Supplementary Material

1 SUPPLEMENTARY TABLES

Table S1. Specifications of gas-exchange calculations in the data-products. See main text for references.

Data-product	gas-exchange parameterization	wind product
Jena-MLS	Quadratic exchange formulation ($k * U^2 * (Sc/660)^{-0.5}$, Wanninkhof 1992) with the transfer coefficient k scale to match a global mean transfer rate of 16 cm/hr (Naegler et al., 2009), the Schmidt number Sc estimated with a third-order polynomial fit of sea surface temperature.	NCEP Kalnay et al (1996)
MPI-SOMFFN	Quadratic exchange formulation ($k * U^2 * (Sc/660)^{-0.5}$, Wanninkhof 1992) with the transfer coefficient k scale to match a global mean transfer rate of 16 cm/hr (Naegler et al., 2009), the Schmidt number Sc estimated with a third-order polynomial fit of sea surface temperature.	ERA Interim Dee et al (2011)
CMEMS	Quadratic exchange formulation ($k * U^2 * (Sc/660)^{-0.5}$, Wanninkhof 1992) with the transfer coefficient k scale to match a global mean transfer rate of 16 cm/hr (Naegler et al., 2009), the Schmidt number Sc estimated with a third-order polynomial fit of sea surface temperature.	ERA5 Simmons et al (2020) Hersbach et al (2020)

Table S2. Specifications of gas-exchange calculations in Global Ocean Biogeochemical Models (GOBMs). See main text for references.
[1]Graven, H. D., Gruber, N., Key, R., Khatiwala, S., Giraud, X (2012): Changing controls on oceanic radiocarbon: New insights on shallow-to-deep ocean exchange and anthropogenic CO_2 uptake. J. Geophys. Res. 117, C10005
[2]Wanninkhof, R, (2014), Relationship between wind speed and gas exchange over the ocean revisited, Limnol. Oceanogr. Methods, 12, doi:10.4319/lom.2014.12.351.
[3]Orr, J. C., et al. (2017): Biogeochemical protocols and diagnostics for the CMIP6 Ocean Model Intercomparison Project (OMIP), Geosci. Model Dev., 10, 2169–2199, doi:10.5194/gmd-10-2169-2017, 2017
[4]Large, W.G. and S.G. Yeager (2009): The global climatology of an interannually varying air–sea flux data set, Clim. Dyn. 33, 341-364, doi:10.1007/s00382-008-0441-3

GOBM	gas-exchange parameterization	wind product	time-step	output frequency
MITgcm-REcoM	Gas exchange is parameterized using the Wanninkhof (1992) formulation considering chemical enhancement. The effective gas exchange is proportional to the ice-free area in each grid box.	JRA55 Kobayashi et al. (2015)	30 min	monthly
MPI	Gas transfer velocity formulation and parameter setup of Wanninkhof (2014)[2], including updated Schmidt number parameterizations for CO_2 to comply with OMIP protocol (Orr et al., 2017)[3]	NCEP 6 hourly forcing	60 min	monthly
CESM-ETH	Gas exchange parameterisation of Wanninkhof (1992) quadratic windspeed dependency formulation, but with coefficient scaled down to $0.31\ cm\ hr^{-1}\ s^2\ m^{-2}$ to reflect recent 14C inventories (Graven et al. 2012)[1] to read $kw = 0.31 * ws^2 * (1 - f_{ice}) * (Sc/660)^{-1/2}$.	JRA55 Kobayashi et al. (2015)	3757 s	monthly
CNRM	see Orr et al (2017)[3]: kw parameterized from Wanninkhof (1992), with $kw = a * (Sc/660)^{-0.5} * ws^2 * (1 - f_{ice})$ with a from Wanninkhof (2014)[2]	NCEP with CORE-II corrections	30 min	monthly
CSIRO	Quadratic exchange formulation $(f(T) + 0.3 * ws^2) * (Sc/660)^{-0.5})$ Wanninkhof (1992)	JRA55-DO Tsujino et al. (2018)	30 min	monthly
NorESM	see Orr et al (2017)[3]: kw parameterized from Wanninkhof (1992), with $kw = a * (Sc/660)^{-0.5} * ws^2 * (1 - f_{ice})$ with a=0.337 following OCMIP-2 protocol	NCEP-R1 (Kalnay et al. 1996) with CORE-II corrections (Large and Yeager, 2009)[4]	3200 s	daily
PlankTOM	Quadratic exchange formulation $(function\ of\ T + 0.3 * ws^2) * (Sc/660)^{-0.5})$ Wanninkhof (1992)	NCEP Kalnay et al (1996)	96 min	monthly
MOM6-COBALT	see Orr et al (2017)[3]: kw parameterized from Wanninkhof 1992, with $kw = a * (Sc/660)^{-0.5} * ws^2 * (1 - f_{ice})$ with a from Wanninkhof (2014)[2]	JRA55 Kobayashi et al. (2015)	30 min	monthly
IPSL	see Orr et al 2017[3]: kw parameterized from Wanninkhof 1992, with $kw = a * (Sc/660)^{-0.5} * ws^2 * (1 - f_{ice})$ with a from Wanninkhof et al 2014 (i.e. fixed at 0.251)	JRA55 Kobayashi et al. (2015)	45 min	monthly
FESOM-REcoM	see Orr et al (2017)[3]: kw parameterized from Wanninkhof 1992, with $kw = a * (Sc/660)^{-0.5} * ws^2 * (1 - f_{ice})$ with a from Wanninkhof (2014)[2]	JRA55-DO Tsujino et al. (2018)	15 min	monthly

