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SMR/1328/16

School on the Physics of Equatorial Atmosphere

(24 September - 5 October 2001)

Equatorial Middle Atmosphere in General Circulation Models

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Equatorial Middle Atmosphere in General Circulation Models

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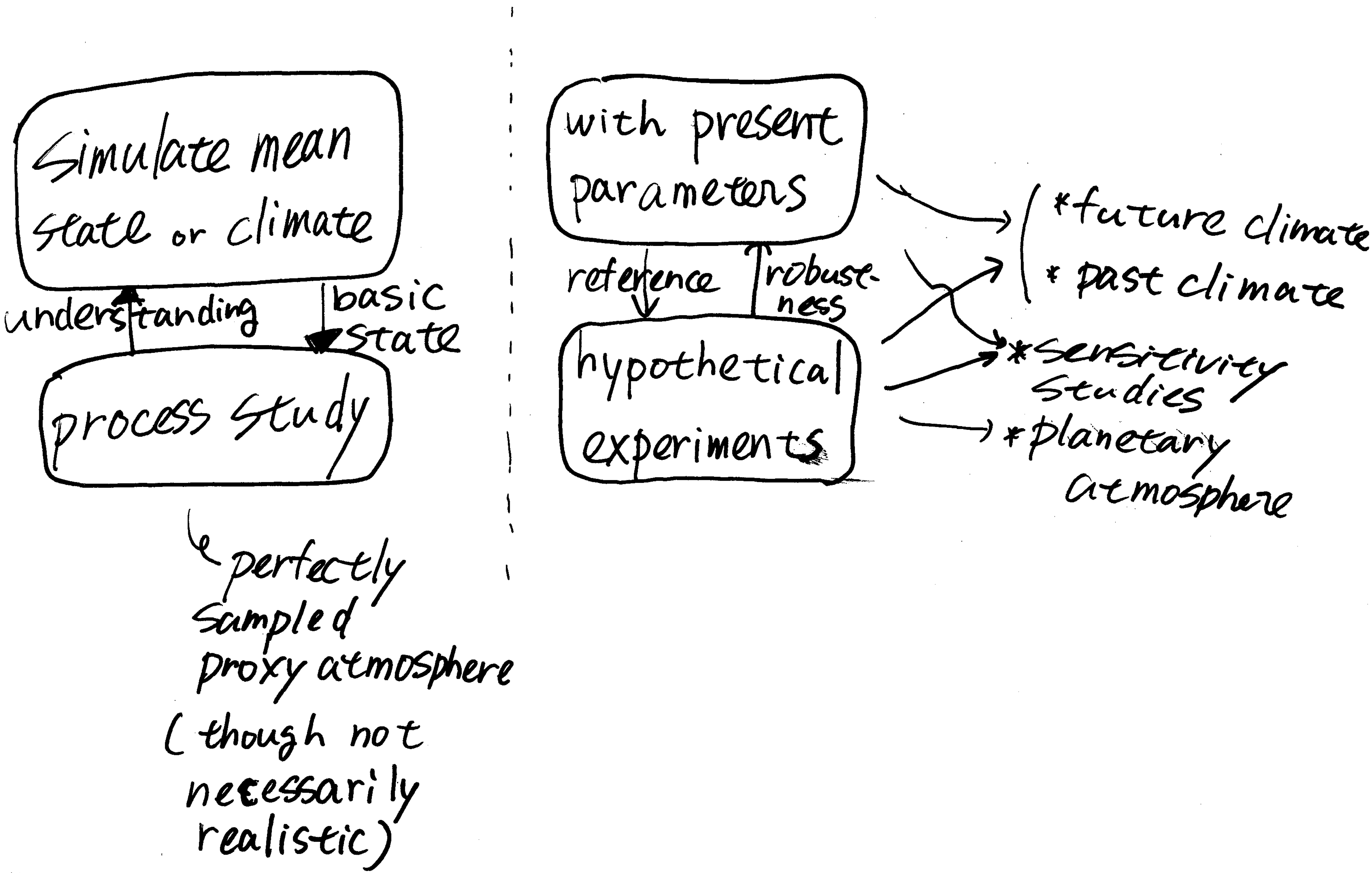
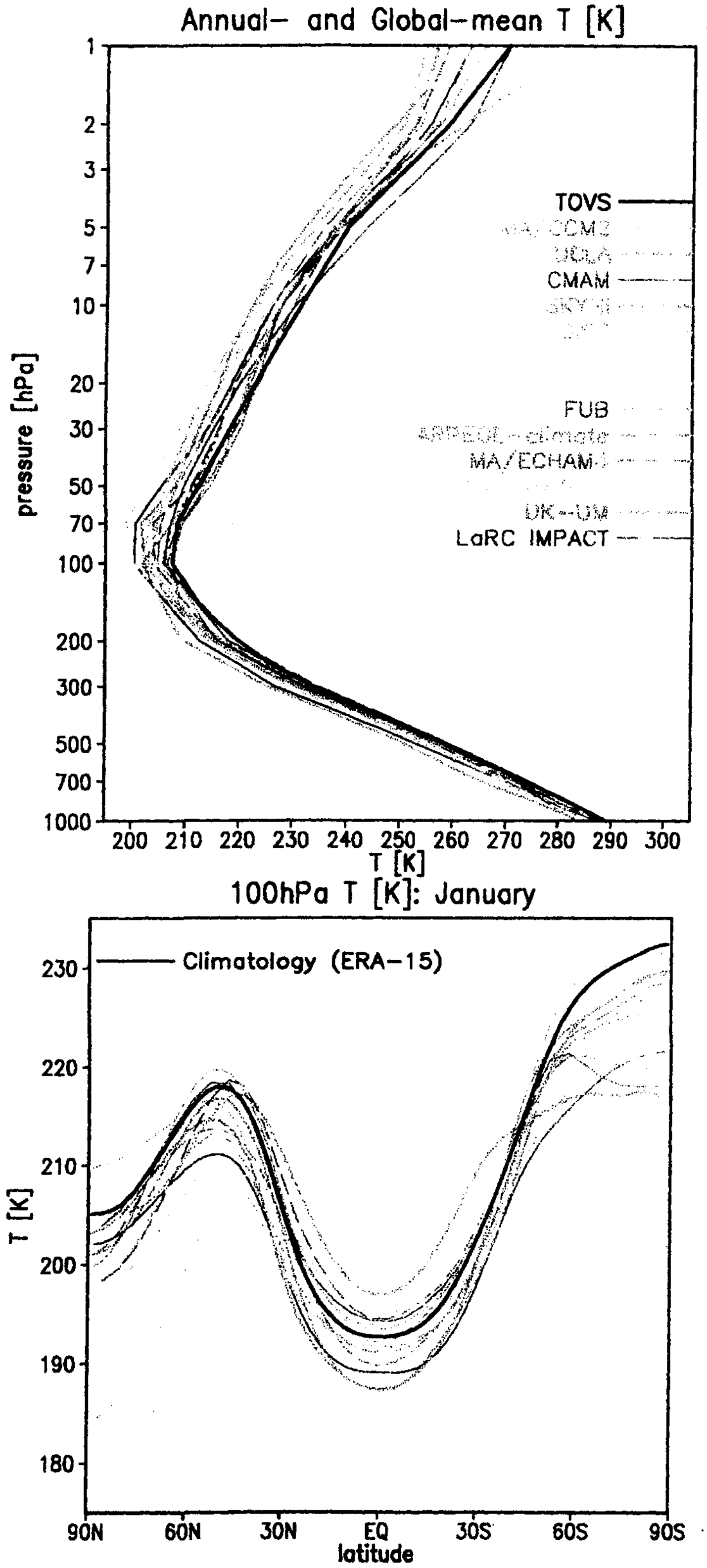
For what GCMs are used

