

the hydrological cycle

**in ERA40 and pre-interim tests
and some consequences for the monthly climate**

(conclusions in this colour)

**ECMWF workshop on reanalysis
June 19-22 2006**

Per Kållberg, ECMWF

pre-interim experiments

- ERA40 3D/Cy23 T159/N080/L60 195709-200208
- 0060 4D/Cy30 T255/N128/L60 198901-199012
- 0471 4D/Cy30 T159/N080/L60 199908-200012
- 1001 4D/Cy30 T255/N128/L60 198901-198906

Cy30 vs. Cy23

4D-Var/12h

variational bias correction of satellite radiances

improved bias correction of radiosondes

major revision in humidity analysis

many revisions to physics (cloud/radiation)

ERA workshop June 19-22 2006

daily mean precipitation 1989-1990

GPCP

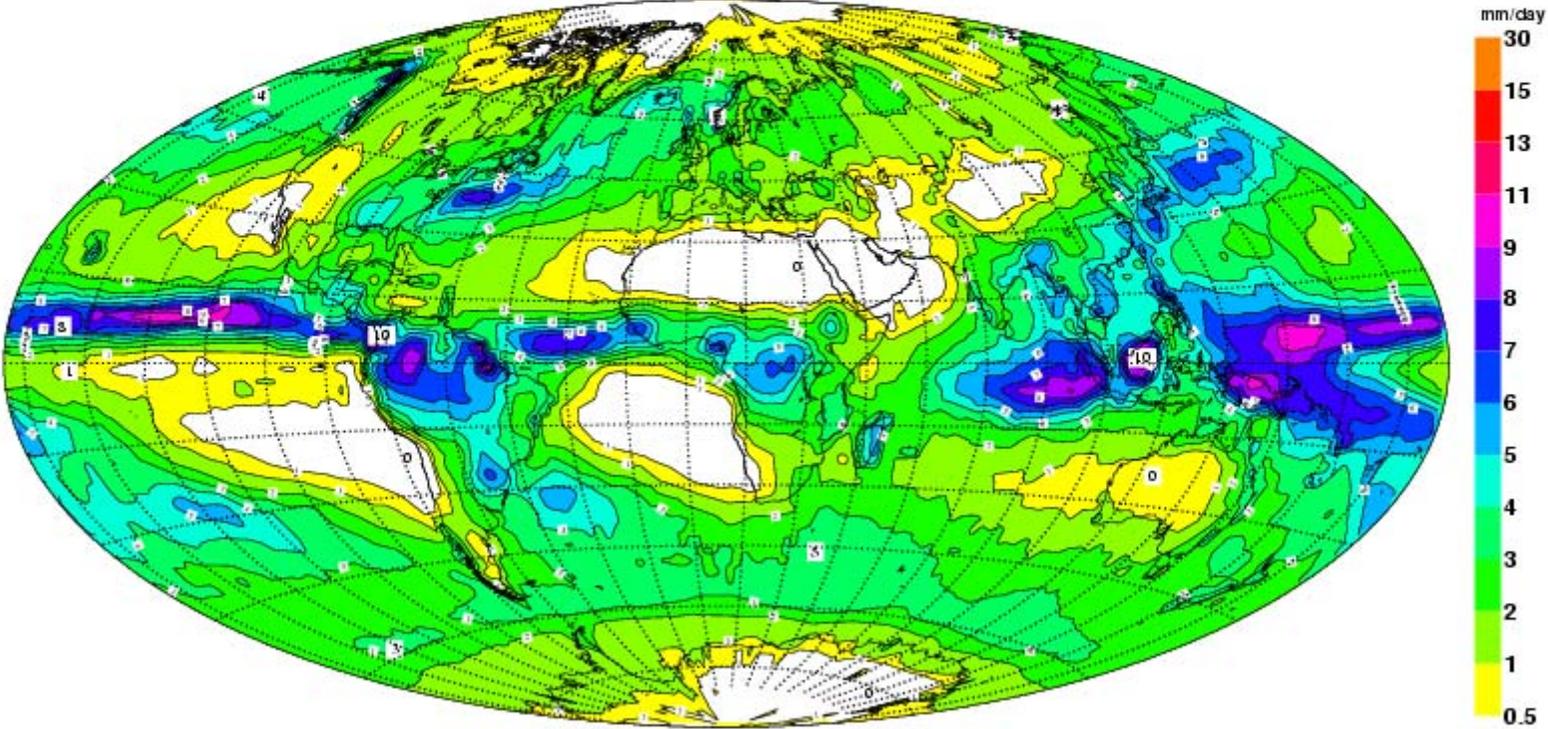
ERA40

0060

0060 – ERA40

GPCP

GPCP 198901 to 199012 2-year mean.
total precipitation

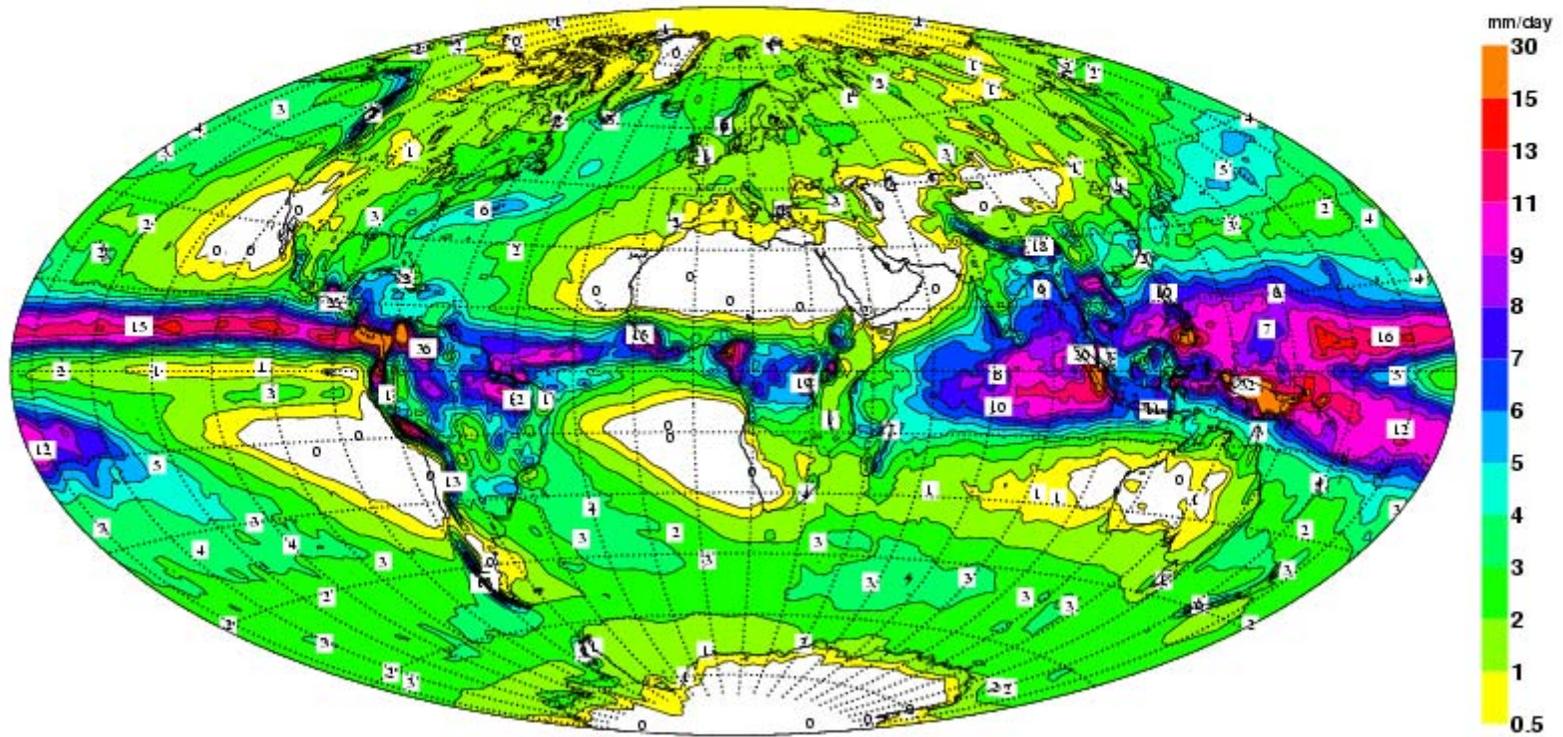


ERA group

ECMWF

ERA40

total precipitation
0001 monthly/daily accumulation. 198901 to 199012 +12h.



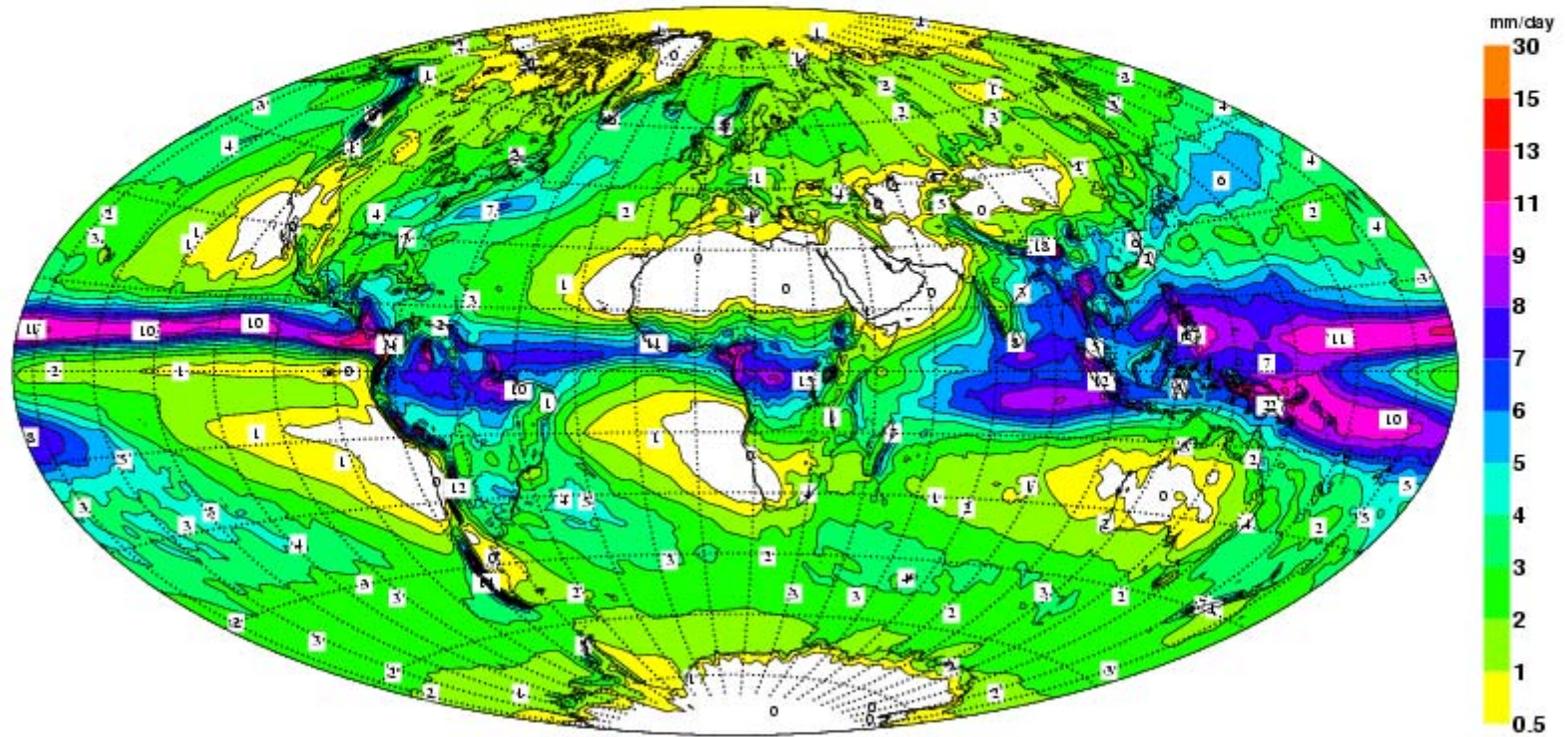
ERA group

ECMWF

ERA workshop June 19-22 2006

0060

total precipitation
0060 monthly/daily accumulation. 198901 to 199012 +12h.



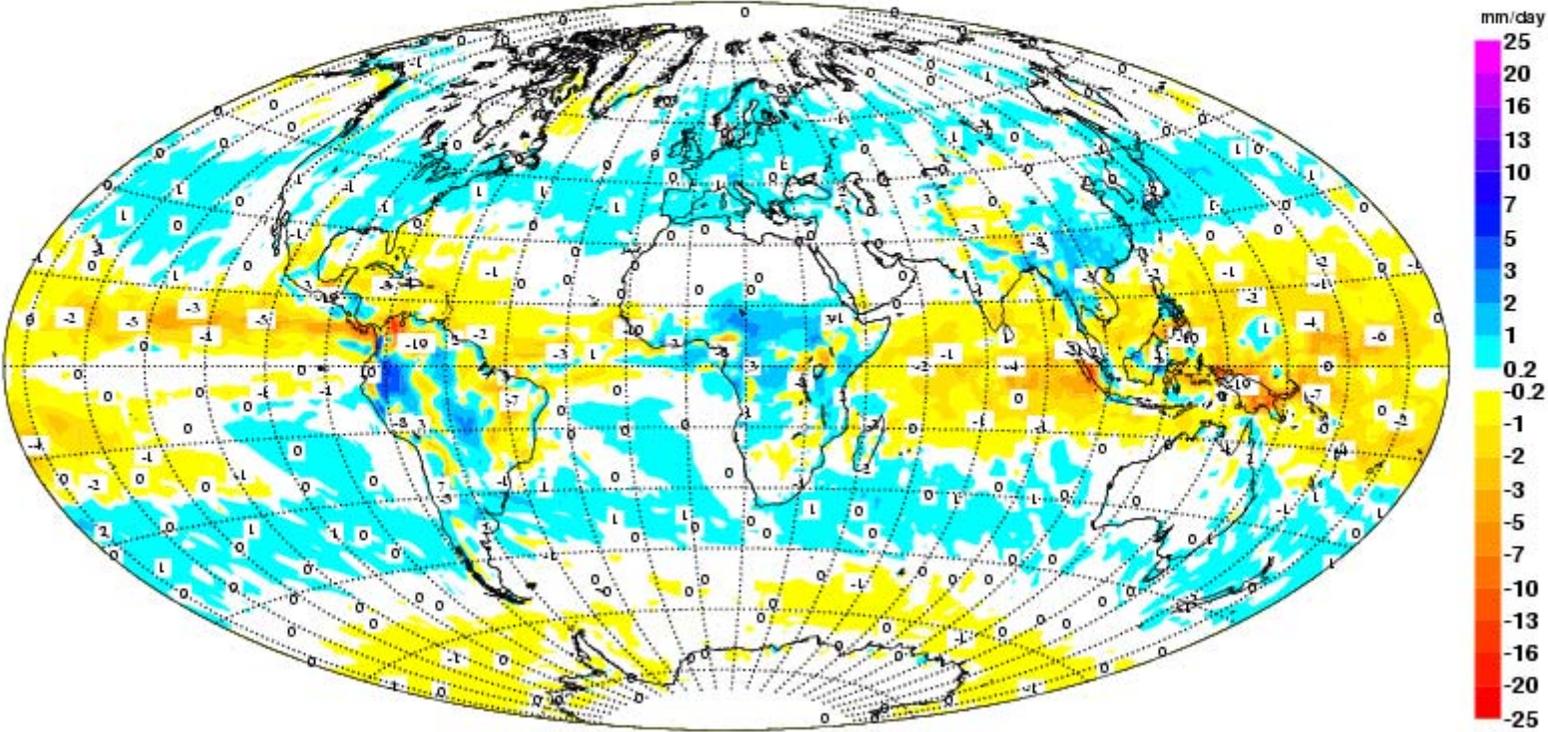
ERA group

ECMWF

ERA workshop June 19-22 2006

0060 – ERA40

total precipitation
0060 2-year (198901 to 199012) +12h
differences to
ERA40 2-year (198901 to 199012) +12h



ERA group

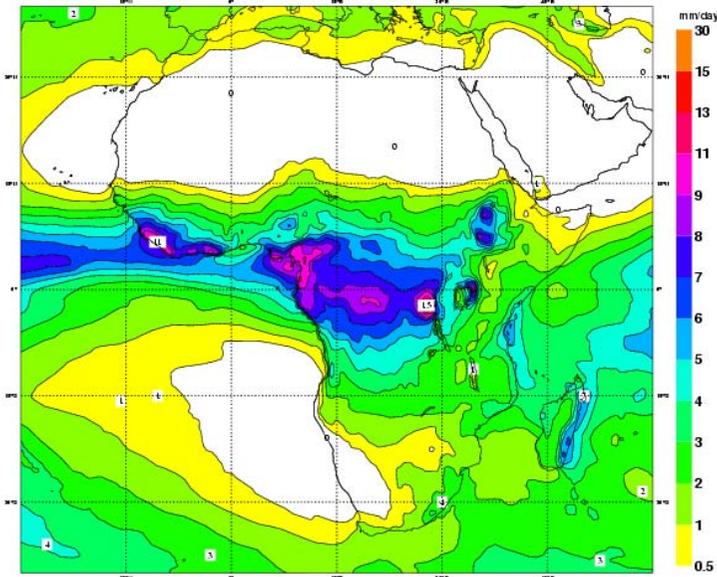
CEMWF

precipitation in different regions

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total precipitation
0000 monthly/daily accumulation, 198901 to 199012 +12h.

0060

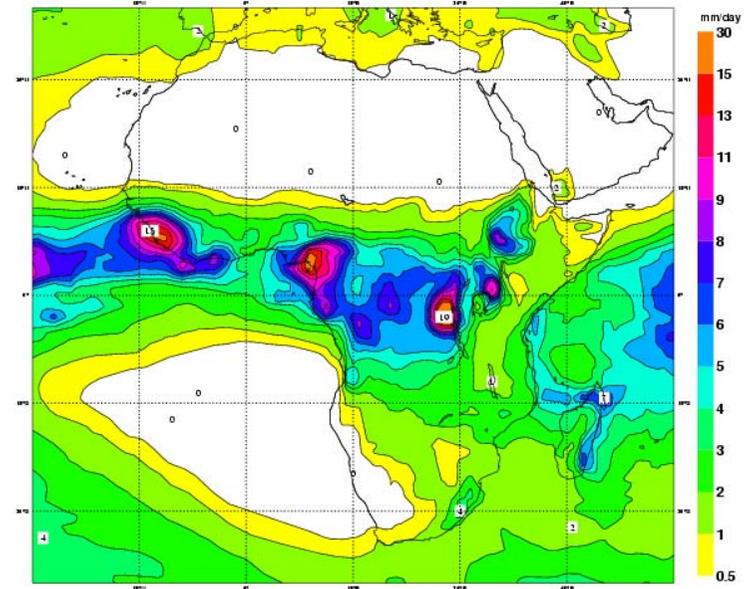


ERA group

mean rain
(mm/day)
in Africa
1989-1990

total precipitation
0001 monthly/daily accumulation, 198901 to 199012 +12h.