2 SUPPLEMENTARY FIGURES

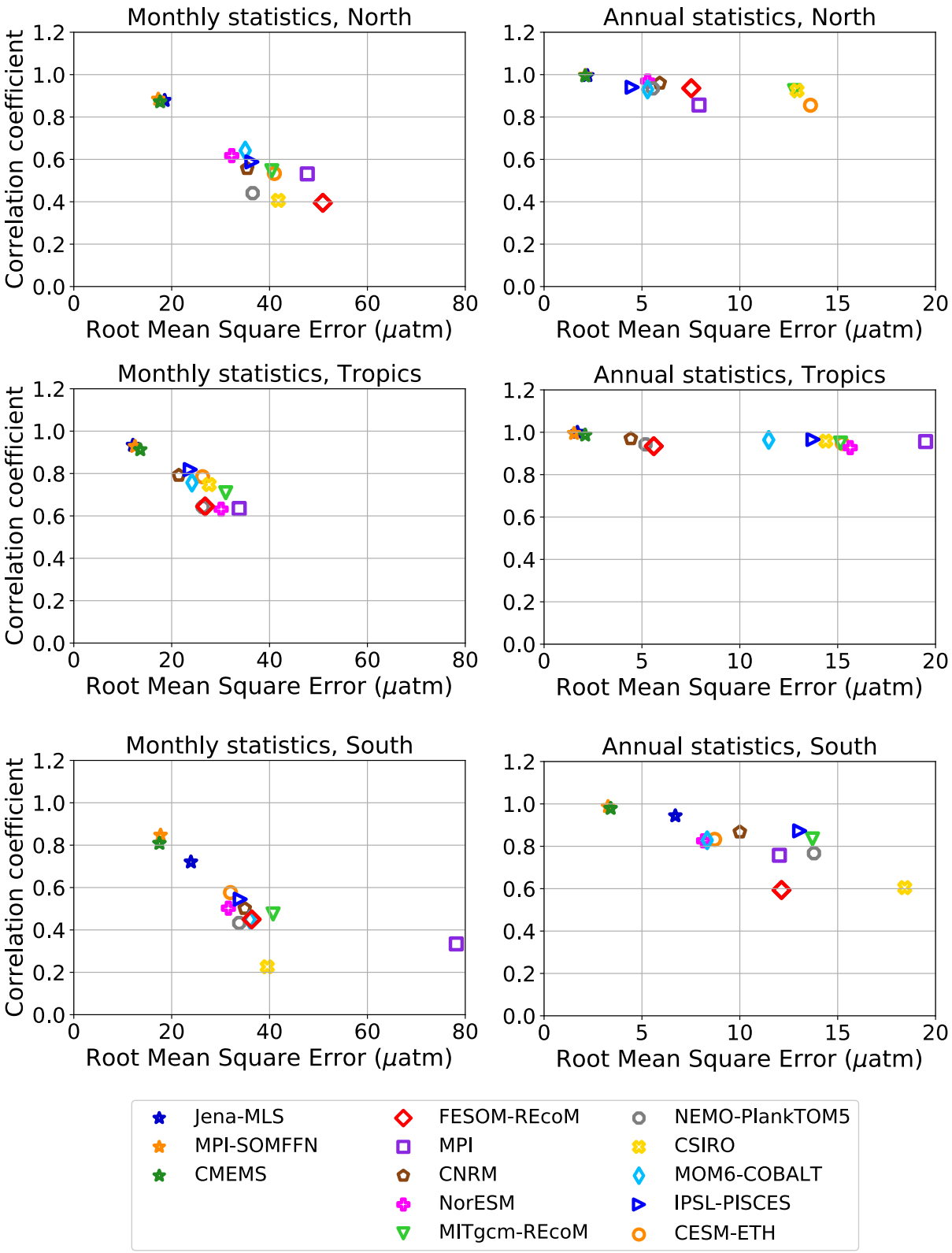

Figure S1. Mismatch of simulated or mapped pCO_2 and observed sea surface pCO_2 for the period 1992 to 2018 on different time-scales: (left column) monthly, (right column) annual+trend as derived from annual statistics. All panels display the mismatch as RMSE and correlation coefficient. Global figures are shown in the main manuscript, regional figures (north, tropics, south) are displayed here as indicated in the figure panels. Note the different scales on the x-axis.

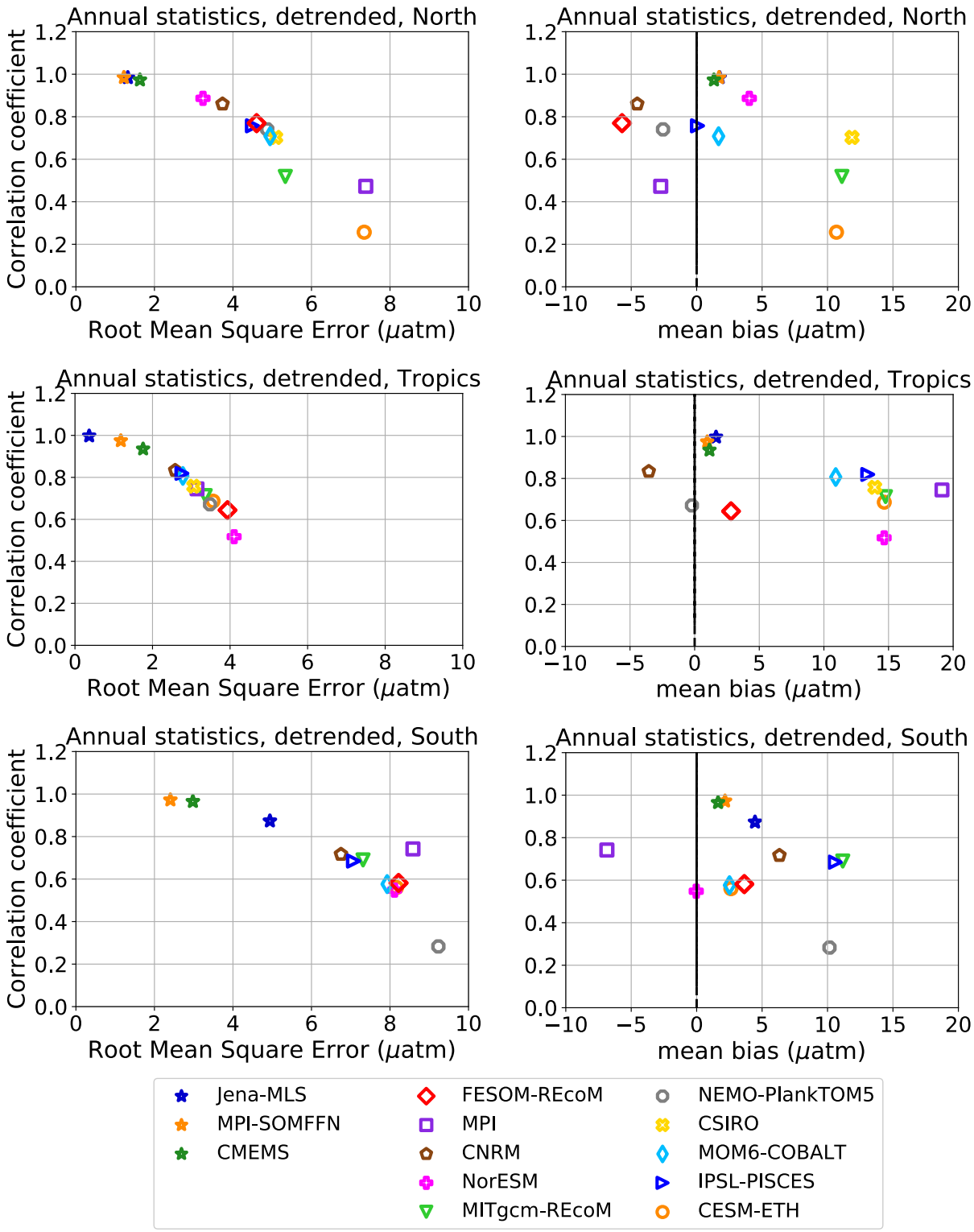

Figure S2. Mismatch of simulated or mapped pCO_2 and observed sea surface pCO_2 for the period 1992 to 2018 on different time-scales: (left column) multi-year variability as derived from detrended annual statistics. This column displays the mismatch as RMSE and correlation coefficient. (Right column) the mean bias (indicative of the mean sink) is plotted against the correlation coefficient. Global figures are shown in the main manuscript, regional figures (north, tropics, south) are displayed here as indicated in the figure panels. Note the different scales on the x-axis.

