5-day wave associated convection in reanalysis and CMIP5 models

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Overview

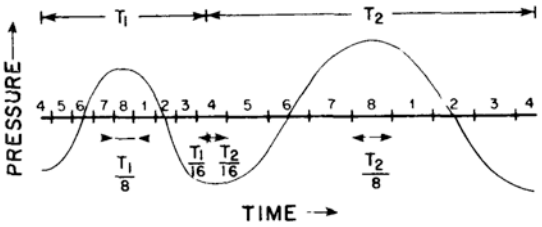
- Previous evidence of 5-day wave/tropical convection interaction
- Seasonal/interannual variability of wave-convection relationship
- Lag composites of wave and associated tropical convection
- CMIP5 model representations

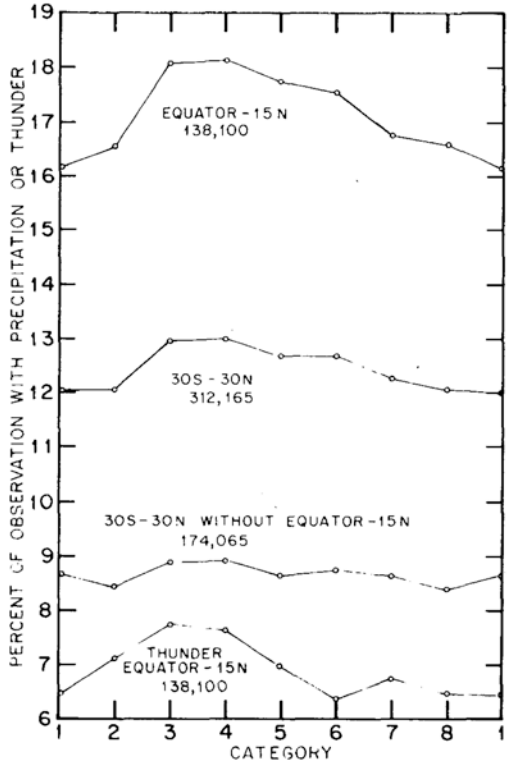
The 5-day wave

- The 5-day wave is the gravest, equatorially symmetric zonal wavenumber 1 external Rossby (or Rossby-Haurwitz) wave
- These waves have not been expected to be related to convection due to barotropic structure, small vertical motion associated with them
- Convection has been shown to be associated with the 5-day wave beyond stochastic heating forcing the wave

Previous evidence of 5-day wave/convection relationship

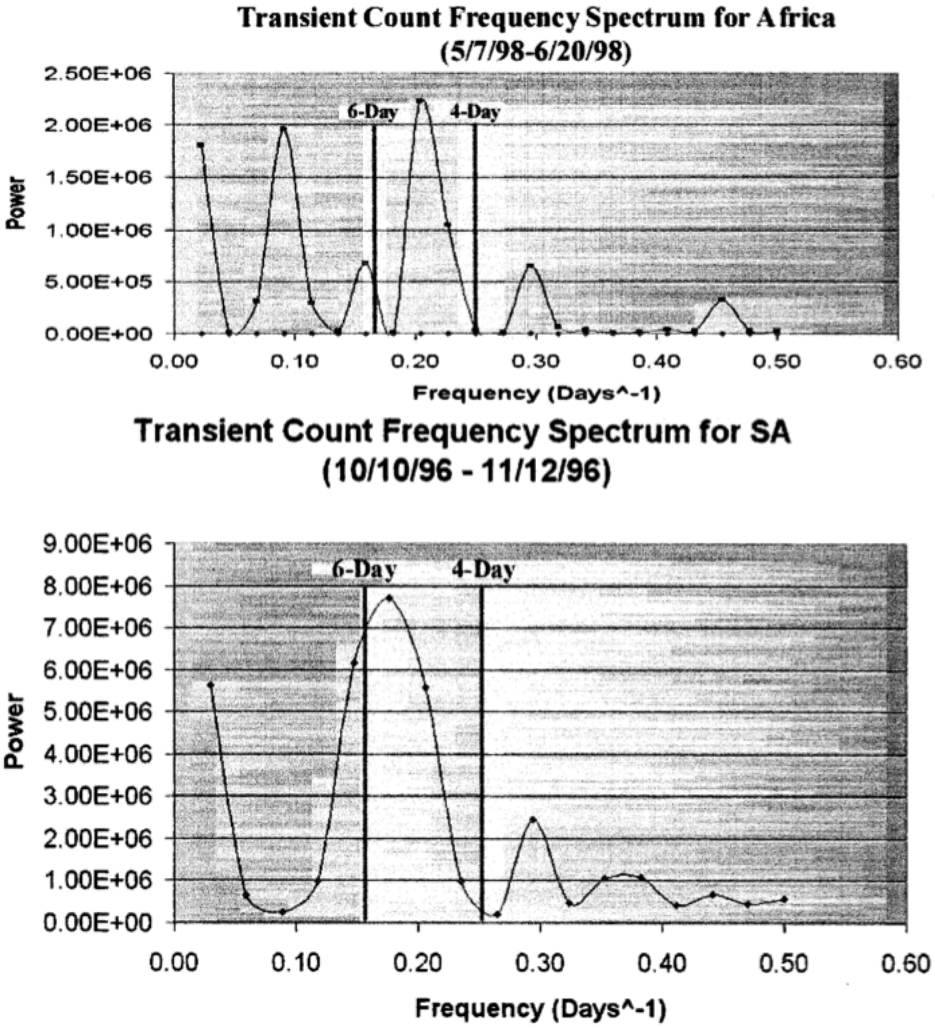
- Burpee, JAS, 1976
  - Filtered JJAS 1966-1969 station surface pressure, 10-20˚N
  - Modulation of ~5% in 3-hrly precipitation observations due to wave
  - ~9% in thunder observations





from Burpee, *JAS*, 1976

Previous evidence of 5-day wave/convection relationship



- Castro, 2000
  - 4-6 day periodicity in African and South American lightning counts
- Patel, 2001
  - Consistent phase relationship between 5-day wave pressure and filtered African lightning