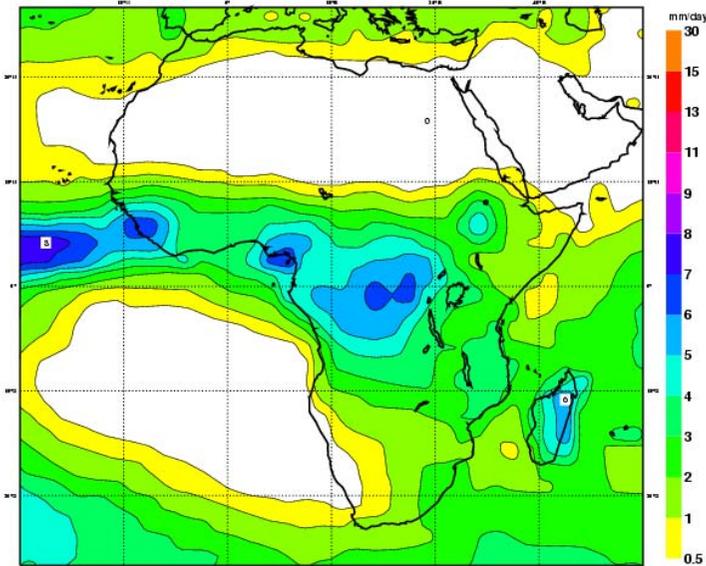
ERA40



CEMWF

GPCP 198901 to 199012 2-year mean.
total precipitation

GPCP

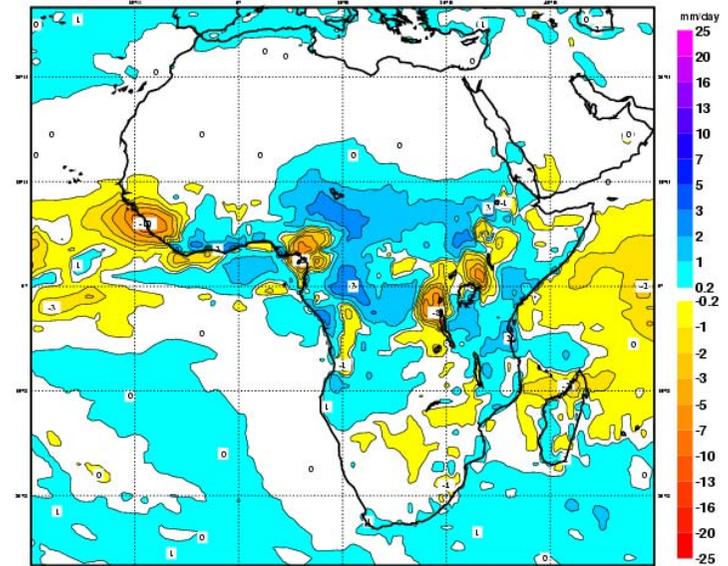


ERA group

0060 better

total precipitation
0000 2-year (198901 to 199012) +12h
differences to
ERA40 2-year (198901 to 199012) +12h

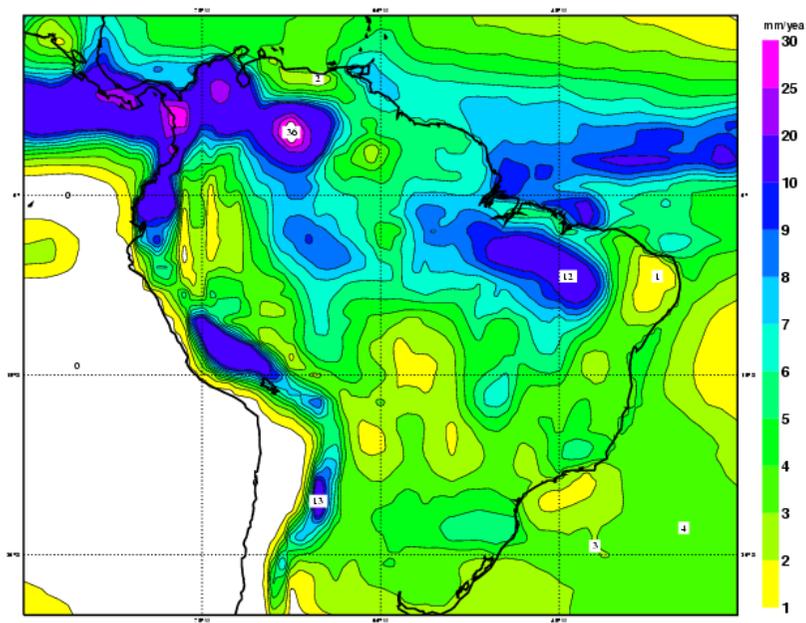
0060 - ERA40



ERA group

≥ 19-2

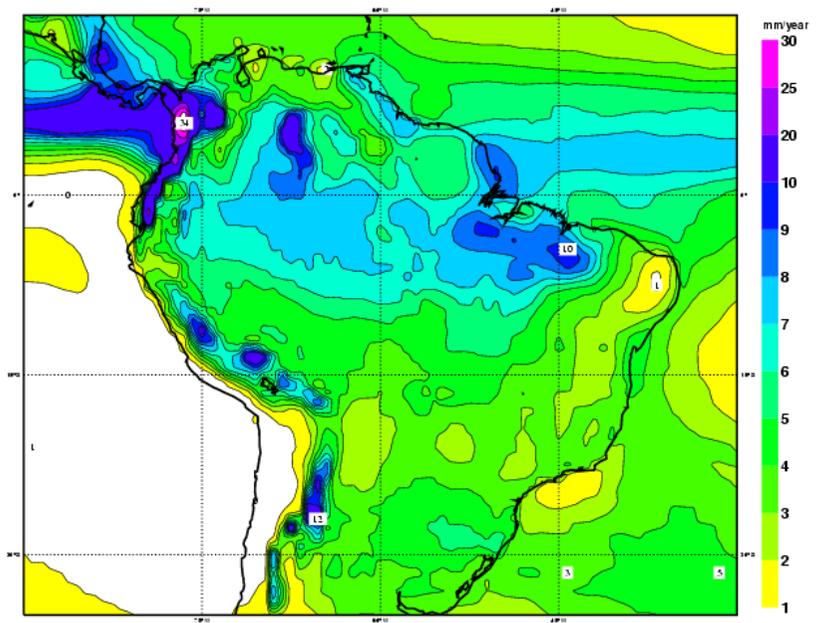
CEMWF



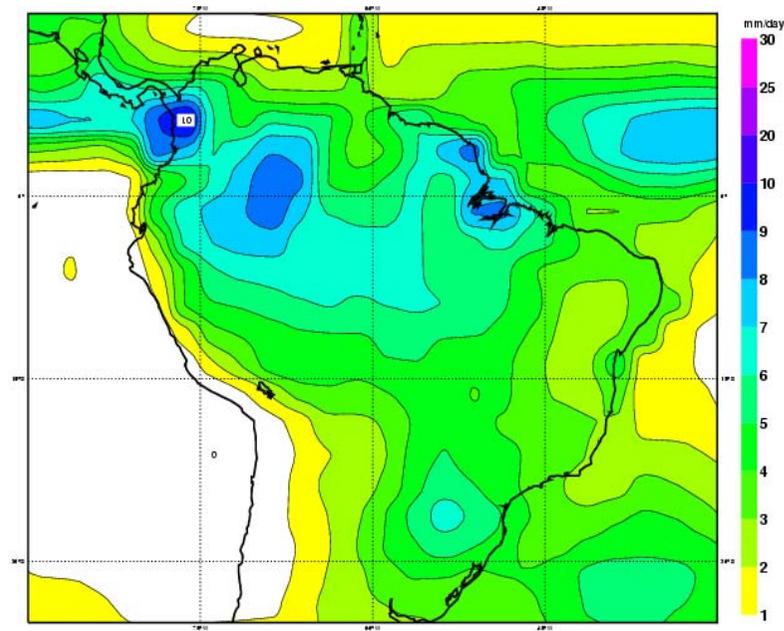
ERA40

ERA group

GPCP 198001 to 199012 2-year mean.
total precipitation



0060 better

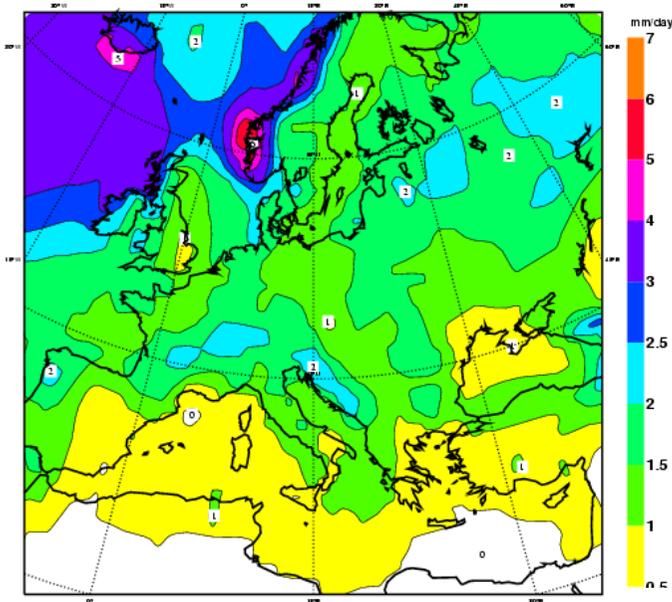


GPCP

ERA group

ECMWF

total precipitation
0001 monthly/daily accumulation. 198901 to 199012 +12h.

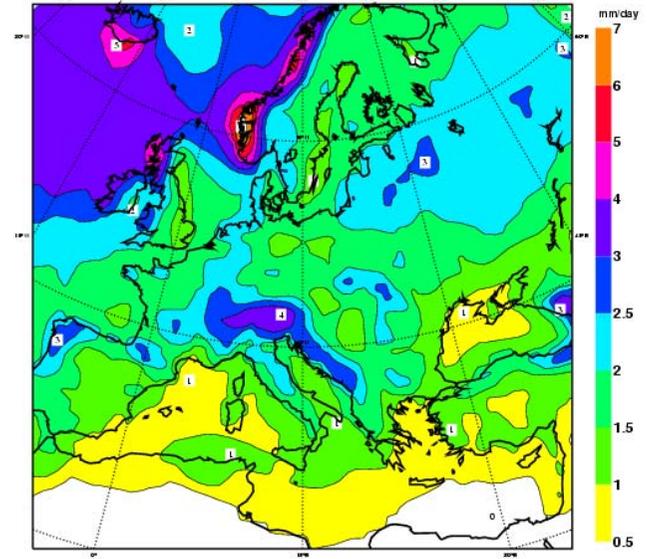


ERA group

ERA40

mean precipitation
(mm/day)
in Europe
1989-1990

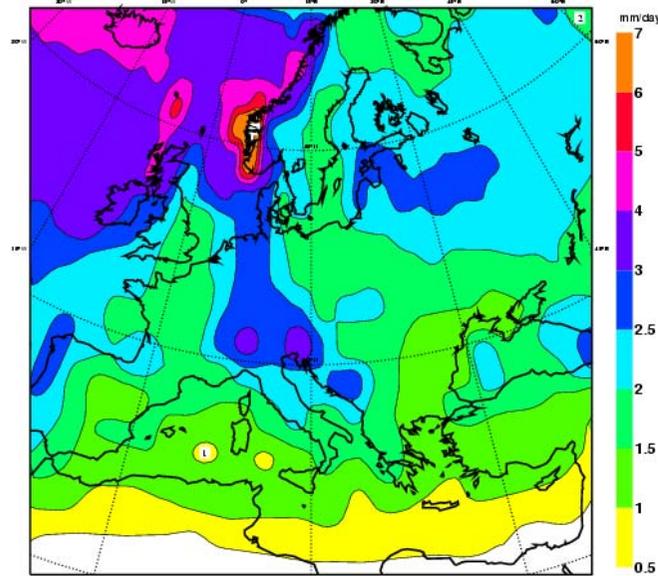
total precipitation
0060 monthly/daily accumulation. 198901 to 199012 +12h.



ERA group

0060 better

GPCP 198901 to 199012 2-year mean.
total precipitation



ERA group

GPCP

CEMWF

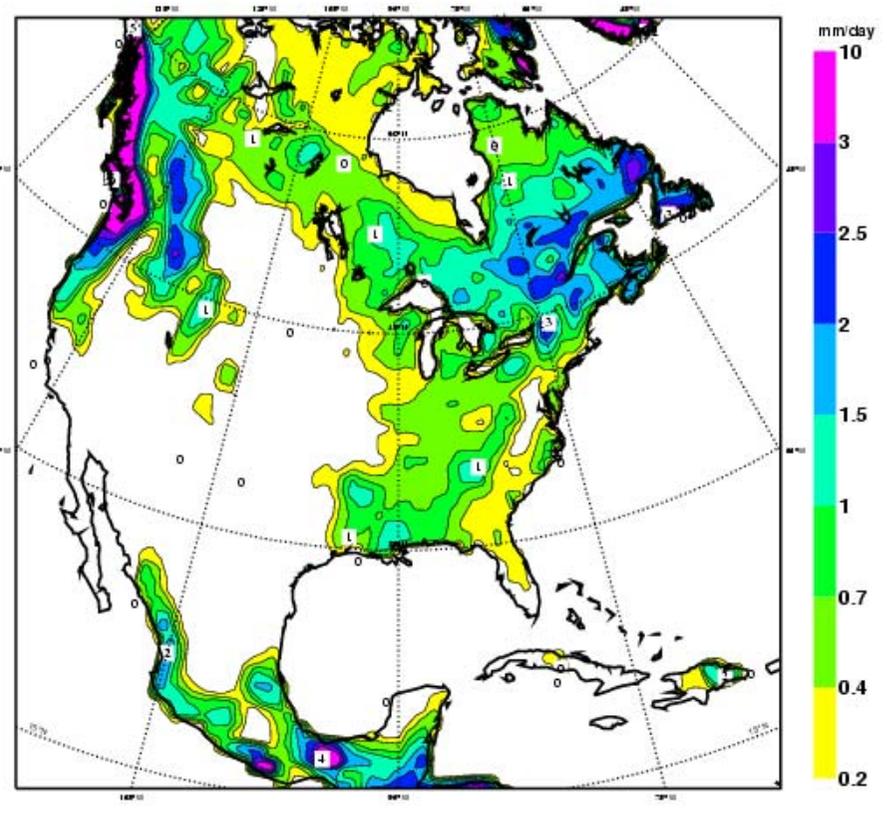
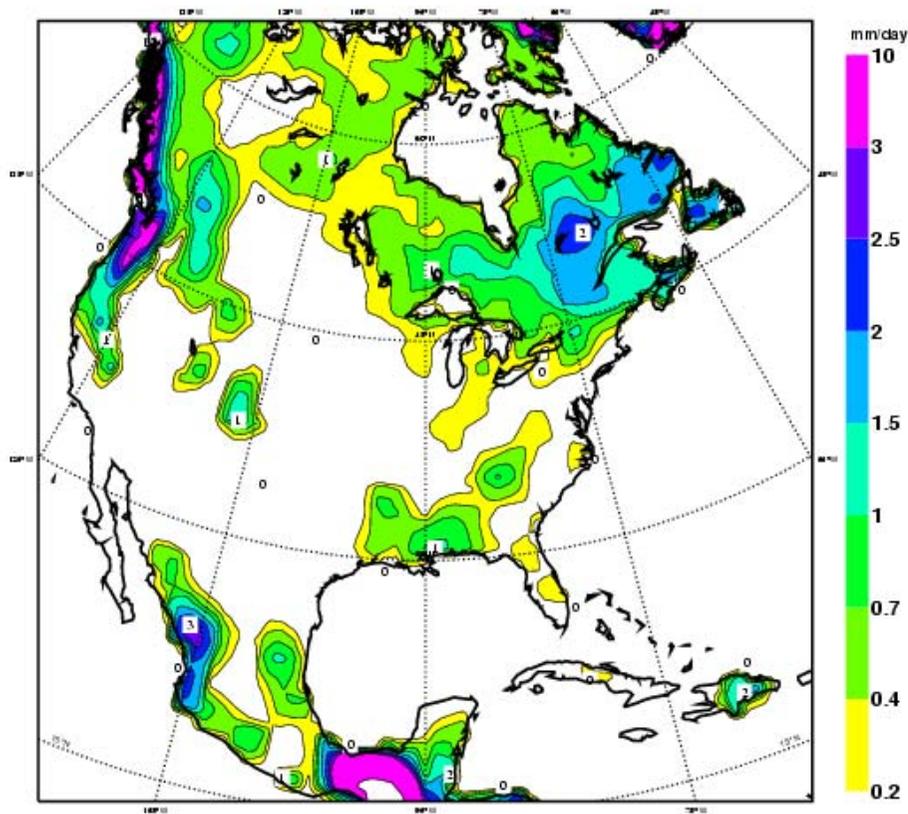
residual run-off
(mm/day)
in North America
1989-1990

ERA40

0060

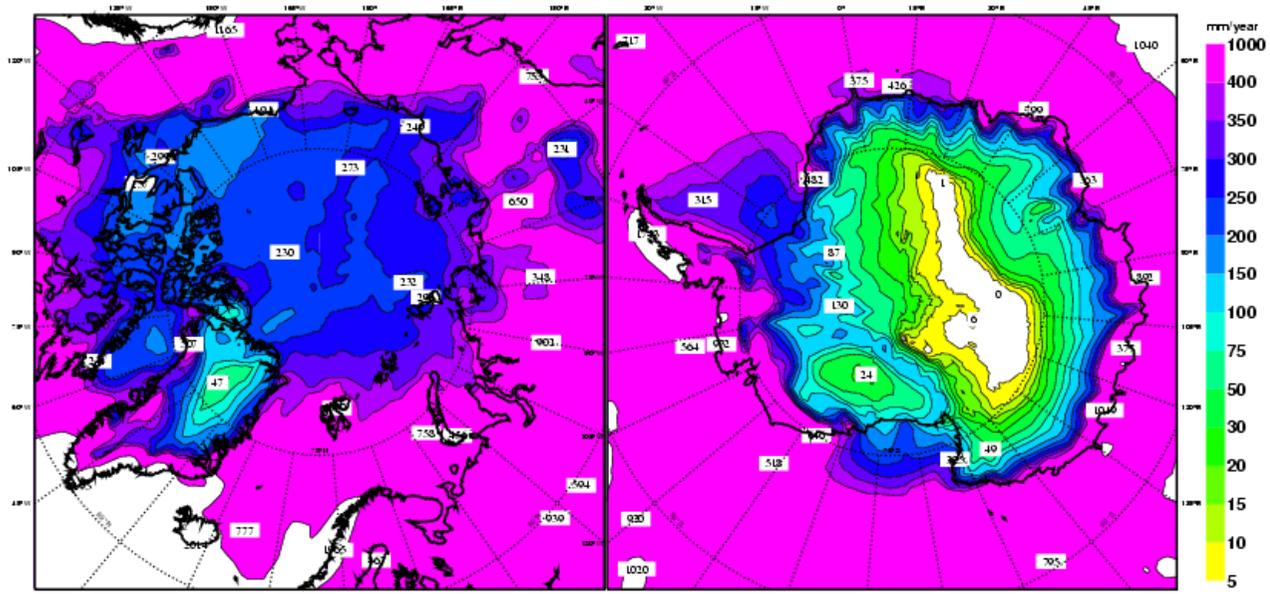
residual runoff
0001 monthly/daily accumulation. 198901 to 199012 +12h.

residual runoff
0060 monthly/daily accumulation. 198901 to 199012 +12h.