- To simulate "climate"
  - of present, past, and future
  - (seasonal) mean state of the atmosphere / low-frequency variability
- Hypothesis Studies
  - "What if" experiments
- For process studies
  - provides perfectly sampled data
  - numerical experiments


Simulate mean state or climate
understanding
basic state
process study
perfectly sampled proxy atmosphere
(though not necessarily realistic)
with present parameters
reference
robustness
hypothetical experiments
*future climate
* past climate
*sensitivity studies
*planetary atmosphere

CAVEAT
GCMs are[1] not super-mighty!



difference among middle-atmos. GCMs

from Pawson et. al. (2000) Bull. American Met. Soc.

Figure 1:

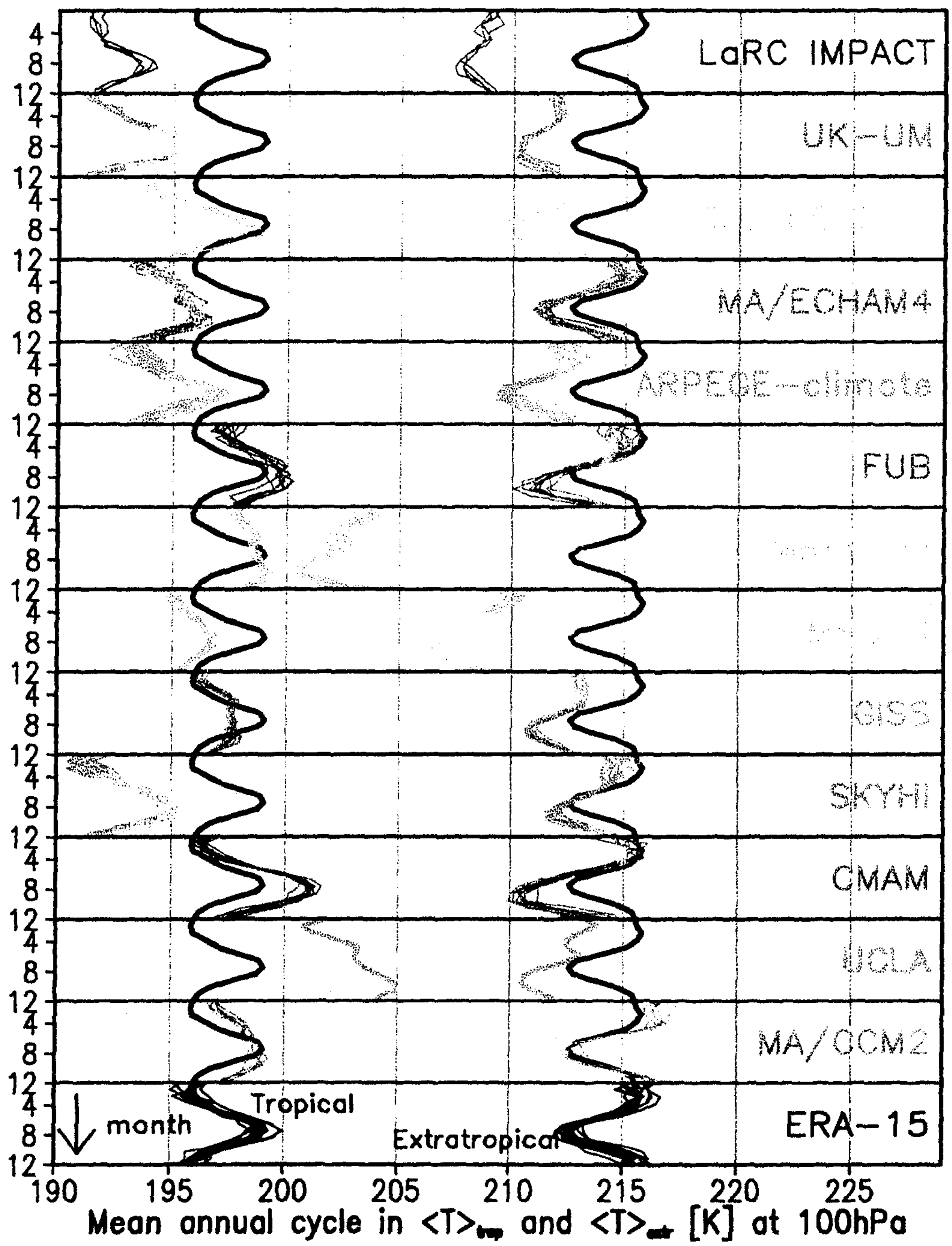

LaRC IMPACT
UK-UM
MA/ECHAM4
ARPEGE-climate
FUB
GISS
SKYHI
CMAM
UCLA
MA/CCM2
ERA-15
month
Tropical
Extratropical
4 8 12
190 195 200 205 210 215 220 225
Mean annual cycle in <T> and <T> [K] at 100hPa

Figure 2:

Equatorial Oscillations

- SAO
  - Produced in many GCMs with a variety of magnitude and phase propagation
- QBO
  - Produced only in limited GCMs – Those with fine vertical resolutions and having convective parameterizations that produce large variance in parameterized diabatic heating

