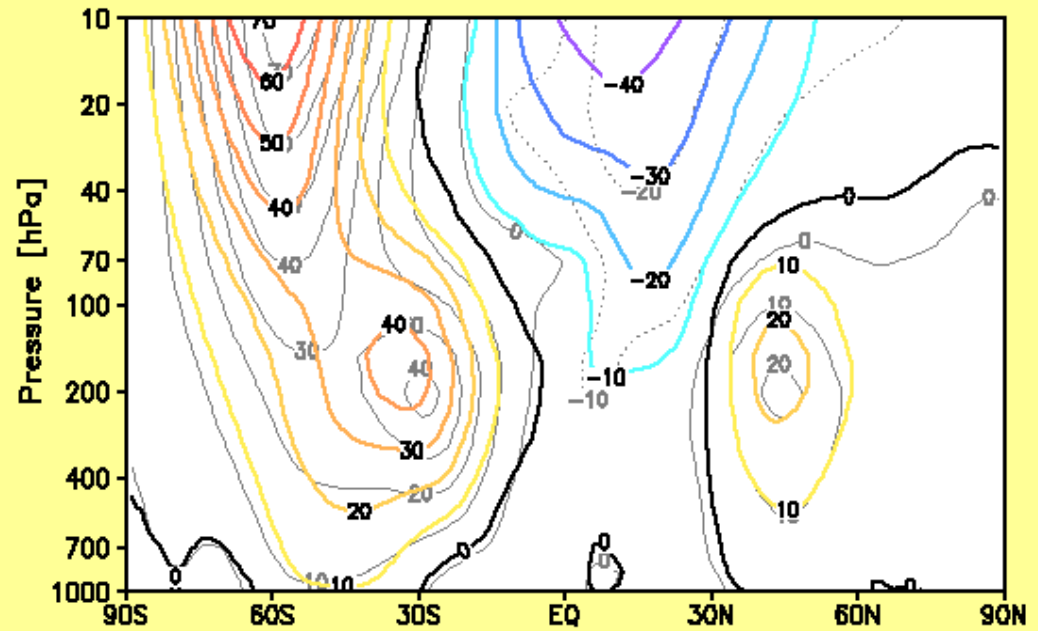
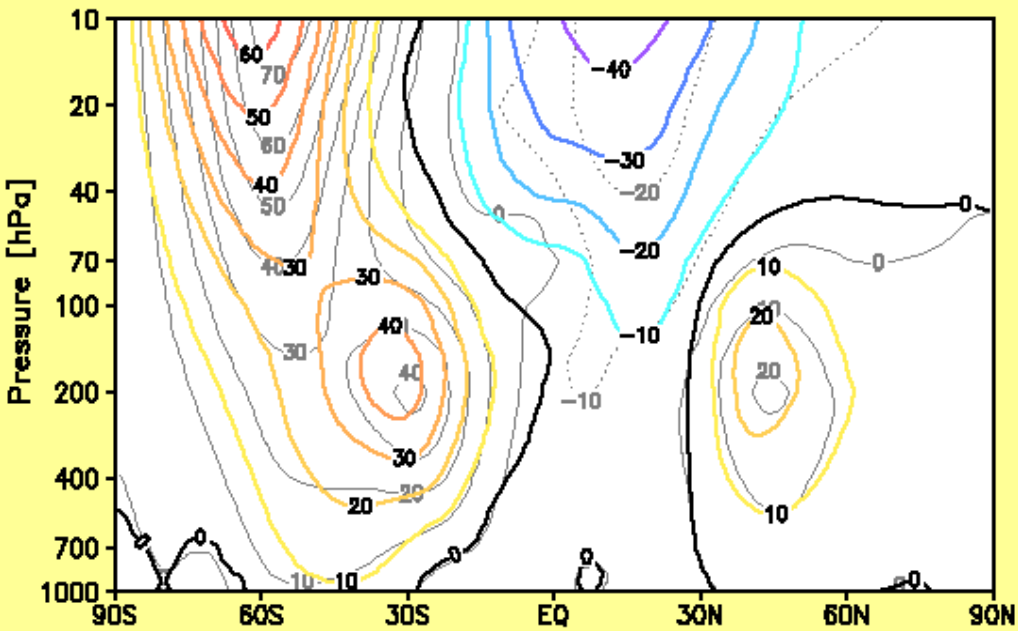
Monthly mean u-wind [m/s], 22 year mean, January

Monthly mean u-wind [m/s], 13 year mean, January

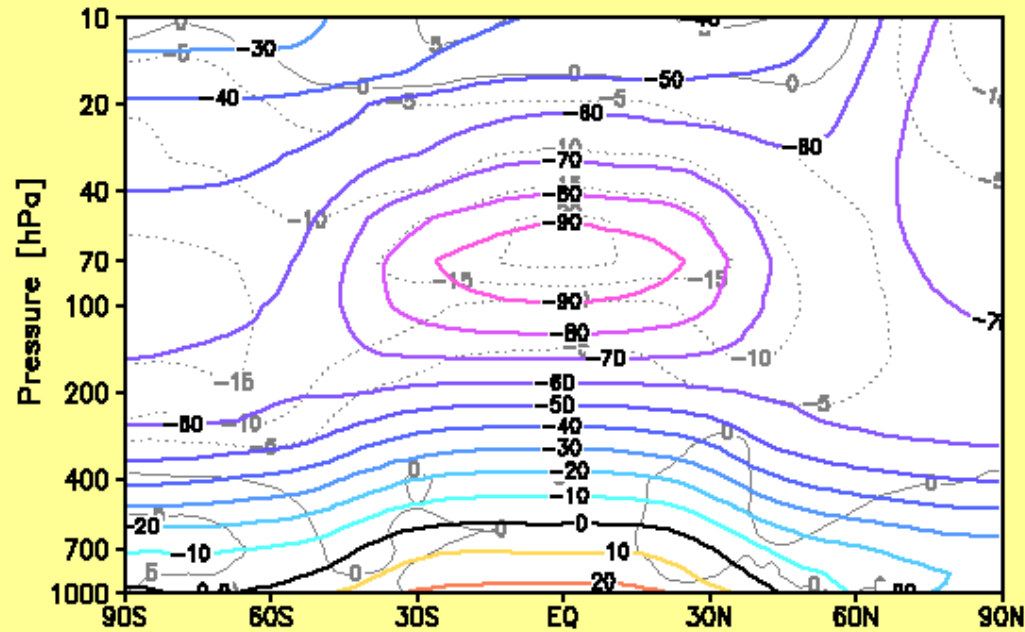


Monthly mean u-wind [m/s], 22 year mean, July

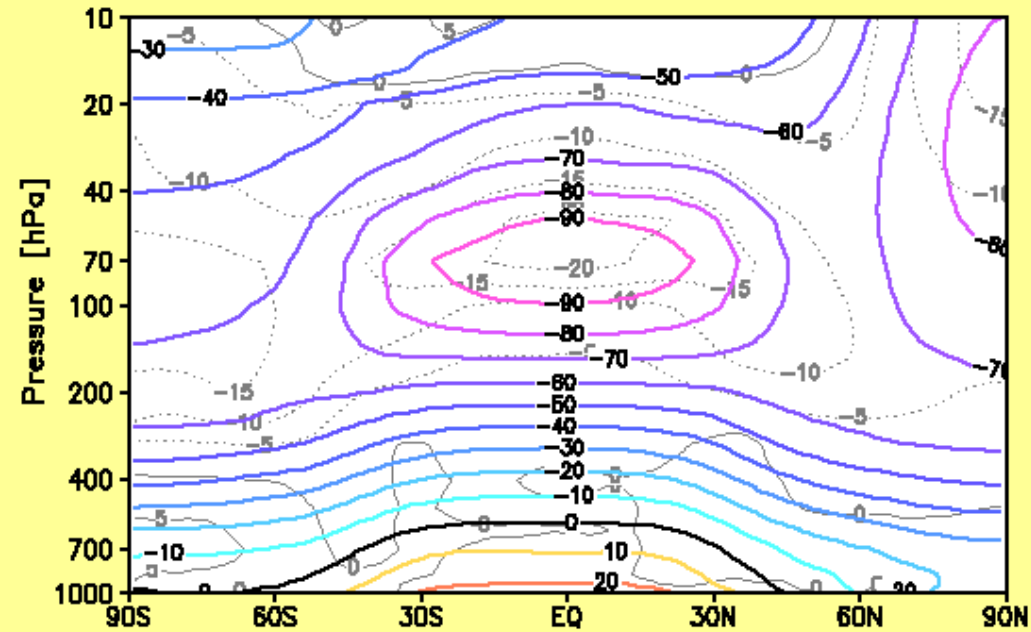
Monthly mean u-wind [m/s], 12 year mean, July



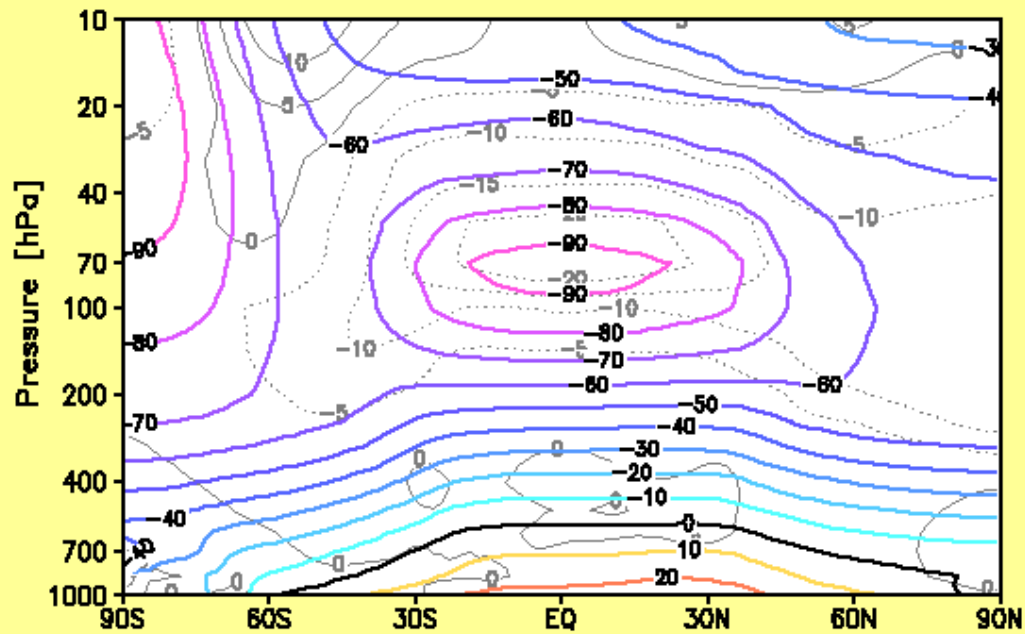
Monthly mean Temperature [$^{\circ}\text{C}$], 22 year mean, January



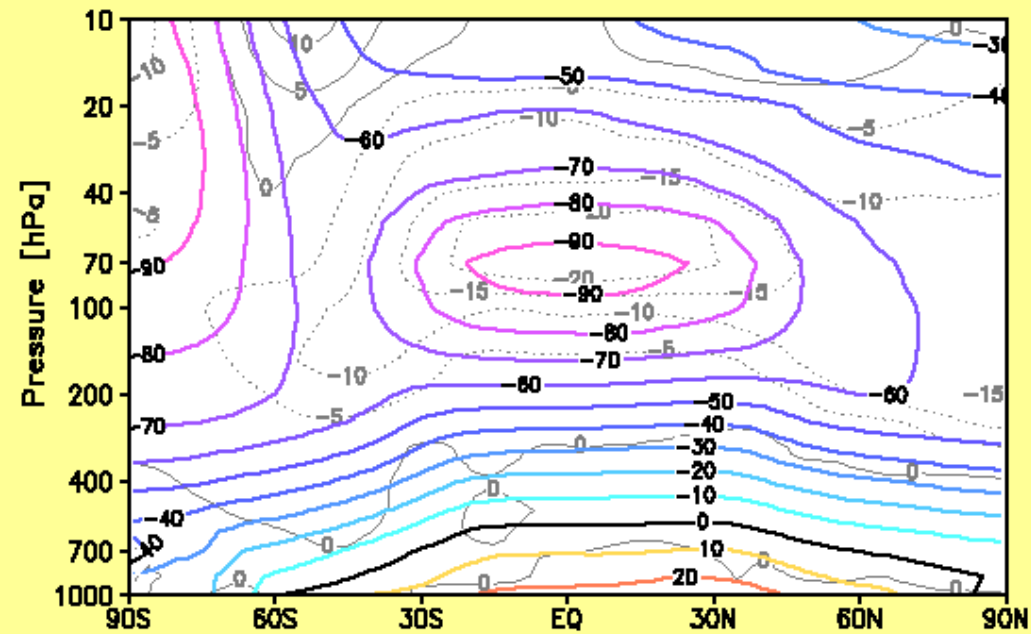
Monthly mean Temperature [$^{\circ}\text{C}$], 13 year mean, January



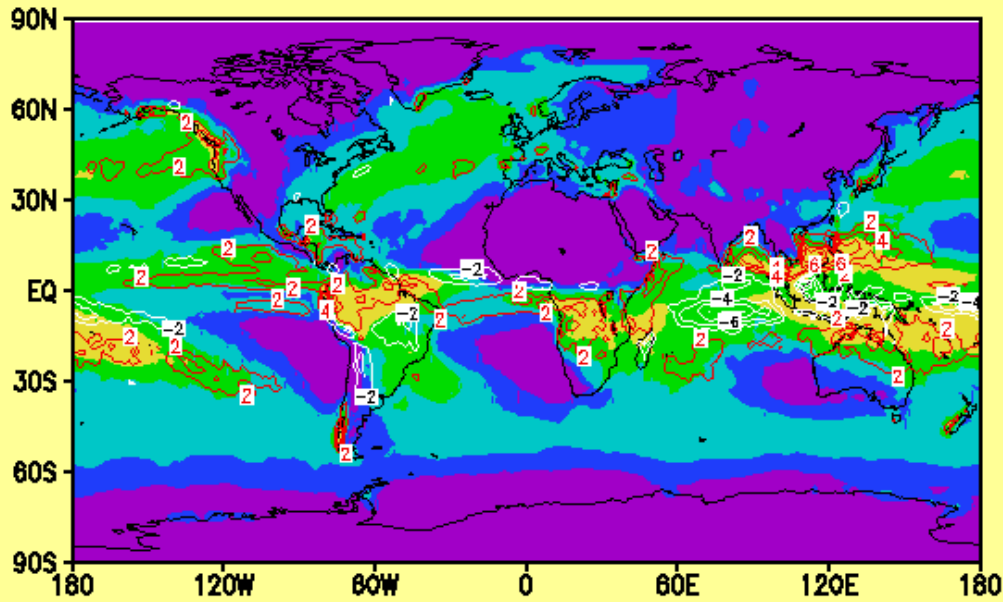
Monthly mean Temperature [$^{\circ}\text{C}$], 22 year mean, July