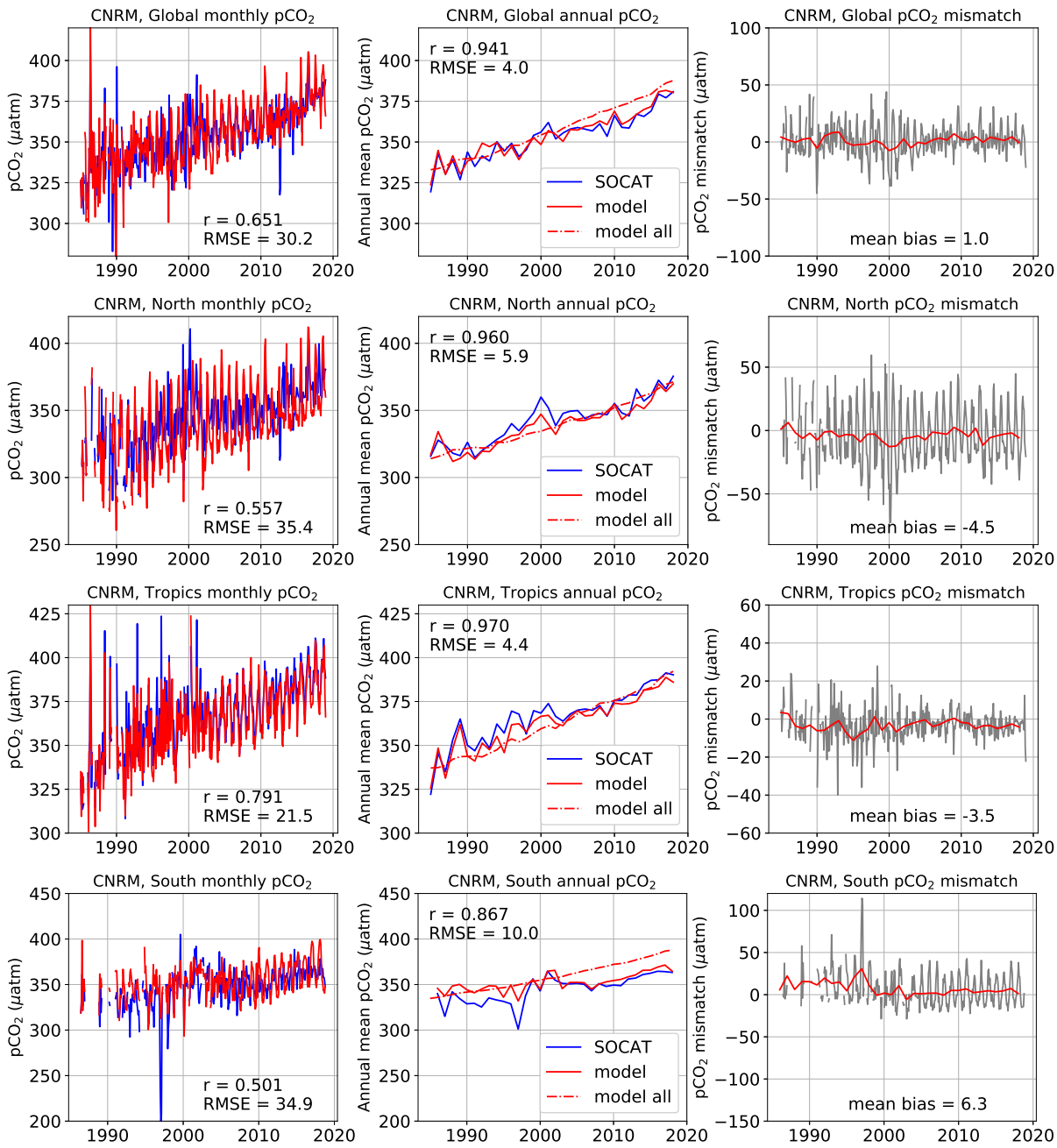

Figure S3. Comparison between sea-surface pCO_2 in CNRM and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

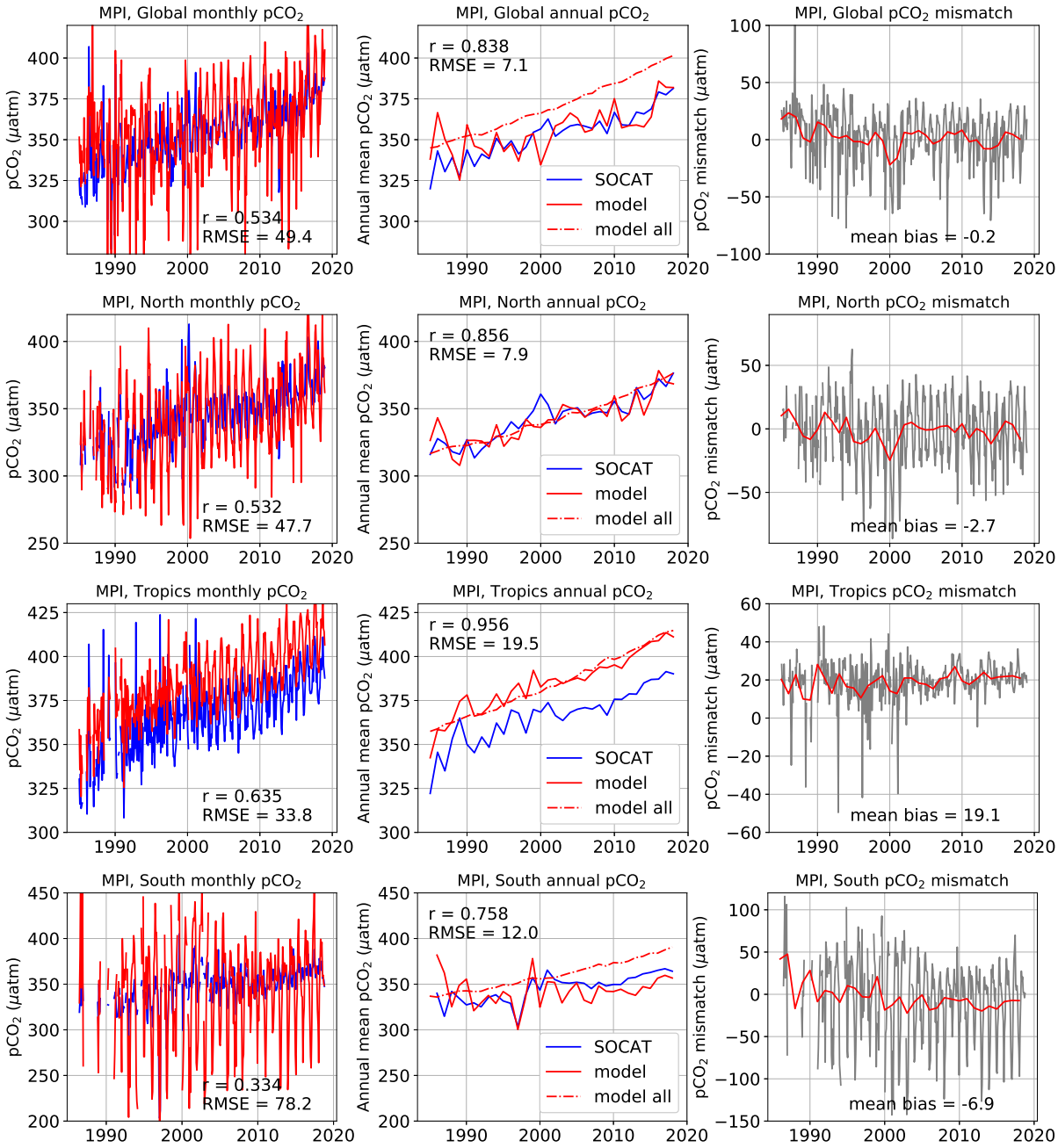

Figure S4. Comparison between sea-surface pCO_2 in MPI and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

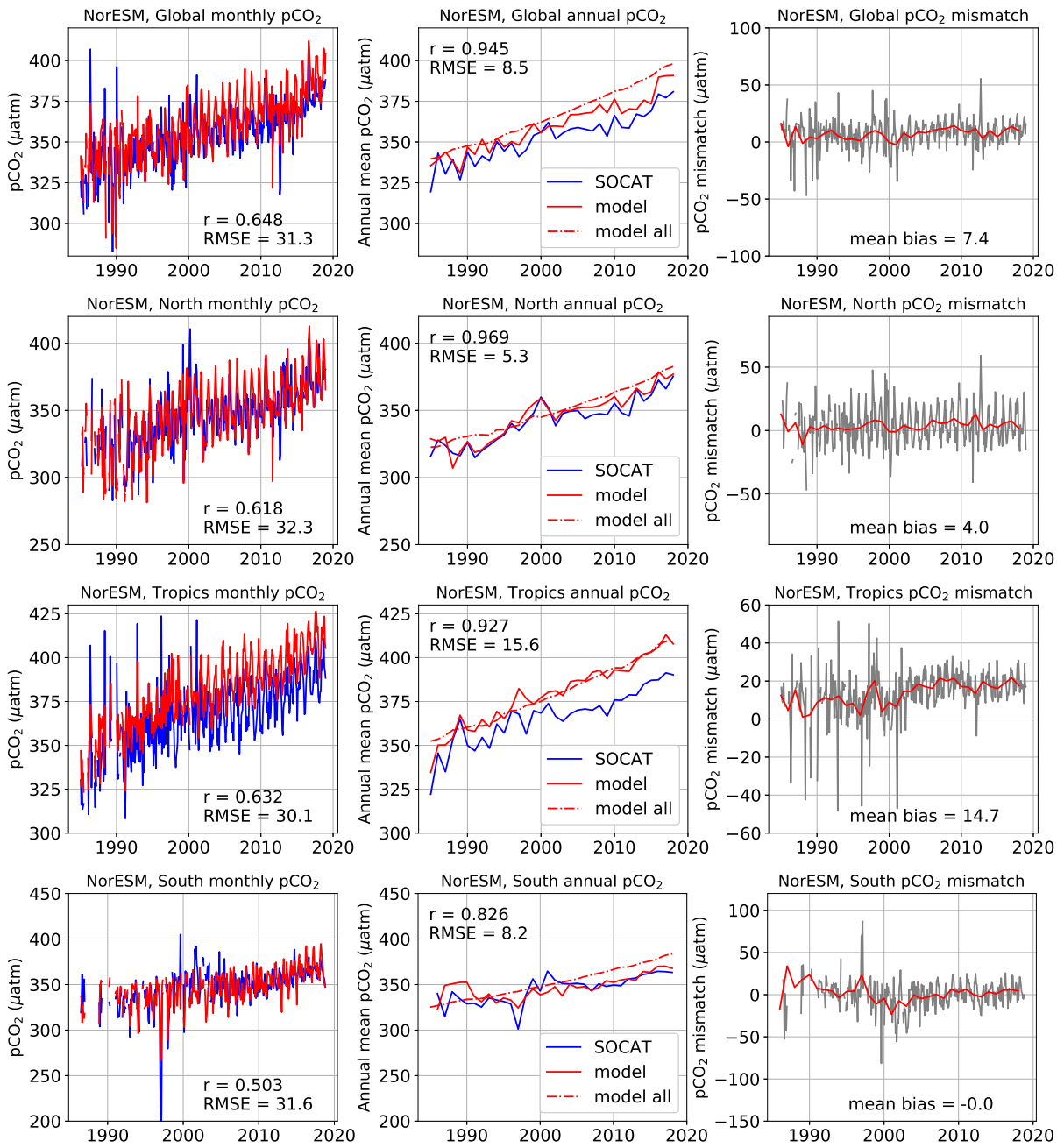

Figure S5. Comparison between sea-surface pCO_2 in NorESM and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