from Castro, MS thesis, 2000

Previous evidence of 5-day wave/convection relationship

- Hendon and Wheeler, JAS, 2008
  - Significant coherency between U850 and OLR at westward wavenumber 1, 4.5-6 day period

after Hendon and Wheeler, *JAS*, 2008

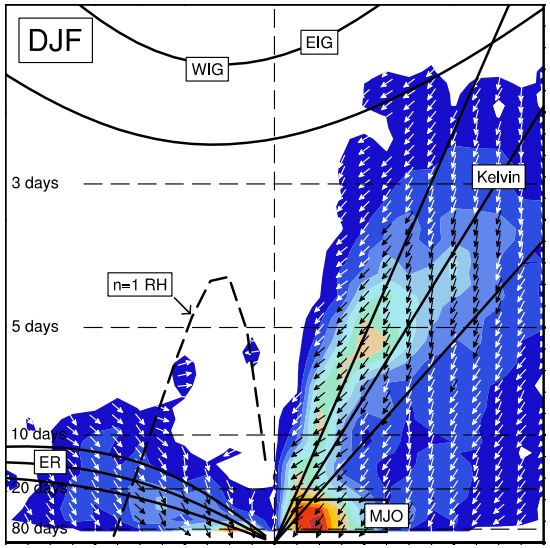
Seasonal and interannual variability

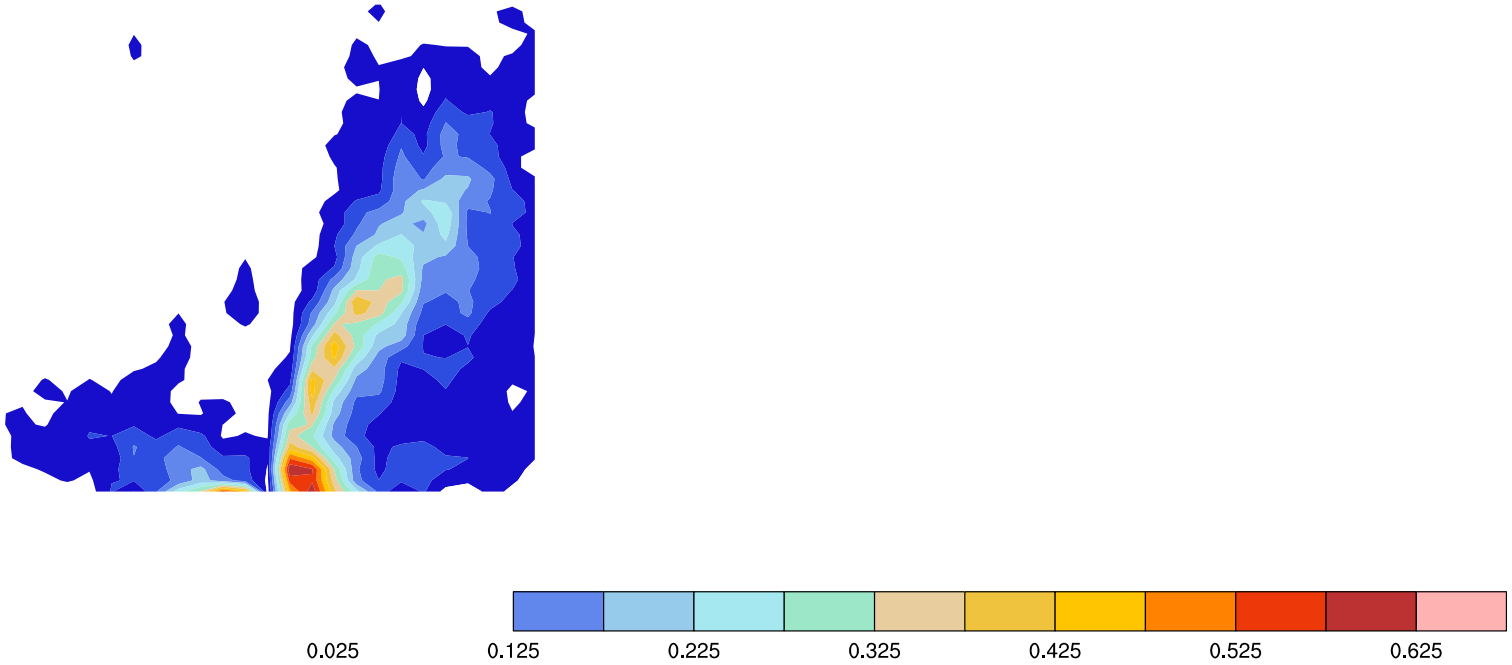
- Investigated using frequency-wavenumber spectra of coherence-squared between NOAA OLR and ERA Interim 850 hPa zonal winds

- Produced for seasons, ENSO phases, QBO phases at 40 hPa and QBO vertical shear regimes

Seasonal spectra

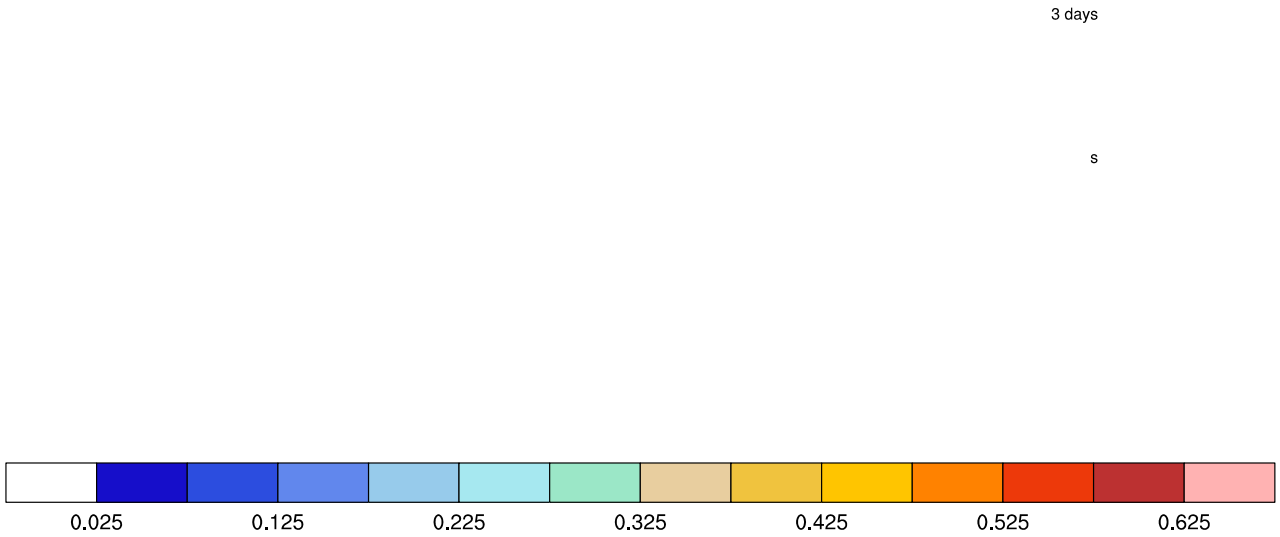
- Coherence is weaker in DJF than other seasons
- Small movement in peak frequency from season to season