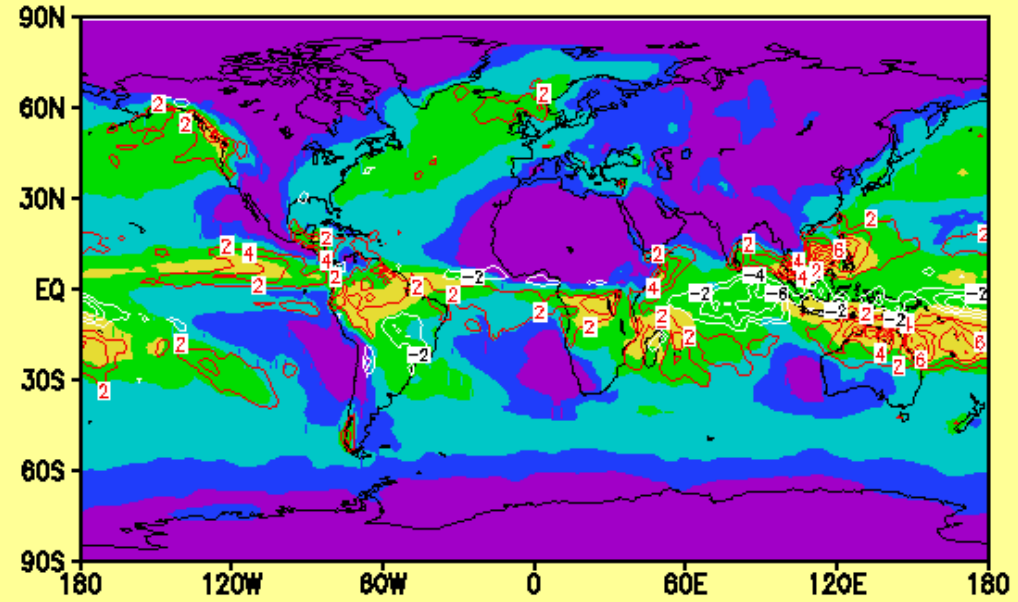
Monthly mean Temperature [$^{\circ}\text{C}$], 12 year mean, July



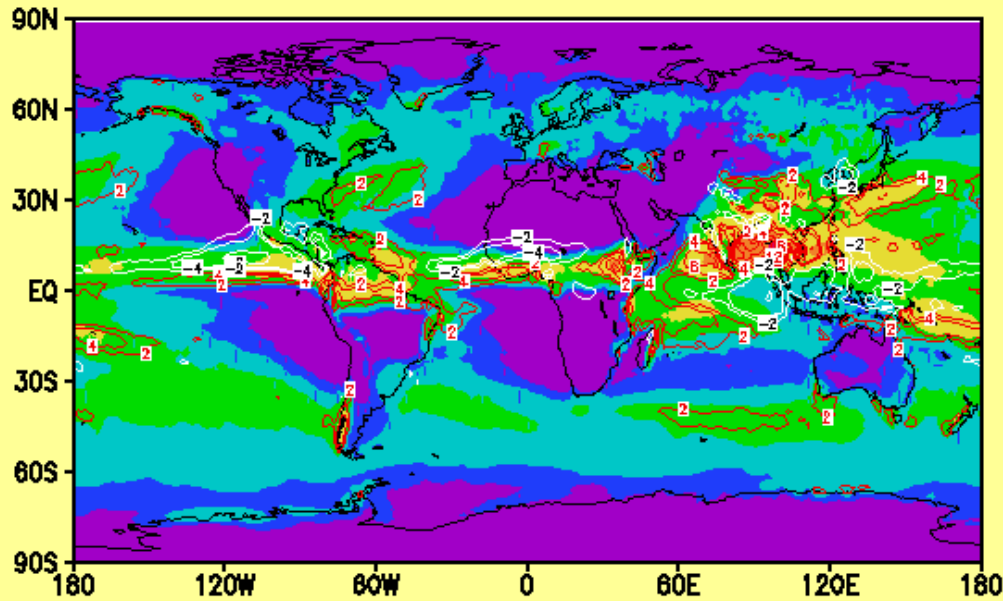
Monthly mean Precipitation [mm/day]
22 year mean, January



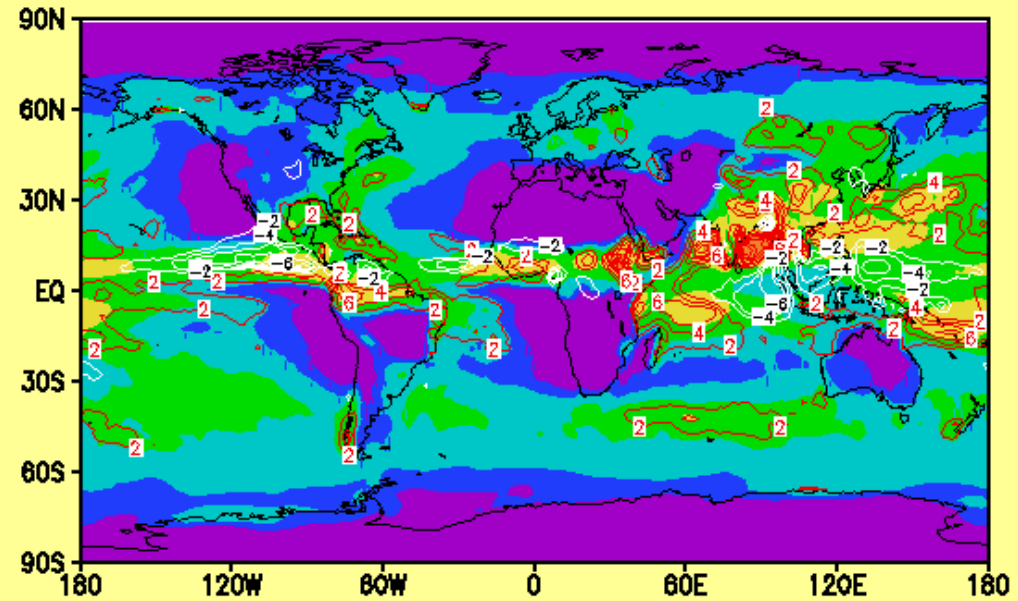
Monthly mean Precipitation [mm/day]
13 year mean, January



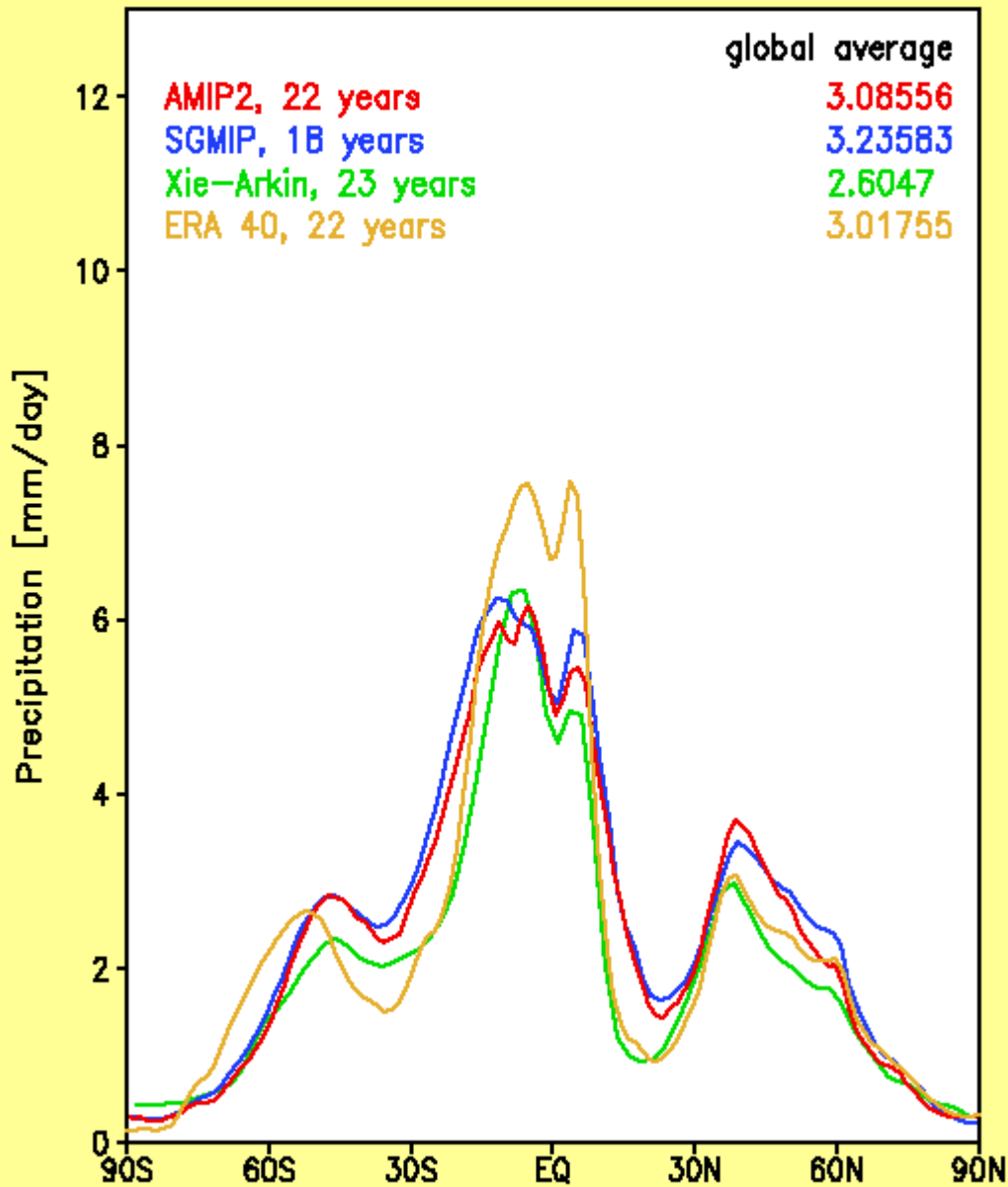
Monthly mean Precipitation [mm/day]
22 year mean, July



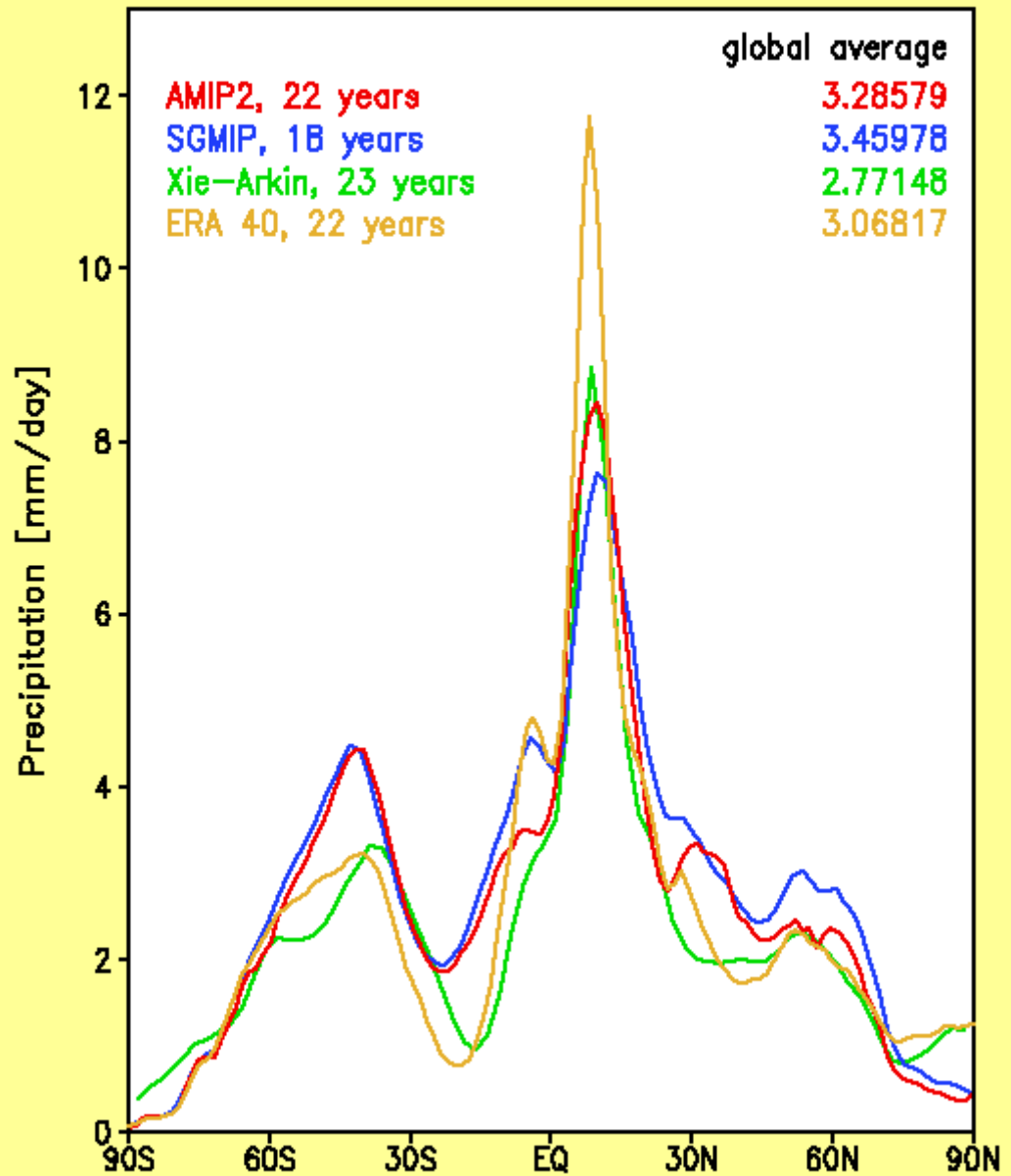
Monthly mean Precipitation [mm/day]
12 year mean, July



