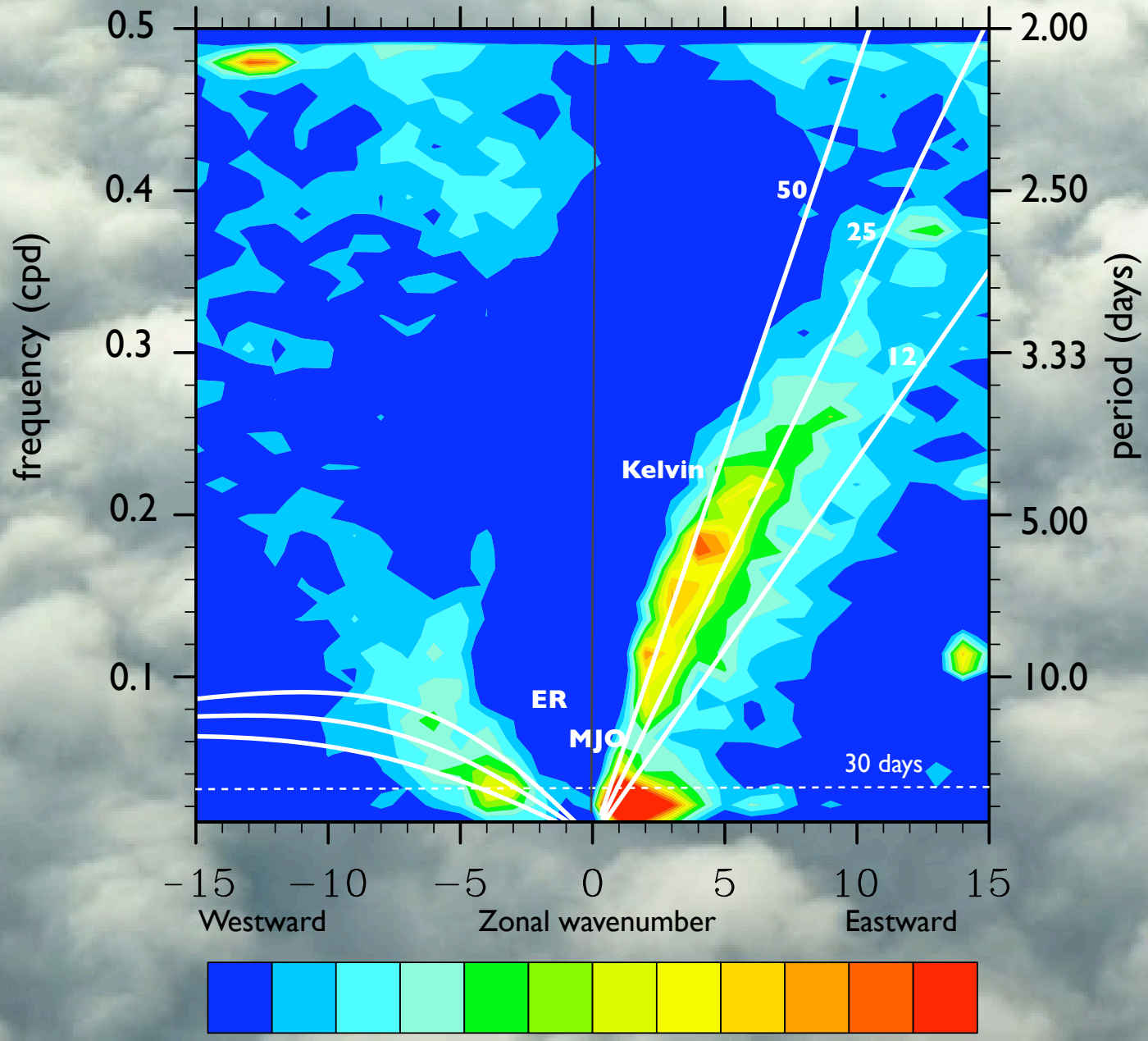
# MJO in CSU MMF

# Main features of MJO

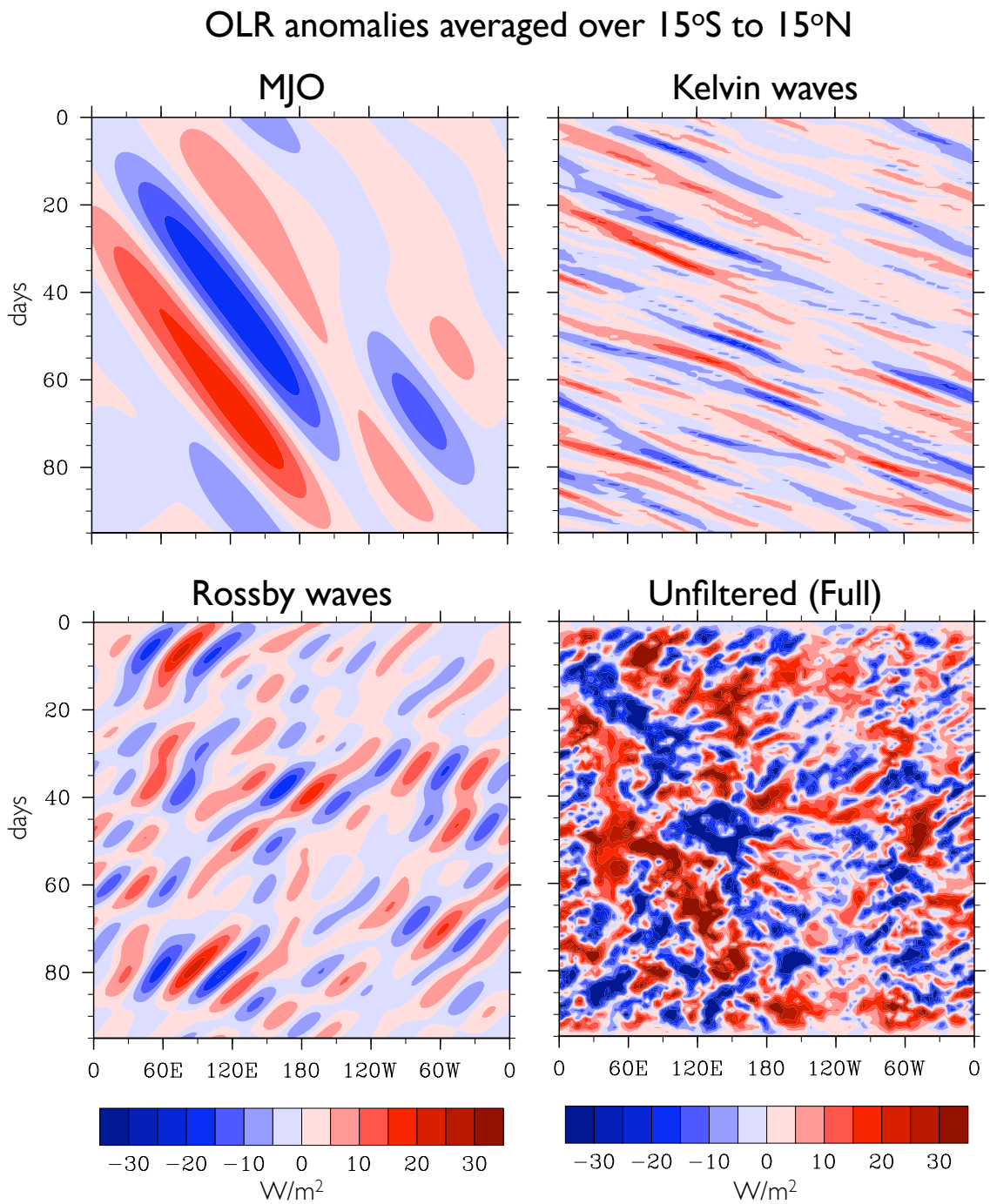
- Eastward propagatation
- Slow speed (about 5 m/s)
- Usually born in the Indian Ocean
- Usually disappears in the Central Pacific
- Time-scale: 30-60 days
- spatial scale: zonal number 1-3
- Westward tilt
- Strong seasonality (strongest in borial winter and spring)

