North Pacific Climate Variability in a New CESM1 Ocean Model Hierarchy

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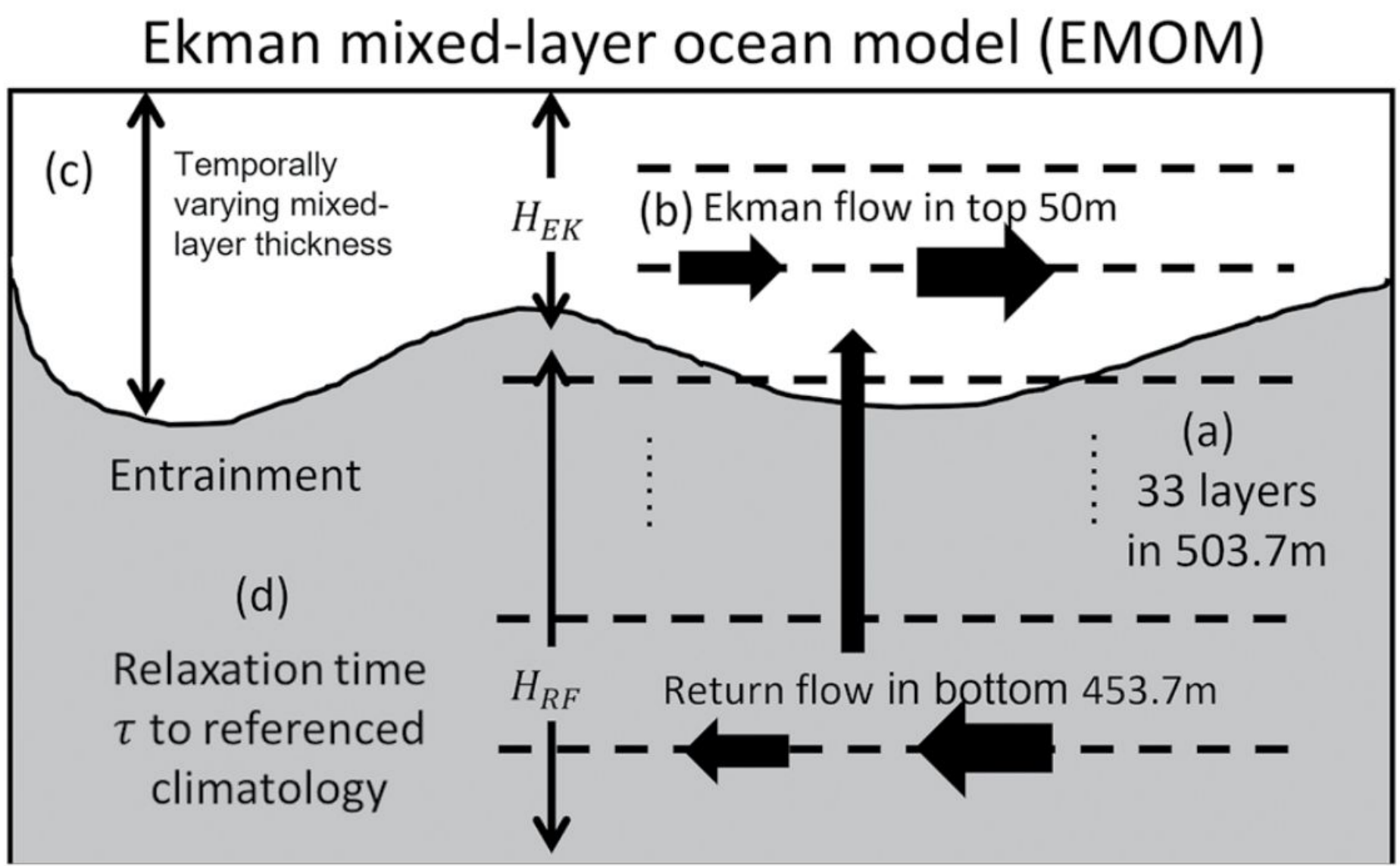