CSLA group

CSLA group

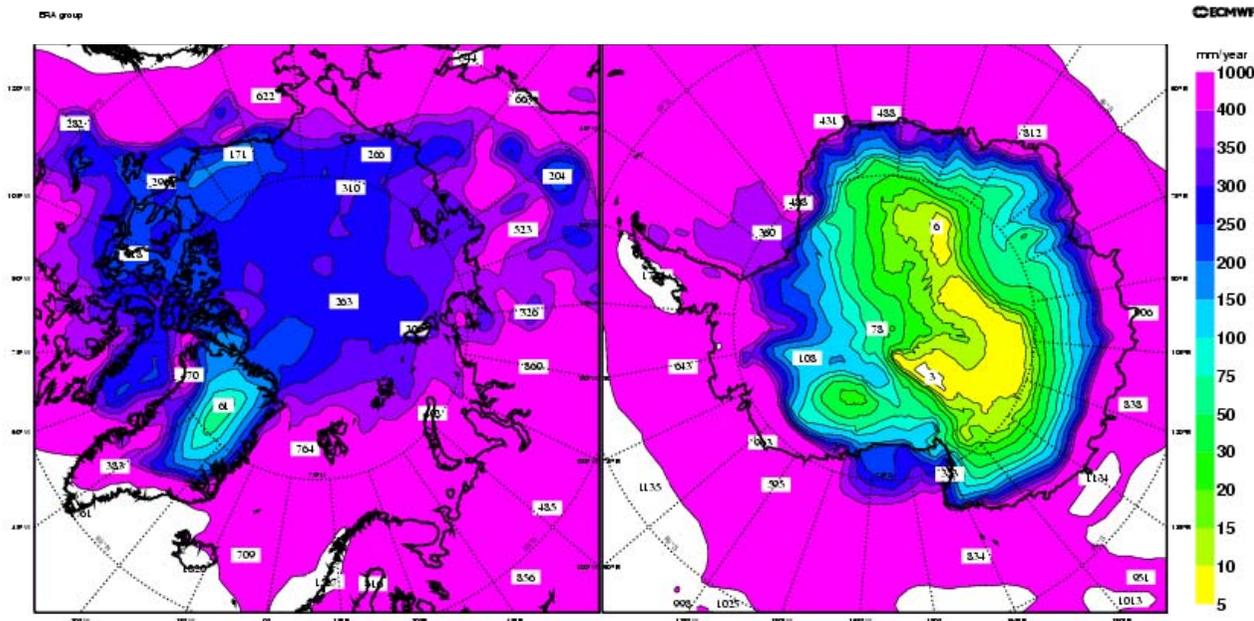


Annual mean precipitation 1989-1990

0060

drier minima in 0060

there was an interpolation error in the SST near the Antarctic coast in 0060



ERA-40

**precipitation
time series 1979-2002**

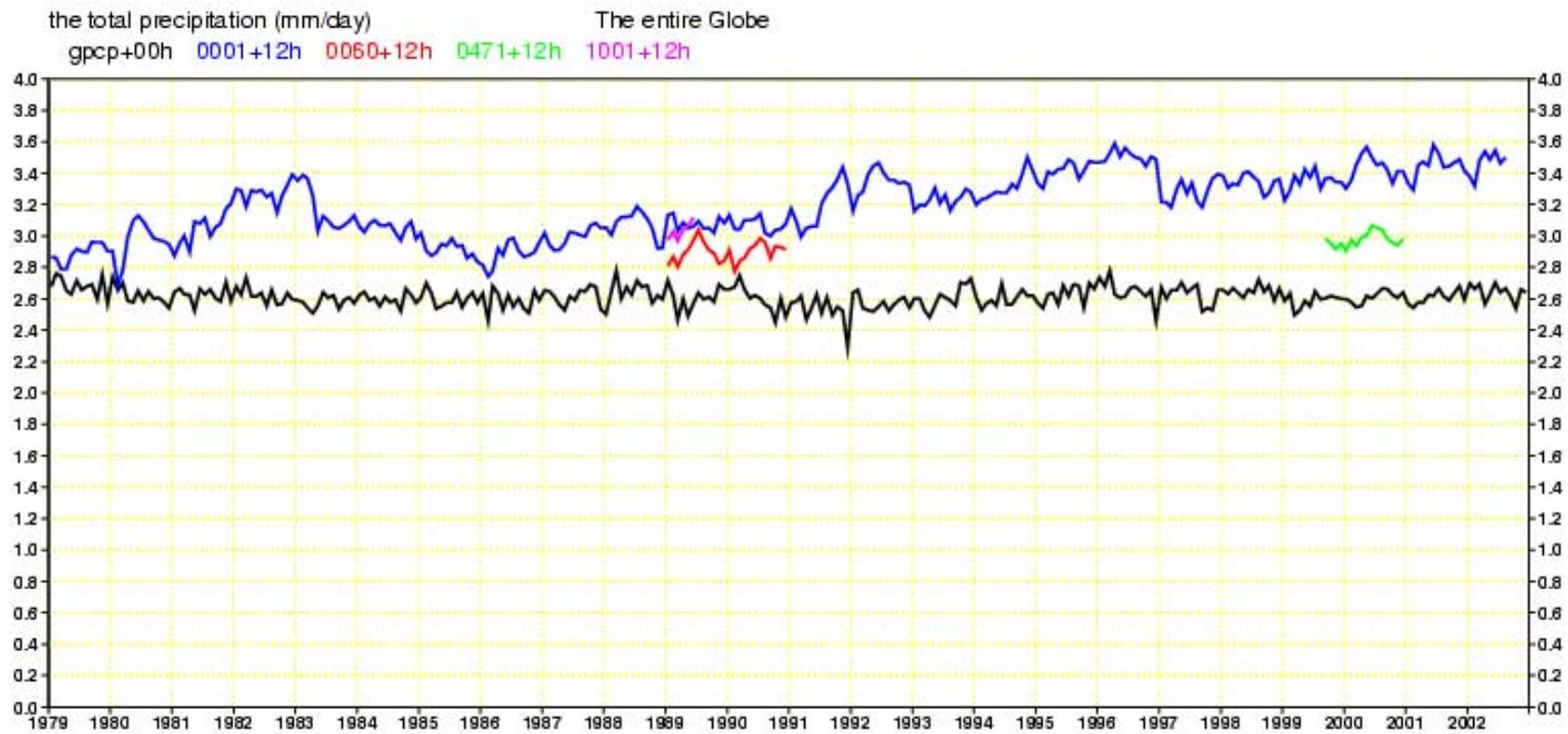
GPCP

ERA40

0060

global precipitation (mm/day) 1979-2002

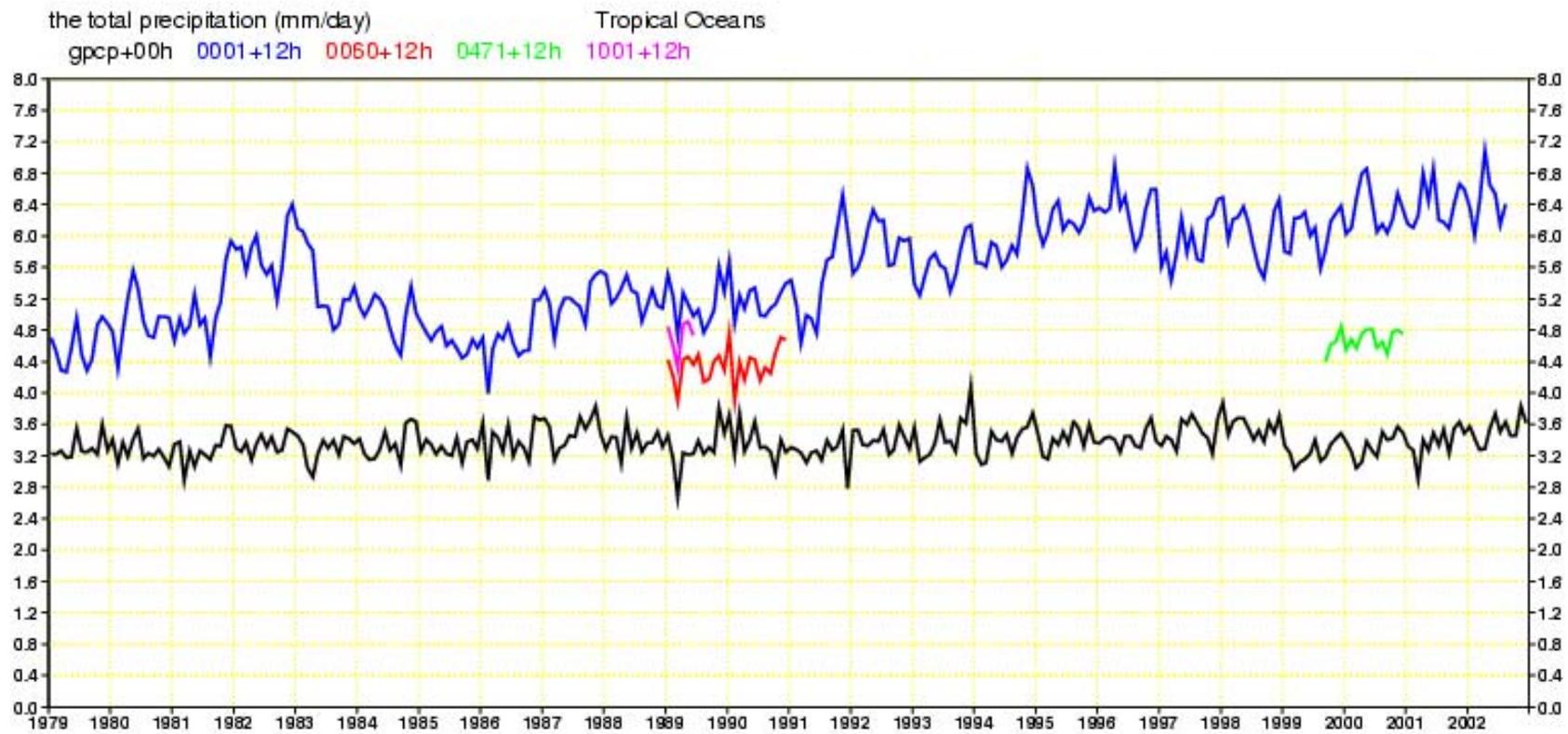
ERA40 0060 0471 1001 GPCP



tropical (20°N-20°S) ocean precipitation (mm/day) 1979-2002

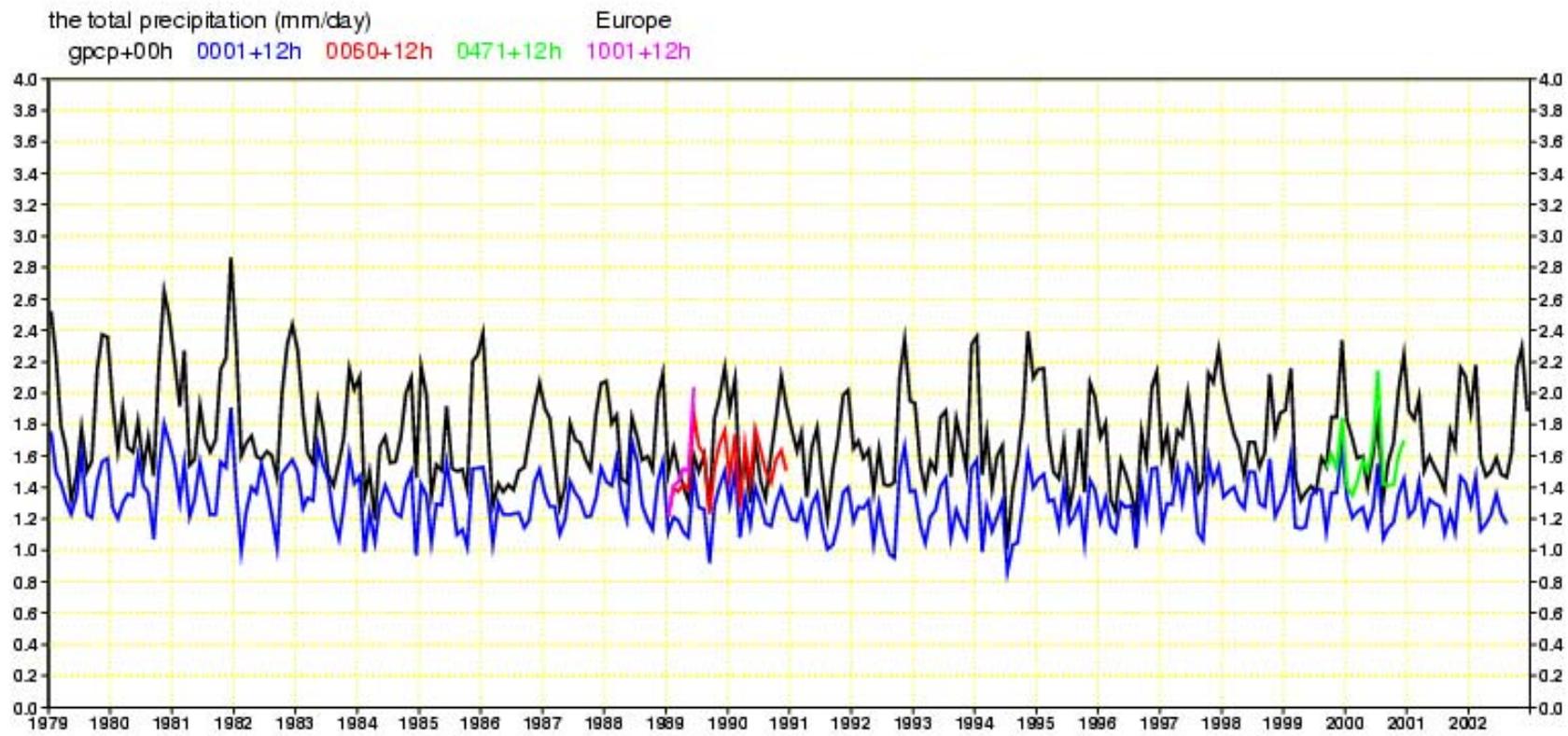
ERA40 0060 0471 1001 GPCP

now no increase from 1989-1990 to 1999-2000



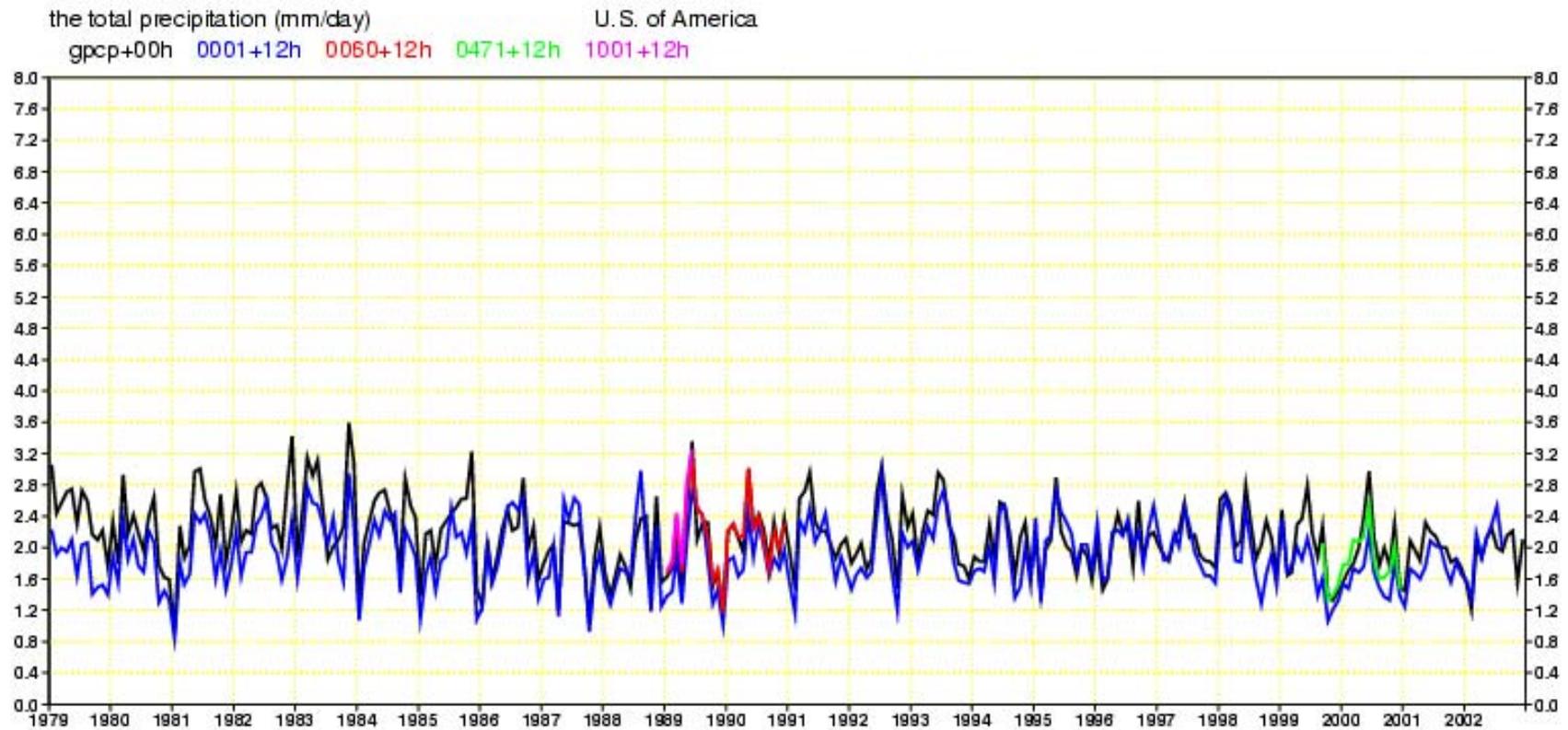
Europe (land) precipitation (mm/day) 1979-2002

ERA40 0060 0471 1001 GPCP



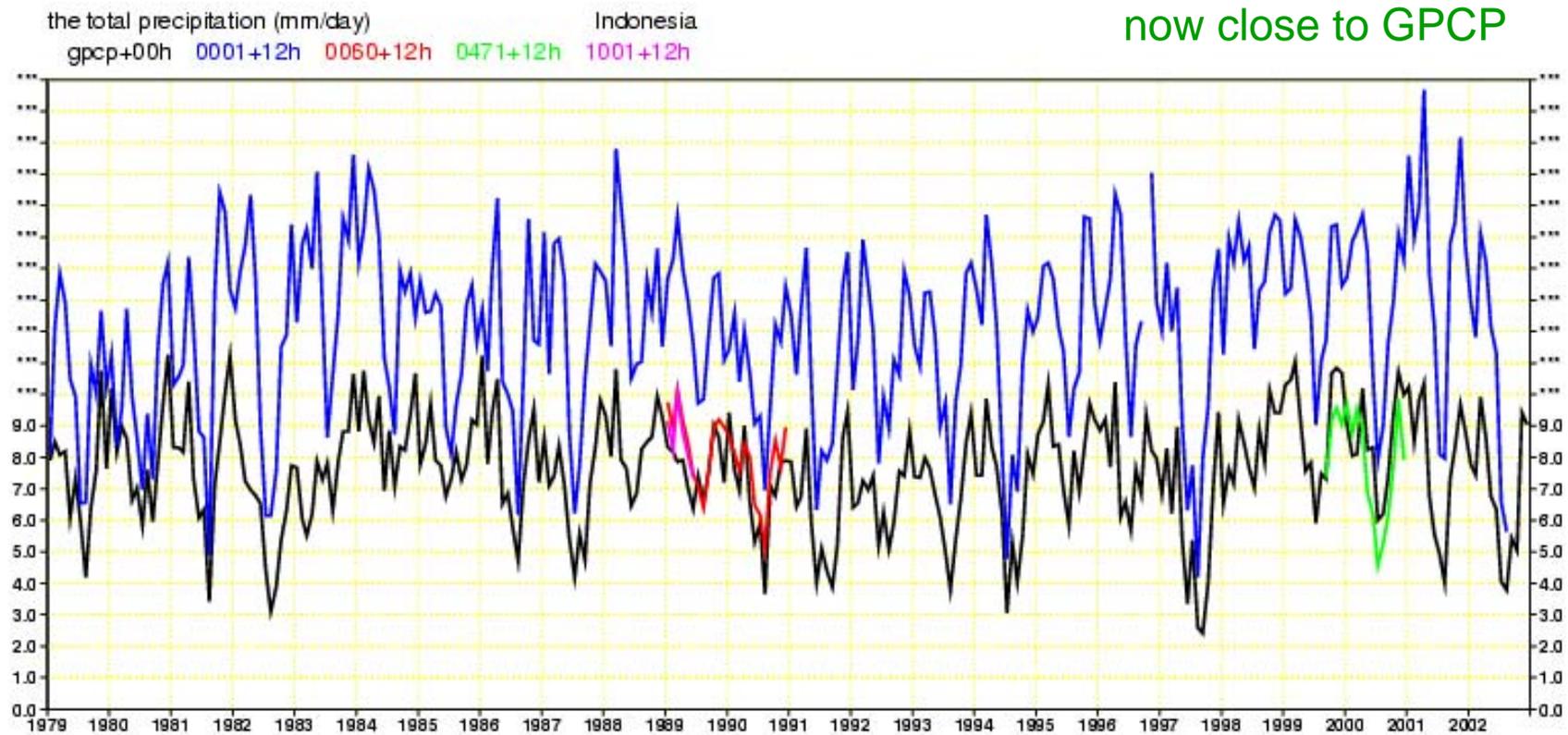
USA (land) precipitation (mm/day) 1979-2002

