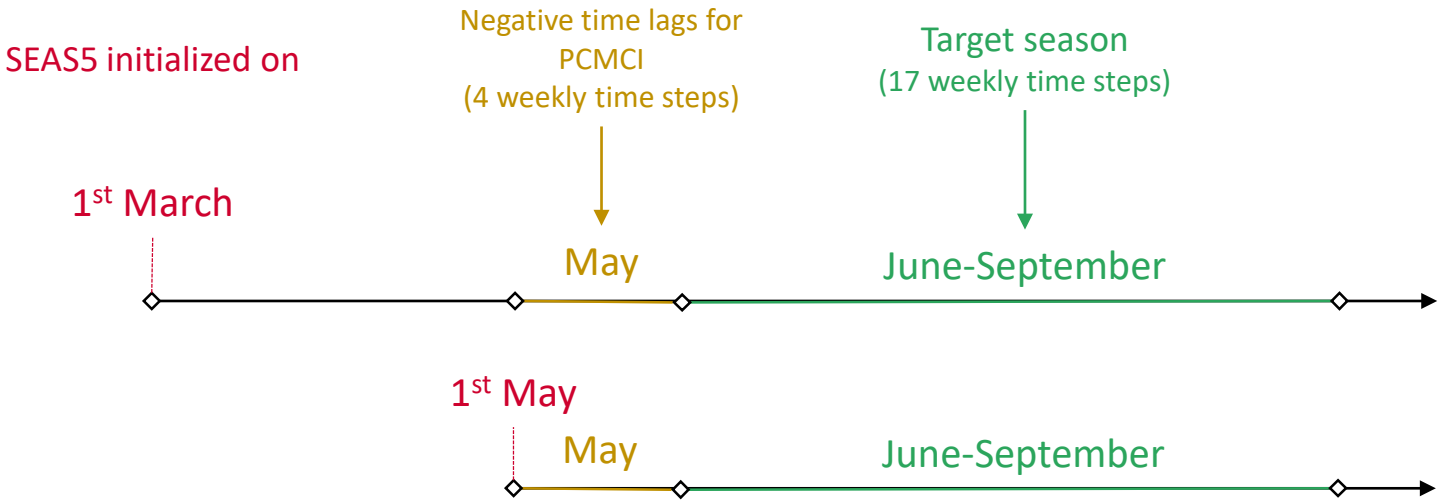
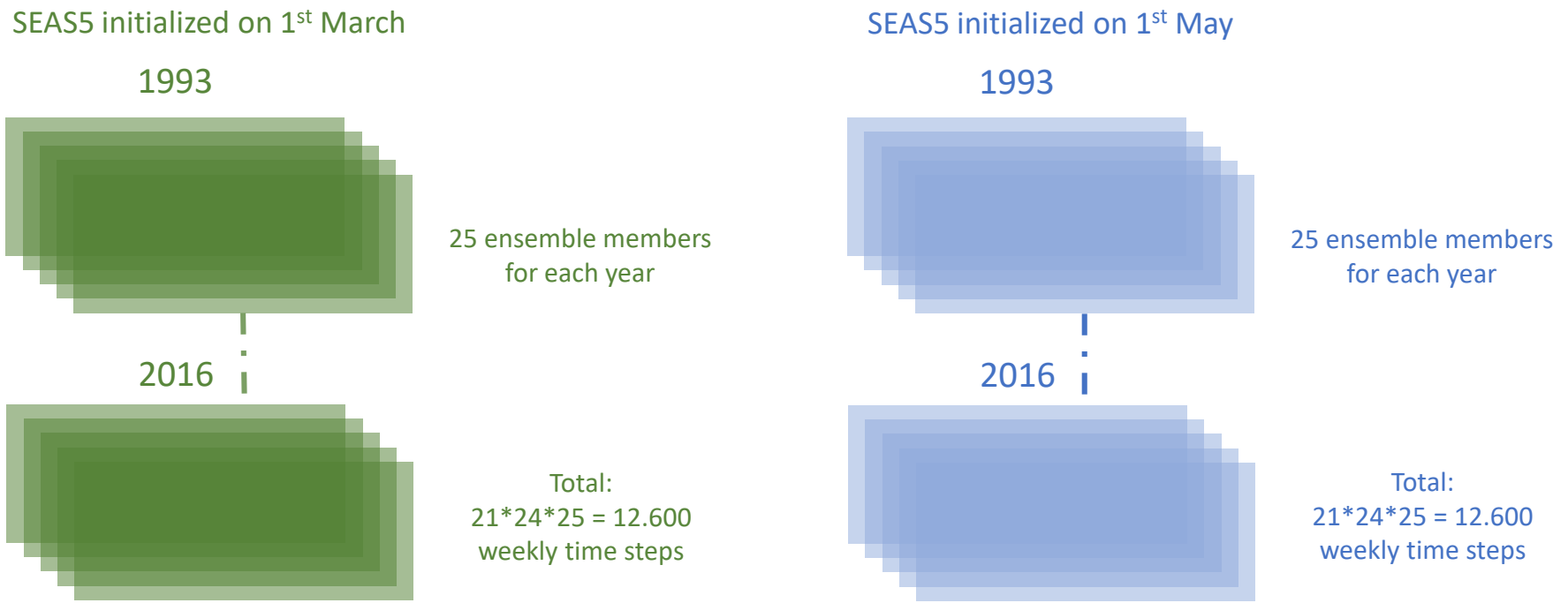
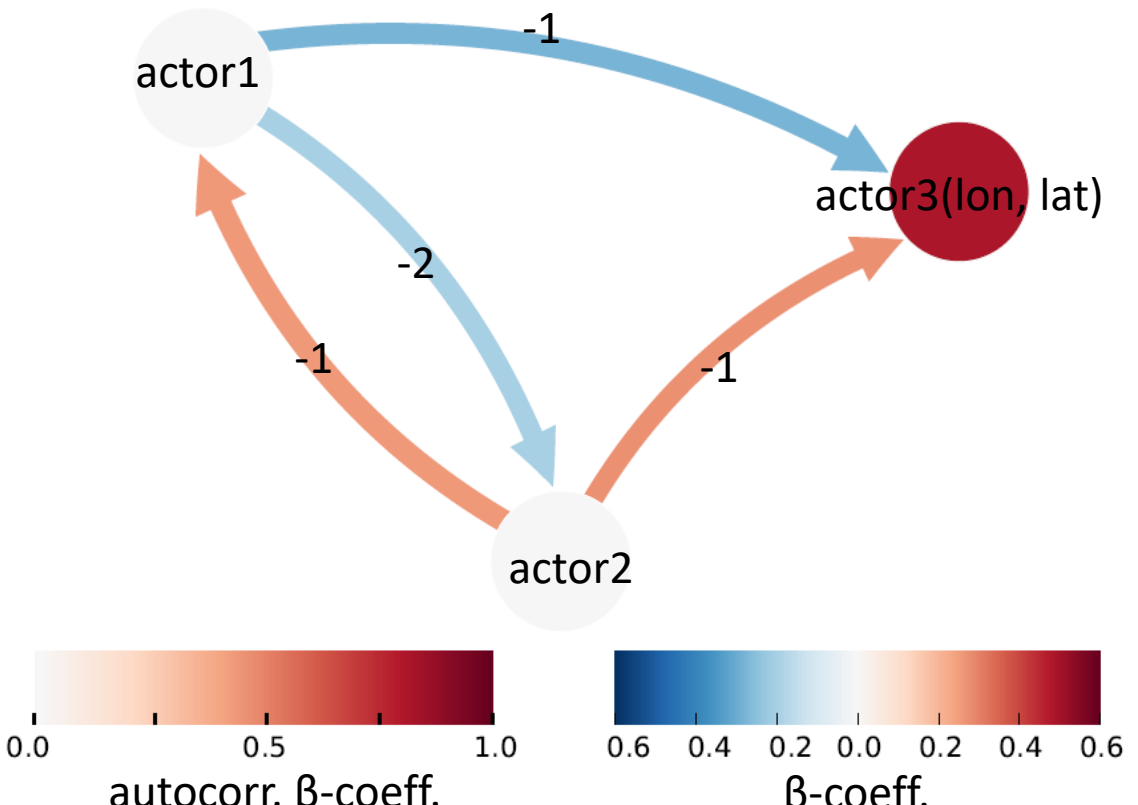
(a) SEAS5 time line



(b) SEAS5 ensemble members

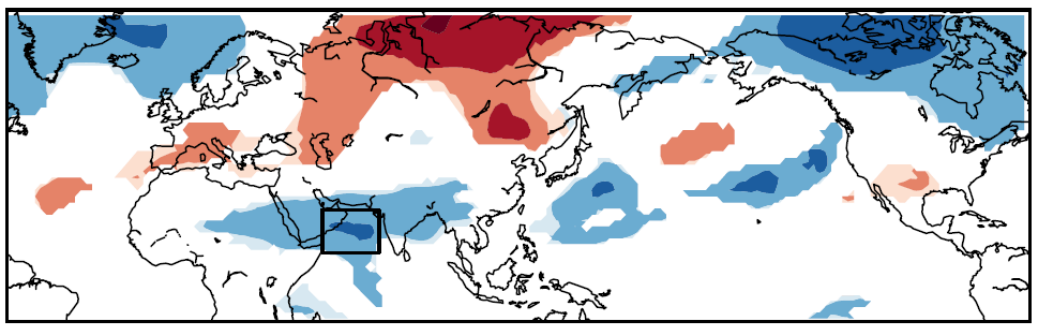


(a) Causal Effect Network

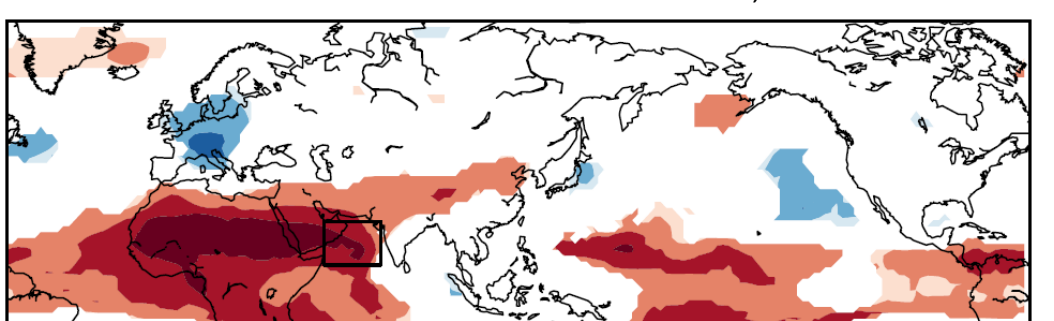


(b) Causal Map

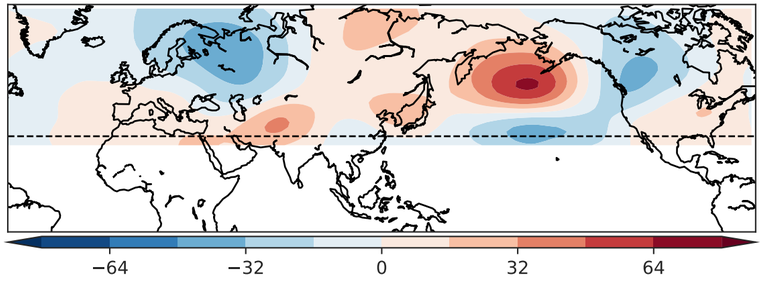
actor1$_{\tau=-1}$ → actor3$_{\tau=0}$ (lat, lon) | all$_{\tau=-1,-2}$