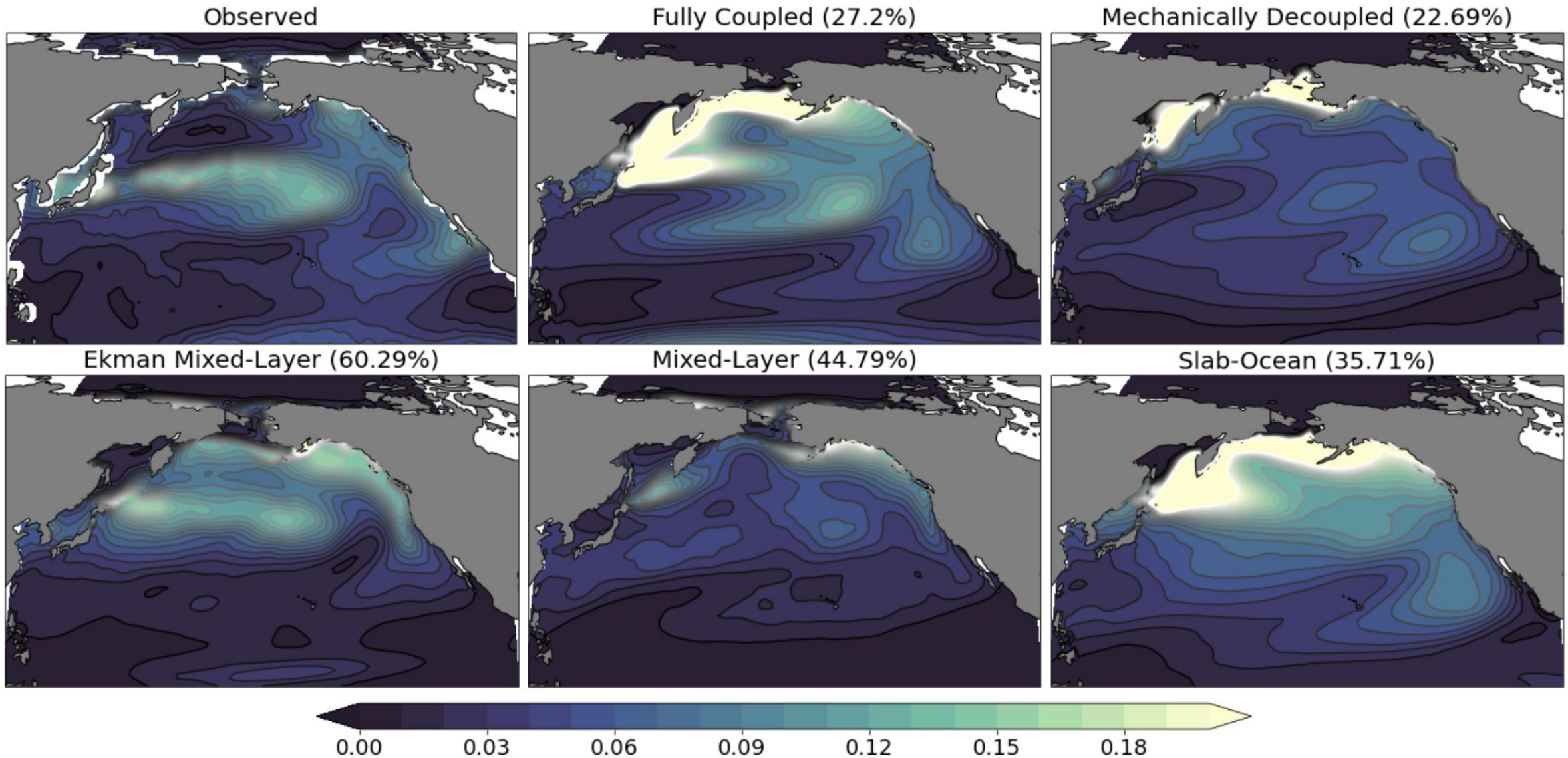
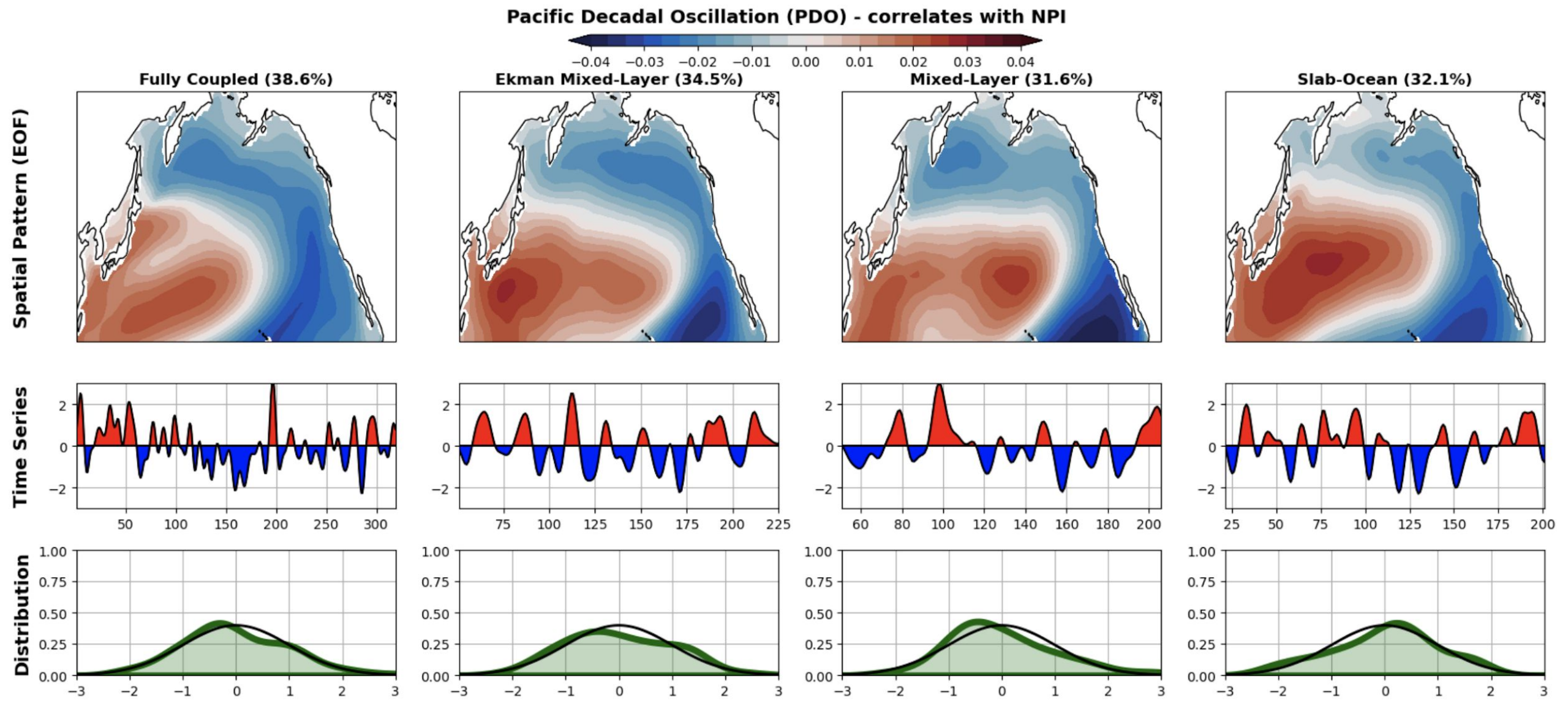
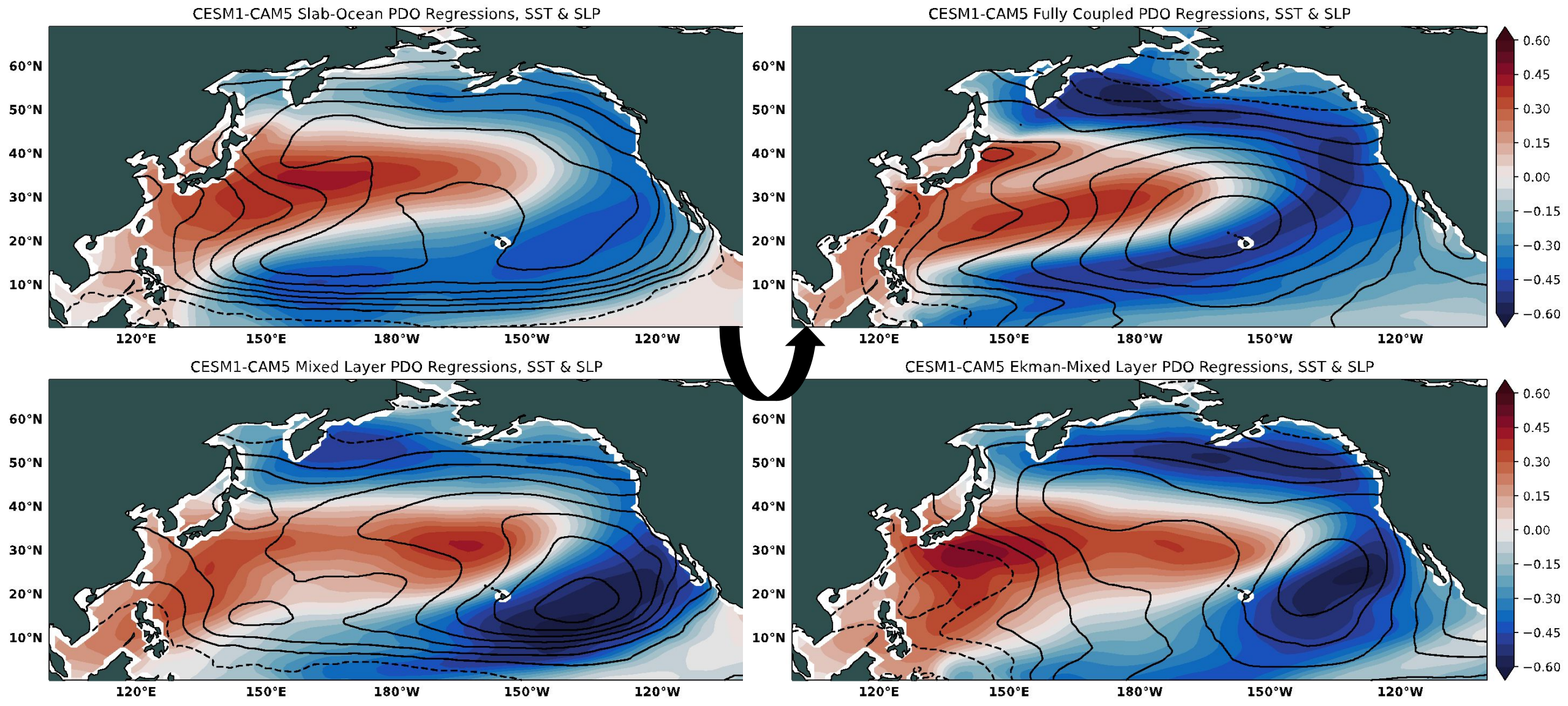
CVCWG Meeting