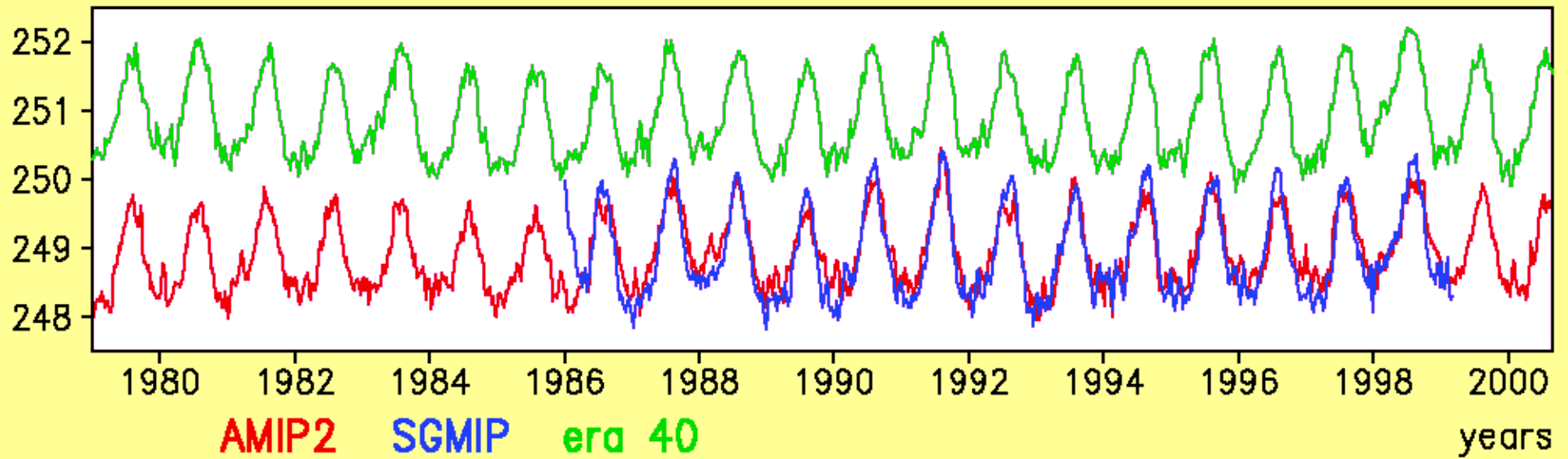
Zonal average of monthly mean precipitation [mm/day]
multi year mean, January



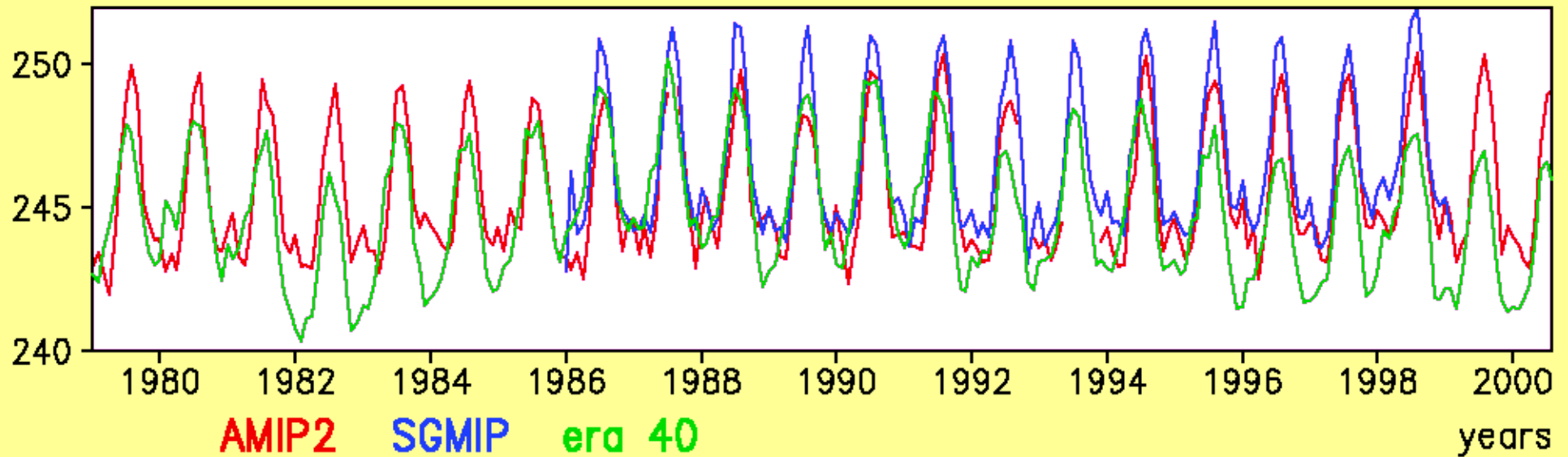
Zonal average of monthly mean precipitation [mm/day]
multi year mean, July



Weekly global Temperature [Kelvin]



Monthly global Outgoing Infra Red Energy Flux at Model Lid [W/m²]



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

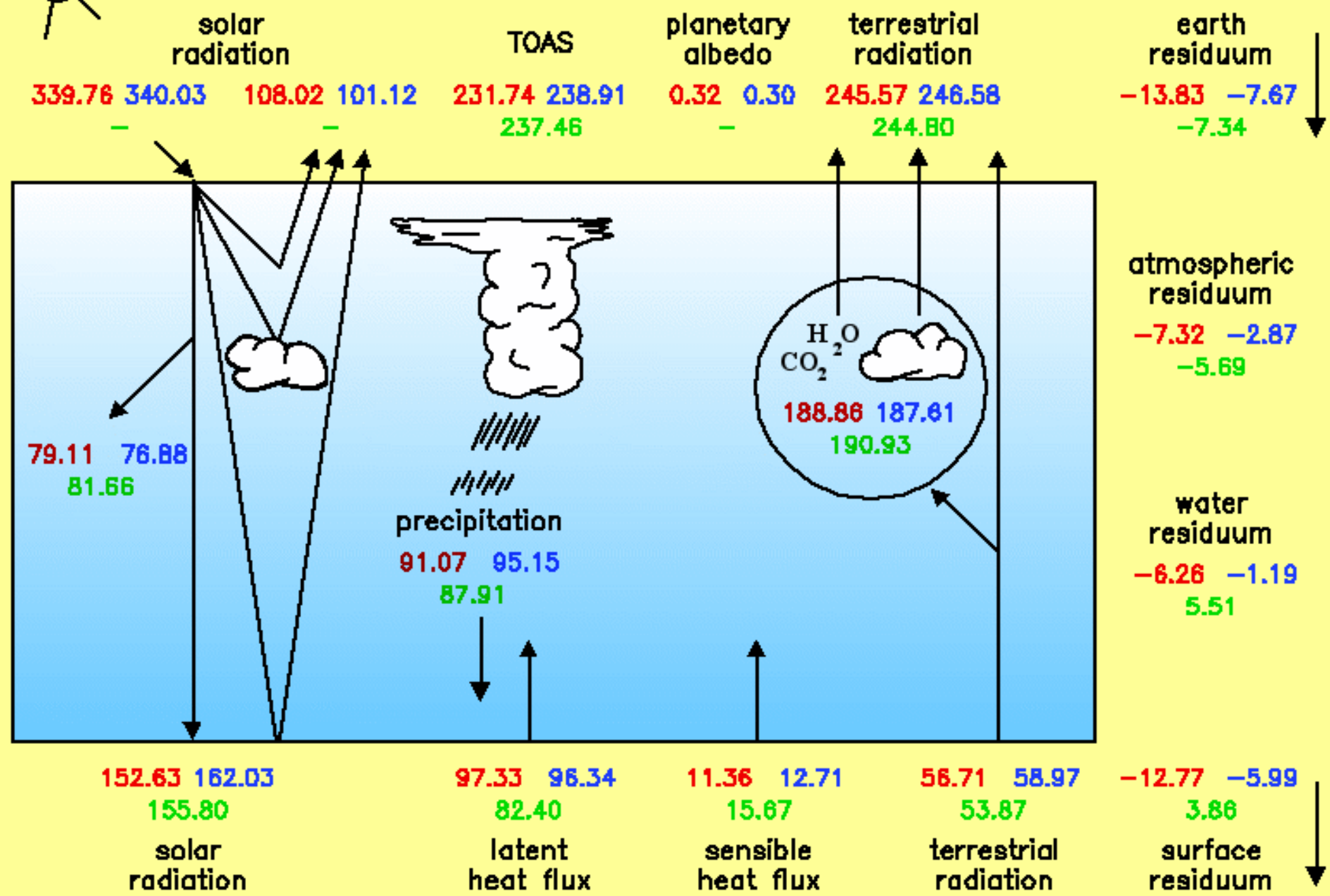
(1979-2000)

g302r03, annual

(1987-1999)

sgmipr01, annual

era40, annual (1979-2000)



Part 2: Where are we now ?

(in collaboration with Stephane Belair, Michel Roch and Anne-Marie Leduc, *et al.*)

The next version of GEM in climate-mode will be used at horizontal resolutions ranging from 35km (LAM and Stretched-grid mode) to 165km (1.5° AMIP2 mode). We want the model to use nearly the same physics configurations at all resolutions. Note that the tests were done with an older meso-global configuration (Dyn v3.1.1, Phy v4.0).

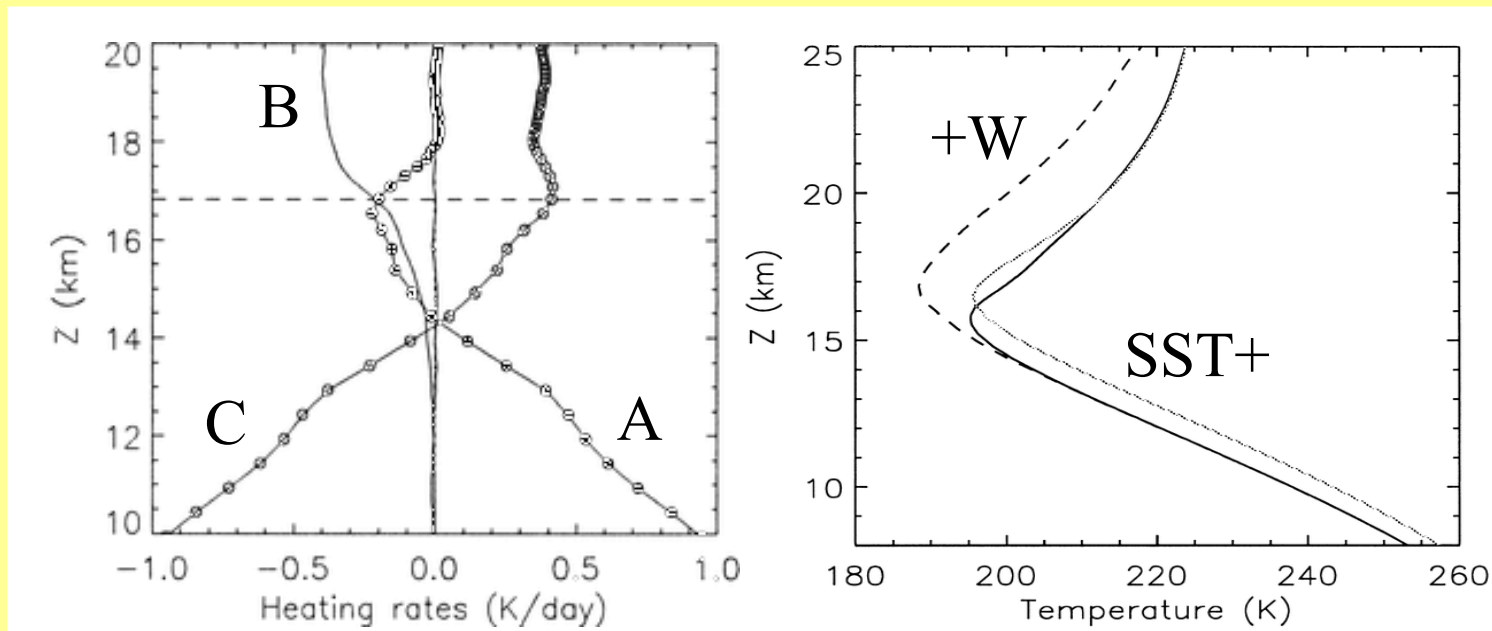
What was tested here (with sets of 2-year simulations):

- ✓ Smaller Kain-Fritsch deep convection trigger parameter values, i.e. 0.01 @ 1.5°, 0.013 @ 1.2° and 0.016 @ 1° (0.05 @ 0.45°)
- ✓ 240X120 (13) , 300x150 (2) and 360x180 (6) uniform resolutions
- ✓ ISBA land-surface scheme everywhere in all simulations
- ✓ Climate-mode setup (AMIP2 monthly SST and sea-ice)

What mechanisms determine the temperature and position of the tropical tropopause layer (from Kuang and Bretherton, JAS Decembre 2004)

Using a CRM to simulate conditions over the ITCZ, the authors show that these statistics are the results of three equilibrating processes, namely...

- Adiabatic cooling by deep convective events (fast time scale) (**A**)
- Adiabatic cooling by large scale rising vertical momentum (**B**)
- Radiative heating (10-day time scale) (**C**)



DJF
1978-79

Resolution	Kfctrig	PC [mm/d]	AE [mm/d]	PR [mm/d]	T (trop.) [°C]	U (trop.) [m/s]		Δ [kg/s]*10 ⁹
						Winter	Summer	
ERA40	n/a	1.17	1.53	2.70	-81	43	31	244
1.0°	0.05	0.95	1.63	2.58	-100	47	34	285
1.2°	0.05	0.68	1.65	2.33	-102	47	35	291
1.5°	0.05	0.70	1.81	2.51	-110	48	35	316

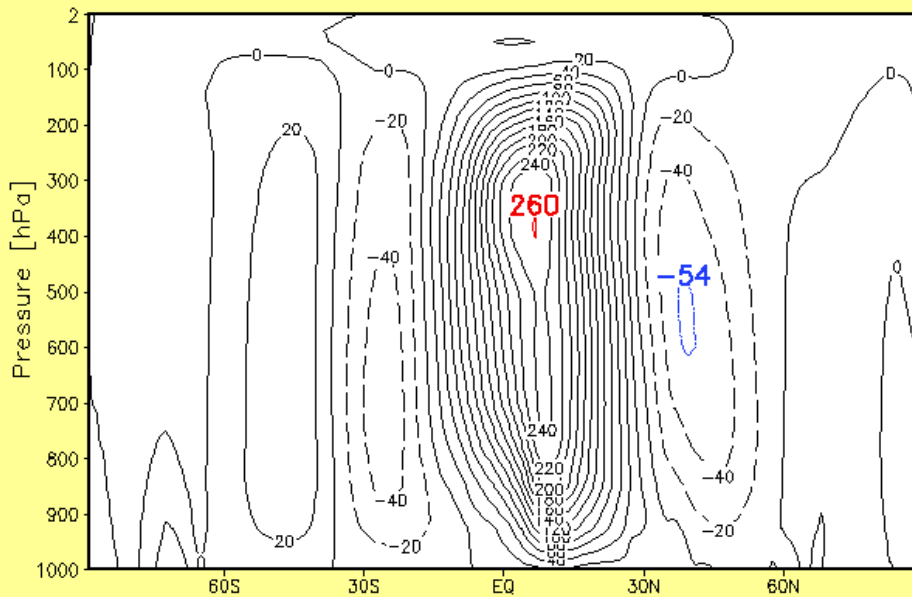


JJA
1978-79

Resolution	Kfctrig	PC [mm/d]	AE [mm/d]	PR [mm/d]	T (trop.) [°C]	U (trop.) [m/s]		$\Delta\Psi$ [kg/s]*10 ⁹
						Winter	Summer	
ERA40	n/a	1.38	1.59	2.97	-78	41	21	302
1.0°	0.05	0.85	1.73	2.58	-97	48	20	369
1.2°	0.05	0.66	1.72	2.38	-98	46	20	380
1.5°	0.05	0.77	1.65	2.35	-104	51	22	421