ERA40 0060 0471 1001 GPCP



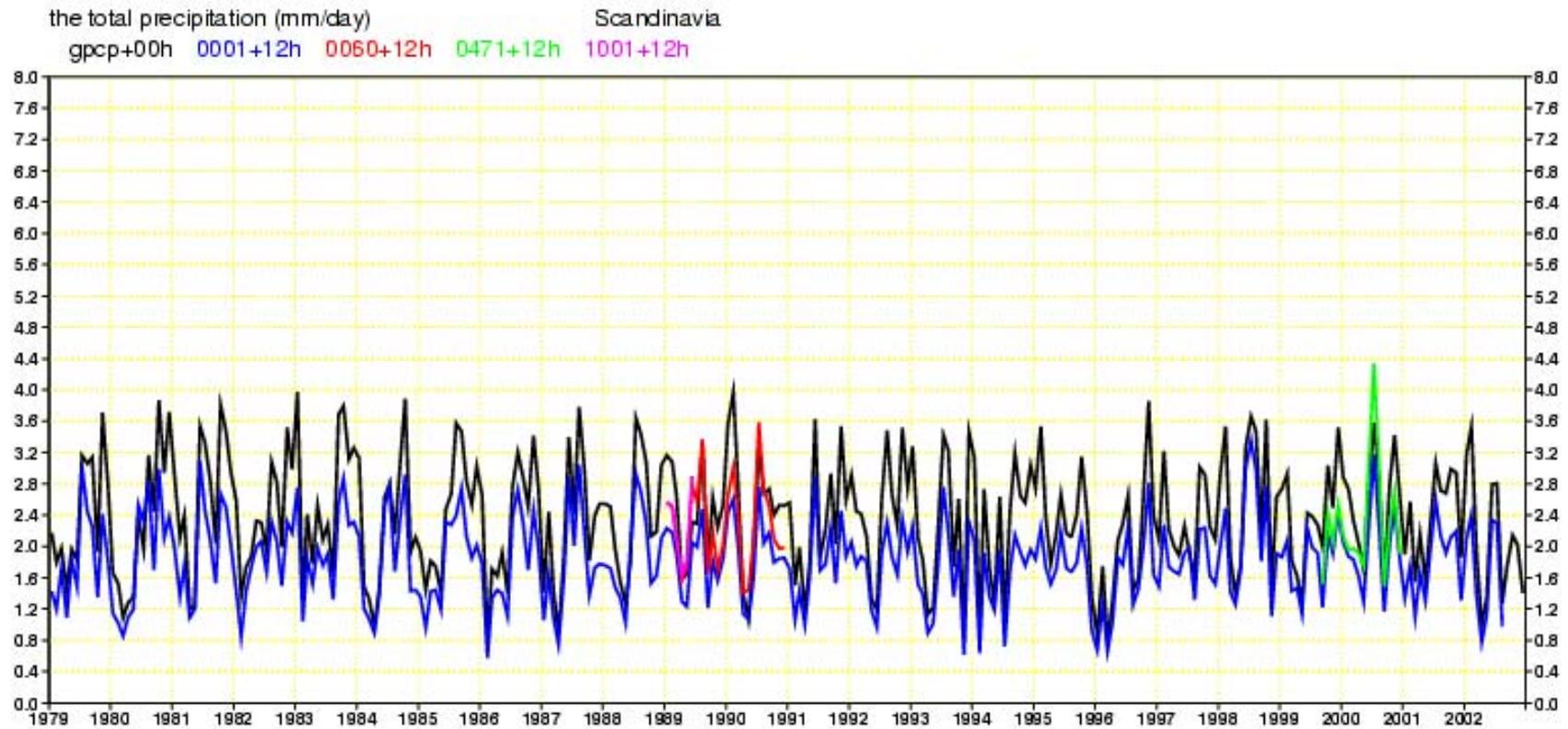
Indonesia (land) precipitation (mm/day) 1979-2002

ERA40 0060 0471 1001 GPCP



Scandinavia (land) precipitation (mm/day) 1979-2002

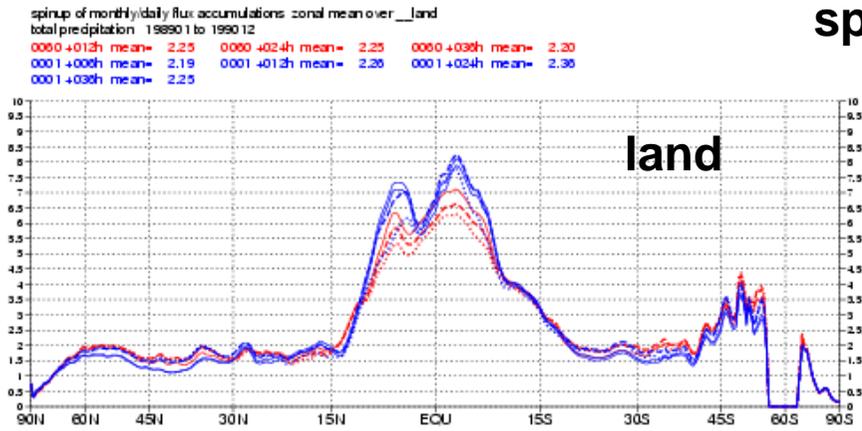
ERA40 0060 0471 1001 GPCP



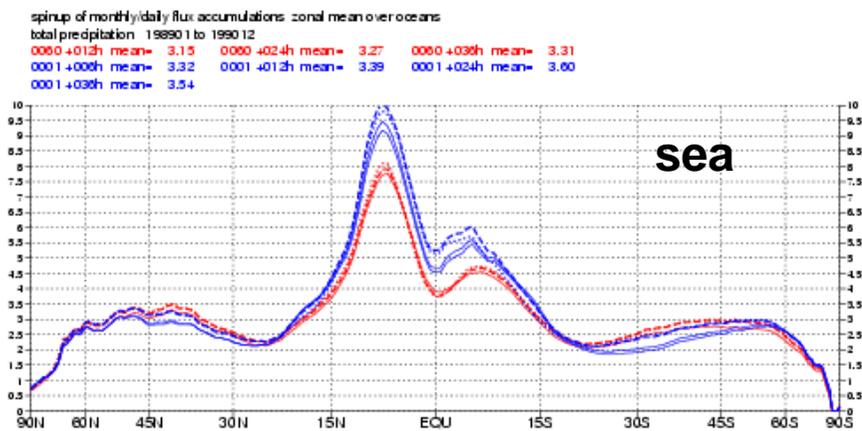
precipitation spin-up

ERA workshop June 19-22 2006

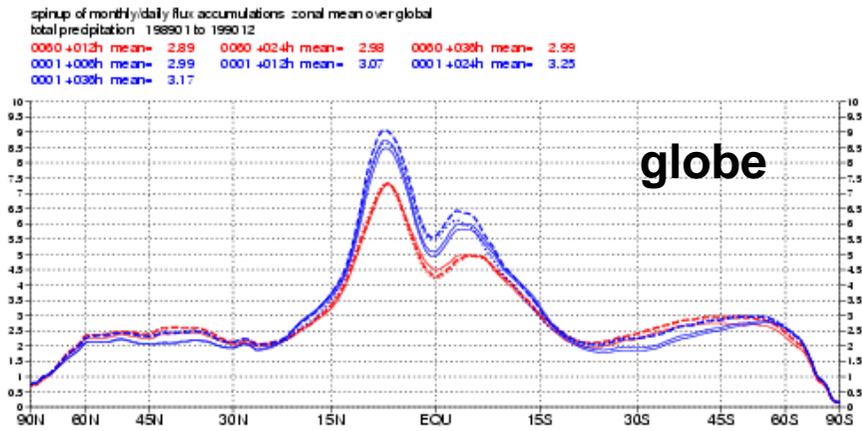
spin-up of total precipitation 1989-1990



land	+06h	+12h	+24h	+36h
ERA40	2.19	2.26	2.36	2.25
0060	-	2.25	2.25	2.20



sea	+06h	+12h	+24h	+36h
ERA40	3.32	3.39	3.60	3.54
0060	-	3.15	3.27	3.31



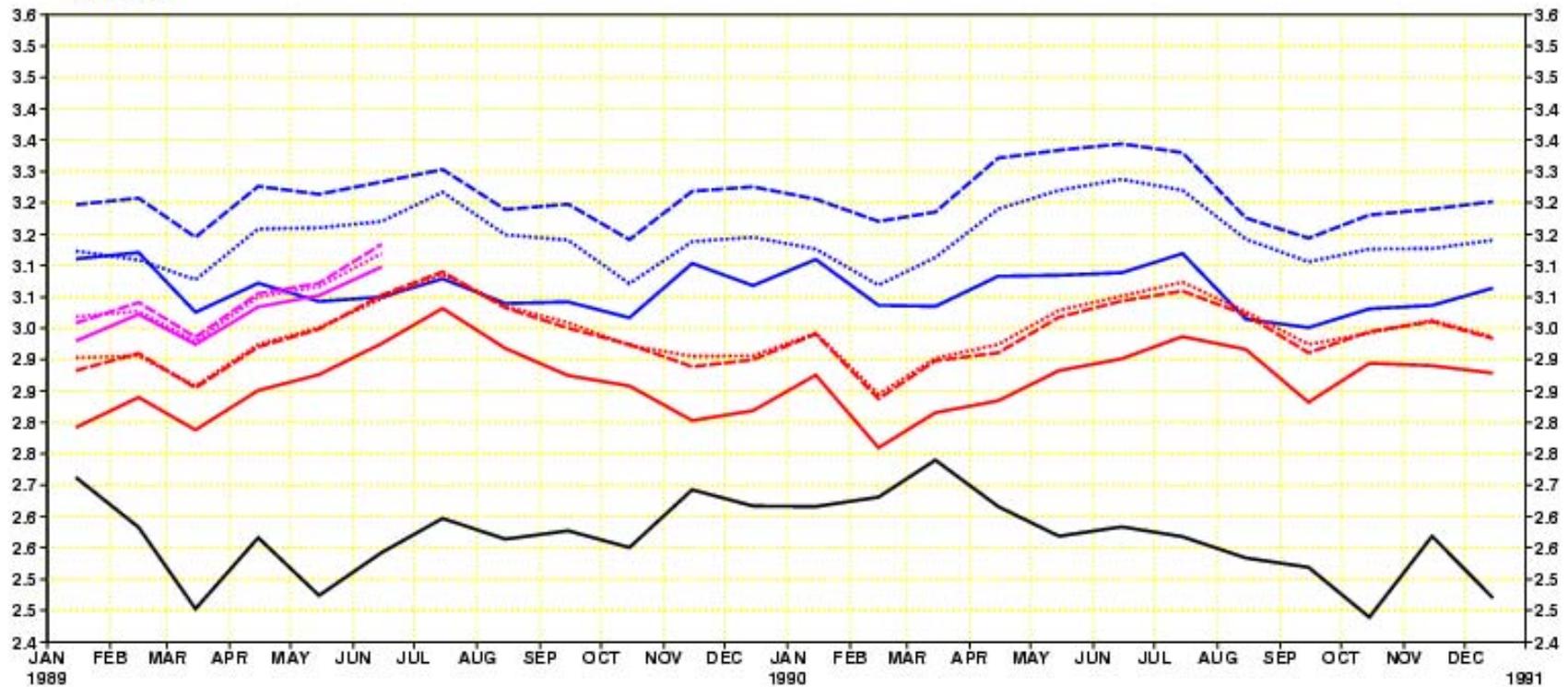
globe	+06h	+12h	+24h	+36h
ERA40	2.99	3.07	3.25	3.17
0060	-	2.89	2.98	2.99

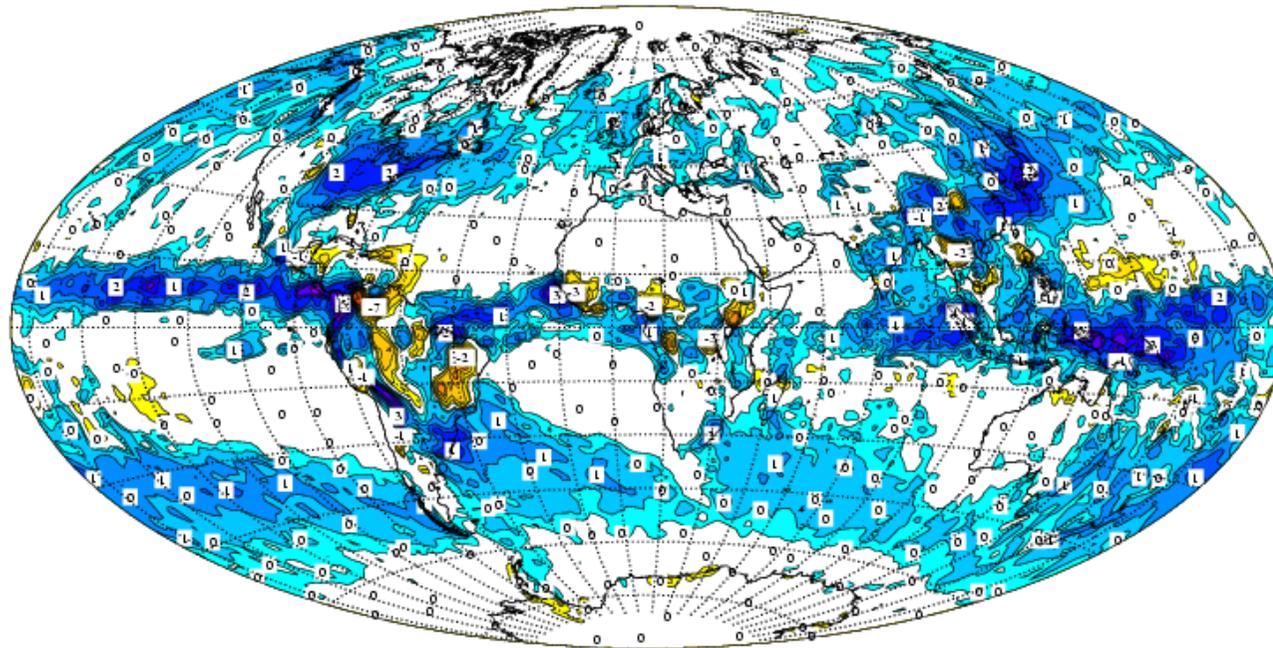
monthly precipitation (spin-up) 1989-1990 globally



the total precipitation (mm/day) The entire Globe

gpcp+00h 0001+12h 0001+24h 0001+36h 0060+12h 0060+24h
 0060+36h 0471+12h 0471+24h 0471+36h 1001+12h 1001+24h
 1001+36h