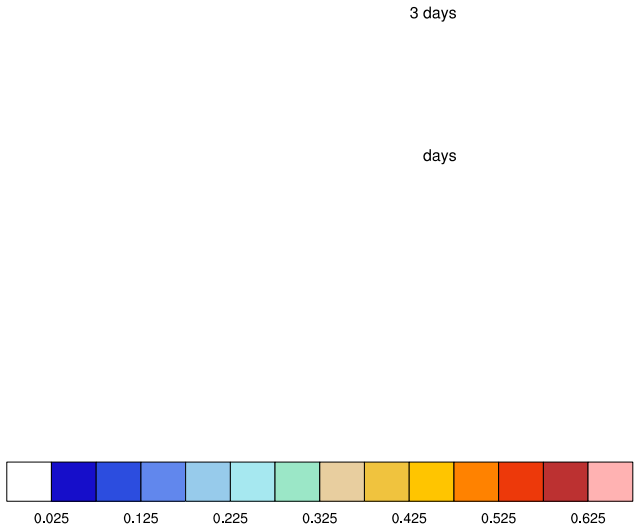
Spectra, ENSO phases

- No large difference in coherence values observed for the 5-day wave between the different ENSO phases



Spectra, QBO phases

- Neutral phase of the QBO at 40 hPa level has higher coherence between U850 and OLR in the 5-day wave range than any other investigated period



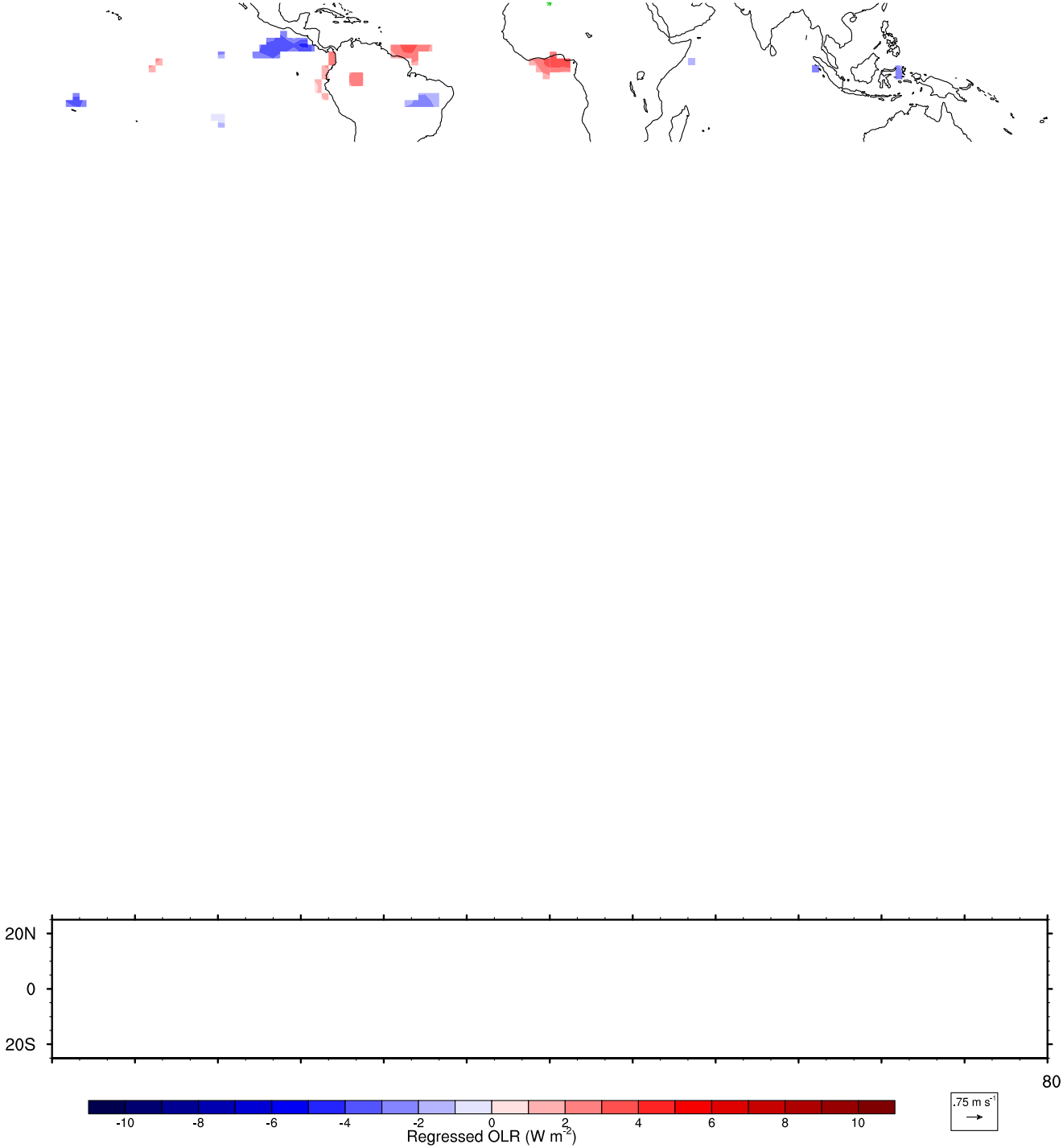
Spectra, QBO shear regime

- Increased coherence in neutral phase of QBO doesn’t seem to be related to QBO shear