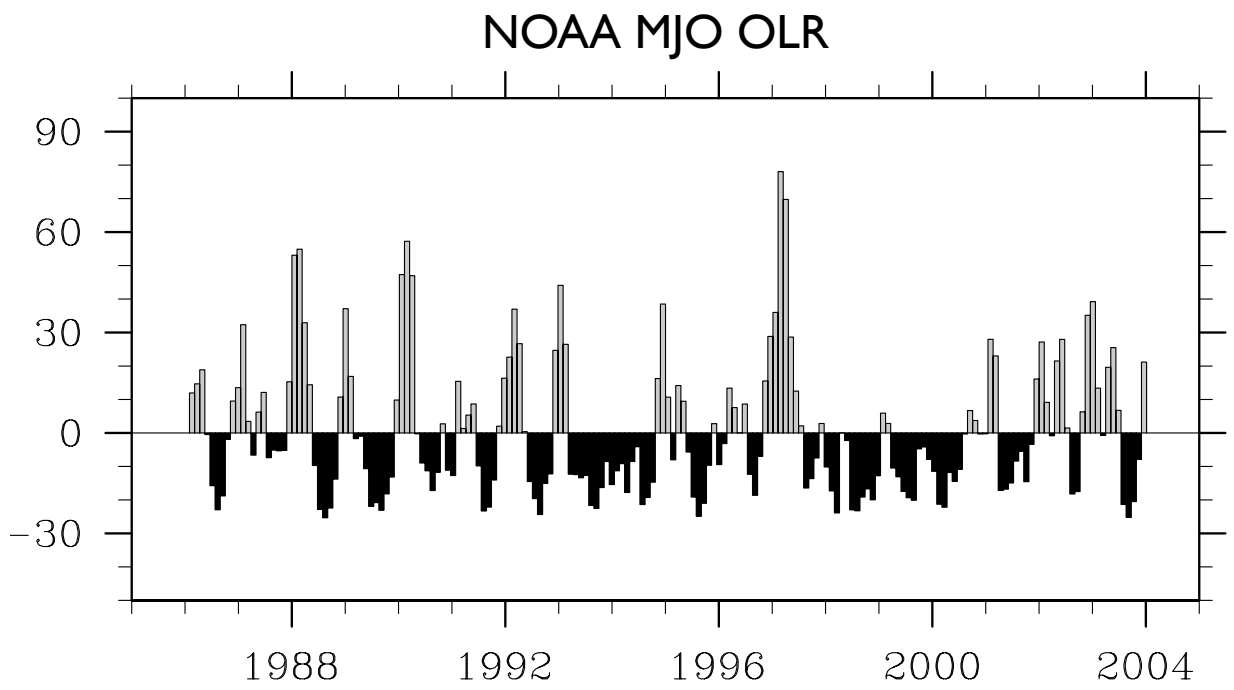
# MJO Theories

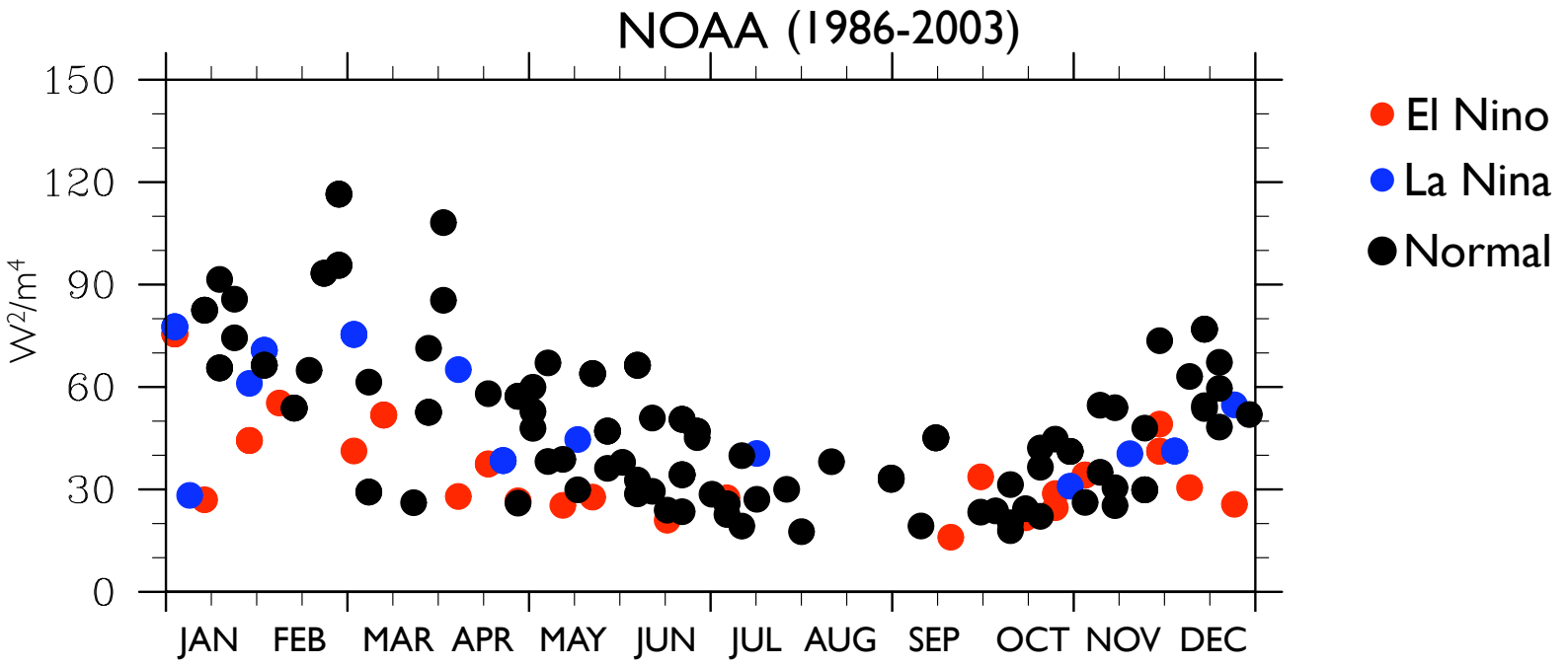
- Atmospheric response to heating?
- Internal instability?
- Air-sea interactions?
- Self-organization of convection (super-clusters, etc.) ?