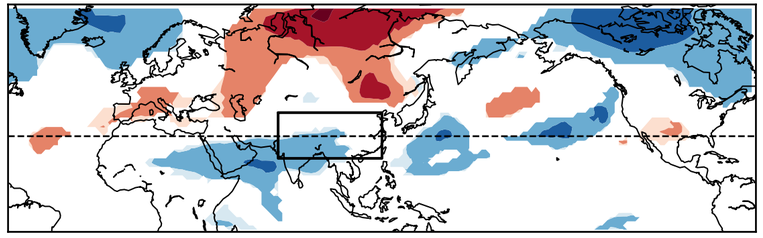
actor2$_{\tau=-1}$ → actor3$_{\tau=0}$ (lat, lon) | all$_{\tau=-1,-2}$



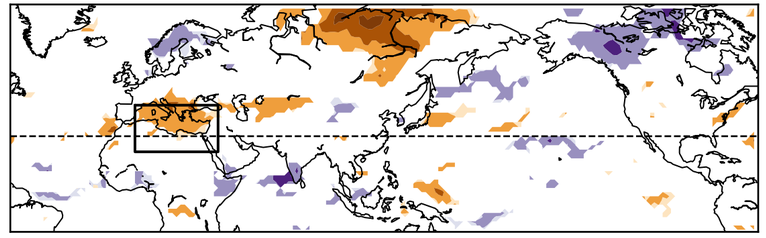
(a) ERA5 (1993-2016), MCA 1 - Z200 [m]



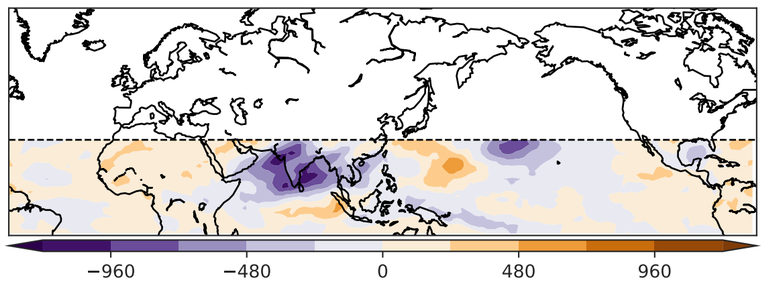
(b) CGT ⇒ Z200 | SAM, lag -1



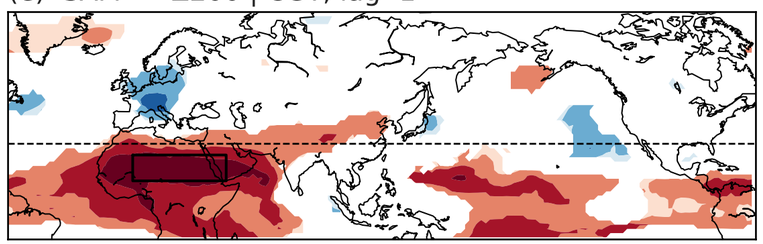
(c) CGT ⇒ OLR | SAM, lag -1



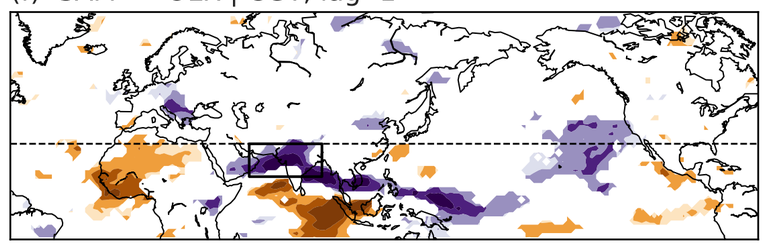
(d) ERA5 (1993-2016), MCA 1 - OLR [J*m^{-2}*10^{3}]



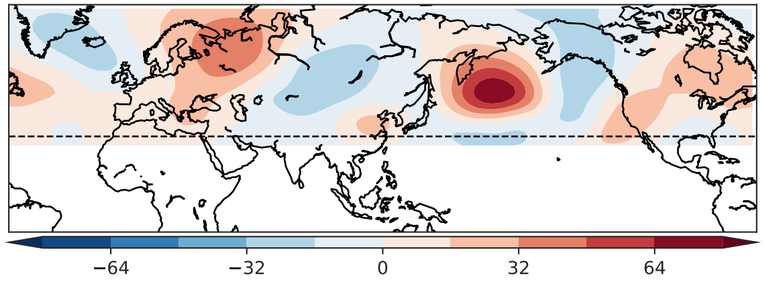
(e) SAM ⇒ Z200 | CGT, lag -1



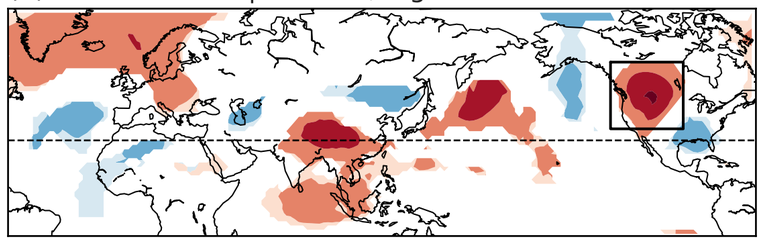
(f) SAM ⇒ OLR | CGT, lag -1



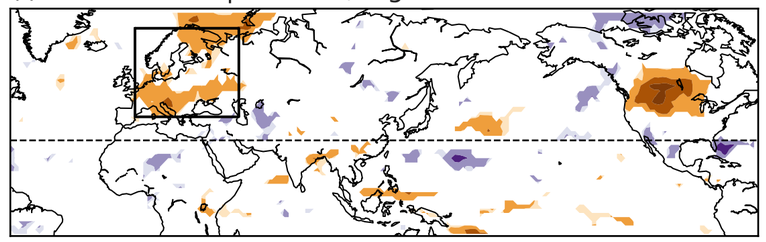
(g) ERA5 (1993-2016), MCA 2 - Z200 [m]



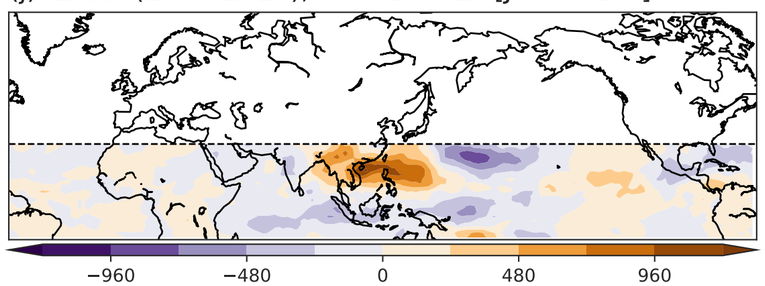
(h) NPH ⇒ Z200 | WNPSM, lag -1



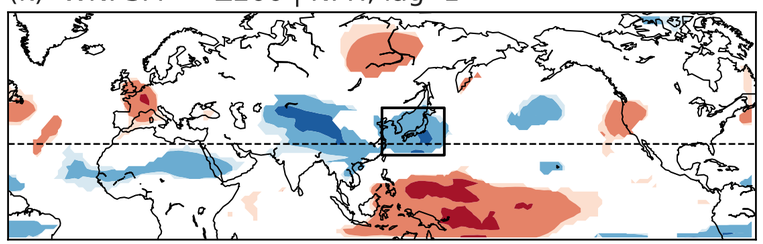
(i) NPH ⇒ OLR | WNPSM, lag -1



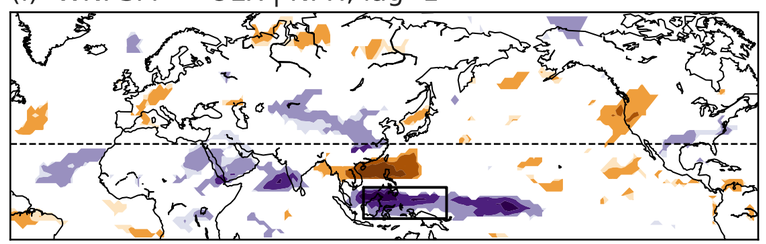
(j) ERA5 (1993-2016), MCA 2 - OLR [J*m^{-2}*10^{3}]