Lag-regression composites

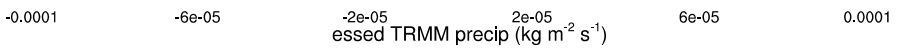
- 4-6 day, westward wavenumber 1 filtered 850 & 150 hPa zonal winds, 5˚N-5˚S
- Average over latitude and pressure at 0˚ longitude used as basis timeseries
- 850 hPa horizontal winds and OLR (also TRMM 3B42 rainfall) regressed against timeseries
- Scaled by 2 s.d. of the basis timeseries

Lag-regression composites: OLR, annual

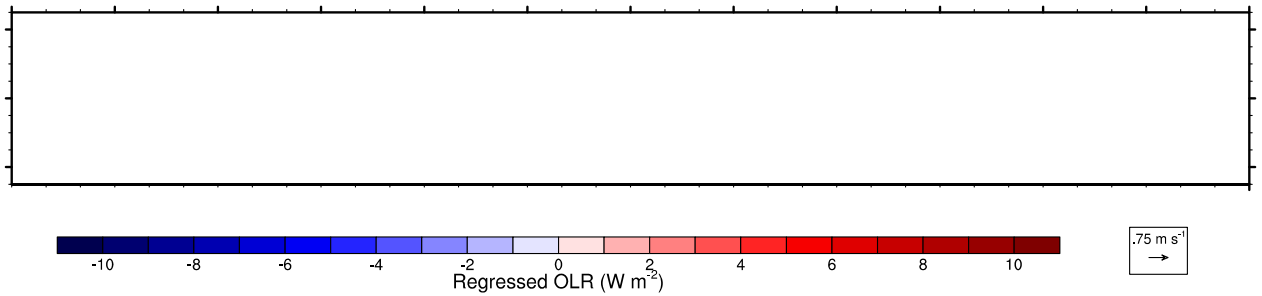


Lag-regression composites: TRMM, annual

- TRMM 3B42 rainfall lag-regression similar to OLR lag-regression



Lag-regression composites: OLR, MAM



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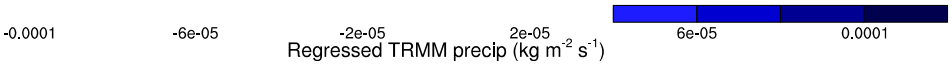
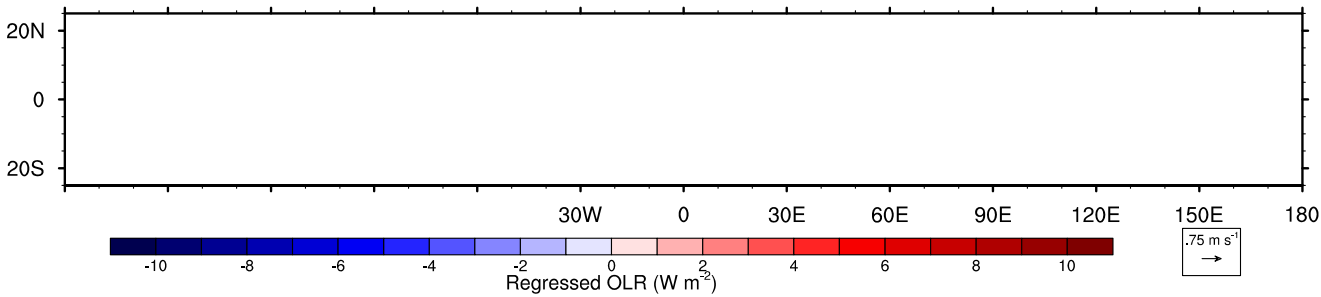


Lag-regression composites: OLR, JJA



Lag-regression composites: TRMM, JJA

- TRMM 3B42 rainfall lag-regression similar to OLR lag-regression

6e-05 -2e-05 2e-05 6e-05 0.0001

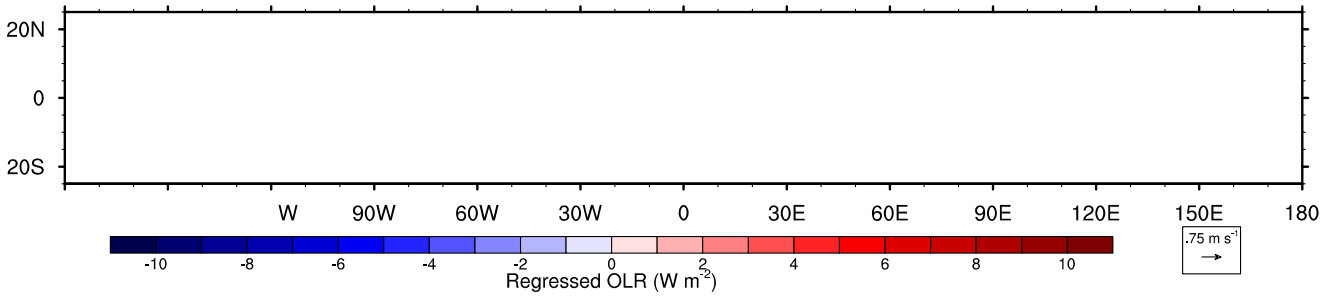
Lag-regression composites: OLR, SON

6 -4 -2 0 2 4 6 8 10

Lag-regression composites: TRMM, SON

- TRMM 3B42 rainfall lag-regression similar to OLR lag-regression

Lag-regression composites: OLR, DJF



Lag-regression composites: TRMM, DJF

- TRMM 3B42 rainfall lag-regression similar to OLR lag-regression

CMIP5 models

Observations
(TRMM 3B42 precip/ERAi winds)