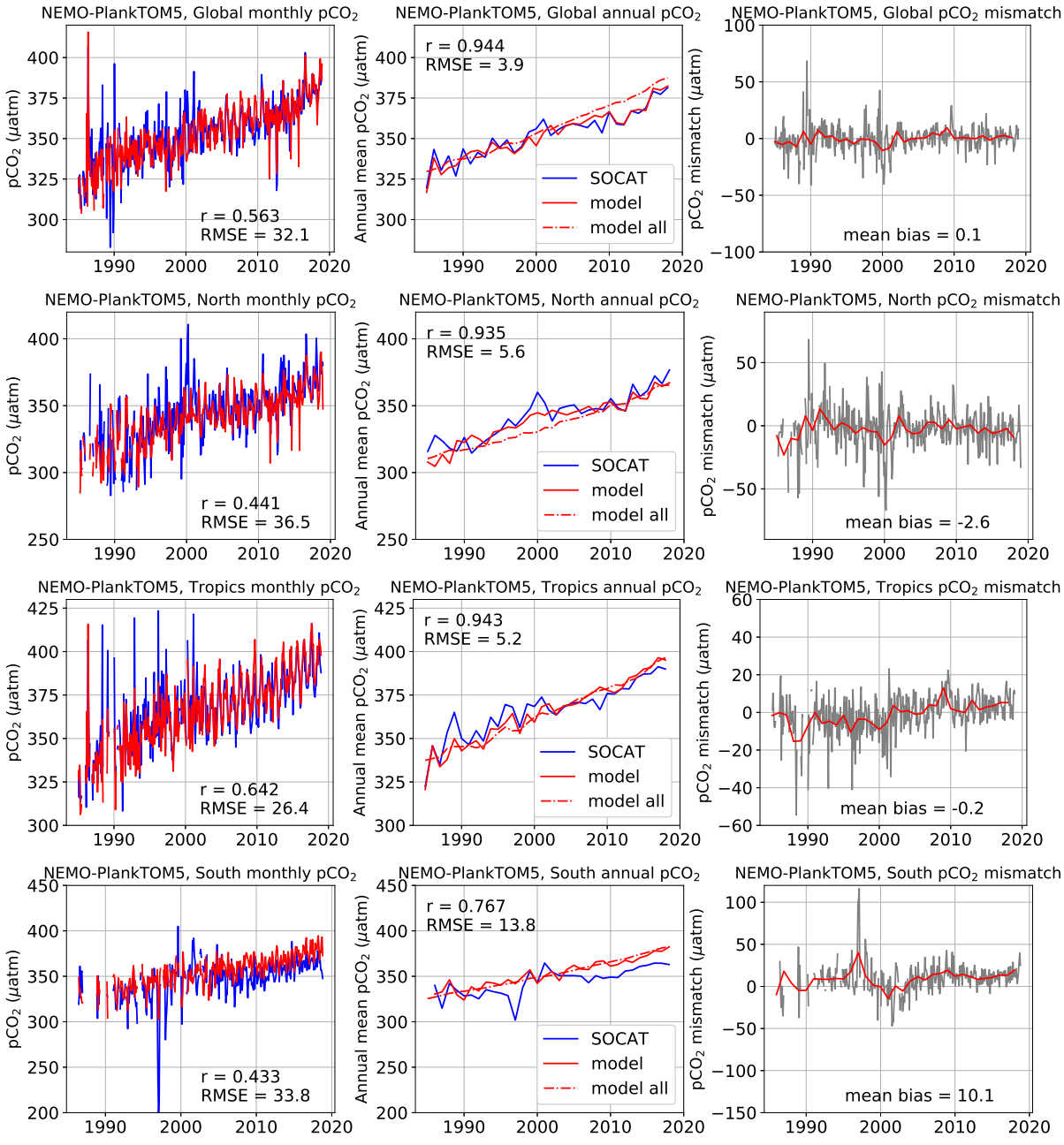

Figure S6. Comparison between sea-surface pCO_2 in NEMO-PlankTOM5 and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

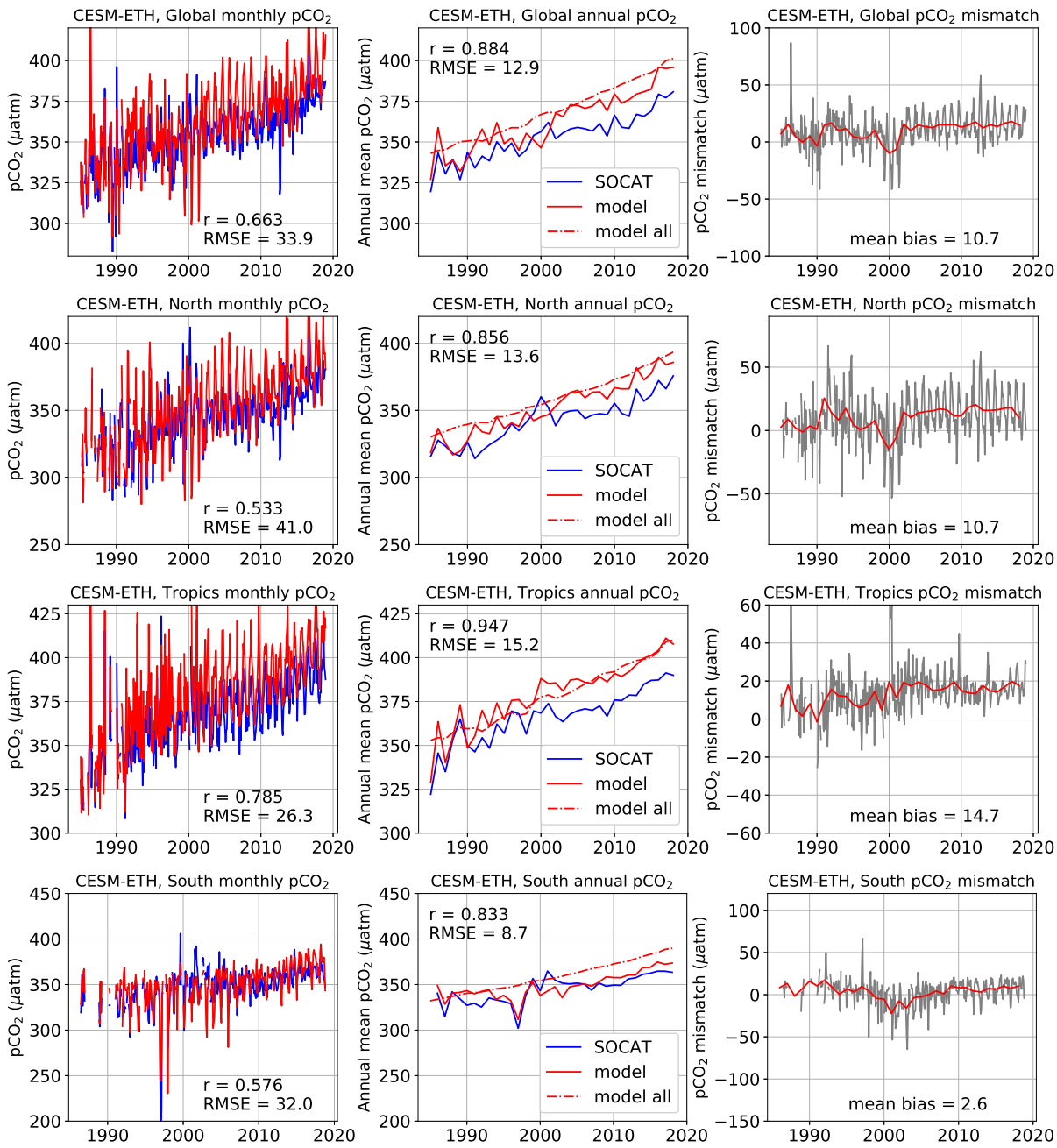

Figure S7. Comparison between sea-surface pCO_2 in CESM-ETH and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

