

Supplementary Information

Impacts of the atmospheric mean state on austral early-winter Indian Ocean teleconnections with Chile in CMIP5/CMIP6 models

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Table S1: List of the 56 CMIP6 models analyzed in this study, along with their respective modeling centers, countries, and the ensemble members used.

Model Name (CMIP6)	Modeling Center	Nation	Ensemble member
ACCESS-CM2	CSIRO-ARCCSS	Australia	r1ilp1fl
ACCESS-ESM1-5	CSIRO-ARCCSS	Australia	r1ilp1fl
AWI-CM-1-1-MR	AWI	Germany	r1ilp1fl
AWI-ESN-1-1-LR	AWI	Germany	r1ilp1fl
BCC-ESM1	BCC/CMA	China	r1ilp1fl
BCC-CSM2-MR	BCC/CMA	China	r1ilp1fl
CAMS-CSM1-0	CAMS	China	r1ilp1fl
CESM2	NCAR	USA	r1ilp1fl
CESM2-FV2	NCAR	USA	r1ilp1fl
CESM2-WACCM	NCAR	USA	r1ilp1fl

Model Name (CMIP6)	Modeling Center	Nation	Ensemble member
CESM2-WACCM-FV2	NCAR	USA	rlilp1f1
CMCC-ESM2	CMCC	Italy	rlilp1f1
CMCC-CM2-HR4	CMCC	Italy	rlilp1f1
CMCC-CM2-SR5	CMCC	Italy	rlilp1f1
CIESM	THU	China	rlilp1f1
CNRM-CM6-1	CNRM	France	rlilp1f2
CNRM-CM6-1-HR	CNRM	France	rlilp1f2
CNRM-ESM2-1	CNRM	France	rlilp1f2
CanESM5-CanOE	CCCma	Canada	rlilp2f1
CanESM5	CCCma	Canada	rlilp1f1
E3SM-1-0	E3SM-Project	USA	rlilp1f1
E3SM-1-1	E3SM-Project	USA	rlilp1f1
E3SM-1-1-ECA	E3SM-Project	USA	rlilp1f1
EC-Earth3	EC-Earth Consortium	Europe	rlilp1f1
EC-Earth3-AerChem	EC-Earth Consortium	Europe	rlilp1f1
EC-Earth3-CC	EC-Earth Consortium	Europe	rlilp1f1
EC-Earth3-Veg-LR	EC-Earth Consortium	Europe	rlilp1f1
FGOALS-f3-L	CAS	China	rlilp1f1
FGOALS-g3	CAS	China	rlilp1f1
FGOALS-s2	CAS	China	rlilp1f1
FIO-ESM-2-0	FIO-QLNM	China	rlilp1f1
GFDL-ESM4	GFDL	USA	rlilp1f1
GISS-E2-1-H	NASA GISS	USA	rlilp1f1
GISS-E2-1-G	NASA GISS	USA	rlilp1f1

Model Name (CMIP6)	Modeling Center	Nation	Ensemble member
HadGEM3-GC31-LL	MOHC	UK	rlilp1f1
HadGEM3-GC31-MM	MOHC	UK	rlilp1f3
ICON-ESM-LR	MPI-M	Germany	rlilp1f1
IITM-ESM	CCCR-IITM	India	rlilp1f1
INM-CM4-8	INM	Russia	rlilp1f1
INM-CM5-0	INM	Russia	rlilp1f1
IPSL-CM6A-LR	IPSL	France	rlilp1f1
KACE-1-0-G	KIOST	South Korea	rlilp1f1
KIOST-ESM	KIOST	South Korea	rlilp1f1
MCM-UA-1-0	UA	USA	rlilp1f1
MIROC-ES2H	JAMSTEC	Japan	rlilp4f2
MIROC6	JAMSTEC	Japan	rlilp1f1
MPI-ESM-1-2-HAM	MPI-M	Germany	rlilp1f1
MPI-ESM1-2-HR	MPI-M	Germany	rlilp1f1
MPI-ESM1-2-LR	MPI-M	Germany	rlilp1f1
MRI-ESM2-0	MRI	Japan	rlilp1f1
NESM3	NUIST	China	rlilp1f1
NorCPM1	NCC	Norway	rlilp1f1
NorESM2-MM	NCC	Norway	rlilp1f1
NorESM2-LM	NCC	Norway	rlilp1f1
SAM0-UNICON	SNU	South Korea	rlilp1f1
TaiESM1	RCEC	Taiwan	rlilp1f1
UKESM1-0-LL	MOHC	UK	rlilp1f2

Table S2: List of the 37 CMIP5 models analyzed in this study, along with their respective modeling centers, countries, and the ensemble members used.