(k) WNPSM ⇒ Z200 | NPH, lag -1

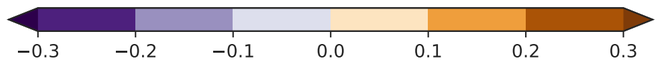


(l) WNPSM ⇒ OLR | NPH, lag -1

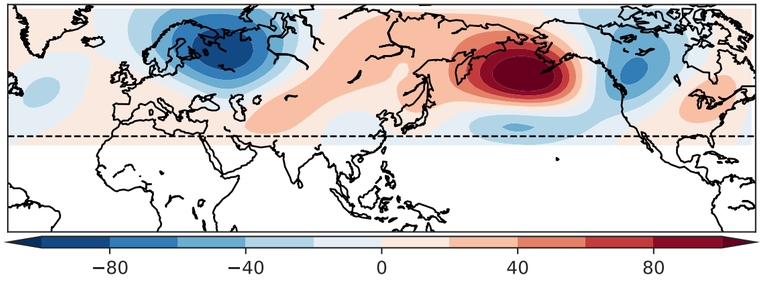


β

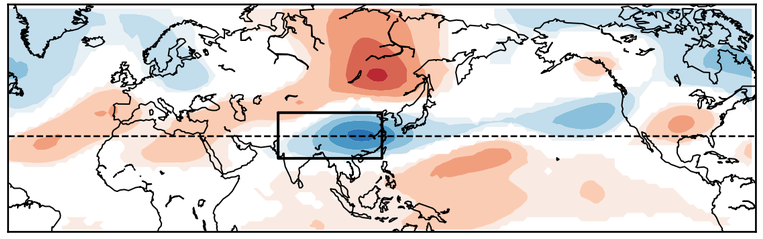
β



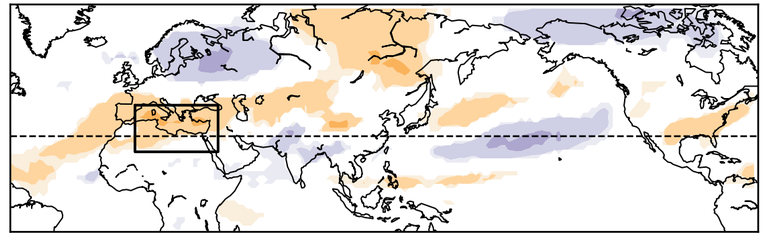
(a) SEAS5 - dotproduct of ERA5 MCA1 - Z200 [m]



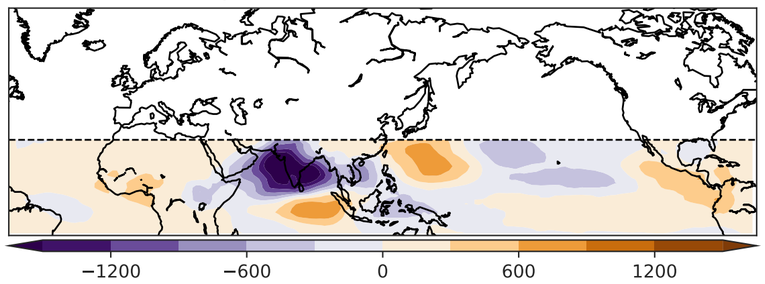
(b) CGT ⇒ Z200 | SAM, lag -1



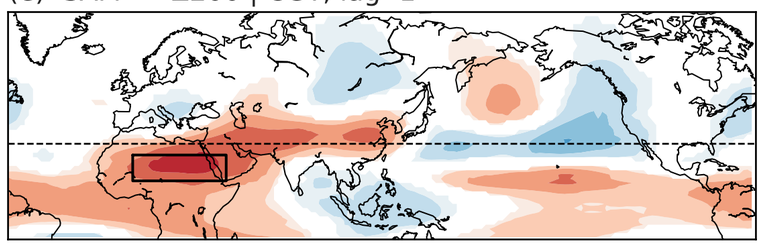
(c) CGT ⇒ OLR | SAM, lag -1



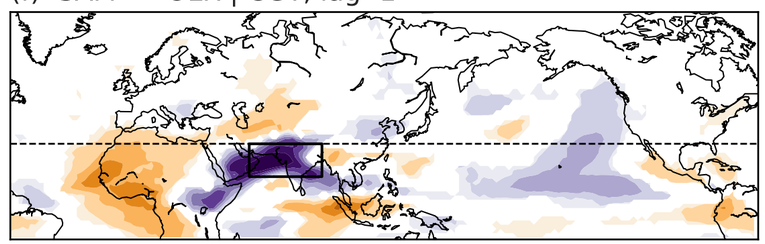
(d) SEAS5 - dotproduct of ERA5 MCA1 - OLR [J*m^{-2}*10^{3}]



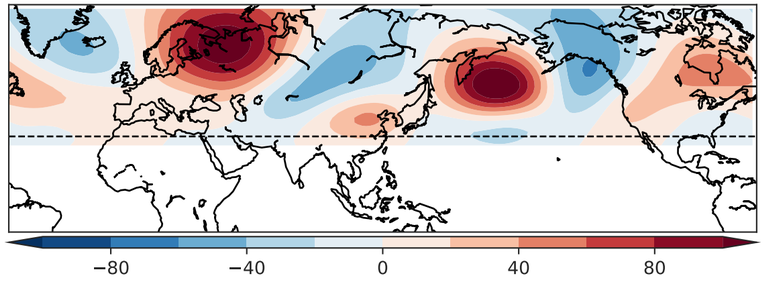
(e) SAM ⇒ Z200 | CGT, lag -1



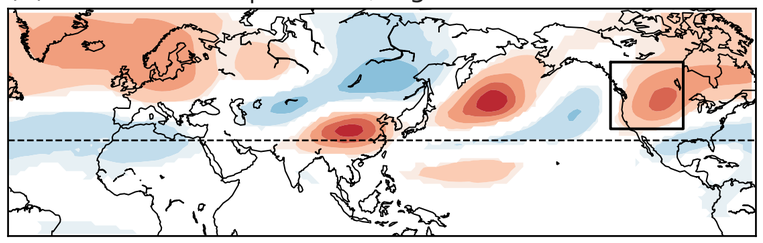
(f) SAM ⇒ OLR | CGT, lag -1



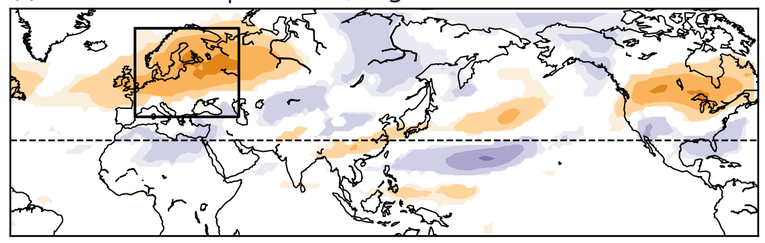
(g) SEAS5 - dotproduct of ERA5 MCA2 - Z200 [m]



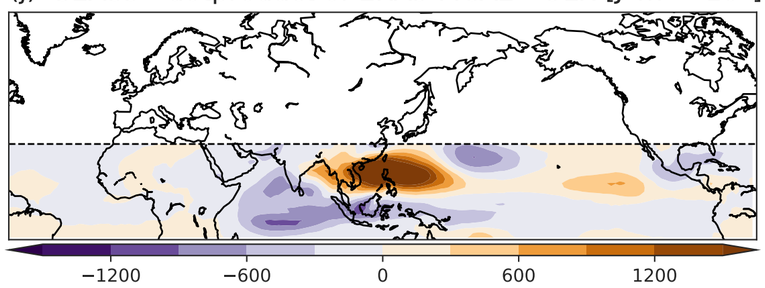
(h) NPH ⇒ Z200 | WNPSM, lag -1



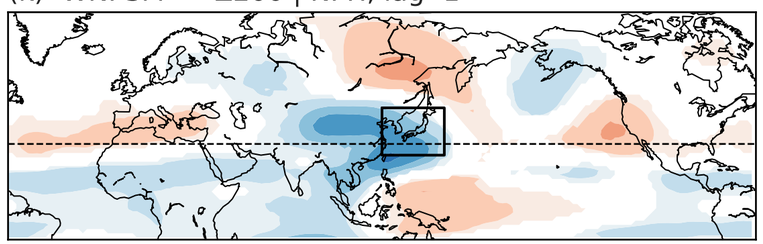
(i) NPH ⇒ OLR | WNPSM, lag -1



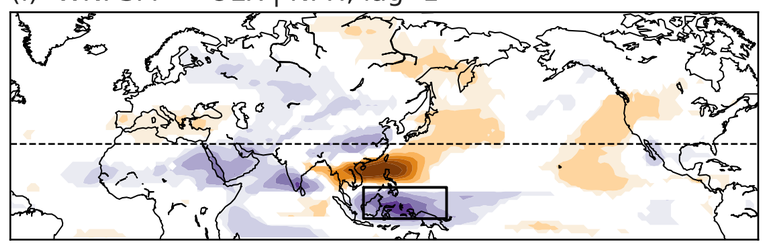
(j) SEAS5 - dotproduct of ERA5 MCA2 - OLR [J*m^{-2}*10^{3}]