Equatorial Oscillations

SAO : crudely simulated, but differs among models

QBO : no QBO at all is common

why? → needs process studies

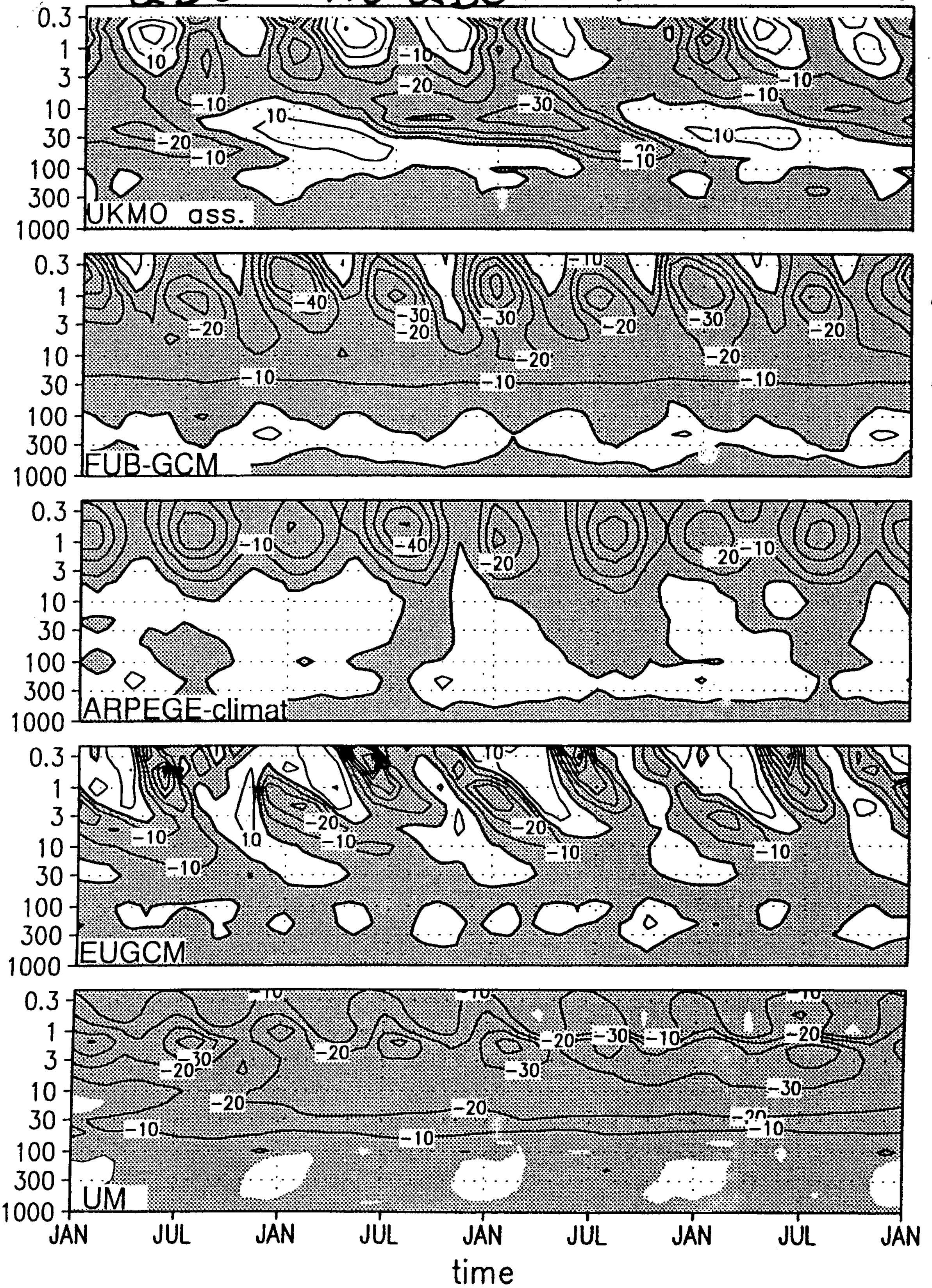


Fig.2

marverous QBO only in limited models