Model Name (CMIP5)	Modeling Center	Nation	Ensemble member
ACCESS1-0	CSIRO-BOM	Australia	rlilp1
ACCESS1-3	CSIRO-BOM	Australia	rlilp1
BCC-CSM1-1	BCC/CMA	China	rlilp1
BCC-CSM1-1-m	BCC/CMA	China	rlilp1
BNU-ESM	BNU	China	rlilp1
CanCM4	CCCma	Canada	rlilp1
CanESM2	CCCma	Canada	rlilp1
CCSM4	NCAR	USA	rlilp1
CESM1-FASTCHEM	NCAR	USA	rlilp1
CESM1-BGC	NCAR	USA	rlilp1
CESM1-CAM5	NCAR	USA	rlilp1
CESM1-WACCM	NCAR	USA	rlilp1
CMCC-CESM	CMCC	Italy	rlilp1
CMCC-CM	CMCC	Italy	rlilp1
CMCC-CMS	CMCC	Italy	rlilp1
CNRM-CM5	CNRM-CERFACS	France	rlilp1
CNRM-CM5-2	CNRM-CERFACS	France	rlilp1
CSIRO-Mk3-6-0	CSIRO-QCCCE	Australia	rlilp1
CSIRO-Mk3L-1-2	CSIRO-QCCCE	Australia	rlilp1
FGOALS-g2	CAS	China	rlilp1
FGOALS-s2	CAS	China	rlilp1
FIO-ESM	FIO	China	rlilp1

Model Name (CMIP5)	Modeling Center	Nation	Ensemble member
GFDL-CM3	GFDL	USA	rlilp1
GISS-E2-G	NASA GISS	USA	rlilp1
GISS-E2-R	NASA GISS	USA	rlilp1
HadCM3	MOHC	UK	rlilp1
HadGEM2-CC	MOHC	UK	rlilp1
HadGEM2-ES	MOHC	UK	rlilp1
INMCM4	INM	Russia	rlilp1
IPSL-CM5A-LR	IPSL	France	rlilp1
MIROC5	JAMSTEC	Japan	rlilp1
MPI-ESM-LR	MPI-M	Germany	rlilp1
MPI-ESM-MR	MPI-M	Germany	rlilp1
MPI-ESM-P	MPI-M	Germany	rlilp1
MRI-CGM3	MRI	Japan	rlilp1
NorESM1-ME	NCC	Norway	rlilp1
NorESM1-M	NCC	Norway	rlilp1

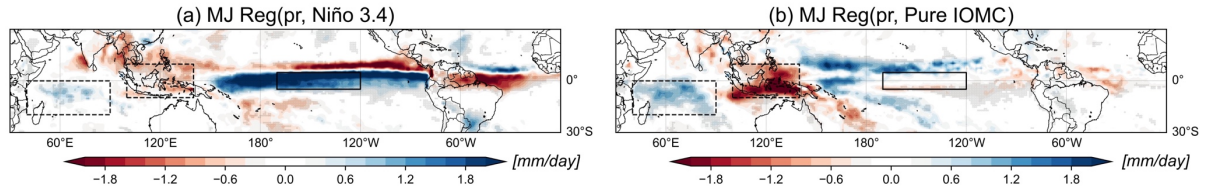


Figure S1: ERA5 MJ precipitation anomalies (unit mm/day per standard deviation) regressed against (a) the Niño 3.4 index and (b) the pure IOMC index. The light-gray stippling indicates the grid points in which the regression is significant at the 95% level of confidence with respect to a two-tailed t -test. The black continuous box indicates the domain (170°E-120°W, 5°S-5°N) used to compute the Niño 3.4 index. The black dashed boxes indicate the domains (40°E-90°E, 20°S-0°) and (100°E-140°E, 10°S-10°N) used to compute the IOMC index.