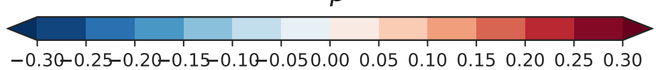


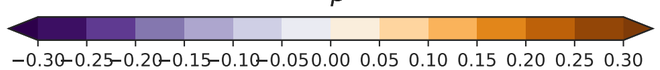
(k) WNPSM ⇒ Z200 | NPH, lag -1



(l) WNPSM ⇒ OLR | NPH, lag -1

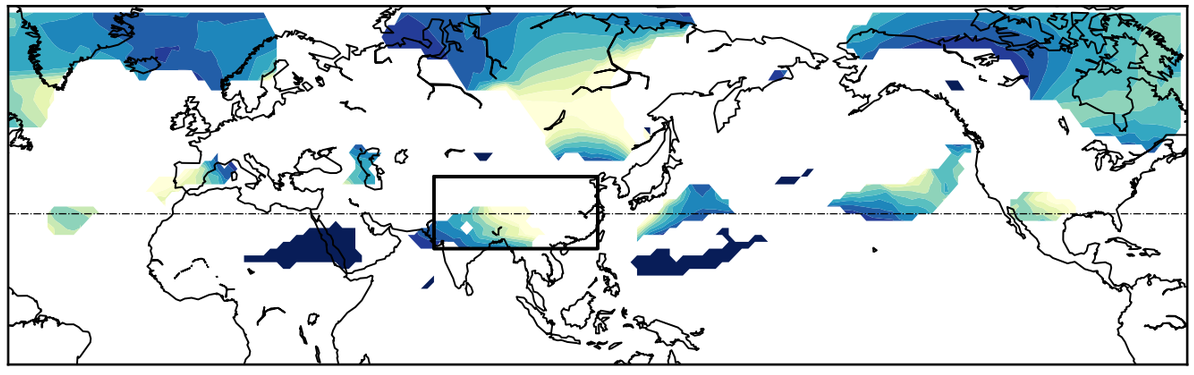




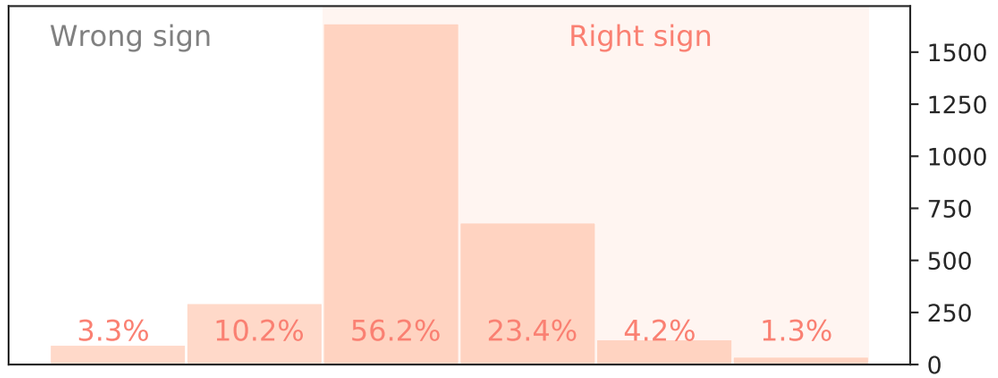


ERA5 - SEAS5 (MCA-ERA5), 1993-2016

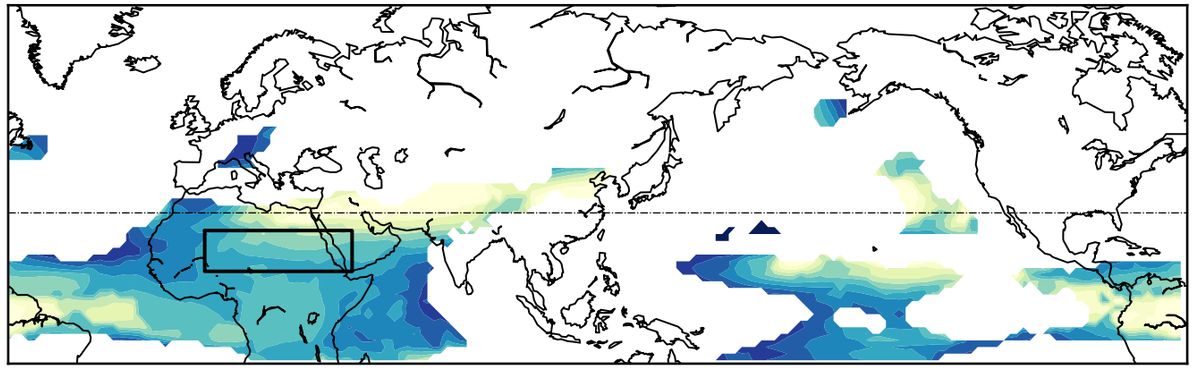
(a) CGT ⇒ Z200 | SAM; mean: 0.39, std: 0.34



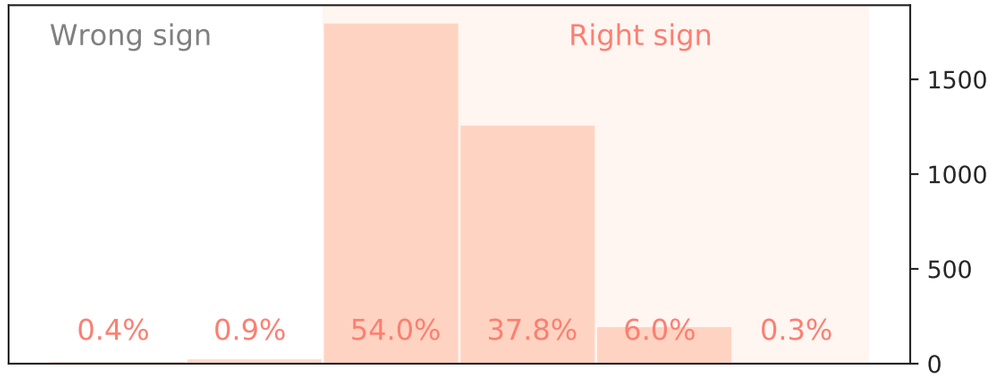
(b) CGT ⇒ Z200 | SAM - Histogram



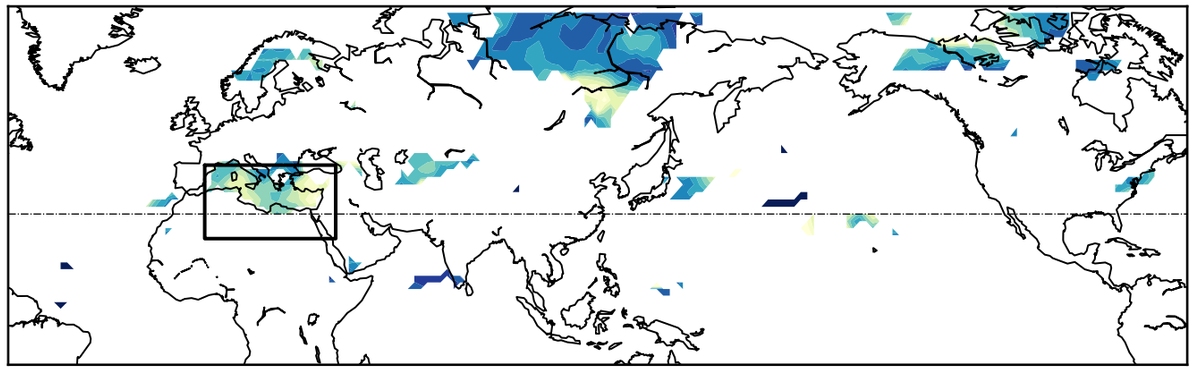
(c) SAM ⇒ Z200 | CGT; mean: 0.54, std: 0.28



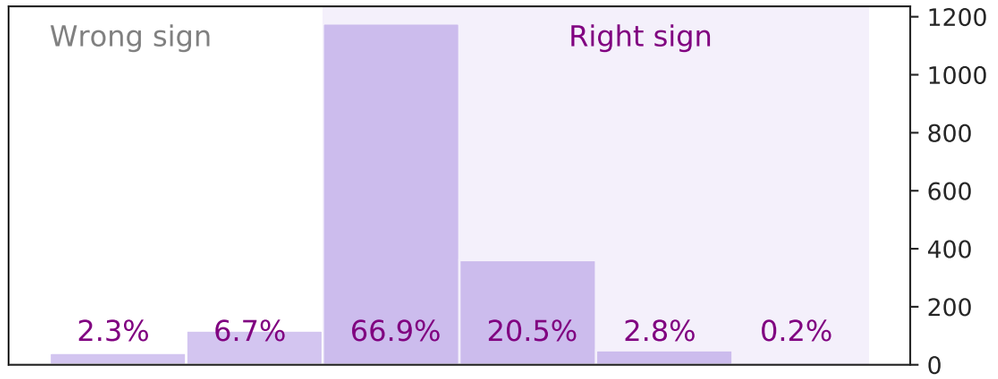
(d) SAM ⇒ Z200 | CGT - Histogram



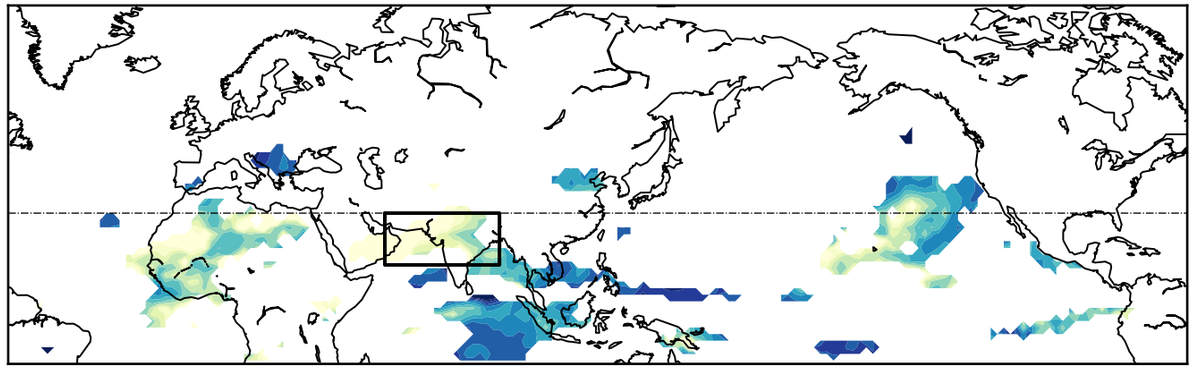
(e) CGT ⇒ OLR | SAM; mean: 0.44, std: 0.28