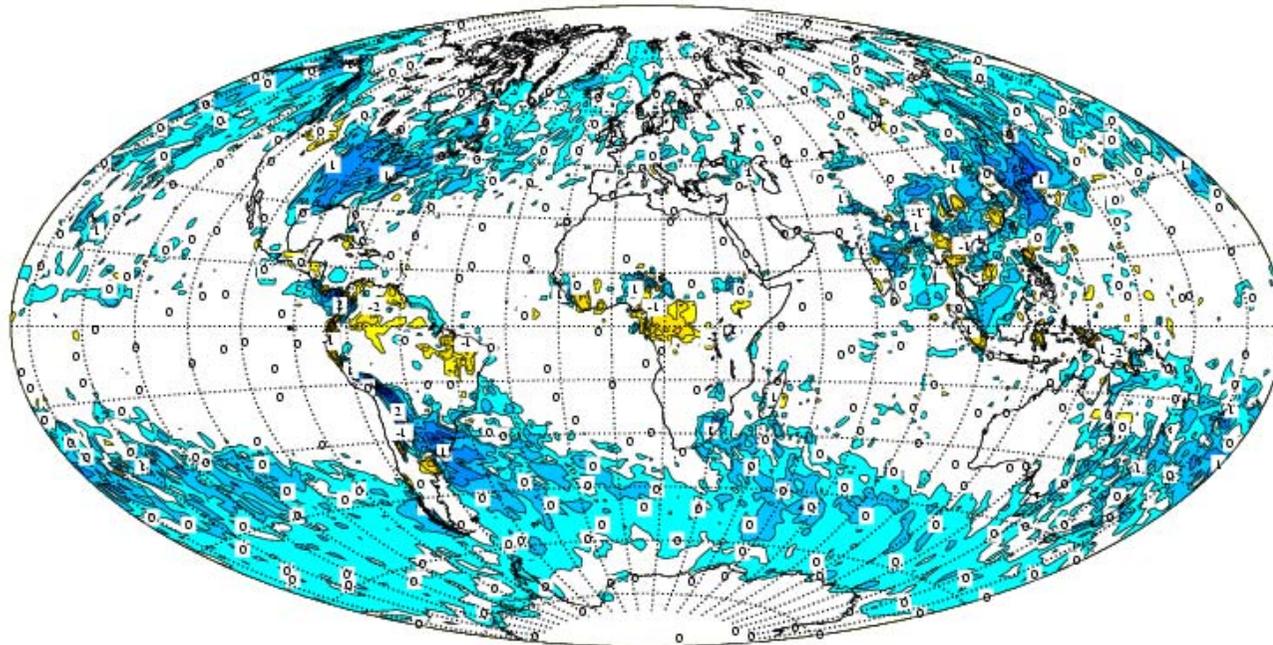




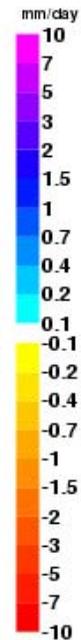
stratiform
precipitation

spin-up +12h to +24h
ERA40

ERA group



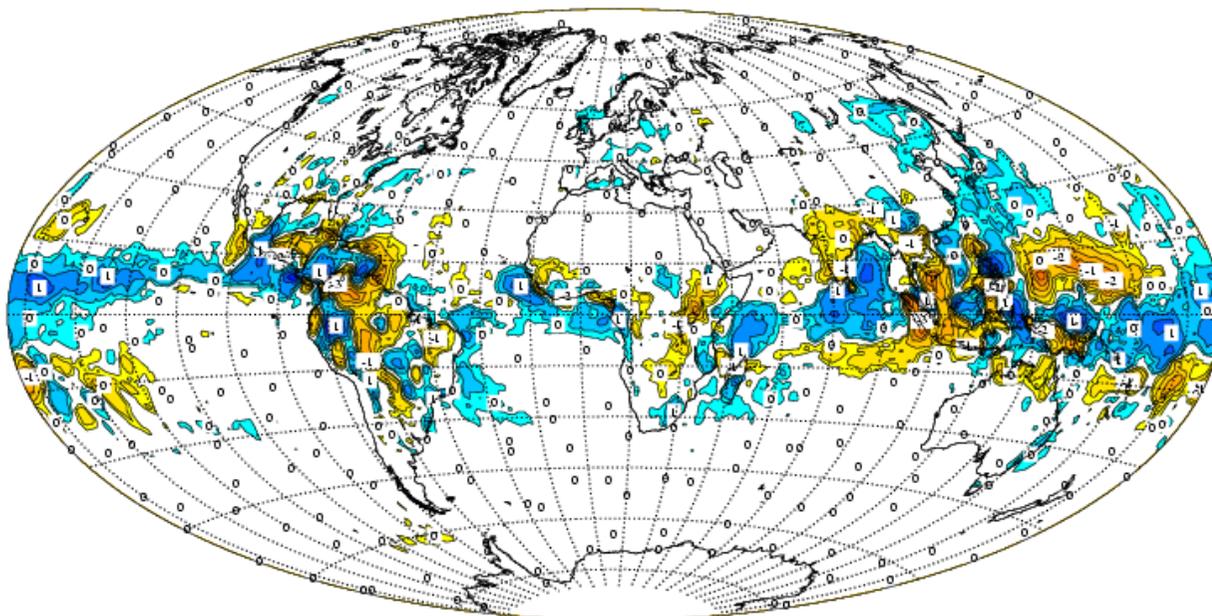
GCMWF



197901-198012

spin-up +12h to +24h
0060

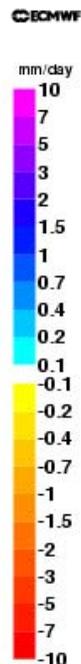
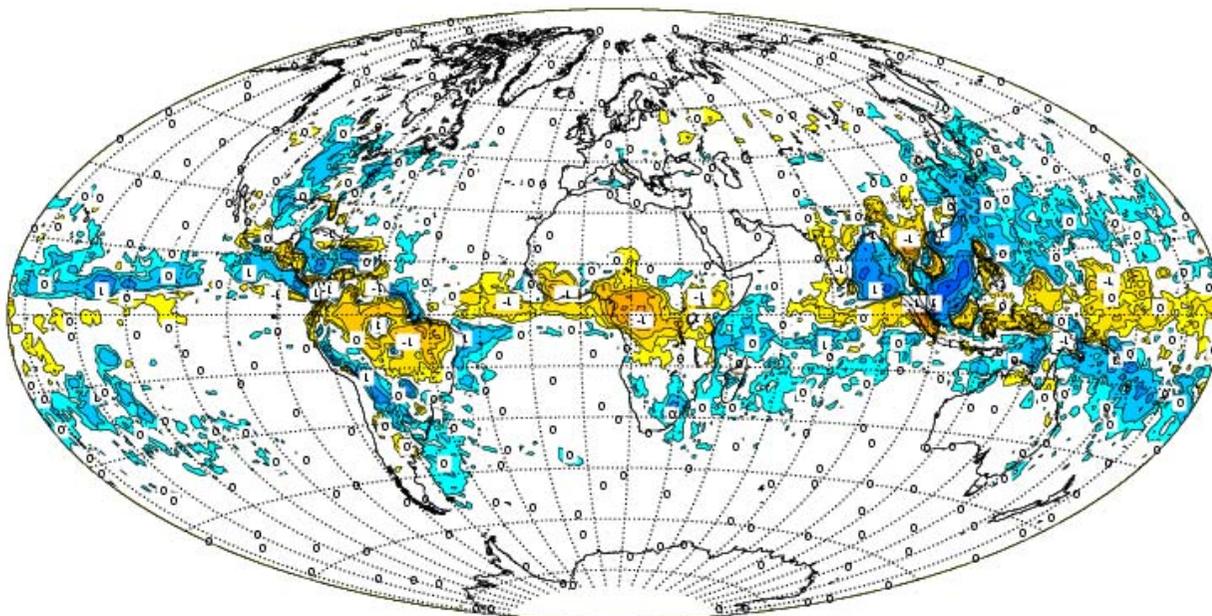
0001 2-year (198901 to 199012) +12h



**convective
precipitation**

**spin-up +12h to +24h
ERA40**

ERA group



197901-198012

**spin-up +12h to +24h
0060**

ERA group

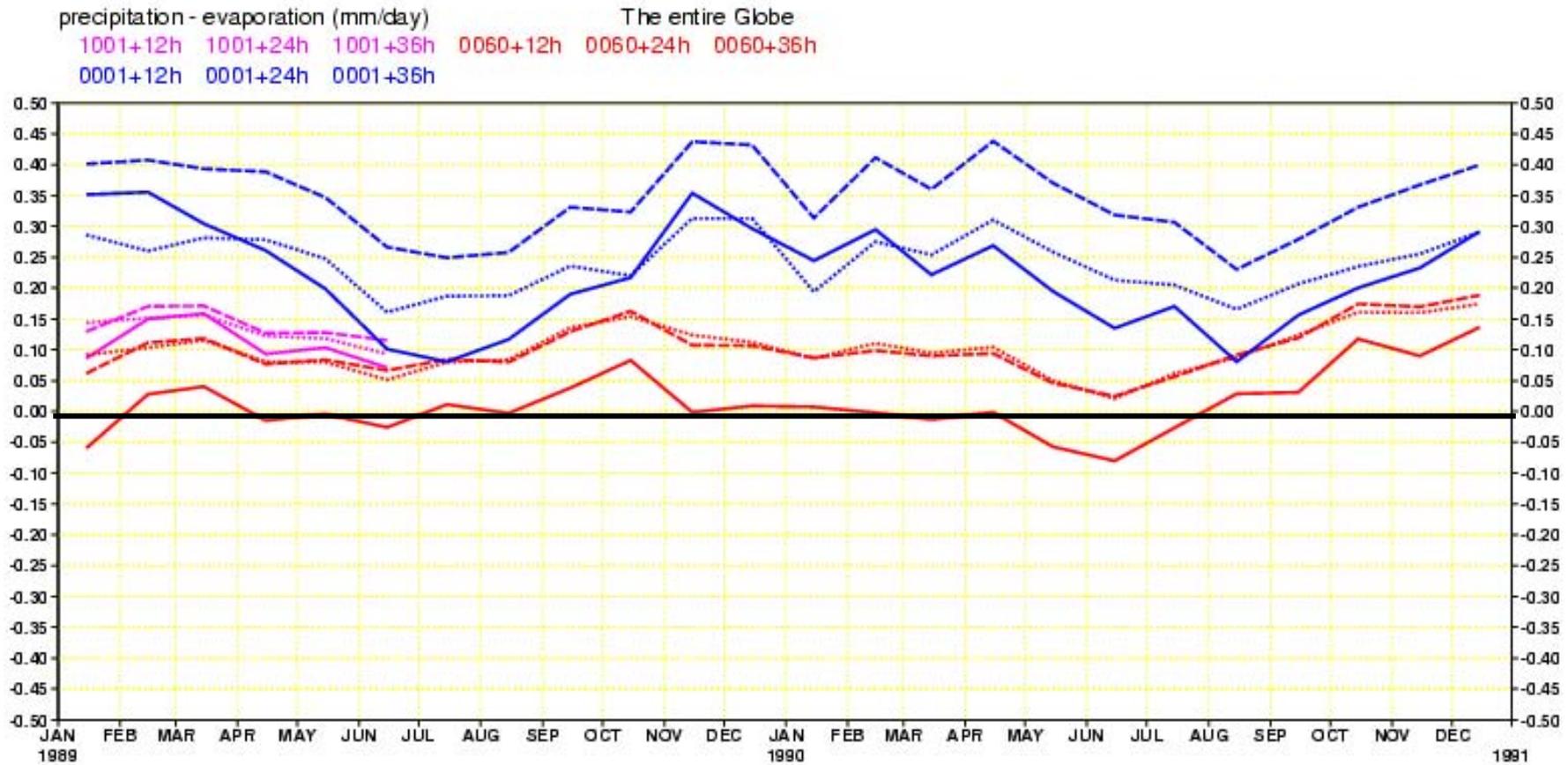
CEMWF

“P minus E”

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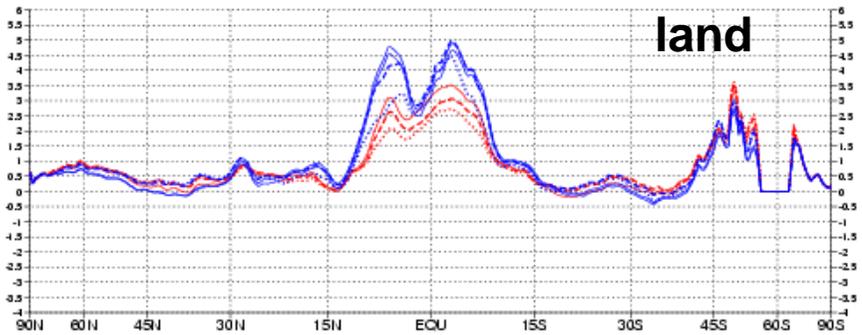
monthly precipitation minus evaporation 1989-1990 globally

- 12h
- - - - 24h - 12h
- 36h - 24h



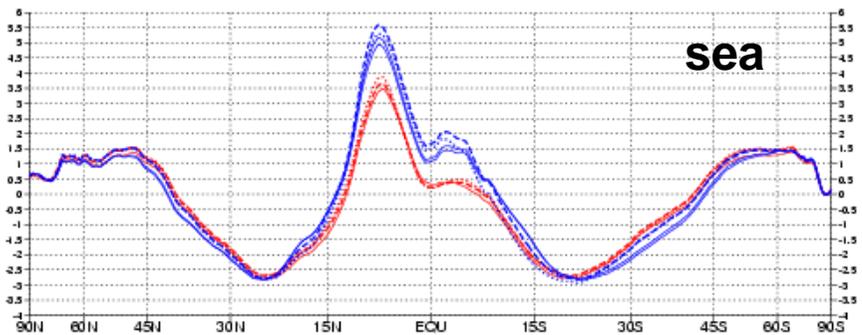
spin-up of P-E 1989-1990

spinup of monthly/daily flux accumulations: zonal mean over __land
 precipitation - evaporation: 198901 to 199012
 0000 +012h mean= 0.72 0000 +024h mean= 0.74 0000 +036h mean= 0.69
 0001 +006h mean= 0.78 0001 +012h mean= 0.85 0001 +024h mean= 0.94
 0001 +036h mean= 0.83



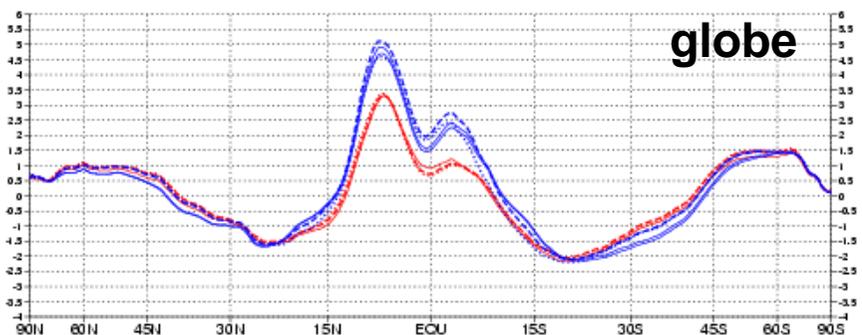
land	+06h	+12h	+24h	+36h
ERA40	0.78	0.85	0.94	0.83
0060	-	0.72	0.74	0.69

spinup of monthly/daily flux accumulations: zonal mean over oceans
 precipitation - evaporation: 198901 to 199012
 0000 +012h mean= -0.28 0000 +024h mean= -0.16 0000 +036h mean= -0.14
 0001 +006h mean= -0.10 0001 +012h mean= -0.04 0001 +024h mean= 0.10
 0001 +036h mean= 0.00



sea	+06h	+12h	+24h	+36h
ERA40	-0.10	-0.04	0.10	0.00
0060	-	-0.28	-0.16	-0.14

spinup of monthly/daily flux accumulations: zonal mean over global
 precipitation - evaporation: 198901 to 199012
 0000 +012h mean= 0.01 0000 +024h mean= 0.10 0000 +036h mean= 0.10
 0001 +006h mean= 0.15 0001 +012h mean= 0.21 0001 +024h mean= 0.34
 0001 +036h mean= 0.24



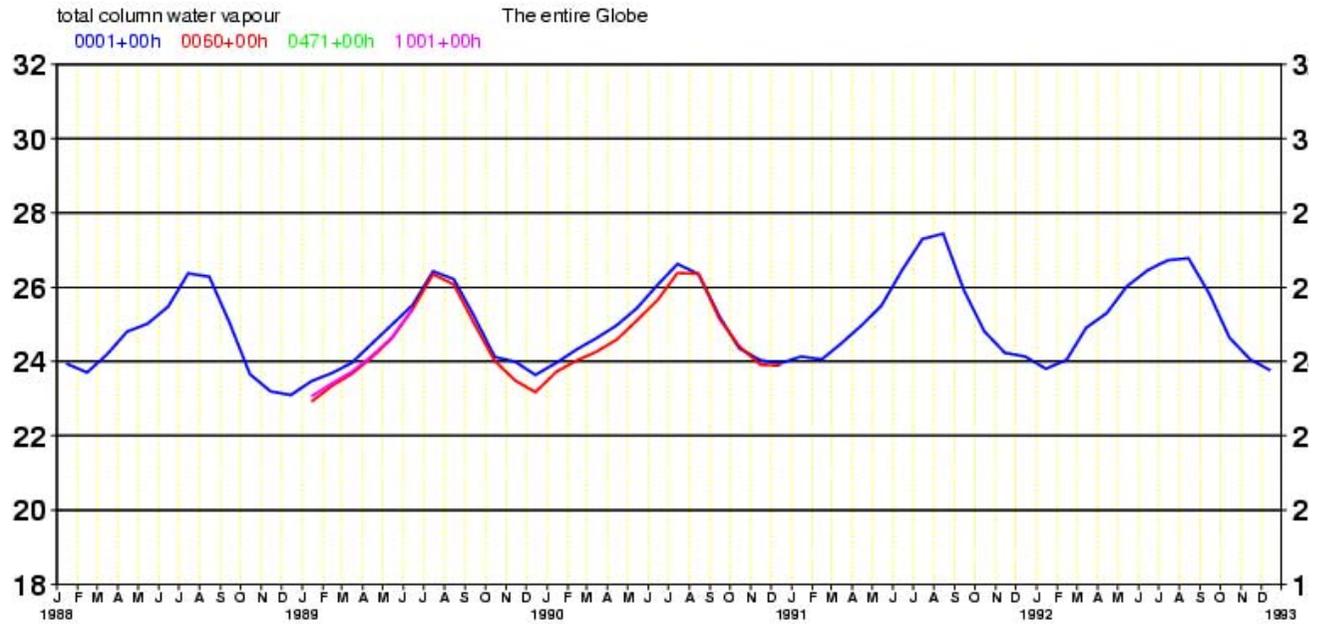
globe	+06h	+12h	+24h	+36h
ERA40	0.15	0.21	0.34	0.24
0060	-	0.01	0.10	0.10

atmospheric water and clouds

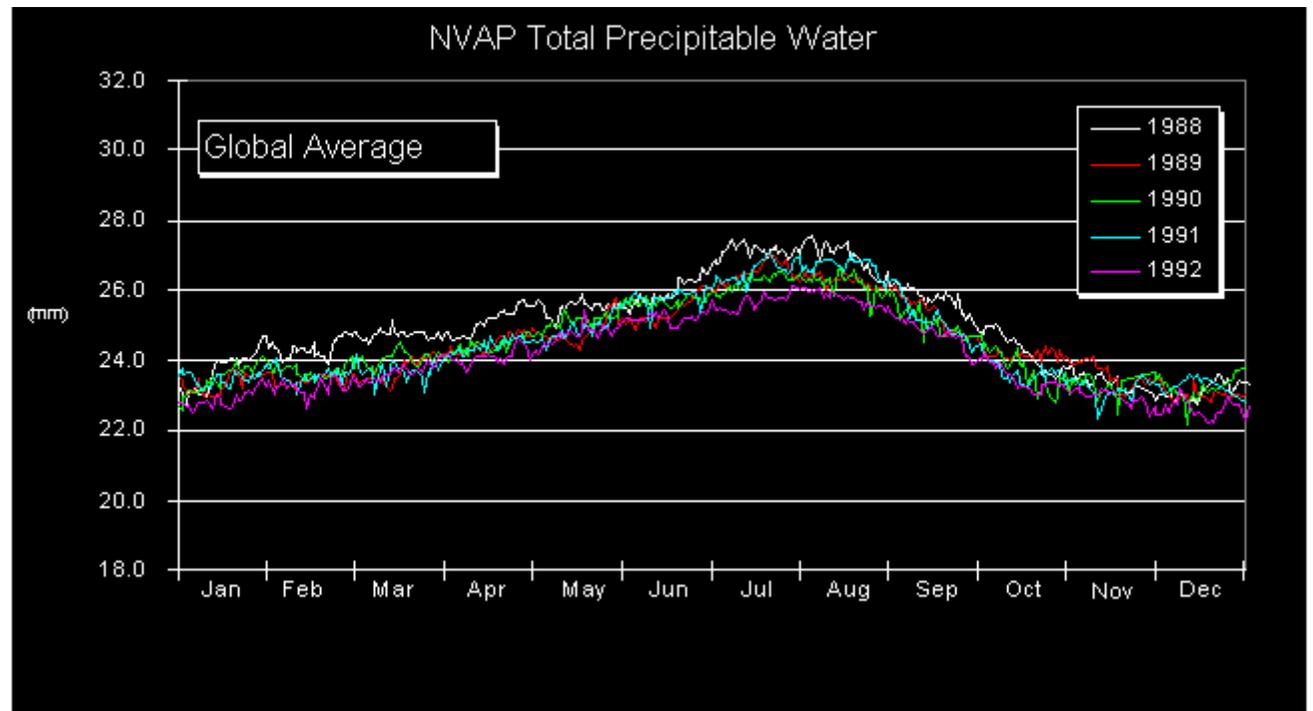
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**TCWV
global monthly mean**