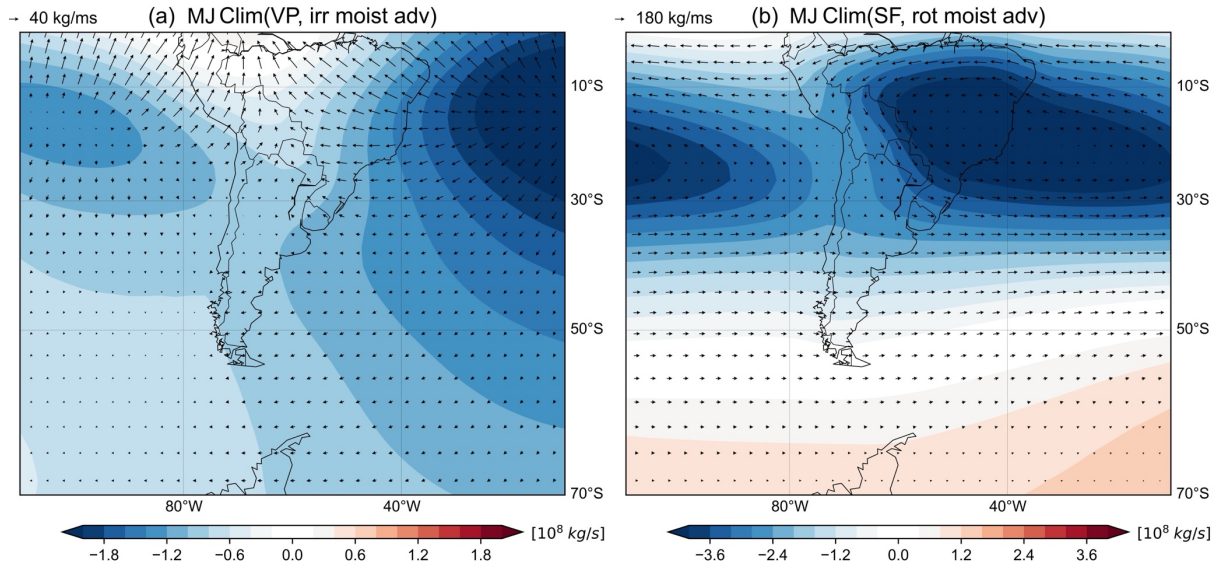


Figure S2: MJ ERA5 (a) irrotational component of climatological vertically integrated moisture advection (vectors; unit kg/ms with unit vector of 40 kg/ms) and associated velocity potential (unit 10^8 kg/s); (b) rotational component of climatological vertically integrated moisture advection (vectors; unit kg/ms with unit vector of 180 kg/ms) and associated streamfunction (unit 10^8 kg/s).