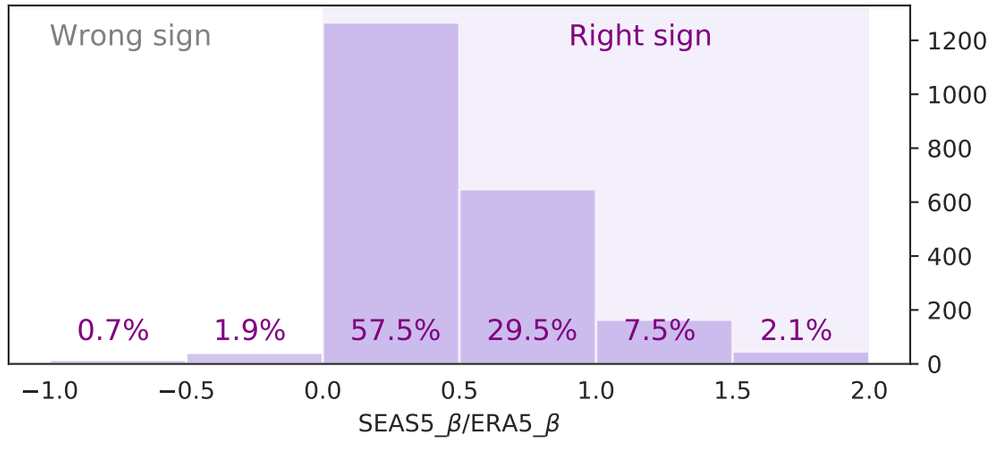
(f) CGT ⇒ OLR | SAM - Histogram

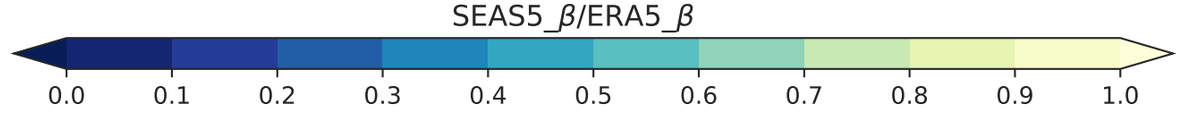


(g) SAM ⇒ OLR | CGT; mean: 0.71, std: 0.4



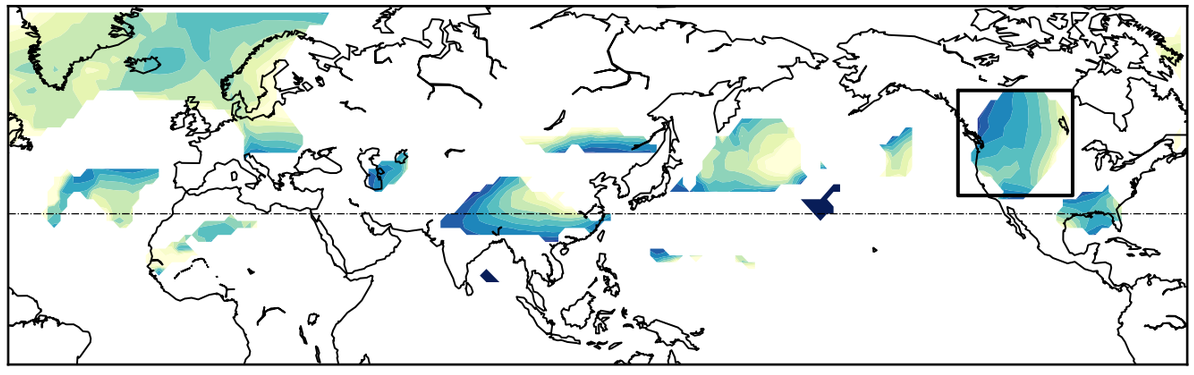
(h) SAM ⇒ OLR | CGT - Histogram



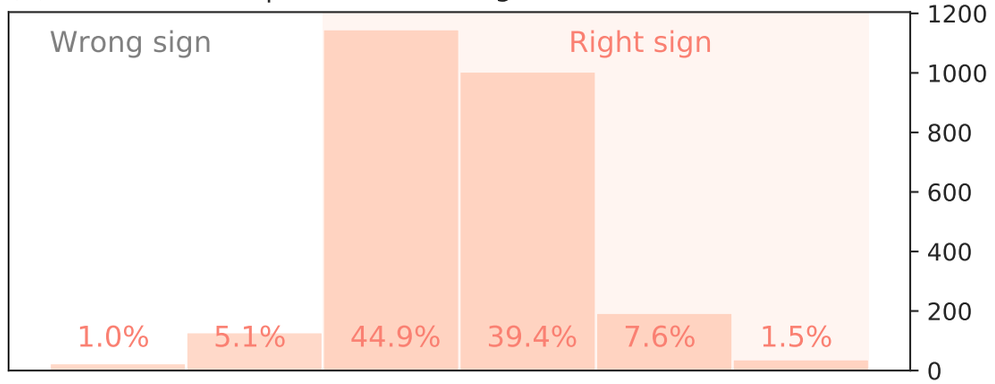


ERA5 - SEAS5 (MCA-ERA5), 1993-2016

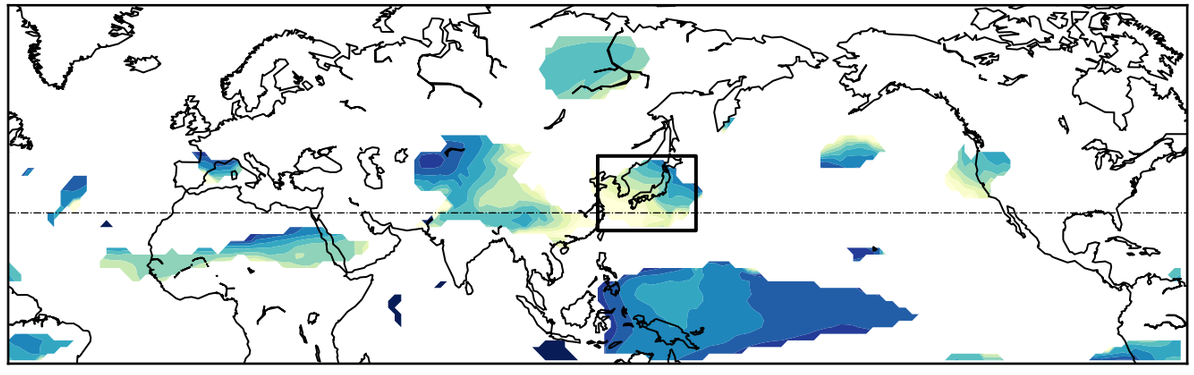
(a) NPH ⇒ Z200 | WNPSM; mean: 0.69, std: 0.4



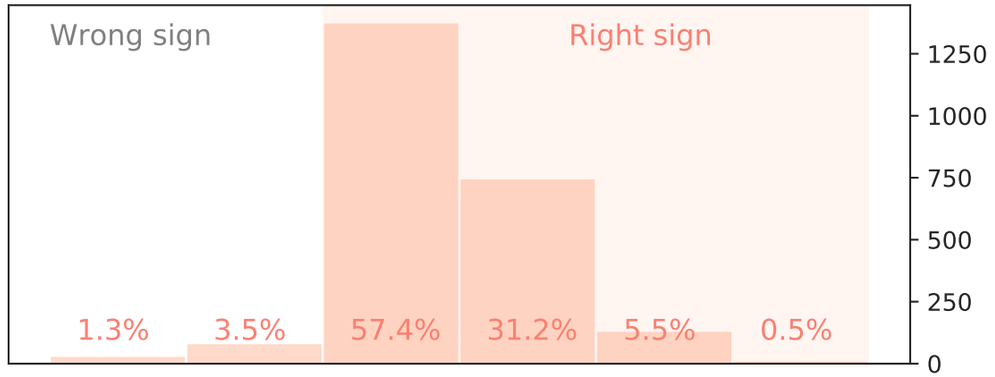
(b) NPH ⇒ Z200 | WNPSM - Histogram



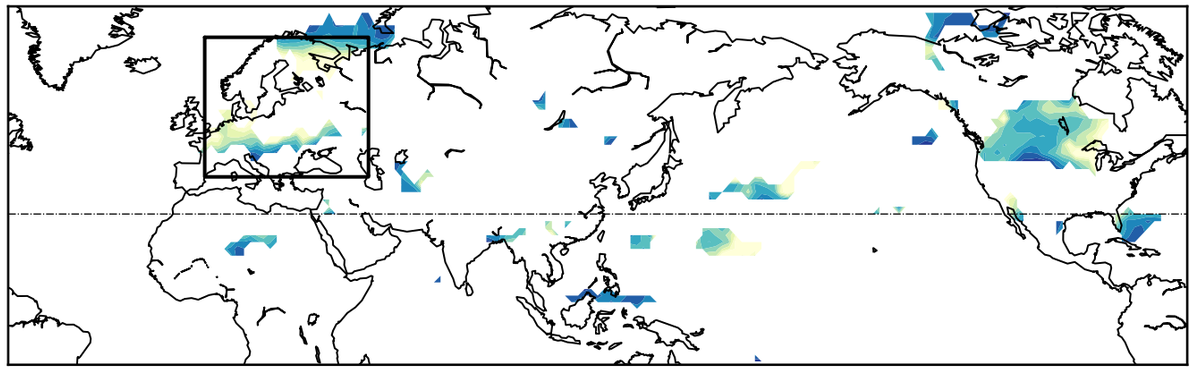
(c) WNPSM ⇒ Z200 | NPH; mean: 0.38, std: 0.56



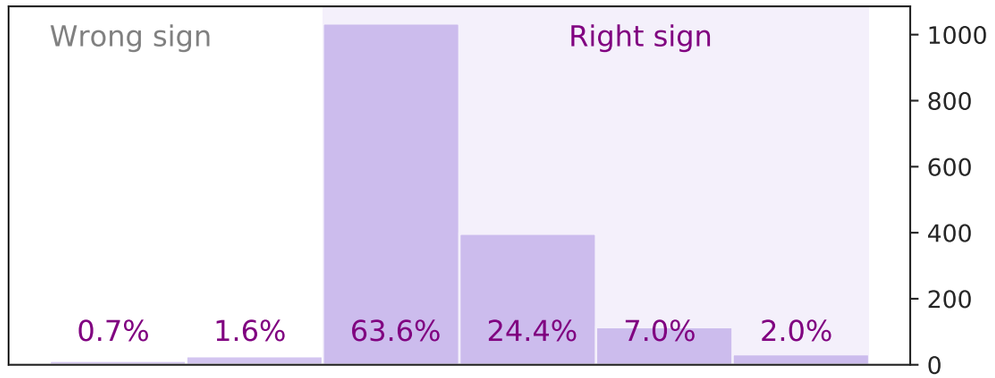
(d) WNPSM ⇒ Z200 | NPH - Histogram



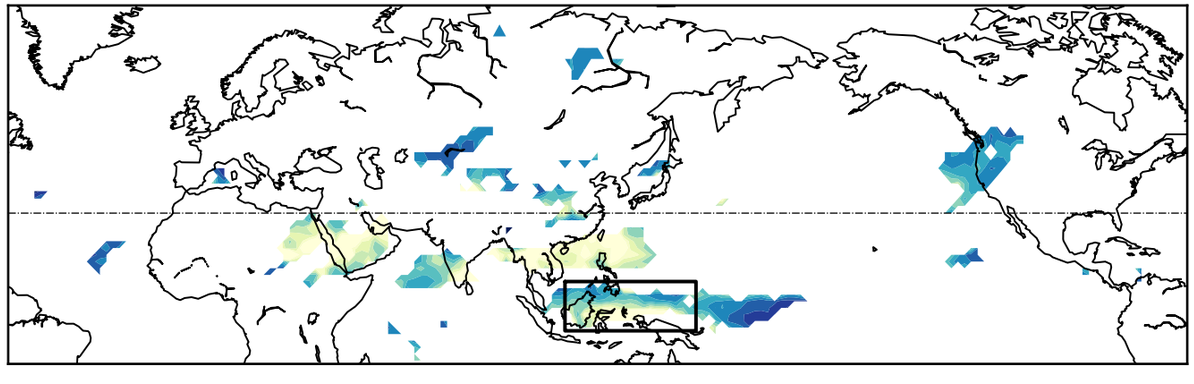
(e) NPH ⇒ OLR | WNPSM; mean: 0.74, std: 0.27