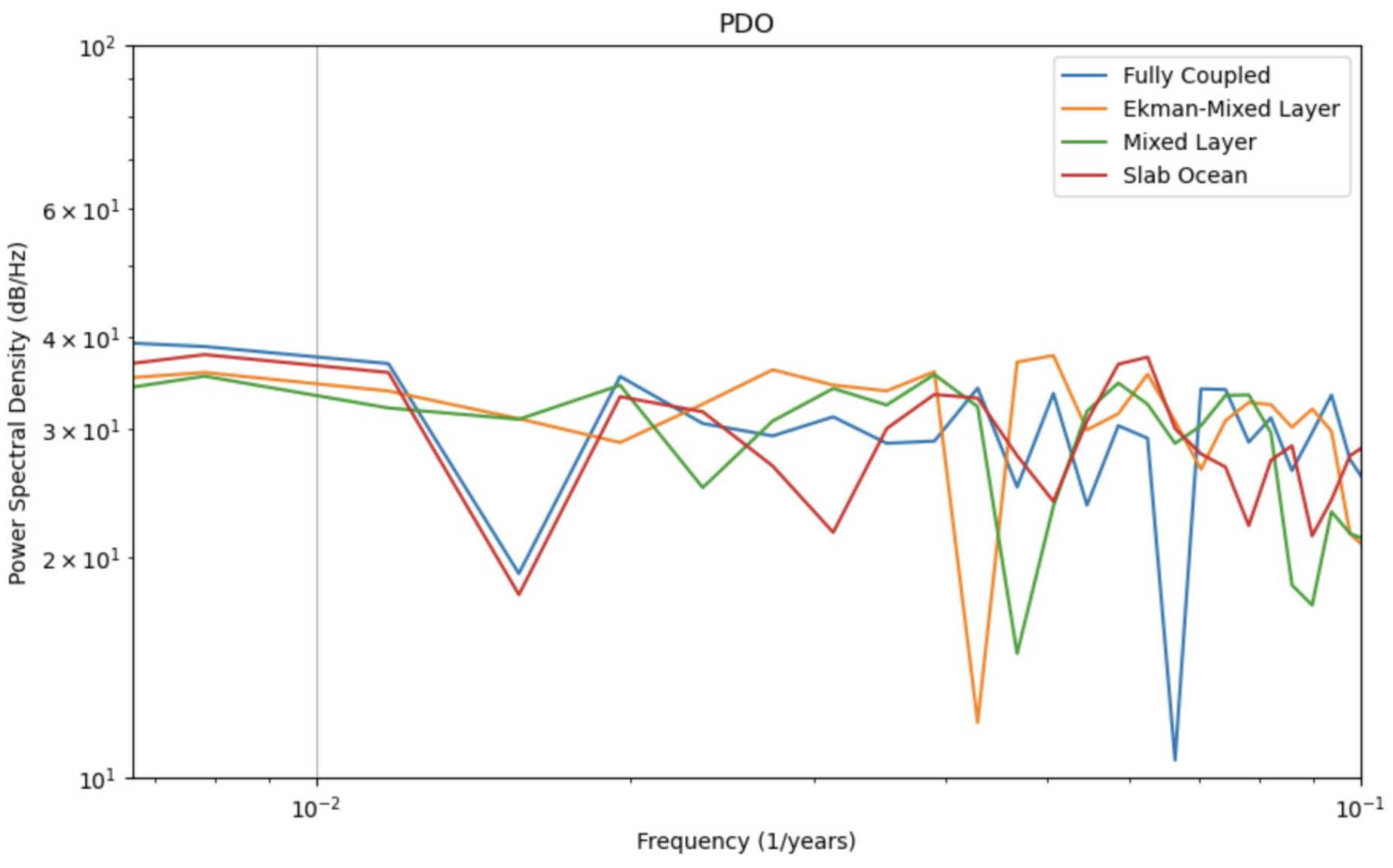
February 21st, 2023

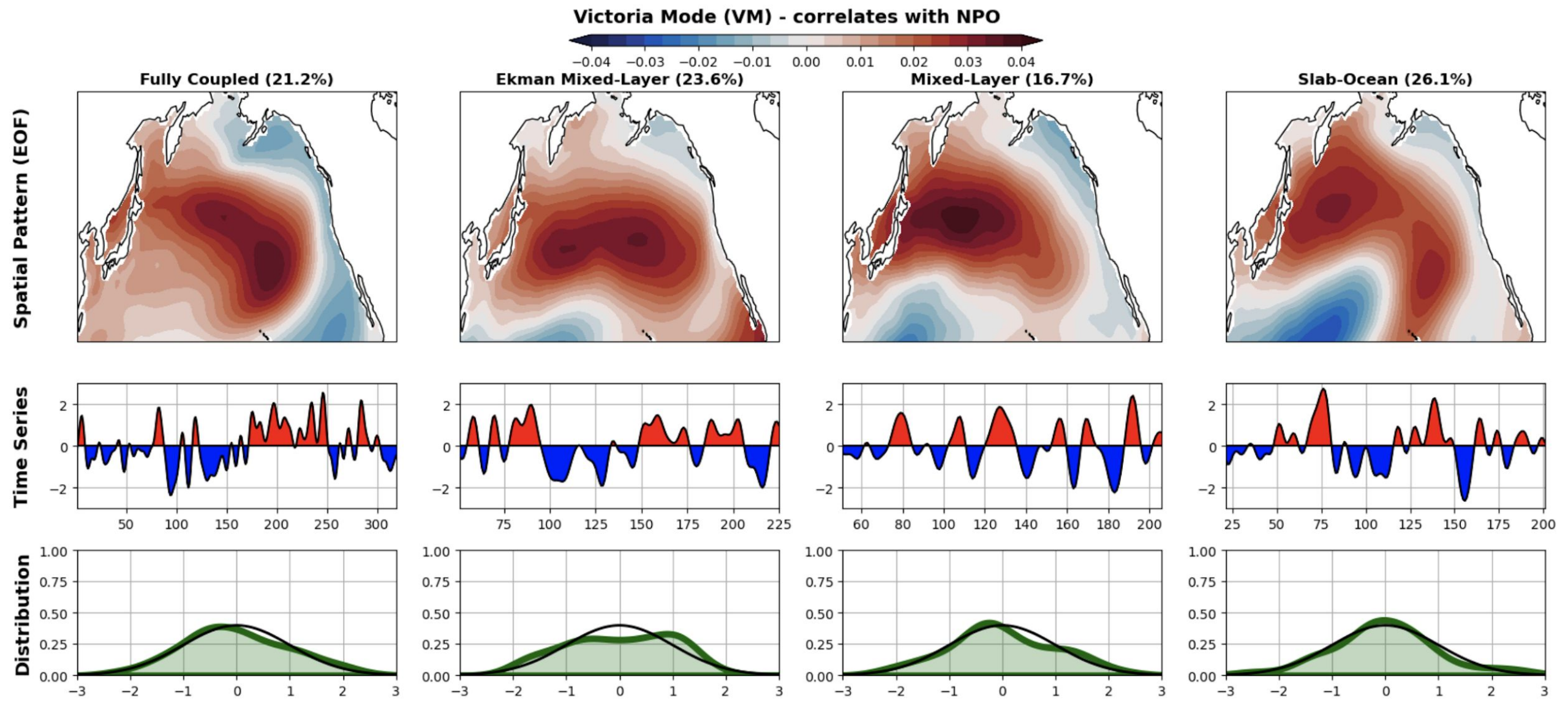

Ekman mixed-layer ocean model (EMOM)
(c)
Temporally varying mixed-layer thickness
H_{EK}
(b) Ekman flow in top 50m
Entrainment
(a)
33 layers
in 503.7m
(d)