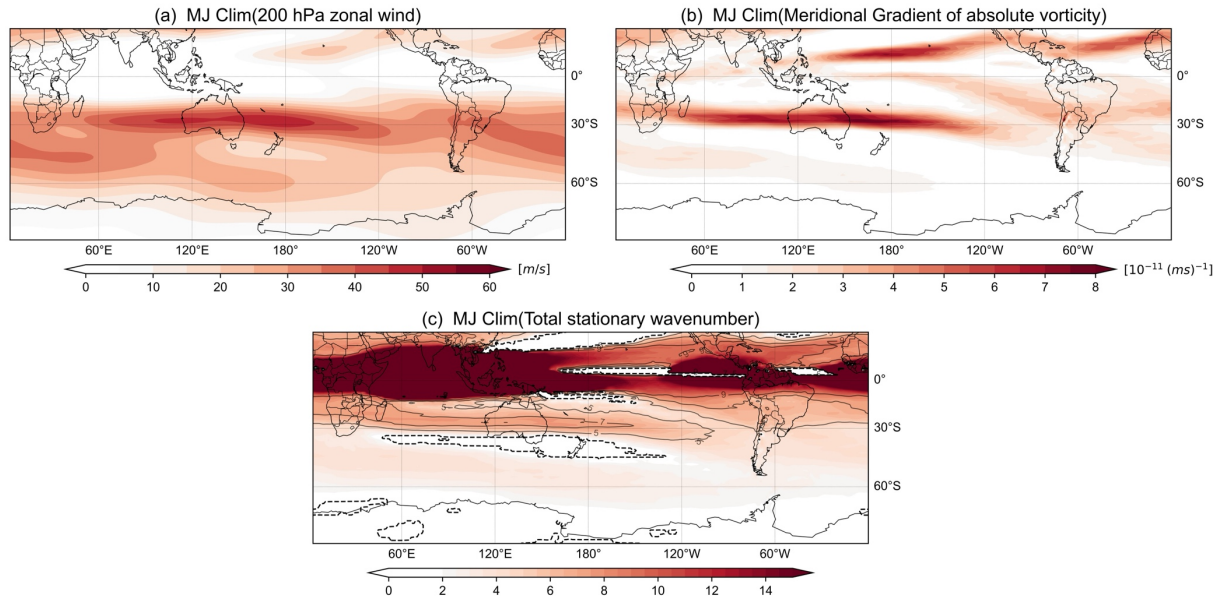


Figure S3: ERA5 climatological MJ (a) 200 hPa zonal wind (shading, units m/s), (b) meridional gradient of absolute vorticity (shading, units 10^{-11} l/ms), and (c) total stationary wavenumber. Contour lines in (c) indicate the total stationary wavenumber at 5, 7, and 9. The white areas enclosed by the thick dashed lines indicate regions in which the total stationary wavenumber is imaginary and poleward wave propagation is not permitted.

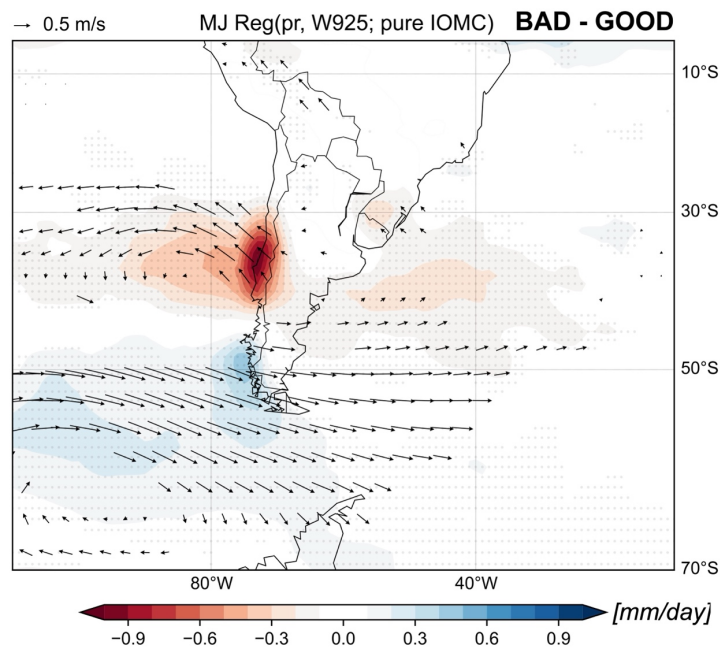


Figure S4: Difference in the ensemble average of MJ precipitation (unit mm/day per standard deviation) and 925 hPa wind (vectors; units m/s per standard deviation, unit vector of 0.5 m/s) anomalies regressed against the pure IOMC index between the ensemble mean of good models (GOOD) and the ensemble mean of bad models (BAD). The light-gray stippling indicates the grid points in which the difference is

significant at the 95% level of confidence with respect to a one-sample *t*-test. Vectors are displayed at the 90% level of confidence.