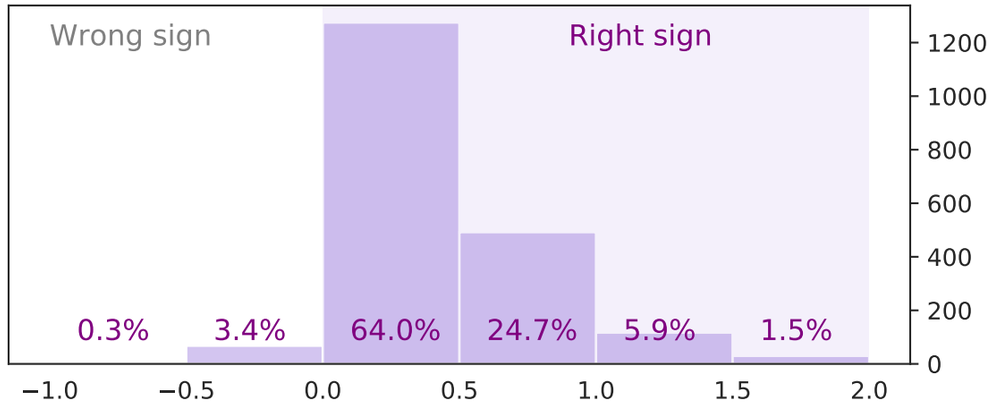
(f) NPH ⇒ OLR | WNPSM - Histogram

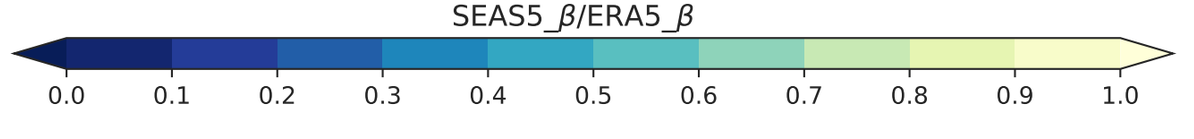


(g) WNPSM ⇒ OLR | NPH; mean: 0.66, std: 0.46

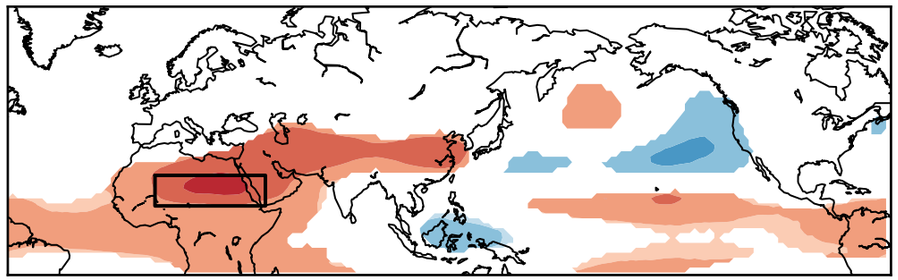


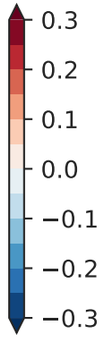
(h) WNPSM ⇒ OLR | NPH - Histogram



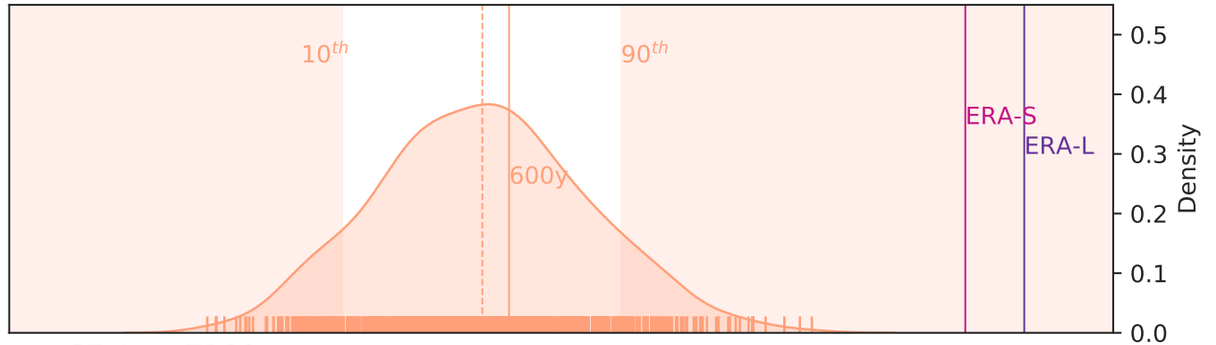


(a) SAM ⇒ Z200 | CGT - Sahel - mean β

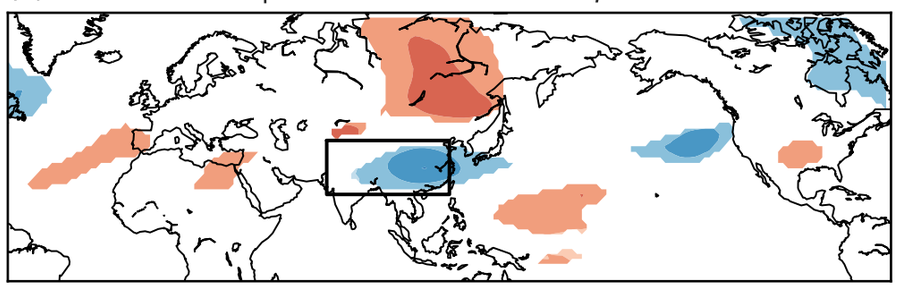


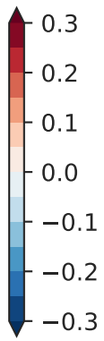


(b) Sahel Z200

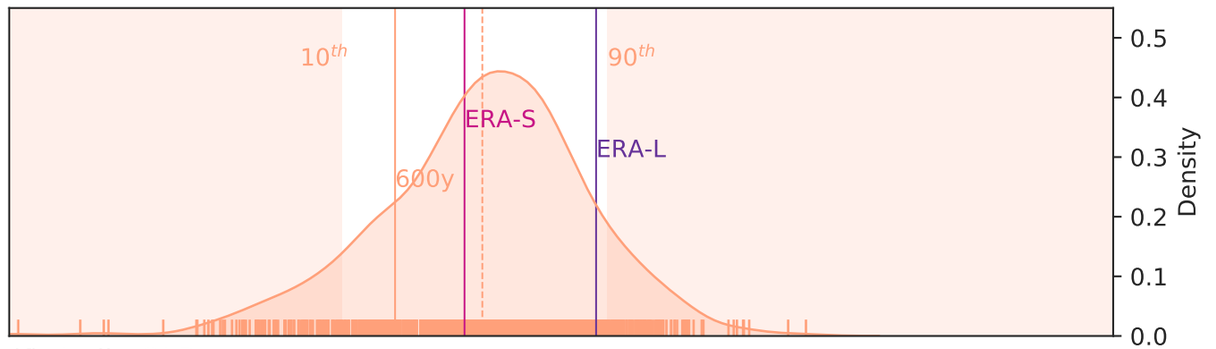


(c) CGT ⇒ Z200 | SAM - SE-Asia - mean β

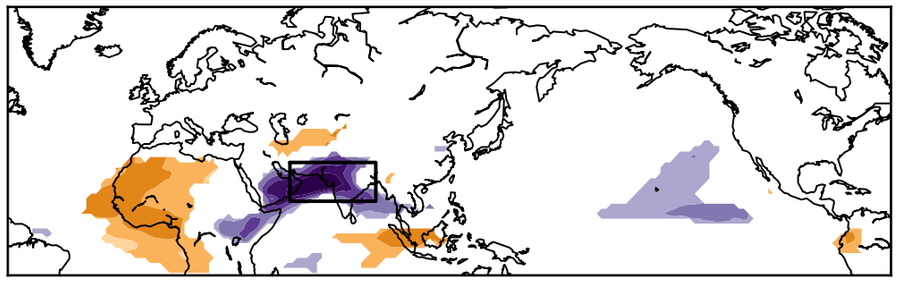


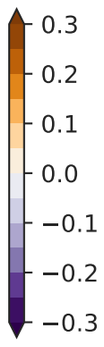


(d) SE-Asia Z200

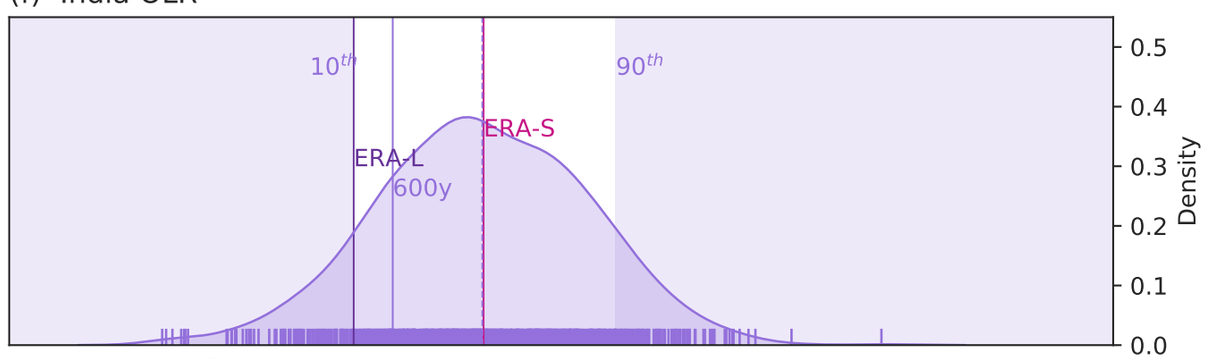


(e) SAM ⇒ OLR | CGT - India - mean β

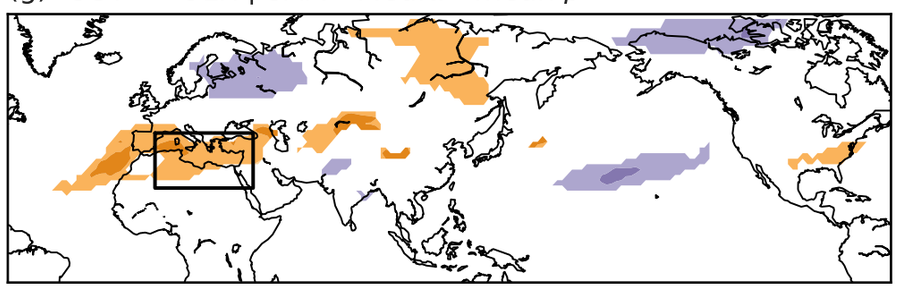


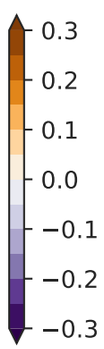


(f) India OLR

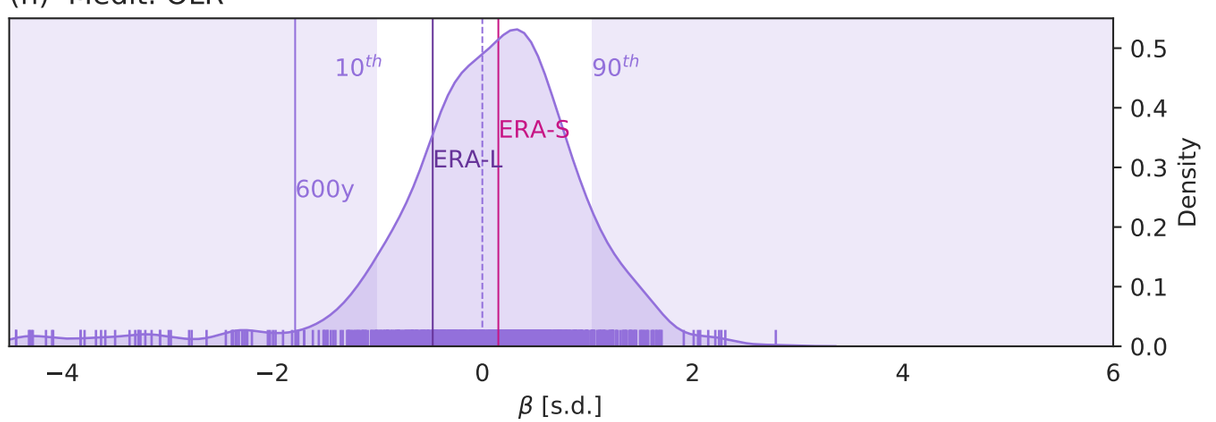