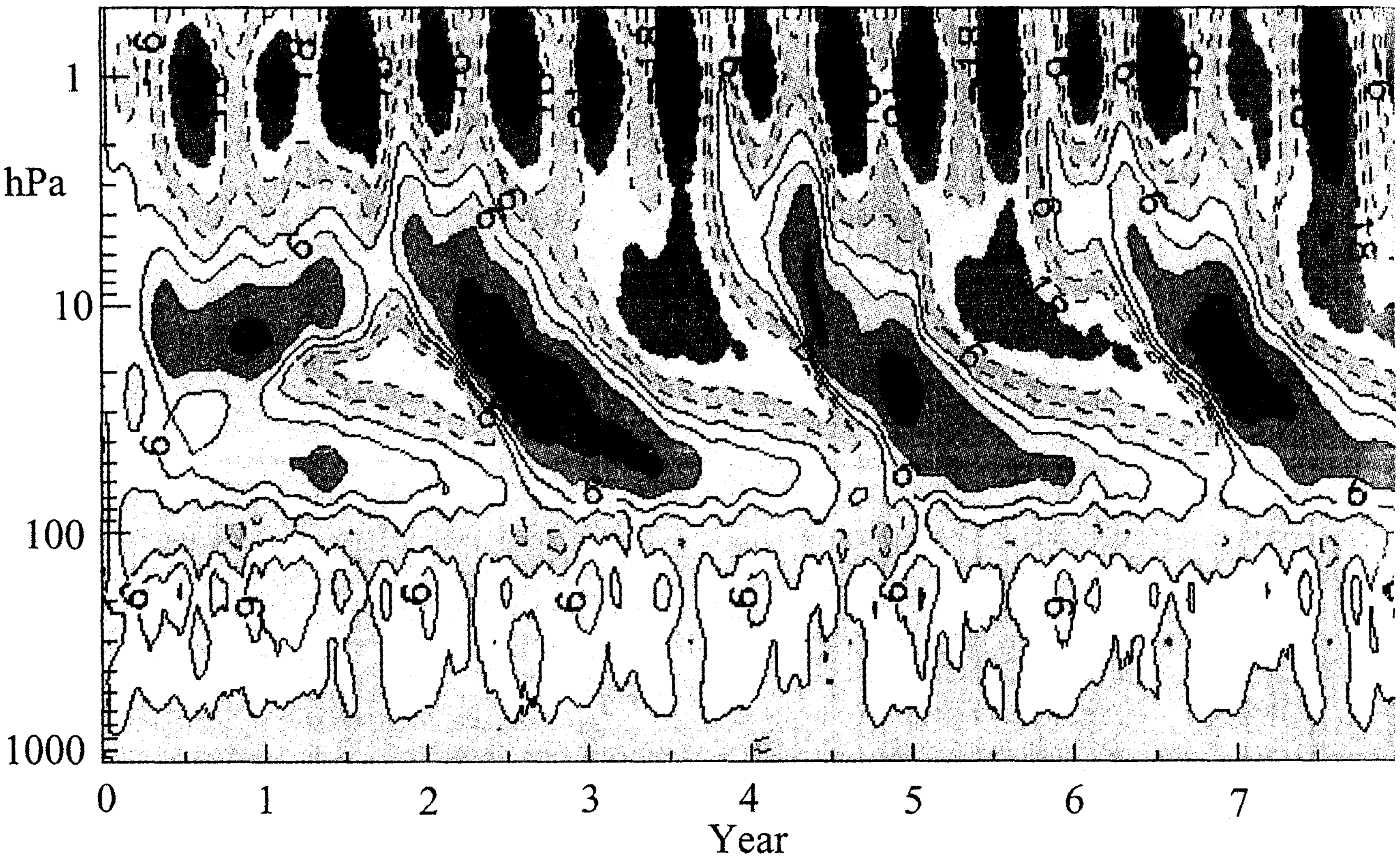
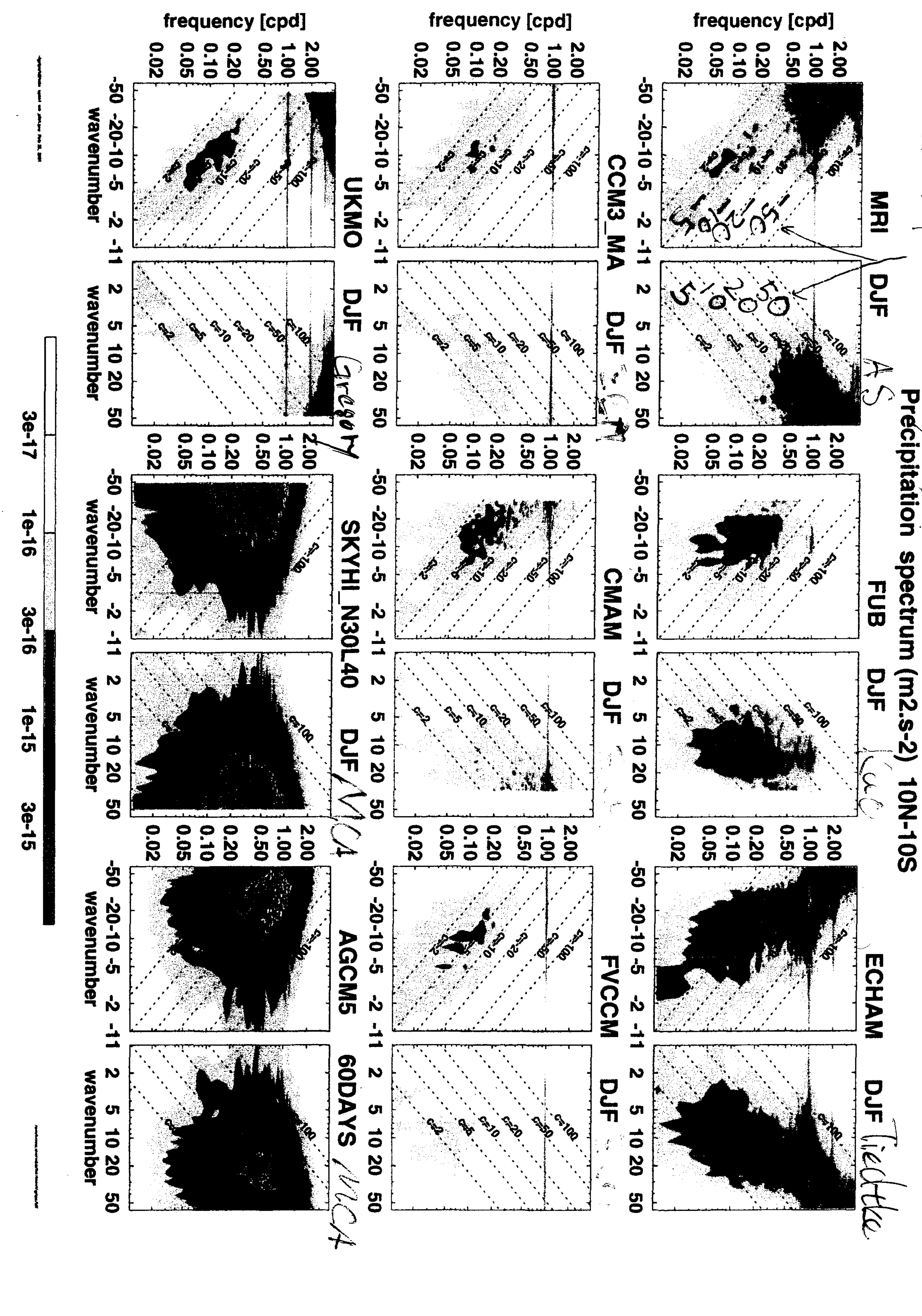
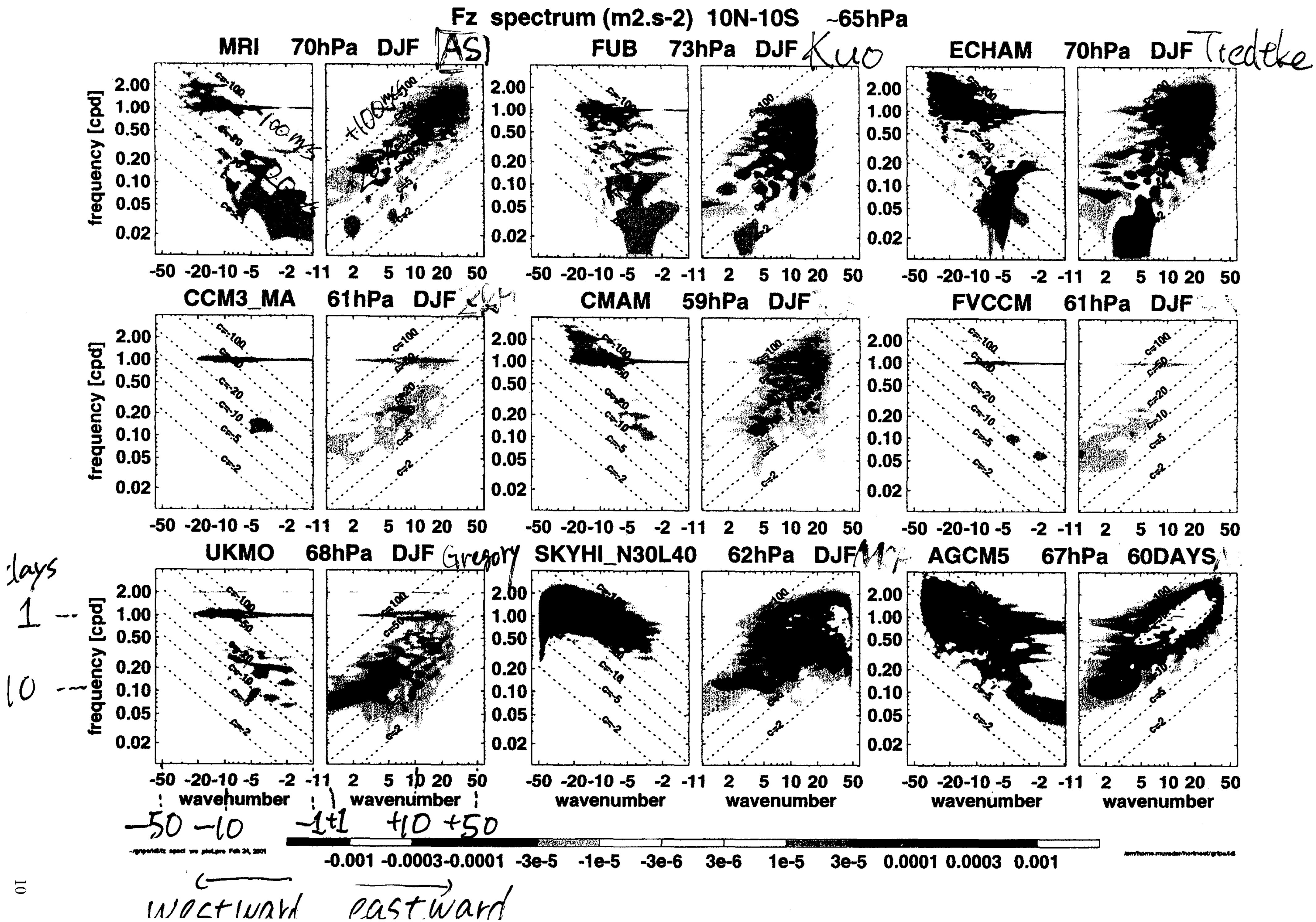