NOAA OLR S/N Spectrum
frequency (cpd)
0.5
0.4
0.3
0.2
0.1
period (days)
2.00
2.50
3.33
5.00
10.0
50
25
12
Kelvin
ER
MJO
30 days
−15
−10
−5
0
5
10
15
Westward
Zonal wavenumber
Eastward

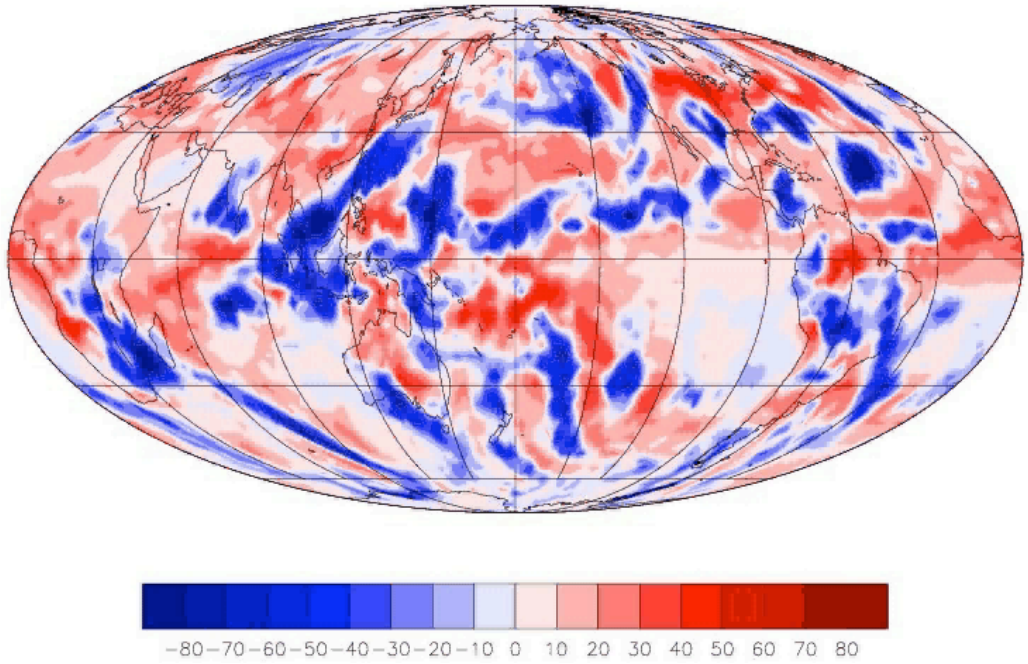
# Equatorially trapped waves and Madden-Julian Oscillation (MJO)



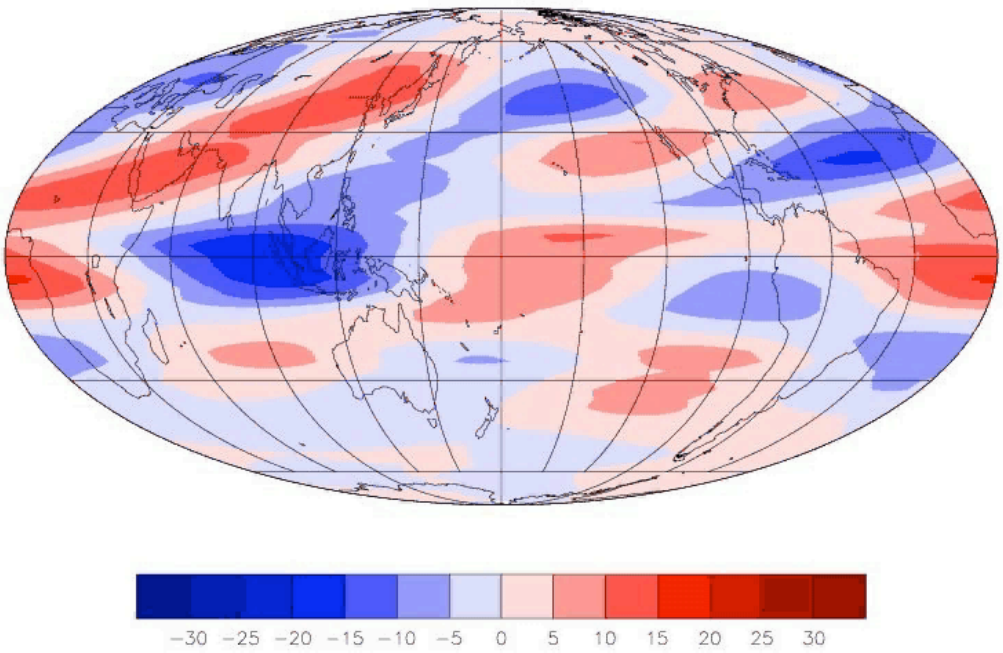

NOAA MJO OLR
90
60
30
0
−30
1988
1992
1996
2000
2004


NOAA (1986-2003)
150
120
90
60
30
0
W²/m⁴
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC
El Nino
La Nina
Normal