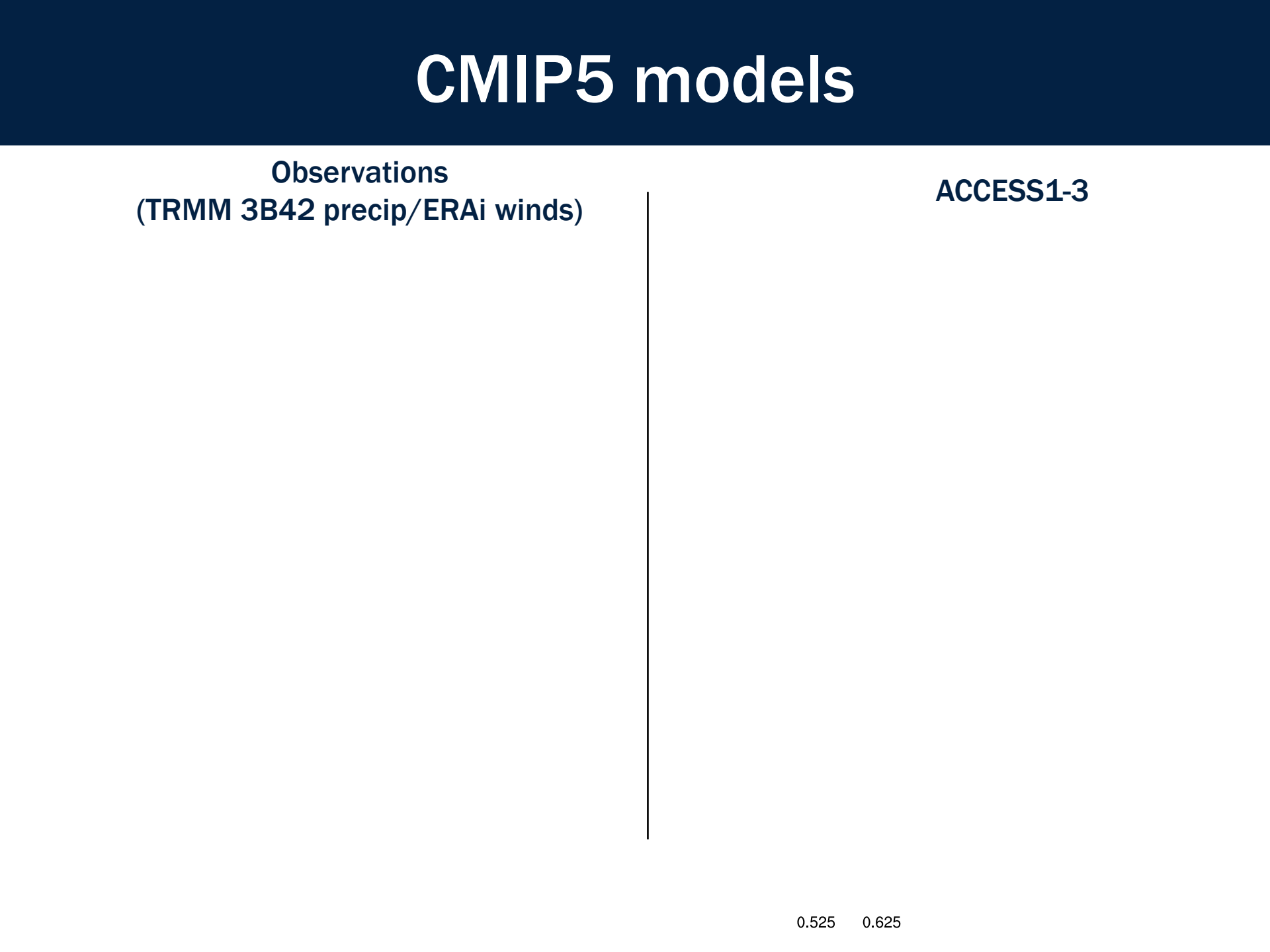
MPI-ESM-P

0.525 0.625

CMIP5 models

Observations
(TRMM 3B42 precip/ERAi winds)

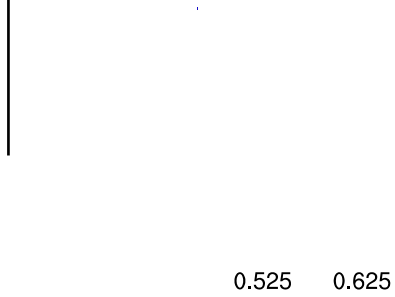
ACCESS1-3



CMIP5 models

Observations
(TRMM 3B42 precip/ERAi winds)