Plate 5. Time-height section of the zonal-mean zonal wind over the equator simulated by *Takahashi* [1999]. The time coordinate ranges from day 0 (January 1, with a 360-day model year) to day 1830. The contour interval is 6 m s^{-1}. Red and blue shading represent westerly and easterly winds, respectively.


Precipitation spectrum (m2.s-2) 10N-10S
MRI DJF
FUB DJF
ECHAM DJF
CCM3_MA DJF
CMAM DJF
FVCCM DJF
UKMO DJF
SKYHI_N30L40 DJF
AGCM5 60DAYS
frequency [cpd]
wavenumber
c=100
c=50
c=20
c=10
c=5
c=2
3e-17
1e-16
3e-16
1e-15
3e-15
Zonal phase velocity (m/s)


Fz spectrum (m2.s-2) 10N-10S ~65hPa
MRI 70hPa DJF
AS
FUB 73hPa DJF
Kuo
ECHAM 70hPa DJF
Tiedtke
CCM3_MA 61hPa DJF
CMAM 59hPa DJF
FVCCM 61hPa DJF
UKMO 68hPa DJF
Gregory
SKYHI_N30L40 62hPa DJF
AGCM5 67hPa 60DAYS
frequency [cpd]
2.00
1.00
0.50
0.20
0.10
0.05
0.02
-50 -20-10 -5 -2 -11 2 5 10 20 50
wavenumber
c=100
c=50
c=20
c=10
c=5
c=2
days
1
10
-50 -10 -1 +1 +10 +50
-0.001 -0.0003 -0.0001 -3e-5 -1e-5 -3e-6 3e-6 1e-5 3e-5 0.0001 0.0003 0.001
westward
eastward