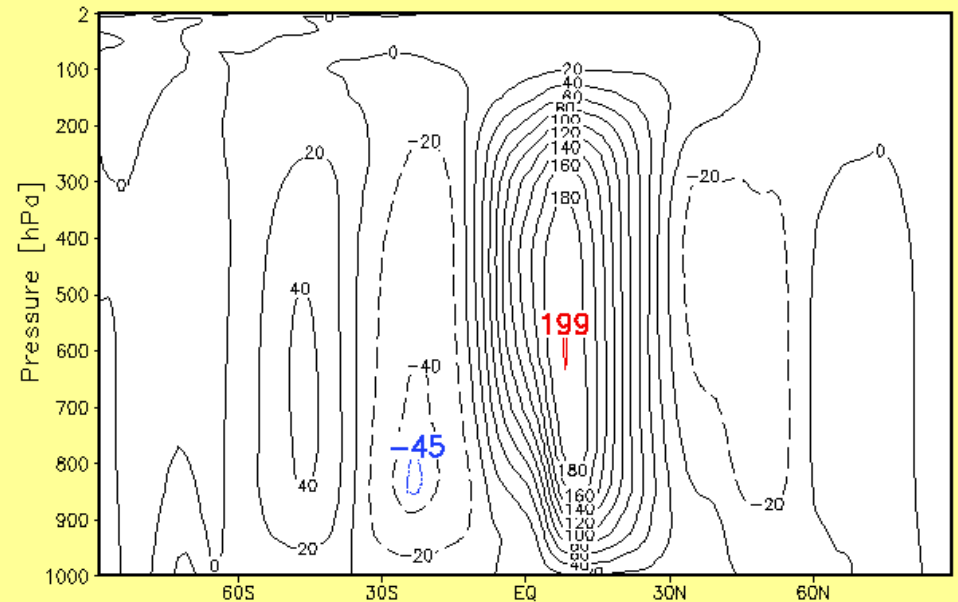
GEM 1.5 degree, kfctrig 0.05

Zonal mean stream function [kg/s]*1e-9, DJF JJA 78/79



ERA 40

Zonal mean stream function [kg/s]*1e-9, DJF JJA 78/79

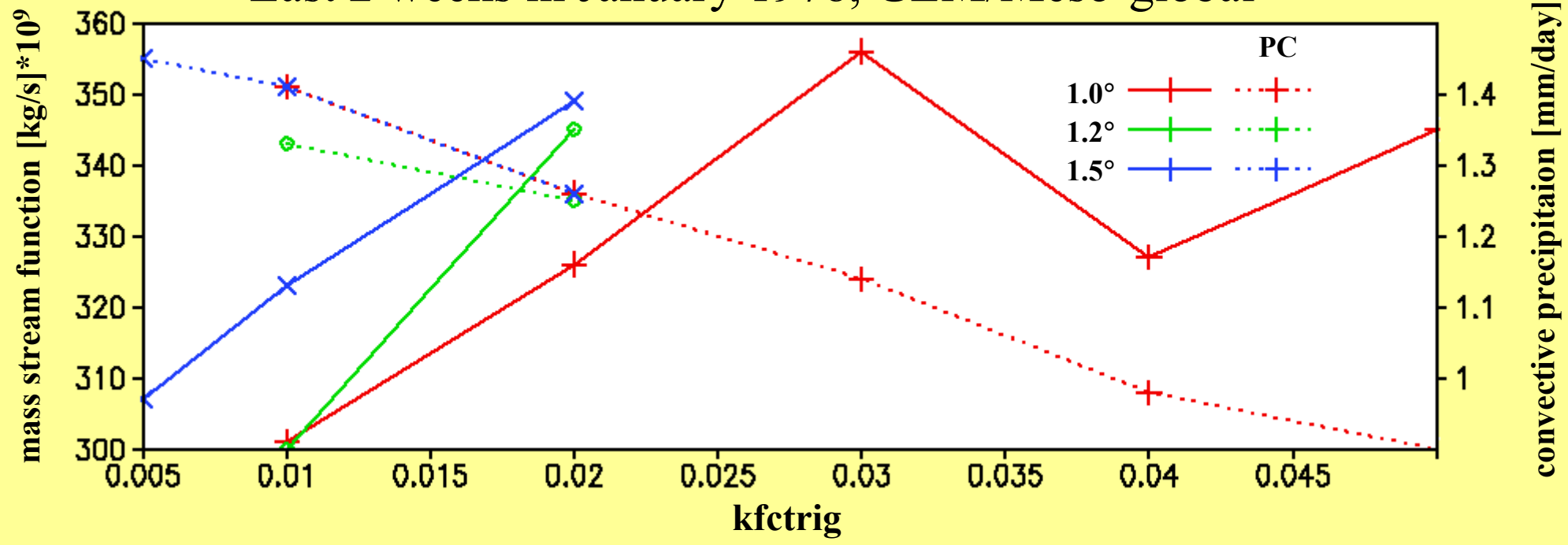


From the Time-mean/Zonal-mean continuity equation in pressure coordinate, we can define the mass-streamfunction Ψ_M such that

$$[\bar{v}] = \frac{g}{2\pi a \cos(\Phi)} \frac{\partial \Psi_M}{\partial P} \quad \text{and} \quad [\bar{\omega}] = \frac{-g}{2\pi a^2 \cos(\Phi)} \frac{\partial \Psi_M}{\partial \Phi}$$

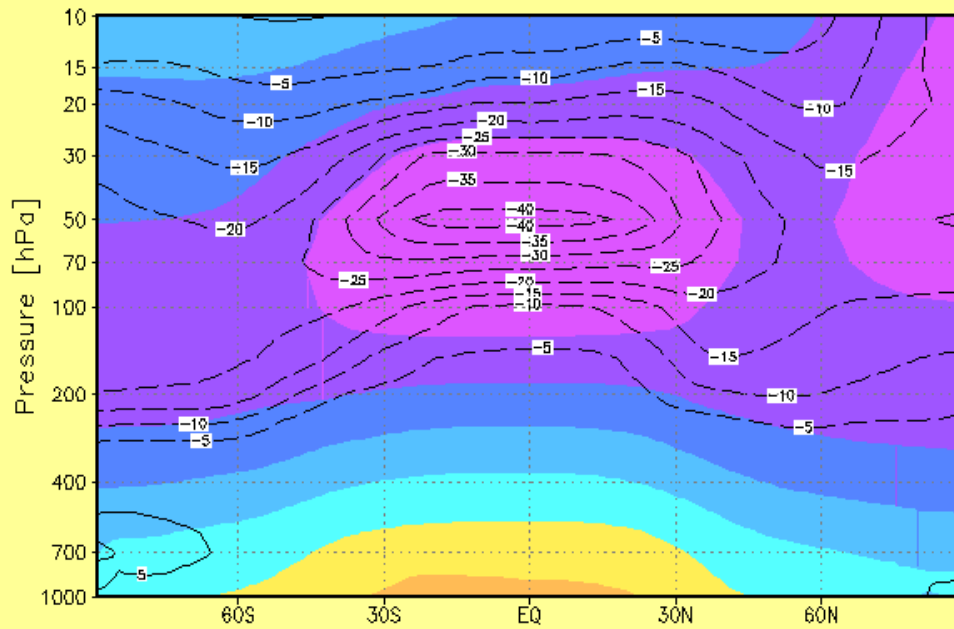
Ψ_M can thus be retrieved from the vertical integral of $[\bar{v}]$.

Last 2 weeks in January 1978, GEM/Meso-global

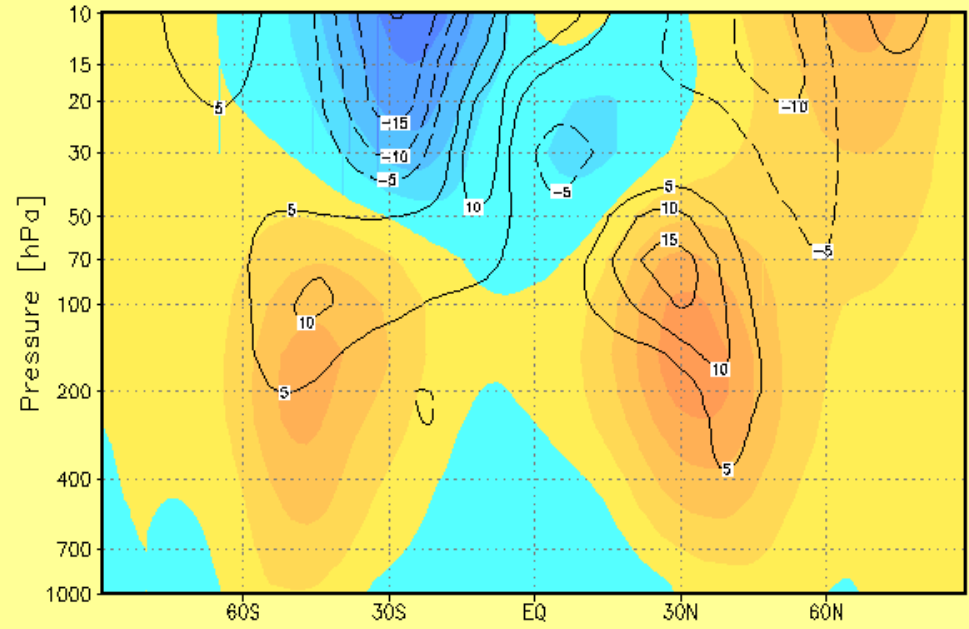


240x120 - 2 year simulation – kfctrig = 0.05

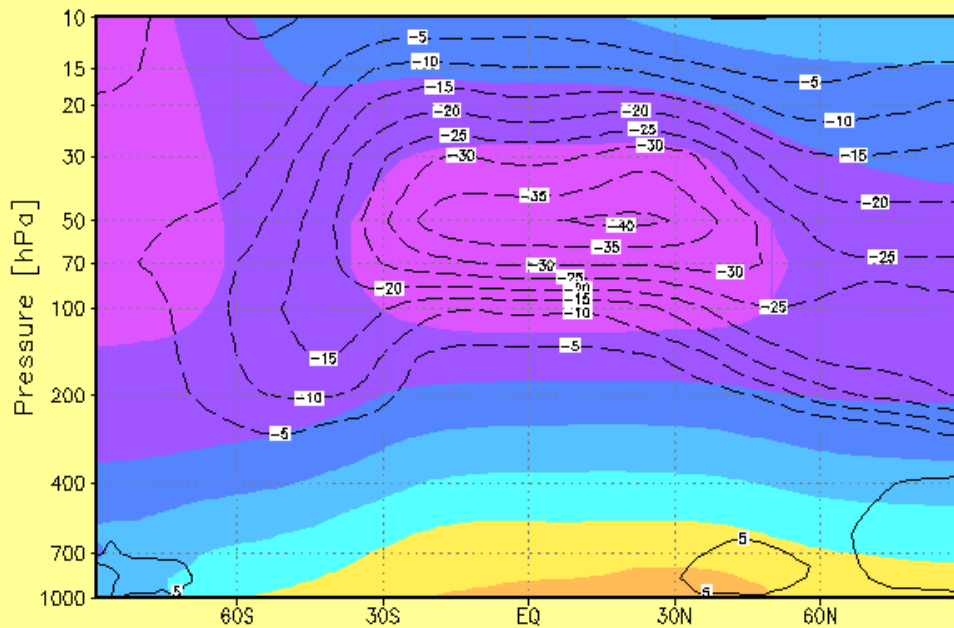
amipm240 (- era40)
Zonal mean Temperature [C], DJF 78/79



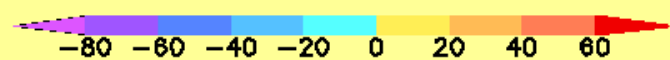
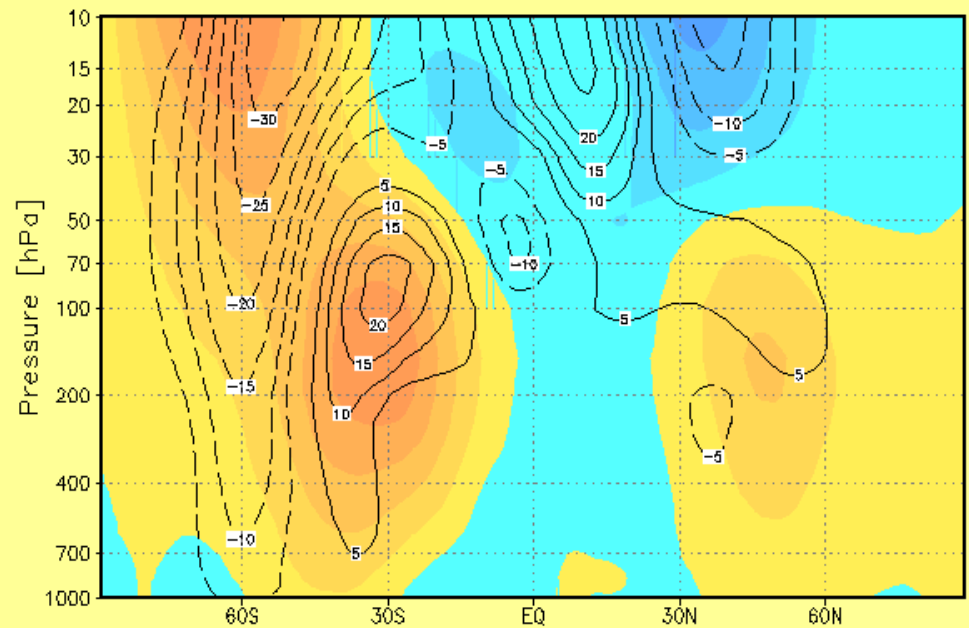
amipm240 (- era40)
Zonal mean U-Wind [m/s], DJF 78/79



amipm240 (- era40)
Zonal mean Temperature [C], JJA 78/79



amipm240 (- era40)
Zonal mean U-Wind [m/s], JJA 78/79



The current 15 km regional system and its close cousin the 24 km, use trigger-based convection parameters, i.e. KFCTRIG=0.11 (15 km after 6 hours) and WKLCL = 0.07 (24 km).

So, assuming the same relationship between the trigger value and a model's resolution, *i.e.*

$$\text{trigger} * \text{resolution} \cong 1.7$$

Then, appropriate values for KFCTRIG are as defined in the following table for the respective horizontal resolutions. At 0.45°, this value is 0.03.