Relaxation time τ to referenced climatology
H_{RF}
Return flow in bottom 453.7m

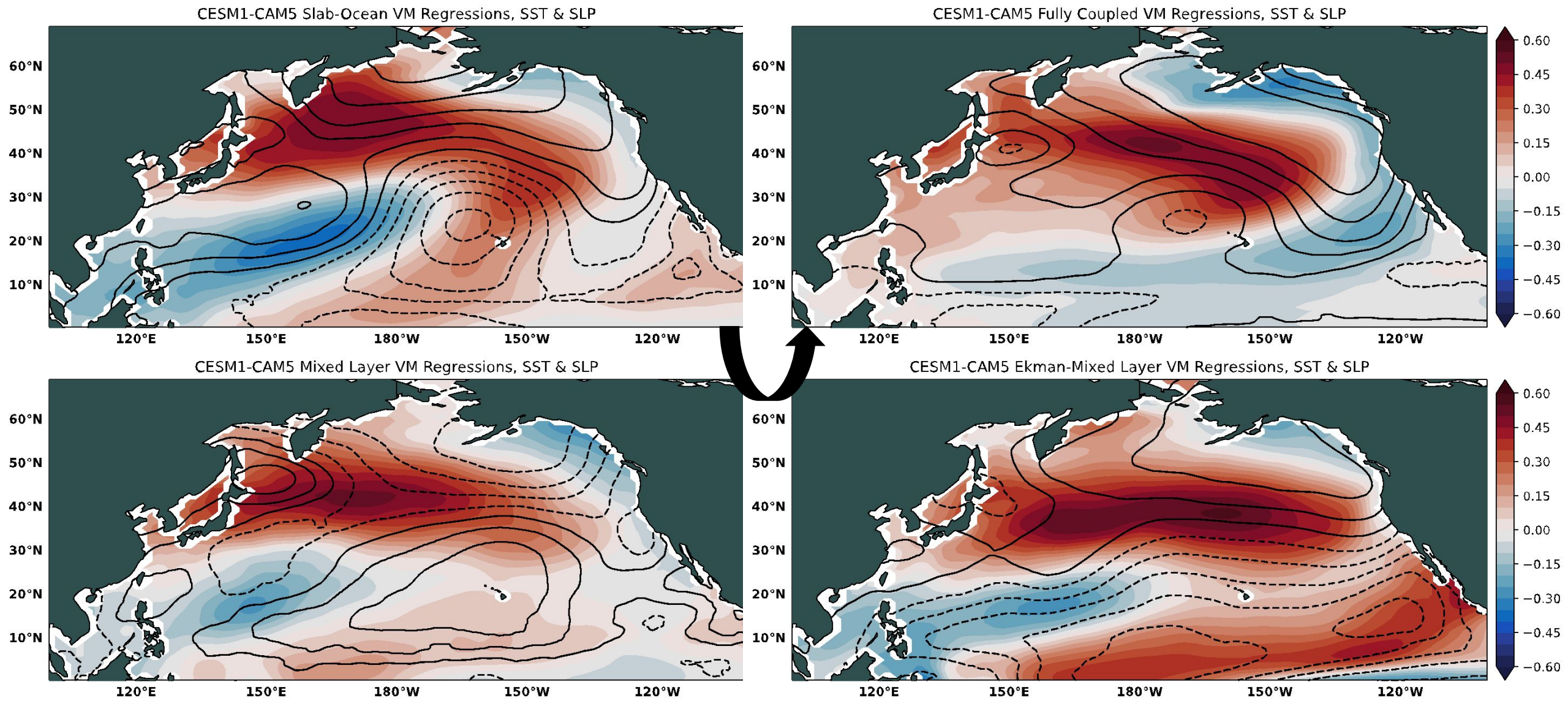

Observed
Fully Coupled (27.2%)
Mechanically Decoupled (22.69%)
Ekman Mixed-Layer (60.29%)
Mixed-Layer (44.79%)
Slab-Ocean (35.71%)
0.00
0.03
0.06
0.09
0.12
0.15
0.18