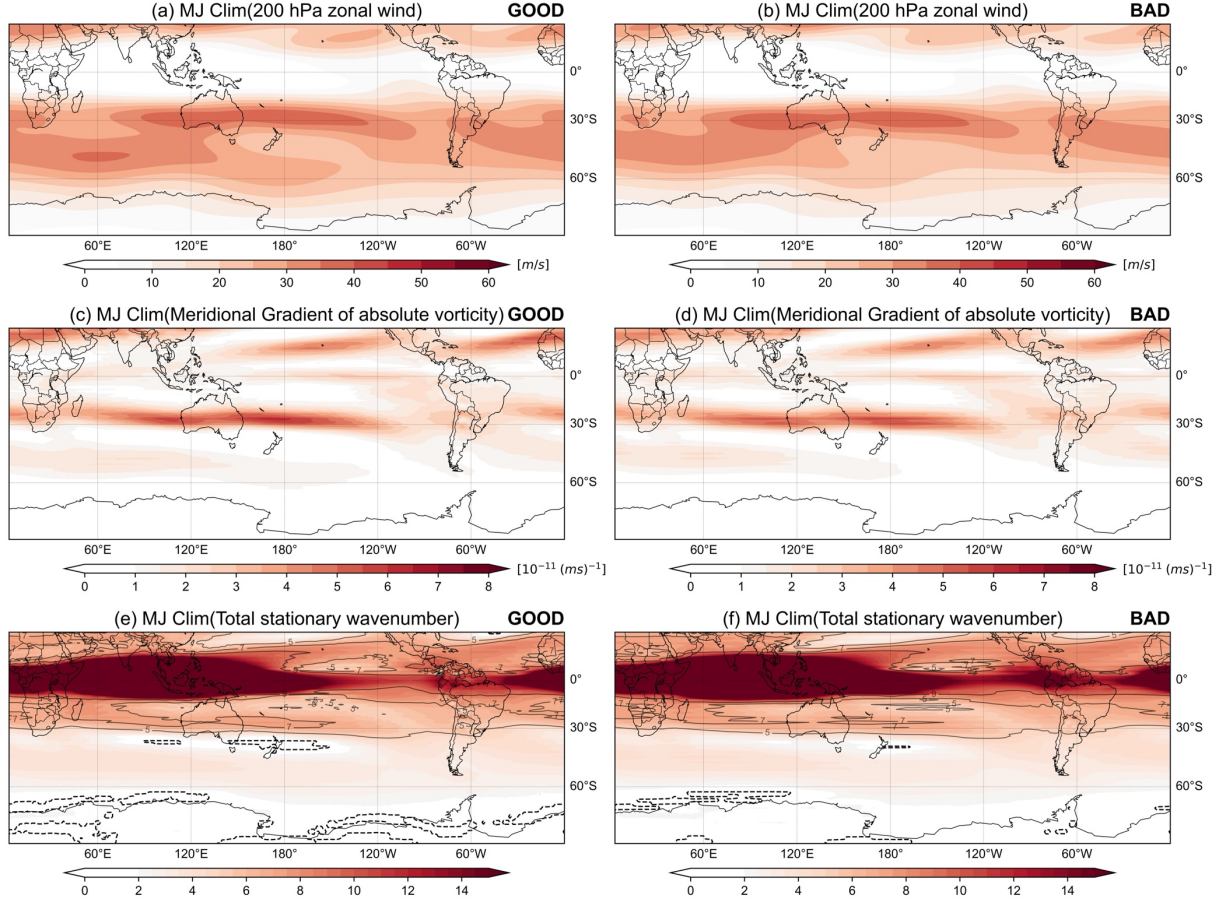


Figure S5: Climatological MJ (a) 200 hPa zonal wind (shading, units m/s), (c) meridional gradient of absolute vorticity (shading, units 10^{-11} 1/ms), and (e) total stationary wavenumber averaged over good (GOOD) models. (b)-(d)-(f) as in (a)-(c)-(e) but for bad (BAD) models. Contour lines in (e)-(f) indicate the total stationary wavenumber at 5, 7, and 9. The white areas enclosed by the thick dashed lines indicate regions in which the total stationary wavenumber is imaginary and poleward wave propagation is not permitted.