## NOAA OLR FULL day 30

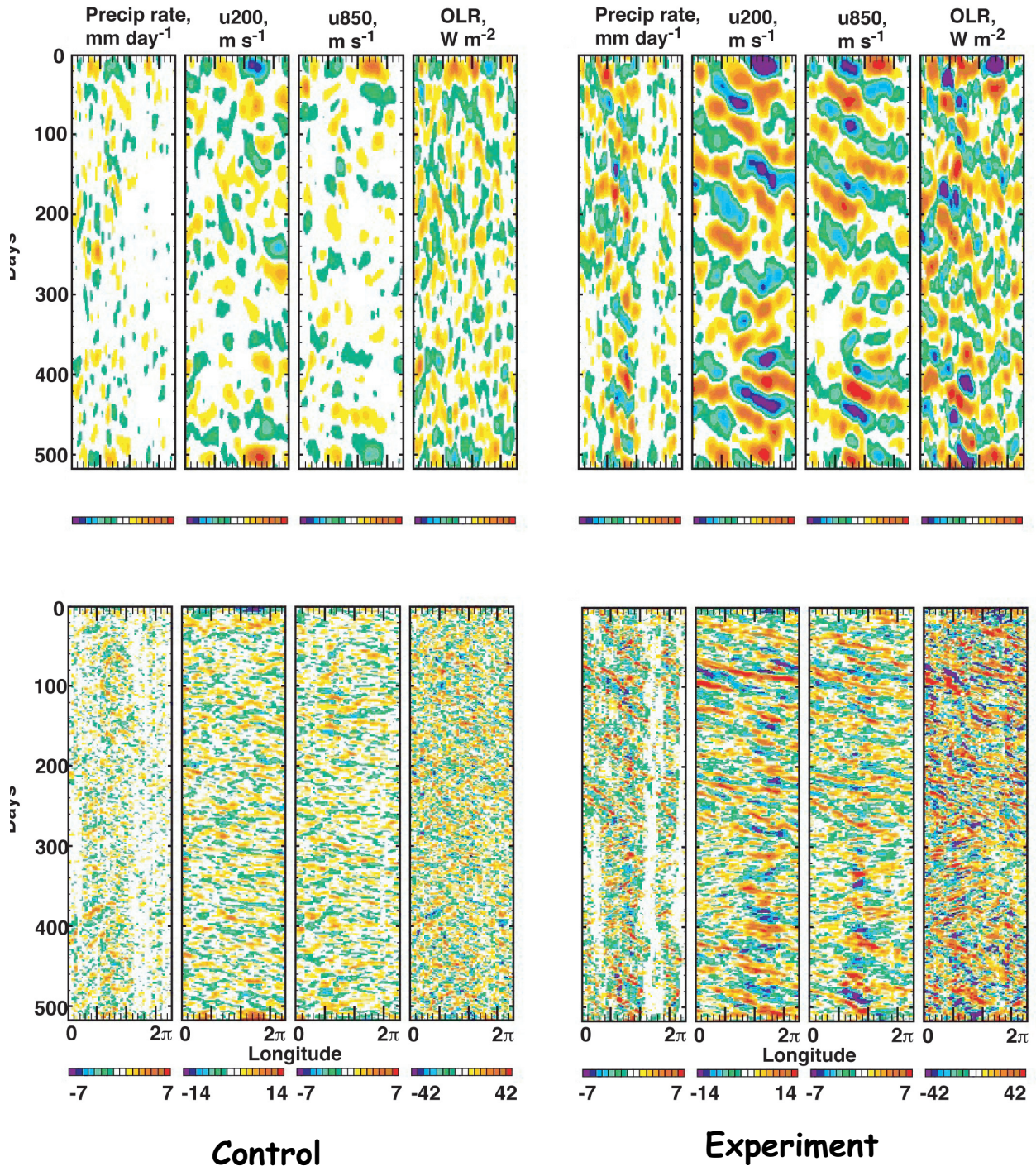



## NOAA OLR MJO day 30



# MJO in GCMs

- GCMs have hard time reproducing MJO
- Simulated MJO is very sensitive to details of parameterization of convection
- Generally, the GCMs include the physical mechanisms suggested by theoretical models of MJO, yet most fail to reproduce it.
- MMF seems able to simulate a robust MJO



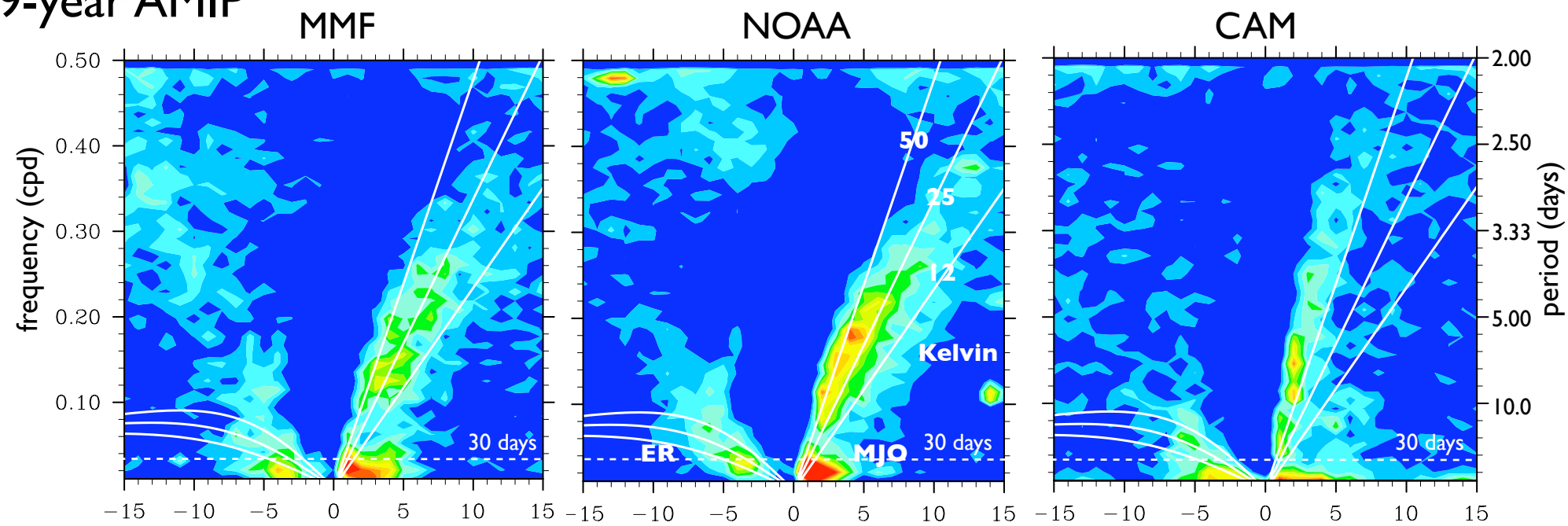

MJO

Randall et al (2003)