**1988 - 1992
0060 & ERA40**

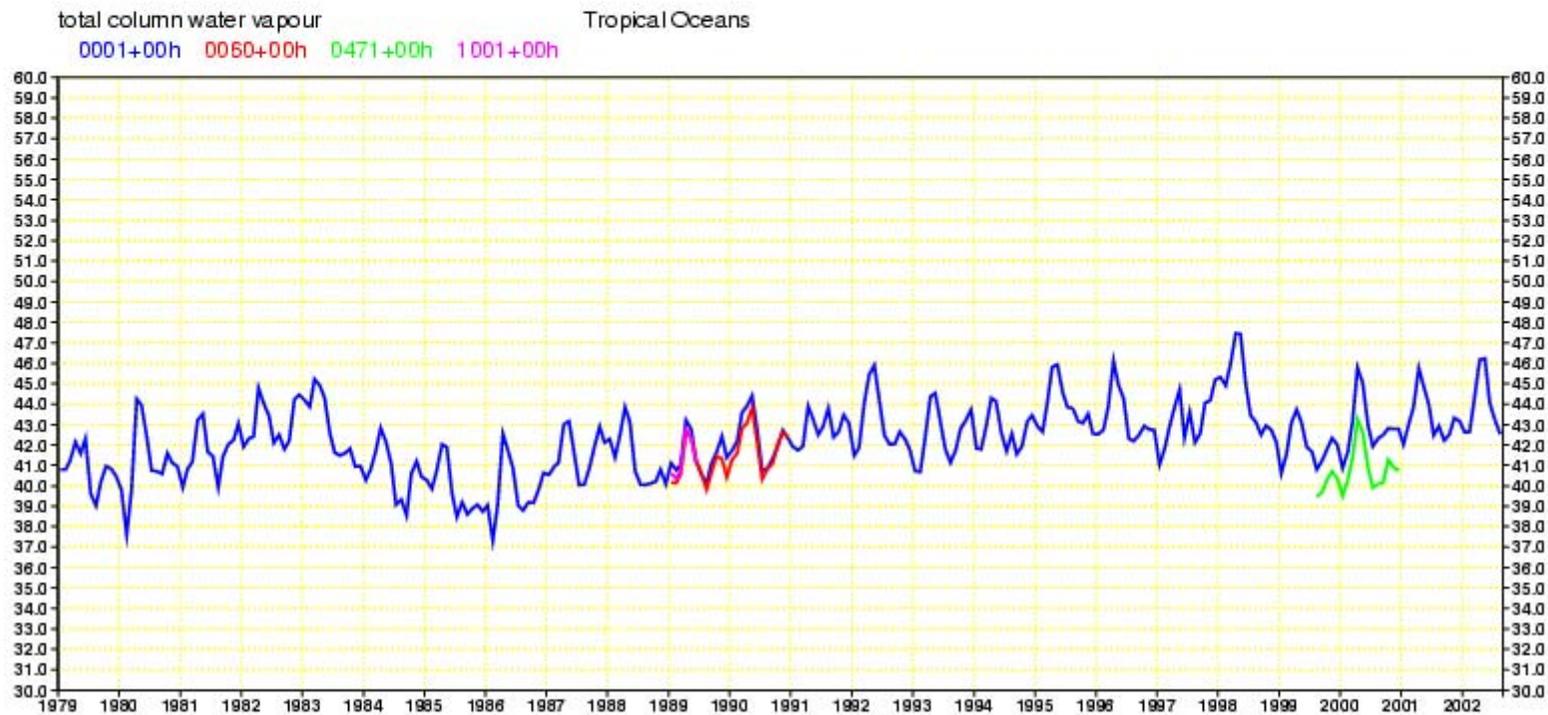


**NVAP global TPW
1988 -1992**



**total column water vapour
monthly mean 1979-2002
tropical oceans (20°N-20°S)**

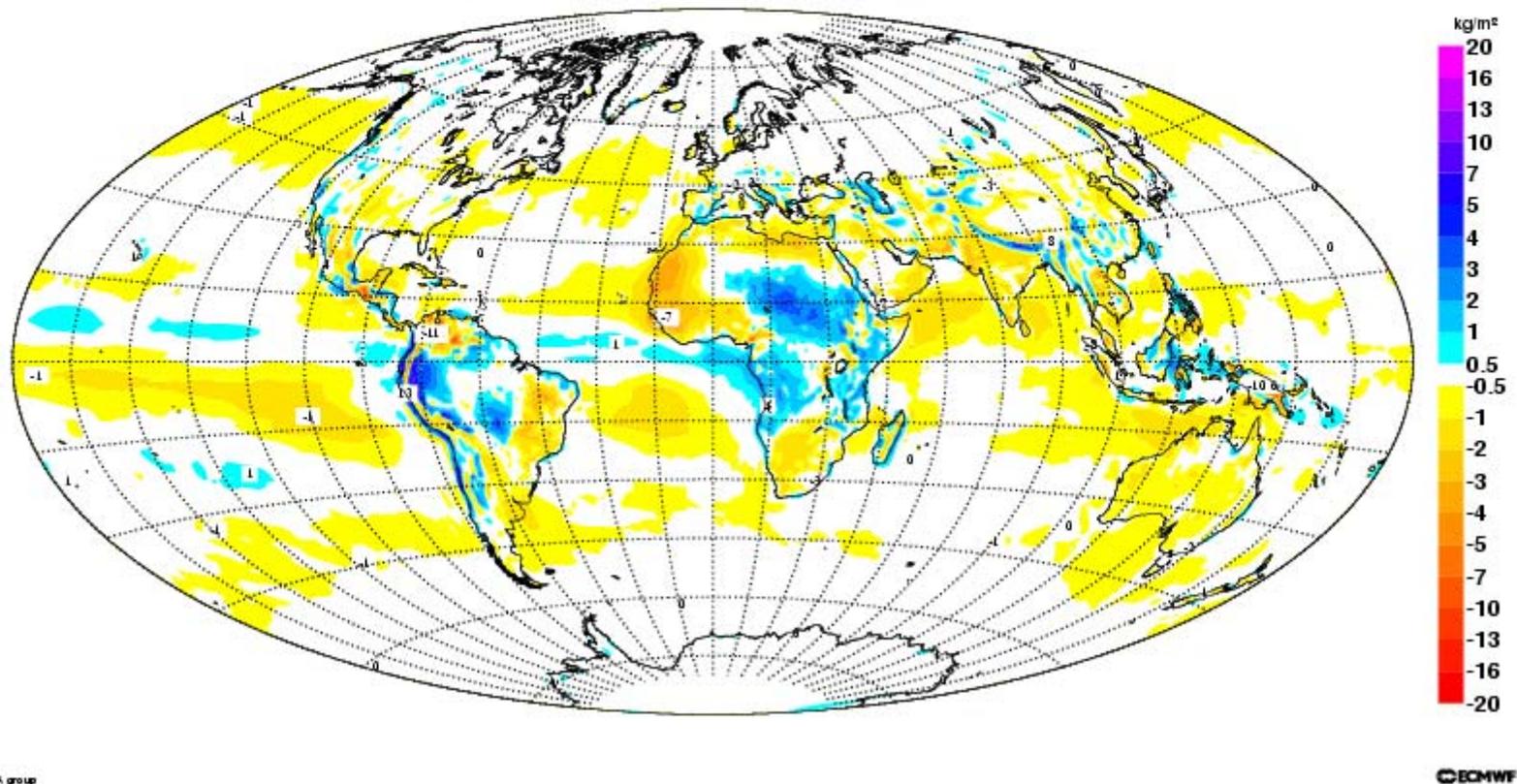
ERA40 0060 0471 1001



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total column water vapour difference between 0060 and ERA-40 1989-1990

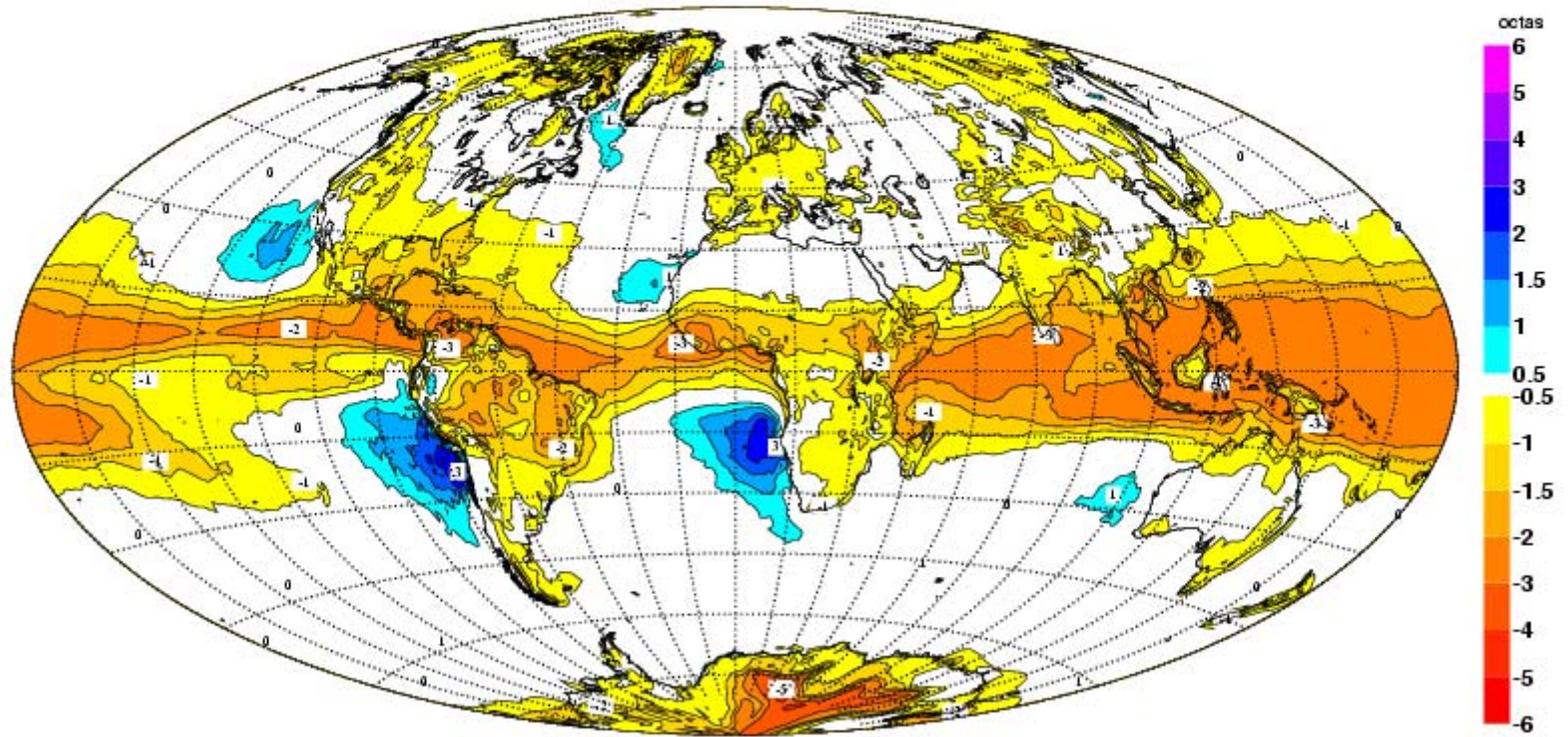
total column water vapour
0060 monthly/daily mean 198901 to 199012
differences to
0001 monthly/daily mean 198901 to 199012



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total cloud cover
difference between 0060 and ERA-40
1989-1990

total cloud cover
0060 monthly/daily mean 198901 to 199012
differences to
0001 monthly/daily mean 198901 to 199012



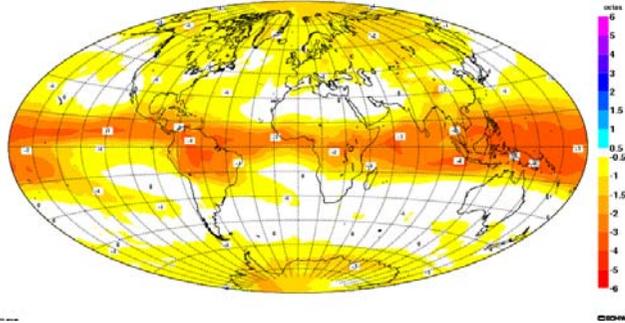
ERA group

ECMWF

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198901-199012

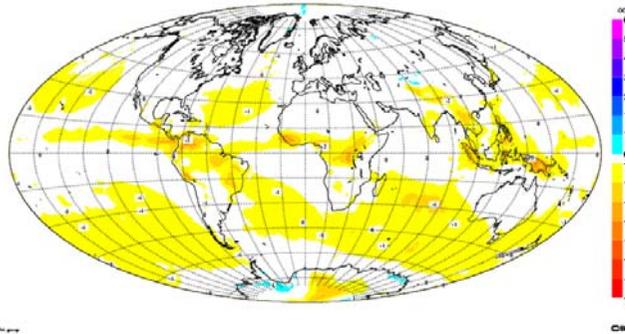
high cloud cover
0060 monthly/daily mean 198901 to 199012
differences to
0001 monthly/daily mean 198901 to 199012



cloud cover differences between 0060 and ERA-40 1989-1990

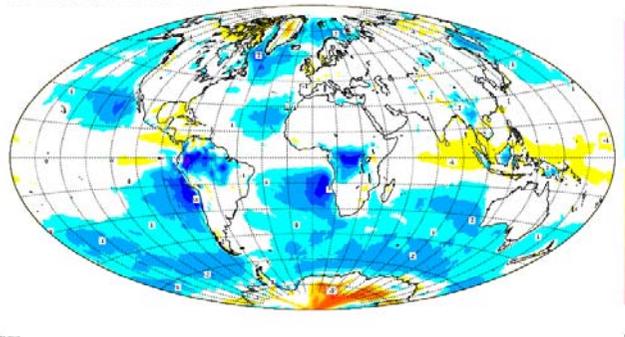
high clouds: less, particularly in the ITCZ,
also less at high latitudes

middle cloud cover
0060 monthly/daily mean 198901 to 199012
differences to
0001 monthly/daily mean 198901 to 199012



middle clouds: somewhat less

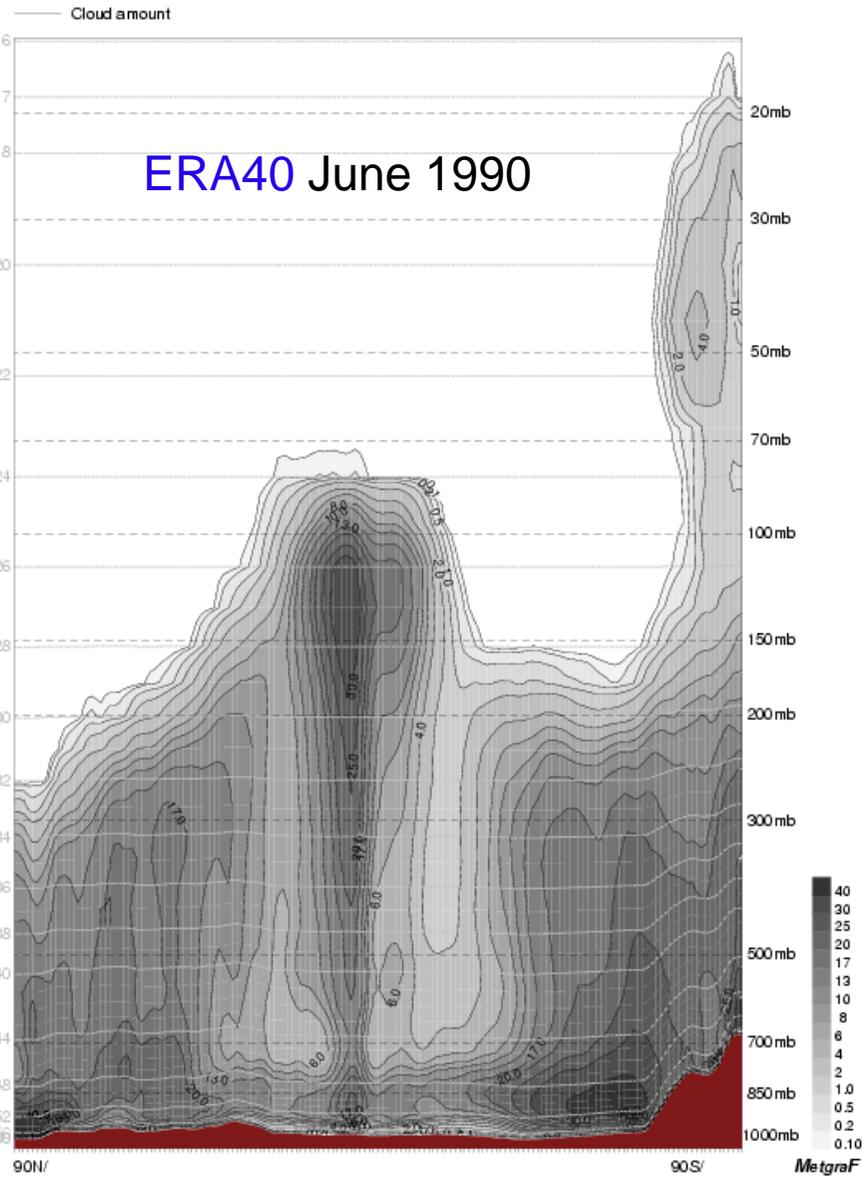
low cloud cover
0060 monthly/daily mean 198901 to 199012
differences to
0001 monthly/daily mean 198901 to 199012



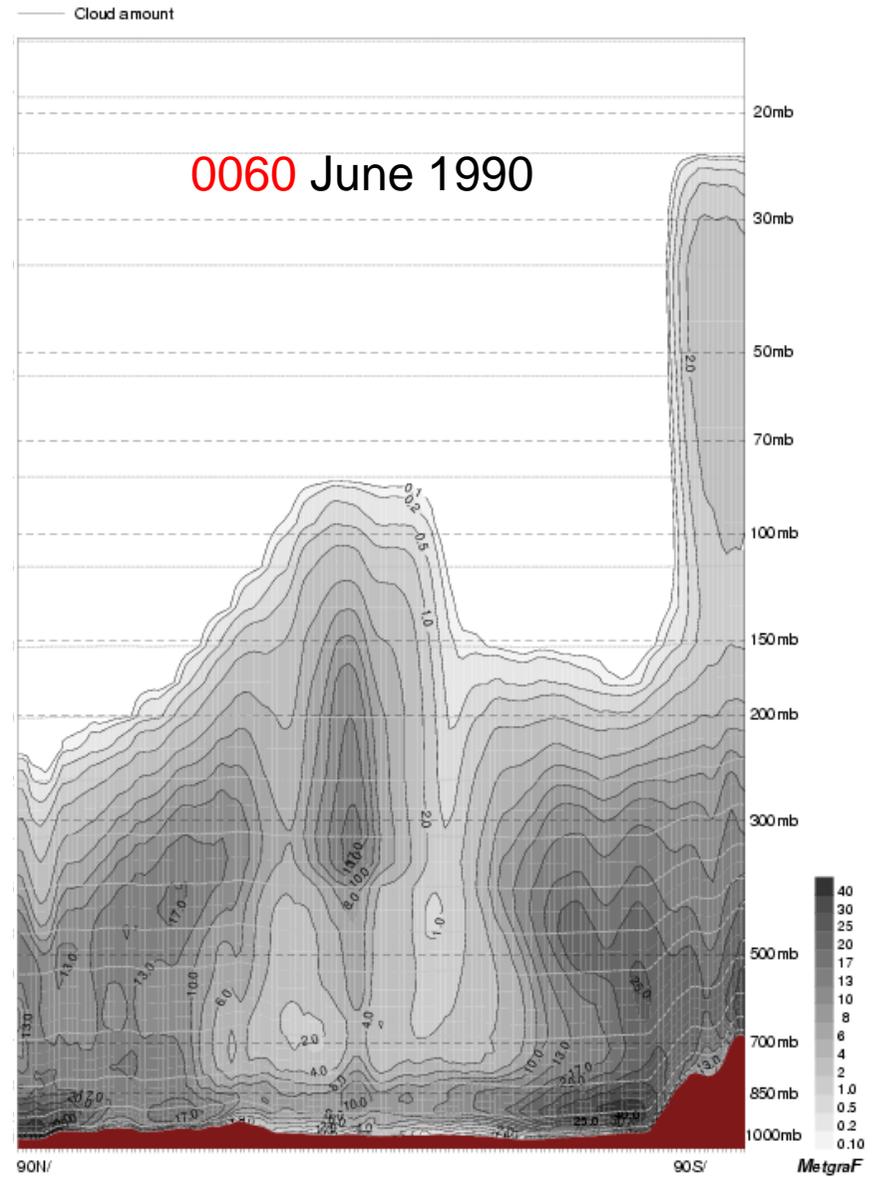
low clouds:
more near eastern shores ('upwelling')
and over rainforests