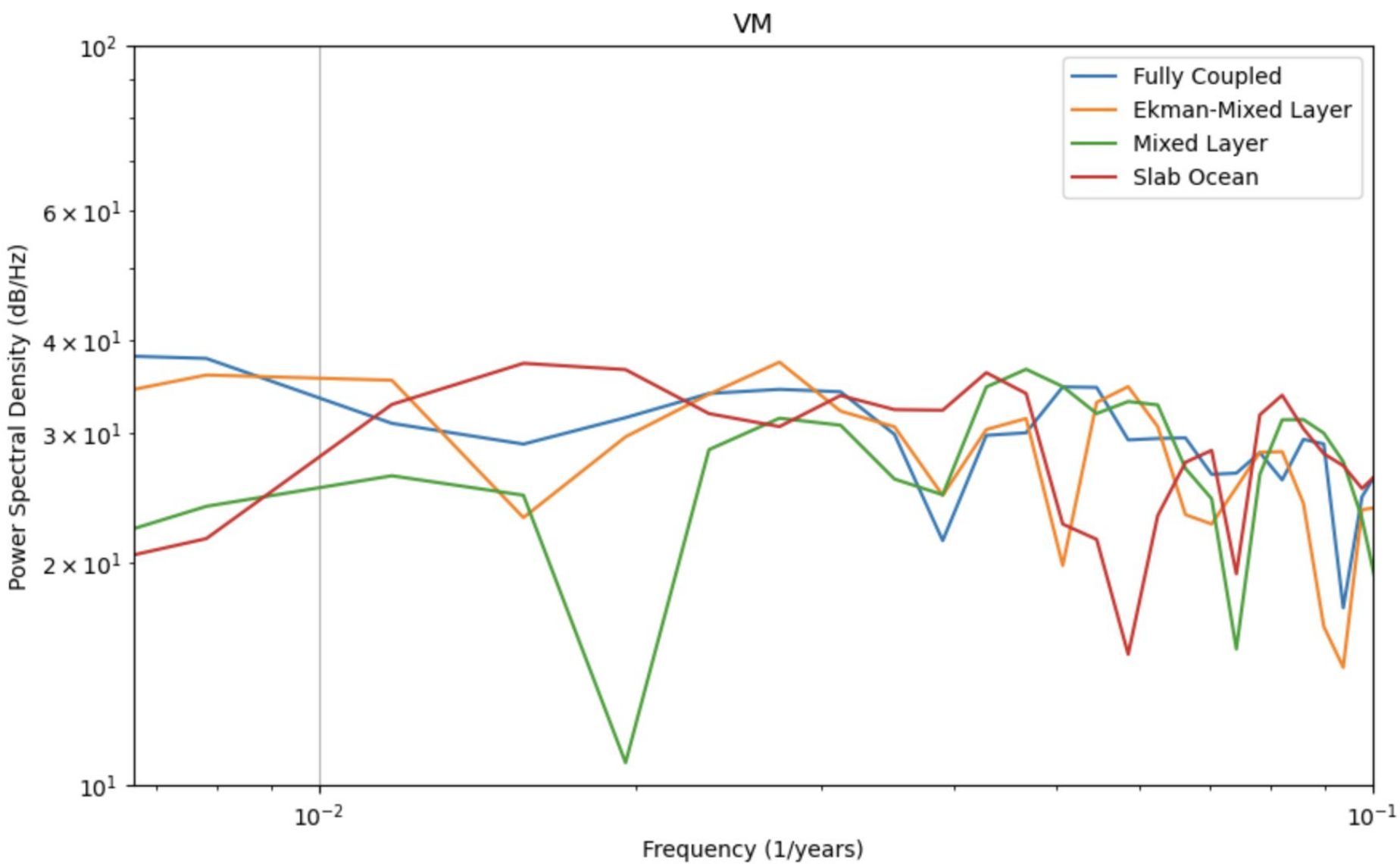

Pacific Decadal Oscillation (PDO) - correlates with NPI
−0.04 −0.03 −0.02 −0.01 0.00 0.01 0.02 0.03 0.04
Fully Coupled (38.6%)
Ekman Mixed-Layer (34.5%)
Mixed-Layer (31.6%)
Slab-Ocean (32.1%)
Spatial Pattern (EOF)
Time Series
Distribution

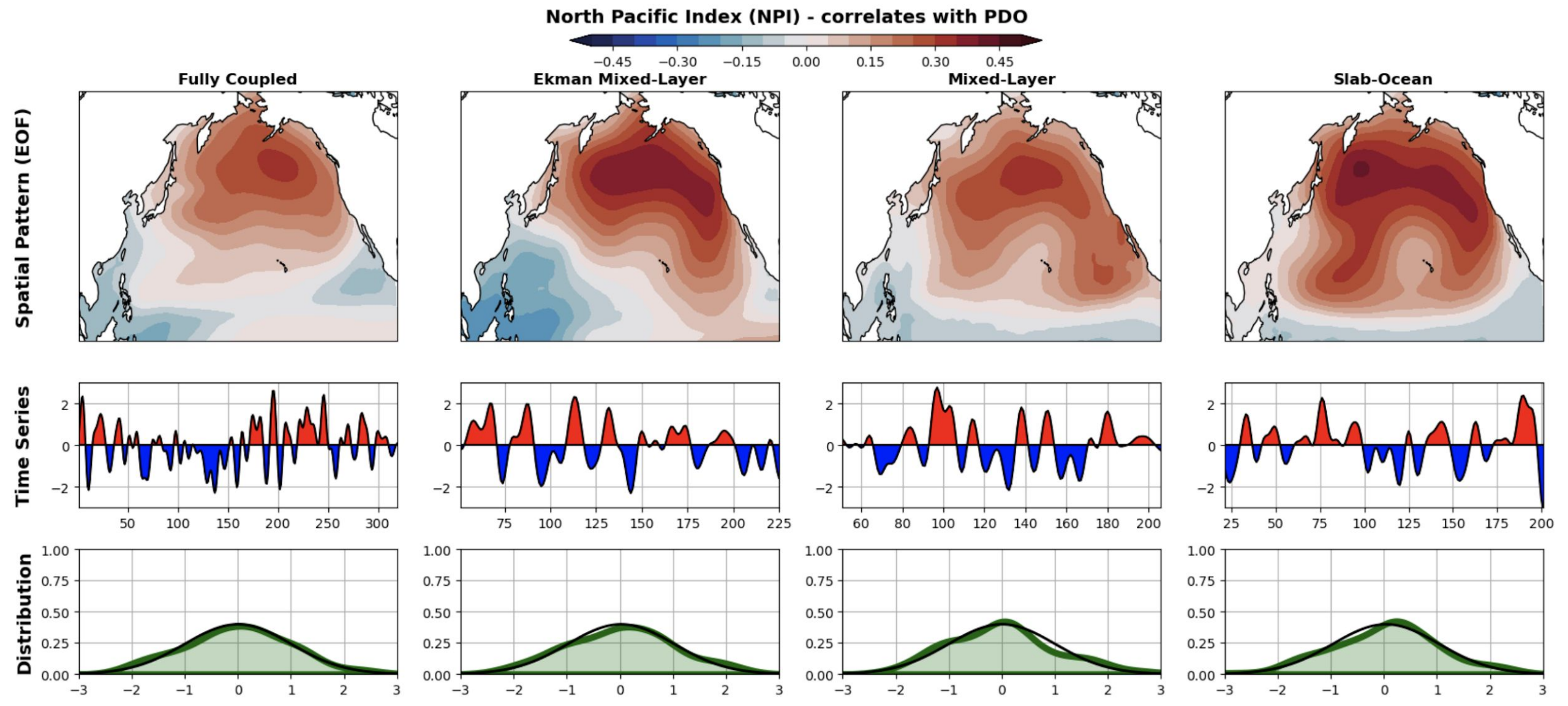

CESM1-CAM5 Slab-Ocean PDO Regressions, SST & SLP
CESM1-CAM5 Fully Coupled PDO Regressions, SST & SLP
CESM1-CAM5 Mixed Layer PDO Regressions, SST & SLP
CESM1-CAM5 Ekman-Mixed Layer PDO Regressions, SST & SLP
60°N
50°N
40°N
30°N
20°N
10°N
120°E
150°E
180°W
150°W
120°W
0.60
0.45
0.30
0.15
0.00
−0.15
−0.30
−0.45
−0.60