Resolution	Kfctrig	PC [mm/d]	AE [mm/d]	PR [mm/d]	T (trop.) [°C]	U (trop.) [m/s]		$\Delta\Psi_M$ [kg/s]*10 ⁹	
						Winter	Summer		
DJF, 2 seasons	1.0°	0.016	1.51	1.18	2.69	-98	45	37	257
	1.2°	0.013	1.46	1.15	2.61	-97	45	36	268
	1.5°	0.01	1.58	1.04	2.62	-97	46	37	272

Resolution	Kfctrig	PC [mm/d]	AE [mm/d]	PR [mm/d]	T (trop.) [°C]	U (trop.) [m/s]		$\Delta\Psi_M$ [kg/s]*10 ⁹	
						Winter	Summer		
JJA, 2 seasons	1.0°	0.016	1.51	1.16	2.67	-94	44	17	322
	1.2°	0.013	1.40	1.16	2.56	-96	48	17	329
	1.5°	0.01	1.54	0.97	2.51	-94	47	19	322

Part 3: Where are we going ?

(in collaboration with Paul Vaillancourt and Donald Talbot, et al.)

We now discuss results from a last set of 2-year runs of the v3.2.0 dynamic and the v4.2 physic packages. This final configuration is very close to the current meso-global configuration; the remaining differences are:

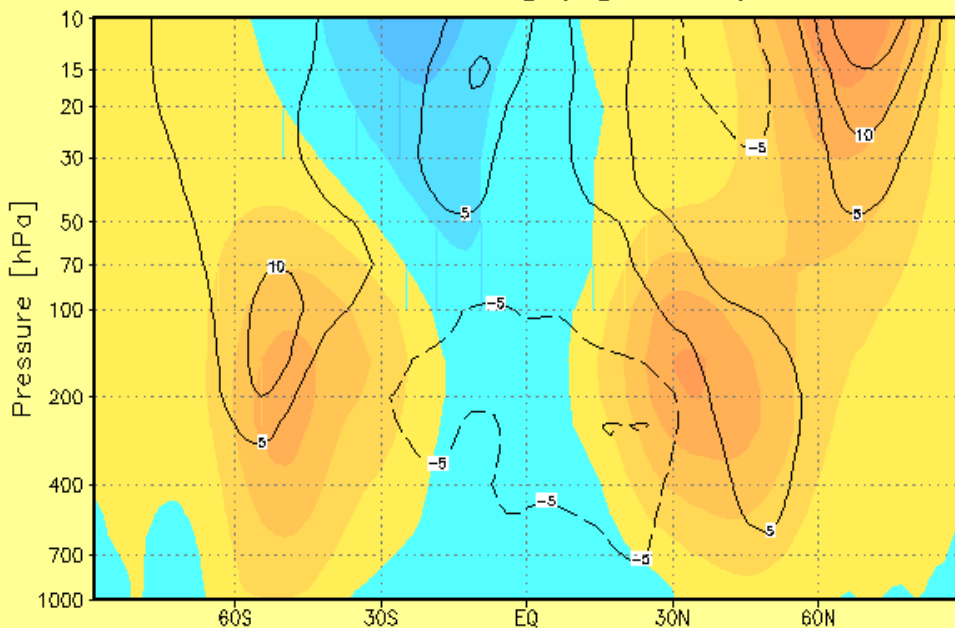
- ✓ Same Kain-Fritsch deep convection trigger as in the previous section
- ✓ New **CCCma correlated-K radiation** (used in 3 runs) @ 1.5°
- ✓ Precipitating shallow-convection (used in 6 runs) @ 1.5°
- ✓ Climate-mode setup (AMIP2 monthly SST and sea-ice)

newrad

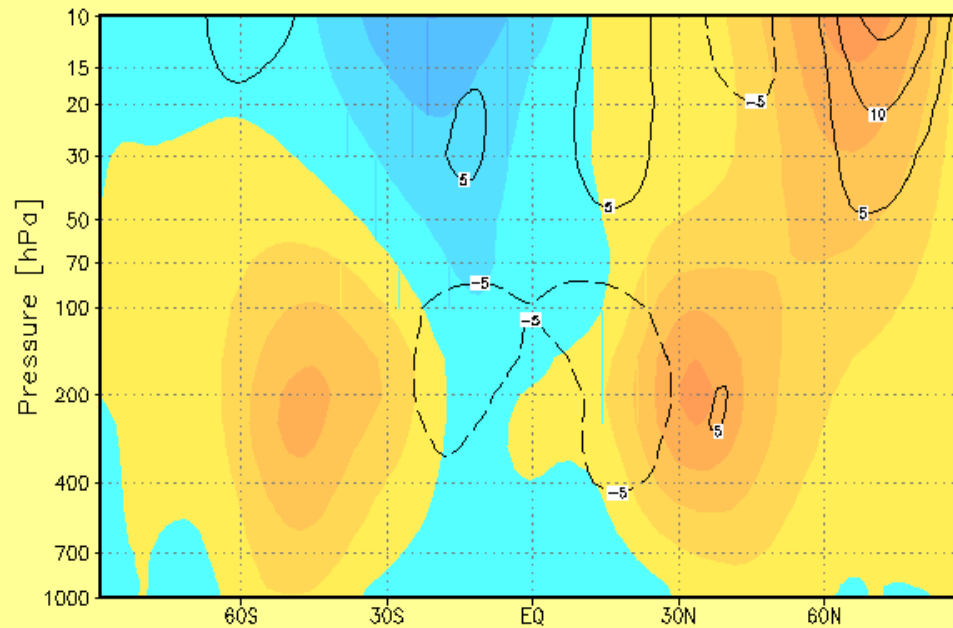
Zonal mean U-Wind

cccmrad

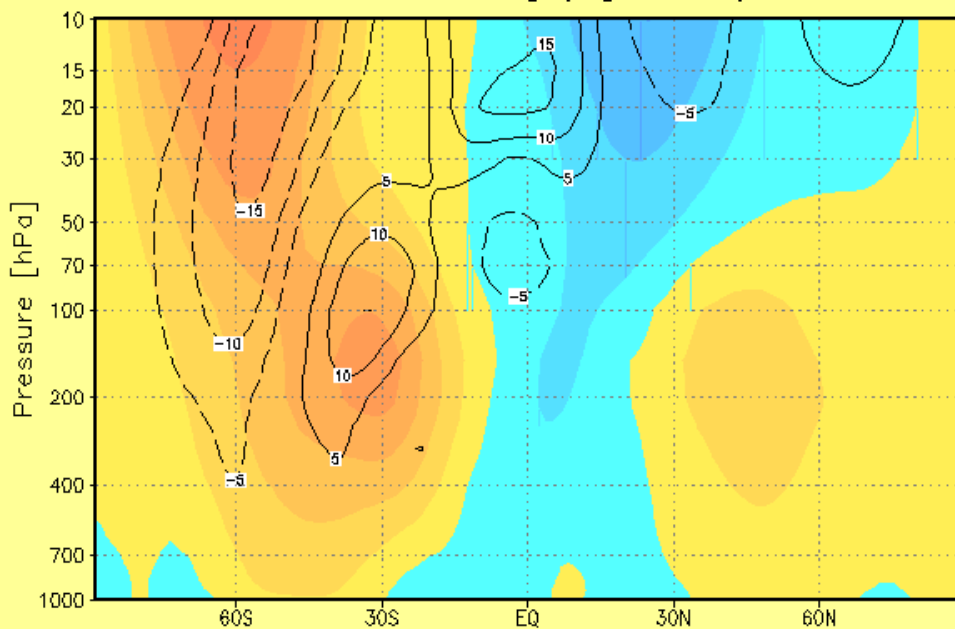
amip240v320mc (- era40)
Zonal mean U-Wind [m/s], DJF 78/79



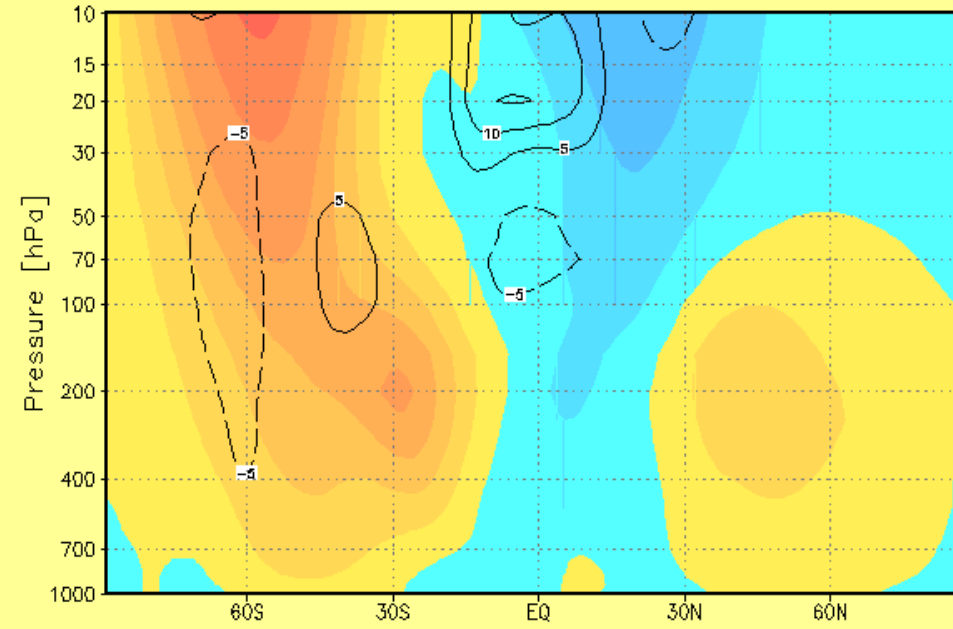
amip240cccradmc (- era40)
Zonal mean U-Wind [m/s], DJF 78/79



amip240v320mc (- era40)
Zonal mean U-Wind [m/s], JJA 78/79



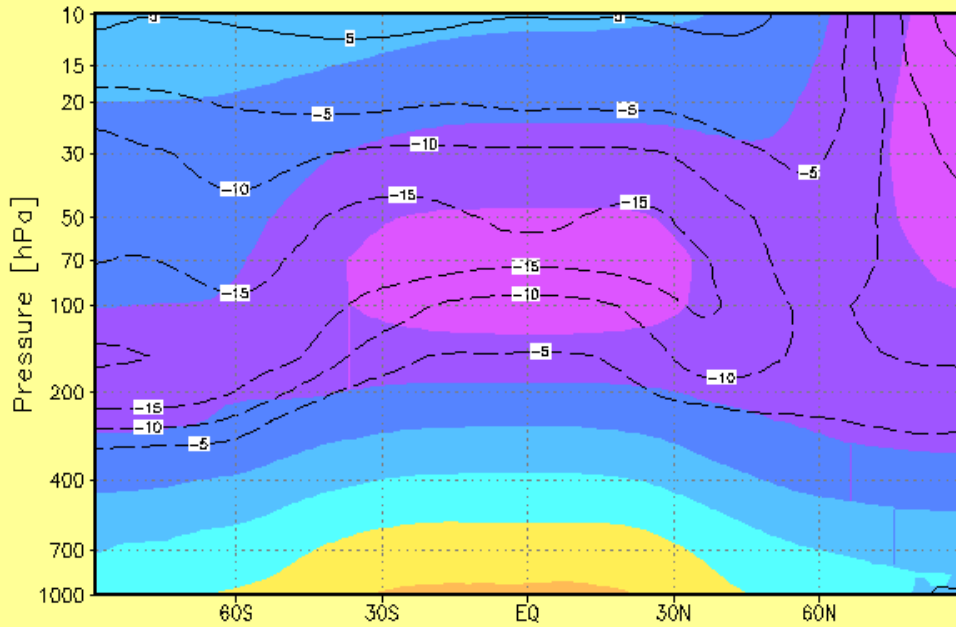
amip240cccradmc (- era40)
Zonal mean U-Wind [m/s], JJA 78/79



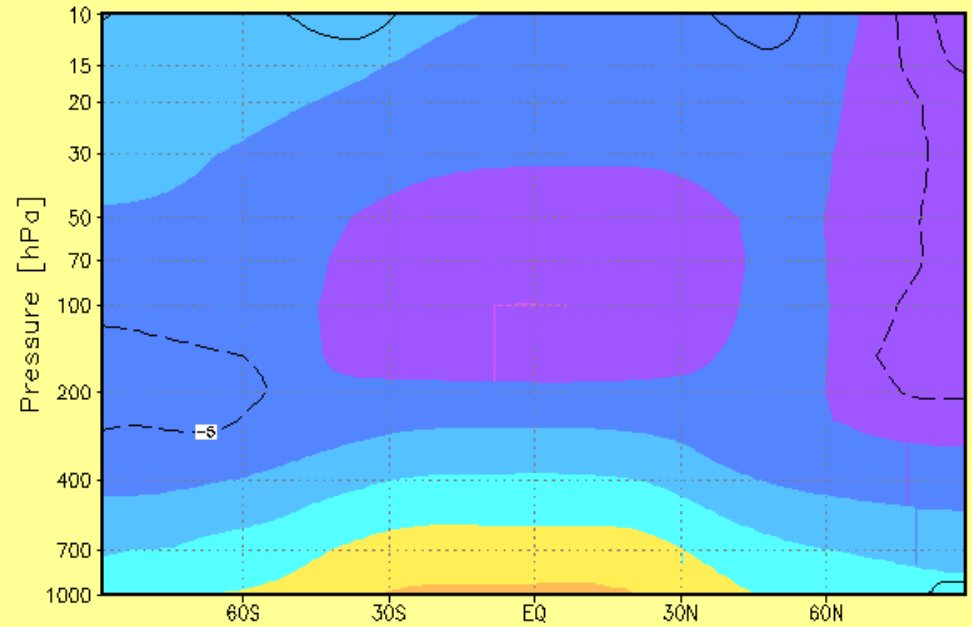
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-70 -60 -50 -40 -30 -20 -10 0 10 20 30 40 60 80 100 120