zonal mean of the cloud fraction in %

0001 1990 06 monthly mean analysis
zonal mean. Units: %

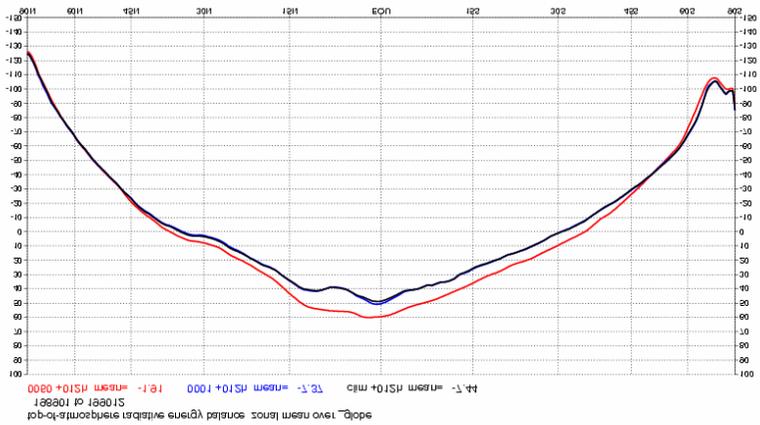


0060 1990 06 monthly mean analysis
zonal mean. Units: %



energy balance

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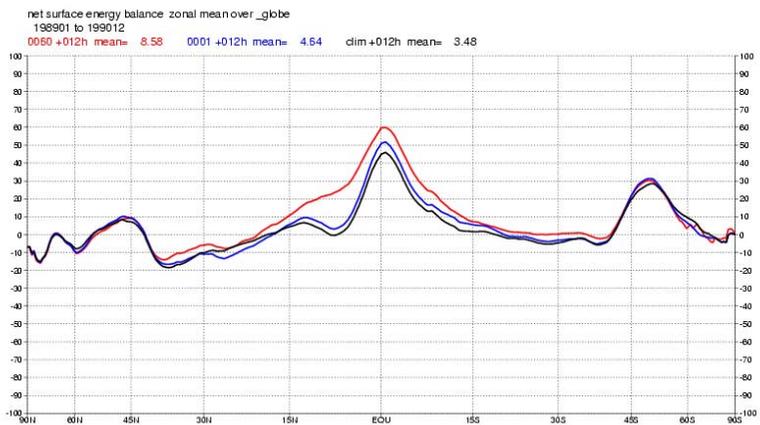
net T.O.A.
energy exchange

global energy balances 1989-1990

W/m ²	0060	ERA40	ERA40 23 year climate
top of atmosphere	-1.9	-7.4	-7.4
cloud forcing	-23.3	-34.9	-35.7
surface	+8.6	+4.6	+3.5



net surface
cloud forcing



net surface
energy exchange

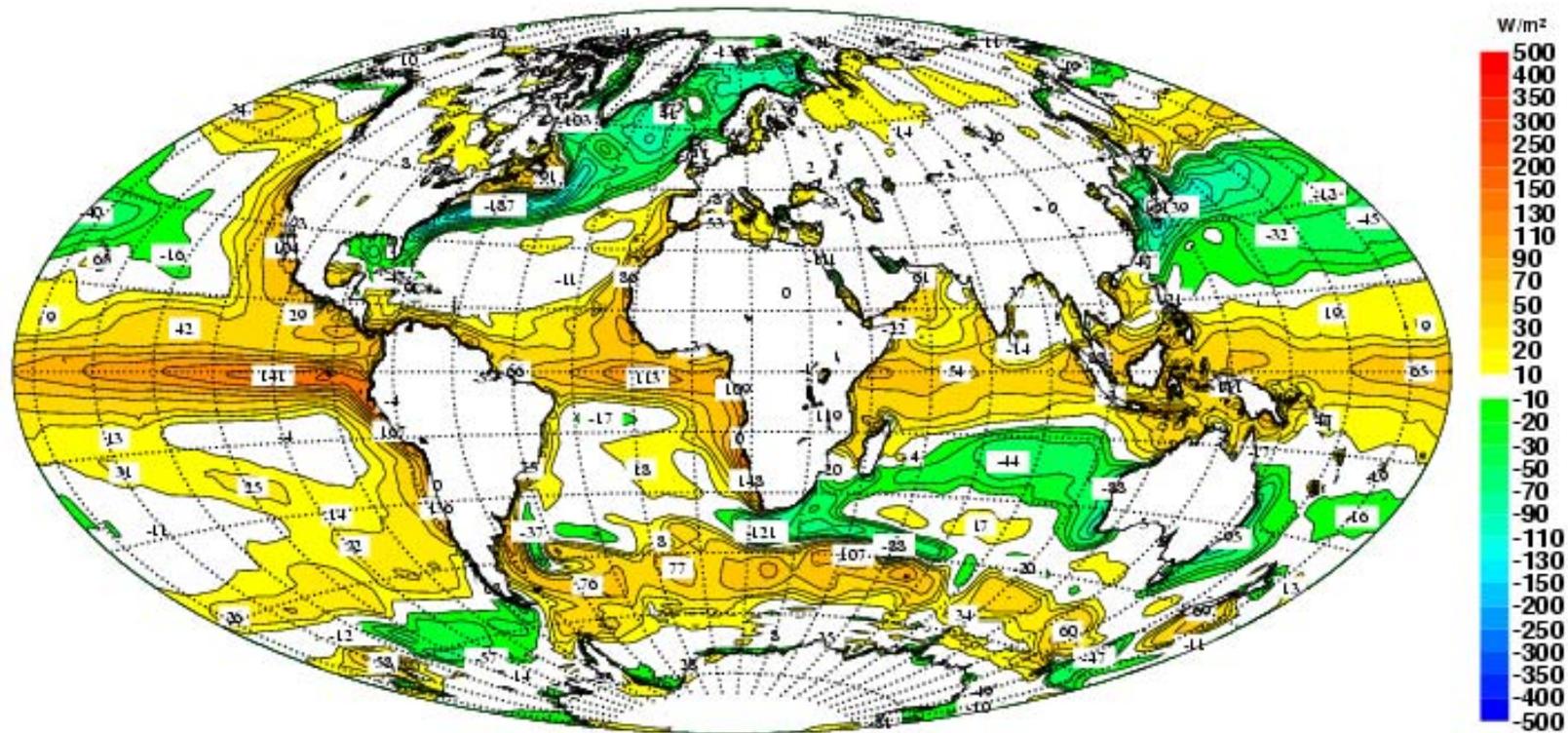
surface energy balance

0060

1989-1990

net surface energy exchange

0060 monthly/daily accumulation. 198901 to 199012 +12h.

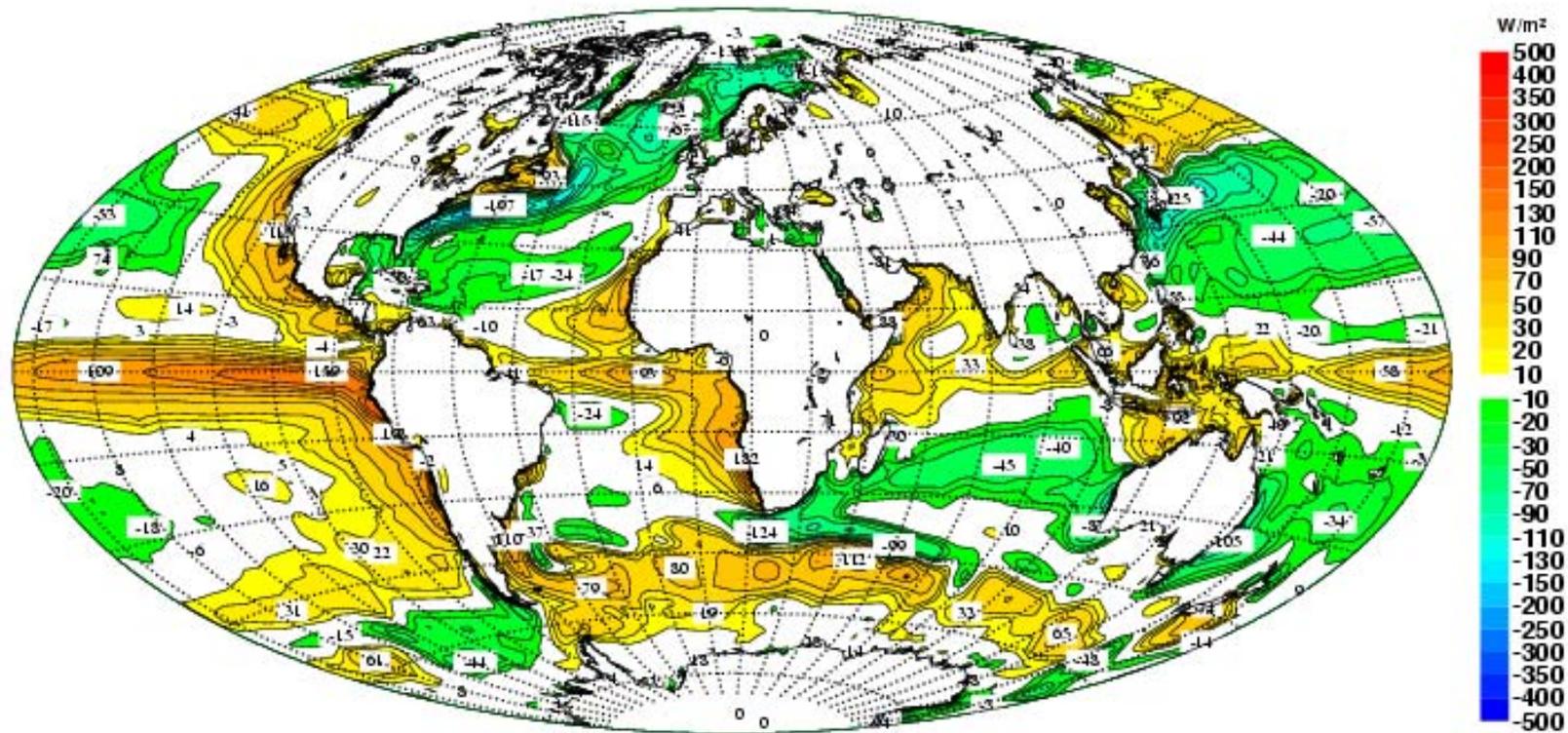


surface energy balance

ERA40

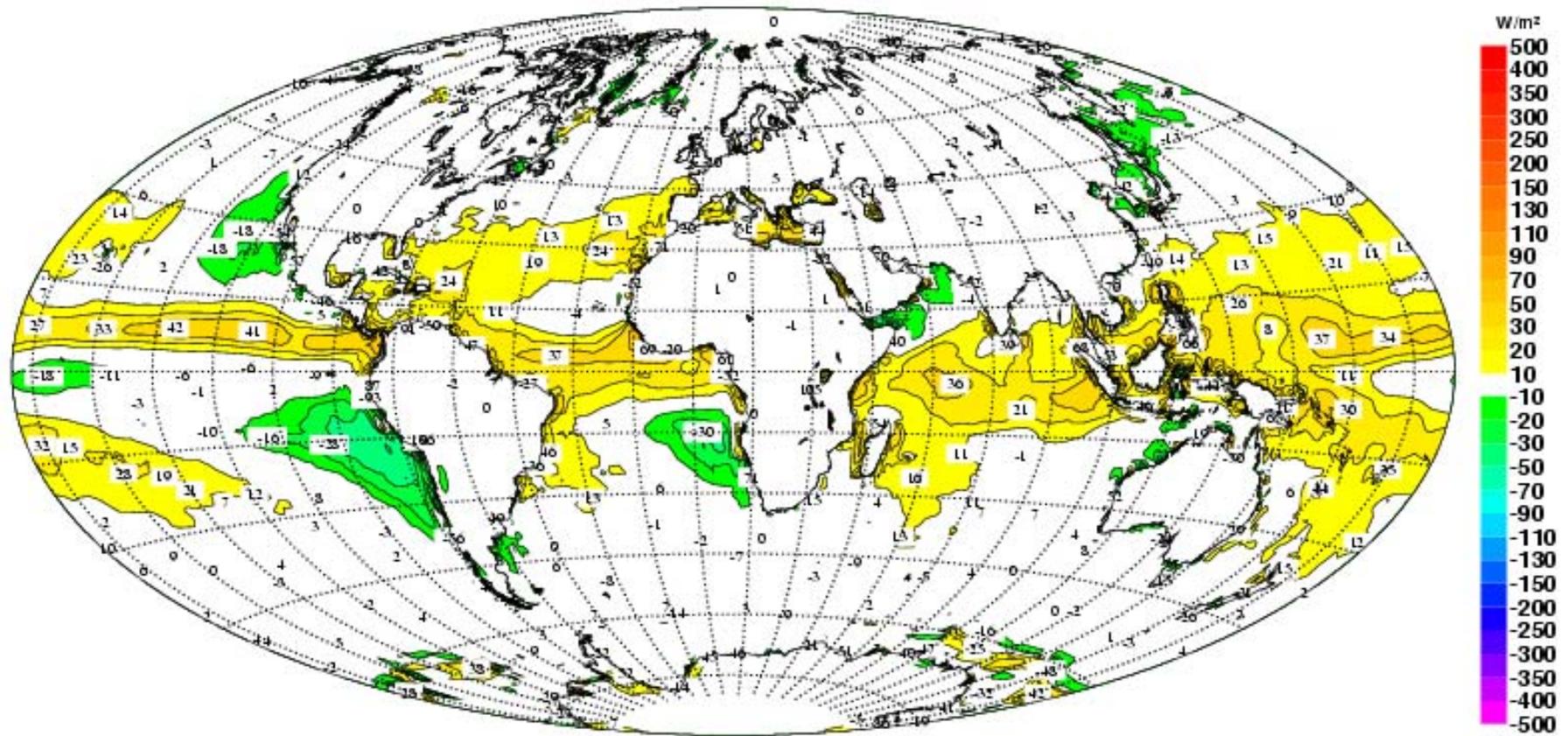
1989-1990

net surface energy exchange
0001 monthly/daily accumulation. 198901 to 199012 +12h.



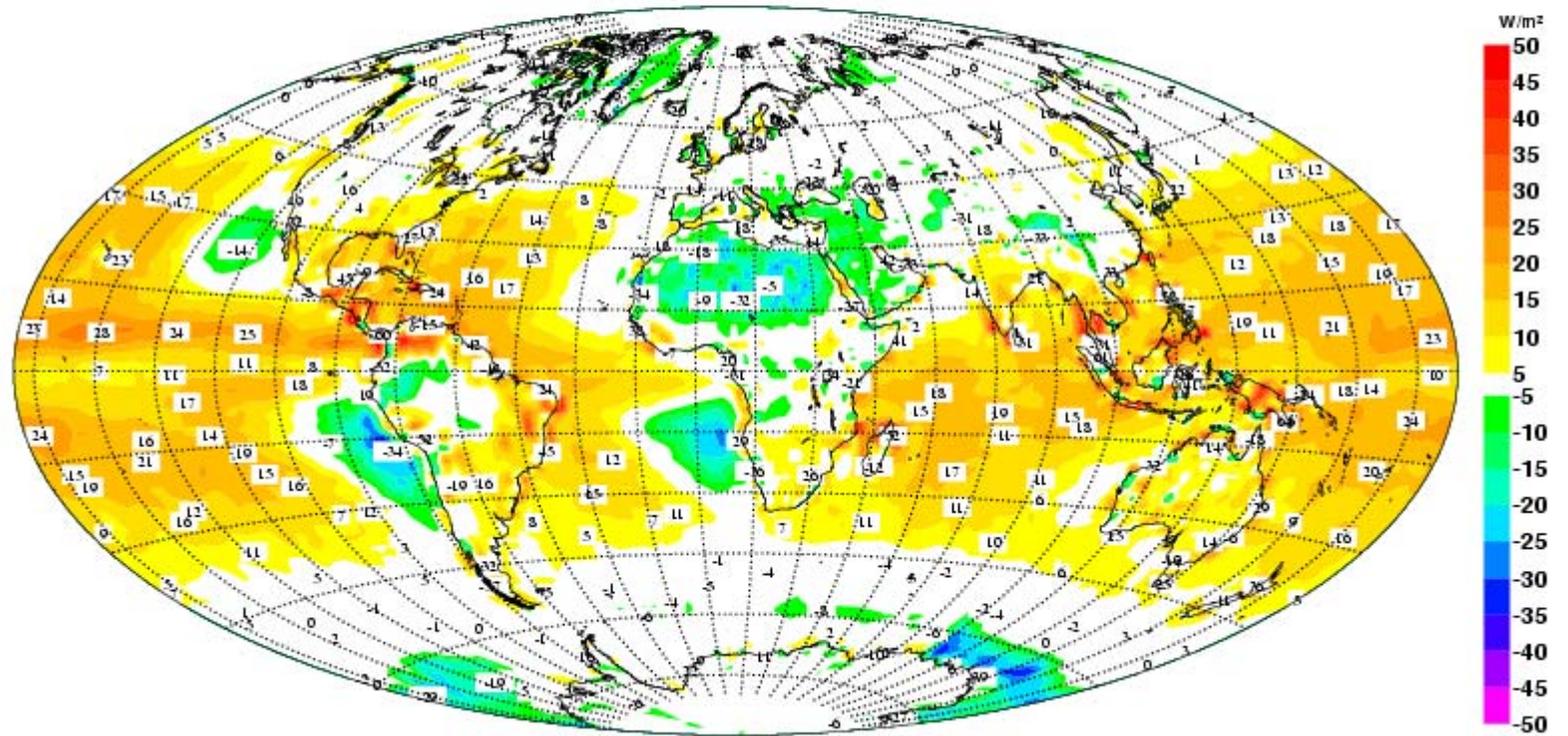
surface energy balance
difference between 0060 and ERA40
1989-1990

Net surface energy exchange.
0060 2-year (198901 to 199012) +12h
differences to
ERA40 2-year (198901 to 199012) +12h

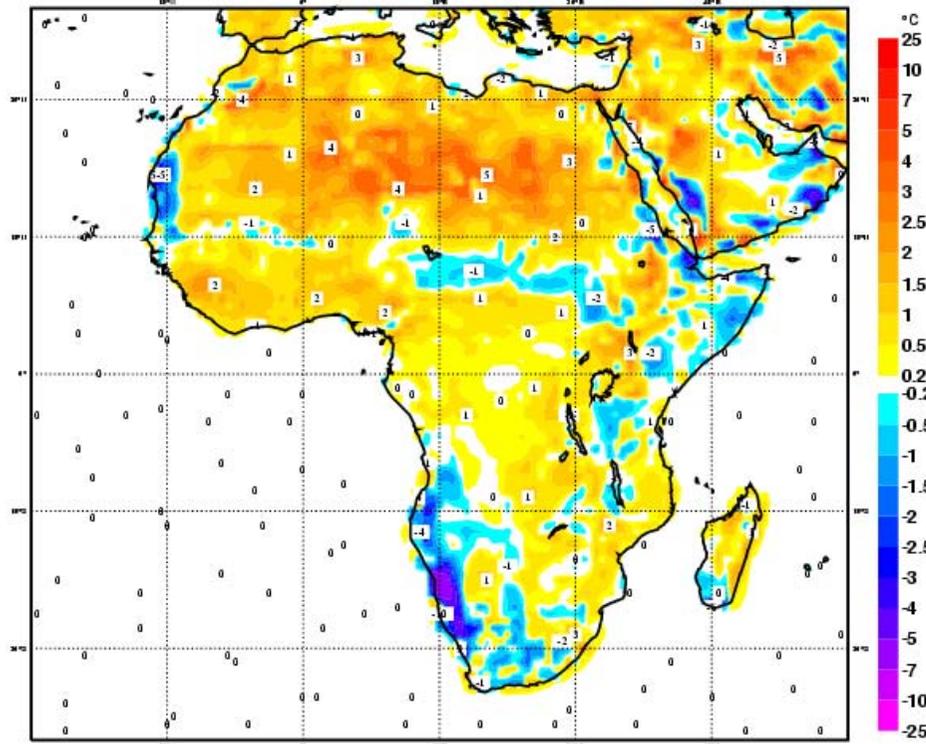


top-of-atmosphere energy balance difference between 0060 and ERA40 1989-1990

Top of atmosphere net energy balance.
0060 2-year (198901 to 199012) +12h
differences to
ERA40 2-year (198901 to 199012) +12h