HadCM3



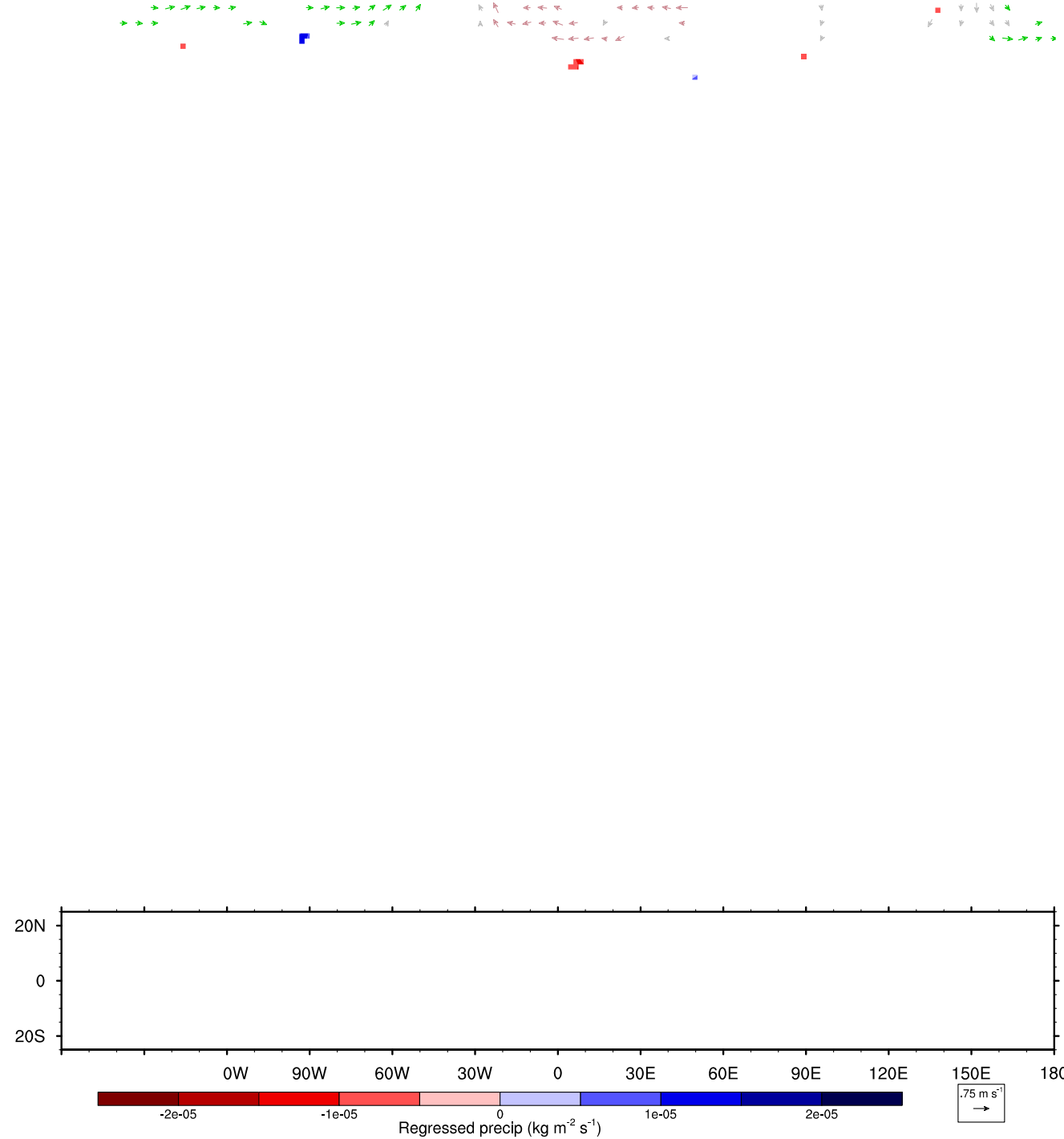
CMIP5 models

Observations
(TRMM 3B42 precip/ERAi winds)

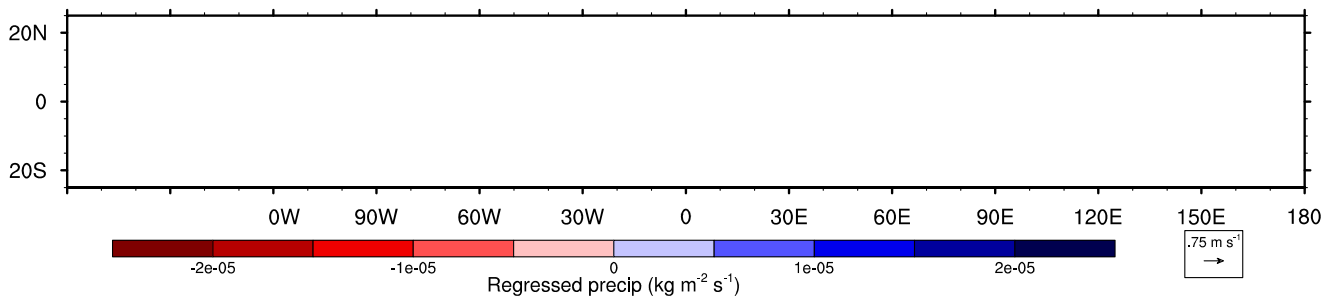
BCC-CSM1-1

0.525 0.625

MPI-ESM-P


20N
0
20S
0W
90W
60W
30W
0
30E
60E
90E
120E
150E
180
-2e-05
-1e-05
0
1e-05
2e-05
Regressed precip (kg m-2 s-1)
.75 m s-1