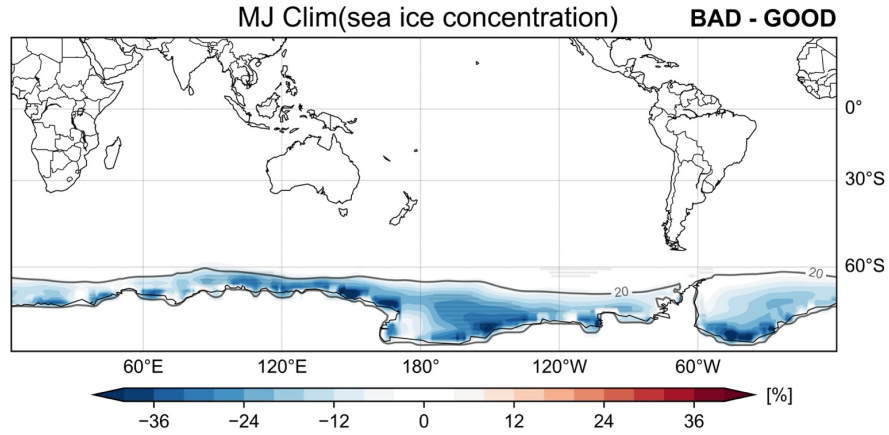


Figure S6: Difference between the ensemble averages of bad and good models (BAD - GOOD) of the MJ sea ice concentration (units %). The contour line indicates the climatology for good models at 20%. The light-gray stippling indicates the grid points in which the difference is significant at the 95% level of confidence with respect to one-sample t-test.

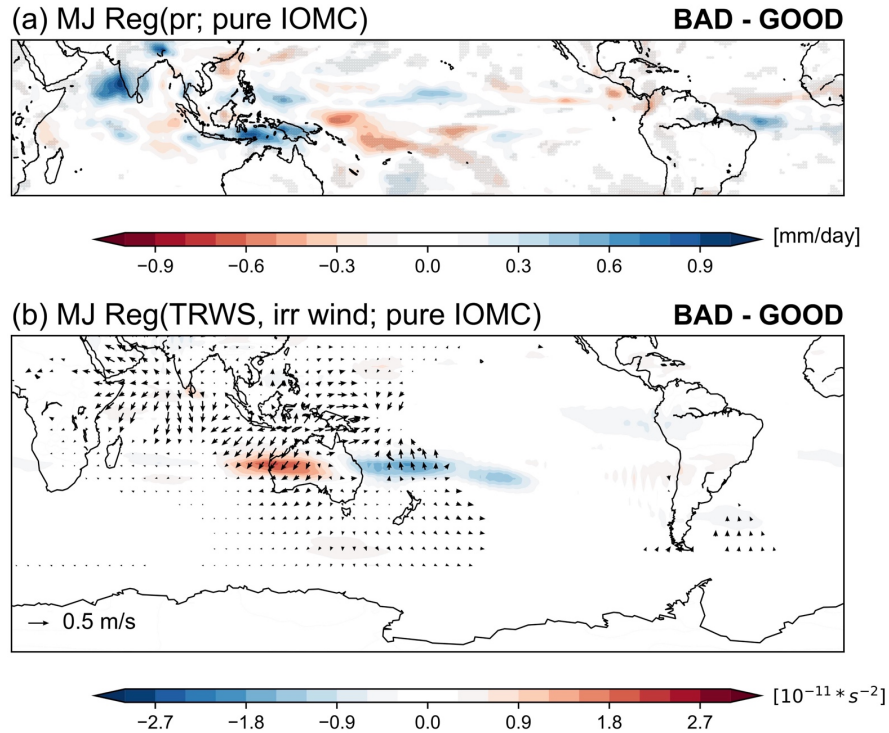


Figure S7: Difference between the ensemble averages of bad and good models (BAD - GOOD) of the MJ (a) regression of precipitation anomalies (unit mm/day per standard deviation) against the pure IOMC index. (b) as in (a) but for 200 hPa TRWS (units 10^{-11} s^{-2} per standard deviation) and irrotational wind anomalies (vectors with unit m/s per standard deviation with unit vector of 0.5 m/s). The light-gray

stippling indicates the grid points in which the difference is significant at the 95% level of confidence with respect to one-sample *t*-test. Vectors are displayed at the 90% level of confidence.