(g) CGT ⇒ OLR | SAM - Medit. - mean β

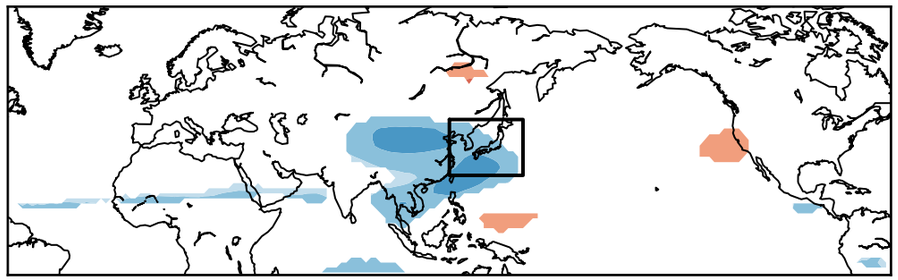


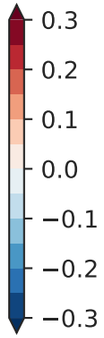


(h) Medit. OLR

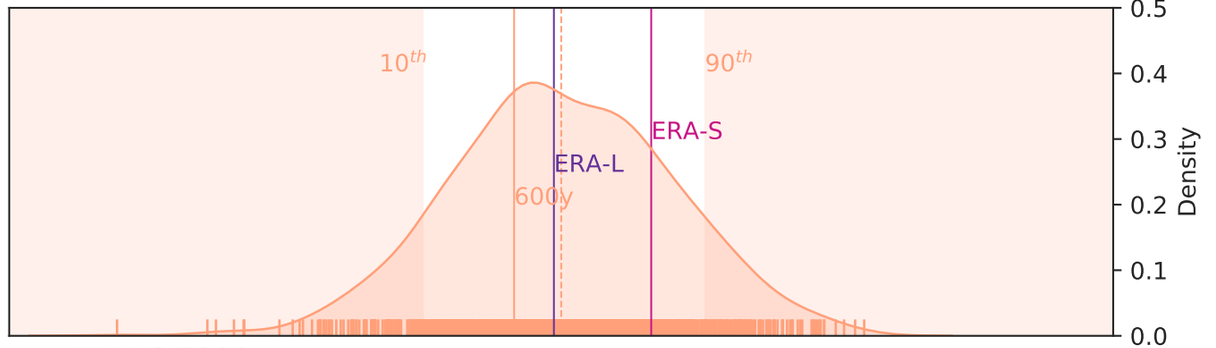


(a) WNPSM ⇒ Z200 | NPH - Japan - mean β

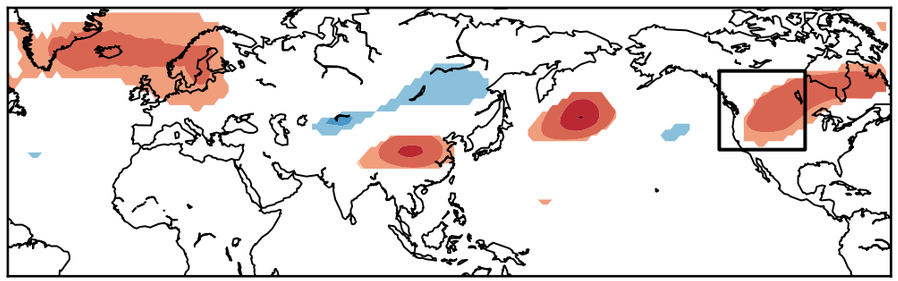


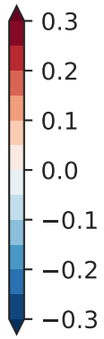


(b) Japan Z200

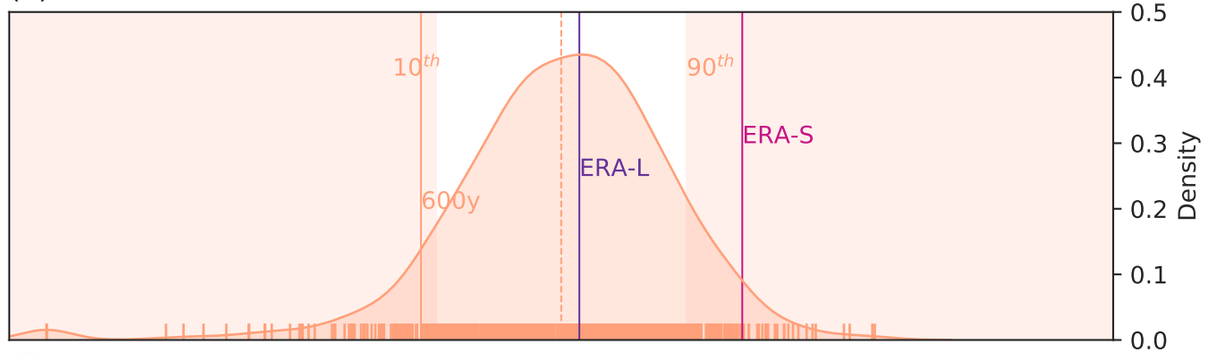


(c) NPH ⇒ Z200 | WNPSM - NW-US - mean β

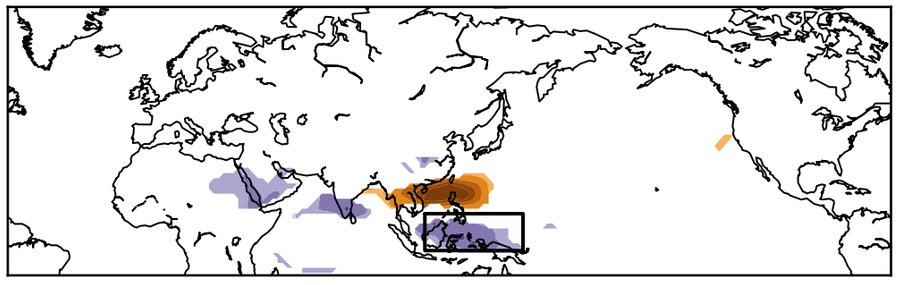


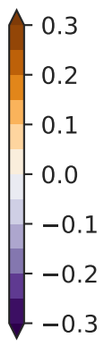


(d) NW-US Z200

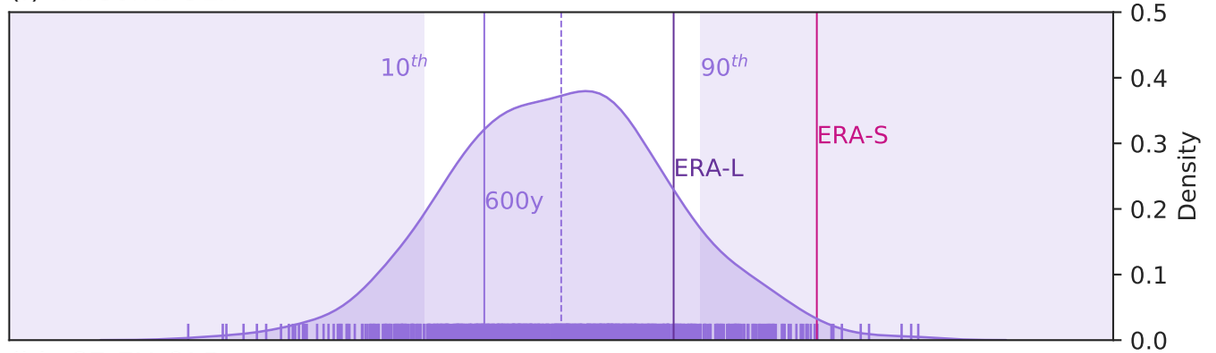


(e) WNPSM ⇒ OLR | NPH - M.Cont. - mean β

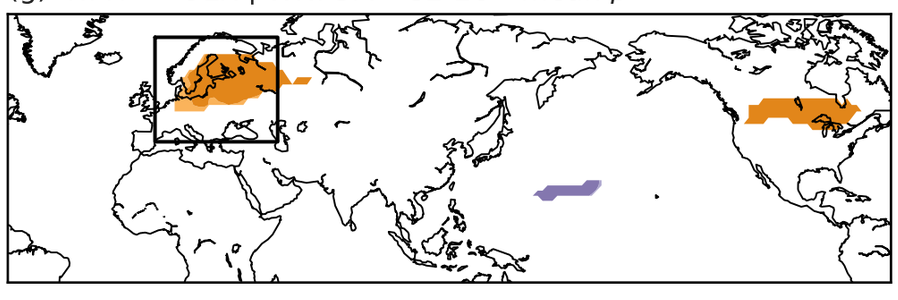


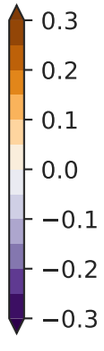


(f) M.Cont. OLR

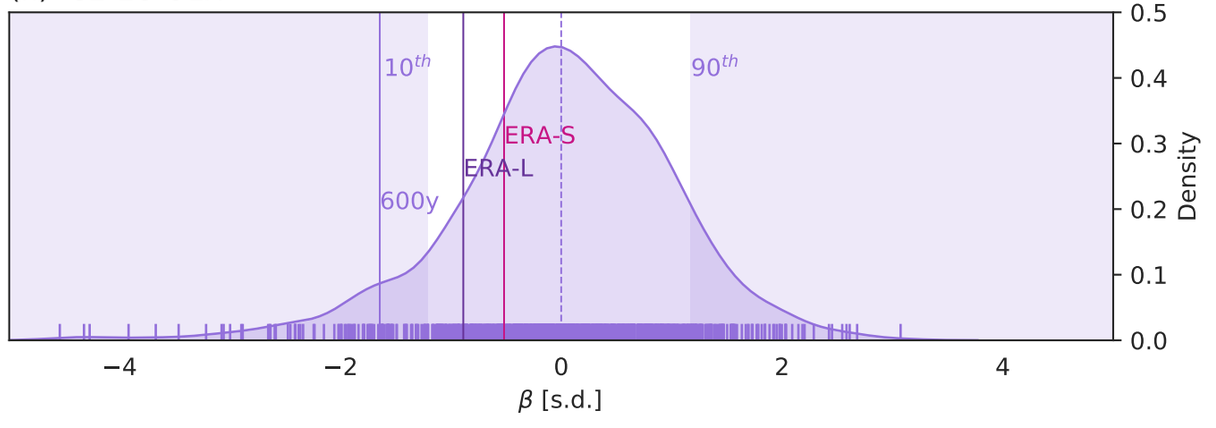


(g) NPH ⇒ OLR | WNPSM - CE-EU - mean β





(h) CE-EU OLR

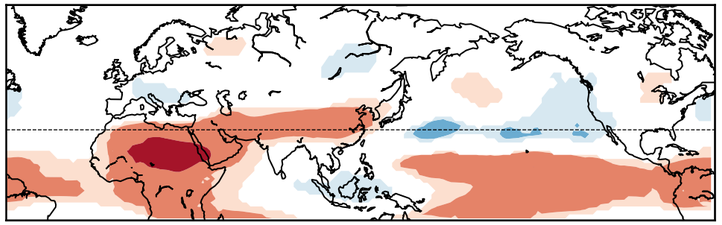


El Niño

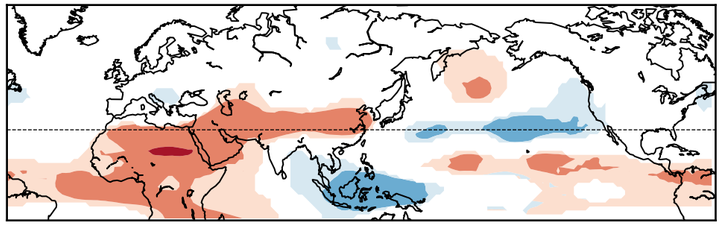