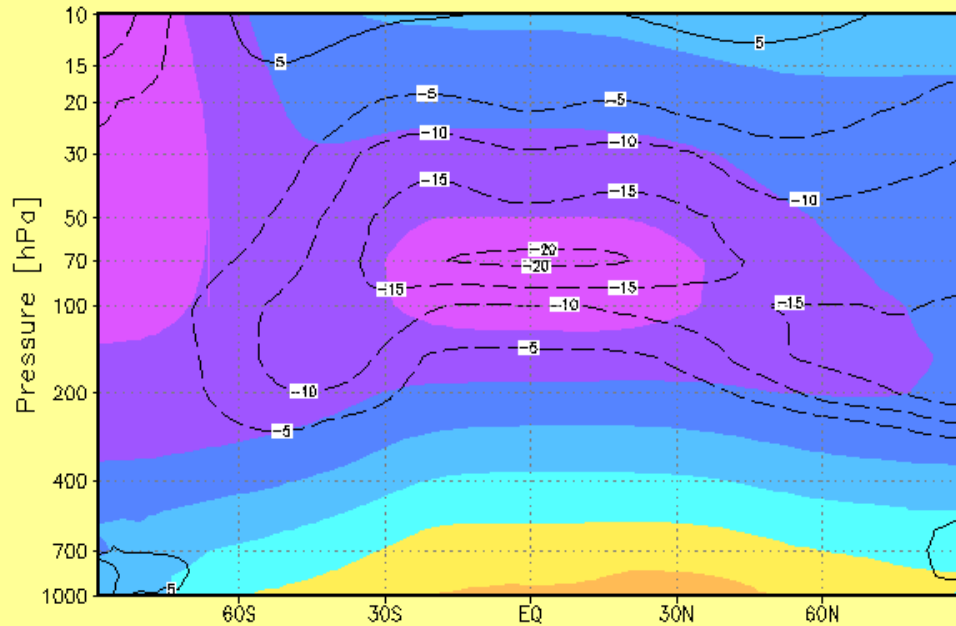
amip240v320mc (- era40)
Zonal mean Temperature [C], DJF 78/79



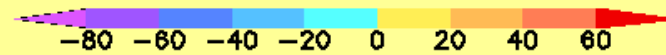
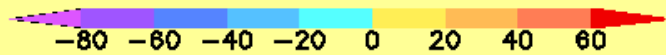
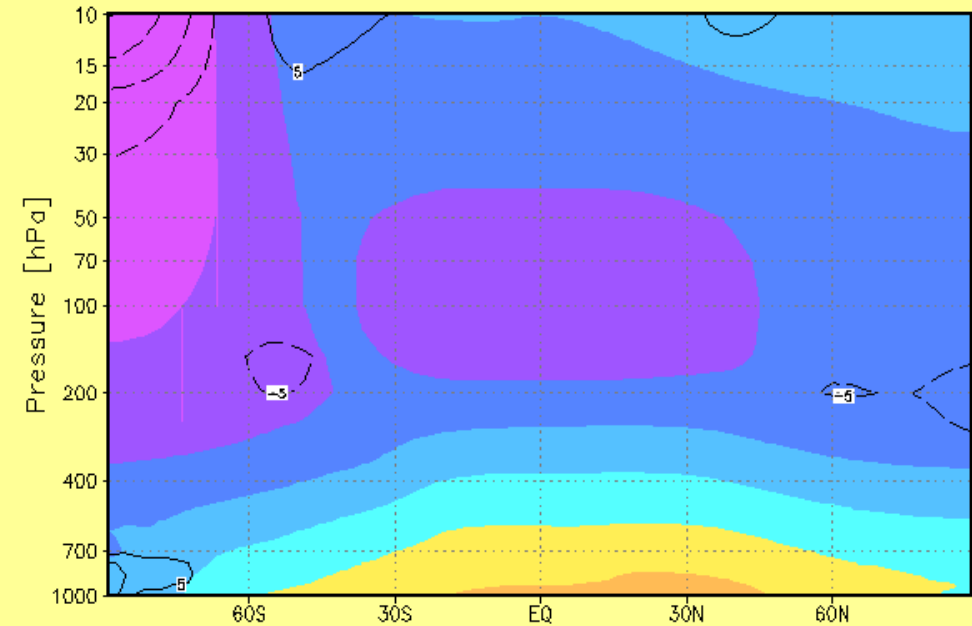
amip240cccradmc (- era40)
Zonal mean Temperature [C], DJF 78/79



amip240v320mc (- era40)
Zonal mean Temperature [C], JJA 78/79



amip240cccradmc (- era40)
Zonal mean Temperature [C], JJA 78/79

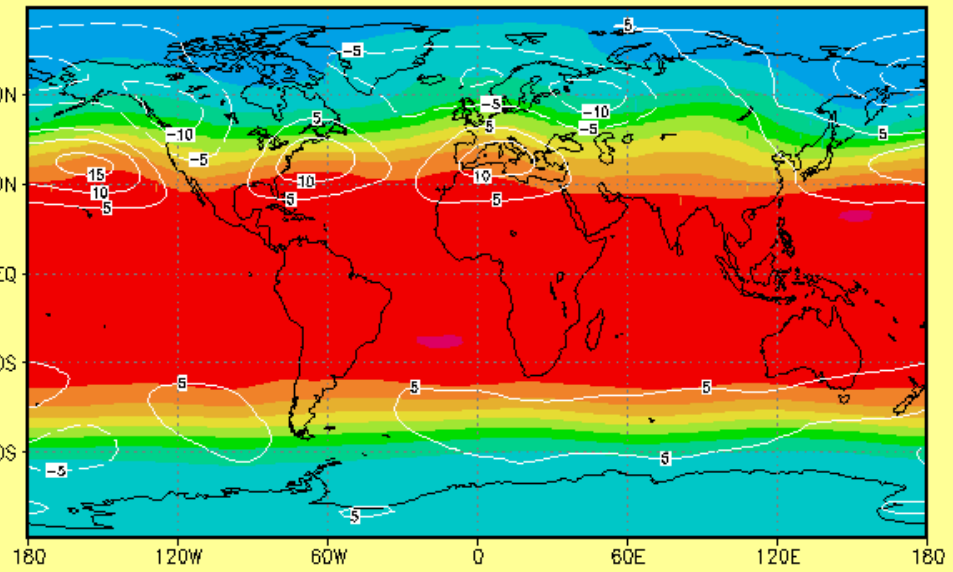


Geopotential at 500 hPa, DJF 78/79

newrad

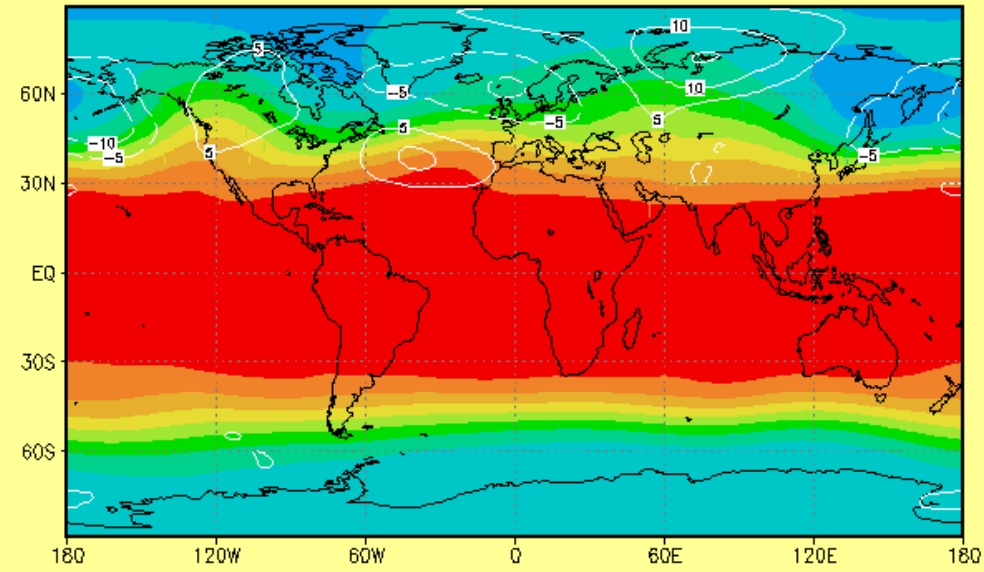
amip240v320mc (- era40)
Geopotential at 500 hPa [gpdm], DJF 78/79

NO shallow convection PCP



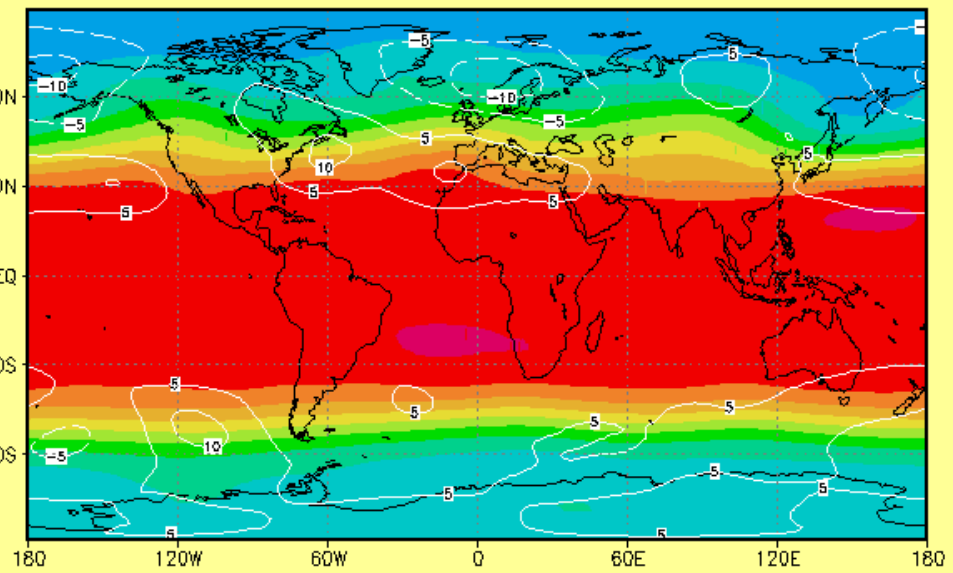
cccmrad

amip240cccradm (- era40)
Geopotential at 500 hPa [gpdm], DJF 78/79

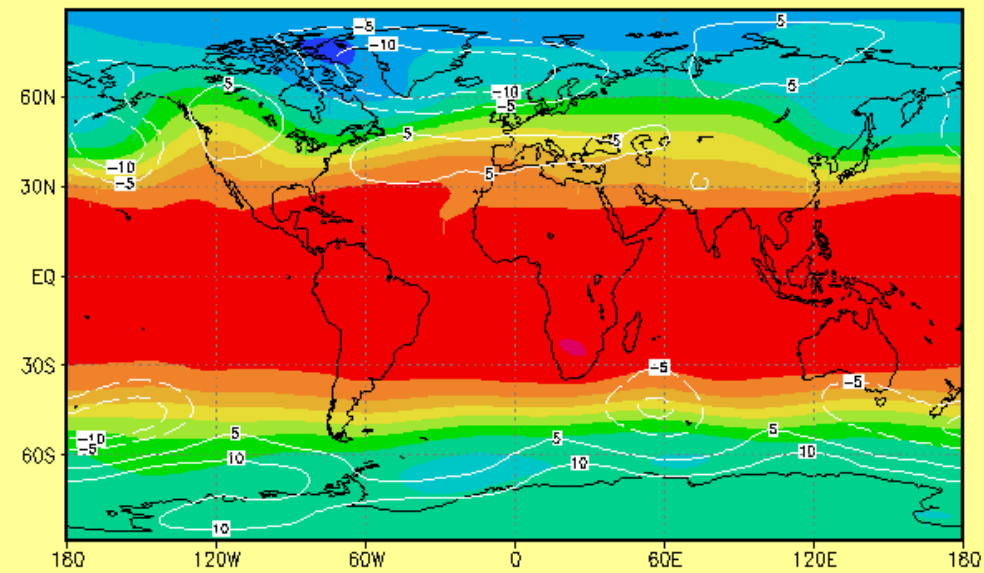


amip240v320ms (- era40)
Geopotential at 500 hPa [gpdm], DJF 78/79

WITH shallow convection PCP



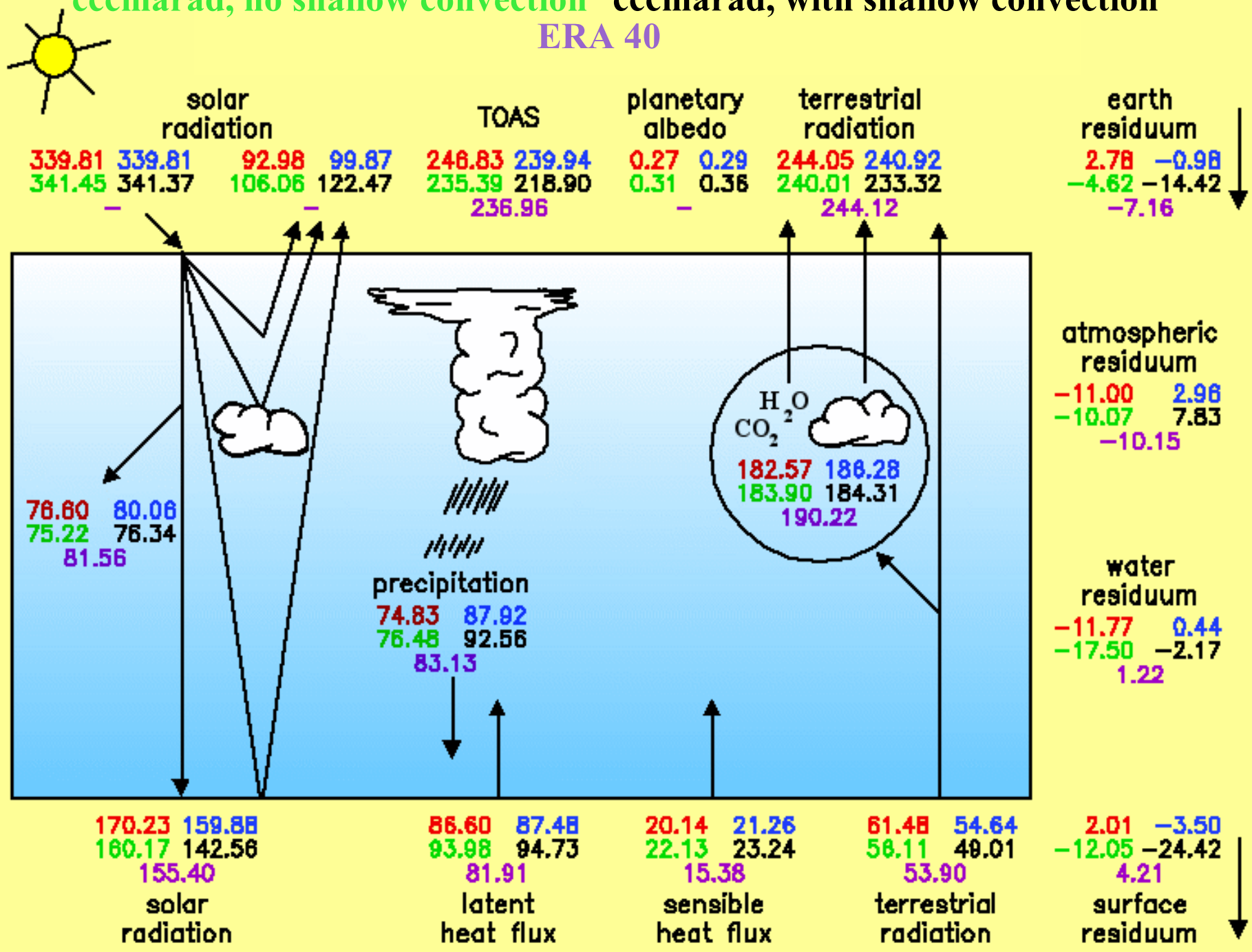
amip240cccradmcs (- era40)
Geopotential at 500 hPa [gpdm], DJF 78/79