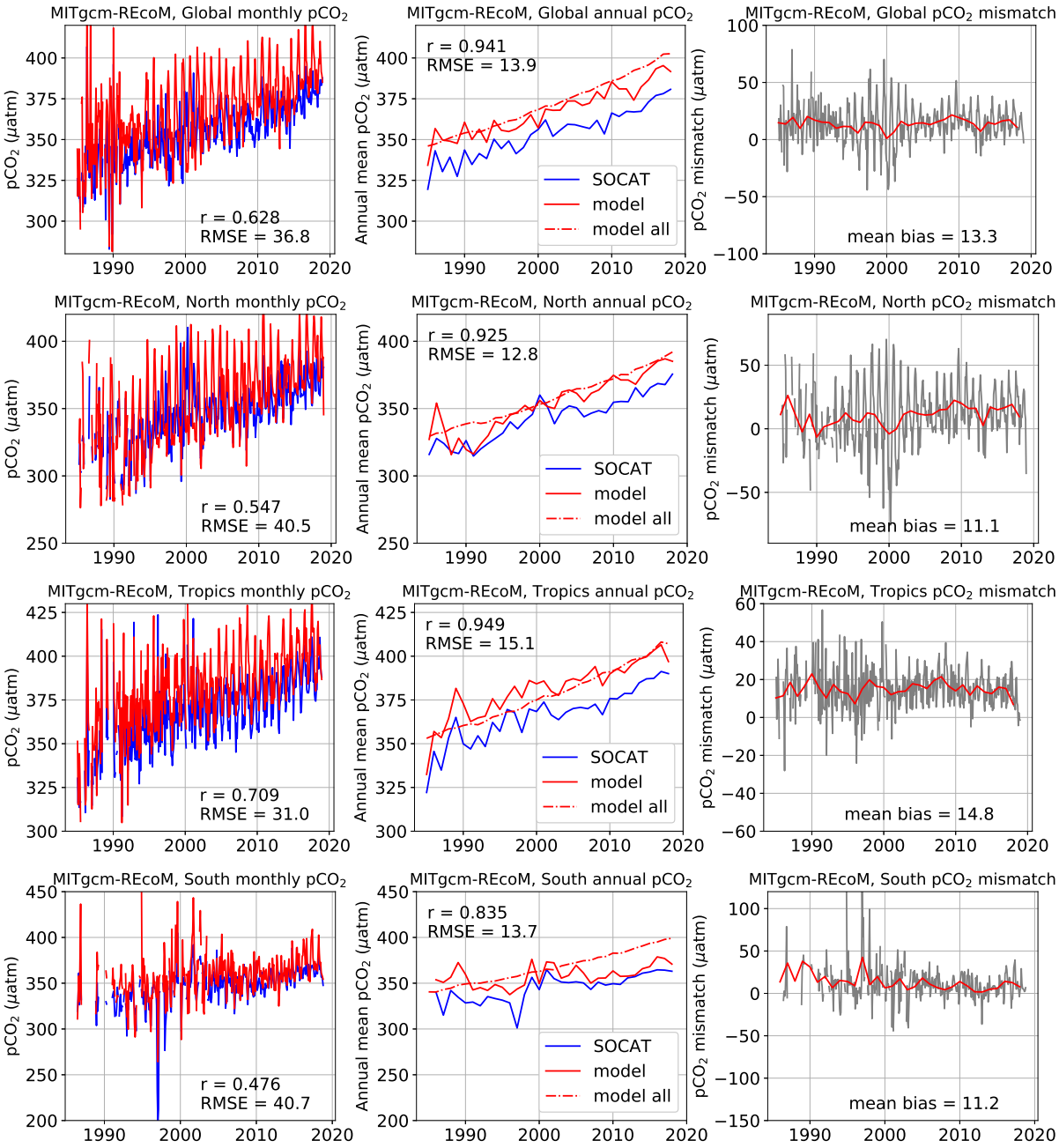

Figure S8. Comparison between sea-surface pCO_2 in MITgcm-REcoM and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

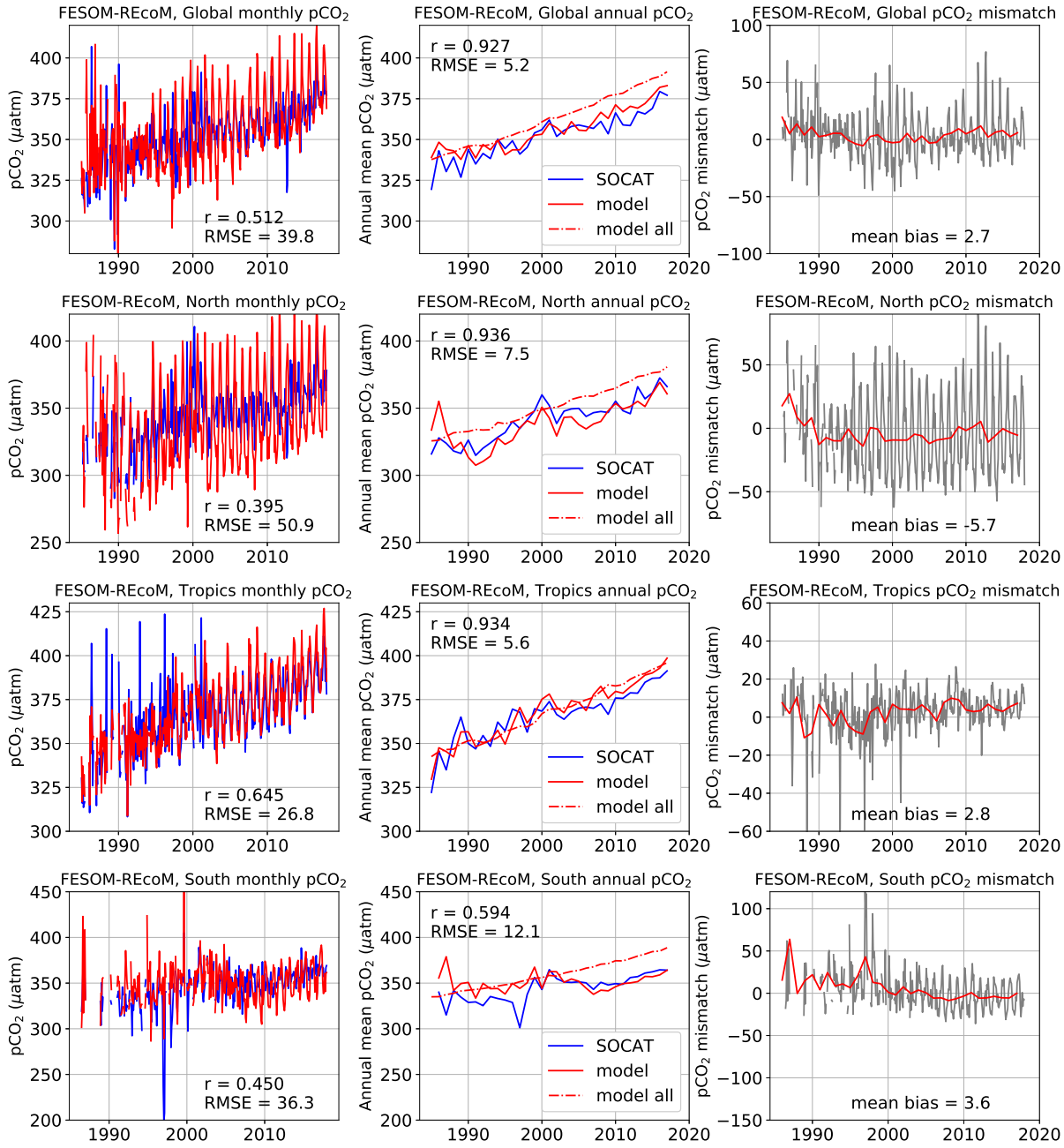

Figure S9. Comparison between sea-surface pCO_2 in FESOM-REcoM and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