Process Studies can be heuristic

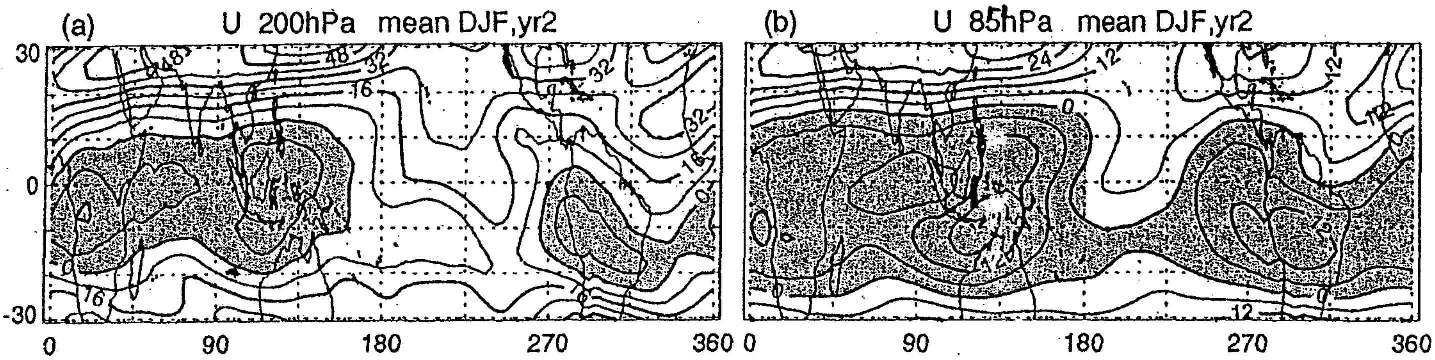


Figure 2. Time-averaged (December-January-February of the second year) zonal mean wind at (a) 200 hPa and (b) 85 hPa. Negative values are shaded.

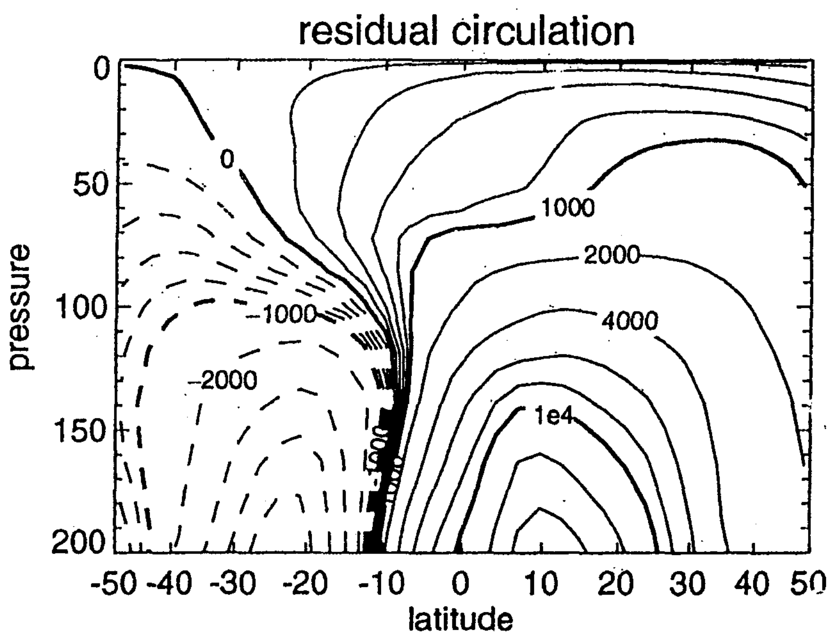


Figure 7. Mass stream function (ψ) of the time-averaged "residual circulation" in the transformed Eulerian equations. The abscissa is scaled by sin(latitude). The contour interval is 200 (kg s^{-3}) for $|\psi| \leq 1000$, 2000 for $2000 \leq |\psi| \leq 10^4$, and 5×10^4 for $|\psi| > 10^4$.