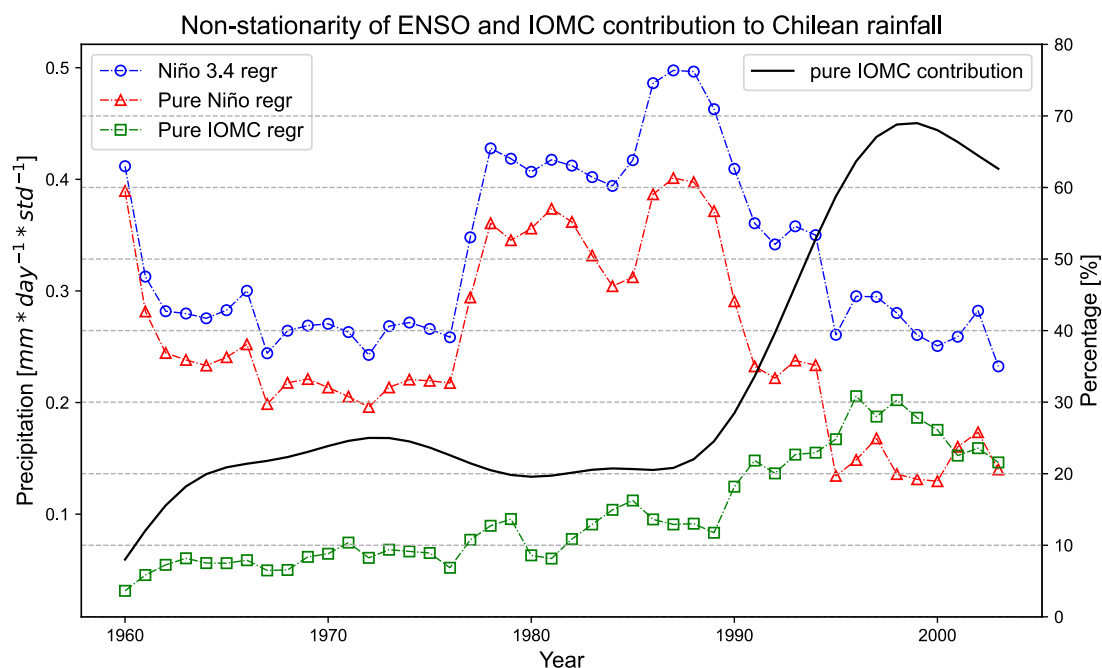


Figure S8: Values of MJ Dipole Chile Rainfall (DCR) index (unit mm/day per standard deviation) regressed against the Niño 3.4 (blue scatters), the pure Niño 3.4 (red scatters), and the pure IOMC (green scatters) indices over a sliding window of 40 years from 1940 to 2024. The black line represents the contribution (%) of the pure IOMC DCR index to the Niño 3.4 DCR index.

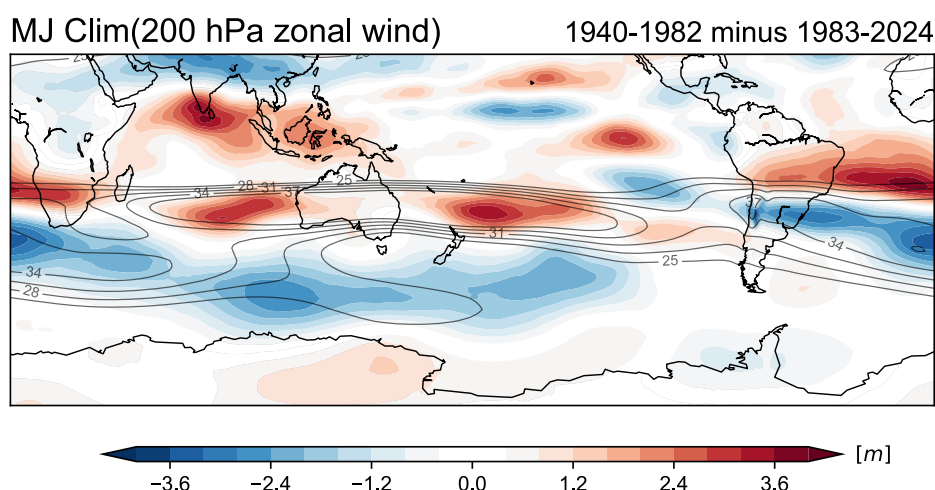


Figure S9: Difference in the ERA5 MJ climatology of 200 hPa zonal wind (units m/s) between 1940-1982 and 1983-2024. The contour lines represent the 200 hPa zonal wind climatology for 1983-2024.