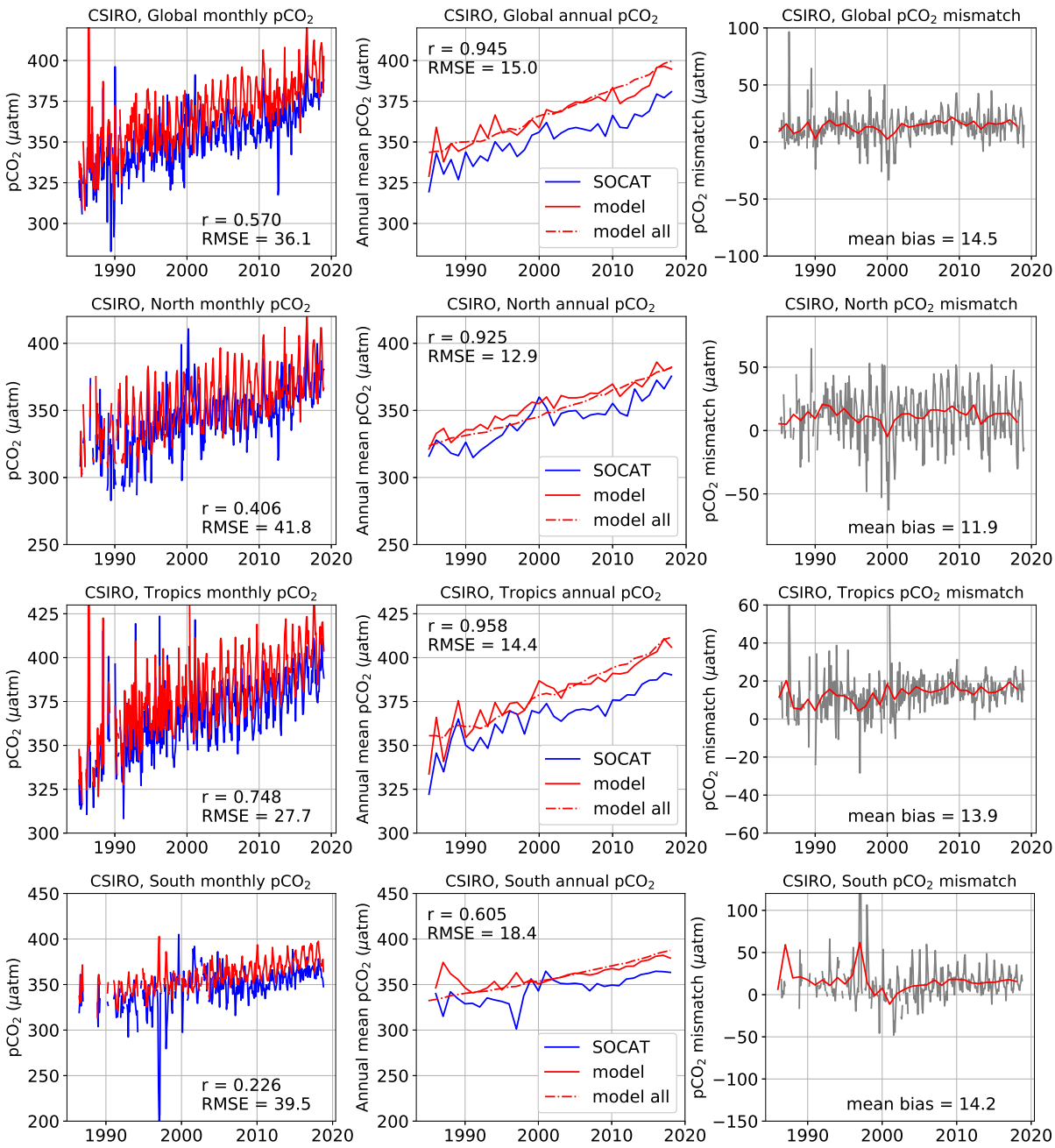

Figure S10. Comparison between sea-surface pCO_2 in CSIRO and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

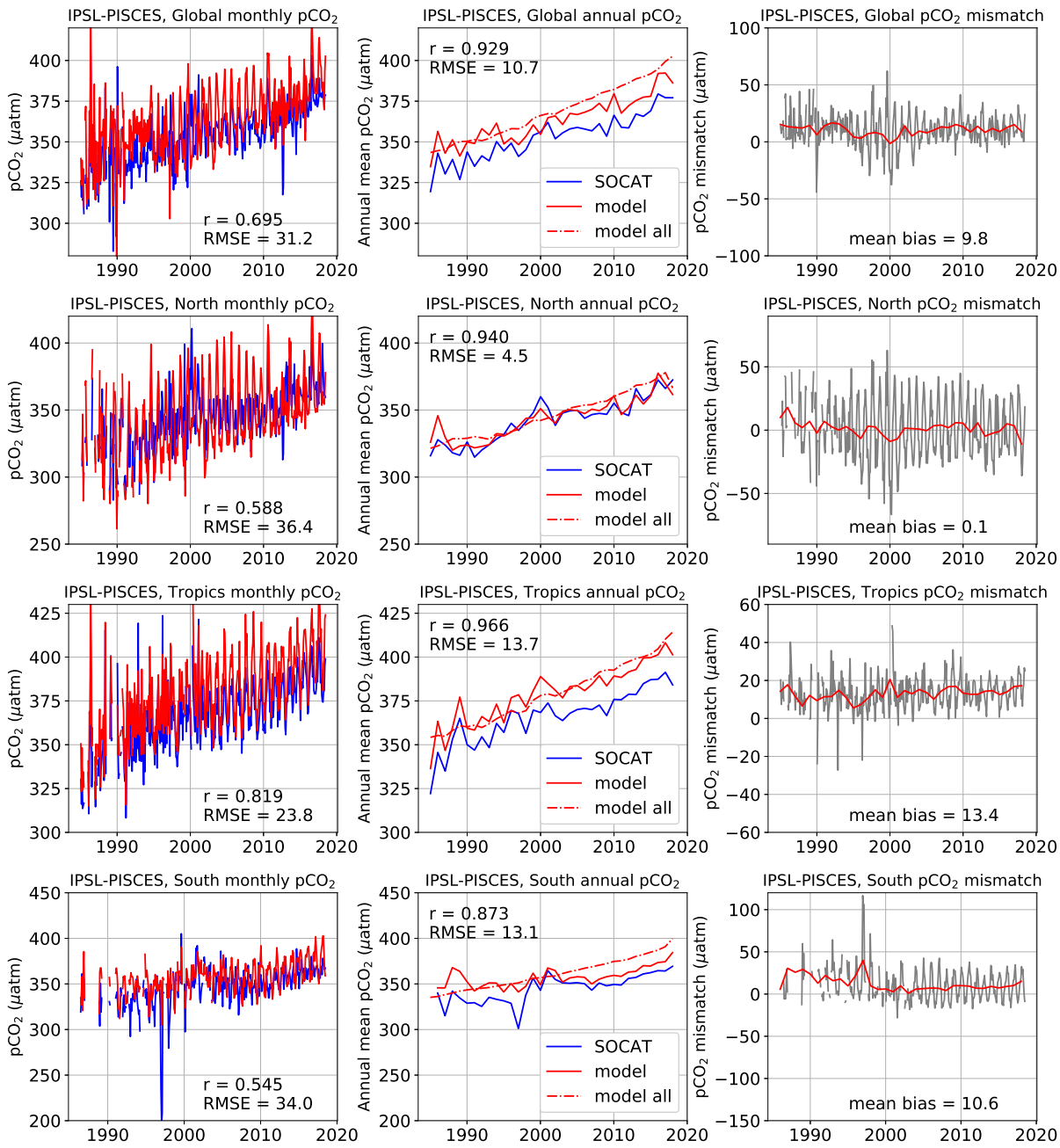

Figure S11. Comparison between sea-surface pCO_2 in IPSL and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