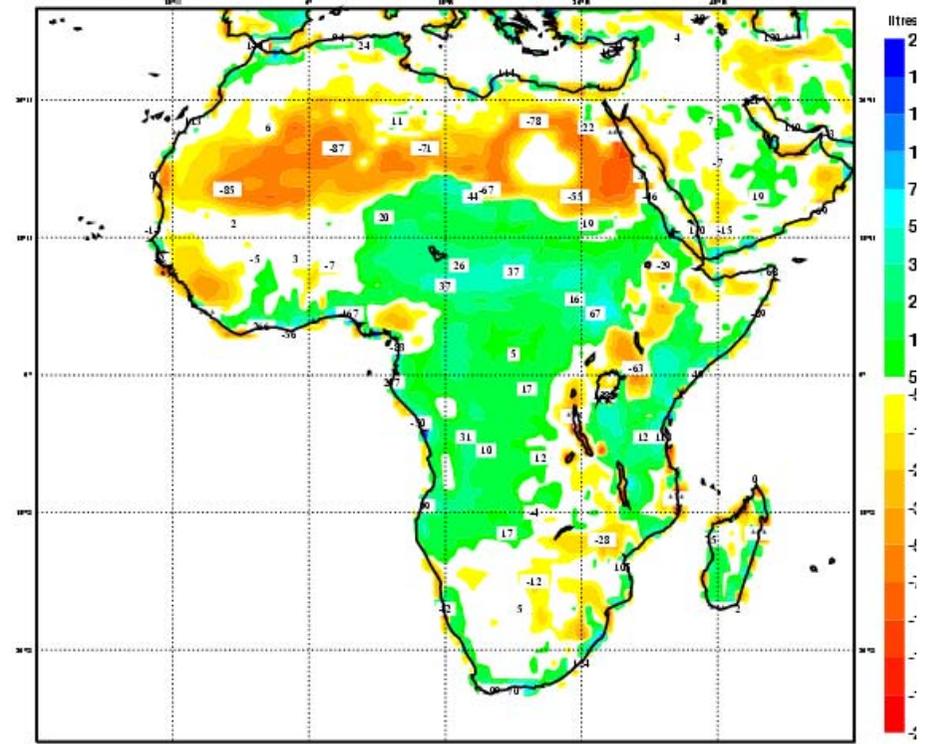


soil temperature (level 1)
0060 monthly/daily mean 198901 to 199012
differences to
0001 monthly/daily mean 198901 to 199012



soil temperature

volumetric soil water (level 1)
0060 monthly/daily mean 198901 to 199012
differences to
0001 monthly/daily mean 198901 to 199012



soil wetness

differences **0060** - **ERA40** in top soil

0060 drier and hotter in Sahara
0060 wetter and cooler in Sahel

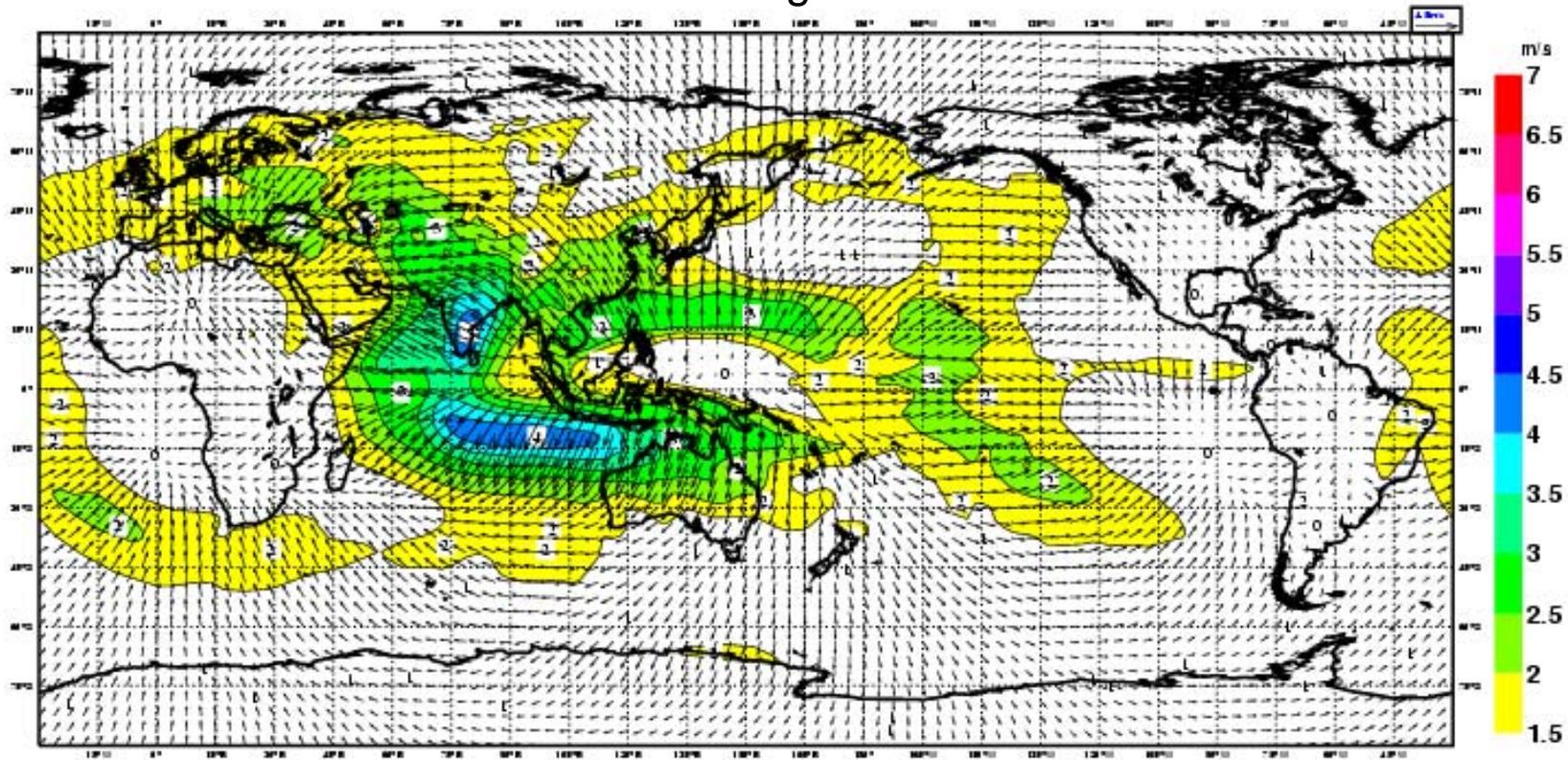
the Walker circulation

annual mean 1989-1990

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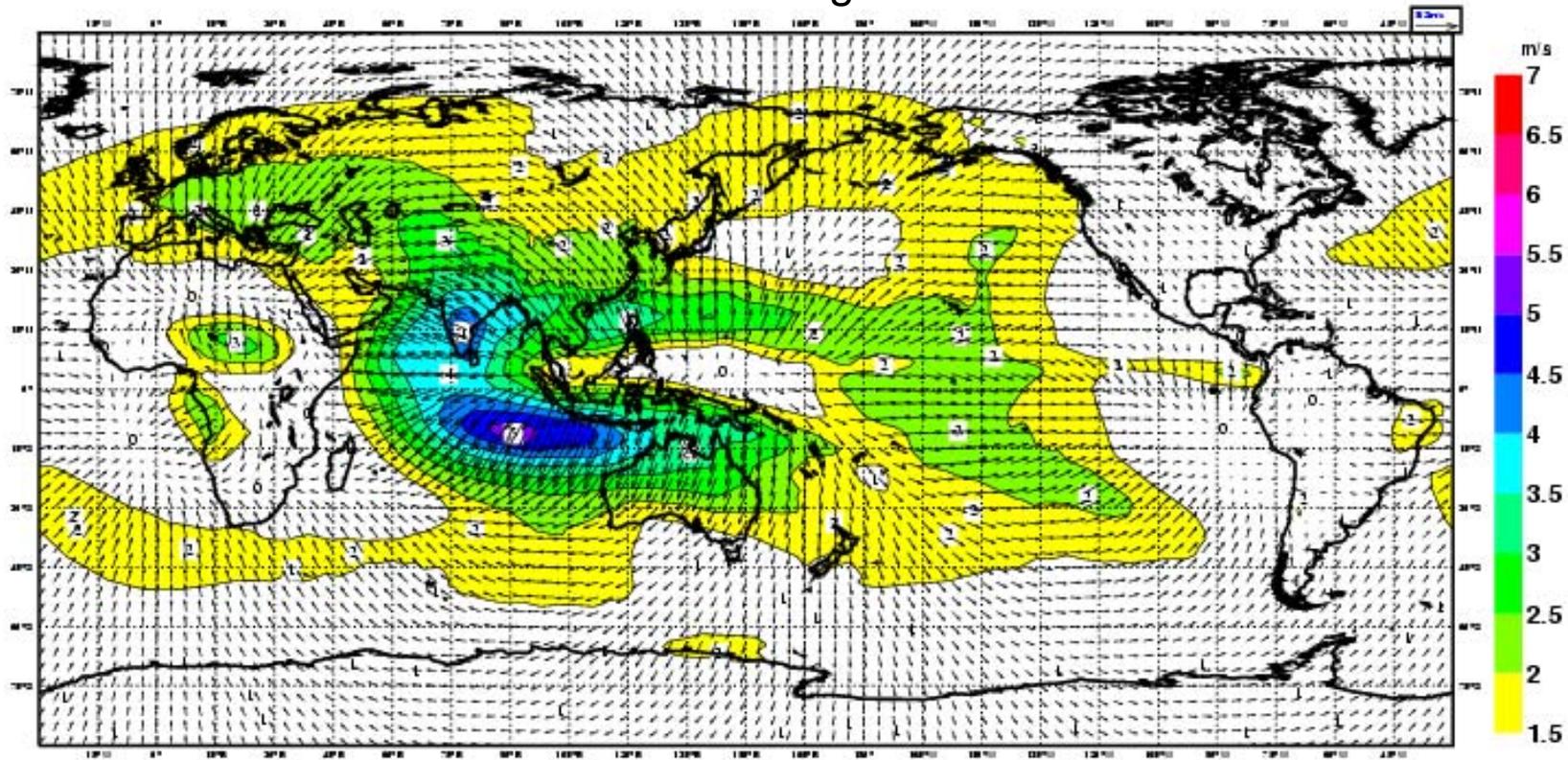
0001 anpl_moda monthly/daily mean.
divergent wind at 150 hPa.

divergent wind at 150 hPa. ERA40



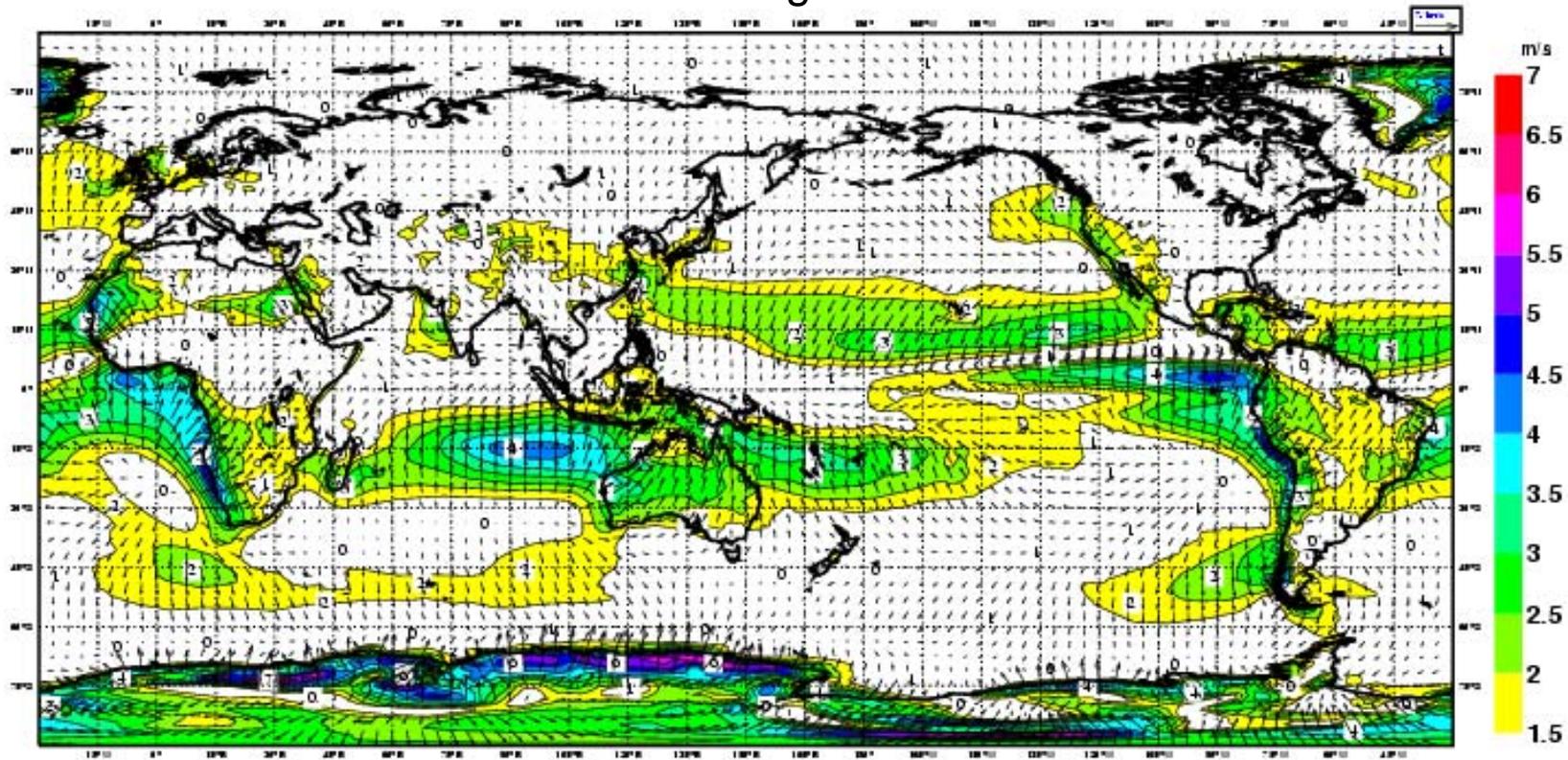
0060 anpl_moda monthly/daily mean.
divergent wind at 150 hPa.

divergent wind at 150 hPa. 0060



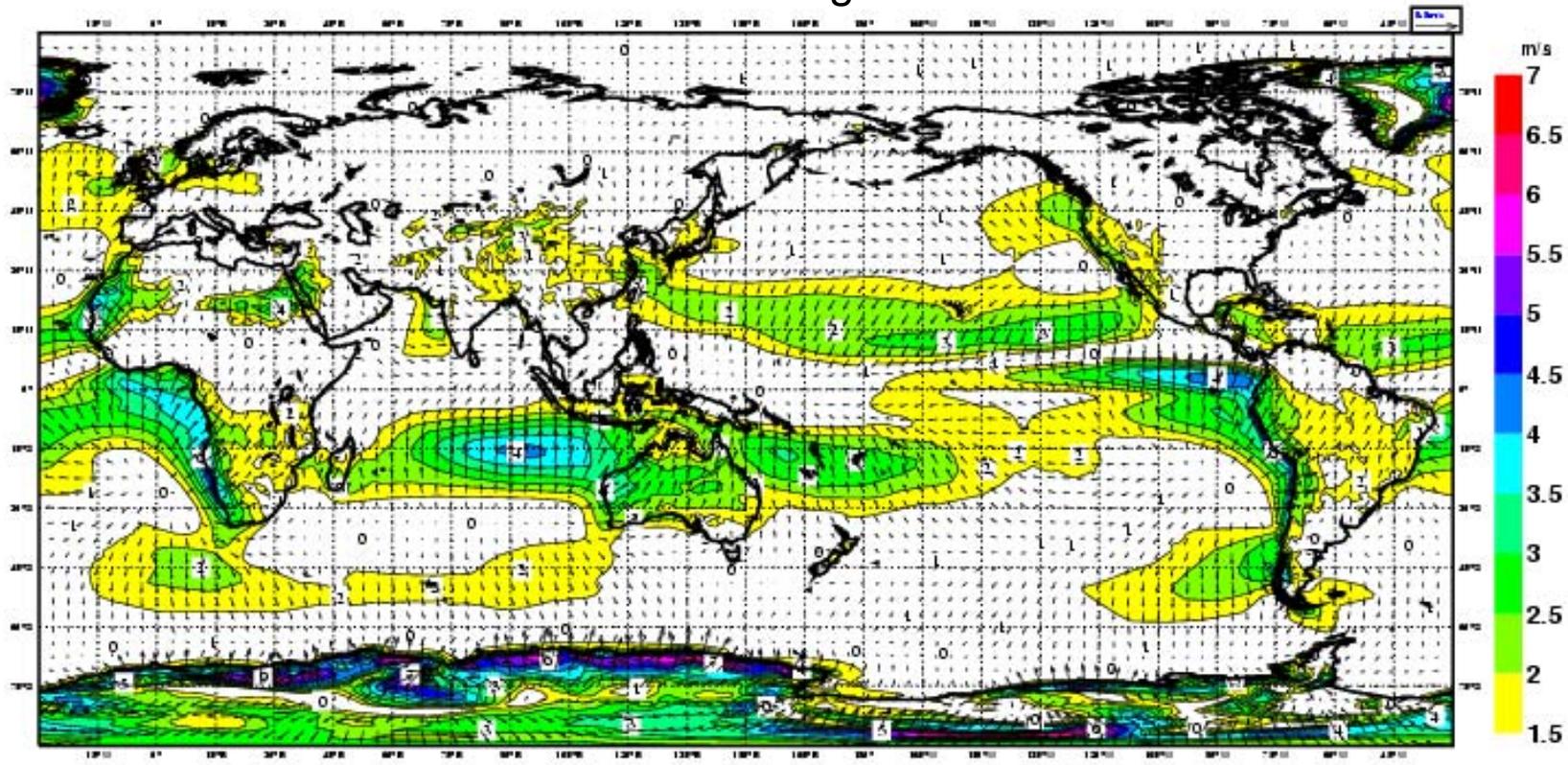
0001 anpl_moda monthly/daily mean.
divergent wind at 1000 hPa.

divergent wind at 1000 hPa. ERA40



0060 anpl_moda monthly/daily mean.
divergent wind at 1000 hPa.

divergent wind at 1000 hPa. 0060



conclusions

(for 1989-1990)

- the precipitation is more realistic (according to GPCP) both in the tropics and at mid-latitudes
- no temporal trend in the total column water vapour nor in the precipitation
- no precipitation spin-up in the most recent test experiment (1001)
- global P-E in good balance (perfect in 0060+12h)
- 'more' Mississippi run-off in 0060
- less cirrus, especially in the tropics
- more stratus over the eastern flanks of the subtropical oceans ('upwelling')
- top-of-atmosphere energy exchange better (0060 -2 W/m² ERA40 -7 W/m²)
- Saharan soil is drier and warmer in 0060
- surface energy exchange worse (0060 +9 W/m² ERA40 +4 W/m²)
- somewhat stronger divergence at 150 hPa in 0060
- slightly weaker convergence at 1000 (and 925/850) hPa in 0060

the end