ACCESS1-3


20N
0
20S
0W
90W
60W
30W
0
30E
60E
90E
120E
150E
180
-2e-05
-1e-05
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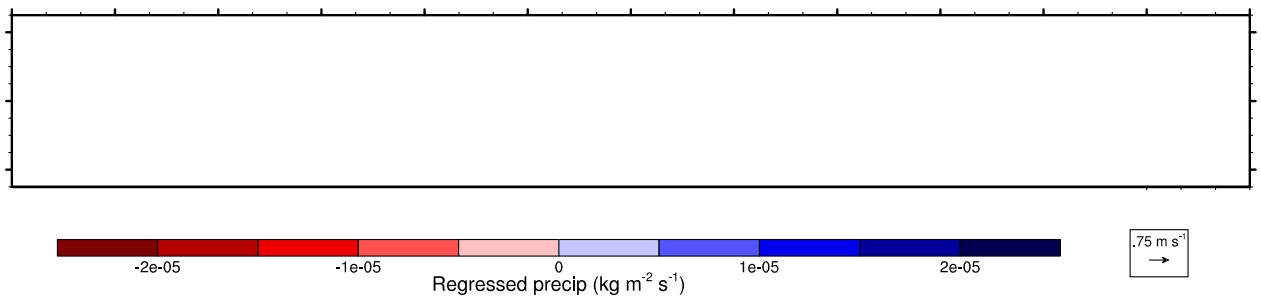
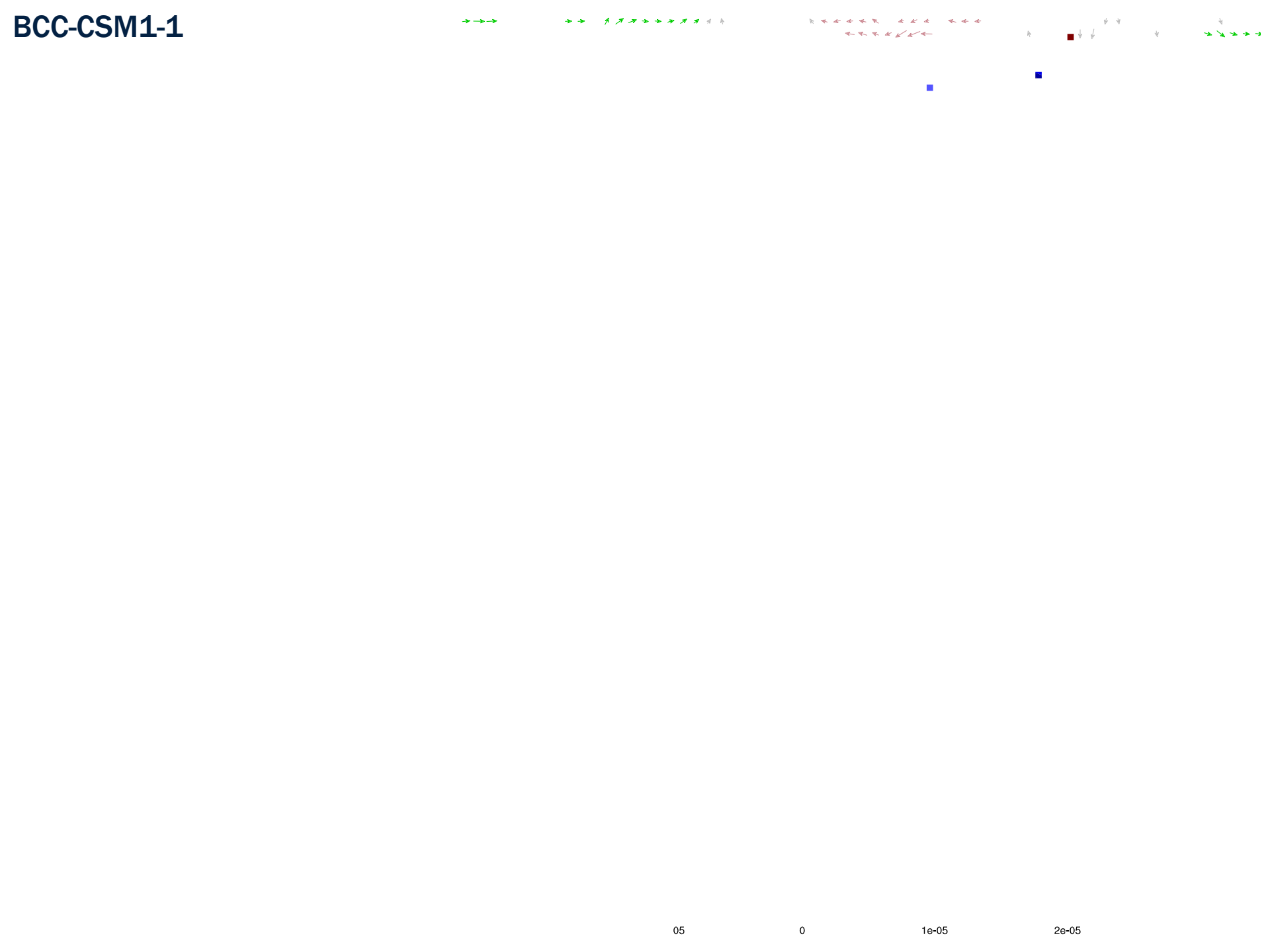