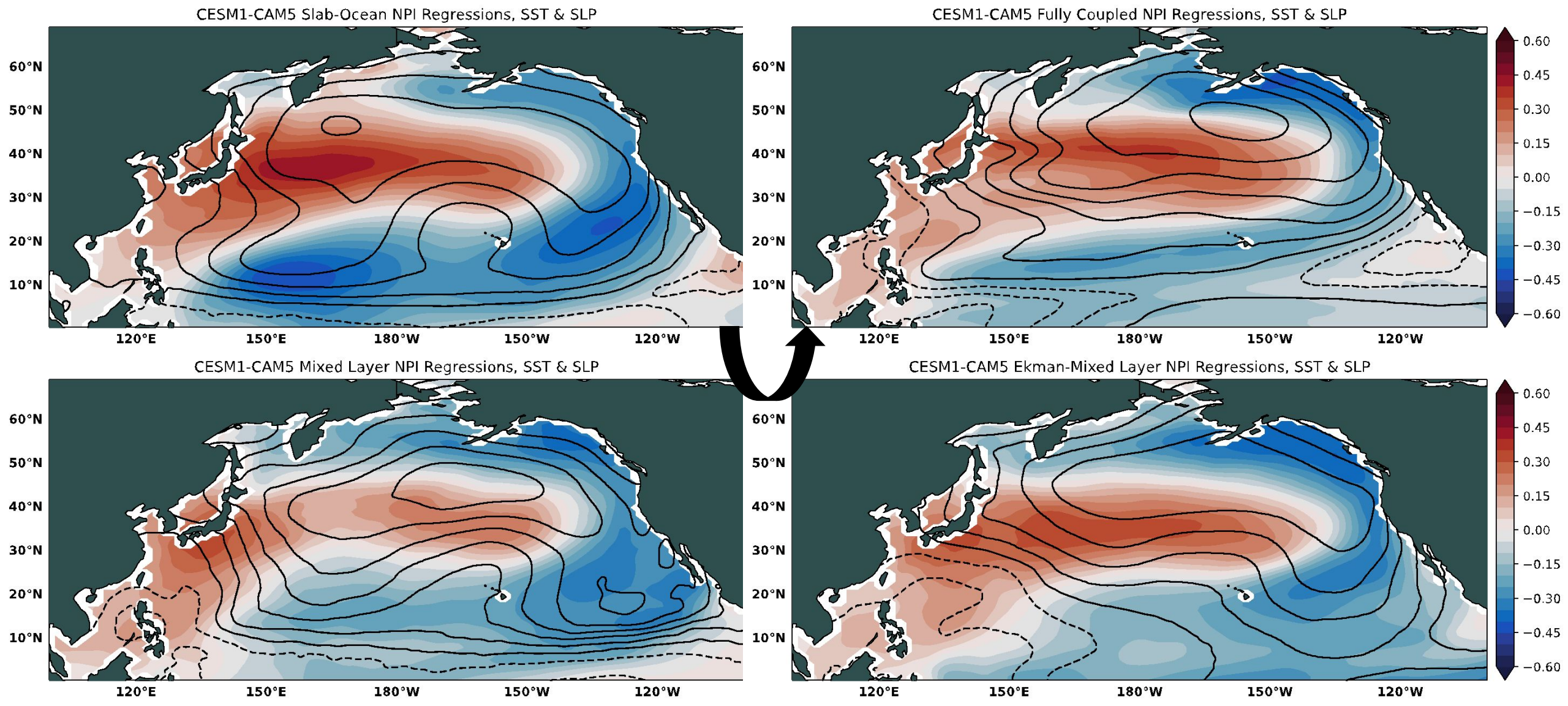

PDO
Fully Coupled
Ekman-Mixed Layer
Mixed Layer
Slab Ocean
Power Spectral Density (dB/Hz)
10^2
6×10^1
4×10^1
3×10^1
2×10^1
10^1
10^{-2}
10^{-1}
Frequency (1/years)


Victoria Mode (VM) - correlates with NPO
−0.04 −0.03 −0.02 −0.01 0.00 0.01 0.02 0.03 0.04
Fully Coupled (21.2%)
Ekman Mixed-Layer (23.6%)
Mixed-Layer (16.7%)
Slab-Ocean (26.1%)
Spatial Pattern (EOF)
Time Series
Distribution


CESM1-CAM5 Slab-Ocean VM Regressions, SST & SLP
CESM1-CAM5 Fully Coupled VM Regressions, SST & SLP
CESM1-CAM5 Mixed Layer VM Regressions, SST & SLP
CESM1-CAM5 Ekman-Mixed Layer VM Regressions, SST & SLP
60°N
50°N
40°N
30°N
20°N
10°N
120°E
150°E
180°W
150°W
120°W
0.60
0.45
0.30
0.15
0.00
−0.15
−0.30
−0.45
−0.60


VM
Fully Coupled
Ekman-Mixed Layer
Mixed Layer
Slab Ocean
10^2
6×10^1
4×10^1
3×10^1
2×10^1
10^1
Power Spectral Density (dB/Hz)
10^{-2}
10^{-1}
Frequency (1/years)