La Niña

El Niño - La Niña

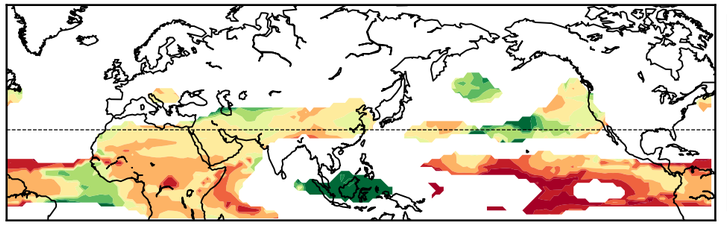
(a) SAM ⇒ Z200 | CGT, init03 [β]



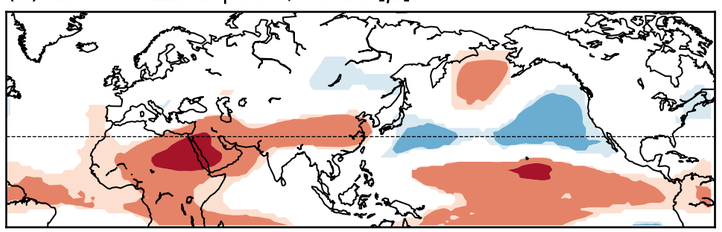
(b) SAM ⇒ Z200 | CGT, init03 [β]



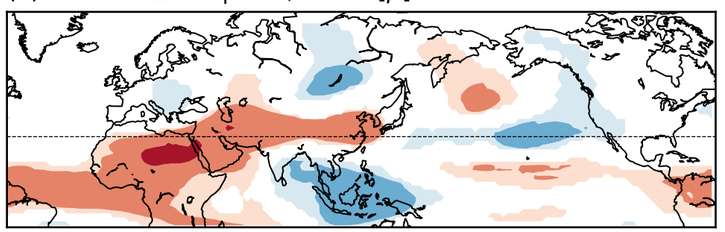
(c) SAM ⇒ Z200 | CGT, init03 [%]



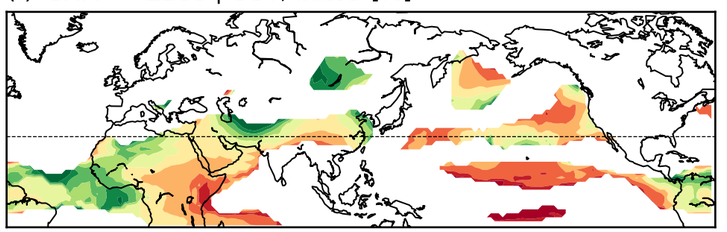
(d) SAM ⇒ Z200 | CGT, init05 [β]



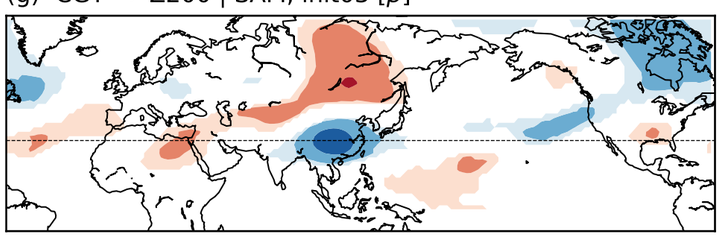
(e) SAM ⇒ Z200 | CGT, init05 [β]



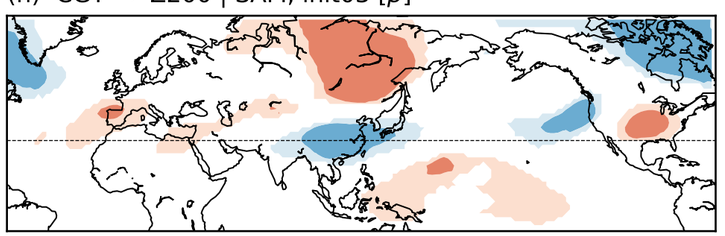
(f) SAM ⇒ Z200 | CGT, init05 [%]



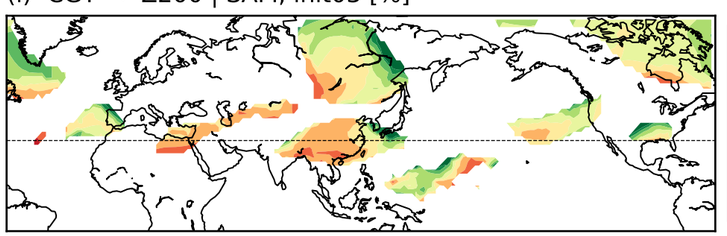
(g) CGT ⇒ Z200 | SAM, init03 [β]



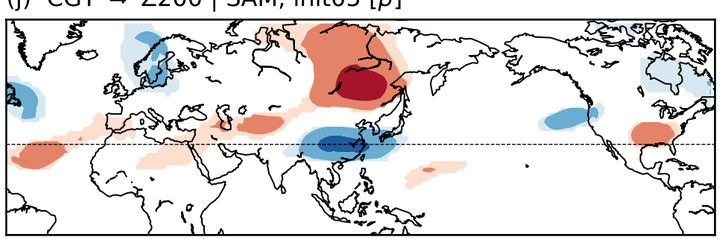
(h) CGT ⇒ Z200 | SAM, init03 [β]



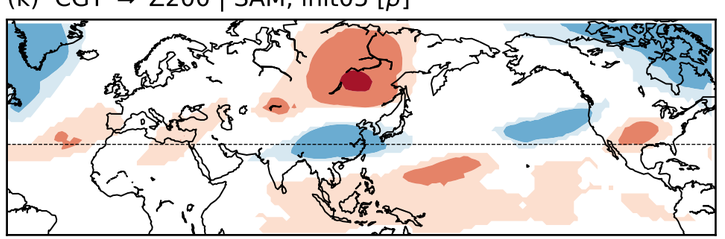
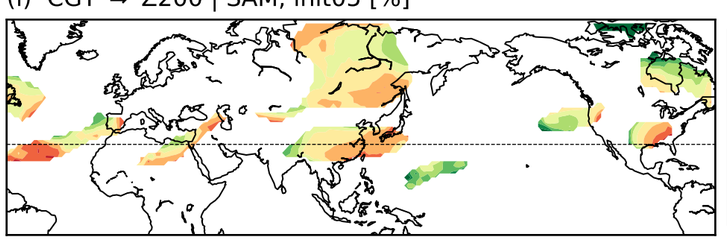
(i) CGT ⇒ Z200 | SAM, init03 [%]



(j) CGT ⇒ Z200 | SAM, init05 [β]



(k) CGT ⇒ Z200 | SAM, init05 [β]



(l) CGT ⇒ Z200 | SAM, init05 [%]