BCC-CSM1-1



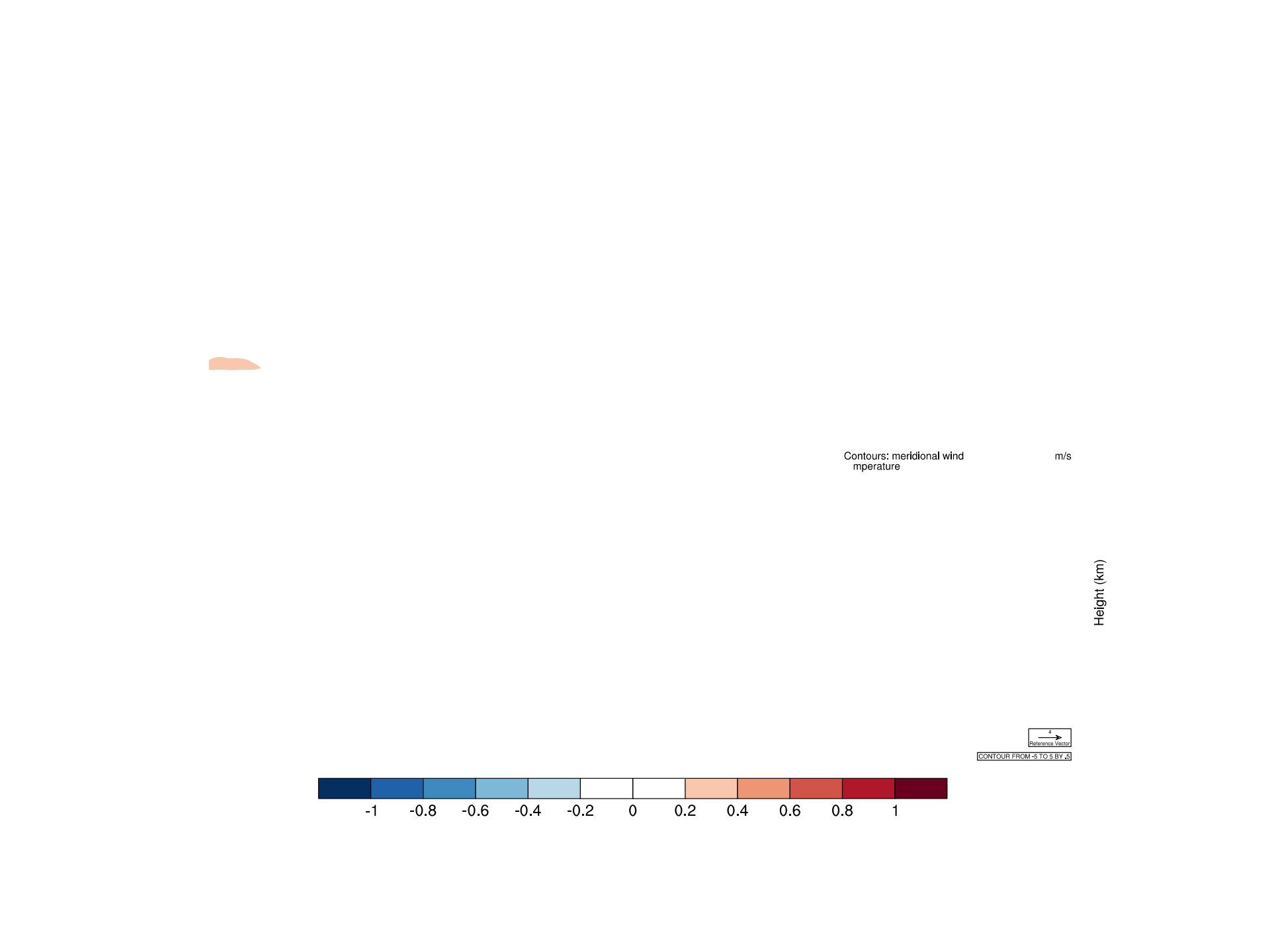
Overview

- Main variability discovered in convection associated with the 5-day wave is seasonal
- Largest and most significant convective anomalies occur over South America and the Gulf of Guinea
- Convection over Andes in phase with easterly anomalies, almost quarter-cycle after easterly anomalies elsewhere
- CMIP5 models OK at convective anomaly locations, little off on phase (individual models vary)

Some of this is in:

- King, MJ; Wheeler, MC and TP Lane, 2015: Association of convection with the 5-day Rossby-Haurwitz wave. *J. Atmos. Sci.*, e-view

6 0.8 1


Contours: meridional wind
mperature
m/s
Height (km)
4
Reference Vector
CONTOUR FROM -5 TO 5 BY .5
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1

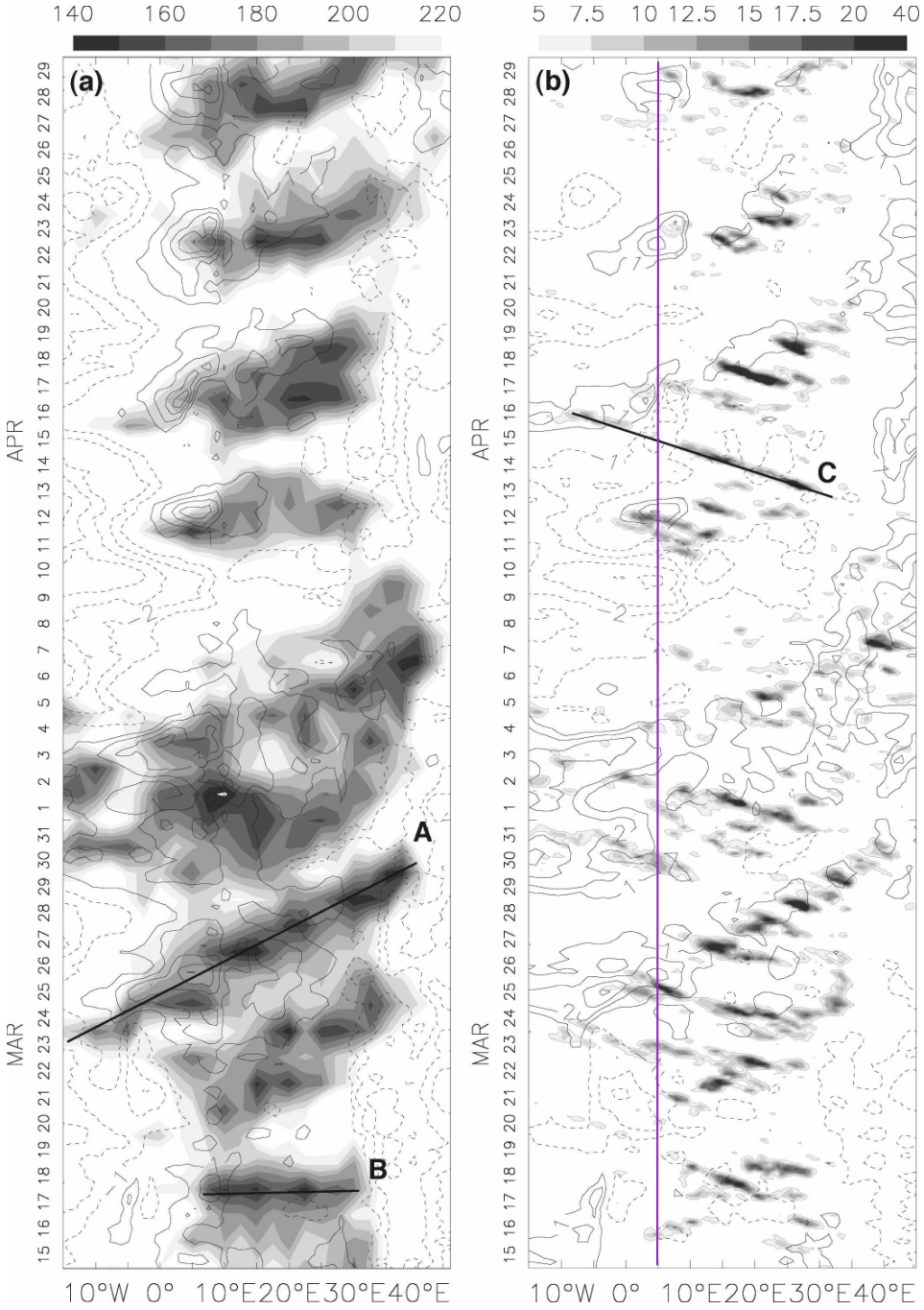


FIG. 7. Time–longitude diagrams of 5°S–5°N averaged in March–April 1997 for (a) daily OLR (shading, W m^{-2}) and 6-hourly ERA-40 surface zonal wind (contours, m s^{-1}), and (b) 3-hourly cloud index (shading, K) and 6-hourly ERA-40 surface zonal wind anomaly (contours, m s^{-1}).

from Nguyen and Duvel, *J Clim*, 2008