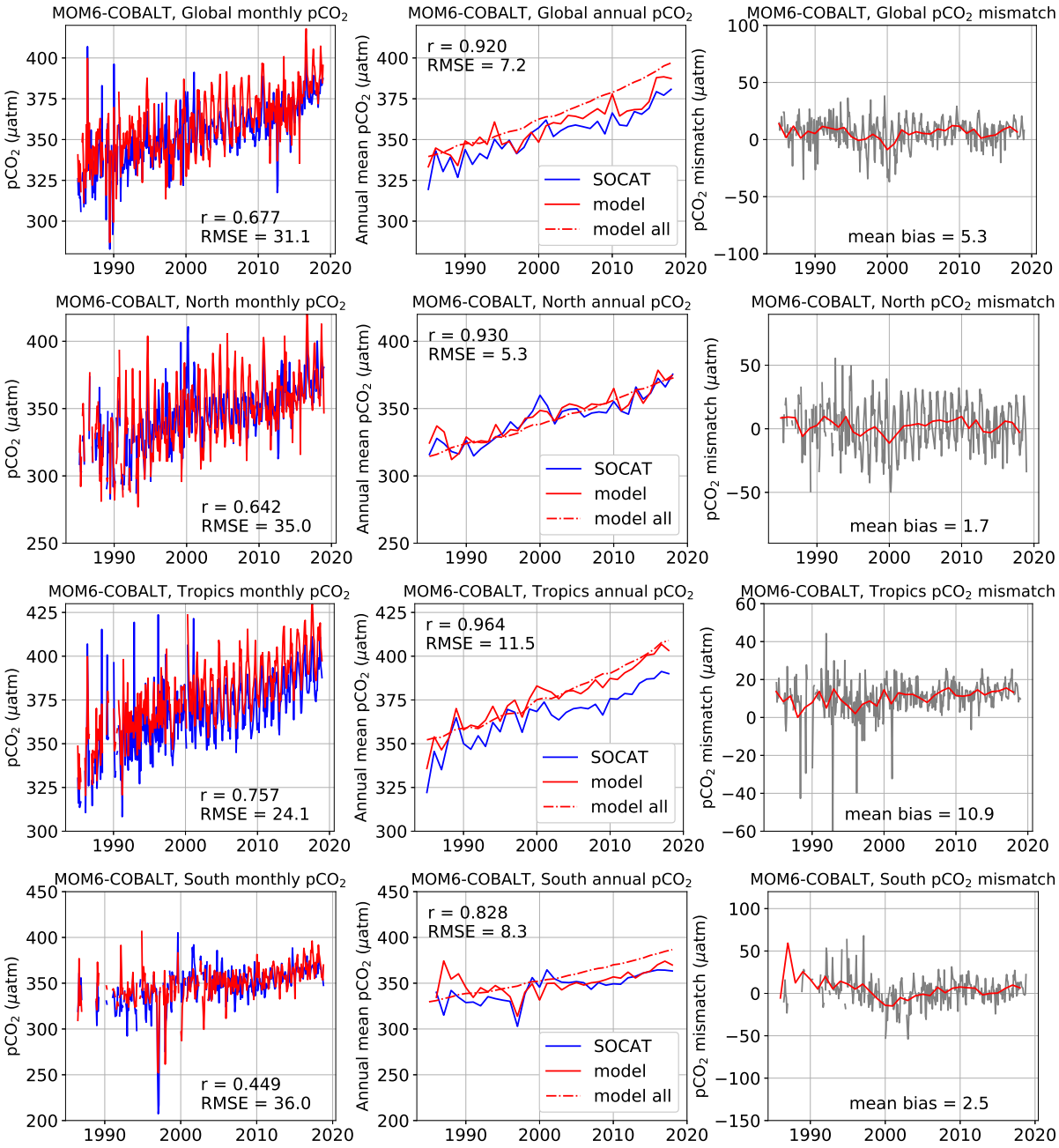

Figure S12. Comparison between sea-surface pCO_2 in MOM6-COBALT and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between modelled and observed pCO_2 (model minus SOCAT).

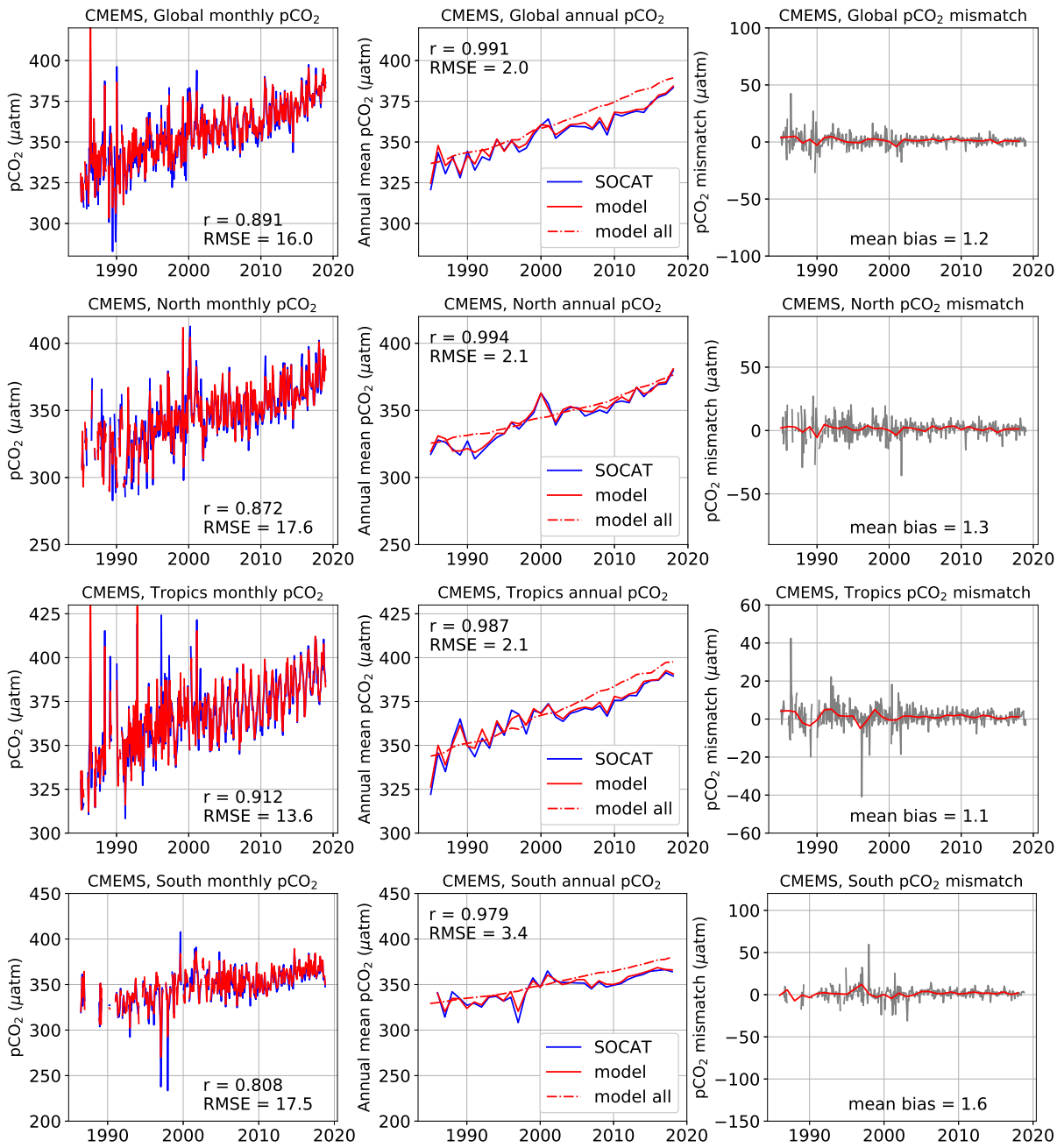

Figure S13. Comparison between sea-surface pCO_2 in CMEMS and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between mapped and observed pCO_2 (data-product minus SOCAT).