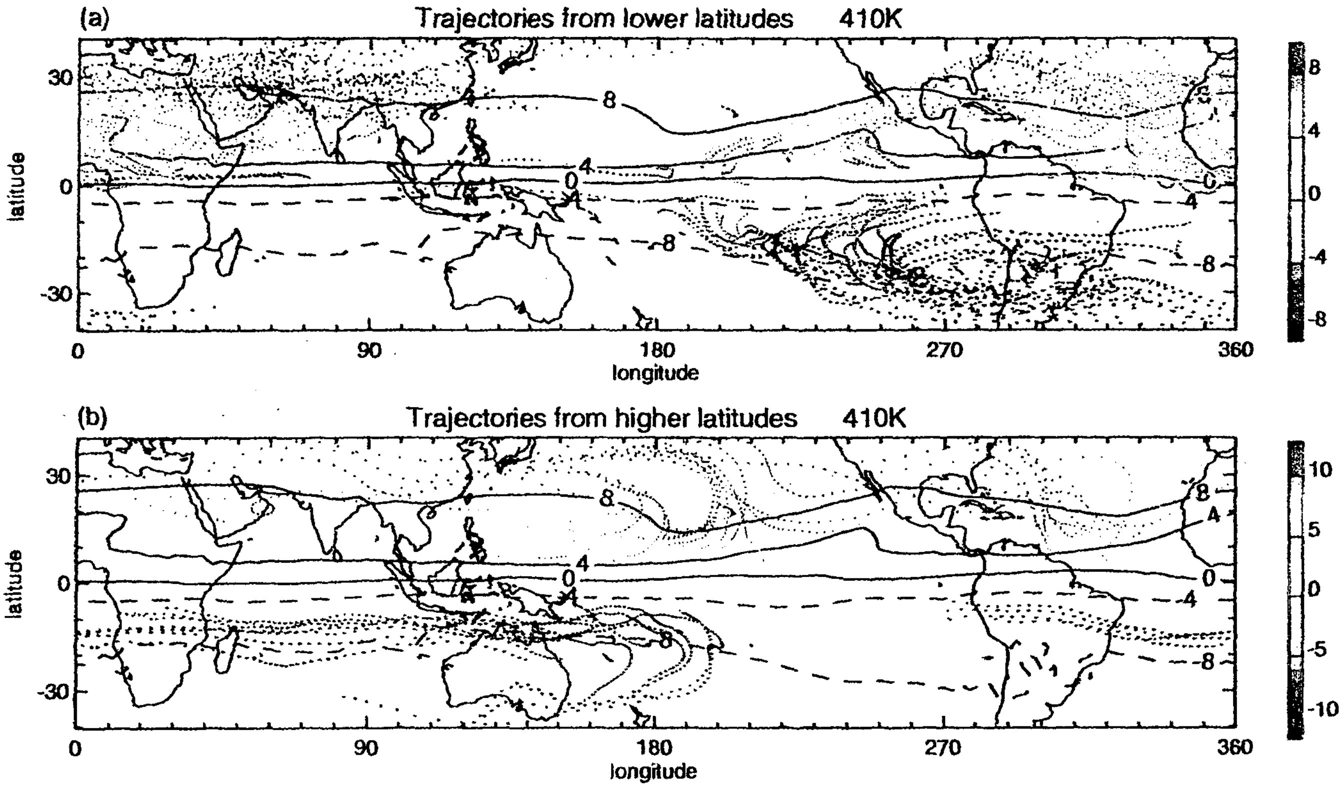


Plate 2. Isentropic trajectories at 410 K for (a) tropical and (b) extratropical particles whose |PV| values reached threshold values (see text for initial locations). The thresholds in Plate 2a are initially <5 PVU and reaching 9 PVU during the advection; the thresholds in Plate 2b are initially >9 PVU and reaching 5 PVU. The particle colors show their instantaneous PV values, and contours show time-averaged PV.

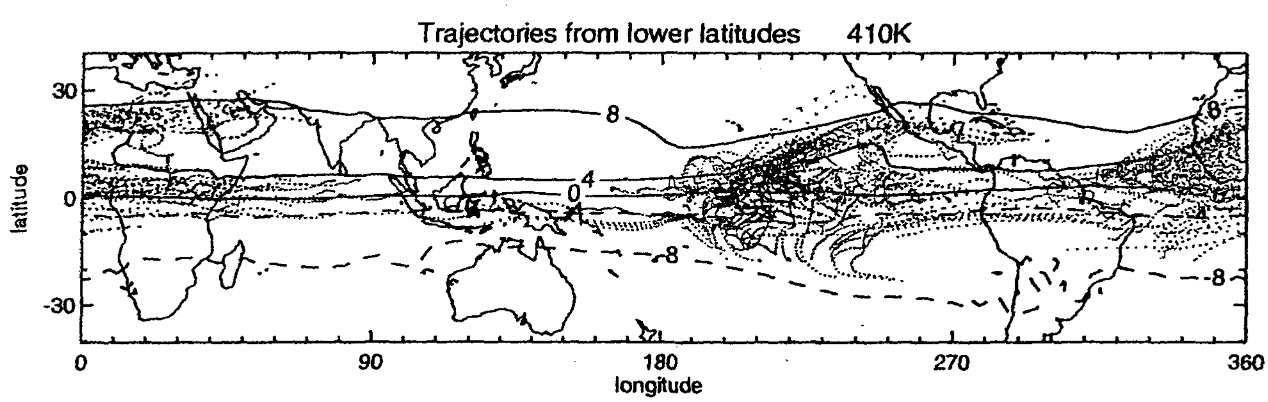


Plate 3. Isentropic trajectories at 410 K for tropical particles initialized on December 1 in the Northern (blue) and Southern Hemispheres (red). Particles with initial |PV| < 4 PVU, and which reach 5 PVU, are plotted from initial time until exceeding the final threshold.