North Pacific Index (NPI) - correlates with PDO
−0.45 −0.30 −0.15 0.00 0.15 0.30 0.45
Fully Coupled
Ekman Mixed-Layer
Mixed-Layer
Slab-Ocean
Spatial Pattern (EOF)
Time Series
Distribution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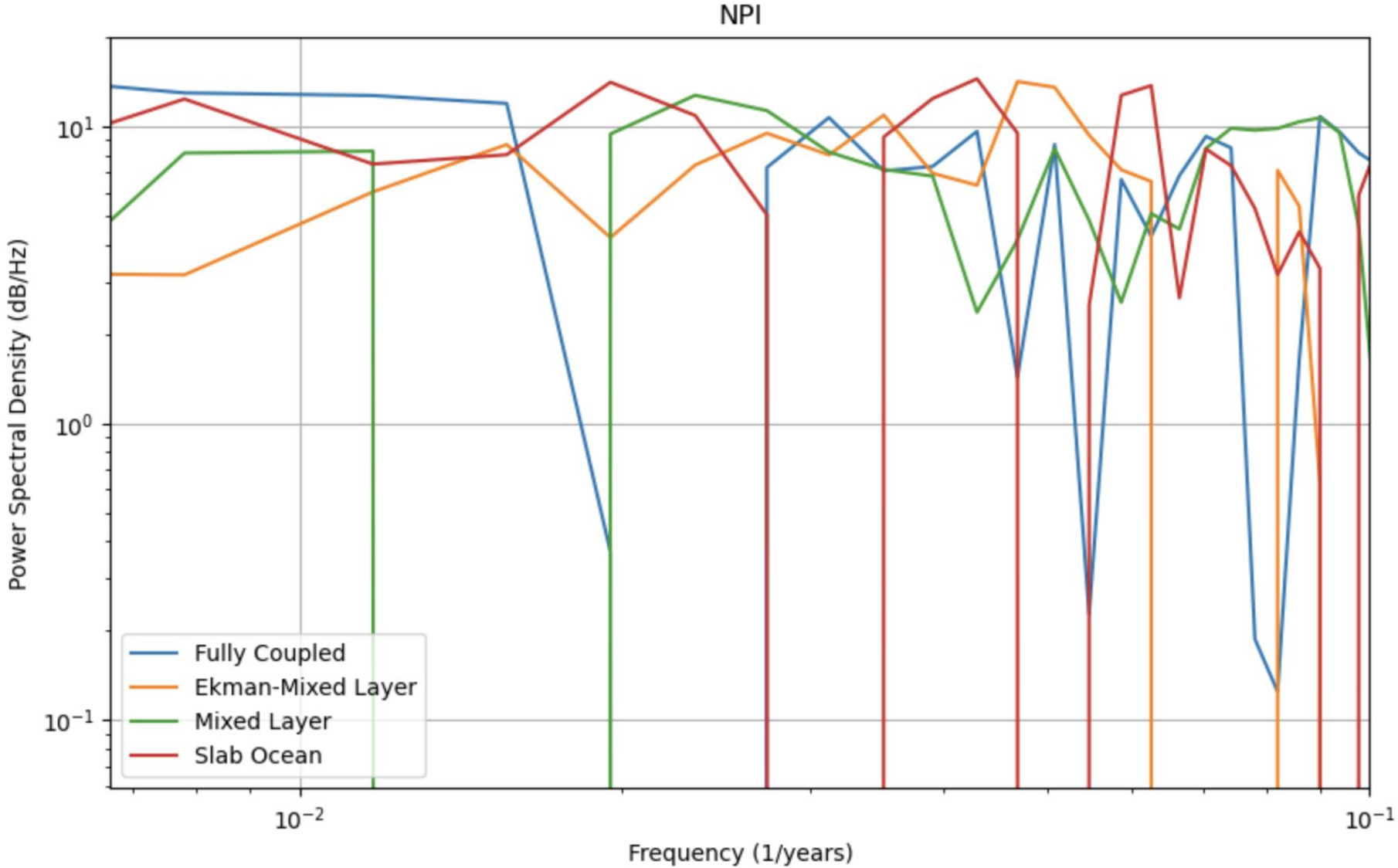
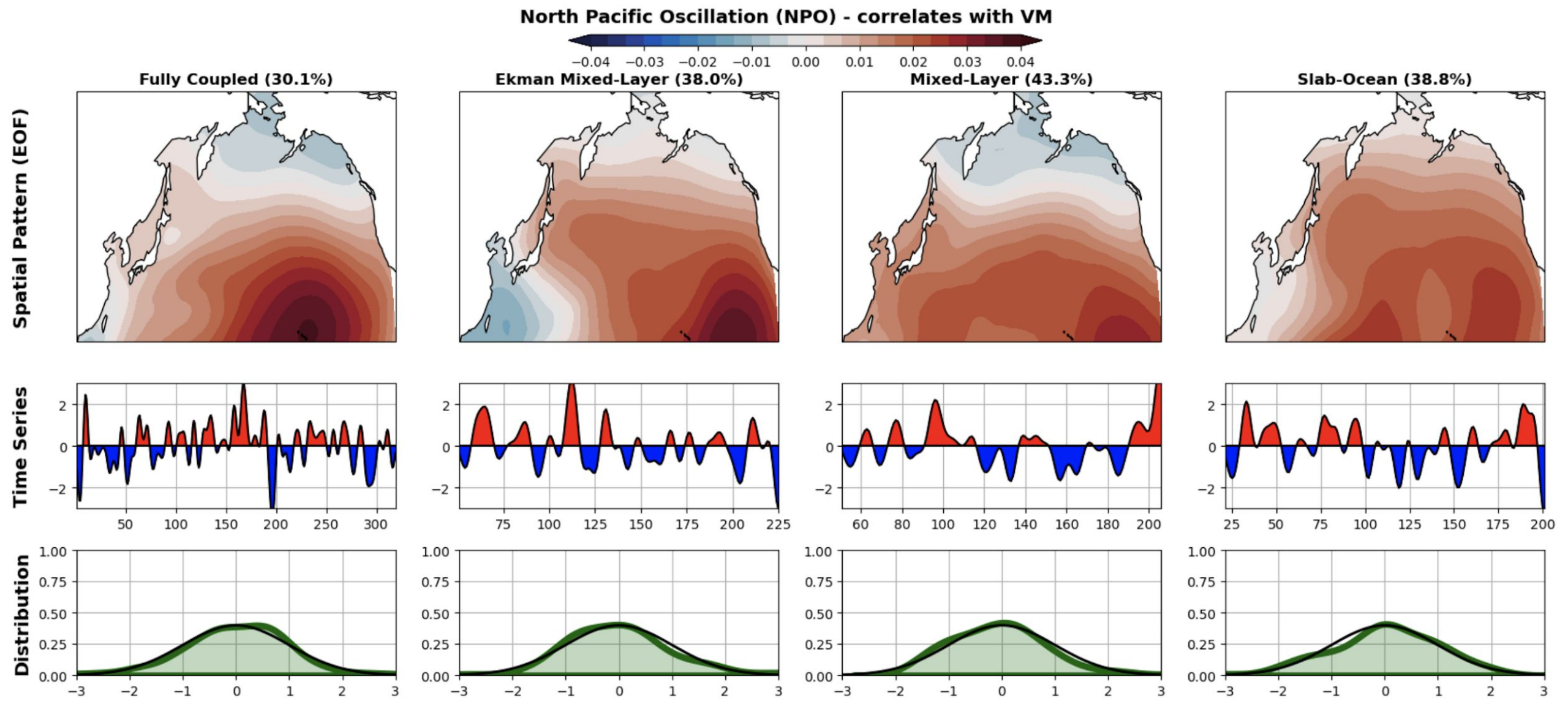
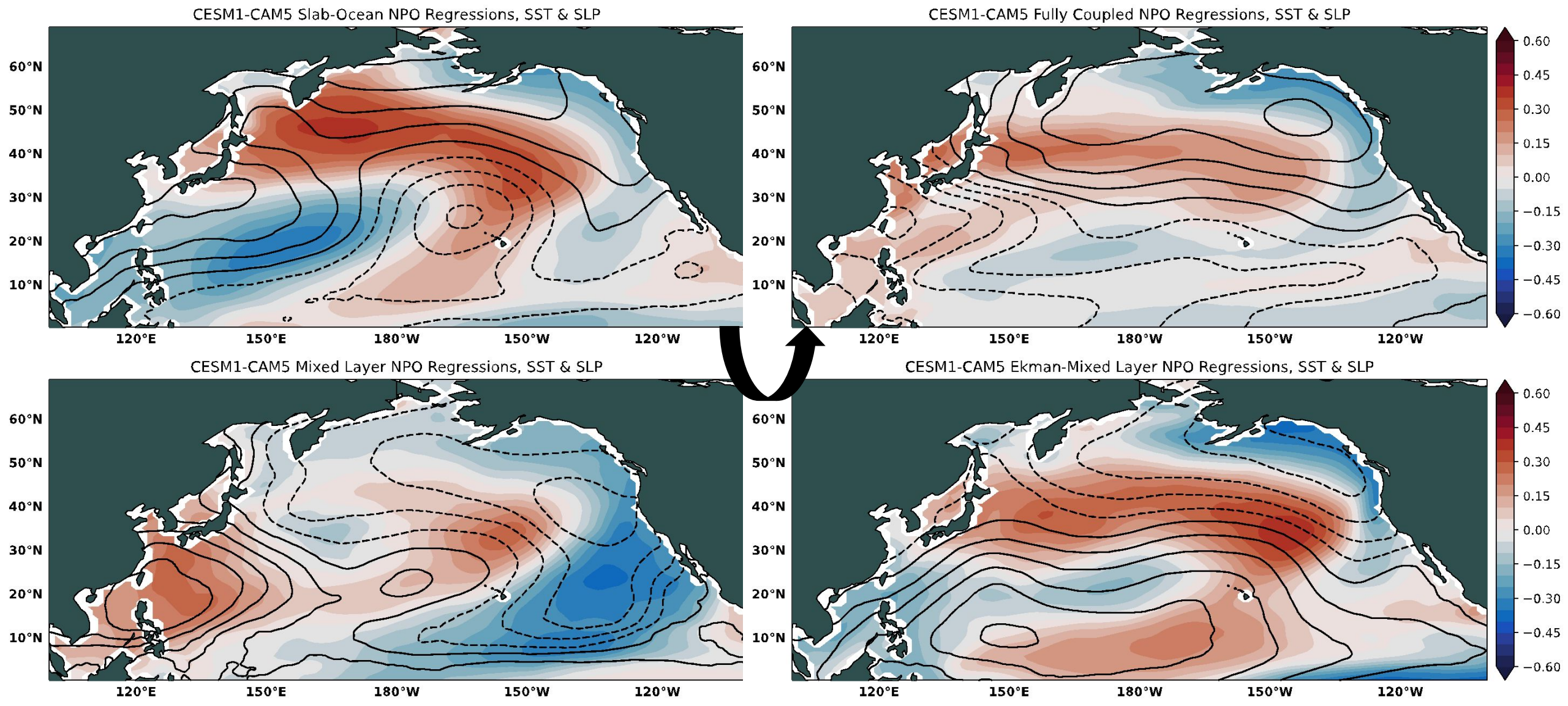
60°N
50°N
40°N
30°N
20°N
10°N
120°E
150°E
180°W
150°W
120°W
0.60
0.45
0.30
0.15
0.00
−0.15
−0.30
−0.45
−0.60