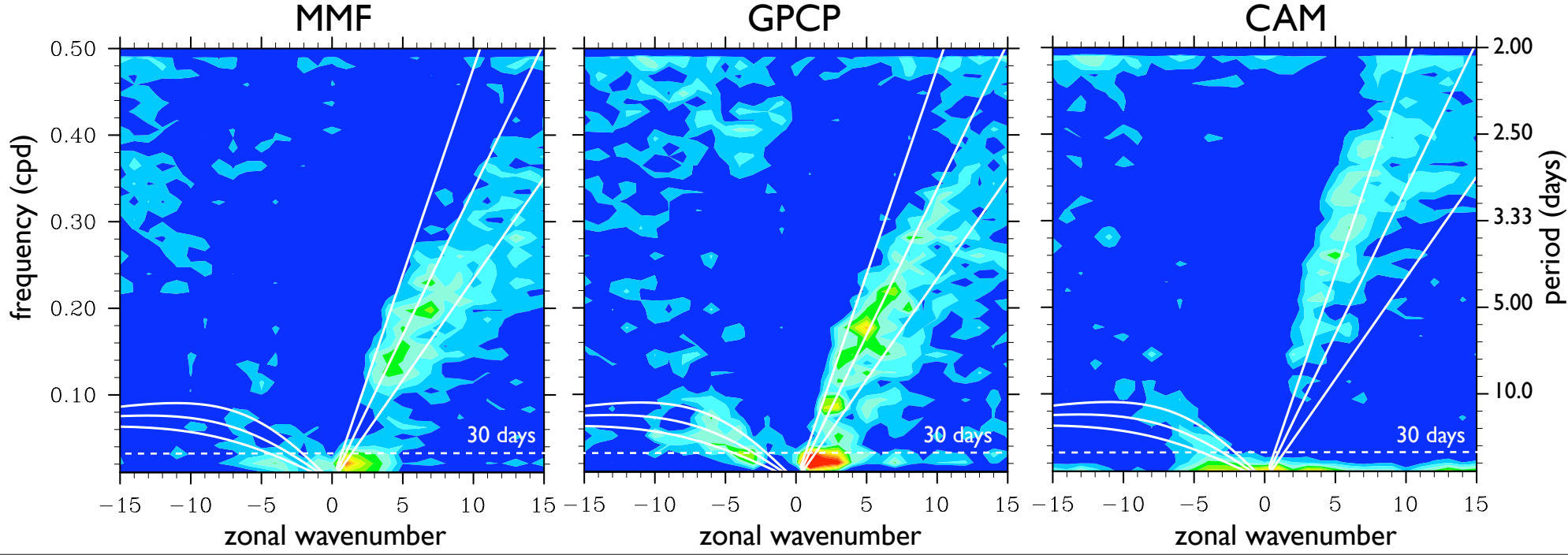
Kelvin

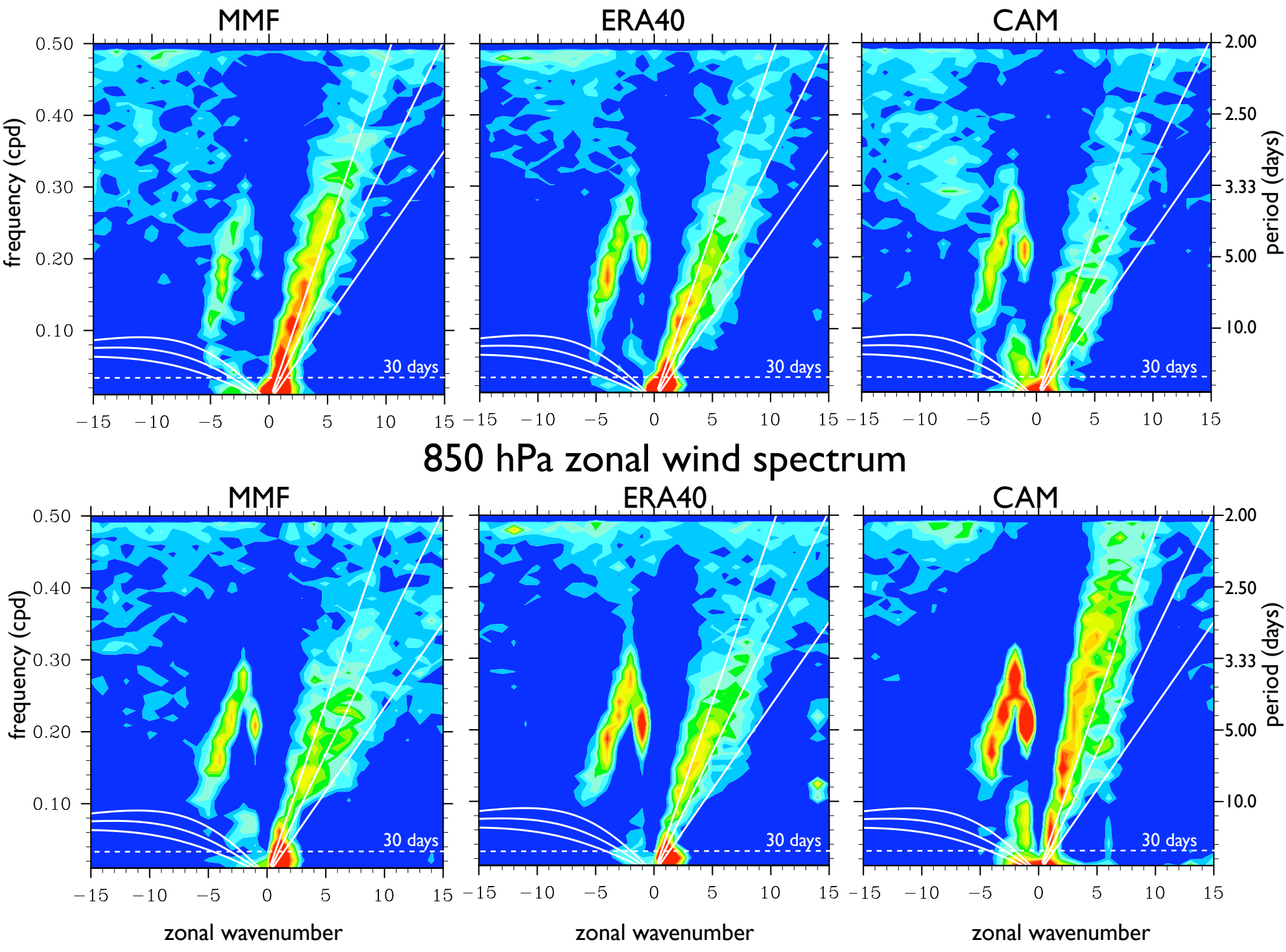
MMF T42
19-year AMIP

# OLR spectrum

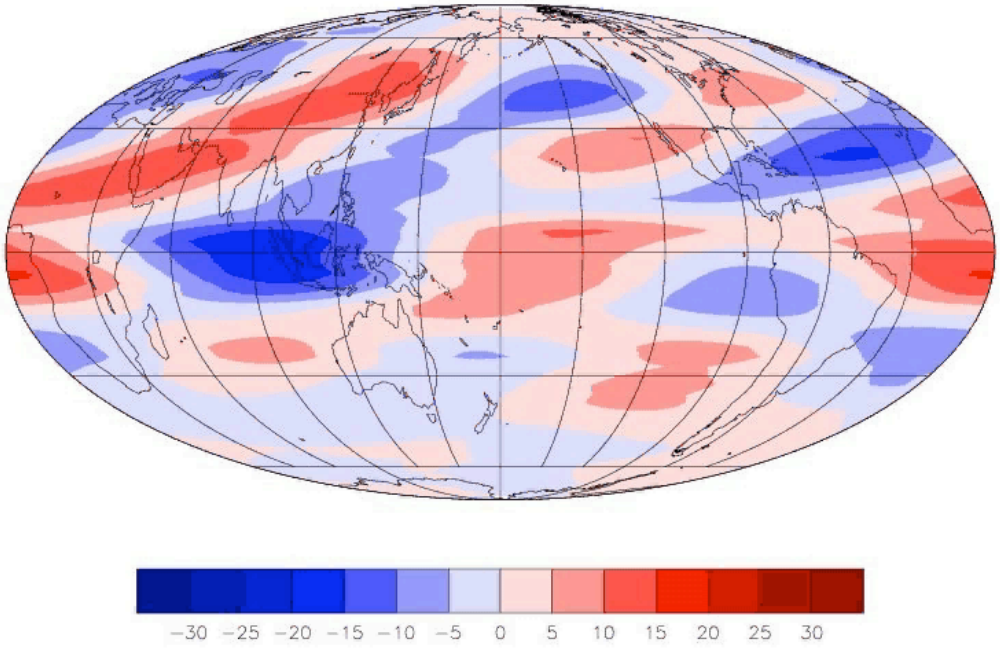



# Precipitation spectrum

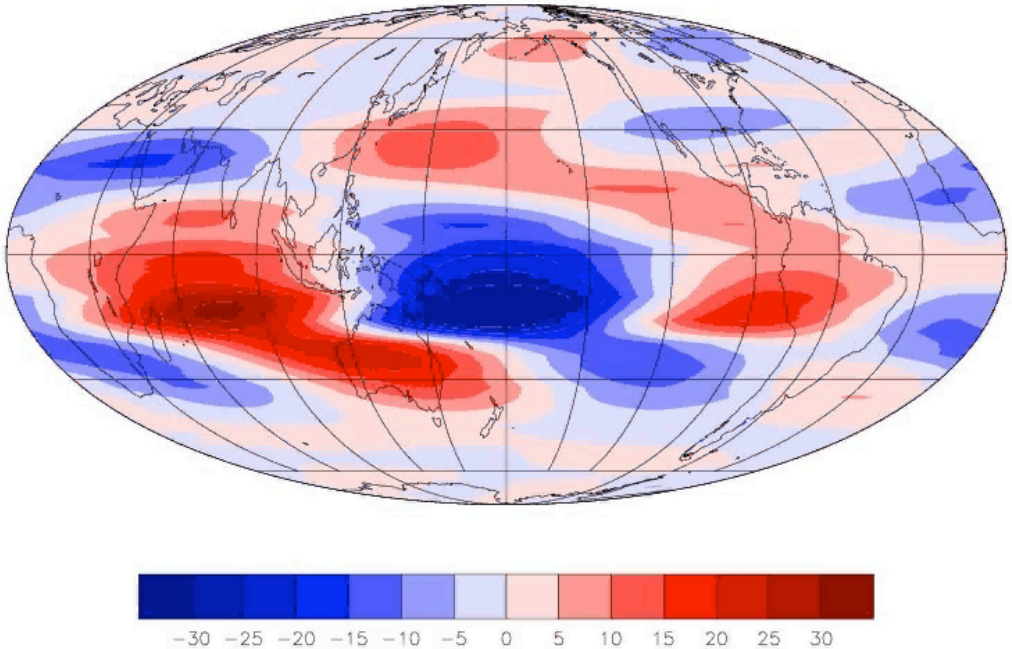



200 hPa zonal wind spectrum
MMF
ERA40
CAM
frequency (cpd)
period (days)
0.50
0.40
0.30
0.20
0.10
2.00
2.50
3.33
5.00
10.0
30 days
−15 −10 −5 0 5 10 15
850 hPa zonal wind spectrum
MMF
ERA40
CAM
frequency (cpd)
period (days)
30 days
zonal wavenumber
zonal wavenumber
zonal wavenumber