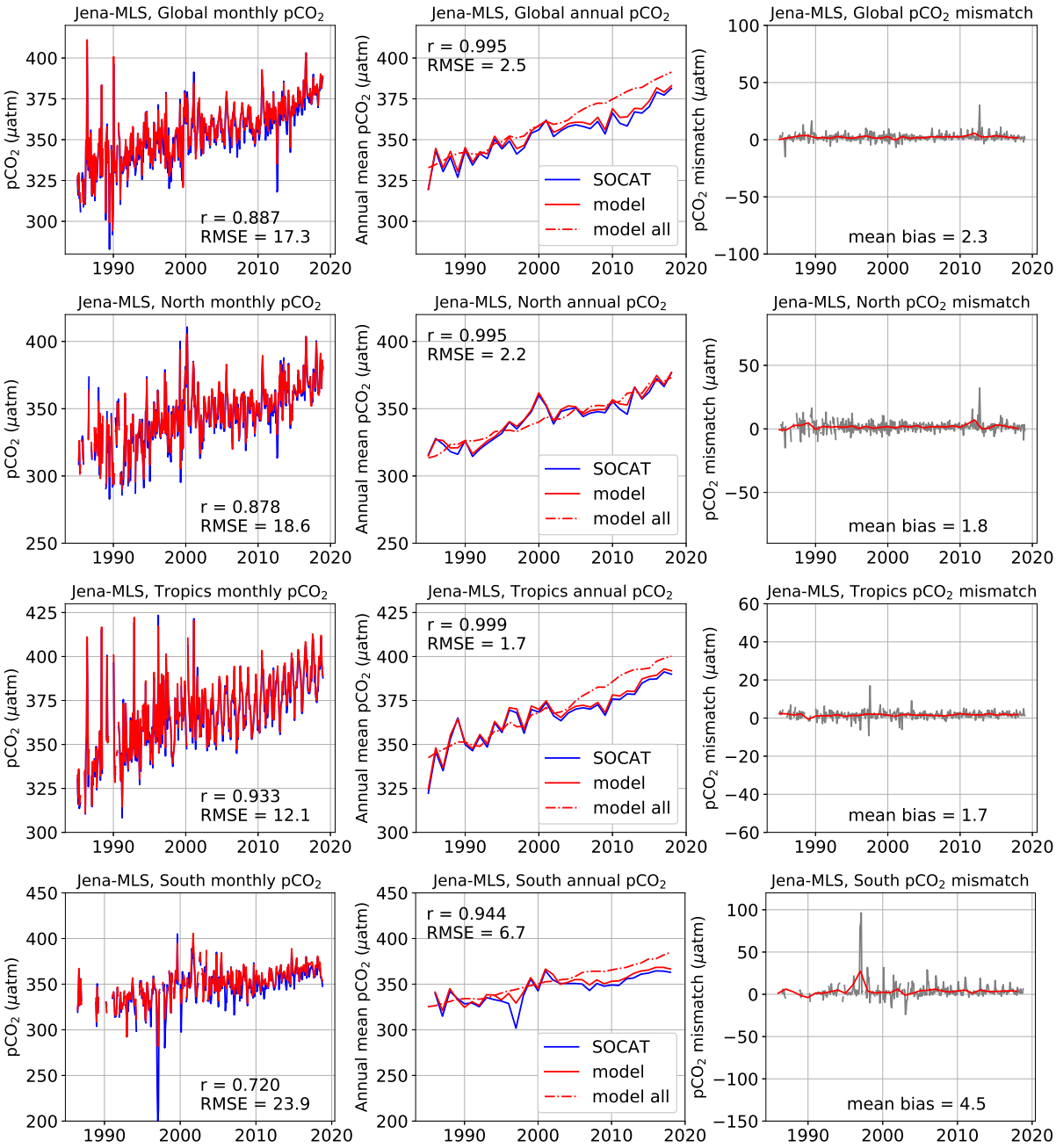

Figure S14. Comparison between sea-surface pCO_2 in Jena-MLS and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between mapped and observed pCO_2 (data-product minus SOCAT).

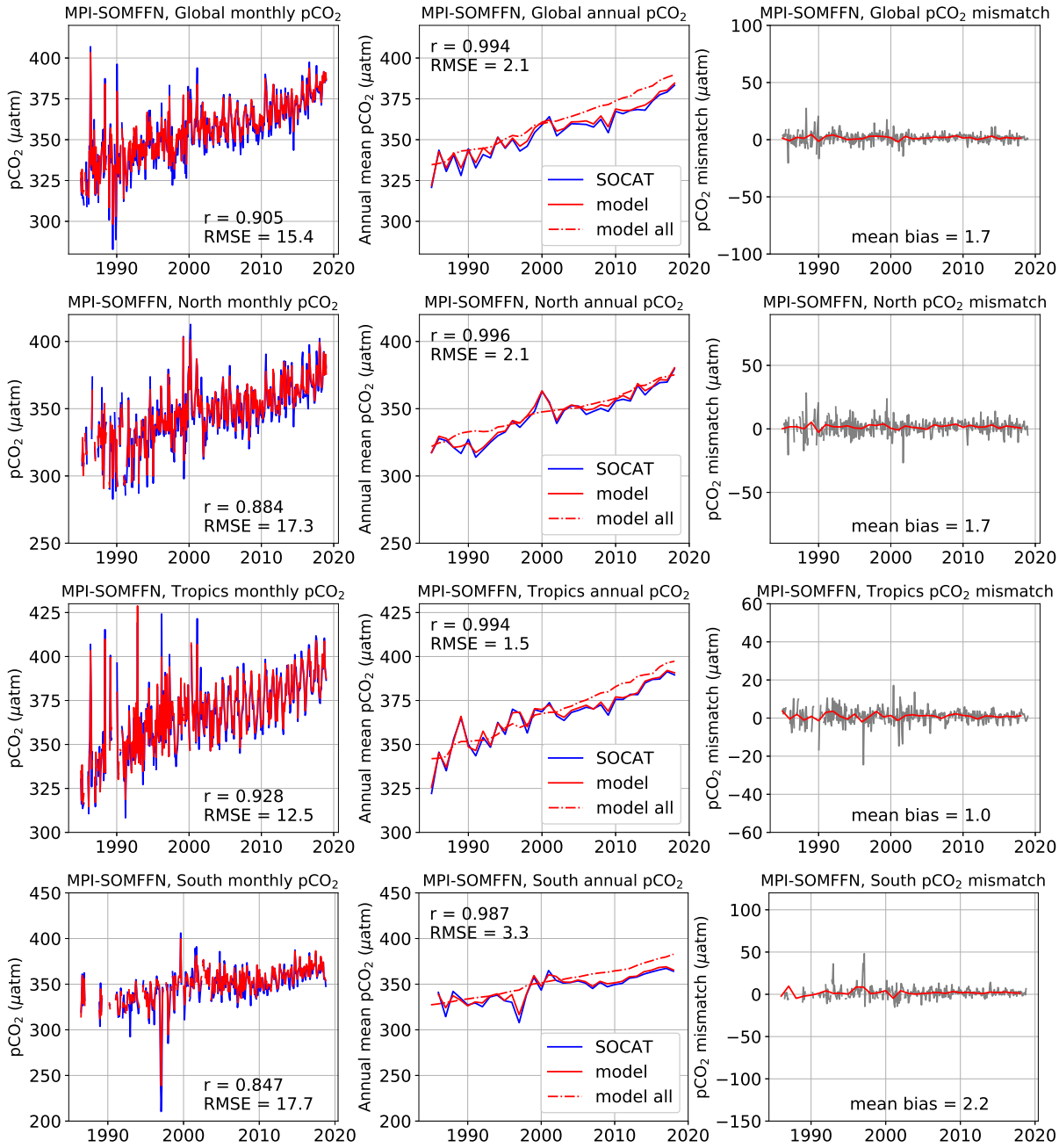

Figure S15. Comparison between sea-surface pCO_2 in MPI-SOMFFN and SOCATv2019. first column: monthly sea-surface pCO_2, second column: annual mean sea-surface pCO_2, third column: monthly (grey) and annual mean (red) mismatch between mapped and observed pCO_2 (data-product minus SOCAT).