Global annual Energy Budgets, 1978/79

newrad, no shallow convection newrad, with shallow convection
 cccmarad, no shallow convection cccmarad, with shallow convection

ERA 40



U-Wind at 200 hPa, DJF 78/79

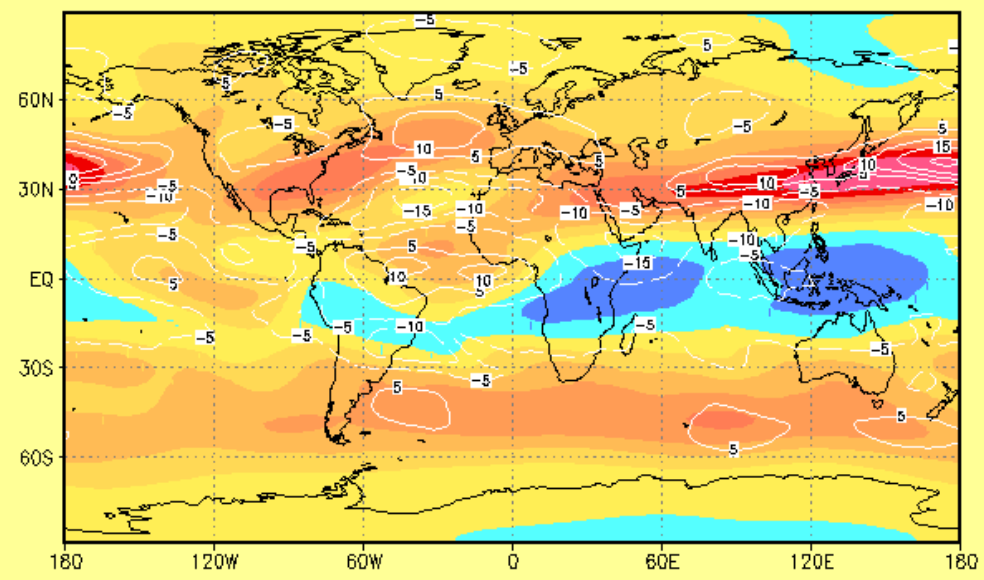
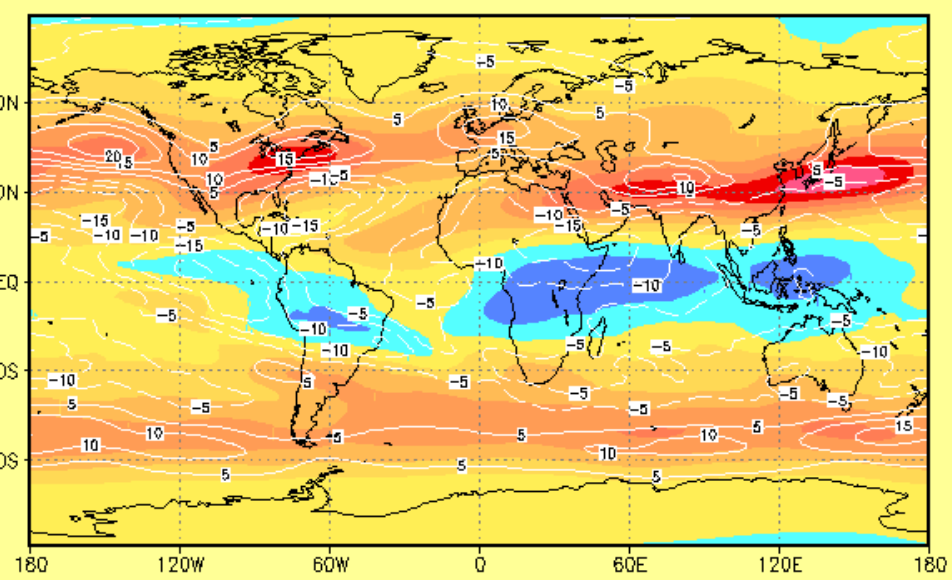
newrad

cccmrad

amip240v320mc (- era40)
UU at 200 hPa [m/s], DJF 78/79

amip240cccradm (- era40)
UU at 200 hPa [m/s], DJF 78/79

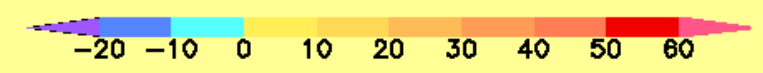
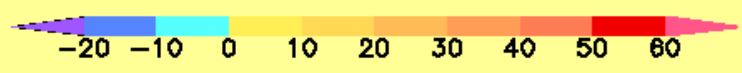
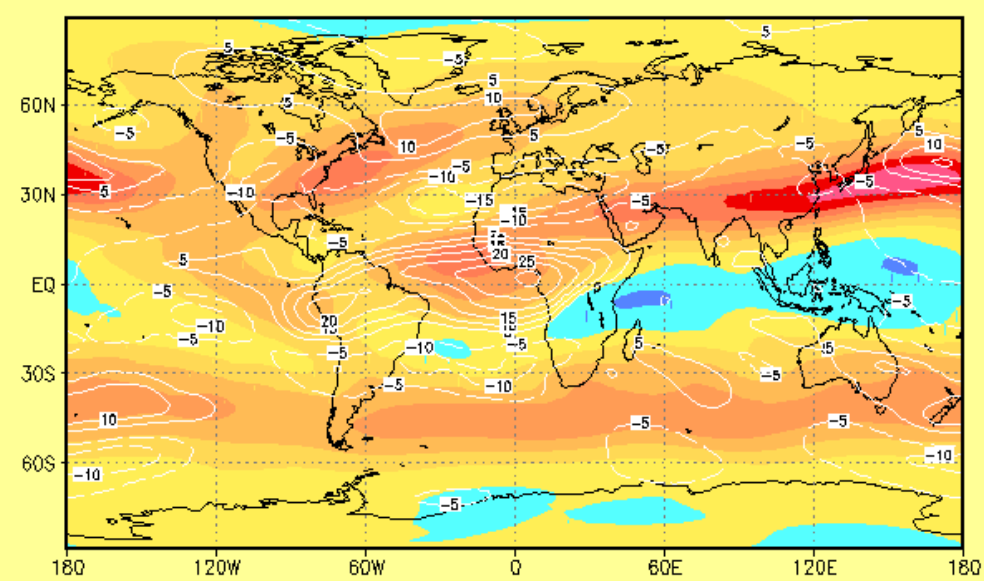
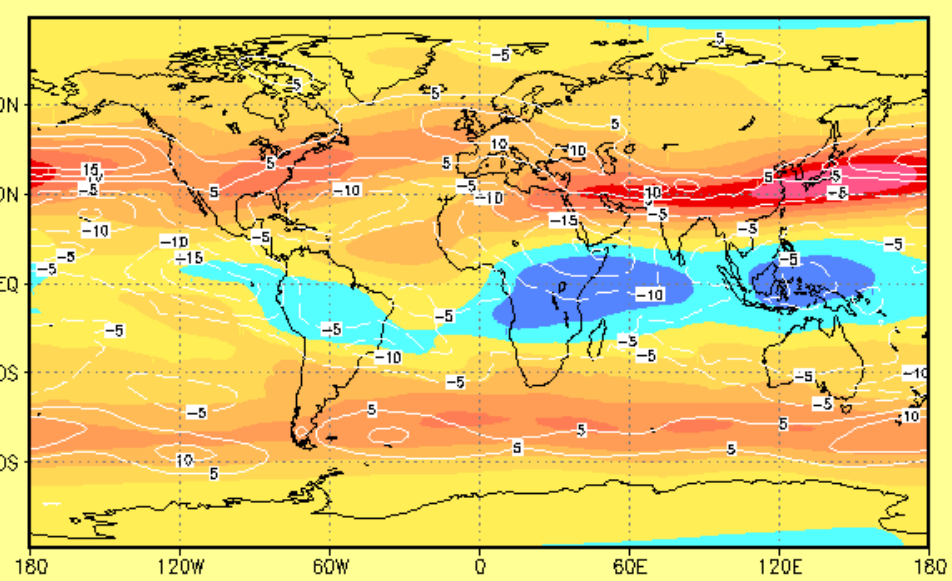
NO shallow convection PCP



amip240v320ms (- era40)
UU at 200 hPa [m/s], DJF 78/79

amip240cccradmcs (- era40)
UU at 200 hPa [m/s], DJF 78/79

WITH shallow convection PCP



Precipitation, DJF 78/79

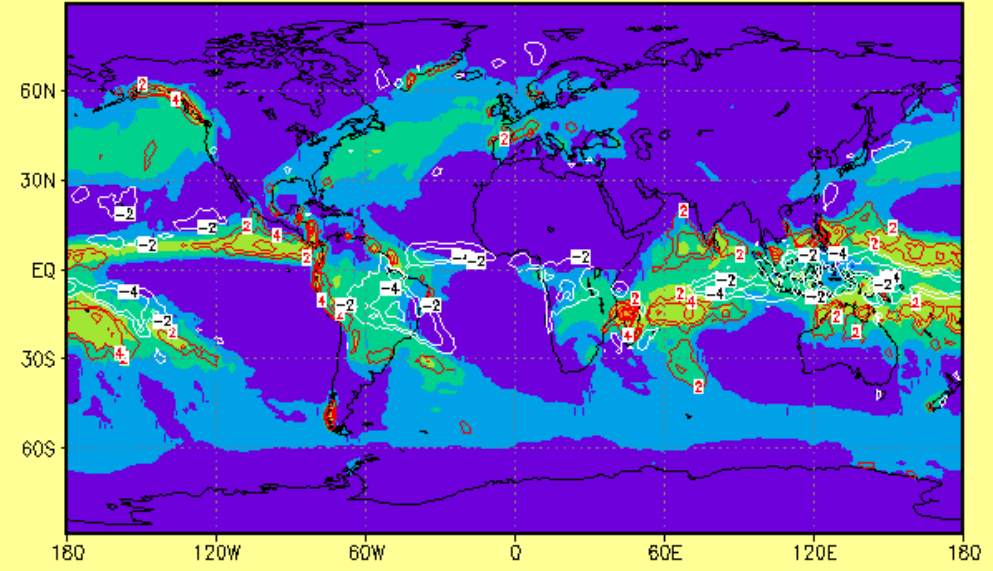
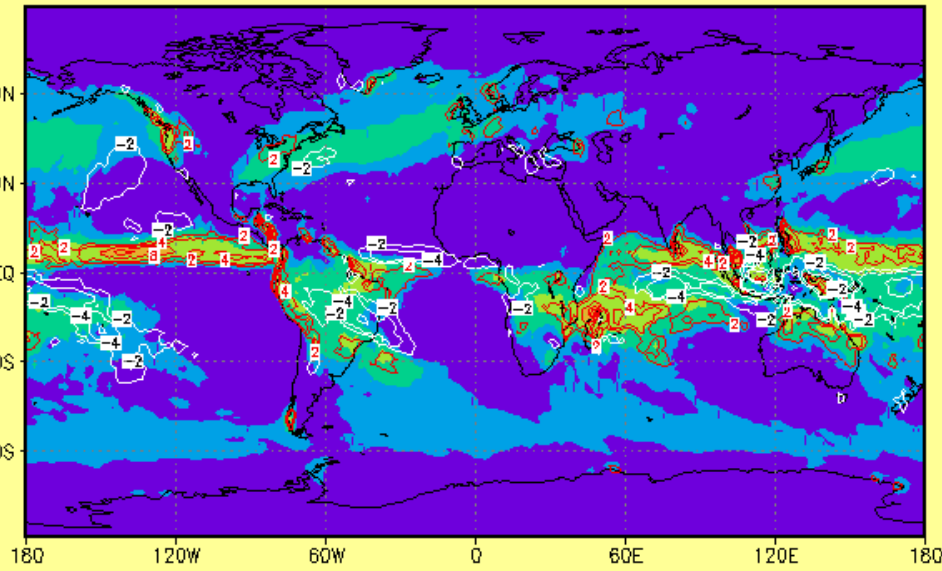
newrad

amip240v320mc (- Xie Arkin)
Total Precipitation [mm/day], DJF 78/79

cccmrad

amip240cccradm (- Xie Arkin)
Total Precipitation [mm/day], DJF 78/79

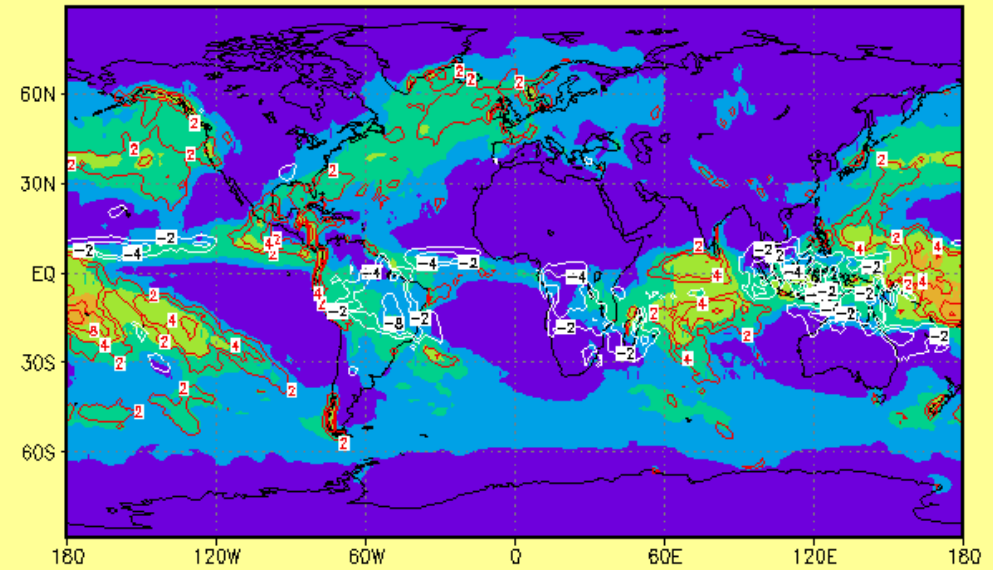
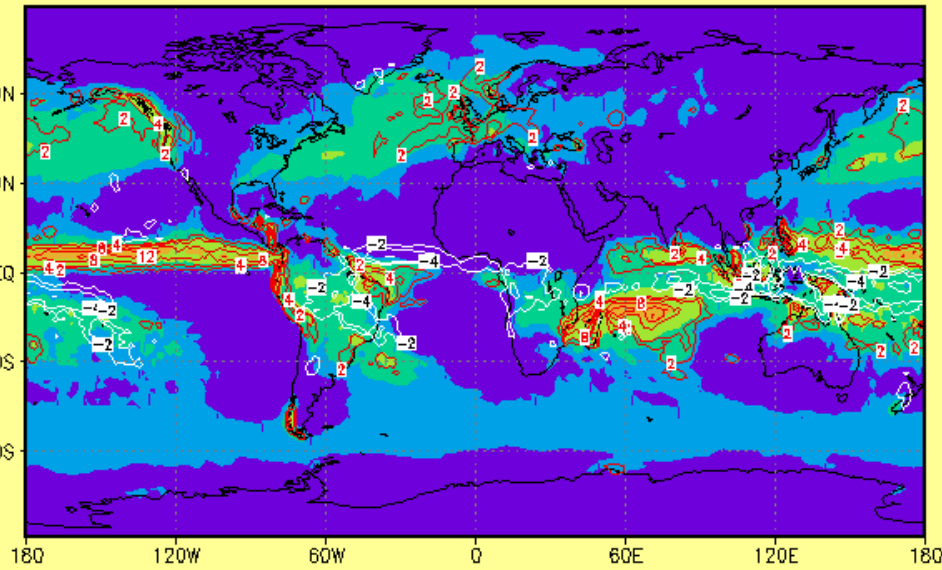
NO shallow convection PCP