Obviously something went wrong here…




North Pacific Oscillation (NPO) - correlates with VM
−0.04 −0.03 −0.02 −0.01 0.00 0.01 0.02 0.03 0.04
Fully Coupled (30.1%)
Ekman Mixed-Layer (38.0%)
Mixed-Layer (43.3%)
Slab-Ocean (38.8%)
Spatial Pattern (EOF)
Time Series
Distribution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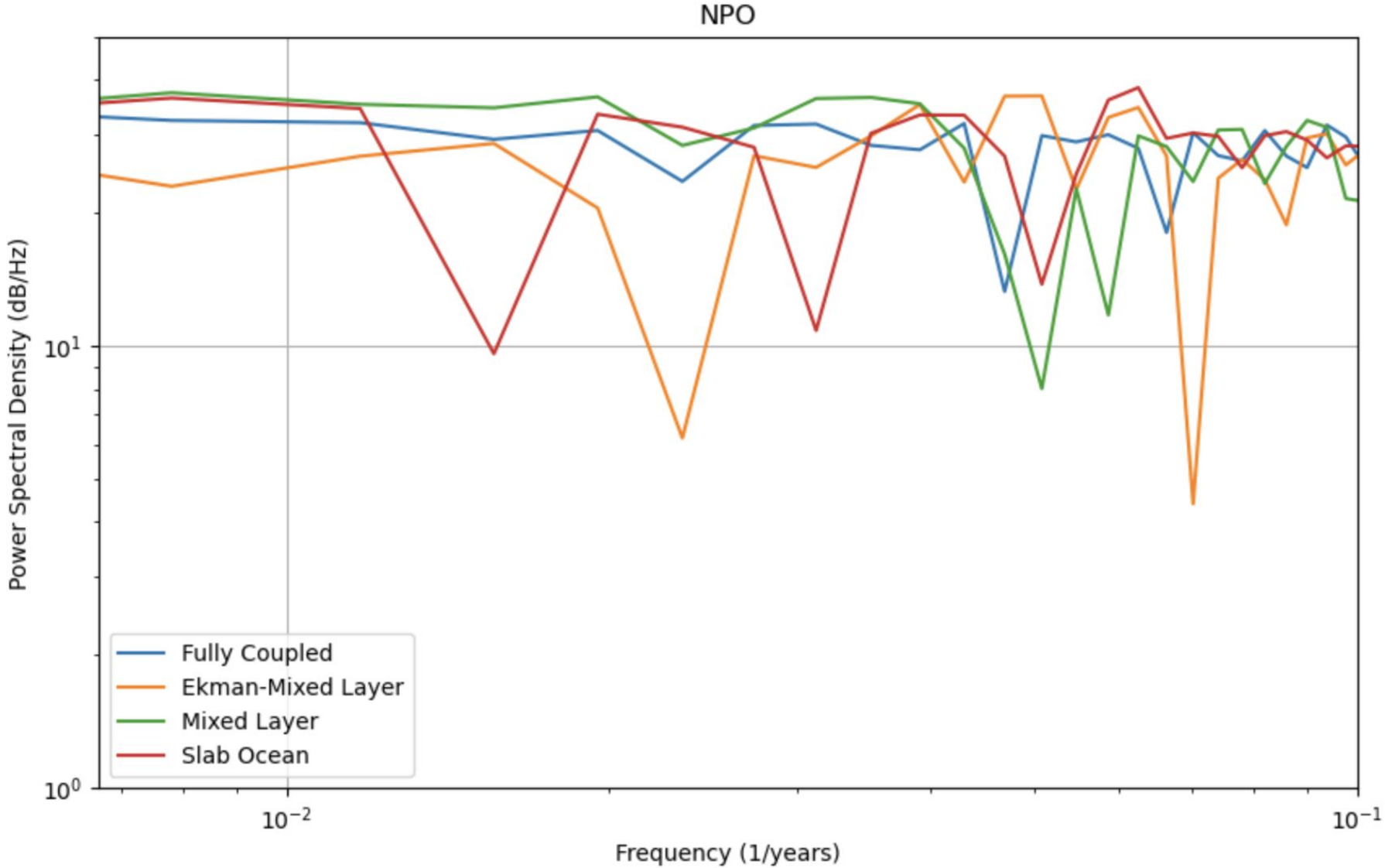
60°N
50°N
40°N
30°N
20°N
10°N
120°E
150°E
180°W
150°W
120°W
0.60
0.45
0.30
0.15
0.00
−0.15
−0.30
−0.45
−0.60


NPO
Power Spectral Density (dB/Hz)
10^1
10^0
10^{-2}
10^{-1}
Frequency (1/years)
Fully Coupled
Ekman-Mixed Layer
Mixed Layer
Slab Ocean

Takeaway Points

- Leading SST, SLP modes in North Pacific are roughly the same across ocean hierarchy
- Shown via linear regressions of each mode time series on SST, SLP
- Power spectra roughly the same as well
- Suggests a minor role for ocean processes as a driver of North Pacific variability within the CESM1 framework