NOAA OLR MJO day 30

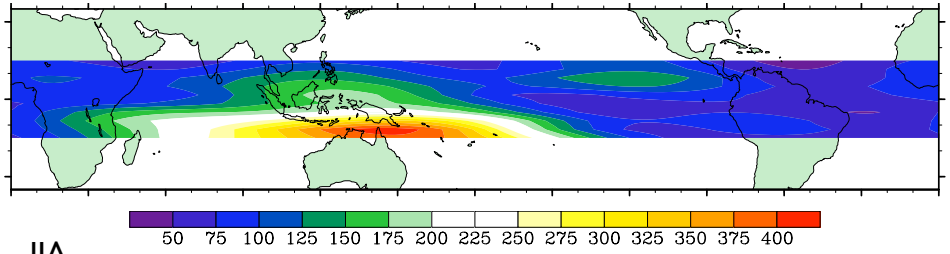



MMF-PERPJAN OLR MJO day 60

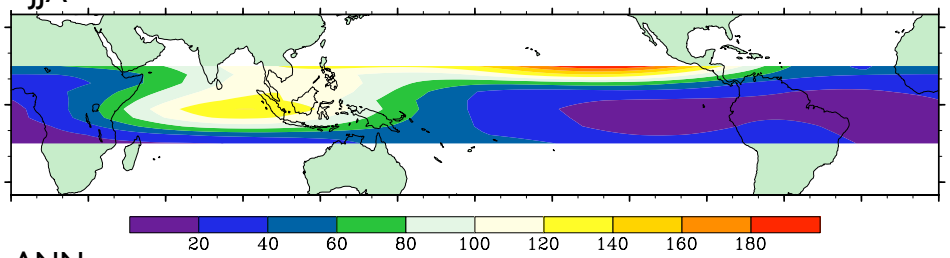


# MJO-filtered variance

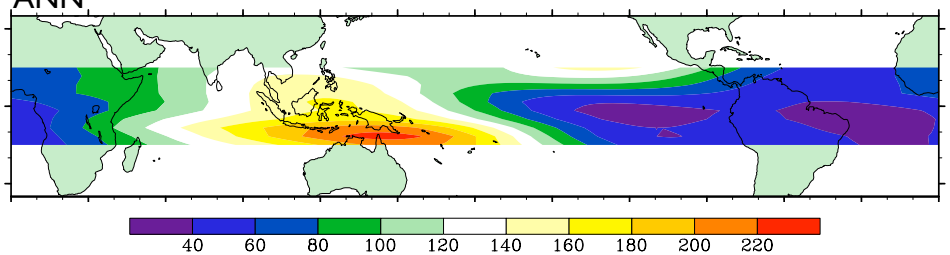
DJF MMF



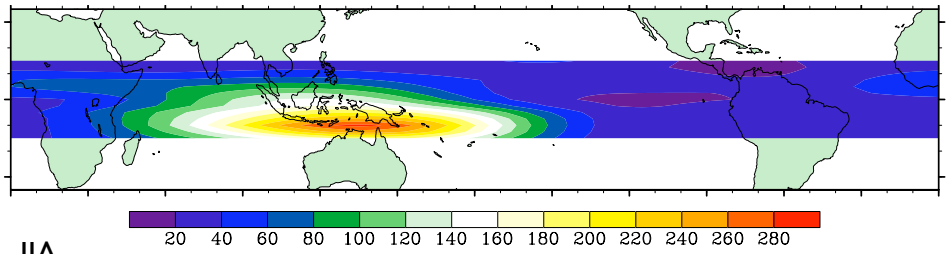

JJA



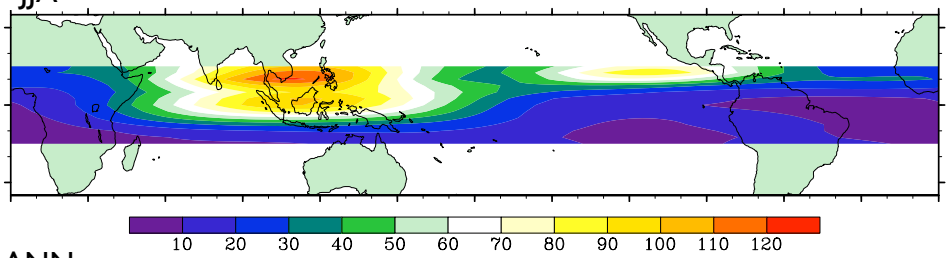

ANN



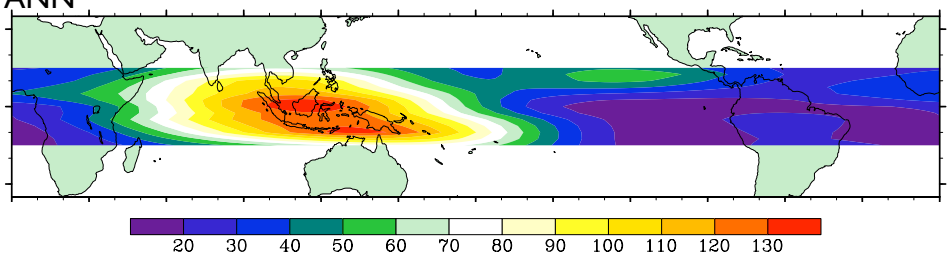

DJF NOAA



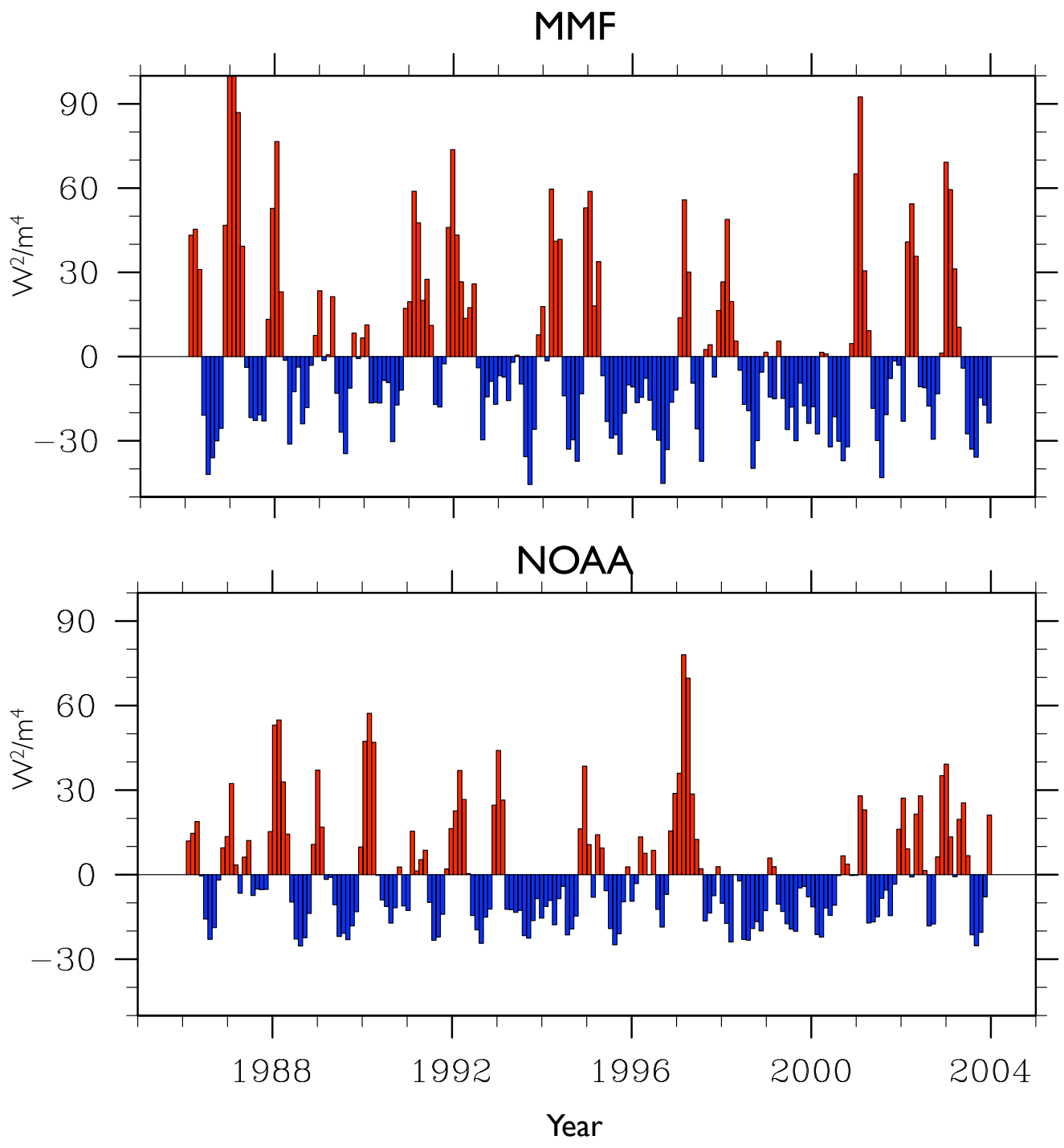

JJA



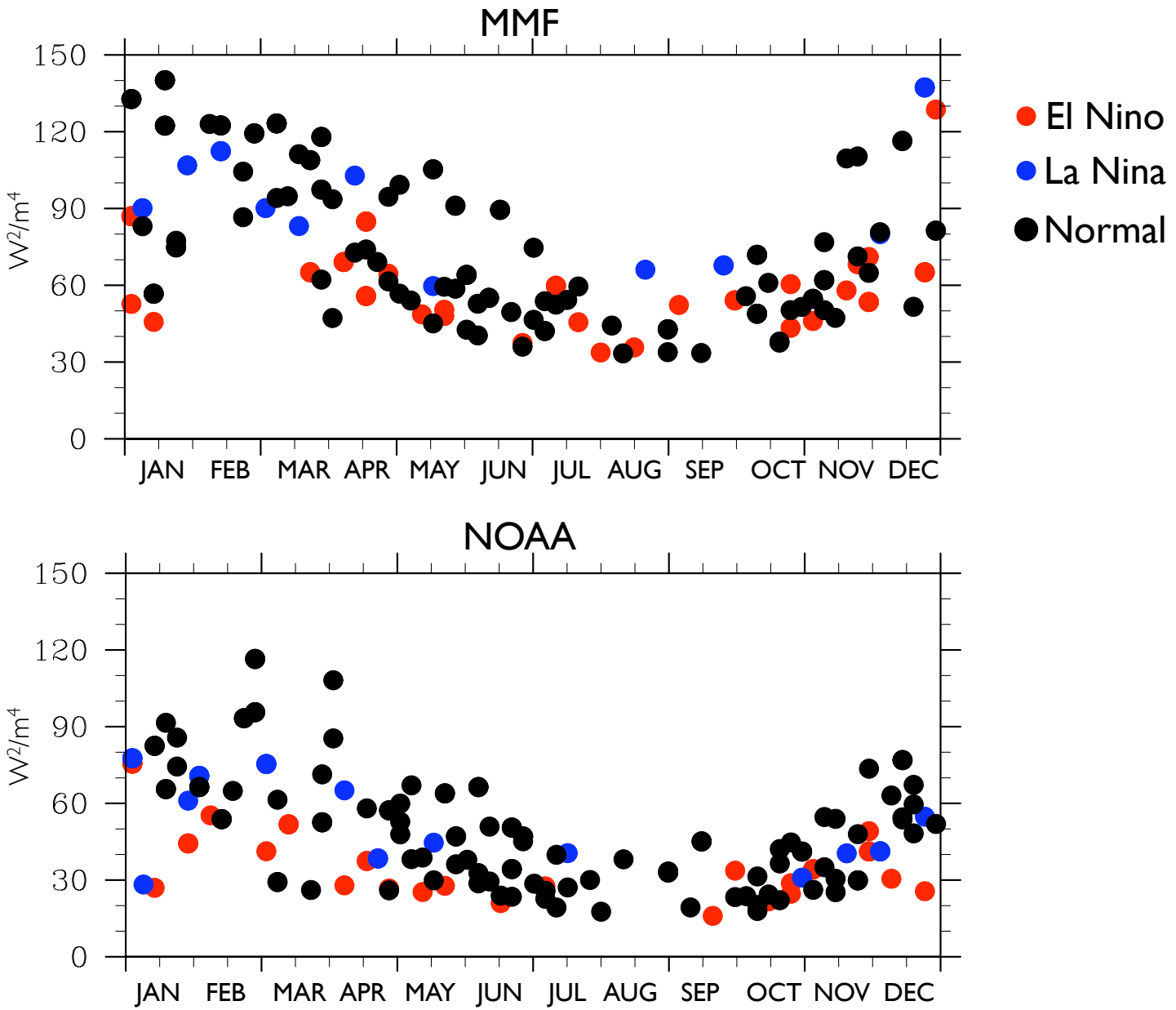

ANN



# MJO-filtered mean OLR anomaly



# MJO-event OLR anomalies
# 1986-2003



# In nutshell

- MJO is a major mode of sub seasonal variability in tropics
- Most fundamental features of MJO are still not explained by theories
- Most GCMs struggle to simulate the MJO showing great deal of sensitivity of the results to small details of parameterizations
- MMF demonstrates a robust MJO-like variability
- MMF simulations together with recent advances in our ability to observe the Earth from space may help to advance our understanding of MJO