amip240v320ms (- Xie Arkin)
Total Precipitation [mm/day], DJF 78/79

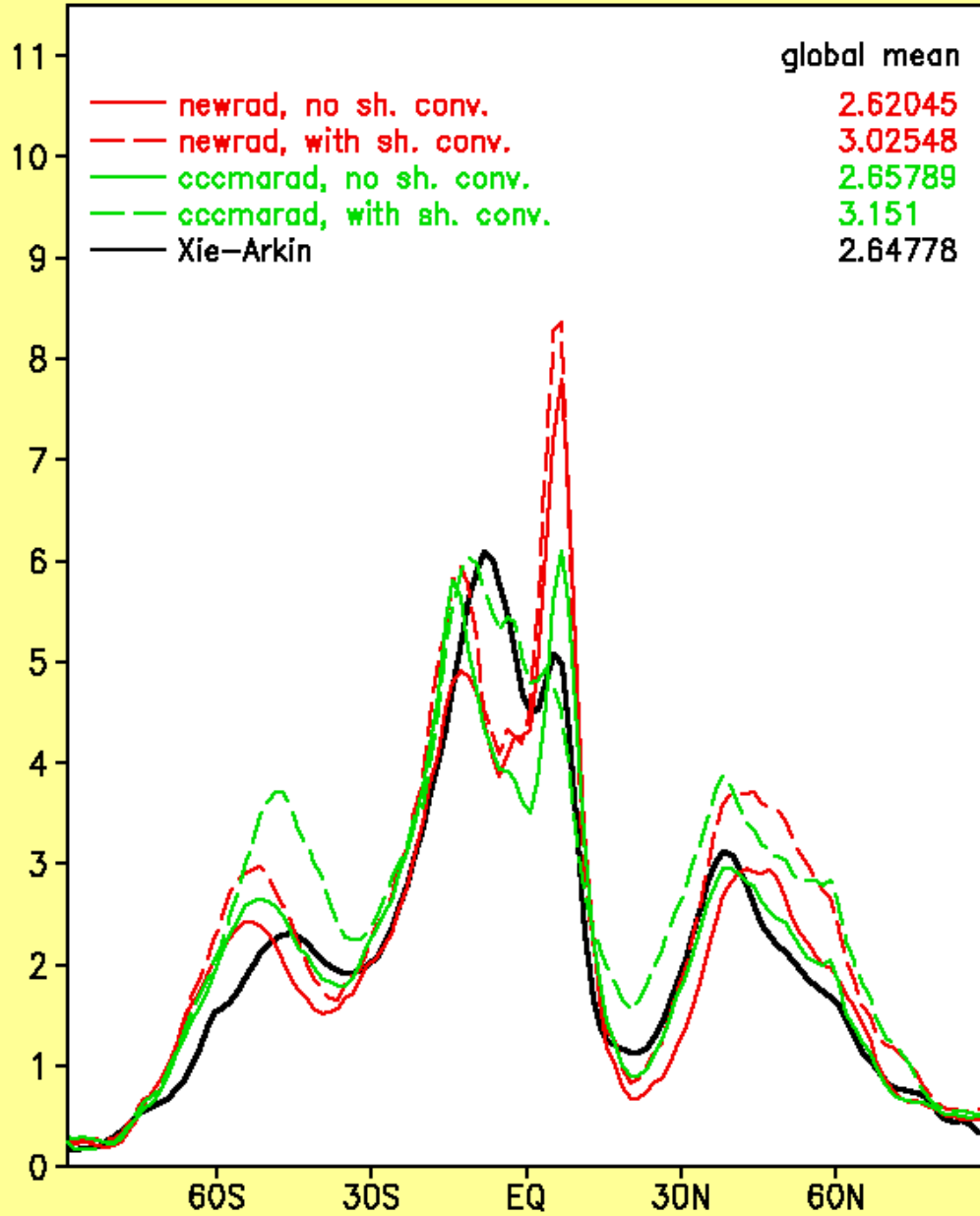
amip240cccradmcs (- Xie Arkin)
Total Precipitation [mm/day], DJF 78/79

WITH shallow convection PCP

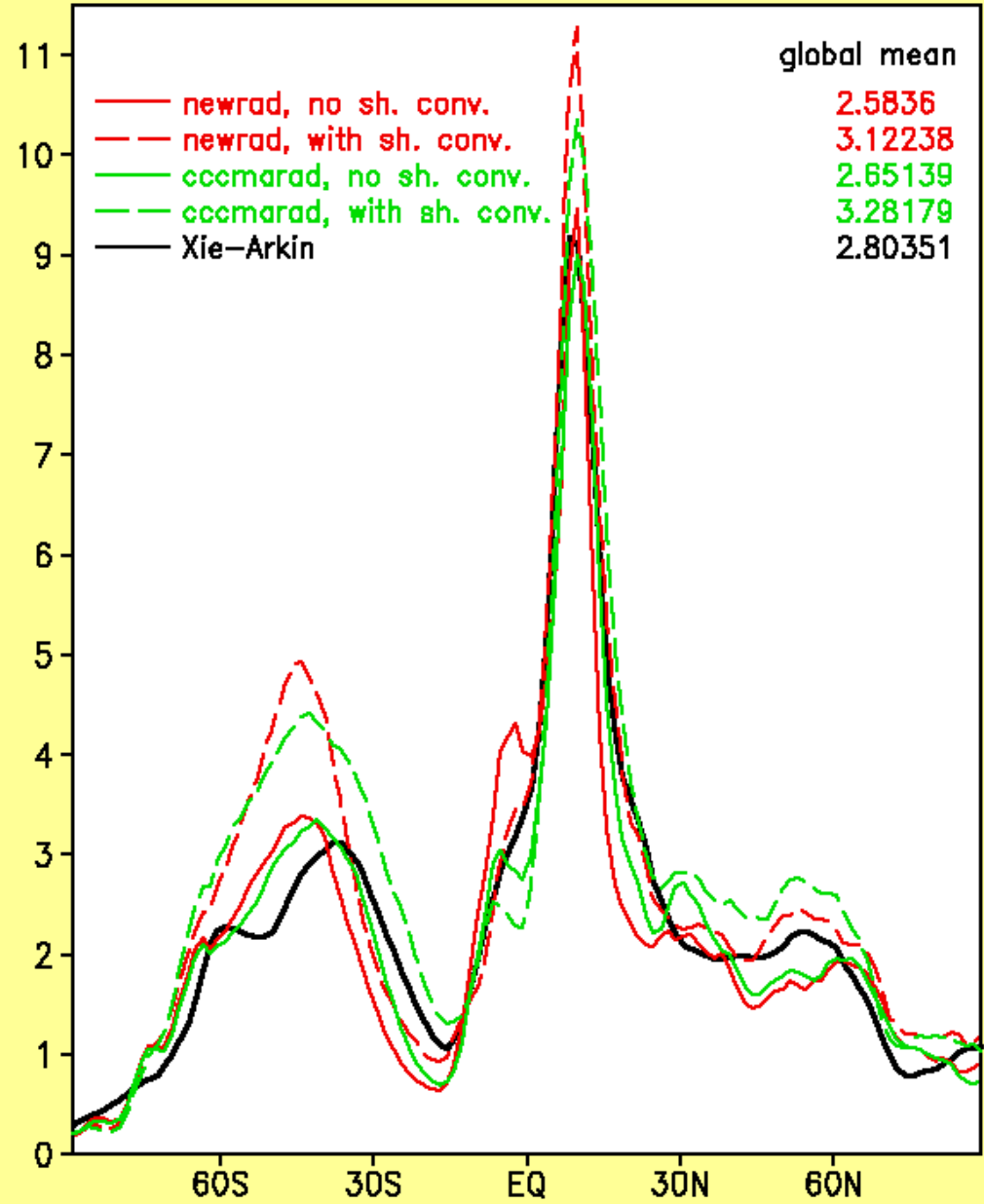


Zonal mean precipitation

Precipitation, zonal mean [mm/day], DJF 78/79

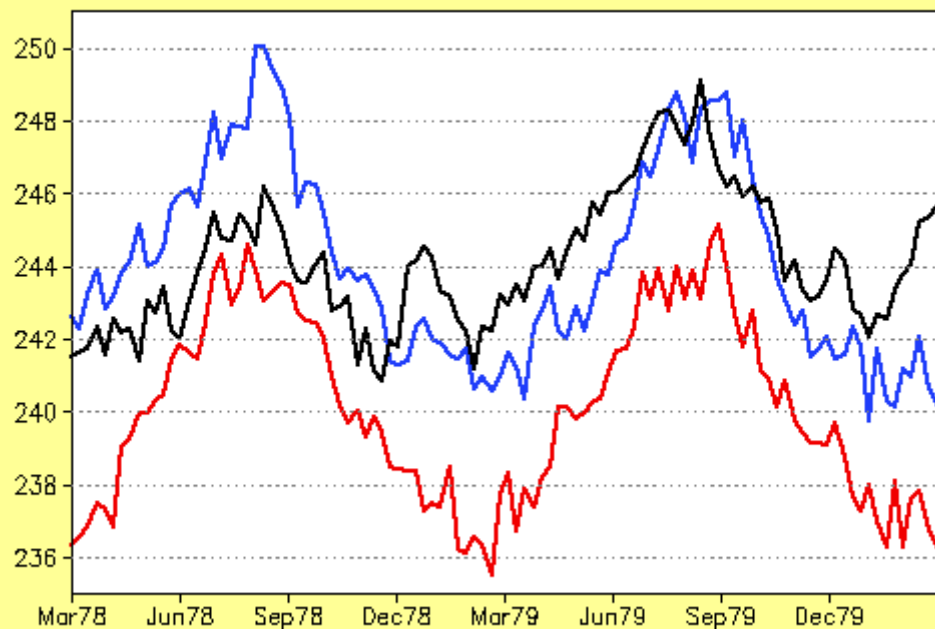


Precipitation, zonal mean [mm/day], JJA 78/79

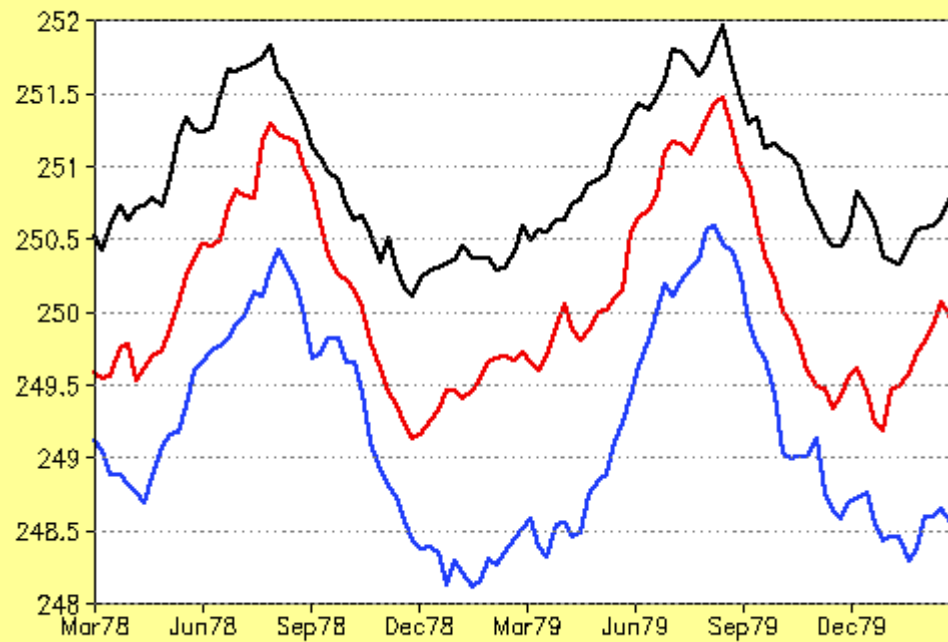


1978-79 Time-series (NO shallow convection PCP)

Weekly global OLR energy flux at model lid [W/m^2]
ERA 40 cccmarad newrad



Weekly global temperature [Kelvin]
ERA 40 cccmarad newrad



Reference data for OLR: TOVS: 236 - 244 W/m^2 , ERBE: 230 - 240 W/m^2 , avhrr: 228 - 236 W/m^2

Experiment	Season 78/79	PC [mm/d]	AE [mm/d]	PR [mm/d]	T (trop.) [°C]	U (trop.) [m/s]		Δ [kg/s]*10 ⁹
						Winter	Summer	
ERA40	DJF	1.17	1.53	2.70	-81	43	31	244
Newrad	DJF	1.59	1.04	2.62	-94	42	36	269
Cccmarad	DJF	1.56	1.10	2.66	-80	42	33	249
ERA40	JJA	1.38	1.59	2.97	-78	41	21	302
Newrad	JJA	1.63	0.95	2.58	-91	46	19	306
Cccmarad	JJA	1.61	1.04	2.65	-78	42	19	286

Conclusions

- ✓ The new meso-global climate-mode configuration performs well.
- ✓ Generally, the 1° version performs better than the 1.5° version !!!
- ✓ Activating the precipitating shallow-convection equilibrates the moisture budget, but destroys nearly everything else.
- ✓ Adding the CCCma radiation fixes some of the model's largest-scale errors both in the stratosphere and in the troposphere. But a cold tropospheric bias still remains.

Thank You